



Engineering Field Notes

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1996 *Engineering Field Notes* Article Award Winners

Congratulations, *Engineering Field Notes* authors! The votes have been tallied and we are proud to announce our 1996 article award winners:

- Richard Sowa for “A History of the Forest Highway Program”
- Christina Lilienthal for “The Wood River Project”
- Bill Renison and Kathleen Tillman for “Bridges: Some Old, Some New; Some Needed, Some Not”

A very special thanks to those who took the time to vote. It's the only way for you, the audience, to let our authors know that you appreciate their efforts. According to our voters, your articles continue to save the Forest Service time and resources.

Thanks also to all our authors who submitted articles. To continue as a valuable resource to our field personnel, we need people who make the time and effort to share their knowledge, experiences, successes, and even failures. Can you think of a project you worked on, a workshop attended, or other information that may be of value Servicewide? If so, send in an article and maybe next year it will be selected as one of the top *Engineering Field Notes* articles of the year.

Faster, Better Data for Burned Watersheds Needing Emergency Rehab

Henry Lachowski
Program Leader
Remote Sensing Applications Center

Paul Hardwick
Remote Sensing Analyst
Remote Sensing Applications Center

Robert Griffith
Regional Soil Program Manager
Region 5

Annette Parsons
Inventory Specialist
Region 5

Ralph Warbington
Soil Scientist
Region 5, Eldorado National Forest

The aftereffects of a wildfire—flooding, mudslides, erosion, loss of diversity—can be as devastating as the fire itself. Immediately after a large wildfire, the Forest Service requires a quick assessment of watershed conditions to determine whether life, property, or natural resource values are threatened. If the assessment indicates that an emergency exists, rehabilitation measures are prescribed.

Called Burned Area Emergency Rehabilitation, the agency's emergency program gathers information on fire-induced watershed conditions after any fire that has burned more than 300 acres. The inventory, analysis, and rehabilitation treatment prescriptions are completed within 3 days after the fire is controlled; actual rehabilitation begins within a week and must be completed before the first damaging storms of the season.

All treatment alternatives are subject to a least-cost-plus risk analysis to ensure that the prescribed rehabilitation is prudent and efficient. In a severe fire year, such as 1996, millions of dollars are spent on rehabilitation treatments. Other agencies, both within the USDA and in the Department of the Interior, as well as State and local agencies, are developing programs patterned after the Forest Service program for land under their jurisdiction. This is a result of partnerships that emerged in the aftermath of fires in recent years.

Burn-Intensity Mapping

Mapping burn intensity is a critical step in the survey because it determines the potential for flooding and the specific flood sources within the burned area. *Burn intensity* refers to the fire's effects on the watershed, not necessarily to the intensity of the fire as defined by flame height, canopy consumption, or rate of spread. Burn intensity is the key measure of the severity of the fire's impact on the ecosystem (Boudreau and Maus 1996).

Typically, burn intensity has been mapped using a combination of intensive ground measurements (such as effective ground-cover reduction, soil aggregate stability reduction, and hydrophobic soil development) based on a judgment sampling technique followed by overlook point or aerial sketch mapping and additional ground verification.

Such techniques can result in oversimplification and imprecise line placement and delineation of burn intensities. These rough maps are used immediately for calculating area and sediment yield and for locating treatment areas. Although they may be refined as more detailed information becomes available, often the initial maps are digitized and made part of the local geographic information system (GIS) planning databases for long-term recovery planning and subsequent environmental analysis.

Many demands are placed on a burn-intensity map: the fire's effects on the watershed must be mapped quickly and cost-effectively; the map must be accessible both on paper and as a layer in a GIS to the people who assess the watershed and implement the rehabilitation program; and the map should be available at varying scales for visual overlay and display with other resource information, such as watershed boundaries, prefire vegetation, soils, and wildlife habitat.

The critical determination of whether a watershed emergency exists and the magnitude and location of expensive rehabilitation measures are all based in large part on the burn-intensity map. Thus, the better the map, the more effective and efficient this effort becomes.

Improving the Mapping Tools

Various attempts have been made to improve burn-intensity mapping techniques. We tested a variety of sensors, cameras, and videography techniques to determine the best scale, image acquisition platform, and resolution that would meet current needs. We tested our choices in 1996 when a fire burned the Middle Creek watershed on the Mendocino National Forest in northern California. The fire was called the Fork Fire.

We selected a color infrared digital camera (Kodak DCS 420) coupled with a global positioning system (GPS) to image the burned area (figure 1). The digital camera stores the images on a digital disk instead of on film (Bobbe, Hoppus, and Evans 1994). Each image is actually a 1,524 by 1,012 array of picture elements, known as pixels. The camera is mounted in a small airplane that ascends to 12,000 feet above the terrain. Shot from that altitude, each image covers an area approximately 9,100 by 6,060 feet, and each pixel covers an area of about 9 by 9 feet. A new image can be taken every 3 seconds. Images are stored in digital format on a card that can hold about 200 images.

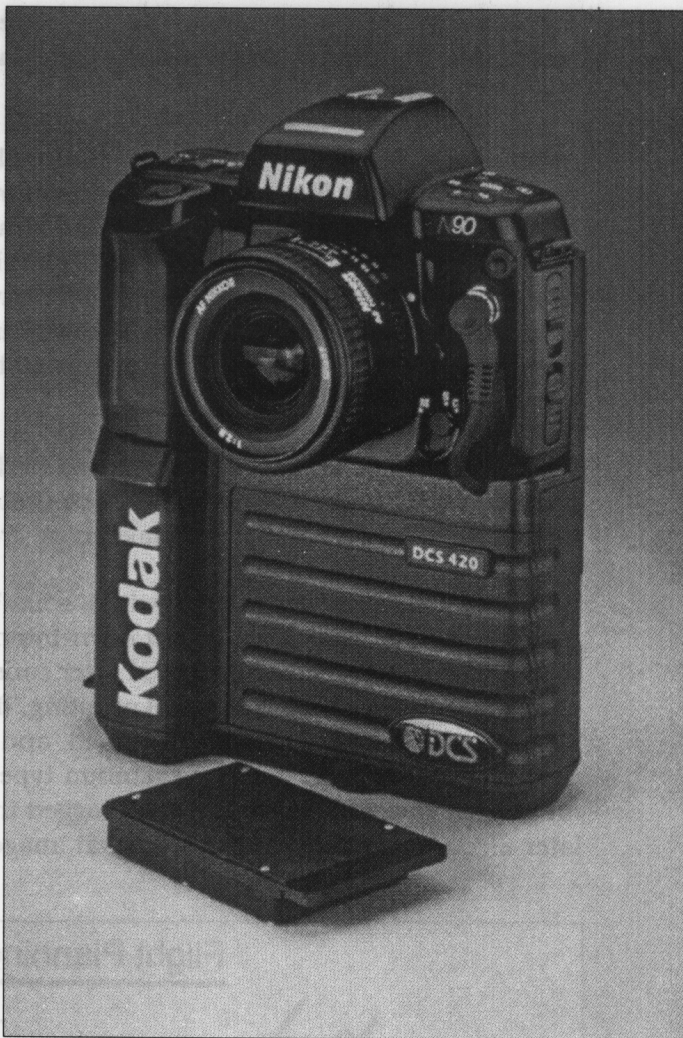


Figure 1. Color infrared digital camera.

