

Rio Grande Trail Corridor Study Trail Surfacing Report

August 2008



Prepared for
New Mexico State Parks
Energy, Minerals and Natural Resources
Department



Prepared by
Anasazi Trails, Inc.

Table of Contents

Introduction.....	1
Background.....	1
National Center for Accessibility Study	1
Americans with Disabilities Act Accessibility Guidelines	2
Rio Grande Trail Community Survey Summary	4
Ditches with Trails Survey Summary	5
Sustainability	5
Benefits of Trails.....	6
New Mexico Statewide Comprehensive Outdoor Recreation Plan 2004-2009	8
Considerations When Choosing Trail Surfacing Options	9
Trail Surfacing Options.....	10
Concrete	10
Asphalt.....	11
Alternative Surfacing Products.....	12
Industrial Byproducts	13
Natural Plant/Animal Byproducts	13
Native Soils	14
Solid Materials	17
Rubber/Plastic Products.....	17
Trail Cost Estimates	17
Per Mile Trail Construction Costs.....	18
Estimated Costs for Trail Related Amenities.....	18
Cost Estimating Considerations	19
Summary and Recommendations.....	20
Appendix	

Introduction

For years, trail consultants, agency land managers and trail stewards have sought after the perfect trail surface for their sustainable, shared-use trail. This quest has resulted in the realization that there may be no economically feasible, perfect solution in some cases or there may be several suitable options in other cases. The myriad of different soils, topography, hydrology, and vegetation on each trail is often as diverse as the people recreating on it. Reaching the best trail surfacing decision can often be a fairly daunting task because each project is unique.

This report is intended to assist New Mexico State Parks sort through the various choices for the most "economical and sustainable" types of trail surfacing options along the southern section of the proposed Rio Grande Trail (RGT) corridor from Belen to Sunland Park, New Mexico. Some of the information is also applicable for the northern section of the RGT corridor.

It is no surprise that urban trail users seek a different type of trail surface and tread width than a backcountry or rural trail user seeks. This diverse range of trail preferences is further complicated by the fact that trail users may desire different types of trail experiences on different days. While some days you may feel like mountain biking three hours and the next day you may only have a half hour to walk the dog.

Background

National Center on Accessibility Study

The National Center on Accessibility (NCA) is currently conducting a five year study of trail surfacing options. The preliminary, unpublished NCA report discusses some of the initial findings of the study as well as other research and publications on the various types of trail surfaces. The NCA study will attempt to answer many surfacing questions over the next few years such as:

- ✓ Which surfaces are accessible?
- ✓ What are the costs of various trail surface applications?
- ✓ Under what climactic conditions are various surface applications accessible?
- ✓ In what geographic areas and how long are surface applications accessible?
- ✓ What are the routine or annual maintenance considerations?
- ✓ What is the impact of soil characteristics, (moisture, soil composition, etc.)?
- ✓ Do various soil applications interact positively, neutrally, or negatively?
- ✓ What impacts do various slope and cross slope grades have on various surface applications?



More information about the NCA's national trails surface study is available on-line. The NCA website is included in the list of website references provided in the Appendix.

Americans with Disabilities Act Accessibility Guidelines

The Americans with Disabilities Act (ADA) accessibility guidelines also provide excellent information on surfacing requirements and standards and the design of trails for mobility-impaired trail users. Basically, the guidelines state ground and floor surfaces should be "firm, stable, and slip-resistant." The three terms are not well defined and may be interpreted differently by many. Here are some common ways to define these terms:

Firmness - The degree to which the surface resists deformation by indentation when a person walks or wheels across it. A firm surface would not compress significantly under the forces exerted as a person walks or wheels on it.

Stability - The degree to which the surface remains unchanged by external applied force. Simply put, surfaces do not shift laterally under foot or when turning. A stable surface would not be significantly altered by a person walking or maneuvering a wheelchair on it.

Slip Resistance - Based on the frictional force necessary to permit a person to ambulate without slipping. A slip-resistant surface does not allow a shoe heel, wheelchair tires, or a crutch tip to slip when ambulating on the surface.



Soft surfaces such as native soils, especially loose sandy soils common along the Rio Grande river valleys, may be unsuitable for mobility-impaired trail users. In this case, desirable goals for universal access must be balanced with some trail user's perception that wide, concrete and asphalt trails detract from the natural beauty of the area. The drastically rising costs of asphalt and concrete must also be considered and balanced when determining if a trail should be constructed with these products to accommodate mobility-impaired users.

Improved or stabilized trail surfaces that are not hard surface but are firm, slip resistant and stable are ideal for a wide variety of non-motorized trail users including the mobility-impaired. There are numerous alternatives for improved or stabilized trail surface construction materials and products presented in this report. When installed correctly, most of these surfacing alternatives can meet the ADA accessibility guidelines.

Improving surfaces by using soil amendments, or chemical or enzymatic additives, is an available option and works in a variety of environments but not all conditions. While these innovative, high-tech products often address concerns of accessibility, transportation and aesthetics they are usually economically challenging. Many of them require installation by trained professionals to ensure quality results and very specific soil types and conditions to perform correctly.

While budgets are shrinking and visitor use is increasing, even simple routine maintenance of existing, well-designed trails is a major concern and challenges public land management agencies and stewardship/advocacy groups. Soil stabilizing products are not always the most economical and sustainable solution to building or altering your trail.

In October 1995, the San Dimas Technology and Development Center (SDTDC) published an initial report on the subject titled "*Soil Stabilizer for Use on Universally Accessible Trails.*" This report discusses the importance of following good design and construction practices. A properly designed trail is essential and is critical regarding water management and drainage aspects.

Land managers and decision makers must consider whether surfacing or applying soil stabilizing products is actually desirable or even appropriate and, if so, whether it is economically viable. If a trail lies within a critical habitat or an environmentally sensitive location, it may be less costly in the long run to relocate that section of trail to a less sensitive area if possible. Critical or sensitive habitats may include flat areas of wet or organic soils, high clay or sand content, threatened or endangered flora and fauna, and edges of water bodies prone to erosion (e.g. flood plain of a river or along a fluctuating reservoir). Designing and constructing trails in these areas often require extra design and engineering and should be closely evaluated due to their higher costs and potential impacts.

