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Engineering Technical Information System

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Engineering Field Notes

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Letter From the Chief



United States
Department of
Agriculture

Forest
Service

WO

Reply to: 1320

Date: JAN 15 1987

Subject: Technology Transfer--Engineering Field Notes

To: Regional Foresters, Station Directors, and Area Director

One of the best tools we have for fostering technology transfer and improving our effectiveness as resource managers is open communication with our co-workers. A good way to achieve this open communication is by using some of the excellent print media that are available within the Forest Service.

One example of effective use of the print medium is Engineering Field Notes (EFN). Engineering Field Notes has been helping Engineers and Engineering Technicians share their professional experiences Service-wide since 1969; it has given colleagues--who have never met--the opportunity to learn from one another and has enlarged the stock of engineering-related ideas and experiences Service-wide. I am certain that the Forest Service has saved substantial time and money over the years through the efforts of those who have authored and read EFN articles.

I urge all Forest Service units to continue to read and "feed" EFN. In these belt-tightening times, it is important that we share as much of our professional skills, experiences, and ideas as possible. Engineering Field Notes has proven to be a good way to do that.

R. MAX PETERSON
CHIEF



ERRATA

Engineering Field Notes would like to give belated credit to Geophysical Survey Systems, Inc., for furnishing all of the illustrations used in "Ground Penetrating Radar: A Review for Resource Managers," (Author: Jerry D. Greer, Nationwide Forestry Applications Program) Engineering Field Notes Volume 18, September-October 1986.

The credit line was inadvertently omitted when the article was published.

--Editor

Some Thoughts on Professionalism

Ted Zeally

*Chief Transportation Preconstruction Engineer
Washington Office Engineering*

CONCEPTS of PROFESSIONALISM

As I visit with associates around the Forest Service, I sense, at times, a feeling of discomfort and concern. All of us--foresters, engineers, biologists, and many others, both "professional" and technician--are working at a time when we cannot do all that we think should be done to manage "our" National Forests. Limitations of personnel and budget preclude our doing what we perceive to be a professional job. With the call for reduced standards, some may even feel that our leaders do not want a professional product.

I recently read an article by Samuel P. Huntington, a Harvard professor, that may help us put our concepts of professionalism in proper perspective and help us hold our heads a little higher. Huntington defined professionalism within the bounds of three concepts: expertise, responsibility, and corporateness.

Expertise

"The professional . . . is an expert with specialized knowledge and skill in a significant field of human endeavor."

Responsibility

"The professional . . . is a practicing expert, working in a social context, and performing a service . . . that is essential to the functioning of society."

Corporateness

"The members of a profession share a sense of organic unity and consciousness of themselves as a group apart from laymen. This collective sense has its origins in the lengthy discipline and training necessary for professional competence, the common bond of work, and the sharing of a unique social responsibility."

WITHIN the FOREST SERVICE

As you consider your job within the Forest Service, are you not better qualified to perform your job than someone outside our organization? Whatever a

person's specific job may be, that person is part of a professional organization having a corporate body of very specialized knowledge and skill. And I hope we all share the belief that managing "our" National Forests for ourselves and, most importantly, for more than 200 million clients, is a significant human endeavor.

We may not now be able or required to apply all the skill and knowledge that we have developed over the years. The doctor that you visit when you have a cold may have the skill and knowledge to remove your appendix; is that doctor less a professional for giving you only the treatment you need to cure your cold? Certainly you justifiably could accuse that doctor of unprofessional conduct were he or she to remove your appendix when it was unnecessary. Our "clients," inside and outside the Forest Service, now are only asking us to use an appropriate level of our professional skill and knowledge as we do our part in managing the National Forests. We are no less professional now than when we were called upon to exercise different aspects of our professionalism.

Certainly all of us are performing a service to society. Service to society is a key aspect of professionalism. When a doctor ceases to serve society in an acceptable manner, that doctor is no longer authorized to practice, regardless of prior skill or knowledge. Our National Forests are an important asset and heritage to manage and protect for citizens. Many of us are called upon to serve in difficult areas and under uncomfortable and even dangerous conditions. We are motivated by values and ethics somewhat peculiar to our professional organization.