A GPS unit captures location information (latitude, longitude, and elevation) to help locate the approximate center of each digital image. The location information is also used to plot flight lines, which can be combined with other GIS layers to determine the relationship of images to landscape features.

The digital camera provided images of the area burned in the Fork Fire. Additional information or base layers, such as prefire vegetation, soils, and topography, were needed to properly map the different burn intensities. These geospatial data already exist in GIS databases maintained by some national forests, Regional Offices, or other land management units. In these assessments, we used the corporate database for the Forest Service Pacific Southwest Region, collected and maintained by the Mendocino National Forest and the Remote Sensing Laboratory in Sacramento (Warbington 1993).

The processing of digital camera images was done at the lab. Processing included georeferencing individual images from the digital camera to a common base and then creating a mosaic of all the frames into contigu-

The Mapping Process

ous coverage for the fire area. The georeferenced image mosaic was projected into the correct coordinate system and datum to be usable with the local GIS database.

As the Fork Fire on the Mendocino National Forest was being brought under control, five flight lines were laid out over a 30,000-acre portion of the Middle Creek watershed. A total of 150 digital camera images were shot from 12,000 feet above ground level. Flight plans were entered into GPS navigation software to assist the airplane navigator and ensure proper coverage. A mosaic consisting of 110 digital images (figure 2) was assembled and registered to SPOT panchromatic satellite imagery; SPOT has resolution of about 30 feet.

While the image acquisition process was under way, burn-intensity mappers, who traditionally would have been sketch-mapping the area from a helicopter, instead had time to make more ground observations.

GPS data collectors were loaded with a soils-based data dictionary to help team specialists record important burn-intensity parameters. Observations included the amount and degree of litter consumed, depth and color of ash, changes in soil structure and soil crusting, fire-induced water repellency, size and amount of live fuels consumed, and site characteristics (such as percent surface rock, prefire vegetation type, slope, aspect, and soil type). All ground observation points were logged in the portable GPS unit for later electronic overlay with the digital image of the burned area.

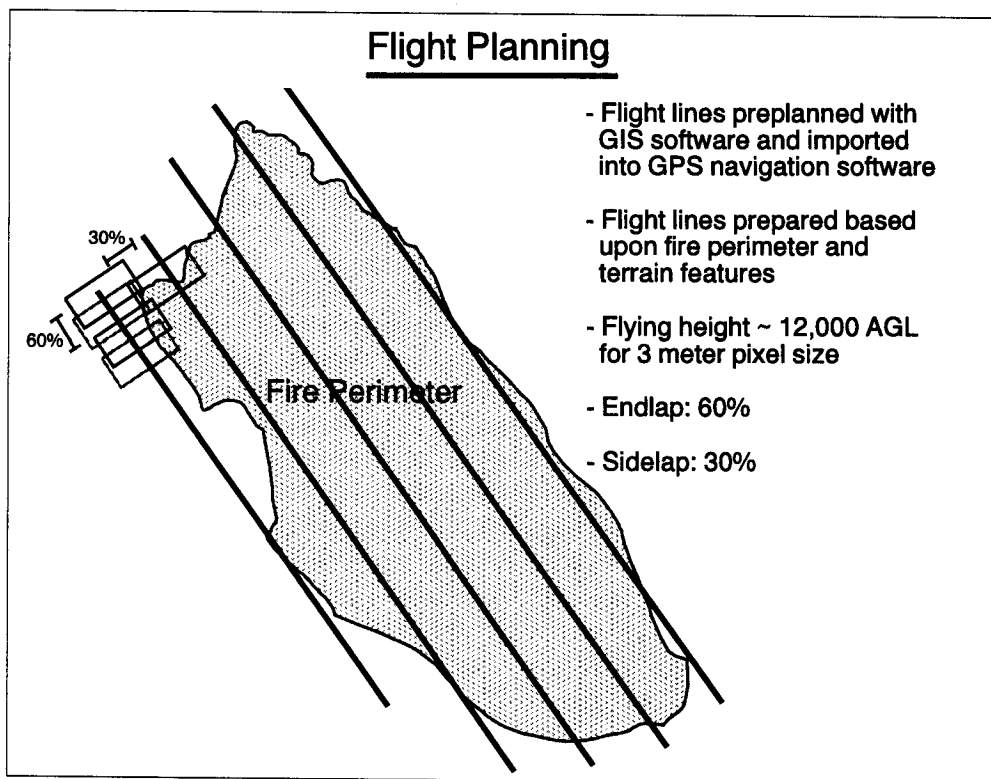


Figure 2. The mosaic of 110 digital camera images was registered to SPOT panchromatic satellite imagery to help create a burn-intensity map for the watershed

percent surface rock, prefire vegetation type, slope, aspect, and soil type). All ground observation points were logged in the portable GPS unit for later electronic overlay with the digital image of the burned area.

Creating the Burn-Intensity Map

The burn-intensity map for the Middle Creek watershed was prepared using a variety of information, including field notes, GPS data points, aerial overview, a mosaic of digital images printed at a scale of 1:24,000, and information from the Mendocino National Forest GIS database on prefire vegetation, streams, and topography. Polygons of burn intensity were manually delineated on the image mosaic (figure 3). A digital version of the mosaic was used on a workstation to observe specific locations in more detail. The minimum polygon size was about 20 acres, with most polygons in the range of several hundred acres.

The process of integrating ground and aerial observations with the digital images produced a map of burn intensity with a higher degree of accuracy and spatial precision than would otherwise have been possible. The ability to interface the digital images with prefire vegetation and topographic information from the GIS allowed even greater accuracy. For example, on the image areas, burned shrub communities looked similar to the severely burned forested areas. Ground observations of representative shrub communities, however, indicated only moderate burn intensity. By using the GIS to overlay the shrub areas on the image, mappers could distinguish moderately burned shrub areas from intensively burned forests.

It was advantageous to have the digital map early in the process. The display of digital data speeded up the process of identifying critical areas within the burn on which to focus the team's limited and expensive field time. The wildlife biologist, for example, could immediately identify how many critical habitat areas burned at high intensity. The hydrologist could quickly calculate the percent of watershed in high burn intensity condition, as well as identify where in the watershed those conditions occurred. The archaeologist could overlay burn intensity with heritage resources. The soil scientist could overlay the burn-intensity map with the GIS data layers of soil erosion groups and slope groups and quickly derive the areas of various burn-intensity-soil-slope combinations. These figures are needed for calculating predicted soil loss, which is part of the program's cost-benefit analysis requirement.

