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Designing Sustainable Off-Highway Vehicle Trails

An Alaska Trail Manager's Perspective

In cooperation with

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Designing Sustainable Off-Highway Vehicle Trails

An Alaska Trail Manager's Perspective

Cover figure—A sustainable off-highway vehicle trail under construction in the White Mountains National Recreation Area, AK.

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Acknowledgments

No trail manager walks an untrodden path. I would be greatly remiss not to give credit to those who have contributed so generously to my knowledge and understanding of trail management.

Don Beers (retired) and Karl Knapp of California State Parks have honed the science of trail management to a fine edge. After training with them in California and Alaska, I have tried to adapt and apply their concepts of sustainable design, layout, construction, and maintenance to the management of motorized trails.

I've also had the privilege of being mentored by Cam Lockwood and Keith Ginn of Trails Unlimited, a U.S. Department of Agriculture, Forest Service enterprise unit. Their approach to trail management is decidedly pragmatic. They have trail dozers, and they know how to use them! These guys shared a wealth of practical trail knowledge from their work, ranging from the subarctic to the Mexican border and from California to the Atlantic seaboard.

The International Mountain Bicycling Association (IMBA) has influenced my concepts of trail design and methods of trail education. Probably more than any other organization, IMBA has taken sustainable trail management concepts to the people. The association's publications, mobile trail care crews, and popular trail training programs have promoted sustainable trail concepts across the globe. I have adapted several of its mountain bike trail concepts to off-highway vehicle (OHV) trails.

Shifting from major influences to in-the-trench partners, Blain Anderson was my long-term trails partner at the U.S. Department of the Interior, National Park Service (NPS). Many of the management concepts and techniques described in this document were developed talking with him while responding to OHV issues on NPS lands in Alaska. Anderson produced the bulk of the technical illustrations in this document. Because each illustration is worth a thousand words, he has been a major contributor to this report.

Another partner is Mike Shields, a retired NPS chief of maintenance. Shields is a master trail builder, bridge expert, blasting specialist, draftsman, illustrator, and educator. He has contributed generously to this report.

I also must thank the staff of the Alaska Region NPS Rivers, Trails, and Conservation Assistance Program (RTCA). Their photos supplement my own throughout this report. I've worked with RTCA staff members Kevin Keeler, Jack Mosby, Lisa Holzapfel, Heather Rice, and Kristen Pearson. I appreciate the opportunities the RTCA gave me to explore bog holes and braided trail snarls in exotic locations all across Alaska. Thanks also to Russ Kucinski and managers at the NPS Alaska Region who recognized the benefits of this work to the NPS and many other resource management agencies.

Special recognition goes to Alaska Trails, the Statewide trail advocacy nonprofit that is extending sustainable trail management training and trails professionalism within Alaska.

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Finally, a big thank you to all of the folks who have advanced, are advancing, or will be advancing the art and science of sustainable trail management.

How To Use This Report

This report is the author's collection of tools for the construction and management of off-highway vehicle (OHV) trails. The author brings together resources from a variety of sources, including the U.S. Department of Agriculture, Forest Service, the U.S. Department of the Interior, National Park Service (NPS), private trail management organizations, the State of Alaska, and others. The author developed some of the tools based primarily on his experience managing OHV trails in Alaska.

The Forest Service and the NPS cooperated in publishing this report to make this collection of tools available to a wider audience. We want to emphasize that, although some agency-prescribed trail management procedures are included in this report, trail managers must refer to and use their particular agency's policies and procedures when designing and managing OHV trails.

Because of the variety of standards and policies established by Government agencies, this document does not specify which methods should be used on specific lands. While the author hopes the tools and resources offered prove beneficial to land managers from multiple agencies, this report does not necessarily represent the views of the Forest Service or the NPS. This report is not intended to replace official policies or mandated procedures adopted by any Government agency.

Chapter 1: Introduction

Proper management of off-highway vehicle (OHV) trails is one of the most important tasks for trail managers today. In 2004, former Forest Service Chief Dale Bosworth identified unmanaged recreation as one of the Four Threats to the Nation's forests and grasslands. His example cited the nearly tenfold growth in popularity of OHV recreation in the preceding 30 years and indicated that even a small percentage of problem use can have a large cumulative impact.

The 10 elements of the management framework presented here will help OHV trail managers develop sustainable trails and protect the environment surrounding the trails. In addition, the framework will help OHV trail managers evaluate trail sustainability and develop OHV trail management programs that meet users' needs and expectations.

The framework provides a step-by-step approach to OHV trail management, incorporating sustainable design and management concepts with traditional trail management expertise and modern technological tools. The framework can be applied in part or in whole and applies whether you are constructing new trails or managing existing trail systems. The framework is helpful when you are initiating a management program for "orphan" trails—those trails that have never had any management whatsoever.

This management framework was field tested in a variety of settings, most often in Alaska, where the author is the regional trails specialist for the National Park Service (NPS), and a consultant for the NPS Rivers, Trails, and Conservation Assistance Program. Alaska, like many other parts of the country, has its own set of OHV management challenges. The management framework presented here was developed to apply to a broad range of OHV trail management settings. An earlier report, "Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments" (Meyer 2002), introduces some of the concepts developed here.

Following Title 36 of the Code of Federal Regulations, Part 212.1, the Forest Service defines an OHV as any motor vehicle designed for or capable of cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other natural terrain. In this report, OHVs include everything from dirt bikes to swamp buggies—off-road vehicles; off-highway motorcycles; all-terrain vehicles; utility-terrain vehicles; four-wheel-drive vehicles, such as pickup trucks and sport utility vehicles; and tracked vehicles. The legitimate use of OHVs is widely recognized by land management agencies, including the U.S. Department of the Interior, Bureau of Land Management and the NPS, as well as the Forest Service. These agencies have designated thousands of miles of OHV trails across national forests, rangelands, and other public lands. Other Federal agencies and many State and local authorities also provide OHV access across their lands.

Although this management framework does not specifically address safety issues involving operation of OHVs, land management agencies may require specialized training before their employees are allowed to operate OHVs. In addition, the agencies may have a number of other safety requirements for OHV operators, such as those detailed in the Forest Service Health and Safety Code Handbook (FSH 6709.11, U.S. Department of Agriculture 1999).

One of the management framework's primary objectives is to help managers develop and maintain sustainable trails. According to American Trails, a national trail nonprofit organization, a sustainable natural surface trail is:

> A trail that supports currently planned and potential future uses with minimal impact and negligible soil loss. The sustainable trail will require little rerouting and minimal maintenance over extended periods of time.

The National Interagency "Trail Management: Plans, Projects and People" training course (Beers 2009) defines a sustainable trail as:

> A trail that has been designed and constructed to such a standard that it does not adversely impact natural and cultural resources, can withstand the impacts of the intended user and the natural elements while receiving only routine cyclic maintenance and meets the needs of the intended user to a degree that they do not deviate from the established trail alignment.

Regardless of how sustainable trails are defined, trail managers can only be successful when they have an understanding of the nature of OHV trails, trail users, and the surrounding environment.

Chapter 2: Sustainable Trail Design Guidelines

This report presents simplified guidelines for off-highway vehicle (OHV) trail design. The author was greatly influenced by the California State Parks' sustainable trail criteria in its draft (2009) trails handbook. The author also took into consideration the International Mountain Bicycling Association's (IMBA 2007) essential elements of sustainable trails. The result is the author's integrated set of six sustainable OHV trail design guidelines:

1. **Contour curvilinear alignment—**Align the trail so it runs along the natural contour of the terrain.
2. **Controlled grade—**Strive for a design trail grade of 10 percent or less and a maximum sustainable trail grade based on local soil and terrain conditions. Limit the length of the segments with maximum grade to less than 100 feet and their combined length to less than 5 percent of the total trail length.
3. **Integrated drainage—**Integrate water control in the design and construction of the trail using outslope, grade reversals, and grade dips to maintain the terrain's natural drainage patterns. Space drainage structures close enough to prevent water erosion on tread surfaces or at points of discharge.

   The very best drainage designs are those built into new construction. These include frequent grade reversals and outsloping the entire tread. The classic mark of good drainage is that it's self-maintaining, requiring minimal care.
4. **Full bench—**Construct a full bench by cutting the full width of the tread into the hillside on native, undisturbed material and casting the excavated soil as far from the trail as possible.

   Full-bench construction requires more excavation and leaves a larger backslope than partial-bench construction. Full-bench construction may have more visual impacts. The trailbed also will be more durable and require less maintenance. Use full-bench construction whenever possible.
5. **Durable tread—**Provide a durable tread surface of compacted mineral soil, imported capping material, bedrock, or a hardened tread surfacing.

   Providing a durable tread for OHV trails is critical for sustainability. In some cases, durable tread can help meet the intent of sustainable trail design guidelines 1 through 4.
6. **Appropriate maintenance—**Conduct routine maintenance and periodic project work to ensure that the trail remains within its original design specifications.

Some sustainable trail design guidelines are illustrated in figures 2–1 through 2–5. Applying these guidelines ensures a high level of environmental protection and long-term utility of the trail and tread surface under most anticipated use and climatic conditions. The six sustainable trail design guidelines are used throughout this report as criteria for evaluating the sustainability of planned and existing trails.

Figure 2–1—This trail in the Chugach National Forest illustrates contour curvilinear alignment, the first sustainable trail design guideline. Note how the trail crosses the slope along the topographic contour rather than running more directly up or down the slope. The sideslope location of the trail and its alignment encourage the natural force of gravity to carry water across the trail rather than directing it down the trail.

Figure 2–2—This off-highway vehicle trail in the Bureau of Land Management White Mountains National Recreation Area illustrates controlled grade and integrated drainage, the second and third sustainable trail design guidelines. Note how the trail slowly descends the sidehill. In this case, the grade never exceeds 10 percent and grade reversals (short, abrupt changes in grade) serve as integrated water control features. The all-terrain vehicle rider visible in the photo is traversing the bottom of one of the grade reversals.

Figure 2–3—Note the angle of the trail tool handle. It shows that the trail tread has outslope, one type of integrated drainage (the third sustainable trail design guideline). Outslope encourages water to flow across the trail. Unfortunately, functional outslope is usually lost on off-highway vehicle trails when wheel ruts form. Grade reversals and rolling dips overcome this problem.

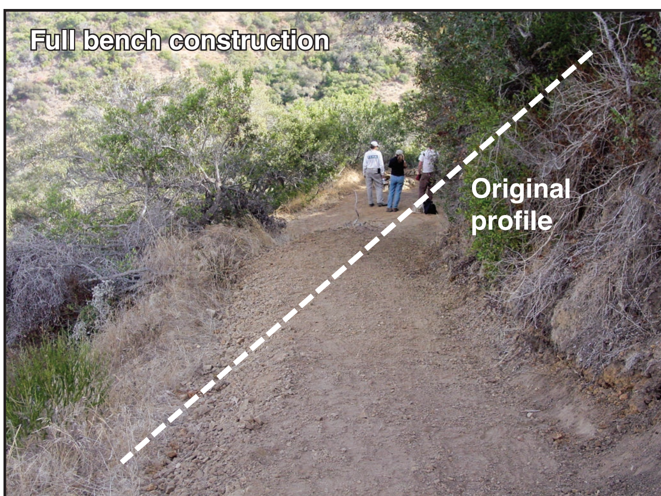


Figure 2–4—This profile of a Catalina Island, CA, foot trail illustrates full bench construction, the fourth sustainable trail design guideline. The dashed line indicates the original profile of the sideslope. Note how the entire slope has been excavated to ensure that the trail tread is supported by the most durable tread surface possible.

Figure 2–5—This figure illustrates the need for durable tread, the fifth sustainable trail design guideline. Even if contour curvilinear alignment, integrated drainage, and full bench construction are provided, some soils and environmental conditions require that surface tread receive extra attention. This photo of a sustainable off-highway vehicle trail alignment in Alaska's Chena River State Recreation Area illustrates a tread surface that is excessively muddy when wet. Capping this area with gravel would ensure a durable wear surface under all climatic conditions.

The sustainable trail design guidelines provide OHV trail managers with a checklist for trail design, layout, and construction. The guidelines can help managers build trails that resist impact from use and are resilient when climate conditions change. Also, they can help trail managers identify design flaws in existing trails and predict their long-term performance. The trail terms explained below are important for understanding the sustainable trail design guidelines.

Trail Terms

The Half Rule (Controlled Grade)

Building sustainable trail grades helps keep maintenance at bay. The half rule (figure 2–6) from "Trail Solutions: IMBA's Guide to Building Sweet Singletrack" (International Mountain Bicycling Association 2004) may be a helpful guideline.

For example, if you're working on a hill with a 16-percent sideslope, the grade of your trail design should be no more than 8 percent. If the trail is any steeper, it will be a fall-line trail. Fall-line trails tend to capture and channel water, causing erosion and ruts.

As sideslopes get steeper than 20 percent, trails designed using the half rule can be too steep. The actual sustainable trail grade for any segment of trail can only be determined by a careful evaluation of all site conditions, such as soil type, hydrology, topography, weather, and tree canopy.

Grade Reversals (Integrated Drainage)

A grade reversal (figure 2–7) is a short, distinct change in grade from ascending to descending (followed by a return to ascending). Sometimes, grade reversals are called grade dips, terrain dips, Coweeta dips, or swales. The Forest Service refers generally to all of these structures as drain dips. The basic idea is to use the reversal in grade to move water off the trail. Grade reversals are designed and built into new trails. A trail with grade reversals and outsloped tread encourages water to continue sheeting across the trail—not down it. The beauty of grade reversals is that they are the most unobtrusive of all drainage features if they are constructed with smooth grade transitions. Also, they require very little maintenance.

Try to place grade reversals in natural dips, swales, and draws, ideally at an interval of every 75 to 125 feet.

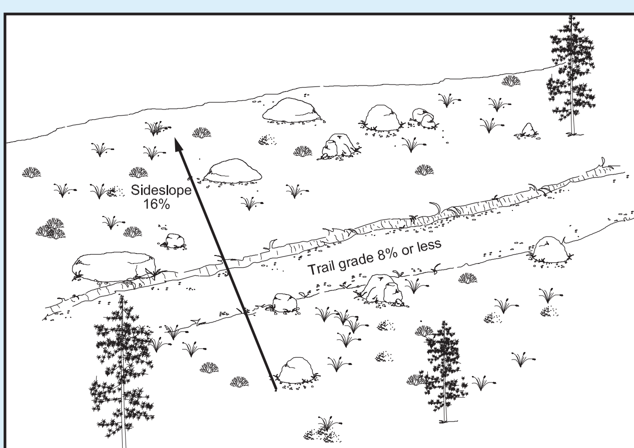


Figure 2–6—The half rule says that the trail grade should be no more than half the sideslope grade, or it will be a fall-line trail.

Figure 2–7—Grade reversals are much more effective than waterbars and require less maintenance.

Trail Terms (continued)

Rolling Grade Dips (Integrated Drainage)

Rolling grade dips (figure 2–8) are another way to direct water off existing trails. A rolling grade dip is typically constructed when maintaining existing trails.

A rolling grade dip is a constructed drain with a long ramp built on its downhill side (figure 2–9). For example, if a trail is descending at a 7-percent grade, a rolling grade dip includes a short dip, a climb of 10 to 20 feet at 5 to 10 percent, and a return to a descending grade down the constructed ramp. Water running down the trail cannot climb over the short rise and will run off the outsloped tread at the bottom of the drain. The beauty of this structure is that there is nothing to rot or be dislodged. Maintenance is simple.

Rolling grade dips should be placed frequently enough to prevent water from building up enough volume and velocity to carry your tread's surface away. Rolling grade dips are pointless at the top of a grade. Midslope locations are best. The steeper the trail, the more rolling grade dips are needed. Rolling grade dips should not be constructed where they might send sediment-laden water into live streams. See appendix A for details on rolling grade dips.

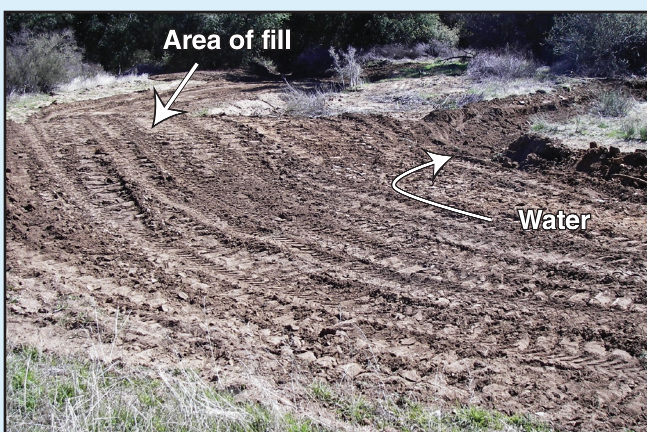


Figure 2–8—Rolling grade dips are constructed to direct water off existing trails.

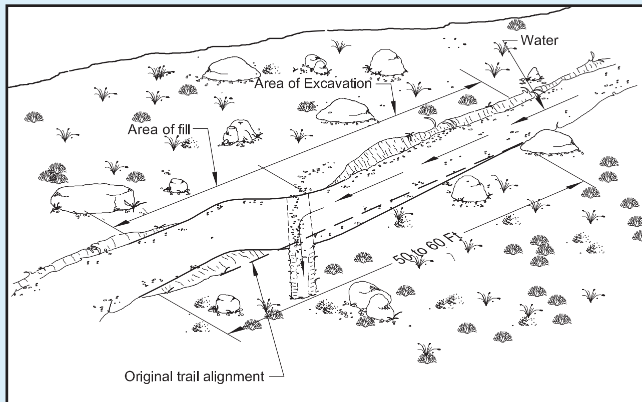


Figure 2–9—This drawing shows how to construct a rolling grade dip.

Outslope (Integrated Drainage)

Outslope (also referred to as cross slope) is when the trail tread is shaped with a slight (5- to 10-percent) slant to the outside of the tread. This encourages water (sheet flow) from the slope above to flow across the trail and drain down the slope below. Outslope is a successful technique for managing water on foot trails, but it is difficult to maintain on wider trails required for off-highway vehicles (OHVs). Motorized use quickly wears wheel tracks that capture and channel sheet flow down the trail. For OHV trails, grade reversals and rolling grade dips do a better job of controlling water than outslope.

Sheet Flow (Integrated Drainage)

When rain falls on hillsides, the water continues to flow down the hill in dispersed sheets—called sheet flow (figure 2–10). The design elements for a contour trail—building the trail into the sideslope, maintaining sustainable grades, adding frequent grade reversals, and outsloped tread—encourage water to flow across the trail where it will do little damage.

Trail Terms (continued)

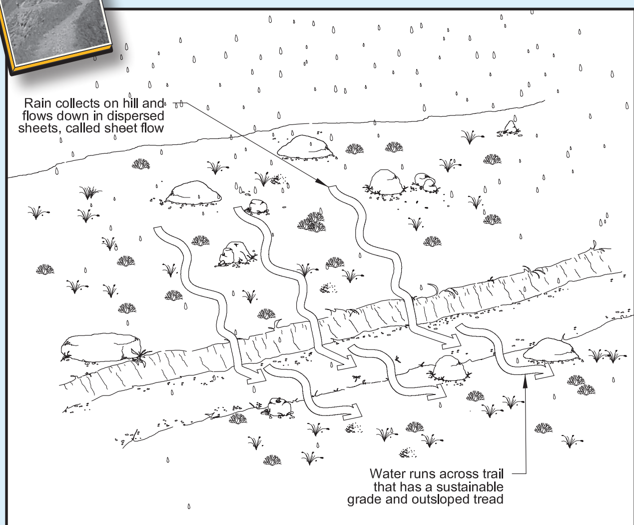


Figure 2–10—Design elements for a contour trail let water flow across the trail. Sheet flow prevents water from being channeled down the trail, where it could cause erosion.

—Adapted for off-highway vehicle trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

Figure 2–11—An off-highway vehicle trail adapted from a forestry road in south-central Alaska. Old roads and four-wheel-drive tracks provide ready access to the backcountry and are commonly adapted for off-highway vehicle use.

Figure 2–12—An evolved off-highway vehicle trail in the Bureau of Land Management White Mountains National Recreation Area. The ridgetop rock outcrops have long drawn attention because they provide a great scenic view of the surrounding terrain.

Challenges of Applying Sustainable Trail Design Guidelines

Applying the sustainable trail design guidelines is relatively easy when constructing new trails, but two situations often confront OHV trail managers when they try to apply the guidelines to existing OHV trails:

- Few existing OHV trails meet all of the guidelines.
- Guidelines 1 through 4 do not apply if a trail is on flat terrain.

Many OHV trails began as old game or four-wheel-drive tracks that were adapted for OHVs or evolved as riders continued to follow a set of OHV tracks that had been pioneered across the landscape. Figures 2–11 and 2–12 show an adapted trail and an evolved trail. Few of these trails were designed or constructed to any guideline, much less the six sustainable trail design guidelines. As a result, many of these trails degrade as use increases or when the types of use change over time.

For a trail to meet the first four sustainable trail design guidelines, the trail must be located on a sideslope. Sloped terrain is required for contour alignment, controlled grade, integrated drainage, and full bench construction. These design elements don't readily apply to flat terrain.

Trails on flat areas often have problems with tread entrenchment and water management. OHV traffic can easily wear and compact surface soils until the tread is below ground level. Water often drains from the surrounding terrain and the trail becomes muddy. Muddy trails contribute to trail widening, ruts, and potholes, reducing the quality of the tread. In extreme cases, the degraded trail segments are avoided or abandoned by users, who develop new tracks around them—a condition referred to as "trail braiding." Figures 2–13 and 2–14 show examples of problems affecting trails on flat terrain.

Trails that cross flat terrain often require special trail design and construction methods to be sustainable. The fifth sustainable trail design guideline, durable tread, addresses this problem. Methods to provide durable tread for these trails are generally referred to as "trail hardening." Appendix B has additional information on trail hardening.

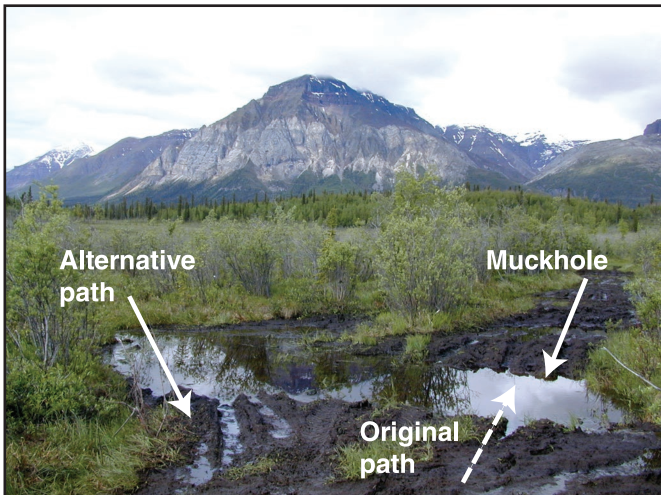


Figure 2–13—This off-highway vehicle trail in Wrangell-St. Elias National Park and Preserve illustrates the problems of flat trails that cross permafrost terrain. Vehicle traffic has worn and compressed the surface cover until it collects and holds water. Repeated traffic has created deep muck holes and forced riders to create alternative paths around the degraded segment.

Figure 2–14—This trail on Alaska State land near Homer, AK, does not have permafrost, but the trail became muddy and rutted after traffic entrenched the trail relative to the surrounding terrain.

The Parts of a Trail

A **trail** is comprised of one or more **trail sections** that have multiple **trail segments.**

This report uses the following terms to describe a trail and its parts:

Trail—A linear route that typically connects a trailhead to a destination or junction or forms a loop route and is comprised of one or more trail sections.

Trail section—A portion of a trail with one or more segments that typically have the same Trail Class or general character. For example:

- A highly developed trail may have one section that serves a wide variety of users and, farther along, another less developed section that serves a single group of users.
- A trail may be divided into sections when the trail crosses different types of terrain (such as flood plains, steep slopes, or extensive wetlands), requiring different types of tread management.

Trail segment—A short portion of a trail or trail section with similar physical characteristics, such as tread width, grade, and surface character. For example:

- A portion of trail that has consistent 8-percent grade, 6-foot width, and a smooth gravel surface. Significant changes in any of these characteristics require a new segment. Typically, a trail has dozens, if not hundreds, of individual trail segments. The number of identified segments depends on the complexity of the trail and the intensity of management.

Chapter 3: Trail Sustainability Categories

The sustainable trail design guidelines can help managers objectively evaluate the sustainability of off-highway vehicle (OHV) trails. Four trail sustainability categories that can be used to describe trails or trail sections are:

- **Design sustainable—**A trail or trail section that meets all six of the sustainable trail design guidelines. These trails or trail sections seldom have degradation issues because they are well designed.
- **Performance sustainable—**A trail or trail section that does not meet all of the sustainable trail design guidelines, but does not display any evident signs of degradation or loss of tread utility. This may occur when trails are lightly used or are used in ways that have low impact. Performance sustainable trails can only be expected to remain sustainable under the existing type of use, volume of use, and intensity of use—and only when weather is favorable. If conditions change, the sustainability of the trail can change abruptly.
- **Maintainable—**A trail or trail section that does not meet all of the sustainable trail design guidelines. With a reasonable level of improvement and regular maintenance, the trail or trail section can support a managed level of use without creating unacceptable environmental degradation or making the travel surface less usable.
- **Unmaintainable—**A trail or trail section that does not meet any of the sustainable trail design guidelines, is significantly degraded, and cannot reasonably be improved or maintained to protect environmental values or keep the trail surface usable at existing or even reduced levels and/or types of use.

Figure 3–1—An example of a design sustainable trail section that meets all six of the sustainable trail design guidelines. This trail is in the Carnegie State Vehicular Recreation Area in central California.

Figure 3–2—An example of a performance sustainable section of the Summit-Lake Miam Trail on Kodiak Island, AK. This section follows a ridgeline that has multiple segments of fall-line alignments. Because of low use levels there is little degradation, but continued or increased use could lead to erosion and rapid degradation.

These trail sustainability categories (figures 3–1 to 3–4) can help trail workers, agency managers, and the general public define the current status of a trail and predict its long-term utility. These categories will help managers evaluate management options, set priorities, and implement management decisions.

"Element 6—Evaluation of Management Options," discusses methods managers can use to sort trails into the four sustainability categories.

Figure 3–3—An example of a maintainable trail section in the Fortymile River area, AK. This section has a contour alignment and an average trail grade less than 10 percent, but it lacks adequate water control. Rolling grade dips could be integrated into the alignment for increased sustainability.

Figure 3–4—An example of an unmaintainable trail section. This section has none of the sustainable trail design elements and displays evidence of extreme degradation. The section has been closed and slated for reclamation.

Chapter 4: Trail Fundamentals

Many trail management concepts used by Federal land management agencies apply to off-highway vehicle (OHV) trails. Among these are five Trail Fundamentals refined and implemented by the Forest Service for all-terrain vehicles (ATVs), motorcycles, and four-wheel drive vehicles, collectively called OHVs. As of May 2011, the U.S. Department of the Interior, Fish and Wildlife Service, National Park Service (NPS), and Bureau of Land Management (BLM) have also adopted four of these fundamentals (indicated below with an "*"). The Forest Service Trail Fundamentals include:

- Trail Type*
- Trail Class*
- Managed Use*
- Designed Use*
- Design Parameters

These fundamentals help managers consistently record and communicate the **intended** design and management guidelines for trail design, construction, maintenance, and use. Direction and guidance regarding the Trail Fundamentals are in the Forest Service Manual (FSM) 2353.13 <http://www.fs.fed.us/cgi-bin/Directives/get_dirs/fsm?2300> and Forest Service Handbook (FSH) 2309.18, Sec. 5, 14, and 20 <http://www.fs.fed.us/cgi-bin/Directives/get_dirs/fsh?2309.18>. Additional information and training materials on Trail Fundamentals are available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Trail Type

The Trail Type is a category that reflects the predominant trail surface and general mode of travel accommodated by a trail (FSH 2309.18, Sec. 14.1). The three Trail Types are:

Standard/Terra Trail—A trail that has a surface consisting predominantly of the ground and that is designed and managed to accommodate use on that surface.

Snow Trail—A trail that has a surface consisting predominantly of snow or ice and that is designed and managed to accommodate use on that surface.

Water Trail—A trail that has a surface consisting predominantly of water (but may include land-based portages) and that is designed and managed to accommodate use on that surface.

Trail Types are exclusive. Only one Trail Type can be assigned per trail or trail section so managers can identify specific trail Design Parameters (technical specifications), management needs, and costs for specific uses and/or seasons. Identify the Trail Type based on applicable land management plan direction, travel management decisions, trail-specific decisions, and other related direction. A single physical route may accommodate a Standard/Terra Trail during the summer and a Snow Trail during the winter. For administrative purposes, these would be considered two separate trails. In this report, OHV trails are considered Standard/Terra Trails.

Trail Class

Trail Class is the prescribed scale of development for a trail, representing its **intended** design and management standards (FSH 2309.18, Sec. 14.2). Only one Trail Class is identified per trail or trail section:

- **Trail Class 1—**Minimally developed
- **Trail Class 2—**Moderately developed
- **Trail Class 3—**Developed
- **Trail Class 4—**Highly developed
- **Trail Class 5—**Fully developed

The descriptions of the Trail Classes are meant to represent the typical development character of trails within that class. Exceptions for individual elements are allowed as long as they are consistent with the general intent of the applicable Trail Class. Identify the appropriate Trail Class for each trail or trail segment based on the management intent in the applicable land management plan, travel management decisions, trail-specific decisions, and other related direction. Apply the Trail Class that most closely reflects the management intent for the trail or trail segment, which **may or may not** reflect the current condition of the trail. For specifics on each Trail Class, see <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml/>.

There is a direct relationship between Trail Class and Managed Use: generally, one cannot be determined without considering the other (FSH 2309.18, Sec. 14.3). Not all Trail Classes are appropriate for all Managed Uses. Figures 4–1 through 4–3 illustrate several Trail Classes for OHV, multiuse, and foot trails in Alaska.

Figure 4–1— This unnamed section of a moderately developed off-highway vehicle trail (Class 2) is on Kodiak Island, AK.

Figure 4–3—The Photo Point Trail is a fully developed foot trail (Class 5) at the Mendenhall Glacier, Juneau, AK.

Figure 4–2—The Powerline Pass Trail is a developed multiuse trail (Class 3) in Chugach State Park, AK.

Managed Use

Managed Use is a mode of travel that is **actively** managed and appropriate on a trail, based on its design and management (FSH 2309.18, Sec. 14.3). Managed Use indicates a decision or intent to accommodate or encourage a specific type of trail use.

Each trail or trail section may have more than one Managed Use. The Managed Uses on a trail are usually a subset of all allowed uses. For example, a trail that is managed for ATVs and motorcycles may also allow mountain biking and hiking.

Identify the Managed Uses for each trail or trail segment based on applicable land management plan direction, travel management decisions, trail-specific decisions, and other related direction. There is a direct relationship between Managed Use and Trail Class: generally, one cannot be determined without consideration of the other. Not all Trail Classes are appropriate for all Managed Uses. The Forest Service provides guidance on the potential appropriateness of each Trail Class to each Managed Use in FSH 2309.18, Sec. 14.3, ex. 01.

Designed Use

The Designed Use is the Managed Use of a trail that requires the most demanding design, construction, and maintenance parameters and that, in conjunction with the applicable Trail Class, determines which Design Parameters will apply to a trail (FSH 2309.18, Sec. 14.4).

Each trail or trail section may have only one Designed Use. Although a trail or trail segment may have more than one Managed Use and numerous uses may be allowed, only one Managed Use is identified as the design driver or Designed Use.

Determine the Designed Use for a trail or trail segment from the Managed Uses identified for that trail. When making this determination, consider all Managed Uses that occur during all seasons of use of the trail or trail segment. Assess any essential or limiting geometry for the Managed Uses of the trail or trail segment to determine whether any trail-specific adjustments are needed for the applicable Design Parameters.

In some situations, when there is more than one Managed Use identified for a trail, the Designed Use may be readily apparent. For example, on a trail with Managed Uses of ATV and motorcycle, ATV use would be the Designed Use because this use requires wider tread and a larger turning radius, as well as lower tolerances for surface obstacles and maximum trail grades.

In other situations involving more than one Managed Use, the Designed Use may not be readily apparent, as is often the case when there are fewer differences between the applicable sets of Design Parameters than in the example above. For example, on a trail that is actively managed for hiker and pedestrian, pack and saddle, and bicycle use, pack and saddle use would likely be the Designed Use. Of the three Managed Uses, pack and saddle use generally has the most limiting design requirements. The pack and saddle Design Parameters may need to be adjusted so this trail's Design Parameters accommodate bicycles.

Design Parameters

Design Parameters are technical guidelines for the survey, design, construction, maintenance, and assessment of a trail, based on its Designed Use and Trail Class.

Design Parameters reflect the design objectives and determine the dominant physical criteria that most define the trail's geometric shape (FSH 2309.18, Sec. 14.5). These criteria include:

- **Design tread width—**Design tread width is expressed in terms of single lane, double lane, and the minimum tread width on trail structures.
- **Design surface—**Design surface is expressed in terms of surface type, protrusions, and obstacles.
- **Design grade—**Design grade is expressed in terms of target grade, short pitch maximum grade, and maximum pitch density.
- **Design cross slope—**Design cross slope is expressed in terms of target cross slope and maximum cross slope.
- **Design clearing—**Design clearing is expressed in terms of width, height, and shoulder clearance.
- **Design turns—**Design turns are expressed in terms of the turning radius.

The Forest Service has developed Design Parameters for each of the Designed or Managed Uses in the list on page 15. Figure 4–4 shows the Forest Service Design Parameters for ATV trails. Definitions of Design Parameter attributes listed in this figure (such as design tread width and short pitch maximum) can be found in FSH 2309.18, Sec. 5.

The Forest Service Health and Safety Code Handbook defines ATVs as off-highway vehicles that travel on three or more low-pressure tires; have handle-bar steering; are less than or equal to 50 inches in width; and have a seat designed to be straddled by the operator. The Forest Service does not define ATV parameters for Trail Classes 1 and 5 because these Trail Classes are typically not designed or actively managed for ATV use, although the use may be accepted.

Design Parameters

Design Parameters are technical guidelines for the survey, design, construction, maintenance, and assessment of National Forest System trails, based on their Designed Use and Trail Class and consistent with their management intent[1]. Local deviations from any Design Parameter may be established based on trail-specific conditions, topography, or other factors, provided that the deviations are consistent with the general intent of the applicable Trail Class.

Designed Use ALL-TERRAIN VEHICLES (ATVs)		Trail Class 1	Trail Class 2	Trail Class 3	Trail Class 4	Trail Class 5
Design tread width	**Single lane**	Typically not designed or actively managed for ATVs, although use may be accepted	48" – 60"	60"	60" – 72"	Typically not designed or actively managed for ATVs, although use may be accepted
	Double lane		96"	96" – 108"	96" – 120"	
	Structures (Minimum width)		60"	60"	60"	
Design surface[2]	**Type**		Native, limited grading May be continuously rough Sections of soft or unstable tread on grades < 5% may be common and continuous	Native with some onsite borrow or imported material where needed for stabilization, occasional grading Intermittently rough Sections of soft or unstable tread on grades < 5% may be present	Native with imported materials for tread stabilization common, routine grading Minor roughness Sections of soft tread not common	
	Protrusions		≤ 6" May be common and continuous	≤ 3" May be common, not continuous	≤ 3" Uncommon, not continuous	
	Obstacles (Maximum height)		12" May be common or placed for increased challenge	6" May be common, left for increased challenge	3" Uncommon	
Design grade[2]	**Target grade**		10% – 25%	5% – 15%	3% – 10%	
	Short pitch maximum		35%	25%	15%	
	Maximum pitch density		20% – 40% of trail	15% – 30% of trail	10% – 20% of trail	

Figure 4–4—Forest Service national trail Design Parameters for all-terrain vehicle trails. —*From FSH 2309.18, "All-Terrain Vehicle Design Parameters," Trails Management Handbook (U.S. Department of Agriculture, Forest Service October 16, 2008)* available at <*http://www.fs.fed.us/recreation/programs/trail-management/index.shtml*>.

Designed Use ALL-TERRAIN VEHICLES (ATVS)		Trail Class 1	Trail Class 2	Trail Class 3	Trail Class 4	Trail Class 5
Design cross slope	Target cross slope		5% – 10%	3% – 8%	3% – 5%	
	Maximum cross slope		15%	10%	8%	
Design clearing	Height		6' – 7'	6' – 8'	8' – 10'	
	Width (On steep side hills, increase clearing on uphill side by 6" – 12")		60" Some light vegetation may encroach into clearing area	60" – 72"	72" - 96"	
	Shoulder clearance		0" – 6"	6" – 12"	12" – 18"	
Design turn	Radius		6' – 8'	8' – 10'	8' – 12'	

[1] For definitions of Design Parameter attributes (e.g., design tread width and short pitch maximum) see FSH 2309.18, section 05.

[2] The determination of trail-specific grades, surface, and other Design Parameters should be based upon soils, hydrological conditions, use levels, erosion potential, and other factors contributing to surface stability and overall sustainability of the trail.

Figure 4–4 (continued)

Forest Service Designed Use Types

- Hiker/pedestrian
- Pack and saddle
- Bicycle
- Motorcycle
- All-terrain vehicle
- Four-wheel-drive vehicle wider than 50 inches
- Cross-country ski
- Snowshoe
- Snowmobile
- Motorized watercraft
- Nonmotorized watercraft

Local deviations to the Design Parameters may be established based on specific trail conditions, topography, and other factors, provided that the variations continue to reflect the general intent of the applicable Trail Class. Grade variances should be based on local soils, hydrologic conditions, use levels, and other factors that contribute to erosion potential. Trail grades steeper than 10 percent should be evaluated carefully because of the likelihood of erosion and tread displacement.

The Forest Service Design Parameters can be adapted by other trail management organizations to fit their OHV management program. Any modifications should reflect the basic intent of the national Trail Classes. Table 4–1 presents a modified version of ATV Design Parameters developed by the author for use in Alaska. The modifications limit the design grades and include wider turn radiuses, guidance regarding water control, and sustainable trail design elements.

Table 4–1—Design Parameters modified by the author for all-terrain vehicle (ATV) trails in Alaska. Trail Classes 1 and 5 are not shown because they are not designed for ATVs as the primary user. *—Adapted from "All-Terrain Vehicle Design Parameters," FSH 2309.18, Trails Management Handbook (U.S. Department of Agriculture, Forest Service October 16, 2008).*

Designed Use: All-terrain vehicle		Trail Class 2 Simple/minor developed	Trail Class 3 Developed/improved	Trail Class 4 Highly developed
Design tread width (If sideslopes are more than 50 percent, increase widths by 6 to 18 inches)	**One lane**	48 to 60 inches	60 inches	60 to 72 inches
	Two lane	Typically not designed for two-lane travel Passing areas (uncommon) 108 inches	Typically not designed for two-lane travel Passing areas (common) 108 inches	Two-lane travel (common) 108 to 120 inches
	Structures (minimum width)	60 inches	72 inches	78 inches
Design surface	**Type**	Native, with limited onsite borrow or imported materials Few loose or soft trail segments, commonly rough	Native, with some onsite borrow or imported materials No loose or soft trail segments, occasionally rough	Native, with extensive gravel, pavers, or other imported materials Firm and stable
	Obstacles	Rough, with embedded rock, holes, and protrusions up to 6 inches	Generally smooth, with few protrusions exceeding 4 inches	Smooth, with few obstacles exceeding 1 to 3 inches
Design grade[1] (also referred to as target grade in Alaska)	**Target range** (more than 90 percent of trail)	Less than 15 percent More than 3 percent	Less than 12 percent More than 3 percent	Less than 10 percent More than 3 percent
	Short pitch maximum (up to 100-foot lengths—with appropriate water control above and within pitch)	25 percent on rock or bedrock 20 percent on soil	20 percent on rock or bedrock 15 percent on soil	15 percent
	Maximum pitch density[2]	Less than 15 percent of trail	Less than 10 percent of trail	Less than 5 percent of trail
Design tread cross slope (outslope)	**Target range**	5 to 10 percent	3 to 8 percent	3 to 5 percent
	Maximum	15 percent	10 percent	8 percent
Design clearing	**Width** (on steep sidehills, increase clearing on uphill side by 6 to 12 inches)	12 inches outside of tread edge Some light vegetation may encroach into clearing area	12 to 18 inches outside of tread edge	More than 18 to 24 inches outside of tread edge
	Height	7 to 8 feet	8 feet	10 feet
Design turns	**Radius**	15 feet minimum	15 to 20 feet minimum	20 feet minimum
	Type	Climbing turns (switchbacks only when absolutely necessary)	Climbing turns	Climbing turns
Water control[3]	**Type**	Grade reversals Dip drains Rolling grade dips No water bars	Grade reversals Dip drains Rolling grade dips No water bars	Grade reversals Dip drains Rolling grade dips No water bars
Sustainable trail design	**Elements**	Contour alignment Controlled grade Integrated drainage Full bench Durable tread	Contour alignment Controlled grade Integrated drainage Full bench Durable tread	Contour alignment Controlled grade Integrated drainage Full bench Durable tread

[1]Target and short pitch trail grades should be based on local soils, hydrological conditions, use levels, and other factors contributing to surface stability and erosion potential.

[2]Maximum pitch density refers to the percentage of the trail length that has the short pitch maximum grade.

[3]Water control structures should be spaced frequently enough to prevent water from eroding the tread surface.

Trail Design Factors

Trail use characteristics, site conditions, and climate and weather affect trail design, layout, construction methods, and maintenance. Figure 4–5 shows the relationship between these factors.

Trail use characteristics refer to the type, volume, intensity, and season of trail use, as well as user satisfaction, preferences, and behavior. Specific characteristics of use types should be identified. Table 4–2 is an example of OHV use characteristics identified by the author. Use characteristics define the potential use and expected wear and tear on the trail tread and associated trail features.

Site conditions, such as slope (or lack of slope), soil type, and local hydrology also affect a trail. As a trail crosses different landscapes, the surface soil, site hydrology, and terrain characteristics change. As these site conditions change, the site's natural ability to support trail use changes. Trail design and construction methods may need to be modified to reflect these changes.

Climate and weather also have a strong effect on trails. Trails in the northern latitudes have seasonal freeze and thaw cycles. Trails in southern latitudes may have predictable dry or wet seasons. Local weather events, regardless of the climate, are important considerations. These events include precipitation frequency, intensity, and volume.

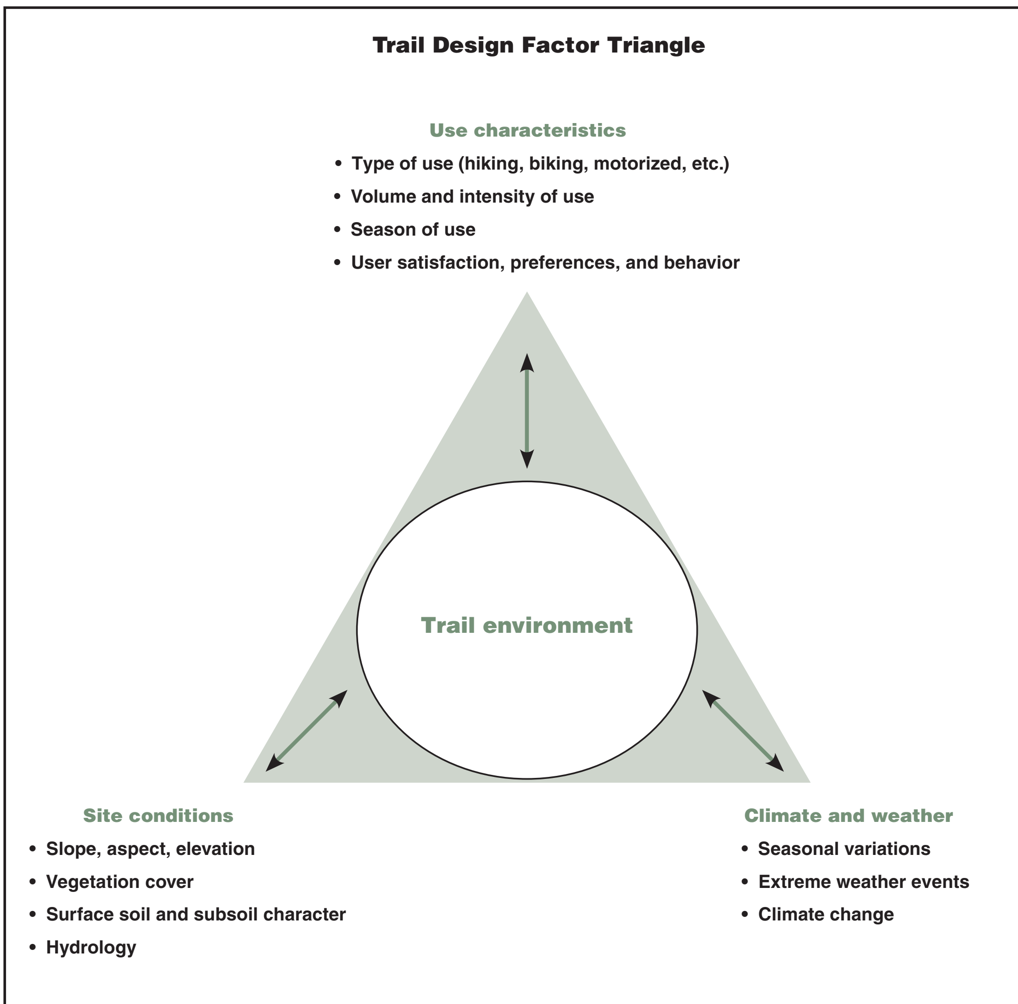


Figure 4–5—The relationship between trail design factors (use characteristics, site conditions, and climate and weather) affect the trail environment. These factors must be considered during trail design, layout, construction, and maintenance.

Table 4–2—Examples of off-highway vehicle uses and characteristics developed by the author.

Type of off-highway vehicle (OHV)	Typical length (feet)	Minimum (optimum) turn radius required (feet)	Typical required width (feet)	Typical required tread width (feet)	Standard clearing width[1] (feet)	Minimum required clearing height (feet)	Typical speed (mi/h)	Average sight distance[2] (feet)	Typical weight range when loaded (pounds)	Approximate pounds per square inch (PSI)	Load on tread	Torque delivered to tread surface	Type of turns	Potential tread displace-ment[3] on flats (less than 8 percent)	Potential tread displace-ment[4] on grades (more than 8 percent)
Off-highway motorcycle	5 to 6	10 (15)	1.6	2	1.5 to 2.0	8	10 to 40	160	400 to 550	17 to 18	High	High	Flat banked super-elevated	High	High
All-terrain vehicle (ATV)	8	15 (20)	4.0	5	2.0	8	5 to 25	80	800 to 1,000	10 to 12	Moderate	Low to Moderate	Flat banked super-elevated	Moderate	High
Utility-terrain vehicle (UTV)	8 to 10	20 (24)	5.0	6	2.0	10	5 to 20	70	1,600 to 1,900	16 to 20	Moderate	Moderate to high	Flat	Moderate	Moderate to high
Four-wheel-drive vehicle	14 to 19	25 (30)	6.0 to 7.0	8 to 9	3.0	10	5 to 25	80	2,400 to 6,400	16 to 30	High	Moderate to high	Flat banked	Moderate to high	High
Light tracked vehicle[5]	8 to 16	20 (25)	4.0 to 6.0	7 to 8	2.0	10	3 to 12	30	1,300 to 2,900	3 to 4	Low	Very low	Flat	Low	Low
Heavy tracked vehicle[6]	16 to 24	30 (35)	7.0 to 10.0	9 to 12	3.0	12 to 14	3 to 8	30	2,900 to 20,000+	3 to 8	Low	Very low	Flat	Low	Low
Unlimited bogger[7]	16 to 24	30 (35)	7.5	9 to 12	3.0	12 to 14	5 to 15	50	6,400 to 10,400	18 to 27	High	Moderate to high	Flat	Moderate	Moderate to high

Note: Structures on OHV trails require load-specific design per span.

[1]May be desirable to narrow clearing widths to reduce speed for certain uses.
[2]Sight distance should be set based on the highest shared use. Figures are based on response to oncoming traffic. If speed is reduced through tread design (increased sinuosity or obstacles), the sight distance may be reduced.
Always assume two-way traffic.
[3]Rutting of moist to saturated tread.
[4]Downhill displacement of tread material.
[5]Tracked ATVs, track-equipped Argos, Weasels, Tracksters, Centaur.
[6]Nodwells, Foremost.
[7] Modified 4-wheel-drive pickups and 2.5-ton trucks with large tires.

Chapter 5: Trail Management Framework

A 10-element management framework allows basic trail sustainability and trail fundamentals to be applied systematically. Taken together, the 10 elements provide managers with guidance on information collection, data evaluation, decisionmaking, and program development and implementation.

The 10 trail management elements are:

- Preliminary status assessment
- Environmental analysis
- Trail Management Objectives
- Documentation of trail location
- Trail condition assessment
- Evaluation of management options
- Trail prescriptions
- Trail maintenance
- Implementation
- Trail monitoring and evaluation

The basic components of each of the 10 elements have been developed and refined—in one form or another—by trail professionals over the decades. These elements can be applied in sequence when a new management program is being developed or, in part, when off-highway vehicle trails have existing administrative oversight. Depending on the situation, certain elements of the framework may be of greater value than others.

Each of the 10 trail management elements is discussed in more detail in the chapters that follow.

Notes

Chapter 6: Element 1—Preliminary Status Assessment

A preliminary assessment is a snapshot of the trail status, based on readily available information. This assessment is particularly useful when little is known about a trail, its environment, or its management history. If trails have had a long history of active management, a preliminary assessment may not be required. A preliminary status assessment provides information on the:

- Trail administrative status
- Trail management status
- Trail condition
- Trail use characteristics
- Related environmental issues and concerns

Table 6–1 shows a preliminary status assessment for the fictional Orphan Trail System. The table allows data for two different trails to be compared quickly. The table can be modified to fit any management scenario or administrative need. Developing such a table helps managers identify data gaps, inconsistencies in management between different trails, the status of agency oversight, and general problems with the trail alignment. The table provides a convenient reference for communication among agency employees, trail users, and the general public.

Table 6–1—A preliminary status assessment for the fictional Orphan Trail System.

Administrative unit name: Orphan Trail System	Annie Trail	Andy Trail
Administrative details		
Length of the route	6.5 miles	About 21 miles
Land ownership	State	State, county
How was the trail developed?	Users	Former forestry road
Is there management oversight?	No	No
Is the route alignment accurately mapped?	Yes, GPS survey 2002	No
Is the alignment data plotted on GIS?	Yes, county trails database	No
Are on-the-ground management actions occurring?	Yes, minor infrequent user improvements	None to date
Are any planning actions pending?	Yes, county roads plan	Yes, county roads plan
Are there trailhead improvements?	Yes, informal parking area	None, trail junction off county road
Is the route signed?	Yes, user-created signs at junction, a few reassurance markers along route	No
Are route maps or directions available to the public?	Yes, appears on county maps	No
Use characteristics		
Types of off-highway vehicles used	ATVs, motorcycles	Two-wheel-drive ATVs, Four-wheel-drive ATVs, Jeeps
Purpose of use	Recreational	Recreational, hunting, access to inholding
Approximate use levels	200 or more passes/week	Unknown, estimated as relatively light
Intensive use periods	Weekends, 4th of July fun run	Hunting season
Other uses	Mountain bikers, horse riders, walkers, local runners	Mountain bikers, local trail runners
Use level trends over the past 5 years		
Motorized use	Increasing	Unknown
Nonmotorized use	Stable	Increasing
Other issues or concerns		
Are there vegetation-related issues or concerns	Yes, invasive species mile 0 to 1.5	Yes, illegal timber cutting near the trailhead
Are there impacts to water quality?	Yes, at 3-mile ford	Unknown
Are there wildlife issues or concerns?	None known	Yes, eagle nest site near mile 8.5
Are there impacts to fisheries?	Yes, fish habitat impacts at 3-mile ford	Unknown
Are there tread-degradation issues or concerns?	Yes, ruts and erosion of tread between miles 4 and 5, muddy conditions at crossing sites, few water control structures	No, trail is generally in good condition
Physical condition trends over the past 5 years	Deteriorating	Stable
Are there conflicts with other users?	Yes, motorcycles and horse riders	No
Are there conflicts with private property owners?	No	Yes, private cabin holder reports break-ins and trash
Are there trespass or other law enforcement issues?	No	Yes, above

ATVs = all-terrain vehicles. GIS = Geographic Information System. GPS = Global Positioning System.

The preliminary assessment can be an internal agency effort or it can be adapted to a public process. The public may be an important source of information, particularly when the trail has little formal management history. Public input can help to identify existing and potential trail users and their expectations and concerns. Public input can be collected in various ways. The setting can be a formal facilitated meeting (figure 6–1). Users may also be contacted in the field while they are using the trail (figure 6–2). User surveys (figure 6–3) administered to a broader, more representative sample of users can also provide important information to managers.

Figure 6–2—Public contacts made in the field can provide valuable information on use characteristics and user expectations. Here the author visits with all-terrain vehicle riders on an off-highway vehicle trail converted from a fireline in the Chena River State Recreation Area, AK.

Figure 6–1—Public meetings can help facilitate data gathering for a preliminary status assessment.

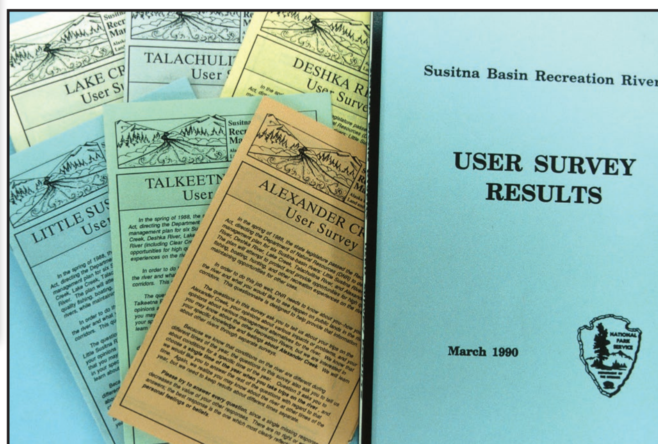


Figure 6–3—Formal user surveys and planning documents are an important source of information for a preliminary status assessment.

Notes

Chapter 7: Element 2—Environmental Analysis

This element documents the impacts, issues, and concerns that off-highway vehicle trails and their use pose for the surrounding environment.

Robert Birkby describes a trail in "Lightly on the Land: the SCA Trail Building and Maintenance Manual" (Birkby and the Student Conservation Association 2005):

> At its most basic, a trail is simply a cleared travel corridor leading from one point to another. While it can be a key tool for resource protection, a trail is also a scar on the landscape, a sacrifice zone devoid of vegetation, a linear clear-cut that can amount to a third of an acre or more per mile. And, yet we accept the denuded surface of a pathway as an almost natural part of the backcountry. It serves our needs extremely well, and by concentrating human use to a thin ribbon of tread, it can spare the larger landscape from being trampled.

Environmental analysis attempts to identify the impacts and concerns associated with a trail. The sustainable trail design guidelines attempt to minimize those impacts, but any trail—no matter how carefully designed, built, and maintained—will affect the surrounding environment. Concerns arise from:

- The introduction of internal combustion engines into the backcountry with their associated sound and exhaust.
- Requirements for wider tread—covering three-fourths of an acre or more per mile.
- Personal protective equipment may limit riders' ability to communicate and interact with other trail users.
- The nature of the machines—their size and weight, sound, and their ability to displace tread material, travel at high speed, and cover long distances.

Concerns for planned and existing trails can include administrative, social, biological, and physical effects.

Environmental analysis covers a broad area of natural resource, social science, and engineering specialties. A trail manager needs to enlist the assistance of planning professionals, as well as agency interdisciplinary specialists (figure 7–1). Their skills can be essential for identifying issues and developing mitigation strategies that resolve management concerns. Table 7–1 identifies sustainable trails evaluation criteria that can be applied during environmental analysis.

Figure 7–1—Resource staff should be enlisted and engaged to identify resource conflicts and opportunities related to trail management.

Although environmental analysis is described as a distinct element within the framework, a lot of environmental analysis needs to be done in other elements as well. For example, many administrative and social issues can be worked out early on when developing land use, travel management, or recreation resource plans. These broader planning efforts will help direct the development of Trail Management Objectives discussed later in this report. Similarly, during design and layout, environmental analysis may be needed to assess impacts at stream crossings and other sensitive sites. Field visits with resource specialists can help trail managers understand site-related environmental issues and assist in developing appropriate mitigation methods (figure 7–2). Other environmental concerns, such as use conflicts, may have to be handled as they arise (figure 7–3).

Table 7–1—Sustainable trails evaluation criteria that can be applied to environmental analyses. —*Adapted with permission from Trail Management: Plans, Projects and People training course (Beers 2009).*

Sustainable trails are designed and constructed so they:
Do not adversely affect natural and cultural resources
Impacts that would be considered “take” are avoided and impacts that are considered “sensitive” are mitigated through the planning and environmental review process.
Do not disrupt or alter the natural hydraulic flow patterns of the landform
Sheet flow runoff is not diverted or accumulated and is allowed to continue on its normal flow path. No drainages (including microdrainages) are captured, diverted, or coupled with other drainages by the trail. Water is not accumulated on the trail and drained off onto the landform where natural drainages do not exist.
Can withstand 25- to 100-year storm events
The trail tread and structures are unaffected by these storm events. This includes impacts above and below the trail.
Meet the needs of the intended user group or groups
The intended user group stays on the designated trail and does not create unauthorized paths or volunteer trails. There is no significant reduction of trail use.

Figure 7–2—Resource specialists conduct a site visit at the Chena River State Recreation Area, AK, to identify problems and develop solutions for resource issues and concerns.

Figure 7–3—Use conflicts may arise at any stage of trail management. Identifying the potential for those conflicts early in the process and developing a management program that addresses the issues will pay off throughout the lifetime of a trail.

The use of Best Management Practices (BMPs) can be an integral part of an environmental analysis. A helpful reference is “Best Management Practices for Off-Road Vehicle Use on Forestlands: A Guide for Designing and Managing Off-Road Vehicle Routes” (Switalski and Jones 2009). The Forest Service National BMP Program takes a slightly different approach to the development of BMPs by approaching them at a national programmatic level. This approach helps to improve agency performance and accountability by managing water quality consistent with the Federal Clean Water Act (CWA) and State water quality programs. Current Forest Service policy establishes compliance with required CWA permits and State regulations and requires the use of BMPs to control nonpoint source

Examples of Potential Issues and Concerns

Administrative

- Multijurisdictional land ownership
- Rights-of-way and easements—status and compliance
- Agency trail management capability
- Skills, time, and resources the agency can commit to on-the-ground trail management

Social

- Motorized user concerns, expectations, satisfaction, and behavior
- Nonmotorized user concerns, expectations, satisfaction, and behavior
- Allocation conflicts among user groups—locations and miles of trails available for distinct user groups
- Changing use trends
- Trespass on private lands
- Littering, graffiti, vandalism
- Human waste
- Illegal timber cutting and other illegal activities
- Development of social trails
- Sound generation and exhaust
- Illegal parking at trailheads
- Inadequate trailhead facilities
- Poor signage
- Health and safety—speed issues, tread design, and trail hazards

Biological

- Impacts to vegetation
- Sedimentation or alteration of wetland vegetation
- Wildlife displacement or habitat loss and fragmentation
- Increased hunting pressure
- Impacts to fisheries
- Impacts to sensitive species and ecosystems
- Introduction or spread of invasive plants

Physical

- Trail braiding
- Tread surface erosion
- Effects on air quality, including increased dust
- Effects on bridges
- Accelerated melting of permafrost
- Soil compaction, entrenchment, and ponding
- Erosion and sedimentation
- Impacts to cultural or archeological resources
- Visual impacts
- Modification of the site's hydrology
- Water quality impacts (direct impacts at crossings, indirect impacts from drainage off adjacent trails)
- Stream diversion or stream capture
- Drainage, creation, or modification of wetlands
- Destabilization of natural slopes and riverbanks
- Fuel and oil spills

A few of these issues and concerns are illustrated in figures 7–4 through 7–7.

pollution to meet applicable water quality standards and other CWA requirements (U.S. Department of Agriculture 2012). "National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide" contains a standard set of core BMPs and a consistent means to track and document the use and effectiveness of BMPs on National Forest System lands across the country. Additionally, site-specific BMPs can be developed at the project level during the environmental analysis to meet specific needs at that site.

Examples of Potential Issues and Concerns (continued)

Figure 7–4—Degraded water crossings can harm water quality.

Figure 7–6—Protecting wildlife and the quality of its habitat should be an important trail management concern.

Figure 7–5—Cultural sites provide both opportunities for historic interpretation and concerns for protection.

Figure 7–7—Avoiding impacts to threatened, endangered, or sensitive plants should always be a trail management concern.

Environmental Compliance

The information collected during environmental analysis will provide critical information for any environmental assessment (EA), environmental impact statement (EIS), or other agency environmental compliance document prepared for a trail project or trail management plan.

Typically, interdisciplinary specialists within an agency would prepare data on impacts or concerns, or a third party would prepare the EA, EIS, or other environmental document. The trail manager plays an important support role by providing accurate trail location data; any pertinent information collected during condition assessments or

Off-Highway Vehicle Trail Siting Considerations

Regulatory Framework

Laws and Regulations

- All proposed actions that meet the requirements of Title 36 of the Code of Federal Regulations (CFR), Part 220.4(a) must comply with the National Environmental Policy Act (NEPA).
- The Forest Service must comply with the 2005 Travel Management Rule by designating those National Forest System (NFS) roads, NFS trails, and areas on NFS lands that are open to motor vehicle use, and identifying those designations on Motor Vehicle Use Maps (MVUMs).

Forest Land and Resource Management Plans

- Forest Plans may identify management areas or other lands that are suitable or not suitable for motor vehicle use while considering compatibility with adjacent uses.
- Forest plans may have standards and guidelines associated with the development of trails designated for motor vehicle use consistent with desired recreational settings, often described as the Recreation Opportunity Spectrum (ROS).

Project Level NEPA Analysis
(Categorical Exclusion/Environmental Analysis/Environmental Impact Statement)

- The environmental analysis is specific to a proposed action and may result in a site-specific decision.
- This analysis may provide specific mitigation and location information for individual segments or sections of trail, including physical characteristics like width of trail, tread composition, type of drainage structures, routing around sensitive resources, and seasonal access/use.
- Environmental analyses often develop project-specific mitigation measures, which may include Best Management Practices (BMPs)[1], to guide the project and minimize or eliminate environmental effects.

Forest Service Directives

Forest Service Manual (FSM 2350)

- Provide a variety of trail opportunities, settings, and modes of travel consistent with the applicable land management plan.
- Emphasize long-term cost-effectiveness and need when developing or rehabilitating trails.
- Provide a trail system that is environmentally, socially, and financially sustainable.

Forest Service Handbook (FSH 2309.18)

- Typical information needed for trail system analysis includes:
  - ✧ Trail Management Objectives, including Trail Class and travel management prescription
  - ✧ Applicable ROS classes
  - ✧ Public concerns
  - ✧ Trail opportunities and constraints
  - ✧ Relationship of the trail system to other Forest Service facilities
  - ✧ Use data
  - ✧ Other resource data (i.e., wildlife habitat, threatened and endangered species, cultural resources, soils, and riparian areas)
  - ✧ Cost-effectiveness
  - ✧ Priorities and management requirements

[1]Such as the "National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide," available at <http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf>.

assessments of natural, social, or cultural issues; and descriptions of mitigation options. Some examples of information the trail manager might provide include public safety issues, the presence of trail hazards, trail conditions, trail trends, and trail sustainability.

Table 7–2 provides a starting point managers can use when searching for sources of information on trails. After collection, organize, evaluate, and display data, possibly as georeferenced data on a map or in a Geographic Information System (GIS). Some examples are illustrated in figures 7–8 and 7–9.

Table 7–2—Potential information sources on trail issues and concerns: administrative, social, biological, and physical.

Administrative	
Topic	**Sources of information**
Multijurisdictional land ownership	Agency land status plats City/county platting departments
Right-of-way status	State records office for property deeds State and Federal land status plats City/county platting departments
Character of agency trail management within the organization	General management plans Transportation or recreation plans Trail Management Objectives Facility managers, trail crews
Level of agency on-the-ground trail management	Trail maintenance records Facility managers, trail crews
Local user involvement with trail management or maintenance	Trail maintenance records Facility managers, trail crews Local newspaper coverage Transportation or recreation plans—public comments Trail Management Objectives Rangers, trail crews Meetings with user groups
Social	
Topic	**Sources of information**
Direct user conflicts Conflicts between user groups	Local newspaper coverage Complaints to land managers, rangers, etc. Law enforcement actions Meetings with user groups Interaction with users on the trail or at trailheads
Trespassing on private lands Illegal parking at trailhead Illegal activities	Agency and local law enforcement actions Ranger reports Public comments
Development of social trails	Condition assessments Monitoring products Trail crews Visual inspection
Littering	Trail crews and rangers Visual inspection
Sound generation	Public comments Monitoring efforts by agency Ranger reports and enforcement actions
Inadequate trailhead facilities Poor signage	Public comments Trail crews Rangers, resource specialists Monitoring Site inspections
Health and safety	Condition assessments and monitoring Public comments Ranger reports and enforcement actions Trail crews Visual inspection

Table 7–2—(continued)

Biological	
Topic	**Sources of information**
Impacts to vegetation from off-trail use	Condition assessments and monitoring Visual inspection Plant ecologist assessments Trail crews and rangers
Impacts to wetland communities from sedimentation	Visual inspection Monitoring Plant ecologist assessments Trail crews and rangers
Illegal timber cutting	Ranger reports and enforcement actions Visual inspection
Wildlife displacement and habitat fragmentation	Wildlife biologist assessments Centerline overlays on habitat maps
Increased hunting pressure	Wildlife biologist assessments State game managers/boards Public comments
Impacts to fisheries habitat at stream crossings	Fisheries biologist assessments Condition assessments Centerline overlays on fisheries habitat maps Trail crews
Impacts to fisheries from overutilization	Fisheries biologist assessments State game managers/boards Public comments
Impacts to sensitive species	Plant ecologist assessments Centerline overlays on plant habitat maps
Physical	
Topic	**Sources of information**
Duplicative trail routes Soil erosion	Centerline map products Condition assessments Visual inspection Monitoring Trail crews and rangers
Air quality and dust	Visual inspection Monitoring Public comments Trail crews and rangers
Accelerated melting of permafrost	Soil scientist/geologist assessments Condition assessments Visual inspection Monitoring Trail crews and rangers
Soil sedimentation—terrestrial and aquatic impacts	Fisheries biologist/resource specialist assessments Condition assessments Monitoring Visual inspection
Bridge structures	Agency engineer assessments Forest Service bridge design specifications Trail crews
Impacts to cultural or archeological resources	Cultural resource specialist assessments Centerline overlays on cultural feature maps
Visual impacts	Visual resource/viewshed analysis Public comments
Microhydrology modifications Water quality impacts Stream diversion Wetland drainage	Hydrologist assessments Condition assessments Trail crews and rangers Monitoring

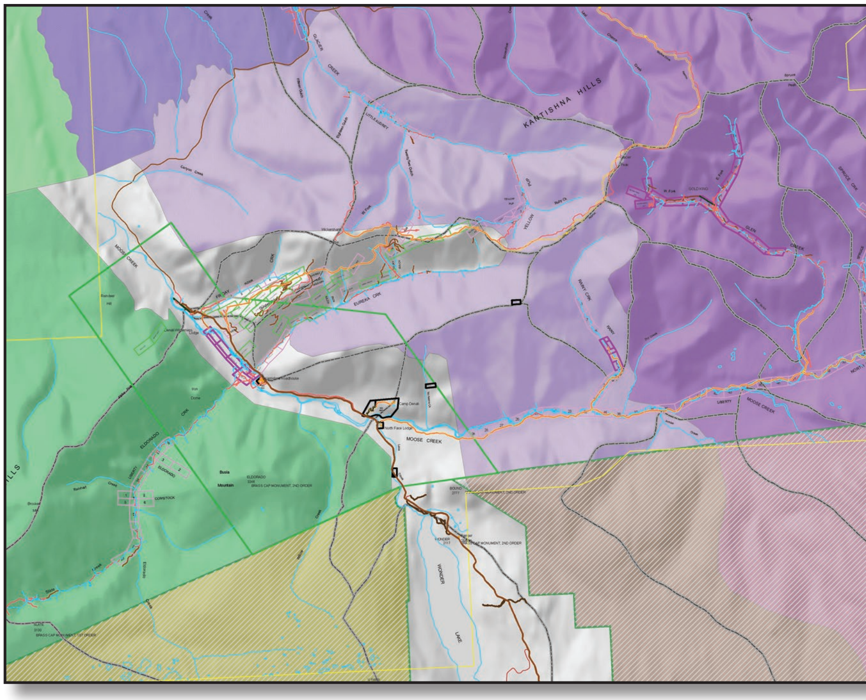


Figure 7–8—A Geographic Information System data display of administrative boundaries (parklands, backcountry units, and mining claims) and watersheds over a shaded relief topographic base map.

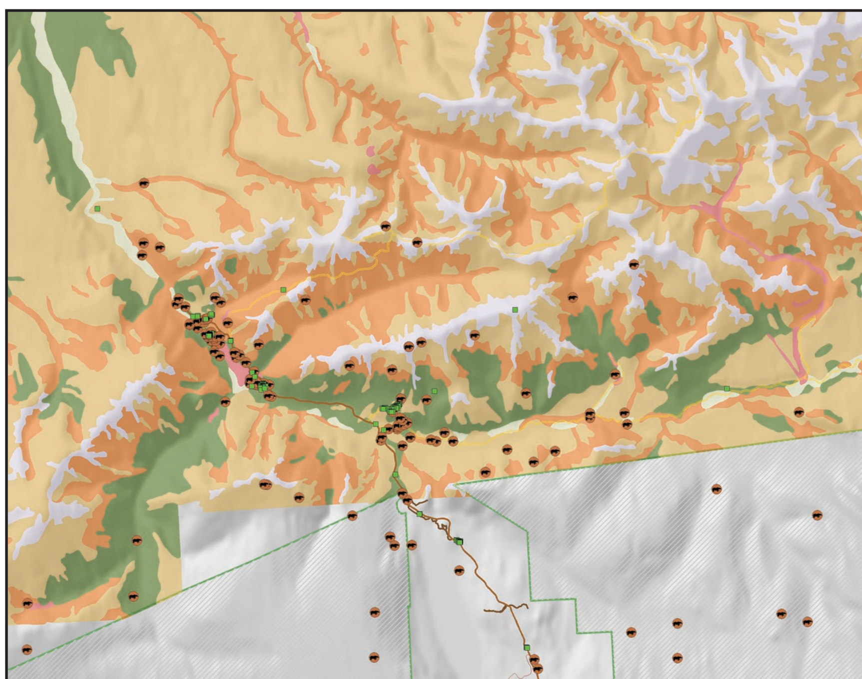


Figure 7–9—A Geographic Information System data display of vegetation cover, wildlife sightings (bears), and trail structure locations over a shaded relief topographic base map.

Chapter 8: Element 3—Trail Management Objectives

The Forest Service defines Trail Management Objectives (TMOs) as "the documentation of the intended purpose and management of a trail based on management direction, including access objectives" (Forest Service Handbook 2353.12). The TMOs document the **desired** management and condition of the trail, which may or may not coincide with the **existing** management and condition of the trail. The TMOs identify basic trail information, including the intended use of the trail, trail-specific Design Parameters, schedules for routine tasks, and special considerations. TMOs are essential for effective trail management and should be developed for all trails.

Depending on the situation, draft TMOs can be developed while additional information is collected, management options are considered, and final management direction is determined. Final TMOs should be reviewed and approved by an agency line officer and subjected to periodic review and modification as necessary.

After TMOs have been developed, they are the primary documentation that guides trail design, assessment, prescription, construction, maintenance, and monitoring for agency and trail managers, trail crews, contractors, and cooperating partners.

The Forest Service developed TRACS (Trail Assessment and Condition Surveys) to provide an approach for the consistent collection of trail inventory, condition, and prescription data. The Forest Service TMOs form also has been used by other agencies and can be adapted to meet agency-specific needs.

The Forest Service TMOs Form

The Forest Service TMOs form is divided into seven parts, including overall trail information, TMOs Trail Section, Designed Use Objectives, Travel Management Strategies, Special Considerations, Remarks/Reference Information, and Line Officer Approval. A full-size copy of this form is available in appendix C. The Forest Service also generates TMOs directly from its corporate database.

TMOs Form, Side 1—Basic Trail Information

The first section of side 1 on the TMOs form (figure 8–1) provides space where users can record basic trail information.

If the management objectives change along the trail, use the TMOs Trail Section block to number and identify the TMOs trail section being described. For example, a trail should be divided into two TMOs sections—each with its own TMOs prescription—if the trail is managed as a highly developed Class 4 trail for a given number of miles before being managed as a less developed Class 2 trail.

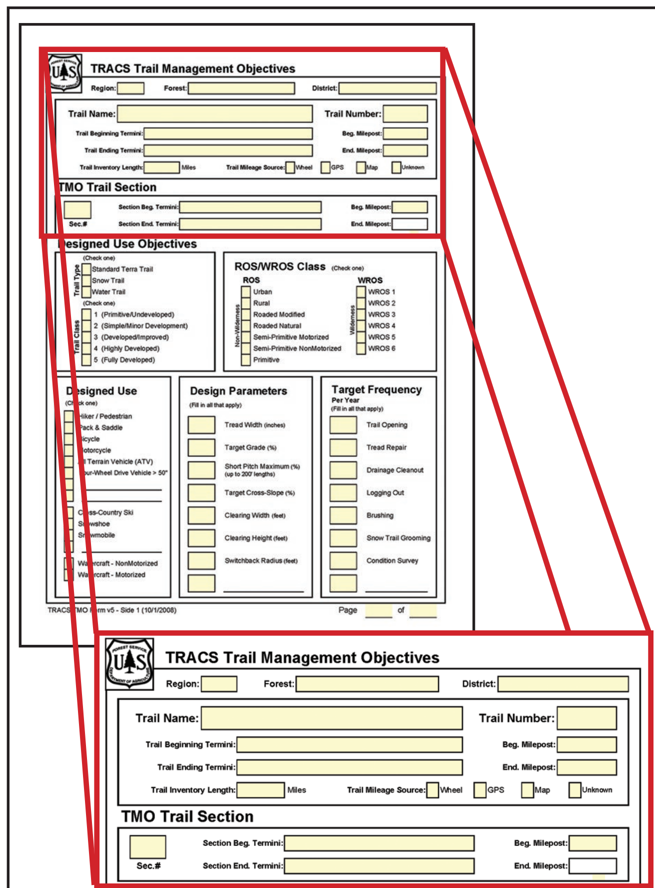


Figure 8–1—Side 1 of the Forest Service Trail Management Objectives form with the basic trail information section enlarged. —*From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

TMOs Form, Side 1—Designed Use Objectives

The second section of side 1 on the TMOs form (figure 8–2) has five blocks for the Designed Use objectives that guide trail planning, design, construction, maintenance, and monitoring. It's important to remember that these are the **designed** or **intended** objectives for the trail and may not reflect existing conditions.

Trail Type—Identify the Trail Type on the TMOs form. Remember, there is only one Trail Type per trail. Trail Types were explained in chapter 4, "Trail Fundamentals."

A trail managed for all-terrain vehicle (ATV) use is typically a Standard/Terra Trail. If this route also is managed for snowmobile use, it also would be inventoried as a Snow Trail. The Standard/Terra Trail and the Snow Trail each would have its own trail name, number, and corresponding TMOs. For example, TMOs would be developed both for Wolverine Trail 476 and Wolverine Snow Trail 476S. In general, the off-highway vehicle (OHV) trail manager only has management responsibility for summer use of Wolverine Trail 476, but would want to coordinate maintenance and other management actions with the Snow Trail manager. The OHV trail manager would pay particular attention to sign location and installation height, clearing width and height, and any major tread modifications that might affect winter use.

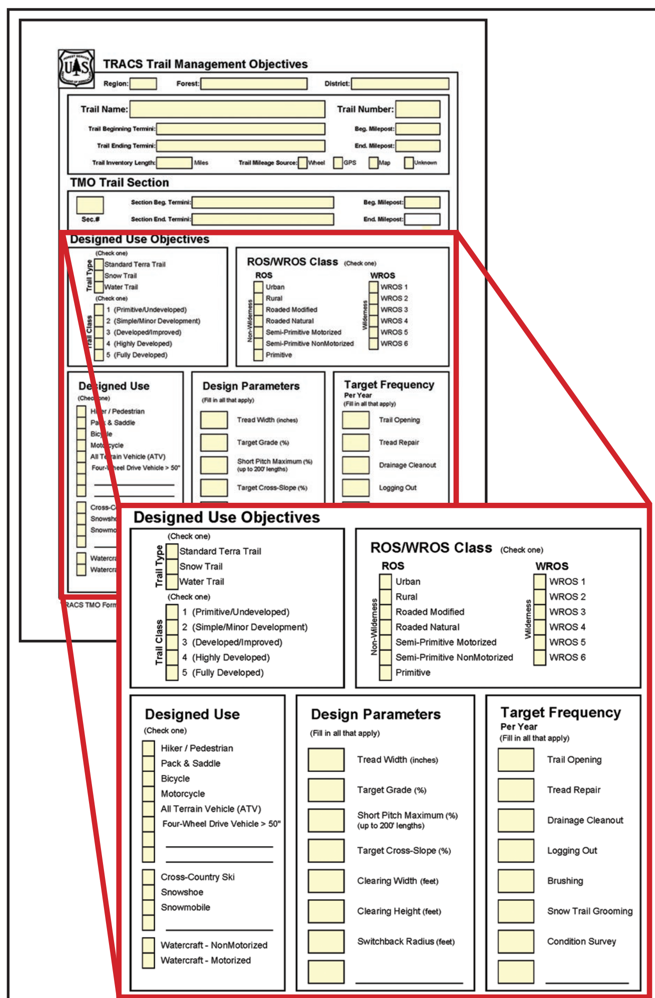
Trail Class—Identify the Trail Class. The five Forest Service Trail Classes were discussed in chapter 4, "Trail Fundamentals." If the prescribed Trail Class changes along the trail, it's important to create a separate TMOs section for each trail segment.

ROS/WROS Class—Choose the applicable recreation opportunity spectrum (ROS) or wilderness recreation opportunity spectrum (WROS). These management categories are used by the Forest Service and Bureau of Land Management.

Designed Use—Identify the Designed Use. Only one Designed Use should be identified for each trail or trail segment. The Designed Use determines the design, construction, and maintenance specifications for the trail. It is selected from the actively Managed Uses identified for the trail. The concepts of Designed Use and Managed Use were explained in chapter 4, "Trail Fundamentals." Again, if the Designed Use changes along the trail, create a separate TMOs section for each trail segment.

Design Parameters—Identify the trail Design Parameters. Refer to the explanation of Design Parameters in chapter 4, "Trail Fundamentals." The TMOs should identify **specific** values for the individual parameters, such as tread width, clearing width, and target grade. The Design Parameters identified for individual trails should take into consideration trail-specific site conditions and the mix of Managed Uses and expected use levels.

Target Frequency—Identify the recommended or target frequency for routine maintenance tasks. The target frequency is the recommended number of times the maintenance task would be performed in a year. For example, routine brushing once a year is expressed as 1, twice a year as 2, every other year as 0.5, and every fifth year as 0.2.



TRACS Trail Management Objectives
Region: Forest: District:
Trail Name: Trail Number:
Trail Beginning Termini: Beg. Milepost:
Trail Ending Termini: End. Milepost:
Trail Inventory Length: Miles Trail Mileage Source: Wheel GPS Map Unknown
TMO Trail Section
Sec.# Section Beg. Termini: Beg. Milepost:
Section End. Termini: End. Milepost:
Designed Use Objectives
Trail Type (Check one): Standard Terra Trail; Snow Trail; Water Trail
Trail Class (Check one): 1 (Primitive/Undeveloped); 2 (Simple/Minor Development); 3 (Developed/Improved); 4 (Highly Developed); 5 (Fully Developed)
ROS/WROS Class (Check one)
ROS (Non-Wilderness): Urban; Rural; Roaded Modified; Roaded Natural; Semi-Primitive Motorized; Semi-Primitive NonMotorized; Primitive
WROS (Wilderness): WROS 1; WROS 2; WROS 3; WROS 4; WROS 5; WROS 6
Designed Use (Check one): Hiker / Pedestrian; Pack & Saddle; Bicycle; Motorcycle; All Terrain Vehicle (ATV); Four-Wheel Drive Vehicle > 50"; Cross-Country Ski; Snowshoe; Snowmobile; Watercraft - NonMotorized; Watercraft - Motorized
Design Parameters (Fill in all that apply): Tread Width (inches); Target Grade (%); Short Pitch Maximum (%) (up to 200' lengths); Target Cross-Slope (%); Clearing Width (feet); Clearing Height (feet); Switchback Radius (feet)
Target Frequency Per Year (Fill in all that apply): Trail Opening; Tread Repair; Drainage Cleanout; Logging Out; Brushing; Snow Trail Grooming; Condition Survey

Figure 8–2—Side 1 of the Forest Service Trail Management Objectives form with the "Designed Use Objectives" section enlarged. *—From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

TMOs Form, Side 2—Travel Management Strategies

Side 2 of the TMOs form (figure 8–3) identifies travel management strategies.

Managed Uses—Document the actively Managed Uses identified for the trail and the corresponding managed seasons of use. Refer to the discussion of Managed Use in chapter 4, "Trail Fundamentals." The Managed Use, along with the Designed Use, helps determine the design, construction, and maintenance specifications for the trail. Managed Use also plays a role when managers identify and communicate travel management strategies, including prohibited and allowed uses.

Prohibited Uses—Identify the prohibited uses. These prohibitions should be specific, by use and by season of restriction. When identifying a prohibited use, cite the specific regulation, rule, or agency order prohibiting the use in the Remarks/Reference Information section of the TMOs form. Closures can be year round. For instance, TMOs may indicate that mountain bike use is prohibited on a trail through a designated wilderness. Some closures are seasonal. For instance, a trail actively managed for ATVs may be closed between March 1 and May 1 because of spring breakup.

Other Uses—Identify other use strategies (optional).

