CHAPTER 3

Trail Design and Construction Standards

The purpose of this section is to outline general construction standards for recreational trail building. Standards are basic guidelines that illustrate typical trail dimensions and construction practices. They are intended to be used as suggested practices for constructing a trail system and may not apply to every situation. The site conditions for a proposed trail route will be variable along every segment of the NBST, so these standards will provide ideas on how best to proceed with construction.

Trail Construction Standards

Trail construction standards for the NBST are defined for both urban and rural trail cross-sections that are designed for use by pedestrians, bicyclists, and equestrians. The urban cross-section (Figure 4) can be constructed in the more densely populated urban regions of the trail, with the rural cross-section (Figure 5) applied in the more remote, rural areas. Some of the NBST alternative alignments follow existing motorized four-wheel drive roads. The NBST is a nonmotorized trail and can be constructed adjacent to a motorized corridor as illustrated in Figure 6. Table 4 outlines trail construction standards for the urban and rural cross-sections. Appendix H shows several sample trail bridge designs.

Accessibility

An important part of trail design is designing for accessibility that will allow everyone to enjoy a trail experience. Communities planning and constructing the NBST have an opportunity to develop segments of the trail that are accessible. Accessible segments could be located anywhere along the trail, but locating them in more urban areas that are using the urban trail cross-section standards would best serve most users. Much of the following guidance on how to make the NBST accessible comes from the *Americans with Disabilities Act Accessibility Guidelines* (1991) and *Designing Sidewalks and Trails for Access* (1999). For more specific information about accessibility, reference those materials.

Accessible trails should be free of debris and avoid motorized roadway crossings. Crushed rock or a road-base material with a high clay content that has been rolled and compacted may be used for wheelchair access. Trail grades should be generally flat (5 percent maximum grades for short distances) and regular rest stops provided. The cross-slope should not be greater than 2 to 6 percent. Bridges should have handrails, and their decks must be flush with the trail surface. Position decking boards perpendicular to the trail path with gaps between boards not exceeding .375 inch. Visually impaired persons can use natural trail treads with guide ropes or definite edges such as logs or railroad ties.