The digital camera work was done in parallel with the regular Burned Area Emergency Rehabilitation effort. As a result, two burn-intensity maps were created—one by the previous methodology, one by the new methodology—and their relative accuracy could be compared. Based on a number of ground observations, a 20-percent improvement in accuracy was realized with the new methodology. This was important for two reasons: first, to protect life and property in areas that may not have been identified as potential flood source areas, and second, to avoid implementing expensive rehabilitation measures on areas that did not require them.

Soil Erosion Models

A burn-intensity map serves as a proxy for cover and runoff factors for use in erosion and runoff models. With soils layer and slope groupings from digital elevation models, it is used in the universal soil loss equation or other models to derive factors for soil cover, soil k-factor, and slope angle. Other factors in the equations, such as slope length and rainfall amount and intensity, are often constant for a given burn area. The result, in acres of the various soil cover, erosion, and slope groups, is output to a database that can quickly calculate the final figures.

This process, currently being done by hand using a planimeter or dot grid, is error prone and can take several hours. The digitally interpreted map provides a quicker, more accurate method to calculate potential erosion and runoff. Until now, emergency rehabilitation of burned watersheds has been hampered by the generality of maps for making site-specific calculations of erosion and sedimentation. For most fire areas a generalized erosion in tons per acre, or sediment generated in tons per square mile for the overall burned area, is calculated. Current erosion and sedimentation computer models help analyze GIS cell-to-cell interactions and generate erosion and sediment routing calculations.

Such models can be used with the GIS database, which itself can now be tied to the digital burn intensity map. This allows the Forest Service to calculate, for example, sediment bulking at specific bridges and culverts within subwatersheds of the burned area.

Efficiency Realized

For emergency rehab work, there are other directions in which the new technology can go as well, but immediate results appear promising. In addition to realizing a 20-percent improvement in mapping accuracy, the Forest Service estimates it saved a quarter of a million dollars on the Fork Fire compared with the previous method, in part because of this test project. The images can be readily acquired and made available through commercial sources. If the new technology is implemented on a wider scale, it may save lives, property, significant resource values, and taxpayer dollars by more precisely and accurately placing emergency treatments in burned watersheds.

Mappers' Checklist

A careful plan is needed to map fire intensities accurately and ensure an efficient rehabilitation process. Well before a fire breaks out, land managers need the following items:

- Access to geospatial data for a potential fire area.
- Computers and other equipment for collecting, processing, and displaying data.
- A team of trained people who can make field observations, collect image data, capture the data and GIS analysis, and produce the necessary prescriptions.
- A mobilization plan to start the assessment as soon as the team can reach the burn area.

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Road Maintenance Frequency vs. Sediment Production

Richard Kennedy
Geotechnical Engineer
Region 4, Bridger-Teton National Forest

Abstract

The subject of road-related sediment has been studied extensively, but few studies have attempted to make a direct tie to the effects of road maintenance on sediment production. Using current research, this paper attempts to show that maintenance frequency may affect road-surface-related sediment production and attempts to quantify the sediment production as a result of reduced maintenance. In 1996 the author developed a road maintenance frequency and prioritization model (Kennedy 1996) for predicting the point at which a road maintenance cycle should be initiated. The model uses the design algorithms contained in *Earth and Aggregate Surfacing Design Guide for Low Volume Roads* (EM 7170-16 1996). The primary criteria for predicting the need for maintenance is rut depth. In addition to rutting and the associated sediment production, there is also the issue of dust control and the effects of not controlling road dust. Judging by this model and current research, it appears that road maintenance done to limit rut development, including dust control, can be justified on the basis of reduced sediment production.

Introduction

The Forest Service maintains more than 560,000 kilometers of unsurfaced and aggregate surfaced roads to access approximately 77 million hectares of forest and grasslands (Foltz 1994). Research indicates that a major source of sediment is associated with roads, particularly poorly maintained roads. This is critical when assessing the effects on water quality and aquatic wildlife. The environmental effects and associated risks of road-generated sediment will depend on the amount of material generated through erosion and the ability of the sediment to reach watercourses.

Generally, road-generated sediment is produced from the erosion of cut and fill slopes, ditches, and the road surface, and can be affected by season of use and traffic. Road-generated sediment can occur throughout the year, although the timing of peak sediment production is a function of the water source and intensity of runoff, that is, direct precipitation, snow melt, thunderstorms, and so forth. This article will focus on road-related sediment originating from the road surface only, and then, only on that sediment affected by road-surface maintenance. This article will not attempt to assess or quantify sediment produced through the process of gullyng that occurs in erosive soils due, primarily, to road grade, a problem exacerbated by the development of surface ruts.

Many factors enter into play when attempting to quantify road-surface sediment including surfacing material thickness and quality (Burroughs and King 1989, Foltz 1994), traffic, grade, climate, operation, maintenance

frequency and quality (EM 7170–16 1996), and so forth. For this reason, sediment production from the road surface can vary significantly, depending on a combination of factors. Although the quantity of sediment generated is site-specific and depends on a number of factors, the effect of rutting on sediment production appears to be nonsite-specific (Foltz 1994). It has been shown that the degree of rutting is proportional to the sediment produced (Foltz 1994, Burroughs and King 1989, Foltz and Burroughs 1990, Foltz 1993). Therefore, the effects of road maintenance done to limit rut development can result in an overall reduction in the quantity of sediment produced.

As indicated, road maintenance frequency has an effect on the amount of rut development in the road surface, but it is important, when developing road maintenance strategies for sediment reduction, to ensure that surface blading is done only when necessary (EM 7170–16 1996). There are indications that, for aggregate-surfaced roads, going from a rut 8 millimeters deep to a rut 32 millimeters deep can increase potential sediment production by as much as 40 percent (Foltz 1994). This could be much greater for native-surfaced roads. For this reason, it is important to be able to accurately predict when the critical rut depth will be reached.

In relation to dust control, it is important to realize that the production of dust shortens the life of the road surface through a loss of surface stability that leads to rutting and other surface damage (Bader 1997). This also results in an increase in the need for surface maintenance. Road dust affects user comfort, road safety, and air quality, and can be a major source of sediment. The potential for dust generation is a function of surface moisture, road surfacing material characteristics, traffic, and maintenance practices, for example, timing of road-surface grading operations, the use or nonuse of dust control, and so forth.