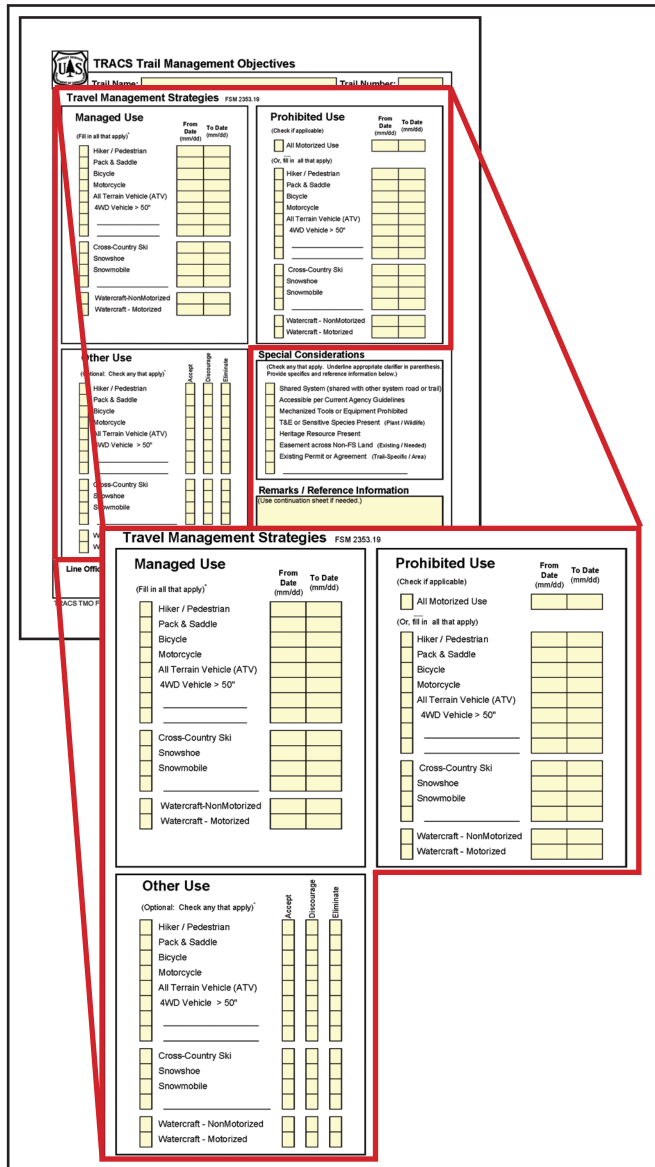


Figure 8–3—Side 2 of the Forest Service Trail Management Objectives form with the "Travel Management Strategies" section enlarged. —*From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

TMOs Form, Side 2—Special Considerations and Remarks/Reference Information

Side 2 of the TMOs form (figure 8–4) includes two blocks for special considerations and remarks/reference information.

Special considerations may affect management or maintenance of the trail. These considerations may be accessibility status, the presence of sensitive species or archeological sites, easement restrictions, or other considerations. If present, these considerations and corresponding management direction or reference information should be included in the Remarks/Reference Information section. If information refers to a certain trail segment, include mileposts or other location coordinates.

The TRACS TMOs form provides space to add information or clarifications or to cite agency decisions. When relevant information has been presented in previous sections of the form, it helps to add a footnote that will direct readers to the Remarks/Reference Information section.

TMOs Form, Side 2—Line Officer Approval

The agency line officer's signature (figure 8–5) shows that the TMOs accurately reflect the management intent for the trail and provide clear management direction to agency and trail management employees. If and when management direction changes for a trail, the TMOs should be updated. Situations that may trigger a change in management direction are addressed later in this chapter. The TMOs form, instructions, and additional information are available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

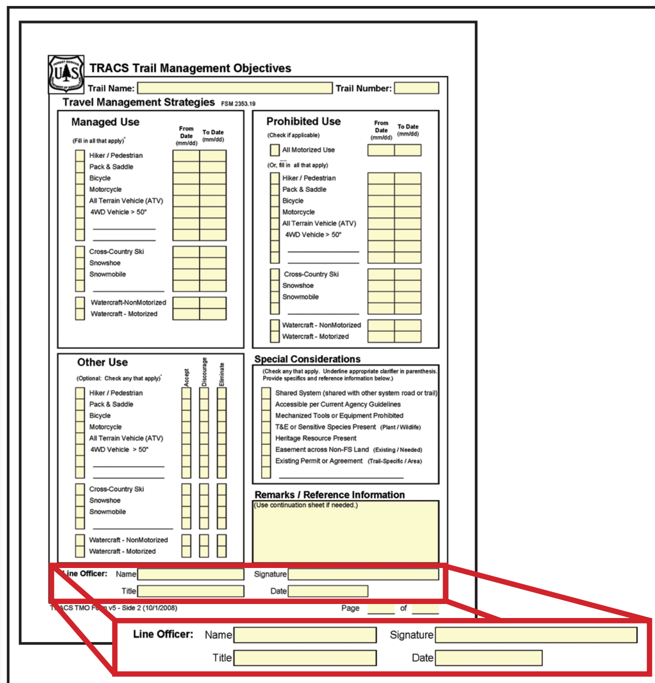


Figure 8–5—Side 2 of the Forest Service Trail Management Objectives form with the "Line Officer" approval section enlarged. *—From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

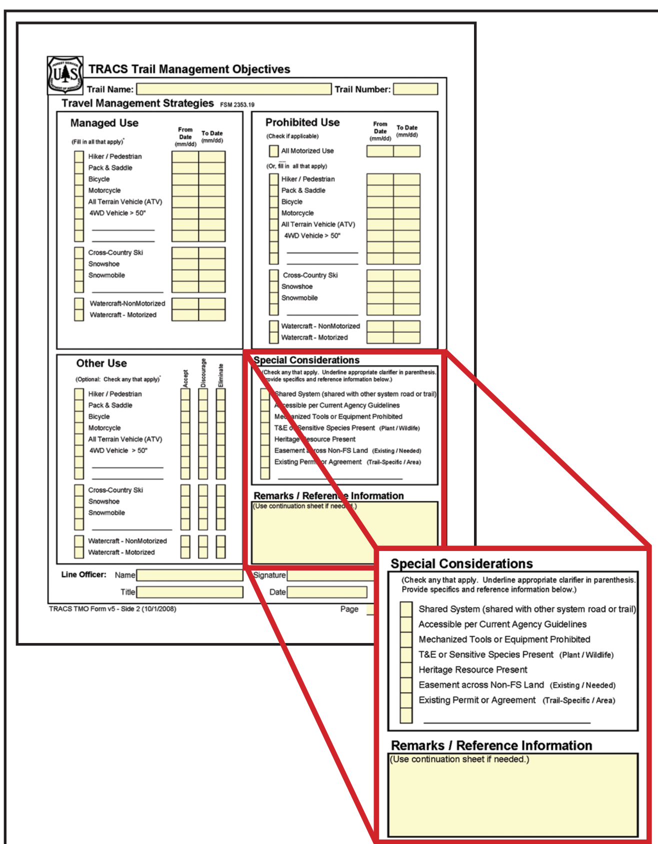


Figure 8–4—Side 2 of the Forest Service Trail Management Objectives form with the "Special Considerations" and "Remarks/Reference Information" sections enlarged. *—From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Developing Trail Management Objectives

The TMOs are critical management tools for planned and existing trails. Few trail management activities should be conducted without one. If TMOs do not exist, develop them as soon as possible, ideally before major resource investments are made on a trail. Developing TMOs requires trained and experienced trail management professionals who are familiar with agency management direction and site specifics of the trail. The TMOs define both the **starting** and the **ending** points of trail management. They document the overall management goals for the trail and provide direction throughout the management process. The TMOs are the essential reference for long-term assessment and monitoring of trail conditions, performance, and maintenance needs.

The process for documenting TMOs is basically the same for new and existing trails, including the need to reference existing management direction for on-the-ground evaluation.

To develop TMOs for an existing trail, the author recommends collecting information on use characteristics, trail conditions, and trail sustainability. This information helps managers identify several key components of TMOs: the appropriate Managed Uses, the Trail Classes, and the Design Parameters.

In some cases, a trail manager may not be sure what the appropriate TMOs should be for an existing trail. This is most common with orphan trails. Orphan trails are trails not covered by a land management or travel management plan, trails without an active trail management program, or trails in areas with a history of unregulated OHV use.

Defining Trail Use Characteristics

Define trail use characteristics using data collected on:

- Existing use types (size, width, weight, and so forth)
- Approximate volume of use
- Relative intensity of use (concentration)
- Seasons of use
- User needs, preferences, satisfaction, and behavior
- Use trends

"Element 1—Preliminary Status Assessment" is a good place to start gathering data. Creating a list of existing uses can help trail managers make decisions about allowed uses, prohibited uses, Managed Uses, and Designed Uses. Before identifying allowed uses, Managed Uses, and Designed Uses in TMOs, it's important to understand the physical characteristics of the trail, the effect past and existing use is having on trail conditions, and the sustainability of the trail alignment and construction.

Assessing Trail Conditions

Collect basic information on the physical character of the trail and its condition. Basic information includes:

- Tread grade (typical trail grade in percent and the range of grades)
- Tread width (width of the area affected by traffic)
- Tread surface character (surface types, roughness, obstacles, hazards, etc.)
- Condition category (good, fair, degraded)

Field data on current trail grade, width, and surface character can be used to evaluate TMOs Trail Class assignments for potential or identified Managed Uses.

Managers should assign trails to a Trail Class that best reflects existing management direction for the trail, which **may or may not** reflect the current condition. This approach, which is required by some agencies, applies when agency plans or directives have been established for management areas, trail networks, or specific trails. Condition assessment data would help managers determine whether the trail meets the specifications for the prescribed Trail Class or how much modification might be required to meet the specifications (discussed in "Element 5—Trail Condition Assessment"). If those modifications are determined to be too costly, a pragmatic approach may be to revise the management prescription for the trail and modify the TMOs accordingly. In either case, knowing the trail grade, width, and surface character helps managers determine the range of possible Managed, allowed, and Designed Uses, and Trail Class assignments.

Before the final use type and Trail Class assignments are made, the effect of existing uses on trail conditions should be considered. If a trail is generally in good condition, existing use types and levels may be appropriate with routine maintenance. Trails that are generally in a degraded condition may have inappropriate uses, poor design, substandard construction, or inadequate maintenance. Determining exactly what has contributed to a degraded condition requires further evaluation of trail sustainability.

Evaluating Trail Sustainability

Two methods can be used to evaluate trail sustainability. The first method is an initial evaluation using a topographic map with an annotated trail alignment (discussed in "Element 4—Documentation of Trail Location"). The second method is a more detailed evaluation based on trail condition and sustainability (discussed in "Element 6—Evaluation of Management Options"). Evaluations of trail sustainability help guide management decisions affecting use characteristics, Design Parameters, maintenance frequency, necessary capital improvements, or any type of mitigation, such as reroutes, rehabilitation, or trail closure.

If an evaluation shows that existing trail use matches agency goals and a trail is in good condition with a sustainable trail design and layout, developing TMOs should be easy and management should be straightforward. If an evaluation uncovers problems, the process will be more difficult. Correcting the problems may require modifying trail use characteristics, increasing maintenance, or making major investments in a trail—changes that may be costly or unpopular.

Having a thorough understanding of trail use, condition, and sustainability provides a solid base for TMOs development and future trail management.

The "TMOs Development Input" form in appendix C, developed by the author, can help trail managers as they collect data on trail use, condition, and sustainability. The completed form also can help them evaluate data during TMOs development and when managing the trail.

Chapter 9: Element 4—Documentation of Trail Location

An accurate map of the trail location provides information that helps answer four important questions:

- Where is the trail, **exactly?**
- Whose land does the trail cross and what features are located nearby?
- What is the character of the physical environment surrounding the trail?
- Does the trail have sustainable design and layout?

Locating the Trail

Since knowing what to manage depends on knowing where to manage, it's important to have an accurate trail location map. Often trail location maps are out of date, incomplete, inaccurate, or of poor quality. Over time, the trail character may change and new spur trails, cutoff trails, or braided trail segments may develop. Trail maps should be updated regularly.

The Global Positioning System (GPS) can help managers map the trail centerline. Figure 9–1 shows a variety of GPS instruments that are used for trail mapping. Determining a trail centerline is relatively quick and simple with a GPS receiver (figure 9–2). The specific method used depends on the operator's training and skill, available equipment, and the accuracy required by the sponsoring agency.

Figure 9–1—Examples of Global Positioning System (GPS) units and support hardware used for trail mapping work. Clockwise from bottom left: external GPS antenna (1), laser rangefinder (2), recreation-grade GPS receiver (3), mapping-grade GPS receiver (4), digital camera with integrated GPS and compass (5), data loggers (6), field GPS backpack (7), and mapping-grade GPS receiver (8).

Figure 9–2—Two National Park Service staff members use mapping-grade Global Positioning System receivers to map a trail centerline on Kodiak Island, AK.

Trail Location Method 1—Recreation-Grade GPS Receivers

Recreation-grade GPS receivers are best used for general reference maps on lands managed by a single land manager. Figure 9–3 shows a map made using data collected with the recreation-grade GPS receivers that are widely available.

This method does not provide highly accurate data, but may be adequate for many management applications. A track log of the centerline of the trail and individual waypoints are obtained while traversing the alignment. The track log provides a reasonably accurate centerline location and the waypoints provide coordinates for points of interest along the trail alignment. The data can be displayed using simple mapping software or downloaded as a shapefile for input into the Geographic Information System (GIS). Other software allows the geographic data collected with a GPS receiver to be linked with digital photos.

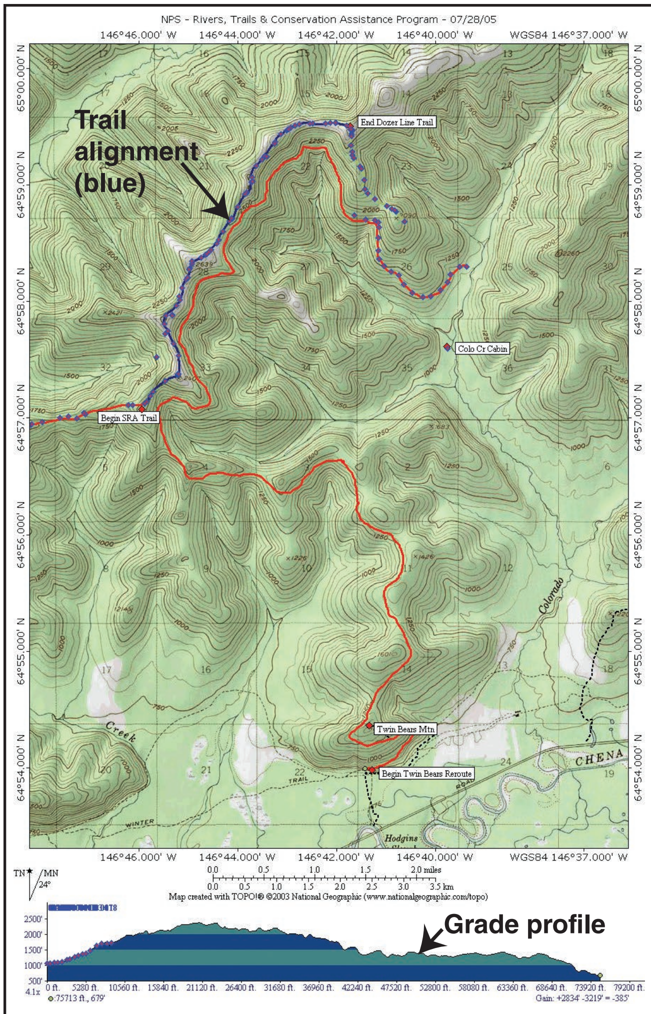


Figure 9–3—Two trail alignments displayed on a topographic map base. This map product was generated from a recreation-grade Global Positioning System receiver and displayed on a shaded relief topographic map to enhance the terrain features. Note the grade profile of one of the trails displayed across the bottom of the image. *—Base map and profile produced using TOPO! ©2008 National Geographic.*

Trail Location Method 2—Mapping-Grade GPS Receivers

Mapping-grade GPS receivers are versatile and quite accurate. They may include an internal data dictionary which allows them to record additional information regarding the trail, such as descriptive labels for point data and attribute descriptions for trail segments. This capability is described in greater detail under "Element 5—Trail Condition Assessment." The software packages of mapping-grade GPS receivers are configured to transfer data directly into GIS. Mapping-grade GPS receivers are considerably more expensive than recreation-grade receivers and require more training for mapping and data processing. Typically, GPS data collection using mapping-grade receivers is limited to agency-supported mapping efforts. Table 9–1 compares recreational- and mapping-grade GPS receivers.

Table 9–1—Comparison of recreation-grade and mapping-grade Global Positioning System (GPS) receivers. Recreation-grade GPS receivers usually cost $100 to $300. Mapping-grade GPS receivers usually cost $3,000 to $5,000.

Features	Recreation-grade GPS receivers	Mapping-grade GPS receivers
Accuracy in the open or under a medium canopy	Generally accurate within 10 to 15 meters or less	Generally accurate within 3 to 5 meters Most units allow for real-time differential correction for improved accuracy
Post field correction	Generally not an option	Integrated component
Accuracy under a dense canopy	Fair to good	Good to very good
Geographic Information System integration	Possible with supplemental software	Integrated within the system
Attribute descriptions	Limited to manually labeled track logs and waypoints	Extremely flexible and detailed

Trail Location Method 3—Survey-Grade Engineering Instruments

A third method of GPS centerline mapping uses survey-grade engineering instruments. This method provides the most accurate data but requires highly sophisticated equipment and professionally trained operators. Typically, this type of work is performed by specialized agency crews or professional land surveyors. Survey-grade accuracy may be required when locating rights-of-way or dealing with complex land status issues.

GPS Accuracy

Most manufacturers test their receivers in open canopies and report the results as expected accuracy. This accuracy may not be achieved when the Global Positioning System (GPS) receiver is used under a forest canopy. The Forest Service Missoula Technology and Development Center (MTDC) tests GPS receivers on special courses and posts the tested accuracies in a spreadsheet that is available at <http://www.fs.fed.us/database/gps>. MTDC also tests GPS receivers for their ease of use, ruggedness, and other characteristics that are important for field users (Karsky and others 2000), <http://www.fs.fed.us/eng/pubs/html pubs/tm00712341/>.

Figure 9–5—This handlebar-mounted Global Positioning System unit was used for centerline data collection on a pioneered off-highway vehicle trail. The use of a mountain bike allowed for quick data collection with little additional environmental impact.

Regardless of the type of GPS receiver that is used, GPS centerline mapping can be conducted relatively quickly. The trail manager or agency usually determines the method used for a specific trail mapping project. Figures 9–4 and 9–5 show some innovative methods of field data collection. All field operations should be conducted safely, after development of a job hazard analysis (see “Element 9—Implementation”).

While mapping, it can be beneficial to establish temporary or permanent milepost markers or record distance measurements to specific features, such as stream crossings, trail junctions, or other prominent trail features. These distance measurements can be helpful during condition assessments or construction and maintenance operations.

Distance measurements can be taken with measuring wheels, GPS receivers, or odometers. Measuring wheels provide the most precise data. Temporary distance measurement stations can be established using survey flagging, lath, posts, or plastic or aluminum tags attached to trees or shrubs. GPS coordinates may be recorded at milepost locations, if desired.

Centerline mapping may be a good time to collect basic physiographical and biological information along the alignment. This information can include trail grade, sideslope, soil type, and brush and timber character. These are Productivity Factors in the Forest Service TRACS Trail Assessment and Condition Survey approach discussed in “Element 7—Trail Prescriptions.” Forest Service TRACS Trail Assessment and Condition Survey information is available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Figure 9–4—Global Positioning System centerline mapping of off-highway vehicle trails may be conducted in the winter by snowmobile. This technique can provide for very rapid data collection in some areas.

Trail Location Method 4—Aerial Photos

High-resolution aerial photography or satellite imagery can also be used for trail location. This may be an attractive option if it's not possible to traverse the trail, GPS data collection is considered too complicated or costly, or a large-scale mapping project is being conducted. The Forest Service and Bureau of Land Management typically have quality aerial photography for lands they manage. In rural America, the U.S. Department of Agriculture, Natural Resources Conservation Service, and State or local forestry offices often have aerial photography coverage. Earth Resources Observation and Science Center has standardized, cloud-free images of all areas of the United States, taken over 5- to 7-year cycles <http://eros.usgs.gov>. When locating and transferring trail location data from aerial photos, determine whether the imagery has been rectified—that is, geometrically corrected to ground features. If not, the location data may not be accurate enough to match up with topographic maps or GIS data.

One source of satellite imagery is Google Earth. In many areas, Google Earth has posted high-resolution rectified imagery that is detailed enough to recognize and delineate trail alignments. Figure 9–6 shows a Google Earth image with a proposed trail alignment. Often, Google Earth images are good enough to use as a project base map. If you use Google Earth images for a base map, the images should be purchased. They are usually available at a reasonable cost.

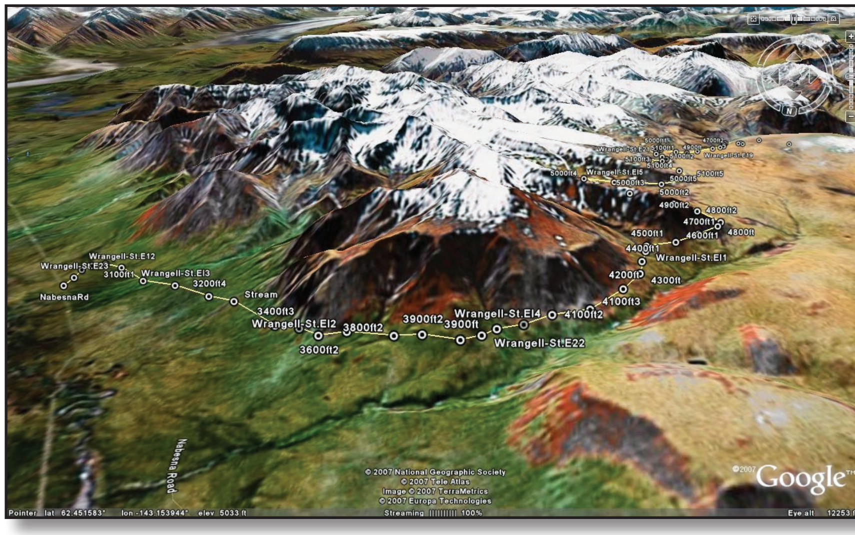


Figure 9–6—Mapping a trail alignment using Google Earth. —*©2007 Google, ©2007 National Geographic Society, ©2007 Tele Atlas, Image ©TerraMetrics, ©2007 Europa Technologies.*

In figure 9–7, a trail alignment crosses four different land ownership types. That information would be valuable to a trail manager because it indicates that management could be complicated. The trail manager should ensure that rights-of-way have been reserved on all private parcels before planning any major trail improvements.

Land Status

With accurate centerline data, trail managers can determine whose land a trail crosses. The **ability** to manage a trail depends on having the **authority** to manage it. Land-status questions are best answered by displaying the trail alignment over a Federal, State, or local land-status plat map.

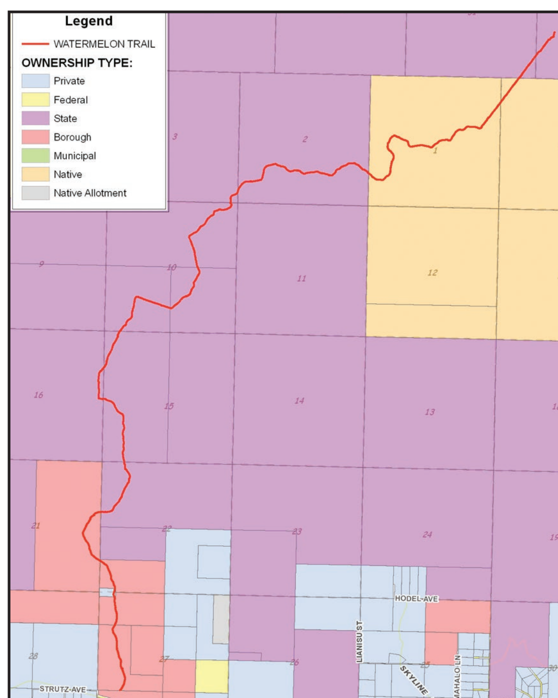


Figure 9–7—A trail alignment projected over a land status plat.

Identifying the Character of the Physical Environment Surrounding the Trail

Accurate trail alignments also help managers evaluate the general physical environment beneath and surrounding the trail. A GIS can display the trail alignment along with any combination of other resource attributes (figure 9–8).

The resource data of particular importance for trail management include:

- **Topography—**Slope, elevation, aspect, watershed boundaries, and relationship to nearby terrain features such as lakes, cliffs, or floodplains
- **Hydrology—**Drainage patterns, stream character, and locations of wetlands, rivers, lakes, and streams
- **Fisheries—**Fish habitat at stream crossings
- **Soils—**Tread surface texture and subsurface drainage
- **Administrative status—**Land administrative status; wilderness boundaries; and Federal, State, and local land management designations
- **Transportation networks—**Location of roads, parking areas, other trails, and nearby facilities
- **Infrastructure—**Location of powerlines, fences, buildings, and utility systems
- **Vegetation—**Data on ground cover, brush, and canopy; location of wetlands, sensitive plant habitats, and invasive species
- **Wildlife—**Critical habitats, nesting sites, calving grounds, den sites, and travel or migration routes
- **Cultural Resources—**Sensitive historic/archeological resources to protect, historic/archeological features to interpret

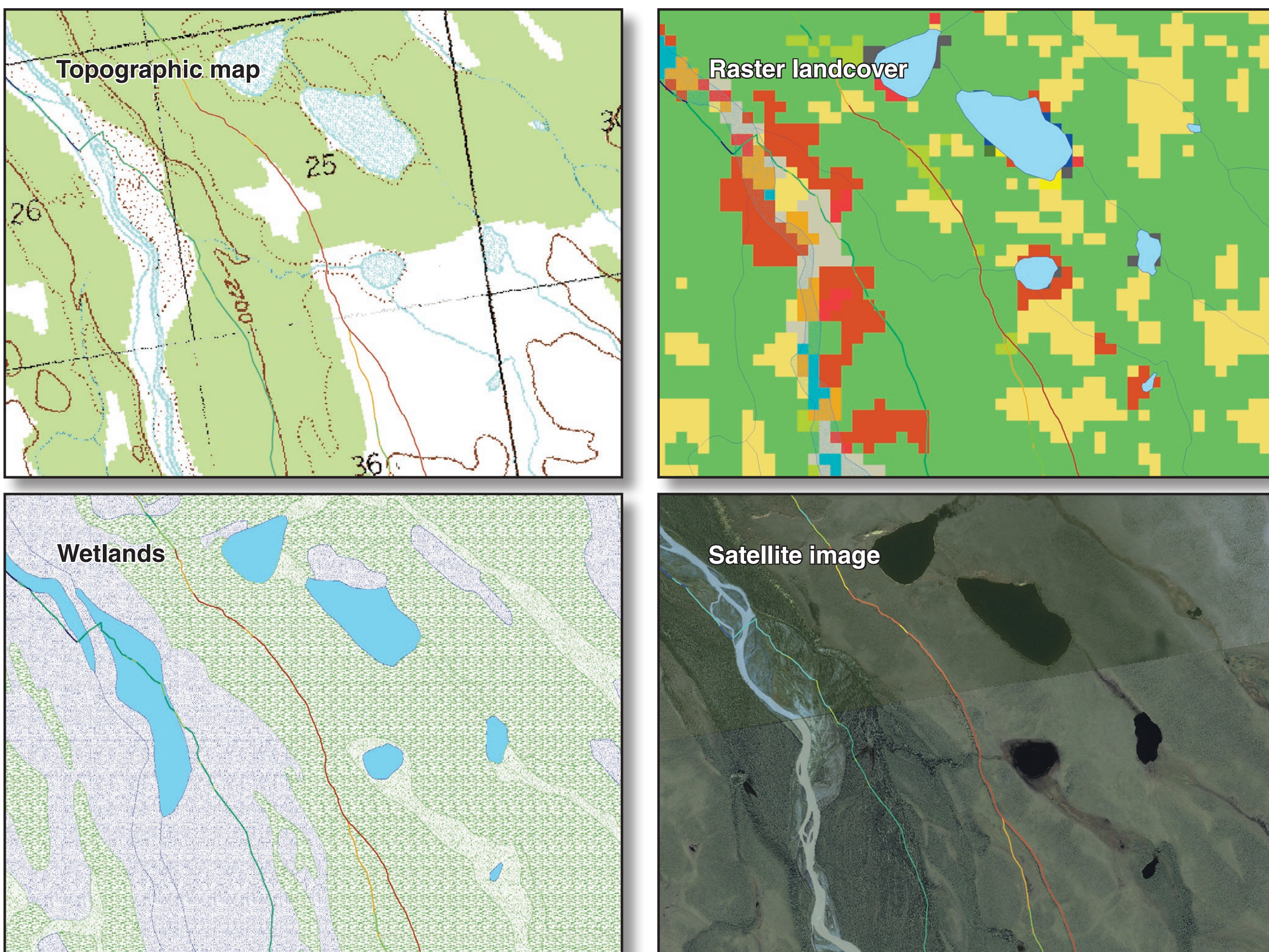


Figure 9–8—A series of Geographic Information System data layer displays for a trail alignment.

Assessing Sustainable Trail Design and Layout

When projected onto a topographic map, the relationships between the trail alignment and the terrain can be examined in detail. Pay close attention to the way the trail runs along or across the terrain and the way the trail crosses drainages. Examining the trail alignment as it crosses map contour lines helps determine whether the trail generally meets two of the six sustainable trail design guidelines: contour and grade. To meet the first guideline, the trail alignment must generally run along contour lines or cross them at a shallow angle (figure 9–9). (See controlled grade in chapter 2, “Sustainable Trail Design Guidelines.”) To meet the second guideline, the trail alignment generally should not exceed a grade of 10 percent.

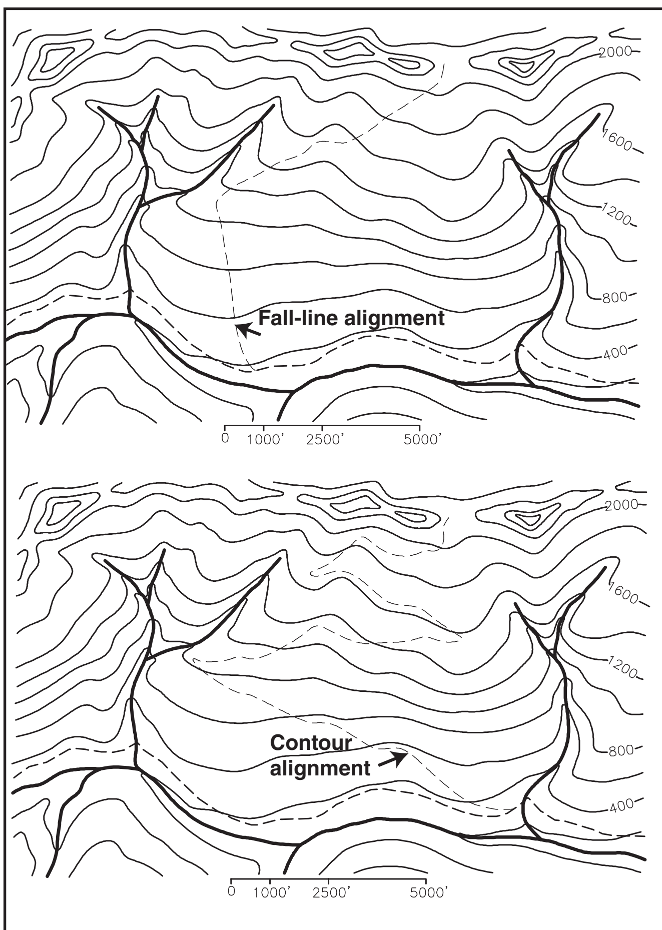


Figure 9–9—Two trail alignments plotted over a topographic map base. In the top image, the trail runs directly up and down the slope, an example of a fall-line alignment. Fall-line alignments are inherently unsustainable. In the bottom image, the trail crosses the contour lines at a shallow angle. This meets the standards for a sustainable contour curvilinear alignment.

Trail grade, calculated as rise over run multiplied by 100, is expressed as a percentage. On a topographic map, the grade is calculated by measuring elevation change (rise) and the distance between two points (run). The two points should be selected to delineate trail segments where the grade is relatively uniform. Figure 9–10 displays a trail alignment climbing a slope before contouring across the head of a drainage. Note the four waypoints, A through D, along the alignment. These points will be used to help calculate the trail grade (table 9–2) for the three trail segments they establish.

In this case, the grade is less than 10 percent for all three trail segments. Each segment meets the sustainable trail design guideline for controlled grade. Contrast the alignment in figure 9–10 with the fall-line alignment shown at the top of figure 9–9, which has an average trail grade of 15.3 percent (1,800-foot elevation difference divided by 11,800-foot trail length multiplied by 100), exceeding the guideline for controlled grade.

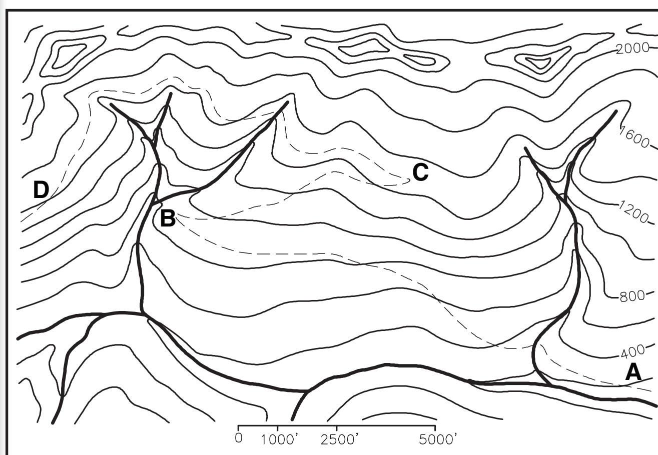
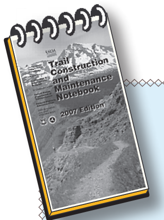


Figure 9–10—A trail alignment with reference points A through D, used in the trail grade calculation example.



Measuring Trail Grade

Percent grade equals the rise (elevation change) divided by the run (horizontal distance) multiplied by 100.

A trail segment 100 feet long with a 10-foot rise would be a 10-percent grade. A 10-foot rise over a 10-foot run is a 100-percent grade.

Elevation change is always expressed as a positive number. In trail management, grades may be expressed as positive (+) for an ascending grade and negative (-) for a descending grade relative to the direction of travel. Percent grade can be expressed as an equation:

$$\frac{Rise}{Run} \times 100$$

A clinometer, sometimes called a clino by trail workers, is a simple, useful, field instrument for measuring grades. Most clinometers have two scales, one indicating percent grade, the other showing degrees (figure 9–11). Percent grade, the relationship between rise or drop over a horizontal distance, is the most commonly used measurement for trail work. Percent readings usually are found on the right-hand side of the clinometer's scale, degree readings on the left-hand side. Do not confuse percent and degree readings. It is easy to do. **If you read RIGHT, you will always be right.**

For more information, "Lightly on the Land" (Birkby and the Student Conservation Association 2005) includes an entire chapter on "Measuring Distance, Grades, and Heights" (chapter 7).

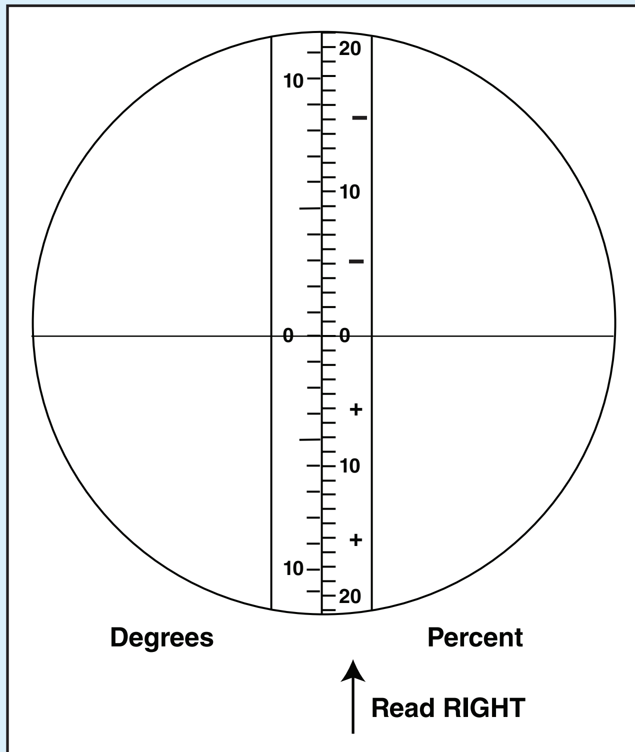


Figure 9–11—The view inside a clinometer, degrees on the left, percent on the right.

—Adapted for off-highway vehicle trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

Table 9–2—An example showing how to calculate trail grade.

Waypoint	**Elevation** (feet)	**Rise between waypoints** (feet)	**Run between waypoints** (feet)	**Rise ÷ Run x 100**	**Trail grade** (percent)
A	300				
B	850	Between A and B = 550	Between A and B = 12,500	550 ÷ 12,500 × 100	6.87
C	1,450	Between B and C = 600	Between B and C = 6,250	600 ÷ 6,250 × 100	9.60
D	1,600	Between C and D = 150	Between C and D = 13,750	150 ÷ 13,750 × 100	1.10

In addition to the specific sustainable trail design guidelines, the following three sustainable layout considerations can be evaluated by examining the topographic trail map display. They include:

- **Landscape position—**The trail's location relative to the terrain helps determine the long-term trail sustainability. In general, the ideal location for a trail is on the upper third of sideslopes because these areas tend to have the fewest surface water issues. Certain terrain features should be avoided: ridgelines, toe slopes, and aspect (depending on climate).
- **Areas with surface slope less than 3 percent—**Flat areas are the bane of trail builders because of the problems of tread entrenchment and inadequate surface drainage. Flat areas should be avoided as much as possible to reduce long-term maintenance.
- **Drainage crossings—**Drainage crossings often require expensive structures, such as improved fords, culverts, or bridges. Placing trails high on sideslopes may eliminate crossings or reduce their size and number. Trail alignments should also dip in and out of all sideslope drainages (even minor drainages) to prevent stream capture, where water is diverted and runs down the trail alignment.

With an accurate trail alignment displayed on a topographic map, a trail manager can understand the sustainable design and layout of a trail (figure 9–12).

The Difference Between Grade and Slope

Grade—Describes the steepness of the trails

Slope—Describes the steepness of the surrounding terrain

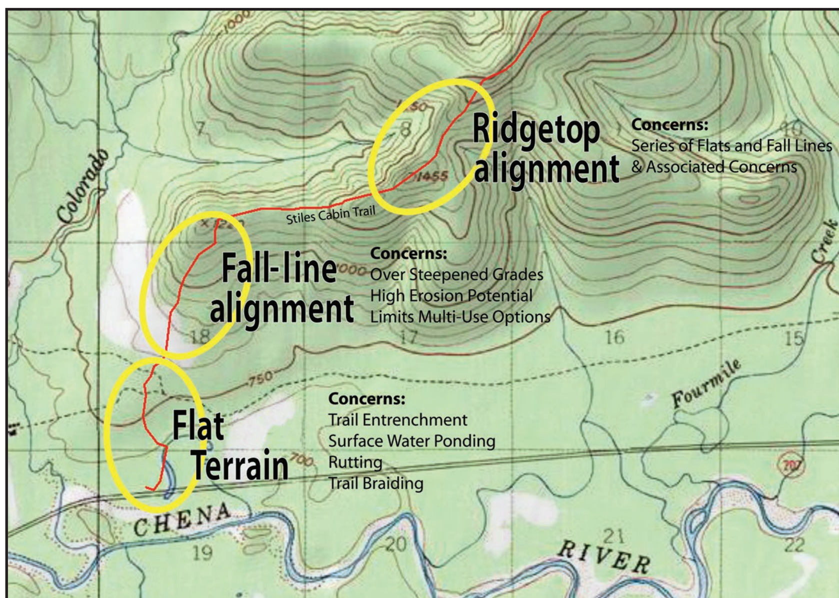


Figure 9–12—A trail alignment on a topographic map base displaying common alignment problems. —*Base map produced using TOPO! ©2008 National Geographic.*

Chapter 10: Element 5—Trail Condition Assessment

A trail condition assessment is a detailed, on-the-ground inventory of the character and physical condition of the trail tread and associated trail structures. This assessment documents parameters such as trail grade, width, surface type, state of repair, and similar characteristics, allowing a trail to be divided into short segments. Trail structures or features like bridges and retaining walls are also identified and described. A condition assessment documents trail conditions at the time the assessment is conducted. It records conditions along every foot of the trail—not just problem sites—to provide baseline data that can be used to assess condition trends. A baseline condition assessment provides a key reference for general trail planning efforts, Trail Management Objectives (TMOs) development, trail evaluation, maintenance, and long-term monitoring.

Trail condition assessments can be conducted using a variety of systems. The Forest Service uses a standardized approach for Trail Assessment and Condition Surveys (TRACS). TRACS combines a basic field inventory and condition assessment with the identification of site-specific prescriptions which identify the work that needs to be done to meet management objectives. For efficiency, the Forest Service uses the TRACS consolidated approach and generally does not conduct stand-alone assessments of trail conditions. The TRACS approach is discussed in “Element 7—Trail Prescriptions.”

Inventory Techniques

Traditionally, trail condition assessments were conducted using a clinometer (figure 10–1) or Abney hand level, measuring wheel or 100-foot tape, field notebook, and a compass. Several assessment techniques still rely on these tried-and-true methods.

Figure 10–1—A clinometer is used to measure trail grade. This small hand-held instrument allows trail grade or terrain sideslope to be measured quickly and easily.

The advent of Global Positioning System (GPS), Geographic Information System (GIS), and portable field computers provides opportunities to increase field mapping capabilities and efficiency. In Alaska, GPS receivers have been used to collect consistent data rapidly while crossing large, remote landscapes (figure 10–2). That data can be integrated efficiently into GIS.

Figure 10–2—Off-highway vehicle trail managers in Alaska often face complex assessment challenges mapping trails in remote areas.

Figure 10–3—A park bench located along a trail alignment is documented as a Global Positioning System point feature.

Figure 10–4—Global Positioning System mapping of a deck at a scenic overlook. The deck could be mapped as a point feature to simply denote its location, or as an area feature to document its footprint. Two surveyors are collecting data. The second instrument provides a backup dataset.

Three general types of data are common to both manual and instrument-assisted trail condition assessments:

Point data—Trail structures and trail or natural features that are best represented by a single point. Examples include a sign, the center point of a trail junction, the bottom of a grade dip, or the location of a survey marker (figure 10–3).

Line data—Linear features are best represented by a single or segmented line. Examples include the trail alignment, roads, fences, powerlines, or administrative or property boundaries.

Area data—Features that occupy large two-dimensional areas. Area features can be angular or irregularly shaped polygons. Examples include trailhead parking lots, braided trail areas, borrow pits, or the footprint of a large structure (figure 10–4).

The full list of specific features to be mapped will vary. The data collected during a trail condition assessment includes **attribute** information about each **feature** and **values** associated with each attribute.

Relationship Between Features, Attributes, and Values

Features (types of points, lines, or areas)
  Attributes (information about the features)
    Values (values of the attributes)

An example of point data:
- HAZARD (feature)
  - TYPE (attribute)
    - Major washout (value)

An example of line data:
- TRAILWAY (feature)
  - TRACKTYPE (attribute)
    - Main (value)

Data terms used to define features and attributes are capitalized (except in figures 10–5 and 10–11). See appendix D, "Definitions of Terms for the Alaska NPS OHV Condition Assessment Data Dictionary" and "Alaska NPS OHV Trail Prescription GPS Data Dictionary," for definitions of data terms.

One way to organize trail features, attributes, and values is to create a data dictionary. Data dictionaries are organized outlines of all the point, line, and area data that might be encountered in the field. Data dictionaries are flexible, so they can be customized to fit a specific need. In general, it is better to be inclusive when preparing a data dictionary, rather than to leave out details. The level of detail can be managed by using drop-down menus, which help ensure that terminology is used consistently when identifying mapped features.

The "Alaska NPS OHV Condition Assessment Data Dictionary" (appendix D) has been developed and refined over 4 years of extensive off-highway vehicle (OHV) trail condition assessment mapping by the National Park Service (NPS) Alaska Regional Office. This dictionary has a fairly complete list of trail tread condition features and associated attributes, but the list of trail structures is incomplete. This combination has worked in Alaska where most trails are inadequately developed and have few structural improvements.

As in any dictionary, a definition of the terms used to describe line, point, and area features, attributes, and values helps ensure consistency in data identification and application.

Figure 10–5 displays examples of the line feature TRAILWAY, with its associated attributes and values, for four representative sites based on the "Alaska NPS OHV Condition Assessment Data Dictionary."

The Forest Service TRACS approach incorporates a standardized data dictionary for identification of constructed features and tasks. The data dictionary is available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>. This extensive data dictionary is integrated with the Forest Service standard drawings and specifications, the corporate database, and cost estimation algorithms.

Federal Trail Data Standards

In 2009, Federal agencies agreed to a set of Federal Trail Data Standards (FTDS) officially published by the Federal Geographic Data Committee in 2011. These standards were developed to provide consistency between agencies for reporting and map production. The standards include a set of defined terms, some of which are used in data dictionaries. The FTDS terms used throughout this report include Trail Type, Trail Class, Managed Use, and Designed Use. Trail managers are encouraged to adopt and use these terms, as defined, when developing data dictionaries or when mapping trails. Information about these standards is available at <http://www.nps.gov/gis/trails/> and <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/trail-data-standard/trail-data-standards>.

Reeve Field Trail, Wrangell-St. Elias National Park (NPS)

Attribute	Value
Track type	Main
Track	Multibraid 5 to 10
Impact width	18 to 24 feet
Trail grade	0 to 3 percent
Tread geometry	Entrenched
Trail surface character	Native fine mineral
Trail drainage	Ponded
Mud and muck	Muck hole
Rutting	17 to 32 inches
Vegetation condition	Stripped

Compeau Trail, Chena River State Recreation Area (Alaska DNR)

Attribute	Value
Track type	Main
Track	Wide track
Impact width	6 to 12 feet
Trail grade	Contour 4 to 8 percent
Tread geometry	Outsloped
Trail surface character	Mixed fines and gravel
Trail drainage	Well drained
Mud and muck	None
Rutting	Less than 2 inches
Vegetation condition	Stripped

Quartz Creek Trail, White Mountains National Recreation Area (BLM)

Attribute	Value
Track type	Main
Track	Multibraid 2 to 4
Impact width	12 to 18 feet
Trail grade	Fall line 4 to 8 percent
Tread geometry	Outsloped
Trail surface character	Mixed fines and gravel
Trail drainage	Well drained
Mud and muck	None
Rutting	2 to 8 inches
Vegetation condition	Heavy impact

Quartz Creek Trail, White Mountains National Recreation Area (BLM)

Attribute	Value
Track type	Main
Track	Double wheel track
Impact width	3 to 6 feet
Trail grade	0 to 3 percent
Tread geometry	Flat
Trail surface character	Geotextile surface
Trail drainage	Well drained
Mud and muck	None
Rutting	None
Vegetation condition	Moderate impact

Figure 10–5—An example of four different trail segments and their condition assessment attributes and values for the feature TRAILWAY.

OHV Trail Assessment Field Mapping

The author recommends that a data dictionary be applied manually during field mapping or be incorporated with a mapping-grade GPS unit or mobile mapping system. Refer to page 88 for information on the Forest Service TRACS approach and page 89 for information on the TRACS data dictionary.

Field Mapping Using Manual Methods

In general, manual OHV trail assessments are most appropriate when:

- A single trail or very simple trail system is being evaluated.
- The trails are fairly short and uncomplicated.
- Heavy tree cover or steep terrain blocks GPS signals.
- A simple data set is being collected.
- The mapping crew does not have access to, experience with, adequate training for, or agency support for more sophisticated mapping-grade GPS and mobile mapping systems.

To easily and consistently record field data, a field data form can be developed and a pick list (list of choices) created. Appendix C includes a blank condition assessment manual data sheet. Appendix C also has the "Condition Assessment Codes and Ranking Weights" pick list from the "Alaska OHV Condition Assessment Data Dictionary."

The manual field mapping method uses a measuring wheel or tape (high precision), GPS trip computer, or OHV odometer (low precision) to determine beginning and ending points for trail segments and locations for point features.

Measuring wheel or tape values may be expressed in the standard engineer's format: 00+00; where hundreds are denoted left of the "+" sign and distances between 0 and 99 feet are denoted right of the "+" sign. For example, 1,235 feet would be recorded as 12+35, and 63 feet would be recorded as 00+63. Trip computer and odometer data would be recorded in miles and the closest tenths of a mile; for example, 12.4 miles.

The manual data sheet in appendix C can be used to record coordinates from a GPS receiver. Note the blocks reserved for waypoint numbers. Individual waypoints can identify a trail segment's beginning and ending points and the locations of trail-related point features.

The GPS data can be downloaded as a track log to represent the trail alignment. The track can be displayed and labeled on a topographic map using commercially available mapping software. The track log also can be downloaded as a shapefile (an attribute table with associated feature locations) for input into GIS.

To ensure accuracy, record GPS waypoints as an averaged reading (a posting based on data collected for 10 seconds or longer).

Transfer between various data formats and software systems is improving as the popularity of GPS mapping increases. If a Garmin GPS unit is used, GPS data can be downloaded using a free software package developed by the Minnesota Department of Natural Resources called DNRGarmin <http://www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html>.

With recreation-grade GPS receivers, waypoints can be individually labeled or assigned a symbol that can enhance the information displayed on final trail maps (figure 10–6).

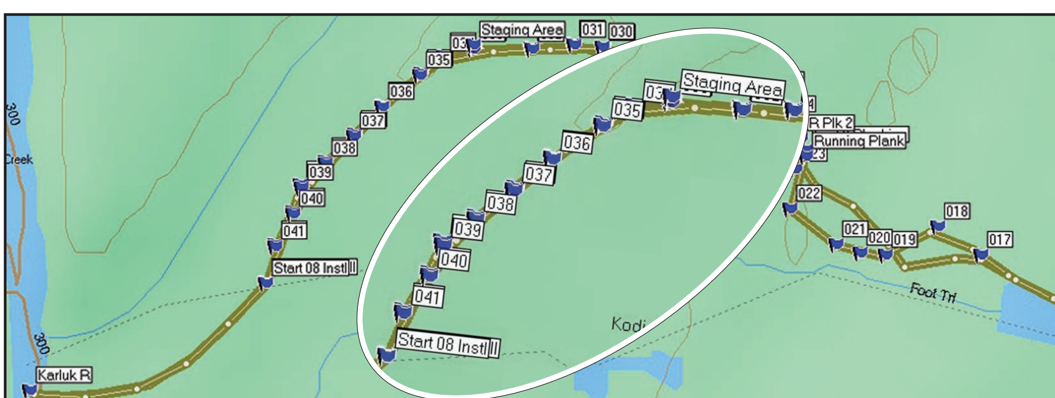


Figure 10–6—A map of a track log representing a trail alignment with waypoints defining trail segment breaks. The map was generated from data collected using a recreation-grade Global Positioning System receiver and displayed on a topographic base map. —*Base map produced using TOPO! ©2008 National Geographic.*

Field Mapping Using Mapping-Grade GPS and Mobile Mapping Systems

Because mapping-grade GPS receivers have better antennas, receivers, and internal processors, they are significantly more accurate and sophisticated than recreation-grade GPS receivers. Mapping-grade GPS receivers can use integrated data dictionaries, and their accuracy can be refined with differential GPS (DGPS) correction.

Differential correction is a method of comparing GPS satellite coordinates with a known base station's location. Any error in the satellite signal is corrected and automatically applied to the GPS data collected in the field. Differential correction can improve point accuracy to 1 meter or less.

Mapping-grade GPS receivers are designed to collect precise data, correct and refine the data with software packages, and export the data to a shapefile that is downloaded into a geodatabase (a relational geographic database used by GIS software). The geodatabase provides the platform for final data editing, analysis, display, and map production.

Mobile mapping systems are typically a rugged field computer or personal digital assistant (PDA) with a GPS receiver. The quality of the GPS antenna, receiver, and processor determine the accuracy and precision of the data.

Figure 10–7—Postprocessing data collected with mapping-grade Global Positioning System receivers can take twice the amount of time as the field data collection effort. The editing should be conducted with assistance from, or directly by, the field mapping crew.

Like mapping-grade GPS receivers, mobile mapping systems use an integrated data dictionary and can use differential correction. They collect precise data and can display georeferenced images, reference documents, calculations, and even integrated photography, depending on the type of system used. Their real strength is their ability to easily access and update existing files in a geodatabase. Mobile mapping systems are an excellent way to monitor changes to baseline trail condition and record changes over time. Monitoring is discussed in more detail in "Element 10—Trail Monitoring and Evaluation."

This sophistication does not come without a downside. For every hour that a field technician spends collecting the data, a skilled GIS technician may need to spend 1 to 2 hours integrating the data into GIS (figure 10–7).

Figure 10–8 shows a mapping-grade GPS display of raw trail condition assessment data that is being edited using GPS software. Note the trail segment circled in red at the top of the image. The Feature Properties box to the right of the screen lists all attributes of that trail segment as it was mapped in the field. Similar data are available for every line, point, or area feature on the screen. Note also the data presented in the Position Properties box to the left, which includes latitude, longitude, precision, and date.

After the data are edited, they are downloaded into the GIS software. Figure 10–9 shows GIS information of a trail alignment. Numbers identify individual trail segments. Segment numbers are cross-referenced to a data table (subsection shown in table 10–1) listing the features, attributes, and values for the trailway and the segment's starting point, ending point, length, and associated coordinates.

Condition assessment data is stored as a data layer in GIS software. The GIS software provides a visual display of specified tabular data, allowing great flexibility. For example, a GIS geodatabase can be queried to display trail segments with trail grades steeper than 15 percent. This dataset can be queried to display trail segments with ruts more than 4 inches deep. The new display of trail segments, which shows the relationship between steep grades and the depth of ruts, can be used to evaluate erosion potential on steeper grades.

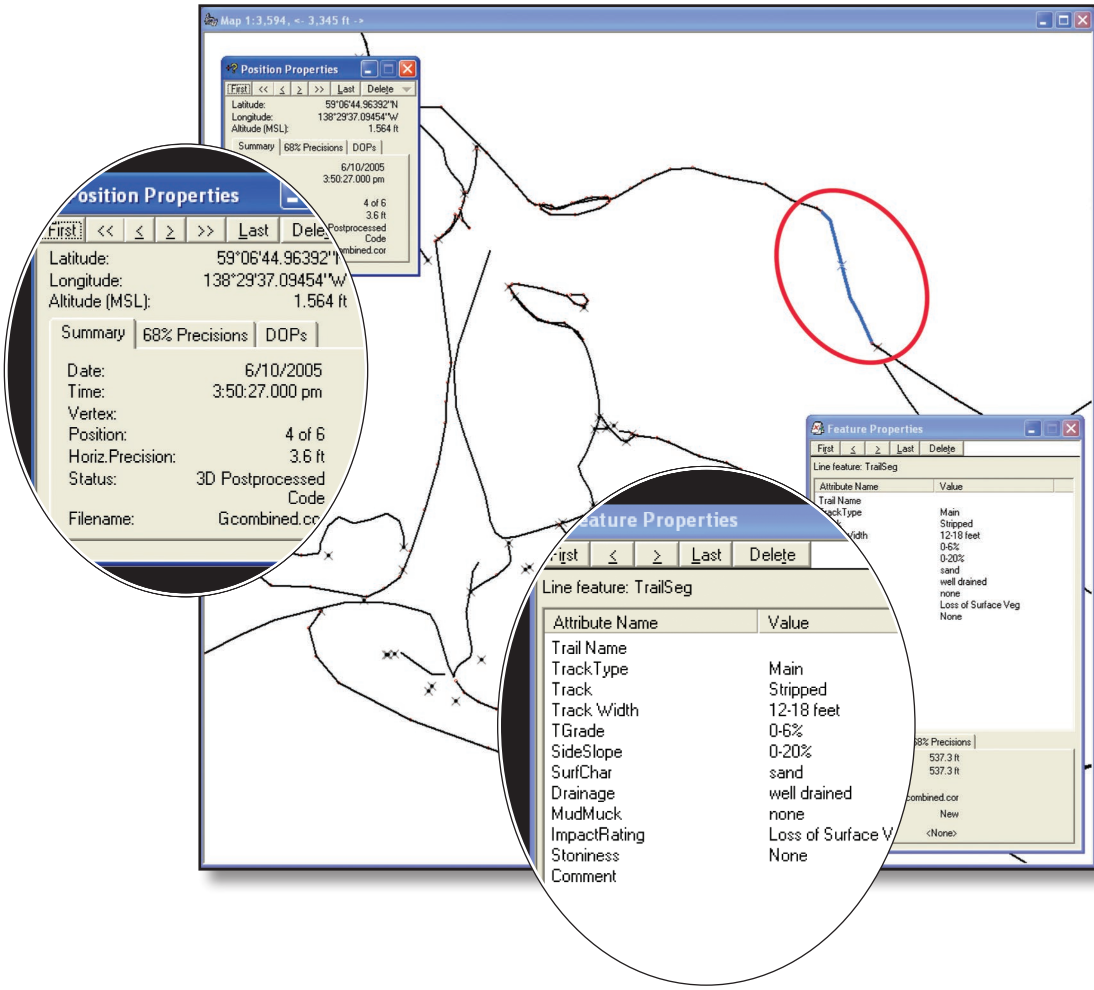


Figure 10–8—An example of Global Positioning System software being used to edit a complex trail system. The properties listed in the data boxes relate to the circled trail segment. —*Information in the screenshots was generated using Trimble GPS Pathfinder Office software.*

Information from the trails data layer also can be combined with information from other resource or administrative data layers. The ability of GIS software to manipulate combinations of data is limited only by the availability and detail of the data layers and by the skill of the GIS specialist.

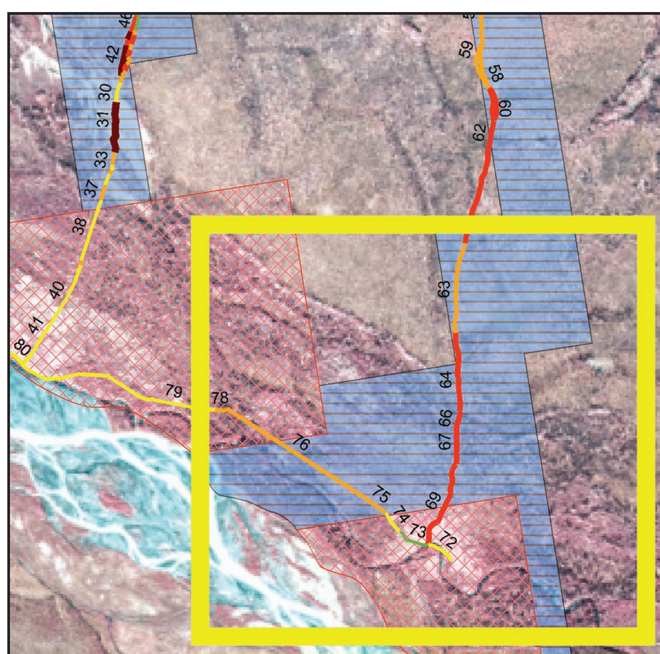


Figure 10–9—A Geographic Information System display of a trail alignment over a color-infrared image. Table 10–1 shows trailway information for the trail segments inside the yellow box (lower right corner of figure).

Table 10–1—Geographic Information System information for a trail alignment (TRAILWAY data for figure 10–9).

TRAILWAY (segment number)	Begin segment (feet)	End segment (feet)	Length (feet)	TGRADE (percent)	TSURFCHAR	DRAINAGE	MUDMUCK	RUTTING (inches)	TRACKTYPE	TWIDTH	SIDESLOPE (percent)	STONES
63	17,405	18,274	869	0 to 6	Native fine mineral	Poorly drained	None	9 to 16	Main	Stripped 6 to 12 feet	0 to 20	None
64	18,274	18,948	674	0 to 6	Native fine mineral	Poorly drained	Muddy	9 to 16	Main	Stripped 6 to 12 feet	0 to 20	None
65	18,948	19,030	82	21 to 40	Native fine mineral	Poorly drained	None	9 to 16	Main	Stripped 12 to 18 feet	0 to 20	None
66	19,030	19,212	182	7 to 20	Native fine mineral	Poorly drained	Muddy	9 to 16	Main	Stripped 6 to 12 feet	0 to 20	None
67	19,212	19,303	91	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Stripped 6 to 12 feet	0 to 20	None
68	19,303	19,413	110	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Multibraid 6 to 20 feet	0 to 20	None
69	19,413	19,959	546	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Stripped 6 to 12 feet	0 to 20	None
70	19,959	20,021	62	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Multibraid 6 to 20 feet	0 to 20	None
71	20,021	20,318	297	0 to 6	Native fine mineral	Poorly drained	Muddy	17 to 32	Main	Stripped 6 to 12 feet	0 to 20	None
72	20,318	20,595	277	0 to 6	Native fine mineral	Moderately well drained	None	Less than 2	Main	1 set wheel tracks	0 to 20	None
73	20,595	20,920	325	0 to 6	Mixed fines and gravel	Well drained	None	Less than 2	Main	1 set wheel tracks	0 to 20	None
74	20,920	21,148	228	0 to 6	Native fine mineral	Moderately well drained	None	2 to 8	Main	1 set wheel tracks	0 to 20	None
75	21,148	21,331	183	0 to 6	Native fine mineral	Poorly drained	Muddy	2 to 8	Main	Stripped less than 6 feet	0 to 20	None
76	21,331	21,422	91	0 to 6	Native fine mineral	Poorly drained	Muddy	2 to 8	Main	1 set wheel tracks	0 to 20	None

Trail Condition Categories

A trail manager looking at condition assessment data will quickly recognize certain patterns. For example, flat trail segments with areas of standing water may have deep ruts or bog holes. These segments would be considered degraded. Trail segments with grades between 4 and 12 percent on well-drained, mixed fine and gravel soils may not have any evidence of tread degradation. These segments generally would be considered in good condition.

Data collected in the condition assessment can be used to sort trail segments into a range of trail condition categories. Standard categories include: good, fair, degraded, very degraded, or extremely degraded.

The "Alaska NPS OHV Condition Assessment Data Dictionary" (appendix D) lists sequential ranges of values for many attributes describing the physical character of a trail. For instance, the **impact width** (IMPACTWIDTH) attribute (the width of disturbance associated with trail use) has values beginning at less than 1.5 feet and ranging to more than 480 feet. The **track** (TRACK) attribute (the type of impression resulting from wheel passage) has values ranging from single track, to multibraided—more than 10 tracks. Similarly, the rut (RUTTING) attribute can range from less than 2 inches to more than 61 inches deep. These attributes, along with certain other attributes, can be used as indicators of trail degradation.

Each indicator of degradation is assigned a degradation ranking value. The fourth column of the "Condition Assessment Codes and Ranking Weights" pick list (appendix C) displays the assigned degradation ranking weight. (Note: The weights reflect patterns of degradation in Alaska and may not reflect patterns of degradation in other regions.) Figure 10–10 displays the ranking weights of the individual values for the **impact width** attribute.

These ranking weights are based on the target Design Parameters in TMOs. In this case, the design specification for trail width is 6 feet. Wider trails are considered an indicator of degradation.

No degradation ranking weights are assigned if the segment is less than 6 feet wide. A ranking weight of 4 is assigned if the segment is 6 to 12 feet wide. The ranking weight increases as the width increases, up to a maximum weight of 20.

Impact width	Ranking weight
Less than 1.5 feet	0
1.5 to 3 feet	0
3 to 6 feet	0
6 to12 feet	4
12 to18 feet	10
18 to 24 feet	12
24 to 40 feet	15
40 to 80 feet	20
80 to 160 feet	20
160 to 320 feet	20
320 to 480 feet	20
More than 480 feet	20
Not indicated	0

Figure 10–10—A subset of the "Condition Assessment Codes and Ranking Weights" pick list (in appendix C, "Forms"), displaying the degradation ranking weight for the **impact width** attribute.

Table 10–2—Condition category assignments (based on cumulative ranking values).

Total ranking weight	Condition category assignment	Code
Less than 10	Good	G
10 to 24	Fair	F
25 to 49	Degraded	D
50 to 75	Very degraded	VD
More than 75	Extremely degraded	XD

Each trail segment accumulates a total degradation ranking value (figure 10–11). The degradation ranking process sorts the relative condition of trail segments numerically; the higher the ranking the more extensive the degradation. The ranking is used to allocate each segment into one of the five trail condition categories. Table 10–2 shows the condition categories.

The condition category assignments for the two trail segments displayed in figure 10–11 would be very degraded for the segment with the ranking of 72 (photo shows an all-terrain vehicle in a muckhole), and degraded for the segment with the ranking of 36. The trail segment with the ranking of 72 is clearly significantly degraded. The second segment, although not as severely degraded, displays evidence of braided trail development and surface erosion. The segment's degraded condition category alerts trail managers to the potential of accelerated degradation at this site.

A trail condition category is assigned to each individual trail segment. If you are conducting a condition assessment inventory manually, the ranking weights are recorded in the row beneath the values for each segment on the manual data sheet (see appendix C). The total value is recorded at the end of the row, and condition category assignments are entered in the last column. If GPS receivers and GIS are used, a table developed by a GIS specialist performs the calculations.

Figure 10–12 shows a trail map displaying trails with individual trail segments color coded based on their condition category. The color display provides an easily understood visual representation of trail conditions. Using colors (green/violet/yellow/orange/red) to show increasing degradation helps agency managers and the public quickly interpret the map.

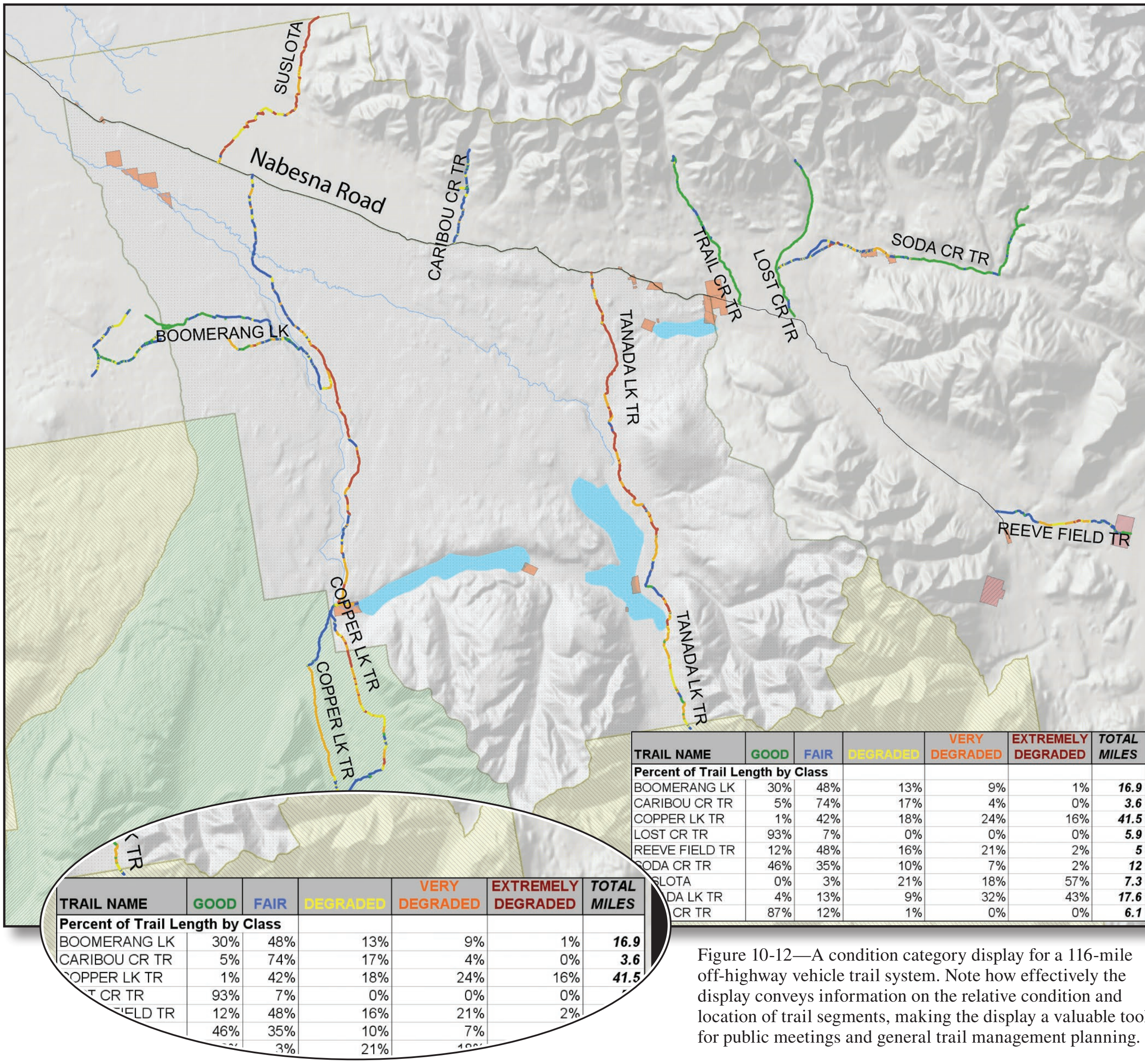
Reeve Field Trail, Wrangell-St. Elias National Park (NPS)

Attribute	Value	Ranking
Track type	Main	0
Track	Multibraid 5 to 10	20
Impact width	18 to 24 feet	12
Trail grade	0 to 3 percent	0
Tread geometry	Entrenched	NA
Trail surface character	Native fine mineral	6
Trail drainage	Ponded	8
Mud and muck	Muck hole	10
Rutting	17 to 32 inches	12
Vegetation condition	Stripped	4
	Total	72

Quartz Creek Trail, White Mountains National Recreation Area (BLM)

Attribute	Value	Ranking
Track type	Main	0
Track	Multibraid 2 to 4	15
Impact width	12 to 18 feet	10
Trail grade	Fall line 4 to 8 percent	4
Tread geometry	Outsloped	NA
Trail surface character	Mixed fines and gravel	0
Trail drainage	Well drained	0
Mud and muck	None	0
Rutting	2 to 8 inches	4
Vegetation condition	Heavy impact	3
	Total	36

Figure 10–11—Calculated total degradation ranking values for two trail segments.



TRAIL NAME	GOOD	FAIR	DEGRADED	VERY DEGRADED	EXTREMELY DEGRADED	*TOTAL MILES*
Percent of Trail Length by Class						
BOOMERANG LK	30%	48%	13%	9%	1%	***16.9***
CARIBOU CR TR	5%	74%	17%	4%	0%	***3.6***
COPPER LK TR	1%	42%	18%	24%	16%	***41.5***
LOST CR TR	93%	7%	0%	0%	0%	***5.9***
REEVE FIELD TR	12%	48%	16%	21%	2%	***5***
ODA CR TR	46%	35%	10%	7%	2%	***12***
SLOTA	0%	3%	21%	18%	57%	***7.3***
DA LK TR	4%	13%	9%	32%	43%	***17.6***
CR TR	87%	12%	1%	0%	0%	***6.1***

Figure 10-12—A condition category display for a 116-mile off-highway vehicle trail system. Note how effectively the display conveys information on the relative condition and location of trail segments, making the display a valuable tool for public meetings and general trail management planning.

Evaluating Sustainability of Trails

A detailed condition assessment provides data on five of the six sustainable trail design guidelines (table 10–3). For example, trail segments with grades steeper than 10 percent do not generally meet the controlled grade sustainable trail design guideline.

Table 10–4 may help managers determine the general sustainability category for an individual trail, based on certain criteria:

- The degree of sustainable trail design elements
- Condition category
- Frequency and adequacy of maintenance

Any of the criteria in the table can be modified to reflect local or regional conditions. A more sophisticated approach for evaluating the general sustainability category of a trail is explained in "Element 6—Evaluation of Management Options."

Table 10–3—Condition assessment data that relates to sustainable trail design guidelines. Features and attributes are given in Global Positioning System format. See appendix D for an explanation of the data dictionary terms (all capital letters).

Guideline	Feature	Attribute	Values that typically meet guideline	Values that typically do not meet guideline
Contour curvilinear	TRAILWAY	TGRADE	Contour	Fall line
Controlled grade	TRAILWAY	TGRADE	Grades generally less than 10 percent	Grades generally more than 10 percent
Integrated drainage	AQUAMGT	TYPE	Water bar Grade dip Natural dip	NA
Integrated drainage	TRAILWAY	TREADGEO	Outsloped Convex	Flat Concave Entrenched
Durable tread	TRAILWAY	TSURFCHAR	Upland vegetation Fines over gravel Mixed fines and gravel Alluvial sands and gravel Gravel Cobble Bedrock or rubble All hardened surfaces	Wetland vegetation Floating vegetation Native organics Sand Churned organics

Table 10–4—Screening table for sustainability categories. Sustainable trail design guidelines include contour alignment, controlled grade, integrated drainage, full bench, durable tread, and appropriate maintenance.

Design guideline status	Condition category	Receives regular maintenance	Receives adequate maintenance	Sustainability category
All present	Fair or good	Yes	Yes	Design sustainable
All present	Less than 10 percent degraded	Yes	No	Maintainable (likely upgradeable to design sustainable)
All present	More than 10 percent degraded	No	No	Maintainable (may be upgradeable to design sustainable)
Few or none	Fair or good	Yes	Yes	Performance sustainable (stable)
Few or none	Fair or good	No	No	Performance sustainable (at risk)
Partial	Fair or good	Yes	Yes	Likely maintainable
Partial	Fair or good	No	No	Likely maintainable
Partial	Up to 20 percent degraded	No	No	Likely maintainable
Partial	Up to 20 percent degraded	Yes	No	Possibly maintainable
Partial	20 to 33 percent degraded	No	No	Possibly maintainable
Partial	20 to 33 percent degraded	Yes	No	Likely unmaintainable
None	33 to 50 percent degraded	Yes	No	Likely unmaintainable
None	33 to 50 percent degraded	No	No	Likely unmaintainable
None	More than 50 percent degraded	Yes or no	No	Unmaintainable

Chapter 11: Element 6—Evaluation of Management Options

The evaluation of management options helps identify alternatives and guides decisionmaking for strategic trail planning and project implementation. The evaluation should consider the trail's social, political, and environmental context. The evaluation also benefits from a review of appropriate best management practices (BMPs) for off-highway vehicle (OHV) trails. Forest Service staff can develop BMPs at the project level for application-specific needs. Land management agencies use BMPs programmatically to improve agency performance and accountability when managing water quality that is consistent with the Federal Clean Water Act (CWA) and State water quality programs. Current Forest Service policy directs compliance with required CWA permits and State regulations and requires the use of BMPs to control nonpoint source pollution to meet applicable water quality standards and other CWA requirements.

Management Options for Planned OHV Trails

The management options for planned trail construction are different than those for existing trails. When constructing a new trail, a trail manager has more latitude in design, layout, and construction than when reconstructing an existing trail. Options for planned trails include:

- Take no action
- Construct a new trail
  - ✧ Focus on use characteristics
  - ✧ Configure the layout
  - ✧ Select the route

Take No Action

No action is always a management option when considering new trail construction. Typically, this option is a required alternative in any environmental assessment (EA), environmental impact statement (EIS), or other environmental review.

When the no action alternative is required for an environmental compliance document, the trail manager needs to be actively involved with the analysis of this alternative and document its positive and its negative consequences.

An agency that decides not to construct a trail may be able to avoid future maintenance costs and prevent wildlife habitat fragmentation. But if the trail is not built, its intended purpose will not be achieved. The trail may have been proposed to provide enhanced recreational opportunities or access, or the new trail may have been intended to relieve the strain on existing, less sustainable trail alignments. New trails may be proposed because of increased use or changing use patterns in the area. New trails constructed using the sustainable trail design guidelines may demonstrate progressive trail design concepts and construction methods.

Occasionally, a trail manager may need to recommend that constructing a new trail is not the best option. If the proposed site has poor soil or terrain characteristics, or the proposed trail cannot possibly be sustainable, the trail manager should highlight the consequences of building the trail, which may include placing a high demand on limited trail maintenance capabilities or posing an unnecessarily high risk to surrounding environmental values. There may be value in having certain areas free of motorized trails. The trail manager may advocate for other types of trails, if appropriate.

Construct a New Trail

If you decide to construct a new trail, you will want to focus on use characteristics, configure the layout, and select a route.

Focus on Use Characteristics

For planned OHV trails, managers have a range of choices, from exclusive use by a single use type to unlimited and unrestricted multiple use. Use characteristics include use type, OHV vehicle size and weight, volume of use, intensity of use, and season of use.

The author recommends using Trail Management Objectives (TMOs) concepts (see "Element 3—Trail Management Objectives") to help identify the intended use characteristics and associated management options. This step should incorporate public involvement and an interdisciplinary analysis at the appropriate planning level (e.g., land management planning, travel management planning, or project-specific planning) to identify Managed Uses and season of use, prohibited uses, other allowed uses, and to help develop the technical specifications of trail Design Parameters. The use characteristics describe the range of use options for a trail and should reflect agency goals and user needs. Intended volume and intensity of use are factored into the TMOs. Although these use characteristics are not specifically identified in the

TMOs, they may need to be considered with supplemental evaluations, especially if the intended use tends to be concentrated during certain periods, such as:

- Hunting seasons
- Periods of high rainfall
- Large competitions or events hosted by specific user groups

An environmental compliance team may also consider broadening or narrowing the intended use characteristics as alternatives in an environmental analysis. The trail manager must clearly outline the variation in tread requirements, trail maintenance costs, and potential environmental effects for each alternative.

It's important to consider the possibility of demographic shifts, increased use by a particular user group, or evolving technologies. An example of an evolving technology is the development of utility-terrain vehicles, which are becoming more common on OHV trails.

Configure the Layout

OHV trails generally are laid out to be utilitarian or recreational. Sustainable trail design guidelines should be followed so that utilitarian and recreational trails have minimal impact on the environment and minimal maintenance costs.

Utilitarian trails, typically part of a transportation infrastructure, provide an improved route between two or more locations. Utilitarian trails may service a wide range of users. These trails can link a parking lot to a picnic area or a trailhead to a nearby overlook, lake, or other point of interest. While utilitarian trails are usually constructed to improve access, don't overlook aesthetics in their design.

Recreational trails enhance the user's experience. Trails are more than simply routes to a destination or some other recreational experience.

Recreational trail layouts allow a great deal of latitude in designing trail flow, complexity, and challenge for a range of riding experiences. For example, mountain bike trails are designed by the International Mountain Biking Association (IMBA) (2004) to be open and flowing, tight and technical, or a hybrid of the two:

Open and flowing trails are relatively gentle. They have long sightlines, gradual turns, and few technical challenges. They appeal to less-skilled cyclists as well as those people who enjoy traveling fast. Open and flowing trails need long sightlines because they invite higher speeds.

Tight and technical trails have sharper turns and twists, rougher surfaces, a narrower tread, and natural obstacles. They provide challenges and thrills for users while keeping speed down, which in turn may reduce user conflict. Tight and technical trails may frustrate hikers or destination-oriented hikers, and shortcutting may result.

IMBA defines a hybrid trail as a successful combination of the open and flowing and the tight and technical trail. Figure 11–1 illustrates these types of recreational trails.

IMBA strongly supports controlled grade limits (10 percent or less average grade) and does not feel that steeper trails are required for great riding opportunities. IMBA's approach to designing mountain bike trails also applies to recreational OHV trails. By the same token, well-designed OHV trails can also provide good opportunities for biking and hiking.

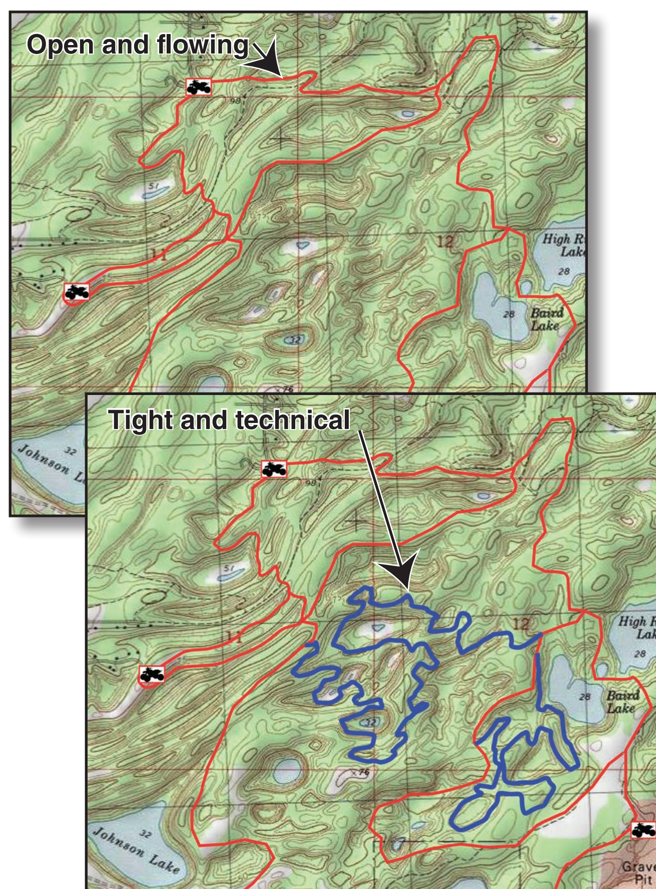


Figure 11–1—Examples of open and flowing (red), and tight and technical (blue) trail layout configurations. —*Base map produced using TOPO! ©2008 National Geographic.*

The National OHV Conservation Council (NOHVCC), in its 2006 publication “Management Guidelines for OHV Recreation” (Crimmins 2006) <http://www.nohvcc.org/materials/ManageGuide.aspx>, mirrors many of the IMBA concepts. NOHVCC reinforces the application of sustainable trail design elements including contour alignments, grade control, and integrated drainage. The NOHVCC publication also lists seven trail layout configurations that can be used to enhance the recreational experience: linear, single loop, stacked loop, multiple loop, spoked wheel, primary and secondary loop, and maze systems (figure 11–2). In addition to information on layout options, the NOHVCC document covers OHV trail planning and design and provides a valuable overview of OHV trail management.