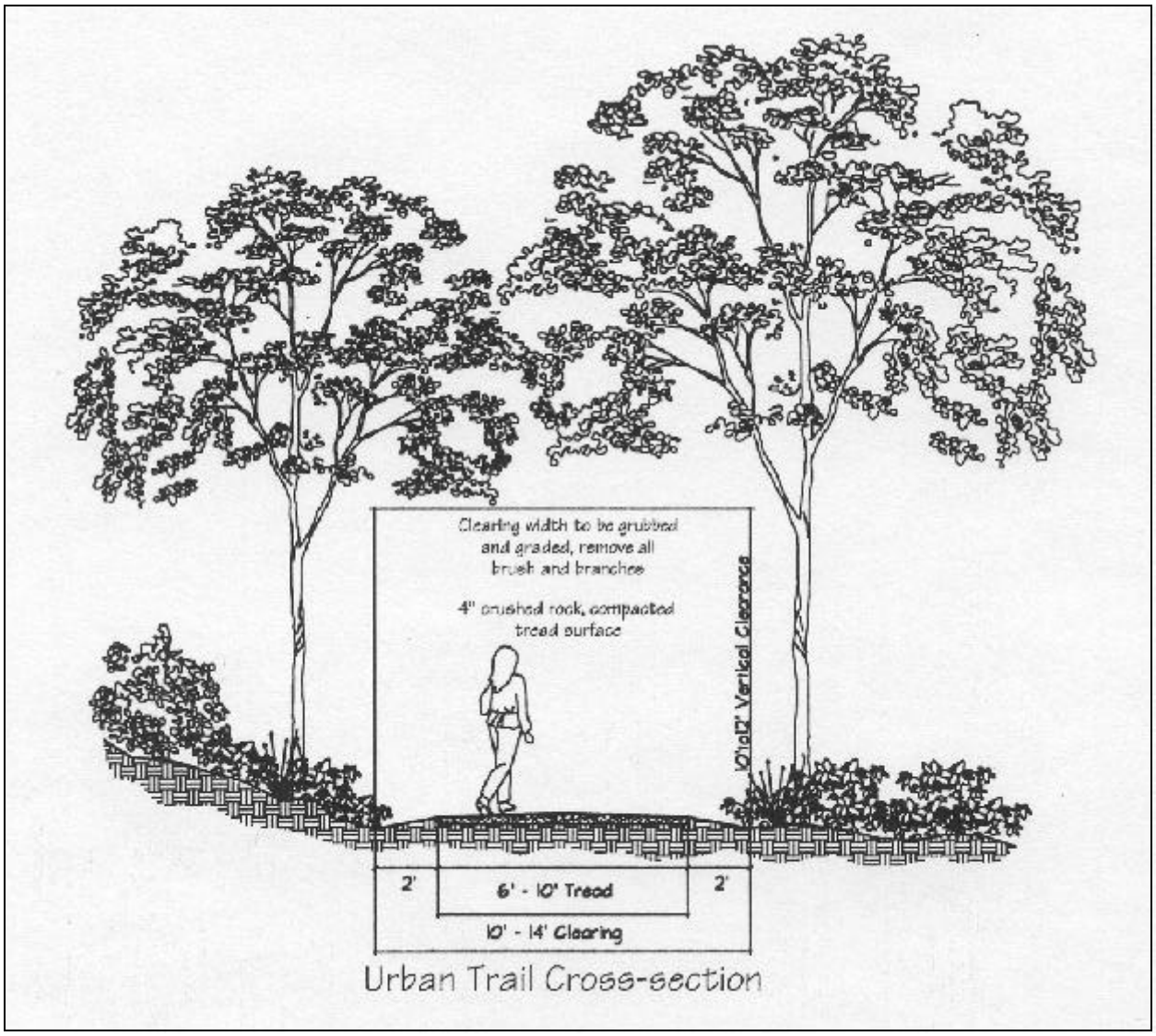

Figure 4. **Urban cross-section trail construction standards.**

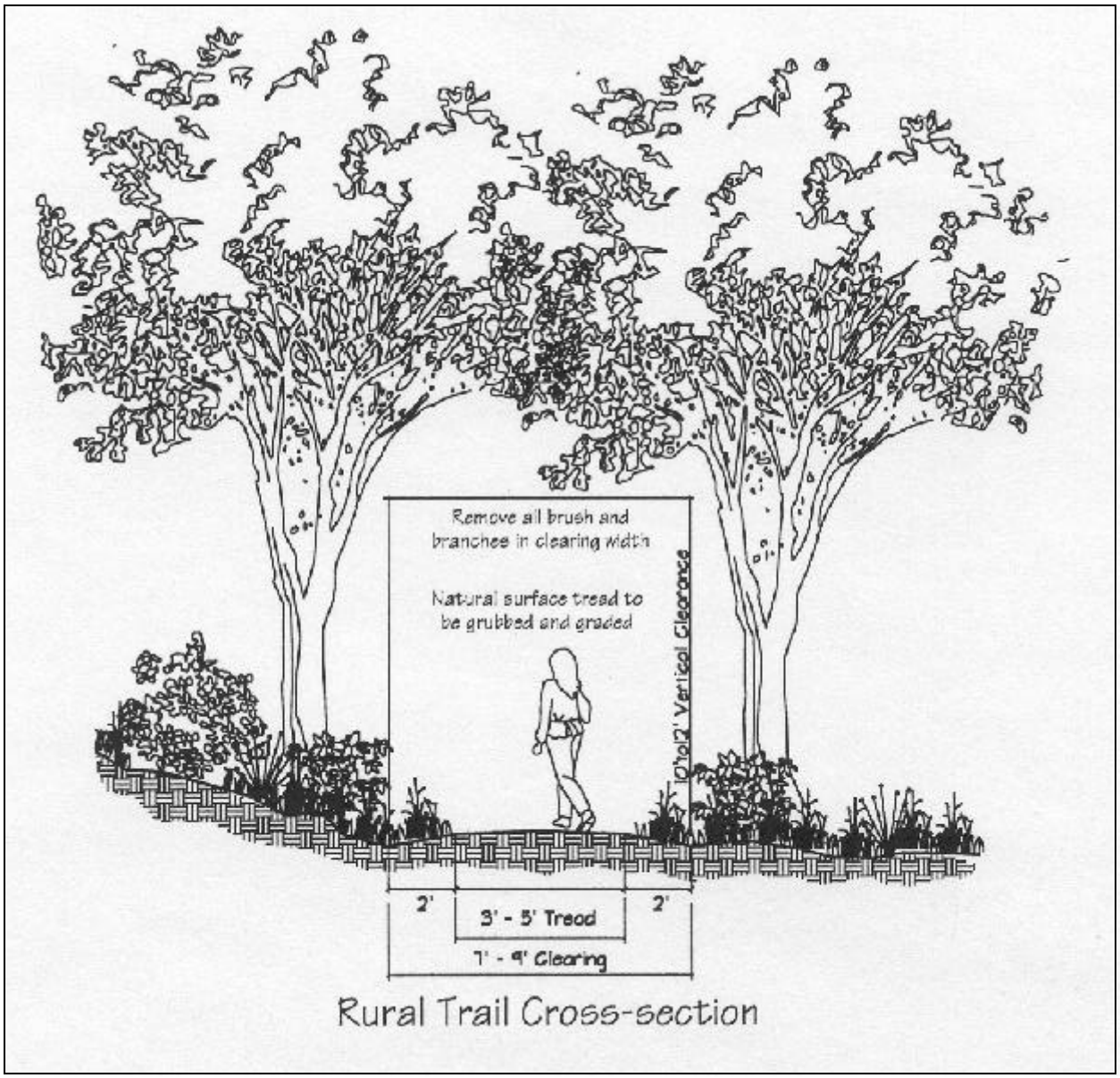

Figure 5. **Rural cross-section trail construction standards.**