Dust abatement can be either by the use of water (short term and limited in its effectiveness) or some type of chemical surface stabilizer. Surface stabilization serves to bind fine soil and aggregate particles together, thus reducing the potential for erosion of the road surface (EM 7170–16 1996, Bollander 1995). Stabilizing the road surface can have two effects on the potential for the production of sediment: (a) The stabilized surface produces much less dust and, as such, traffic-generated sediment production is reduced; and (b) The stabilized surface tends to rut less than an unstabilized surface, reducing the need for frequent maintenance cycles (EM 7170–16 1996, Bader 1997).

Dust-control agents have been shown to reduce dust production by 50 to 70 percent as compared to no treatment (Bader 1997) and when used along with aggregate surfacing can reduce road-surface sediment production by as much as 80 to 90 percent as compared to an unsurfaced road, depending on the treatment used and specific site conditions (EM 7170–16 1996, Burroughs and King 1989).

When faced with making possible tradeoff decisions, it is important to understand the potential risk associated with alternatives. Because research indicates that road-surface generated sediment can be reduced with the use of dust-control agents, it is important to recognize and under-

stand the possible risks to roadside vegetation and aquatic and terrestrial wildlife associated with the use of dust-control agents. The Forest Service makes extensive use of calcium and magnesium chlorides and ligninsulfonates for dust control. Calcium and magnesium chloride are salts found naturally in brine deposits. Ligninsulfonate is a waste byproduct from the pulp and paper industry (Bader 1997, Heffner 1997). Research indicates that the effect of these dust-control agents on roadside plants and wildlife is negligible at application rates normally used to control dust (Bollander 1995, Heffner 1997).

Results and Analysis

Current research indicates that surfacing a road with a minimum of 150 millimeters of good quality aggregate can reduce the production of sediment by 90 to 97 percent as compared to an unsurfaced road (Burroughs and King 1989). This reduction in potential sediment is realized only in the case of unrutted roads. Rut development increases erosion and sediment production for both aggregate- and native-surfaced roads (EM 7170-16 1996, Foltz 1994, Burroughs and King 1989, Foltz and Burroughs 1990, Foltz 1993). Reduction of rut development can reduce sediment production by 50 to 65 percent for aggregate-surfaced roads (Foltz 1994) and by 50 to 75 percent for unsurfaced roads (Burroughs and King 1989, Foltz 1993), depending on rut depth (Foltz 1994) and specific site conditions. Table 1 shows relative sediment yields for aggregate- and nonaggregate-surfaced roads with and without rutting.

The relative average sediment yields shown in table 1 could be used (with caution) to project the relative effects of reduced maintenance on Forest Service roads. From table 1, it is apparent that a rutted road can produce 200 to 500 percent as much sediment as an unrutted road. Using the sediment production values shown (with caution) and assuming an aggregate surfaced to unsurfaced ratio for roads in the Forest Service road

Table 1. Relative average sediment yields for aggregate and unsurfaced roads with and without rutting from a single simulated storm (kg/m of road length)

Surface Type	Rutted	Unrutted	Rut/No Rut Ratio
Aggregate Surfaced (Foltz 1994)	0.9–1.9*	0.6	150–300%
Unsurfaced (Foltz and Burroughs 1990, Foltz 1993)	8.1–8.3	1.8–3.8	200–500%

*Depending on rut depth

Note: The above values should be used for comparison purposes or rough estimates of potential sediment production only. Sediment production will vary depending on differing site conditions.

system of 25 percent and 75 percent, respectively, the estimated potential sediment reduction, if the roads were maintained to limit rut development, could range from 1 million to more than 3 million metric tons of sediment for a single storm event over the entire road system.

To put this into terms we can better relate to: Maintaining a typical forest's road system (Kennedy 1996) to limit rut development could bring about a reduction in sediment production of 6,000 to 10,000 metric tons for a single storm event over the forest's entire road system. It must be realized that expanding the limited data to project sediment yields for the entire Forest Service road system is not advised unless the goal is to develop relative environmental effects of reduced road maintenance.

Summary

From the available research, it appears that considerable reduction in road surface-generated sediment can be realized with appropriate and timely road maintenance. Using the road maintenance frequency and prioritization model (Kennedy 1996) developed by the author and *Earth and Aggregate Surfacing Design Guide for Low Volume Roads* (EM 7170-10 1996), the road manager can accurately predict rut development and the associated road maintenance cycle frequency to substantially reduce road surface-generated sediment from native- and aggregate-surfaced roads.

Dust control can directly reduce sediment production by binding road surface soil and aggregate particles. It can indirectly reduce the production of sediment by reducing road-surface rutting and the associated need for frequent road-surface maintenance.

Further Study

Very limited data are available to indicate the effects of reduced road maintenance or dust control on sediment yield. To develop this to a level where accurate predictions could be made, it would necessary to conduct long-term tests with varying site conditions.

It may also be beneficial to attempt to quantify the effects of not controlling the development of surface ruts and the gullying that occurs in very erosive soils due, primarily, to road grade. This could be expanded to include the effects of soil type and road grade.

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Lasersoft Instructions

Jeff Moll
Senior Project Leader
San Dimas Technology and Development Center

These instructions assume that the reader has an LTI Criterion 400 survey laser instrument downloading data into Lasersoft and running on either a data recorder or a PC.

Instructions for a simple traverse and cross-section survey routine are illustrated first; other routines are discussed under Options. The instructions aim to acquaint the Lasersoft operator with the system. Proficiency should be attained through practice surveys prior to attempting production work. Many questions will be answered under Options.

A *traverse* is a collection of measurements reducible to 3-D coordinates for a string of points, called *points of intersection* (PI's). *Traverse point*, *section point*, and *PI* are used interchangeably herein for PI's on traverses. This simple routine duplicates standard traverse and cross-sectioning; each PI is sectioned. Slope distance and angles in degrees for both horizontal and vertical control comprise the traverse, while distance and vertical angle measurements only are required for side shots on cross-sections, as the sections are assumed to lie along the traverse angle bisects.

Example 1: Traverse

In this example, the traverse is completed prior to cross-sectioning, and cross-sections are completed in reverse order; the crew traverses in and sections out of the project. This is recommended for a crew of two people.

Setup

Connect both the laser cable and data recorder cable to the laser battery. The order of battery porting does not matter. The data recorder does not draw from the battery; the hookup is for data transmission only. Prior to executing Lasersoft, make a subdirectory in the Lasersoft directory called *travdata*. In the first Lasersoft menu that comes up, highlight Config and press ENTER on the recorder. Pressing ENTER with Laser COM1 highlighted changes COM1 to COM2. Leave the appropriate data recorder COM invoked and arrow down to Decimals, again ENTERing. It is suggested that all precisions be specified to 1 decimal point accuracy.

ENTER through OK, press ESC, and arrow up to File.