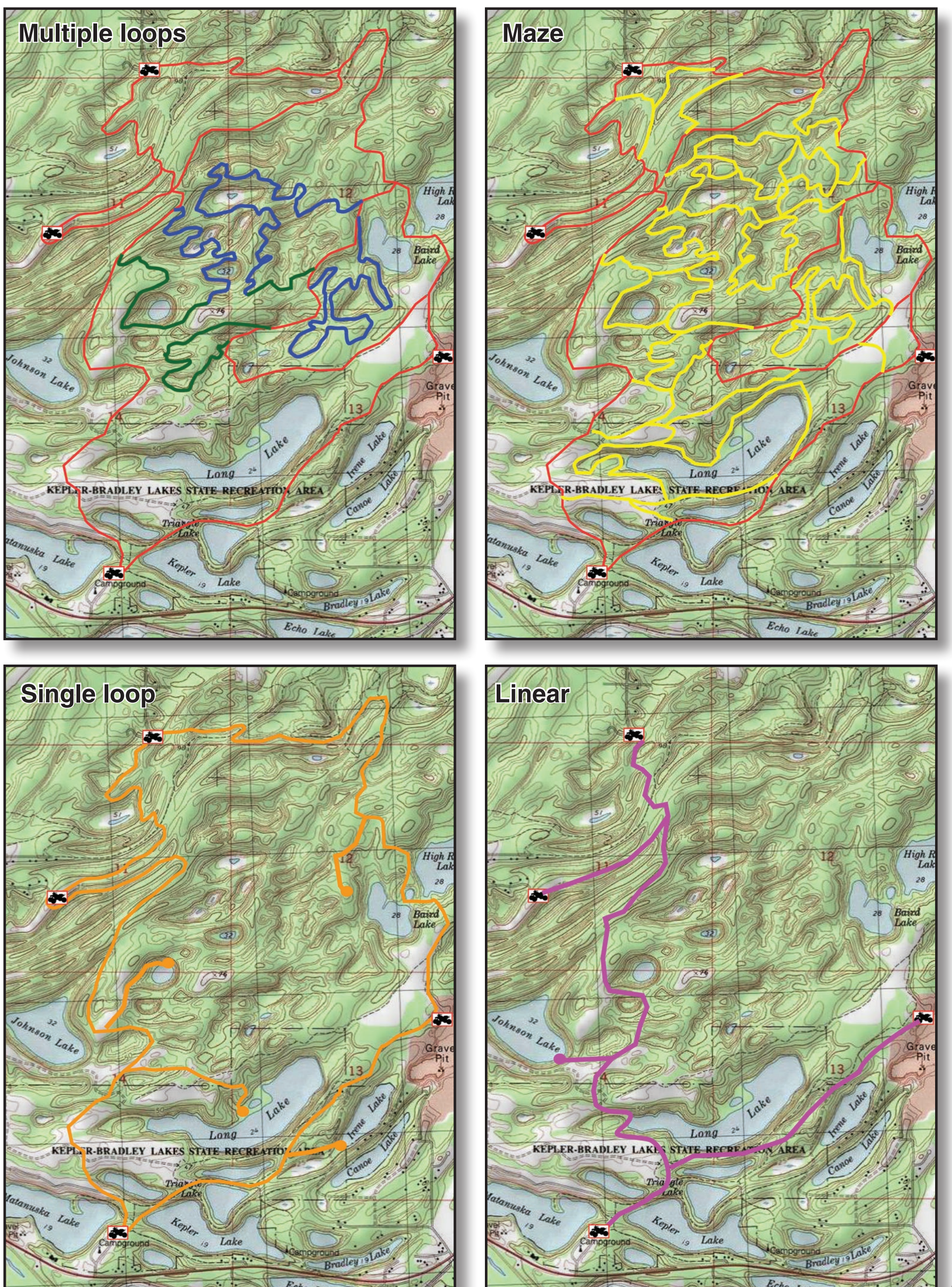


Figure 11–2—Examples of four trail configurations (multiple loops, maze, single loop, and linear). —*Base map produced using TOPO! ©2008 National Geographic.*

Another valuable resource for recreational OHV trail design and layout is “Off-Highway Motorcycle and ATV Trails: Guidelines for Design, Construction, Maintenance and User Satisfaction” (Wernex 1994). This document provides an excellent overview of recreational OHV trails from a user’s perspective. Wernex has incorporated many of the sustainable trail design principles. These include controlling grade and incorporating water control using grade dips or grade reversals. This document is available from the American Motorcyclist Association at <http://www.americanmotorcyclist.com/legisltn/downloads/WernexReport.pdf>.

Wernex further suggests that exposure along the trail—locations where there would be serious consequences if a rider should fall or lose control—adds to the range of experiences. Table 11–1 is a summary of some of Wernex’s eight elements of difficulty. Although the table does not include trail alignment, sideslope, and isolation, these elements can be incorporated into trail design to change difficulty levels.

The Minnesota Department of Natural Resources’ (DNR) “Trail Planning, Design, and Development Guidelines” (2007) is also helpful to OHV trail planners and designers. This publication covers a wide range of trail types and presents its own framework for planning sustainable trails.

Table 11–1—A summary of some of Joe Wernex’s “Trail Bike Trail Difficulty” elements. —*Adapted with permission from the American Motorcyclist Association.*

Aspect	Easiest	More difficult	Most difficult
Grade	Maximum sustained pitch 8 percent Maximum pitch 15 percent	12 percent 30 percent	15 percent 50 percent (rare)
Minimum clearing width	Downhill side 2.0 feet Uphill side 3.0 feet Level each side 1.5 feet	1.5 feet 3.0 feet 1.5 feet each side	1.5 feet 2.5 feet 1.5 feet each side
Minimum clearing width (wooded)	Downhill side 2.0 feet Uphill side 3.0 feet Level each side 2.0 feet	1.5 feet 3.0 feet 2.0 feet each side	1.5 feet 2.5 feet 1.5 feet each side
Clearing height	9.0 feet	8.0 feet	8.0 feet
Tread width	Minimum 18 inches[1] Maximum 30 inches	18 inches 24 inches	12 inches 24 inches
Tread surface	Relatively smooth throughout, no rocks or roots protruding more than 3 inches Avoid sand and loose materials	Some segments relatively rough Some loose sand, etc.	Relatively rough with some segments very rough Long stretches of loose rock and sand, etc., desirable on occasion

[1]Increase tread width 6 to 20 inches on switchbacks or where sideslopes exceed 50 percent. Trails for all-terrain vehicle use will have to be widened accordingly. All-terrain vehicle trails will generally not include the slopes seen in the most difficult category. The trail becomes less structured and more primitive as it progresses from easiest to most difficult.

The Minnesota DNR adapts Wernex's "Trail Bike Trail Difficulty" chart and expands it to include curve radius, mud surface, and separate tread surface character for all-terrain vehicles (ATVs), off-highway motorcycles, and general OHVs. The Minnesota DNR also identifies maximum grades (figure 11–3) allowed for short pitches and length restrictions for the difficulty classes.

Wernex uses the terms "difficulty," "class," and "challenge" somewhat interchangeably to describe the skill level required to ride a particular trail. Wernex uses the terms "easiest," "more difficult," and "most difficult" to describe trails with increasingly steeper grades, narrower clearings and tread width, and rougher tread surfaces.

Aspect	Easiest	More difficult	Most difficult
Grade	8 percent maximum sustained 15 percent short pitch (~25 feet long maximum) 25 percent very short pitch	12 percent maximum sustained 25 percent short pitch (~15 feet long maximum) 35 percent very short pitch	15 percent maximum sustained 35 percent short pitch (~12 feet long maximum) 50 percent very short pitch (rare)

Figure 11–3—Off-Highway Vehicle (OHV) Tread Guidelines for Difficulty Levels. —*Courtesy of Minnesota Department of Natural Resources. Adapted from Joe Wernex's "Trail Bike Trail Difficulty" chart and modified for OHV travel and Minnesota conditions.*

Trail Grades Steeper Than 10 Percent

Both Wernex and the Minnesota DNR allow trail grades steeper than 10 percent on more difficult and most difficult trails. Trail grades steeper than 10 percent are more susceptible to degradation from erosion and to having the surface tread displaced by the torque of off-highway vehicle (OHV) tires. The soil used as a surface tread material needs to be carefully evaluated before constructing alignments on grades of 10 to 15 percent and even more carefully evaluated on grades steeper than 15 percent. Additional mitigation for steeper grades could include placing water control structures closer together, increasing maintenance intensity and frequency, and improving durability of the tread surface.

A trail manager needs to recognize that OHV trails with trail grades steeper than 10 percent do not meet the sustainable trail design guidelines promoted in this report. Designing trails with higher grades is certainly within a manager's prerogative, but doing so carries a greater management responsibility. Before building steeper trails, an OHV trail manager needs to answer two questions:

- Are steeper grades—with their increased susceptibility to degradation—required for a challenging riding experience?
- Can the manager **ensure** that the agency will always have the resources to provide for the higher level of tread maintenance, upkeep of water control structures, or hardened tread surfaces needed for steeper grades?

If the trail manager cannot answer both questions with a resounding "yes," the trail design should follow the sustainable trail design guidelines.

Additional Resources

Troy Scott Parker, president of Natureshape, LLC, has designed and built trails for the National Park Service, the Forest Service, The Nature Conservancy, and others. Parker writes and publishes trail books and provides trail book reviews, trail-related training and workshops, consulting, and trail design services.

The Natureshape Web site lists several publications on trail design and construction, including:

- "Natural Surface Trails by Design: Physical and Human Design Essentials of Sustainable, Enjoyable Trails." 2004. 80 p. This book dives deep into the foundation of trail design. Parker introduces the concept of trailshaping to teach trail workers, volunteers, designers, and planners how to see and analyze complex information and solve problems in most sites or locations. The term "trailshaping" and other trail design language introduced in the book can help communicate the details of trail design.
- "Trails Design and Management Handbook." 1994. 228 p. Troy Scott Parker wrote this design guide for Pitkin County, CO. He includes information on multiple-use concrete/asphalt trails, crushed stone trails, boardwalks, and other trail topics.
- "Trail Planning, Design, and Development Guidelines." 2007. 300 p. Troy Scott Parker wrote the natural surface portions of this comprehensive guidebook on trail planning, design, construction, and maintenance. The guidebook was written for the Minnesota Department of Natural Resources. It is intended to help land managers apply new, innovative, and environmentally sustainable approaches to trail planning, design, and construction.

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There is a general correlation between the Forest Service ATV Design Parameters for Trail Classes 2 through 4 and the design specifications for Wernex's difficulty levels. The only major difference is that Trail Class 2 identifies trail grades up to 25 percent, while Wernex's most difficult level tops out at 50 percent. The Forest Service does stipulate that the determination of trail-specific grade, surface, and other design factors should be based on soils, hydrological conditions, use levels, erosion potential, and other factors contributing to surface stability. The agency further stipulates that steeper pitches must be carefully evaluated.

In general, OHV trails with 15- to 25-percent average grades do not meet sustainable trail design guidelines unless they are on rock or an equally durable tread surface. Some OHV trails on bedrock surfaces in the Southwest are steep, but sustainable.

Table 11–2 presents a challenge matrix for new sustainable OHV trails that includes three ATV challenge levels. This matrix, expanding on Wernex's elements of difficulty and the Forest Service Trail Classes, defines additional parameters and options. An OHV trail manager can use these options to provide a wide range of riding experiences while ensuring long-term sustainability and low maintenance costs.

Table 11–2—Challenge matrix developed by the author for new off-highway vehicle trails meeting sustainable trail design guidelines.

Element	Least challenging	More challenging	Most challenging
Design grade	3 to 6 percent	6 to 9 percent	9 to 12 percent
Maximum design grade (based on specific site conditions for durability of tread)	Up to 15 percent	Up to 15 percent (up to 25 percent is allowed for some segments on extremely durable tread)	Up to 15 percent (up to 35 percent is allowed for some segments on extremely durable tread)
Length of maximum grade	Up to 50 feet* for no more than 5 percent of the total trail length	Up to 75 feet* for no more than 10 percent of the total trail length	Up to 100 feet* for no more than 15 percent of the total trail length
Width			
Off-highway motorcycle	18 to 30 inches	18 to 24 inches	12 to 18 inches
All-terrain vehicle	6 to 9 feet	5 to 7 feet	4 to 6 feet
Four-wheel drive vehicle	10 to 12 feet	8 to 10 feet	7 to 8 feet
Tread outslope			
Typical	3 to 6 percent	3 to 6 percent	3 to 6 percent
Range	3 to 8 percent	3 to 12 percent	3 to 20 percent
Design speed	Up to 20 miles per hour	10 to 15 miles per hour	Less than 10 miles per hour
Flow	Open and flowing	Tighter and more technical	Tightest and most technical
Variation—vertical and horizontal direction changes (may have a water control component)			
Frequency	Low, less than 50 per mile	Moderate, 50 to 70 per mile	High, more than 70 per mile
Magnitude	Shallow and gentle	Noticeable, occasionally steeper and more abrupt	Frequently steep and abrupt
Interrelationships	Usually separate changes in horizontal and vertical alignments	Occasional combined changes in horizontal and vertical alignments	Frequent combined changes in horizontal and vertical alignments
Optional challenge sites (large irregular rocks, rock climbs, log crossings, narrow bridges, loose sand, water features, extreme outslope)	Occasional, low-challenge rock gardens, rock slabs, choke points, tree obstacles, or other features Alternative route to avoid low-challenge obstacles	Frequent, mixed low- and moderate-challenge rock gardens, rock slabs, choke points, tree obstacles, or other features Alternative route to avoid moderate-challenge obstacles	Frequent, mixed moderate- and high-challenge rock gardens, rock slabs, choke points, tree obstacles, or other features Alternative route to avoid high-challenge obstacles
Curves			
Radius	25 to 30 feet minimum	15 to 25 feet minimum	Less than 15 feet occasionally
Geometry	Flat	Flat and superelevated	Flat and superelevated
Type	Simple	Climbing/sweep	Climbing/sweep, occasional switchback

*With increased drainage management

Table 11–2 (continued)

Natural sideslope	Less than 30 percent	Up to 60 percent	Up to 150 percent
Element	**Least challenging**	**More challenging**	**Most challenging**
Clearance minimums			
General	6 to 7 feet	5 to 6 feet	4 to 5 feet
Trees	All cleared within clearing limits	Rarely within clearing limits	Occasionally within clearing limits
Clearance height (higher if the trail is also used in winter)	9 feet	8 feet	8 feet
Sightlines	Long and open	Moderate and occasionally obscured	Short and frequently obscured
Multiuse	Possible	Discouraged	Restricted
Tread roughness (variations may be greater in challenge sites)	Generally smooth with a few variations up to 4 inches	Some segments rough with occasional variations up to 6 inches	Generally rough with frequent variations up to 8 inches
Isolation	Low degree of isolation Numerous signs Trail is close to front country or developed as a primary travel corridor with many other users	Moderate degree of isolation Occasional signs Trail is far from front country Trail is a secondary travel corridor with reduced use	High degree of isolation Few signs Trail is remote and far from primary travel corridors
Design exposure to hazards	Tread design and maintenance presents very low hazard from falling or loss of control Open and flowing alignment and unobstructed sight distances may result in excessive speed issues	Tread design and maintenance presents low hazard from falling or loss of control Optional challenge features may result in a low to moderate hazard of falling or loss of control, generally without serious consequences to the rider	Tread design and maintenance presents low hazard from falling or loss of control Optional challenge features may result in a moderate hazard of falling or loss of control, generally without serious consequences to the rider

Select the Route

The final management option when planning a new trail is route selection. Although at first it might appear there is a wide range of routes where a new trail could be placed, the choice usually is constrained by administrative, social, technical, terrain, and environmental factors. Table 11–3 provides a partial list of these constraints.

In general, constraints that affect trail location are called major control points. The trail should be located near positive control points, while negative major control points should be avoided. Control points can be points, lines, or areas.

Positive and negative control points are plotted on a base map used to identify a potential corridor (or corridor options) for the trail. This process, called preliminary trail layout, is described in more detail in "Element 7—Trail Prescriptions."

Table 11–3—Factors affecting route selections.

Administrative
Land ownership Existing infrastructure—trailheads, roads, parking areas, campsites Land use classifications Connections with other trail systems
Terrain
Lakes and ponds Uncrossable rivers and streams Terrain barriers—cliffs, unstable slopes Wet areas Flat areas Poor quality surface soils Exceedingly steep sideslopes Extremely dense vegetation cover Suitable sites for stream crossings
Social and technical
User group(s) requirements Specified challenge level Design specifications—grade, width Sustainable design criteria Buffers for private land, highways, etc.
Environmental
Wetlands Critical habitats—plants and animals Cultural resource sites Sensitive waterways Coastal zones Invasive species Habitat fragmentation Sound and air quality conflicts

Typically, the alignment that best accommodates the TMOs, major control points, and sustainable trail design guidelines would be the preferred option. Alternative alignments may be identified for environmental compliance.

Management Options for Existing Trails

Managing existing trails can be more complex than managing newly constructed trails. The goal is to determine the management options that are most appropriate.

Options include:

- Take no action
- Modify use controls
- Increase maintenance and mitigate impacts
- Close the trail

Take no action—The no action management option is appropriate for existing trails when existing use does not degrade the trail or the environment, condition trends are positive or neutral, and users' needs are met. Nothing needs to change.

Modify use controls—Use controls affect type, volume, and seasons of use. Restricting certain types of use can be an appropriate management option when the type of use is the source of degradation. The simplest restriction is setting weight and width limits for vehicles. These restrictions help control the physical size of vehicles and may allow the trail width to be reduced.

Controlling the amount or intensity of use is appropriate when overuse is causing degradation. Trailhead parking or onsite sanitation facilities also may be too limited to support the level of use.

Determining appropriate use levels can be difficult. There may not be a linear relationship between use levels and impact. After a certain level of use is reached, trail conditions may continue to degrade even if the trail is closed.

Restrictions on seasons of use are appropriate when the durability of the trail surface is strongly affected by conditions that vary with the season, such as surface moisture or ground temperature. Typically, trail surfaces are most sensitive when soils are saturated with water. Surface tread is typically saturated during spring thaw and fall freeze-up, and may be saturated during periods of heavy rainfall.

In other areas, use during dry seasons may cause dust problems or winds may displace trail surface materials. Temporarily closing trails during periods when the trail is most sensitive may significantly reduce trail degradation.

Increase maintenance and mitigate impacts— Increased maintenance and project level mitigation are the appropriate management actions when they address degradation and the costs are reasonable. This can include modifying the frequency, type, and intensity of maintenance. It can also include work such as reconstruction, rerouting, or trail hardening to construct a more sustainable trail tread.

Close the trail—It can be appropriate to permanently close trails that are unmaintainable. Temporary trail closures may be needed for maintainable trails and even design-sustainable or performance-sustainable trails when funding does not allow adequate maintenance.

Identify alternatives such as reconstruction, rerouting, trail hardening, or seasonal or type-of-use restrictions and discuss them in a public forum. Trail managers should discuss compliance issues, agency budgets, and workforce limitations that may affect management alternatives. Agencies should also be prepared to direct users to more sustainable trails or to discuss replacing the trail.

User groups may be willing to accept some responsibility for maintaining the trail, mitigating some of the problems, or implementing necessary trail improvements. This assistance may prevent or delay trail closure.

Wildlands CPR developed the publication "Six Strategies for Success: Effective Enforcement of Off-Road Vehicle Use on Public Lands" (Archie 2007), which provides some suggestions for effective enforcement of OHV regulations <http://www.wildlandscpr.org/files/SixStrategiesReport.pdf>.

Analysis Flowchart

The analysis of management options for existing trails is supported by three steps:

- Step 1—Determine whether the trail meets its TMOs.
- Step 2—Assess the trail's physical condition.
- Step 3—Evaluate the trail for sustainability.

The "Analysis Flowchart" (figure 11–4) provides more details about this three-step analysis.

Step 1—Determine Whether the Trail Meets Its TMOs

When trail use matches the use characteristics specified in the TMOs and the tread matches the Design Parameters, the trail meets its TMOs (see figure 11–4, step 1).

If the trail does not comply with its TMOs, the trail manager should determine what use characteristics or physical design changes are required for compliance.

It is important to determine the costs of these changes. For use characteristics, the costs may be social or political. For Design Parameters, the costs are typically labor, equipment, and materials. If the costs are reasonable, evaluation can continue. If the costs are excessive, the trail manager needs to take one of three actions:

- Temporarily accept the inconsistency with the TMOs.
- Reevaluate and modify the TMOs to reflect the revised management intent of the trail.
- Close the trail.

Accepting conditions that are inconsistent with the TMOs may be necessary until further evaluations (steps 2 and 3) are conducted. Modifying the TMOs may be appropriate in situations where use patterns or agency TMOs have changed. Closing a trail because it does not meet its TMOs may be necessary if resources are not available to meet management objectives or if continued trail use would cause significant impacts.

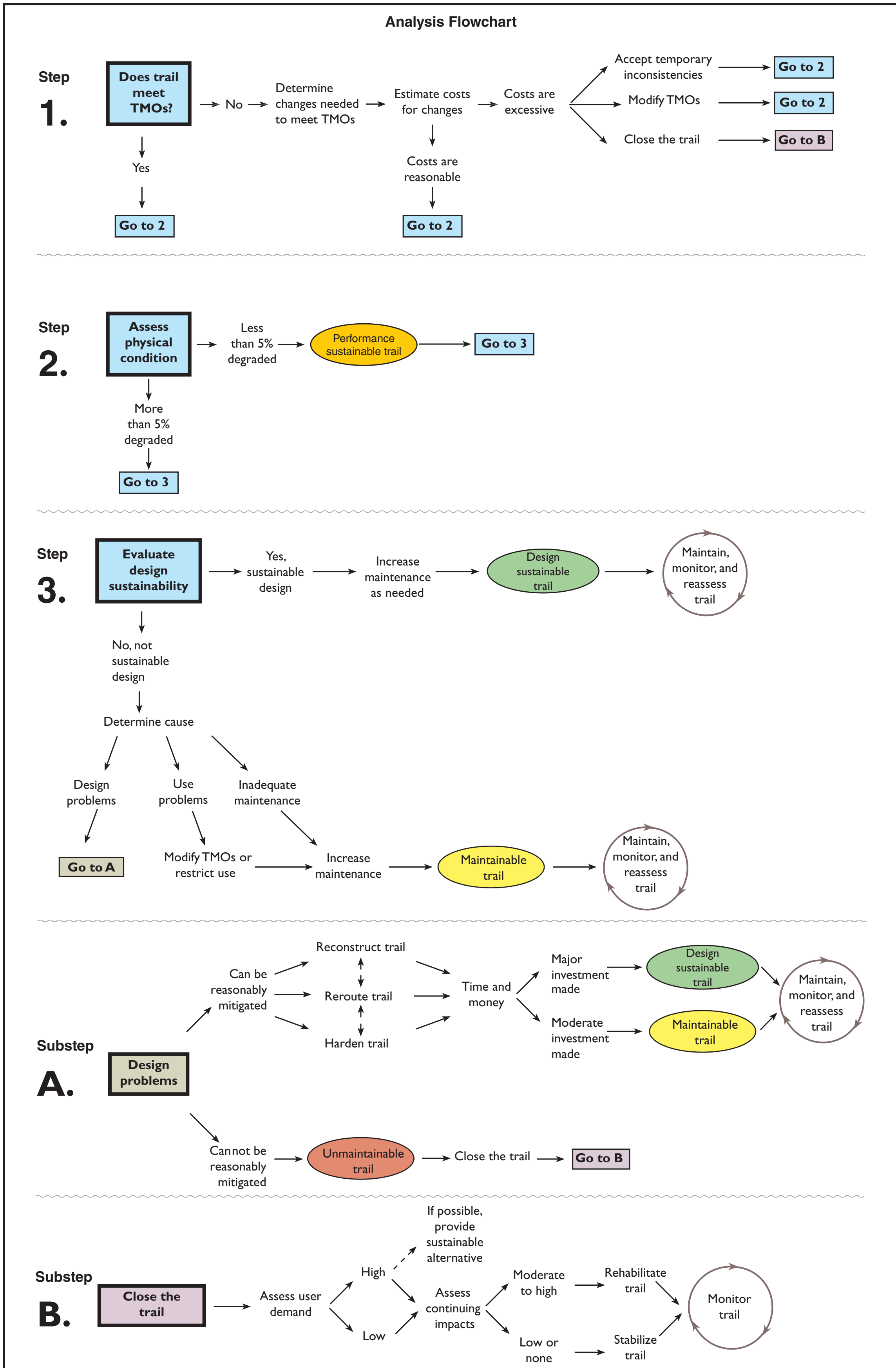

Figure 11–4—An analysis flowchart developed by the author for existing trails.

Step 2—Assess the Trail's Physical Condition

If the trail complies with its TMOs, if temporary inconsistency with the TMOs is acceptable, or if the TMOs are modified, the trail's physical condition is assessed (see figure 11–4, step 2).

If the trail meets its TMOs and 95 percent or more of the entire trail is in good or fair condition, the trail is at least performance sustainable. However, trail conditions may not remain stable, so the trail should be evaluated for its design sustainability.

Performance sustainable trails need regular maintenance, monitoring, and occasional reassessment.

If more than 5 percent of the trail is degraded, move to step 3.

Step 3—Evaluate the Trail for Sustainability

Evaluate how well trail segments comply with sustainable trail design guidelines for contour alignment, controlled grade, integrated drainage, full bench construction, and durable tread. This evaluation provides the trail manager with a better understanding of why a trail is or is not performing well (see figure 11–4, step 3).

A trail meeting sustainable trail design guidelines may have some degradation if routine maintenance is inadequate. In many cases, an increase in maintenance frequency, type, or intensity may correct problems. After maintenance is completed, the trail would be considered design sustainable.

If trails do not meet sustainable trail design guidelines, evaluate the problems that may have caused them to become degraded and determine the management actions that are needed to correct them. Usually degradation is caused by design, use, or maintenance problems.

If the trail does not meet sustainable trail design guidelines and the degraded conditions are caused by inadequate maintenance, increasing the level or modifying

Causes of Trail Degradation

Design Problems

- Trails have a fall-line alignment (not a contour alignment).
- Trails exceed their sustainable grade.
- The alignment has inadequate water control structures.
- The tread is constructed on less than a full bench and the tread foundation is failing.
- The trail tread is not constructed on durable soils.
- The trail is poorly located.

Use Problems

- Type of use is inappropriate for trail design.
- Volume or intensity of use exceeds design capacity.
- Use occurs during an inappropriate season or during unfavorable weather conditions.

Maintenance Problems

- Trail receives no maintenance.
- Maintenance is inadequate or infrequent.
- Maintenance is performed incorrectly, or it's the wrong type or intensity.

the type of maintenance may solve the problem. If degradation issues can be managed through a reasonable increase in maintenance, the trail is considered maintainable.

Design problems may need to be addressed and will require more detailed analysis and evaluation (see figure 11–4, substep A). The trail manager needs to determine how much the existing trails deviate from the sustainable trail design guidelines and the degree of degradation. This evaluation should identify whether or not the design problems can be mitigated.

Address design problems that can be reasonably mitigated through some combination of trail reconstruction, rerouting, and hardening. These projects typically take longer and cost more than routine maintenance but may be needed to address design problems.

Table 11–4 summarizes common problems affecting OHV trails and the solutions to those problems.

Reconstruction is most appropriate when the trail design comes close to meeting sustainable trail design criteria and degradation is not too extreme. For instance, a trail with long, gentle grades may be degraded because of inadequate water control. A cost-effective solution might be to reshape the tread with a series of rolling grade dips.

Rerouting is appropriate when a trail can be relocated readily to more durable soils or better terrain. A good example would be relocating a trail from a wetland to a nearby upland. Decisions to reroute a trail require a thorough onsite evaluation of surrounding vegetation, soils, and terrain. Study soil surveys, aerial photos, and land cover maps for additional information.

When rerouting a trail, use sustainable trail design, layout, and construction practices. Figure 11–5 shows a trail that is a good candidate for rerouting. Figure 11–6 displays rerouting alternatives.

Table 11–4—Summary of off-highway vehicle trail issues, problems, and solutions. Possible alternative solutions common to all four issues include implementing user controls or closing the trail.

Issue	Problem	Solutions
Overly steep grades	Water erosion Tread surface displacement from wheel torque Ruts and braiding Too steep to accommodate multiuse	Reroute the segment to reduce the grade Increase water control Increase maintenance Increase durability of the tread
Wheel tracks form on the tread surface	Wheel ruts defeat the outslope and channel water along the trail causing increased erosion and tread loss	Increase maintenance frequency to reshape the tread Increase water control by constructing rolling grade dips
Excessive speed	Decreased safety Tread displacement Formation of superelevated or banked turns	Narrow the trail clearing width Increase sinuosity Introduce challenge Increase maintenance
Flat grades or flat terrain	Tread entrenchment Water collection and pooling Muddy surface conditions and ruts Braided trail development	Reroute the segment to sidesloped terrain Increase durability of the tread (trail hardening) Improve drainage

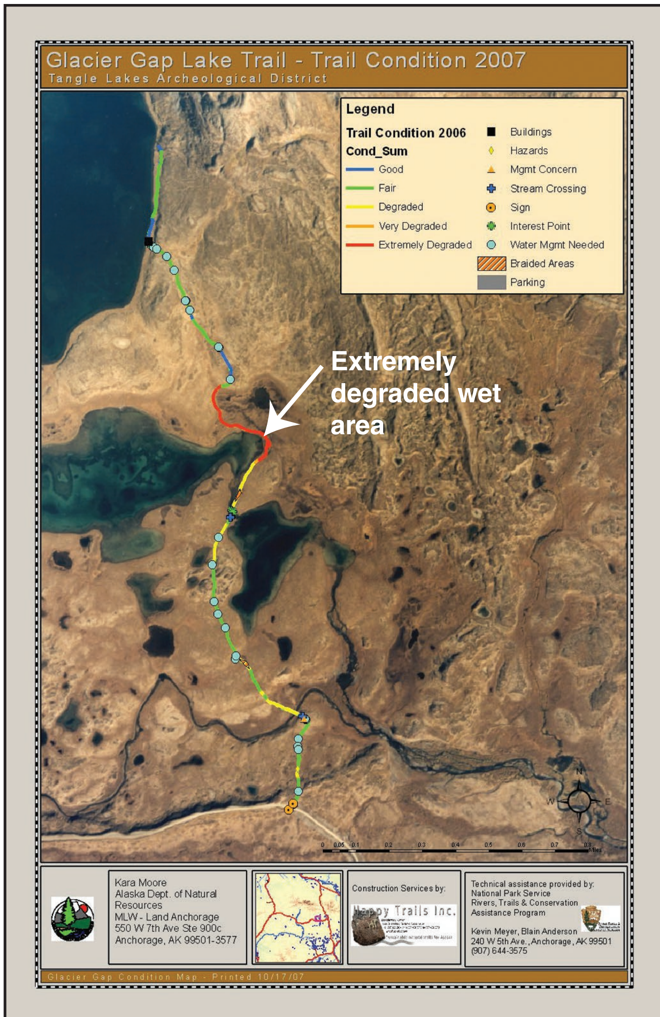

Figure 11–5—A trail alignment with its (colored) condition class assignments. Note the extremely degraded trail segment (red). This segment crossed an extensive wetland with no viable tread improvement options.

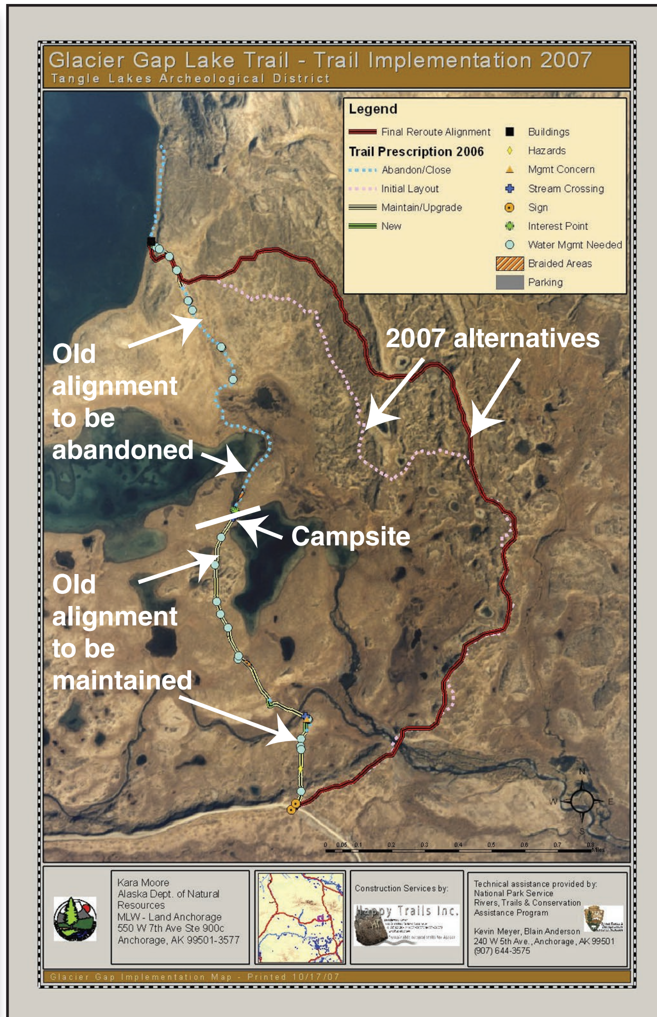

Figure 11–6—The same trail with two reroute alternatives located on uplands to the east. The alternative (dark red) was constructed in 2007 using sustainable trail design guidelines. The old alignment is slated for partial abandonment/closure and partial maintenance and upgrade. The retained portion will be used to provide access to the lower lake and a stream between the lakes. A small undeveloped campsite is located at the terminus of the retained portion of the old trail.

Trail hardening (figure 11–7) improves a substandard tread surface by replacing or augmenting the surface or capping it with gravel. Rerouting should be considered first because trail hardening is expensive. Trail hardening is appropriate when trail segments are:

- Degraded or do not provide a durable tread surface
- Causing or may cause unacceptable environmental impacts
- Difficult to reroute because alternative trail locations are not available, environmentally acceptable, or economically feasible

Appendix B includes a detailed discussion of trail-hardening methods. Documents that provide information about trail hardening include "Geosynthetics for Trails in Wet Areas: 2008 Edition" (0823–2813P–MTDC), "Trail Construction and Maintenance Notebook" (0723–2806–MTDC), and "Accessible Trail Surfaced with Resin-Based Pavement" (1223–2309–MTDC).

Figure 11–7—A trail-hardened surface of porous pavement panels provides passage over permafrost-associated wetlands on the Karluk River Portage Trail within Alaska's Kodiak Island National Wildlife Refuge.

Trail-Hardening Basics

The benefits of trail hardening include:

- Defines a single alignment for vehicle travel
- Stabilizes surface conditions along the hardened trail segment
- Provides a stable, durable trail surface for off-highway vehicle and other traffic
- Prevents widening of trails and the development of braided trail segments
- May allow abandoned areas to stabilize naturally
- May allow for vegetation growth (or regrowth) within the hardened trail surface

Methods of trail hardening include:

- Gravel capping with or without a geotextile underlayment
- Turnpike
- Causeway
- Boardwalk or puncheon
- Running plank
- Wood chips or chunk wood surfacing
- Paver blocks
- Porous pavement panels
- Surface paving

Trails that can be reconstructed, rerouted, or hardened at a reasonable cost are considered maintainable or even design sustainable. Trails with design problems that cannot be reasonably mitigated by reconstructing, rerouting, or hardening are unmaintainable.

Generally, unmaintainable trails should be closed (see figure 11–4, substep B). Assess user demand before closing any trail. If user demand is high, provide a sustainable alternative to the closed trail.

Even after a trail is closed, it may continue to degrade or have other environmental impacts. If the impacts are low, the trail should be stabilized so it can restore itself. If the impacts are moderate or high, the closed trail should be rehabilitated with water control, vegetation plugs, seeding, and fertilization, or other methods of rehabilitation. In either case, closed trails should be monitored for any continued degradation.

Whether a trail is design sustainable, performance sustainable, or maintainable, it should be maintained regularly and be monitored for degradation and TMOs compliance. Periodically, the trail should be reassessed using steps 1 through 3 of the flowchart.

Chapter 12: Element 7—Trail Prescriptions

A trail prescription defines the appropriate actions for new trail construction and maintenance of existing trails. This prescription forms the implementation plan for the trail. A condition assessment supports the prescription, especially if draft or final Trail Management Objectives (TMOs) have not been developed for a trail. Condition assessments are discussed in "Element 5—Trail Condition Assessment."

TMOs identify the uses for which a trail is managed. TMOs are discussed in "Element 3—Trail Management Objectives."

The Forest Service uses Trail Assessment and Condition Surveys (TRACS). Each TRACS is based on trail-specific TMOs and includes a field inventory, condition assessment, and trail prescription identifying the work that needs to be done to meet standards. TRACS is discussed in more detail later in this chapter.

Knowing the types of off-highway vehicles (OHVs) that use a trail is critical. Actual and planned volume and intensity of use need to be considered. Periods of high use also should be identified.

Use may be evenly distributed over a season or concentrated during brief periods—sometimes when weather is unfavorable. Uses may include organized recreational events such as fun runs or poker runs, or heavy use over holiday weekends or during the hunting season.

The trail design should take into consideration the season of the year when most use occurs. Manage the trail primarily for that season. For example, if the managed use occurs early in the spring when the tread is easily degraded, the trail may need to be designed and constructed to provide a more durable surface or may require more frequent maintenance.

Table 12–1 shows an example of trail use characteristics and use controls for the fictional Bob White multiuse trail. The specific use data may validate the TMOs or may point out the need to consider modifying or refining the TMOs.

When a Trail Assessment Is Needed

A trail assessment is needed in some situations before developing a trail prescription:

- When establishing a management program for a trail.
- When poorly developed or managed trails present complex management issues that need to be fully understood before specific prescription actions are identified. Mixing condition assessment with prescription development can complicate inventory, mapping, and analysis. Worse yet, it can lead to prematurely developing prescriptions for existing alignments that may not be retained, given future management objectives.
- When local trail experts are not available to determine the best maintenance or mitigation actions needed to address trail degradation or resource damage. Such experts are often in short supply. Condition assessments do not require as much expertise as development of prescriptions, mostly because they involve measuring and recording rather than analysis and decisions.
- When a developed set of trail prescriptions changes over time. These changes may occur because of changes in management direction, lack of funding or resources, long delays before implementation, changes in mitigation techniques, or differences in interpretation among trail experts who developed the original prescription and the staff who are attempting to implement it. Unless a prescription is based on existing Trail Management Objectives and the maintenance program is active and adequately funded, a prescription can become outdated.
- When it may be more appropriate to consider a wider range of management options. Separating condition assessments from prescriptions, especially on poorly developed or managed trails, can encourage trail managers to explore a wider range of options rather than continually pumping maintenance dollars into unmaintainable trail alignments.

Table 12–1—Trail use characteristics and use controls for the fictional Bob White multiuse trail.

Use type	**Width requirement** (feet)	**Gross vehicle weight** (pounds)	**Season of use**	**Volume of use**
Four-wheel drive vehicle	7 to 8	Up to 4,000	Spring breakup	Prohibited
			Summer	Prohibited
			After fall freeze	Less than 4 per day (hunting) by permit only
Two-wheel drive all-terrain vehicle	5 to 6	Up to 1,200	Spring breakup	Prohibited
			Summer	About 100 per day
			After fall freeze	Prohibited
Four-wheel drive all-terrain vehicle	5 to 6	Up to 1,600	Spring breakup	Prohibited
			Summer	About 50 per day
			After fall freeze	Estimated 100 passes
Off-highway motorcycle	2 to 3	Up to 700	Spring breakup	Prohibited
			Summer	About 50 per day
			Rider Rally Day (July 4th) 3 days	About 250 per day by 3-day permit
			After fall freeze	Prohibited
Mountain bike	2 to 3	Up to 300	Spring breakup	Prohibited
			Summer	About 20 per day
			National Trails Day (Memorial Day)	About 175 by 1-day permit
			After fall freeze	About 5 per day
Foot travel	2 to 3	Not applicable	Spring breakup	Less than 10 per day
			Summer	10 to 40 passes per day
			After fall freeze	20 passes per day (10 hunting)

Developing prescriptions for new construction or maintenance of existing trails requires a high level of trail expertise, including expertise on sustainable trail design concepts and layout methods. For maintenance, expertise is required to identify the cause of maintenance issues, conduct engineering evaluations of bridges and other trail structures, identify appropriate corrective actions, and tailor actions to the capability and capacity of available maintenance resources.

Trail Design Parameters

Trail Design Parameters or specifications are the foundation of trail prescriptions. Design Parameters direct new construction and guide maintenance of existing trails (figure 12–1). Parameters include tread width, target grade, surface character, clearing limits, and trail riding character.

See appendix E for more information on design parameters in "Identifying Trail-Specific Design Parameters," which also includes a set of design specifications for a standard utilitarian summer-use OHV trail.

Figure 12–1—A trail crew uses handtools to shape the final tread surface to meet the design specifications.

Figure 12–2—This public-use cabin would be a positive major control point during the preliminary trail layout.

Prescriptions—New Trails

A major task in building new trails is identifying the trail construction corridor. A trail construction corridor can be 25 to 50 feet wide or more, including lands on either side of the centerline of the proposed trail alignment. The construction corridor forms a buffer area around the proposed trail alignment, allowing the trail centerline to be adjusted as needed when the trail is being constructed.

Layout

Layout configurations (utilitarian and recreational) were discussed in "Element 6—Evaluation of Management Options." During layout, the best possible route is identified for a new trail or for a trail section that is being rerouted. Major control points help define options when laying out the trail corridor. Examples of positive major control points include a good trailhead location, an area with soils of good quality, a popular scenic overlook, or the alignment of an existing trail to a lake or campsite. Examples of negative major control points include a private property boundary, a cliff edge, a wetland, or an endangered species nest site. Figures 12–2 and 12–3 provide examples of positive and negative major control points.

Figure 12–3—Cottongrass is an indicator of wetland conditions. This wetland meadow would be identified as a negative major control point.

All major positive and negative control points (table 12-2) along the proposed trail route should be plotted on a map. Depending on the nature of the project, the complexity of the area, and the detail of available data, mapping the control points usually narrows the range of trail corridor options.

Table 12–2—Examples of positive and negative minor control points. Type of feature: P = point, L = line, A = area.

Positive control points	Type of feature	Negative control points	Type of feature
Terrain is between 15 to 45 percent sideslope	A	Terrain has less than 3-percent sideslope	A
Climbing turn platforms 10 to 22 percent sideslope	P	Terrain has more than 80-percent sideslope	A
Good stream crossing locations	P	Cliffs, sudden dropoffs	P or L
Good sites for bridges	P	Unstable slopes	P or A
Exposed bedrock	P or A	Exposed bedrock	P or A
Good ridge crossing point	P or A	Shallow bedrock	P or A
Excellent soils	A	Wetlands	A
Low passes, saddles	P or A	Seep zones, pocket bogs	P or A
Trail junctions	P	Stream confluences	P
Good campsites	P or A	Active landslide areas	P or A
Good overlooks, viewpoints	P	Major avalanche tracks	P or A
Right-of-way corridors	L or A	Unstable scree	P or A
Easement corridors	L or A	Weak or unstable soils	A
Unique natural feature	P or A	Ice-rich or frost-active soils	A
Cultural or historic resources	P or A	Cultural or historic resources	P or A

Basic Considerations for Layout

Layout is the most critical element affecting the long-term management of the trail. A good layout enhances users' experiences, helps control construction costs, and minimizes long-term maintenance requirements. Layout is worth a major investment in both time and effort considering the tens of thousands of dollars that will be spent on construction and long-term maintenance. Remember, a trail has a service life of 100 years or more. Do not skimp on applying the analysis, necessary expertise, and field time to do the best layout possible.

- Lay out trails using the sustainable trail design guidelines: curvilinear alignment, controlled grade, integrated drainage, full bench construction, and durable tread.
- Locate trails on upland, sloped terrain as much as possible. Avoid flat areas (less than 3 percent sideslope) because of problems associated with trail entrenchment and drainage. Avoid the steepest areas (sideslopes steeper than 60 percent) because trails become less stable as sideslopes become steeper.
- If possible, locate trails on sites with sideslopes between 15 and 45 percent. The lower limit ensures enough slope for water control techniques to be used. The upper limit helps reduce the amount of material excavated in bench cuts and the need for extensive structures to stabilize the backslopes.
- Locate trails on the upper third of sideslopes, if possible. Placing trails near the top of slopes reduces the volume of water intercepted as sheet flow from areas above the trail and allows trails to cross drainages near their upper reaches, reducing the need for major water crossing improvements.
- Use climbing turns for changes in direction rather than switchbacks (see appendix A).

There are two types of climbing turns. Standard climbing turns are constructed on 6- to 15-percent sideslopes. Cut-through climbing turns (also called sweep turns) are used on 16- to 22-percent sideslopes. Turns for OHV trails on sideslopes steeper than 22 percent require extensive entrenchment. Sideslopes steeper than 22 percent usually require switchbacks. Avoid switchbacks for OHV trails, if possible, because of poor traffic flow and extremely high construction costs. Identifying good locations for climbing turns is critical during initial layout. Topographic features, such as rises along ridge crossings, knobs, and small hill-like features, can sometimes be used rather than constructing turns to change direction. These topographic features should be identified as positive minor control points during initial layout.

The next step during layout is to consider terrain, soil type, surface vegetation, tree canopy, and other site conditions. If detailed geology, hydrology, soil, and land cover inventories are available, these should be studied to identify favorable and unfavorable conditions. Studying detailed aerial photography or satellite imagery also can help. Table 12–3 provides information on general site suitability.

Climbing Turns

Climbing turns (figure 12–4) are often constructed incorrectly. A common problem occurs when a climbing turn is built (or attempted) on terrain that is too steep. Climbing turns allow a radius turn of 15 to 20 feet in appropriate terrain and are relatively easy to construct. Appendix A describes the required construction methods.

Trails that serve off-highway vehicle (OHV) traffic often use insloped, or banked, turns so that riders can maintain their speed. The tread should be full-bench construction. To prevent shortcutting, wrap the turn around natural obstacles or place guide structures along the inside edge of the turn. The psychologically perfect place to build climbing turns is through dense brush or dog-hair thickets of trees, but be sure to provide adequate sight distance throughout the turn.

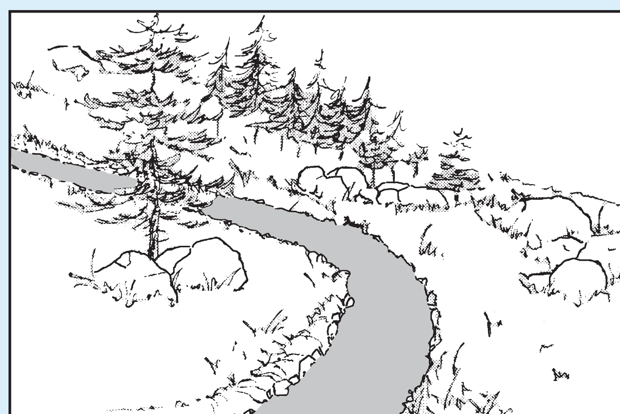

Figure 12–4—Climbing turns continue the climb throughout the turn, and they should be insloped. Add grade reversals at both approaches to keep water off the turn.

—Adapted for OHV trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

Table 12–3—Trail site suitability matrix developed by the author.

Elements	Generally good	Generally moderate	Generally marginal	Generally unsuitable	Comment/mitigation
Terrain					
Slope	10 to 45 percent	3 to 10 and 45 to 60 percent	0 to 3 and 60 to 80 percent	More than 80 percent	For Alaska, 16 to 45 percent when a thick surface vegetation mat is present More than 80 percent has major excavation and backslope stability issues
Aspect	Southern (in northern climates)	Eastern Western	Northern (in northern climates)	No aspect is totally unsuitable	None
Position	Upper sideslopes	Mid to lower sideslopes	Flat valley floors Footslopes Ridgelines	Areas with active slides or rockfalls	Ratings are subject to slope considerations Flat areas may require trail hardening
Landscape type (partial listing)	Mostly well- to moderately well-drained upland sites High gravel bars and terraces	Active flood plains and outwash plains	Old lake basins Depressions Dunes Active alluvial fans	Areas with active slides, erosion, or rockfalls	Ratings are subject to slope and other site considerations
Hydrologic influence	Occasional shallow swales and drains with low waterflow	(Nothing specified)	Deep, steep gullies and drains with frequent high waterflow	Steep-walled gullies with frequent flash floods	None
Soil					
Soil type	Most mineral soils	(Nothing specified)	Organic	(Nothing specified)	Organic sites may require trail hardening
Soil texture	Mixed rocky or gravelly	Loamy Silty	Clayey Sandy	(Nothing specified)	Poor quality soils may require capping, augmentation, or trail hardening
Large rocks	Few, deep	(Nothing specified)	Many, at surface	Extreme rockiness	Extreme situations may require capping or major construction actions
Soil depth	More than 30 inches	10 to 30 inches	Less than 10 inches	(Nothing specified)	None
Soil moisture	Moist	(Nothing specified)	Consistently dry or saturated	Frequently ponded	Sensitivity of saturated and ponded sites depends on soil texture May require fill or trail hardening
Water table depth	More than 30 inches	18 to 30 inches	Less than 18 inches	Frequently ponded at the surface	Persistent shallow water table sites may require trail hardening
Permafrost	None	Deep, ice free	Shallow, ice rich	Rapidly decaying	Marginal sites typically require trail hardening
Soil stability	Stable	(Nothing specified)	Loose, unstable	Sites of soil flows (including solifluction) or soil creep	None
Vegetation					
Vegetation type	Most upland vegetation communities	Most mesic types Some alpine sites	Some alpine sites Wetlands Floating vegetation	Sites with rare or endangered species	Wetlands and floating vegetation sites may require trail hardening
Large trees	Few, well spaced	Many, well spaced	Many, tightly spaced	Pistol grip or leaning	Many large, tightly spaced trees may require extensive clearing and construction operations
Vegetation mat thickness	Less than 4 inches	4 to 8 inches	More than 8 inches	More than 16 inches	Deep vegetation mats may require removal and fill or other trail-hardening techniques

Preliminary Route Selection

After major control points have been identified, preliminary routes are drawn on the base map and around key control points (figure 12–5). If the route crosses major terrain features, it can be divided into sections at major topographic breaks (ridges, toeslopes, valleys, and saddles) with grades calculated between topographic breaks. The complexity of the layout may increase when major terrain features are crossed.

The average trail grade along the proposed alignment can be calculated by identifying points on the topographic map that fall at major terrain transitions.

Using a topographic map to provide distance and elevation data, the average grade between two points can be calculated. Percent grade equals:

$$\frac{\text{Elevation (higher point)} - \text{elevation (lower point)}}{\text{Distance between the points}} \times 100$$

This provides the average grade between the two points as a percentage. Because grade is a critical element of the sustainable design guidelines, a preliminary trail layout should not be steeper than 8 percent. The 8-percent grade allows for the inclusion of grade reversals and minor adjustments in the final on-the-ground layout.

In addition to the 8-percent upper limit for preliminary layout, a lower limit of 3-percent grade allows adequate trail drainage. To meet this guideline, the trail must be on an area with a natural sideslope steeper than 6 percent (satisfying the half rule—trail grade should not exceed half the steepness of the sideslope to avoid a fall-line alignment).

If the proposed trail location is on sideslopes gentler than 6 percent, try to relocate the alignment to a steeper area. If that is not possible, the trail may have to be hardened to increase tread durability.

If the calculated grade between two points is more than 8 to 10 percent, the layout needs to be modified. Sometimes it's as simple as adjusting the alignment so the trail does not ascend or descend as quickly. It may also be possible to adjust the grade of an adjacent trail segment. For example, if an adjacent segment has an average trail grade of 5 percent, it may be possible to increase the grade of that segment to 6 or 7 percent and decrease the grade of the steeper segment.

In some cases, trail segments need to be lengthened to reduce their grade. To achieve an 8-percent grade, the length of trail needed between two points can be calculated based on the difference in elevation between two points. Length needed equals:

$$\frac{\text{Elevation change} \times 100}{8}$$

When terrain and conditions permit, length can be added to a segment between control points by integrating one or more climbing turns in the layout.

Many off-the-shelf or free topographic mapping software packages can help during preliminary route layout. The software can calculate trail length, sideslopes, and trail grade and display elevation automatically for various layout alternatives.

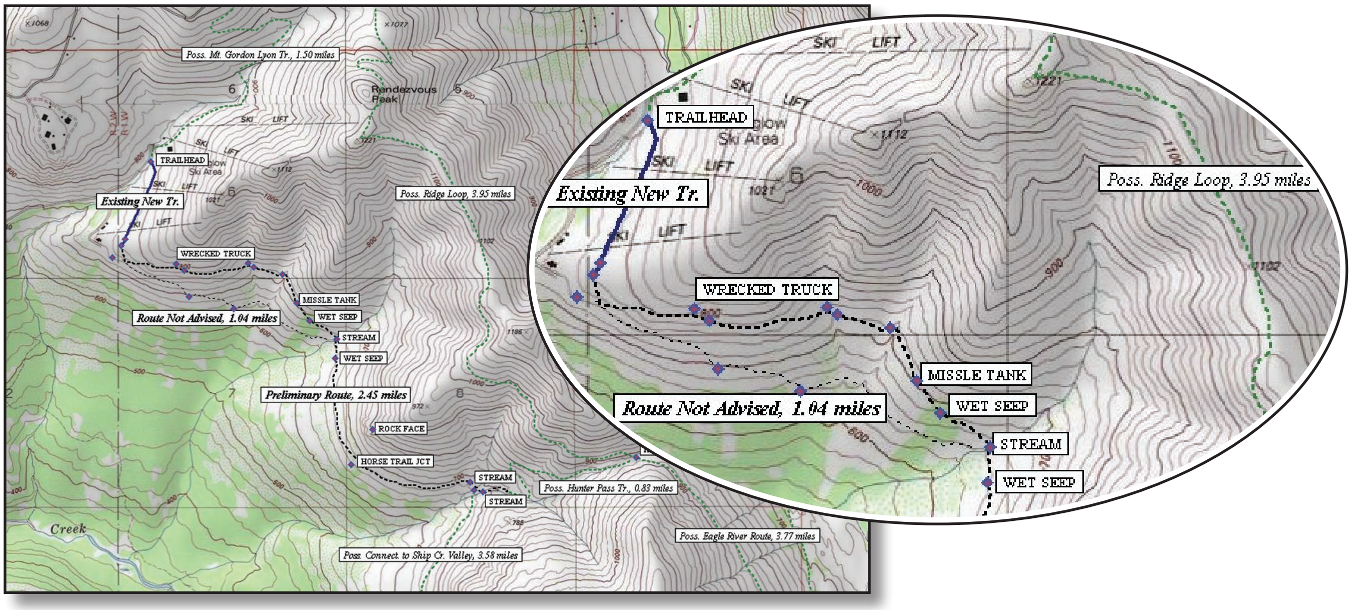

Figure 12–5—A topographic map with a proposed trail alignment showing key control points. *—Base map produced using TOPO! © 2008 National Geographic.*

On-The-Ground Layout

At this point, a field investigation is needed to inspect the preliminary route and identify minor control points, such as the locations of climbing turns and major topographic breaks. Minor control points can be positive or negative and consist of point, linear, or area features.

Minor control points are usually too small to be identified on topographic maps, resource inventories, or aerial photos. Whether a control point is positive or negative is far more important than whether it is major or minor. Figures 12–6 and 12–7 show examples of minor control points that might be identified during field investigation.

Table 12–2 lists examples of positive and negative minor control points that should help guide field investigations. Some control points, such as exposed bedrock and cultural or historic resources, can be positive or negative depending on circumstances. Table 12–4 provides additional information on sideslope considerations during field investigation. Note the sideslope limitations for climbing turns and cut-through climbing turns. An upper limit of 22 percent is recommended for cut-through climbing turns. Identifying locations large enough to accommodate a 15-foot radius (30-foot diameter) climbing turn is a critical objective during trail layout (figures 12–8 and 12–9). Appendix A provides details on the layout of climbing turns.

Figure 12–6—This bear den discovered during trail layout reconnaissance would become a negative minor control point.

Figure 12–7—An area of excellent soil conditions may be identified as a positive minor control point.

Layout Tools and Equipment

- Clinometer
- Altimeter
- Global Positioning System (GPS)—recreation grade
- Magnetic compass
- 50-foot tape
- 12-foot tape
- Laser rangefinder
- Pocket calculator
- Small hand ax or saw
- Soil spade, probe
- Compact binoculars, monocular
- Digital camera (integrated GPS optional)
- Two-way radios with integrated GPS
- Extra batteries
- Base map, imagery
- All weather notebook, data sheets
- Tech notes on layout, turns, and similar technical matters
- Pens, pencils, wax crayons, permanent markers, spray paint, aluminum tag markers
- Flagging—two colors (one for crew or construction instructions and one for final layout)
- Pin flags, stakes, lath

Table 12–4—Sideslope considerations.

Sideslope (percent)	Tread location suitability	Recommended average trail grade (percent)	Maximum design trail grade[1] (percent)	Half rule	Tread geometry	Turn location suitability	Turn type	Tread	Maximum distance between water control structures (feet)[2]
0 to 2	Not recommended[3]	1.0 to 2.0	2	Not applicable*[4]	Crowned	Suitable	Simple/banked	Elevated (recommended)	Not applicable
3 to 5	With caution[5]	1.0 to 2.5	5	Not applicable[4]	Crowned/ outsloped	Suitable	Simple/banked	Elevated to full bench	125 to 175
6 to 15	Good	3.0 to 7.5	4 up to 15[6]	Applies	Outsloped	Suitable	Climbing	Full bench	100 to 150
16 to 22	Ideal	3.0[7] to 10.0	15[8]	Applies	Outsloped	Suitable	Cut-through climbing	Full bench	75 to 125
23 to 30	Ideal	3.0[7] to 10.0	15[8]	Not applicable[9]	Outsloped	Marginal	Cut-through/ switchback	Full bench	75 to 125
31 to 60	Suitable	3.0[7] to 10.0	15[8]	Not applicable[9]	Outsloped	Not recommended	Switchback only	Full bench	75 to 125
61 to 80	Marginal[10]	3.0[7] to 10.0	15[8]	Not applicable[9]	Outsloped	Not recommended	Switchback only	Full bench with retaining walls	75 to 125
More than 80	Not recommended[10]	3.0[7] to 10.0	15[8]	Not applicable[9]	Outsloped	Highly not recommended	Switchback only	Full bench with retaining walls	75 to 125

*Not applicable

1 Up to 50 feet, not to exceed the percent of the total trail length specified in the design specifications.

2 May vary, depending on climate, weather, and site conditions.

3 Flat slopes are prone to surface failure—water pooling and degradation—and often require supplemental trail hardening.

4 On low gradients, the half rule cannot be practically applied because it is difficult to control traffic moving across shallow slopes.

5 Low gradient slopes are also prone to surface failure, and it's difficult to restrict shortcutting across climbing turns required by the half rule.

6 Maximum trail grade of up to 15 percent allows for climbing turns on this slope class, but in general, the maximum sustainable tread grade for ascending tread should not exceed 75 percent of the sideslope. Also see 8 below.

7 Grade may be slightly increased (1 to 2 percent) at sites with very resilient soil conditions or a high level of maintenance.

8 Maximum sustainable trail grade depends on local site conditions, such as soil type, hydrology, and use characteristics. Grades steeper than 15 percent generally require naturally durable or artificially hardened surfaces.

9 Average 10 percent trail grade standard overrules the half rule on slopes steeper than 20 percent.

10 Large backslope excavations may require installation of crib walls to stabilize backslopes.

Figure 12–8—A clinometer is used during trail layout reconnaissance to measure sideslope (see table 12–4).

Water control features should be integrated into the trail alignment to control erosion. Grade reversals are the best way to control water on OHV trails and should be placed along the alignment at roughly regular intervals. Here's how to integrate grade reversals into the layout of an ascending segment:

> For every 75 to 125 feet of climbing (+3 to +10 percent) grade, lay in a 15- to 20-foot segment of descending (-3 to -5 percent) grade, followed by another 75- to 125-foot climbing segment before repeating the pattern. If possible, the lowest point of the grade reversals should be at naturally occurring terrain drainages.

For descending trail segments, it's just the opposite. The trail should descend at a grade of -3 to -10 percent for 75 to 125 feet and then ascend at a grade of +3 to +5 percent for 15 to 20 feet before descending again. Water will be forced off the trail at each point where the grade reverses (figure 12–10).

Make sure there is a distinct change from a negative to positive grade at the bottom of the reversal and that the grade does not just level out. A level grade at the bottom will not force the water off the alignment. Instead, the water will run across the level segment and continue its descent. At the reversal point, the combined difference between the ascending and descending grades should be at least 6 percent.

Figure 12–9—Measuring the turn radius with a tape is the best way to ensure that the sideslope area is large enough to accommodate the entire climbing turn layout.

Figure 12–10—This trail displays the stair-step alignment that is characteristic of integrating grade reversals when ascending or descending a sideslope.

Even when the trail is simply traversing a sideslope, do not lay the trail out with a 0-percent grade. Rather, lay out a long (75 to 125 feet), gentle (+3 to +5 percent) ascending trail segment, followed by a gentle (-3 to -5 percent) descending segment that is about as long. Grade reversals will be at the low points of this subtle elongated W-shaped layout (figure 12–11). The rise and descent provide enough grade to move water off the trail at the grade reversal points. This W-shaped layout minimizes the number of reversal points required along the alignment, reducing long-term maintenance of these critical drainage features.

Vary the spacing between grade reversals somewhat to keep the spacing from becoming unnaturally repetitive. Duplicate natural drainage as much as possible and mimic landform patterns to enhance the natural feel of the alignment. Troy Scott Parker's publication "Natural Surface Trails by Design" (2004) provides advice on enhancing the aesthetics of trail design and layout.

When grade reversals are being laid out, use a clinometer to ensure accurate grade control.

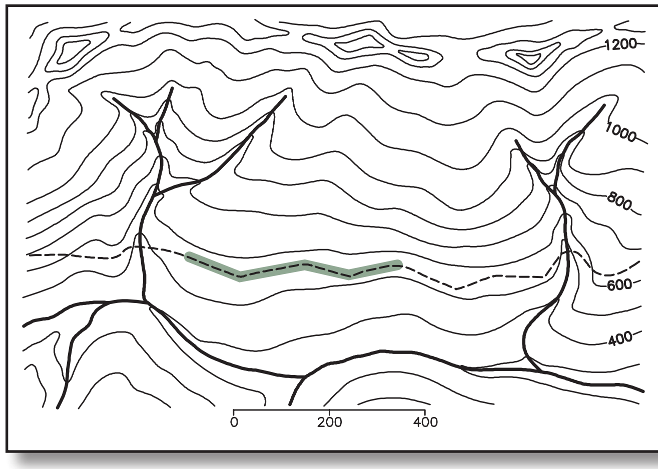

Figure 12–11—A W-shaped layout.

Rolling grade dips are another method of drainage control. Rolling grade dips can be used to supplement grade reversals during new construction in some situations. "Rolling Grade Dips for Drainage of OHV Trails" (Poff 2006) describes the technical details of constructing rolling grade dips (see appendix A).

Tips for Layout Crews

- Do not trust an eyeball guess for grade; always use your clinometer (clino).
- Heavily flag the centerline location, particularly in difficult terrain.
- Avoid laying a trail out on flat terrain because water has no place to drain.
- Use a soil spade to investigate subsurface soil and moisture conditions along the route, especially near wetlands.
- Locate your trail on the uphill side of a large tree rather than on the downhill side where you will sever root systems and generally undermine the tree. Large trees often have natural benches on their uphill side. Your trail design specifications will tell you how close the trail can be to the tree.
- Look for natural platforms or terrain breaks for turn locations. They save construction costs and better fit the trail to the land.
- Double-flag the drain point of grade reversals or rolling grade dips.
- Look for small swales to locate grade reversals. The trail should climb gently for 10 to 12 feet on each side of the swale.
- Cross ravines at an angle rather than going straight up and down the ravine banks.
- Look for indications of shallow bedrock, such as patches of sparse vegetation.

—Adapted for off-highway vehicle trails from the "Trail Construction and Maintenance Notebook" (Hesselbarth and others 2007).

Using GPS During Final Layout

Recreation- or mapping-grade Global Positioning System (GPS) units are helpful when laying out trails. A preliminary trail alignment, developed in the office and entered into the device as a GPS route, can be used to navigate along the proposed alignment when the GPS unit is taken into the field. Minor control points can be entered and labeled as GPS waypoints for transfer to the project base map, such as good crossings at streams and ridgelines and locations for climbing turns.

Once field investigations have been completed, the final proposed alignment can be mapped in the field as a GPS track and transferred to a topographic base map. This final alignment map can be used for environmental compliance review and permitting.

Figure 12–13—Blazes on trees can be used to supplement flagging to provide a more durable long-term delineation of the layout. Blazes should only be used for the final alignment marking.

Flagging and Clearing

Often a variety of colored ribbon flags or pin flags are placed along the alignment during field work (figure 12–12). Specific colors or types of flagging may identify different features and trail alignment alternatives. Once the final proposed alignment has been identified, all extraneous flagging should be removed and a single color and type of flagging should identify the centerline. The alignment also can be marked with painted blazes on trees (figure 12–13), wooden stakes or lath, and distance stations.

Figure 12–12—Surveyor's flagging is hung at the eye level of the person using the clinometer during trail layout.

More durable markings should be used when there might be a long delay between flagging and construction. A continuous flagging line should be visible when traveling from either direction along the alignment. A detailed trail log that includes distance stations and construction notes should be prepared. Double flags should be used to identify the lowest point of grade reversals and other water control features along the alignment. Some crews use blue flags instead. These flags prevent relatively small but critical alignment details from being missed during construction.

Extensive clearing of the alignment should await completion of the environmental compliance process. Unforeseen environmental values discovered during field reviews may force alignment modifications. It's also a good idea to clear a footpath, if necessary, to make it easier to walk along the alignment. The path will help during field work and will provide easy access for crews.

Major and Minor Rerouting Along Existing Alignments

Rerouting a portion of an existing trail can:

- Eliminate fall-line alignments
- Reduce grades on trail segments that are too steep
- Provide a better alignment to avoid degraded segments or poor quality sites
- Modify the flow and character of trail alignments

The trail condition assessment is the primary reference when determining areas where trails may need to be rerouted. Examples of areas that might benefit from rerouting include:

- Trail segments with grades steeper than maximum sustainable grade
- Grades too steep for the surrounding sideslope
- Fall-line alignments
- Degraded trail segments that are too wide, braided, or entrenched
- Trail segments with unsuitable soils or poor drainage, extreme surface muddiness, or ruts

These segments would be listed as degraded in the condition class ranking system described in "Element 5—Trail Condition Assessment."

Proposed reroutes should be compared to the cost and long-term benefits of implementing use controls, increasing maintenance or project-level mitigation, or closing the trail. These options were discussed in "Element 6—Evaluation of Management Options." This evaluation, which should be made for individual trail segments, depends on an agency's capabilities, the adjacent site conditions, and logistic issues. Major reroutes require the same careful layout as new trails.

Prescriptions—Existing Trails

Prescriptions for existing alignments can be made using wheel and clipboard inventories, electronic data recorders, and GPS-supported inventories.

Forest Service TRACS

TRACS is the Forest Service's prescription-based approach for conducting Trail Assessment and Condition Surveys. TRACS is designed to provide consistent, credible, and useful data for trail program planning and management at all levels of the agency. TRACS field data are recorded in Infra, the Forest Service corporate database, where they are used for the national trail system inventory, reporting deferred maintenance, planning capital investments, and planning for trail maintenance and management.

TRACS includes field inventory, condition assessment, and site-specific prescriptions. These three components are completed during each TRACS survey—hence, the basis for the TRACS slogan "collect the right information the first time."

TRACS field data can be recorded on paper forms or with an electronic data recorder called eTRACS. The eTRACS recorder automatically collects milepost data with an electronic distance measuring instrument and can be used with a GPS receiver.

Forest Service TRACS surveys must be conducted by adequately trained and experienced employees with local field knowledge. TRACS surveyors must:

- Fully understand the TMOs for a given trail
- Be able to recognize whether the trail meets agency standards
- Develop an effective and reasonable prescription for the trail if the trail does not meet agency standards

TRACS surveys are conducted with sustainable trail design concepts in mind. Trail expertise is needed to evaluate maintenance, resource, or other issues. Sustainable trail design guidelines, use controls, or other management options can mitigate issues identified during a TRACS survey.

TRACS includes the following components, which are fully explained in the TRACS User Guide available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>:

- **Trail Management Objectives (TMOs)—**The establishment of a draft or final Trail Management Objective for each trail documenting the intended trail uses, Trail Class, and Design Parameters (see "Element 3—Trail Management Objectives"). TMOs are a prerequisite for and serve as key references when conducting a TRACS survey.
- **Condition Assessment Survey Matrix (CASM)—**A guide for determining trail condition survey methods based on Trail Class assignments. The matrix provides recommended minimums for data accuracy and specificity (figure 12–14). A TRACS survey on a Class 4 trail requires greater accuracy and more specificity than a TRACS survey on a Class 2 trail.
- **TRACS data dictionary—**The "Trails Data Dictionary" of trail features and tasks, including standardized drawings, units of measure, and task severity factors.
- **TRACS survey forms—**Standardized paper and electronic forms for data collection.
- **Supplemental field data—**Site Productivity Factors, sign inventories, photo records, and trail bridge inventories and inspections.
- **Application of field data—**TRACS field data are incorporated into Infra, where they can be accessed for trail program management, planning, and reporting.

CASM

Trail Condition Assessment Survey Matrix

A Guide to Recommended Survey Methods & Accuracies

4/27/2005

CASM is the Forest Service's guide for conducting efficient and appropriate trail inventory and condition surveys, based on the on the level of trail development or Trail Class, investment in trail structures, and visitor expectations. CASM values are recommended minimums for data accuracy and specificity. Local managers may select more rigorous frequencies, methods, or accuracies as determined necessary.

Assessment Factors	Trail Class 1	Trail Class 2	Trail Class 3	Trail Class 4	Trail Class 5
Survey Method [1]	*Walk-through & Make Notes on Map or GPS* [2]	Cyclometer or GPS [2]	Cyclometer or GPS [2]	Cyclometer	Tape or Cyclometer & Hand Level with Digital Readout
			Recommended Survey Accuracy & Specificity		
Measurement Interval [3]	Major Physiographic Changes	Minor Physiographic Changes or ½ Mile	Typical Grade Changes of 10% or 500 Feet	Typical Grade Changes of 10% or 500 Feet	*Inter-visible Alignment Changes, 2% Grade Changes,* or 25 Feet
Typical Grade [4]	+/- 10%	+/- 10%	+/- 5%	+/- 5%	+/- 1%
Typical Width [5]	Not Measured	Optional +/- 6"	+/- 6"	+/- 6"	+/- 3"
Obstacles [6]	Not Measured	Not Measured	Optional	*Formidable Obstacles* (e.g. narrow width with steep drop off)	All those defined as Obstacles
Typical Cross Slope[7]	Not Measured	Not Measured	+/- 1%	+/- 1%	+/- 0.1%
Features & Tasks [8]	Maximum Grouping of Features & Tasks	Grouping of Features & Tasks	Grouping of Features & Tasks Optional	Each Feature & Task Inventoried & Assessed Individually	Each Feature & Task Inventoried & Assessed Individually

Figure 12–14—An excerpt from "Trail Condition Assessment Survey Matrix" (CASM). —*From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Feature Types

The data dictionary divides constructed trail features and reference points into eight major feature types. These feature types are listed in table 12–5 with their abbreviated code and the number of features and subtypes in each category.

For each constructed feature, the data dictionary identifies whether it is a point or line feature, the required units of measure, the corresponding standard drawing, and primary material types.

Within each feature type, several standardized features are identified. For example, trailside structures (figure 12–15) are broken into seven features, including traffic counters (SS-CNT), registration box (SS-RBX), docks (SS-DOK), benches (SS-BNH), information boards (SS-INF), garbage containers (SS-GAR), and a place holder for a custom trailside structure that may be identified for a specific trail, forest, or region (SS-CUS). Each of these features is further divided into subtypes. For example, the data dictionary identifies two subtypes of information board: flat-panel information board (SS-INF-PAN) and information kiosk (SS-INF-KSK).

Table 12–5—TRACS data dictionary feature types. —*Adapted from "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Feature type	Code	Number of features and subtypes
Trailway	TW	12 standardized features with 11 subtypes
Trail structures	TS	15 standardized features with 40 subtypes
Trail bridges	TB	1 standardized feature with 10 subtypes
Drainage structures	TD	9 standardized features with 20 subtypes
Trailside structures	SS	7 standardized features with 14 subtypes
Restrictive devices	RD	5 standardized features with 14 subtypes
Route markers and signs	RM	8 standardized features with 20 subtypes
Adjacent reference points	RP	3 standardized features with 19 subtypes

Feature / Tasks					Basic Inventory & Dimensions											Materials												
Feature / Task Code	Feature[1]	Line or Point Feature	Task UoM (Unit of Measure)	Standard Drawing	BMP: mi, ft (km, m)	EMP: mi, ft (km, m)	Quantity: ea	Length: ft (m)	Width in (mm)	Depth: in (mm)	Height: in (mm)	Radius: ft (m)	Diameter: in (mm)	Material Type (primary)	Distance to Material Source or Nearest Trailhead: ft (m)	Rock	Native Log	Treated Log	Native Sawn Wood	Treated Sawn Wood	Metal	Concrete	Composites	Plastic or Rubber	Native Soil	Select Borrow	Aggregate	Asphalt
TRAILSIDE STRUCTURES																												
SS-CNT	**TRAFFIC COUNTERS**	P																										
SS-CNT-BRD	Buried Counter	P	EA	*(needed)*	R		R[1]								R						•							
SS-CNT-TRE	Tree-Mounted Counter	P	EA	*(needed)*	R		R[1]								R						•							
SS-RBX	**REGISTRATION BOX**	P																										
SS-RBX-RBG	Ground-Mounted Registration Box	P	EA	*(needed)*	R		R[1]							R	R				•	•	•			•				
SS-RBX-RBE	Post-Mounted Registration Box	P	EA	*(needed)*	R		R[1]							R	R				•	•	•			•				
SS-DOK	**DOCKS**	P																										
SS-DOK-STA	Stationary Dock	P	SF	*(needed)*	R		R[1]	**R**	**R**		O			R	R		•	•	•	•	•	•						
SS-DOK-FLT	Floating Dock (simple)	P	SF	*(needed)*	R		R[1]	**R**	**R**		O			R	R		•	•	•	•	•	•						
SS-BNH	**BENCHES**	P																										
SS-BNH-PRM	Primitive Bench	P	EA	*(needed)*	R	R+	R+	O	O		O			R	R	•	•	•	•	•	•	•	•	•				
SS-BNH-MNF	Manufactured Bench	P	EA	*(needed)*	R	R+	R+	O	O		O			R	R	•	•	•	•	•	•	•	•	•				
SS-INF	**INFORMATION BOARD**	P																										
SS-INF-PAN	Flat-Panel Information Board	P	SF	*(needed)*	R		R[1]		**R**		**R**			R	R		•	•	•	•	•		•					
SS-INF-KSK	Information Kiosk	P	SF	*(needed)*	R		R[1]		**R**		**R**			R	R	•	•	•	•	•	•		•					
SS-GAR	**Garbage Containers**																											
SS-GAR-CAN	Residential-Style Garbage Can	P	EA	*(needed)*	R		R[1]	R	R					R	R	•	•	•	•	•	•	•	•	•				
SS-GAR-BIN	Commercial Bin	P	EA	*(needed)*	R		R[1]	R	**R**					R	R	•	•	•	•	•	•	**h**	•	**h**				
SS-CUS	**CUSTOM TRAILSIDE STRUCTURE**	L / P																										
SS-CUS-SS1	Custom Trailside Structure 1	P	EA		R		R[1]	R	R					R	R	•	•	•	•	•	•	•	•	•				
SS-CUS-SS2	Custom Trailside Structure 2	L	LF		R	O	R[1]	**R**	O					R	R	•	•	•	•	•	•	•	•	•				

Figure 12–15—"TRACS Data Dictionary: Features and Tasks Spreadsheet." An excerpt that includes the feature/task codes, features, basic inventory and dimensions, and materials list for trailside structures. There is a similar list for the other seven feature types. —*From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Condition Codes

In addition to feature identification, the TRACS data dictionary incorporates feature condition codes describing required actions to meet trail standards. The condition codes are subdivided into maintenance categories: annual maintenance, deferred maintenance, and capital improvement. These condition codes are not individually recorded during TRACS surveys, but are automatically incorporated into the TRACS task codes described below.

Annual Maintenance

Condition code 1—Routine maintenance. The feature is functioning within its design standard as designed and is within normal maintenance cycle (generally at a cost of less than 20 percent of replacement).

Deferred Maintenance

Condition code 2—Repair/rehabilitate. The feature may or may not be usable, but needs to be repaired to bring the feature up to standard (generally at a cost of between 21 and 50 percent of replacement).

Condition code 3—Replace in kind. The feature is beyond its life cycle or generally is unable to perform as designed or constructed (generally replacement, including demolition and removal of the existing feature, costs more than 51 percent of new construction).

Condition code 4—Decommission. The feature is not needed for operation of the trail or is inappropriate for the setting and should be removed from the system with no replacement planned.

Capital Improvement

Condition code 5—Expansion. The feature is basically functioning as designed but is undersized. The feature typically would be lengthened or widened, but in some cases size may be reduced.

Condition code 6—Alter function. The feature would be modified to change function to increase capacity, change function, or change durability.

Condition code 7—Install new. A new feature is needed.

For efficiency during TRACS surveys, Forest Service employees document condition codes as part of the prescribed task, rather than identifying conditions as a separate survey element.

Task Codes

Tasks identify the specific maintenance or improvement action needed to meet the trail design specifications. For every feature, the TRACS data dictionary identifies a series of corresponding tasks. On the TRACS survey form, applicable tasks can be written out or annotated using an abbreviated task code. Each standardized task automatically includes a corresponding condition code, saving the surveyor the extra step of separately recording condition data. For example, the data dictionary (figure 12–16) identifies 19 standardized tasks for the tread and prism feature.

Feature / Tasks					Severity 1	Severity 2	Severity 3	Severity 4	Severity 5
Feature / Task Code	Feature[1] / Task Description	Line or Point Feature	Task UoM (Unit of Measure)	Condition Class	Description	Description	Description	Description	Description
TW-TRD	TREAD & PRISM	L	SF						
TW-TRD-01a	Routine Tread Maintenance		Mi	Annual Mtce	AutoCalculated				
TW-TRD-01b	Routine Tread Drainage		Mi	Annual Mtce	AutoCalculated				
TW-TRD-01c	Snow Grooming - Large Dual-Track class		Mi	Annual Mtce	6-8 mph	4-6 mph	2-4 mph	< 2 mph	
TW-TRD-01d	Snow Grooming -Track-Setting with Snowmobile		Mi	Annual Mtce	15-20 mph	10-15 mph	5-10 mph		
TW-TRD-02a	Reestablish original native tread		LF	Repair	Recut < 10% of original prism dimensions	Recut between 10 & 25% of original prism	Recut between 25 & 50% of original prism	Recut between 50 & 100% of original prism	Recut 100% of original prism
			MI	Repair	Recut < 10% of original prism dimensions	Recut between 10 & 25% of original prism	Recut between 25 & 50% of original prism	Recut between 50 & 100% of original prism	Recut 100% of original prism
TW-TRD-02b	Stump removal		EA	Repair	Less than 6-in	Between 6-in and	Between 12-in and	Between 24-in and	Over 48-in

Figure 12–16—"TRACS Data Dictionary: Tasks." An excerpt that includes some of the feature/task codes, feature/task descriptions, and condition classes and severity descriptions for the tread and prism feature. There is a similar list for the other seven feature types. *—From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Severity Factors

The data dictionary includes one or more severity factors for most tasks, allowing surveyors to prescribe needed work with site-specific precision. These severity factors rank increasing work load effort, complexity, and cost from 1 to 5. For example, the task "TW-TRD-02h—Import and place top soil" includes three severity factors:

1. ½-inch thick soil placement
2. 1-inch deep soil placement
3. 2-inch deep soil placement

TRACS Survey Form

An important part of a TRACS survey is determining whether the trail complies with TMOs-specified Design Parameters and, if not, determining what is needed to bring the trail into compliance. Standardized paper or electronic TRACS survey forms have blocks to document existing trail features, describe their condition, and identify specific maintenance or improvement tasks needed to meet trail standards. Figure 12–17 shows a portion of the form. The complete form is in appendix C and is available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

In addition to the features, condition codes, and tasks identified in the data dictionary, the TRACS survey form includes space to indicate the priority and frequency for each task. A critical priority addresses a serious threat to public health or safety, a natural resource, or the ability to carry out the organization's mission. A noncritical priority addresses potential risk to the public or employee safety or health; compliance with codes, standards, regulations; or needs that address potential adverse consequences to natural resources or mission accomplishment. A check mark or "X" in the appropriate block indicates the task's priority. Task frequency is the number of times each year that routine or recurring tasks should be accomplished to meet the standard. Once a year is denoted as 1, twice a year as 2, once every 2 years as 0.5, and so forth.

Depending on the surveyor's preference, the feature, condition, and task prescriptions can be recorded on TRACS survey forms using the full description or the abbreviated feature and task codes. With the TRACS approach, each task code efficiently captures all three pieces of information in one step. Surveyors are encouraged to make clarifying narrative comments and provide additional detail during the field survey. These comments can become valuable references for data editing and project planning. The TRACS survey form is not meant to be a rigid format for field data collection. It can be adapted or modified as desired.

TRACS Survey

Trail Name: | Trail No: | Survey Date:

Termini this Survey: BMP | Description: — EMP | Description: — Surveyors:

Overall Trail Condition Comments:

Unit of Measure: English / Metric — Measure Method: Wheel / Tape — Trail Use Comments

Trail Management Objectives (TMO): Established / Attached / Not established

TMO Comments:

Other Attachments: Productivity Factors Form / Photo Log Form(s) / Photo Record Form / Sign Inventory Form(s) / Trail Bridge Form(s)

BMP / EMP	Feature: Code	Feature: Comments	Condition: Code	Condition: Comments	Task: Code	Task: Comments	Critical / Freq	Non-Crit / Sevty
Qnty= Lgth= Wdth= Dpth= Hgth= Rad= Dia= DistToMtl= Mtl=								
Qnty= Lgth= Wdth= Dpth= Hgth= Rad= Dia= DistToMtl= Mtl=								

Figure 12–17—"TRACS Survey" form. —*From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Supplemental Field Data

The Forest Service also has identified several categories of supplemental field data that can be collected during TRACS surveys. These include standardized sign inventories and prescriptions, trail bridge inventories and inspections, photo logs, and Productivity Factor surveys. With the exception of Productivity Factors, these supplemental data are not discussed in any detail here. See the TRACS Web site at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml> for additional information on sign, bridge, and photo data collection.

Productivity Factors

Productivity Factors are a key set of physical factors that affect the production rate and cost of trail construction and maintenance. The Productivity Factors are:

- Typical trail grade
- Typical sideslope
- Typical soil type
- Typical vegetation (brush and regeneration)
- Typical vegetation (timber)

Productivity Factors can be inventoried separately, during a TRACS survey, or when documenting the trail location (see “Element 4—Documentation of Trail Location”). Productivity Factor surveys generally do not need to be updated unless there is a change in field conditions (such as reconstruction) affecting trail grade or rerouting.

Productivity Factor data are used for planning trail construction and maintenance and for refining trail cost data in the Forest Service Infra database. Infra has a default value (displayed in bold in the “TRACS Productivity Factor Codes” list in appendix F) identified for each Productivity Factor. A cost estimate based on that default value is assigned a cost and productivity rate coefficient of “1.” A coefficient has been calculated for each value above or below the default. For example, the cost and production rate to construct new trail through heavy brush is about 2.5 times higher than through light brush. Appendix F includes the “OHV Trail Adjustment Factors” list adapted by the author for trail construction and maintenance. Although this list is not as detailed as the Forest Service database, the list may be adapted for estimating costs and project planning.

Application of Field Data

Trail managers can use TRACS survey data stored in Infra to identify tasks and create specific work assignments for individual field crews. Tasks can be sorted so task assignments can be developed separately for unskilled volunteer crews or highly trained crews. A trail work list can be printed to help crews locate work areas, complete identified work, document task accomplishments, and note other work requirements. Completed trail work lists, compiled electronically or printed, provide managers with a record of annual trail work accomplishments and supplemental field notes. These lists can be used to update task assignments, make annual reports, or plan future work and budget requests.

TRACS is an effective approach to trail inventory, condition assessment, and prescription that is well documented and that can be adapted by any OHV trail manager. If well-developed trails have draft or final TMOs, the TRACS approach is recommended for developing maintenance prescriptions. TRACS documentation, training materials, and standard forms are available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>. Standard trail specifications and drawings are available at <http://www.fs.fed.us/.ftproot/pub/acad/dev/trails/trails.htm>.