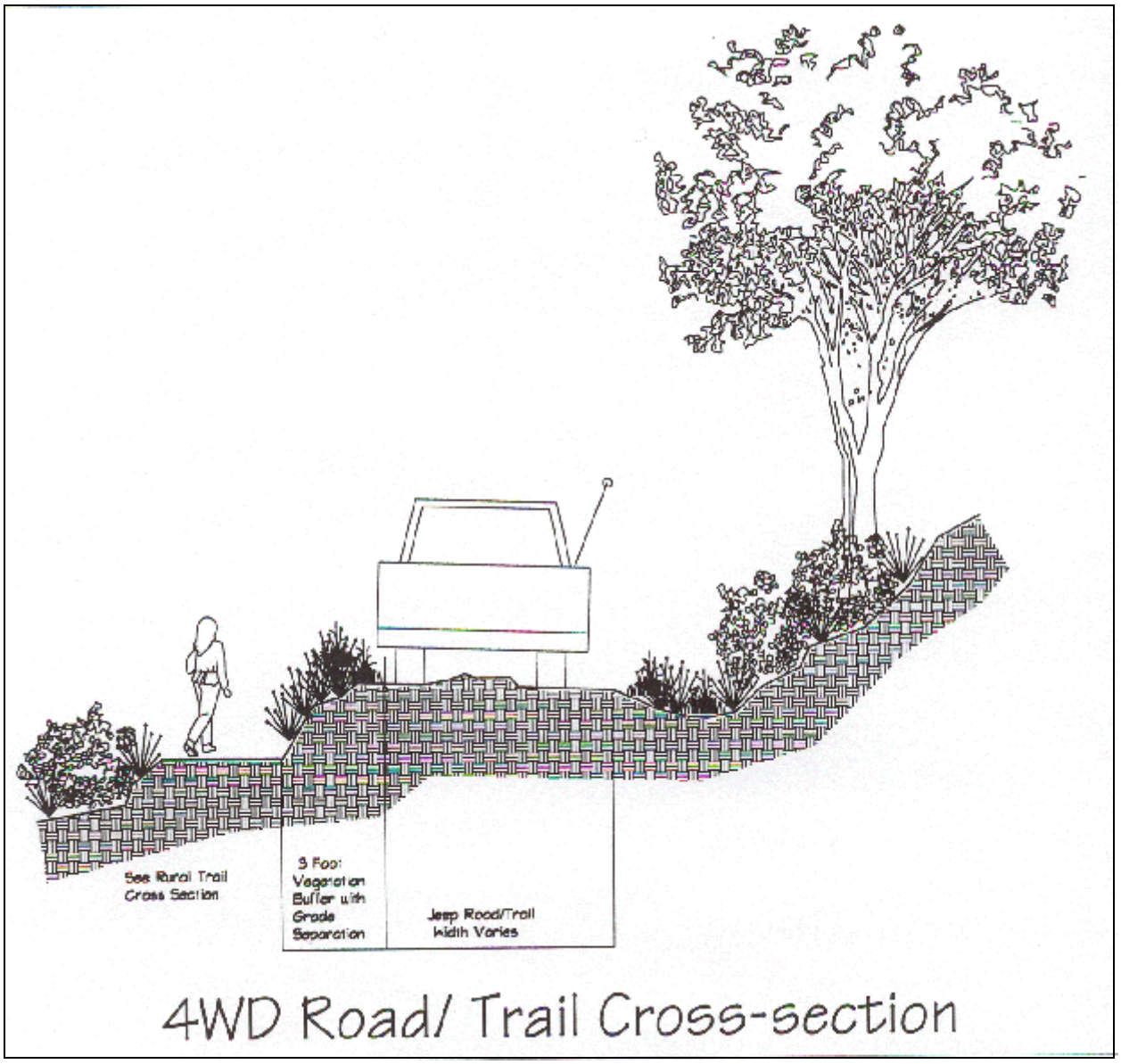

Figure 6. Cross-section of nonmotorized trail adjacent to road.

Table 4. Trail construction standards for urban and rural trail cross-sections.