1. File—ENTER
2. New—ENTER
3. Key in a file name, example: a123—ENTER
4. Highlight Trav—ENTER

5. Toggle checkmarks on, by highlighting and pressing ENTER, for:
 Trav FS
 Side Shots (Toggle any other checkmarks off)
6. Highlight Begin (or Press B)—ENTER
7. Press ENTER 4 times
8. Traverse Add—ENTER
9. U (Toggles Auto Points ON/OFF; leave ON. U is a quick key, which will be discussed later)

Enter Traverse Data

Bring up the horizontal vector screen on the laser instrument by pressing the POWER button, the down arrow, and the ENTER button twice. Make certain the filter is installed on the receiving (lower) lens of the instrument. Proper rod plumbing, steadiness, and aiming of the instrument are critical for accuracy.

1. The instrument is set up on PI 1, while the reflector assembly is on PI 2. Make traverse measurements between PI 1 and PI 2 by sighting on the reflector assembly target and triggering the instrument. Press ENTER on the laser to download data. The data will flash momentarily on the data recorder screen as the next traverse point screen is brought up and section point is incremented. Repeat for successive PI's.
2. At the last PI, manually key 0 (zero) into the data recorder for FS AZ, FS VI, and FS SD. Press ENTER on the data recorder after each 0. This concludes the traverse.

Example 2: Side Shots

Collect Data

In this example, side shots are measured from far left to far right.

1. Press F4. (F4 is another quick key that brings up the side shot point screen for side shots from the traverse point from which it was pressed.)
2. Make side shot measurements with the laser. Press ENTER on the laser to download.
3. Press A. (A is the quick key to Add the next side shot point screen.) Repeat B and C for any other breaks on the left of the PI.

For side shot measurements to the right, press R for right. Make sure shots on the left have the L button invoked, and shots on the right have the R button invoked.

4. Repeat steps 2 and 3 for any other breaks to the right of the PI.

Note: Pressing A is not required after downloading data for the last break.

5. Press F5. This quick key shows the current traverse point and deletes (removes) the last unused side shot point screen if A is pressed.
6. Press P. This shows the previous traverse point. Remember, the PI's are cross-sectioned in reverse order.
7. Press F4. This brings up the first side shot point screen for this traverse point.

Repeat steps 2 through 7 for cross-sections on each remaining PI on the traverse, except the first. At the first PI, stop after step 5.

This concludes the survey.

Convert and Save Data

Convert and transfer files to the PC:

1. ESC out to the menu headed up by File. Highlight CONVERT and press ENTER.
2. Select the desired format: LUMBERJACK, FLRDS, RDS, ROADCALC, or ASCII COORD, by highlighting and pressing ENTER. Any or all may be selected. Extensions for converted files are .LBJ, .RDS, .RC, and .ACD, respectively.
3. Arrow down to CONVERT and press ENTER. After conversion, press ESC. Prior to transferring files to the PC, copy filelink.exe (included with Lasersoft) into the PC target directory for the data files. Change into this directory and type at the prompt: filelink set comn:9600 (where the "n" is the PC COM port connected to the appropriate data recorder port). Highlight File, press ENTER, highlight Transfer, and either key in the file name (with extension as described above, or wildcard) or ENTER through and tag files slotted for transfer with the T quick key. Then type at the PC prompt: filelink sla, and press RETURN. Answer queries to transfer the files to the PC.

Quick Key Help Menus

Press F1 to bring up the Help Menus from either the traverse point screen or the side shot point screen.

Help Menu for Traverse Point Screen

F3, F4	Remove Last Unused Side Shot		
F3	Add traverse point	I	Insert trav point
F4	Add first new side shot	M	Display memory
A	Add traverse point	N	Next trav point
B	Angle bisect	P	Previous trav point
D	Delete trav point	U	Auto mode toggle
F	Save to file	S	Show current side shot

Help Menu for Side Shot Point Screen

F3, F4, F5 Remove Last Unused Side Shot

F3	Add traverse point	M Display memory
F4	Add first new side shot	N Next side shot
F5	Show current traverse point	P Previous side shot
A	Add side shot	U Auto mode toggle
B	Angle bisect	L Left side select
D	Delete side shot	R Right side select
F	Save to file	T Turn toggle
I	Insert side shot	V Show current traverse point

Options

Setup step 7 states “Press ENTER 4 times.” The first defaults through 1 for the starting section, or PI, and the second for the section increment, also a default of 1. A start section of 10 and an increment of 10 would result in PI’s being numbered 10, 20, 30, and so forth. PI numbers should be assigned in accordance with target design software requirements. The section default is 0.000000, or 0+00. Some designers might prefer the initial PI to be stationed 10+00; for example, in this case key in 1000. The last ENTER simply OK’s these traverse configurations.

Auto Points (U) may be left off in Setup step 9. The next traverse point screen is brought up by pressing A (the quick key for Adding).

Side shots may be made prior to traversing forward by not invoking U (Auto Points) in Setup step 9. The instrument person “Traverse Adds” (Setup step 8) but uses F4 to make and download sideshots prior to traverse measurements forward. This is recommended for crews of 3 or more people.

Side shots can be measured from far left to far right, or from far right to far left, on the cross-section. Use the L and R quick keys to invoke the appropriate button on the side shot point screen.

Auto points (U) may be invoked from both traverse point and side shot point screens.

The N (Next) and P (Previous) quick keys may be used to scroll up and down a stack of filled traverse point or side shot point data screens. Jump to any filled traverse point or side shot point screen in the survey by pressing ESC from the traverse point screen and accessing the Goto option.

Reference coordinates may be input for any section point. Calculated Coordinates may be input for any section point and are used in calculating coordinates for every other point in the survey.

Traverse points may be inserted or deleted in a string of filled screens. Quick keys are I and D, respectively. Subsequent section points and stationing are automatically renumbered. Side shot points may also be inserted or deleted.

Data may be keyed manually into Lasersoft. For example, on a high-order survey, angles may be turned with a transit, converted into azimuths, and keyed into the appropriate line of the traverse point screen.

Foresight or back light traverses, or both, are made by toggling on or off the appropriate choices in the menu that follows choosing Trav from the main menu (Setup step 5). Choosing both results in averaging and provides for error tracking should differences fall outside tolerances. Backsights from the first PI are 0's, as are foresights from the last PI, as shown in Traverse step 3. A closed traverse requires $N + 1$ setups, where N is the number of PI's. PI 1 is the first and last setup.

Turning-point side shots are identified by pressing T, which invokes the turn button in the side shot point screen for the data to the turning point.

The bisect angle (BI) direction may be determined and located by invoking the bisect angle option from the screen at Setup step 8, or by using the quick key B from the traverse point or side shot point screens. Shoot the back azimuth and ENTER, then the fore azimuth and ENTER, as prompted. The BI Left and BI Right azimuths are displayed. Key either angle into the laser instrument and follow the procedure for Target and Aim in the C400 Operator's Guide using the instrument's audible variable-pitch tone feature for direction determination.