Alaska NPS OHV Trail Prescription Process

Typically, National Park Service (NPS) trail specialists conduct a condition assessment of a trail on the outgoing leg of a trail traverse and develop a prescription on the return. The outgoing leg provides the opportunity to observe and document trail conditions, develop an understanding of what is causing the degradation, and get ideas about the mitigation and maintenance actions that might be needed. Prescription actions are identified and documented on the return leg using a data dictionary.

The NPS Alaska Region used the principles described in "Element 5—Trail Condition Assessment," to develop a GPS-based data dictionary. The "Alaska NPS OHV Trail Prescription GPS Data Dictionary" (Alaska NPS data dictionary) works particularly well in less well-developed or remote trail systems.

The Alaska NPS data dictionary can be used for manual mapping without a sophisticated GPS unit that records attributes. Figure 12–18 shows the data collected during mapping (lower left corner). Appendix C includes the "Prescription Manual Data Sheet" and the "Prescription Codes." The data sheet provides space to enter waypoint numbers when using a recreation-grade GPS unit.

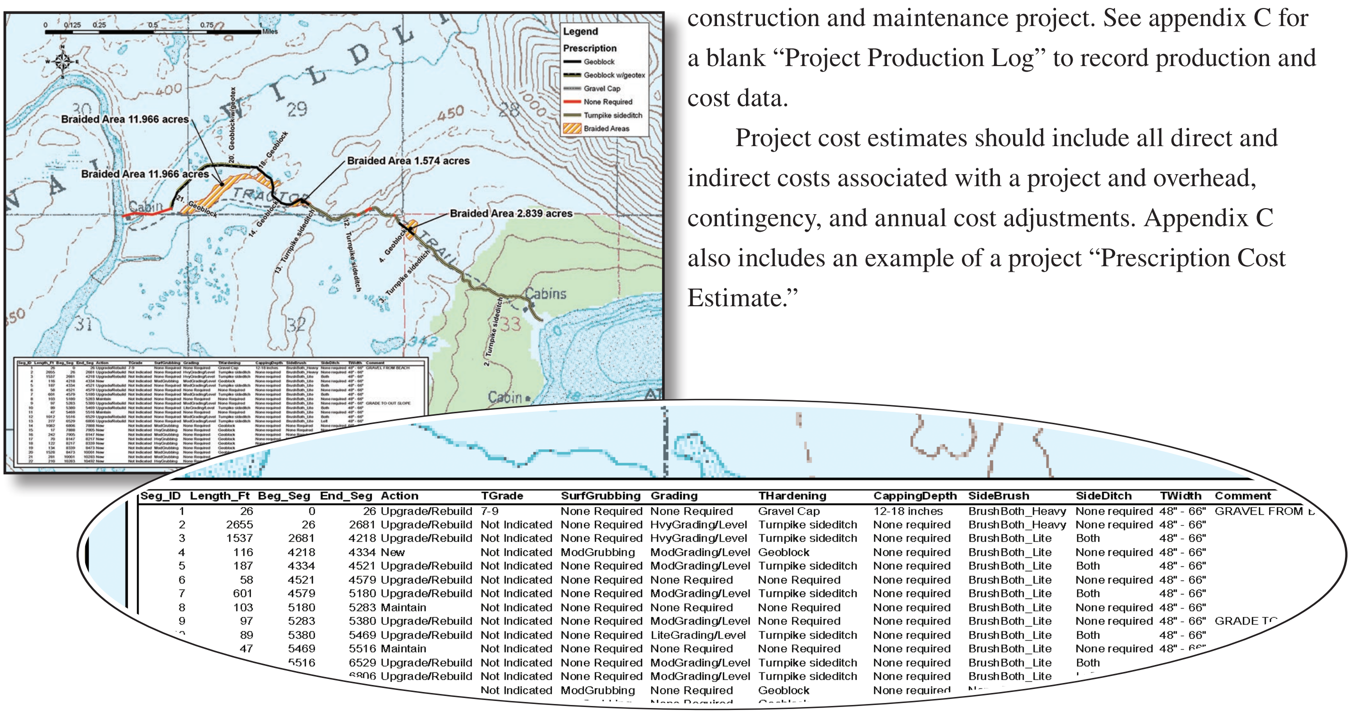

Figure 12–18—An off-highway vehicle trail prescription map with manual data sheet (lower left corner).

Appendix D includes the complete "Alaska NPS OHV Trail Prescription GPS Data Dictionary." This data dictionary helps managers identify major maintenance needs for tread and support structures.

Estimated Costs and Labor Requirements for Trail Prescriptions

Estimating costs and labor requirements is an important part of the trail prescription. These estimates provide the basis of funding and budget requests and for any cost/benefit analysis conducted for a project.

The cost of a project and the amount of labor needed to complete the work depend on local conditions, methods used, and the difficulty of the task. Some OHV trail managers may have well-developed cost systems. The Forest Service TRACS approach, for example, includes integrated software that provides cost estimates, which trail managers can refine. Some trail managers have inherited detailed cost and labor estimate data from previous OHV trail managers, or they may be able to adapt data from other types of trail construction. Other trail builders also may be willing to share their estimates. These data are valuable.

Some trail managers will have to develop cost estimates from scratch, diligently tracking the cost of each construction and maintenance project. See appendix C for a blank "Project Production Log" to record production and cost data.

Project cost estimates should include all direct and indirect costs associated with a project and overhead, contingency, and annual cost adjustments. Appendix C also includes an example of a project "Prescription Cost Estimate."

Alaska National Park Service (NPS) Data Dictionary
Attributes and Values

The prescription feature TRAILWAY (Global Positioning System format for “trailway”) includes 16 prescription attributes:

ACTION (Action)
TGRADE (Trail grade)
SURFGRUB (Surface grubbing)
GRADING (Grading)
THARDENING (Trail hardening)
CAPPING (Capping depth)
SUBBASE (Subbase)
CLEARING (Clearing)
SIDEBRUSH (Sidebrush)
SIDEDITCH (Sideditch)
WATERMGT (Water management)
CUTFILLSEG (Cut/fill segment)
REHAB (Rehabilitation)
TWIDTH (Trail width)
NAME (Name)
COMMENT (Comment)

Each prescription attribute has a list of values the user can select. For example, the values for the ACTION, SIDEDITCH, and REHAB prescription attributes are:

ACTION	SIDEDITCH	REHAB
New	None required	None required
Maintain	Maintain left	Scarify
Upgrade/rebuild	Maintain right	Reseed
Narrow/reduce	Maintain both	Rehabilitate
Widen/enlarge	New left	
Abandon	New right	
Close/barricade	New both	
Rehabilitate		
Other		

The Alaska NPS data dictionary (appendix D) includes additional information for:

- Line attributes for bridges
- Point attributes for anchor point, aqua management, stream crossing, development, physical reference point, photopoint, hazard, control point, signs, and trailside structures
- Area attributes for braids and parking areas

Major Tasks That Should Have a Cost Estimate

- Project planning
- Prescription development
  - ✧ Existing trails
    - » Condition assessments
    - » Prescription preparation
      - ¤ Tread and structures evaluation
      - ¤ Rerouting evaluation
      - ¤ Rehabilitation or stabilization
  - ✧ New trails
    - » Trail corridor research
    - » Layout and initial flagging
    - » Design and construction specification
      - ¤ Engineering review
    - » Construction method determination
- Compliance review (National Environmental Policy Act, environmental analysis, or environmental impact statement)
  - ✧ Office review
  - ✧ Field investigation
  - ✧ Document preparation
- Permitting
  - ✧ Permit research
  - ✧ Application submission
  - ✧ Permit fees
  - ✧ Permit administration
- Clearing
  - ✧ Mobilization and demobilization
  - ✧ Direct clearing
    - » Crew labor
    - » Equipment
    - » Fuel and supplies
  - ✧ Associated crew support
    - » Transportation
    - » Per diem
    - » Potential lodging or base camp
  - ✧ Field inspection and quality control
  - ✧ Reflagging
- Construction
  - ✧ Mobilization and demobilization
  - ✧ Tread construction
    - » Equipment
    - » Supplies and materials
    - » Labor
  - ✧ Structure construction
    - » Equipment
    - » Materials
    - » Labor
  - ✧ Support
    - » Material transport, storage, handling
    - » Associated crew support
      - ¤ Transportation
      - ¤ Per diem
      - ¤ Lodging or base camp
  - ✧ Field inspection and quality control
  - ✧ Maintenance or mitigation projects
    - » Mobilization and demobilization
    - » Equipment, materials, and supplies
    - » Crew labor
    - » Associated crew support
      - ¤ Transportation
      - ¤ Per diem
  - ✧ Reporting and documentation
- Monitoring
  - ✧ Mobilization and demobilization
  - ✧ Crew labor
  - ✧ Equipment, materials, and supplies
  - ✧ Associated crew support
    - » Transportation
    - » Per diem
  - ✧ Office analysis and documentation

Overhead costs may be assessed as a set percentage of total costs or may be assessed at several layers in the organization. They may include:

- An allowance for office supplies and motor pool
- Field inspections
- Clerical, procurement, budget, and contracting administration support

A contingency of 10 to 15 percent should be set aside to cover unforeseen expenses. An annual inflation adjustment may be needed if a project is scheduled several years into the future.

Chapter 13: Element 8—Trail Maintenance

Responding to maintenance issues has been one of the biggest concerns in off-highway vehicle (OHV) trail management. Trail maintenance helps return tread surfaces and trail structures to their original specifications, prolonging the utility of the trail and reducing environmental impacts. Maintenance includes identification of maintenance needs, allocation of resources, and the maintenance activities themselves.

Figure 13–1—Off-highway vehicle (OHV) traffic on this cut-through climbing turn quickly forms wheel ruts and banked turns that can disrupt tread surface drainage. Regrading these to their original specifications is one of the primary purposes of OHV tread maintenance.

Maintenance Scenarios

In general, there are two contexts for maintenance:

- Maintenance of trails designed and constructed specifically for OHVs
- Maintenance of trails informally developed by OHV users or adapted for OHVs

If a trail was designed and constructed for OHVs, the maintenance objective is to restore the trail to its original design specifications. If a trail does not have Trail Management Objectives (TMOs) or a set of Design Parameters, they should be developed before beginning trail maintenance.

Trails that were not designed or constructed for OHVs may require maintenance to address tread degradation, associated environmental impacts, and major trail design flaws. Maintenance needs for these trails can vary tremendously depending on use characteristics, environmental conditions, and character and location of the original trail alignment.

All OHV trails require regularly scheduled maintenance, such as brushing, removal of material sloughing from backslopes, and repairs of trail structures. OHV trails may also require maintenance to regrade entrenched wheel tracks, center humps, or banked turns (figure 13–1).

Determining Maintenance Needs

This report describes two methods to identify and document maintenance needs: the Forest Service Trail Assessment and Condition Surveys (TRACS) approach and the Alaska National Park Service (NPS) OHV trail prescription system. Both were discussed in "Element 7—Trail Prescriptions." Whichever method is used, trail prescriptions should be the primary reference for determining specific maintenance requirements.

The TRACS approach applies to a wide range of trail situations and feeds directly into Forest Service trails planning and management systems. The Alaska NPS system works well when a trail prescription needs to be developed for inadequately developed OHV trails. Both systems require technical knowledge of maintenance, sustainable design, and appropriate mitigation.

Types of Maintenance

General maintenance actions include:

- Season opening
- Tread, drainage, and trail structure repair
- Brushing
- Structure replacement and reconstruction
- Project-scale reconstruction, rerouting, or trail-hardening projects

Season Opening

During season-opening maintenance, usually in the spring, crews cut out fallen trees that block trails, remove brush crushed by snow, open and clear culverts, clean drainage structures, sweep bridge decks, make minor repairs, and conduct quick inspections to identify more substantial maintenance needs.

Tread, Drainage, and Trail Structures

Regularly scheduled maintenance addresses problems with tread, drainage, and trail structures. The tread surface is reshaped by removing slough at the toe of the backslope, grading the tread to reestablish outslope, and compacting the tread surface. Reshaping removes the berms that have developed beside wheel tracks and encourages sheet flow across the bench. Supplemental gravel may be added and some minor trail-hardening measures installed. Grade reversals, rolling grade dips, and other drainage features are reshaped and compacted. Drains, ditches, and culverts are cleared and cleaned. Puncheon, bridge decking, and handrails are inspected and repaired. Minor repairs may be made to retaining walls, bridge abutments, and other trail-related improvements.

Brushing

Brushing removes vegetation growing inside specified clearing limits along the trail. A crew equipped with loppers, brush cutting tools, weed whips, chain saws, mowers, or other power equipment traverses the trail and cuts and clears vegetation. Brushing also may be conducted as part of regularly scheduled maintenance.

The need for brushing varies, depending on the vegetation type and growing conditions. Some trails need to be brushed several times a year, while others only need to be brushed once a year or once every second or third year. Trails in desert settings and trails that cross alpine tundra may never require brushing.

Structure Replacement and Reconstruction

All structures have a service life that depends on structure type, material, construction quality, weather, and impacts from use. Figure 13–2 is an NPS estimate of the service life of common trail equipment and features.

Item (material)	Years
Bench (wood)	20
Bridge—abutment (rock)	40
Bridge—abutment (wood)	20
Bridge—footlog	10
Bridge—deck (wood)	20
Bridge—railing (wood)	20
Bridge superstructure (steel stringers)	50
Checks (rock)	45
Checks (wood)	20
Retaining wall (log)	20
Retaining wall (stone)	45
Culvert—closed (metal)	25
Culvert—closed (rock)	30
Culvert—open (rock)	30
Dip drain	5
Fencing/gates (concrete)	30
Fencing/gates (rock)	35
Fencing/gates (metal)	20
Fencing/gates (wood)	10
Handrail (cable)	3
Paved surface (asphalt)	20
Paved surface (concrete)	40
Puncheons	20
Retaining wall (rock)	40
Retaining wall (concrete)	50
Signage (concrete)	30
Signage (masonry/stone)	30
Signage (metal)	20
Signage (wood)	10
Steps (iron rung)	30
Trailhead kiosk	20
Turnpikes (wood)	20
Turnpikes (rock)	45
Waterbars (rock)	45
Waterbars (wood)	25

Figure 13–2—National Park Service life-cycle estimates for common trail equipment and features.

Structures may be replaced or reconstructed during regularly scheduled maintenance or as a separate project, depending on how much work is required.

Project-Scale Reconstruction, Rerouting, and Trail Hardening

Significant changes to the trail or its physical or social environment require project-scale actions. These actions include projects to accommodate a change in use dictated by agency planning or TMOs. Major reconstruction or rerouting may also be needed because of major design flaws, overuse, neglect, significant degradation, or damage from extreme weather. Project-scale work may require detailed planning, environmental compliance, and permitting.

The Forest Service TRACS approach divides maintenance into three types: annual maintenance, deferred maintenance, and capital improvement. Figure 13–3 displays the breakdown of maintenance types by condition codes. Annual maintenance would include season opening, routine brushing, and most related regularly scheduled maintenance. Deferred maintenance would include replacement, heavy repair, and reconstruction needed in future years. Capital improvement would include new trail construction and trail alteration or expansion.

Condition Code	Condition Class	Condition Class Description	Annual Maintenance	Deferred Maintenance	Capital Improvement
1	**Routine maintenance**	Feature is **functioning within standard** as designed and is within normal maintenance cycle (generally at a cost of less than 20 percent of replacement).	●		
2	**Repair/rehab**	Feature is in **disrepair**, and may or may not be usable, but needs to be repaired to bring feature to standard (generally at a cost between 21 percent and 50 percent of replacement).		●	
3	**Replace in-kind**	Feature is **dysfunctional** and is beyond its designed lifecycle or generally has deteriorated to a point where unable to perform as designed or constructed (generally at a cost of over 51 percent of new construction and includes demolition and removal of existing).		●	
4	**Decommission**	Feature is **not needed** for the operation of the trail or is inappropriate for the setting and should be removed from system with no replacement planned.		●	
5	**Expansion**	Feature is basically functioning as designed but is **undersized**. Would typically be lengthened or widened, but in some cases size may be reduced.			●
6	**Alter function**	Modify feature to **change function** to increase capacity, change function, or change durability.			●
7	**Install new**	**New feature** is needed.			●

Figure 13–3—TRACS Condition Codes. —*From "TRACS User Guide," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Maintenance Timing and Frequency

Season-opening maintenance should be done after the surface tread and subsoils are completely thawed and drain freely, often as late as mid-June in northern latitudes.

Tread should be reshaped when soil moisture allows good surface compaction after grading. This is particularly important when constructing or maintaining drainage dips or reshaping the outslope.

To test for soil moisture, compact soil into a fist-sized ball. If the tread material won't compact into a ball without crumbling, the soil is too dry and soil particles won't bond properly. If the ball is muddy or water drains out, the tread material is too wet and water between the soil particles will prevent the material from compacting.

In some regions, ideal soil moisture conditions occur seasonally. Try to schedule tread reshaping during those periods. Schedule work that does not require tread surface disturbance—such as sign maintenance, bridge deck replacement, trail hardening, brushing, and layout—when soil moisture is usually less than ideal. Keep a long list of projects that can be conducted under various weather conditions or seasons and be ready to redirect your crews.

The TMOs form (figure 13–4) identifies the desired frequency of maintenance. A full-size copy of this form is available in appendix C. Ideally, every trail would receive some maintenance each year. How often the work is done depends on funding, the number of employees available and their level of experience, the equipment available, overall trail conditions, and the number of trail miles requiring maintenance. Efficiency may be improved by using heavy equipment (such as a trail dozer) for tread grading, reshaping, and compaction.

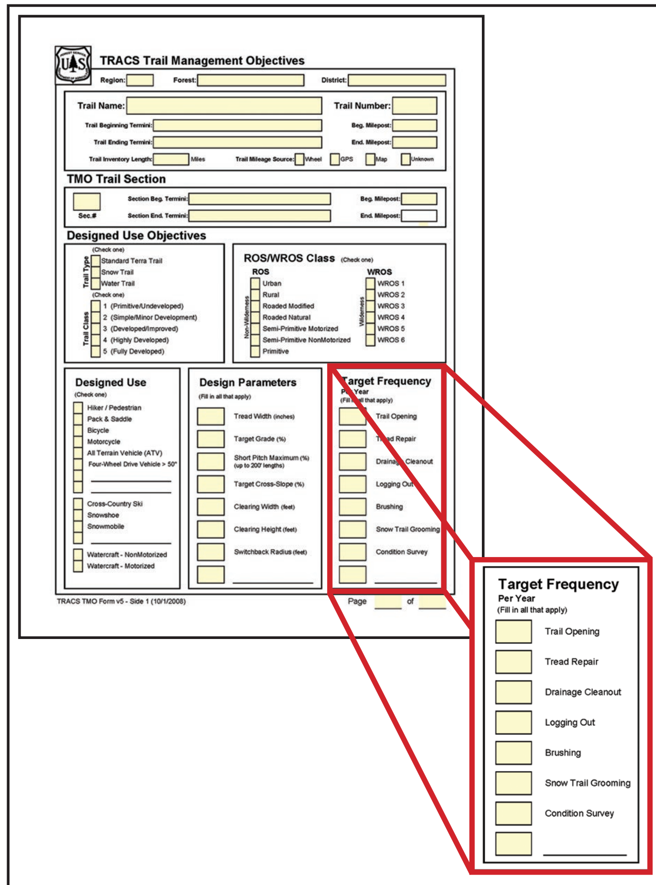

Figure 13–4—Side 1 of the Forest Service Trail Management Objectives form with the "Target Frequency" section enlarged. —*From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.*

Allocating Limited Maintenance Dollars

A familiar challenge within most trail organizations is having too few resources to complete all of the maintenance that is needed. Many agencies have developed a method for allocating funds (discussed later in this chapter).

The Forest Service allocates funds based on National Quality Standards. The NPS has developed an asset priority/facility condition index that guides allocation of funds.

Forest Service National Quality Standards

The Forest Service has identified National Quality Standards to guide maintenance. These standards outline the baseline level of service for trails.

Forest Service policies require prompt action (which may include closing the trail to public use) to correct or mitigate problems when trails do not meet Critical National Standards.

Forest Service National Quality Standards for Trails

Forest Service Handbook 2309.18, Section 15, Exhibit 01

Key Measures

Health and Cleanliness

1. Visitors are not exposed to human waste along trails.
2. The trail and trailside are free of litter.
3. The trail and trailside are free of graffiti.

Resource Setting

1. Effects from trail use do not conflict with environmental laws.*
2. Resource management adjacent to and along the trail corridor is consistent with recreation opportunity spectrum (ROS) objectives and the desired conditions of adjacent management areas.
3. Trail opportunities, trail development, and trail management are consistent with ROS objectives, the Recreation Management System (ROS, Scenery Management System, and Benefits Based Management) objectives, and the applicable forest land management plan.
4. The trail, use of the trail, and trail maintenance do not cause unacceptable damage to other resources.
5. Trail use does not exceed established trail capacity.

Safety and Security

1. Hazards do not exist on or along the trail.*
2. Laws, regulations, and special orders are enforced.

Responsiveness

1. When signed as accessible, the trail meets current agency policy and accessibility guidelines.*
2. Information is posted in a clear and professional manner.
3. Visitors are provided opportunities to communicate expectations and satisfaction.

Condition of Facilities

1. **Annual Maintenance—**The trail and its structures are serviceable and in good repair throughout their designed service life.
2. **Deferred Maintenance—**Trails that are in disrepair due to lack of scheduled maintenance, are in violation of applicable safety codes or other regulatory requirements (such as accessibility guidelines), or are beyond their designed service life are repaired, rehabilitated, replaced, or decommissioned.
3. **Capital Improvement—**New, altered, or expanded trails meet Forest Service design standards and are consistent with standards and guidelines in the applicable land management plan.

If Critical National Standards ("*") cannot be met, actions must be taken as soon as practicable to correct or mitigate the problem.

National Park Service Asset Priority/Facility Condition Index

The NPS Facility Management Program has a process for allocating funds: the asset priority/facility condition index. This process determines the relative value of the asset and compares its relative value to its condition. The NPS system uses a series of attributes to help determine the value of its facility assets, including trails. These attributes include cultural significance, national significance, importance for visitor use, importance to park operations, and potential for substitution.

Each attribute is evaluated independently and assigned a total point value of 0, 5, 10, 15, or 20, depending on its relative importance. The sum of the assigned values produces a final ranking between 0 and 100, allowing trails to be ranked as high, moderate, or low value (figure 13–5).

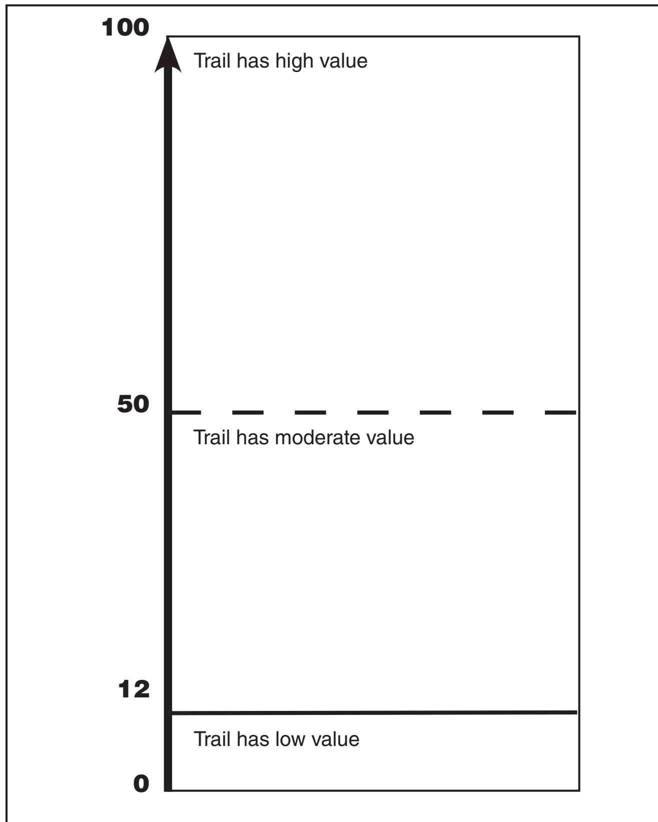

Figure 13–5—A trail value index.

National Park Service (NPS) Off-Highway Vehicle Attribute Value List and Point Rankings

The NPS system for allocating funds could be adapted for off-highway vehicle (OHV) trails with this attribute list and point ranking:

1. Importance of the trail in accessing developed unit facilities.
   Critical (20 points)..One of many options (0 points)
2. Value of the trail in enhancing OHV user experience
   Highly valuable (15 points) ....Little contribution (0 points)
3. Historic/cultural/social significance of the trail
   National significance (5 points) ....No significance (0 points)
4. Quality of the trail design/layout
   Sustainable (20 points) ....Poor design (0 points)
5. Multiple-use value of the trail
   Heavy multiple use (10 points).............................No multiple use (0 points)
6. Availability of other OHV trails to provide alternative opportunities
   No other opportunities (20 points) ....Many opportunities (0 points)
7. Environmental/social compatibility of the trail
   No conflicts (10 points).......................................Many conflicts (0 points)

Trail Condition Indexes

The NPS facility condition index compares replacement values to projected cost of repairs. The facility condition index is calculated as:

$$\frac{DM + RDM + CRDM + IPH}{\text{Current replacement value}}$$

Where:

DM = *Deferred maintenance costs*
RDM = *Recurring deferred maintenance costs*
CRDM = *Component renewal deferred maintenance costs*
IPH = *Immediate personal hazard*

The NPS method works well if you are an employee with access to the agency's facility management computer system, adequate training, and data for the equation.

Another approach is to develop a trail condition index that assigns a relative condition value to the trail. This could be a purely subjective evaluation or one based on a systematic condition assessment (see "Element 5—Trail Condition Assessment").

The condition assessment evaluates the physical attributes of each trail segment, assigns a ranking weight to each attribute, and classifies each segment as good, fair, degraded, very degraded, or extremely degraded. Examining a map or summary showing those condition classes would help a manager develop a relative trail condition assignment. A trail condition index might be calculated as:

$$\frac{\text{Sum of all segment values x their length}}{\text{Total trail length}}$$

Trail condition indexes calculated with this equation could be used to compare different trails or to determine threshold values for good, fair, degraded, or very degraded condition.

Regardless of the method used to develop the trail condition index, the results should produce a final ranking between 0 and 100 (figure 13–6).

Figure 13–7 combines the trail value and trail condition indexes. Individual trails would be plotted on the combined index based on their priority and condition index. Trails would be assigned to one of four quadrants: high value/good condition, high value/poor condition, low value/good condition, and low value/poor condition. Figure 13–8 shows a strategy for allocating trail maintenance resources; identifying relative annual, periodic, and project-level maintenance priorities, and recommending sustainability evaluations and management alternatives for trails in low value and poor condition.

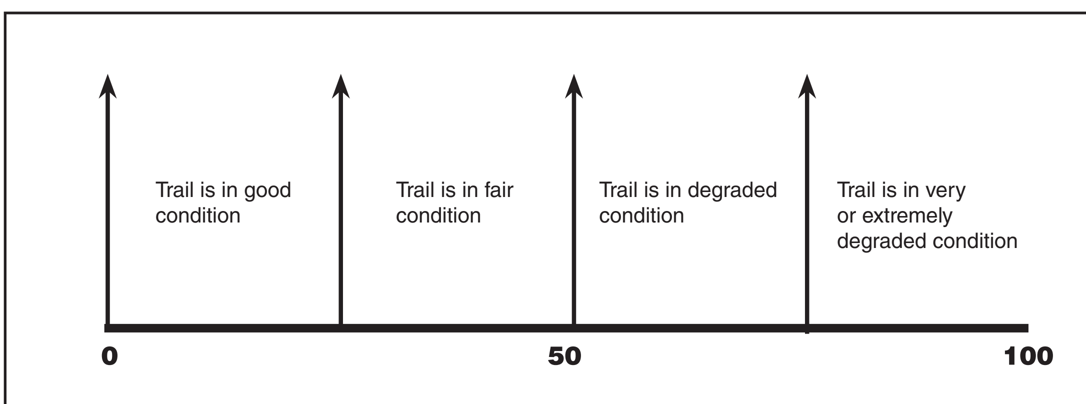

Figure 13–6—Trail condition index.

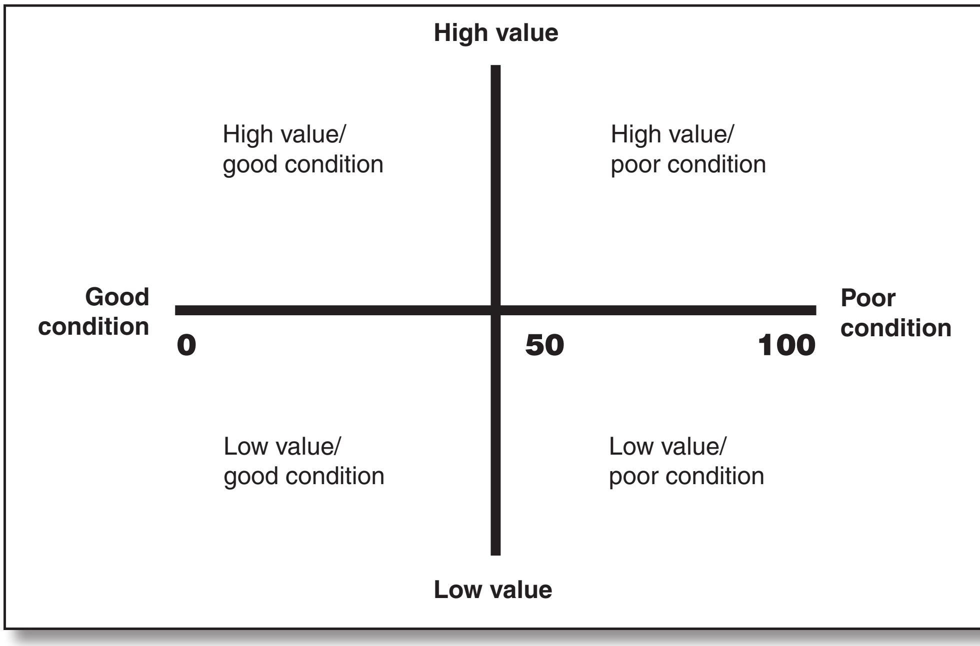

Figure 13–7—Combined trail value and trail condition indexes.

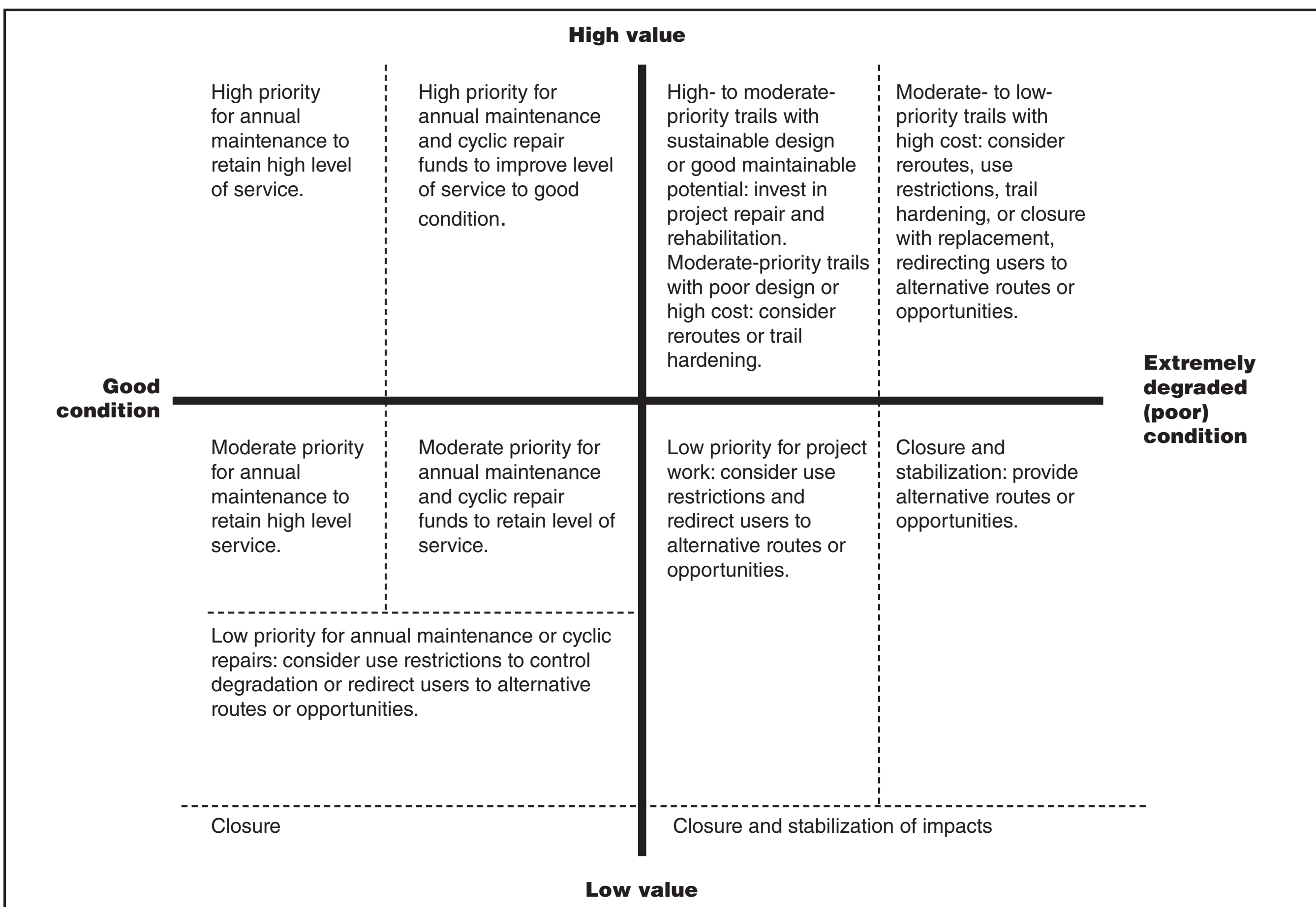

Figure 13–8—Using the combined trail value and trail condition indexes to allocate trail management resources.

Chapter 14: Element 9—Implementation

Implementation deals with all aspects of the work for a new trail construction project or a maintenance project for an existing trail. Implementation addresses funding considerations, compliance and permitting concerns, logistics planning, job hazard analysis, and management oversight and documentation.

Funding Considerations

Constructing a new off-highway vehicle (OHV) trail is not cheap, but continually maintaining a poorly designed or degraded trail can be much more expensive. Whether you are constructing new trails or maintaining existing trails, it is important to work as efficiently as possible.

Heavy equipment can minimize the workload for hand crews, allowing projects to be completed more quickly and less expensively. For example, the Forest Service Trails Unlimited enterprise unit typically fields a three-person crew equipped with a trail dozer (figure 14–1), a compact excavator (figure 14–2), and a rake and drag (figure 14–3) pulled by an all-terrain vehicle (ATV). The Trails Unlimited crews also use full-sized bulldozers, skid-steer loaders, and tracked carriers, depending on the requirements of the job.

Figure 14–1—A trail dozer is an efficient piece of earth-moving equipment for trail construction and maintenance.

Figure 14–2—A miniexcavator is a versatile piece of equipment for trail construction and maintenance and plays a valuable role in supporting trail dozer operations.

Figure 14–3—A spring-tooth rake is pulled by an all-terrain vehicle for final tread shaping.

The cost of new OHV trail construction using heavy equipment starts at about $15,000 to $20,000 a mile, but can increase considerably depending on site conditions, the length of trail being constructed, logistic difficulties, and the type and number of structures required along the alignment. Appendix G includes project reports that document the use of heavy equipment on two Alaska trails. Both projects were constructed on sideslopes using sustainable trail design guidelines. Because they were laid out carefully, neither project required bridges or other structures. Direct construction costs were less than $14,000 per mile.

Maintenance and mitigation projects on existing OHV trails vary so widely that it's difficult to provide an estimated starting point. Cost varies depending on:

- Access
- Site conditions
- Trail character
- History of maintenance and mitigation actions
- Severity and type of degradation
- Length of trail requiring treatment
- Logistics (for example, crew support and staging)
- Type and number of structures
- Length and character of reroutings
- Extent and character of rehabilitation
- Operator skill and efficiency

For maintenance projects, hand crews are required to brush overgrown vegetation, construct structures, and rehabilitate trail segments. They also may provide finishing touches in areas maintained by machines. The costs of hand crews are significant in overall project costs.

Labor costs vary depending on whether the labor is provided by internal staff, seasonal employees, volunteers, or contract crews. Projects often rely on volunteer crews. Consider all costs, including the costs of supervision, training, and logistic support.

Trail hardening can also inflate costs dramatically. In Alaska, trail-hardening projects have cost from $11,000 to more than $291,000 per mile. The "OHV Trail Project Comparison Chart" in appendix G includes costs for 12 Alaska trail construction and maintenance projects completed between 2001 and 2007.

Typically, funding for trail projects is an internal process managed by the agency itself. Each organization has its own process for handling funding requests, allocating funds, and managing budgets. OHV trail managers should apply their agency's funding system when implementing maintenance and construction projects. OHV managers may be able to apply for Federal, State, and private grants for trail projects.

More Information About the Forest Service Volunteer Program

The Forest Service Volunteer Program was established in 1972 by the Volunteers in the National Forest Act. Volunteers help ensure that important interpretive and project work gets done, but they need supervision and management. In the Forest Service, volunteer coordinators provide leadership that is reflected in volunteers' attitudes and work.

The Missoula Technology and Development Center developed:

- "Volunteers in the Forest Service: A Coordinator's Desk Guide" <http://www.fs.fed.us/eng/pubs/htmlpubs/htm09672814/>
- "Welcome to the Forest Service: A Guide for Volunteers" <http://www.fs.fed.us/eng/pubs/htmlpubs/htm09672813/>

These guides provide Forest Service employees and volunteers with consistent information, forms, and guidance.

Compliance and Permitting

Compliance with the National Environmental Policy Act (NEPA) is a requirement for all new construction and for any major projects that involve extensive rerouting or trail hardening. NEPA requires environmental analysis for Federal agency actions and programs. In general, any action that includes Federal funding requires some level of NEPA documentation to describe the environmental effects of the project. Depending on agency policy, regular maintenance on existing trails may fall under a categorical exclusion that simplifies this NEPA documentation. Many States also require environmental review under State law that affects non-Federal projects. Check with your agency compliance specialist or cooperating Federal or State agencies to determine the compliance steps required for your project.

Permits may be required for construction and major maintenance projects that affect wetlands, coastal zones, water quality, fish passage, or wildlife habitat. Check with local Federal and State environmental protection agencies for permit requirements. Some States have clearinghouses to simplify the permitting process.

Appendix G includes a brief (and incomplete) summary of compliance and permitting requirements.

Logistics Planning

A logistics plan pays off when it's time to implement a project. The logistics plan provides details of all major elements of a project and can serve as a handy checklist to track and monitor progress. Appendix G includes a blank "OHV Trail Project Logistics Plan." A project's major tasks might include:

Task A—Final construction layout and flagging with ground control, integrated drainage, and marked clearing limits

Task B—Timber and heavy brush clearing

Task C—Tread construction, trail dozer/excavator operations

Task D—30-foot bridge construction, milepost (MP) 15+35

Task E—25-foot bridge construction, MP 340+16

Task F—Trail hardening, 2-meter-wide, unfilled porous pavement, 84 feet long, from MP 480+12 to MP 480+96

Organizing the project into major tasks can simplify management and allow for resources to be allocated efficiently throughout the project.

Other valuable project support documents include detailed task descriptions and crew instruction sheets. Appendix G includes examples of instruction sheets for clearing and construction crews.

Job Hazard Analysis

Each project task can have a different mix of employees, equipment, supplies, materials, and hazards (figures 14–4 and 14–5). Most agencies have developed their own job hazard analysis (JHA) process. The Forest Service JHA lists individual tasks and identifies associated hazards and possible abatement actions. The abatement actions include engineering controls, substitution (using a less hazardous approach), administrative controls, and personal protective equipment. Appendix H includes two examples of Forest Service JHAs, one for Trail Assessment and Condition Surveys at the Chugach National Forest in Alaska and one for trail maintenance and construction at the Sawtooth National Recreation Area in Idaho. The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) addresses JHAs in a 46-page booklet available at <http://www.osha.gov/Publications/osha3071.pdf>.

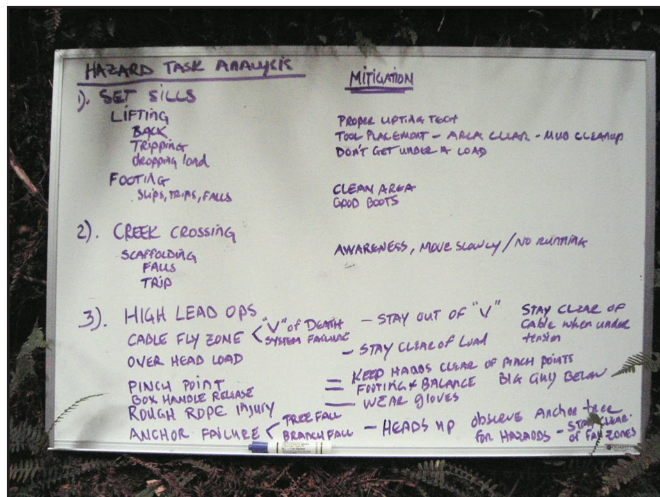

Figure 14–4—A tailgate safety session before work on primary job tasks helps instill a safe working attitude.

Figure 14–5—Job hazards vary by project task. The hazards associated with chain saw use are different than operating equipment, working on a construction line, or conducting a helicopter sling operation. Note the use of appropriate personal protective equipment for this sawing operation—hardhat, gloves, chaps, and ear and eye protection.

Management Oversight and Documentation

Management oversight is a critical element of any trail project. This oversight is necessary to monitor a crew's compliance with layout, clearing, and construction design specifications and to make sure the crew completes the work safely and efficiently.

For Federal contracts, the agency's contracting officer is responsible for management oversight. Contracts require an inspection report showing compliance with bid items and specifications. The inspection report is a legal document that can be cited in any dispute hearing or litigation action. Contracting officers often recruit an onsite inspector or a contracting officer's representative to monitor projects and complete the inspection reports. The OHV trail manager may play this role.

The "OHV Trail Project Oversight Checklist" in appendix G is organized by major phases of the project and can be modified for specific projects.

Excavation Volumes

Why use heavy equipment for new trail construction? Table 14–1 and figure 14–6 show the volumes of material that must be moved for full bench construction (500 cubic yards is about 650 tons of material).

Table 14–1—Excavation volumes in cubic yards per 100 linear feet (Shields 2009).

Bench width (feet)	Excavation type[1]	Sideslope (percent)					
		15	25	35	45	[2]55	[2]70
4	BE	4.44	7.41	10.40	13.30	16.30	20.70
	BsE	1.51	5.69	16.20	43.50	33.50	93.10
	Total	6.00	13.10	26.60	56.80	49.80	14.00
6	BE	10.00	16.70	23.30	30.00	36.70	46.70
	BsE	3.40	12.80	36.50	97.80	75.40	209.00
	Total	13.40	29.50	59.80	128.00	112.00	256.00
8	BE	17.80	29.60	41.50	53.30	65.20	83.00
	BsE	6.00	22.80	65.00	174.00	134.00	372.00
	Total	23.80	52.40	107.00	227.00	199.00	455.00
10	BE	27.80	46.30	64.80	83.30	102.00	NA
	BsE	9.40	35.60	101.00	272.00	210.00	NA
	Total	37.20	81.90	166.00	355.00	312.00	NA
12	BE	40.00	66.70	93.30	120.00	NA	NA
	BsE	13.60	51.20	146.00	391.00	NA	NA
	Total	53.60	118.00	240.00	511.00	NA	NA

Note: Backslope is 1½:1 up to 50-percent sideslope, 1:1 for sideslopes steeper than 50 percent.
[1]BE = Bench excavation, BsE = backslope excavation.
[2]Sideslopes steeper than 60 percent typically require backslope retaining walls.

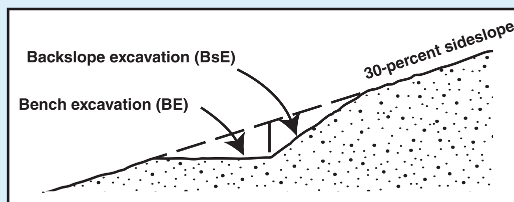

Figure 14–6—Terms used when estimating excavation volumes for full bench construction.

Chapter 15: Element 10—Trail Monitoring and Evaluation

Periodic trail monitoring and evaluation provide data that can be used to review changes in trail condition and to assess the adequacy of maintenance. Trail managers can review the results of their on-the-ground actions and make adjustments. The types of monitoring discussed here include compliance monitoring, identifying maintenance needs, and trail condition monitoring.

Compliance Monitoring

Compliance monitoring documents basic compliance with trail design and sustainability standards, providing feedback to the trail manager on trail maintenance status, sustainable trail design, and the Trail Management Objectives (TMOs) applicability to actual trail conditions.

Knowing whether a trail complies with its Design Parameters lets the trail manager know whether the trail is providing the desired level of service. Minor failures to comply with Design Parameters, such as reductions in cross slope or vegetation regrowing inside clearing limits, can be corrected with regular maintenance. The development of social trails or widened or braided trail segments may indicate major problems. These problems can occur when the trail does not lead to features trail users are trying to access, when users detour around degraded segments of trail, or when the trail does not meet users' needs and expectations. The trail design, level of maintenance, or changes in use characteristics may need to be reviewed. For instance, a change in use characteristics would suggest that the TMOs may need to be reviewed and possibly updated.

An assessment of Design Parameters and sustainable trail design guidelines can be conducted relatively easily because only items that are not in compliance need to be noted. The assessment can also be conducted by technicians with limited trails expertise because they are comparing existing trail conditions against a set of measurable standards.

Figure 15–1 shows a sample data collection sheet, developed by the author, that could be used to quickly document noncompliance with TMOs Design Parameters and sustainable trail design guidelines. A companion monitoring effort could identify use characteristics such as use types, volume of use, intensity of use, and season of use. Although some use information could be extracted from trail logbooks, it's important to supplement that information by monitoring use at the site.

Data Collection Sheet

Trail name | **Date** | **Inspectors**

Target design grade______(percent) **Maximum grade**_____(percent) **Trail width**______ **Cross slope**______(percent) **Clearing limits** **width**____(feet) **height**_____(feet)

TRAILWAY				Item of noncompliance				Sustainable design					Notes
Starting waypoint	Ending waypoint	Length	Grade	Trail width	Cross slope	Clearing limits	Off-trail impacts	Contour	Controlled grade	Integrated drainage	Full bench	Durable tread	

Figure 15–1—A data collection sheet developed by the author for documenting noncompliance with Trail Management Objectives parameters and guidelines.

Identifying Maintenance Needs

When the Forest Service Trail Assessment and Condition Surveys (TRACS) approach (see "Element 7—Trail Prescriptions") is used, trail experts traverse the trail to assess compliance with TMOs Design Parameters and identify maintenance or improvement needs. The TRACS approach also satisfies the compliance monitoring objectives. The Forest Service specifies the interval for conducting TRACS surveys based on Trail Class. Class 5 trails (the most developed trails) should be surveyed every 5 years. Less developed trails are surveyed less frequently.

Once an initial TRACS survey has been completed, it becomes the baseline inventory, condition assessment, and prescription for the trail. Subsequent TRACS surveys, called validation surveys, evaluate current trail conditions against the TMOs and national standards, document any changes in condition, document the results of maintenance conducted between monitoring periods, and identify changes that might be needed in prescriptions. Validation surveys can be conducted with eTRACS data recorders that allow quick comparison between baseline data and current field conditions. The eTRACS system allows data to be updated quickly onsite and transferred to the agency's database later. Comparing the baseline survey and validation surveys allows trail condition trends and the maintenance methods, intensity, and frequency to be assessed.

Monitoring Frequency

Regardless of the technique, off-highway vehicle trails should be monitored regularly—at least once every 5 to 10 years—depending on levels of use, trail conditions, and other environmental factors. The frequency could be increased if environmental values are at risk, but enough time should pass between monitoring so that any changes are meaningful and not just short-term changes related to weather patterns or changes reflecting the subjectivity of field inventory crews. To the extent possible, monitoring inventories should be conducted at roughly the same time of year when soil surface moisture levels are similar to those during earlier inventories.

Trail Condition Monitoring

Trail condition monitoring tracks changes in trail conditions over time. A variety of techniques can be used, including:

Stratified Point Sampling

A stratified point sampling technique for trails was developed in the mid-1980s (Connery and others 1986), adapted for National Park Service (NPS) off-highway vehicle (OHV) trails in Alaska during the 1990s (Happe and others 1998), and further refined by researchers at the Virginia Polytechnic Institute and State University under Jeffrey Marion (Marion and Leung 2001). This technique uses a random sample of specific locations where detailed measurements are taken of trail cross section, associated vegetation cover, and other site features. The distribution of the sample points is stratified by use type, terrain, vegetation community, or other factors. The sample sites are resampled periodically.

This technique uses recognized statistical evaluation methods, collects quantifiable measurements, and is repeatable. The monitoring can be done by technicians who do not need to be trail experts. The technique quantifies changes in a scientific manner and allows trends to be projected, but provides little additional information on segment management for trail managers. Acquiring a statistically valid sample can be expensive if the trail environment is highly stratified (when a trail has a wide variation in attributes such as terrain, soils, grades, and use characteristics). This technique is best used for academic studies or to meet formal monitoring compliance requirements of the National Environmental Policy Act or a lawsuit.

Ground Photopoints

Photopoints are a popular, inexpensive, and simple monitoring technique often used to document qualitative changes in trail conditions over time. Representative trail segments or locations of special interest are identified and permanently marked. Global Positioning System coordinates are recorded to help photographers find the locations. The sites are visited periodically so photos can be taken showing the same area. Photographers who carry copies of the original photos to the field will find it easier to take new pictures that accurately show changes. When the old and new photos are compared, the changes can be quite dramatic. This method can be used by almost anyone and requires little or no trail expertise.

One limitation of the photopoint technique is that it is difficult to describe condition trends for a trail scientifically based on a few photopoints. Photopoints are useful only to document conditions and make general qualitative observations at specific sites. Trail conditions could be misrepresented by a few dramatic or blasé photos.

Remote Sensing

Another way of identifying condition trends is to compare aerial or satellite photographs of the same area taken at different times. With satellite imagery available through such Web sites as Google Earth, the opportunities for using this technique have improved dramatically. While the detail of tread surface conditions may be limited by the resolution of the images or by vegetation cover, changes in certain features may be evident. These include:

- Trail extensions
- Development of social trails, spurs, and cutoffs
- Significant widening or narrowing of the tread surface
- Development or abandonment of trail braids
- Development of campsites, parking areas, or play areas
- Installation of trail improvements such as bridges or hardened trail segments
- Vegetation changes on and alongside the trail
- Significant erosion or deposition areas (possibly including discharge plumes into bodies of water)
- Stream capture by trail alignments, changes at ford sites, or other hydrologic alterations
- Extensive surface water ponding along the tread
- Other noticeable modifications in the trail alignment and the surrounding landscape, such as landslides

Because the images may include a 100-percent sample of visible trail data, the analysis has scientific validity. Imagery also can be used to identify sites that require further ground examination, allowing general observations and interpretations to be verified on the ground.

Changes between images can be detected by sophisticated computer programs that overlay the images or with special scale-matching stereoscopes. Simpler methods include:

- Printing photos to the same scale and transferring data between them with transparent overlays
- Digitizing or scanning annotated overlays and modifying their scales to match one another
- Visually sketching in changes observed on a newer image to the older image

Repeat Condition Assessments

Repeat condition assessments have not been extensively tested, but they would provide detailed data on changes in trail physical condition over time. A baseline condition assessment would be conducted and the trail would be reinventoried after a specified interval, using the same data dictionary that was used in the original condition assessment. This technique would document changes along the entire length of a trail, essentially a 100-percent sample. The accurate spatial and statistical dataset could be used to document changes in trail condition and to project trends.

One of four methods could be used. The first method **updates the original map.** Technicians return to the field with the original dataset on printed maps and attribute tables. When they return to trail segments identified in the original inventory, they review the original attribute values and change values as new conditions warrant.

Another method would be to **conduct a completely separate inventory** using the same data dictionary. The technicians would traverse the trail and identify their own segment breaks and assign attribute values independent of the original baseline inventory. The primary point of comparison between the two datasets would be the summary statistics, such as condition categories and the lengths of trail segments with various attribute values. Direct comparisons between individual trail segments would be more difficult because technicians may identify different segment breaks during the two inventories.

Datasets collected by this method would be completely independent—the technicians would not be biased by previous methods of data acquisition. The disadvantages would be the time required to conduct the inventory, the need to postprocess the new data, and the wide variation likely in identification of trail segments and interpretation of attributes. These disadvantages would generally outweigh the advantages of this method unless completely independent, unbiased monitoring was required.

A third method uses a **hybrid point sampling technique.** Random sample points are distributed along the trail. The allocation of points could be stratified by one or more attributes, such as trail grade category or trail surface character. The dataset also could be stratified based on physiographic characteristics such as flat lands and uplands, or based on administrative units such as Trail Classes or land ownership.

Stratification generally increases the accuracy and utility of an analysis, but requires a larger sample size. Because variation between trail segments would have been documented in the original dataset, a statistician could develop a sampling protocol for any level of accuracy that was needed.

The sample points are distributed along the trail alignment, and a table is generated with the physical coordinates (latitude and longitude) of the sample points and their segment attribute values. Technicians go directly to each sample point along the route, review the attribute class values of the segment, and make changes to reflect new conditions. This method generates a statistical summary of change at the sample sites that could indicate condition trends for the entire trail.

Because this method studies just a sample of sites, it does not document changes for every individual segment along the trail. The method could be used to indicate the need for maintenance, the need to modify maintenance intervals, or the need to change the intensity of maintenance.

A fourth method relies on a **geodatabase comparison.** In this technique, a dataset from a previous inventory effort could be compared to current conditions. The dataset would be checked out of the Geographic Information System (GIS), loaded in a mobile mapping system, and taken to the field. Mapping techniques would make changes to the dataset based on observed conditions. The dataset would be checked back into the GIS, and a report would be run showing the changes between the two datasets. This method is similar to updating the original map, but takes advantage of current technology.

Monitoring To Evaluate Maintenance Level

Determining trail condition trends over long periods is the key to evaluating whether the level of maintenance is adequate. The objective of all maintenance should be to stabilize or improve trail conditions. In general, if the trail condition trend is negative, maintenance levels are not adequate; if the trend is stable, they are about right; and if the trend is positive, the maintenance levels are adequate or may be excessive—at least for the use and weather conditions experienced between the monitoring periods.

Maintenance levels are only one factor affecting the trail condition and its trend. Other factors include changes in use characteristics, the quality of trail design and construction, and weather and climate conditions. Figure 15–2 illustrates the relationship of these factors to trail maintenance. The OHV trail manager must step back and evaluate the entire trail environment to determine whether the maintenance program is adequate.

The most appropriate monitoring type, technique, and method depend on the objectives of monitoring and the availability of resources, such as equipment, time, funding, and expertise. Table 15–1 compares monitoring techniques to help trail managers select the most appropriate approach.

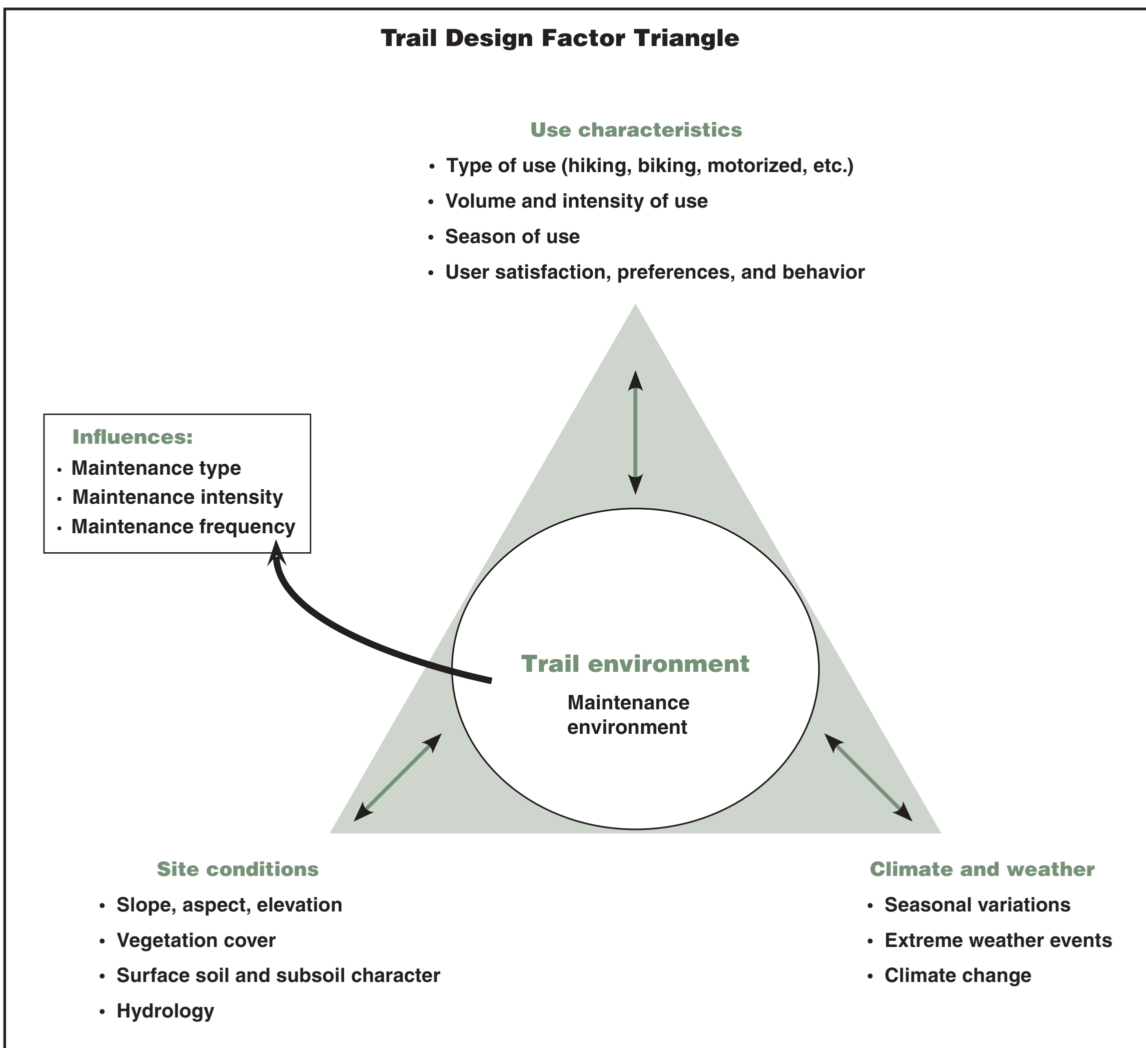

Figure 15–2—Trail design factors influence trail maintenance type, intensity, and frequency.

Table 15–1—Comparison of monitoring techniques.

Monitoring techniques	**Review of TMOs specifications provided?** (S = sometimes)	**Review of sustainable elements provided?** (S = sometimes)	**Provides indicators of condition trend**	**Trails expertise required**	**GPS expertise required**	**GIS expertise required**	**Photo interpretation skills required**	**Statistical methods required**	**Access to computer software needed**	**Access to agency hardware/ software needed**	**Quantified dataset**	**Statistically valid dataset**	**Qualitative dataset**	**Method: T = transverse P = point**	**Provides detail for maintenance actions**	**Technical complexity**	**Relative equipment requirements**	**Relative time investment**	**Relative cost**
General monitoring																			
Design specifications/ sustainable compliance	Yes	Yes	Yes	Low	No	No	No	No	No	No	Yes	Yes	No	T	Partial	Low	Low	Mod-erate	Mod-erate
Maintenance needs	Yes	No	Yes	High	No	No	No	No	Mod-erate	Yes	Yes	Yes	No	T	Yes	Mod-erate	Mod-erate	High	High
Trail condition monitoring																			
Stratified point	Sample only	Sample only	Sample only	No	Mod-erate	No	No	Yes	Low	No	Yes	Yes	No	P	No	Mod-erate	Low	Mod-erate	High
Ground photo point	No	No	Varies	No	Mod-erate	No	No	No	No	No	No	No	Yes	P	No	Low	Low	Low	Low
Remote sensing	No	Partial	Yes	Low	No	Mod-erate	Mod-erate	No	Mod-erate	No	Yes	Yes	Yes	Varies	Partial	Mod-erate	Low to mod-erate	Mod-erate	Mod-erate
Repeat condition assessments																			
Updates	S	S	Yes	Low	Mod-erate	Mod-erate	No	No	Mod-erate	No	Yes	Yes	No	T	Partial	Mod-erate	High	Mod-erate	Mod-erate
Independent	S	S	Yes	Mod-erate	High	High	No	No	High	No	Yes	Yes	No	T	Partial	High	High	High	Very high
Hybrid point	Sample only	Sample only	Sample only	Low	Mod-erate	Low	No	Yes	High	No	Yes	Yes	No	P	No	Mod-erate	Mod-erate	Low	Mod-erate
Geodatabase comparison	S	S	Yes	Low	Mod-erate	Mod-erate	No	No	Mod-erate	Yes	Yes	Yes	No	T	Partial	Mod-erate	High	Mod-erate	Mod-erate

Chapter 16: Closing Thoughts

The sustainability concepts, Trail Fundamentals, and the 10 elements of the management framework in this guidebook provide a systematic approach to off-highway vehicle (OHV) trail management. Proper management of OHV trails is one of the most important tasks for trail managers today. Traditionally, trail management was the province of a handful of skilled backcountry maintenance workers. Today, trail resources concern a wide range of trail users, natural resource professionals, and technical specialists.

Trail management is fast becoming a field of study in its own right. Amateurs and professionals are beginning to apply scientific principles to all areas of trail management. Their goal is to integrate trails harmoniously with the local environment and provide sustainable trail recreation opportunities. Such opportunities will help meet the needs and expectations of diverse user groups while protecting valuable resources for the next century.

Notes

Chapter 17: References and Additional Resources

Each reference and the additional resources provide valuable information on trail design, construction methods, maintenance, or general trail management. While some may be regional in nature or focus on other types of trails, their basic concepts can readily be adapted to off-highway vehicle (OHV) trails.

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Additional Trail-Building Resources

Manuals

A Handbook on Trail Building and Maintenance: For National, State and Local Natural Resource Managing Agencies, 1996.
Stephen S. Griswold, Sequoia Natural History Association, phone: 559–565–3759.

AMC's Complete Guide to Trail Building and Maintenance, 4th Edition, 2008.
Appalachian Mountain Club.
Note: Readers may enjoy an earlier version ("AMC Field Guide to Trail Building and Maintenance 2d ed.") by Robert D. Proudman and Reuben Rajala. Used copies of the 1981 guide are available through online bookstores and libraries.

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Danny Basch, John Giordanengo, and Greg Seabloom, Colorado Outdoor Training Initiative (COTI), 600 South Marion Parkway, Denver, CO 80209.

Slope Structures and Trail Stability, 2008.
Mike Shields, Alaska Trails, 750 W. 2d Avenue, Suite 205, Anchorage, AK 99501.

Trail Drainage Structures and Basic Terrain Hydrology, 2008.
Mike Shields, Alaska Trails, 750 W. 2d Avenue, Suite 205, Anchorage, AK 99501.

Trails Primer: A Glossary of Trails, Greenway, and Outdoor Recreation Terms, 2001.
Jim Schmid, American Trails, available at <http://www.americantrails.org/resources/info/glossary.html>.

Wetland Trail Design and Construction: 2007 Edition, Tech. Rep. 0723–2804–MTDC, 2007.
Robert T. Steinholtz, Brian Vachowski, U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. Available at <http://www.fs.fed.us/t-d/pubs/htmlpubs/htm07232804/index.htm>.

Web Sites

Federal Geographic Data Committee
Federal Trail Data Standards
<http://www.nps.gov/gis/trails/>
<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/trail-data-standard/trail-data-standards>

International Mountain Bicycling Association
Technical resources
<http://www.imba.com/resources/trail_building/>

National Off-Highway Vehicle Conservation Council
Technical resources
<http://www.nohvcc.org/>

National Trails Training Partnership
Training and technical resources
<http://www.americantrails.org/nttp/>

Professional Trail Builders Association
Technical resources
<http://www.trailbuilders.org/resources/>

Trails Unlimited
Consulting and trail training opportunities
<http://www.fs.fed.us/trailsunlimited/>

U.S. Department of Agriculture, Forest Service
Forest Service National Trail Drawings and Specifications
<http://www.fs.fed.us/.ftproot/pub/acad/dev/trails/trails.htm>

U.S. Department of Agriculture, Forest Service
Trail Management Web site for Trail Fundamentals, TMOs, and TRACS <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>

U.S. Department of Agriculture, Forest Service
Travel Management and OHV Program Web site
<http://www.fs.fed.us/recreation/programs/ohv/>

U.S. Department of the Interior, National Park Service Rivers, Trails, and Conservation Assistance Program
Technical resources and assistance
<http://www.nps.gov/ncrc/programs/rtca/>

U.S. Department of the Interior, U.S. Fish and Wildlife Service
National Interagency Trails Course
<http://training.fws.gov/>
Click on "course search" and enter "trail management" in the keyword search box.

Appendix A: Technical Guidance

- Climbing Turns—Concepts, Layout, and Plan Views
- Rolling Dips for Drainage of OHV Trails

Climbing Turns—Concepts, Layout, and Plan Views

The information on pages 122 to 129 is adapted courtesy of Alaska Trails <http://alaska-trails.org> from "Turns: Design and Layout" (Shields 2007) .

A cut-through climbing turn (sweep turn) is a means of reversing trail direction while avoiding the design and construction difficulties, and the traffic flow restriction, of switchbacks. Ideally a sweep turn would reverse the trail direction while gaining enough elevation within the turn to preclude any entrenchment, and thus the possible need for a drainage ditch within the turn. "Entrenchment" (measured as trench depth) is the difference between tread level and slope surface **at the outer tread margin** (figure 1). As the trail leaves the turn, it must quickly climb out of the trench in a transition segment that's called "runout (to daylight)."

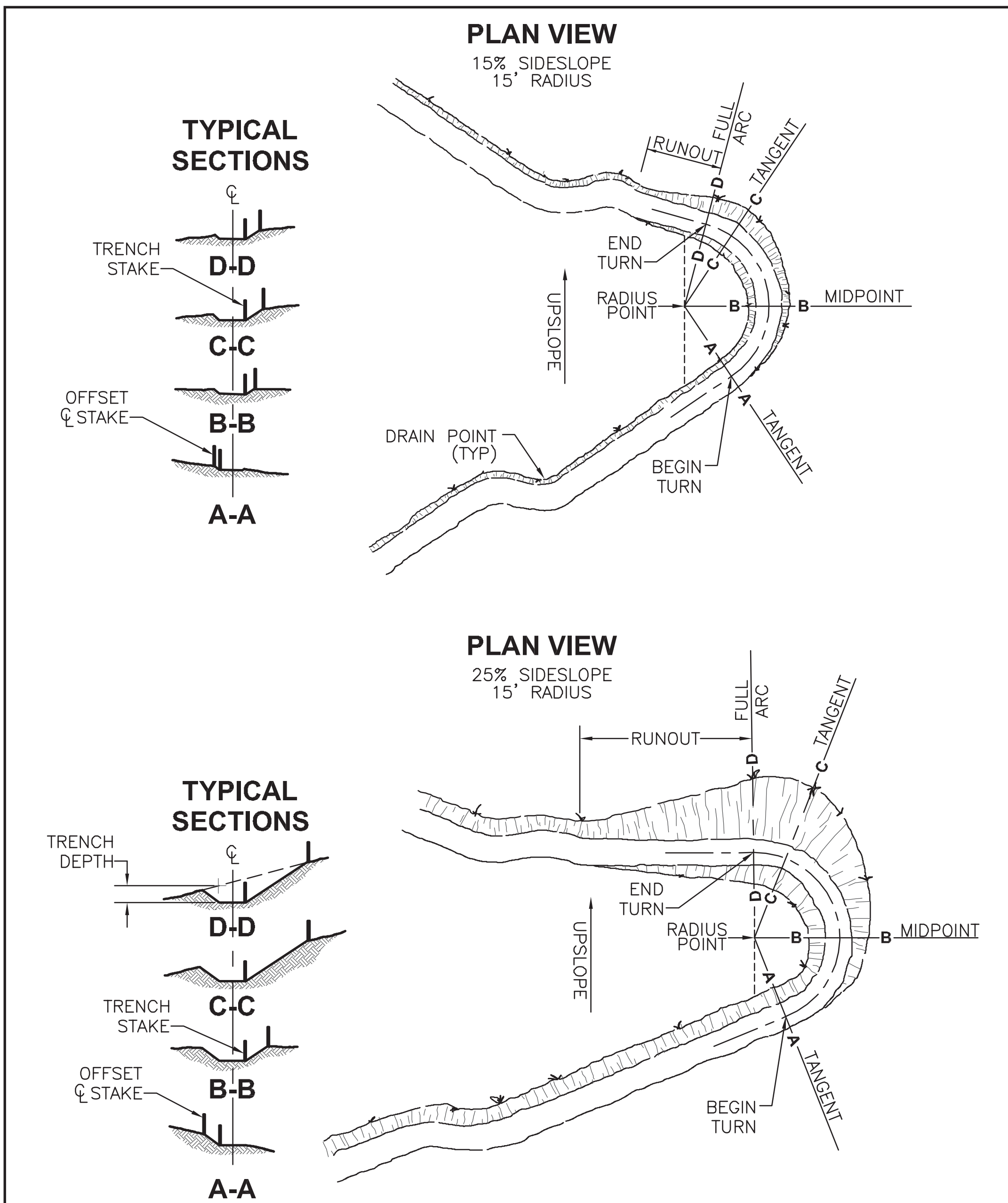

Figure 1.

To truly understand the function and limits of sweep turns, several factors must be considered:

1. The maximum trail grade allowed through the turn
2. The average sideslope at the turn location
3. The radius of the tread centerline as it goes through the turn
4. The tangent point where the turn begins (see figure 1)
5. The full arc angle at which the turn ends (see figure 1)
6. The runout length and the across sideslope grade
7. Drainage through the turn

Maximum Trail Grade Through the Turn

In order to limit or avoid entrenchment, the trail must gain enough elevation through the turn to nearly match the elevation gain of the sideslope between the upper and lower tangent points. This results in a slope grade turn (standard climbing turn) instead of a cut-through climbing turn. But the factors controlling the grade are the **type of use** and the **wear resistance** of the tread material, rather than the desire to gain elevation. A maximum grade of 10 percent through the turn works for most soils and traffic types. If the soil is particularly wear resistant, **and the traffic exerts little lateral pressure through the turn** (e.g., hikers and livestock), trail grades up to 15 percent may work. Obviously, on poorer soils grades under 10 percent may be necessary, which will increase the depth of entrenchment.

Note that a higher trail grade may have already been identified for the particular trail as its maximum allowable grade. Use of this grade through the turn is subject to two important cautions:

1. The physical tread conditions permitting that higher grade (e.g., a high percentage of rock or gravel in the substrate) must be **confirmed** onsite and not simply assumed to be present.
2. The lateral displacement forces in turns, particularly from wheeled traffic, are considerably higher than in straight runs. Therefore, it is wise to take a conservative approach to pushing grades through the turn unless frequent maintenance is planned for the trail.

Sideslope

The steepness of the sideslope relative to the rate of the trail's climbing grade through the turn directly affects the depth of trail entrenchment. The trench depth is greater at the trail centerline, but it is the outer margin difference that forms the trench wall. To achieve no entrenchment at a 10-percent grade through the turn requires a sideslope around 11 percent; at 12 percent grade the sideslope limit is around 14 percent. Sideslopes that gentle are rare in hilly country, so a certain amount of entrenchment is almost inevitable. The real question should be "When does the sideslope drive us away from climbing turns and toward switchbacks?" based on the amount of excavation and drainage construction required. My personal guide is to question the suitability of a climbing turn when the trench depth exceeds 2 feet and/or the runout length exceeds 20 feet at 10 percent. That results in the general limits shown in table 1.

Table 1—General limits for climbing turns.

Curve radius (feet)	**Sideslope limit** (percent)
8	25
10	22
15	20
20	18

Turn Radius

This is the measured distance between the staked radius point of the turn and the tread centerline through the turn. The size of the radius controls the tightness of the turn (a radius under 8 feet becomes a switchback in actual use) and needs to be matched to the intended trail user group(s).

Once the sideslope steepness requires entrenchment to build an acceptable grade through the turn, the turn radius begins to have an effect on both the trench depth and the runout length. The entrenchment effect is illustrated in table 2 for a 10 percent trail grade through the turn.

Table 2—Trench depth (in feet) at the upper tangent of a climbing turn.*

Sideslope (percent)	**8-foot radius** (feet)	**10-foot radius** (feet)	**15-foot radius** (feet)	**20-foot radius** (feet)	**30-foot radius** (feet)
30	2.6	3.2	4.8	6.4	9.6
25	1.8	2.3	3.4	4.5	6.8
20	1.1	1.4	2.1	2.7	3.7
15	0.4	0.5	0.8	1.1	1.6

*For trench depth at 12 percent trail grade, multiply by 0.26; for 15 percent sideslope, multiply by 0.68; for 20 percent sideslope, multiply by 0.79; for 25 percent sideslope, multiply by 0.84 for 30 percent sideslope.

For trench depth at 15 percent trail grade, multiply by 0.18 for 20 percent sideslope, multiply by 0.47 for 25 percent sideslope, multiply by 0.61 for 30 percent sideslope.

Tangent Angle

The less the sideslope percent, the wider the tangent angle is and the shorter the curve length (figure 2). If the trail grade and sideslope are matched so there is no entrenchment, the trail enters and leaves the turn at the tangent points (slope grade turn instead of a climbing turn).

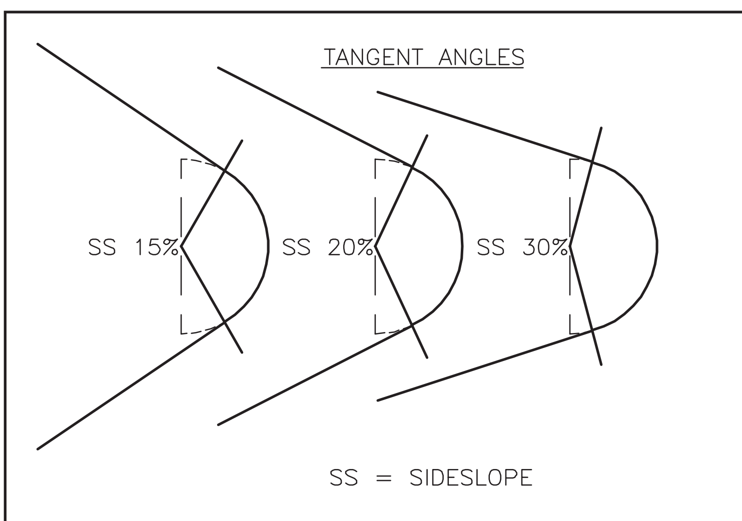

Figure 2.

Full Arc Angle

Once entrenchment becomes a factor, things get more complicated at the upper tangent point. If the trail simply proceeds across the slope at the trail's normal tangent angle and grade (10 percent), it will never rise out of its trench, so some trail realignment is necessary to preclude that. On sideslopes of 17 percent or more, this means continuing the turn beyond the upper tangent to the **full arc point,** and entering the runout from there. On sideslopes **under** roughly 17 percent, this presents another alignment problem—the tangent angle is so wide on gentle slopes that the transition from runout to normal trail alignment becomes a sharp turn at less than the minimum turn radius. The full arc must be adjusted to prevent that. To further complicate matters on gentle slopes, the turn radius itself influences where the full arc must end to accommodate both alignment and reasonable runout length. Tables 3a and 3b show both tangent-to-tangent and full arc angles for a 10-percent trail grade through the turn. (Also see figure 1.)

Table 3a—Sideslope control of the full arc angle.

Sideslope (percent)	**Angle between tangents** (degrees)	**Full arc angle** (degrees)
20	127	153
25	136	158
30	143	162

Table 3b—The influence of turn radius on gentle sideslopes (in this case, 15 percent sideslope).

Radius at 15 percent sideslope (feet)	**Angle between tangents** (degrees)	**Full arc angle** (degrees)
8	112	123
10	112	125
15	112	130
20 to 30	112	132

Runout

The trail centerline stake placed at the full arc point is above the actual trail tread level, reflecting the fact that the trail is still entrenched at that point. We want to get out of the trench as quickly as possible, but without going above 10 percent trail grade. This means running the trail centerline from the full arc point **across** the sideslope for the distance necessary (the runout) to allow the trail's grade to bring the tread level to the sideslope surface. When the sideslope is less than 17 percent, use the clinometer reading shown in table 4 for 15 percent sideslope; it will get you in the ballpark. (Also see figure 3.) When the sideslope is 17 or more percent, shoot a 0-percent clinometer reading across the runout distance.

Table 4—Runout (in feet) at clinometer readings (in percent) shot at centerline.*

Radius (feet)	**15 percent sideslope** (runout in feet)	**20 percent sideslope** (runout in feet)	**25 percent sideslope** (runout in feet)	**30 percent sideslope** (runout in feet)
8	9½ at 6 percent	8½ at 0 percent	16 at 0 percent	24 at 0 percent
10	12 at 5 percent	10½ at 0 percent	20 at 0 percent	30 at 0 percent
15	12 at 4 percent	16 at 0 percent	30 at 0 percent	45 at 0 percent
20	15 at 3 percent	22 at 0 percent	41 at 0 percent	60 at 0 percent
25	17 at 3 percent	27 at 0 percent	51 at 0 percent	75 at 0 percent
30	19 at 3 percent	33 at 0 percent	62 at 0 percent	91 at 0 percent

*For runout distance at 12 percent trail grade, multiply by the table runout distance by 0.83;
at 15 percent trail grade, multiply the table runout distance by 0.67.

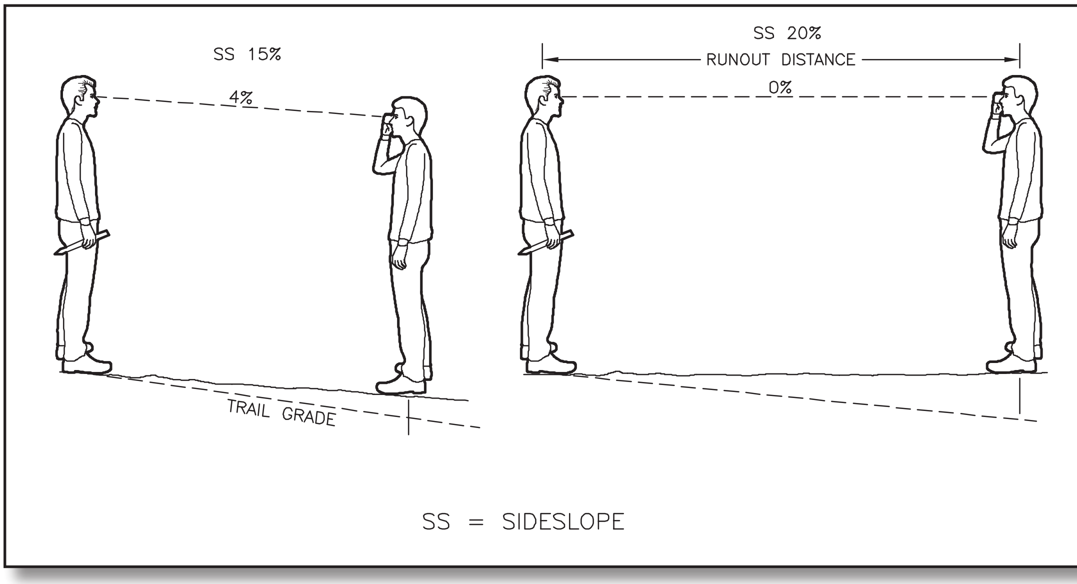

Figure 3.

This may seem like a lot of referencing tables and shooting angles for what is really a pretty simple turn, and you'll find that professionals often simply "eyeball" the layout. But accurate eyeballing takes experience; using the tables, clinometer, and compass will gain you that experience much quicker than if you rely solely on hit-or-miss layouts in the field. The pros will also make use of even minor variations in sideslope, topography, and angles to shorten the runout and reduce the user's temptation to shorten the turn abruptly (shortcut the turn).

Turn Drainage

In the ideal situation where there is no entrenchment, grade reversal drain points are incorporated into the trail legs, usually some 30 feet before entering the lower end of the curve and within 20 feet of leaving the upper end of the curve. Where entrenchment is included, the upper leg drain is placed within 10 feet of the end of the runout, and the lower leg drain is placed to catch and divert any downslope flow from the upper drain.

The more critical question is what to do for drainage **through the turn,** and the answer is dictated by the particular combination of use, tread erosion resistance, and surface moisture flow for the site. On tight-radius turns with short runouts, there may be no undue erosion. In these cases, nothing need be done. When the combined length of turn plus runout means 50 feet or more of waterflow in the trench that carries water to the lower leg drain point, a ditch may be necessary along the inner margin of the turn. Note that this will widen the excavation through the turn by 2 to 4 feet. In extreme cases, it may also be necessary to move the upper leg drain to a point **in the runout trench** and construct it as a 20-foot-long grade dip with the drain outlet punched through the outer trench wall; unfortunately, that will also increase the total length of the runout segment.

Turn Layout Problems and Solutions

There are a few questions to be answered in climbing turn layout.

1. **How do I know what angle to use between the lower tangent and full arc points, and how do I measure that angle in the field?** Use the full arc table (table 3) for the angle. Take the table into the field with you. It's based on a 10-percent trail grade, but it will put you in the ballpark for grades between 8 percent and 12 percent.

Carry a compass with you—it can be used like a protractor (figure 4). Standing at the point on the trail centerline where you want to start the turn, align the east-west axis with the trail, and place the radius point stake along the north-south axis (it takes two people to do this accurately). Then stand at the radius point, align the north-south axis with the radius line, and place the full arc point stake at the appropriate angle (for example, 130º). You can also locate the upper tangent (maximum entrenchment) point in the same manner.