DESIGN ELEMENT	URBAN TRAIL CROSS-SECTION	RURAL TRAIL CROSS-SECTION
Clearing Width	10 - 14 feet	7 - 9 feet
Tread Width	6 - 10 feet	3 - 5 feet
Tread Surface	4-inch crushed rock base that has been compacted	Natural / native soil
Firebreak (optional)	10 feet of fire resistant native vegetation on each side of trail. Total corridor width should equal 30 feet. (See Appendix F for plant list).	N/A[a]
DESIGN ELEMENT	**URBAN AND RURAL CROSS-SECTIONS**	
Percent Grade	Grades should not exceed 10 percent because they become difficult for trail users to sustain and lead to trail erosion problems. **Desired Grade**: 0 to 5 percent **Maximum Grade**: 5-10 percent (sustained), 15 percent (shorter than 50 yards) **Outslope Grade**: 4 percent (maximum)	
Clearing Height	10 - 12 feet to allow for horseback riding. Additional clearance may be needed to compensate for branches drooping with heavy rain or snow.	
Trail Layout	Wet areas and steep slopes pose extreme difficulties to trail maintenance and should be avoided. Keep water and motorized road crossings to a minimum. Frequently occurring curves and grade changes will add interest.	
Turning Radius	Wide, gentle curves with good forward sight distances are critical for safety, aesthetically pleasing, and easier to maintain. Avoid sharp-angled turns, turns on steep slopes, or turns at the base of a hill.	
Sight Distance	Forward sight distances of 100 feet (50 feet minimum) are important because the trail will be shared between hikers, equestrians, and bicyclists. Although curves should be carefully designed to maintain good sight distances, turns and bends tend to help reduce travel speeds and add variety to the trail experience.	
Road Crossings	Motorized road crossings must be carefully located, designed, and signed 100 to 200 feet in advance to insure that trail users and vehicle drivers have good sight distances in all directions.	

DESIGN ELEMENT	URBAN AND RURAL CROSS-SECTIONS
Water Crossings	Some water crossings along the NBST may require bridges. See Appendix H for a standard bridge design. Bridges should be used in areas of perennial and intermittent stream crossings; however, slow-moving water less than 24 inches deep may be forded. Bridge design should meet the following requirements: ❖ meet the needs and weight of horse travel; ❖ orient planking at a 45- to 90-degree angle to the direction of travel, gaps between planking oriented in the direction of travel may trap bicycle tires and endanger trail users; ❖ make approaches straight, level, and when possible, at least 100 feet long; ❖ must be located above ordinary high water mark; ❖ have railings or log barriers on both sides (see Appendix H); ❖ have an 8-foot minimum width for horses; and ❖ weight capacity varies depending on maintenance equipment and length of bridge
Other Facilities	Parking area with space for trailers, picnic area, resting areas, overlooks, campsites, water, information board, signs, hitching post or tether line, campsite with corral, sanitation facilities, and restrooms.
Signage	❖ Helps with orientation ❖ Helps with safety issues such as road crossings ❖ Shows etiquette for all users ❖ Gives mileage

[a] NA=Not applicable.

Place an accessible trail information sign that describes the length and difficulty of the trail, location of rest stops, and potential trail hazards at the trail entrance. Design rest rooms, parking lots, and ramps carefully to ensure access.

Trail Construction Techniques

After a particular trail segment for the NBST has been planned, located, and negotiated, actual construction of the trail is the next step. This can be accomplished in a variety of ways including: (1) hiring a professional contractor that specializes in trail construction, (2) hiring the Utah Conservation Corps Americorps trail construction crew, (3) bringing together a group of trail construction volunteers, or (4) integrating all of the above options. The following sections describe the general guidelines for trail construction and maintenance, and general trail construction costs.

Guidelines for Sustainable and Aesthetic Trail Construction

A sustainable trail surface can be created with minimal disturbance and maximum variety and interest if the following goals are met:

- ❖ Minimize soil disturbance in order to allow plants and animals the best chance for survival; aesthetic appeal will be correspondingly high.
- ❖ Eliminate the potential for erosion.
- ❖ Use arboriculturally correct and aesthetic pruning or removal of tree limbs and shrubs.
- ❖ Minimize drainage problems by removing water at the first opportunity.
- ❖ Do not allow water to stand on trail.
- ❖ Maintain existing drainage patterns; do not force nature.
- ❖ Outslope the trail to dispose of sheet drainage; accurately shape backslope to prevent erosion.
- ❖ Coordinate excavation with vegetation and drainage considerations.
- ❖ Use select borrow or retaining walls to improve less than adequate trail surface areas.
- ❖ Attain proper slope and compaction through a detailed analysis of on site conditions during wet and dry periods.
- ❖ Make decisions to benefit the trail user; remove sharp plants from close proximity to the trail.
- ❖ Consider the physical and visual relationship of vegetation to the trail.
- ❖ Where appropriate, narrow the clearing width by leaving brush close to the trails edge; excessive clearing allows bicycles to travel faster and leave the tread when cornering.
- ❖ Retain dead standing trees (commonly known as snags) when safety permits because wildlife use trails and snags offer homes and feeding locations for many bird and mammal species. Consider erecting nest boxes or creating artificial snags in woodlands near the trail route.

