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CONTRACTING FOR AERIAL PHOTOGRAPHY

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(Paper presented by Richard Bradley at the Seminar, "New Horizons in Color Aerial Photography" sponsored by The American Society of Photogrammetry and the Society of Photographic Scientists and Engineers)

The Forest Service long ago recognized the utility of aerial photographs as an aid in the management of the natural resources within our National Forests. In 1928, we were obtaining area coverage of some of our Montana forests. This was working photography, and not for experimental or research purposes. This use spread rapidly through the Forest Service and in the years 1938, '39 and '40, for example, we acquired aerial coverage of over 30 forests in Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, and Wyoming. At the present time, almost every National Forest is covered by recent aerial photography.

To keep our aerial photography current, we rephotograph each forest on a 4 to 8 year cycle, depending on the amount of cultural and natural change on the forest. In an average year, we contract for something like $250,000 worth of aerial photography. An on-the-shelf management tool, our aerial photography is used for a multitude of purposes. Interpretation of forestry, range, water shed, and wildlife resources is routine. As photography is also used for both large and medium scale mapping and extraction of photogrammetric data, the use of a reconnaissance type camera is ruled out. Consequently, we specify a mapping-type camera with high resolution and minimum distortion.

Because of the very mountainous terrain usually prevalent in the National Forests, displacement of the photographic image, due to relief, is a serious problem. Thus a long focal length or narrow angle lens is preferable to the shorter, wide angle one. We have found the 8-1/4 inch lens to provide the best compromise between the relief displacement problem and the photogrammetric plotting needs for mapping purposes. An exception to this is the aerial photography used solely for mapping; it is taken with a 6 inch lens.

Presently, almost all of our aerial photography is acquired through contract procedures. Manpower and equipment investment considerations dictate that we will continue to obtain our photography by contract.

By law, we are required to make award of a contract to the lowest responsive qualified bidder, and an adequate set of contract specifications is our insurance that we will obtain the high quality photography we desire. We have two basic kinds of specifications. One is the set of general items that are common to all aerial photography projects. These common specifications are coded, indexed, and bound. They are titled "Specifications for Aerial Photography," and given a date to distinguish from earlier revisions. Back in the late 1950's, there was a common specification for all USDA agencies. The first Forest Service specification was based on the USDA specification and was issued in 1962. A revision was made in 1965 and again in 1969. The latter one included specifications for color photography for the first time.

The second kind of specification tailors the first (or general items) specification to a specific project. It gives the project size and location, the photographic season, the scale, the film emulsion, the lens focal length, etc. These supplemental specifications are issued to prospective bidders as a part of the bid solicitation. Any resulting contract incorporates both the general and the supplemental specifications.

The development of high speed polyester-base color aerial film and its superiority for photo interpretation work caused us to revise our specifications to include color aerial photography. Our first thought was that we could simply adopt the specifications in use by another agency. Alter a brief investigation we found that no such specification existed and if we wanted color specifications we would have to formulate them to our specific needs.

Based on discussions with other agencies, especially the Geological Survey and the National Bureau of Standards, and drawing on our own experience, we developed color specifications. These color specifications are given in detail in our "Specifications for Aerial Photography," copies of which are available on request from the Director, Division of Engineering, Forest Service, USDA, Washington, D.C. 20250.

First, these color specifications establish minimum camera standards as to lens resolution, lens distortion, platen flatness, filter flatness, and spectral transmission characteristics of the lens. Under these standards only the more modern precision mapping cameras can qualify. Our specifications further evaluate the ability of a camera to produce a high quality color aerial photograph.

This is accomplished by requiring the bidder to submit with his bid sample overlapping color negatives taken with the camera and filter that he proposes to use. These samples must be vertical, of medium scale, over timbered terrain and exposed during the portion of the day when the sun angle approaches its maximum. Color prints made from the negatives are also required. These negatives are evaluated for color saturation and balance, uniformity of illumination, detail sharpness, clarity, and absence of image motion. Prints are evaluated for detail, color balance, and stereoscopic resolution. If necessary, we prepare glass diapositives from the negatives, orient them in a stereo plotter, and evaluate for any residual Y-parallax and model flatness.

In developing these specifications, we first considered requiring only color prints to form one or two stereo models. Since there are so many possible manipulations in making color prints, we concluded that we also needed the corresponding negatives so they could be evaluated. This permitted the making of diapositives for the Y-parallax and model flatness checks referred to.

Other matters being acceptable, if the camera meets our requirements, as evidenced by a NBS Report of Calibration, and if our evaluation of the sample materials is favorable, then the bid is deemed to be responsive to the solicitation. If a bidder proposes to use more than one one camera on a project, an evaluation is made of each camera-filter combination to be used. Award is made to the lowest responsive qualified bidder. Negatives and prints delivered by the contractor in fulfillment of contract terms must be of a quality equal to those submitted as samples.

For area coverage to be used as a working tool, we specify that the film be processed to a negative. For single-purpose projects, such as insect infestation detection, we may specify that film be developed to a transparency.

About our only other specification on color is one that prohibits "banding" in negatives due to the use of a wind-rewind processor. These "endproduct" specifications have the advantage of allowing the contractor to select his own processes, chemistry, equipment, etc., as he sees fit. Further, they are somewhat independent of the rapidly developing technology of color in that acceptable tolerances are not pinned down to mathematical limitations. They do require judgment on the part of the individual evaluating the samples submitted with the bid and evaluating the materials delivered as part of the contract. If a sample negative is borderline, is it acceptable or not? Is a delivered print equal in quality to the sample submitted? These can be controversial questions.

We encountered one problem while our specifications were in an interim stage of development. A solicitation for color photography was issued, calling for a "color-corrected" 8-1/4 inch lens. The low bidder proposed to use an older camera having only fair resolution and distortion characteristics. Surprisingly, it did give good color rendition, and in the absence of a legally accepted definition of a "color-corrected" lens, we were obliged to accept the low bid. Now, we specify a minimum acceptable resolution and a maximum acceptable distortion. Cameras which meet these resolution and distortion requirements also have lens designed to handle color emulsions. We feel there is a need for the American Society of Photogrammetry to develop standards for the evaluation and certification of lenses as to their color capabilities.

As both color technology and our own experience develop, we probably will shift toward specifications that will be more restrictive as to sensitometry, to densities, to color proportion, etc., and require less expert judgment on the part of the contract administrator.

One thing is certain — color is here to stay, at least for us. The incremental cost over comparable black and white photography, (presently about 20 to 25 percent) is more than offset by the much greater information content and the ease with which less trained individuals can perform photo interpretation work. Within the next five years, we expect to utilize color for 90 to 95 percent of our aerial photography needs.

Our current specifications, while new, have been tested by use in one form or another. One such project was our Sierra National Forest photogrammetry study. This project was designed to demonstrate the maximum potential contribution of photogrammetric systems to natural resource management. Color negative photography at 3 scales (1/6000, 1/24,000, and 1/48,000) was specified to be exposed over the same general area. Sample materials and camera forts submitted were satisfactory. Award was made to the Mark Hurd Company of Minneapolis.

# "Watts" Happening in Energy Conservation: Tips for Saving Energy in Facilities, Part III

***Editor's Note:*** *"Watts" Happening is a series of articles on energy conservation. We hope facility and equipment managers will use this forum to share their own tips on this subject. We need your input! Submit tips to Bobbi Baca, WO Engineering, 201 14th Street SW, Washington, DC 20250 or B.Baca:W01A.*

## Recycling

This is our third installment of energy saving tips for facilities. We have also had two installments dealing with vehicle energy efficiency.

The Forest Service can truly be proud of its Service-wide recycling program. According to Environmental Protection Agency officials, our agency has one of the most active and successful programs in government.

Why has this effort been so successful? One reason is that we have a well organized network of recycling coordinators—in fact, one for every office. Several other reasons are:

- It is a "from-the-bottom-up program." People are involved because they believe in it. We each make the program what it is.
- We are all empowered to participate. Each of us has a stake in recycling at our desks, at the vending machine, or at home.
- It makes sense economically. Recycling returns money to the treasury and helps reduce the cost of solid waste removal at our many administrative, research, and recreation sites.
- Recycling saves ENERGY. Materials made from recycled materials use far less energy to manufacture.
- Federal recycling, like energy conservation, is a program in which we as an agency are required to actively participate by law.

## Energy Conservation

It sounds like recycling and energy conservation have a lot in common. Why does energy conservation make sense? Because:

- It must involve all of us. We are all empowered to make it happen at every Forest Service site.
- It makes sense economically. Funds saved benefit the local unit.
- It makes sense environmentally. Energy saved through lower actual energy usage and in purchasing products made with recycled materials reduces the pollution caused via power generation.
- Our energy conservation program was mandated by the Energy Policy Act of 1992.

Read on for more about saving energy.

(1) Avoid using low voltage lamps, such as the MR-16, for general illumination. These lamps provide only around 13 lumens per watt. Low voltage lighting can be successfully used for task or display illumination in conjunction with energy efficient ambient lighting. Plan to get qualified assistance through your Regional Office to make the most of efficient lighting design for your particular needs.

(2) Avoid dimming fluorescent lighting unless using modern ballasts, such as T-12, T-8, or T-5 biaxials. Do not dim screw-in fluorescent lights with a standard wall dimmer switch. This will cause lamp operation and light problems. You can damage many ballasts by trying to dim them.

*(Note: There has been much discussion within the agency on whether or not to turn off lights.)*

(3) Question: Does leaving incandescent lights on save money?

*Answer: No. Turning on the light causes a rush of about 20 times the normal current, leading some to assume that a large amount of energy is used, but this cycle only lasts about one-tenth of a second, resulting in a break-even point of about 3 seconds. However, turning incandescent lamps on and off does shorten their life.*

(4) Install a timer on your electric water heater to limit the time of operation.

(5) Four-tube fluorescent light fixtures can be retrofitted with two higher efficiency lamps with specular reflectors.

(6) Institute a water conservation program. Repair all leaks in the system. A faucet drip of only 2 tablespoons per minute will equal 5,460 wasted gallons per year! This includes water pumped, water heated, and, maybe, water treated! Monitor irrigation water used for lawns.

(7) Seal off unused portions of buildings. Consolidate activities where possible.

(8) Shut off furnace pilot lights in summer.

(9) Shut down heating and cooling an hour before quitting time.

(10) Give out desk lamps to cut down on overhead light use during non-working hours.

(11) Paint all rooms a light color.

(12) Replace broken or cracked windows promptly.

(13) Replace old or worn weatherstripping and old caulking.

(14) Seal openings in walls for piping, electrical conduits, through-wall units, etc.

(15) Provide covers for window air conditioning units and swamp coolers during winter.

(16) Insulate and weatherstrip attic ceiling entrances.

(17) Install an insulated cover on whole-house fan louvers during winter.

(18) Start an energy conservation team on your unit.

## References

Architects and Engineers Guide to Energy Conservation in Existing Buildings, DOE/RL01830P-H4, April 1990.

Energy Ideas, Center for Study of Responsive Law, Washington, DC.

Executive Order on Federal Energy Management, E.O. 12759, April 17, 1991.

Federal Energy Management Improvement Act of 1988, PL 100-615.

Federal Property Management Regulations, 41 CFR 101-20.107, Energy Conservation.

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135.

## Energy Coordinators List

The following are the current energy coordinators for each Region and Station. It is subject to change. In addition to Regions and Stations, each Forest and Laboratory will designate a local energy coordinator to facilitate on-the-ground activities. Contact your unit's coordinator to find out how you can do more to save energy.

| Unit | Name | DG Address |
|---|---|---|
| WO | Terry Gossard | W01A |
| Region 1 | Jim Hogan | R01A |
| Region 2 | Ken Tompkins | R02A |
| Region 3 | Ken Boll | R03A |
| Region 4 | Clyde Lay | R04A |
| Region 5 | Mike Alaux | R05D |
| Region 6 | Dan Helm | R06C |
| Region 8 | George Palmer | R08B |
| Region 9 | Tom George | R09A |
| Region 10 | Don Schultz | R10A |
| INT | Dave Kimbrough | S22A |
| NC | John Jakel | S23A |
| NE | Steve Oravetz | S24A |
| PNW | Sally Sullivan | R06A |
| PSW | Grace Yonemura | S27A |
| RM | Sue Janzen | S28A |
| SE | Jim Holbrook & Tom Chappell | S29A |
| SO | Darryl Landeau & Tom Chappell | S30A |
| FPL | Larry Anderson | S32A |

# Canyon Creek Bluffs Rock Slope Stabilization
# Sweet Home, Oregon

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*Region 6, Willamette National Forest*

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## Abstract

A major rock slope stabilization project was completed between June and November 1992 by Continental Drilling Company West, Madera, CA, under contract to the USDA Forest Service. Stabilization measures included mechanical scaling and installation of 2,000 linear feet of medium and high strength tensioned rock bolts, 28,000 square feet of reinforced and free-hanging rockfall protection netting, 1,200 square feet of reinforced shotcrete, permanent soil anchors, shear dowels, and a shotcrete-placed stream diversion wall.

The rock slopes, adjacent to a primary forest access road, consist of Tertiary basalts with pyroclastic interbeds. The slopes through the reconstructed section are over 130 feet high and 600 feet long. The road was initially constructed in 1948 with little regard for long-term slope stability, stress relief, or cyclic hydrostatic and ice loading.

In 1985, a 2,000-cubic-yard overhang failure destroyed a tied-back H-beam retaining wall and removed a section of roadway. Repair costs were over $100,000. Between 1985 and 1990, rockfall frequencies increased, and several vehicle hits and near-misses were reported. A 1990 monitoring program and rockfall probability study indicated that the risk of public injury and property damage were beyond acceptable limits.

After slope scaling, Forest Service engineers and geologists conducted a 3-week intensive program of structural discontinuity mapping that provided data for artificial support analysis and design. It was completed in 5 months at a cost of approximately $316,000.

## Introduction

**Site Location**

The Canyon Creek Bluffs are a 600-foot-long section of steep rock outcrops located on the Willamette National Forest at milepost 5.2 on forest road 2022, approximately 19 miles southeast of Sweet Home, OR (figure 1). Road 2022 is a single-lane, aggregate-surfaced road with turnouts (oriented roughly north-south through the project section) with an average daily traffic count of approximately 50 vehicle trips.

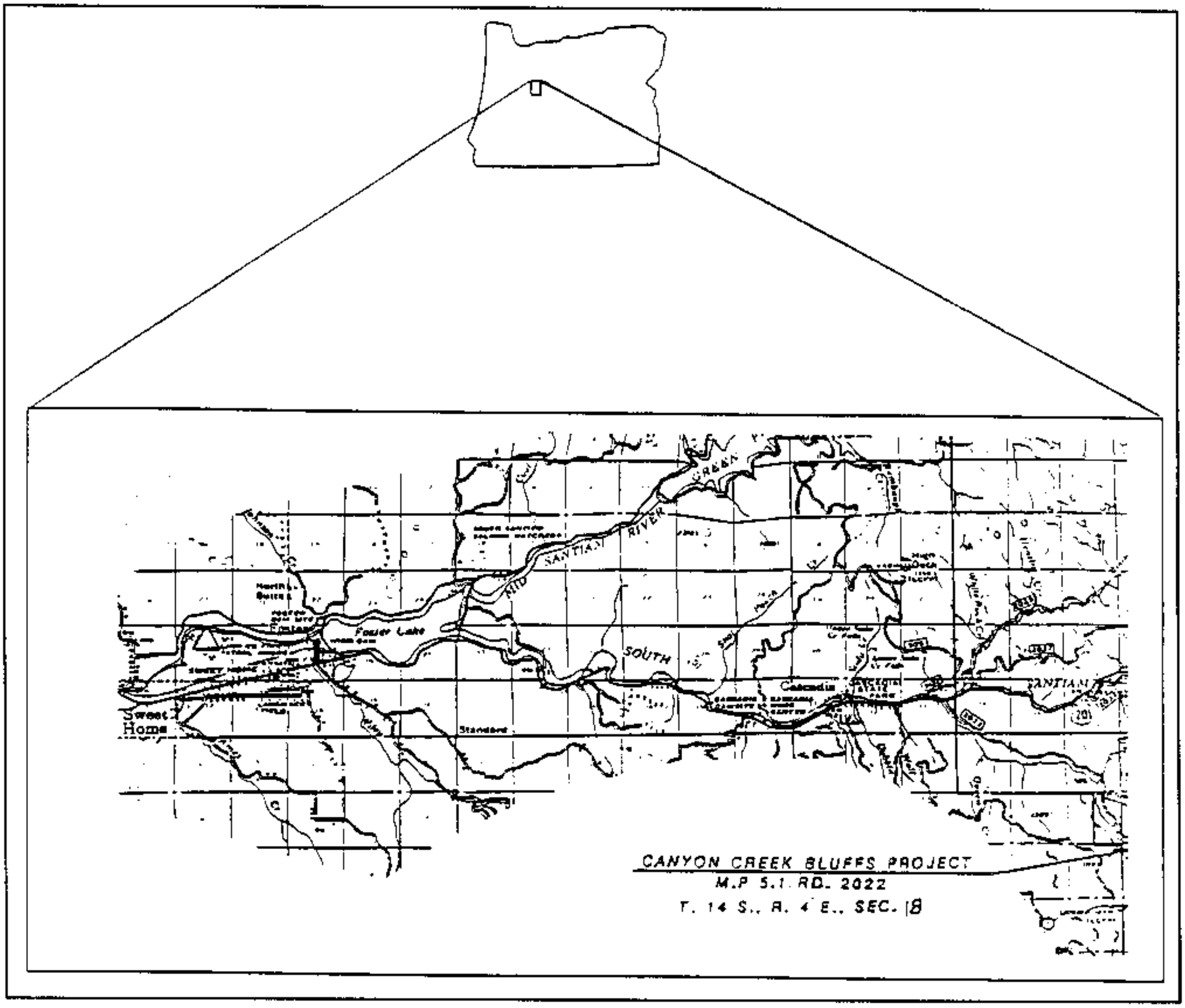



*Figure 1.—Site location.*

**Site Geology**

The bluffs are composed of a series of Miocene basalt flows, overlying and interbedded by lapilli tuff (Walker and Duncan 1989; Baldwin 1981). The road cut through the section forms rock slopes from 40 to 130 feet in height with slope angles ranging from 70° to overhanging (figure 2).