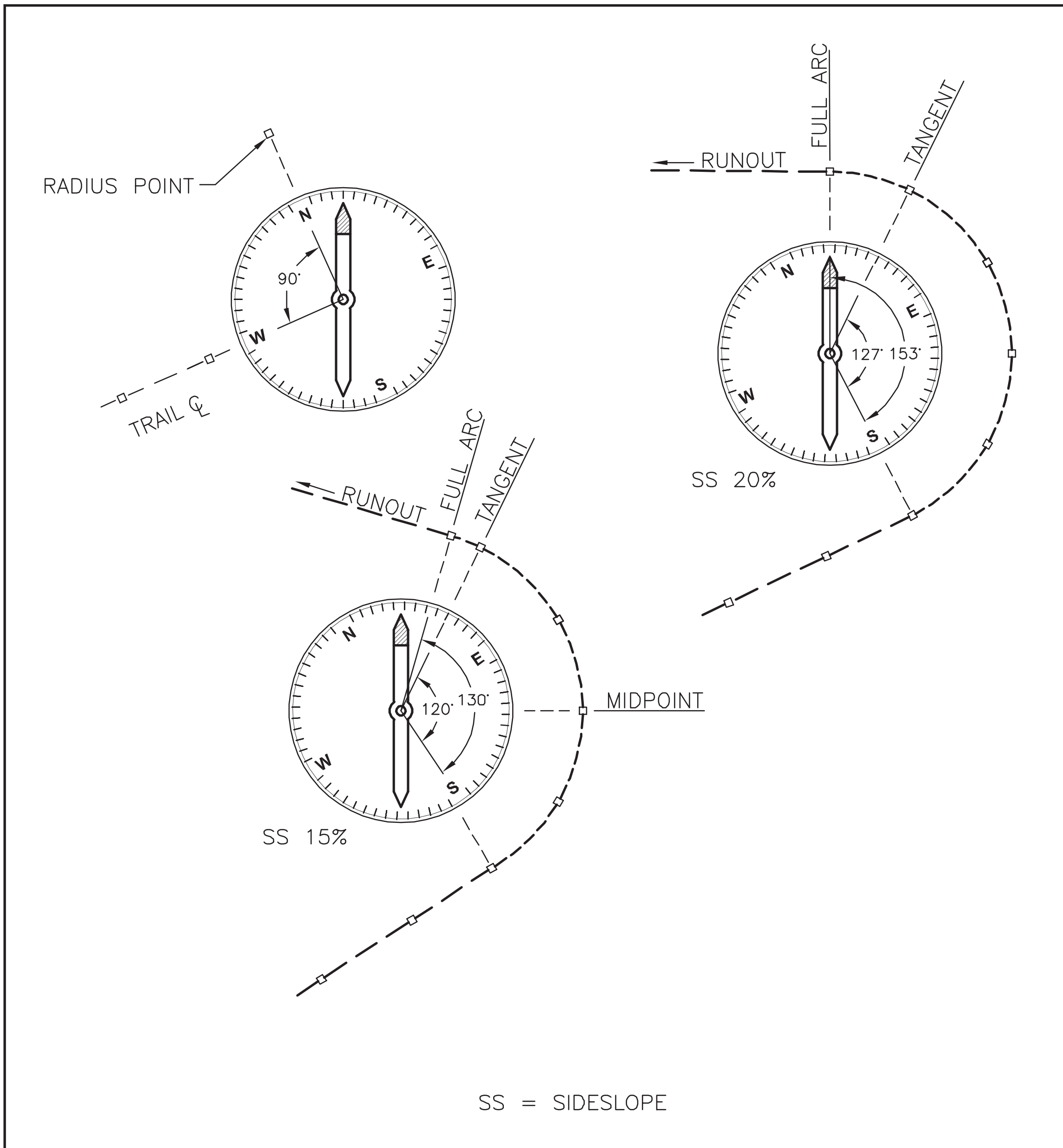

Figure 4.

2. **How do I know what runout length is needed and what clinometer reading to use for it?** As with the angles, take table 4, the runout table, into the field with you. Wrap copies of the tables in clear plastic packaging tape to protect them from the rain.
3. **Do I need to find the midpoint of the tangent-to-tangent arc, and, if so, how do I do that?** It's nice, but not critical, to locate that point. Stand at the radius point and shoot a level line (0 percent) to the trail centerline. (See figure 1.)
4. **The centerline excavation depth and the trench depth are different, and the centerline depth varies with the width of the tread while trench depth does not. As a construction control, it would be good to mark the start-of-runout (full arc) stake with one or the other, or perhaps both—so how do I calculate those depths?** The simple answer is don't, because it's too much math to fiddle with in the field. Instead, use tables 5a through 5d below (take them with you). The best method is to use a centerline stake and also set an outer-tread-margin stake. Mark the outer-tread-margin stake with "trench" and the depth. If you use only a centerline stake, mark it with "CL exc." and the depth. For reconstruction, mark the offset distance in a circle at the top of the stake (figure 5). It is poor practice to use only an outer-tread-margin stake marked with trench depth.

Table 5a—Trench and centerline excavation depths for 15 percent sideslope.

Turn radius (feet)	**Trench depth at tread margin** (feet)	**Centerline excavation at tread width** (feet)						
		2	**2.5**	**3**	**4**	**5**	**6**	**8**
8	0.4	0.5	0.5	0.6	NA	NA	NA	NA
10	0.4	0.6	0.6	0.7	0.7	NA	NA	NA
15	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.2
20	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4
25	1.0	1.1	1.2	1.2	1.3	1.3	1.4	1.6
30	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.7

Table 5b— Trench and centerline excavation depths for 20 percent sideslope.

Turn radius (feet)	**Trench depth at tread margin** (feet)	**Centerline excavation at tread width** (feet)						
		2	**2.5**	**3**	**4**	**5**	**6**	**8**
8	0.9	1.1	1.1	1.2	NA	NA	NA	NA
10	1.1	1.3	1.3	1.4	1.5	NA	NA	NA
15	1.6	1.8	1.9	1.9	2.0	2.1	2.2	2.4
20	2.2	2.4	2.4	2.5	2.6	2.7	2.8	3.0
25	2.7	2.9	3.0	3.0	3.1	3.2	3.3	3.5
30	3.3	3.5	3.6	3.6	3.7	3.8	3.9	4.1

Table 5c— Trench and centerline excavation depths for 25 percent sideslope.

Turn radius (feet)	**Trench depth at tread margin** (feet)	**Centerline excavation at tread width** (feet)						
		2	**2.5**	**3**	**4**	**5**	**6**	**8**
8	1.6	1.9	1.9	2.0	NA	NA	NA	NA
10	2.0	2.3	2.3	2.4	2.5	NA	NA	NA
15	3.0	3.3	3.4	3.4	3.6	3.7	3.8	4.1
20	4.1	4.4	4.4	4.5	4.6	4.7	4.9	5.1
25	5.1	5.4	5.4	5.5	5.6	5.7	5.9	6.1
30	6.2	6.4	6.5	6.6	6.7	6.8	6.9	7.2

Table 5d— Trench and centerline excavation depths for 30 percent sideslope.

Turn radius (feet)	Trench depth at tread margin (feet)	Centerline excavation at tread width (feet)						
		2	2.5	3	4	5	6	8
8	2.4	2.7	2.8	2.8	NA	NA	NA	NA
10	3.0	3.3	3.4	3.4	3.6	NA	NA	NA
15	4.5	4.8	4.9	5.0	5.1	5.3	5.4	5.7
20	6.0	6.3	6.4	6.5	6.6	6.8	6.9	7.2
25	7.5	7.8	7.9	8.0	8.1	8.3	8.4	8.7
30	9.1	9.4	9.4	9.5	9.7	9.8	10.0	10.3

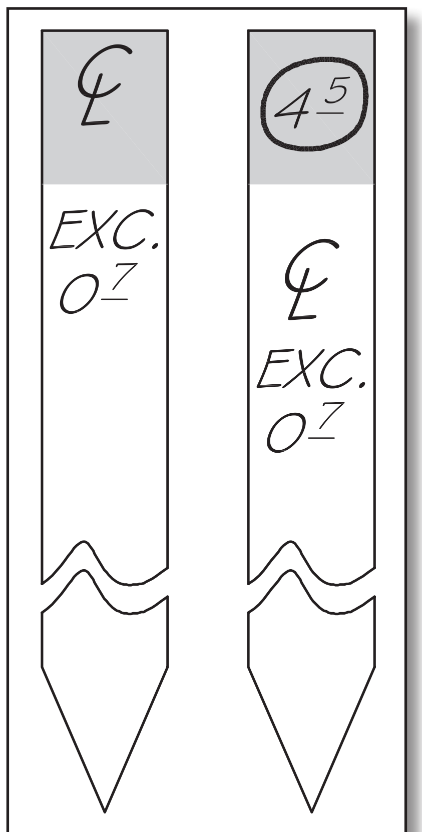

Figure 5.

Walls and Barriers

Climbing turns have the advantage over switchbacks in that the trail legs entering and leaving the turn are fairly well separated, somewhat reducing the temptation to shortcut the turn. But as the turn radius decreases below 20 feet, this advantage wanes, and placing physical barriers like boulders or logs between the legs may be necessary. On very short-radius turns in less stable soils, it may even be necessary to construct a rock or timber retaining wall in the lower turn backslope to support the upper turn tread margin and further discourage shortcutting. Such walls can also be used in the upper turn backslope to reduce the upslope reach of the backslope cut on steeper sideslopes.

—Adapted courtesy of Alaska Trails at http://alaska-trails.org

Rolling Dips for Drainage of OHV Trails

Rolling Dips for Drainage of OHV Trails

prepared for

USDA-Forest Service, Pacific Southwest Region

by

Roger Poff

R. J. Poff & Associates, Nevada City, CA

under

Natural Resources Professional Services Contract 53-91S8-NRM11

North State Resources, Inc., Redding, CA, Prime Contractor

January, 2006

INTRODUCTION

This report contains a set of drawings of OHV rolling dips for erosion control on off-highway-vehicle (OHV) trails. The report includes specifications for rolling dips suitable for use on motorcycle, ATV, and 4x4 trails. In addition to the drawings, the report includes general instructions on the location and installation of rolling dips. A draft of the drawings and specifications was reviewed by Cam Lockwood, Don Trammell, and Keith Ginn of Trails Unlimited. Their recommended modifications have been incorporated into the final drawings. This report was prepared under contract 53-9S8-04-NRM11, North State Resources, Inc., prime contractor.

TRAIL DRAINAGE

The importance of controlling runoff from OHV trails cannot be underestimated. Soil erosion on OHV trails is a major cause of tread loss, and sediment from eroded trails is a threat to water quality. The goal is to maintain OHV trails in a condition that will allow their continued recreational use without impacts to resources, including water quality. The purpose of trail drainage structures is to disperse runoff water before it concentrates and develops the energy to erode soils.

Providing drainage on OHV trails is not the same as providing drainage on roads, although the basic principles are the same. Compared to OHV trails, roads generally have a wider prism, are less steep, and have a well-compacted running surface. Runoff from roads generally contains less sediment and has more power to erode. Roads are typically drained by outsloping, crowning, or insloping with inside ditches and cross drains. These drainage methods are not practical for most OHV trails.

Compared to roads, OHV trails are typically narrower, steeper, and unsurfaced, and produce runoff that is high in sediment. Outsloping is not effective on OHV trails, and inside ditches and cross drains are rarely used. Although OHV trails produce less runoff per unit length than roads (trails are narrower), OHV trails do require more frequent drainage. This is in part because OHV trails are steeper, and because traffic tends to loosen the tread, making runoff more sediment-laden.

DEVELOPMENT OF OHV ROLLING DIPS

Many OHV trails were not originally designed for OHV traffic, but were constructed as logging roads, ranch roads, skid trails, fire lines, fuel breaks, mining roads, etc. Because of this history, trail alignment and gradient are often less than ideal for OHV use. Existing drainage structures that may have been suitable for the original purpose are usually not suitable for OHV traffic. The main problem with these inherited trails is that they do not roll the grade to allow frequent diversion of water from the trail. When trails are specifically designed for OHV use, rolling the grade is built into the alignment to providing drainage and avoid long, sustained grades. Old roads converted to OHV trails are difficult to drain because of their long, sustained gradients.

Initially, OHV trails were drained with waterbars, structures commonly used to divert runoff on skid trails and logging roads. While waterbars work well where there is occasional or no traffic, they can not withstand OHV traffic. OHV traffic tends to cut through waterbars, causing them to fail.

Over time, OHV managers began to alter the design of the typical waterbar so it could withstand the wear of OHV traffic. The angle of the waterbreak was changed to be more perpendicular to the trail; the height was increased; the profile elongated; and the length greatly increased. These modifications allowed OHVs to ride up and over the drainage structure rather than cut through it. At the same time, more attention was paid to compacting the core of the structure to make it more resistant to the wear of OHV traffic. The specifications in this report represent the result of more than 20 years of incremental changes made through trial and error.

Technical Guidance

There is a common misconception that outsloping can be used to drain OHV trails. Outsloping can be a good drainage strategy on many types of roads, and even on some types of 4x4 trails, but outsloping is not effective on OHV trails. This is because OHV traffic very quickly causes a berm to build up on the outside edge of a trail, preventing the flow of water off to the side and forcing the flow down the trail. Trail gradient is also a factor. Outsloping only works when the outslope gradient is at least as great as the trail gradient. Even on roads, this limits the application of outsloping to fairly gentle gradients, usually less than 6 percent. OHV trails typically have gradients greater than this.

OHV ROLLING DIPS FOR MOTORCYCLE AND ATV TRAILS

This report includes drawings of drainage structures for three types of trails: (1) single-track motorcycle trails, (2) ATV trails, and (3) 4x4 trails and primitive roads. The OHV rolling dip is designed primarily for use on single-track motorcycle and ATV trails. The drain dip is designed for use on 4x4 trails and primitive roads.

Plan and profile drawings and oblique views are provided for the following OHV trails:

- Figure 1A. ATV Trail, 8%, 6-foot tread, plan and profile views
- Figure 1B. ATV Trail, 8%, 6-foot tread, oblique view
- Figure 2A. ATV Trail, 20%, 6-foot tread, plan and profile views
- Figure 2B. ATV Trail, 20%, 6-foot tread, oblique view
- Figure 3A. Motorcycle Trail, 8%, 2-foot tread, plan and profile views
- Figure 3B. Motorcycle Trail, 8%, 2-foot tread, oblique view
- Figure 4A. Motorcycle Trail, 20%, 2-foot tread, plan and profile views
- Figure 4B. Motorcycle Trail, 20%, 2-foot tread, oblique view
- Figure 5. Drain Dip, for use on 4x4 trails and primitive roads

The drawings and specifications shown at 8% are for trails with gradients that range from 0 to15%. The drawings and specifications shown at 20% are for trails with gradients that range from 15 to 25%.

The specifications incorporate the features that a properly constructed OHV rolling dip should include, but will usually need fine-tuning to fit the landscape at each specific location. The dimensions in the profile and plan sketches are strongly recommended, but may also need modification for specific sites. Specific dimensions will vary with the location, trail gradient, and type and speed of the OHV traffic.

OHV Rolling Dips vs. Waterbars

A few features stand out when comparing OHV Rolling Dips to the typical waterbars they evolved from:

- *Length* The structures are much longer than a typical waterbar. The increased length allows OHV traffic to flow up and over the structure without cutting through it.
- *Height* The height of the structure is greater than most waterbars. This allows some wear to take place between maintenance intervals. The increased height is also needed to get an effective grade reversal on trails with steeper gradients.
- *Angle* The angle across the trail has been reduced to about 5 degrees. This also allows a smoother flow of OHV traffic up and over the structure.
- *Compaction* The core of the structure is compacted during construction. A typical waterbar is cut into firm soil, and the loose soil piled up behind it. It is the cut below grade into firm soil that

diverts water. In OHV rolling dips, the compacted core and the reverse grade of the structure itself is also important in diverting water.

- *Sediment trap* Waterbars and other drainage structures on roads typically have lead-off ditches at the outlets to disperse runoff. Road runoff is fairly clean and erosive. Rather than a long lead-off ditch, the OHV rolling dip has a small sediment trap at the outlet. Runoff from trails is often heavily sediment-laden. The sediment trap allows soil eroded from the trail tread to be recycled into the tread or structure during maintenance.

Soil Compaction

The core of the rolling dip needs to be compacted to the maximum extent possible to resist the wear of OHV traffic. A well-compacted OHV rolling dip also requires less frequent maintenance. To get maximum compaction, soils need to be moist during construction and maintenance. Compaction is achieved by adding moist soil in small lifts and making repeated passes over it with a trail tractor. Additional information on relationships between soil moisture and compaction and how to achieve the maximum compaction in the core of the rolling dip structure is provided in the final section "Soil Moisture and Compaction" and in Table 1.

OHV Traffic

The type of OHV traffic and its speed affect the design of OHV rolling dips. Dips should be shaped so OHVs are either in the air when they cross the top of the dip, or at least cross it with less ground pressure without spinning or digging into the structure.

The shape of the apex of the mound portion of the rolling dip affects how OHVs will ride over it. A 5 degree shoulder at the top will smooth out the traffic flow and reduce wear on the top of the structure. Sketch 1 illustrates correct and incorrect profiles at the apex of rolling dip.

Sediment Traps

It may not be possible to install a sediment trap at every OHV rolling dip, but sediment traps should be installed wherever possible. The purpose of the sediment trap is to capture eroded soil and recycle it back into the trail and/or drainage structure during maintenance. Any soil not recaptured is permanently lost from the tread and reduces the useful operating life of the trail.

Gradient Limitations

The rolling dips shown in the diagrams will not work on trails with gradients greater than about 25 to 30 percent. On gradients steeper than this, the approaches and transitions of adjacent OHV rolling dips begin to merge. Also, as the gradient increases, the height necessary to create a grade reversal oversteepens the downhill approach.

DRAIN DIPS FOR 4X4 TRAILS

OHV traffic is generally slower on 4x4 trails and primitive roads. The structure type that is most effective for draining 4x4 trails and primitive roads is the Drain Dip (Figure 5). This structure is also designed to allow a smooth flow of traffic. Drain dips are often used in conjunction with outsloping and rolling the grade. Challenging or highly technical 4x4 trails rarely have constructed drainage structures. Instead, drainage is provided by rolling the grade, making frequent grade reversals, keeping steep trail segments short, and choosing an alignment that takes advantage of landscape features such as ridgelines or hard bedrock.

SPACING AND LOCATION

There is no “cookbook” rule for spacing drainage structures on OHV trails. Drainage does need to be provided frequently enough to disperse water before it can concentrate and cause erosion. Actual spacing depends on trail gradient, amount and type of OHV traffic, runoff from adjacent slopes, and soil type. On most trails drainage is needed every 100 to 200 feet, but closer spacing is necessary on steeper slopes. The location of drainage structures is usually more important than the spacing.

Drainage should be provided as frequently as possible, particularly on landscapes with shallow soils that have a low capacity for absorbing additional runoff. Drainage is also needed on approaches to watercourse crossings. Natural breaks in grade should be used to locate drainage structures whenever possible.

Three factors are important in drainage location: (1) where drainage is needed, (2) what the runoff will be dispersed onto and (3) how the flow of OHV traffic is affected. Where trails include steep sections, drainage is needed at the top, just before the slope break. The diverted runoff, whether through a drainage outlet or into a sediment trap, should be onto soils with the capacity to absorb the runoff energy.

Climbing switchbacks are challenging to drain. Drainage is needed just above and before the turn, but water drained at this location could run onto the trail below, which should be avoided. Making sure there is enough filtering capacity between the drainage outlet and the trail below is important. Providing drainage on sweeping turns also has it challenges. These are just examples of why location is more important than a set spacing interval.

When locating OHV rolling dips, it is important to evaluate the site, determine where diverted runoff will flow, and analyze how the drainage structure will affect the flow of OHV traffic.

MAINTENANCE

The rolling dips described in this report, if properly constructed, can remain functional for 3-5 years before needing maintenance, even on trails with heavy OHV traffic.

SOIL MOISTURE AND SOIL COMPACTION

In order to have the strength to resist the wear of OHV traffic, OHV rolling dips must be compacted. The degree of compaction that can be achieved during construction is a function of soil moisture content. This section explains how soil moisture affects soil compaction, and describes some simple field observations that can be used to determine when soils are sufficiently moist for construction or maintenance.

Basic Principles of Soil Compaction

Soil compaction is a process whereby soil strength and density are increased by reducing soil pore space, essentially squeezing the air out of the soil. Soil is most easily compacted when soils are moist and pores are partially filled with water. Under these conditions the fine pores contain enough water to reduce internal friction, but the coarse pores are empty and compressible. When a load is applied, soil particles are rearranged and packed tightly. This increases soil density and soil strength, and increases resistance to the wear of OHV traffic.

When soils are wet, or nearly saturated, soil strength is very low. Compaction does not occur under these conditions because nearly all soil pores are filled with water and water is not readily compressed. When a load is applied to saturated soils a form of displacement called puddling occurs. This is similar to squeezing toothpaste from a tube. Puddling destroys soil structure, and although puddled soils may increase in density as they dry out, puddled soils do not have the strength of compacted soils.

When soils are dry, soil strength is high. Dry soils are difficult to compact because particle bonding is strong and there is insufficient moisture to lubricate soil particles and facilitate packing. Mechanical disturbance of dry soils destroys soil structure and shatters compacted soils. After disturbance, dry soils cannot be recompacted as long as they remain dry, and additional disturbance merely displaces the soil.

Field tests For Soil Moisture

To determine whether soils are moist enough to compact, simply take a handful of soil and squeeze it, trying to mold it into a ball. If squeezing reduces the volume of soil, and a ball can be formed that holds together when handled, the soil is sufficiently moist to compact. If the volume of soil cannot be reduced, and a ball cannot be formed, or if the soil separates when pressure is released, the soil is too dry to compact. If water or wet soil oozes from between the fingers when the soil is squeezed, the soil is too wet to compact.

The moisture content at which compaction will occur varies by soil type. Soil particle size distribution, or soil texture, affects the range of moisture content within which compaction will occur. Where the clay content is high, compaction occurs over a wide range of soil moisture; where the clay content is low, compaction occurs within a narrow range of soil moisture. Table 1 describes by soil texture groups some indicators of soil moisture levels at which compaction will occur.

Moisture Variability

When determining whether a trail segment has sufficient moisture for construction or maintenance activities, examine soil moisture at several locations and depths. Under field conditions, soil moisture varies by soil type, with depth, from place to place along a trail, and even from place to place within a single drainage structure. Aspect, elevation, vegetative type, shading, and surface drainage all affect soil moisture content.

Adding Water

Soils thoroughly moistened by rainfall or snowmelt generally provide the best conditions for trail maintenance. However, situations may occur where maintenance is needed, but where soils are too dry to compact. If water is available, the soil may be artificially moistened to facilitate compaction. However, it is important to bring all the soil that will be used for construction up to the proper moisture content before grading and compaction. Moist soil should be added to drainage structures in small lifts before compacting it. Wetting down structures that have already been constructed with dry soil will not result in compaction or an increase in soil strength.

Assessing Results

Observing how equipment interacts with the soil can indicate how well the soil is being compacted. Equipment tracks without berms indicate compaction is taking place; berms of soil along tracks indicate displacement.

The effectiveness of soil compaction can be tested in the field with a simple T-handle probe constructed of 3/8-inch rebar. The force needed to push the probe into the soil is an indicator of soil strength. Comparing the resistance to penetration between the compacted rolling dip and a nearby compacted trail tread can indicate how well the rolling dip has been compacted.

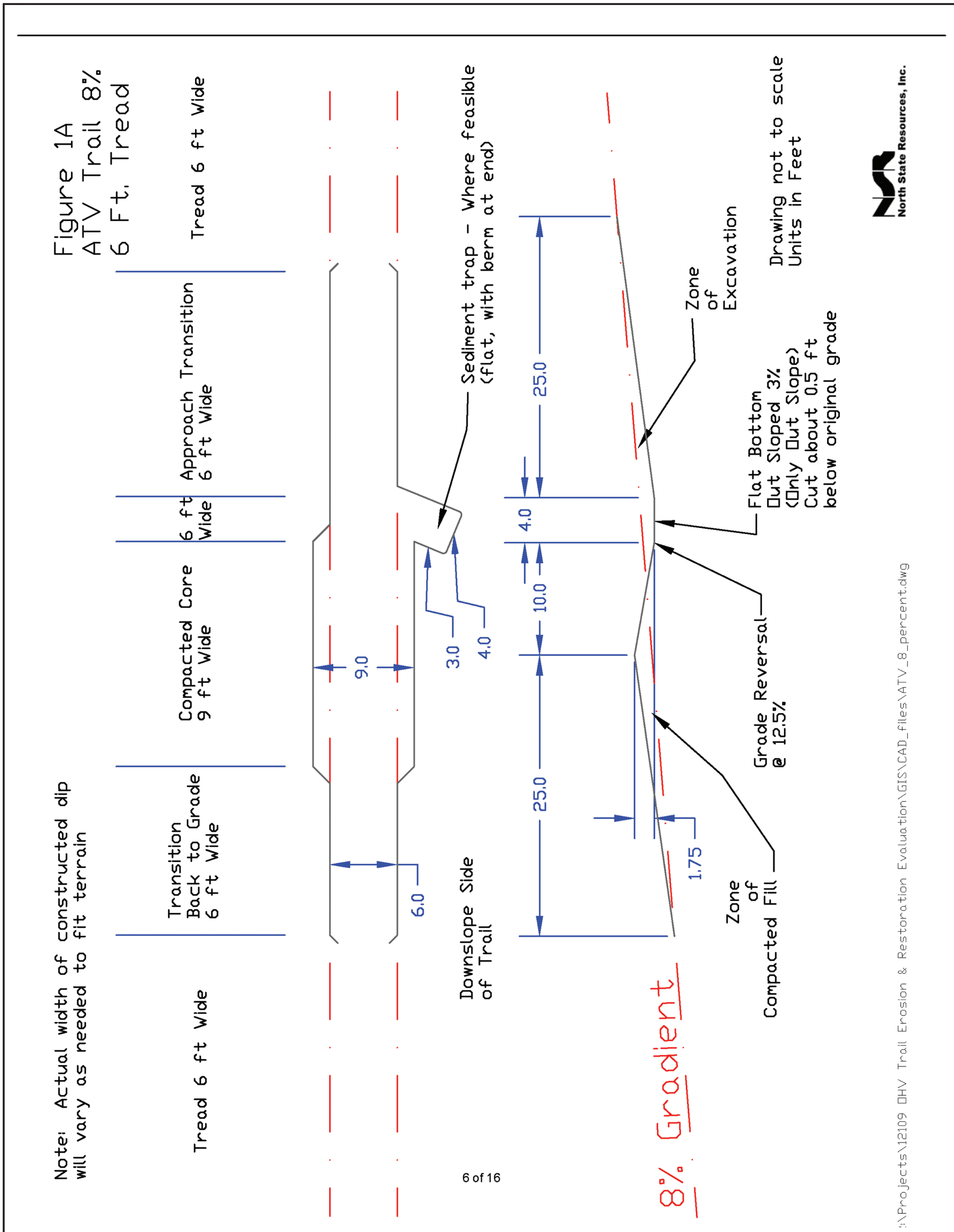
Figure 1A
ATV Trail 8%
6 Ft, Tread
Note: Actual width of constructed dip will vary as needed to fit terrain
Tread 6 ft Wide
Transition Back to Grade 6 ft Wide
Compacted Core 9 ft Wide
6 ft Wide
Approach Transition 6 ft Wide
Tread 6 ft Wide
6.0
9.0
3.0
4.0
Sediment trap - Where feasible (flat, with berm at end)
Downslope Side of Trail
25.0
10.0
4.0
25.0
1.75
8% Gradient
Zone of Compacted Fill
Grade Reversal @ 12.5%
Flat Bottom Out Sloped 3% (Only Out Slope) Cut about 0.5 ft below original grade
Zone of Excavation
Drawing not to scale
Units in Feet
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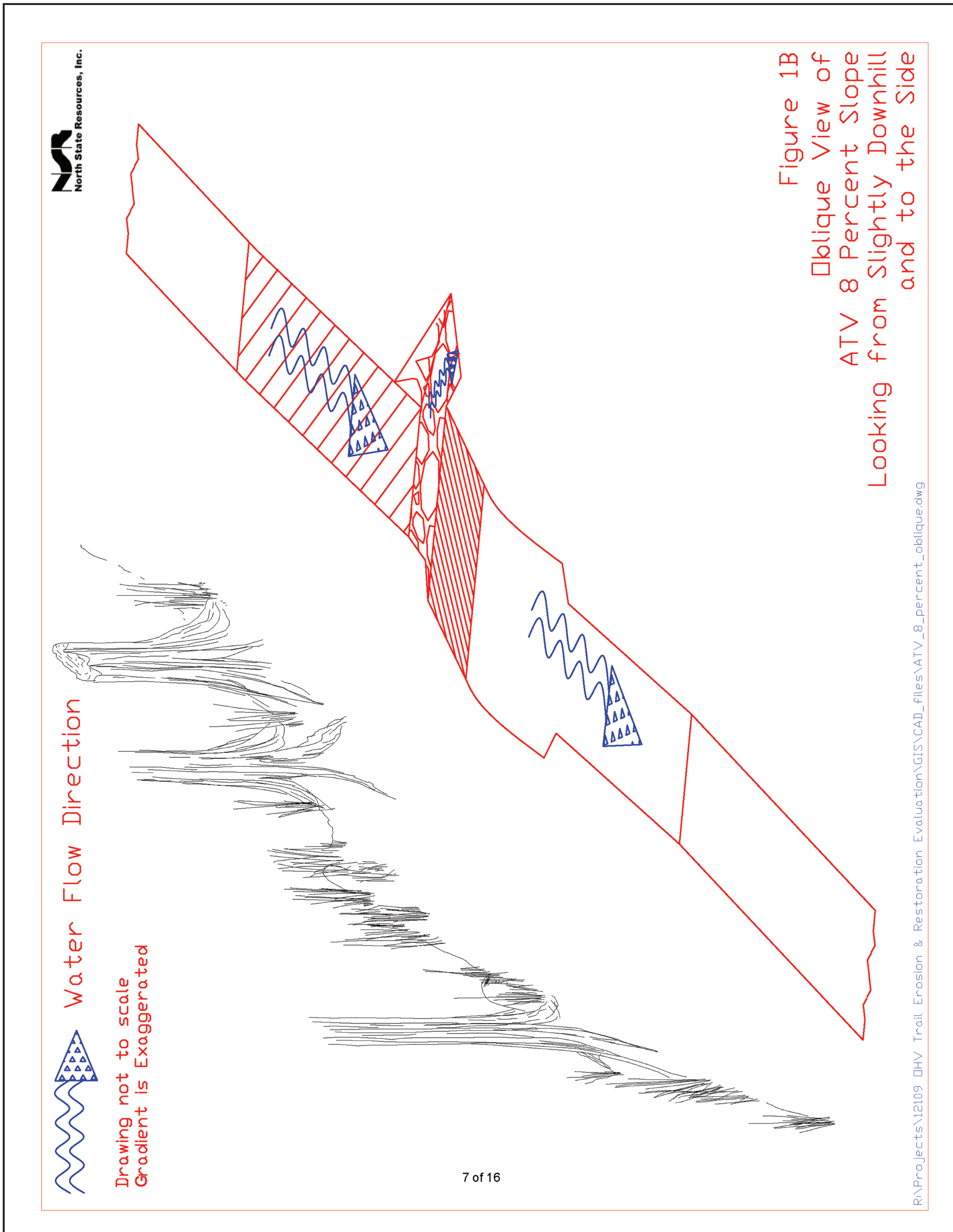
North State Resources, Inc.
Figure 1B
Oblique View of
ATV 8 Percent Slope
Looking from Slightly Downhill
and to the Side
Water Flow Direction
Drawing not to scale
Gradient is Exaggerated
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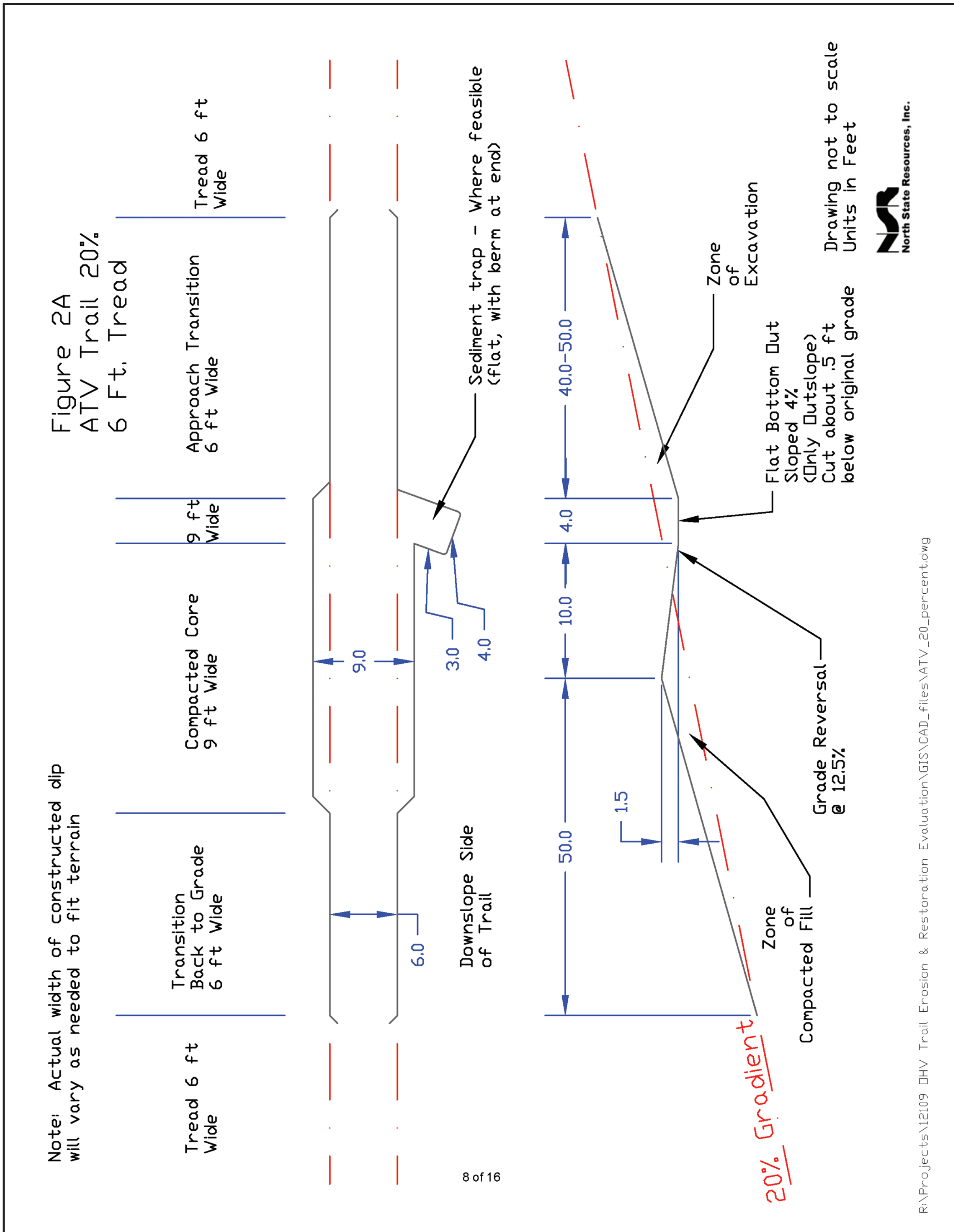
Figure 2A
ATV Trail 20%
6 Ft. Tread
Note: Actual width of constructed dip will vary as needed to fit terrain
Tread 6 ft Wide
Transition Back to Grade 6 ft Wide
Compacted Core 9 ft Wide
9 ft Wide
Approach Transition 6 ft Wide
Tread 6 ft Wide
6.0
9.0
3.0
4.0
Downslope Side of Trail
Sediment trap - Where feasible (flat, with berm at end)
50.0
10.0
4.0
40.0-50.0
1.5
20% Gradient
Zone of Compacted Fill
Grade Reversal @ 12.5%
Flat Bottom Out Sloped 4% (Only Outslope) Cut about .5 ft below original grade
Zone of Excavation
Drawing not to scale
Units in Feet
North State Resources, Inc.
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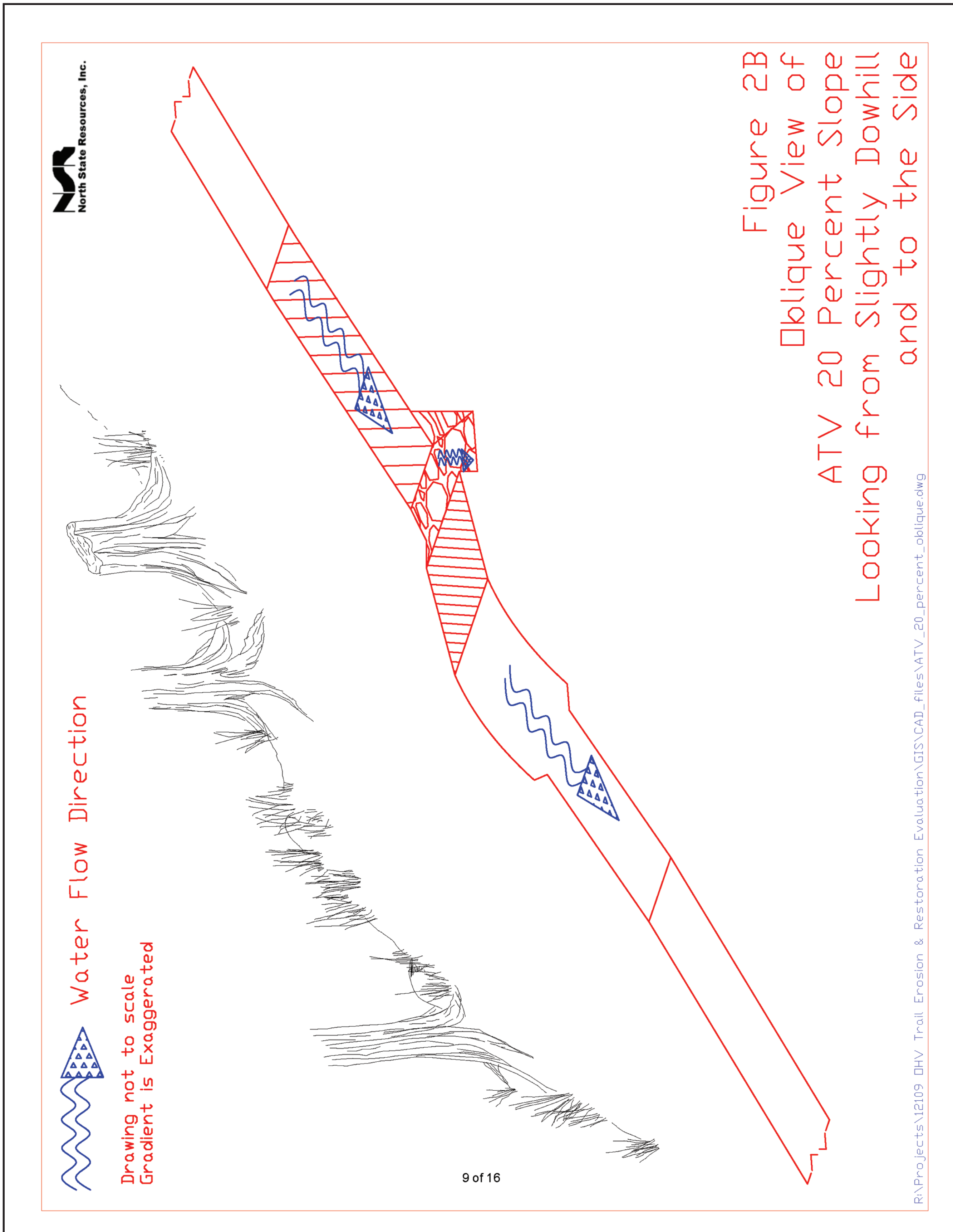
8 of 16


North State Resources, Inc.
Figure 2B
Oblique View of
ATV 20 Percent Slope
Looking from Slightly Dowhill
and to the Side
Water Flow Direction
Drawing not to scale
Gradient is Exaggerated
9 of 16
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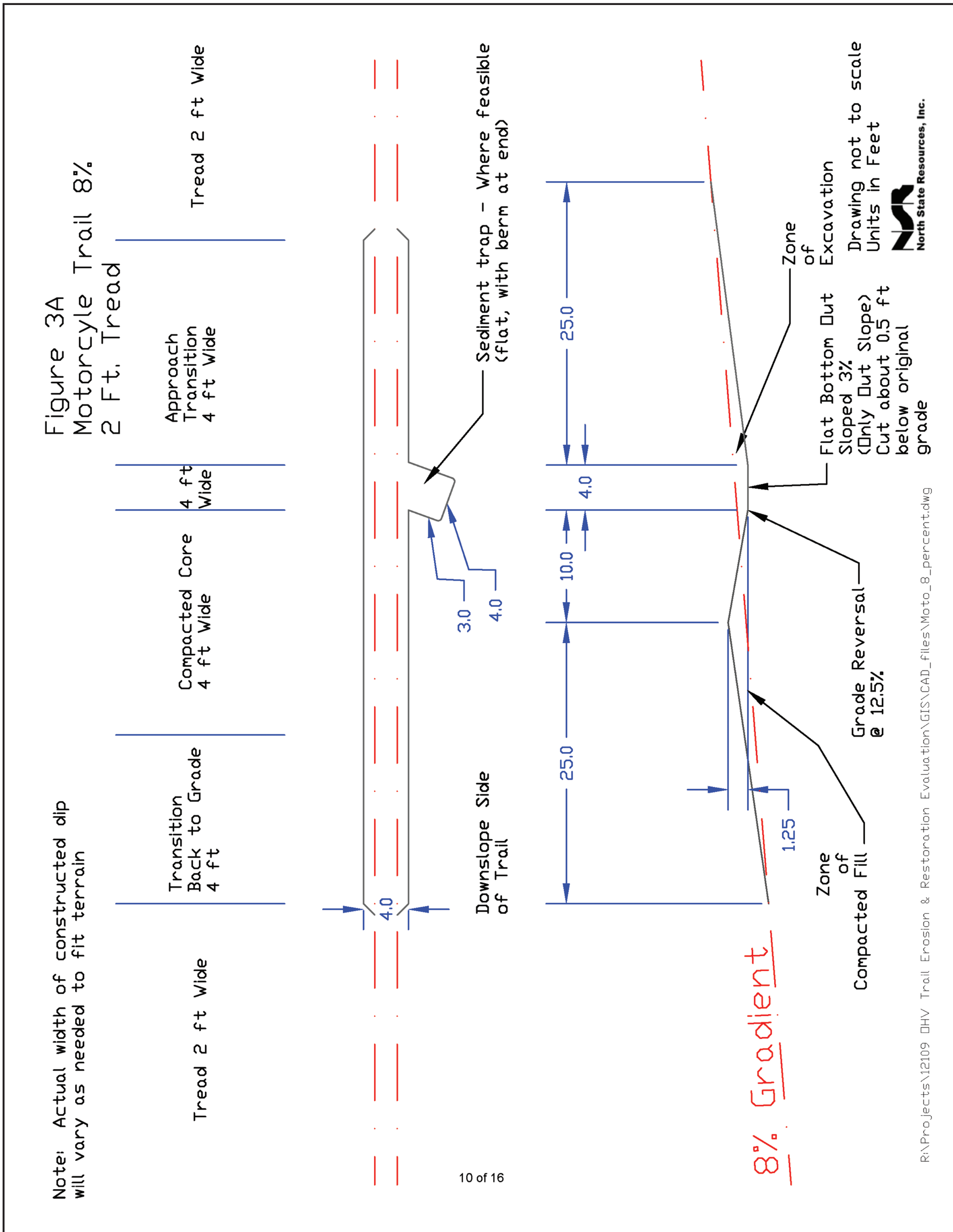
Figure 3A
Motorcycle Trail 8%
2 Ft. Tread
Note: Actual width of constructed dip will vary as needed to fit terrain
Tread 2 ft Wide
Transition Back to Grade 4 ft
Compacted Core 4 ft Wide
4 ft Wide
Approach Transition 4 ft Wide
Tread 2 ft Wide
4.0
3.0
4.0
Downslope Side of Trail
Sediment trap - Where feasible (flat, with berm at end)
25.0
10.0
4.0
25.0
1.25
8% Gradient
Zone of Compacted Fill
Grade Reversal @ 12.5%
Flat Bottom Out Sloped 3% (Only Out Slope) Cut about 0.5 ft below original grade
Zone of Excavation
Drawing not to scale
Units in Feet
North State Resources, Inc.
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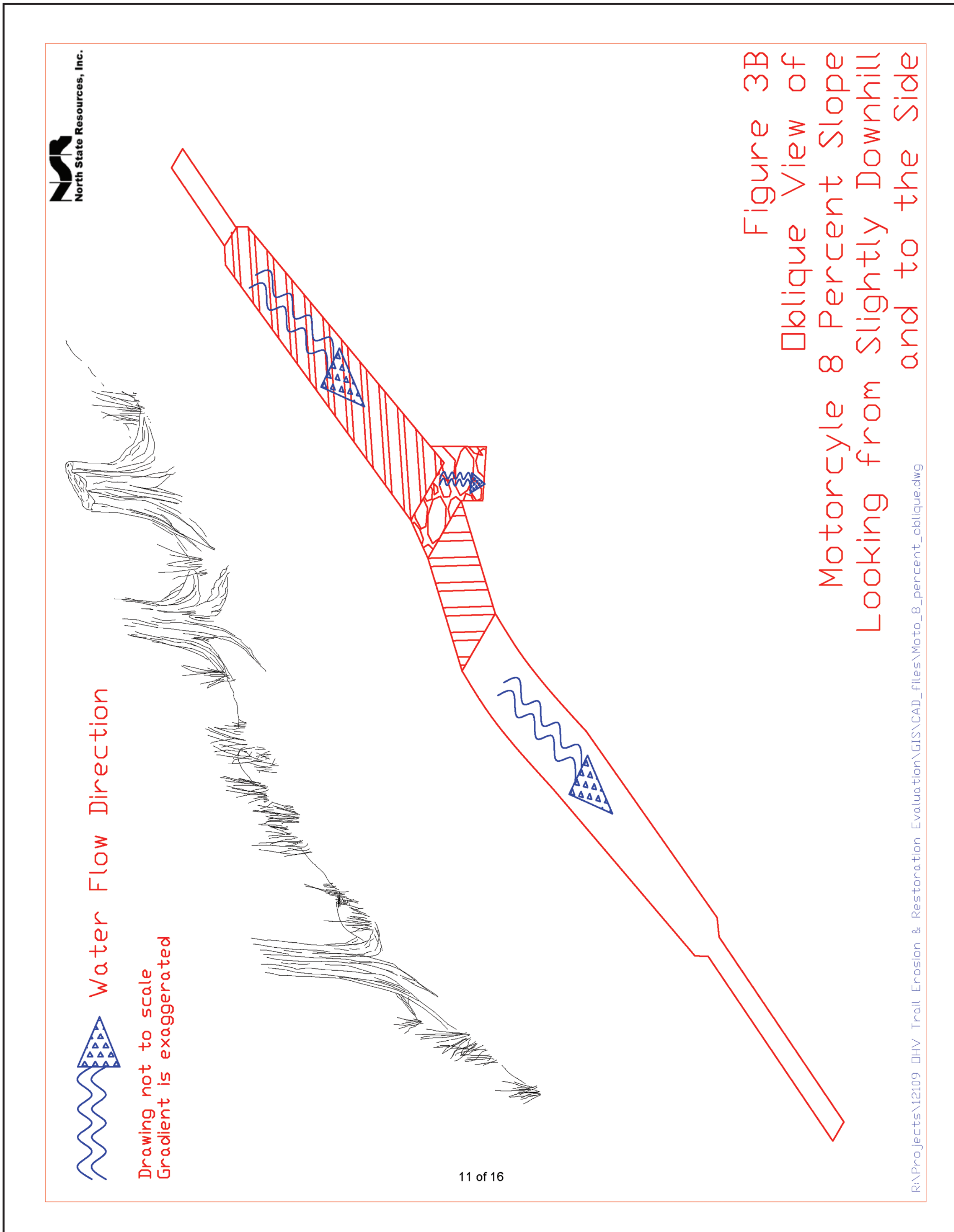
10 of 16


North State Resources, Inc.
Figure 3B
Oblique View of
Motorcyle 8 Percent Slope
Looking from Slightly Downhill
and to the Side
Water Flow Direction
Drawing not to scale
Gradient is exaggerated
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11 of 16

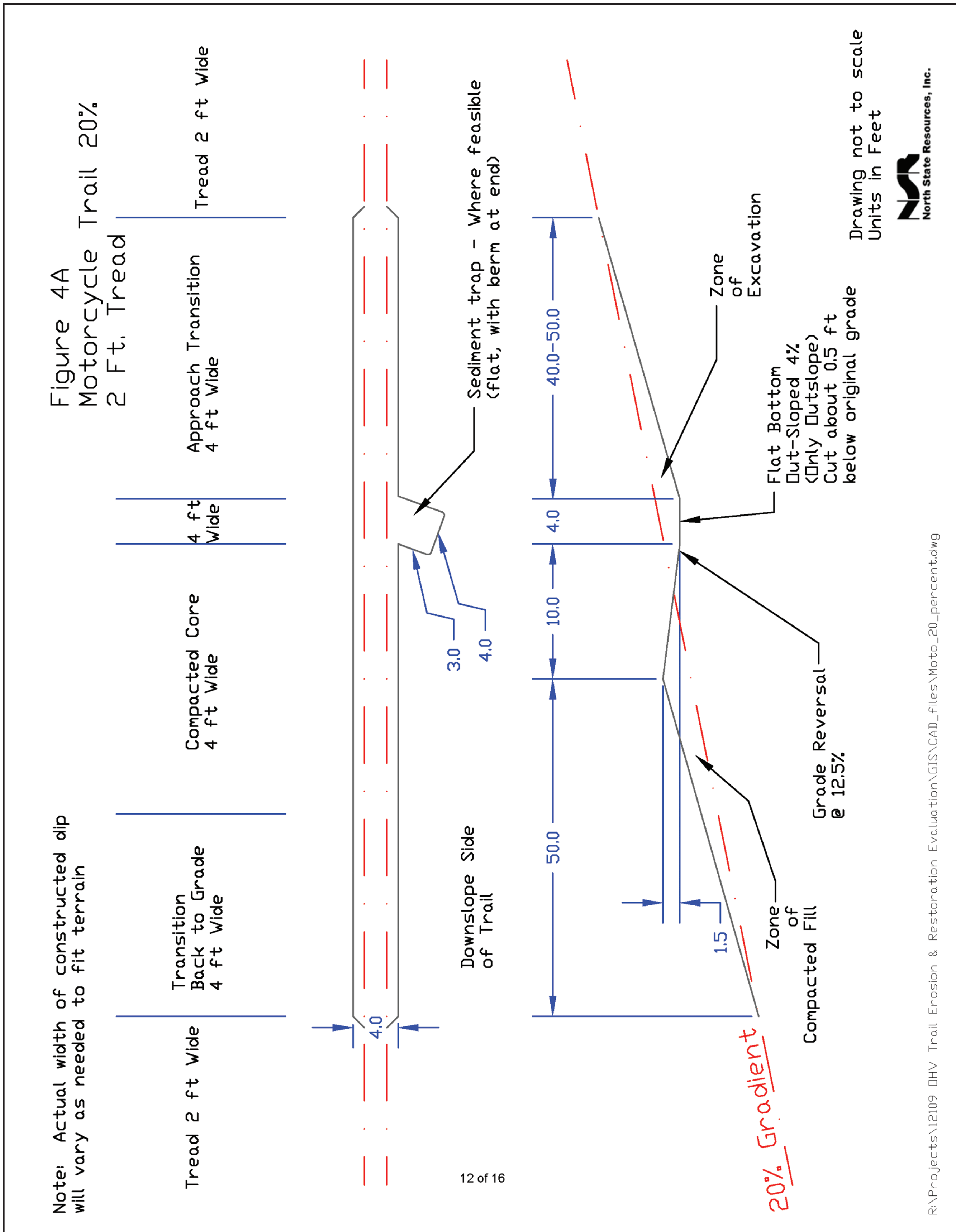
Figure 4A
Motorcycle Trail 20%
2 Ft. Tread
Note: Actual width of constructed dip
will vary as needed to fit terrain
Tread 2 ft Wide
Transition
Back to Grade
4 ft Wide
Compacted Core
4 ft Wide
4 ft
Wide
Approach Transition
4 ft Wide
Tread 2 ft Wide
4.0
Sediment trap - Where feasible
(flat, with berm at end)
3.0
4.0
Downslope Side
of Trail
50.0
10.0
4.0
40.0-50.0
1.5
20% Gradient
Zone
of
Compacted Fill
Grade Reversal
@ 12.5%
Flat Bottom
Out-Sloped 4%
(Only Outslope)
Cut about 0.5 ft
below original grade
Zone
of
Excavation
Drawing not to scale
Units in Feet
North State Resources, Inc.
12 of 16
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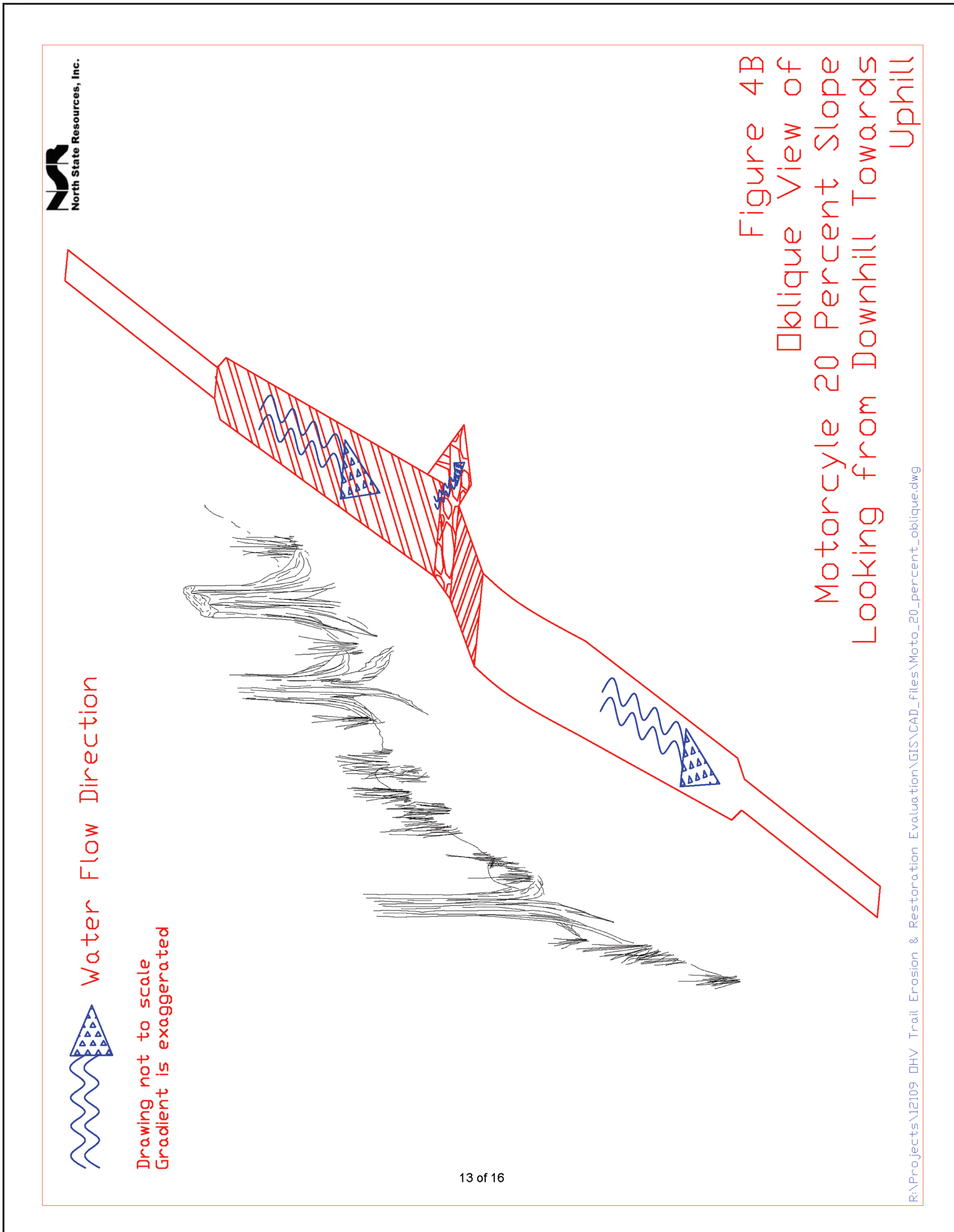
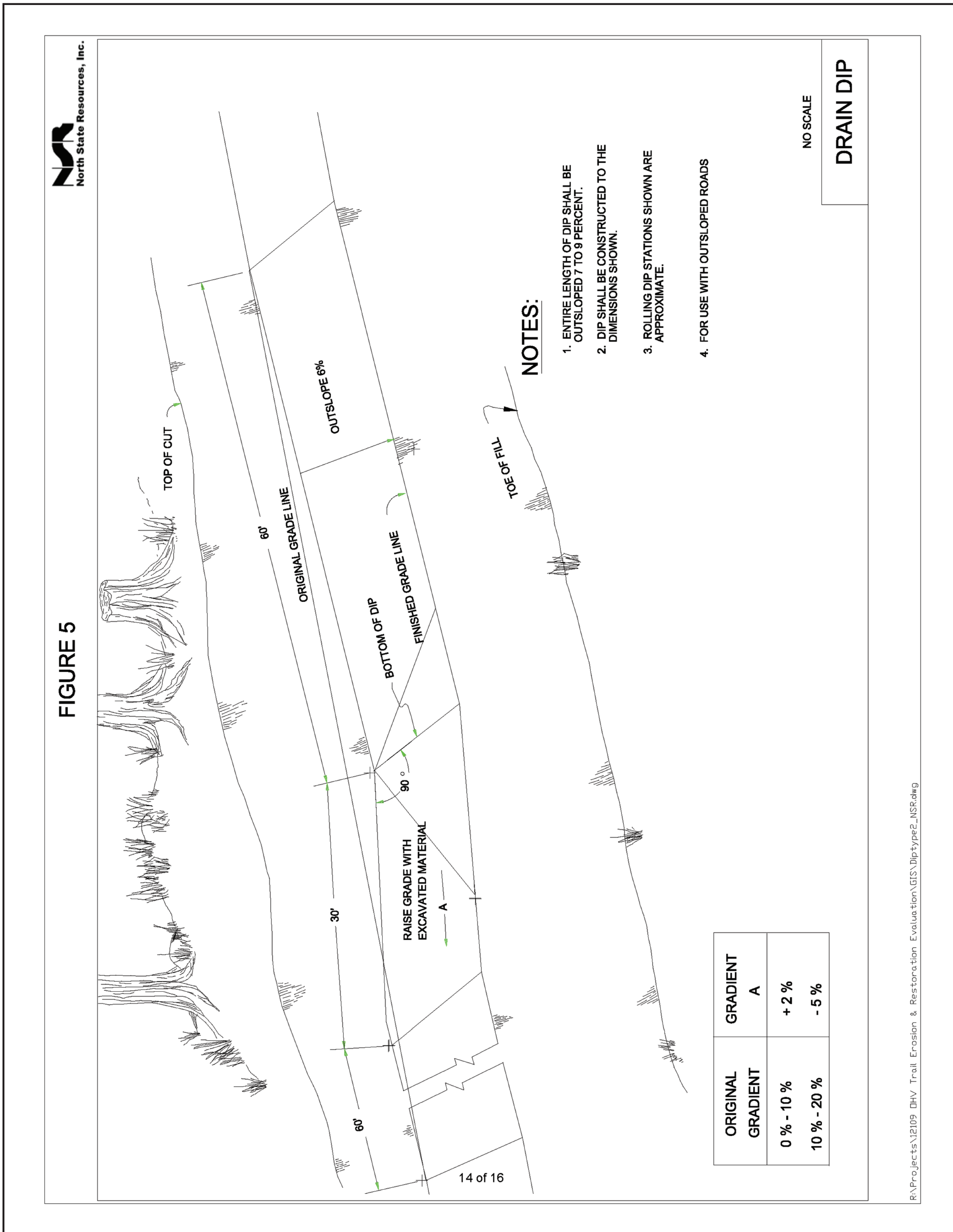

North State Resources, Inc.
Figure 4B
Oblique View of
Motorcyle 20 Percent Slope
Looking from Downhill Towards
Uphill
Water Flow Direction
Drawing not to scale
Gradient is exaggerated
13 of 16
R:\Projects\12109 OHV Trail Erosion & Restoration Evaluation\GIS\CAD_files\Moto_20_percent_oblique.dwg



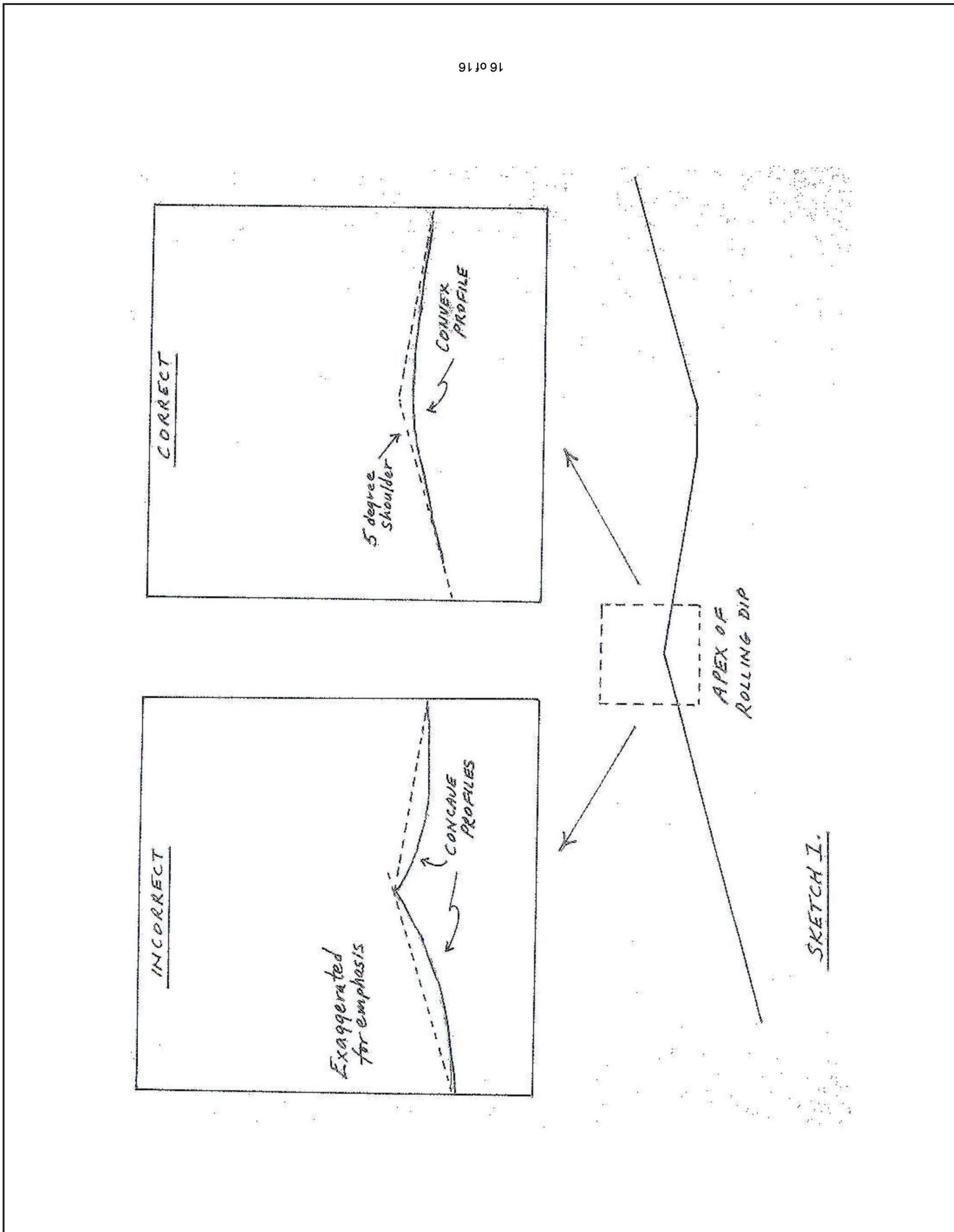
ORIGINAL GRADIENT	GRADIENT A
0 % - 10 %	+ 2 %
10 % - 20 %	- 5 %

Table 1 Field indicators of soil moisture contents suitable for compaction, by soil texture groups

Soil Moisture Content	Coarse Soils*	Light Soils	Medium Soils <35% clay	Heavy Soils >35% clay
	Sands, Loamy Sands, and Very Coarse Sandy Loams	*Coarse, Medium, and Fine Sandy Loams*	*VF Sandy loam, Loam, Silt Loam, Sandy Clay Loam, Light Clay Loam*	*Heavy Clay Loam, Silty Clay Loam, Sandy Clay, Clay*
Dry	loose, single grained; flows through fingers	loose; flows through fingers	powdery; sometimes slightly crusted but breaks down into powder	hard, baked, cracked; sometimes has loose crumbs on surface
Slightly Moist	still appears dry; will not form a ball with pressure	still appears dry; will not form a ball with pressure	somewhat crumbly, but ball holds together after release	somewhat pliable; forms a ball under pressure
Moist	still appears dry, will not form a ball with pressure	tends to form ball with pressure, but ball seldom holds together	forms a ball and is very pliable; slicks readily if high in clay	easily ribbons out between fingers; has a slick feeling
Very Moist	tends to stick together slightly; sometimes forms a very weak ball	forms a weak ball with pressure; ball breaks easily; will not slick	forms a ball and is very pliable; slicks readily if high in clay	easily ribbons out between fingers; has a slick feeling
Wet	free water may appear on squeezing; wet outline is left on hand	free water may appear on squeezing; wet outline is left on hand	can squeeze out free water; wet outline is left on hand	puddles and free water forms on surface; wet outline is left on hand

(dark grey)	moisture level suitable for compaction
(light grey)	moisture level marginally suitable for compaction
(white)	soil too dry or too wet for compaction

* Coarse soils cannot be compacted by force when moist; compaction requires vibration


16 of 16
CORRECT
5 degree shoulder
CONVEX PROFILE
INCORRECT
Exaggerated for emphasis
CONCAVE PROFILES
APEX OF ROLLING DIP
SKETCH I.

Appendix B: Trail Hardening

- **Trail Hardening 101**
- **Selected Trail-Hardening Methods**
- **Evaluation of OHV Trail-Hardening Methods**

Trail Hardening 101

The information in this appendix was developed by the author.

Definition

The modification of a trail tread surface by the replacement, capping, modification, integration, or addition of a natural or synthetic medium to improve tread characteristics, to reduce degradation, to mitigate impacts associated with trail use, or to increase tread utility and/or durability.

When To Harden a Trail

- When existing trail impacts are causing or may cause unacceptable onsite or offsite impacts; **and**
- Alternative trail locations are not available, **or**
- Alternative trail locations are not environmentally acceptable or economically feasible.

Alternatives to Trail Hardening

- Reroute to a better location.
- Manage use characteristics.
  - ✧ Control type of use.
  - ✧ Control volume and intensity of use.
  - ✧ Control season of use.
- Abandon or close the trail.

Sites Where Trail Hardening May Be Required

- Localized seep zones
- Sandy surface soils
- Clayey surface soils
- Shallow surface soils
- Alpine tundra crossings
- Ponded trail surfaces
- Flooded areas
- Flat terrain
- Ice-rich permafrost sites
- Overly steep trails
- Stream crossings and fords
- Bridge approaches
- Areas of heavy use
- Irregular surfaces
- Wet or saturated soils
- Entrenched trails
- Degraded trail segments
- Temporary access

Benefits of Trail Hardening

- Defines a single trail alignment for travel.
- Provides a stable, durable trail surface for traffic.
- Stabilizes surface soil conditions along the hardened trail alignment.
- Halts trail widening and braiding.
- Allows abandoned trail alignments to heal.

Some methods (such as porous pavement) may allow vegetation to regrow along the hardened trail alignment, reducing visual impacts, increasing stability, and improving habitat.

Methods of Trail Hardening

This information was developed by the author. For more detail, see "Selected Trail-Hardening Methods" in this appendix.

Author's trail hardening method	Corresponding Forest Service method	Forest Service standard trail plan and specifications reference number*	Trail construction specification
Gadbury bridge	No deck puncheon	934.20	Trail structure
Elevated boardwalk	Elevated boardwalk	938.20	Trail structure
Elevated puncheon	Standard puncheon	934.10	Trail structure
Ground contact boardwalk	Standard boardwalk	938.10	Trail structure
Ground contact puncheon	Standard puncheon	934.10	Trail structure
Running plank	NA	NA	NA
Corduroy	Corduroy	918.50	Foundation
Paver blocks	Grid unit surfacing	913.40	Surfacing
Porous pavement–unfilled cells	Geosynthetics	918.40	Foundation
Porous pavement–filled cells	Geosynthetics	918.40	Foundation
Porous pavement panels –geotrack configuration	Geosynthetics	918.40	Foundation
Gravel cap –with or without geotextile	Aggregate surfacing and base course	913.10	Surfacing
Cellular confinement systems	Geosynthetics	918.40	Foundation
Causeway	Type 1—standard turnpike	932.10	Trail structure
Turnpike or ditch and elevate	Type 1—standard turnpike Type 2—standard turnpike with foundation	932.10 and 932.20	Trail structure
Slot trench inversion	Underdrain	924.00	Drainage structure
Wood chips or chunkwood	Chunkwood surfacing	913.60	Surfacing

*Numbered references reflect the updated standard trail plans and specifications scheduled for publication in October 2012. More information is available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Trail-Hardening Selection Criteria

The following section describes seven situations where trail hardening is required. The text roughly follows the order in which the different methods should be considered based on increasing cost and the level of difficulty. The text presents the process an experienced trail manager might use when considering trail-hardening options for a degraded site.

Situation 1—The site requiring hardening is near the trail head.

If the area to be hardened is near the trail head (or other point of access) and gravel can be economically delivered, consider the following options:

- Gravel cap
- Gravel cap with geotextile (geotextile use depends on site conditions)
- Causeway

In general, gravel capping is the simplest and most cost-effective method of trail hardening for all types of use. Gravel is placed directly on the tread surface or over a geotextile fabric if there are deep bog holes, or gravel is placed on organic or saturated silt-rich soils. A causeway is simply a gravel cap confined by rock or wood curbing.

The effective use of gravel largely depends on having an efficient way to transport gravel to the hardening site. Gravel hauling operations decrease in efficiency the farther the treatment site is from the gravel source. Efficiency is affected by type and size of equipment used to transport gravel. For example, if standard highway-licensed vehicles can be used, high efficiency is expected because these vehicles are widely available. However, highway-licensed vehicles require a wide, firm, and durable trail surface to prevent secondary trail degradation issues. They also require developing turnaround points along the trail. On narrower trails, specialized tracked haulers, hopper-equipped skid steer loaders, ½- to 1-cubic-yard belly dump trailers, or all-terrain vehicle trailers must be used. Bucket dumping with a skid steer loader, livestock, or wheelbarrow also is an alternative. As the distance from the gravel source increases, the size of the load should increase to justify the time spent to deliver it. For instance, it is inefficient to deliver half a cubic yard of gravel farther than a quarter mile from the gravel source when capping a 5-foot-wide trail.

Using mechanical equipment is key to making a gravel hauling operation cost effective. But carrying a lot of gravel in each load presents an additional challenge—gravel is heavy. A cubic yard of gravel typically weighs 3,200 pounds. As a general rule: **you must have a durable tread surface from the gravel source to the delivery point.** The larger and heavier the load of gravel, the more there may be a need to repair, upgrade, harden, or otherwise mitigate tread degradation along the delivery route. Tread degradation can be reduced by limiting your gravel hauling operations to times when trails are dry, soil is well frozen, or snow has been compacted to provide a tread surface. Consider stockpiling gravel along the route during the winter and redistributing the gravel over shorter distances when working conditions are favorable.

Situation 2—There is a local borrow source along the trail route.

If there is a local borrow source or a source that can be developed along the trail route (such as a riparian gravel bar, elevated terrace, gravelly hillside, cut face of friable bedrock, or some other source), the expense of importing gravel to the trail head may be minimized or eliminated. If the borrow material is high quality, such as ¾- to 1½-inch diameter stones with a good mix of finer fragments for bedding and compaction, consider using the borrow material for:

- Gravel cap
- Gravel cap with geotextile (geotextile use depends on site conditions)
- Causeway

If the borrow material is not high quality but is superior to the existing trail tread, it may be used as a subbase layer that can be capped with a small amount of high-quality imported gravel.

Poorer quality borrow material also may be used as:

- Infill for cellular confinement systems
- Infill for porous pavement

Cellular confinement systems can be filled with substandard mineral material ranging from sand to mixed clays. The cell membrane provides an engineered structure that supplements the fill material. Other components of cellular confinement systems include a base geotextile fabric, the geotextile cell membrane, intercell connectors, and a gravel cap. The handling characteristics of borrow material, rather than the material's quality, will determine whether the material is suitable to fill and compact in the system's small individual cells.

When the borrow material is used as infill for **porous pavement panels,** poor-quality material can be used because the rigid panel cell walls provide structural support. The material used for infill improves the tread surface characteristics of the cells for walking, bike riding, accessibility, and possibly horse use. The material also can be used to provide a growth medium for surface vegetation.

Transporting borrow material from its source to the hardening site has similar issues concerning haulage efficiency and tread degradation as discussed in Situation 1.

In addition, an extensive evaluation of the potential borrow site should be attempted. This should include opening soil pits to define the surface extent, depth of deposits, and the quality of the material. A small backhoe would be ideal for this work, but for small projects the evaluation can be accomplished with small powered augers, posthole diggers, hand shovels, or other suitable equipment.

The borrow source may be developed most efficiently with mechanical equipment. A tracked excavator can strip and stockpile vegetation and overburden, load gravel haulers, and reclaim the pit. With the wide range of excavators available in the rental market, it should be possible to match equipment to the size of the operation. Smaller operations can be developed using handtools.

Plan to reclaim the pit and its access trail as part of the project. The use of porous pavement panels for the access trail may simplify that process. Don't forget to consider the impacts associated with pit development during the trail planning stage.

Situation 3—Good quality mineral soil or mixed gravel is along or beneath the trail alignment.

Often degraded trail segments develop because the tread has become entrenched. Entrenchment is common on flat or low gradients with thick surface vegetation or a surface layer of fine textured soils. Trail use compacts the surface layers. The entrenched trail collects water, leading to wet, muddy conditions. To avoid those conditions, seek out drier ground. To evaluate trail-hardening options for entrenched trail surfaces, determine the character of the subsoil underlying the tread. If the subsoil is mineral soil of relatively good quality (ideally with a gravel component) beneath, one of the following trail-hardening methods may be effective:

- Turnpike
- Ditch and elevate
- Slot trench inversion

Turnpike and ditch and elevate methods use material excavated from side ditches cut along the existing tread to elevate the trail tread. The tread is shaped and graded (crowned) so it drains to either side. The ditches improve the drainage of the site either by collecting and diverting water away from the site (on sites where there is enough slope) or by lowering the water table relative to the newly elevated tread (on flat sites). In a **turnpike,** the material placed on the tread is contained by log or rock curbs; the **ditch and elevate** method does not use curbs.

One disadvantage of these methods is that they disturb a larger area than the trail tread. For a trail with a 3-foot-wide tread, the ditches roughly double the width of the area disturbed by the trail. When this additional disturbance is not a concern, these methods should be considered.

The primary advantage of these methods is that the material used to harden the trail is excavated from ditches immediately adjacent to the site that requires hardening. In some cases, a small amount of supplemental capping material may be needed. While handtools could be used for small projects, work can be accomplished more effectively with mechanical equipment. A tracked excavator is ideal for this task. For large operations, a tracked excavator working with a small dozer is a good combination.

Slot trench inversion uses fill material dug from beneath the trail to cap or elevate the tread. No side ditches are developed.

1. Poor quality surface material is stripped and set aside.
2. Higher quality material is excavated from beneath the trail tread.
3. Surface material is placed in the excavated area.
4. Surface material is covered with the higher quality materials excavated from beneath the trail tread.

For slot trench inversion to be successful, a relatively thin surface layer of poor quality material must overlie higher quality material close to the surface. The trail needs to have at least three times as much higher quality subsurface material as poor quality surface material. In other words, about 3 cubic feet of higher quality material must be excavated for every 1 cubic foot of poor quality material. The subsurface material tends to swell when dug up (increasing up to 20 percent in volume). The excavated subsurface material should have good infiltration characteristics to help keep the surface tread dry and good percolation characteristics to help transfer excess surface water into subsoils.

When a tracked excavator is used, gravel can be excavated and placed with one swing of the bucket while overburden can be buried with the return swing, leading to highly efficient trail construction.

Situation 4—Remote sites with available timber onsite.

Where the degraded trail segment is short (less than 50 feet) and there is a wealth of small-diameter (less than 6 inches diameter breast height) timber, consider using **corduroy.**

Normally, corduroy is not recommended because corduroy doesn't last long, uses a lot of small-diameter trees, takes a lot of work to install, and has a rough, unfinished appearance. In spite of those limitations, corduroy has long been used when crossing wet or boggy ground. Traditionally, the corduroy poles were buried beneath a surface cap of soil and gravel, which provided a durable traffic surface and encapsulated the wood to help preserve it. This method is preferred for trail applications, but it is seldom used because of the amount of labor required. Usually, poles are embedded in the muck, spiked to stringer poles, or lashed together. None of these methods is particularly desirable or effective. Embedded poles often shift and become ineffective and spiked poles quickly rot out (leaving the spikes as a hazard). Lashing corduroy is a time-consuming, awkward, and muddy task. Short of burying the poles beneath a surface cap, weaving ropes around the corduroy poles is the recommended alternative. This method of lashing keeps traffic from displacing the poles and the direct ground contact increases the potential for long-term wood preservation (wood preserves best when its moisture content is higher than 20 percent).

When moderate-diameter timber (10 to 16 inches diameter breast height) is readily available onsite, consider hardening the trail with **puncheon**.

For constructed puncheon, use the onsite timber for sills and stringers. Only planks and hardware for decking will have to be imported, reducing the amount of material that needs to be transported for a trail-hardening project. Longevity is an issue for puncheon. Project economics need to be considered carefully.

When there is a mix of timber available and extensive trail hardening is required, consider using medium-size timber for sill and stringers and milling large-diameter material onsite for decking.

A **Gadbury bridge** uses split or sawn large-diameter logs for the deck with smaller diameter material used for sills and crowder and bull rails. This method has the advantage of not requiring any imported material. Chain saws and log handling gear will be needed. Gadbury bridges are most suitable when the sites that require hardening are not too extensive (shorter than 20 feet for each bridge segment) and relatively narrow. The limiting factors are the length and diameter of the logs used for the deck and the size of log needed for the sill (20 inches in diameter or larger) to link bridge segments together for longer installations.

Situation 5—Very remote sites, extensive degraded segments, no onsite timber, nonmineral soils, organic or ice-rich permafrost.

In this situation, the trail manager faces a challenging problem that is common in Alaska and some northern areas where vast stretches of muskeg, wetlands, and black spruce woodland dominate the landscape. Usually, all trail-hardening material must be transported to the site. In general, gravel is too heavy to be transported long distances except during winter over snowpacked or ice roads. If this is possible, see Situation 1. If gravel is ruled out, consider one of the following:

- Transporting wood timbers or planks for:
  - ✧ Boardwalk or puncheon
  - ✧ Running plank
- Transporting structural geotextiles for:
  - ✧ Porous pavement
- Transporting wood chips for:
  - ✧ Chunkwood

A discussion on the advantages and disadvantages of each of these methods is provided below.

Boardwalk or Puncheon, Running Plank

Transporting wood timbers and planking does have some potential for remote sites. Material costs are fairly economical, but transportation tends to be expensive. The large volume of material needed for boardwalk and puncheon installations (less so for running plank) creates transportation issues. These materials will have to be ferried to the construction site, either overland or by air. Winter transport using sleigh or wheeled vehicles over packed snow may be a good option. Slinging loads below a helicopter is also an option, although costs can be quite high (see discussion on helicopter sling operations). Another concern is the potentially short service life for the materials. Carefully evaluate the project to make sure the use of wood products is economically viable over the long term. Commercially preserved wood will last longer and may be worth the additional cost.

Porous Pavement

Porous pavement is well suited to this situation. Although porous pavement is expensive, it might not cost as much to transport as wood—especially in the geotrack configuration (two parallel installations of porous pavement that form a two-track running surface). Porous pavement panels have excellent longevity and are easy to handle in the field; each panel weighs less than 10 pounds and is about 19 by 39 inches. The panels have minimal effects on local hydrology and support vegetation regrowth at disturbed sites. Porous pavement panels are packaged in roughly 500-pound pallets that are just the right weight for slinging beneath a medium-size helicopter.

The publication "Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments" (Meyer 2002) has a detailed installation guide for porous pavement panels.

Chunkwood

Chunkwood has several advantages for hardening trails in semiremote locations. Chunkwood:

- Is lightweight.
- Is simple to handle, transport, and spread.
- Has good longevity in many northern environments.
- Is fairly cheap.

There are several disadvantages, however. Chunkwood:

- Has never been widely tested for trails.
- Uses a lot of wood.
- Requires special chunkwood production equipment.
- Requires specialized pieces of equipment for hauling.
- May rot fairly quickly unless the moisture content of the wood remains above 20 percent or below 4 percent.

This method is attractive when chunkwood can be produced onsite and transported with standard road equipment along the trail. Applying a cap of soil or gravel over the chunkwood would improve the quality of the tread surface and help retain moisture in the chunkwood. Chunkwood could be economically transported by helicopter in large self-dumping sling sacks.

Helicopter Sling Operations

For helicopter sling operations, secure the materials (metal bands work well) in sling-sized bundles (by weight) from the mill, lumber yard, or manufacturing facility to help facilitate safe handling in the field. Plan on spotting the sling load drops along the trail alignment with a spacing equal to the material coverage on the ground. Using three sets of sling gear can increase efficiency. While one set of sling gear is in flight with a load, the ground crew on the sending end is rigging a second set of sling gear and the crew on the receiving end is retrieving a third set from an earlier load. When a load is dropped, the helicopter picks up a set of sling gear to carry back. The helicopter never has to wait for a set of sling gear.

Situation 6—Wetlands or shallow ponds, areas subject to flooding.

For wetland sites with standing water or shallow ground water, shallow ponds, or areas subject to flooding, consider:

- Elevated boardwalk
- Ballasted or anchored porous pavement

Elevated boardwalk on piers or boardwalk supported by helix screw anchors or other types of post structures would be the preferred trail-hardening method for these sites. At some sites, thick sill timbers may elevate the boardwalk above the water.

Porous pavement panels can be used in areas where the trail can be allowed on the ground. Because the panels are positively buoyant, they must be secured or they will float off during high water. In ballasted porous pavement, the grid cells are secured by filling them with 1½- to 3-inch diameter washed gravel. In anchored porous pavement, earth screw or duckbill anchors are used to secure the panels.

Both of these methods work well to protect wetlands and aquatic areas. The appropriate method should be selected based on the site and project requirements.

Situation 7—Floating vegetation.

Floating vegetation is found in shallow depressions where ponds have slowly filled with thick layers of vegetation. A probe will penetrate the vegetation mat to water below. The vegetation is often thick enough to support foot or all-terrain vehicle passage but degrades quickly with frequent use. At these sites, a highly effective method of trail hardening is **porous pavement panels** (unfilled, 6-foot-wide configuration).

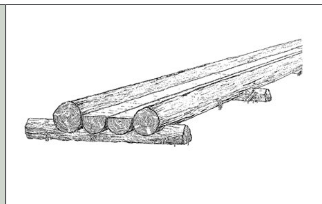
Use of porous pavement panels was discussed earlier.