In lieu of good intentions and the use of environmentally-responsible construction materials and techniques, realize that a surfaced trail can alter a user's aesthetic experience and create visitor displacement. As an example, displacement becomes apparent when runners and joggers seek to use the softer adjacent natural surface next to a concrete or asphalt path eventually creating a parallel social trail.

When considering the aesthetics of an area and whether to surface, it is also important to consider the width of the trail corridor. With 10-foot wide concrete trails the area of disturbance often exceeds 20 feet in width. This is due to the large equipment required to construct concrete trails efficiently. This wider trail corridor, regardless of surface type, often feels less intimate with nature than a narrow trail does to most trail visitors.

A smaller corridor and trail tread disturbs less area, minimizing negative impacts to the environment by reducing bare soil and decreasing opportunities for weedy species to become established. Smaller trails also expose less soil to erosion and invasive plants and are less disruptive to sensitive habitat areas.

In high use or urban areas, the ideal solution may consider a 10-foot wide concrete or asphalt trail with 3-foot wide soft shoulders of crusher fines thereby satisfying the needs of a wider variety of users. Often smaller social trails, or non-designated trails, will develop off from the main route and allow access to the river or other areas of interest. These social trails, or trails formed by random trail users, may be created by visitors desiring a quite, slow, more intimate natural trail experience than the hard surface path user.

The next photograph shows three different trail surfaces adjacent but slightly separated from one another within the same trail corridor. A narrow, 24-inch wide, native soil trail for angling and pedestrian water access down along the river, a 48-inch wide surfaced trail for a wider variety of trail use including, mountain bikers, runners and kayakers on foot, and a 10-foot wide concrete trail at the top right for strollers, road bikes and mobility-impaired users.



Results from the RGT Community Survey and the Middle Rio Grande Conservancy District (MRGCD) Ditches with Trails Survey are summarized to provide insight to, and help better understand, New Mexicans' trail surfacing preferences.

Rio Grande Trail Community Survey Summary

The Rio Grande Trail Community Survey was available online in English and Spanish versions via the New Mexico State Parks website and copies were available to the public upon request and provided to participants at four public workshops held in May 2008.

As of the closing date of July 2008, ninety respondents completed surveys. The English version had eighty-nine responses while the Spanish version had one. This low response rate scientifically restricts the validity, reliability and accuracy of the survey. However, the limited response is still valuable in attempting to understand the public's desires and concerns regarding general trail surfacing preferences.

In summarizing survey results related to trail surfacing questions, most users preferred natural or improved surfaces to concrete and asphalt, even though some users preferred the harder surfaces. Results showed that 55% of survey respondents felt concrete and asphalt trails were least desirable. Firm surfaces, like native soil, road base, crusher fines, and stabilized soils were listed as moderately desirable by most users. Natural surface trails with native soils ranked the highest with 51% being the most desirable surface and another 32% ranking them as moderately desirable.

Wider trails, greater than four feet in width, were the preference for 75% of the respondents. Specifically, 28% preferred 4-6 foot wide, 21% preferred 6-8 foot wide and 26% preferring 8-10 foot wide trails. Less than 25% of the participants preferred trails less than four feet in width. These results may also be supported by similar results from the Ditches with Trails Survey that was completed in May of 2007.

Ditches with Trails Survey Summary

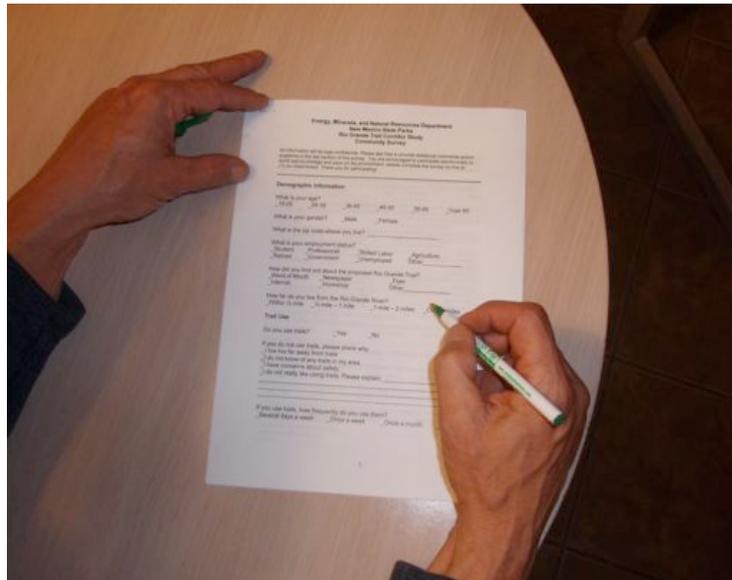
The Ditches with Trails (DWT) Survey was completed in May 2007 for the Middle Rio Grande Conservancy District to help understand how and why people currently use trails along MRGCD ditches, and to understand what improvements would be most, if at all, welcome.

The MRGCD survey encompasses the greater Albuquerque metropolitan area between Bernalillo and Belen, New Mexico and is directly north and adjacent to the RGT corridor study area. The DWT survey enveloped many of the same questions the RGT survey covered. MRGCD's survey had a significantly larger response rate totaling almost 900 completed surveys and may be attributed to the more urban and populous region of the Bernalillo County area. Results from the DWT survey as they relate to trail surfacing are summarized and are very much activity-based.

Bicyclist and horseback riders hold opposite preferences as approximately 80% of bicyclists in the MRGCD survey preferred a paved or stabilized dirt surface and 80% of horseback riders preferred an unimproved or graded dirt surface.

Most walkers and runners/joggers preferred graded or stabilized dirt. Bicyclists and horseback riders did agree about trail length, with most preferring 5 miles or more. Most walkers and runners/joggers were content with 1-5 miles of trails.

A full summary of the Ditches with Trails Survey can be found on-line. The website link is provided in the Appendix. The RGT Community Survey results are presented in the August 2008 Rio Grande Trail Corridor Study Community Survey report.



Sustainability

Sustainability on natural surface trail corridors is defined as the characteristic of a travel surface to support currently planned and future uses with minimal impact to the natural systems of the area. Sustainable trails have negligible soil loss or movement while allowing the naturally occurring plant systems to inhabit the area, recognizing required pruning and eventual removal of certain plants over time. Sustainable trails will not adversely affect the naturally occurring fauna. Sustainable trail design will accommodate existing and future uses while only allowing appropriate uses. The sustainable trail will require little rerouting and minimal maintenance over extended periods of time.