And do not we all belong to that corporate body called the Forest Service? Forest Service employees certainly fit the last of Huntington's criteria, corporateness. Huntington would classify us as a "bureaucratic profession," one that renders "collective service to society as a whole." We do not serve society fully by practicing our individual professions independently. We provide the greatest service to society as we act corporately and collectively.

OUR OWN ATTITUDES

It all comes down to our own attitudes about ourselves and the jobs we have. If we recognize our expertise, responsibility, and corporateness, we can

readily see that we continue to provide the professional service that has so long been the hallmark of the Forest Service. If we approach our tasks professionally, then we shall remain, in spite of the particular task we may be called upon to do today, professional.

RTIP Update

Ted Zeally

*Chief Transportation Preconstruction Engineer
Washington Office Engineering*

RTIP 5, CLEARING & GRUBBING

Issue 1 is selecting the lowest cost slash disposal method consistent with management needs; and Issue 2 is selecting minimum clearing limits consistent with management needs.

Action Items 5-1-1, 5-1-3, and 5-2-1, 5-2-3 dealt with selecting the lowest cost slash disposal options and clearing limits consistent with management needs. In April 1986, the Washington Office sent a 7700 letter to Regions outlining systematic methods to make such selections. Art Marty and Jack Weissling subsequently published articles covering these topics in Engineering Field Notes.

The Roads Productivity Improvement Team also emphasized these issues in their report to the Chief in October 1986. The final PIT Report should be sent to the field early in 1987.

Action Items 5-1-2 and 5-2-2 required the revision of Activity Evaluation Standards (FSH 7109.52) to include evaluation criteria covering the systematic selection of low-cost slash disposal options and clearing limit widths. A proposal was developed and submitted to the Regions for comment in May 1986. Based on field input, the final draft revision was changed to include the systematic selection of all road design standards in the activity evaluation standards for Preconstruction. The amendment to FSH 7109.52 was signed by NFS in November 1986.

Buffalo Pass Turnkey

*Jerry Lancaster
Contract Officer's
Representative
Steamboat Zone
Routt National Forest*

*Wayne Hamilton
Zone Engineer
Steamboat Zone
Routt National Forest*

INTRODUCTION

In February 1985, the Steamboat Engineering Zone of the Routt National Forest was given the opportunity to prepare and administer what we think is the first "Turnkey" road construction project in the Forest Service.

A "Turnkey" project is one that is designed, constructed, and inspected by the contractor. The contractor completes each phase of the project and submits the work for approval by the Forest Service. The contractor submits inspection reports and test results to the Forest Service Engineer, and the Forest Service performs compliance testing and inspection as necessary.

BACKGROUND

The Buffalo Pass Road was chosen for this project because of its heavy recreation use. This road provides access to several lakes and campgrounds, and it serves as a major access point to the Mount Zirkel Wilderness Area. At its beginning at the edge of the city of Steamboat, Colorado, the road provides access to several homes. It was a single-lane road with a surface width of approximately 14 feet, and the road had severe drainage problems. All of the fine aggregate material had washed away from the surface, leaving large rocks protruding through the subgrade.

REQUIREMENTS

Under the contract, the existing road was widened to a 26-foot-wide subgrade plus necessary curve widening, and 8 inches of compacted gravel was applied. This project was one of the Routt's most difficult road construction jobs because of its use and nature of construction. Several thousand cubic yards of rock required drilling and blasting (see figures 1 and 2). Much of the drilling and blasting had to be done adjacent to existing homes along the



Figure 1.--Typical rock section during early stages of construction.