References

Meyer, Kevin G. 2002. Managing degraded off-highway vehicle trails in wet, unstable, and sensitive environments. Tech. Rep. 0223–2821P–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 48 p. Available at http://www.fs.fed.us/eng/pubs/htmlpubs/htm02232821/.

Selected Trail-Hardening Methods (1 to 5)

Methods 1 to 5 were developed by the author.

					
Author's description	**Gadbury bridge**	**Elevated boardwalk**	**Elevated puncheon**	**Ground contact boardwalk**	**Ground contact puncheon**
Forest Service equivalent	**Puncheon without decking 934.20**	**Elevated boardwalk 938.20**	**Standard puncheon 934.10**	**Standard puncheon 934.10**	**Standard puncheon 934.10**
General trail type suitability	Foot trails predominantly	All trail types	All trail types	All trail types	All trail types
General site soil type suitability[1]	All soil types, except floating vegetation mats	All soil types, except floating vegetation mats	All soil types, except floating vegetation mats	All soil types including floating vegetation mats	All soil types including floating vegetation mats
Construction type or method	Historic method using local materials and no or minimal fasteners in remote locations. Two face-up half logs form a split log deck (running lengthwise) set on log sills with a crowder rail. Notched long timbers, not sills, are used. Round bull rail is placed between the crowder rail and log deck. May be set in series to span long runs. Typically elevated 10 to 20 inches above the ground with logs peeled.	Deck of crosswise planks supported by two or more dimensional timber stringers. Stringers rest on ground-contact timber sills, posts, pilings, helical screws, or other supports. Typically elevated at least 8 inches above the surface. Excellent for wet or irregular surfaces. Minimal site impact.	Large, generally log stringers, 3-inch decking and always on sills (no posts or piers). Two to three or more stringers larger than 8 inches diameter are used on the small end. Elevated at least 8 inches above the surface.	Structure with stringers in direct contact with the ground surface (no mud sills, posts, or pilings).	Puncheon with stringers in direct contact with the ground surface (no mud sills, posts, or pilings).
Typical width (feet)	1.5 to 4	4 to 8	3 to 6	3 to 6	3 to 6
Accessibility	Typically used in remote sites. Not a particularly good design for accessibility because of rough construction, longitudinal gaps, and the need for ramping at ends.	Very common construction method for accessibility. Design and construction must meet specific criteria.	Method can be readily adapted for accessibility. Design and construction must meet specific criteria.	Very common construction method for accessibility. Design and construction must meet specific criteria.	Method can be readily adapted for accessibility. Design and construction must meet specific criteria.
Surface character	Tread surface reflects character of split or cut half logs. Typically rough surface, nonuniform edge and width, angular, low to moderately high profile.	Smooth surface, uniform edge, level, angular form, uniform width, elevated surface.	Smooth surface, uniform edge, level, angular form, uniform width, elevated surface.	Smooth surface, regular to irregular edge, generally level, uniform width, angular form, low profile.	Smooth surface, irregular edge, generally level, uniform width, angular form, low profile.

(continued)

Author's description	Gadbury bridge	Elevated boardwalk	Elevated puncheon	Ground contact boardwalk	Ground contact puncheon
Forest Service equivalent	**Puncheon without decking 934.20**	**Elevated boardwalk 938.20**	**Standard puncheon 934.10**	**Standard puncheon 934.10**	**Standard puncheon 934.10**
Environmental considerations					
Degraded site stabilization[1]	Provides for good stabilization with minimum ground contact. Low to moderate site disturbance.	Provides for good stabilization with minimum ground contact. Moderate site disturbance.	Provides for good stabilization with minimum ground contact. Moderate site disturbance at the installation.	Provides for good stabilization with direct ground contact. Moderate site disturbance.	Provides for good stabilization with direct ground contact. Moderate site disturbance at the installation.
Site revegetation potential first 5 years (native species regeneration)	Fair to good native revegetation potential. Revegetation rate is limited by shading under the bridge.	Fair to good native revegetation potential. Revegetation rate is limited by shading under the boardwalk. Rate increases with elevated decks that reduce shading. Rate can also be increased with grid decking.	Fair to good native revegetation potential. Revegetation rate is limited by shading under the puncheon. Rate increases with elevated decks that reduce shading. Rate can also be increased with grid decking.	Fair to poor native revegetation potential. Revegetation rate is limited by shading under the boardwalk. Rate is lowest with low, wide, tightly planked boardwalks. Rate can be increased with grid decking.	Fair to poor native revegetation potential. Revegetation rate is limited by shading under the puncheon. Rate is lowest with low, wide, tightly planked puncheon. Rate can be increased with grid decking.
Irretrievable or irreversible commitment of resources	Not significant. Very little modification of original site conditions. Bridges can be removed with low to moderate site disturbance and no long-term effects.	Not significant. Very little modification of original site conditions. Boardwalks can be removed with minimal site disturbance and no long-term effects.	Not significant. Very little modification of original site conditions. Puncheon can be removed with minimal site disturbance, and no long-term effects.	Moderate commitment. Some minor modification of original site conditions. Boardwalks can be removed with some site disturbance. Effects will be reduced as revegetation occurs along the installation.	Moderate commitment. Some minor modification of original site conditions. Puncheon can be removed with some site disturbance. Effects will be reduced as revegetation occurs along the installation.
Long-term wetlands protection or enhancement	Very good. Protects and supports original species regeneration with no hydrologic modification.	Very good. Protects and supports original species regeneration with no hydrologic modification.	Very good. Protects and supports original species regeneration with no hydrologic modification.	Fair to good. Stabilizes the site but may affect vegetation. May cause minor hydrologic modifications.	Fair to good. Stabilizes the site, but may affect vegetation. May cause minor hydrologic modifications.
Maintenance after installation or during the first season of use[1]	Very little required.	Some minor leveling. Planks may have to be refastened.	Some minor leveling. Planks may have to be refastened.	Some minor leveling. Planks may have to be refastened.	Some minor leveling. Planks may have to be refastened.
Permits required	Probably none, if the bridge is short.	COE[2] 404 site permit will probably be required if the boardwalk is in a wetland.	COE[2] 404 general permit may be required if the puncheon is in a wetland.	COE[2] 404 general permit may be required if the boardwalk is in a wetland.	COE[2] 404 general permit may be required if the puncheon is in a wetland.

(continued)

Author's description	Gadbury bridge	Elevated boardwalk	Elevated puncheon	Ground contact boardwalk	Ground contact puncheon
Forest Service equivalent	**Puncheon without decking 934.20**	**Elevated boardwalk 938.20**	**Standard puncheon 934.10**	**Standard puncheon 934.10**	**Standard puncheon 934.10**
Maintenance[1]					
Routine maintenance requirement (over service life)	Very little required. Sills may need to be leveled and crowder rails may need to be replaced.	Occasional releveling. Replacement of deck planks and timbers, increasing toward the end of the service life.	Occasional releveling. Replacement of deck planks and timbers, increasing toward the end of the service life.	Occasional replacement of deck planks, increasing toward the end of the service life.	Occasional replacement of deck planks, increasing toward the end of the service life.
Service life (years)	15 to 20, varying based on material and site conditions.	10 to 15, varying based on material and site conditions.	15 to 20, varying based on material and site conditions.	8 to 12, varying based on material and site conditions.	10 to 12, varying based on material and site conditions.
Labor requirement[3] (work hours)	16 to 24	22 to 26	22 to 26	18 to 20	18 to 20
Material cost[3] (dollars)	20	1,270	1,270	1,240	1,240
Equipment needed	Handtools	Varies	Handtools	Handtools	Handtools
Example trail project reports are available from the National Park Service's Rivers, Trails, and Conservation Assistance Program (NPS-RTCA) 907–644–3586	None available at this time	None available at this time	Caribou Lake Trail Project Report	None available at this time	Caribou Lake Trail Project Report
Comments[1]	Typically requires large timber for half logs and methods to move logs in the woods. Very economical if trees are available near the site. Spans longer than 10 feet require no hardware. Use is limited to sites where large logs (more than 12 inches diameter at small end) are available.	Simple construction techniques do not require special skills. Materials are readily available. Elevated structures may present a potential hazard to other surface traffic.	Economical because local materials may be used for stringers. Elevated structures may present a potential hazard to other surface traffic. Relatively economical for long installations if local materials can be used.	Longevity of material is an issue because of ground contact.	Longevity of material is an issue because of ground contact.

[1] See "Evaluation of OHV Trail-Hardening Methods."

[2] U.S. Army Corps of Engineers.

[3] Rough estimates per 100 feet of installation 5 to 6 feet wide. Cost estimates include project materials and installation labor only and depend on material sources, local labor costs, and site conditions. Estimates only provide a relative comparison between treatment options. Actual costs will depend on the project and may benefit from economies of scale and other factors not considered in this comparison.

Selected Trail-Hardening Methods (6 to 9)

Methods 6 to 9 were developed by the author.

				
Author's description	**Running plank**	**Corduroy**	**Paver blocks**	**Porous pavement** (unfilled 1- or 2- inch-thick panels)
Forest Service equivalent	**NA**	**Corduroy foundations 918.50**	**Grid unit surfacing 913.40**	**Geosynthetic foundations 918.40**
General trail type suitability	All trail types	All trail types except livestock and mountain bike trails. Generally not a preferred structure on Forest Service trails.	All trail types	Motorized trails predominantly
General site soil type suitability[1]	All soil types, except floating vegetation mats	All soil types, including floating vegetation mats	All mineral soil types—unsuitable for organic soils, floating vegetation mats	All soil types, including floating vegetation mats when a geotextile sublayer is used
Construction type or method	Planked foot or wheel tread surface with planks running along direction of travel. Timber crossties. Open space between wheel tracks. Decking has ground contact or is slightly elevated (4 to 8 inches typically).	Native poles laid directly on the surface. Poles may or may not be attached to each other with cables, nailed to stringers, or covered with soil or gravel. Peeled poles may last longer.	Precast interlocking concrete blocks are installed as a tread surface. Foundation blocks are keyed in at the base of the installation. Additional blocks are laid upslope to provide trail tread. May be solid or grid surface depending on the block type. May be threaded with cable.	Interconnected open grid cell plastic panels placed directly on the soil surface. Supplemental geotextiles used underneath as required by site conditions.
Typical width (feet)	1 to 5	2 to 8	2 to 8	4.8, 6.5, 8
Accessibility	Generally not adaptable for accessibility because of narrow tread width, longitudinal gaps, and lack of curbing.	Generally not adaptable for accessibility because of rough surface and lack of curbing. Soil or a gravel cap may improve the tread surface characteristics.	Method can be readily adapted for accessibility. Design and construction must meet specific criteria.	Does not meet accessibility standards.
Surface character	Smooth surface, irregular edge, generally level, uniform width, angular form, low profile.	Rough surface, irregular edge, conforms to landscape irregularities, regular to irregular width, angular form, low profile.	Smooth surface, regular edge, level, uniform width, angular form, stepped turns, low profile.	Grid surface, uniform edge, conforms to landscape irregularities, uniform width, angular form, low profile.

(continued)

Author's description	Running plank	Corduroy	Paver blocks	Porous pavement (unfilled 1- or 2- inch-thick panels)
Forest Service equivalent	**NA**	**Corduroy foundations 918.50**	**Grid unit surfacing 913.40**	**Geosynthetic foundations 918.40**
Environmental considerations				
Degraded site stabilization[1]	Provides for good stabilization with direct ground contact. Low site disturbance.	Provides for good stabilization with direct ground contact. Low site disturbance at the installation.	Provides for good stabilization with direct ground contact. Moderate site disturbance.	Provides for good stabilization with direct ground contact, low site disturbance.
Site revegetation potential first 5 years (native species regeneration)	Revegetation is limited to spaces between planking and the gap between wheel tracks. About 35 percent of openings are available for regrowth across the width of the track.	Revegetation is limited to spaces between poles. Typically less than 20 percent of openings are available to support revegetation. Revegetation rate can be increased if the corduroy is capped with mineral soil.	Poor revegetation potential with solid blocks, fair potential with grid cell blocks. Revegetation depends on the character of the fill in the grid cells.	Excellent revegetation potential. Cell openings readily support regrowth of native species. Grid cells tend to fill with native material, enhancing revegetation potential.
Irretrievable or irreversible commitment of resources	Moderate commitment. Some minor modification of original site conditions. Installations can be removed with some site disturbance. Effects will be reduced as revegetation occurs along the installation.	Moderate commitment. Some minor modification of original site conditions. Installations can be removed with some site disturbance. Effects will be reduced as revegetation occurs along the installation.	Major commitment. Major modification of original site conditions. Installation removal requires major site disturbance and long-term effects on vegetation.	Moderate commitment. Minor modification of the original site conditions. Installations can be removed with some site disturbance. Effects will be reduced as revegetation reestablishes itself on the panel footprint.
Long-term wetlands protection or enhancement	Fair to good. Stabilizes the site, but affects vegetation beneath the planking. May cause some hydrologic modifications.	Fair to good. Stabilizes the site, but affects vegetation beneath poles. Some hydrologic modifications.	Fair to poor. Stabilizes the site, but affects vegetation. May cause significant hydrologic modifications. Cross drains may be required.	Excellent. Protects and enhances the site with little effect on vegetation. Little hydrologic modifications.
Maintenance after installation or during the first season of use[1]	Some planks may need to be refastened.	Some poles may need to be refastened. Fill may need to be added on top of the corduroy. Fill may need to be graded.	Minimal. May require some grading at beginning and end of installation.	Some joint reinforcement and repair after the first year. Expansion joints may need to be installed or modified.
Permits required	COE[2] 404 general permit may be required if the running plank is in a wetland.	COE[2] 404 general permit may be required for extensive corduroy in a wetland.	Alaska Department of Fish and Game stream crossing permit may be required if paver blocks are used in an anadromous stream.	COE[2] 404 general permit may be required if porous pavement is used in a wetland.

(continued)

Author's description	Running plank	Corduroy	Paver blocks	Porous pavement (unfilled 1- or 2- inch-thick panels)
Forest Service equivalent	**NA**	**Corduroy foundations 918.50**	**Grid unit surfacing 913.40**	**Geosynthetic foundations 918.40**
Maintenance[1]				
Routine maintenance requirement (over service life)	Occasional replacement of deck planks, increasing toward the end of the service life.	Regular replacement of poles, increasing toward the end of the service life.	Very little. If the blocks were keyed in improperly, the installation could break apart.	Minimal long-term maintenance to tread surface. May require some vegetation control and marking of the trail alignment if regrowth is substantial.
Service life (years)	10 to 12, varying based on material and site conditions	Highly variable	20^{+} with minimal maintenance	20^{+} with occasional maintenance
Labor requirement[3] (work hours)	22 to 26	18 to 24	90 to 120	24 to 28
Material cost[3] (dollars)	1,045	200	Price can vary widely, depending on the supplier.	3,200
Equipment needed	Handtools	Handtools	Handtools	Handtools
Example trail project reports are available from the National Park Service's Rivers, Trails, and Conservation Assistance Program (NPS-RTCA) 907–644–3586	Portage Trail Project Report	None available at this time	None available at this time	Portage/Arluk Landing, Summit Lake, Middle Fork, and Hooper Bay Trail Project Reports
Comments[1]	Economical if local materials are available. Longevity of material is an issue. Economical for long installations.	Economical if local materials are available. Difficult to efficiently secure poles without top capping. Fair for short fixes in remote areas. Not practical for long installations. Corduroy is prone to rotting if the poles are not completely covered or submerged. Rotten poles could leave hazardous holes in the installation.	Blocks are heavy, which can be a major logistics problem for transportation to the construction site. Very durable once installed. Excellent for reinforcing stream crossing fords and hardening bridge approaches. A wide vide variety of block sizes and styles are available—check with local suppliers.	Expensive, but durable. Several panel types are available. Good for remote medium-length installations. Light enough to transport to remote sites. Excellent regrowth through panels. Moderate technical skill is needed to install porous pavement. There are many good examples of porous pavement installations in Alaska. The pavement includes recycled materials.

[1] See "Evaluation of OHV Trail-Hardening Methods."

[2] U.S. Army Corps of Engineers.

[3] Rough estimates per 100 feet of installation 5 to 6 feet wide. Cost estimates include project materials and installation labor only and depend on material sources, local labor costs, and site conditions. Estimates only provide a relative comparison between treatment options. Actual costs will depend on the project and may benefit from economies of scale and other factors not considered in this comparison.

Selected Trail-Hardening Methods (10 to 13)

Methods 10 to 13 were developed by the author.

				
Author's description	**Porous pavement** (filled 2-inch-thick panels)	**Porous pavement panels–geotrack configuration**	**Gravel cap and gravel over geotextile**	**Cellular confinement system with fill and cap**
Forest Service equivalent	**Geosynthetic foundations 918.40**	**Geosynthetic foundations 918.40**	**Aggregate surfacing and base course 913.10**	**Geosynthetic foundations 918.40**
General trail type suitability	All trail types	Motorized	All trail types	All trail types
General site soil type suitability[1]	All soil types, except floating vegetation mats	All soil types, except floating vegetation mats	All soil types, except floating vegetation mats	All soil types, except floating vegetation mats
Construction type or method	Plastic panel grid cells are filled with earth material—either onsite native material or imported material—soil, pit run gravel, or washed and graded gravel. Low-quality material can be used because fill does not provide structural strength. Higher quality interlocking fill used for bikes or livestock.	Porous pavement panels are placed along wheel tracks with wood timber crossties at every panel joint (about every 3 feet). Generally no fill is needed.	Imported gravel is placed on the ground surface with supplemental geotextile fabric used for separation, as required. Depth of gravel depends on site conditions.	Cellular confinement system supports trail tread consisting of base geotextile, then expanded confinement cells (4 to 10 inches deep) filled with local fill or gravel and capped with a gravel wear surface. May be installed in a trench or on the surface with curbing or a graded edge.
Typical width (feet)	4.8, 6.5	5	4 to 12	6 to 8
Accessibility	Good to excellent potential for accessibility depending on the quality of the fill material. Design and construction must meet specific criteria.	Generally not adaptable for accessibility because of narrow tread width, longitudinal gaps between the tracks, and lack of curbing.	Very common construction method for accessibility. Design and construction must meet specific criteria.	Good to excellent potential for accessibility depending on the quality of the fill material. Design and construction must meet specific criteria.
Surface character	Smooth surface, uniform edge, conforms to landscape irregularities, uniform width, angular form, low profile.	Grid surface, uniform edge, conforms to landscape irregularities, uniform width, angular form, low profile.	Relatively smooth surface, irregular edge, can be graded to minimize landscape irregularities, slightly variable width unless curbed, curvilinear form.	Smooth surface, regular edge, regular width, angular form, low or slightly elevated profile.

(continued)

Author's description	**Porous pavement** (filled 2-inch-thick panels)	**Porous pavement panels–geotrack configuration**	**Gravel cap and gravel over geotextile**	**Cellular confinement system with fill and cap**
Forest Service equivalent	**Geosynthetic foundations 918.40**	**Geosynthetic foundations 918.40**	**Aggregate surfacing and base course 913.10**	**Geosynthetic foundations 918.40**
Environmental considerations				
Degraded site stabilization[1]	Provides for good stabilization with direct ground contact, low site disturbance.	Provides for good stabilization with direct ground contact, low site disturbance.	Provides for good stabilization with direct ground contact, low to moderate site disturbance.	Provides for good stabilization with direct ground contact, moderate site disturbance.
Site revegetation potential first 5 years (native species regeneration)	Native species regeneration depends on the character of the fill. Because cells carry the load, local low-quality fill may be used to enhance native regrowth. Drier tread surfaces may alter species composition.	Excellent revegetation potential. Cell openings and open center track readily support regrowth of native species. Grid cells also tend to fill with native material, enhancing revegetation potential.	Revegetation potential is poor because of gravel capping. Species composition will change because of drier site conditions. Invasive species may be introduced in the fill.	Revegetation depends on the character of the capping material. Modified species regrowth composition because of drier site conditions. Invasive species may be introduced in the fill.
Irretrievable or irreversible commitment of resources	Moderate commitment. Moderate modifications of the original site conditions. Installations cannot be removed without moderate surface impact and some effects if the fill is not completely removed.	Minor commitment. Some minor modifications of the original site conditions. Installations can be removed with minimal site disturbance and little long-term effect.	Major commitment. Major modifications of the original site conditions. Installations cannot be removed without major surface impacts and long-term effects on the site.	Major commitment. Major modifications of the original site conditions. Installations cannot be removed without major surface impacts and long-term effects on the site.
Long-term wetlands protection or enhancement	Fair. Protects the site, but affects vegetation. Some hydrologic modifications are likely. May require some cross drainage.	Excellent. Protects and enhances the site with little effect on vegetation. Little hydrologic modification.	Fair to poor. Protects the site, but significantly affects vegetation. May cause significant hydrologic modifications. Cross drains may be required.	Fair to poor. Protects the site, but significantly affects vegetation. May cause significant hydrologic modifications. Cross drains may be required.
Maintenance after installation or during the first season of use[1]	Some grading and replacement may be required.	Some joint reinforcement and repair after the first year. Expansion joints may need to be installed or modified.	Some crown grading and additional capping material may be required.	Some crown grading and additional capping material may be required.
Permits required	COE[2] 404 site permit may be required if the porous pavement is used in a wetland.	COE[2] 404 general permit may be required if the panels are used in a wetland.	COE[2] 404 site permit may be required if the gravel is used in a wetland.	COE[2] 404 site may be required if the cellular confinement system is used in a wetland.

(continued)

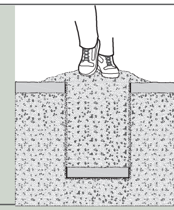
Author's description	**Porous pavement** (filled 2-inch-thick panels)	**Porous pavement panels–geotrack configuration**	**Gravel cap and gravel over geotextile**	**Cellular confinement system with fill and cap**
Forest Service equivalent	**Geosynthetic foundations 918.40**	**Geosynthetic foundations 918.40**	**Aggregate surfacing and base course 913.10**	**Geosynthetic foundations 918.40**
Maintenance[1]				
Routine maintenance requirement (over the service life)	Minimal long-term maintenance. Fill can be maintained, but maintenance is not required for structural integrity.	Minimal long-term maintenance to tread surface. May require some vegetation control and trail alignment marking if regrowth is substantial.	Gravel grading on an annual basis is recommended. Top capping on a routine basis may be required, especially if there is motorized use.	Gravel grading and top capping on an annual basis may be required. Necessary to maintain surface capping to prevent damage to cell walls.
Service life (years)	20+ with occasional maintenance	20+ with occasional maintenance	20+ with regular maintenance	20+ with regular maintenance
Labor requirement[3] (work hours)	30 to 34	4 to 6	10 to 15	20 to 25
Material cost[3] (dollars)	3,200 plus gravel cost	1,930	Gravel cost	920 plus gravel cost
Equipment needs	Handtools	Handtools	Gravel hauler	Gravel hauler
Example trail project reports are available from the National Park Service's Rivers, Trails, and Conservation Assistance Program (NPS-RTCA) 907–644–3586	Middle Fork, Palmer Hay Flats Trail Project Reports	Summit-Lake Miam Trail Project Report	None available at this time	None available at this time
Comments[1]	Gravel transport to the site may be an issue, but because grid cells provide structure, low quality local soil or muck can be used for fill. The pavement includes recycled materials.	Cheaper than full width panel installations. Excellent for remote long-length installations. The panels include recycled materials.	Gravel transport requires large equipment for efficient operation. Transporting heavy loads may degrade the existing trail surface—must have a hardened trail from the gravel source.	Requires quite a bit of material handling for entrenchment, cell filling, and compaction. May use substandard material for cell fill but good-quality material is needed for the cap. Cap requires a lot of maintenance. Not viable for long segments of trail.

[1] See "Evaluation of OHV Trail-Hardening Methods."

[2] U.S. Army Corps of Engineers.

[3] Rough estimates per 100 feet of installation 5 to 6 feet wide. Cost estimates include project materials and installation labor only and depend on material sources, local labor costs, and site conditions. Estimates only provide a relative comparison between treatment options. Actual costs will depend on the project and may benefit from economies of scale and other factors not considered in this comparison.

Selected Trail-Hardening Methods (14 to 17)

				
Author's description	**Causeway**	**Turnpike or ditch and elevate**	**Slot trench inversion**	**Wood chips or chunk wood**
Forest Service equivalent	**Type 1—standard turnpike 932.10**	**Type 1—standard turnpike 932.10 Type 2—standard turnpike with foundation 932.20**	**Underdrains 924.00**	**Chunk wood surfacing 913.60**
General trail type suitability	All trail types	All trail types	All trail types	All trail types
General site soil type suitability[1]	All soil types, except floating vegetation mats	Underlying mineral or gravelly soils only	Underlying gravel or rocky mineral soils only	All soil types
Construction type or method	Tread is contained within rock or log curbing and built up with imported fill and a gravel cap. No side ditch. Geotextile fabric may be used beneath the fill.	Tread surface is built up using material from excavated side ditches. Tread may be curbed to contain the fill. Tread may also be capped with gravel. Geotextile fabric may be used beneath the fill.	Handtools or an excavator are used to dig a trench below the foot tread or between the tire tracks into good quality underlying gravels. The trench is backfilled with surface vegetation and substandard soils. Tread is finished by spreading excavated gravel along the surface.	Wood may be chipped or chunked onsite or transported to the site. Typically "end-dumped" along alignment. Geotextile may be needed under the chunkwood at some sites. Mineral soil or gravel may be mixed into the surface layers to improve tread characteristics.
Typical width (feet)	2 to 8	2 to 16	2 to 12	3 to 12
Accessibility	Very common construction method for accessibility. Design and construction must meet specific criteria.	Fair to good potential for accessibility, depending on the quality of the cap material. Design and construction must meet specific criteria.	Fair to good potential for accessibility, depending on the width and quality of the cap material. Design and construction must meet specific criteria.	Poor to fair potential for accessibility, depending on the quality of the cap material. Design and construction must meet specific criteria.
Surface character	Smooth to rough surface, irregular edge with rock curbing and regular with log curbing, can be graded to minimize landscape irregularities, regular width, curvilinear form with rock curbing, or linear form with log curbing.	Smooth to rough surface, irregular edge, can be graded to minimize landscape irregularities, irregular width, curvilinear form.	Smooth to rough surface, irregular edge, can be graded to minimize landscape irregularities. Irregular width, curvilinear form.	Smooth to rough surface, irregular edge, can be graded somewhat to minimize landscape irregularities, irregular width, curvilinear form.

(continued)

Author's description	Causeway	Turnpike or ditch and elevate	Slot trench inversion	Wood chips or chunk wood
Forest Service equivalent	**Type 1—standard turnpike 932.10**	**Type 1—standard turnpike 932.10 Type 2—standard turnpike with foundation 932.20**	**Underdrains 924.00**	**Chunk wood surfacing 913.60**
Environmental considerations				
Degraded site stabilization[1]	Provides for good stabilization with direct ground contact. Moderate site disturbance.	Helps stabilize degraded sites. Significant site impact during installation.	Helps stabilize degraded sites. Moderate site impact during installation.	Provides for good stabilization with direct ground contact. Low site disturbance.
Site revegetation potential first 5 years (native species regeneration)	Revegetation potential is poor because of gravel capping material. Modified species composition due to drier site conditions. Invasive species may be introduced with imported fill.	Modified species composition because of drier site conditions. Invasive species may become established on disturbed soils.	Modified species composition because of drier site conditions. Invasive species may become established on disturbed soils.	Revegetation potential is limited because of the character of the woody surface. Native species regeneration may be improved with a top cap of fine-textured material. Drier site conditions may limit native species regeneration.
Irretrievable or irreversible commitment of resources	Major commitment. Modifications of the original site conditions. Installations cannot be removed without major surface impacts and long-term effects on the site.	Extreme commitment. Significant modifications of the original site conditions. Installations cannot be removed without major surface impacts and long-term effects on the site.	Extreme commitment. Significant modifications of the original site conditions. Installations cannot be removed without major surface impacts and long-term effects on the site.	Moderate commitment. Some minor modification of the original site conditions. Wood will rot and incorporate itself into the soil over time with minimal site disturbance. Moderate effects as revegetation occurs.
Long-term wetlands protection or enhancement	Fair to poor. Stabilizes the site, but significantly affects vegetation. Significant hydrologic modifications. Cross drains are usually required.	Poor. Stabilizes the site, but significantly affects vegetation. Significant hydrologic modifications.	Poor. Stabilizes the site, but significantly affects vegetation. Moderate hydrologic modifications.	Fair. Stabilizes the site, but significantly affects vegetation. Moderate hydrologic modification.
Maintenance after installation or during the first season of use[1]	The crown may need to be graded and additional capping material may be required.	Ditch dressing and crown grading may be required.	The crown may need to be graded and additional capping material may be required.	The crown may need to be graded and additional capping material may be required.
Permits required	COE[2] 404 site permit may be required if the causeway is in a wetland.	COE[2] 404 site permit may be required if the turnpike is in a wetland.	COE[2] 404 site permit may be required if the slot trench is in a wetland.	COE[2] 404 site permit may be required if the wood chips are used in a wetland.

(continued)

Author's description	Causeway	Turnpike or ditch and elevate	Slot trench inversion	Wood chips or chunk wood
Forest Service equivalent	**Type 1—standard turnpike 932.10**	**Type 1—standard turnpike 932.10 Type 2—standard turnpike with foundation 932.20**	**Underdrains 924.00**	**Chunk wood surfacing 913.60**
Maintenance[1]				
Routine maintenance requirement (over the service life)	Crown grading annually to semiannually is recommended. Top capping on a routine basis will probably be required.	Crown grading annually to semiannually is recommended. Ditch maintenance is recommended.	Crown grading annually to semiannually is recommended.	Surface grading and wood patching annually to semiannually is recommended. Durability depends on use and site conditions.
Service life (years)	20+ with regular maintenance	20+ with regular maintenance	20+ with regular maintenance	Highly variable
Approximate costs				
Labor requirement[3] (work hours)	20 to 30	2 to 4	2 to 4 estimated	10 to 15
Material cost[3] (dollars)	Gravel cap cost (if required)	260	150 to 200 estimated	50 to 500
Equipment needs	Gravel hauler	Dozer and excavator	Excavator or handtools	Chipper or chip hauler
Example trail project reports are available from the National Park Service's Rivers, Trails, and Conservation Assistance Program (NPS-RTCA) 907–644–3586	None available at this time	Quartz Creek Trail Project Report	None available at this time	None available at this time
Comments[1]	Curbing, fill, and gravel transport are major issues. May require large equipment for efficient operation. Transporting heavy loads may degrade the existing trail surface—must have a hardened trail from fill and gravel sources.	Requires heavy equipment to be efficient. May require supplemental surface hardening that will increase costs. Underlying mineral soil is a requirement. Economical for long installations.	Adapted from an old forest road construction method. Untested for Alaska trails but has very good potential at suitable sites. Heavy equipment increases efficiency—size the equipment to the job. This method is viable only on sites with shallow underlying gravel or rocky mineral soils and shallow overburden. Could be economical for long installations.	Cost effectiveness depends on having a local supply of wood and a chipper or chunker onsite. Lightweight material facilitates transportation, but is bulky. Lots of positive applications on winter trails in Fairbanks, AK. Longevity of the material is questionable, as is its suitability for some user types.

[1] See "Evaluation of OHV Trail-Hardening Methods."

[2] Rough estimates per 100 feet of installation 5 to 6 feet wide. Costs do not include local logistics and support requirements—project materials and installation labor only—and depend on material sources, local labor costs, and site conditions. Estimates are only provide relative comparison between treatment options. Actual costs will depend on the project and may benefit from economies of scale and other factors not considered in this comparison.

Evaluation of OHV Trail-Hardening Methods (1 to 8)

Methods 1 to 8 were developed by the author.

Author's methods	Gadbury bridge	Elevated boardwalk and puncheon	Ground contact boardwalk and puncheon	Running plank	Exposed woven corduroy	Exposed spiked corduroy	Paver blocks	Unfilled porous pavement panels
Forest Service equivalent	Puncheon without decking 934.20	Elevated boardwalk 938.20 and standard puncheon 938.10	Standard puncheon 934.10	Not applicable	Corduroy foundations 918.50	Corduroy foundations 918.50	Grid unit surfacing 913.40	Geo-synthetic foundations 918.40
Trail Management Objectives considerations								
General quality of traffic surface for all-terrain vehicle use	Very good	Very good	Very good	Very good	Good	Good	Good	Very good
General quality of traffic surface for foot traffic	Very good	Very good	Very good	Very good	Fair	Fair	Good	Good
General quality of traffic surface for mountain bikes	Fair	Fair to good	Fair to good	Poor	Poor	Poor	Fair to good	Fair
General quality of traffic surface for heavy tracked vehicles	Poor	Very poor	Very poor	Very poor	Poor	Poor	Poor to fair	Poor
General quality of traffic surface for horses	Very good	Depends	Very poor	Very poor	Poor	Poor	Poor to fair	Poor
General quality of traffic surface for wildlife crossings	Good	Poor	Fair	Good	Poor	Poor	Good	Good
How slippery is the surface when wet?	Somewhat	Somewhat	Somewhat	Somewhat	Somewhat	Somewhat	Slightly	Slightly
Resource management considerations								
Public perception	Good	Good	Good	Good	Good	Good	Fair	Good
Natural appearance of materials	Very good	Good	Good	Good	Good	Good	Fair	Poor
Ability to halt trail degradation	Very good	Very good	Very good	Very good	Good	Good	Very good	Good
Ability to promote site stabilization	Good	Fair	Fair	Moderate to good	Good	Good	Very good	Very good
Support for vegetation regrowth	Poor	Fair	Poor	Poor to moderate	Poor	Poor	Fair	Excellent
Site disturbance during installation	Low	Moderate	Moderate	Low	Low to moderate	Low to moderate	Moderate to high	Low
Visual contrast on installation	Moderate	High	High	High	Moderate	Moderate	High	Moderate
Visual contrast after revegetation	Moderate	High	High	Moderate	Moderate	Moderate	Moderate	Low
Longevity of product	Fair	Fair	Poor	Poor to fair	Poor to fair	Poor to fair	Very good	Excellent
Cost	Moderate	High	High	Moderate	Low	Low	High	Moderate

(continued)

Author's methods	Gadbury bridge	Elevated boardwalk and puncheon	Ground contact boardwalk and puncheon	Running plank	Exposed woven corduroy	Exposed spiked corduroy	Paver block	Unfilled porous pavement panels
Forest Service equivalent	**Puncheon without decking 934.20**	**Elevated boardwalk 938.20 and standard puncheon 934.10**	**Standard puncheon 934.10**	**Not applicable**	**Corduroy foundations 918.50**	**Corduroy foundations 918.50**	**Grid unit surfacing 913.40**	**Geo-synthetic foundations 918.40**
Logistics considerations–transport, time on site, crew configuration								
Weight of material on the surface	Moderate to high	Low	Moderate	Low to moderate	Low	Low	High	Very low
Effort to transport material to site	Moderate to high	High	High	Moderate	Low to moderate	Low to moderate	Very high	Low
Relative effort to install	Moderate	High	High	Moderate	Moderate	Low	Very high	Moderate
Level of technical skill for installation	Moderate	Moderate	Moderate	Moderate	Low	Low	High	Moderate
Time required for installation	Moderate	High	High	Moderate	High	Moderate	Very high	Moderate
Long-term maintenance requirements	Moderate to low	Moderate to high	Moderate to high	Moderate	Moderate	High	Low	Low
Technical and engineering considerations								
Strength of material	Good	Good	Good	Good	Fair to good	Fair to good	Very good	Excellent
Suitability for irregular surfaces (hummocks, roots, rocks, etc.)	Good	Very good	Good	Poor to fair	Fair	Good	Fair to good	Poor to fair
Suitability in very rocky terrain	Good	Good	Good	Moderate	Fair	Good	Poor to fair	Poor
Suitability in extremely wet or deep bog holes	Fair	Fair	Good	Poor	Poor	Good	Poor to fair	Poor
Suitability for underwater applications	None	Very poor	Very poor	Very poor	Poor—it floats	Fair	Good	Not suitable
Suitability for steep slopes	Poor	Fair	Poor	Poor	Fair	Fair	Very good	Poor to fair
Level surfaces	Very good	Very good	Very good	Fair to good	Good	Good	Good	Fair to good
Suitability for curves	Poor	Poor	Poor	Fair	Poor	Poor to fair	Poor to fair	Fair
Installation over center humps	Fair	Good	Good	Fair to good	Poor	Fair to good	Poor	Fair
Transfer lateral loads	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Good	Good
Susceptibility to displacement	Low	Moderate	Moderate	Low	Low	Low	Low	Low
Negative effects on permafrost	Low	Low	Low	Low	Low	Low	Moderate	None
Susceptibility to frost heaving	Moderate	High	Moderate	Moderate	Low	Low	High	Low

Evaluation of OHV Trail-Hardening Methods (9 to 17)

Methods 9 to 17 were developed by the author.

Author's methods	Unfilled porous pavement panels	Filled porous pavement panels	Unfilled geotrack porous pavement panels	Gravel cap with or without geotextile	Cellular confinement system	Causeway	Turnpike or ditch and elevate	Slot trench inversion	Wood chips or chunk-wood
Forest Service equivalent	Geo-synthetic foundations 918.40	Geo-synthetic foundations 918.40	Geo-synthetic foundations 918.40	Aggregate surfacing and base course 913.10	Geo-synthetic foundations 918.40	Not applicable	Turnpike 932.00	Under-drains 924.00	Chunk wood surfacing 913.60
Trail Management Objectives considerations									
General quality of traffic surface for all-terrain vehicle use	Very good	Very good	Very good	Very good	Good	Very good	Good	Good	Fair to good
General quality of traffic surface for foot traffic	Fair	Very good	Fair	Very good	Good	Very good	Good	Good	Fair to good
General quality of traffic surface for mountain bikes	Poor	Very good	Poor	Very good	Good	Very good	Good	Good	Fair to good
General quality of traffic surface for heavy tracked vehicles	Fair	Good	Poor	Very good	Good	Very good	Very good	Very good	Fair to good
General quality of traffic surface for horses	Poor	Fair	Poor	Very good	Good	Very good	Very good	Very good	Fair to good
General quality of traffic surface for wildlife crossings	Good	Good	Good	Very good	Good	Very good	Very good	Very good	Good
How slippery is the surface when wet?	Somewhat	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly
Resource management considerations									
Public perception	Good	Good	Good	Good	Good	Good	Good	Good	Fair to good
Natural appearance of materials	Poor	Good	Poor	Good	Poor	Good	Good	Good	Good
Ability to halt trail degradation	Very good	Very good	Good	Very good	Fair to good	Very good	Good	Good	Fair to good
Ability to promote site stabilization	Excellent	Very good	Very good	Good	Good	Good	Good	Good	Good
Support for vegetation regrowth	Excellent	Poor	Excellent	Poor	Fair	Poor	Fair to good	Fair	Fair to good
Site disturbance during installation	Low	Low	Low	Moderate	Moderate	Moderate	Very high	Moderate	Low to moderate
Visual contrast on installation	Moderate	High	Moderate	High	High	High	High	High	High
Visual contrast after revegetation	Low	Not applicable	Low	Not applicable	Moderate	Not applicable	Low to moderate	Low to moderate	Low to moderate
Longevity of product	Excellent	Excellent	Good to very good	Fair to good	Fair to good	Very good	Good	Good	Poor to fair
Cost	High	High	Low to moderate	Highly variable	Moderate	Moderate to high	Low	Low	Low to moderate

(continued)

Author's methods	Unfilled porous pavement panels	Filled porous pavement panels	Unfilled geotrack porous pavement panels	Gravel cap with or without geotextile	Cellular confinement system	Causeway	Turnpike or ditch and elevate	Slot trench inversion	Wood chips or chunk-wood
Forest Service equivalent	**Geo-synthetic foundations 918.40**	**Geo-synthetic foundations 918.40**	**Geo-synthetic foundations 918.40**	**Aggregate surfacing and base course 913.10**	**Geo-synthetic foundations 918.40**	**Not applicable**	**Turnpike 932.00**	**Under-drains 924.00**	**Chunk wood surfacing 913.60**
Logistics considerations–transport, time on site, crew configuration									
Weight of material on the surface	Low	Moderate to high	Very low	High	High	High	Moderate	Moderate	Low
Effort to transport material to site	Moderate	High	Low	High	Moderate to high	Moderate to high	Not applicable	Not applicable	Low to moderate
Relative effort to install	Moderate	High	Moderate	Moderate	Moderate to high	Moderate to high	Low	Low	Low
Level of technical skill for installation	Moderate	Moderate	Moderate	Low	Moderate to high	Low to moderate	High	Moderate	Low
Time required for installation	Moderate to high	High	Low	Low	Moderate	Moderate	Low	Low	Low
Long-term maintenance requirements	Low	Low	Low	Moderate to high	High	Low to moderate	Low to moderate	Low to moderate	Moderate to high
Technical and engineering considerations									
Strength of material	Excellent	Excellent	Excellent	Good	Good	Good	Variable	Good	Low
Suitability for irregular surfaces (hummocks, roots, rocks, etc.)	Poor to fair	Poor to fair	Poor to fair	Good	Fair	Good	Good	Good	Good
Suitability in very rocky terrain	Poor	Poor	Poor to fair	Good	Poor	Good	Poor	Poor	Good
Suitability in extremely wet or deep bog holes	Fair to good	Fair to good	Poor to fair	Good	Fair	Poor	Poor	Not applicable	Fair to good
Suitability for underwater applications	Poor	Very good	Not suitable	Moderate	Poor	Moderate	Not applicable	Not applicable	Not applicable
Suitability for steep slopes	Fair to good	Fair to good	Poor to fair	Good	Poor to fair	Moderate	Fair	Fair	Poor to fair
Level surfaces	Fair to good	Fair to good	Fair to good	Good	Good	Good	Good	Good	Good
Suitability for curves	Fair	Fair	Fair	Good	Poor	Good	Good	Good	Good
Installation over center humps	Fair	Fair	Fair to good	Good	Poor	Good	Fair	Fair	Good
Transfer lateral loads	Very good	Excellent	Good	Fair to good	Excellent	Fair to good	Not applicable	Not applicable	Not applicable
Susceptibility to displacement	Low	Low	Low	High	Low	Moderate	Low	Low	Low
Negative effects on permafrost	None	Low	None	Moderate to high	Low	Moderate to high	Moderate to high	Low	Low
Susceptibility to frost heaving	Low	Moderate	Low	Moderate	Low	Moderate	Not applicable	Not applicable	Low

Notes

Appendix C: Forms

- Forest Service Trail Assessment and Condition Surveys (TRACS) Trail Management Objectives Form
  - ✧ Forest Service TRACS Trail Management Objectives—Electronic Form Example
  - ✧ TMOs Development Input Form
- Condition Assessment Manual Data Sheet
- Condition Assessment Codes and Ranking Weights
- Forest Service TRACS Survey Form
- Prescription Manual Data Sheet
- Prescription Codes
- Project Production Log
- Prescription Cost Estimate

Forest Service Trail Assessment and Condition Surveys (TRACS) Trail Management Objectives Form

The Trail Management Objectives (TMOs) form is updated periodically by the Forest Service. For the most current version of the TMO form, examples, and associated guidance and instructions, refer to "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

TRACS Trail Management Objectives

Region: ____ Forest: ____ District: ____

Trail Name: ____ Trail Number: ____

Trail Beginning Termini: ____ Beg. Milepost: ____

Trail Ending Termini: ____ End. Milepost: ____

Trail Inventory Length: ____ Miles Trail Mileage Source: ☐ Wheel ☐ GPS ☐ Map ☐ Unknown

TMO Trail Section

Sec.# ____ Section Beg. Termini: ____ Beg. Milepost: ____

Section End. Termini: ____ End. Milepost: ____

Designed Use Objectives

Trail Type (Check one)

- ☐ Standard Terra Trail
- ☐ Snow Trail
- ☐ Water Trail

Trail Class (Check one)

- ☐ 1 (Primitive/Undeveloped)
- ☐ 2 (Simple/Minor Development)
- ☐ 3 (Developed/Improved)
- ☐ 4 (Highly Developed)
- ☐ 5 (Fully Developed)

ROS/WROS Class (Check one)

ROS (Non-Wilderness)

- ☐ Urban
- ☐ Rural
- ☐ Roaded Modified
- ☐ Roaded Natural
- ☐ Semi-Primitive Motorized
- ☐ Semi-Primitive NonMotorized
- ☐ Primitive

WROS (Wilderness)

- ☐ WROS 1
- ☐ WROS 2
- ☐ WROS 3
- ☐ WROS 4
- ☐ WROS 5
- ☐ WROS 6

Designed Use

(Check one)

- ☐ Hiker / Pedestrian
- ☐ Pack & Saddle
- ☐ Bicycle
- ☐ Motorcycle
- ☐ All Terrain Vehicle (ATV)
- ☐ Four-Wheel Drive Vehicle > 50"
- ☐ ____
- ☐ ____
- ☐ Cross-Country Ski
- ☐ Snowshoe
- ☐ Snowmobile
- ☐ ____
- ☐ Watercraft - NonMotorized
- ☐ Watercraft - Motorized

Design Parameters

(Fill in all that apply)

- ☐ Tread Width (inches)
- ☐ Target Grade (%)
- ☐ Short Pitch Maximum (%) (up to 200' lengths)
- ☐ Target Cross-Slope (%)
- ☐ Clearing Width (feet)
- ☐ Clearing Height (feet)
- ☐ Switchback Radius (feet)
- ☐ ____

Target Frequency

Per Year

(Fill in all that apply)

- ☐ Trail Opening
- ☐ Tread Repair
- ☐ Drainage Cleanout
- ☐ Logging Out
- ☐ Brushing
- ☐ Snow Trail Grooming
- ☐ Condition Survey
- ☐ ____

TRACS TMO Form v5 - Side 1 (10/1/2008) Page ____ of ____

(continued)

TRACS Trail Management Objectives

Trail Name: ________ Trail Number: ________

Travel Management Strategies FSM 2353.19

Managed Use

(Fill in all that apply)*

Use	From Date (mm/dd)	To Date (mm/dd)
Hiker / Pedestrian		
Pack & Saddle		
Bicycle		
Motorcycle		
All Terrain Vehicle (ATV)		
4WD Vehicle > 50"		
________		
________		
Cross-Country Ski		
Snowshoe		
Snowmobile		
________		
Watercraft-NonMotorized		
Watercraft - Motorized		

Prohibited Use

(Check if applicable)

Use	From Date (mm/dd)	To Date (mm/dd)
All Motorized Use		

(Or, fill in all that apply)

Use	From Date (mm/dd)	To Date (mm/dd)
Hiker / Pedestrian		
Pack & Saddle		
Bicycle		
Motorcycle		
All Terrain Vehicle (ATV)		
4WD Vehicle > 50"		
________		
________		
Cross-Country Ski		
Snowshoe		
Snowmobile		
________		
Watercraft - NonMotorized		
Watercraft - Motorized		

Other Use

(Optional: Check any that apply)*

Use	Accept	Discourage	Eliminate
Hiker / Pedestrian			
Pack & Saddle			
Bicycle			
Motorcycle			
All Terrain Vehicle (ATV)			
4WD Vehicle > 50"			
________			
________			
Cross-Country Ski			
Snowshoe			
Snowmobile			
________			
Watercraft - NonMotorized			
Watercraft - Motorized			

Special Considerations

(Check any that apply. Underline appropriate clarifier in parenthesis. Provide specifics and reference information below.)

- ☐ Shared System (shared with other system road or trail)
- ☐ Accessible per Current Agency Guidelines
- ☐ Mechanized Tools or Equipment Prohibited
- ☐ T&E or Sensitive Species Present (Plant / Wildlife)
- ☐ Heritage Resource Present
- ☐ Easement across Non-FS Land (Existing / Needed)
- ☐ Existing Permit or Agreement (Trail-Specific / Area)
- ☐ ________

Remarks / Reference Information

(Use continuation sheet if needed.)

Line Officer: Name ________ Signature ________

Title ________ Date ________

TRACS TMO Form v5 - Side 2 (10/1/2008) Page ____ of ____

(continued)

TRACS Trail Management Objectives

Trail Name: ______ **Trail Number:** ______

Remarks / Reference Information (Continuation Sheet)

(Type notes over this message. To insert spaces between lines of text in Excel, press Alt and Enter.)

TRACS TMO Form v5 - Continuation (10/1/2008) Page ____ of ____

Forest Service TRACS Trail Management Objectives—Electronic Form Example

Below is an example of a TMOs form that was completed electronically using the Forest Service Infra database. For the most current version of the TMOs form, examples, and associated guidance and instructions, refer to “Trail Fundamentals and Trail Management Objectives Training Reference Package,” 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Trail Management Objectives

Sweet Grass Trail #122 (Standard/Terra)

TMO Status : APPROVED 10/16/2008

Region : 01 **Forest :** Gallatin National Forest **District :** 011101 - Big Timber Ranger District

Beginning Milepost : 0.0000 **Beginning Termini :** West Boulder Trailhead (# 12905)
Ending Milepost : 10.7000 **Ending Termini :** Continental Divide NST
Trail Length : 10.7000 **Mileage Source :** Measuring Wheel (0.0000 to 10.7000)

TMO **BMP (mi):** 0.0000 **EMP (mi):** 10.7000

This TMO documents the intended purpose and management of National Forest System trail segments, and may or may not reflect the current condition of the trail.

Travel Management Strategies

ATM Managed Use

Strategy	Travel ID	Mode of Travel	BMP (mi)	EMP (mi)	Length	From	To	Comment
Manage	2.1	HIKER/PEDESTRIAN	0.0000	10.7000	10.7000	05/01	10/31	
Manage	2.2	PACK AND SADDLE	0.0000	10.7000	10.7000	05/01	10/31	

Designed Use Objectives

ROS/WROS Class

BMP (mi)	EMP (mi)	Length	Value	Comments
0.0000	10.7000	10.7000	RN - ROADED NATURAL	

Trail Class

BMP (mi)	EMP (mi)	Length	Value	Comments
0.0000	10.7000	10.7000	TC4 - HIGHLY DEVELOPED	

Designed Use

BMP (mi)	EMP (mi)	Length	Value	Comments
0.0000	10.7000	10.7000	PACK - PACK AND SADDLE	

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(continued)

Trail Management Objectives

Sweet Grass Trail #122 (Standard/Terra)

TMO Status : APPROVED 10/16/2008

Region : 01 **Forest :** Gallatin National Forest **District :** 011101 - Big Timber Ranger District

Beginning Milepost : 0.0000
Ending Milepost : 10.7000
Trail Length : 10.7000

TMO **BMP (mi):** 0.0000 **EMP (mi):** 10.7000

Design Parameter Segment

BMP (mi)	EMP (mi)	Length	Trail Class - Designed Use
0.0000	10.7000	10.7000	TC4 - PACK AND SADDLE

Design Parameter	Trail DP Value	Exceptions
Design Tread Width - Wilderness (Single Lane)	24" May be up to 48" along steep side slopes 48" - 60" or greater along precipices	N/A
Design Tread Width - Non-Wilderness 1 (Single Lane)	48" 48" - 60" or greater along precipices	
Design Tread Width - Non-Wilderness 2 (Double Lane)	Not applicable	
Design Tread Width - Structures (Minimum Width)	Other than bridges: 36" Bridges without handrails: 60" Bridges with handrails: 84" clear width	
Design Surface - Type	Native, with improved sections of borrow or imported material, routine grading Minor roughness	
Design Surface - Protrusions	3" Uncommon, not continuous	
Design Surface - Obstacles (Maximum Height)	3"	
Design Grade - Target Grade	10%	
Design Grade - Short Pitch Maximum	15%	
Design Grade - Maximum Pitch Density	5% of trail	
Design Cross Slope - Target Cross Slope	5%	
Design Cross Slope - Maximum Cross Slope	5%	
Design Clearing - Height	10'	
Design Clearing - Width	96"	
Design Clearing - Shoulder Clearance	12" Pack clearance: 36" x 36"	
Design Turn - Radius	6'	

Target Task Frequency

Routine Tasks

Task ID	Description	BMP (mi)	EMP (mi)	Length	Frequency	TMO Reference Information
TW-CLR-01F	Trail Opening	0.0000	10.7000	10.7000	1.000	
TW-TRD-01A	Tread Maintenance	0.0000	10.7000	10.7000	0.500	
TW-TRD-01B	Tread Drainage	0.0000	10.7000	10.7000	0.500	
TW-CLR-01A	Logging Out	0.0000	10.7000	10.7000	0.500	
TW-CLR-01B	Brushing Or Mowing	0.0000	10.7000	10.7000	0.500	
TW-S&D-01A	Tracs Survey	0.0000	10.7000	10.7000	0.200	

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(continued)

Trail Management Objectives

Sweet Grass Trail #122 (Standard/Terra)

TMO Status : APPROVED 10/16/2008

Region : 01 **Forest :** Gallatin National Forest **District :** 011101 - Big Timber Ranger District

Beginning Milepost : 0.0000
Ending Milepost : 10.7000
Trail Length : 10.7000

TMO	**BMP (mi):** 0.0000	**EMP (mi):** 10.7000

	TMO Status :	APPROVED		
Line Officer :	**Name :**	Grant Marnier	**Signature :**	
	Title :	District Ranger	**Date :**	10/16/2008

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TMOs Development Input Form

This form (pages 180 to 184) was developed by the author. Note: In addition to reviewing and incorporating existing management direction for the trail, the author recommends considering the following factors when documenting or validating TMOs.

Administrative Elements

Management unit _____________________________ Subunit _______________________________

Trail name ____________________________________ Facility number ________________________

Trail management section ____

Location Data (from "Element 4— Documentation of Trail Location")

Attach a topographic map with trail location and land status.

Notable land status conflicts ____

Existing Use Conditions (from "Element 1—Preliminary Status Assessment")

Type of use ___Recreational ___Subsistence ___Administrative ___Other___________

Off-highway vehicle classes	Volume	Season	Use trend
____All-terrain vehicles (ATVs), less than 1,500 lbs. gross vehicle weight (GVW), less than 60 inches wide	________	_______	_______
____Track vehicles (weasels, others)	________	_______	_______
____4-wheel-drive ATVs	________	_______	_______
____Motorcycles	________	_______	______
____Unlimited	________	_______	_______
____Unknown	________	_______	_______
Estimated multiple use levels	________	_______	_______
____Foot traffic	________	_______	_______
____Mountain bike	________	_______	_______
____Winter use			
_____Snowmachine	________	_______	_______
_____Ski	________	_______	_______
_____Dog sled	________	_______	_______
____Other _______________________	________	_______	_______

Codes:

Estimated volume of use	***N*** None	***Low*** Less than 50 passes/year	***Moderate*** 50 to 100	***High*** More than 100
Season of use	***S*** Summer/thaw season	***W*** Winter/freeze season	***U*** Unknown	
Trend	> Increasing	= Stable	< Decreasing	

Existing Physical Conditions (from "Element 5—Trail Condition Assessment")

Tread character

___________Average width Range _________ to ___________ inches

___________Average/typical grade Range _________ to ___________ percent

Surface character

___________Roughness ___________Size of obstacles

Clearing limits

___________Width ___________Height

(continued)

Existing Use, Class, and Condition

Type of managed use

___________________________	Trail Class	1	2	3	4	5
___________________________	Trail Class	1	2	3	4	5
___________________________	Trail Class	1	2	3	4	5
___________________________	Trail Class	1	2	3	4	5

Trail condition summary

_____Percent in good condition _____Linear feet
_____Percent in fair condition _____Linear feet
_____Percent in degraded condition _____Linear feet
_____Percent in very degraded condition _____Linear feet
_____Percent in extremely degraded condition _____Linear feet

Date of assessment_________ by____

Estimated condition trend ____Degrading ____Stable ____Improving

Issues with alignment location (from "Element 4— Documentation of Trail Location")
____Ridgetops ____Water crossings _____Flat lands

Other ____

Integrated sustainable design guidelines (from "Element 5—Trail Condition Assessment")

Controlled grade	____None	____Partial (_____percent)	______Totally
Integrated water control	____None	____Partial (_____percent)	______Totally
Full bench	____None	____Partial (_____percent)	______Totally
Durable tread	____None	____Partial (_____percent)	______Totally

Presently, the trail is (from "Element 6—Evaluation of Management Options"):

____Design sustainable
____Performance sustainable (for existing use types and levels of use)
____Maintainable
____Unmaintainable

Estimates of Necessary Investments (from Elements 7 through 9: Trail Prescriptions, Trail Maintenance, and Implementation)

Estimated investment to maintain sustainable condition	_________Dollars	_________ Labor
Estimated investment to obtain sustainable condition	_________Dollars	_________ Labor
Estimated investment to maintain maintainable condition	_________Dollars	_________ Labor
Estimated investment to obtain maintainable condition	_________Dollars	_________ Labor

(continued)

Other Concerns/Conflicts (From "Element 2—Environmental Analysis")

Administrative ____
Social ____
Biological ____
Physical ____

Existing Management

Maintenance

_____None _____Minimal yearly _____Minimal occasional _____Moderate yearly

_____Moderate occasional _____Heavy yearly _____Heavy occasional

Last maintenance ___________ by ____________________________________

Monitoring

____None to date ____Yearly _____Occasional ____Planned

Last monitoring __________ by ______________________________________

Method ____

Recommendations for Desired Future Condition

_______Manage for present use type and levels of use

_______Manage for decreased or increased use levels (circle one)

_______Manage to improved multiple use

_______Manage change in use types ____

Desired trail status

_____Maintain design sustainable or performance sustainable

_____Obtain design sustainable

_____Maintain maintainable

_____Obtain maintainable

_____Close and abandon

_____Close and stabilize/rehabilitate

_____Create alternative route ____

_____Monitor only

_____Other ____

Recommended OHV vehicle types and characteristics

_________Type _______Width ______Weight ______Season _________Volume

_________Type _______Width ______Weight ______Season _________Volume

_________Type _______Width ______Weight ______Season _________Volume

(continued)

Allowed use recommendations

____________________________ Type ________ Season _________Volume
____________________________ Type ________ Season _________Volume
____________________________ Type ________ Season _________Volume

Managed Use recommendations

____________________________ Type ________ Season _________Volume
____________________________ Type ________ Season _________Volume
____________________________ Type ________ Season _________Volume

Designed Use recommendations

____________________________ Type ________ Season _________Volume

Appropriate Design Specifications (for type of designed use)

Tread width	_____Inches		
Grade (percent)	_____Average	_____Maximum	
Outslope (percent)	_____ to _____		
Minimum turn radius	_____Feet		
Turn types	_____Switchback	_____Climbing	_____Super elevated
Clearances (inches)	_____Width	_____Height	
Surface	_____Smooth	_____Moderate	_____Rough
Structures	_____Drainage	_____Culverts	
	_____Bridges	_____Retaining walls	_____Trail hardening (method)______

Drainage control methods________________________________

Recommended interval______________

Signs _____ Regulatory _____ Interpretive ____ Trail markers

Management Actions (from "Element 6—Evaluation of Management Options")

______No action required or the status quo appears to be adequate
______Increased maintenance recommended
______Reroutes recommended
______Durability of tread improvements required
______Trail closure recommended with

_____Stabilization _____Rehabilitation _____Reclamation

Comments/details ____

Recommended construction/maintenance techniques ____
____

(continued)

Implementation Status

Maintenance/mitigation status

____None required
____Desirable but unplanned
____Proposed but unfunded____________
____Funded ________________________
____In process
____Completed _______Date

Monitoring status

____None required
____Desirable but unplanned
____Proposed but unfunded___________
____Funded ________________________
____In process
____Completed _______Date

Next steps ____
____
____

Assessment completed by

_____________________________________Date_________

_____________________________________ Date_________

Condition Assessment Manual Data Sheet

This form was developed by the author.

Trail name____________________ **Track log name**____________________ **Sheet** ________ **of**______

Line data

Trail identification numbers	**Begin 00+00**	**End 00+00**	**Length** (feet)	**TRACK TYPE** (code)	**TRACK** (code)	**IMPACT WIDTH** (code)	**TGRADE** (code)	**TREAD GEO** (code)	**SIDE SLOPE** (code)	**SURFACE** (code)	**DRAINAGE** (code)	**MUD MUCK** (code)	**RUTTING** (code)	**VEG COND** (code)	**STONES** (code)	**Total rank value**	**Condition category code** (see below)
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													
TRAILWAY																	
GPS waypoint number				Ranking weight													

Point data

Station 00+00	**GPS waypoint number**	**Feature**	**Attribute**	**Value**	**Notes**	**Condition category code**		
						Point value	**Category label**	**Code**
						Less than 10	Good	G
						10 to 24	Fair	F
						25 to 49	Degraded	D
						50 to 75	Very degraded	VD
						More than 75	Extremely degraded	XD

See “Condition Assessment Codes and Ranking Weights” for codes and ranking weights. GPS = Global Positioning System.

Condition Assessment Codes and Ranking Weights

This table was developed by the author.

Line data

Feature	Attribute	Code	Description and value options	Ranking weight (NV = no assigned value)
TRAILWAY	TRACKTYPE (track type)	M	Main	NV
		SA	Secondary–active	NV
		A-D	Abandoned–degrading	25
		A-S	Abandoned–stabilized	-10
		A-R	Abandoned–reclaimed	-20
		A	Access	NV
		C	Cutoff	NV
		SP	Spur	NV
	TRACK (track characteristic)	ST	Single track	NV
		DT	Double wheel track	2
		WT	Wide track	6
		M2	Multibraid 2 to 4	25
		M5	Multibraid 5 to 10	50
		M >	Multibraid more than 10	75
		NI	Not indicated	NV
	IMPACTWIDTH (impact width)	<	Less than 1.5 feet	NV
		1–3	1.5 to 3 feet	NV
		3–6	3 to 6 feet	NV
		6–12	6 to 12 feet	8
		12–18	12 to 18 feet	20
		18–24	18 to 24 feet	25
		24–40	24 to 40 feet	50
		40–80	40 to 80 feet	75
		80–160	80 to 160 feet	75
		160–320	160 to 320 feet	75
		320–480	320 to 480 feet	75
		> 480	More than 480 feet	75
		NI	Not Indicated	NV
	TGRADE (trail surface grade)	0–3	0 to 3 percent	4
		4–8	4 to 8 percent	0
		9–11	9 to 11 percent	0
		12–15	12 to 15 percent	4
		16–20	16 to 20 percent	8
		21–30	21 to 30 percent	10
		31–40	31 to 40 percent	15
		41–60	41 to 60 percent	20
		> 61	More than 61 percent	20
		3FL	0 to 3 percent fall line	4

(continued)

Feature	Attribute	Code	Description and value options	Ranking weight (NV = no assigned value)
TRAILWAY (continued)	TGRADE (continued)	8FL	4 to 8 percent fall line	4
		11FL	9 to 11 percent fall line	6
		15FL	12 to 15 percent fall line	8
		20FL	16 to 20 percent fall line	10
		30FL	21 to 30 percent fall line	15
		40FL	31 to 40 percent fall line	20
		50FL	41 to 50 percent fall line	20
		60FL	51 to 60 percent fall line	20
		> FL	More than 60 percent fall line	20
	TREADGEO (tread geometry)	F	Flat	4
		OS	Outsloped	-4
		IN	Insloped	NV
		CC	Concave	15
		CV	Convex	-4
		ENT	Entrenched	25
		NI	Not indicated	NV
	SIDESLOPE (hill sideslope)	0–3	0 to 3 percent	4
		4–12	4 to 12 percent	NV
		13–30	13 to 30 percent	NV
		31–60	31 to 60 percent	NV
		61–80	61 to 80 percent	4
		81–100	81 to 100 percent	6
		> 100	More than 100 percent	8
		NI	Not indicated	NV
	SURFACE (trail surface character)	*Natural surfaces*		
		UV	Upland vegetation	NV
		WV	Wetland vegetation	20
		FV	Floating vegetation	20
		NO	Native organic	20
		FM	Native fine mineral	8
		F/G	Fines over gravel base	5
		M	Mixed fines and gravel	-4
		ASG	Alluvial soil and gravel	-8
		S	Sand	15
		G	Gravel	-10
		C	Cobble	-5
		BR	Bedrock or rubble	-20
		WXF	Water crossing over fines	20
		WXS	Water crossing over sand	10
		WXC	Water crossing over coarse material	5

(continued)

Feature	Attribute	Code	Description and value options	Ranking weight (NV = no assigned value)
TRAILWAY (continued)	SURFACE (continued)		*Altered surfaces*	
		IG	Imported gravel	-8
		T	Timbers/planking	-8
		P	Pavers	-10
		CDR	Corduroy	-2
		GTX	Geotextile surface	-10
		TP	Turnpike	-6
		BR	Brush/rough filled	20
		PD	Paved	-20
		W/C	Wood chips or chunkwood	-4
		O	Other	NV
	DRAINAGE (soil drainage)	W	Well drained	-4
		M	Moderately well drained	2
		P	Poorly drained	10
		S	Saturated	15
		PD	Ponded	20
		WR	Water running	20
		NI	Not indicated	NV
	MUDMUCK (mud and muck index)	N	None	NV
		M	Muddy	8
		EM	Extremely muddy	20
		MH	Muckhole	35
		MM	Multiple muck holes	60
		SI	Seasonally impassable	25
		I	Impassable all times	75
		CO	Churned organics shallower than 6 inches	15
		CO+	Churned organics deeper than 6 inches	35
		NI	Not indicated	NV
	RUTTING (Rut depth)	N	None	NV
		< 2	Ruts shallower than 2 inches	8
		8	2- to 8-inch ruts	25
		16	9- to 16-inch ruts	50
		32	17- to 32-inch ruts	75
		60	33- to 60-inch ruts	75
		> 60	Ruts deeper than 60 inches	75
		Not indicated	NV	NV

(continued)

Feature	Attribute	Code	Description and value options	Ranking weight (NV = no assigned value)
TRAILWAY (continued)	VEGCOND (vegetation condition)	N	None	NV
		L	Light impact	NV
		M	Mod impact	2
		H	Heavy impact	3
		S	Stripped	4
		E-R	Elevated roots	25
		R-H	Regrowth–herbaceous	-5
		R-W	Regrowth–woody	-15
		R-N	Regrowth–natural	-25
	STONES (stoniness)	N	None	NV
		< 10	Less than 10 percent	4
		25	11 to 25 percent	15
		75	26 to 75 percent	25
		100	75 to 100 percent	50

This table was developed by the author.

Point data

Feature	Attribute	Code	Value
ANCHORPT (anchor point)	TYPE	B	Beginning
		M	Middle
		E	End
		JCT	Junction
		A	Angle
		TB	Trail break
AQUAMGT (water management)	TYPE	WB	Water bar
		GD	Grade dip or grade reversal
		ND	Natural dip
		C-R	Culvert–round
		C-O	Culvert–other
		OXD	Open topped cross drain
		CKD	Check dam
		D-A	Ditch start
		D-B	Ditch angle or end
		CD-A	Curtain drain start
		CD-B	Curtain drain angle or end
		DL	Drainage lens
		O	Other
	CONDITION	S	Serviceable
		M	Requires maintenance
		RP	Replace
		RM	Remove
	CULVERT SIZE	(Numeric value)	Diameter in inches

(continued)

Feature	Attribute	Code	Value
AQUAPROB (water problem)	TYPE	SF	Structure failure
		BKD	Blocked drain
		WO	Wash out
		HC	Headcut
		EZ-A	Erosion zone start
		EZ-B	Erosion zone angle, mid, or end
		D	Dam or blockage
		PD	Ponded area
		S/S	Spring or seep
		EC-A	Erosion channel start
		EC-B	Erosion channel angle or end
		DZ	Deposition zone
		SDP	Sediment discharge point
		O	Other
STREAMX (stream crossing)	TYPE	UNF	Unimproved ford
		IF	Improved ford
		B	Bridge
		C	Culvert
		O	Other
	STREAM NAME	(Text entry)	Name of stream
	WATER WIDTH	(Numeric value)	Water width at crossing (in feet)
	NAT BANK-BANK	(Numeric value)	Width of natural banks (in feet)
	CROSSING WIDTH	(Numeric value)	Water width at crossing (in feet)
	STRUCTURE WIDTH	(Numeric value)	Structure width (in feet)
	STRUCTURE LENGTH	(Numeric value)	Deck length (in feet)
	CFS	(Numeric value)	Approximate flow in cubic feet per minute
PHYREFPT (physical reference point– single point or line feature)	TYPE	TMM	Temporary mileage marker
		MP	Milepost
		TM	Trail marker
		C	Cairn
		SM	Survey marker
		PM	Property marker
		MM	Management marker
		RJX	Road junction or crossing
		PLX	Powerline crossing
		FX	Fence crossing
		O	Other
	MILEPOST	(Numeric value)	Milepost value (in miles)
	NAME/VALUE/COMMENT	(Text entry)	Name or value
INTRSTPT (interest point– 3-dimensional feature)	TYPE	VP	Viewpoint
		S	Shelter
		CS	Campsite

(continued)

Feature	Attribute	Code	Value
INTRSTPT (continued)	TYPE (continued)	G/B	Gate or barrier
		B	Bollard
		TC	Trail counter location
		CS	Cabin
		STR	Structure
		PO	Pullout
		K	Kiosk
		RS	Ranger station
		OUT	Outhouse
		RR	Restroom
		W-P	Water–potable
		SA	Staging area
		HS	Helicopter landing area
		GS	Gravel source
		TS	Timber source
		CR	Cultural resource
		S-H	Site–human activity
		NS	Nest site
		T&E	Threatened or endangered plant
		W	Weeds
		TH	Trail head
		D	Debris
		O	Other
SURVEY (survey control point)	TYPE	S	Cadastral section
		P	Property
		E	Elevation
		BM	Benchmark
	LABEL	(Text entry)	Text on survey marker
	ELEVATION	(Numeric value)	Elevation on survey (in feet)
	SOURCE	(Text entry)	Source of value: topographic map, GPS, altimeter, monument, other
PHOTOPT (photo reference point)	TYPE	(Text entry)	Subject of photo
		(Numeric value)	Frame reference number
		(Numeric value)	Bearing in degrees

(continued)

Feature	Attribute	Code	Value
HAZARD	TYPE	ST	Standing tree hazard
		FT	Fallen tree
		BRS	Brush/branches/vegetation
		SSD	Steep side dropoff
		SG	Steep grade
		WO	Major washout
		A	Abrupt trail end
		XCS	Extreme cross slope
		XRS	Extreme rough surface
		SS	Slick surface
		R	Rocks on trail
		L	Landslide/debris flow
		SWH	Still water hazard (deep)
		RWH	Running water hazard
		BH/D	Boghole/depression
		PP	Pinch point
		BC	Blind corner
		BI	Blind intersection
		WH	Wildlife hazard–bear den, bees
		VH	Vegetation hazard–poison plant
		HZM	HAZMAT (hazardous material)
		O	Other
SIGNS	TYPE	D	Directional
		R	Regulatory
		I	Informational
		W	Warning
	TEXT	(Text entry)	Sign message
	CONDITION	S	Serviceable
		M	Requires maintenance
		RP	Replace
		RM	Remove
PTGEN (point generic)	COMMENT	(Text entry)	Comment

Forest Service TRACS Survey Form

TRACS Survey

Trail Name:		**Trail No:**		Survey Date:	
Termini this Survey:	BMP	Description:		Surveyors:	
	EMP	Description:			
Overall Trail Condition Comments:					

Unit of Measure:	English	Metric	Measure Method:	Wheel	Tape		Trail Use Comments	
Trail Management Objectives (TMO):	Established	Attached	Not established					
TMO Comments:								
Other Attachments:	Productivity Factors Form	Photo Log Form(s)	Photo Record Form	Sign Inventory Form(s)	Trail Bridge Form(s)			

BMP / EMP	Feature		Condition		Task		Critical	Non-Crit
	Code	Comments	Code	Comments	Code	Comments	Freq	Sevty
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=

TRACS Survey Form v4 - (2/2004)

Page ____ of ____

(continued)

TRACS Survey (continuation sheet)

Trail Name:				Trail No:		Survey Date:		
Beg Station / End Station	Feature Code	Feature Comments	Condition Code	Condition Comments	Task Code	Task Comments	Critical Freq	Non-Crit Sevty
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=
Qnty=	Lgth=	Wdth=	Dpth=	Hgth=	Rad=	Dia=	DistToMtl=	Mtl=

TRACS Survey Form v4 - Continuation (2/2004)   Page ____ of ____

Prescription Manual Data Sheet

This form was developed by the author.

Trail name________________ Track log name________________ Sheet ________of_______

Line data

Trail identification numbers	Begin 00+00	End 00+00	Length (feet)	ACTION	TGRADE	SURF GRUB	GRADING	THARDENING	CAPPING	SUBBASE	CLEARING	SIDE BRUSH	SIDE DITCH	CUT FILL SEC	REHAB
TRAILWAY															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											
TRAILSEG															
GPS waypoint number				Notes											

Point data

Station 00+00	GPS waypoint number	Feature	Attribute	Value	Notes

See “Prescription Codes” for codes to use when filling out this form. Refer to the trail’s trail management objectives for management-defined design parameters. GPS = Global Positioning System.

Prescription Codes

This table was developed by the author.

Line Data

Feature	Attribute	Value code	Value
TRAILWAY	ACTION		Type of action to take
		New	New
		M	Maintain
		U/R	Upgrade/rebuild
		N/R	Narrow/reduce
		W/E	Widen/enlarge
		A	Abandon
		C/B	Close/barricade
		R	Rehabilitate
		O	Other
	TGRADE (Trail grade, in percent)		Segment specified trail grade range (in percent)
		0–3	0 to 3
		4–6	4 to 6
		7–9	7 to 9
		10–12	10 to 12
		13–15	13 to 15
		16–20	16 to 20
		21–25	21 to 25
		Other	Some other percent not listed above
	SURFGRUB (surface grubbing—typically new construction)		Surface grubbing (vegetation stripping and leveling/shaping surface)
		NR	None required
		L	Light
		M	Moderate
		H	Heavy
	GRADING (typically maintenance)		Shaping and/or reshaping already exposed tread surface
		NR	None Required
		L	Light
		M	Moderate
		H	Heavy
	THARDENING (trail hardening)		Trail-hardening method specified
		N	None required
		GC	Gravel cap (specify depth in CAPPING)
		GCF	Gravel cap with geotextile (specify depth in CAPPING)
		PPP	Porous pavement panels (specify configuration in your field notes)
		PPPF	Porous pavement panels with geotextile
		PPPI	Porous pavement panels infilled cells (specify depth of infill in CAPPING)
		C	Corduroy
		CC	Chunkwood or wood chips (specify depth in CAPPING and SUBBASE)
		CCF	Chunkwood or wood chips with geotextile
		P/BE	Puncheon/boardwalk–elevated
		P/BG	Puncheon/boardwalk–ground contact

(continued)

Feature	Attribute	Value code	Value
TRAILWAY (continued)	THARDENING (continued)	T	Turnpike
		TXD	Turnpike with cross drain
		C	Causeway (specify wood or rock rim in your field notes)
		CXD	Causeway with cross drain
		SLT	Slot trench inversion
		RA	Rock armor
		P	Pavers (specify type in your field notes)
		PAV	Pavement (specify type in your field notes)
		O	Other (specify type in your field notes)
	CAPPING (depth in inches)		Gravel or infill depth (in inches, for capping or infill)
		NR	None required
		2–4	2 to 4
		4–8	4 to 8
		8–12	8 to 13
		12–18	12 to 18
		> 18	More than 18
	SUBBASE (depth in inches)		Coarse material or general fill—as subgrade or drainage lens (depth in inches, specify material requirements)
		NR	None required
		2–4	2 to 4
		4–8	4 to 8
		8–12	8 to 12
		12–18	12 to 18
		18–24	18 to 24
		24–36	24 to 36
		36–48	36 to 48
		> 48	More than 48 (specify)
	CLEARING (typically new construction)		Estimated amount of trees and heavy brush to be removed—removal rate
		NR	None required
		L	Light–more than 500 feet/person hour
		M	Moderate–100 to 500 feet/person hour
		H	Heavy–less than 100 feet/person hour
	SIDEBRUSH (typically maintenance)		Vegetation removal to specified clearing limits
		N	None required
		L	Left side requires brushing (outbound)
		R	Right side requires brushing (outbound)
		B	Both sides require brushing
	SIDEDITCH		Ditch work alongside trail—new construction or maintenance
		NR	None required
		M-L	Clean or maintain left ditch (outbound)
		M-R	Clean or maintain right ditch (outbound)
		M-B	Clean maintain both right and left ditches

(continued)

Feature	Attribute	Value code	Value
TRAILWAY (continued)	SIDEDITCH (continued)	N-L	Construct new ditch left side (outbound)
		N-R	Construct new ditch right side (outbound)
		N-B	Construct new ditch both sides
	CUTFILLSEG (cut or fill segment)		Cut or fill segment—area of full bench construction on sideslope or constructed fill on flat ground
		NA	Not applicable
		< 15%	Cut full bench construction across a sideslope less than 15 percent
		15–45%	Cut full bench construction across a sideslope between 15 and 45 percent
		45–100%	Cut full bench construction across a sideslope between 45 and 100 percent
		> 100%	Cut full bench construction across a sideslope more than 100 percent (requires full bench)
		COF	Cut on flat—downward cut ramp (e.g., one bench level to a lower bench level)
		FOF	Fill on flat—fill to build a ramp (one bench level to upper bench level) or to fill a depression
	REHAB		Rehabilitation of abandoned segments with integrated water management
		NR	None required—abandon with no treatment
		S	Scarify surface to encourage natural reseeding and revegetation
		RS	Reseed
		RH	Rehabilitate with vegetation transplants or by scattering debris, etc.

(continued)

This table was developed by the author.

Point Data

Feature	Attribute	Value codes	Value
BRIDGE	TYPE	EST	Existing
		NEW	New
	ACTION	CST	Construct
		RP	Replace
		M/U	Maintain/upgrade
		A/B	Abandon/barricade
	LENGTH (in feet)	(Numeric value)	(Length)
	WIDTH (in inches)	(Numeric value)	(Width)
ANCHOR POINT	TYPE	B	Beginning
		MID	Mid
		END	End
		JCT	Junction
		ANG	Angle or apex of turn
AQUAMGT (water management)	ACTION	NEW	New
		M	Maintain
		RE	Replace
		RC	Recondition
		E/E	Expand/enlarge
	TREATMENT	WBR	Water bar
		GR	Grade reversal (new construction) or dip (existing)
		RGD	Rolling grade dip
		ND	Natural dip (enhancement)
		CUL-R	Culvert–round
		CUL-O	Culvert–other (specify)
		OXD	Open top cross drain
		CKD	Check dam
		HCTX	Headcut treatment
		SF	Spot fill
		OD	Open drain
		DITA	Ditch A'–start point
		DITB	Ditch B'–angle or end point
		DRN-A	Drain A'–start point for discharge drain ditch
		DRN-B	Drain B'–angle or end point for discharge drain ditch
		SMP	Drainage sump–open or rubble-filled infiltration pit
		CUR-A	Curtain drain A'–start of vertical collection drain
		CUR-B	Curtain drain B'–angle or end of collection drain
		SD-A	Sheet drain A'–start of horizontal transfer drain
		SD-B	Sheet drain B'–angle or end of horizontal transfer drain
	CULVERT SIZE (diameter in inches)	(Numeric value)	(Diameter)

(continued)

Feature	Attribute	Value codes	Value
STREAMX (stream crossing)	ACTION	NEW	New
		M	Maintain
		U	Upgrade
		RP	Replace
		RC	Recondition
		E/E	Expand/enlarge
		A/C	Abandon/close
	TYPE	UF	Unimproved ford
		IF	Improved ford
		BDG	Bridge
		CUL	Culvert
	LENGTH (in feet)	(Numeric value)	(Length)
	WIDTH (in feet)	(Numeric value)	(Width)
DEVELOPMNT	ACTION	NEW	New
		M	Maintain
		RP	Replace
		RC	Recondition
		E	Expand
		A/C	Abandon/close
	TYPE	PO	Pullout
		VPT	Viewpoint
		SHEL	Shelter
		CMP	Campsite
		CAB	Cabin
		STR	Structure
		SA	Staging area
		HELI	Helispot
		GRS	Gravel source
		FIS	Fill source
		RKS	Rock source
		TBS	Timber source
		DP/DS	Dump/disposal site
		O1	Other 1
		O2	Other 2
PHYREFPT (physical reference point)	ACTION	NEW	New
		EST	Existing
		M	Maintain
		RP	Replace
		RC	Recondition
		EXP	Expand
		A/C/R	Abandon/close/remove

(continued)

Feature	Attribute	Value codes	Value
PHYREFPT (continued)	TYPE	TH	Trail head
		BOL	Bollard
		MP	Milepost
		TM	Trail marker
		SURM	Survey marker
		PRPM	Property marker
		RJCT	Road junction/crossing
		TJCT	Trail junction
		G/B	Gate or barrier
		COR	Corridor boundary
		TCTR	Trail counter
		PWRX	Powerline crossing
		FENX	Fence crossing
		O	Other
	MILEPOST	(Numeric value)	(Milepost number)
PHOTOPT (photo point)	FRAME#	(Text entry)	(Photo reference number)
	BEARING (in degrees)	(Numeric value)	(Compass bearing)
HAZARD	TYPE	HZTR	Hazardous tree removal
		DTC	Down timber clearing
		SR	Stump removal
		BBV	Brush/branches/vegetation
		PBAR	Place barrier
		IGR	Install guardrail
		EDR	Earth debris removal
		ODR	Other debris removal
		RK	Rock removal
		WPP	Widen pinch point
		CSD	Clear for sight distance
		IWS	Install warning sign
		IGU	Install guide marker
		SLO	Slow traffic
		FH	Fill hole(s)
		O	Other
CNTROLPT (control point)	TYPE	MAJP	Major positive control point
		MINP	Minor positive control point
		MAJN	Major negative control point
		MINN	Minor negative control point
	ELEVSTA	(Numeric value)	(Elevation station)
	METHOD	NI	Not indicated
		GPS	GPS
		ALT	Altimeter

(continued)

Feature	Attribute	Value codes	Value
CNTROLPT (continued)	METHOD (continued)	TOPO	Topographic
		MON	Monument
		O	Other
SIGNS	ACTION	NEW	New
		EST	Existing
		M	Maintain
		RP	Replace
		RC	Recondition
		EXP	Expand
		REM	Remove
	TYPE	DIR	Directional
		REG	Regulatory
		INF	Informational
		WRN	Warning
SIDESTRUC (side structure)	TYPE	SCP	Switchback centerpoint
		CTCP	Climbing turn centerpoint
		RW-A	Retaining wall A'
		RW-B	Retaining wall B'
		FS-A	Fill segment A'
		FS-B	Fill segment B'
		CS-A	Cut segment A'
		CS-B	Cut segment B'

Project Production Log

This form was developed by the author.

Project____ **Crew boss**___________________________

Date	Activity/task	Crew size	Total hours	Accomplishments	Production rate/hour	Mobilize/ demobilize (hours)	Materials	Material cost (dollars)

Prescription Cost Estimate

An example of proposed preliminary trail improvements for a **maintainable trail.** This table was developed by the author.