National Park Service – Rocky Mountain Region, January 1991

While sustainable trails are more economical in the long run, economical trails are not always sustainable. Poor trail design that does not follow sustainable principles will inevitably result in erosion problems or sustainability issues on most types of trail surfaces even with proper construction techniques.

The most important design specification for limiting soil erosion is keeping trail grades below 10% or 12%. A design grade of less than 9% is recommended for equestrian trails and a design grade of 6% is recommended for trails constructed in the desert.

In the International Mountain Bicycling Association's popular publication, *Trail Solutions*, IMBA's *Guide to Building Sweet Singletrack*, professionals discuss guidelines for designing and constructing sustainable trails. The following five principles of sustainable trails are briefly described.

Half Rule - A trail's grade should not exceed half the grade of the side slope it traverses. This is especially important in gently sloping flood plains and bosque areas with sideslopes less than 5%. This rule is not applicable to concrete and asphalt trails.



Ten Percent Average Guideline - The lower the overall trail grade of a trail, or a section of trail, the more sustainable the trail will be regardless of soils, vegetation, topography, rainfall, or types of user. Try and keep overall grades at 10% or less except in arid desert soils with high sand content or other highly erosive soils where grades less than 6% will be less prone to erosion.

Maximum Sustainable Grade - Grades of up to 20% may be sustainable for short distances less than 50 linear feet in most soils where the trail encounters relatively low-impact visitors. In desert climates with low soil moisture and high sand content, a good rule of thumb is a maximum sustainable grade of 6% or less. Grades over 6-10% are significantly more prone to user-created erosion.

Grade Reversals - Changes in trail grade that provide gentle dips in trails to encourage drainage. These features can be from 20 feet up to 100 feet in length, and ideally should be integrated into the design and layout of the flag line.

Outslope - The outward tilting or canting of a trail tread to shed water which encourages it to sheet flow across the trail. Trails constructed with outslope will compact normally. However, it is critical to eliminate any soil berm along the trail's downhill edge which will allow water to drain across, and not down it, and help to prevent soil erosion.

Water is the most common cause for erosion problems on trails. Encouraging water to sheet flow off the trail and not concentrate on the trail enhances sustainability and user satisfaction. An important note about trail use is the harder the surface, the faster the speeds typically become for most users. Be sure to properly engineer your design to minimize user speeds especially where line-of-site visibility is limited and at trail junctions.

Benefits of Trails

Trails can be a great component of community tourism, economic development, conservation, and health/fitness strategies. Trails increase opportunities for healthy living and create a sense of community in the areas through which they pass. Long-distance trails often serve locally as

venues for community activities; fundraisers and other special events, while long-distance trail users in need of supplies, lodging and food boost riverside community economies. Trails that connect schools, businesses and parks provide environmentally friendly alternative transportation and offer increased fitness opportunities. Trails that follow waterways can easily provide fishing and boating access as well as a parallel water trail for canoes and kayaks. Finally, trail-based interpretation efforts could reconnect the public to the significance of the river and go hand in hand with the restoration, protection and beautification of the riparian corridor.

Dave Simon of New Mexico State Parks, Rio Grande Trail Concept Paper 2006

Trails provide opportunities for people to participate in outdoor recreation and outdoor adventure pursuits. Trails welcome all people regardless of age, income, ethnic background, or beliefs and provide benefits to a wider population than golf courses, soccer fields, tennis courts, and other so-called “indispensable” public facilities.

Trails along the Rio Grande currently offer access to a vast multitude of trail uses including hiking, birding, skating, biking, equestrian, strolling, all-terrain vehicle (ATV) riding, angling, swimming, hunting, boating, and naturalist who like to contemplate and enjoy nature.

Over 20 years ago the 1987 Presidential Commission on Americans Outdoors, first mentioned trails as a national priority and called for a “*nationwide system of greenways within easy access of all Americans.*”

Following suit in 1988, the National Park Service provided its vision on a national trail system with its report, “*Trails for All Americans.*” It included the following goals:

- ✓ Trail opportunities should exist within 15 minutes of most American’s homes;
- ✓ The system should be made up of a combination of federal, state, local and private trails, with entities working together to make an interconnected system;
- ✓ Planning for trail corridors and networks should be a grassroots effort to ensure there is adequate support for their development, management and long-term protection.



Trails provide fundamental access to open space by allowing users to immerse themselves in the natural flora and fauna of the area and experience the beauty of nature. Without trails, users may not fully experience the natural resources of the area, and often end up creating more impact by trampling vegetation, disturbing sensitive wildlife and ultimately creating a non-sustainable, poorly planned, informal trail system. Trampling and vehicular traffic can also fragment and directly degrade wildlife habitats and the presence of uncontrolled users may disrupt essential wildlife activities such as feeding, sleeping, or reproduction and the raising of young.

Trails allow access to natural areas that provide many unique opportunities for environmental

education. Schools often use trails as dynamic living laboratories. By allowing children to have fun learning about their environment, they may genuinely begin to understand its ecological systems and develop life-long stewardship to minimize their impact upon it.

The relatively non-consumptive, sustainable activity of recreating on trails offers land managers another option to generate revenue without consuming natural resources. Trails can also be very cost effective in comparison to other recreational facilities. They occupy minimal land and may be located in right-of-ways, floodplains, along levees and ditch access roads, utility corridors, irrigation canals, highways, and in areas that cannot be developed. The simplistic nature of trails typically lend themselves to less maintenance, less vandalism, and involve less risk management and potential for lawsuits.

New Mexico Statewide Comprehensive Outdoor Recreation Plan 2004-2009

The 2004 Statewide Comprehensive Outdoor Recreation Plan (SCORP) identifies trails as the #1 recreation priority for the public in New Mexico. The National Survey on Recreation and the Environment, the most comprehensive survey of its kind, also identifies trail/street/road activities as the most popular recreational pursuit nationwide.

Long distance trails across the country are proving increasingly popular and are becoming destinations in and of themselves. Completing a publicly accessible multi-use trail along the Rio Grande would be truly visionary and would give New Mexico one of the longest multi-use trails in the United States.

According to public input, the following SCORP concepts emerged. Among them were a number of high-priority issues that are common throughout New Mexico.