*Figure 2.—The Canyon Creek Bluffs.*

Surface drainage along the slope is controlled by two dip-slip faults that intersect the cut-slope on the northern third of the site. The south fault had previously been an open plane of separation, which subsequently filled with alluvial material, and now consists of sub-rounded cobbles and boulders that range from 1 inch to over 3 feet in diameter in a matrix of overconsolidated, nearly lithified clay. This area was a continual source of material that raveled onto the road.

The two distinctive rock types were designated Rock Units 10 (basalt) and 12 (tuff). Engineering properties were estimated in the field according to the Unified Rock Classification System (Williamson 1984). Rock Unit 10 has three-dimensional open planes of separation and was estimated to have an unconfined compressive strength between 5,000 and 8,000 psi from field hammer-blow impact tests. Later laboratory unconfined compressive tests (ASTM 1991) confirmed this to be 7,700 psi. Rock Unit 12 is massive and has random breakage characteristics except for exfoliation surfaces. It was estimated to have an unconfined compressive strength of between 1,000 and 3,000 psi.

North of the fault intersection, a 50-foot-wide by 80-foot-high basalt bluff (Rock Unit 10) overhangs the road. A localized stream discharged approximately 150 gallons per minute at the top of the overhang, forming a waterfall onto the roadway. This posed additional safety and road maintenance problems by producing a wet, weak road surface and ice fall in the winter.

South of the fault intersection, a 450-foot-long face of Rock Unit 10 composes most of the project area and has the highest incidence of rockfall. In this section discontinuities in the rock mass form unit joint blocks with volumes of 5 to 20 cubic yards along the northern edge. The size of loose blocks decreases to the south, where blocks average 1 cubic foot in volume.

## History

Canyon Creek Road was constructed in 1948 by the Santiam Lumber Company and accesses land owned by several private timber companies and the Forest Service. The grade was constructed at approximately 5 percent to minimize timber haul costs. This resulted in major rock overhangs as the alignment was excavated with uncontrolled blasting down through relatively soft interbeds of altered tuff underlying the basalt flows. Rockfall due to tension relief and small overhang failures was a constant maintenance and safety issue after initial road construction.

In 1976, two tied-back H-beam retaining walls were constructed, at a cost of $125,000, to provide additional road width at the bluffs. One of these retaining walls replaced a 45-foot-long cedar log half-bridge supporting the road. This section was located beneath a rock outcrop which overhung the road prism by 10 feet.

In 1985, approximately 2,000 cubic yards of the overhanging rock slope failed, destroying the road prism and the southern retaining wall. Rock and soil were deposited for approximately 200 feet below the road and into Canyon Creek (figure 3). This material was removed and the

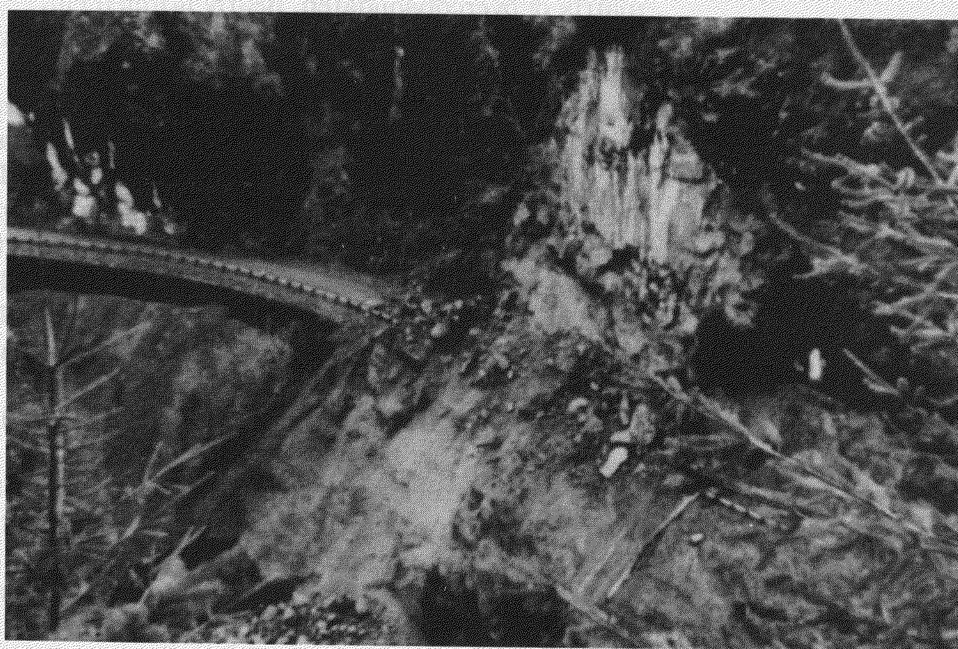


*Figure 3.—1985 slope failure.*

retaining wall rebuilt at a total cost of over $100,000. While constructing the retaining wall, the contractor chose to install wire mesh slope containment mats to protect workers from rockfall associated with freeze-thaw conditions.

## Preliminary Investigation

### Risk Analysis

Due to increased rockfall activity and near-misses, it was decided that a scientific analysis of the slope was warranted. Initially, timber company and Forest Service maintenance records were reviewed. Maintenance supervisors reported that rockfalls large enough to close the road occurred every 3 to 5 years. The site required maintenance with a motor grader approximately four times per year. In 1989, a motor grader was nearly struck by 10 cubic yards of rock as the equipment operated at the bluffs.

In order to obtain an independent assessment of site conditions, the Willamette National Forest contracted with Systems West Engineering, Eugene, OR, to provide a risk analysis (Systems West 1990). Under this contract, Systems West Engineering reviewed the historical information, performed a field investigation, evaluated the findings, and presented recommendations and preliminary cost figures. A rock face profile was produced by tracing identifiable areas of concern onto a mylar sheet superimposed on a photograph of the site (figure 4). This face map was later used to identify construction design zones. Accessing the face with climbing equipment, the contractor surveyed four cross-sections (figure 5). Probabilities of various rockfall events were calculated based on estimations of traffic exposure times, rockfall frequencies, and rockfall types. On average, the probability of a vehicle "hit" was reported to be 1 in every 2,000 trips.

A monitoring program was established to further assess the overall stability of the site. Reflectors were mounted onto portions of the face with the goal of monitoring slope movements using an electronic distance measuring (EDM) device equipped with total station capabilities. Silhouettes of predominant rock overhangs were also recorded from two temporary benchmarks to measure any discrete movements. During the first winter of the monitoring program, 11 of the 14 reflectors had fallen from the face, either due to inadequate bonding or as a result of rockfall. None of the silhouettes showed any movement. The conclusion drawn from the year-long monitoring was that the project area was predominantly a rockfall problem as opposed to a large mass movement. After later examination and analysis, it was determined that there were also local areas of potential mass instability.

### Reconnaissance

A photograph of the site taken from across the canyon was enlarged to 20 by 30 inches and covered with a mylar transparency to serve as a visual reference for further analysis and visual display. Design zones were

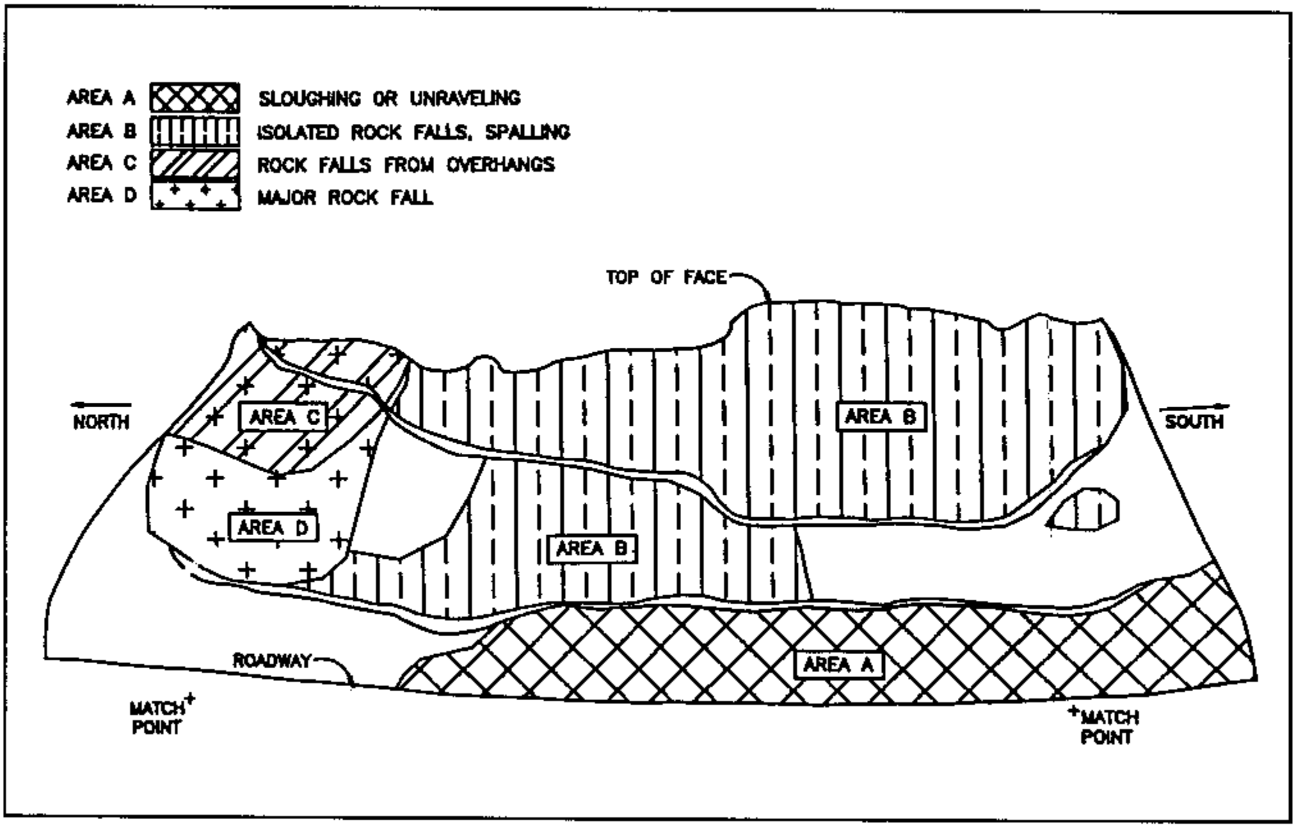



*Figure 4.—Face map delineating potential failure areas.*

identified where the rock mass could be separated into definable areas based on the geometry of visible discrete blocks, likely failure mechanisms, and potential mitigating actions (figure 6).

Once the design segments were identified, they were traced onto the mylar photo overlay and then digitized into a two-dimensional AutoCAD® drawing file. The AutoCAD® program enabled estimates of the surface areas to be made for design and cost estimation. The cross-sections and preliminary discontinuity mapping helped in estimating preliminary rock bolt and dowel lengths. The digitized design segments were used later for individual contract drawings to better portray the locations of specific items, such as limits of slope containment mats and shotcrete.

An economic analysis of options—including two alternate routes, stabilizing the bluffs, and relocating Canyon Creek Road—was completed by Forest Service transportation planners. The analysis indicated that stabilizing the Canyon Creek Bluffs was the most affordable alternative by approximately $240,000.

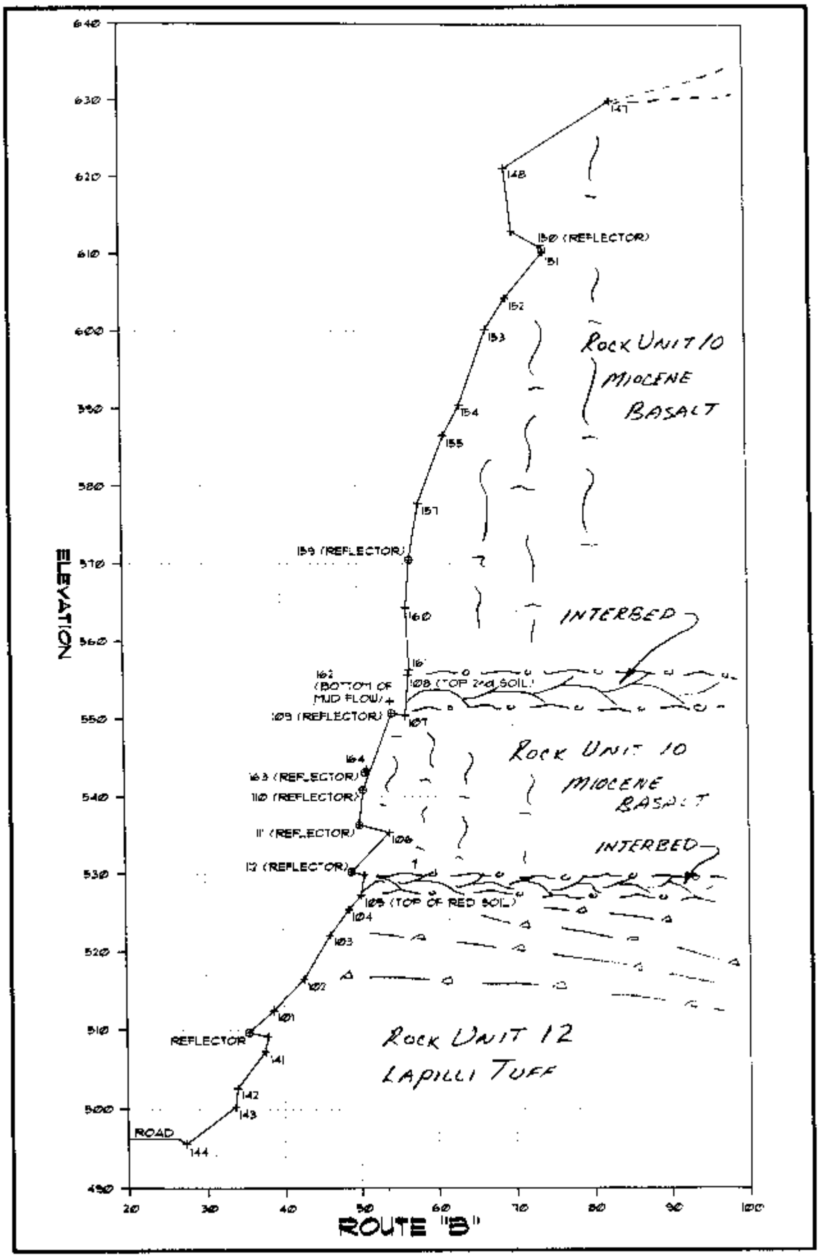
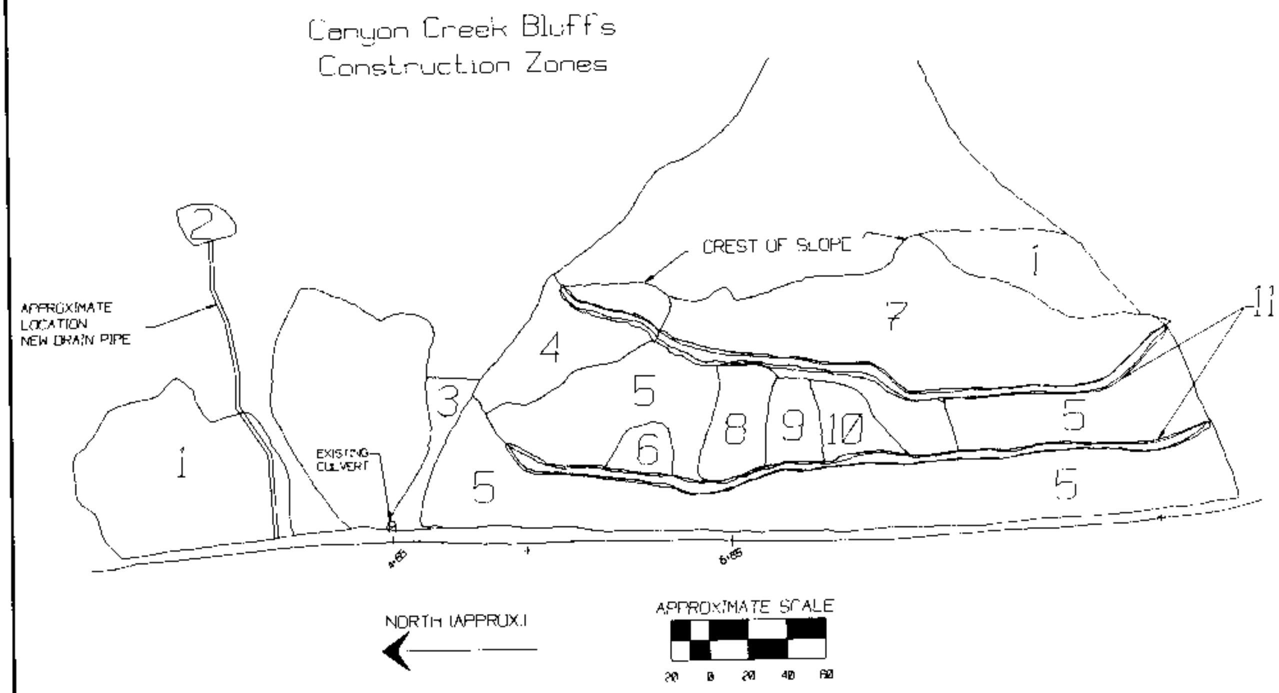



*Figure 5.—Surveyed cross-section.*

## Preliminary Structural Mapping

Field personnel working for Systems West reported poor access for rapelling and hazards from loose soil and rock. Therefore, further field work by the Forest Service was limited to observations made from the road surface, on high lift equipment, or above the upper crest of the bluffs until after the slope was scaled.

In order to determine the most effective methods for detailed discontinuity mapping, preliminary data was obtained from the overhanging outcrops north of the fault intersection. The outcrop was divided into six




CONSTRUCTION ZONE 1:
Scale

CONSTRUCTION ZONE 2.
Construct drainage collection, cutoff wall, and associated anchored and unanchored drain pipe.