Steps to Trail Construction

There will be a variety of ways to accomplish construction of the NBST, ranging from building the trail completely with hand tools and volunteers to having the trail constructed by professionals with trail building machinery. The Utah Conservation Corps is a group of Americorps Volunteers, based in Logan, that has expertise in trail construction. The Utah Conservation Corps has expressed interest in being involved with construction of the NBST (a fee is charged for services). The USFS has also played a large roll in construction of the SBST in Salt Lake and Weber Counties. It is another resource that may be available to assist in construction of the NBST.

After the final route has been determined (see the Trail Development Process section in Chapter 4), the actual construction of the trail is ready to begin. The following is a general guide to trail construction for both the rural and urban trail cross-sections (Figures 4 and 5) that describes individual steps for construction within a trail corridor that has no existing trail.

Rural Trail Cross-Section Construction

Step One - Stake the Route

- Stake the trail route from start to finish, stake the center-line or both sides of the trail, place the stakes to define the trail bed and clearing limits.
- Begin construction by removing trees, brush, and rocks from the tread.
- Site characteristics will determine what tools are needed. Hand tools, such as axes, loppers, bow saws, weed whips, and chain saws will be sufficient in most cases.
- The trail can be cleared much faster with motorized equipment. Motorized equipment is not recommended for trail less than 4 feet wide.

Step Two - Grade the Trail Bed

- Grade the trail bed on slopes as required.
- On slopes, remove leaf litter and topsoil material from the cut-and-fill areas and save for later use.
- Select an angle for cut-and-fill slopes based on site soil conditions, amount of rainfall, and plant cover. Ideally, retain cut and fill slopes at less than 1:1.
- Spread topsoil and organic material on large embankments susceptible to erosion to encourage vegetation regeneration.
- On very steep slopes use netting material, such as jute mesh or chicken wire held in place with stakes, to hold the topsoil and mulch in place. Round out the top of embankment shoulders to prevent soil from sliding onto the trail.
- Remove boulders, logs, and other debris that may fall onto the trail.

- ❖ Avoid disturbing plants at the top of the cut slopes and at the base of embankments.

- ❖ Pitch the trail tread at 1.5-3.0 percent toward the outside edge to allow for drainage. Make the tread slightly wider in areas where sloughing of the trail edge is likely to occur.

- ❖ On talus or rubble where little or no soil is present, construct the outside part of the trail with hand placed rocks, 50 percent of which are 12 inches in diameter or greater. Build the outside bench from rock other than those forming the inside bench. Fill in all voids and under the trail bed surface with rock and mineral soil deep enough to provide a firm tread.

Step Three - Remove and Clear Vegetation

- ❖ Cut shrubs and small trees flush with the ground to prevent tripping and to reduce stump sprouting. Avoid cutting healthy trees larger than 7 inches in stem diameter. Some trees, such as box elder, elm, and cottonwood, may require chemical stump treatments to prevent resprouting.

- ❖ Prune overhanging branches cleanly at the branch collar on the tree trunk or where a branch forks. To avoid rapid regrowth, it may be better to remove small trees than to cut off their tops.

- ❖ Trim exposed roots flush with the soil surface.

- ❖ Remove large rocks and fallen logs from the trail, unless they are to be kept as obstacles to prevent motorized use.

- ❖ Scatter branches and other debris off the trail or pile for wildlife cover.

Step Four - Finish Tread

- ❖ For the rural NBST segments, the ideal surface is natural soil free of large stones, stumps, and protruding roots.

- ❖ Natural trails often become easily distinguishable and comfortable to walk on after a month of regular traffic.

- ❖ Always avoid unnecessary disruptions of the ground surface. If leveling is required, use a shovel, small caterpillar (D-2 or equivalent) or Sweco 480 trail dozer to sheer off a thin layer of topsoil, level humps, and fill holes. Gravel or other fill materials may be used to elevate the trail in wet areas.

Urban Trail Cross-Section Construction

The urban trail cross-section (Figure 4) is most likely to be constructed using trail construction professionals and a mixture of hand and mechanized trail construction equipment. The two trail construction machines used are the small caterpillar (D-2 or equivalent) or the Sweco 480 trail dozer. These machines clear and grade the trail after the necessary vegetation has been removed from the staked trail corridor. Handwork includes grading the side slopes, removing vegetation, construction in trail obstacle areas, and placing/removing waste vegetation. After the trail has been graded, the crushed rock fill is placed in the tread area and compacted using the trail dozer.

Trail Signage

Once constructed, the trail should be marked so that its route is clear. A standard trail marker for the NBST needs to be developed. A recommended marker option, used on other regional trails, is a plastic (carsonite) stake marked with the NBST logo. These stakes are placed at regular intervals and at junctions along the trail. Keep the number of signs to a minimum as they detract from the user's outdoor experience and are frequent targets for vandalism and theft.