- ✓ Increase multi-use trails and open space;
- ✓ Preserve access to open space and public lands through preservation of open space and purchasing of easements;
- ✓ Reduce user conflicts, competition, and overcrowding through education and development of additional areas/trails/facilities;
- ✓ Improve the quality of the environment to preserve and improve the quality of the user's experience;
- ✓ Create more opportunities for youth to engage in outdoor activities;
- ✓ Foster more collaboration and cooperation between federal, state, tribal, and local government to develop and enhance outdoor recreation and economic development opportunities.

Several prominent statewide suggestions for improving the quality of outdoor recreation emerged from the SCORP community involvement process including:

- ✓ Expansion or development of new multi-use urban trail networks;
- ✓ Address increasing use conflicts of recreational areas and trails;
- ✓ Address problems of user conflicts and environmental degradation caused specifically by off-road vehicles (ORVs);
- ✓ Ensure access to public lands;

- ✓ Increase cooperation and communication among federal, state, tribal, and local jurisdictions responsible for management of outdoor recreation.

Considerations When Choosing Trail Surfacing Options

There are many factors to consider when deciding which trail surface is most suitable. Aside from funding source and initial capital cost considerations, the following items must be addressed before reaching a decision on trail surfacing:

What are the existing soil and environmental conditions in the area?

- characteristics of the native soils
- soil constraints and possible solutions
- hydrologic patterns of the area
- topographic relief

What are the aesthetical considerations?

- curving, undulating shapes in nature
- dealing with the feel of straight, dusty roads (levee/canal roads)
- diversity of views during trail experience

What is the overall management strategy and what will be the long-term operating costs?

- effects of user groups on different surfaces, depths and widths
- maintenance and long-term durability
- law enforcement and park/trail patrol
- vandalism issues (graffiti on hard surfaces, deformation, arson)

What is the anticipated trail use?

- volume of use
- types of use
- seasons of use

What is the availability of surfacing materials?

- cost/benefit analysis for surfacing types
- distance of material source to project site
- methods and equipment required for proper installation
- embodied energy requirements from processing and transportation of materials

Even when a trail surface has a longer life expectancy (e.g. 25+ years for concrete), agencies responsible for long-term management must understand what level of routine maintenance will be required to manage hazards and associated risks and protect their trail investment. Maintenance tasks include sweeping, corridor trimming, hazard removal, mowing, tread work, weed control, and routine safety inspections.

In the case of severe weather events like flash flooding which can cause massive soil erosion, or even the normal freeze/thaw cycle that some areas experience, most agencies would have significant challenges managing these occurrences without additional funding and staff.

Surfacing decisions must factor a variety of aspects including economic, social, and environmental conditions specific to each surface type and balance these with the desired trail characteristics and the site-specific conditions. Visitor desires must be weighed against potential negative impacts to the natural, cultural, and historical resources and consider the economic limitations of the managing agency.

New Mexico is fortunate to have with large deposits of alluvial sediments that are readily accessible along the Rio Grande and its tributaries. There are over a dozen sand and gravel companies within the southern 270 mile stretch from Belen to Sunland Park. Usually they are located within a few miles of the river and rarely further than 30 miles from any potential project site up and down the RGT corridor.



Other consideration when selecting trail surfacing options should include the desired modes of recreational use, topography, and hydrology; single-use verses shared-use; type of trail experience and level of resource protection desired; trail funding/budget; available grants; existing soils and their limitations; and the ability of the agency to manage visitor use.

After assessing these considerations, trail managers may find many surfacing options are immediately excluded from further consideration. For instance, if the capital available for the project is low, more expensive materials such as asphalt, concrete and boardwalks may not be economically feasible. If there is limited budget or human resources available for long-term maintenance, a grant for a hard surface trail may be appropriate in areas of high use and poor soil conditions.

As discussed, there are many factors to consider when deciding whether to surface a trail or not. If evaluation of the factors point toward surfacing a trail, there are various types of surfaces and surfacing products available.

Trail Surfacing Options

Concrete

- ✓ Non-permeable
- ✓ Permeable
- ✓ Pavers

Concrete is a mixture of sand, gravel, and mortar and provides the hardest, fastest, and smoothest surface for recreational activities. It typically has the longest lifespan of any trail

material assuming it was designed and installed correctly. When properly constructed and maintained on a regular basis, concrete can last 25 years or more. The high cost of concrete trails is often the most limiting factor since it is one of the most expensive surfaces to install. Concrete may be used for constructing trails with grades exceeding 15% without significant erosion concerns.

Concrete trails are generally more appropriate for urban settings and areas where there is a high volume of trail use. These trails are appropriate for the widest variety of trail uses, ages and abilities. When placed in an intimate, natural setting, the wider, bright white concrete often detracts from the aesthetic beauty. However, the lighter color of concrete reflects more heat and is cooler than asphalt. Concrete can be tinted to blend in with native soil color but ultimately increases the cost of the material.



Concrete is also produced in the form of blocks, bricks and pavers. When placed on a well-drained base course, pavers can provide space for vegetation to grow through, permeability of surface water, and provide excellent support for trail users. Numerous types of permeable concrete treatments are available and help address concerns associated with non-permeable trail and parking surfaces. These are very costly and may be appropriate for heavily landscaped areas or crosswalks, especially since they rarely conform to ADA accessibility guidelines.

Concrete prices continue to soar due to escalating fuel prices and are rarely guaranteed for more than a few weeks from suppliers. This makes the grant fund budgeting process more challenging than in the past.

Asphalt

- ✓ Permeable
- ✓ Non-Permeable
- ✓ Recycled Asphalt
- ✓ Recycled Glassphalt

Asphalt is composed of a small aggregate held together by either a hot-mix or cold-mix bituminous (coal-based) compound. The resulting trail surface is hard and smooth, also very suitable for a wide range of recreational activities. Asphalt may be used on steeper alignments without significant erosion concerns.

Trail managers should pay close attention to the sub-base preparation that will underlay asphalt trails as the surface is typically thinner than concrete and more susceptible to cracking by



frost heaving and tree roots. Proper drainage is also required since asphalt and concrete channel the surface water, often resulting in erosion concerns.

Numerous types of permeable asphalt are now available and help address some of the concerns associated with non-permeable trail and parking surfaces. Recycled materials are also becoming common in asphalt paving, including Recycled Asphalt Products (RAP), which reuses old recycled asphalt or glassphalt which uses recycled crushed glass as an aggregate substitute.