CONSTRUCTION ZONE 3:
Scale soil chute, blasting and mechanical scaling may be used as approved by the Forest Service. Construct slope reinforcing mat as shown on Sheet 15. Install soil anchors as shown on Sheet 16.

CONSTRUCTION ZONE 4:
Scale, install 35 Type I rock bolts, 15 ft. long on 12' (vert.) by 9' (horiz.) pattern as shown on Sheet 7. Install approximately 15 additional Type I rockbolts 15 ft. long as directed by the engineer. Place slope reinforcing mat and Type 2 dowels as shown on Sheets 11 & 13.

CONSTRUCTION ZONE 5
Scale, place free hanging slope containment mat as shown on Sheets 11 & 14.

CONSTRUCTION ZONE 6:
Scale, install approximately 4 Type I rock bolts, 12 ft. long as directed by the engineer. Place free hanging slope containment mat as shown on Sheets 11 & 14.

CONSTRUCTION ZONE 7:
Scale, install approximately 40 Type I rockbolts, 15 ft. long as directed by the engineer. Place free hanging slope containment mat as shown on Sheets 11 & 14.

CONSTRUCTION ZONE 8:
Scale install 22 Type 2 rockbolts 23 ft. long on 10' (vert.) by 8' (horiz.) pattern as shown on Sheet 7. Place free hanging slope containment mat as shown on Sheets 11 & 14.

CONSTRUCTION ZONE 9:
Scale, install approximately 10 Type I rock bolts 8 ft. long on a 13' (vert.) by 9' (horiz.) pattern as shown on Sheet 7. Place free hanging slope containment mat as shown on Sheets 11 & 14.

CONSTRUCTION ZONE 10:
Prepare surface for shotcrete, install drains and anchor bars, and apply shotcrete. See Sheet 10

*Figure 6.—Construction zones.*

map cells, approximately 20 feet high by 30 feet long. Discontinuity data was gathered within these cells using detailed line mapping techniques (Piteau 1980). A self-propelled high-lift bucket with a 60-foot reach was used for accessing and mapping the areas. This method proved effective; however, the reach was insufficient for most of the project. The magnetic interference from the steel mass of the vehicle also posed a problem for accurate magnetic compass readings. Final detailed discontinuity mapping was accomplished by mapping crews suspended by rappelling gear after the slopes were mechanically scaled.

### Test Rock Bolt Installation

The need for artificial support using tensioned rock bolts was identified during initial reconnaissance and mapping. Williams expansion shell anchors were chosen for this application based on reduced setup time. Previous expansion shell installations for retaining wall tie-back construction in the relatively soft underlying tuffs (Rock Unit 12) were unsuccessful. The expansion shells did not provide sufficient friction in the borehole to withstand the design loads, and two-stage grouted anchors were required instead. Therefore, a 10-foot-long number 8 bar with expansion shell was installed as a test bolt in the basalt (Rock Unit 10). The shell was expanded and the bolt successfully tested to 110 percent of design load.

## Contract Preparation

Specifications needed to be written and cost estimates prepared for numerous items. Much of that effort focused on the following key items:

- Scaling loose rock and removing vegetation, which also allowed Forest Service personnel safe access for final detailed discontinuity mapping and identification of rock bolt locations.

- Construction of a drainage collection structure to divert a small waterfall from the north bluff.

- Drilling and installation of rock bolts and dowels.

- Shotcrete application to the soft pyroclastic interbeds.

- Installation of slope reinforcing and rockfall containment matting.

After reviewing access and travel management needs, it was decided to completely close the road during reconstruction. This increased the contractor's flexibility and reduced costs and contract time. Emergency access was required within 24 hours' notice for wildland fire suppression.

Table 1 (at the end of this article) provides a summary of estimated and final costs and quantities. Preliminary quantities and cost estimates were calculated for the following:

## Scaling

Slope scaling by mechanical removal of loose surface rocks and vegetation reduces the possibility of rockfall striking workers or equipment during construction. Scaling also decreases the amount of material that needs to be contained or reinforced with mats. An estimate of the surface area requiring scaling was made using the AutoCAD® digitized photographic image. The estimated area was then checked for accuracy in the field. Approximately 35,000 square feet of slope required scaling.

Scaling crews were required to consist of an experienced working supervisor and two scalers. Three-person crews offer a relatively high production rate. Safety and work quality is generally improved by the presence of an experienced supervisor. A crew production rate of 115 square feet per hour was estimated. Production rates obtained from the Oregon Department of Transportation (of about 150 square feet per hour) were reduced by 30 percent to account for difficult slope access and unforeseen conditions. Hourly costs were based on prevailing wage rates for similar labor in the area. Debris removal costs were added based on time and equipment.

Payment was calculated on a crew-hour basis. A crew-hour consisted of three people either scaling the slope or moving their ropes and equipment to the next anchor position to continue. Once clearly defined, crew-hours are easily measured and give the inspector the flexibility to control the number of passes across any area.

## Rock Bolts

Contract estimates for the type, number, and length of rock bolts were hampered by initial limited access to the slope. If structural mapping were attempted prior to scaling, the data would become inaccurate as discontinuities were exposed or removed during scaling operations. Therefore, the entire rock slope was divided into more manageable construction zones that could be given initial individual estimates.

Construction zones were distinguished by potential failure mechanisms, locations on the slope face, and anticipated mitigating actions and analyzed separately. The number of single "spot" rock bolts were estimated by evaluating the number of individual rock blocks likely to be reinforced. Larger blocks having predominant structures were analyzed using the commercial computer software programs ROCKPACK® and BACKPACK®. Dimensions and geometries were estimated in the field. Strength parameters were back-calculated from existing conditions. An assumed dry surface condition, resulting in a safety factor of 1.05, was used in the calculations. The general design objective was to increase the stability by 25 percent to a calculated safety factor of 1.30. The increase was selected to account for variation in shear strength for intact rock and filled and unfilled discontinuities. It is emphasized that these values were only used for obtaining quantity estimates in contract preparation. Final analyses were based on geometries measured directly on the slope.

Two types of rock bolts were specified. Type 1 bolts were 1-inch Williams® Spin-Lock® rock bolts tensioned to 30 kips. Type 2 bolts were 1-3/8 inch Williams® high grade Spin-Lock® rock bolts tensioned to 80 kips. The 30-kip rock bolts were selected because their working loads in shear and tension were adequate for most applications. The 30-kip bolts could also be tensioned with a pneumatic wrench instead of the cumbersome hollow ram jack needed for the 80-kip bolts. The 80-kip bolts were specifically chosen for construction zone 8 where a massive block overhung the road by about 12 feet. Specifications were developed using the U.S. Army Corps of Engineer's Rock Reinforcement Design Manual (Corps of Engineers 1980).

Cost estimates for rock bolts were based on estimates from the literature (Abramson and Daley 1986; Watters and Karvaki 1986), contractor contacts, and historical costs obtained from other agencies. Linear foot costs historically have ranged from $20 to $50 for bolts tightened by pneumatic wrench. The slope face was relatively high and remote, so the higher cost estimate of $50 per linear foot was chosen for type 1 bolts. An additional 20 percent was added for the high tension type 2 bolts. Handling of the heavy hollow ram jack and relatively fewer installations were the reasons for this increase.

### Shotcrete

The original estimate for applying shotcrete was based on square feet. Area was obtained by measuring the lengths of the interbeds to be covered and the average height. A base unit cost of $6 per square foot was used and then increased by 100 percent to cover mobilization and risk due to slope height and the small shotcrete volume. Later, during negotiations with contractors, the method of measurement was changed from area to volume because volume estimates were much easier to quantify based on truck tickets. Close inspection was required to minimize waste from rebound or excessive coverage (ACI 1981).

### Rockfall Protection Netting

The area covered by netting was estimated from the digitized AutoCAD® profile. Historical data (Ciarla 1986) and information from mesh manufacturers were used to obtain an installed unit cost of $1.93 per square foot for free-hanging mat. Additional materials and labor were added to the free-hanging mat cost to obtain an installed unit cost of $2.75 per square foot for reinforced slope containment mats.

### Stream Diversion Structure

A stream diversion or collection structure was required to control the flow of water from the north overhang. Steep slopes, heavy vegetation, and safety concerns limited access at the top of the waterfall. The preliminary design consisted of a 30-foot-long formed concrete headwall to catch the surface water and an 18-inch corrugated metal pipe, anchored to the rock face, to act as a down-drain, delivering the water to an existing catch basin in the ditch. This structure would have been difficult to construct and maintain. It was decided that, after the area was cleared and scaled, the water source area could be better assessed. A design change or value engineering proposal were anticipated. If the change or proposal was not satisfactory, the original design would be used. Later in the project, a value engineering proposal for a diversion structure without a drain pipe was accepted.

The cost estimate for the original drainage and diversion structure—based on labor, equipment, and materials—was $42,000.

## Construction

Continental Drilling Company West of Madera, CA, was awarded a contract for $314,000. Work for this 140-day contract began on July 7, 1992, and was completed on November 26, 1992.

Forest Service geotechnical personnel familiar with the project were selected as primary inspectors for the reconstruction contract. These inspectors reported to the contracting officer's representative, who was in charge of administering the contract.

This approach worked well because it allowed the technical personnel to be on the ground, inspecting the work and communicating with the contractor daily. Critical design considerations were already understood by the inspectors, which allowed considerable latitude in the construction process. Problems and potential solutions were identified quickly and reported to the contracting officer's representative. The representative understood the contract's limits and opportunities and was able to authorize alternative construction materials or methods.

### Scaling

Scaling was used to remove loose rock and vegetation, increasing safety during construction. Removing vegetation reduces the widening of cracks by root wedging and eliminates the levering action of wind blowing against trees near the slope crest. The scaling method specified removal of loose rocks with pry bars or powered splitters. Hydraulic splitters were inserted into small boreholes and forced the rock apart by expanding the size of the splitter inside the borehole. Blasting was not allowed due to the proximity of the two retaining walls and Canyon Creek. There was also concern that the large overhanging block (construction zone 8) could fail as a result of blasting operations.

Scaling was completed by three-person crews rappelling down the face. Vegetation, such as scrub oak on terraces and Douglas-fir along the slope crest, was also removed. Hydraulic splitters were used to remove 10-foot-diameter blocks from the fault in construction zone 3. Overhanging portions of the slope could not be accessed by rappelling and were scaled by two people working in a lift basket attached to the crane. Production rates using the lift basket were comparable to a three-person crew.

The contractor protected the guardrail and retaining wall by placing 6-foot-high rolls of straw on the outside road edge. The straw bales—locally available and inexpensive—were high enough to keep most debris from bouncing over them. They worked well, even after repeated repositioning and impacts with falling rock. After scaling was completed, the contractor hauled the straw to a local cattle rancher.

Approximately 35,000 square feet of rock slope were scaled using 283 crew-hours. Over 400 cubic yards of rock and vegetation were removed from the slope.

## Structural Mapping

The contractor began scaling on the south end of the site and worked to the north. After loose rocks were removed from the slope, Forest Service engineers and geologists could safely rappel down the face and collect data (figure 7). This information was used to evaluate the number and types of reinforcement devices used on specific blocks or in rectangular patterns.

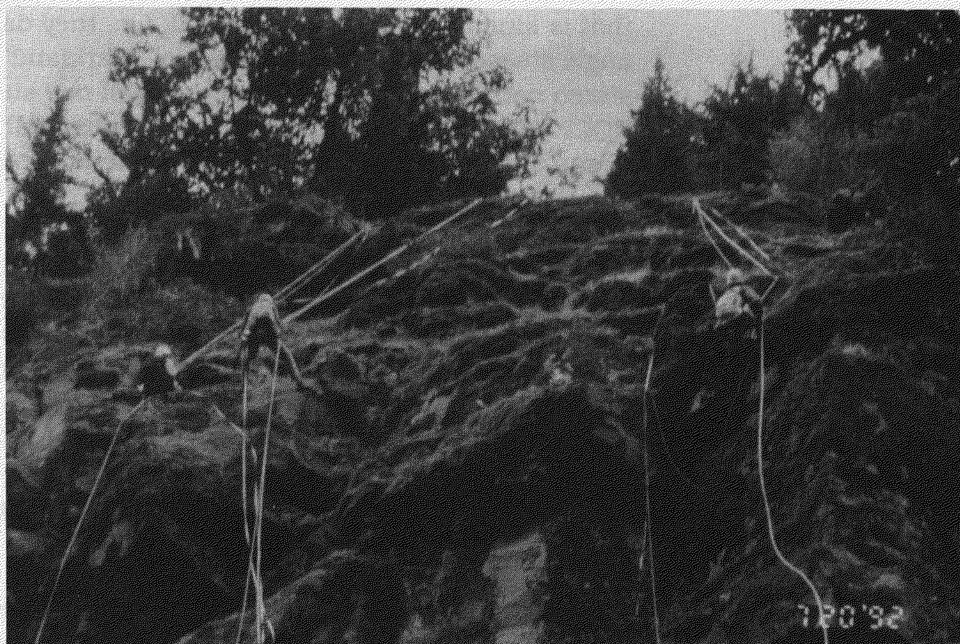


*Figure 7.—Discontinuity mapping and data collection.*

Four large photographs of the southern face were taken from across the creek. These photographs were covered with mylar transparencies to which structural domain boundaries and discontinuity data were transferred. The mylar overlays also provided a visual reference to the slope face during analysis in the office.

The face was studied from the ground prior to rappelling. As the team moved down the slope, they were guided by a spotter on the ground using two-way radios. The spotter was responsible for marking structures on the photographs, taking notes from the mapping team, and keeping the team in the needed position. As they moved down the face, the team would note the orientation of the face and discontinuities, dimensions of blocks in the rock mass, and indications of water conditions and fillings in the discontinuities. A measuring tape was used to reference their location from the slope crest. Structures were marked with paint, indicating their specific map line and structure number.

While the Forest Service had access to the large southern rock face, the contractor began work on a diversion structure along the north overhang. This allowed the contractor to continue work while the engineers and geologists determined the final bolt locations on the southern face.

## Analysis

Various methods were used to evaluate the number of rock bolts required for any single block, depending on the failure mechanism and block geometry. Blocks were first evaluated using Markland's kinematic test for plane and wedge failure (Markland 1972; Watts 1986). The Markland test is used to evaluate if discontinuities can form a geometry that is kinematically possible to fail, i.e., they daylight in the slope at an angle steeper than the friction angle. Markland's test is displayed on a stereo net. Figure 8 shows the results of one such analysis using ROCKPACK®. When a block had a kinematically viable failure potential, it was analyzed for reinforcement with tensioned rock bolts or shear dowels.

For blocks overhanging with a potential vertical failure plane, the number of bolts needed was evaluated using the block's weight and the bolt's available shear strength. Using the bolt manufacturer's recommendations, it was calculated that a single 1-inch-diameter hollow core rock bolt could hold a shear load of about 18,000 pounds, or 75 percent of ultimate tensile strength, with a safety factor of 2. This is the equivalent of a 117-cubic-foot block. If the rock block was smaller than 117 cubic feet, no further analysis was performed. For larger blocks, analysis was done using the BACKPACK® program.

Analysis for discontinuities forming planar or wedge geometries followed the limit equilibrium equations developed by Hoek and Bray (FHWA 1989). In these cases, the compressive force applied by tensioned rock bolts was assumed to increase shear strength by increasing normal forces along a defined set of planes. Friction angles and apparent cohesion (where appropriate) were estimated by back-calculation on exposed surface geometries from past local failures using BACKPACK® software. Unit weights and dimensions were based on field data. A safety factor of 1.05 was assumed for a dry (no water in tension cracks) condition. Due to the variability of shear strength along discontinuities, a conservative value of 30° was used as the internal angle of friction for design purposes.

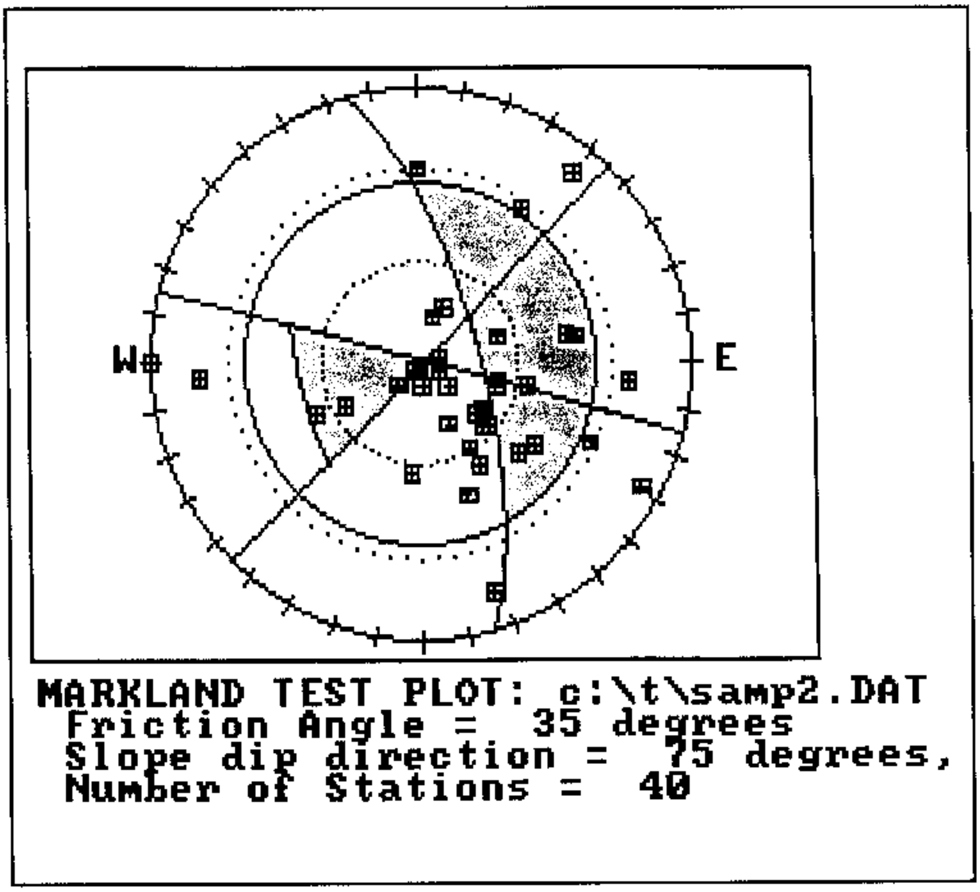



*Figure 8.—Example of a Markland test plot.*

The number of rock bolts in any single location was evaluated using this information and assuming a design safety factor of 1.3. Based on historical observations, water levels were generally estimated at 70 percent of the tension crack being filled.