Entrance signs should be placed at the NBST trailheads. These signs should include maps, trail distances, potential hazards, places of interest, and the types of trail uses permitted. Examples of BST entrance and trail signs are provided as Figures 7 and 8.

Trail Construction Obstacles

Along the trail route you may encounter an obstacle that requires special attention. Recognizing and protecting such areas during construction will help reduce later maintenance costs and potential environmental damage. Some methods are relatively simple and inexpensive; others can be extremely difficult and expensive.

Subsurface Drainage

Water tends to pool on trails that are located on low-lying, level terrain. Raising the tread way 3 to 6 inches (or more) above the surrounding terrain will allow water to drain away, reduce maintenance costs, and ensure comfortable trail use. Use gravel, flat stones, or other fill material to elevate the trail surface. A less-expensive technique for moving water off the trail is center crowning. Fill materials can be obtained from gutters cut on both sides of the trail to facilitate drainage.

Surface Drainage

On steep slopes, poorly designed and constructed tread ways allow water to accumulate, gain downhill velocity, and erode the trail. Flowing water must be diverted off the trail. One effective method is to outslope the trail surface at a 2 to 3 percent grade toward the downhill side. Grade dips or water bars also may be used. Grade dips are short trail sections cut at a grade opposite that of the prevailing trail surface. Grade dips typically are established at natural drainage ways or ditches with intermittent flows.

Figure 7. **Example of Bonneville Shoreline Trail (BST) entrance sign.**

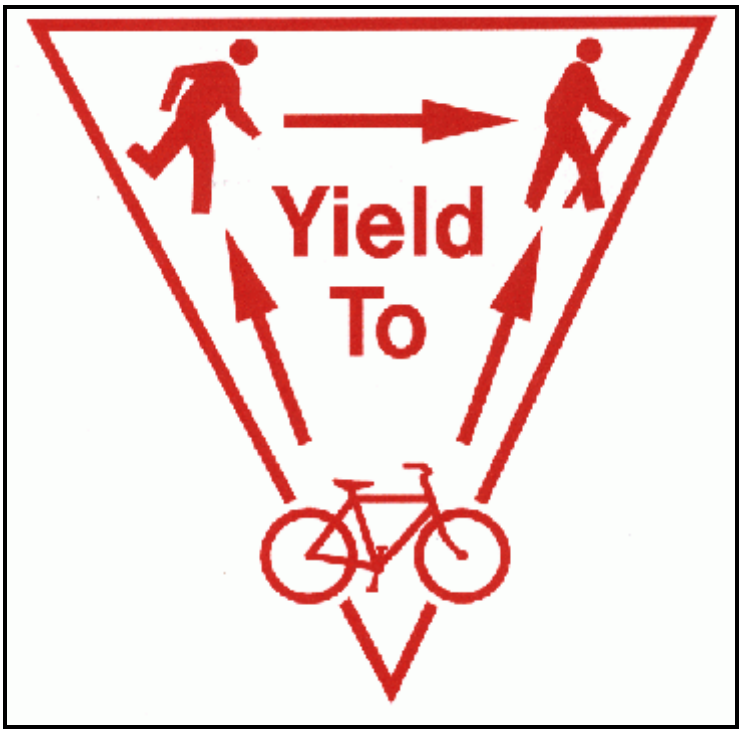

Figure 8. **Example of Bonneville Shoreline Trail (BST) etiquette sign.**

Water bars are obstructions on the trail surface designed to divert water off the trail (Table 5). They usually are constructed with logs or stones placed at a 30-degree angle from the trail's edge. Such water bars must extend well beyond both sides of the trail to prevent water or people going around them. Logs must be at least 6 to 8 inches in diameter. Rubber water bars are another option that reduces potential hazards to bicyclists. Increase the number of water bars as the trail's grade increases.

Table 5. Water-bar spacing for various trail slopes.

PERCENT GRADE	SPACING BETWEEN WATER BARS (FEET)
2	250
5	130
10	80
15	50
25+	40

Stream Crossings

Many trails eventually cross a drainage ditch or small stream. Before initiating any project, contact your local department of natural resources hydrologist to determine if the trail crosses a protected water or wetland. State jurisdiction over the use of protected waters and wetlands generally begins at a point known as the ordinary high water mark. Permits from the U.S. Army Corps of Engineers and/or your local department of natural resources may be required before constructing any crossing, including stream fords. Some local governments impose additional restrictions. In Utah, any project constructed below the ordinary high water mark that alters the course, current, or cross-section of protected waters or wetlands is subject to regulatory jurisdiction of the Utah Department of Natural Resources (statute 105.42).

Fords (or natural crossings) often can be used to traverse slow moving streams less than 24 inches deep. Favor locations with gently sloping, stable banks and gravel or sand bottoms. Most hikers can safely negotiate a crossing on flat stones placed at convenient intervals.