When installed properly on suitable sub-grade, asphalt products typically have a life span less than half that of a concrete trail, averaging approximately 10 years. As with any surfaced trail, proper installation is imperative. Poorly installed asphalt or concrete trails may not last three years before problems begin to arise. Like concrete, asphalt prices are directly influenced by the rising fuel costs and price quotes from suppliers are rarely guaranteed for more than a few weeks.

Alternative Surfacing Products

As new products evolve and innovative technologies emerge, trail professionals will continue to experiment with a variety of alternative surface types in search of building the perfect trail.

Whether organic or natural by-products from agricultural or industrial processes, alternative surfacing products may be considered viable because a firm, stable and slip-resistant surface can result with proper installation. As with concrete and asphalt, these products require specific installation procedures and ideal site conditions to perform optimally. Many require soil testing and specific soil textures to ensure performance/longevity.

Innovative trail surfaces derived from industrial processes, use recycled materials or by-products to bind native soils with or without imported aggregates. Bottom ash and fly ash by-products from coal-fired power generation have been used in trail construction. Other unique examples include the use of crushed ceramics, crushed oyster or pecan shells, wood chips or shredded wood as a alternative trail surfaces. These surfacing alternatives have had mixed results and may only be considered feasible, economical and appropriate if the source of the material is close to the project site and suitable to the various aspects discussed.

A growing number of products are available as stabilizers for trail surfaces. Many of the most common include:

Soiltac – This is an eco-safe, biodegradable, liquid copolymer used to stabilize and solidify soil or aggregate and is also used for erosion control and dust suppression.

Poly Pavement – This product is a liquid soil solidifier that converts native soils into a durable wear surface.

Natural Pave – Natural Pave XL resin pavement binder emulsion is mixed with aggregate materials to produce compacted pavement surfaces that retain the natural coloration and texture of the constituent aggregate material. Resin pavement mixtures contain no petroleum ingredients and are appropriate for use in sensitive natural environments, including access to beach, estuary and riparian areas.

EMC Squared – EMC Squared is highly effective in improving the stability behavior of a broad spectrum of aggregate and soil materials for service applications in a wide variety of climatic conditions. The product technology is both user-friendly and environmentally affable.

StaLok/Stabilizer – Made from ground seed hulls of the plantago plant native to Arizona. Stabilizer is a nontoxic, non-staining organic soil stabilizer. StaLock is a polymer enhanced

version of the 20-year-old product.

Soil-Sement – Soil-Sement is an environmentally safe, advanced powerful polymer emulsion that produces highly effective dust control, erosion control and soil stabilization.

Roadbond EN-1 – This product contains a strong oxidizer, a powerful solvent and a natural dispersant. The interaction of these components activates the naturally occurring mineral cements in the soil and bonds the soil grains together.

Mountain Grout – Mountain Grout is a soil stabilizer. Sprayed onto or mixed into the sand, Mountain Grout binds with the sand to form a hardened surface within hours.

Dura Road PX-300 – This is a liquid copolymer soil stabilization product which produces an abrasion and water resistant surface made of natural soil.

Lignosite – This is a byproduct of the calcium bisulfite pulping process.

RoadOyl – This product is a resin-modified emulsion that provides treatment for bare earth or unpaved surfaces. Formulated from tree resin, this state-of-the-art emulsion is unique in its high bonding strength and is appropriate for use even in close proximity to wetland areas and other areas of environmental sensitivity.

Klingstone – Klingstone 400 is a moderate viscosity, single component, moisture curing liquid (polymer) designed to stabilize soils for foot traffic and light vehicular traffic.

Permazyme 11X – This product produces all weather roads, increases compaction up to 15% with no extra effort, it is environmentally safe.

Earthzyme – This product is a totally natural bio-degradable product. It improves a soil's physical and chemical properties, which result in significantly less mechanical effort to achieve greater densities. For use in soils less than 20% clay, binds only with clay particles, not silts, sands or gravels.

All of these products come in powder and/or liquid form and are applied topically or are mixed in with the soils or imported aggregate material. More information on each of these products can be found using the website links provided in the Appendix.

Industrial Byproducts

- Fly ash is a byproduct obtained from the stacks of coal-burning power plants.
- Bottom ash is the coarse, granular, incombustible by-product collected from the bottom of furnaces that burn coal for the generation of steam, the production of electric power, or both.

Natural Plant/Animal Byproducts

- Crushed Pecan Shells
- Shredded Wood
- Engineered Wood Chips
- Crushed Oyster Shells

Native Soils

Trails constructed in native soils are most often the least costly to build, especially in areas with undulating topography, loamy soils, and good drainage. However, these ideal conditions are not always the norm along the RGT corridor. Soil types vary from those with higher clay content to almost pure sand; sandy soils being most typical. Soil survey maps can generally aid in determining the soil types in your area can be obtained from the USDA's Natural Resource Conservation Service (NRCS). The NRCS website link is provided in the Appendix.

High clay content soils typically cause trails to be slick and muddy when wet. Water often puddles and when horse hoof pock marks or a linear bike tire rut dry out, they are very difficult to smooth out. Clay based soils take significantly longer to dry out since their extra fine particles have a high rate of cohesion and refuse to give up water easily.

Bentonite, a naturally occurring clay, has also been used as a soil additive in other areas of the United States for successfully amending soils with high sand content to achieve a firmer surface. Like other additives, it requires costly preparation, transportation, and installation unless the material is readily available on or near the construction site.

Soils with high sand content are usually course and drain very well, but rarely do they provide a firm, stable and slip resistant surface. Deep loose sands are not uncommon along the Rio Grande and are typically the least preferred surface for most users; some equestrians and ATVs being the exceptions. Hikers and mountain bikers typically do not seek out deep loose soils because of the significant difficulty required to efficiently travel over them.

Crushed Aggregates

Crushed aggregate is simply crushed rocks and boulders. The raw materials originate from glacial till and alluvial sediments from the eroding Rocky Mountains to the west and north. This random mixture of crushed rocks and aggregate becomes valuable and useful once it is separated into distinct sizes and materials of sand, gravel and rock using screens of various dimensions. In many places along the Rio Grande flood plain these alluvial deposits are several miles deep providing an almost infinite source of material for surfacing trails with crusher fines.