WCM 17B Easement Subunit
Trail prescription segment numbers 3 through 166

Priority	Task	Amount	Unit	Type	Descriptor unit	Requirement per unit	Total labor (hours)	Cost per unit (dollars)	Total cost (dollars)	Notes/assumptions
Moderate	Gravel cap	641	Linear feet	Labor/ equipment	Linear feet	Not applicable	Not applicable	3.00	1,923.00	Uses National Park Service bobcat and gravel haulers
		43	Cubic yards	Material	Not applicable	Not applicable	Not applicable	10.00	430.00	Local commercial gravel source
Moderate	Gravel cap	277	Linear feet	Labor/ equipment	Linear feet	Not applicable	Not applicable	2.00	554.00	Uses National Park Service bobcat and gravel haulers
		47	Cubic yards	Material	Not applicable	Not applicable	Not applicable	8.00	376.00	Uses onsite gravel source
High	Turnpike (ditch, elevate)	1,201	Linear feet	Labor	Linear feet	0.04	48.04	18.00	864.72	National Park Service excavator, laborer
		1,201	Linear feet	Trail dozer	Hours	20.00	Not applicable	125.00	2,500.00	Rental trail dozer with operator
		1,201	Linear feet	Excavator	Hours	40.00	Not applicable	80.00	3,200.00	Rental excavator with National Park Service employee operator
High	Grading, leveling, ditching	4,433	Linear feet	Trail dozer	Hours	40.00	Not applicable	125.00	5,000.00	Rental trail dozer with operator
High	Puncheon	142	Linear feet	Materials	Not applicable	Not applicable	Not applicable	30.00	4,260.00	Purchase–some local materials
		142	Linear feet	Labor–installation	Job	1.00	160.00	18.00	2,880.00	National Park Service crew: four people, 4 days at 10 hours/day
Moderate	Trail hardening	385	Linear feet	Material–geotrack	Not applicable	Not applicable	Not applicable	19.32	7,438.20	Purchase
		385	Linear feet	Labor–installation	Linear feet	0.25	96.25	18.00	1,732.50	National Park Service crew: three people, 3.2 days at 10 hours/day
		385	Linear feet	Labor–grubbing	Linear feet	0.05	19.25	18.00	346.50	National Park Service crew time
Moderate	Bridges	60	Linear feet	Materials	Not applicable	Not applicable	Not applicable	60.00	3,600.00	Purchase
		3	Each	Labor–installation	Each	60.00	Not applicable	18.00	3,240.00	National Park Service crew: three people, 2 days at 10 hours/day
High	Grade dips and drains	36	Each	Trail dozer	Hours	0.50	Not applicable	125.00	2,250.00	Rental trail dozer with operator

(continued)

WCM 17B Easement Subunit
Trail prescription segment numbers 3 through 166
(continued)

Priority	Task	Amount	Unit	Type	Descriptor unit	Requirement per unit	Total labor (hours)	Cost per unit (dollars)	Total cost (dollars)	Notes/assumptions
High	Drainage sump	1	Each	Excavator	Hours	2.00	Not applicable	80.00	160.00	Rental excavator with National Park Service employee operator
High	Culverts	5	Each	Arch culverts	Not applicable	Not applicable	Not applicable	300.00	1,500.00	Purchase
		5	Each	Excavator–installation	Hours	1.00		80.00	400.00	Rental excavator with National Park Service employee operator
		5	Each	Excavator operator	Hours	1.50		18.00	135.00	Rental excavator with National Park Service employee operator
		5	Each	Labor–installation	Hours	3.00		18.00	270.00	National Park Service crew: two people, 1.5 hours each
High	Hand finish–all	Not applicable	Not applicable	Labor	Hours	Not applicable	120.00	18.00	2,160.00	National Park Service crew: three people, 4 days at 10 hours/day
High	Material delivery	1	Each	Freight–lumber	Each	Not applicable	Not applicable	800.00	800.00	None
High	Slinging operations	1	Each	Helicopter	Hours	8.00		600.00	4,800.00	National Park Service charter with National Park Service ground crew
High	Trail dozer staging	1	Each	Not applicable	Not applicable	May be shared costs	Not applicable	1,200.00	1,200.00	Trail dozer provider mobilize/demobilize
High	Excavator staging	1	Each	Not applicable	Not applicable	May be shared costs	Not applicable	1,000.00	1,000.00	Excavator provider mobilize/demobilize
									$53,019.92	Total project
									$33,379.72	**High priority items only**

(continued)

WCM Winston Creek Access
Trail prescription segment numbers 173 through 198

Priority	Task	Amount	Unit	Type	Descriptor unit	Requirement per unit	Total labor (hours)	Cost per unit (dollars)	Total cost (dollars)	Notes/assumptions
High	Grade dips and drains	3	Each	Trail dozer	Hours	0.50	1.50	125.00	187.50	Rental trail dozer with operator
High	Enhance drainage dip	1	Each	Trail dozer	Hours	0.50	0.50	125.00	62.50	Rental trail dozer with operator
High	Hand finish	Not applicable	Not applicable	Labor	Hours	Not applicable	10.00	18.00	180.00	National Park Service crew: two people, 0.5 days at 10 hours/day
Moderate	Trail hardening	355	Linear feet	Material–geotrack	Not applicable	Not applicable	Not applicable	19.32	6,858.60	Purchase
		355	Linear feet	Labor–installation	Linear feet	0.25	88.75	18.00	1,597.50	National Park Service crew: three people, 3 days at 10 hours/day
		355	Linear feet	Labor–grubbing	Linear feet	0.05	17.75	18.00	319.50	National Park Service crews
High	Barrier/gate	2	Each	Purchase	Not applicable	Not applicable	Not applicable	100.00	200.00	Buck and rail
		2	Each	Labor	Hours	8.00	16.00	18.00	288.00	National Park Service crew: two people, 1 day at 8 hours/day
High	Signs	4	Each	Purchase	Not applicable	Not applicable	Not applicable	50.00	200.00	Carsonite
		4	Each	Labor	Hours	1.00	4.00	18.00	72.00	National Park Service staff
High	Trail dozer staging	1	Each	Not applicable	Not applicable	May be shared costs	Not applicable	1,200.00	1,200.00	Trail dozer provider mobilize/demobilize
	Trail dozer walk in or out	3	Not applicable	Not applicable	Hours	Not applicable	3.00	125.00	375.00	None
High	Excavator staging	1	Each	Not applicable	Not applicable	May be shared costs	Not applicable	1,000.00	1,000.00	Excavator provider mobilize/demobilize
	Excavator walk in or out	3	Not applicable	Not applicable	Hours	Not applicable	Not applicable	80.00	240.00	None
									$12,780.60	Total project
									$4,005.00	**High priority items**

(continued)

WC-SW Willy Creek Bowl Trail–NPS Lands
Trail prescription segment numbers 213, 218, 232, and 233

Priority	Task	Amount	Unit	Type	Descriptor unit	Requirement per unit	Total labor (hours)	Cost per unit (dollars)	Total cost (dollars)	Notes/assumptions
High	Grade reversals	2	Each	Trail dozer	Hours	0.50	1.00	125.00	125.00	Rental trail dozer with operator
High	Grade dips and drains	5	Each	Trail dozer	Hours	0.50	2.50	125.00	312.50	Rental trail dozer with operator
High	Enhance drainage dip	1	Each	Trail dozer	Hours	0.50	0.50	125.00	62.50	Rental trail dozer with operator
High	Hand finish	Not applicable	Not applicable	Labor	Hours	Not applicable	20.00	18.00	360.00	National Park Service crew: two people, 1 day at 10 hours/day
High	Barriers and gates	2	Each	Purchase	Not applicable	Not applicable	Not applicable	100.00	200.00	Buck and rail
		2	Each	Labor	Hours	8.00	16.00	18.00	288.00	National Park Service crew: two people, 1 day at 8 hours/day
High	Signs	2	Each	Purchase	Not applicable	Not applicable	Not applicable	50.00	100.00	Carsonite
		2	Each	Labor	Hours	1.00	2.00	18.00	36.00	National Park Service staff
High	Rehabilitate–water control	1,299	Feet	Labor	Hours	Not applicable	80.00	18.00	1,440.00	National Park Service crew: four people, 2 days at 10 hours/day
Moderate	Rehabilitate–revegetate	1,299	Feet	Labor	Hours	Not applicable	160.00	18.00	2,880.00	National Park Service crew: four people, 2 days at 10 hours/day
Moderate	Rehabilitation materials	1,299	Feet	Purchase	Not applicable	Not applicable	Not applicable	Not applicable	500.00	Matting, seed, misc.
									$6,304.00	Total project
									$2,924.00	**High priority items**

(continued)

CW-S Cando Airstrip
Trail prescription segment numbers 243 through 274

Priority	Task	Amount	Unit	Type	Descriptor unit	Requirement per unit	Total labor (hours)	Cost per unit (dollars)	Total cost (dollars)	Notes/assumptions
High	Grade reversals	1	Each	Trail dozer	Hours	0.75	0.75	125.00	93.75	Rental trail dozer with operator
High	Grade dips and drains	7	Each	Trail dozer	Hours	0.75	5.25	125.00	656.25	Rental trail dozer with operator
Moderate	Trail hardening	198	Linear feet	Material–geotrack	Not applicable	Not applicable	Not applicable	19.32	3,825.36	Purchase
		198	Linear feet	Labor–installation	Linear feet	0.25	49.50	18.00	891.00	National Park Service installation crew
		198	Linear feet	Labor–grubbing	Linear feet	0.05	9.90	18.00	178.20	National Park Service installation crew
Moderate	Slinging operations	1	Each	Helicopter	Hours	2.00		600.00	1,200.00	None
High	Trail dozer walk in or out	4	Not applicable	Not applicable	Hours	Not applicable	3.00	125.00	500.00	None
High	Barrier and gate	1	Each	Purchase	Not applicable	Not applicable	Not applicable	200.00	200.00	Buck and rail
		1	Each	Labor	Hours	8.00	8.00	18.00	144.00	National Park Service crew: two people, 0.5 day at 8 hours/day
High	Signs	1	Each	Purchase	Not applicable	Not applicable	Not applicable	50.00	50.00	Carsonite
		1	Each	Labor	Hours	1.00	1.00	18.00	18.00	National Park Service staff
									$7,756.56	Total project
									$1,662.00	**High priority items**

(continued)

Pyro Peak Trail Trail prescription segment numbers 168 through 183										
Priority	**Task**	**Amount**	**Unit**	**Type**	**Descriptor unit**	**Requirement per unit**	**Total labor (hours)**	**Cost per unit (dollars)**	**Total cost (dollars)**	**Notes/assumptions**
High	Moderate clearing	406	Linear feet	Saw crew	Hours	Not applicable	20.00	18.00	360.00	National Park Service crew: two people, 1 day at 10 hours/day
High	Puncheon	488	Linear feet	Materials	Not applicable	Not applicable	Not applicable	35.00	17,080.00	Purchase–some local materials
		488	Linear feet	Labor–installation	Job	1.00	400.00	18.00	7,200.00	National Park Service crew: four people, 10 days at 10 hours/day
High	Material delivery	1	Each	Freight–lumber	Each	Not applicable	Not applicable	1,200.00	1,200.00	None
High	Barrier and gate	1	Each	Purchase		Not applicable	Not applicable	200.00	200.00	Buck and rail
		1	Each	Labor	Hours	8.00	8.00	18.00	144.00	National Park Service crew: two people, 0.5 day at 8 hours/day
High	Signs	1	Each	Purchase				50.00	50.00	Carsonite
		1	Each	Labor	Hours	1.00	1.00	18.00	18.00	National Park Service staff
High	Slinging operations	1	Each	Helicopter	Hours	6.00		600.00	3,600.00	National Park Service charter with National Park Service ground crew
High	Crew support logistics	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	40.00	18.00	720.00	None
									$30,572.00	**Total project–all high priority**

Project totals		
Entire project area (dollars)		**With 8-percent inflation/contingency for 07/08 fiscal year operations** (dollars)
Total project	110,433.08	119,268.00
Total high priority	66,875.72	72,226.00
NPS lands only (dollars)		**With additional 15 percent to cover higher unit costs (equipment rentals) when the scope of the project is reduced** (dollars)
Total project	57,413.16	66,025.00
Total high priority	39,163.00	45,037.00

Notes

Appendix D: Data Dictionaries

- **Alaska NPS OHV Condition Assessment Data Dictionary**
- **Definitions of Terms for the Alaska NPS OHV Condition Assessment Data Dictionary**
- **Alaska NPS OHV Trail Prescription GPS Data Dictionary**

The Forest Service Trail Data Dictionary for trail structures and associated tasks is available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Alaska NPS OHV Condition Assessment Data Dictionary

This table was developed by the National Park Service (NPS) and adapted by the author for this publication.

Line data

Feature	Attribute	**Value/description** (menu selection options)
TRAILWAY	TRAILNAME	(Text entry)
	TRACKTYPE	Main, secondary-active, abandoned-degrading, abandoned-stabilized, abandoned-reclaimed, access, cutoff, spur.
	TRACK	Single track, double wheel track, wide track, multibraided 2 to 4, multibraided 5 to 10, multibraided more than 10, not indicated.
	IMPACTWIDTH	Less than 1.5 feet, 1.5 to 3 feet, 4 to 6 feet, 7 to 12 feet, 13 to 18 feet, 19 to 24 feet, 25 to 40 feet, 41 to 80 feet, 81 to 160 feet, 161 to 320 feet, 321 to 480 feet, more than 480 feet.
	TGRADE (trail surface grade)	Contour: 0 to 3 percent, 4 to 8 percent, 9 to 11 percent, 12 to 15 percent, 16 to 20 percent, 21 to 30 percent, 31 to 40 percent, 41 to 60 percent, more than 60 percent.
		Fall line: 0 to 3 percent, 4 to 8 percent, 9 to 11 percent, 12 to 15 percent, 16 to 20 percent, 21 to 30 percent, 31 to 40 percent, 41 to 60 percent, more than 60 percent.
	TREADGEO (tread geometry)	Flat, outsloped, insloped, concave, convex, entrenched, not indicated.
	SIDESLOPE	0 to 3 percent, 4 to 12 percent, 13 to 30 percent, 31 to 60 percent, 61 to 80 percent, 81 to 100 percent, more than 100 percent, not indicated.
	TSURFCHAR (trail surface character)	Natural surfaces: Upland vegetation, wetland vegetation, floating vegetation, native organic, native fine mineral, fines over gravel, mixed fines and gravel, alluvial sand and gravel, sand, gravel, cobble, bedrock or rubble, water crossing over fines, water crossing over sand, water crossing over coarse material.
		Altered surfaces: Imported gravel, timbers/planking, pavers or block, corduroy, geotextile surface, turnpike, brush/rough fill, paved, wood chips/chunkwood, other.
	DRAINAGE	Well drained, moderately well drained, poorly drained, saturated, ponded, water running across surface, not indicated.
	MUDMUCK	None, muddy, extremely muddy, muck hole, multiple muck holes, seasonally impassable, impassable at all times, shallow churned organics (shallower than 6 inches), deeply churned organics (deeper than 6 inches), not indicated.
	RUTTING	None, shallower than 2 inches, 2 to 8 inches, 9 to 16 inches, 17 to 32 inches, 33 to 60 inches, deeper than 60 inches, not indicated.
	VEGCONDITION (vegetation condition)	None, light impact, moderate impact, heavy impact, stripped, elevated roots, regrowth-herbaceous, regrowth-woody, regrowth-natural.
	STONES	None, less than 10 percent, 11 to 25 percent, 26 to 75 percent, 76 to 100 percent, not indicated.
	SIDEBRUSH	None, light, moderate, heavy, not indicated.
	COMMENT	(Text entry)
ROAD	TYPE	Access, primary highway, secondary, subdivision, unimproved, other.
	SURFACE	Paved, gravel, dirt, other.
	WIDTH	Less than 8 feet, 8 to 12 feet, 13 to 16 feet, 17 to 20 feet, 21 to 30 feet.
	ROAD NAME	(Text entry)
LINEGEN (line generic)	COMMENT	(Text entry)

(continued)

This table was developed by NPS and adapted by the author for this publication.

Point data

Feature	Attribute	Value/description (menu selection options)
ANCHORPT (anchor point)	TYPE	Beginning, middle, end, junction, angle, trail break.
AQUAMGT (water management point)	TYPE	Water bar, grade dip, rolling dip, natural dip, culvert-round, culvert-other, open top cross drain, check dam, ditch A (starting point), ditch B (turn or end point), curtain drain A, curtain drain B, other.
	CONDITION	Serviceable, requires maintenance, replace, remove.
	CULVERT SIZE	(Numeric value in inches)
AQUAPROB (water problem point)	TYPE	Structure failure, blocked drain, wash out, head cut, erosion zone A, erosion zone B, dam, ponded area, spring/seep, erosion channel A, erosion channel B, deposition zone, sediment discharge point.
STREAMX (stream crossing point)	TYPE	Unimproved ford, improved ford, bridge, culvert, other.
	STREAM NAME	(Text entry)
	WATER WIDTH	(Numeric value in feet)
	NATURAL BANK-TO-BANK WIDTH	(Numeric value in feet)
	CROSSING WIDTH	(Numeric value in feet)
	APPROXIMATE FLOW	(Numeric value in cubic feet per second [cfs])
	STRUCTURE WIDTH/DIA	(Numeric value in feet or inches)
	STRUCTURE LENGTH	(Numeric value in feet)
PHYREFPT (physical reference point)	TYPE	Temporary mileage marker, milepost, trail marker, cairn, property marker, management marker, road junction, powerline crossing, fence crossing, other.
	MILEPOST	(Numeric value in miles–0.5 to 999)
	NAME/VALUE/ COMMENT	(Text entry)
INTRSTPT (interest point)	TYPE	Viewpoint, shelter, campsite, cabin, structure, pullout, gate or barrier, kiosk, ranger station, outhouse, restroom, water-potable, staging area, helispot, gravel source, timber source, cultural resource, site of human activity, nest site, threatened or endangered plant site, weeds, bollard, trail counter, debris, trail head, other.
	COMMENT	(Text entry)
SURVEYPT (survey point)	TYPE	Section, property, elevation, bench mark.
	LABEL	(Text entry)
	ELEVATION	(Numeric value in feet MSL [mean sea level].)
	SOURCE	Topographic map, Global Positioning System, altimeter, monument, other.
PHOTOPT (photo point)	FRAME/REFERENCE NUMBER	(Numeric value)
	BEARING	(Numeric value in degrees–1 through 360)
	SUBJECT	(Text entry)

(continued)

Feature	Attribute	**Value/description** (menu selection options)
HAZARD (hazard point)	TYPE	Standing tree, fallen tree, brush/branches/vegetation, steep side dropoff, steep grade, major washout, abrupt trail end, extreme cross slope, extremely rough surface, slick surface, rocks on trail, landslide/debris flow, still-water hazard, running water hazard, boghole/depression, pinch point, blind corner, blind intersection, wildlife hazard, vegetation hazard, hazmat, other.
	NOTE/COMMENT	(Text entry)
SIGNS	TYPE	Informational, directional, regulatory, warning, other.
	TEXT	(Text entry)
	CONDITION	Serviceable, poor, replace, remove.
PTGEN (point generic)	COMMENT	(Text entry)

This table was developed by NPS and adapted by the author for this publication.

Area data

Feature	Attribute	**Value/description** (menu selection options)
BRAIDED IMPACT AREA	COMMENT	(Text entry)
PARKING	TYPE	Paved, gravel, compacted dirt, vegetation, other, mixture.
	CONDITION	Serviceable, poor.
SOILTER (soil/terrain)	COMMENT	(Text entry)
AREAGEN (area generic)	COMMENT	(Text entry)

Definitions of Terms for the Alaska NPS OHV Condition Assessment Data Dictionary

This table was developed by NPS and adapted by the author for this publication.

Line data

Feature	Attribute	Value	Description
TRAILWAY			Measurable segment of trail (varying length) with similar physical parameters throughout its length.
	TRAILNAME		Trail name.
	TRACKTYPE		Unofficial designation of overall trail use patterns.
		Main	Primary active route of travel.
		Secondary–active	Actively used trail, but not the most active. There may be more than one secondary trail.
		Abandoned–degrading	Alignment is no longer in use—has active erosion/degradation issues.
		Abandoned–stabilized	Alignment is no longer in use—is stable, for example, no active erosion or continued degradation.
		Abandoned–reclaimed	Alignment is no longer in use—is completely revegetated by natural or artificial means.
		Access	Secondary route to main trail, such as from a secondary trail head.
		Cutoff	Alignment between two legs of main or secondary trails.
		Spur	Alignment from main or secondary trail to an end point.
	TRACK		On-the-ground pattern of trail surface disturbance.
		Single track	A single track—typically a narrow footpath or cycle path.
		Double wheel track	One set of parallel wheel tracks with a mostly vegetated center hump—more than 75 percent vegetated.
		Wide track	A wide travel track, mostly stripped of vegetation—less than 25 percent vegetated.
		Multibraid 2 to 4	Between 2 and 4 sets of tracks—single tracks, double tire tracks, or wide tracks.
		Multibraid 5 to 10	Between 5 and 10 sets of tracks—single tracks, double tire tracks, or wide tracks.
		Multibraid > 10	More than 10 sets of tracks—a whole lot of tracks affecting a very large area.
		Not indicated	Value was not mapped during inventory.
	IMPACTWIDTH		Width of the total surface impact associated with the trail—not just trail width—measured perpendicular to the direction of travel.
		< 1.5 feet	Surface impact is less than 1.5 feet wide—typical of well-defined single track.
		1.5 to 3 feet	Surface impact is 1.5 to 3 feet wide—typical of well-defined social trail.
		4 to 6 feet	Surface impact is 4 to 6 feet wide—typical of well-defined ATV trail.
		7 to 12 feet	Surface impact is 7 to 12 feet wide—typical of well-used ATV trail, wide or braided segment.
		13 to 18 feet	Surface impact is 13 to 18 feet wide—typical of well-used ATV trail, wide or braided segment.
		17 to 24 feet	Surface impact is 19 to 24 feet wide—typical of well-used ATV trail, wide or braided segment.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	IMPACTWIDTH (continued)	25 to 40 feet	Surface impact is 25 to 40 feet wide—typically a braided impact area.
		41 to 80 feet	Surface impact is 41 to 80 feet wide—typically a braided impact area.
		81 to 160 feet	Surface impact is 81 to 160 feet wide—typically a braided impact area.
		161 to 320 feet	Surface impact is 161 to 320 feet wide—typically a braided impact area.
		321 to 480 feet	Surface impact is 321 to 480 feet wide—typically a braided impact area.
		> 480 feet	Surface impact is more than 480 feet wide—typically a braided impact area.
		Not indicated	Value was not mapped during inventory.
	TGRADE (trail grade)		The grade of the trail in percent as measured by a clinometer, inclinometer, or Abney hand level.
		0 to 3 percent	Trail grade along the segment is essentially flat, between 0 and 3 percent—a contour alignment.
		4 to 8 percent	Trail grade along the segment is 4 to 8 percent—a contour alignment.
		9 to 11 percent	Trail grade along the segment is 9 to 11 percent—a contour alignment.
		12 to 15 percent	Trail grade along the segment is 12 to 15 percent—a contour alignment.
		16 to 20 percent	Trail grade along the segment is 16 to 20 percent—a contour alignment.
		21 to 30 percent	Trail grade along the segment is 21 to 30 percent—a contour alignment.
		31 to 40 percent	Trail grade along the segment is 31 to 40 percent—a contour alignment.
		41 to 60 percent	Trail grade along the segment is 41 to 60 percent—a contour alignment.
		> 60 percent	Trail grade along the segment is more than 60 percent and is a contour alignment.
		0 to 3 percent fall line	Trail grade along the segment is 0 to 3 percent and is more than half the percent grade of the adjacent sideslope.
		4 to 8 percent fall line	Trail grade along the segment is 4 to 8 percent and is more than half the percent grade of the adjacent sideslope.
		9 to 11 percent fall line	Trail grade along the segment is 9 to 11 percent and is more than half the percent grade of the adjacent sideslope.
		12 to 15 percent fall line	Trail grade along the segment is 12 to 15 percent and is more than half the percent grade of the adjacent sideslope.
		16 to 20 percent fall line	Trail grade along the segment is 16 to 20 percent and is more than half the percent grade of the adjacent sideslope.
		21 to 30 percent fall line	Trail grade along the segment is 21 to 30 percent and is more than half the percent grade of the adjacent sideslope.
		31 to 40 percent fall line	Trail grade along the segment is 31 to 40 percent and is more than half the percent grade of the adjacent sideslope.
		41 to 60 percent fall line	Trail grade along the segment is 41 to 60 percent and is more than half the percent grade of the adjacent sideslope.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	TGRADE (continued)	> 60 percent fall line	Trail grade along the segment is more than 60 percent and is more than half the percent grade of the adjacent sideslope.
	TREADGEO (tread geometry)		Tread shape.
		Flat	Tread is essentially flat with less than 3 percent cross slope.
		Outsloped	Tread slopes more than 3 percent to the outer edge.
		Insloped	Tread slopes more than 3 percent to the inside edge.
		Concave	Tread is worn in the center and has a concave shape.
		Convex	Tread is crowned in the center.
		Entrenched	Tread is worn into the ground with distinct vertical sides, typically deeper than 2 inches.
		Not indicated	Value was not measured.
	SIDESLOPE		The percent sideslope, as measured by a clinometer, of the native landform the trail crosses.
		0 to 3 percent	Slope of adjacent terrain is 0 to 3 percent.
		4 to 12 percent	Slope of adjacent terrain is 4 to 12 percent.
		13 to 30 percent	Slope of adjacent terrain is 13 to 30 percent.
		31 to 60 percent	Slope of adjacent terrain is 31 to 60 percent.
		61 to 80 percent	Slope of adjacent terrain is 61 to 80 percent.
		81 to 100 percent	Slope of adjacent terrain is 81 to 100 percent.
		> 100 percent	Slope of adjacent terrain is steeper than 100 percent (45 degrees).
		Not indicated	Value was not mapped during inventory.
	TSURFCHAR (trail surface character)		Natural or altered soil or substrate of the trail tread.
		Upland vegetation	Trail tread is directly on upland plant species—typically light use on dry sites.
		Wetland vegetation	Trail tread is directly on wetland plant species—typically light use on wet sites.
		Floating vegetation	Trail tread is directly on a vegetated floating bog.
		Native organic	Trail tread is on an organic subsurface layer of peat or muck.
		Native fine mineral	Trail tread is on clay or silt that may have some mixed organics.
		Fines over gravel	Trail tread is on clay or silt with gravel at a shallow enough depth to improve surface drainage.
		Mixed fines and gravel	Trail tread is on a mixture of gravel with fines filling voids.
		Alluvial soil and gravel	Trail tread is on naturally deposited riverine/alluvial sand and gravel deposits.
		Sand	Trail tread is on fine to coarse sands with little binder.
		Gravel	Trail tread is on a natural gravel surface—typically alluvial gravel with mixed fines.
		Cobble	Trail tread is on a rounded rock surface with rocks 3 to 10 inches in diameter, few fines.
		Bedrock or rubble	Trail tread is on solid, compacted, or natural angular rock.
		Water crossing over fines	Trail fords a river, stream, lake, or impoundment over a silt or clay bottom.
		Water crossing over sand	Trail fords a river, stream, lake, or impoundment over a sandy bottom.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	TSURFCHAR (continued)	Water crossing over coarse material	Trail fords a river, stream, lake, or impoundment over a gravel or cobble bottom.
		Imported gravel	Trail tread is on imported (not in-situ native) gravel mix—may be from a local borrow source or transported from the trailhead.
		Timbers/planking	Trail tread is on dimensional lumber, such as boardwalks, bridge decks, running plank.
		Corduroy	Trail tread is on perpendicular natural poles or logs buried or on the surface.
		Geotex surface	Trail tread is on a structural geotextile surface or panels, such as Geoblock or Solgrid.
		Turnpike	Trail tread is elevated fill from adjacent ditches—may or may not be curbed.
		Causeway	Trail tread is on imported elevated fill contained by log or rock curbing.
		Brush/rough filled	Trail tread crosses an area filled with brush, logs, or other fill—generally not engineered.
		Paved	Trail is paved with asphalt, concrete, or other paving—typically in a front country setting.
		Wood chips/chunkwood	Trail tread is on processed wood chips or chunk wood (large chips).
		Other	Trail tread is on some other surface not listed above.
	DRAINAGE		Typical long-term soil moisture level of the tread foundation, as indicated by moisture level, soil mottling, and ground water levels. Note: the tread may have better or poorer drainage than the surrounding terrain because of tread construction and management history.
		Well drained	Tread typically has high infiltration, is usually well drained, dries quickly, and is not subject to ponding—this is the usual case for gravel and coarse textured soils. Subsoil is not mottled.
		Moderately well drained	Tread typically has good infiltration, may have short periods when it is wet or moist, but dries fairly quickly. Usually, water does not pond on the surface. Sandy soils and light and moderate loams. Typically, mottles are generally absent within 12 inches of the surface.
		Poorly drained	Soils are fine textured, hold moisture, and drain poorly. Often they are wet, muddy, and occasionally ponded. Typically, soils are fine textured loams and finer soils. Mottles are present within 12 inches of surface.
		Saturated	Soils are always wet with the water table at or very near (less than 3 inches below) the surface—typically wetland sites.
		Ponded	Water is held on the tread surface or there is clear evidence of ponding during the majority of the use period.
		Water running	Water is running across or along the surface of the trail at the time of inspection.
		Not indicated	Soil moisture levels were not mapped during inventory.
	MUDMUCK (mud and muck)		Relative muddiness of the trail tread during typical use periods and seasonal wet conditions.
		None	Tread surface is not muddy under typical moisture conditions.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	MUDMUCK (continued)	Muddy	Trail is typically muddy on the surface during wet periods but ruts are not typically formed.
		Extremely muddy	Trail surface develops a thick surface of mud during wet periods and ruts more than 1 inch deep form easily.
		Muckhole	A single, solitary large deep water and/or mud-filled hole along the tread alignment.
		Multimuck holes	A nearly continuous series of muck holes.
		Seasonally impassable	Degraded conditions—typically multiple muck holes—that limit passage during wet periods.
		Impassable all times	Degraded conditions—typically multiple muck holes—that make the trail totally unusable.
		Churned organics < 6 inches	Trail crosses organic soil. Surface materials have been churned shallower than 6 inches.
		Churned organics > 6 inches	Trail crosses organic soil. Surface materials have been churned deeper than 6 inches.
		Not indicated	MUDMUCK index was not mapped during inventory.
	RUTTING		Extent of surface disturbance in the form of ruts, erosion, or soil compaction below the original constructed, graded tread surface (or the original terrain surface if the trail was not constructed).
		None	No erosion or ruts are evident—typical of a very lightly used trail or a hard surface.
		< 2 inches	Erosion or rut depth is less than 2 inches below the surrounding soil surface.
		2 to 8 inches	Erosion or rut depth is 2 to 8 inches below the original tread or the surrounding soil surface.
		9 to 16 inches	Erosion or rut depth is 9 to 16 inches below the original tread or the surrounding soil surface.
		17 to 32 inches	Erosion or rut depth is 17 to 32 inches below the original tread or the surrounding soil surface.
		33 to 60 inches	Erosion or rut depth is 33 to 60 inches below the original tread or the surrounding soil surface.
		> 60 inches	Erosion or rut depth is more than 60 inches below the original tread or the surrounding soil surface.
		Not indicated	Rutting was not mapped during inventory.
	VEGCONDITION (vegetation condition—often abbreviated VEGCOND)		Extent of vegetative disturbance from off-highway vehicle impact along the trail or the amount of regrowth on abandoned or lightly used trails.
		None	Persistent tire tracks are not visible on the vegetated surface, or there is no existing vegetation along the track, such as naturally bare gravel soil.
		Light impact	Traffic has lightly impacted vegetation along the tire tracks—some woody stems are broken and/or surface vegetation is compacted—but there is little or no soil compaction. Less than 10 percent of the surface vegetation is stripped away. Tracks are visible but largely transient. If not subject to additional disturbance, most sites would likely return to its original native state in one to two seasons.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	VEGCONDITION (continued)	Moderate impact	Traffic has moderately impacted vegetation along the tire tracks and tracks are obvious. Woody component is largely stripped. Herbaceous vegetation is compacted and partially stripped (more than 25 percent of the vegetation remains along wheel tracks). Underlying soils are partially exposed and may be lightly rutted and/or churned. If not subjected to additional disturbance, most upland sites could be expected to return to near original natural state within five seasons (within three seasons for wetland herbaceous sites).
		Heavy impact	Traffic has heavily impacted vegetation along the tire tracks. Tire tracks are distinct with woody and herbaceous vegetation nearly or completely stripped along tracks (less than 25 percent of the vegetation remains along tire track). A center hump typically remains (for more than 75 percent of the trail's length) that contains native composition. Underlying soils are compacted on upland sites and churned on wetland sites continuously along the route of travel. On upland sites, there is clear evidence of long-term alteration of site characteristics because of soil loss and modification of the surface hydrology. On wetlands dominated by herbaceous vegetation, there is significant organic churning and increased ponding. Impacts will modify site plant composition if or when regrowth occurs. If left undisturbed, reestablishment of vegetation will probably take longer than five seasons on upland impacted sites (three seasons on wetland herbaceous sites).
		Stripped	All vegetation has been lost across the trail tread, very little (less than 25 percent along the trail length) or no remaining center hump; soils are completely exposed and are compacted on upland sites and heavily churned on herbaceous-dominated wetland sites. On upland sites, there is clear evidence of long-term alteration of site characteristics because of soil loss and modification of surface hydrology. On some upland sites, larger woody roots may remain and temporarily armor the surface. On herbaceous-dominated wetlands, organic materials have been heavily churned and liquefied and surface hydrology has been modified, increasing the long-term percentage of open water. Impacts to uplands and wetlands will modify site plant composition if or when regrowth occurs. If left undisturbed, reestablishment of vegetation is likely to take more than five seasons for uplands and more than three seasons for wetlands.
		Elevated roots	Original surface is completely stripped, leaving only a network of large woody roots and compacted soil that may temporarily prevent further degradation.
		Regrowth–herbaceous	Abandonment or low use levels have allowed an herbaceous vegetative component to reestablish itself along the impacted area—may not be original native composition.
		Regrowth–woody	Abandonment or very low use levels have allowed a woody vegetative component to reestablish itself along the impacted area—may not be original native composition.
		Regrowth–natural	Abandonment or extremely low use levels have allowed the native plant community to reestablish itself along the impacted area in a manner that approximates original native composition.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	STONES		Extent to which surface stones or rocks create a rough surface or barrier to travel.
		None	Little or no rocks appear in the tread.
		< 10 percent	A few rocks or large stones affect travel.
		11 to 25 percent	11 to 25 percent of the trail surface has enough large rocks to affect travel.
		26 to 75 percent	26 to 75 percent of the trail surface has enough large rocks to affect travel.
		76 to 100 percent	76 to 100 percent of the trail surface has enough large rocks to affect travel.
		Not indicated	Value was not mapped during inventory.
	SIDEBRUSH		Extent to which vegetation along the trail margins affects passage.
		None	Brush has no effect on passage.
		Light side brush	Occasional branches must be avoided while traveling.
		Moderate side brush	Branches and regrowth of woody plants impede travel.
		Heavy side brush	Thick brush or deadfall impedes travel and may be a significant hazard.
		Not indicated	Value was not mapped during inventory.
	COMMENT	(Text entry)	Label or comment.
ROAD			Identification of roads associated with the trail.
	TYPE		Type of road.
		Access	Road designed to provide access to a trailhead.
		Primary highway	Major paved highway—adjacent to, crossing, or a point of access to a trail.
		Secondary highway	Paved or gravel road—adjacent to, crossing, or a point of access to a trail.
		Subdivision	Paved or gravel road through or serving a subdivision—adjacent to, crossing, or a point of access to a trail.
		Unimproved	Dirt track with few improvements—adjacent to, crossing, or a point of access to a trail.
		Other	Other road not included above.
	SURFACE		Composition of the road surface.
		Paved	Asphalt, concrete, or other pavement.
		Gravel	Gravel surface.
		Dirt	Native soil surface.
		Other	Other surface type—specify.
	WIDTH		Width of the drivable road surface, usually shoulder to shoulder, measured perpendicular to the direction of travel.
		< 8 feet	Road surface is less than 8 feet wide.
		8 to 12 feet	Road surface is 8 to 12 feet wide.
		13 to 16 feet	Road surface is 13 to 16 feet wide.
		17 to 20 feet	Road surface is 17 to 20 feet wide.
		21 to 30 feet	Road surface is 21 to 30 feet wide or wider.
	NAME	(Text entry)	Name of the road—up to 30 characters.
LINEGEN (line generic)			Mapped line feature that is not categorized above.
	COMMENT	(Text entry)	Label for generic line or comment.

(continued)

Point data

Feature	Attribute	Value	Description
ANCHORPT (anchor point)			Points collected to provide accurate GPS ground reference for editing line features.
	TYPE		Type of anchor point.
		Beginning	Point at the beginning of a linear feature.
		Middle	Point midway along a linear feature.
		End	Point at the end of a linear feature.
		Junction	Point used to anchor a trail intersection.
		Angle	Point used to anchor a major turn along the alignment.
		Trail break	Point used to anchor an abrupt end to the trail, GPS data “crash,” or end-of-day mapping point.
AQUAMGT (water management)			Constructed structure to facilitate water management along the trail.
	TYPE		Type of water management structure.
		Water bar	Location of a constructed water bar.
		Grade dip	Location of a constructed grade dip or grade reversal.
		Rolling dip	Location of a constructed rolling grade dip.
		Natural dip	Location of a point where the trail naturally drains.
		Culvert–round	Round culvert in place for cross drainage—indicate size below.
		Culvert–other	Box, U-shaped, or other type of culvert.
		Open top cross drain	Open cross drain—timber, rock, or other material.
		Check dam	Constructed structure to stop or slow waterflow.
		Ditch A’	Starting point of a ditch for water management.
		Ditch B’	Angle or end point of a ditch for water management.
		Curtain drain A’	Starting point of a curtain drain for water management.
		Curtain drain B’	Angle or end point of a curtain drain for water management.
		Drainage lens	Horizontal constructed drainage feature filled with rock rubble or cobbles.
		Other	Other water management feature not listed.
	CONDITION		Water management structure condition as it pertains to maintenance attention of feature.
		New	New installation.
		Maintain	Existing structure—provide minor routine maintenance.
		Replace	Existing structure—replace with a new structure of similar type.
		Recondition	Existing structure—make major repair or improvement.
		Expand/enlarge	Existing structure—expand or enlarge.
	CULVERT SIZE	(Numeric value)	Culvert diameter or width in inches.
AQUAPROB (water problem)			Water related trail problem.
	TYPE		Type of water problem.
		Structure failure	Constructed trail water feature that has failed.
		Blocked drain	Plugged or blocked drainage feature or drain.

(continued)

Feature	Attribute	Value	Description
AQUAPROB (continued)	TYPE (continued)	Washout	A portion of the trail has been washed away by water.
		Headcut	Site of active headcut erosion.
		Erosion zone A	Beginning point of an area or site of major active erosion along a trail alignment.
		Erosion zone B	End point of an area or site of major active erosion along a trail alignment.
		Dam	Site of an unplanned dam or blockage.
		Ponded area	Site of a ponded area affecting the use of the trail—may want to map the area as AREAGEN.
		Spring/seep	Site of a natural spring or seep area.
		Erosion channel A	Beginning point of an active erosion channel off the trail alignment.
		Erosion channel B	Angle or end point of an active erosion channel off the trail alignment.
		Deposition zone	Area where eroded material has been deposited—consider mapping the area.
		Sediment discharge point	Point where eroded material enters a water course.
		Other	Other water-related problem not listed above.
STREAMX (stream crossing)			Significant stream or river crossing—do not include small drainage features, seeps, or cross drains.
	TYPE		Type of stream crossing.
		Unimproved ford	Simple unimproved crossing.
		Improved ford	Crossing with some minor to major structural improvements.
		Bridge	A constructed bridge of any kind elevating the trail over a water feature.
		Culvert	Culvert or culverts of any type.
		Other	Other crossing type.
	NAME		Stream name.
	WATER WIDTH	(Numeric value)	Typical water crossing width in feet.
	NATURAL BANK-TO-BANK WIDTH	(Numeric value)	Estimated width (in feet) of the floodplain during bank-full flow at the undisturbed site.
	CROSSING WIDTH	(Numeric value)	Full width (in feet) of a crossing at a ford, including the approaches.
	APPROXIMATE CFS	(Numeric value)	Approximate streamflow (in cubic feet per second) at the time of site inspection.
	STRUCTURE WIDTH/DIA	(Numeric value)	Bridge width (in feet) or culvert diameter (in inches).
	STRUCTURE LENGTH	(Numeric value)	Existing bridge span or culvert length in feet.
PHYREFPT (physical reference point)			Single point or linear feature that is a distinct reference point along the trail alignment.
	TYPE		Type of physical reference point.
		Temporary mileage marker	A GPS point or other temporary marker, such as flagging or lath, used to mark irregular trail mileage—0.6 miles, 100+63', etc.

(continued)

Feature	Attribute	Value	Description
PHYREFPT (continued)	TYPE (continued)	Milepost	Permanent marker or temporary mileage point to indicate regular mileage interval—1 mile, 6 miles, etc.
		Trail marker	Reassurance marker, flagging, tripod, reflector, post, etc.
		Cairn	Hand-stacked rock marker denoting a trail route.
		Property marker	Sign, post, cleared line, or other marker denoting a property line.
		Management boundary	Sign, post, or other marker denoting a change in agency management—wilderness boundary, right-of-way, easement corridor, etc.
		Road junction	Junction point with a road or crossing point with a road.
		Powerline crossing	Point where a power or other utility line crosses the trail.
		Fence crossing	Point where a fence crosses the trail.
		Other	Other physical reference point not listed above.
	MILEPOST	(Numeric value)	Milepost value in miles—0.5 to 999.
	NAME/VALUE/ COMMENT	(Text entry)	Associated name or value of the feature—up to 30 characters
INTRSTPT (interest point)			Area of interest associated with the trail—may also want to map the interest point as AREAGEN.
	TYPE		Type of interest point.
		Viewpoint	Good scenic or overlook site.
		Shelter	Natural or manmade shelter.
		Campsite	Existing or potential campsite.
		Cabin	Cabin or cabin ruins.
		Structure	Structure other than a cabin.
		Pullout	Good resting area adjacent to the trail alignment.
		Gate or barrier	Installed gate or other permanent barrier to travel.
		Kiosk	Informational kiosk for educational or regulatory signs.
		Ranger station	Seasonal or permanent agency ranger station.
		Outhouse	Primitive privy.
		Restroom	Bathroom with or without running water.
		Water–potable	Drinkable water source—well, water fountain, etc.
		Staging area	Active or potential staging area for trail work.
		Helispot	Active or potential helicopter landing or operations site.
		Gravel source	Active or potential source for gravel.
		Timber source	Active or potential source for timber for bridges, corduroy, or chips.
		Cultural resource	Cultural or historic resource.
		Site–human activity	Generic site of some human activity warranting documentation.
		Nest site	Nest site for a species of concern.
		Threatened and endangered plant site	Known or suspected location of a threatened or endangered plant.
		Weeds	Exotic or invasive plant species.
		Bollard	Temporary or permanent bollard placed as a barrier to travel.
		Trail counter	Device installed to count trail users.

(continued)

Feature	Attribute	Value	Description
INTRSTPT (continued)	TYPE (continued)	Debris	Trash, debris, garbage, dump.
		Trail head	Official beginning point for trail (map any associated features).
	COMMENT	(Text entry)	Other point of interest not listed above.
SURVEYPT (survey point)			Engineering survey or elevation station.
	TYPE		Type of survey point.
		Section	Survey monument location for a section or township marker.
		Property	Survey monument or marker for a property boundary survey.
		Elevation	Elevation monument, bridge with elevation, or established elevation station.
		Benchmark	Benchmark survey monument.
	LABEL	(Text entry)	Monument text—up to 30 characters. Document surveyed elevations here.
	ELEVATION	(Numeric value)	Numeric elevation reading in feet above MSL (mean sea level).
	SOURCE		Source of elevation data.
		TopoMap	Paper map with elevation contours or lake altitudes.
		GPS	Geographic positioning system.
		Altimeter	Digital or analog altimeter.
		Monument	Survey marker, benchmark, bridge, or other formal monument with annotated elevation.
		Other	Another source—add a note in COMMENT.
PHOTOPT (photo point)			Photo collection point.
	FRAME/ REFERENCE	(Text entry)	Frame or reference number—up to 10 characters.
	BEARING	(Numeric value)	Compass direction of photo in degrees—1 to 360 (true north).
	SUBJECT	(Text entry)	Photographic subject name or identifier.
HAZARD			Physical hazards along the trail corridor affecting user safety.
	TYPE		Type of hazard.
		Standing tree	Tree that may fall across the trail unexpectedly or that presents an aerial hazard.
		Fallen tree	Tree that blocks, or partially blocks, the trail.
		Brush/branches/ vegetation	Any woody debris that poses a hazard.
		Steep side dropoff	Steep slope adjacent to the trail that poses a hazard.
		Steep grade	Steep grade poses a rollover or tipover hazard.
		Major washout	Washed out segment of the trail that creates a hazardous condition.
		Abrupt trail end	Trail ends abruptly with risk of a collision or loss of control.
		Extreme cross slope	Trail surface has a high cross slope that could make OHVs unstable.

(continued)

Feature	Attribute	Value	Description
HAZARD (continued)	TYPE (continued)	Extremely rough surface	Trail surface is extremely rough and poses a hazard to users.
		Slick surface	Trail surface is extremely slick under wet conditions and poses a hazard to users.
		Rocks on trail	Rocks on the trail pose a hazard to users.
		Landslide/debris flow	Trail is subject to, or has, landslides or debris flows within the alignment.
		Stillwater hazard	Ponded area along the trail poses a risk to users.
		Running water hazard	Deep or swift moving stream or river crossing poses a hazard to users.
		Boghole/depression	Deep hole or depression poses a hazard to users.
		Pinch point	Narrowing of the trail poses a hazard to users.
		Blind corner	A corner with reduced visibility poses a hazard to users.
		Blind intersection	An intersection with reduced visibility poses a hazard to users.
		Wildlife hazard	Some form of wildlife poses a hazard—such as a bear's den or wasp nest, etc.
		Vegetation hazard	Some form of vegetation poses a hazard—poisonous plants, thorns, etc.
		Hazmat	Some form of hazardous material poses a hazard.
		Other	Some hazard not identified above.
	NOTE/COMMENT	(Text entry)	Note or comment.
SIGNS			Erected signs on or along the trail alignment.
	TYPE		Type of sign.
		Directional	Sign providing directions for trail users.
		Regulatory	Sign informing users of regulations.
		Informational	Sign providing general or specific information.
		Warning	Sign informing the public of a hazard.
		Other	Sign informing the public of some topic not covered above.
	MESSAGE	(Text entry)	Sign text or message.
	CONDITION		Sign condition.
		New	New installation.
		Maintain	Existing sign—provide minor routine maintenance.
		Replace	Existing sign—replace with a new structure of similar type.
		Recondition	Existing sign—make major repair or improvement.
		Expand/enlarge	Existing sign—expand or enlarge.
PTGEN (point generic)			Mapped point feature that is not categorized above.
	LABEL	(Text entry)	Label for mapped point feature that is not categorized above.
	COMMENT	(Text entry)	Label for generic point.

(continued) This table was developed by NPS and adapted by the author for this publication.

Area data

Feature	Attribute	Value	Description
BRAIDED IMPACT AREA			Area impacted by OHV traffic, mapped along the outermost used alignments—typically used only for major braided areas.
	LABEL	(Text entry)	Label for braided impact area.
PARKING			Highway vehicle parking area associated with a trail head.
	TYPE		Type of parking surface.
		Paved	Parking surface is asphalt, concrete, or other pavement.
		Gravel	Parking surface is gravel.
		Compacted dirt	Parking surface is native soil.
		Vegetation	Parking surface is covered with grass or other growing plants.
		Other	Other surface type.
		Mix	Parking surface is a mixture of surface types.
	COMMENT	(Text entry)	Comment.
SOILTER (soil/terrain)			The perimeter of a discrete soil type, unique terrain feature, or fill area.
	COMMENT	(Text entry)	Label to describe characteristics of a mapped soil-terrain unit.
AREAGEN (area generic)			Mapped area feature that is not categorized above.
	COMMENT	(Text entry)	Label for generic area.

Alaska NPS OHV Trail Prescription GPS Data Dictionary

This table was developed by NPS and adapted by the author for this publication.

Line data

Feature	Attribute	Value	Description
TRAILWAY			Trailway—segment of trail.
	ACTION		Identifies the type of action to be taken on a trail segment.
		New	New trail segment—to be constructed (includes reroutes).
		Maintain (default)	Existing trail alignment—actively maintain.
		Upgrade/rebuild	Existing trail alignment—rebuild or upgrade.
		Narrow/reduce	Existing trail alignment—narrow or reduce.
		Widen/enlarge	Existing trail alignment—widen or enlarge.
		Abandon	Existing trail alignment—abandon.
		Close/barricade	Existing trail alignment—close and barricade.
		Rehabilitate	Existing trail alignment—close and rehabilitate.
		Other	Existing trail alignment—other action not listed above.
	TGRADE (trail grade)		Trail grade—to be constructed.
		0 to 3 percent	New construction–0 to 3 percent.
		4 to 6 percent	New construction–4 to 6 percent.
		7 to 9 percent	New construction–7 to 9 percent.
		10 to 12 percent	New construction–10 to 12 percent.
		13 to 15 percent	New construction–13 to 15 percent.
		16 to 20 percent	New construction–16 to 20 percent.
		21 to 25 percent	New construction–21 to 25 percent.
		> 25 percent	New construction–more than 25 percent.
	SURFGRUB (surface grubbing)		Surface grubbing—removing vegetation cap, leveling, and reshaping the soil surface (typically used for new construction).
		None required (default)	No surface grubbing required.
		Light grubbing	Light labor required to strip vegetation and level and reshape the surface.
		Moderate grubbing	Moderate labor required to strip vegetation and level and reshape the surface.
		Heavy grubbing	Heavy labor required to strip vegetation and level and reshape the surface.
	GRADING		Grading—shaping or reshaping the exposed mineral tread surface (typically used when maintaining existing trails).
		None required (default)	No action required.
		Light grading/leveling	Light labor required to shape or reshape the trail tread.
		Moderate grading/ leveling	Moderate labor required to shape or reshape the trail tread.
		Heavy grading/leveling	Heavy labor required to shape or reshape the trail tread.
	THARDENING (trail hardening)		Trail hardening—supplemental application of material to improve the durability of the tread surface.
		None required (default)	No trail hardening required.
		Gravel cap	Gravel cap required—use CAPPING below to specified cap depth.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	THARDENING (continued)	Gravel cap with geotextile	Gravel cap with underlying geotextile.
		Porous pavement panel	Rigid structural geotextile without underlayment.
		Porous pavement panel with geotextile	Porous pavement panel installation with underlying geotextile.
		Porous pavement panel with infill	Porous pavement panel installation with specified infill—usually includes geotextile fabric.
		Corduroy	Elevated or ground contact corduroy.
		Chunkwood/chips	Chunkwood or wood chips—use CAPPING to specify depth.
		Chunk/chip with geotextile	Chunkwood or chip installation with underlying geotextile.
		Puncheon/boardwalk–elevated	Puncheon/boardwalk construction on stringers over sills.
		Puncheon/boardwalk–ground contact	Puncheon/boardwalk construction with stringers directly on the ground (no sills).
		Turnpike	Elevated treadway with side ditches.
		Turnpike–with cross drain	Elevated treadway that incorporates a horizontal drainage lens.
		Causeway	Elevated treadway with rock or log side curbs—no side ditches.
		Causeway–with cross drain	Elevated treadway that incorporates a horizontal drainage lens.
		Slot trench	Slot trench inversion construction.
		Rock armor	Hardened tread with large stone or slab surface.
		Pavers	Paving blocks, stones, or bricks or flat stones found at the site.
		Pavement	Asphalt or concrete pavement.
		Other	Other trail-hardening method not identified above.
	CAPPING		Capping depth—depth of capping course (gravel, soil, or chips) required.
		None required (default)	No capping material required.
		2 to 4 inches	2 to 4 inches of capping material.
		5 to 8 inches	5 to 8 inches of capping material.
		9 to 12 inches	9 to 12 inches of capping material.
		13 to 18 inches	13 to 18 inches of capping material.
		19 to 24 inches	19 to 24 inches of capping material.
		25 to 36 inches	25 to 36 inches of capping material.
		37 to 48 inches	37 to 48 inches of capping material.
		> 48 inches	More than 48 inches of capping material.
	SUBBASE		Coarse material or general fill—inches of material used for subgrade or for a drainage lens.
		None required (default)	No rock or cobble fill required.
		1 to 4 inches	1 to 4 inches of fill.
		5 to 8 inches	5 to 8 inches of fill.
		9 to 12 inches	9 to 12 inches of fill.
		13 to 18 inches	13 to 18 inches of fill.

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued)	SUBBASE (continued)	19 to 24 inches	19 to 24 inches of fill.
		25 to 36 inches	25 to 36 inches of fill.
		37 to 48 inches	37 to 48 inches of fill.
		> 48 inches	More than 48 inches of fill.
	CLEARING		Clearing trees or heavy brushing (removal of trees and brush)—generally used to clear the alignment of newly constructed trails.
		None required (default)	No clearing required.
		Light clearing	Light labor required to remove trees and shrubs along the alignment (more than 500 feet can be cleared per person hour).
		Moderate clearing	Moderate labor required to remove trees and shrubs along the alignment (100 to 500 feet can be cleared per person hour).
		Heavy clearing	Heavy labor required to remove trees and shrubs along the alignment (less than 100 feet can be cleared per person hour).
	SIDEBRUSH		Cut brush alongside the trail—remove trees and brush to specified clearing limits (typically used when maintaining existing trails).
		None required (default)	No clearing or brushing required.
		Brush left	Remove trees and brush on left side (outbound).
		Brush right	Remove trees and brush on right side (outbound).
		Brush both	Remove trees and brush on both sides.
	SIDEDITCH		Side ditch—ditch work alongside the trail tread.
		None required (default)	No ditching required.
		Maintain left	Clean or maintain the left ditch (outbound).
		Maintain right	Clean or maintain the right ditch (outbound).
		Maintain both	Clean or maintain both the right and left ditches.
		New left	Construct new ditch left side (outbound).
		New right	Construct new ditch right side (outbound).
		New both	Construct new ditch both sides.
	WATERMGT (water management)		Water control management—effort required to install, improve, or maintain basic water control structures when features are not individually identified.
		None required (default)	No action required.
		Light water management	Light labor required to install or maintain water control structures.
		Moderate water management	Moderate labor required to install or maintain water control structures.
		Heavy water management	Heavy labor required to install or maintain water control structures.
	CUTFILLSEG (cut or fill segment)		Cut or fill segment—identifies area of sideslope cut or fill construction.
		None required (default)	No cut or fill required.
		< 15 percent sideslope	Cut full bench construction across a sideslope (less than 15 percent).
		15 to 45 percent sideslope	Cut full bench construction across a sideslope (between 15 and 45 percent).

(continued)

Feature	Attribute	Value	Description
TRAILWAY (continued	CUTFILLSEG (continued)	46 to 100 percent sideslope	Cut full bench construction across a sideslope (between 46 and 100 percent).
		> 100 percent sideslope	Cut full bench construction across a sideslope (steeper than 100 percent).
		Cut on flat	Down cut on flat ground (ramp down).
		Fill on flat	Fill on flat ground (ramp up) or infill a depression.
	REHAB		Rehabilitation—abandoned alignments (also may require WATERMGMT above).
		None required (default)	No rehabilitation required.
		Scarify	Roughen surface, break up compacted surface to increase natural regeneration.
		Reseed	Scarify with supplemental reseeding and/or fertilization.
		Rehabilitate	Scarify to rehabilitate surface with vegetation transplants, scatter debris.
	TWIDTH (trail width)		Trail width—final constructed or improved tread width.
		Single track 18 inches	18-inch wide track for foot, horse, dirt bike, and bicycle traffic.
		19 to 30 inches	19- to 30-inch wide track–social trail configuration.
		31 to 48 inches	31- to 48-inch wide track–social trail configuration.
		49 to 66 inches	49- to 66-inch wide track–narrow OHV track.
		67 to 78 inches	67- to 78-inch wide track–standard OHV track.
		79 to 96 inches	79- to 96-inch wide track–jeep or unlimited OHV track.
		> 96 inches	More than 96-inch wide track–unlimited vehicle track.
	NAME	(Text entry)	Trail name.
	COMMENT	(Text entry)	Comment for a trail segment—up to 30 characters.
BRIDGE			Bridge data—see STREAMX point data for fords and culverts.
	TYPE	Existing	Bridge is in place and functional.
		New (default)	New bridge needs to be constructed.
	ACTION	Construct	Build new bridge—approaches, abutments, structure, decking, and rails as specified.
		Replace	Existing structure—remove and replace with new structure as specified.
		Maintain/upgrade (default)	Existing bridge—actively maintain or improve as specified.
		Remove	Existing bridge—dismantle (no planned replacement).
		Close/barricade	Existing bridge—temporarily restrict access.
	LENGTH	(Numeric entry)	Length of bridge stringer span (in feet).
	WIDTH	(Numeric entry)	Width of bridge deck required (in inches).
	COMMENT	(Text entry)	Comment or specification for a bridge—up to 60 characters.
LINEGEN (line generic)			Line generic—a line feature not listed above.
	TYPE	(Text entry)	Up to 30 characters.

(continued) This table was developed by NPS and adapted by the author for this publication.

Point data

Feature	Attribute	Value	Description
ANCHORPT (anchor point)			GPS anchor point—points collected to provide accurate GPS ground reference for line features (typically used during field data editing).
	TYPE	Beginning	Point at the beginning of a linear feature.
		Mid	Point midway along a linear feature.
		End	Point at the end of a linear feature.
		Junction	Point used to anchor an intersection or junction center point.
		Angle	Point used to anchor an angle or apex of a major turn along the alignment.
	COMMENT	(Text entry)	Comment or specification for an anchor point—up to 30 characters.
AQUAMGT (water management)			Water management—maintenance or construction of water control structures.
	ACTION	New	New installation.
		Maintain	Existing structure—provide minor routine maintenance.
		Replace	Existing structure—replace with a new structure of similar type.
		Recondition	Existing structure—make a major repair or improvement.
		Expand/enlarge	Existing structure or feature—expand or enlarge.
	TREATMENT	Water bar	Cross slope water bar (approved for rehabilitation, not recommended for active trails).
		Grade reversal/dip	Grade reversal or grade dip—generally designed into new construction.
		Rolling dip	Constructed rolling grade dip—usually an amendment to an existing alignment.
		Natural dip	Enhance natural topographic drainage feature.
		Culvert–round	Round culvert for cross drainage (specify size in CULVERT SIZE below).
		Culvert–other	Box, U-shaped, or other type of culvert.
		Open top cross drain	Open topped cross drain—constructed of timber, rock, or other material.
		Check dam	Constructed structure to slow water.
		Headcut treatment	Treatment to stabilize headcut erosion.
		Spot fill	Fill placement needed at a specified location (no specified volume).
		Open drain	Clear blocked drain.
		Ditch A'	Starting point of a collection ditch for water management.
		Ditch B'	Angle or end point of a collection ditch for water management (more than one may be mapped).
		Drain A'	Starting point of a discharge ditch for water management.
		Drain B'	Angle or end point of a discharge ditch for water management (more than one may be mapped).
		Drainage sump	Open or French (rubble-filled) water drain or infiltration pit.
		Curtain drain A'	Starting point of a vertical collection drain for water management.
		Curtain drain B'	Angle or end point of a vertical collection drain for water management (more than one may be mapped).

(continued)

Feature	Attribute	Value	Description
AQUAMGT (continued)	TREATMENT (continued)	Sheet drain A'	Starting point of a horizontal transfer drain for water management.
		Sheet drain B'	Angle or end point of a horizontal transfer drain for water management (more than one may be mapped).
		Other	Other water management feature.
	CULVERT SIZE	(Numeric entry)	Data field for culvert diameter specification in inches.
	COMMENT	(Text entry)	Comment or specification for water management—up to 30 characters.
STREAMX (stream crossing)			Water crossing—stream, river, seep, or wet crossing.
	ACTION	New	New stream crossing—to be constructed.
		Maintain	Existing stream crossing—actively maintain.
		Replace	Existing stream crossing—replace with a new crossing.
		Recondition	Existing stream crossing—make a major repair or improvement.
		Expand/enlarge	Existing stream crossing—expand or enlarge.
		Abandon/close	Existing stream crossing—abandon or close.
	TYPE	Unimproved ford	Crossing with no structural improvements.
		Improved ford	Apply structural improvements at the crossing site (specify under COMMENT below).
		Bridge < 10 feet	Install a bridge less than 10 feet long (specify under COMMENT below).
		Bridge 10 to 20 feet	Install a 10- to 20-foot bridge (specify under COMMENT below).
		Bridge 20 to 40 feet	Install a 20- to 40-foot bridge (specify under COMMENT below).
		Bridge > 40 feet	Install a bridge longer than 40 feet (specify under COMMENT below).
		Culvert	Install a culvert or culverts (specify under COMMENT below).
		Other	Install some other stream crossing structure (specify under COMMENT below).
	BANK2BANK	(Numeric entry)	Measurement of stream bank to bank (in feet).
	STRUCTLENG	(Numeric entry)	Length of measured structure span (in feet).
	STRUCWIDTH	(Numeric entry)	Structure width—1 to 999 (in inches).
	CULVERTSZ	(Numeric entry)	Size of the culvert (in inches).
	NAME	(Text entry)	Name of the stream or site.
	COMMENT	(Text entry)	Comment or specific specification for the crossing—up to 60 characters.
DEVELOPMNT			Development area.
	ACTION	New	New construction or development.
		Maintain	Existing feature—provide minor maintenance.
		Replace	Existing feature—replace with a new feature of similar type.
		Recondition	Existing feature—repair or update.
		Expand	Existing feature—expand or enlarge.
		Abandon/close	Existing feature—abandon or close.
	TYPE	Pullout	Resting area adjacent to the trail alignment.
		Viewpoint	Scenic or overlook site.
		Shelter	Natural or constructed shelter.
		Campsite	Campsite.

(continued)

Feature	Attribute	Value	Description
DEVELOPMNT (continued)	TYPE (Continued)	Cabin	Cabin site.
		Structure	Other structure.
		Staging area	Staging area.
		Helispot	Helicopter landing/operations site.
		Gravel source	Source for gravel.
		Fill source	Source for fill.
		Rock source	Source for construction rock.
		Timber source	Source for timber for bridges, corduroy, or chips.
		Dump/disposal site	Dump or disposal site.
		Other 1	Other area not listed above.
		Other 2	Another feature (different from Other 1).
	DESCRIPTION	(Text entry)	Up to 30 characters.
	COMMENT	(Text entry)	Comment or specification for trail development—up to 60 characters.
PHYREFPT (physical reference point)			Physical reference point—single point or linear feature that is a distinct reference point along the trail alignment.
	ACTION	New	New development.
		Existing (default)	Existing feature—no maintenance required.
		Maintain	Existing feature—provide minor maintenance.
		Replace	Existing feature—replace with a new feature of similar type.
		Recondition	Existing feature—repair or improve.
		Expand	Existing feature—expand.
		Abandon/close/remove	Existing feature—abandon, close, or remove.
	TYPE	Trail head	Beginning point for trail (also map the associated features).
		Bollard	Post or barrier.
		Milepost (default)	Permanent marker or temporary mileage point.
		Trail marker	Reassurance marker, flagging, tripod, reflector, post, etc.
		Survey marker	Survey location point (also may be mapped under CNTROLPT).
		Property marker	Sign, post, cleared line, etc. denoting property line.
		Road junction/crossing	Junction point with a road or crossing point with a road.
		Trail junction	Junction point with a trail.
		Gate or barrier	Gate or barrier constructed to direct or control access.
		Corridor boundary	Boundary of a designated area—Wilderness Area, Wild and Scenic River, etc.
		Trail counter	Trail counter to measure trail use.
		Powerline crossing	Point where a power or other utility line crosses the trail.
		Fence crossing	Point where a fence crosses the trail (include a note if there is an associated gate).
		Other	Other physical reference point.
	MILEPOST	(Numeric entry)	Milepost location value—0.5 to 999 (in miles).
	COMMENT	(Text entry)	Comment or specification for physical reference point—up to 30 characters.

(continued)

Feature	Attribute	Value	Description
PHOTOPT (photo point)			Photo reference point.
	FRAMREF	(Text entry)	Frame/reference number—up to 10 characters.
	BEARING	(Numeric entry)	Compass direction of photo in degrees—1 to 360 (true north).
	COMMENT	(Text entry)	Comment or specification for photo point—up to 30 characters.
HAZARD			Hazard management—manage physical hazards along the trail corridor.
	TYPE	Hazard tree removal	Remove a tree that may fall across the trail or that presents an aerial hazard.
		Down timber	Remove a tree that blocks or partially blocks the trail.
		Stump removal	Remove a hazardous stump.
		Brush/branches/ vegetation	Clear woody debris that poses a hazard.
		Place barrier	Place a barrier or barriers.
		Install guardrail	Install a railing or guardrail.
		Earth debris removal	Remove slump or other debris.
		Other debris removal	Remove and dispose other debris.
		Rock removal	Remove rocks on the trail that pose a hazard to users.
		Widen pinch point	Widen trail at this point.
		Clear for sight distance	Remove trees and brush to increase sight distance.
		Install warning sign	Install sign to warn users of hazards.
		Install guide marker	Install guide marker to reassure trail users of the trail's route.
		Slow traffic	Install structures to reduce speed along the trail.
		Fill hole(s)	Fill hole or depression to remove a hazard.
		Other 1	Take specified action to reduce a hazard.
		Other 2	Take another specified action (different from Other 1) to reduce a hazard.
	COMMENT	(Text entry)	Comment or specification for hazard management—up to 30 characters.
SIGNS			Signs—signs on or along the trail alignment.
	ACTION	New	New sign required.
		Existing	Sign is in place—no maintenance required.
		Maintain	Existing sign—provide minor maintenance.
		Replace	Existing sign—replace with a new sign.
		Recondition	Existing sign—repair or improve.
		Expand	Install more signs at this location.
		Remove	Existing sign—remove (no longer needed).
	TYPE	Directional	Sign providing directions for trail users.
		Regulatory	Sign informing users of regulations.
		Informational	Sign providing general or specific information.
		Warning	Sign informing the public of a hazard.
	TEXT	(Text entry)	Sign text—up to 30 characters.
	COMMENT	(Text entry)	Comment or specification for sign.

(continued)

Feature	Attribute	Value	Description
CNTROLPT (control point)			Trail layout control point.
	TYPE	Major positive	Major routing point or area.
		Minor positive	Minor or secondary routing point or area.
		Major negative	Major point or area to avoid.
		Minor negative	Minor or secondary point or area to avoid.
	ELEVSTA	(Numeric entry)	Elevation station—1 to 10,000 (in feet).
	ELSOURCE	NA (default)	No elevation value obtained for control point.
		GPS	Elevation from GPS.
		Altimeter	Elevation from altimeter.
		Topographic	Elevation from topographic map.
		Monument	Elevation from monument.
		Other	Elevation from another source.
	TEXT	(Text entry)	Elevation or other entry—up to 30 characters.
	COMMENT	(Text entry)	Comment or specification for control point.
SIDESTRUC (side structure)			Sideslope or cut/fill structures.
	TYPE	Switchback centerpoint	Center point for a switchback to be constructed.
		Climbing turn centerpoint	Center point for a climbing turn to be constructed.
		Retaining wall A'	Starting point for construction of a retaining wall.
		Retaining wall B'	Angle point or end point for a retaining wall.
		Fill segment A'	Starting point for a fill segment.
		Fill segment B'	Angle point or end point for a fill segment (may be more than one).
		Cut segment A'	Starting point of a cut segment.
		Cut segment B'	Angle point or end point for a cut segment (may be more than one).
	COMMENT		Comment or specification for a sideslope structure.
PTGEN (point generic)			Point generic—generic point not identified above.
	NAME/TYPE	(Text entry)	Label generic point—up to 30 characters.

(continued) This table was developed by NPS and adapted by the author for this publication.

Area data

Feature	Attribute	Value	Description
BRAIDS			Braided impact area (area impacted by OHV traffic, mapped along the outermost used alignments)—typically used only for major braided areas where impacts are being mitigated.
PARKING			Parking area—highway vehicle parking area associated with a trail head.
	ACTION	New	New development.
		Maintain	Existing parking area—provide minor maintenance.
		Replace	Existing parking area—replace existing area with new parking area.
		Recondition	Existing parking area—repair or improve.
		Expand	Existing parking area—expand.
		Abandon/close	Existing parking area—abandon or close.
	TREATMENT	None (default)	No action necessary.
		Grade and level	Grade and level with material on the site (may require clearing and brushing).
		Gravel cap	Cap existing surface with gravel (may require grading).
		Pave	Pave parking area with asphalt or concrete.
	CAPPING	(Numeric entry)	Gravel capping depth (in inches).
	COMMENT	(Text entry)	Comment or specification for parking area—up to 30 characters.
AREAGEN (area generic)			Area generic—generic area not identified above.
	TYPE	(Text entry)	Label for generic area—up to 30 characters.

Notes

Appendix E: Examples of Trail Design Parameters and Specifications

- Set of Design Specifications for a Utilitarian Off-Highway Vehicle (OHV) Class Trail, Summer Use Only
- Specification Guidelines for Sustainable OHV Trail Layout and Construction
- Identifying Trail-Specific Design Parameters

The Forest Service Design Parameters for All-Terrain Vehicles (ATVs) are included on page 14 of this report and are available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

The Forest Service Design Parameters for Four-Wheel Drive Vehicles greater than 50 inches are available at <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Set of Design Specifications for a Utilitarian Off-Highway Vehicle (OHV) Class Trail, Summer Use Only

These design specifications were developed by the author for OHV summer use trails.

Design elements	Component	Specifications
Tread width	General	60 inches
	Structures	72 inches over bridges 60 inches over all other structures
Design tread grade	Target range	3 to 10 percent (0 to 15 percent allowable)
	Average	Up to 10 percent
	Maximum	15 percent—short pitch maximum grade
	Allowable maximum	50 feet—allowable length of individual maximum grade segment 5 percent—total length of maximum grades as a percentage of the trail's length
Cross slope	Target	3 to 8 percent desired final outslope 2 to 4 percent on crowned tread
	Allowable range	3 to 10 percent—allowable range of outslope
Clearing	Height	8 feet
	Width	6 feet from tread centerline
Brushing	Width	3 feet maintenance brushing from the outside edge of the tread
	Height	8 feet
Turn radius	Range	15 to 30 feet
Turn type	Allowable turn types	Simple, climbing, cut-through climbing, super-elevated
Water control spacing	Spacing	125 feet maximum between features
Layout	Guidelines	Contour, curvilinear
		Integrated water control with drainage to match natural surfaces to the maximum extent possible
Bench construction	Type	Full
Tread surface	Type	Durable mineral, bedrock, or hardened surface

Refer to the trail's completed trail management objectives (TMOs) data form for project specifications.

Specification Guidelines for Sustainable OHV Trail Layout and Construction

This information was developed by the author.

1. **Alignment—**Trail is to be aligned along the natural contour of the landscape **(contour curvilinear trail alignment)** with climbing and descending runs up to a 10-percent grade as specified below.

2. **Grade—**Maximum sustainable grades should be determined based on native tread character and local environmental conditions. In general, the **target trail grade** should not exceed 10 percent, and the grade of any segment of the trail alignment should not exceed 50 percent of the sideslope grade of the slope it crosses, unless specifically approved. The **maximum trail grade** segments generally should not be longer than 50 feet or cumulatively be longer than 5 percent of the length of the entire trail. If maximum sustainable grades are exceeded, allowances for increased maintenance and/or tread hardening should be included in construction and long-term management plans.

3. **Location—**Trail layout should avoid, to the greatest extent possible, areas with sideslopes shallower than 3 percent. For example, avoid flat bottoms, meadows, ridgelines, and natural benches. Trail layout should be on sloped areas to allow integrated drainage features to be constructed. In general, the ideal trail location is on a 15- to 45-percent sideslope. Locate climbing turns on 10- to 22-percent sideslopes.

4. **Flagging—**Initial preconstruction reconnaissance trail centerline layout should not exceed an 8-percent grade **if water control is not integrated** into the layout (8 percent is 2 percent less than the final desired average grade to allow for the construction of water control features). Final construction flagging **with integrated water control** (grade reversals) should not exceed a 10-percent grade.

5. **Cross slope—**The final tread outslope should be specified at 3 to 8 percent. During construction, the tread surface should be shaped and compacted with a 4- to 7-percent outslope to allow for settling and compaction. On relatively flat trails (sideslope less than 2 percent), the tread surface should be crowned with a 2- to 4-percent outslope from the center of the tread.

6. **Integrated drainage—**Water control will be facilitated by the use of outslope, grade reversals, natural grade dips, and negative grades (3 to 5 percent) dipping into and out of existing drainages. Rolling grade dips also may be used where other methods are not applicable. **Water bars are not to be employed at any time** or at any location. Water will be directed off the trail surface by one of the approved methods, **at the minimum,** using the following spacing interval as guidance—unless otherwise specifically approved:
    - On areas where the sideslope is shallower than 6 percent (trail grade 0 to 3 percent), there should be one water control feature for every 125 to 175 feet of alignment.
    - On areas where the sideslope is 7 percent to 15 percent (trail grade 3 to 6 percent), there should be one water control feature for every 100 to 150 feet of alignment.
    - On areas where the sideslope is steeper than 15 percent (trail grade more than 6 percent), there should be one water control feature for every 75 to 125 feet of alignment.

Note: Spacing of water control features is measured from the point of water discharge.

7. **Water crossings—**Trail grades must drop into all natural drainages, including seasonal intermittent drainages, from both directions with a minimum grade of minus 3 percent for at least 12 feet to the water's edge. These guidelines prevent stream capture by the trail alignment.
8. **Full bench construction—**On cutslope segments, full bench construction is required unless an approved retaining wall is constructed to support the filled area.

9. **Turns—**A minimum 15-foot turning radius is required for OHV trail curves. Climbing turns should be used as the primary turn when gaining elevation. Standard climbing turns can be constructed on sideslopes up to a 12-percent grade. Cut-through climbing turns can be constructed on slopes up to 22 percent. Sideslopes steeper than 22 percent generally require a switchback and should be avoided. Superelevated or banked turns may be allowed, depending on the trail management objectives.

10. **Durable tread—**A durable trail tread surface must be one of the following:
    - Compacted high-quality mineral soil
    - Bound aggregate
    - An approved trail-hardened surface

Identifying Trail-Specific Design Parameters

The author recommends the following parameters should be specified for any new construction, rerouting, or trail maintenance:

Tread width (inches)—Trail travel surface width

Tread width, structures (inches)—Minimum tread width over bridges and other structures

Design surface

Type—Surface tread material and character

Obstacles—Character (for example, roots and rocks), percentage, and allowable size of obstacles

Design tread grade

Range (percent)—Allowable range

Design grade (percent)—Target grade desired

Short pitch maximum (percent)—Short pitch maximum sustainable grade based on site conditions

Maximum pitch density

—Allowable length (in feet) of individual maximum sustainable grade segments

—Total length of maximum grades (a percentage of total trail length)

Design cross slope

Target cross slope (percent)—Desired final outslope

Allowable range of cross slope (percent)—Minimum and maximum outslope

Construction clearing

Width (feet)—Timber clearing from tread centerline

Design clearing

Width (feet)—Future maintenance brushing, specified from the tread centerline or the outer edge of the tread

Height (feet)—Overhead brushing

Turn radius—Minimum radius in feet

Turn type—Allowable turn types (simple, climbing, cut-through climbing, switchback, superelevated)

Water control spacing (feet)—Allowable maximum distance between water control features, such as drain dips or grade reversals, for different trail grades or terrain or soil types along the trail alignment

Weight loading (pounds)—Live weight loading requirements for bridge and decking structures based on allowed vehicle types and possible snow loading

In addition, sustainable trail design guidelines should be specified as an integrated component of any trail design.

Layout

—Contour curvilinear alignment

—Not to exceed specified average and maximum grades

Water control

—Integrated drainage to match the natural terrain drainage patterns to the maximum extent possible

—Designed to accommodate, at a minimum, a 25-year storm event

Bench construction—Full bench on sideslope trail segments

Tread surface—Durable mineral soil, bedrock, aggregate, or hardened surface

Appendix F: Productivity Factors

- Trail Assessment and Condition Surveys (TRACS) Productivity Factor Codes
- Off-Highway Vehicle (OHV) Trail Adjustment Factors

Trail Assessment and Condition Surveys (TRACS) Productivity Factor Codes

TRACS Productivity Factor Codes

(Updated 11/14/2006)

Note: For each Productivity Factor, the center-point (default) values are highlighted in **bold** letters below for quick reference.

Factor Code	Factor Value	Definition
Typical Trail Grade		Percent gradient ahead measured along the tread centerline.
TG01	+ 0-5%	
TG02	**+ 5-8%**	
TG03	+ 8-10%	
TG04	+ 10-12%	
TG05	+ 12-20%	
TG06	+ 20-30%	
TG07	+ 30-40%	
TG08	+ 40-50%	
TG09	> +50%	
TG10	- 0-5%	
TG11	- 5-8%	
TG12	- 8-10%	
TG13	- 10-12%	
TG14	- 12-20%	
TG15	- 20-30%	
TG16	- 30-40%	
TG17	- 40-50%	
TG18	> -50%	
Typical Side Slope		Percent side slope of the surrounding ground measured along the slope fall line.
SS01	0-20%	
SS02	**20-40%**	
SS03	40-60%	
SS04	60-80%	
SS05	80-100%	
SS06	> 100%	

(continued)

Factor Code	Factor Value	Definition
Typical Soil Type		Engineering soil composition and texture
ST00	Wetland	Characterized as a wetland or swamp with year-around standing water, wetland-type vegetation, and/or saturated organic soils. (Does not include seasonal wet spots or groundwater seeps.)
ST01	Fine/Organics	Soils with uniform fine texture with little or no rock content. May be dark with high organic content. Demonstrates low carrying capacity, especially when wet. Trenches easily, highly dusty when dry, highly erosive.
ST02	Sand	Material with uniform sand-grain texture with few fines. Refuses to compact when dry. Highly susceptible to erosion.
ST03	Pumice	Broken-up pumice cobbles with few or no fines. Refuses to compact. Highly susceptible to erosion, particularly with ability to float in water.
ST04	**Common**	Material with a good mixture of fines and small rock. May be loose or highly compacted. Compacts well. Good erosion resistance.
ST05	Common w/ Larger Rock	Material with a good mixture of soil and small rock intermixed with larger cobbles or small boulders. May be loose or highly compacted. Methods for removal of larger rock may include digging out or breaking in-place.
ST06	Talus or Boulders	Material that is mostly rock of uniform or varying sizes containing little or no soil. Removal may include hand, machine, or blasting methods.
ST07	Bedrock	Bedrock or very large boulders (larger than a VW Bug) where blasting is generally the only method of removal.
Typical Vegetation: Brush & Regeneration		All brush and tree regeneration less than 4" diameter within Trail Corridor
BR01	None	No brush or regen within Trail Corridor
BR02	Extra Light	Grasses, light perennials, or other non-woody plants. Capable of being worked with hand sickles, mowers or weed whips.
BR03	**Light**	Small regen shorter than knee height; slow-growing woody brush that typically grows to knee height. Diameters typically no greater than 1/2". Capable of being worked with a hand sickle or for regen being pulled by hand.
BR04	Medium	Faster growing woody brush or regen with diameters typically between 1/2" and 1" and heights lower than chest high. Typically would be worked with hand nippers, sandiks, machetes or chainsaws.

(continued)

Factor Code	Factor Value	Definition
BR05	Heavy	Fast-growing brush or regen above head height with typical diameters greater than 1". Typically would be worked with sandiks, machetes or chainsaws.
BR06	Extra Heavy	Very dense and fast-growing brush or regen above head height with typical diameters greater than 1". Typically would be worked with sandiks, machetes, or chainsaws.
Typical Vegetation: Timber		Mature or maturing timber over 4" diameter (all species) within trail corridor
TT01	None	Meadow or opening where no trees could fall within Trail Clear Zone.
TT02	Extra Light	Open scattered timber where some trees may fall into the trail Clear Zone.
TT03	Light	Low density (greater than 10' spacing) small diameter (4-12") trees. Trail relocations would likely avoid most trees. Mostly young stable and maturing live trees.
TT04	**Medium**	Moderate density (6-10' spacing) small-to-medium diameter (4-18") trees or dense (less than 6' spacing) small diameter trees. Dead component starting to be noticeable. Relocations would likely require a substantial number of small-to-medium diameter tree removals. Typically maturing to mature timber.
TT05	Heavy	Moderately dense large diameter (18-36") trees or dense medium diameter (12-24") trees. Dead component may be substantial or fire-burned small-to-medium diameter. Relocations would likely require removal of many medium to large diameter trees. Typically mature timber.
TT06	Extra Heavy	Dense medium-to-very large diameter (over 24") trees; moderately dense very large diameter (over 36") trees; or Fire-burned areas with dense medium-to-large diameter (18-36") trees. Relocations would require removal of a substantial number of medium-to-large trees. Typically mature to over-mature timber.

—From "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Off-Highway Vehicle (OHV) Trail Adjustment Factors

This table was developed by the author.

Adjustment factors are for new sustainable construction or regular maintenance for a 5- to 6-foot wide OHV trail. This would not include major reconstruction as a maintenance action, but would include new construction of rolling grade dips for drainage control. Construction of trails wider than 5 to 6 feet would significantly increase the level of effort for mechanical construction (1.5 to 2.0 times), and make hand construction difficult on steep sideslopes because of the excessive excavation required. Figures in **bold** indicate default (standard) values.