Culverts can be used to cross deep streams or ditches. Professional assistance is required for design and installation of a culvert stream crossing.

Bridge designs vary depending on the length and height of the crossing, type and amount of trail use, and size of maintenance equipment. On hiking trails, a simple log bridge may be used for stream crossings less than 10 feet wide. Professional assistance should be sought to assist in designing and installing a bridge crossing.

Fence Crossings

A self-closing gate or stile will reduce fence damage and permit safe crossing. Stile designs vary depending on the size of the livestock and the availability of building materials.

Trail Construction Costs

Trail construction costs for building segments of the NBST will vary depending on the type of trail constructed and the construction mechanism. Options for construction include hiring a professional trail building contractor to build the trail using mechanized equipment, working with volunteers and community construction crews, or a mixture of both. Trail construction costs do not need to be prohibitively expensive. Most of the BST trail construction costs to date have been for signage, trail heads and, on occasion, surmounting major obstacles (e.g., steep drainages, highway crossings).

Construction costs for individual trail segments will also vary depending on whether the proposed trail corridor contains an existing trail. If so, the trail construction costs could be very minimal. Professional assistance in planning, whether from public or private sources, is recommended for all segments to insure minimal maintenance, longevity of the trail, identification of cost-boosting factors, and realistic cost estimates vital for fund raising. The following sections describe trail construction costs for the above-mentioned construction techniques.

Professional Construction Assistance

Four recreational trail building contractors belonging to the Western Trail Builders Association were contacted for construction cost estimates relating to constructing the NBST. These companies are Alpine Trails located in Park City, Utah; Arrowhead Trails located in Salida, Colorado; ASI Trails located in Sagle, Idaho; and Trio Construction located in Priest River, Idaho.

The least-expensive width for a mechanically constructed recreational trail is between 4 to 6 feet because all contractors mentioned earlier use a Sweco 480 trail dozer, which has the capacity for clearing and grubbing a 4- to 6-foot trail. Trails any smaller than 4-feet wide would be entirely hand built. All the contractors contacted agreed that a hand-built trail constructed with professional labor would quadruple the price. Contractors price trail construction in linear feet. The pricing for the 4- to 6-foot mechanically constructed trail ranged from $1.75 to $3.75 a linear foot, depending on the type of existing vegetation and rock outcrops (Table 6). This pricing is just for the clearing and grubbing of the trail surface. If construction required a large amount of chain saw work and/or the vegetation cut needed to be hauled off instead of scattered along the trail, the price would increase.

Some contractors may be willing to work with volunteer groups and offered a rough cut for the trail with the volunteers doing the finish work. This arrangement dropped the price per linear foot to between $1.00 and $2.75.

Table 6. General professional trail construction cost estimate[a].

TRAIL WIDTH	TRAIL SURFACING	OBSTACLES	COST PER MILE
3- to 4-Foot Trail	natural	❖ soft soil and light to no vegetation	❖$8,000
		❖ large rocks or heavy vegetation	❖13,200
10-Foot Trail	crushed aggregate, 4-inch depth	❖ soft soil and light to no vegetation	❖$37,000
		❖ large rocks or heavy vegetation	❖$48,000
10-Foot Trail	asphalt	❖ soft soil and light to no vegetation	❖$125,000
		❖ large rocks, heavy vegetation, or wet soils	❖$300,000
10-Foot Trail	concrete	❖ soft soil and light to no vegetation	❖$ 188,000
		❖ large rocks and heavy vegetation	❖$600,000
5-Foot Trail with Grade Separation from Off-road Vehicle Road	crushed aggregate	❖ soft soil and light to no vegetation	❖$42,250
		❖ large rocks and heavy vegetation	❖$58,100

Note: Construction costs made available from Troy Duffin, owner of Alpine Trails, 435-655-0779.

[a]Work from contractor includes: field flagging trail route, brushing and clearing, trail cutting with erosion controls installed, off slope berm removal, major root removal, base preparation, base material laid and spread, and final smoothing, raking or finishing. Hauling any refuse off the trail will be extra.

Materials used by the contractors for the trail surface range from bark mulch to crushed rock to road base. In terms of accessibility, the professionals agreed that crushed rock and road base provide a surface that can be immediately used by wheelchair trail users. The bark mulch is less favorable for accessibility but could possibly be used a season after construction, as it needs time and recreational use to harden. The cost for trail surfaces range from $2.00 a linear foot for bark mulch spread 4 feet wide at a depth of 4 inches to crushed rock at $4.00 per linear foot spread 4 feet wide and 4 inches deep. This pricing will increase if dumping the material requires excessive trips back to the stock pile.

Volunteer Trail Construction

A feasible trail construction technique, particularly for implementing the typical rural trail cross-section, is construction via volunteer labor. This technique has been implemented for constructing a majority of the SBST. The cost of trail construction using volunteer labor varies, depending upon: (1) the conditions within the corridor, (2) the need for minimal professional assistance, (3) the need for volunteer supervision, and (4) city/county/other personnel involvement. Costs may range from nothing to approximately $5,000 per mile.