## Rock Bolt Installation

Once the final analyses were completed, a list of rock bolt locations was prepared for the contractor. Tensioned rock bolts improve stability by applying an additional normal and up-slope force component on the failure plane by transfer of load, through tension on the bolt and compression on the face bearing plate, analogous to a pair of pliers pinching a deck of playing cards. Two popular types of tensioned bolts are those with a mechanical expandable shell anchor at the base of the bolt, anchoring it in place at the bottom of the drill hole, and those employing a two-component resin cartridge system, one of which sets quickly, anchoring the bolt in place prior to tensioning. Utilizing either system requires only one equipment setup for grout or resin placement, unlike conventional two-stage portland cement grouting.

Corrosion protection is accomplished by pumping cement grout either through a small diameter center-hole in hollow-core bolts or by spinning a solid rod through resin cartridges inserted in the drill hole.

Rock bolts having the mechanical expandable shell were specified following a test installation at the site. Resin cartridge systems were not specified because of corrosion protection concerns expressed by other agencies. Design lives for materials used in this project were estimated at 50 years, similar to steel and concrete used in bridges and retaining walls.

Continental Drilling used a 75-ton crane with a 150-foot boom to raise the drill and lift basket. A pneumatic rotary-percussion drill was mounted in a lift basket. The crane was able to lift the basket to practically any location on the slope (figure 9).

*Figure 9.—Lift basket and drill used to install rock bolts.*

The number and location of rock bolts for each block was reviewed with the contractor on a daily basis. The rock bolt expansion shells were set with a pneumatic torque wrench. Once the expansion shells were anchored, the bolt was tensioned by tightening a nut against the bearing plate with the calibrated pneumatic torque wrench. The torque wrench was field calibrated by tensioning an extension rod against the calibrated hollow ram jack. The extension rod had the same diameter and thread-pitch as the rock bolts. Field calibration was essential because the manufacturer's conversion from wrench gage reading (psi) to torque (ft-lb) and then to tension (lb) proved inaccurate.

Testing specifications required that the first three rock bolts of each type and 10 percent of the remainder be tested. An independently calibrated hollow-ram hydraulic jack was used for the test. An extension rod was threaded onto the end of the tensioned rock bolt and placed through the jack. The bolt was tested by jacking the end of the tensioned bolt against the rock face. Seating of the rock bolt expansion shell was tested by the bolt's ability to maintain pressure in the jack. The tension in the bolt was tested by jacking the bolt to the working load and maintaining pressure for 10 minutes. If a drop in pressure was noted, or if the nut against the bearing plate was loose, the bolt was determined not to be tensioned to working load. The 30-kip rock bolts were tensioned to 32 kips for testing. The 80-kip bolts were tested at their working load of 80 kips.

Grouting took place about once every 10 working days. Additional tests were made to ensure that the rock bolts had not slipped between the time they were tensioned and when they were grouted. Just prior to grouting, 10 percent of the bolts were checked with the pneumatic torque wrench. Only one bolt was found to have lost tension. As soon as this was discovered, the contractor immediately checked nine additional bolts. All were tensioned adequately.

As rock bolt analyses and installation proceeded, it became evident that additional rock bolts or untensioned dowels were needed. Some of the smaller blocks could be reinforced using untensioned steel dowels and still provide an acceptable safety factor. Because of an earlier change order, 1-inch galvanized steel rods were already purchased and on site. These rods were installed as an additional 192 linear feet of reinforcement.

## Shotcrete Application

Differential erosion between the basalt and weak underlying interbeds produced overhanging basalt blocks, similar to the large mass that failed in 1985. Shotcrete was applied to the interbeds to prevent continued differential erosion. (Portland cement concrete applied to a slope by pneumatically blowing it through a nozzle is termed "shotcrete" or sometimes "gunite.") Polypropylene reinforcing fibers were mixed with the concrete to increase strength. Short sections of rebar were installed in the slope prior to application to act as hangars. Weep drains were provided to prevent hydrostatic forces from building behind the shotcrete.

Continental Drilling selected Johnson Western Gunite Company, Seattle, WA, as the shotcrete subcontractor. The shotcrete drainage diversion structure and the two interbeds were completed in 3 days, using 890 cubic feet of shotcrete. Shotcrete was delivered to the site as wet mix, after being processed at a local ready-mix batch plant.

It was determined that strict adherence to the ACI aggregate specifications for shotcrete was very critical for effective pumping and application.

In this case, the prime contractor requested a variance in the aggregate gradation specification. The variance was granted on the condition that the adjusted mix would meet the strength specifications. The mix design submitted by the batch plant had too much aggregate retained on the no. 4 sieve and not enough passing the no. 100.

The first truckload of shotcrete was returned by the subcontractor because it could not be pumped. With the material on-hand, the batch plant operator could not produce an aggregate that would meet the specification. Several modifications were tested at the plant. The one which produced a satisfactory product resulted from increasing the fine content of the mix by adding two sacks of cement and 4 percent entrained air, resulting in an 8.5-sack mix with 36 ounces per cubic yard entrained air. Shotcrete application resumed the next morning.

Once the mix was adjusted, the shotcrete was applied very quickly. The subcontractor encountered a small problem as the single-sided plywood form for the diversion wall was placed on the downhill side. This required him to crawl along the uphill side of the wall to place the shotcrete while the crane suspended the hoses (figure 10). The finished wall mirrors the plywood forms instead of the rounded "gun finish." Shotcrete was applied to the two interbeds without any problems.

Shotcrete application was closely monitored to ensure minimum waste by rebound and excessive volume. The subcontractor did an outstanding job of covering all the interbeds to the required depths without significant rebound or waste. However, the vertical and horizontal

*Figure 10.—Constructing the shotcrete diversion structure.*

curvature and overhangs were not adequately estimated, and an additional 75 percent was required to complete the job. The subcontractor later indicated that he would have added around 75 percent to the original estimate to compensate for curvature and overhangs. The estimate was based on cloth tape measurements for length and width and a constant thickness of 4 inches.

## Rockfall Protection Netting

Free-hanging or cable-reinforced wire netting can be installed on rock slopes with a potential for continual rockfall and ravel. Double- or triple-twisted gabion wire mesh is now widely used due to its flexibility, ease of handling, and durability. When a tear or puncture occurs, it does not translate further than the diameter of the hole.

Free-hanging double-twisted gabion wire mats were used to control small (less than 3 feet in diameter) rockfall on the face. The rocks fall from the face but are contained by the netting and land in the ditch. Reinforced wire netting was used for overhung areas where the smaller rocks needed to be retained by the mesh and not allowed to fall onto the underlying road. In this area, the netting was reinforced by attaching it to small dowels or plates on the end of existing rock bolts.

Grouted eyebolts were used to anchor 3/8-inch wire rope along the slope crest. Wire ropes were installed horizontally along the crest and vertically every 20 feet. Gabion wire mesh was unrolled from the top of the face using the crane and lift basket. The free-hanging gabion mesh was relatively easy to install. Attaching the mesh to the wire rope with 9-gage wire fasteners was the most time-consuming task. Reinforced containment netting was somewhat more difficult to construct. Mesh was unrolled from the top in shorter 30-foot lengths. The mesh was then pulled into the face and attached to the plates on short grouted dowels. Additional plates attached to the ends of rock bolts were used to keep the mesh close to the slope face. As the reinforced netting was being attached to overhanging or undulating surfaces, there were problems cause by puckering or wrinkles in the mesh.

## Stream Diversion Structure

Once the area above the waterfall was cleared and scaled, safe access was available to assess the surface water flow. Water flowed from numerous seeps and springs in the thin overburden along a broad, poorly defined channel some 15 feet wide. This channel flowed over the slope crest, forming a waterfall during the winter months.

An alternative design was submitted by the contractor and accepted. A 50-foot-long diversion wall was constructed to channel the flow from the overhanging slope crest to a natural drainage channel formed by the large northern dip-slip fault. The wall was constructed by applying shotcrete to a one-sided plywood form (figure 10). This eliminated the corrugated metal pipe down-drain—an estimated savings of $8,700 on labor, material, and equipment.

A footing was excavated into the basalt (Rock Unit 10) using pneumatic hammers. The diversion wall was anchored by no. 8 rebar grouted into 18-inch-deep holes on 3-foot horizontal centers. The rebar extended completely through the height of the diversion wall (3 to 5 feet). Additional tensile strength in the wall was provided by 9-gage wire mesh, 6 inches square, and the fiber-reinforced shotcrete.

## Construction Management

Continental Drilling's bid was approximately $314,000. An additional $6,000 was obligated for shotcrete volume increases. The project budget did not allow for further changes or variance in quantities. As a result, the amounts of some items had to be reduced in order to cover increases in others. Once mapping and analysis were completed, it was decided to eliminate portions of the slope containment netting to pay for additional untensioned rock bolts. These untensioned rock bolts, or dowels, were needed to reinforce additional blocks identified in mapping. The netting was eliminated in areas where rockfall would produce large blocks that would destroy the mesh. It was decided to reinforce these blocks with bolts. One-inch galvanized rebar was already purchased and on site for pipe anchors (which were eliminated by the diversion wall). These rebar sections were used as dowels for smaller blocks not requiring tensioned rock bolts.

The project was completed on schedule with no contract claims. Weather conditions did slow the contractor's efforts for a few weeks when fire precaution levels were extremely high.

Table I.– Summary of costs and quantities.

| Item | Unit | Estimated Quantity | Estimated Unit Cost | Final Quantitiy | Bid Unit Cost | Item Total |
|---|---|---|---|---|---|---|
| Mobilization | lump sum | one | $8,000 | one | $15,000 | $15,000 |
| Scaling | crew-hour | 300 | $109.43 | 283 | $175.00 | $49,525 |
| Rock Bolts, 30 kip | linear feet | 1,478 | $50.00 | 1,478 | $50.00 | $73,900 |
| Rock Bolts, 80 kip | linear feet | 506 | $60.00 | 429 | $62.00 | $26,596 |
| Dowels to Hang Containment Mats | each | 36 | $240.00 | 30 | $92.00 | $2,761 |
| Small Dowels to Pull Mat Against Face | each | 36 | $80.00 | 22 | $100.00 | $2,200 |
| Shear Dowels (4 ft.) | each | 4 | $259.00 | 21 | $300.00 | $6,300 |
| Untensioned Dowels (8 to 12 ft.) | linear feet | 0 | n/a | 192 | $44.00 | $8,448 |
| Rappelling Anchors | each | 50 | $80.00 | 14 | $60.00 | $840 |
| Soil Anchors (#6 galvenized rebar) | linear feet | 105 | $75.00 | 105 | $50.00 | $5,250 |
| Additional Drain Holes | linear feet | 0 | n/a | 60 | $30.00 | $1,800 |
| Shotcrete for Interbeds | cubic feet | 400 | $27.00 | 702 | $45.60 | $32,011 |
| Drainage Diversion Structure | lump sum | one | $41,811 | one | $33,118 | $33,118 |
| Free Hanging Netting | square-ft. | 34,900 | $1.93 | 22,350 | $1.81 | $40,454 |
| Reinforced Netting | square-ft. | 5,200 | $2.75 | 5,400 | $2.00 | $10,800 |
| Crushed Aggregate | cubic yd. | 220 | $24.30 | 220 | $17.00 | $3,740 |
| Recondition Road Bed | station | 9 | $133.00 | 9 | $400.00 | $3,600 |
| | | | | | PROJECT TOTAL = | $316,345 |
| | | | | | minus COST ESTIMATE | $310,894 |
| | | | | | TOTAL OVER BUDGET = | $5,451 |

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# The Marking of a Man

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*Gloria A. Reams, Historian, Region 6, Regional Office*

***Editor's Note:*** *The U.S. Board on Geographic Names (BGN) was created by President Benjamin Harrison by Executive Order in 1890, and the Board was restructured by public law in 1947. The Board's mission is to encourage uniform name usage to eliminate confusion and to promote consistency in the adjudication of name decisions. The need for such a Board became evident as the American population expanded, and features were given multiple names. Today, the Board, which is composed of representatives from many Federal agencies, continues to promote uniform name usage by standardizing the spelling and application of geographic names on all official maps and publications. The Board, on a monthly basis, dockets and reviews name proposals received from public land agencies and private individuals. Each name is researched and voted on based on the policies of the BGN.*

*As part of its unique mission, the Board has the responsibility of reviewing name proposals commemorating individuals for their exemplary contribution to a particular feature or area (figure 1). The Board's Commemorative Naming Policy sets specific criteria that must be met before a feature is named honoring an individual. The Board considers commemorative name proposals only for individuals who have been deceased for at least 1 year; have had a direct, long-term association with the feature, or have made a significant contribution to the area or State in which it is located; and meet the same basic criteria required of any other name proposal. All criteria must be met before the Board votes to approve naming a feature after an individual for their outstanding achievements or contributions.*

Too often the monuments men build for themselves are washed away by time, but monuments provided by nature are a lasting tribute; such a monument is "Fulkerson Peak" (figure 2).

The docket of names proposed for unnamed geographic features in the United States just "states the facts" to the U.S. Board on Geographic Names. Under Idaho—"Fulkerson Peak" is the statement:

*proposed name for an unnamed feature in honor of a deceased person... Mr. Fulkerson was the first forest land surveyor for the newly consolidated Idaho Panhandle National Forests in 1976; in 1981, he was honored as "Surveyor of the Year" and was named Regional Land Surveyor for the Pacific Northwest Region of the USDA Forest Service; Mr. Fulkerson died at the age of 46 while on the job.*

U.S. Department of the Interior
U.S. Geological Survey

Factsheet

# Commemorative Naming in the United States

**Introduction**

Naming is a basic human tendency; it allows us to perceive the distinct identities of people and places and conveys those characteristics that make them unique. The name of a geographic feature can describe spectacular physical attributes (such as the Grand Canyon or Half Dome in Yosemite National Park), indicate cultural or historical significance (such as Washington Crossing on the Delaware River), or commemorate a worthy individual (such as the Hudson River, named for Henry Hudson, the explorer). Names have many different origins, and regardless of the type of name, they give us a greater familiarity with our surroundings and a sense of belonging to our environment.

Naming rivers, mountains, and valleys after individuals was one way settlers marked the land; it signified their lives on these lands were important, and in addition to being a point of reference, usually satisfied the need for stability and enhanced the general concept of sense of place. Even today, naming geographic features after individuals helps us to recognize their special achievements and contributions to the physical or cultural landscape. However, what may be most significant about the present commemorative naming decisions is their permanence. It is important for us to realize that the commemorative names assigned today may last for centuries.


Commemorative naming recognizes individuals who have made a significant contribution to a specific geographic area or feature. The name of the city of Washington, D.C., depicted in this 1792 map, commemorates the first President of the United States, George Washington.

**The U.S. Board on Geographic Names**

President Benjamin Harrison created the U.S. Board on Geographic Names by Executive order in 1890, and the Board was restructured by Public Law in 1947. The Board's mission is to encourage uniform name usage to eliminate confusion, and to promote consistency in the adjudication of name decisions. The need for such a Board became evident as the American population expanded and features were given multiple names. Printed materials such as maps, journals, and newspapers conveyed different usage, and simply finding out what a feature was called or where it was located depended on to whom one spoke or what source was used. Today, the Board, which is composed of representatives from many Federal agencies, continues to promote uniform name usage by standardizing the spelling and application of geographic names on all official maps and publications.

The Board also is responsible for collecting and standardizing names of places outside the United States to meet official U.S. needs. In these functions, the Board collaborates with national and international organizations. This factsheet, however, deals with commemorative naming only in the United States.

The following five principles have been followed by the Board in national geographic name standardization for over 100 years:

1. The Roman alphabet is used as normally employed in the English language.

2. Precedence is given to names in local usage.

3. Names established by Act of Congress are official by law.

4. Names of political subdivisions, bounded areas of administration, structures, and establishments—as determined by the appropriate, responsible public or private authorities—normally are recognized as official.

5. One name, one spelling, and one application are authorized for each geographic entity.

*Figure 1.—Commemorative naming in the United States.*

In addition, the Board's actions are guided by the following policies:

1. Derogatory names or names that cause confusion are unacceptable.

2. Duplicate names within a local political jurisdiction are not normally approved.

3. Within wilderness areas, unnamed features remain unnamed, unless a name is required for purposes of safety, education, or area administration.

4. Ownership of land is not sufficient grounds to justify Board approval of a commemorative name.

**Commemorative naming policy**

In the United States, thousands of people have contributed and will continue to contribute to society in many different ways. Many deserve to be honored. Such recognition can take many forms, including scholarships or charitable funds established in an individual's name; a commemorative plaque; or a donation to support some aspect of the individual's education, career, or recreational interests. Commemorative naming of geographic features is but one of many options to consider when memorializing individuals and their accomplishments.

Although the Board realizes that such recognition may be desirable, it is neither possible nor appropriate to approve every commemorative naming proposal submitted. To objectively evaluate the increasing number of commemorative requests received each year, the Board uses the following principles, policies, and procedures in making decisions:

Section 1—The U.S. Board on Geographic Names will consider proposals for assignment of the names or nicknames of deceased persons to geographic features in the United States and areas under the jurisdiction of the United States. The Board will not consider names that commemorate or may be construed to commemorate living persons. In addition, a person must be deceased at least 1 year before a commemorative proposal will be docketed for consideration.

Section 2—The person being honored by the naming should either have had a direct long-term association with the feature or have made a significant contribution to the area or State in which it is located.

Section 3—A proposal commemorating an individual with an outstanding national or international reputation will be considered even if the person was not directly associated with the geographic feature.

Section 4—All commemorative name proposals must meet the same basic criteria required of any other name proposal.