The rock dust screenings or fines are usually the smallest particles that fall out of the crushing bin. The larger rocks keep moving further and are separated depending on operator's goals and range in size from 1/4 inch and larger. Typically, those materials with the suffix of "minus" contain the smaller particles rendered from the crushing process and are referred to as "crusher fines". Other aggregates are simply crushed stone with minimal to no fines (i.e. gravel), separated into different sizes for different uses and range from 1/4 inch to 1-1/2 inch and up.



Surfacing sections of unsuitable soils with 4-6 inches of compacted crusher fines over a landscape fabric and/or a compacted base course material can eliminate many of the problems inherent with unsuitable native soils.

It must be noted that even with a firm, stable surface when dry, trails constructed of crusher fines

A good indication of the strength of a rock binder is the hardness of the parent material. The harder the source rock, the stronger the binders will be. Crushed fines contain the original rock cements and binders within the rock dust. These binders combined with water and subsequently compacted with a vibratory roller or plate compactor should produce a solid surface that resists significant deformation from horse hooves, hiking boots and mountain bike tires. On a well compacted crusher fines trail it is not uncommon to find baby strollers and road bikers.

A sieve analysis using 3/8 inch minus crusher fines typically describes the material with the following specifications:

- 100% of the material passing through a 3/8 inch sieve
- 65% of the material passing through a 1/4 inch sieve
- 50% of the material passing through a 3/16 inch sieve
- 35% of the material passing through a 1/8 inch sieve
- 25% of the material passing through a 1/16 inch sieve

If the surface of a crusher fines trail becomes loose and uncompacted over time it can often be wetted, reshaped and recompact provided the fines have not sifted to the bottom and the larger particles floated to the top. Poor compaction can be the result of a variety of influences that include improper wetting and compacting during installation, lack of particle angularity, trail grades greater than 6%, and/or inadequate amounts of natural soil cements or lack of fines in the parent material that act as binders. Some “refreshing” of trail surfacing material is required on a routine basis. Trail tread grades over 6% will require significantly more maintenance since they tend to unravel or erode faster.

Ultimately, simple dish testing of the available materials and comparing them to one another will likely give you the best results. Don't forget that the majority of your aggregate costs will be in the transportation of the material and not the material itself. It is prudent to consider paying higher costs in transportation if no suitable material can be located close to your project site. The worst situation is to use inadequate material that will never compact and unravels with minimal use.

In summary, the best crusher fines or aggregate material for trails construction exhibit three critical characteristics.

- ✓ The rock source is crushed into irregular angular particles that interlock and bind into a firm matrix.
- ✓ The material has particles ranging from dust to a specified maximum particle size in order to mechanically bind the matrix.
- ✓ The material must retain all of its original binders in order to be re-compacted to a firm surface after shaping, wetting and vibratory compaction.



Solid Materials

Solid materials used for trail treads include natural wood (e.g. planks, decking), artificial or plastic "wood," rubber mats, rock including riprap, flag stone, brick or concrete pavers or slabs, or porous pavement panels. Most of these materials are best suited for highly developed, heavily used trails in urban settings. However, lumber and rock can be used in a wide variety of urban and rural trail environments where the natural soil does not make a suitable tread.

There are a number of innovative, yet costly options to natural wood and rock. However, some will last significantly longer and may be easier to install than traditional materials.

Rubber/Plastic Products

EcoTrack – EcoTrack system provides years of high performance no-hassle outdoor use for typically for track sports with uniform thickness that comes in a variety of colors. High pressure construction allows for extreme longevity with a proven history in areas where freezing and thawing cycles are common.

Super Deck – Super Deck modular walk and deck panels are made of polyethylene with ultraviolet light inhibitors. The panels are connected using stainless steel hardware.

Gravel Pave 2 – Gravel Pave 2 porous paving allows you to park, drive, walk, or ride on. Gravel Pave2 is a structure to provide heavy load bearing support and true containment of gravel to create a porous surface with unlimited traffic volume and/or duration time for parking.

Geoweb – Geoweb's cellular confinement system has been widely used for trail stabilization, earth retention, slope protection, and stream channel protection.

Geoblock – Geoblock System is a series of interlocking, high-strength blocks made from recycled plastic materials. The system is designed to handle the most demanding turf protection and load support requirements.

Nike Grind – Nike Grind is part of Nike's Reuse-A-Shoe program for collecting post-consumer, nonmetal-containing athletic shoes of any brand, and recycling them into tracks, trails and courts.

Safety Deck II – Safety Deck II Mats can be installed to create safer, natural playground, and recreational and trail surfaces - an excellent application for pedestrian and vehicular traffic.

Trail Cost Estimates

The costs for trails and trail-related amenities are provided for the purpose of budgetary estimating and have been generated using a range of 2008 prices. When possible, cost estimates should always be supported with the most current prices from local contractors and vendors.

The presented costs range in price and have been generated from variety of government agency trail budgets and trail grant application sources encountered on the Internet. They have also been verified against actual costs from past trail projects completed over a 15 year period throughout the United States. New Mexico State Parks, Sante Fe County Open Space and Trails, City of Santa Fe Public Works Department, and the City of Albuquerque Open Space all contributed local pricing information.

Prices include all materials, labor, equipment and supplies for installation, which is common practice in the trail construction industry. The estimates do not include costs for design and engineering, administrative, contingency, land easements/land acquisitions purchases,

landscaping, unusual erosion control measures, regulatory-driven environmental assessments, natural/cultural/historical resource inventories, or any other scientific research, clearances or permitting requirements.