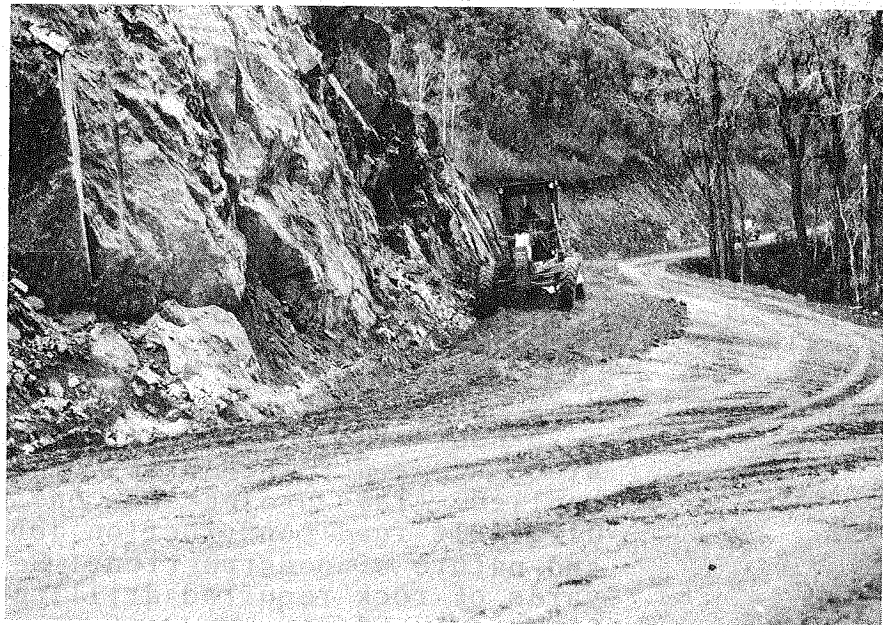


Figure 2.--Typical rock section during final shaping of subgrade.

roadway. Existing driveways had to be maintained, power and telephone lines had to be replaced, and traffic delays could not exceed 1 hour at a time.

BIDDING PROCESS

Unlike other road construction projects, which have several bid items, this project had only one: The Design, Construction Staking, and Construction of 3.0 miles of road. The Method of Measurement was Lump Sum.

The Engineer's Estimate on this job was \$464,000. There were five bidders, with bids ranging from \$420,000 to \$539,000. The job was awarded to Richmond Construction from Grand Junction, Colorado, for \$420,000. After five change orders, the final contract amount turned out to be \$428,113.

DESIGN

The contractor was required to submit a resume for the engineering firm he planned to use. The engineering firm had to have had a minimum of 5 years of road design experience, including at least two design projects in mountainous terrain.

The design criteria and warrants were specified in the contract and the design was submitted at various stages for Forest Service approval. When the design was complete, a plans-in-hand was done in the field before approval. This plans-in-hand step is critical, because once the plans are completed and approved, all design changes will result in cost adjustments. It is also very important to include the prime contractor (not just the designer) during the review process, to make the prime contractor aware of any changes in the design.

The engineering firm for this project asked for and received our survey notes and visited the project before bidding. They plotted up a cross section every 1,000 feet in the common material and every 500 feet in the rock. They then offered preliminary quantities and an engineering quote for the design, construction staking, and construction inspection to the prospective bidders, provided that the bidder would lock them in at their quote. The successful bidder was the only bidder to agree to this, and thus was the only bidder to have access to these preliminary quantities. This information was the key to the successful bid.

CONSTRUCTION STAKING

Construction staking was accomplished by the same engineering firm after the approval of the design. (We recommend that the staking be done after the preliminary approval but before the final approval of the plans. This step allows physical review of the stakes before acceptance of the design.)

QUALITY CONTROL

The contract required quality control by the contractor. This involved sampling and testing and road inspection. A quality control plan was required that included authorities, responsibilities, and experience and qualifications of inspecting and testing personnel. The contractor had to submit the plan 5 days before beginning work. It was the contractor's responsibility to maintain and keep current all records of inspections and tests performed. All documents were provided to the Contracting Officer's Representative for review.

CONSTRUCTION

All work was performed during the summers of 1985 and 1986. The job was accepted on July 30, 1986.

CONCLUSION

The "Turnkey" concept is ideal from the standpoint of staffing for the "valleys" in workload and still being able to cover the "peaks." It also is a reasonable solution to an "emergency" job--one in which the construction must be completed in a short period of time. The job can be offered as a "Turnkey" and thus eliminate 2 years of preconstruction engineering time--a significant time savings. A significant cost savings was not apparent on this job; however, we believe that contractors will submit lower bids on difficult projects if they can tailor the design to their available equipment and manpower.

For more information, contact Jerry Lancaster or Wayne Hamilton at 8-303-879-1722.