**Guidelines**

A proposal to commemorate an individual must contain evidence of local support for the name and its application. Such evidence can be letters from local residents and administrative agency personnel and petitions containing signatures of local citizens.

Proposers must petition their State Names Authority as well as the Federal Board. In States with no official State Names Authority, approval must be obtained from local governing bodies, such as the County Commissioners, Supervisors, or Town Selectmen.

The Board defines a "significant contribution" as an action(s) by an individual to protect, restore, enhance, or maintain a feature that produces substantial, long-term improvements.

The Board defines "direct long-term association" as 20 years or more of continued or periodic service to a feature. However, some proposals that do not meet this 20-year test may still be approved under special circumstances. Usually, an association of a significantly shorter time period requires strong local agreement on the importance of that association. This agreement might take the form of current local usage of the name being proposed or a general sense that the history of the area has been enriched through the individual's involvement with the feature.

A person's death on or at a feature, such as in a mountaineering accident or plane crash, or the ownership of land or the feature, does not normally meet the "direct association" criterion.

Ultimately, the decision on whether a proposal meets the "direct long-term association" or "significant contribution" criteria rests solely with the Board.

**Procedures for submitting and reviewing a proposal**

1. Proposer should submit the name proposal with proper documentation.

2. Proposer should obtain evidence of local support for the proposed name in the form of letters and petitions.

3. The Board, working through State and local governing bodies, determines whether the name is in the public interest based on appropriateness, acceptability, and need.

**For more information**

For more information on commemorative naming, contact:

Executive Secretary
Domestic Names Committee
U.S. Board on Geographic Names
U.S. Geological Survey
523 National Center
Reston, VA 22092
703-648-4544; Fax 703-648-5542

The Board urges proposers to carefully consider an individual's association with the identified feature and evaluate this relationship based on the policies of the Board.

Because of these policy constraints on naming geographic features, commemorative name proposals often cannot be approved by the Board. When a proposal is disapproved, it is usually because of a failure to meet policy criteria rather than being a negative reflection on an individual's achievements.

April 1993

*Figure 1. (cont'd.)—Commemorative naming in the United States.*

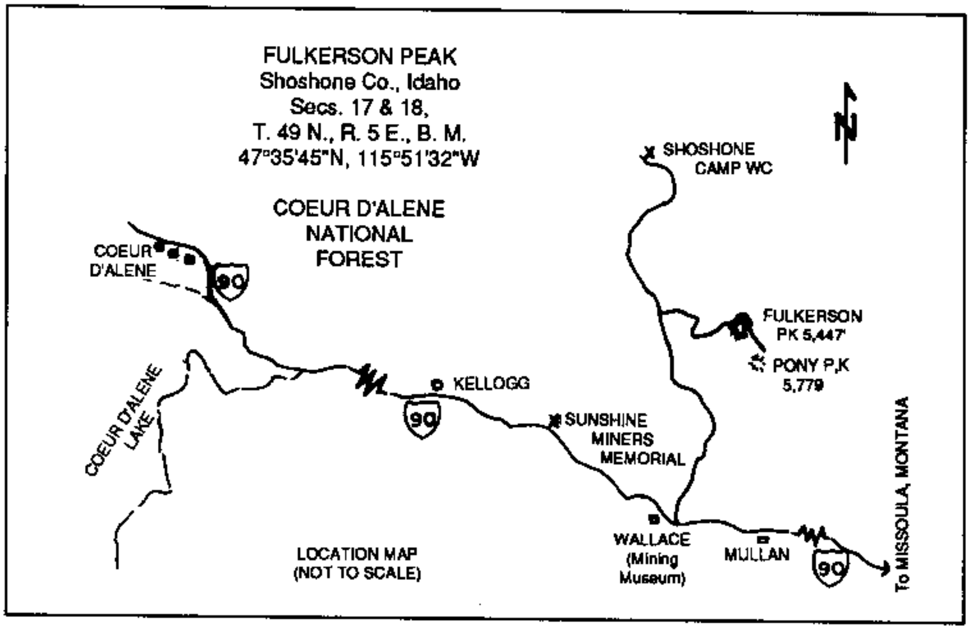


*Figure 2.—Location of Fulkerson Peak.*

Why should T. Marshall Fulkerson have a peak in the Coeur d'Alene National Forest named for him? Because **Marshall Fulkerson had a dream:** he wanted to survey and reestablish both homestead entry surveys (HES) and mineral surveys (MS) within the public domain.

Starting in a historically significant area, he followed the footsteps of two U.S. Deputy Mineral Surveyors who worked the gold and silver belt regions within the Coeur d'Alene Mountains in Idaho. George Trask and Charles Merriam recorded the areas initial mineral plats from the 1880's through the 1910's. The era of pioneer settlements and brawling mining camps, urged on by a young Nation on the move, created the great influx of homestead entries. This rush for ownership of land led to the extensive recording and survey frauds associated with the Western States during the developmental years.

Marshall Fulkerson's interest as the first cadastral surveyor for the Idaho Panhandle National Forests (Kaniksu, Coeur d'Alene, and St. Joe) focused on the early settlement and mineral lands. Following the original surveyor's notes, he found and remonumented as many original corners as he could, while carrying out his duties as Forest Cadastral Surveyor.

With dedication, Marshall preserved and updated the basic historical integrity, so important in understanding the areas mineral ownership. He made extensive studies of the forest HES and made numerous presentations to various surveyor's groups. He was probably the Nation's foremost authority on that saga of our survey history and freely shared this knowledge with others. He tried to instill his enthusiasm for understanding the social ineptitude and greed inherent in the early landowners by teaching an advanced cadastral class at the University of Arizona every year until his death.

Marshall Fulkerson began his surveying career with the Forest Service in the Intermountain Region in the early 1960's (figure 3). From the Challis National Forest, ID, he went to the Regional Office in Ogden, UT, as Assistant Regional Land Surveyor. He began his final odyssey in St. Maries, ID, in 1973, then went on to Coeur d'Alene as Staff Surveyor for the Idaho Panhandle National Forests.

*Figure 3.—T. Marshall Fulkerson.*

In 1981, Marshall was named Regional Land Surveyor for the Pacific Northwest Region, and he moved his family to the Portland area. Even with new job responsibilities, he remained active in Idaho, Oregon, and Washington Land Surveyor's Associations and the American Congress of Surveying and Mapping. He was honored by the Idaho Association of Land Surveyors as "Surveyor of the Year" for his work as editor of the *Gem State Surveyor*, the society's newsletter.

Fulkerson's 17 years as a cadastral surveyor are emulative of his lifelong work to survey and reestablish both the HES and MS within the public domain. The unnamed topographic feature commemorating Marshall is located within the Coeur d'Alene National Forest in an area surrounded with early mineral surveys. These mineral surveys are representative of the original reestablishment work that Marshall carried out within the Coeur d'Alenes. It is fitting that he have a rocky promontory dedicated as

Fulkerson Peak honoring him in an area where he started his cadastral work.

Born in 1937 in Norfolk, VA, Marshall attended schools in southern California and studied 2 years at Bob Jones University in South Carolina. After hours, Marshall enjoyed golf, tennis, hunting, and his favorite— mountain climbing. He learned to climb on the Wasatch front, then climbed in City of Rocks in southern Idaho, Yosemite National Park, Teton National Park, and the Idaho Panhandle. Marshall and his wife, Adria, met in Ogden, UT, where both were working in the Regional Office. They married in 1971 and had two children, Kjersti and Lindsey.

Marshall died unexpectedly October 8, 1983, stricken by a recurrence of an infection from a 1980 injury. He was doing research on the Colville National Forest prior to a Spokane, WA, seminar. Although he was plagued by health problems all his life, it neither diminished his pursuit of excellence in his professional career nor prevented his full enjoyment of his friends and family.

Not all of Marshall's achievement came from his profession. Although he was never a Boy Scout, his outdoor skills drew him into becoming a Scoutmaster while on the Idaho Panhandle National Forests. After his death, one of the many boys he had encouraged and urged to excellence asked Adria to accompany him to the Boy Scout "Court of Honor" where he was to receive his Eagle Scout award. He said it was Marshall who had motivated him and made his achievement possible.

Not everyone makes such an indelible mark in this world; even after 10 years, his image remains alive. When Adria and the children trekked to the top of Fulkerson Peak this past summer, they saw slashes of fireweed in a previously burned area, rocky outcroppings, stands of trees, and the spectacular view of ridge after ridge of mountains, fading from blue to purple—truly a "feast for the soul." Pony Peak is the highest point in the basin, with Fulkerson Peak next in height at 5,447 feet.

This pristine beauty will be shared by others as Marshall's accomplishments are noted on a commemorative Forest Service sign. According to John Criswell, the Idaho Panhandle National Forests intends to formally mark the site and have a dedication ceremony sometime during the summer of 1993. Perhaps a fitting statement is this poem, written immediately after Marshall's death in 1983. Ike worked closely with Marshall:

## FOR MARSHALL—

Woodsman
Surveyor
Friend...

Your spirit
Walks before
The wind...

Where once
We stood
On mountain
High...

Wildflowers
Grow
And warm winds
Sigh...

A stone with
Notches made
Before

A weathered
Post,
Surveyor's Lore...

Your mark you
Left on yonder
Tree...

The scribe cut
Deep
For all to see.

*—Dwight (Ike) Makinson*

# Chunkwood Roads

*Dick Karksy, Mechanical Engineer*
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## Abstract

Chunkwood is a viable alternative material for constructing low-volume roads, including temporary roads. Chunkwood is an excellent lightweight fill for use on swamps and muskeg. It stabilizes soils, such as clay or sugar sand, and it can be used to fill mudholes and eliminate road dust. It can effectively support traffic or be combined with sand, gravel, and geotextile fabric to improve performance. For the Timber and Roads Technology and Development Steering Committee, the Missoula Technology and Development Center (MTDC) constructed a prototype chunkwood machine similar to a whole-tree chipper. The MTDC chunker cuts whole trees or logs into fist-sized fragments, which interlock to form a stable road surface. Evaluations of chunkwood have proven that it is an effective road surface that reduces road-building costs, conserves gravel, and eliminates the need for unsightly gravel pits and the cost of restoring the land after construction. It is about one-fifth the weight of gravel, has high water permeability, is biodegradable, and creates no dust.

## Introduction

Chunkwood has been successfully used as lightweight fill for temporary roads (figure 1). The concept of chunking, the reduction of small unmerchantable trees and forest residues into elongated particles, was introduced by USDA Forest Service researchers in the mid-1970's. Chunkwood was originally envisioned as a raw material for the composite wood products industry and a fuel source for energy production.

Two prototype chunking machines were built—a stationary laboratory model at the Houghton, MI, research facility and a field unit at MTDC. In 1987, a cooperative research and demonstration program—involving MTDC, the Chequamegon National Forest in Region 9, the North Central Forest Experiment Station, and Michigan Technological University—began investigating the use of chunkwood in temporary road construction.

After initial tests, the field unit was deployed to Beinville National Forest in Mississippi, the Kisatchie National Forest in Louisiana, and the Winema National Forest in Oregon to further demonstrate this road-building technique under diversified forest conditions.

*Figure 1.—Chunkwood used on a temporary road.*

MTDC, working with C&H Forest Service, Ltd., also tested the machine on several very wet sites in British Columbia. Aspen chunkwood, 4–6 inches (10–15 centimeters) deep, was successfully used to bridge and stabilize problem "gumbo" clay pockets in secondary haul roads. The Canadians have also shown interest in utilizing chunkwood in muskeg areas for building temporary oil exploration roads.

Chunking produces fist-sized wood particles (figure 2) that, when used as material for fill or subgrade, interlock and form a relatively stable matrix. This structure has high water permeability, is biodegradable, and eliminates dust problems. It is also an excellent light fill at one-fifth the weight of gravel. Chunkwood can stabilize soils, such as clay or sugar sand, and can fill mudholes. Because of its light weight and insulating qualities, it could be especially beneficial in permafrost areas. Chunkwood can by itself support traffic and may be combined with sand, gravel, or geotextiles to improve its overall performance. In steep terrain, its light weight and high permeability make it ideal for fill construction and backfilling behind retaining structures.

There are, however, problems with this material under certain conditions and in particular applications. If the road building takes place in winter and chunkwood particles are suspended or lubricated by ice and snow, they will not interlock. Chunkwood is relatively compressible and must be covered by top fill if severe rutting is to be avoided. The short-term potential leaching of tannic acid from cedar and some other species must be considered when constructing a chunkwood road close to stream.

*Figure 2.—Typical chunkwood particles.*

Chunkwood does have other applications. The MTDC chunker can be used to help remove slash and other debris (figure 3). Chunking this material will reduce potential fire hazard and remove unacceptable residue.

*Figure 3.—The MTDC chunker.*

Chunkwood is also a more efficient energy source than wood chips. It has a higher bulk density, reduces the chance of spontaneous combustion in storage, and provides better drying when piled. In a test run on the Colville National Forest in the Pacific Northwest Region, utilizing the Washington Water Power wood-fired generating plant at Kettle Falls, WA, the MTDC chunker produced fuel at a 5- to 10-percent cost saving over the hog fuel normally used.

Commercial wood chunking machines are not yet available. Starting with the Morbark Model 20 whole tree chipper, MTDC engineers designed a modified cutter unit and revised feed system to produce the prototype machine used in these demonstration tests. This machine is trailer-mounted and can be transported on highways. Its total weight is 32,000 pounds (14,515 kilograms), and it can be towed by a 4.5-ton semi-tractor or tandem axle dump truck. As presently configured, it can accept material up to 12 inches (30 centimeters) in diameter; however, the optimum material is 8- to 10-inch (20- to 25-centimeter) green whole trees. Softwoods are more successfully processed than hardwoods, and green material is better than dry.

The best operational system uses a skidder to deliver the material to the machine. Chunks are conveyed rather than blown. The chunkwood conveyor loader is a separate unit and must be positioned with the machine on site.

Production rates depend greatly on setup configuration and the type of material being processed, but some rough estimates can be made. The MTDC chunker will process 8 to 10 tons (7,257 to 9,072 kilograms) of dry material per hour, or more than 20 tons (18,144 kilograms) of 8- to 9-inch (20- to 23-centimeter) diameter green trees in the same amount of time.

Demonstration tests have proven that chunkwood is a viable alternative material in low-volume road building. It has unique qualities that make it especially desirable when underlying soils are wet and weak. Its limited durability is an advantage when the construction is designed to be temporary.

For more information on chunkwood and chunkwood equipment, contact: Dick Karsky, Project Leader, Missoula Technology & Development Center, Building 1, Fort Missoula, Missoula, MT 59801; telephone (406) 329-3921.

# Evaluating GPS in a Dense Tree Canopy

*Tony Jasumback, Mechanical Engineer*
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## Abstract

The Trimble Pathfinder Professional Global Positioning System (GPS) Receiver was tested on a typical dense canopy of eastern hardwoods to determine its usefulness in performing Forest Service tasks. Results showed a differentially corrected average of 3.7 meters (12.7 feet) and about half the efficiency obtained in the open.

## Introduction

Recent tests show that the Trimble Pathfinder Professional GPS Receiver can efficiently collect data under a dense canopy. The average data collection rate was 34.5 position records per minute compared to 60 position records per minute in the open.

## Background

Data collection under dense canopies has been a longstanding problem for GPS users (figure 1). The receiver encounters a multitude of signal conditions that affect its operation. The signal can be fairly strong where no foliage interferes with it, or it can be completely blocked. It can also be anywhere in between and vary to both extremes from second to second. The amount of foliage in the signal path can change rapidly due to movement from the wind. Small movements of the antenna and movement of the satellite also affect the signal. As the signal gets weaker, the receiver has a harder time tracking it and consequently starts picking up noise, causing a degradation in position accuracy. Thus, improvements in the signal tracking ability of the receiver are expected to greatly improve the operation efficiency and accuracy under the canopy.

GPS is a satellite-based radio navigation/positioning system that will consist of 24 satellites located in 6 orbital planes. It will provide all-weather, 24-hour worldwide coverage of position and time information. Each satellite orbits the earth every 12 hours, constantly transmitting radio signals that contain its own unique identification code and position. The receiver uses this code to determine the time it takes for the signal to travel from the satellite to the receiver antenna. With this information, the receiver can then determine the distance to the satellite based on the speed of light. If the receiver can simultaneously determine the distance to four satellites, with the position of each satellite known, the receiver can then compute its position (latitude, longitude, and altitude).

*Figure 1.—Typical dense forest canopy.*

The Department of Defense (DOD) is currently using selected availability (SA), a method of systematically degrading system accuracy for national security purposes. This can severely limit GPS accuracy. The best way to overcome this limitation is to use differential GPS (DGPS), which requires a base station. The base station receiver is placed at a location whose position is accurately known. The data collected by the base station receiver, its known position, and the remote receiver data are loaded into the computer. The post-processing software compares this known position to that computed by the base station receiver. It then applies these corrections to the remote receiver data. This differential process greatly improves the position accuracy of the remote unit. Receivers operating in an area with a base station produce an accuracy level of positioning down to 5 meters circular error probability (CEP) even with SA in operation.

## Evaluation

An evaluation of the Trimble Pathfinder Professional GPS Receiver was conducted in a typical eastern forest. Evaluations were conducted at the GPS hardwood test site on the Wayne-Hoosier National Forest near Bedford, IN. Two remote GPS receivers were used: one with the Omnidata Polycorder Data Logger and the other with the Corvallis Microtechnology MC-V Data Logger. The purpose of the evaluation was to determine the horizontal position error obtainable with the units and the operating efficiency of the units under the dense hardwood canopy.

The horizontal position error is the error between the known position and that obtained after differential corrections. Differential corrections were provided using data from a local base station and a base station in Atlanta, GA. The operating efficiency was a measure of the receiver's ability to produce three-dimensional (3D) position data under these canopy conditions. Results showed a differentially corrected average of 3.7 meters (12.1 feet) and efficiency about half that attainable in the open.