Height of Instrument (HI) and Height of Reflector (HR) values may be input by invoking the Inst/Targ Height option. Unique values may be input for each PI; values remain in effect for all measurements made from the PI and subsequent PI's until new values are input. Range/Prism offset values are likewise treated; the value is the horizontal distance in inches from the reflector surface to rod center. Lasersoft automatically adds the value to slope distance measurements.

A Boot Height, or change in elevation of the reflector, may be made to provide sight distance to the instrument person for any traverse shot or side shot. The boot is measured by the reflector person and entered into the appropriate blank in the traverse point or side shot point screen by the Lasersoft operator.

Short notes consisting of up to 16 characters may be keyed in for each traverse point or side shot point. Long notes of up to 76 characters are input for a traverse point by pressing ESC from the traverse point or side shot point menu and invoking the Note option.

The repeating radial survey is performed similarly to the standard traverse and cross-section survey. Azimuths must be tracked on the side shots, however, as side shots may be made in any direction. Lasersoft requires azimuth readings on side shots by checking SS Azimuth in the Survey Type menu at Setup step 5.

More than one line of side shots may be taken at a PI. At the conclusion of one line, press ESC, arrow down to Line Add, and press ENTER. Cross-sections 2 through 9999 are made in a similar fashion to section 1.

Physical numbering allows up to 9999 side shot lines at a PI, each with up to 9999 side shots. Be certain to investigate the capacity of the target design software for side shots and side shot lines prior to surveying. For example, LUMBERJACK with the LUMJK+1 option will accept up to 20 shots—on one line only—at each of 399 PI's. A rough conservative estimate for the capacity of a single project is 6 side shots per line at several hundred PI's. The ASCII coordinate conversion in Lasersoft will reduce up to 100 shots per line; this constitutes a reasonable upper limit.

Additional information on the LTI Criterion 400 survey laser and the Lasersoft program may be obtained from LTI at (303) 649-1000.

Stabilization and Protection of the Cape Creek Shell Midden

Carl Davis
Forest Archaeologist
Region 1, Helena National Forest

Dan Mummey
Forest Transportation Planner
Region 6, Suislaw National Forest

Abstract

Finding ways to stabilize and protect fragile prehistoric heritage sites from the forces of nature and modern human activities is a major site preservation challenge. Because heritage resource sites occur in many environmental settings, successful stabilization requires site-specific resource knowledge and engineering creativity (Thorpe 1991).

Coastal erosion, foot traffic across the exposed midden, and looting by relic collectors prompted the Forest Service to sponsor archaeological investigations in 1991 and 1992 at the Cape Creek Shell Midden (35LNC57) in the Cape Perpetua Scenic Area. In addition to extracting scientific information about Native American use of this archaeological site, a principal project objective was to excavate a vertical face into the shell midden, against which a protective sea wall or buttress could be built immediately following completion of the fieldwork.

All project objectives were successfully met. The Cape Creek site is the first shell midden on the Oregon coast to be intentionally protected by an artificial structure. In view of the fragile and rapidly disappearing nature of this cultural resource type, the details of the Cape Creek site sea wall are described here as a contribution to the limited literature about prehistoric site stabilization and preservation.

Site Setting

The Cape Creek site is situated in a protected cove on a low marine terrace above Cape Creek. The midden extends about 50 feet along the terrace bank and as much as 50 feet inland. Although the midden is not affected by daily tides, its low elevation exposes it to wind and water erosion during winter storms. The terrace is well drained and contains no springs. The midden itself is endangered by the user-built trail to the beach and artifact looter's holes, but it is not in a state of imminent collapse or mass wasting. In fact, the midden is well stabilized by a dense cover of salal, thimbleberry, and other bushy vegetation. A large, wind-shaped shore pine shields much of the terrace from coastal winds and has thus attracted picnickers to the location for many years.

The available literature that was first consulted (cf. Gilbert 1989; Hester and Nickens 1990; Lynott 1989; Thorne 1988, 1990, 1991; Zallar et al. 1979) did not contain structural plans or designs for a buttress or retaining

wall that suited the site conditions. Our efforts were further constrained by the need to develop a visually unobtrusive, if not appealing, structure within the scenic area. In fact, the shell midden is located directly adjacent to several heavily used trails that provide access to the nearby and very popular Cape Perpetua Visitor Center, several vista points, tidepools, and beach. A scientific concern was to build a sea wall or buttress that could be removed in whole or in part should additional archaeological investigations be undertaken at the site. Ultimately, one of the authors (Mummey) designed a buttress that met the site conditions and design criteria (figure 1).

Buttress Design

Following the completion of the archaeological investigations, forms for pouring concrete were built along the entire base of the shell midden using 2" x 4" dimensional lumber, wire, and rebar (figure 2). The 2-foot-wide forms were reinforced with horizontally laid 5/8-inch diameter (#5) rebar. The horizontal rebar was tied to 5/8-inch diameter rebar set at 2-foot intervals on-center inside the wooden forms. A total of 20 pieces of rebar, ranging from 8 to 16 feet in length, were vertically embedded in the sandstone below the footing to depths of 1 to 2 feet, using a maul. The vertical rebar was carefully laid against the midden until the concrete was cured, then was bent back into vertical position.