Per Mile Trail Construction Costs

<u>Materials</u>	<u>Price Range</u>
Concrete (10' wide)	\$264,000 – \$900,000/mile
Concrete (8' wide)	\$150,000 – \$500,000/mile
Asphalt (8-10' wide)	\$211,000 – \$591,000/mile
Asphalt (6' wide)	\$150,000 – \$300,000/mile
Stabilized Soils (5' wide, 6 products)	\$162,000 – \$191,000/mile
Crushers Fines (3/8" minus) (4-5' wide)	\$40,000 – \$60,000/mile
(2-3' wide)	\$30,000 – \$50,000/mile
Natural Surface (2-4' wide)	\$10,000 – \$30,000/mile

Estimated Costs for Trail Related Amenities

<u>Items</u>	<u>Price Range</u>
Trailheads (includes parking area, surfacing, fencing and signage)	
Community (10 cars)	\$7,500 – \$15,000
Regional (30 cars)	\$30,000 – \$60,000
Equestrian (Trailer compatible)	\$50,000 – \$90,000
Bulletin Boards/Kiosks	\$2,000 – \$7,500
Vandal Resistant Signage	\$300/sign (\$5,000/mile)
Boardwalks	\$100 – \$200/square foot
Bridges	\$50 – \$165/ square foot
Culverts	\$20 – \$80/linear foot
Low Water Crossings	\$20 – \$40/square foot
Pedestrian/Bike/Horse Gates	\$250 – \$800
Motor Vehicle Pipe Gate	\$500 – \$1250
Picnic Sites (tables, grills, etc.)	\$1,500/site and up
Benches	\$300/bench and up
Drinking Fountains	\$1,000 – \$4,000/unit
Campsites	
Primitive	\$1,500 – \$4,000/site
Electricity/Dump	\$10,000 – \$15,000/site
Pavilions/Shelters	\$10,000/site and up
Restrooms	\$10,000/unit and up

Bike Parks (Pump track/jump park/skills area)	\$25,000 – \$1,000,000/site
Fish/Waterfowl Cleaning Stations	\$1,500/site and up

Even with the added cost, you should seriously consider planning your amenities to be as vandal resistant as possible. As an example, consider using a thin (1 millimeter), flexible, transparent polyester over-laminate on metal signs that provides graffiti-resistance and protection from damaging UV rays and abrasion and it's easy to clean.

Cost Estimating Considerations

Estimating the costs of a trail project is perhaps the most challenging part of the planning process. As trail construction costs continue to escalate due to rapidly rising fuel costs, it is like trying to hit a moving target when preparing your budget. Plan ahead by including some contingency or apply an escalation factor like a projected cost of living increase for each year between the time you prepare your cost estimate and your projected construction date. Be prepared to deal with the ongoing challenges like, changes in scope of work, schedule delays due to inclement weather and potential shortages or lack of key materials.

Several budget templates and grant application forms are available online. These documents will help estimate costs for different types of trails and amenities throughout the United States. The National Park Service and the U.S. Forest Service also have cost estimating handbooks for engineers and other employees. Local trail contractors are often the best source to assist with determining project logistics that will affect your trail construction cost estimate. Some of the budgetary considerations include trail surfacing options and costs, duration of trail construction (time is money) and types/sizes of equipment to efficiently execute the project.

Using local trail building expertise will help ensure current cost analysis and engineering estimates generated for trail projects have identified all the variables such as excavation, sub-base preparation, drainage, appropriate materials for the job, transportation costs, material placement, wetting, compaction, and finish work.

The overall cost of constructing a concrete, asphalt or alternative surfaced trail depends largely on whether it is built on an existing subgrade (e.g. canal or levee road) or pioneered through virgin terrain. For example, trail construction along a canal or levee road usually requires little to no engineering and significantly less site preparation work because a suitable sub-base often already exists. When new surfaced trail is built through virgin terrain or where a dirt footpath is being upgraded, the trail route must be cleared of vegetation, properly excavated and an adequate sub-base provided prior to application of trail surfacing material.

Other ways that overall costs may fluctuate are required thickness of sub-base and surfacing materials, surface width, geotextile material (if required), motorized vehicle use requirements, access/driveways, signage/signals, revegetation/landscaping, and other amenities related to the proposed trail.

More frequent now than in the past, is an actual loss of grant funding due to escalating project costs over the 1-3 year long project application and implementation process. Meaning the cost of the project increased beyond the grant funds awarded and the project could not be implemented and the funding had to be returned. Consider erring on the side of "expensive budgeting" to offset this ongoing evolution of higher fuel and transportation costs.

Summary and Recommendations

In summary, the following recommendations suggest ways for trail managers to enhance the enjoyment and sustainability of their projects while minimizing any negative impacts to the environment.

The more information a trail manager collects on different options for trail surface types, and the advantages and disadvantages of each, the more likely they will be successful in reaching their trail project goals. Sound knowledge of sustainable trail design and construction principles is mandatory in providing an enjoyable, durable, and environmentally appropriate trail experience. Trail managers should consider the full spectrum of surfacing materials that are fiscally prudent and available in the local area to manage their visitor use and impacts. Remember, aside from concrete and asphalt, no surfacing material is sustainable on poorly designed sections of trail with grades over 10% or sections not designed following the five principles of sustainability.

The majority of trail surfacing research has shown that there are benefits and drawbacks to each type of surface for different recreational, environmental and organizational settings. However, one surface that deserves serious consideration, especially along the Rio Grande, is locally imported road base or crusher fines material. When constructed properly, these trail surfaces provide an excellent tread which can be fully accessible, long-lasting, low impact and relatively inexpensive to construct given close access to suitable materials along the 270 mile RGT corridor study area. This means your project is rarely more than an hour from the aggregate source. The lower embodied energy of crusher fines and road base as compared to concrete, asphalt or soil additives also helps minimize our carbon footprint. By using local sand and gravel companies, money used to purchase these materials is infused into the local economy. No need to buy material from other locations across the country. Simply put, the closer materials are to the site, the less costly the trail project.

Except for extremely high-use areas or for ADA accessibility purposes, trail managers should consider minimizing the use of asphalt and concrete in rural, backcountry, or more natural settings due to its high cost and low acceptability among the majority of trail users. In the past year alone, concrete costs have doubled making cost estimating very challenging particularly for those agencies responsible for implementing multi-year trail grant projects.

Ideally, trail managers should increase the sharing of trail surfacing successes and failures amongst agencies and organizations. Increased communication between trail managers, through organizations such as the NCA can offer an opportunity for increased dialogue, ultimately resulting in less failure and more success stories. Trail-related surveys like the RGT and DWT surveys may also help to understand the complexities of visitor use and their preferred trail surfaces.

We must also acknowledge the various perceptions between different users, different people, and our own subjective opinions. When determining what is suitable and appropriate for trail surfacing in your project area, remember to save time by only evaluating those that are economically feasible, logical, and sustainable.