Valle Vidal Global Positioning System (GPS) Demonstration Project

*Dennis J. Mouland
Regional Land Surveyor
Southwestern Region*

INTRODUCTION

In 1982, the Pennzoil Corporation donated 100,000 acres to the Carson National Forest in northern New Mexico. Initial surveying and engineering work was done to provide maps, legal descriptions, easements, and road construction. It was discovered that the area was very poorly covered by the national geodetic reference system. The adjoining Questa Ranger District also was poorly covered. These factors greatly limited various operations on the Valle Vidal unit, especially in mapping and survey operations.

In fiscal year 1986, the Washington Office provided Land Line Location funds for Global Positioning System (GPS) demonstration projects. Region 3 obtained \$25,000 and decided to conduct a geodetic control densification project in the area of the Valle Vidal Unit. The total project area included approximately 1,200 square miles. Within that area, only five existing triangulation stations were known at the time.

PROJECT PREPARATION

Because of the limitations with the GPS receivers regarding interference from trees and other obstructions below 20 feet above the horizon, the project site was a good choice. All stations were close to or above the tree line and were never near any man-made objects. All stations would be set on mountaintops or ridges where no clearing would be required.

The project site is in rugged mountainous country with elevations ranging from 8,000 feet to more than 13,000 feet. The average elevation for the new stations was 10,500 feet. All stations were accessible only by helicopter. In May 1986, a crew went in for 3 days and toured the entire project area to select new station locations and verify existing monumentation.

Actual monumentation of the new stations was delayed until July, when most snow cover was gone. Stations were set using precast concrete monuments placed into fresh cement in excavated holes. Three stations conveniently fell on bedrock and were marked by brass disks epoxied to the rock.

Specifications were written to acquire the actual GPS services. Although price was a major factor, a set of evaluation criteria was established to make sure firms had appropriate experience. GPS surveying is a relatively new technology and very few engineering or surveying firms have ever tried it.

The criteria required the firm to have experience in GPS, experience in geodetic computations, equipment that had been across the NGS test range, and equipment that could be handled by two persons if walking was required. Seven firms submitted quotations on the project and four were found to be technically acceptable. The highest scoring firm also submitted the lowest quotation. There was very little dollar difference among the acceptable firms.

No two firms proposed to use the same models of equipment. The contractor was allowed to use any number of units and use any field operation desired, as long as the National Geodetic Survey (NGS) standards were met. The final product was to be geodetic and state-plane coordinates and elevations on all of the new stations. GPS 4th order accuracy was required. The Forest Service would provide the helicopter.

The successful contractor was Sunrise International of Mesa, Arizona, who proposed to use the ISTAC 2002 codeless receivers (four units). The payment structure allowed for a mobilization-demobilization fee to be paid and a per-point price for ties to existing stations and setting of new station positions. Prices were as follows:

Item 1, Mobilization/Demobilization	Lump sum	\$4,000	\$4,000
Item 2, Ties to Existing Stations	5 ea.	530	2,650
Item 3, New Stations	18 ea.	530	9,540
Project Total			\$16,190

TECHNOLOGY TRANSFER

Although obtaining geodetic positions in the area was the purpose of the project, the main emphasis was on exposing the Land Surveyors of the Region to GPS. All land survey personnel (with one exception) from the Region were able to attend. This included all surveyors and all technicians, including non-permanent people. The Region tried to make this a major training and exposure opportunity for all. The chief design engineer for Motorola's GPS division was invited to provide formal training on the basics of GPS. He also brought their 14-pound GPS receiver, which was used to try several other land surveying applications of GPS technology.

A private land surveyor, the Region 3 Director of Lands and Minerals, and the helicopter support personnel brought the total number of participants to 35. The training and then the real, hands-on use of two different models of GPS equipment proved to be a fantastic example of technology transfer.

PUBLICITY, TOO

A television news crew from CBS in Albuquerque spent 2 days with the project, and we got some very good publicity as a result. They did a special segment entitled "High Tech in the Heavens," which aired a few days later. The Albuquerque Journal is planning an article in the near future describing the project and the technology.