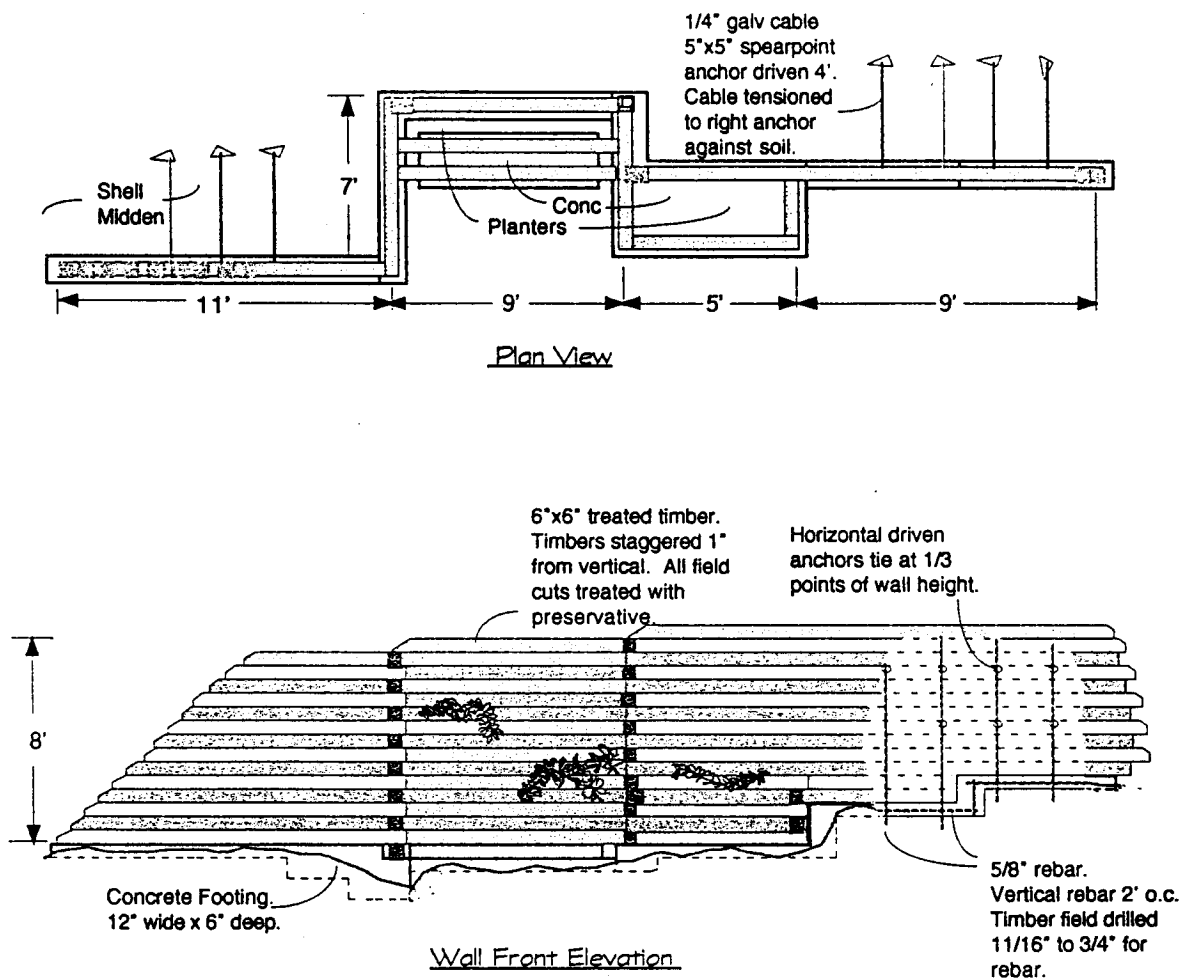
A motorized wheelbarrow was used to transport bags of Sacrete and aggregate via a paved trail to the construction site. The concrete was mixed in a large tub onsite, using a long water hose connected to a Forest Service recreation facility (Devils Churn) on the slope directly above the project area. Concrete was poured into the continuous-spread footing to a thickness of about 1 to 1.5 feet. The concrete footing was allowed to cure for 2 days before sea wall construction was begun.

Because shell middens are typically friable and subject to collapse, our next concern was to develop a barrier that would keep the original midden face intact next to the buttress. This was accomplished by covering the midden face with heavy filter cloth and visqueen plastic. It was initially thought that the visqueen might prevent effective water drainage through the midden face, thus adversely affecting the archaeological deposits. However, close inspection of the terrace showed that hydrostatic pressure would be relieved at both ends of the sea wall.

During actual construction (described below), the intervening space between the filter cloth and visqueen and the timbers was filled with beach sand mixed (5 to 10 percent) with cement. The backfill was firmly tamped. As the sand and mortar took on moisture, the backfill actually set, forming a cast next to the filter cloth and visqueen that held the original midden profile firmly in place.

The buttress is composed of five interlocking walls made of the rebar, dimensional lumber, and metal soil anchors. Pressure-treated, rough-cut (Douglas fir) timbers (6" x 6") were pre-cut in the recreation facility parking lot and handcarried by two people to the construction site. The lumber was cut to the proper length and holes were drilled through each beam to accommodate the vertical rebar. With a three-person crew, the timbers were then laced through the vertical rebar and stacked directly atop each other.

Cape Creek Shell Midden Buttress



SCHEDULE OF ITEMS

Footing - reinforced concrete	90 lb sacrete	50 ea.
Wall - treated timber	6"x6"x20' D.F.	50 ea.
Vertical Reinforcement	#5 st'l rebar	320 LF
Tie-back Reinforcement	galv st'l cable/anchor	12 ea.
Backfill	sand & 10% cement mix	10 CY
Membrane (separation of materials)	6 mil plastic	500 SF
Topsoll	landscape & planters	20 CY

Figure 1. Design of the Cape Creek Shell Midden buttress



Figure 2. Concrete footing and vertical rebar constructed at base of prehistoric shell midden, is denoted by white shells and darkened soil behind rebar

The buttress is 15 timbers high. The treated, cut ends were staggered so that all corners interlocked and had vertical rebar through the joints. Every other timber was recessed 1 inch to provide visual texture by breaking up an otherwise smooth appearance. In addition, three planter boxes were incorporated into the sea wall to add structural strength and to provide bedding for eventual vegetation cover. The planter boxes were made by extending the timber members of the vertical wall as it was constructed.

When the buttress was at one-half and two-thirds its design height, horizontal soil anchors were tied into the structure. The anchors, composed of galvanized cable and standard spear-point ends, were driven horizontally into intact midden/terrace soil at a 4-foot distance from the retaining wall. At both wall heights, the anchor system was bolted to the wall at 4-foot intervals, but the horizontal spacing was staggered between the two levels. The anchors were put under 7,000 pounds of tension each. Once the anchor systems were in place, the area was backfilled with sand and dirt. Anchors were not added to the center wall because its boxed-in configuration would naturally resist movement.

The buttress was raised to a vertical height approximating the natural ground surface of the terrace. The area between the wall and the excavated midden area (above the anchor systems) was further backfilled so that the entire midden was capped by soil. The area above the buttress was seeded with grass. The three planter boxes incorporated into the wall were planted with native salal (*Gaultheria shallon*). Boulders and driftwood were placed around the base of the newly completed structure to soften its somewhat stark appearance (figure 3). Stones from the creekbed below the midden were mortared into place at the wall ends to help contain the backfill.

The project was completed by a work crew ranging from two to six people over a 7-day period. It took about 2 days to complete the concrete footing work and 5 days to build the buttress wall. The most arduous labor involved the transport of lumber, Sacrete, rebar, and tools to the site. The total cost of the project was approximately \$5,000, including materials (\$3,000) and labor (\$2,000).

Conclusion

The Cape Creek site sea wall has survived two Oregon coast winters without incurring any damage, although neither season has witnessed exceptional winter storms. The buttress timbers are now weathered and blend more naturally into the ocean landscape of the Cape Perpetua Scenic Area. Grass, salal, and other vegetation are well established atop the buttress and within and below the planter boxes. A small interpretive sign has been placed on the buttress. The picnic area atop the midden and under the craggy shore pine has been removed. An alternative trail to the beach is now routed around the midden area. No recent signs of artifact looting have been observed at the Cape Creek Shell Midden.