Productivity factor	Factor value	Mechanical construction (relative work-effort coefficient) *More than 1.00 is more work* *Less than 1.00 is less work*	Mechanical construction (linear feet/day) (approximate production rate using a 3-person crew with a trail dozer, excavator, and swamper/drag)	Hand crew construction (relative work-effort coefficient) *More than 1.00 is more work* *Less than 1.00 is less work*	Hand crew construction (linear feet/day) (approximate production rate with an organized, experienced 8- to 10-person crew)	Mechanical maintenance (relative work-effort coefficient) *More than 1.00 is more work* *Less than 1.00 is less work*	Mechanical maintenance (linear feet/day) (approximate production rate using a 3-person crew with a trail dozer, excavator, and swamper)	Hand crew maintenance (relative work-effort coefficient) *More than 1.00 is more work* *Less than 1.00 is less work*	Hand crew maintenance (linear feet/day) (approximate production rate using an organized, experienced 8- to 10-person crew)
Typical trail grade (assumes the sideslopes increase as the trail grade increases)	TG00 0 to +/-2 percent (flat tread typically requiring tread hardening and/or drainage improvements)	1.30	3,696	3.00	500	3.00	5,280	3.00	1,000
	TG01 +3 to 5 percent (working upslope)	1.00	5,280	0.80	1,800	1.00	21,120	0.80	3,600
	TG02 +5 to 8 percent	1.00	5,280	1.00	1,500	1.00	21,120	1.00	3,000
	TG03 +8 to 10 percent	1.00	5,280	1.00	1,500	1.00	21,120	1.20	2,400
	TG04 +10 to 12 percent	1.00	5,280	1.40	900	1.00	21,120	(Note 2)	Not applicable
	TG05 +12 to 20 percent	1.20	4,224	2.80	535	1.50	14,080	(Note 2)	Not applicable
	TG06 +20 to 30 percent	1.50	2,640	3.20	468	3.00	5,280	(Note 2)	Not applicable
	TG07 +30 to 40 percent	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 2)	NA	(Note 2)	Not applicable
	TG08 +40 to 50 percent	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 2)	NA	(Note 2)	Not applicable
	TG09 more than +50 percent	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 2)	NA	(Note 2)	Not applicable
	TG10 -3 to 5 percent (working downslope)	1.00	5,280	0.80	1,800	1.00	21,120	0.80	3,600
	TG11 -5 to 8 percent	1.00	5,280	1.00	1,500	1.00	21,120	1.00	3,000
	TG12 -8 to 10 percent	1.00	5,280	1.00	1,500	1.00	21,120	1.20	2,400
	TG13 -10 to 12 percent	0.90	5,808	1.40	900	1.00	21,120	(Note 2)	Not applicable
	TG14 -12 to 20 percent	0.80	6,336	2.80	535	1.50	14,080	(Note 2)	Not applicable
	TG15 -20 to 30 percent	1.20	4,224	3.20	468	3.00	5,280	(Note 2)	Not applicable
	TG16 -30 to 40 percent	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 2)	Not applicable	(Note 2)	Not applicable
	TG17 -40 to 50 percent	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 2)	Not applicable	(Note 2)	Not applicable
	TG18 more than -50 percent	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 2)	Not applicable	(Note 2)	Not applicable

(continued)

Productivity factor	Factor value	Mechanical construction	Mechanical construction (linear feet/day)	Hand crew construction	Hand crew construction (linear feet/day)	Mechanical maintenance	Mechanical maintenance	Hand crew maintenance	Hand crew maintenance (linear feet/day)
Typical sideslope	SS00 0 to 5 percent (flat terrain typically requiring tread hardening and/or drainage improvements)	1.30	3,696	1.40	535	2.00	10,560	2.00	1,500
	SS01 5 to 20 percent	0.70	6,864	0.50	1,500	1.00	21,120	0.50	4,500
	SS02 20 to 40 percent	1.00	5,280	1.00	750	1.00	21,120	1.00	3,000
	SS03 40 to 60 percent	2.00	2,640	3.50	214	1.20	17,600	1.20	2,500
	SS04 60 to 80 percent	3.00	1,760	7.70 (not recommended)	97	2.80	7,542	2.80	1,071
	SS05 80 to 100 percent (Note 3)	8.50	621	10.00 (not recommended)	75	3.50	6,034	3.50	857
	SS06 more than 100 percent (Note 3)	10.00 or greater	528 or less	12.00 or greater (not recommended)	62 or less	4.00	5,280	4.00	500 or less
Typical soil type (under good soil moisture conditions)	ST00 Wetland/organics	Not recommended	Not applicable	3.00 to 5.00		Not recommended	Not applicable	Highly variable	Highly variable
	ST01 Fine mineral—silt or clay	1.20	4,400	2.00	750	1.50	14,080	1.40	2,142
	ST02 Sand	1.50	3,220	0.70	1,800	1.30	16,246	1.40	2,142
	ST03 Pumice	2.00	2,640	0.70	1,800	1.60	13,200	1.80	1,666
	ST04 Common	1.00	5,280	1.00	1,500	1.00	21,120	1.00	3,000
	ST05 Common with larger rock	2.00	2,640	1.30	1,153	1.30	16,246	1.20	2,500
	ST06 Talus or boulders	4.00	1,320	3.00 to 4.00	500 to 375	2.50	8,448	1.40	2,142
	ST07 Bedrock	Not recommended	Not applicable	Highly variable	Highly variable	Not recommended	Not applicable	Highly variable	Highly variable
Typical vegetation brush	BR01 None	1.00	5,280	0.80	1,800	Not applicable	Not applicable	Not applicable	Not applicable
	BR02 Extra light	1.00	5,280	0.85	1,725	(Note 5)	Not applicable	0.40	33,792
	BR03 Light	1.00	5,280	1.00	1,500	(Note 5)	Not applicable	1.00	21,120
	BR04 Medium	1.50	3,520	2.00	750	(Note 5)	Not applicable	1.30	16,246
	BR05 Heavy	3.50 (Note 4)	1,508	3.50	428	(Note 5)	Not applicable	2.00	10,560
	BR06 Extra heavy	4.20 (Note 4)	1,257	4.50	333	(Note 5)	Not applicable	3.00	7,040
Typical vegetation timber	TT01 None	1.00	5,280	0.95	1,500	Not applicable	Not applicable	Not applicable	Not applicable
	TT02 Extra light	1.00	5,280	0.95	1,500	(Note 7)	Not applicable	0.70	68,640
	TT03 Light	1.00	5,280	1.00	1,300	(Note 7)	Not applicable	0.80	63,360
	TT04 Medium	1.25	4,224	2.00	650	(Note 7)	Not applicable	1.00	52,800
	TT05 Heavy	2.00 (Note 6)	2,640	4.00	325	(Note 7)	Not applicable	2.00	26,400
	TT06 Extra heavy	4.00 (Note 6)	1,320	6.00 or greater	216 or less	(Note 7)	Not applicable	3.00 or greater	17,600 or less

(continued)

Notes

1. New construction of OHV trails with grades above 10 to 12 percent is strongly discouraged, and new construction of OHV trails above 20 percent is not recommended unless the tread surface is extremely durable.
2. Mechanical maintenance on trail grades above 30 percent is not recommended because of the overly steep rolling grade dips required. Hand crew maintenance on OHV trails with grades over 10 percent is not recommended because the construction of rolling grade dip drainage structures is very labor intensive.
3. Constructing OHV trails on sideslopes more than 80 percent is not recommended because of the extreme volume of material that requires excavation and the likely need for expensive retaining wall structures.
4. Mechanical construction in heavy or extra heavy brush may require supplemental hand brush clearing.
5. Using mechanical heavy equipment is not generally considered a maintenance technique for typical vegetation brushing.
6. Mechanical blading or dozing can be used during construction on light to medium timber cover. Heavy or extra heavy timber typically requires hand falling of timber. Heavy equipment can be used effectively to remove stumps and downed timber from alignment. For hand crews this is very labor intensive.
7. Using mechanical heavy equipment is not considered a typical maintenance technique for timber clearing.

—Adapted from "Trail Fundamentals and Trail Management Objectives Training Reference Package," 2011 <http://www.fs.fed.us/recreation/programs/trail-management/index.shtml>.

Notes

Appendix G: Trail Work Case Study Information

- Glacier Gap Lake Trail Project Summary
- Compeau Trail, Chena River State Recreation Area, Project Summary
- Off-Highway Vehicle (OHV) Trail Project Comparison Chart
- Trail Work Compliance Considerations
- OHV Trail Project Logistics Plan
- Example Timber and Brush Clearing Crew Instructions
- Example Construction Crew/Equipment Operator Instructions
- OHV Trail Project Oversight Checklist

Glacier Gap Lake Trail Project Summary

Project title	Glacier Gap Lake Trail Reroute			
Project date	August 2007			
Project type	Sustainable curvilinear alignment—multiuse, multiple season			
Tread	*Type* *Underlayment*	Native soil None	*Width* *Type*	6 to 8 feet Not applicable
Trail name	Glacier Lake Trail			
User types	Off-highway vehicles, hikers, mountain bikers, snowmachines, cross-country skiers, etc.			
Management Issue	Poor routing for hikers. Degraded trail conditions—braiding and erosion through lake inlet/outlet and large wetland area. Threat to cultural resources.			
Location	Mile 30 Denali Highway, AK			
	Lat. 63°5´22.483¨N.	Long. 146°14´34.857¨W.		

A Sweco 480 trail dozer roughs out the trail bench on the Glacier Lake Trail above Rock Creek. The Sweco 480 is specially designed for trail work. It has a track width of 4 feet and a six-way blade that is 5 feet wide. Jon Underwood of Happy Trails, Inc., Fairbanks, AK, was the owner/operator for the project excavation.

Land ownership	Alaska Department of Natural Resources (DNR) Tangle Lakes Archaeological District
Managing agency or organization	DNR, Division of Mining, Land and Water (DMLW)
Project cooperators	Kara Moore, Land Manager (DNR)
	Final layout and construction—Happy Trails, Inc.
	Condition assessment, prescription, proposed reroute layout, construction assistance, and oversight— National Park Service–Rivers, Trails, and Conservation Assistance Program (NPS-RTCA)
Technical guidance provided by	NPS-RTCA
Primary project contact **Agency or organization** **Phone number and e-mail**	Kara Moore DNR, DMLW 907–269–8116, kara.moore@alaska.gov
Secondary project contact **Agency or organization** **Phone number and e-mail**	Kevin Meyer NPS-RTCA 907–644–3575, Kevin_Meyer@nps.gov
Project dates	
Field work	August 20 to 30, 2007—10 days onsite

Brief narrative project description: This project was initiated in 2004 to address management problems with the alignment—degradation issues, cultural resource impacts, etc. NPS-RTCA conducted a condition assessment and developed a prescription on the existing route and developed two reroute alternatives. After receiving public and agency comment, constructing a major reroute was chosen as the best alternative to provide a sustainable multiuse trail. Grant funds were secured by DNR in order to contract with Happy Trails, Inc., for trail construction. The trail was designed to demonstrate sustainable layout and construction techniques—contour curvilinear alignment, controlled grade, integrated water control and full bench construction. The trail specifications called for a 7- to 8-foot wide tread, an average trail grade not to exceed 10 percent, integrated water control in the form of a 3- to 5-percent tread outslope and grade reversals, minimum 15-foot curve radii, and full bench construction on sideslopes steeper than 30 percent.

The layout avoided ridgetops because they have a high probability of containing cultural material. Several minor adjustments of NPS-RTCA's original alignment were made to avoid known cultural sites and improve routing. DNR project manager and State cultural staff availability onsite allowed for timely clearance and approval of minor route adjustments. Trail construction was completed with both a Sweco 480 trail dozer and a miniexcavator. The Sweco 480 was used to complete the actual trail bed construction, while the miniexcavator was used to compact fill slopes, reduce root wads, replace vegetative mats, place stepping stones across Rock Creek, and do other finish work. Construction was monitored by NPS-RTCA and DMLW staff. Both were very happy with the quality of the construction and the final completed trail.

After construction was completed, DMLW returned to seed and fertilize the trail. A total of 120 pounds of certified native seed and 500 pounds of fertilizer were applied with a hand spreader from an ATV.

The new trail route was scheduled to open for general public use after July 4, 2008. The initial 1-year closure was to allow the tread surface to dry out during spring breakup and to allow the seed to become established before use. DMLW will perform regular seasonal maintenance of the trail, including reshaping of the tread surface outslope with manual techniques, brush clearing, and maintenance of drains.

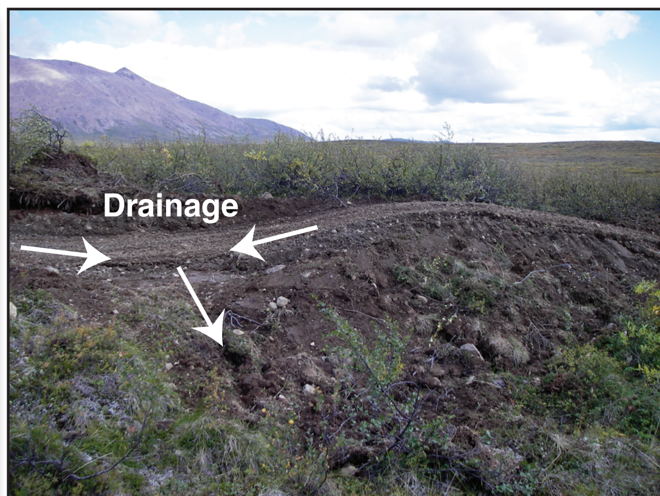
Project outcomes: 3.2 miles of multiuse trail meeting sustainable design standards including contour curvilinear alignment, controlled grade, integrated water control, and full bench construction.

Crew size	Three layout, three construction (two machine operators and one helper)		
Production rate (layout, clearing, and construction only) Does not include permitting, compliance, and site-specific logistics.	Layout—222 linear feet/person hour or 0.34 miles/day. Construction—211 feet/hour with both machines running, 0.40 miles/day Seeding—1,056 linear feet/person hour, or 1.60 miles/day (total of 16 person hours for hand seeding and fertilizing)		
Equipment	Sweco 480 trail dozer, John Deere 27C miniexcavator, all-terrain vehicles		
Supplies	About 200 gallons of diesel, shovels, McLeods, loppers, 120 pounds of native seed, 500 pounds of fertilizer		
Total onsite labor hours	Total 306 hours—230 construction, 16 seeding, 60 onsite layout		
Overall project cost	$17,144.00—Does not include hourly costs for agency person, layout, or monitoring.		
Major preproject work done: Initial assessment and reroute layouts by NPS-RTCA, grant application and grant paperwork, project logistics planning, cultural clearance, permit review and environmental compliance.			
Estimated person hours preproject	590		
Estimated installation costs (onsite construction, without logistics)	**Materials** (dollars)	**Equipment** (dollars)	**Labor** (person hours)
Approximate costs of materials and equipment and number of person hours per linear foot	$1.01	$0.80	0.014
Approximate costs of materials and equipment and number of person hours per 100 linear feet	$101.44	$79.50	1.36
Estimated cost of materials and equipment and number of person hours per mile	$5,357.50	$4,200.00	71.86
Major funding source(s)	Alaska State Parks Recreational Trails Program Matching provided by DNR–DMLW		
Special logistics requirements: The nearest fueling station was an hour away in Paxson, making the time for a refueling trip at least 2 hours. The Denali Highway is a long way from any major repair area, so if the equipment needed repair, progress on the trail would have been stalled for at least 2 days.			
Unanticipated costs or challenges: Silty clay soil at the site was very difficult to work with when wet. The soil has very poor infiltration rates so a slippery, muddy surface quickly developed during wet periods. This increases the probability of surface ruts from use and having a muddy surface during breakup and wet periods. Seeding the tread surface was a recommended mitigation method implemented following construction. Additional seeding and fertilizer applications may be needed to encourage the development of a vegetated trail surface to reduce long-term maintenance issues associated with the limitations of this soil type.			
Recommendations for future efforts: Use a hand crew during construction to help compact fill slopes, replace vegetation mats, and for final shaping of drainage features. Exaggerate the outslope in drains to reduce ponding in drain dips.			

The Glacier Lake Trail was designed as a 7- to 8-foot wide tread with a full bench. The Sweco 480 is digging the grade down to native material to meet the full bench specification.

Trail specifications included contour curvilinear alignment, controlled average grade (not to exceed 10 percent), and integrated water control.

Weighing nearly 10,000 pounds with 83 horsepower, the Sweco 480 (now known as the Sutter 480) is well equipped to handle the many large rocks encountered along the alignment.



Detailed photo of an integrated water control feature. Arrows show the direction of drainage off the tread within a grade reversal. A grade reversal or other water control feature was integrated into the alignment every 100 feet on average.

Superelevated (banked) turns also are integrated into the alignment. This design element reflects the heavy expected use of the trail by all-terrain vehicles (ATVs). The outside edge elevation works with the forces exerted on the tread by the ATVs as they traverse the turn.

A miniexcavator was used to compact fill slopes, shape backslopes, reduce root wads and place mats of stripped vegetation on exposed soil.

Compeau Trail, Chena River State Recreation Area, Project Summary

Project title	Compeau Trail, Chena River State Recreation Area
Project date	May to October 2006
Project type	Sustainable curvilinear alignment, multiuse, multiple season
Tread	*Type* Native soil *Width* 7 to 8 feet *Underlayment* None required *Type* Not applicable
Trail name	Compeau Trail
User types	Off-highway vehicles, snowmachines, mountain bikers, hikers, horses, crosscountry skiers, cabin users
Management issue	Demonstrate sustainable trail design and construction with a Sweco 480 trail dozer
Location	Chena Recreation Area, trailhead milepost 29.9, Chena Hot Springs Road, AK
	Lat. 63°53.513´N. Long. 146°41.234´W.

A segment of the Compeau Trail running through birch forest displaying sustainable design elements: curvilinear contour alignment, integrated water control (outslope, grade reversals), and full bench construction. The Compeau Trail was one of the first multiple-use trails constructed in the Alaska Interior to integrate sustainable design criteria.

Land Ownership	Alaska Department of Natural Resources (DNR)
Managing agency or organization	Alaska State Parks—Chena Recreation Area
Project contractors	Layout—Mike Shields, Palmer, AK 907–746–2515
	Construction—Happy Trails, Inc., Fairbanks, AK 907–451–557
Technical guidance provided by	National Park Service–Rivers Trails and Conservation Assistance Program (NPS-RTCA)
Primary project contact	Brooks Ludwig, chief ranger
Agency or Organization	Alaska State Parks, Northern Region
Phone number and e-mail	907–451–2695; brooks_ludwig@dnr.state.ak.us
Secondary project contact	Kevin Meyer
Agency or Organization	NPS-RTCA
Phone number and e-mail	907–644–3575, Kevin_ Meyer@nps.gov
Project dates	May to October 2006

Brief narrative project description: The project was initiated to provide a sustainable, multiple season, multiuse trail from the central valley of the Chena Recreation Area to a ridgetop fireline constructed in 2004, continuing to a recreation cabin on the Upper Colorado Creek drainage. From the beginning, the project was formulated to demonstrate sustainable layout and construction techniques: contour curvilinear alignment, controlled grade, integrated water control, and full bench construction. It also provided the opportunity to demonstrate the utility of the Sweco 480 trail dozer for trail construction in Alaska. The Sweco 480 is a 10,000-pound, 4-foot-wide, turbo-powered, 83-horsepower dozer with a 5-foot-wide blade specifically designed for trail construction.

Sustainable layout concepts and construction specifications were provided to Alaska State Parks by the NPS-RTCA Program as part of a 2-year cooperative trail planning and assessment project between the two agencies. The trail specifications called for an 8-foot-wide tread to accommodate the passing of two snowmachines, an average trail grade not to exceed 10 percent, a maximum trail grade of 15 percent for no more than 50 feet, integrated water control in the form of a 3- to 5-percent tread outslope and grade reversals (specified on an interval based on sideslope), minimum 15-foot curve radii, and full bench construction on sideslopes steeper than 30 percent. Preliminary layout design routed the preferred alignment on the upper flanks of southern facing sideslopes to avoid the need for expensive structures to cross drainages (culverts, bridges, fords) and to minimize construction on cold, wet, northern aspects. The design also avoided fall lines (running directly up slopes), ridgetops, and terrain shallower than 3-percent slope to avoid water management problems. A contract was awarded to Mike Shields, a private trails consultant out of Palmer, AK, to do the final on-the-ground centerline layout alignment flagging/blazing (with integrated water control) and to provide a mileage log and construction notes. The layout of the entire 12.6 miles required 21 days using a two-person, and at times, a three-person crew. The steep and rugged terrain, heavy thickets of timber, and remoteness presented a challenging environment for layout.

A variety of techniques for initial clearing were used, including a fire suppression crew, a Southeast Alaska Guidance Association trails crew, and various combinations of State parks staff. Again the terrain, remoteness, and thick density of the cover presented many challenges and the clearing effort developed into one of the more costly elements of the project. About 4,284 person hours were required to clear approximately 8 miles. As the project progressed, about 4 miles were cleared directly by the Sweco 480, creating large debris piles along the alignment in some areas that could benefit from additional cleanup.

Brief narrative project description (continued)**:** The construction of the trail was contracted to Jon Underwood of Happy Trails, Inc., a Fairbanks trail contractor who used a Sweco 480 trail dozer to construct the trail along the flagged alignment. Some minor modifications of the flagged route were required to adjust to localized soil conditions, drainage issues, and construction methods. These included modifying the size and location of some of the flagged-in grade reversals and slightly modifying a few of the climbing turns. The Sweco 480 proved adequate to the task of constructing the 8-foot-wide tread across the rugged terrain and its narrow size helped limit the overall width of the disturbance, a problem with larger equipment. A supporting tracked miniexcavator would have been valuable in the areas where the Sweco 480 was required to strip and clear timber along the alignment. Some late-season thawing delayed final shaping in a few segments, but generally the tread configuration was laid in the initial pass by the Sweco. The constructed trail served as a daily access route for equipment operations as they extended along the route. This allowed the dozer operator to assess and refine the function (water management and tread surface durability) and flow (riding characteristics) of the trail as construction progressed. Final finish work was completed as the trail dozer worked its way back from the end of the trail alignment near the end of the contract period. Construction was continuously monitored by Alaska State Parks staff to ensure that the trail met project specifications. NPS-RTCA also provided a qualitative assessment. Both State parks and NPS-RTCA were very pleased with the quality of the work, attention to detail displayed by the contractor, and efficiency of the operation. Public use of the trail alignment will be restricted during breakup (between April 15th and June 15th) because the soils of the tread surface are very sensitive to impact (rut formation and subsequent water channeling) during that period. Because of the nature of the tread surface soils, the alignment will require regular seasonal maintenance to reshape the tread surface outslope (by dragging or raking) and occasional clearing of brush. State parks also intends to monitor tread conditions regularly to document sustainability and to determine how frequently the trail needs to be maintained.	
Project outcomes: 12.6 miles of multiuse trail meeting sustainable design standards consisting of: contour curvilinear alignment, integrated water control, controlled grade, and full bench construction. Demonstration of the utility of the Sweco 480 trail dozer for Alaska construction.	
Crew size	Three for layout, one to eight for timber clearing, two for construction
Production rate (approximate linear feet/hour/crewmember)	Layout—0.7 mile/day/crew
	Timber clearing—highly variable (6 to 15 feet/hour/person)
	Construction—0.31 miles/day (165 feet/dozer hour)
Equipment	Sweco 480 trail dozer, all-terrain vehicles (ATVs), and ATV trailers
Supplies	Dozer and chain saw fuel
Total onsite labor hours	3,760
Overall project cost (layout, clearing and construction only) Does not include permitting, compliance, and site-specific logistics.	About $144,000, or $11,428/mile Note: This project was conducted very efficiently. For future estimation purposes use $13,000 to $15,000/mile, plus structures. For example, with a project requiring bridges, retaining walls, or trail hardening, costs could go as high as $20,000 to $50,000/mile.
Major preproject work done: Project planning, preliminary layout, budgeting, contracting for layout, permit review, and environmental compliance. Cultural clearance.	

Estimated person hours preproject	400				
Estimated installation costs (onsite construction without logistics)	**Diesel/gas** (dollars)	**Labor** (person hours)			
		Layout	**Clearing**		**Construction**
Approximate costs of materials and number of person hours per foot	$0.03	0.01	0.06		0.01
Approximate costs of materials and number of person hours per 100 feet	$2.85	0.63	6.40		1.20
Estimated costs of materials and number of person hours per mile	$150.80	33.30	340.00		64.00
Major funding source(s)	State budget line item. (NPS-RTCA work through a no-cost cooperative agreement)				

Special logistics requirements: Base and spike camps for layout and clearing crews. Base camp for construction crews. Site transport for heavy equipment.

Unanticipated costs or challenges: Expense and difficulty in fielding clearing crews in steep terrain with heavy cover—especially given the distance from base camp. The lack of drinking water along ridges limited the option of spike camps.

Recommendations for future efforts: Layout larger grade reversals—with a minimum 20- to 25-foot change in grade. Increase turn radii on climbing turns to 25 feet where possible (see note below) to better accommodate snowmachine grooming operations. Fully hand clear timber along the route to the full clearing limits. Time the clearing operations just ahead of the construction so the clearing crews can use the partially constructed trail to support field operations: mobilizing/demobilizing daily crews, supporting remote spike camps, and providing for emergency evacuation. Use a tracked excavator to support construction, particularly with berm and backslope shaping, drain development, and clearing operations.

Note about turn radii from Mike Shields: Cut-through climbing turns (also known as sweep turns), no matter what their radius, only work on sideslopes of 22 percent or less. At 30-percent sideslope, switchbacks using a constructed turning table are the only realistic option, and their maximum practical radius is somewhere between 10 and 15 feet, depending on slope steepness. With between 22- and 30-percent sideslope, we have to use a cut-through turn, which is a fairly crude way to start a climbing turn and complete it as a semi-entrenched switchback. About half the turns on Compeau are standard climbing turns, the rest are cut-throughs. Unfortunately, there's a limit to designing wide radius turns for snowmachines (which usually have a minimum design turn radius of 30 feet) on slopes over 25 percent.

General view of the forested high ridges and steep sideslopes characteristic of the terrain along the Compeau Trail, AK.

This photo shows an example of the roughed in double-wide, two-tiered pass the Sweco 480 had to make to meet the 8-foot tread width specification.

A Sweco 480 trail dozer similar to the one used to construct the Compeau Trail. The Sweco 480 is a 4-foot-wide machine with a 5-foot-wide blade.

One of the many grade reversals integrated into the trail alignment to make sure that water flows on average for no more than 100 feet along the tread surface.

One of several climbing turns. Note the maintained uniform grade through the turn and good vertical separation between the upper and lower approaches.

One of the areas where the Sweco 480 was used to directly clear timber from the alignment. Note the trees pushed into the forest.

A portion of the ridgetop fireline used to access the Compeau trail. Note the fall-line alignment and lack of integrated water control—a few of the features that limit the sustainability of this adapted trail segment.

Off-Highway Vehicle (OHV) Trail Project Comparison Chart

This table was developed by the author.

Project[1]	Year	Terrain	Construction type	Construction method	Install length	Material cost per mile[2] (dollars)	Heavy equipment cost per mile (dollars)	Total material (dollars)	Labor[3] per mile (hours required)	Labor costs (dollars at $20/hour)	Labor (percent of cost)	Approximate total cost per mile[4] (dollars)
Surface and subsurface soil												
Compeau	2006	Upland	Sustainable bench cut	Dozer	12.6 miles	150.80	3,300	3,451	64	1,280	37.09	11,000
Glacier Gap	2007	Upland	Sustainable bench cut	Dozer/excavator	3.2 miles	200	5,357	5,557	73	1,460	26.27	14,000
Quartz Creek	2001	Upland	Ditch and elevate/turnpike	Dozer/excavator	250 feet	300	10,728	11,028	296	5,920	53.68	16,400
Wood deck or planking												
Portage	2005	Lowland	Running plank	Hand crew	550 feet	55,180	None	55,180	1,267	25,340	45.92	80,520
Caribou Lake	2005	Lowland	2-meter-wide boardwalk/puncheon	Hand crew	11,400 feet	67,056	None	67,056	1,267	25,340	37.79	92,400
Porous pavement panels												
Palmer Flats	2001	Lowland	2-meter-wide, 2-inch-thick porous pavement	Hand crew	700 feet	147,840	None	147,840	2,323	46,460	31.43	194,300
Barrow	2006	Lowland	2-meter-wide, 2-inch-thick porous pavement	Hand crew	800 feet	263,445	None	263,445	1,156	23,120	8.78	291,200
Summit	2002	Lowland	2-meter-wide, 2-inch-thick porous pavement	Hand crew	700 feet	168,960	None	168,960	1,795	35,900	21.25	204,860
Middle Fork	2002	Lowland	2.5-meter-wide, 2-inch-thick porous pavement	Hand crew	1,020 feet	168,960	500	169,460	1,056	21,120	12.46	190,600
Karluk	2007	Lowland	2-meter-wide, 1-inch-thick porous pavement	Hand crew	1,275 feet	115,632	None	115,632	554.40	11,088	9.59	126,700
Hooper Bay	2007	Lowland	2-meter-wide, 1-inch-thick porous pavement	Hand crew	2,290 feet	145,486	None	145,486	1,614	32,280	22.19	[5]177,766
Summit	2005	Mixed	Wheel track, 2-inch-thick porous pavement	Hand crew	1,181 feet	102,000	None	102,000	264	5,280	5.18	107,300

[1] See Alaska trail improvement project summary reports (TPRs) for more detailed descriptions of individual trail projects. The reports are available from NPS-RTCA, 907–644–3586.
[2] Does not include all site logistics costs, but generally includes shipping costs for materials.
[3] Labor is expressed as hours required. Project labor was usually a combination of agency donated and volunteer time and contracted work.
[4] The total cost was calculated with a standard labor rate of $20/hour for all projects to provide a comparison.
[5] Actual cost was $219,314.

Trail Work Compliance Considerations

This table was developed by the National Park Service, Alaska Regional Office.

TRAIL WORK COMPLIANCE CONSIDERATIONS
A Summary of the Most Commonly Required Permits & Authorizations
(In the State of Alaska)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
	*The National Environmental Policy Act and the State Coastal Management Programs are ***Umbrella Processes That Also Provide a Framework for Compliance with Other Environmental Statutory Requirements ****			
National Environmental Policy Act (NEPA)	**Is your project a "major federal action" that could significantly affect the quality of the human environment?** (Federal actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies. (See additional details in "Terminology" section at end of this document.))	Since this is not a straightforward, easy-to-answer question, always contact the federal agency associated with your project funding, permit, license, or approval to find out more about the NEPA requirements for your project. *http://www.nepa.gov/nepa/nepanet.htm*	Depending on the potential for significant impact and other considerations, your project may be Categorically Excluded from the full NEPA process *OR* you may be required to prepare an Environmental Assessment *OR* you may be required to prepare an Environmental Impact Statement. (See "Terminology" for details on these documents.)	The National Environmental Policy Act (NEPA) is our basic national charter for protection of the environment. NEPA requires us to follow a public process to make sure we: ❖ Consider environmental effects ❖ Encourage & facilitate public involvement ❖ Identify & assess reasonable alternatives ❖ Avoid or minimize adverse effects ❖ Integrate other environmental requirements

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(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
Coastal Zone Management Program (Alaska Coastal Management Program—ACMP) Alaska Only	**Is your project within or potentially affecting resources within a state coastal zone?**	If so or if you don't know, contact your state Coastal Zone manager. Your project may require an ACMP consistency review if it is: ❖ Located in or will affect resources of the coastal zone; and ❖ Requires state, federal, or local permit(s).	The ACMP requires that projects in a coastal zone be reviewed by coastal resource management professionals and found consistent with the statewide standards of the ACMP. It is called the consistency review process. A finding of consistency with the ACMP must be obtained before permits can be issued for the project. Think of the ACMP consistency review as ***one-stop shopping for permits***. If you have to go through the ACMP process, a state representative will help you figure out what permits you need and will help coordinate getting them. If your project doesn't require an ACMP review, you may still have permit requirements, but no one coordinates the process for you. (Note, many of the permits and authorizations described below under "Specific Federal and State Permits and Authorizations" are included as part of the ACMP consistency review process.)	The Coastal Zone Management Act (CZMA) promotes the orderly development and protection of the country's coastal resources. The CZMA established a voluntary partnership among the federal government, coastal states, and local governments to develop individual state programs for managing coastal resources.
	Specific Federal and State Permits and Authorizations			

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(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
Clean Water Act (CWA)	**Will your project result in any point source effluent discharges?**	If so or if you don't know, contact your Region Headquarters of the US Environmental Protection Agency. *http://www.epa.gov/*	A Section 402 National Pollution Discharge Elimination System Permit (NPDES) is required before discharging any point source effluent. Currently, the EPA issues National Pollutant Discharge Elimination System (NPDES) permits, which are then certified by state governments.	The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water nor with water quantity issues.)
Clean Water Act (CWA)	**Does your project involve any of the following?** ❖ **Discharging fill or dredged material in waters of the U.S., including wetlands.** ❖ **Site development fill for residential, commercial, or recreational developments.** ❖ **Construction of revetments, groins, breakwaters, levees, dams, dikes, and weirs.** ❖ **Placement of riprap and road fills.**	If so or if you don't know, contact the U.S. Army Corps of Engineers at the USACE Regulatory Branch. Section 404 Permits – *http://www.poa.usace.army.mil/reg/NeedPermit.htm* Nationwide Section 404 General Permits – *http://www.poa.usace.army.mil/reg/NWPs.htm* Regional Section 404 General Permits – *http://www.poa.usace.army.mil/reg/ gps.htm*	A CWA Section 404 Permit is required before discharging dredged or fill material into waters of the US, including wetlands. There are several kinds of Section 404 Permits, depending on the actual project and impacts:: ❖ Nationwide General Permit; ❖ Regional General Permit; or ❖ Individual Permit (See "Terminology" for details.)	The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water nor with water quantity issues.)
Clean Water Act (CWA)	**Does your project involve actions requiring a CWA Section 402 or 404 Permit?**	If so, contact your state department of environmental conservation or Natural Resources management.	A Certificate of Reasonable Assurance from the State is required for any activities needing a CWA Section 402 or 404 Permit. Certificates can only be issued if the state determines the proposed activity complies with Section 401 of the CWA and that any discharge would comply with applicable state water quality standards.	The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water nor with water quantity issues.)

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(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
Rivers and Harbors Appropriation Act	**Does your project involve any of the following?** ❖ **Construction of piers, wharves, breakwaters, bulkheads, jetties, weirs, dolphins, marinas, ramps, floats, intake structures, and cable or pipeline crossings.** ❖ **Work such as dredging or disposal of dredged material.** ❖ **Excavation, filling, or other modifications to navigable waters of the U.S.**	If so or if you don't know, contact the U.S. Army Corps of Engineers at the USACE Regulatory Branch at 907-753-2712. *http://www.poa.usace.army.mil/reg/NeedPermit.htm*	A Rivers and Harbors Act Section 10 Permit is required prior to doing any work in, over, or under navigable waters of the United States, or which affects the course, location, condition or capacity of such waters.	The Rivers and Harbors Appropriation Act requires authorization from the U.S. Army Corps of Engineers (Army Corps) for the construction of any structure in or over any navigable water of the United States, the excavation/dredging or deposition of material in these water or any obstruction or alteration in a "navigable water." Structure or work outside the limits defined for navigable waters of the U.S. require a §10 permit if the structure or work affects the course, location, condition, or capacity of the water body.

(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
Endangered Species Act (ESA)	**Will your project potentially jeopardize the continued existence of any listed threatened or endangered species?**	Always contact the local office of the NOAA National Marine Fisheries Service (NMFS) to determine if listed marine species including marine mammals and fish that migrate from the sea to spawn in rivers, such as salmon are present within your project area or may otherwise be affected by your project. *http://www.fakr.noaa.gov/* Always contact the local office of the U.S. Fish and Wildlife Service (USFWS) to determine if listed terrestrial species are present within your project area or may otherwise be affected by your project. *http://fws.gov/*	Section 7 consultation is required for all actions taken by a federal agency *OR* by the applicant as the designated non-Federal entity. Steps in the consultation process include: 1. The Federal agency or applicant contacts the local Service office to determine if listed species are present within the action area. If the Service provides a negative response, no further consultation is required. 2. If listed species are present, the Federal agency/applicant must determine if the action *may affect* the species. If the determination is no and the Service agrees with that determination, the Service provides concurrence in writing and no further consultation is required. 3. If the Federal agency/applicant determines that the action is likely to adversely affect listed species, then it must request initiation of formal consultation with the Service.	The Endangered Species Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Section 7(a)(2) states that each Federal agency shall insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. This section of the Act sets out the consultation process, which is further implemented by regulation (50 CFR §402).

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(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
National Historic Preservation Act	**Will your project potentially impact cultural resources such as historic properties?**	If yes or if you don't know, contact your state State Historic Preservation Office (SHPO) or office of history and/or archeology.	Your project may require Section 106 Review. Through the Section 106 review process, State history preservation staff work with federal and state agencies during the early stages of project planning to protect cultural resources. They do this by providing information on the location of sites and on cultural resources surveys previously done in an area. If the potential to discover unknown sites is high, a survey may be recommended. When there are sites in a project area, OHA consults with the agency on National Register eligilbility, on how the project will affect sites, and on ways to lessen unavoidable damage.	Section 106 of the National Historic Preservation Act requires review of any project funded, licensed, permitted, or assisted by the federal government for impact on significant historic properties. The agencies must allow the State Historic Preservation Officer and the Advisory Council on Historic Preservation, a federal agency, to comment on a project.
Alaska Statute	**Is your project located on or does it require temporary crossing of a designated State Game Refuge, Critical Habitat Area, or State Game Sanctuary?**	If yes or if you don't know, call your local Game Division.	Your project may require a Special Area Permit from your state Game Division.	Many states have classified certain areas as being essential to the protection of fish and wildlife habitat. These areas are often designated as either a refuge, critical habitat area, or sanctuary. Management of these special areas is the responsibility of the State's game management agency.
Alaska Statute	**Is your project located on or does it require temporary crossing of a unit of the State Park System?**		Your project may require a Special Use, Non-Compatible Use, Commercial Use or other such permit.	

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(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
Alaska Statute	**Is your project located on or does it require temporary crossing of state-owned land or water including but not limited to a unit of the State Park System or a designated State Game Refuge, Critical Habitat Area, or State Game Sanctuary?**	If yes or if you don't know, call your State's Lands office.	Your project may require a State Land Use Permit. Land use permits are authorizations issued to use state land, on a temporary basis, for a variety of purposes. The permits range in duration. They are generally intended for temporary, non-permanent uses such as floating lodges, log storage, scientific research, guide camps, equipment storage and commercial recreation uses. These permits do not convey any interest in the land and permanent structures are not allowed.	
Alaska Statute	**Does your project involve any of the following?** ❖ **Stream diversion** ❖ **Streambank or streambed disturbance** ❖ **Gravel removal** ❖ **Stream crossings** ❖ **Bridge or culvert construction and maintenance** ❖ **Streambank restoration/ protection; erosion control** ❖ **Stream fluming** ❖ **Ice bridge/road construction** ❖ **Water withdrawal** ❖ **Dam and impoundment construction** ❖ **Placer mining activities** ❖ **Recreational suction dredging** ❖ **Use of explosives near stream corridors**	If so or if you don't know, call the local office game or waterways management office.	A Fish Habitat Permit may be required for listed activities.	State Statutes may require that an individual or government agency notify and obtain authorization from the State for activities within or across a stream used by fish if the activities could represent an impediment to the efficient passage of fish.

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(continued)

Law or Program	Regulated Activities	Agency Contact	Possible Permits/Authorizations	Additional Information
US Coast Guard	**Do you plan to construct a bridge or causeway over tidal (ocean) waters or navigable rivers, streams, or lakes; building access to an island; or siting, constructing, or operating a deepwater port?**	If yes or if you don't know, contact the US Coast Guard.	Your project may require a US Coast Guard Permit.	
Federal Aviation	**Is your project located within 5 miles of any public airport?**	If so or if you don't know, contact the Airports Division of the Federal Aviation Administration (FAA).	Your project may require FAA authorization.	
Various	**Is your project located on or will you need to cross:** ❖ **Private land** ❖ **Private Corporation land** ❖ **City land** ❖ **Borough land** ❖ **Federal land (e.g., US Fish & Wildlife Service, National Park Service, US Forest Service, Bureau of Land Management, Department of Defense, etc.)**	If so or if you don't know, call the appropriate land owner/manager (e.g., private landowner, Private Corporation, city manager, borough manager, federal land manager).	Your project may require varying permits or authorizations from the land owner or land managing entity.	

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(continued)

TERMINOLOGY

Categorical Exclusion – A category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a federal agency in implementation of NEPA regulations and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. (40 CFR 1508.4)

CFR – Code of Federal Regulations

Endangered Species – A species listed under the Endangered Species Act as in danger of extinction throughout all or a significant portion of its range.

Environmental Assessment – A concise public document that serves to (a) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; (b) aid an agency's compliance with NEPA when no environmental impact is necessary; or (c) facilitate preparation of an environmental impact statement when one is necessary. (40 CFR 1508.10)

Environmental Impact Statement – A detailed written statement prepared when an action has the potential for a significant impact on the human environment.

Human Environment – The natural and physical environment, and the relationship of people with that environment. Economic or social effects are not intended by themselves to require preparation of an EIS. When an EIS is prepared and economic or social and natural or physical environmental effects are interrelated, then the EIS will discuss all of these effects on the human environment. (40 CFR 1508.14)

Individual Section 404 Permit – Individual permits are issued following a full public interest review of an individual application for a Department of the Army permit. A public notice is distributed to all known interested persons. A final decision is made after evaluating all comments and information received.

Major Federal Actions – New and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals. Actions do not include funding assistance solely in the form of general revenue sharing funds, distributed under the State and Local Fiscal Assistance Act with no federal agency control over the subsequent use of such funds. Actions do not include bringing judicial or administrative civil or criminal enforcement actions. (40CFR 1508.18)

Nationwide Section 404 General Permit – A form of General Permit issued by USACE Headquarters nationally. NWPs authorize specific activities in areas under Corps Regulatory jurisdiction (for example, navigable waterways, wetlands, etc.). These activities are minor in scope and must result in no more than minimal adverse impacts both individually and cumulatively. Individuals wishing to perform work under these NWPs must ensure that their project meets all applicable terms and conditions, including the regional conditions specific to Alaska. If the conditions cannot be met, a regional general permit or individual permit will be required.

Navigable Waters – Water that have been used in the past, are now used, or are susceptible to use as a means to transport interstate or foreign commerce up to the head of navigation. Section 10 and/or Section 404 permits are required for construction activities in these waters (list of Navigable Waters in Alaska). (33 CFR 329)

Regional Section 404 General Permit – Permits issued by the Alaska District Engineer for a general category of activities when: (1) the activities are similar in nature and cause minimal environmental impact (both individually and cumulatively), and (2) the regional permit reduces duplication of regulatory control by State and Federal agencies.

Threatened Species – A species listed under the Endangered Species Act as likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Waters of the United States – Essentially all surface waters, including all navigable waters and their tributaries, all interstate waters and their tributaries, all impoundments of these waters, all wetlands adjacent to these waters, and certain isolated wetlands. (33 CFR Part 328)

Wetlands – Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include tundra, permafrost areas, swamps, marshes, bogs, and similar areas.

—Courtesy of the National Park Service

OHV Trail Project Logistics Plan

This form was developed by the author.

Project description______________ **Project title**______________ **Agency funding code**______________

General Information				
Dates	Major tasks		Crew leader	Crew members
	A			
	B			
	C			
	D			
	E			

Estimates									
Estimated level of effort		**Equipment time** (hours)		**Other**	**Estimated costs** (dollars)				
Task	Labor (hours)	Trail dozer	Excavator		Labor	Equipment	Materials	Supplies	Per diem
A									
B									
C									
D									
E									

Work schedule									
Task	5-day	Other	Start time	End time	Hours required for mobilization and demobilization	Task hours	Overtime	Total hours/day	Per diem
A									
B									
C									
D									
E									

(continued)

Mobilization and demobilization									
Van	Foot	OHV	OHVs assigned					Other	
Equipment									
Task	**Vehicles**			**Heavy equipment**					
	Vans	Trucks	OHVs	Trail dozer	Excavator	Totes	Onsite fuel/oil	Other	Other
A									
B									
C									
D									
E									
Handtools									
Task	Pulaskis	McLeods	Shovels	Saw kits	Fuel and oil	First aid	Communication	Other	Other
A									
B									
C									
D									
E									
Special logistics (helicopter slinging, pack crews, spike camp setup, etc.)									
Task	Cost	Description	Timing			Contacts			
Materials and supplies									
Task	Item	Ordered	Received	Staged	Task	Item	Ordered	Received	Staged

(continued)

Administrative tracking									
Task	NEPA	Permits	Fuel management	Job Hazard Analysis	Evacuation plan	Highest qualified medic	Safety officer	Quality assurance, quality control	Report of time and results
A									
B									
C									
D									
E									

Trail Work

Example Timber and Brush Clearing Crew Instructions

This information was developed by the author.

(To be posted at the trailhead. Crewleaders are to read and review with all crewmembers at the beginning of the clearing project and daily as necessary.)

1. Clear along the designated ________flagging line (agency specifies color). The flagging marks the centerline of the trail corridor for motorized (OHV) trails and the outside or critical edge for nonmotorized (foot) trails. This project is for a motorized trail. The flagging marks the centerline.
2. Leave all flags hanging in their original location. Flag locations guide future construction. Cut off the top of trees or brush above the flagging if you can do so without disturbing the flagging. If flagging is accidentally removed, replace it at eye level as close to its original location as possible.
3. Clearing provides a corridor wide enough for future trail construction, defined as the "clearing limits." The appropriate clearing limit (CL) is a function of the natural terrain's sideslope (SS), the specified tread width (TW), the backslope (for uphill stability), and an area below the trail where excavated material (side cast) can be disposed. Typically, there is a 1:1 backslope above the trail and a 1:2 area below the trail for the side cast. Typical CL are:

An 8-foot-wide trail		A 6-foot-wide trail	
Sideslope* (percent)	Clearing limit (feet)	Sideslope* (percent)	Clearing limit (feet)
10 to 40	16	10 to 40	12
40 to 60	20	40 to 60	16

*As measured in the field with a clinometer—The clearing crew should make frequent sideslope measurements, adjusting the clearing width when the sideslope becomes gentler or steeper than 40 percent.

This project is for a ______ -foot-wide trail (agency specifies width).

4. On sideslopes less than 40 percent, clear equally along both sides (above and below) of the flagging line. When you are done, the flagging line should be centered in the corridor. On sideslopes steeper than 40 percent, about three-fifths of the clearing width should be on the uphill side. Try to feather edges along the outer 2 feet of the cut to help soften the hard edge of the clearing. Occasionally, locations may be double flagged (one flag below the other), or flagged in blue or a different color. These are drain dip (grade reversal) locations along the alignment. Clear through these areas the same as you would at other locations. The cleared corridor should dip up or down slightly for the slight change in alignment needed for drainage along the alignment.
5. Cut all trees and brush as close to the ground surface as possible—except for flagged trees and trees larger than 10 inches diameter at breast height. Stumps of smaller trees should not be taller than 6 inches. Brush stumps should not be taller than 8 inches. Cut the top of the stump as flat as possible (don't leave sharp stumps). Stumps of trees larger than 10 inches diameter at breast height should be 36 to 40 inches tall to provide leverage so the stumps can be removed by heavy equipment (unless otherwise directed by the project supervisor).

6. Buck larger diameter logs into 6- to 7-foot lengths. You do not need to stack the logs. Logs within the clearing limits need to be removed, ideally by rolling or throwing logs downhill from the trail corridor when it is safe to do so. Leave logs where they fall outside the clearing limits, unless they might roll within the clearing limits during construction.
7. All brush, small trees, and the tops of larger trees should be scattered outside the trail corridor to reduce visual impact. Avoid large piles of slash, which will trap side cast when the trail is constructed. To the extent possible, drag and scatter brush downslope with the cut ends pointing away from trail. Wherever possible, use steep sideslopes or open areas to get brush far off the trail (sometimes a steep section will allow you to easily toss material from the corridor off the trail where it will disappear from view).
8. Help develop a cleared walking trail along the alignment for crews and resource specialists to use during subsequent field work.

Specific questions on clearing should be referred to:______________________________

Phone: ______________________________

Backup contact:

____

Phone: ______________________________

Thank you for your attention to these details and a job well done!

Example Construction Crew/Equipment Operator Instructions

This information was developed by the author.

1. Make sure that you have a copy of the detailed trail alignment map and trail segment description. Become familiar with these materials, and use them as references during construction.
2. The trail construction corridor has been cleared of trees and large brush for a width of about 12 feet. Centerline flagging has been retained in the corridor. **Flagging (specify color)** denotes the center of the final trail tread. Double flagging denotes the lowest point of drainage features along the centerline.
3. The specifications for construction are as follows (figure 1):
   - Final trail tread width—84 inches
   - Surface roughness—no obstacles more than 3 inches above the tread
   - Outslope—initial construction outslope specification is 5 to 8 percent
     —final design outslope after settling is 3 to 6 percent

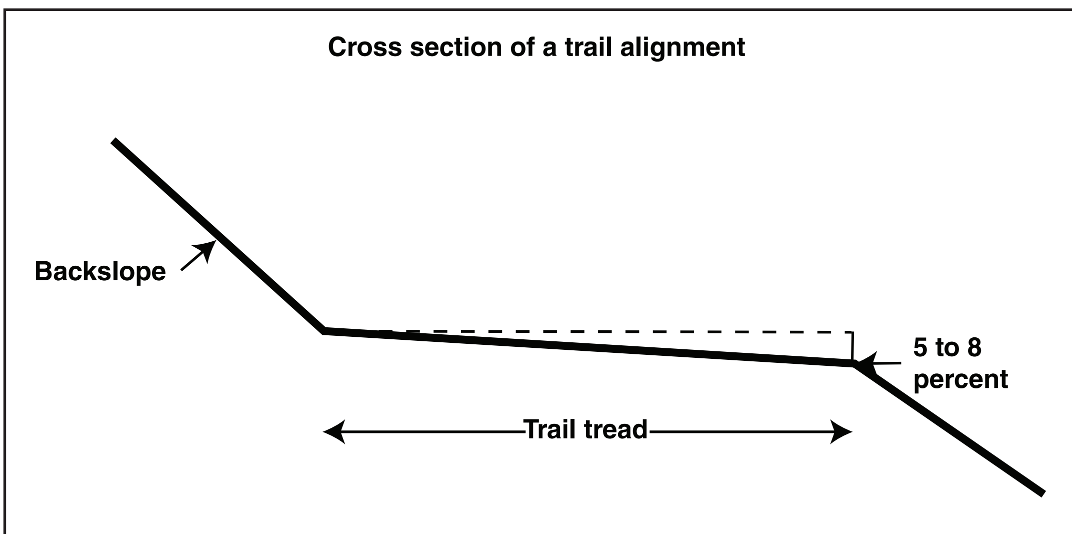

Figure 1—Diagram showing the outslope for trail tread.

4. The trail layout has integrated drainage features in the form of grade reversals. These are designed changes in grade for 15- to 25-foot segments every 75 to 100 feet on average along the trail. It is critical that these grade reversals be retained during construction. That is the primary reason that centerline flagging is retained along the alignment and that the bottom of the grade reversals are double flagged. When constructing the trail, the final grade when entering and leaving the lowest point in the grade reversal must be at least +3 percent in both directions (figure 2).

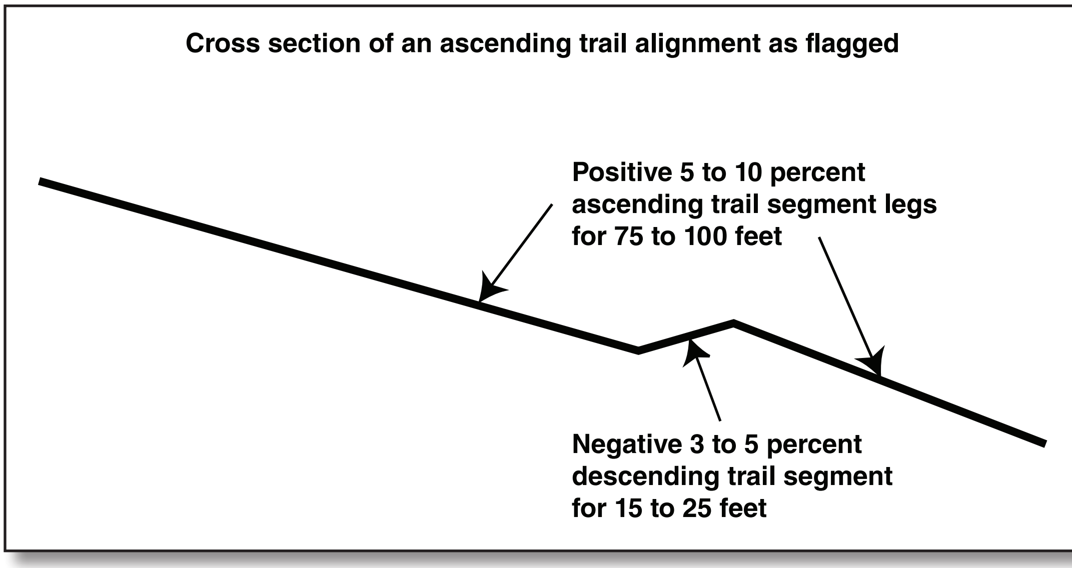

Figure 2—Diagram of a grade reversal. This illustration exaggerates the differences in trail grade to show the reversal.

5. Backslopes should be cut back to a 2:1 angle on sideslopes shallower than 30 percent and 1:1 on sideslopes steeper than 30 percent, unless otherwise specified.
6. All benches should be full bench construction. Fill segments will be subject to approval.
7. Spoil from bench cuts should be side cast and scattered downslope. Minimize side casting materials into drainages. Spoil, root wads, cleared timber, and organic mats should be broken up and scattered to facilitate outslope drainage and reduce visual impact. A tracked excavator does a good job when scattering material. Clumps and piles of debris should be smaller than 10 cubic feet. Organic material may be retained for a scattered capping on backslope and faceslope cuts.

Specific questions on clearing should be referred to: ____

Phone____

OHV Trail Project Oversight Checklist

This checklist was developed by the author.

Layout

Trailhead and desired destination(s) linked	Meets ❑	Fails ❑	Exceptions________________
Positive control points linked	Meets ❑	Fails ❑	Exceptions________________
Negative control points avoided	Meets ❑	Fails ❑	Exceptions________________
Quality of layout	Good ❑	Poor ❑	Problems________________
Upland and sideslope sites maximized	Good ❑	Poor ❑	Problems________________
Sideslope placement	Good ❑	Poor ❑	Problems________________
Lowland sites minimized	Good ❑	Poor ❑	Problems________________
Water crossing sites	Good ❑	Poor ❑	Problems________________
Ridge crossing sites	Good ❑	Poor ❑	Problems________________
Support structure sites	Good ❑	Poor ❑	Problems________________
Turn bench sites	Good ❑	Poor ❑	Problems________________
Turn centerpoint sites	Good ❑	Poor ❑	Problems________________
Turn layout provided	Good ❑	Poor ❑	Problems________________
Minimum turn radius	Meets ❑	Fails ❑	Exceptions________________
Drainages dipped into and out of	Meets ❑	Fails ❑	Exceptions________________
Average grade specification	Meets ❑	Fails ❑	Exceptions________________
Maximum grade specification	Meets ❑	Fails ❑	Exceptions________________
Percentage of total trail length	Meets ❑	Fails ❑	Exceptions________________
Integrated water control	Meets ❑	Fails ❑	Exceptions________________
Specified control spacing	Meets ❑	Fails ❑	Exceptions________________
Flagging and staking	Meets ❑	Fails ❑	Exceptions________________
Spacing and visibility requirements	Meets ❑	Fails ❑	Exceptions________________
Durable flagging and stakes	Meets ❑	Fails ❑	Exceptions________________
Linear distance stations established	Meets ❑	Fails ❑	Exceptions________________
Trash or debris removed	Meets ❑	Fails ❑	Exceptions________________
Required documentation provided	Meets ❑	Fails ❑	Exceptions________________

Other layout comments:

Clearing

Specified alignment followed	Meets ❑	Fails ❑	Exceptions________________
Flagging retained (if required)	Meets ❑	Fails ❑	Exceptions________________
Clearing to specified limits	Meets ❑	Fails ❑	Exceptions________________
Width	Meets ❑	Fails ❑	Exceptions________________
Height	Meets ❑	Fails ❑	Exceptions________________

(continued)

Quality of edge feathering	Good ❑	Poor ❑	Exceptions____________________
Minimum diameter size brush removal	Meets ❑	Fails ❑	Exceptions____________________
Stump height requirement	Meets ❑	Fails ❑	Exceptions____________________
Clean flat cuts on small diameter material	Meets ❑	Fails ❑	Exceptions____________________
Brush disposal	Meets ❑	Fails ❑	Exceptions____________________
Scattered or reduced volume	Meets ❑	Fails ❑	Exceptions____________________
Visibility	Meets ❑	Fails ❑	Exceptions____________________
Cut edge	Meets ❑	Fails ❑	Exceptions____________________
Up or down slope as specified	Meets ❑	Fails ❑	Exceptions____________________
Cleared walking corridor provided	Meets ❑	Fails ❑	Exceptions____________________
Trash or debris removed	Meets ❑	Fails ❑	Exceptions____________________
Proper fuel storage	Meets ❑	Fails ❑	Exceptions____________________
No evidence of fuel spills	Meets ❑	Fails ❑	Exceptions____________________
Food storage (in bear country)	Meets ❑	Fails ❑	Exceptions____________________
Required documentation provided	Meets ❑	Fails ❑	Exceptions____________________

Other clearing comments:

New construction/reroutes

Tread	Meets ❑	Fails ❑	Exceptions____________________
Alignment layout followed	Meets ❑	Fails ❑	Exceptions____________________
Flagged grade reversals cut in	Meets ❑	Fails ❑	Exceptions____________________
Positive grades out of reversals (+3 percent)	Meets ❑	Fails ❑	Exceptions____________________
Width specifications	Meets ❑	Fails ❑	Exceptions____________________
Full bench construction	Meets ❑	Fails ❑	Exceptions____________________
Outslope specifications	Meets ❑	Fails ❑	Exceptions____________________
Surface roughness specifications	Meets ❑	Fails ❑	Exceptions____________________
Obstacle specifications	Meets ❑	Fails ❑	Exceptions____________________
Surface compaction specifications	Meets ❑	Fails ❑	Exceptions____________________
Backslope cut specifications	Meets ❑	Fails ❑	Exceptions____________________
Vegetation mat or debris scattering specifications	Meets ❑	Fails ❑	Exceptions____________________
Berm removed	Meets ❑	Fails ❑	Exceptions____________________
Slough removed	Meets ❑	Fails ❑	Exceptions____________________
Lower slope fill areas compacted	Meets ❑	Fails ❑	Exceptions____________________
Drainages dipped into and out of	Meets ❑	Fails ❑	Exceptions____________________
Vegetative buffer provided at stream crossings	Meets ❑	Fails ❑	Exceptions____________________

(continued)

Fill disposal	Meets ❑	Fails ❑	Exceptions_____________________
Side cast	Meets ❑	Fails ❑	Exceptions_____________________
Under maximum volume limits	Meets ❑	Fails ❑	Exceptions_____________________
Disposal sites	Meets ❑	Fails ❑	Exceptions_____________________
Fill sites	Meets ❑	Fails ❑	Exceptions_____________________
Quality of finish	Good ❑	Poor ❑	Problems______________________

Other tread comments:

Structure construction	Meets ❑	Fails ❑	Exceptions_____________________
Proper locations	Meets ❑	Fails ❑	Exceptions_____________________
Meets design specifications	Meets ❑	Fails ❑	Exceptions_____________________
Correct materials	Meets ❑	Fails ❑	Exceptions_____________________
Appropriate construction methods	Meets ❑	Fails ❑	Exceptions_____________________
Construction quality	Good ❑	Poor ❑	Problems______________________

Other structure comments:

Trash or debris removed	Meets ❑	Fails ❑	Exceptions_____________________
Proper fuel storage	Meets ❑	Fails ❑	Exceptions_____________________
No evidence of fuel spills	Meets ❑	Fails ❑	Exceptions_____________________
Food storage (in bear country)	Meets ❑	Fails ❑	Exceptions_____________________
Required documentation provided	Meets ❑	Fails ❑	Exceptions_____________________

Other new construction/reroute comments:

Maintenance actions

Work on proper segments conducted	Meets ❑	Fails ❑	Exceptions_____________________
Width specs	Meets ❑	Fails ❑	Exceptions_____________________
Water control	Meets ❑	Fails ❑	Exceptions_____________________
Spacing requirements	Meets ❑	Fails ❑	Exceptions_____________________
Properly constructed structures	Meets ❑	Fails ❑	Exceptions_____________________
Berm removed	Meets ❑	Fails ❑	Exceptions_____________________

(continued)

Slough removed	Meets ❏	Fails ❏	Exceptions____________________
Outslope reshaped to specs	Meets ❏	Fails ❏	Exceptions____________________
Tread compacted to specs	Meets ❏	Fails ❏	Exceptions____________________
Excess soil properly disposed	Meets ❏	Fails ❏	Exceptions____________________
Clearing limits brushed	Meets ❏	Fails ❏	Exceptions____________________
Low stumps to specifications	Meets ❏	Fails ❏	Exceptions____________________
Vegetation debris properly disposed	Meets ❏	Fails ❏	Exceptions____________________
Trail hardening	Meets ❏	Fails ❏	Exceptions____________________
Proper locations	Meets ❏	Fails ❏	Exceptions____________________
Specified length	Meets ❏	Fails ❏	Exceptions____________________
Specified width	Meets ❏	Fails ❏	Exceptions____________________
Fill depth and volume, diameter of poles	Meets ❏	Fails ❏	Exceptions____________________
Correct materials	Meets ❏	Fails ❏	Exceptions____________________
Appropriate construction methods	Meets ❏	Fails ❏	Exceptions____________________
Construction quality	Good ❏	Poor ❏	Problems_____________________
Other trail-hardening comments:			

Structure maintenance	Meets ❏	Fails ❏	Exceptions____________________
Proper locations	Meets ❏	Fails ❏	Exceptions____________________
Meet design specifications	Meets ❏	Fails ❏	Exceptions____________________
Correct materials	Meets ❏	Fails ❏	Exceptions____________________
Appropriate construction methods	Meets ❏	Fails ❏	Exceptions____________________
Construction quality	Good ❏	Poor ❏	Problems_____________________
Other structure maintenance comments:			

Proper material handling	Meets ❏	Fails ❏	Exceptions____________________
Trash or debris removed	Meets ❏	Fails ❏	Exceptions____________________
Proper fuel storage	Meets ❏	Fails ❏	Exceptions____________________
No evidence of fuel spills	Meets ❏	Fails ❏	Exceptions____________________
Food storage (in bear country)	Meets ❏	Fails ❏	Exceptions____________________
Required documentation provided	Meets ❏	Fails ❏	Exceptions____________________
Other material handling comments:			

Notes

Appendix H: Job Hazard Analysis

- Example Job Hazard Analysis (JHA)—Trail Assessment and Condition Surveys (TRACS)
- Example Job Hazard Analysis (JHA)—Trail Maintenance and Construction

Example Job Hazard Analysis (JHA)—Trail Assessment and Condition Surveys (TRACS)

FS-6700-7 (2/98)

U.S. Department of Agriculture Forest Service	1. WORK PROJECT/ACTIVITY **Trail condition surveys (TRACS)**	2. LOCATION **Cordova R.D.**	3. UNIT **Chugach N.F.**
JOB HAZARD ANALYSIS (JHA) References-FSH 6709.11 and .12 (Instructions on Reverse)	4. NAME OF ANALYST **David A. Zastrow**	5. JOB TITLE **Forestry Technician**	6. DATE PREPARED **03/28/2008**

7. TASKS/PROCEDURES	8. HAZARDS	9. ABATEMENT ACTIONS Engineering Controls * Substitution * Administrative Controls * PPE
***NAVIGATION**	**Disorientation**	**Familiarize everyone on crew with project area during planning stages. Everyone on crew should have at least a rudimentary knowledge of topographic map reading and use. Compass skills should be reinforced if necessary. GPS units should have spare batteries with them. Crew members should avoid travelling alone.**
***GENERAL GUIDELINES FOR FOOT TRAVEL**	**Sprains/strains**	**Be sure of footing. Wear sturdy, properly fitted boots. Take into consideration wet, snowy, or icy conditions. Stretch and warm up before strenuous walking.**
	Uneven terrain	**Become familiar with topography by studying topo maps in planning stages of project. Be aware of cliffs, drop-offs, streams, etc.**
	Avalanche/slide areas	**Become familiar with these areas before traversing them, if possible. Watch for falling rock, snow, or debris. Traverse these areas using the shortest safe route (usually perpendicular to the slide path).**
	Blisters	**Blisters can make foot travel difficult to impossible, so precautions should be taken to prevent them. Wear properly fitted boots, sock liners under outer socks, and keep feet as dry as possible.**
	Dehydration	**Exertive walking, especially in the dense vegetation and steep terrain encountered here necessitates that crew members keep well hydrated to prevent heat related injuries. Drink plenty of fluids throughout the day, even when not thirsty. Modify clothing to changing weather conditions and exertion levels.**
	Insects	**Large numbers of biting insects can make field work difficult if preventive measures are not taken. Use repellents or headnets or a combination of both. Long sleeves and gloves will also offer some relief.**
***WORKING IN GLACIAL TERRAIN**	**Falls**	**Be aware of possible unstable ground near glacially scarified areas. Use caution on icy spots.**
***LARGE MAMMAL ENCOUNTERS**	**Bear encounters**	**Make noise, especially by talking, when working in areas frequented by bears. Be wary of sows with cubs. Use caution when travelling near streams with salmon runs. Carry firearms as required. If encountered, stand your ground while waving arms and making noise. If charged, stand your ground and react appropriately as per bear encounter training.**

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	Moose encounters	Same avoidance technique as bears. Be especially wary of cows with calves and rutting bulls. For any possible injury caused by an animal, make sure first aid kit is properly equipped to deal with these injuries.
*TRANSPORTING EQUIPMENT ON THE TRAIL	Falls Strains/sprains Cut injury	Carry reasonably sized loads. Make sure packs are well balanced. Be sure of footing. Use guards on tools with sharp edges.
*COMMUNICATIONS	Faulty radio	Carry spare batteries for portable radios. Have more than one radio per crew available.
	Faulty transmission	Be aware of proper repeater channels for use in work areas. Try transmitting from different locations. Have a backup, such as a satellite or cellular phone for use in dead zones, if working in remote areas. Enact a plan for inter-crew and outside communications, including emergency transmissions. Practice proper radio etiquette.
*FIRST AID		Every crew should have a properly equipped first aid kit both in camp and on the trail. Crew members should be certified in basic first aid and in CPR. Evacuation plan should be in place in the event that a serious injury should occur. Crew leader should be aware of previous medical conditions of crew members, such as illnesses and allergies, especially anaphalactic responses to insect bites/stings.
*STREAM CROSSINGS	Drowning Hypothermia Slippage	Do not attempt to cross swollen steams. Wear hipboots if possible or at least sturdy shoes. Try to "sound" streams with rocks or long sticks if unsure of depth. Cross diagonally upstream. Use a staff to assist in crossing and proceed slowly. Make sure pack hipbelts and straps are unfastened and loosened before crossing. If crossing on downed log, be sure it is stable and wide enough. Provide rope crossings if other options are not available. Be familiar with first aid for hypothermia victims.
*WORKING IN INCLEMENT WEATHER	Lightning	Discontinue work if a lightning storm occurs.
	Falling limbs	Be aware of possible falling branches in high winds. Cease fieldwork if windspeeds exceed 35 mi/h. Always wear hard hat when in the field.
	Hypothermia	Use appropriate clothing; dress in layers. A wicking layer should be worn next to skin, followed by an insulating layer if necessary, and a wind and waterproof shell. Modify as needed. Avoid wearing cotton in wet conditions. Remember that

(continued)

		hypothermia can occur in temperatures as high as fifty degrees.
*TRAVELING THROUGH HEAVY BRUSH	Eye injury	Wear protective goggles or glasses.
	Thorns/Devil's club	Wear protective clothing. Medium weight rain bibs have proven very effective in preventing injuries from thorns. Wear long sleeved shirt, leather gloves, and hard hat.
*WORKING IN STEEP TERRAIN	Sprains Falls	Stretch and warm up before working in the field. Wear appropriate, sturdy footwear. Proceed slowly and carefully through steep terrain. Maintain three points of contact on very steep grades. Be aware of what is underfoot; proceed slowly. Do not carry loads beyond your ability. Use switchbacks, rather than traverse straight up and down steep terrain. Study topographic maps to become familiar with possible hazards.
	Falling rocks or logs	When walking in a group, be aware debris loosened by crew members ahead and above one another.
As per 29 CFR Part 1910, Subpart I, 1910.132(d)(2), the required workplace hazard assessment has been performed. This document serves as the certification of hazard assessment for the work activities described within.		

10. LINE OFFICER SIGNATURE	11. TITLE	12. DATE

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JHA Instructions (References-FSH 6709.11 and .12)

The JHA shall identify the location of the work project or activity, the name of employee(s) writing the JHA, the date(s) of development, and the name of the appropriate line officer approving it. The supervisor acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity.

Blocks 1, 2, 3, 4, 5, and 6: Self-explanatory.

Block 7: Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP).

Block 8: Identify all known or suspect hazards associated with each respective task/procedure listed in block 7. For example:

a. Research past accidents/incidents
b. Research the Health and Safety Code, FSH 6709.11 or other appropriate literature.
c. Discuss the work project/activity with participants
d. Observe the work project/activity
e. A combination of the above

Block 9: Identify appropriate actions to reduce or eliminate the hazards identified in block 8. Abatement measures listed below are in the order of the preferred abatement method:

a. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and furniture.

b. Substitution. For example, switching to high flash point, non-toxic solvents.

c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.

d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, portable water pumps)

e. A combination of the above.

Block 10: The JHA must be reviewed and approved by a line officer. Attach a copy of the JHA as justification for purchase orders when procuring PPE.

Blocks 11 and 12: Self-explanatory.

Emergency Evacuation Instructions (Reference FSH 6709.11)

Work supervisors and crew members are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite.

Be prepared to provide the following information:

a. Nature of the accident or injury (avoid using victim's name).
b. Type of assistance needed, if any (ground, air, or water evacuation)
c. Location of accident or injury, best access route into the worksite (road name/number), identifiable ground/air landmarks.
d. Radio frequency(s).
e. Contact person.
f. Local hazards to ground vehicles or aviation.
g. Weather conditions (wind speed & direction, visibility, temp).
h. Topography.
i. Number of person(s) to be transported
j. Estimated weight of passengers for air/water evacuation.

The items listed above serve only as guidelines for the development of emergency evacuation procedures.

JHA and Emergency Evacuation Procedures Acknowledgment

We, the undersigned work leader and crew members, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents:

SIGNATURE	DATE	SIGNATURE	DATE
Work Leader			

Example Job Hazard Analysis (JHA)—Trail Maintenance and Construction

U.S. Department of Agriculture Forest Service	1. WORK PROJECT/ACTIVITY Trail Maintenance and Construction	2. LOCATION Sawtooth National Recreation Area	3. UNIT D4
JOB HAZARD ANALYSIS (JHA) References-FSH 6709.11 and .12 (Instructions on Reverse)	4. NAME OF ANALYST Debra Peters, Jay Dorr	5. JOB TITLE Forestry Technician	6. DATE PREPARED 5/4/2005

7. TASKS/PROCEDURES	8. HAZARDS	9. ABATEMENT ACTIONS Engineering Controls * Substitution * Administrative Controls * PPE
1. Tool Preparation (hand file, power disk)	Cut fingers, arms	Wear gloves, safety goggles, and long sleeve shirt. Have a stable work surface. Watch what you are doing. When using grinder, wear shield and apron and get instructions. Take your time. Replace tool handle if it is extremely dry, cracked, or warped. Also, replace handle if it is loose and already has 2 or more wedges in it. When using a file, make sure it has both a handle and a guard. Remove pitch from tools before going into the field. Refer to pages 131–132 of *Trail Construction and Maintenance Notebook (TC&MN)* for sharpening instructions or watch the video *An Axe to Grind.*
2. Vehicle Operation	Mechanical failure Flat tires Vehicle fire Exhaust leaks Internal projectiles Carbon monoxide gas Large vehicles Narrow, rough roads Animal/object collision Icy/muddy roads Flying debris Poor visibility backing Run-away vehicle Roadway obstacles Fatigue	Adhere to the vehicle's schedule of preventative maintenance. Use only vehicles appropriate to work needs and the driving conditions expected. Check daily for tire cuts, fluid leaks, flat tires, body damage, windshield cracks, and other damage. Check daily lights, wipers, fluid levels, and seat belts. Ensure the vehicle has a complete and current first aid kit and fire extinguisher, warning signs and/or flares. Ensure the vehicle is equipped with a working mobile radio or carry a handheld radio. Place heavy objects behind a secure safety cage if they must be carried in a passenger compartment. Never carry hazardous materials in the passenger compartment. Carry and use chock blocks, use parking brake, and do not leave vehicle unattended while it is running. Check and maintain the vehicles exhaust system. Carry more fuel than is needed to get to and from destinations. Inform someone of your destination and estimated time of return. Call in if plans change. Carry extra food, water, and clothing. Refer to pages 20–70 thru 20–72 in the H&SC handbook.

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3. Handtools: General use	Bodily injury and fatigue	Always carry tool on the downhill side. Keep proper spacing, 10 feet minimum between coworkers. Do not swing tools toward body. Maintain proper grip on tools. Wear PPE (eye protection, long sleeves, hardhat, gloves, long pants, and good sturdy leather boots). Notify coworkers when you are passing. When working with a tool, position body securely and square to the target. Do not pry with a digging or chopping tool. Refer to tool preparation section of this JHA for more information.
Pulaski	Bodily injury to self and people close-by	Check for overhanging branches when chopping. Keep good control over the tool and be aware of where the sharp ends are. Keep tool sharp and clean. When limbing a fallen tree, always clear the limbs on the opposite side of the tree you are standing on. When using the hoe, stand bent at the waist with your back straight and parallel to the ground. Knees flexed, and one foot slightly forward. Hold the handle with both hands and keep the tool at an angle to the body. Strike the ground with the corner of the hoe. Use the axe end to chop large roots after the dirt has been cleared by the hoe. When carrying the tool, hold it at your side with the axe head pointed down.
Rock Bars	Personal injury, broken fingers, arms, legs, ribs; strained back	Always ensure rock bar is in good working order with no visible cracks. Maintain the factory bevel on the tip with a file or grindstone. Always lay the bar down when not in use, NEVER lean it up against another object. When operating the bar, use both hands. If the bar begins to bend, release the tension. If necessary, use a fulcrum for leverage. If a second bar is needed, ensure there is good communication between the two operators. Do not put your hands under a rock while the rock bar is in use. Do not pry with the bar between your legs. Carry rock bar at your side, tip forward, with a good grip in the center to balance the weight.
Pick	Bodily injury	Use the pointed tip for breaking hard objects and the chisel tip on softer materials. When using a pick, stand comfortably with your feet about shoulder width apart and one foot slightly forward. Grasp the handle with your forward hand near the head; place the other hand near the handle end. Bend over at the waist with your back straight and work the tool with short, deliberate downward strokes. Do not raise the pick over your head.

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Adze Hoe	Broken legs, hands, feet, ankles; strained back	Follow the same guidelines as using the grubber on the pulaski. The adze hoe is a more efficient grubber so use it when there is less of a need for the chopping side of the pulaski. Control the swing by gripping the handle near the end with one hand and near the middle with the other.
Shovel	Broken toes, strained back; bodily Injury	When shifting or scooping materials, bend at your knees and lift with your legs. When shoveling, support your upper body by bracing the forearm closest to your body against your thigh as you pivot the blade sideways. Carry the shovel with the head forward. Grip the handle near the head and hold it away from the body. Keep the edge sharp. Never use shovel as a pry bar.
Log Carrier	Strained back	Lift with your legs. Make sure both hooks on the carrier are secured to the log. Use good communication between all people involved in the operation.
Pick Mattocks	Broken legs, hands, feet, ankles	Use the pointed end like the pointed tip of the pick. The grubbing end is used the same way as the grubber on the pulaski. However, the pick mattocks can be used to remove roots or small stumps. Keep both ends sharp.
Crosscut Saw and Chainsaw	Bodily injury and fatigue, damage to saw	Always size up a log before starting a cut. Reevaluate tree between each cut. Keep body parts away from cutting edge of saw. Communicate between sawyers. Use wedges to prevent saw pinching. Sheath saw when transporting. Keep saw out of dirt and away from rocks. Ensure saw is sharp and free of excessive pitch. Plan escape routes if cutting goes awry. Refer to chain saw and crosscut saw JHAs for more detailed precautions.
Nippers/Lopping Shears	Bodily Injury and fatigue	Be aware of falling limbs. Be careful when nipping overhead.
4. Cleaning Waterbars	Bodily injury	Bend at the knees. Get as comfortable as possible. Use caution with tool. Do not clean waterbars with the side of your foot; it will cause extreme damage to the knee and back.
5. Lifting (i.e. rocks, logs)	Back injury/hernia	Lift with the legs. Hold object close to body. Ask for help if needed. Use mechanical devices when objects are too large or heavy. Don't be afraid to cut the log again to make it easier to move.

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6. Working on Switchbacks	Personal injury, injury to coworkers, injury to the public	If working on switchbacks, be aware when coworkers are directly below or above you. Use flaggers if the trail below is not visible and the object being cut or moved has the potential to take off downhill.
7. Rock Work	Crushed extremities, strained backs, loose footing	Keep your back straight, lift with your legs, and work in unison. Use a mechanical advantage with heavy rocks when available. If rock is too heavy, leave it alone.
8. Radio Communication	Improper use/radio failure/dead areas	Ensure radio is in working order and has an extra set of batteries before leaving on trip. Be fully trained in the proper use of a radio. Know whom to contact at all times. Learn location of repeater stations. Check in with dispatch daily. Know proper channels to use to communicate within the crew. Never drive and talk on the radio at the same time. Become familiar with geographic features (i.e., steep canyons) that might make it hard to transmit out. Take satellite phone if working in areas without radio communications.
9. Backcountry Travel	Late arrival – important messages	Inform dispatch and your supervisor of your intended itinerary. Always radio in any changes. Have dispatch say important messages if they can't contact you, as sometimes you can hear them, but they can't hear you, and vise versa. Always carry extra gear in case the unexpected occurs.
	Dehydration	Drink 2–5 quarts of water per day when the temperature is above 80 degrees. Increase fluids on hotter days or during extremely strenuous activity. Be sure to drink fluids at all meals. Stay away from fluids with a high sugar content, caffeine, or alcohol. Maintain blood sugar and electrolyte balance.
	Contaminated water	Drink water from a municipal source. If none available, use proper filtering techniques. Boil water for 3–5 minutes, treat it with iodine tablets, or use an approved water filtration pump.
	UV exposure	Be sure to apply an adequate sunscreen lotion in the morning. It is good to reapply after lunch. Wear approved sunglasses. Take break in the shade.
	Extreme weather conditions	Be prepared for all types of weather. Carry a raincoat and pants for unexpected showers. A hat, gloves, and warm coat are important for sudden drops in temperature.

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	Hypothermia or hyperthermia	Know the symptoms for both conditions. Know the first aid response to each situation. Refer to the H&SC Handbook page 50–40 and 50–35 respectively.
	Falls and Slips	Avoid walking on logs. Avoid working around blowdowns during wet conditions. Ensure proper footing at all times, especially when using a tool. Do not overreach.
	Fatigue	Know your limits—the crew should work as fast as the slowest person. On hot days, take breaks in the shade. Eat and drink plenty. Use extra care working at the end of the day as this is when fatigue sets in and accidents are more likely.
	Disorientation	Carry a map and know how to use it. Monitor travel on a map and note landmarks along the way. Carry extra survival equipment.
	Contact with ticks, spiders, mosquitoes, bees	Know what a tick is and how to properly remove it from the body. Check for ticks several times a day and after work. Wear light colored clothing, as bright colors attract ticks and bees. If bitten by anything, watch for signs of illness. Report all bites to your supervisor as soon as possible. Avoid wearing perfume-scented things. For all biting animals, it is best to avoid being bitten by wearing long pants (tucked into boots), long sleeve shirts, and a mosquito net in extremely boggy conditions. The use of DEET is approved. Use DEET or other effective repellent when mosquitoes are present. West Nile Virus could spread into our area anytime.
10. LINE OFFICER SIGNATURE	11. TITLE	12. DATE

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JHA Instructions (References-FSH 6709.11 and .12)	Emergency Evacuation Instructions (Reference FSH 6709.11)
The JHA shall identify the location of the work project or activity, the name of employee(s) involved in the process, the date(s) of acknowledgment, and the name of the appropriate line officer approving the JHA. The line officer acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity. Blocks 1, 2, 3, 4, 5, and 6: Self-explanatory. Block 7: Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP). Block 8: Identify all known or suspect hazards associated with each respective task/procedure listed in block 7. For example: a. Research past accidents/incidents. b. Research the Health and Safety Code, FSH 6709.11 or other appropriate literature. c. Discuss the work project/activity with participants. d. Observe the work project/activity. e. A combination of the above. Block 9: Identify appropriate actions to reduce or eliminate the hazards identified in block 8. Abatement measures listed below are in the order of the preferred abatement method: a. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and furniture. b. Substitution. For example, switching to high flash point, non-toxic solvents. c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices. d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills, and portable water pumps). e. A combination of the above. Block 10: The JHA must be reviewed and approved by a line officer. Attach a copy of the JHA as justification for purchase orders when procuring PPE. Blocks 11 and 12: Self-explanatory.	Work supervisors and crew members are responsible for developing and discussing field emergency evacuation procedures (EEP) and alternatives in the event a person(s) becomes seriously ill or injured at the worksite. Be prepared to provide the following information: a. Nature of the accident or injury (avoid using victim's name). b. Type of assistance needed, if any (ground, air, or water evacuation). c. Location of accident or injury, best access route into the worksite (road name/number), identifiable ground/air landmarks. d. Radio frequencies. e. Contact person. f. Local hazards to ground vehicles or aviation. g. Weather conditions (wind speed & direction, visibility, temperature). h. Topography. i. Number of individuals to be transported. j. Estimated weight of individuals for air/water evacuation. The items listed above serve only as guidelines for the development of emergency evacuation procedures. JHA and Emergency Evacuation Procedures Acknowledgment We, the undersigned work leader and crew members, acknowledge participation in the development of this JHA (as applicable) and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents: SIGNATURE DATE SIGNATURE DATE

Notes

About the Author

Kevin G. Meyer is the regional trails specialist for the National Park Service in Anchorage, AK, and a consultant for the National Park Service's Rivers, Trails, and Conservation Assistance Program (RTCA). He earned a bachelor's degree in soil science and natural resources management from the University of Wisconsin-Madison in 1976 and a master's degree in forestry from Colorado State University in 1985. Meyer has worked in the area of surface protection and resource management for the U.S. Department of the Interior in Alaska since 1977. Since 2000, he has focused on responding to the challenges of off-highway vehicle management in Alaska's sensitive environments. He is the author of a 2002 MTDC report: "Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments." He is an active consultant for RTCA throughout Alaska; conducts trails training sessions for Alaska Trails (a Statewide nonprofit organization); and has developed numerous sustainable trails training programs, technical trails publications, and management techniques. Meyer is a nationally recognized expert on trail-hardening methodologies for permafrost and wetlands. In 2008, he received a U.S. Department of the Interior 2008 National Cooperative Conservation Award. In 2009, he was invited to join the instructor pool for the national interagency trails training course, "Trail Management: Plans, Projects and People." In 2010, Meyer participated as an associate trails instructor for California State Parks, William Penn Mott Jr. Training Center.

Library Card

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In this report, Kevin Meyer, regional trails specialist for the National Park Service, shares his years of experience addressing surface protection, resource management, and off-highway vehicle (OHV) issues on Federal, State, and private lands. He describes sustainability concepts, trail fundamentals, and 10 management elements for a systematic, Scientific Approach to OHV management. Eight appendixes cover a range of information.

Keywords: all-terrain vehicles, ATVs, Bureau of Land Management, BLM, four-wheel-drive vehicles, 4WD vehicles, geographic information systems, GIS, global positioning systems, GPS, motorized recreation, National Park Service, NPS, off-road vehicles, OHVs, planning, recreation management, safety at work, sustainability, trail maintenance, U.S. Department of Agriculture Forest Service, U.S. Department of the Interior, U.S. Fish and Wildlife Service, utility-terrain vehicles, UTVs

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Electronic copies of MTDC's documents are available on the Internet at:

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Designing Sustainable Off-Highway Vehicle Trails

An Alaska Trail Manager's Perspective