## Test Site

The GPS Hardwood Test Site was near the Hardin Ridge Recreation Area on Monroe Lake on the Wayne-Hoosier National Forest, about 48 kilometers (30 miles) north of Bedford, IN. The test site was established by the Wayne-Hoosier National Forest, using a GPS survey for control and conventional survey for the traverse. All points/stations are second-order class I or better. It consists of a seven-station closed traverse, a nearby base station, and several alternate stations. The closed traverse starts at the top of a finger ridge and proceeds down the ridge into the bottom of a gully, then back up an adjoining ridge to the starting point. The stations in the traverse are lettered A through G. They are located under a dense, uneven-age oak, beech, and hickory canopy, typical of the eastern hardwood forests. The tops of the canopy are about 30.5 to 36.6 kilometers (100 to 120 feet) above the ground.

## Procedures

Testing was conducted over a consecutive 3-day period in late June when the foliage was fully matured. On the first 2 days, the satellite window that existed in the late afternoon (1515 to 1640 hours local time) was used, and on the third day, the 1025 to 1205 hour window was used. The procedure generally consisted of placing the antenna, which was mounted on a range pole about 2 meters (6.4 feet) above the ground, near the station pin and moving the antenna in a small circular path until the receiver indicated 3D operation.

Data were recorded until 160 or more position records had been recorded. This was accomplished by counting the audible beeps produced by the data loggers as the positions were logged. Separate data files were created for each station. If 3D operation was lost (the beeping sound stopped), the circular movement of the antenna was continued until 3D was reacquired. Only 3D position data were recorded and used during the evaluation.

The local base station was located approximately 0.5 kilometers (0.3 miles) from the test site. It consisted of the Pathfinder Professional with the MC-V Data Logger. It was configured as follows:

(1) Auto 2D/3D operation.

(2) Elevation mask angle 10 degrees.

(3) Signal level mask 4.

(4) PDOP (Position Dilution of Precision) mask 12.

(5) PDOP switch 8.

The data logging interval was set at 5 seconds for both raw and position data. A dome antenna was mounted on a tripod about 2 meters (6.6 feet) above the pine. The Atlanta Community Base Station, located about 607 kilometers (377 miles) from the test site, was set to record both raw and position data at 5-second intervals.

For the 3 days of testing, the remote GPS receiver was configured as follows:

(1) Manual 3D operation.

(2) Elevation mask angle 15 degrees.

(3) Signal level mask 4.

(4) PDOP switch 6.

(5) PDOP mask 12.

The position recording interval was set at 1 second. The only exception was that on day 1 the MC-V Data Logger was set with a PDOP mask of 6. Both remote units used the dome antenna mounted on a range pole about 2 meters (6.6 feet) above the ground.

## Discussion

In general, the stations were occupied in sequence, A through G, and an attempt was made to collect data at each station each day. However, because of some technical problems, this was not accomplished in all cases. The receivers were to be kept at different stations during the test. However, due to operator inexperience and the length of the satellite 3D availability window, this idea was dropped after the first couple of stations on the first day. When both receivers occupied the same stations, an effort was made to keep the antennas about 0.5 to 0.6 meter (1-1/2 to 2 feet) apart.

By attempting to keep the units at different stations, the receiver with MC-V Data Logger did not occupy station A on day 1, and at station C the operator experienced a signal reception problem and elected to skip the station and go to the next one because he thought he could pick up station A and C at the end of the test. Also, no data were collected at station G because a severe thunderstorm caused the test to be terminated while still at station F. None of the missed stations was reoccupied because the satellite availability window closed before the storm ended.

The operators of the MC-V Data Logger were inexperienced with the unit and had trouble with its general operation and in opening and closing files. This greatly increased the time required to run the course. This, and the length of the satellite availability window, resulted in a failure to complete the course (stations F and G) on days 2 and 3. The operators of the receiver with Polycorder Data Logger were experienced and completed the course on those days.

Table 1 shows the horizontal position error calculated from autonomous/ remote data collected at each station by each GPS receiver during the 3-day test. The error is derived by using the average value of the position data recorded in the file for that station. This average position (lat/lon), along with the known position (lat/lon), for that station are then used to calculate the horizontal position error. The overall average autonomous horizontal position error obtained for all stations and both receivers during the test was 26.1 meters (85.6 feet), with a maximum of 58.9 meters (193.3 feet) using 3D unedited data. Also, if the data file did not contain 120 or more position records, the data were not used. (This was the case for station F and the receiver with MC-V on all 3 days.) This autonomous horizontal position error depends to a great extent upon the level of SA in use by the DOD when the data were collected, and it can vary considerably over time. Differential corrections practically eliminate the effects of SA and reduce the horizontal position error.

Table 2 shows the horizontal position error calculated from differentially corrected data for each station and GPS receiver. The horizontal error is calculated from this differentially corrected average value of position (lat/ lon) and the known position (lat/lon) for that station. The differential corrections were obtained using the Pathfinder Software Program MCORR200-Ver 2.14 and data from two base stations—one was a local base station about 0.5 kilometers (1/4 mile) from the site and the other was an Atlanta station about 607 kilometers (377 miles) from the site. All data are 3D and are not edited. However, if a differentially corrected file did not contain 120 or more positions, the data were not used. This is an arbitrary number, but it is necessary for consistently good results.

Table 2 shows that only two files were corrected by the local base on day 2, because the local base station quit recording data for about 50 minutes during the test. Trimble is investigating the situation. The local base station started recording again while the receiver with MC-V Data Logger was at station E and the receiver with the Polycorder Data Logger was at station F. However, it did not come on soon enough to correct the 120 position records collected by the receiver with the Polycorder and to collect enough data with the MC-V Data Logger before the window closed. On all 3 days, the local base station did not always correct all the data in a file, but, in all cases, more than the 120 minimum required were corrected. This was because a large oak tree near the base station attenuated (blocked) the satellite signal at times. The Atlanta base corrected all the data for each station each day, except in cases where the test was terminated because of a storm or the 3D window closed.

*Table 1.—Horizontal position error using autonomous data for each station, receiver, and day.*

| Day 1 Station | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | Meters | | | | | | |
| Polycorder | 15.6 | 26.9 | 21.6 | 28.9 | 14.8 | 7.3 | (1,3) |
| MC-V | (1) | 49.3 | (1) | 11.3 | 20.1 | (2,3) | (1,3) |

| Day 2 Station | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | Meters | | | | | | |
| Polycorder | 27.8 | 40.5 | 16.4 | 24.9 | 22.1 | 20.1 | 11.6 |
| MC-V | 14.3 | 19.2 | 27.4 | 7.8 | 23.7 | (2,4) | (1,4) |

| Day 3 Station | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | Meters | | | | | | |
| Polycorder | 36.0 | 58.9 | 31.6 | 28.2 | 39.4 | 32.9 | 49.1 |
| MC-V | 27.7 | 30.2 | 18.7 | 22.3 | 35.1 | (2,4) | (1,4) |

*Overall Average* = 26.1 meters

Data Logger configured as follows:

Autonomous Data
Mode—Manual 3D
Signal Level Mask 4
PDOP Mask 12
PDOP Switch 6

(1)—No data recorded at this station.
(2)—Insufficient number of positions recorded (threshold 120 positions).
(3)—Test terminated due to thunder storm.
(4)—Window closed, insufficient number of satellites for 3D operation.

Using the local base station data to differentially correct the autonomous/remote data for each station and each day produced an average differentially corrected horizontal position error of 3.7 meters (12.1 feet) (table 2) with a maximum value of 6.9 meters (22.6 feet). Using the Atlanta base station, the average value was 5.6 meters (18.4 feet) and the maximum value was 11.8 meters (38.7 feet). The local base produced the least horizontal error. The further the base is from the remote receiver, the larger the error. By comparing these values with the autonomous average value (table 1), 26.1 meters (85.6 feet), the benefits of DGPS can be seen. DGPS not only eliminates the effects of SA, but it increases the position accuracy of the autonomous/remote data, even over data obtained when the SA was off. So, even if SA is turned off by DOD, DGPS will improve accuracy.

*Table 2.—Horizontal position error from differentially corrected data using a local base station—0.5 kilometer (1/4 mile) from site—and the Atlanta base station—607 kilometers (377 miles) from site—for each station, receiver, and day.*

| Station | Data Logger | Day 1 Base Station Local-Atlanta | Day 2 Base Station Local-Atlanta | Day 3 Base Station Local-Atlanta |
|---|---|---|---|---|
| | | Meters | | |
| A | Polycorder | 2.8 - 3.3 | (4) - 4.4 | 3.3 - 5.6 |
| | MC-V | (1) | (4) - 4.5 | 4.8 - 8.2 |
| B | Polycorder | 4.6 - 5.2 | (4) - 8.1 | 5.3 - 11.8 |
| | MC-V | 6.0 - 7.7 | (4) - 4.0 | 1.8 - 6.6 |
| C | Polycorder | 6.9 - 10.7 | (4) - 4.7 | 1.9 - 10.3 |
| | MC-V | (1) | (4) - 5.3 | 1.3 - 5.5 |
| D | Polycorder | 1.4 - 2.6 | (4) - 4.0 | 1.2 - 10.1 |
| | MC-V | 3.9 - 1.9 | (4) - 1.5 | 1.9 - 0.4 |
| E | Polycorder | 4.9 - 5.6 | (4) - 7.1 | 4.7 - 3.4 |
| | MC-V | 4.5 - 6.8 | 2.5 - 11.0 | 5.5 - 3.4 |
| F | Polycorder | 5.0 - 3.9 | (2) - 2.8 | 6.3 - 7.8 |
| | MC-V | (2,3) | (2,5) | (2,5) |
| G | Polycorder | (1,3) | 1.4 - 2.9 | 2.4 - 3.2 |
| | MC-V | (1,3) | (1,5) | (1,5) |

*Average:* Local = 3.7 meters, Atlanta = 5.6 meters

Data Logger configured as follows:

DGPS Using MCORR200 - Ver. 2.14
Mode - Manual 3D
Signal Level Mask 4
PDOP Mask 12
PDOP Switch 6

(1)—No data recorded at this station.
(2)—Insufficient number of positions recorded (threshold 120 positions).
(3)—Test terminated due to thunder storm.
(4)—Local base station receiver quit logging data during this period.
(5)—Window closed, insufficient number of satellites for 3D operation.

The data collection rate for each station, receiver, and data can be seen in table 3. They were obtained by dividing the number of position records in the remote data file by the time required to collect the data. The time is the difference between the time of the first position record and the last position record in the file. For this test, the overall data collection rate was 34.5 position records per minute with a minimum of 15.89 and a maximum of 49.36 records per minute. However, the daily averages are about the same (34.07, 35.25, and 34.06 records per minute).

Under the canopy, the data collection rate depends on several factors: the canopy attenuation of a signal, the number of satellites available, and the PDOP of the various satellite selections available at the time. If the canopy completely blocks a signal, the receiver cannot calculate a 3D position, and, therefore, no data are recorded until the signal is reacquired unless there are more than four satellites available. With more than four available, it can switch and use the fifth satellite signal if the PDOP is good. Even if there are more than four satellites available and all combinations have good PDOP, the canopy could be blocking more than one signal at the same time. All this reduces the data collection rate under the canopy.

*Table 3.—Data collection rate (number of records per minute) using the SSF (raw) file.*

| Station | Data Logger | Day 1 No. Records-Rate | Day 2 No. Records-Rate | Day 3 No. Records-Rate |
|---|---|---|---|---|
| A | Polycorder | 224 - 35.62 | 196 - 41.70 | 305 - 31.61 |
| | MC-V | (1) | 181 - 38.65 | 362 - 49.36 |
| B | Polycorder | 186 - 22.20 | 155 - 31.74 | 282 - 25.33 |
| | MC-V | 295 - 31.27 | 200 - 26.09 | 303 - 15.89 |
| C | Polycorder | 171 - 35.53 | 211 - 27.89 | 254 - 26.14 |
| | MC-V | (1) | 228 - 27.20 | 262 - 39.50 |
| D | Polycorder | 148 - 36.85 | 198 - 31.10 | 214 - 32.51 |
| | MC-V | 203 - 31.47 | 314 - 28.50 | 275 - 26.53 |
| E | Polycorder | 193 - 41.81 | 212 - 44.95 | 202 - 39.74 |
| | MC-V | 244 - 41.12 | 252 - 41.65 | 223 - 47.11 |
| F | Polycorder | 271 - 32.78 | 211 - 48.51 | 211 - 27.46 |
| | MC-V | (2) | (2) | (2) |
| G | Polycorder | (1) | 282 - 35.03 | 206 - 47.54 |
| | MC-V | (1) | (1) | (1) |
| Daily Average | | 34.07 | 35.25 | 34.06 |

*Average:* 34.50 position records/minute

Data Logger configured as follows:

Signal Level Mask - 4
Mode - Manual 3D
PDOP Mask 12

(1)—No data recorded at this station.
(2)—Insufficient number of positions recorded (threshold 120 positions).

For comparison, the data collection rate is 1 per second, or 60 per minute, which is that set in the data logger. This approximates a receiver operating in an open area with no obstruction to the signals. By comparing the average rate of 34.50 position records per minute obtained during this test to the ideal rate of 60, it can be seen that the operating efficiency under the hardwood canopy is about one half that expected in the open. It would take about twice as long to collect the same amount of data under the hardwood canopy as it would take in an open area.

## Results

The under-canopy evaluation showed that the Trimble Pathfinder Professional GPS Receiver can collect data and operate efficiently under a dense hardwood canopy. The operating efficiency in terms of the average data collection rate, was 34.5 position records per minute (table 3). This compares to a rate of 60 per minute in the open. Thus, the user should expect it to take about twice as long to collect the same amount of data under a canopy as in the open.

The data were differentially corrected using data from a local base station, approximately 0.48 kilometer (1/4 mile) away, and produced an average horizontal position error of 3.7 meters (12.1 feet) (table 2). The data were also differentially corrected using a base station in Atlanta, GA, located about 607 kilometers (377 miles) away. It produced an average horizontal position error of 5.6 meters (18.37 feet) (table 2). The difference is about 2 meters (5.6 - 3.7 = 1.9). That is expected, because the further the base station is from the remote receiver, the greater the position error. Thus, the user can expect better horizontal position accuracy using a local base station. The closer to the work area, the better. The Atlanta base station, 607 kilometers (377 miles) away, which is further than the 500-kilometer (300-mile) radius of operation being recommended, did produce good results.

By comparing the autonomous (uncorrected) average position error (table 1), which was 26.1 meters (85.6 feet), to the differentially corrected average (table 2) of 3.7 meters (12.4 feet), the benefits of DGPS are apparent. It reduced the autonomous average 22.4 meters (73.5 feet).

In the near future, improvements in signal tracking circuitry and signal processing technology are expected to greatly increase the operating efficiency and accuracy under the canopy. These improvements will allow the receiver to track an even weaker/noisier signal and, at the same time, produce less noise. Tracking a weaker/noisier signal will mean increased efficiency, and less noise will mean increased accuracy.

For additional information on GPS, contact Tony Jasumback at:

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# Barrier Free Accessible Trail Surface Materials—Region 1 Materials Engineering Investigations

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*Region 1, Regional Office Engineering*

## Introduction

During the past 2 years, several "new" alternatives for barrier free accessible trail surface materials have been evaluated by the Region 1 Materials Engineering Section. The purpose of this article is to:

- Review traditional alternatives.
- Review what has been learned from investigating new alternatives.
- Provide recommendations.

With the increased emphasis on accessibility, there has been a significant increase in requests for assistance from our forest engineering and recreation personnel for information on materials stabilization. Input from the material engineering discipline is requested because of similar work done in road construction with building materials, such as soil, rock, asphalt, wood, fabrics, cement, and soil/aggregate stabilization agents.

## Barrier Free Trail Surface Requirements and Objectives

The primary requirement of barrier free trail surfaces is to provide universal access for individuals who utilize wheelchairs and other aids, requiring that the following conditions be met during wet and dry weather conditions:

- Smooth, hard, skid-resistant surface.
- No loose aggregate over 3/8 inch.
- Very little cracking or noticeable rutting.
- Resistance to surface abrasion.

Engineering and recreation personnel have identified the following objectives specifically related to trail surface materials:

- 10-year life without maintenance.
- Low cost.
- Natural appearance that blends with the surrounding environment.

- Practical methods of construction for remote locations—minimizing imported construction materials.
- Simple construction techniques—limiting the amount of specialized equipment and skilled labor, so volunteer groups can successfully participate.
- Adequate vegetation control to limit the amount of maintenance and structural damage.
- Minimizing delays to trail users during construction.

The listed requirements and objectives may be applicable for some barrier free trails and not for others. Table 1 provides a predicted long-term rating of each alternative discussed in this article. The ratings are based on satisfying the surface requirements and objectives shown above.

## Traditional Alternatives Used in Region 1

**Hot Mix** is primarily used for paving highways, and it may be the most widely used trail paving material. It is a mixture of aggregate and asphalt cement that must be placed and compacted hot (above 200°F for trails). Costs are high for the hot mix and underlying base course, depending primarily on the remoteness of the site and how much work is done by hand or machine. If the material is hand placed, the finished surface can be irregular enough to present problems for wheelchair mobility. A working width of at least 8 feet is needed for laydown machines used by most paving contractors. After paving a 5-foot-wide trail with a laydown machine, the extra subgrade width can be bladed off and seeded. After several years, problems with cracking and vegetation damage can make the riding surface rough. Vegetation damage can be restricted by placing the hot mix on construction fabric. Mix life can be increased by using a heavy asphalt spray seal. The mix blends better with the forest environment if the sealed surface is sanded.

**Cold Mix** is another type of paving material made by mixing liquid or emulsified asphalt with aggregate. It is not as readily available as hot mix, but it can be mixed and placed without heating. A cold mix does not have as long a life as hot mix, and the cracking damage by vegetation is often more severe unless the mix is placed on construction fabric. Because cold mix may be placed at ambient temperature, it is easier to use at remote locations. Mix life can be increased by using a heavy asphalt spray seal. The mix blends better with the forest environment if the sealed surface is sanded.