ACTUAL PROJECT

Finally, after months of logistical preparations, the project was conducted in September 1986. The project required use of a special helicopter because of the high altitudes and the weights involved. The weather was a major factor, and the first 3 days saw constant changes in plans because of low clouds and rain. On the afternoon of the third day, a sudden snowstorm entered the area and two people were stranded on top of a 12,500-foot peak. They had to hike out before nightfall and a rescue party was sent in to locate them and get them back to the lodge.

Another problem that came up was the battery power on the ISTAC units. The cold seemed to affect the batteries' charging ability, and the generator at the base area may have contributed to additional problems of voltage irregularities. Even with these situations, the project was successfully carried out, with only one of the new stations never being occupied. That station was at 13,000 feet and was never out of the clouds long enough to occupy and make observations.

There was no phone service at the base area so all data reduction had to be done by the contractor after returning home. The Forest Service received final data 3 weeks later, which revealed that the results far exceeded the plan. Observation times ranged from 55 minutes to 90 minutes and produced a much higher quality of accuracy, mostly in the first and second order area. Moving one of the satellites during the project did not bother the ISTAC equipment, because it does not use the transmitted codes for data reduction.

CONCLUSION

The project was a resounding success both as a training opportunity and as a real-life geodetic project. We proved that GPS does work in any kind of weather, that the logistical problems can be dealt with, and the future of surveying will include GPS as a major source of data. The ISTAC equipment performed well, although the weight was at times awkward. The battery problem caused some difficulty and could be prevented in the future with more planning and forethought.

Total expenditures on this project were about \$45,000, including all the helicopter time for reconnaissance, monumentation, and GPS--an overall cost of \$2,500 per point. More than half of the total cost was helicopter-related.

The Region is grateful for the opportunity to try GPS. We are convinced that this new technology will play a big part in our future. We are already planning new and different Forest Service applications with GPS technology.

Engineering Systems Guidelines & Standards

*Jerry D. Bowser
Washington Office Staff Engineer
System Operations, Analysis & Development*

INTRODUCTION

During the period of May 6 through 8, 1986, Regional Engineering Systems representatives and Washington Office Engineering Systems staff assembled in Arlington, Virginia, for an Engineering Systems National Workshop. Participants worked on some software development and maintenance guides that should have national utility.

SOFTWARE DEVELOPMENT GUIDELINES

These guidelines should assist programmers and systems managers who are developing new programs. They should be followed whenever they seem appropriate to the type of program under consideration. Direct benefits of the guidelines will be lower costs, more easily understood programs, better maintained programs, and greater flexibility if future enhancements or changes are needed.

- (1) Try to trap common errors and give the user understandable responses. Avoid leading error trapping to the operating system default codes. For example, "error 44A" could be replaced with "a problem has occurred with the space manager; please refer to page ___ of manual."
- (2) Use variable names that are as meaningful to the user as possible without being excessively long (for example, use "total" instead of "t1").
- (3) Provide menu structure for programs that will be used primarily by inexperienced computer users. Provide alternate methods for experienced users, allowing them to bypass the more time-consuming, menu-driven sections.
- (4) Maintain a menu hierarchy to reflect the logical order of any current process and possibly the next logical process.

- (5) Provide references to the user's manual at opportune times within the program to assist those with additional questions.
- (6) Display date, system name, and revision number on the main menu. Label subsequent menus with identification of their location within the program.
- (7) Avoid using menus that contain more than eight selection items (they are less efficient for the end user).
- (8) Provide meaningful prompts and help keys at all levels within the program.
- (9) Provide a mechanism that allows the end user to make a file selection from a catalog rather than requiring the user to type a file name.
- (10) Standardize the programming of special functions keys where possible (for example, on the CEO template, use F11 for cancel/exit, F8 for delete character, and so on).
- (11) Follow the concept of modular programming at all levels.
- (12) Use full-screen editing techniques when data inputs are required and prompts when a single response is expected.
- (13) Use device drivers to facilitate transportable data output.
- (14) Use code-generating programs where appropriate.
- (15) Use system software as much as possible (for example, PRESENT on the Data General).
- (16) Integrate descriptive remarks into code to help define process internally.
- (17) Include author's name and contact information within the code.
- (18) Write auto copy and auto load capabilities within the code.
- (19) Design all data structures to be compatible with future expansions and/or enhancements.