APPENDIX

References

Books, Articles, and Other Publications

- Aust, M., Kyle, K., and Marion, J. 2005. Research for the Development of Best Management Practices to Minimize Horse Trail Impacts on the Hoosier National Forest. Virginia Tech, Department of Forestry. 74 pages.
- Beneficial Designs, Inc., July 1999. Designing Sidewalks and Trails for Access, Part I of II: Review of Existing Guidelines and Practices. 169 pages.
- Callander Associates Landscape Architecture, Inc. 2007. Trail Program: Use of Recycled Pavements. City of San José Departments of Environmental Services, Parks, Recreation, Neighborhood Services, and Public Works. 42 pages.
- Flink, C., Olka, K., and Searns, R. 2001. Trails for the 21st Century, Planning, Design, and Management for Multi-Use Trails. Rails to Trails Conservancy. 212 pages.
- Giles, A. 2000. Exploring the Social, Environmental and Economic Aspects of Trail Surfacing Decisions. Masters Thesis, University of Waterloo. 74 pages.
- International Mountain Bicycling Association. 2007. Managing Mountain Biking, IMBA's Guide to Providing Great Riding. International Mountain Bicycling Association. 256 pages.
- International Mountain Bicycling Association. 2004. Trail Solutions, IMBA's Guide to Building Sweet Singletrack. International Mountain Bicycling Association. 272 pages.
- Parker, T. 2004. Natural Surface Trails By Design. Cimarron Design, 78 pages.
- Parker, T. 1994. Trails Design and Management Handbook. Pitkin County Open Space and Trails Program. Cimarron Design, 200 pages.
- President's Commission on Americans Outdoors. 1987. The Report of the President's Commission on Americans Outdoors. 10 pages.
- Siqueros, B. Personal conversation. 2008. Sante Fe Open Space and Trails. Discussion of 2007 trail project budgets and cost analysis.
- State of Minnesota, Department of Natural Resources, 2007. Trail Planning, Design, and Development Guidelines. Trails & Waterways Division. 306 pages.
- United States Department of Agriculture, 2000. Soil Stabilizers On Universally Accessible Trails. United States Forest Service, San Dimas Technology and Development Center. 82 pages.
- United States Department of Agriculture, 2001. Wetland Trail Design and Construction. United States Forest Service, Missoula Technology and Development Center. 82 pages.
- United States Department of the Interior, 1992. Mountain Trails Management: An Outline. United States National Park Service, Rocky Mountain Region. 50 pages.
- United States Department of the Interior, 1990. Trails for All Americans: The report of the National Trails Agenda Project. U.S. National Park Service. 20 pages.
- Wang, G. et al. 2004. Cost Analysis of the Built Environment: The Case of Bike and Pedestrian Trails in Lincoln, NE. American Journal of Public Health. Vol. 94 #4

General Website Links

ADA Accessibility Guidelines Home Page

<http://www.access-board.gov/adaag/about/index.htm>

American Trails – Trail Resources Articles

<http://www.americantrails.org/resources/trailbuilding/ArtCrushedStone.html>

<http://www.americantrails.org/resources/accessible/stabilizerstudy.html>

<http://www.americantrails.org/resources/planning/BooneBidding.html>

Columbia Tribune – Trail Cost: Concrete Verses Gravel Article

http://blogs.columbiatribune.com/government/2008/06/what_it_costs_to_lay_a_trail.html

Construction Materials Recycling Association

<http://www.concreterecycling.org/links.html>

Ditches with Trails Project – Report and Survey Articles

<http://www.ditcheswithtrails.org/documents/DWTFINAL.pdf>

http://ditcheswithtrails.org/documents/MRGCD_survey_report.pdf

2008 Grant Cost Estimate for Silver Bow Creek Greenway, MT

<http://www.doj.mt.gov/lands/naturalresource/resources/proposals/2008/SilverBowCreekGreenway.pdf>

New Mexico State Parks - Rio Grande Trail

<http://www.emnrd.state.nm.us/prd/riograndeconcept.htm>

Federal Highways Administration – Various Articles

<http://www.fhwa.dot.gov/pavement/recycling/index.cfm>

<http://www.fhwa.dot.gov/environment/fspubs/00231202/page02.htm>

<http://www.fhwa.dot.gov/environment/fspubs/00231202/lc00231202.htm>

US Forest Service – Accessibility Guidebook for Outdoor Recreation and Trails

<http://www.fs.fed.us/recreation/programs/accessibility/htmlpubs/htm06232801/page09.htm>

National Center on Accessibility – Article: Trail Surfaces: What Do I Need to Know?

<http://www.ncaonline.org/index.php?q=node/332>

California State Park – Article: How Much Will That Trail Cost?

http://www.parks.ca.gov/pages/1324/files/how_much_will_that_trail_cost_fri2007.pdf

Northwest Regional Planning Committee – Ped & Pedal Trail Cost Analysis (Appendix B)

<http://www.nirpc.org/OldNirpc/pdf/PPApenB.pdf>

Orlando Sentinel – Article: Blazing a Costly Trail

http://www.orlandosentinel.com/news/orl-trails2706feb27_0,2424649.story

Natural Resource Conservation Service

<http://websoilsurvey.nrcs.usda.gov/app/>

Surfacing Additive Products

Soil Tac – <http://www.soiltac.com/>

Poly Pavement – <http://www.polypavement.com/>

Natural Pave – <http://www.sspco.com/>

EMC Squared – <http://www.sspco.com/>

StaLok Stabilizer – <http://www.stabilizersolutions.com/>

Soil-Sement – <http://www.midwestind.com/soilsementbrochure.htm>

Roadbond EN-1 – <http://www.roadbond-en1.com/aboutRoadbonden.htm>

Mountain Grout – <http://www.mountaingrout.com/>

Dura Road PX-300 – <http://www.duraroadcr.com/>

Lignosite – <http://www.hillbrothers.com/msds/pdf/n/lignosite-458-dry.pdf>

RoadOyl – <http://www.midwestind.com/roadoyl.htm>

Klingstone – <http://www.klingstone.com/>

Permazyme 11X – <http://www.pacificenzymes.com/>

Earthzyme – <http://www.cypherltd.com/9630.html>

Rubber/Plastic Trail Surfacing Products

EcoTrack – <http://www.hornerflooring.com/systems/ecotrack.pdf>

Super Deck – <http://www.superdecksystems.com/trailways.html>

GravelPave 2 – <http://www.invisiblestructures.com/GV2/gravelpave.htm>

Geoweb – <http://www.sspco.com/>

Geoblock – <http://www.sspco.com/>

Nike Grind – http://en.wikipedia.org/wiki/Nike_Grind

Safety Deck II – <http://matfactoryinc.com/>