**Soil Cement** is a mixture of native soil and portland cement. This material has been used to improve the strength of soils and base courses in highway construction for many years. Portland cement is most commonly used with aggregate to make portland cement concrete for highway pavements, sidewalks, driveways, etc. Soil cement trail construction has had varied success due to the following construction problems: incorrect percent cement; inadequate mixing; and improper

*Table 1.—Ratings of traditional and "new" alternatives.*

| | Traditional Alternatives | | | | 'New' Alternatives | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hot Mix (a) | Cold Mix (a) | Soil Cement (b) | Clay & 3/4" Agg. | Fabric/ Asphalt-Sand Slurry (a) | Enzyme & Native Soil | ECO-CF Polymer with 3/4" Agg. | Fabric & Asphalt Macadam (3/8" Agg) (a) | Soil Sement 3/8" Minus Agg. | Soil Sement Conc Sand | ECO-CF Polymer 3/8" Minus Agg. | ECO-CF Polymer Conc Sand | Road Oyl 3 gal/sy 3/8" Minus Agg. | Road Oyl 3 gal/sy Conc Sand | Portland Cement & Sand Mix 1" thick |
| **Surface Requirements** | | | | | | | | | | | | | | | |
| Smoothness | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 2.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2.5 |
| Hardness | 3 | 2 | 2 | 0 | 2 | 0 | 1 | 2 | 1.5 | 0.5 | 1.5 | 0.5 | 1.5 | 1 | 3 |
| Skid Resistance in Wet Condition | 3 | 2 | 2 | 0 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Loose Aggregate over 3/8 inch | 3 | 2 | 2 | 1 | 3 | 2 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Cracking | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 0 |
| Rutting | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 0 | 3 |
| Resistance to Surface Abrasion | 3 | 2 | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| **Objectives** | | | | | | | | | | | | | | | |
| 10 year life without Maint. | 3 | 2 | 0 | 0 | 2 | 0 | 0 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low Initial Construction Cost | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Natural Appearance | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 1 |
| Practical for Remote Locations | 0 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Construction by Unskilled labor | 0 | 2 | 1 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| Vegetation Control With Fabrics | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Without Fabrics | 2 | 1 | 1 | 0 | NA | 0 | 0 | NA | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| Min. Delays during Construction | 3 | 2 | 1 | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 |

Notes: (a) Sand spread over finished surface. (b) Portland Cement mixed in place with native soil
Ratings: 0 = Unacceptable 1 = Poor 2 = Fair 3 = Good

moisture control, compaction, and curing. Performance problems include raveling of coarse aggregate, cracking, heaving, freeze-thaw damage, and lack of abrasion resistance.

**Clay-Aggregate Mixes** have been used on several projects in Region 1 with some success. The amount of clay additive is critical, depending on the aggregate gradation and plasticity of the natural fines. Too much clay results in a slick surface that may rut when wet; too little clay results in loose ravelled aggregate that makes wheelchair movement difficult.

## Investigation of "New" Alternatives

**Fabric/Asphalt Sand Slurry—Trail Test Section.** In the fall of 1991, eight short segments of trail were constructed similar to the cross-section shown in figure 1. The slurry was made by mixing asphalt emulsion and sand in a wheelbarrow to a pancake batter consistency. The purpose of the construction fabric is to provide a barrier to vegetation growth and increase rutting resistance by providing tensile strength. Early in 1992, we detected bond failures between the slurry and the woven fabric, which led to changing fabric type. Ultimately a change was made to the asphalt macadam alternative shown in figure 2. Due to the problems we encountered (and other comments and conclusions shown in figure 1), the slurry alternative was never used on an actual forest trail.

Comments:

A. Vegetation damage existed on each section where fabric was not used.

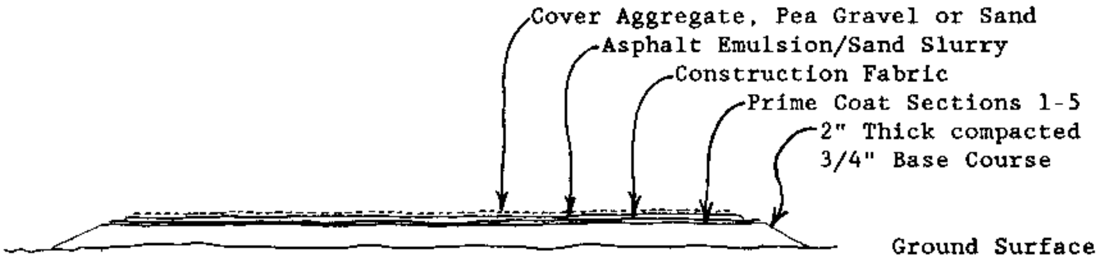
B. Complete coverage of base course surface was difficult because the prime was poured on. Poured prime coat provided no significant benefit.

C. Slurry bond to fabric failed at edges of trail after 12 months.

D. After freeze-thaw cycles, pea gravel could be loosened from the surface by scuffing foot traffic. This problem could have been eliminated by lightly rolling the pea gravel after placement.

**Enzyme Stabilization—Lab Investigation.** California bearing ratio (CBR) tests were performed with enzyme materials from two manufacturers with dense-graded aggregate samples containing 20 percent minus no. 200 and plastic fines (PI = 10). CBR is a traditional road material strength test. All samples were mixed, compacted, and cured by the enzyme manufacturers recommendations. They were room temperature cured for 4 days and 14 days. According to the enzyme distributors, the products should have worked well because the aggregate was dense graded and had plastic fines. Test results showed *no improvement* in strength over the untreated specimens.

Typical Cross Section



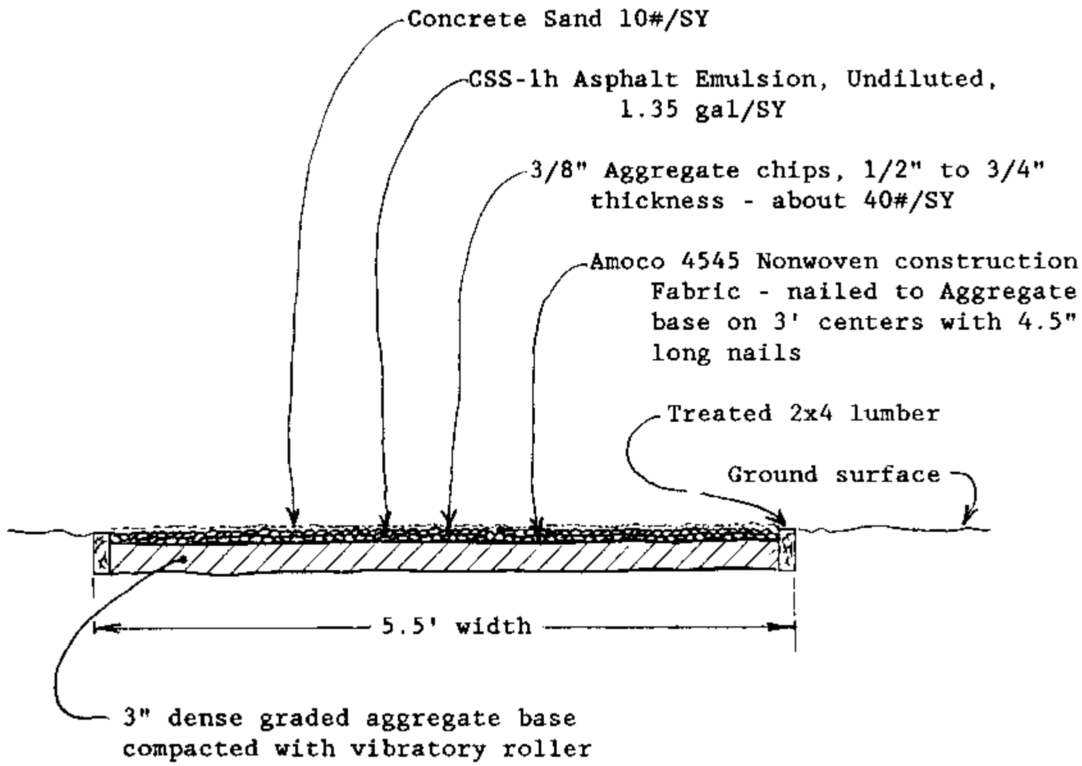

Configuration and Comments

| Section | Prime | Fabric | Slurry Formula (Qty for 1 SY) | Cover Material | Comments |
|---|---|---|---|---|---|
| 1 | MC-70 (Sections 1-3) | None | 0.8 gallons CSS-1h Asphalt Emul.<br>15.5# Sand<br>12# Cement<br>5# Water (Sections 1-4) | 20#/SY Pea Gravel (Sections 1-2) | A,B,D |
| 2 | | Poly Filter GB (Sections 2-7) | | | B,C,D |
| 3 | | | | 10#/SY Concrete Sand (Sections 3-6) | B,C |
| 4 | CSS-1h (Sections 4-5) | | | | B,C |
| 5 | | | 0.6 gallons CSS-1h Asphalt Emul.<br>15.5# Sand<br>5# Water (Sections 5-8) | | B |
| 6 | NA | | | | C |
| 7 | NA | | | 20#/SY Pea Gravel (Sections 7-8) | D |
| 8 | NA | None | | | A,D |

Comments:

A Vegetation damage existed on each section where fabric was not used.
B Complete coverage of base course surface was difficult since the prime was poured on. Poured prime coat provided no significant benefit.
C Slurry bond to fabric failed at edges of trail after 12 months.
D After freeze thaw cycles, pea gravel could be loosened from the surface by scuffing foot traffic. This problem could have been eliminated by lightly rolling the pea gravel after placement.

*Figure 1.—Fabric/asphalt slurry trail.*




Results

| CSS-1h Asphalt Emulsion | | 3/8" Aggregate Chips | |
|---|---|---|---|
| Saybolt Vis @ 77°F | 36 | % Pass 3/8" | 100% |
| % Residue by Evaporation | 60% | % Pass #4 | 16% |
| Residue Penetration @ 77°F | 69 | % Pass #200 | <1.0% |
| | | % Fracture | 60% |

*Figure 2.—Fabric/asphalt macadam trail—Fort Fizzle.*

The specimens were soaked for short periods to simulate saturation conditions normally occurring in trails built level with the surrounding ground and where poor drainage conditions exist. We found that, regardless of cure time, the samples fell apart after slight agitation in water.

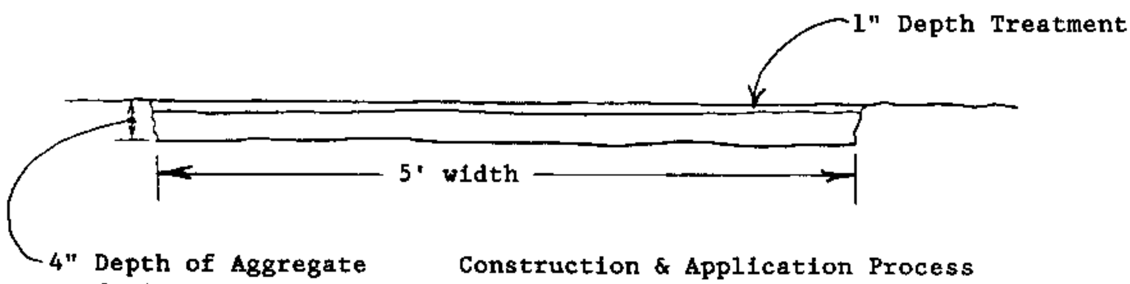
We found similar problems with enzymes on two road construction projects. Although there are conflicting opinions on performance for the road projects, the Regional Materials Engineer and some Forest personnel conclude that there is *no difference* in performance between the sections treated with enzymes and the untreated control sections.

We also conclude that the poor performance of lab samples relates well to poor field performance. Due to short-term weathering/durability problems experienced with lab specimens, and past disappointments on field projects, we do not recommend use of enzyme materials for trail or road construction without preconstruction lab testing.

**ECO-CF Polymer Stabilization—MaClay Flat Trail.** During July 1992, the Missoula District, Lolo National Forest, reconstructed three short trail segments of the MaClay Flat Trail with ECO-CF Polymer. Polymers of this type, which resemble diluted "Elmers" glue, are reportedly a byproduct of the latex paint industry. This trail (figure 3) was originally constructed in 1986 with a clay-aggregate mix.

Three short segments of this trail, where loose coarse aggregate on the surface was causing problems with wheelchair mobility, were reconstructed with ECO-CF Polymer. Although the loose aggregate problem was not solved by using ECO-CF Polymer at the application rates indicated by the manufacturer, the product did last much longer than the control sections treated with water. Moisture from precipitation reduced the stabilization effects significantly. During the reconstruction process, we learned that it is difficult to rework 3/4-inch minus aggregate without creating segregation problems, despite the use of a heavy duty tiller and vibratory compactor. Based on the segregation problems encountered on this project, we decided to use concrete sand from concrete batch plants and dense-graded 3/8-inch minus aggregate from asphalt hot plants for future projects where in-place mixing was required.

**Fabric/Asphalt Macadam Trail—Fort Fizzle Trail.** During August 1992, the Missoula District, Lolo National Forest, constructed a 400-foot-long segment of this trail at Fort Fizzle. The cross-section shown in figure 2 is similar in concept to the fabric/asphalt sand slurry




4" Depth of Aggregate
Surfacing - Dense Graded
% Pass 3/4 100
% Pass #4 46
% Pass #200 16
Liquid Limit: 20
Plasticity Index: 3

Construction & Application Process
Day 1:
Dampen Aggregate Surfacing with water
Till to depth with rear tine Baretto tiller
Spray 10:1 ECO-CF @ 1 gal/SY
Compact with Bomag vibratory drum compactor
Spray apply 10:1 diluted ECO-CF @ .2 gal/SY
Day 2:
Spray apply 10:1 diluted ECO-CF @ .2 gal/SY

*Figure 3.—ECO-CF Polymer stabilization—MaClay Flat Trail.*

constructed in 1991 (figure 1). The change from slurry mixing to pouring asphalt emulsion over a thin layer of pea gravel or 3/8-inch aggregate chips simplified the construction process. After construction, we tried out the trail surface with a narrow hard-rubber-tired wheelchair and found that it performed quite well. We learned the following:

- The treated 2 by 4 border may not be necessary or desirable in all cases. The 2 by 4 border has risen above the ground surface in several areas due to frost heaving.
- The base course is probably not necessary except in very poor drainage areas or where very poor soils exist.
- CSS-1h undiluted emulsion application is relatively simple—it can be pumped with a 2-cycle "water bug" type pump from 55-gallon drums.
- The pea gravel should be lightly rolled with a lawn roller prior to the emulsion application.
- The sand blotter should be placed the day after emulsion application to prevent delayed emulsion curing.
- Loose sand over 1/2 inch in depth should be broomed from the surface.
- Freeze-thaw durability of the surface was evaluated in the spring of 1993 and does not appear to be a problem.

Small lab samples were fabricated with both CSS-1 and CSS-1h asphalt emulsion so comparisons could be made for hot weather rutting resistance. The potential for rutting is greater with CSS-1 because the asphalt is softer than CSS-1h. We concluded that CSS-1 should only be used where temperatures do not exceed 100°F and where narrow hard-rubber-tired wheelchairs are not expected. This comparison was conducted because CSS-1 is more readily available than CSS-1h.

**Soil Sement/ECO-CF Polymer/Road Oyl/Portland Cement-Sand Mix— Trail Test Section.** In late August 1992, the Materials Engineering section constructed 3-foot-long by 4-foot-wide trail segments with these materials behind the Regional Office Materials Laboratory. A description of each section is shown in figure 4. Distributors of the three proprietary/patented products indicated that they had performed well on hard surface trails. The distributors provided construction techniques and application rates for the concrete sand and for the dense-graded 3/8-inch minus aggregate.

The 3/8-inch minus aggregate and the concrete sand were selected as surfacing material because they can be duplicated by most asphalt hot

| Section | Surface Mat'l | Product | Construction Process | Performance - # of Wheel Chair Passes | | |
|---|---|---|---|---|---|---|
| | | | | After 13 day Cure | | After 36 hour Soak |
| | | | | Initial Rutting | 1/2" Ruts | Rutting greater than 1/2" |
| 1 | 3/8" minus Hot Plant Mix Blend 2" Thick | Soil Sement | 1.4gal/sy(5:1) on compacted surface<br>.28gal/sy(5:1) on compacted surface | 50 | 100 | Failed @ 10 passes |
| 2 | | | 2.3gal/sy(9:1) on loosened surface<br>.35gal/sy(5:1) on compacted surface | No ruts evident after 150 passes | | Failed @ 50 passes |
| 3 | | ECO-CF Polymer | 1.2gal/sy(10:1) on loosened surface<br>.25gal/sy(10:1) on compacted surf.<br>.25gal/sy(10:1) on compacted surf. | | | Failed @ 50 passes |
| 4 | | Road Oyl | 3 gal/sy mixed 2" deep, compacted | 10 | 100 | Failed @ 50 passes |
| 5 | | | 2 gal/sy mixed 2" deep, compacted | 100 | 1/4" Ruts @ 150 | Failed @ 50 passes |
| | | Untreated | | 30 | 50 | Impassable |
| 6 | Concrete Sand 2" Thick | Road Oyl | 2 gal/sy mixed 2" deep, compacted | 10 | 20 | Impassable |
| 7 | | | 3 gal/sy mixed 2" deep, compacted | 10 | 20 | Impassable |
| 8 | | Portland Cement | Mix in 12#/SY cement to treat 2 inch depth, compacted | 10 | 100 | Impassable |
| 9 | | Soil Sement | 2.3gal/sy(9:1) on compacted surface<br>1.2gal/sy(5:1) on compacted surface | 30 | 100 | Failed @ 20 passes |
| 10 | | | 2.3gal/sy(9:1) on loosened surface<br>1.3gal/sy(5:1) on compacted surface | 40 | 100 | Failed @ 20 passes |
| 11 | | ECO-CF Polymer | 1.2gal/sy(10:1) on loosened surface<br>.25gal/sy(10:1) on compacted surf.<br>.25gal/sy(10:1) on compacted surf. | No ruts evident after 150 passes | | Failed @ 20 passes |

Notes: Surfacing Material Gradations:

| Sieve Size | #4 | #16 | #200 |
|---|---|---|---|
| Conc Sand | 100% | 67% | 1.1% |
| 3/8" minus | 97% | 51% | 14% |

Significant weed growth through the trail surface was noted where fabric was not placed.