Figure 3. Completed sea wall at Cape Cove Shell Midden

placed on the buttress. The picnic area atop the midden and under the craggy shore pine has been removed. An alternative trail to the beach is now routed around the midden area. No recent signs of artifact looting have been observed at the Cape Creek Shell Midden.

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This bibliography contains information on publications produced by the Washington Office Engineering Publications Section and the Technology & Development Centers located in Missoula, Montana, and San Dimas, California. Arranged by series, the list includes the title, author or source, document number, and date of publication.

This issue lists material published since our last bibliography (*Engineering Field Notes*, Volume 28, September–December 1996). Copies of *Engineering Field Notes*, *Technology & Development News*, and Engineering Management Series documents are available to Forest Service personnel through the Engineering Staff Technical Information Center (TIC). Copies of *Tech Tips*, Project Reports, and Special and Other Reports can be obtained from the Technology & Development Center listed as the source. Copies of *Remote Sensing Tips* can be obtained from the Remote Sensing Applications Center.

Forest Service—USDA
Engineering Staff
Technical Information Center
201 14th Street SW
Washington, DC 20250

Forest Service—USDA
San Dimas Technology & Development Center
444 E. Bonita Avenue
San Dimas, California 91773

Forest Service—USDA
Missoula Technology & Development Center
Fort Missoula, Bldg. 1
Missoula, Montana 59801

Forest Service—USDA
Remote Sensing Applications Center
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Engineering Field Notes (EFN)

This publication, which is published every 4 months, provides a forum for the exchange of information among Forest Service personnel. It contains the latest technical and administrative engineering information and ideas related to forestry.

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1996 <i>Engineering Field Notes</i> Article Awards	Editor. EFN 29 (January–April 1997): 1–4.
1996 <i>Engineering Field Notes</i> Article Award Winners	Editor. EFN 29 (September–December 1997): 1.
1997 Forest Service Engineers of the Year	Editor. EFN 29 (January–April 1997): 5–18.
Bibliography of Washington Office Engineering and Technology & Development Publications	Editor. EFN 29 (September–December 1997): 27–35.
Construction Certification Program	Styer, Brenda. EFN 29 (January–April 1997): 45–49.
Faster, Better Data for Burned Watersheds Needing Emergency Rehab	Lachowski, Henry; Hardwick, Paul; Griffith, Robert; Parsous, Annette; and Warbington, Paul. EFN 29 (September–December 1997): 3–9.
(The) KISS System Outwits Beavers: A Success Story From the Town of South Bristol	Nuggets & Nibbles. EFN 29 (May–August 1997): 41–42.
Lasersoft Instructions	Moll, Jeff. EFN 29 (September–December 1997): 15–19.
New Facilities Program at the Missoula Technology and Development Center	Oravetz, Steve. EFN 29 (January–April 1997): 29–33.
Restoration of the Historic Vierhus Playhouse	Peacock, Cherie. EFN 29 (January–April 1997): 21–29.
Retaining Wall With an Eye on the Past	Freel, Robert L. EFN 29 (May–August 1997): 13–20.
Road Maintenance Frequency vs. Sediment Production	Kennedy, Richard. EFN 29 (September–December 1997): 11–14.
Stabilization and Protection of the Cape Creek Shell Midden	Davis, Carl and Mummey, Dan. EFN 29 (September–December 1997): 21–26.
Stress-Skin Panel Construction of a Small Cabin	Hebrandson, Gerald. EFN 29 (May–August 1997): 29–39.
Sustainability—Building Green for Both Humans and the Environment	Jones-Crabtree, Anna J. EFN 29 (May–August 1997): 21–28.
Washington Office Engineering Staff	Editor. EFN 29 (May–August 1997): 1–12.

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Dust-Abatement Compounds

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Davis, Carl and Mummey, Dan.
EFN 29 (September-December
1997): 21-26.

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Restoration of the Historic
Vierhus Playhouse

Construction Certification
Program

Technology & Development News

Technology & Development News contains information on specific projects, ideas, and technologies being developed by the Technology & Development Centers to help solve many resource management problems.

Title	Issue
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New GPS Equipment Test Course	November–December 1997
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Guidelines for Digital Base Map Updates (August 1997)	Part of EM 7140-14
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Remote Sensing Tips

Remote Sensing Tips are brief descriptions of specific remote sensing projects involving new equipment, techniques, materials, or operating procedures.

Title	Number
Burned Area Emergency Rehabilitation (BAER) Use of Remote Sensing and GIS (August 1997)	RSAC-7140-1
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Mapping and Monitoring Noxious Weeds Using Remote Sensing (September 1997)	RSAC-7140-2

Tech Tips

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Title	Source	Number	Date
Alternatives to Tracer Paint	SDTDC	9724-1302	3/97
ATV Utility and Gravel Trailer	MTDC	9723-2310	2/97
Containment Systems for Small Volume Retardant Spills	SDTDC	9751-1304	7/97
Crosscut Saw Guards	MTDC	9723-2341	10/97
Cruiser's Gear Carrying System	MTDC	9724-2302	1/97
Demonstration of the Aventechn Aircraft Mounted Meteorological Measurement System	MTDC	9734-2323	5/97
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Wide Area GPS Enhancement (WAGE) Evaluation	MTDC	9771-2327	8/97

Project Reports

Project Reports are detailed engineering reports that generally include procedures, techniques, systems of measurement, results, analysis, special circumstances, conclusions, and the rationale for recommendations.

Title	Source	Number	Date
Logging With Air-Cushion Vehicles	SDTDC	9724-1201	3/97
Operational Evaluation Test Report for Phos-Chek Fluid Concentrate Fire Retardants	SDTDC	9751-1204	1/97
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CTI Service Bulletin No. 1	SDTDC		8/97
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MTDC 1996 Documents (Brochure Order Form)	MTDC	9771-2818	4/97
Nonchemical Seed Tree Orchard Sanitation—ASAE Publication No. 71053	MTDC	9724-2828	1997
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VALDRIFT—A Valley Atmospheric Dispersion Model with Deposition, Ninth Joint Conference on the Applications of Air Pollution Meteorology with A&WMA	MTDC	9634-2822	1997
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Wildland Fire Safety and Health References	MTDC	9751-2834	8/97

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Inquiries	Regional Information Coordinators should send material for publication and direct any questions, comments, or recommendations to the following address:			

FOREST SERVICE—USDA
Engineering Staff—Washington Office
ATTN: Sonja Beavers, Editor
Kitty Hutchinson, Assistant Editor
201 14th Street SW
Washington, DC 20250
Telephone: (202) 205-1421

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