Trail User Conflicts

The NBST invites several trail user groups to use the trail for a variety of purposes. Hikers, walkers, joggers, cyclists, mountain bikers, and horseback riders, in addition to other groups including families and school and environmental education groups, will be using the trail together. This broad spectrum of trail users has the potential for conflict because of their varying trail needs and styles of recreation. Education of the various trail users will help in reducing trail conflicts (Appendix I).

A lack of communication between different trail users is the root of many clashes and collisions on trails. Users must realize that communication is a two-way interaction and make an effort to warn others of their needs and intentions. Bicycle speeds could likely be the source of a majority of user conflicts. If trail users are educated in a basic and universal system of communication, such as what ringing a bike bell means, chances for conflict and crashes are minimized. Signs, speed limits, and good user etiquette along the NBST can minimize conflicts between trail user groups.

Promoting responsible behavior on the NBST can minimize user conflict. Trail etiquette standards can be publicized on trail signs and in existing educational materials. For example, a particular sign that should be used on the trail is a yield sign showing bicycles yielding to pedestrians, and pedestrians and bicycles yielding to horses. Trail users might be less likely to become offended at the actions of other people once they understand how each group is supposed to act. Trail users also might be less likely to violate an established code of behavior if they believe the rules will be enforced.

Damage

A certain amount of vandalism, as well as accidental damage, can be expected on heavily used trails that are open to the public. Damaged and vandalized items, if not promptly removed or repaired, stimulate more damage. Regular inspection of trails with early identification of damaged areas will help reduce vandalism.

Proper trail design methods can also reduce damage. Select trail routes that avoid sensitive environments. Use brush piles, drainage ditches, or vegetation to keep people on the trail. These methods, unfortunately, detract from the outdoor experience and can increase the amount of accidental damage when users leave the trail to examine attractive sights. If accidental damage is occurring, it may be wise to route the trail closer to the site and thus eliminate the need to leave the trail. Trail signs also can be used to encourage

compliance. However, it is important to avoid the use of negatively worded signs. When space permits, explain the reasons for protecting the area. For example, "Prevent erosion, please stay on trail."

Dog Waste

Dogs are allowed on the BST. Dog waste tends to be a problem on heavily used trail that are used by persons walking their dogs. This waste needs to be removed because it is unsightly and can pose a health risk to dogs and trail users. The two options for controlling dog waste are: (1) the provision of dog waste bags and receptacles at trailheads, and (2) educating and requiring dog owners to remove and dispose of their dog's waste. The provision of dog waste receptacles and bags at trailheads requires regular maintenance to facilitate waste removal and bag restocking for the program to be successful. Educating trail users in dog waste removal requires interpretive signs at trailheads. This approach is more difficult for users because they may be required to take the dog waste into their automobiles, which is not pleasant. Either approach should be implemented along the NBST.

Trail Maintenance Program

A maintenance program helps ensure the safety of the trail user and the preservation of the trail environment. A high maintenance standard implies quick response to trail deterioration. Programs such as "Adopt a Trail" encourage local volunteers to maintain a section of trail as a service for all the recreational users of the trail.

General Trail Maintenance Guidelines

- Practice environmentally sound maintenance and use techniques appropriate for the type of trail. For example, avoid the use of chemicals to retard vegetation growth.
- Prepare an annual Trail Maintenance Plan.
- Assess the type and volume of use with trail register records and by counting the type and volume of vehicles at the trailhead.
- Repair heavily used trails in the spring, and maintain them throughout the season on an as-needed basis.
- Prioritization of trail maintenance tasks are: 1) to correct unsafe trail conditions, 2) to repair environmental damage, and 3) to restore the trail to the desired conditions.

Annual Spring and Early Summer Tasks

- Clear windfalls and dangerous trees from the trail bed for safety and to prevent detouring.
- Remove loose rocks and debris from the tread surface.
- Repair trail wash-outs.

- ❖ Remove new plant growth on the trail annually. Clear in the spring and early summer when the new growth is soft.

- ❖ Level the trail tread as necessary and restore the tread grade to the original slopes. Use local material to fill ruts, holes, low spots, or muddy areas.

- ❖ Repair erosion-damaged facilities promptly to prevent further damage. Check for erosion effects after spring runoff. Check and repair water bars, drainage ditches, culverts, and drainage dips. Construct additional drainage structures if needed.

- ❖ Check and repair all structures after spring runoff and after severe summer storms.

- ❖ Check, repair, or replace signs and trail markers prior to the major use season.

Weekly or Monthly Tasks (As Trail Use Warrants)

- ❖ Maintain trailhead facilities such as toilets or waste containers.

- ❖ Resupply trailhead information kiosks with route or safety brochures.