*Figure 4.—Soil Sement/ECO-CF Polymer/Road Oyl/portland cement-sand mix.*

plants or concrete batch plants and their characteristics do not vary as much as native soil. They are easily mixed and compacted, and segregation problems encountered with hand construction techniques are eliminated due to a limited amount of coarse aggregate. Materials were compacted with a vibratory plate compactor prior to treatment and compacted with 14-pound hand tampers after treatment. We felt that hand compaction was a more appropriate method for trail construction, and the method did achieve a tight surface. The test sections were allowed to cure for 13 days without precipitation prior to testing with a loaded wheelchair.

We found that all of the treated sections failed by rutting when subjected to multiple passes of a loaded wheelchair. Some of the trail segments were soaked prior to detecting rutting failures, but, in all cases, failure occurred in the stabilized material. Our general conclusion is that these products, applied at the rates shown, do not provide a long-term stable surface. The following conclusions were made in this investigation:

- The construction fabric placed on the north side of each trail section provided an effective barrier to vegetation damage. Significant weed growth was noted through the trail surface where fabric was not placed.

- Portland cement-sand mix should perform better if mixed in wheel-barrows or other containers rather than on the ground surface.

- The Road Oyl product was not easy to utilize with hand mixing equipment and softened when soaked with water— similar to lab results on materials from several forest road projects. After reviewing the draft copy of this report, the distributor of Road Oyl indicated that the aggregate gradation should be similar to a dense-graded hot mix aggregate with 4 to 8 percent minus no. 200. Because the concrete sand and 3/8-inch minus gradations do not meet this requirement, compaction and curing problems would be expected. If more testing is done with this product, it will be mixed with cleaner dense-graded aggregate from a hot mix plant. (We may also do a comparison section with CSS-1 asphalt emulsion, which is much less expensive and may provide better resistance to moisture damage.)

- Higher application rates of Soil Sement with dense graded 3/8-inch minus deserve further investigation because lab specimens using three times the distributor's recommended rate improved resistance to moisture damage significantly.

- The concrete sand surface material did not perform as well as dense-graded 3/8-inch minus aggregate from a hot mix batch plant.

Based on the rutting failures, we felt none of the alternatives used in this test section would meet the 10-year life objective. Further investigations are planned with some of the products at different application rates, aggregates, and construction procedures.

## Future Work

Another trail test section is currently under construction. This project will consist of a number of short sections of trail using the alternatives listed below and shown in figure 5.

Section 1: Trail Master Trail System with and without fabric underlayment. This product is a thick plastic sheet with 1/2-inch-diameter holes.

Section 2: Fabric/asphalt macadam trail with PVC border.

Section 3: Portland cement-sand mix. This will be mixed in a wheel-barrow and placed on construction fabric.

Section 4: "Stabilizer" with 3/8-inch minus dense-graded aggregate. (This product is manufactured from seed hulls of the plantego plant by Stabilizer, Inc., Phoenix, AZ.)

Section 5: Soil Sement at a high application rate with 3/8-inch minus dense-graded aggregate.

## Recommendations

### Specific

See table 2.

*Table 2.—Specific recommendations.*

| "New" Alternatives | Recommendations/Comments |
|---|---|
| Fabric/Asphalt Sand Slurry | Not Recommended - other similar alternatives being investigated |
| Fabric/Asphalt Macadam with 2x4 border & base course | Not Recommended - Observations of Fort Fizzle planned |
| Fabric/Asphalt Macadam with PVC border | Recommended for small project - investigations planned |
| Enzymes | Not Recommended - Prior lab testing with project materials required |
| EGO-CF Polymer | Not Recommended - additional investigation planned if cost drops |
| Soil Sement | Not Recommended - additional investigation planned |
| Road Oyl | Not Recommended - additional investigation being considered |
| Portland Cement - Sand Mix | Not Recommended - additional investigation planned |
| Trail-Master with Fabric underlayment | Recommended for small project - investigation planned |
| "Stabilizer" (Stabilizer Inc, Phoenix AZ) | Not Recommended - investigation planned |

### General

(1) If a long-term life is desired, do not use proprietary/patented products like EGO-CF Polymer, enzymes, Road Oyl, and Soil Sement without prior lab testing.

(2) Try the fabric/asphalt macadam/PVC alternative on a short forest trail.

(3) Try the Trail Master Trail System on a short forest trail.

(4) Use hot mix for all major facilities until other products are proven by small scale investigations. Emulsion seal and sand the hot mix surfaces to extend their effective life.

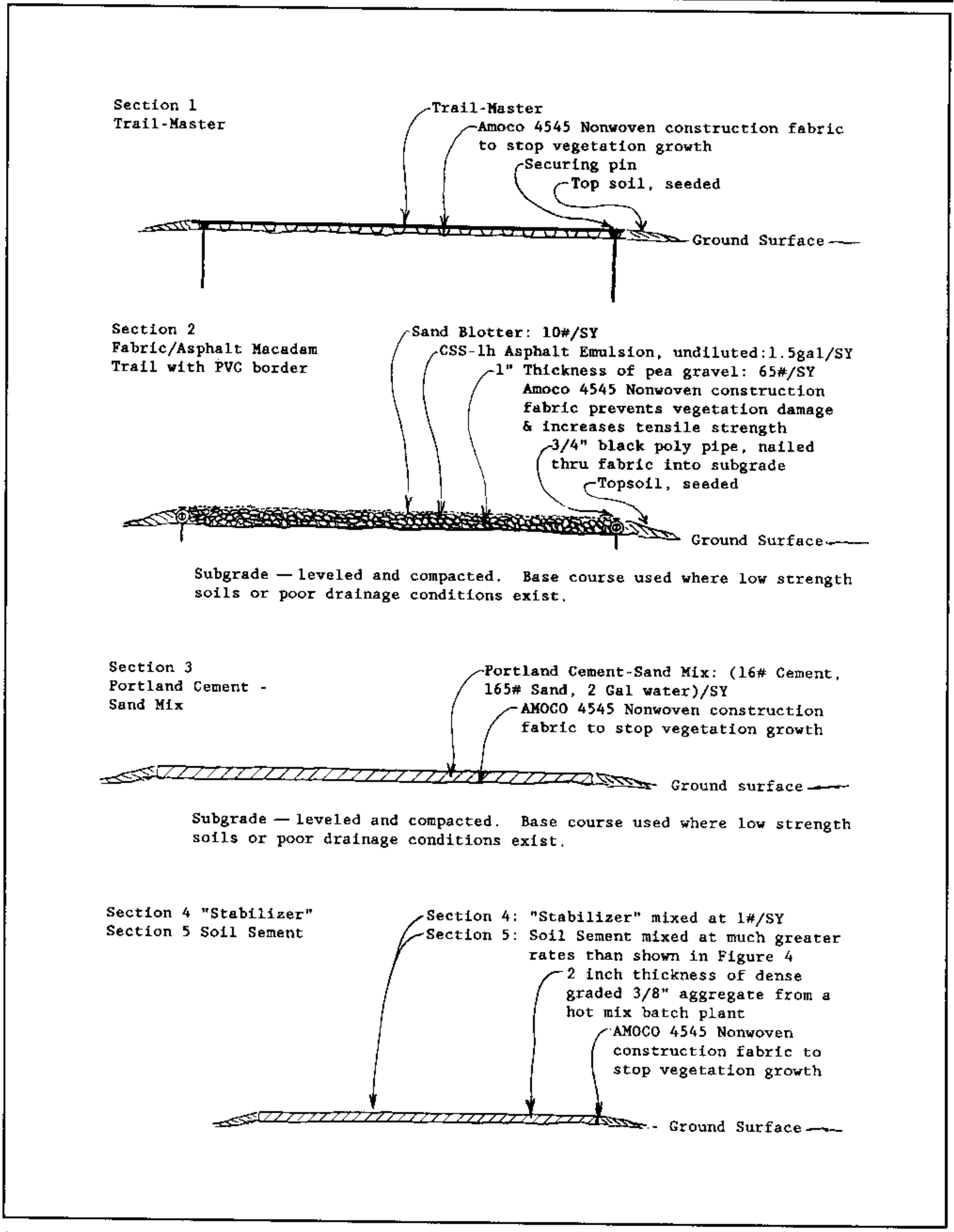



*Figure 5.—Future trail test sections.*

# Modification of GSA Metal Wastebaskets for Use as Seed and Litter Traps

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*Southern Forest Experiment Station*

## Introduction

Seeds collected in traps of known area can be used to monitor the occurrence of natural seedcrops, which are critical to the success or failure of natural forest regeneration. According to Scholtens (1979), the basic performance criteria of seed traps include a well-defined sampling area, positive collection and protection of trapped seeds, and ease of servicing for seed inspection and removal.

Over the years, numerous seed traps have been described in the literature. Easley and Chaiken (1951) utilized a 10.9-square-foot (1/4-milacre) expendable seed trap made of corrugated kraft paper-board to sample loblolly pine (*Pinus taeda* L.) seedcrops in South Carolina. Boe (1955) described the construction of 1-foot-square wire seed traps, which were reported to be as reliable as 10.9-square-foot seed traps when sampling seedfall from western larch (*Larix occidentalis* Nutt.). Jones (1967) modified Boe's wire seed trap by making the sides of the trap from a strip of galvanized sheet metal to increase durability in heavy snowpacks. Allen and Trousdell (1961) monitored loblolly pine seedfall in North Carolina and Virginia with 10.9-square-foot seed traps constructed of wood with window-screen bottoms and hinged tops of 3/4-inch mesh wire. Grano (1971) used 2.2-square-foot (1/20-milacre) seed traps constructed of galvanized hardware-cloth to monitor loblolly and short leaf pine (*Pinus echinata* Mill.) seedfall in southern Arkansas. Grano's seed traps were so durable that Cain (1987) was able to use them for monitoring pine seedcrops 10 years later. Estimates of acorn production from oaks (*Quercus* L.) have been obtained by using bushel baskets with 1.6-square-foot openings covered with poultry netting (Wigley and others 1989).

The problems associated with most of the previously described seed traps are construction cost, availability, durability, and portability. In this article, we describe a container that has been used for monitoring natural pine seedcrops and fine litter production in mixed pine-hardwood stands in Arkansas, Louisiana, and Mississippi for the last 3 years. Components for constructing the seed traps are readily available and highly durable, and the traps are easily transported to the field. Labor cost for assembling individual units is relatively low.

## Seed Trap Design and Construction

The basic component of the seed trap is a round steel wastebasket (GSA catalog number 7520-00-285-5416 or 7520-00-281-5911) that can be ordered from the U.S. General Services Administration Customer Supply Center. These wastebaskets have a 10.5-inch bottom diameter, a 13-inch top diameter, and are 14.5 inches tall. In October 1992, the per unit price was $4.17 for the brown and $4.13 for the gray wastebaskets.

Specifications for constructing the seed traps are provided in figure 1. Additional materials will be needed for preparing the traps and can be purchased at local hardware stores: aluminum window-screen wire ($0.20 per square foot from large rolls), silicone caulk ($3.00 per tube), galvanized hardware cloth with 1/2- or 3/4-inch mesh ($0.40 per square foot for 1/2-inch mesh from large rolls), oil-base spray paint ($3.00 per can), concrete reinforcement rods (3/8 inch by 20 feet, $2.50 per rod), a roll of lightweight galvanized wire to secure the traps in the field, and an electric hand-drill with 1/8- and 1/4-inch drill bits.

The spray paint is applied to inhibit rust wherever holes are drilled into the wastebaskets. This procedure is especially important on the bottom after holes are drilled for drainage. Drainage holes are drilled from the bottom up so that sharp edges are not exposed. Window-screen wire is attached inside the wastebasket to the bottom circumference with silicone caulk.

Stability in the field is achieved by tying the wastebasket to a 24-inch length of concrete reinforcement rod driven into the ground. The trap must be level so that the area sampled is accurate. The top of the rod should be below the rim of the wastebasket so that small mammals cannot gain access by climbing the rod. A wire-basket insert made of 1/2- or 3/4-inch mesh, galvanized hardware cloth (installed about 6 inches above the bottom of the wastebasket) is optional. The insert provides additional protection against access by small mammals, especially when heavy logging slash allows vertical entry to the trap's opening. In poorly drained areas, wooden boards or branches are used to elevate the trap's bottom from the soil surface to promote drying.

## Field Testing

These traps have been in place for a minimum of 3 years on research areas, testing a variety of natural regeneration methods, and are used to collect loblolly and shortleaf pine seeds during the winter months and to monitor pine and hardwood litterfall throughout the year. Consequently, the traps have proven to be quite durable under field use. The only maintenance required over the 3-year period has been minor touchup painting to control rust, and additional silicone has been applied to some traps. Several traps can be nested, one inside the other, to facilitate

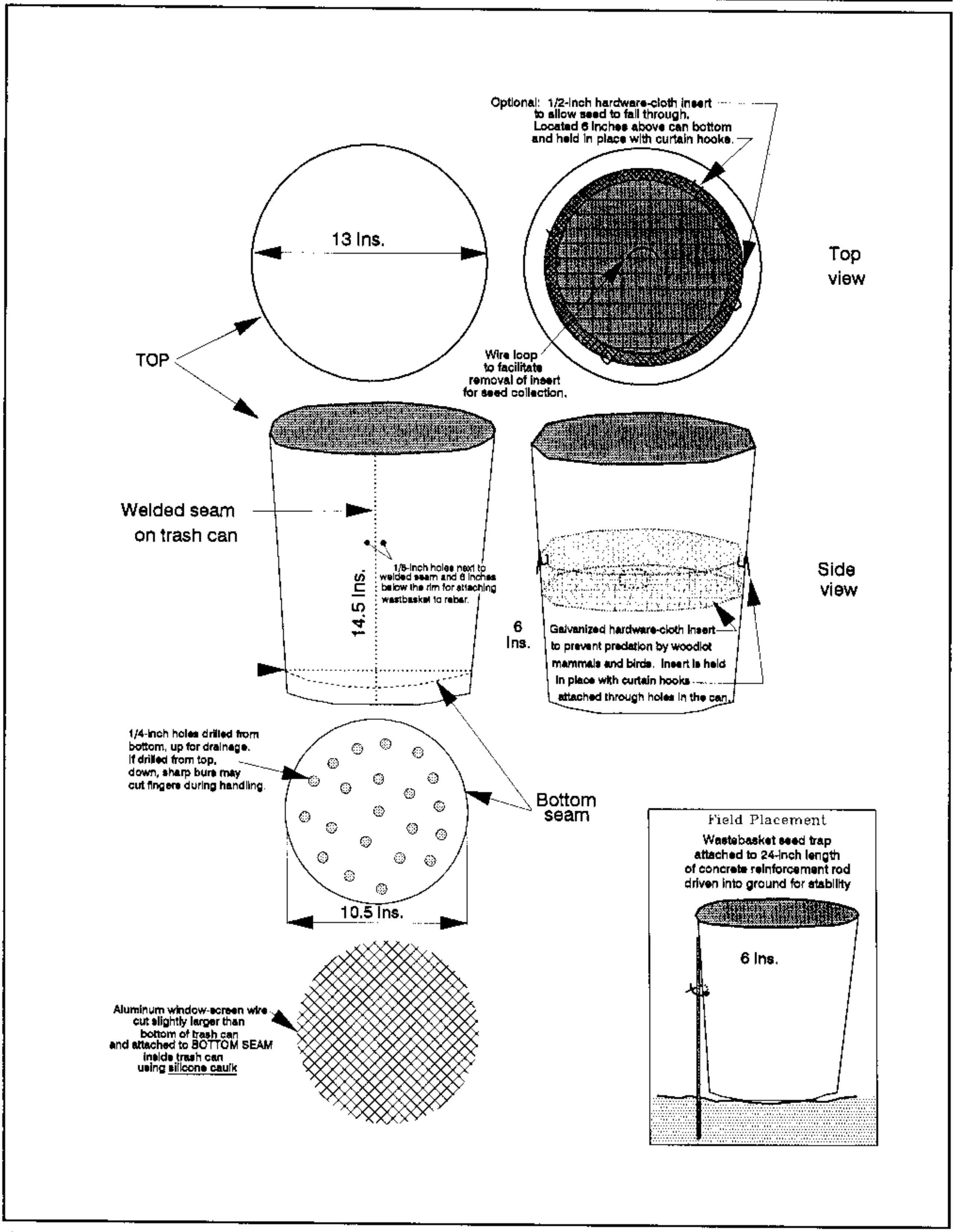


*Figure 1.—Specifications for construction of seed traps using GSA metal wastebaskets.*

transportation to the field. Each trap weighs about 4 pounds, and a backpack frame is used to carry them to remote locations.

Because of the deep-well structure, a month or longer can lapse between inspections for seed collection. We generally make three field inspections to monitor pine seed production: in early October to clean out the traps before seedfall begins, in early December after peak seedfall, and in late February or early March when seedfall is essentially complete. These infrequent collections are an important advantage of this trap over wire-covered seed traps where weekly collections are needed. One week's litterfall on top of wire-covered traps has been found to form an impenetrable barrier to falling seed. Fewer inspections for seed removal lowers the cost of monitoring.

One person can collect the contents of 50 traps located in a 40-acre research area in about 3 hours of field time, but additional time will be required if seeds are to be separated from litter in the field. In studies where only seed production is being monitored, the larger branches and leaves are discarded in the field, and the litter fragments and seeds are transferred to sealable plastic bags for later separation indoors. Collection of seeds and litter is facilitated when the litter is dry and easily bagged.

Opening size for these traps is quite uniform because the GSA wastebaskets are manufactured to strict specifications. The 13-inch top diameter provides an opening of 0.92 square foot, which is comparable in size to the 1-foot-square traps described by Boe (1955) and Jones (1967). The disadvantage of using traps with small openings is that more are needed on an area in order to achieve adequate sampling. However, numerous small traps generally provide better coverage of an area than a few large collectors. In our studies, the coefficient of variation obtained with these traps will typically be in the vicinity of 100 percent for a good pine seedcrop (about 100,000 sound seeds per acre per year). These values may be useful in determining the number of seed traps needed to obtain an adequate sample. For a discussion of sampling design, refer to any statistical textbook (e.g., Steel and Torrie 1960).

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