SOFTWARE MAINTENANCE & IMPLEMENTATION STANDARDS

The Maintenance Level and Confidence Level for all engineering programs should be public information. These descriptions are an indication of what the user can expect when operating a certain piece of software. The following are definitions useful to understanding the level descriptions:

- (1) Documentation. History file, source code, organized manner.
- (2) Clean Code. Code that is well documented, structured, modular.

Maintenance Levels

Maintenance Level 1. Level 1 programs are fully maintained. An appointed person takes care of the program maintenance and operation. These programs are fully documented, the code is "clean," and a user's guide is available. Whenever the user encounters a problem in the program, the user can call the person in charge of maintenance for the program to get the problem corrected. This person will tell users what they are doing wrong, how to get around the problem, or will fix the program to correct the problem. In any case, the problem is corrected within 1 to 3 days from the time the users call.

An example of level 1 maintenance is how RDS has been maintained for the past years.

Maintenance Level 2. Level 2 programs are maintained as time permits. An appointed person maintains the program; this is often the person who developed the program. These programs may or may not be documented, and the code is not likely to be "clean." A user's guide is available. Users can call the person in charge of maintenance whenever encountering a problem. This person may tell the user what he or she is doing wrong or how to get around the problem. However, if the problem requires a program fix, the maintenance person will only work on the program error as time permits.

An example of level 2 maintenance would be a program developed by a Region employee and then maintained for all Regions by that employee.

Maintenance Level 3. Level 3 programs are not usually maintained. However, an appointed person keeps the programs operational whenever hardware or system software change. These programs may or may

not be documented, and the code is not likely to be "clean." A user's guide may or may not be available. Users are expected to use the program as is. In case of a problem, users must try to figure a solution out themselves from the user's guide, if one is available.

An example of level 3 maintenance is a program picked up from another agency or a program developed by a Region or Forest that the Region or Forest does not have the time to maintain for everyone else.

Maintenance Level 4. Level 4 programs are not maintained at all. No one is appointed to keep the program operational. Should hardware or system software changes make these programs inoperable, the programs are likely to be abandoned. These programs may or may not be documented and the code is not likely to be "clean." A user's guide may or may not be available. Users are expected to use the programs as is. In case of a problem, users must try to figure out a solution on their own.

An example of a level 4 maintenance is a level 3 program when the person appointed to keep the program operational leaves and no one else can be found to take over the program.

Confidence Levels

Confidence Level 1. These programs work nearly all the time. They contain few if any known problems.

Confidence Level 2. These programs work most of the time. They contain a number of known problems that can be bypassed by adjusting the way the program is used or by adjusting the data.

Confidence Level 3. These programs work; however, users usually can expect to encounter some problems.

Confidence Level 4. These programs have numerous problems. Users should be extra cautious about using them and should question results they give.

PAIRWISE, A New Decisionmaking Tool Available to Forest Service Engineers

Robert J. Hrubes
Management Sciences Staff
Pacific Southwest Forest
& Range Experiment Station

PREFACE

PAIRWISE is described in a recent Washington Office publication, Making Sound Facility Development Decisions (EM-7310-2) and in a forthcoming PSW Experiment Station publication.

PAIRWISE also was mentioned in the Washington Office slide/tape presentation on facilities planning. This presentation, released September 1986, currently is being routed to all units for viewing. Contact your Regional Facilities Engineer for details.

Engineering management and planning decisions frequently involve the analysis and selection of a preferred alternative from among a set of several. Alternatives usually represent proposed courses of action. Prospective alternatives or courses of action are examined and their expected performance compared to a set of goals or objectives relevant to the particular problem being addressed. Goals and objectives are represented by evaluation criteria. The preferred alternative is the alternative judged to present the best overall performance with respect to all criteria.

When, as is usually the case, a problem involves several alternatives and evaluation criteria, the decisionmaking task quickly becomes very complex and burdensome. The number of comparative judgments required by the decisionmaker rises exponentially with the number of alternatives and evaluation criteria. Unfortunately, a common response of decisionmakers is to opt for ad hoc, informal, and noncomprehensive procedures. With such procedures, the chance for making an inappropriate and poorly documented decision is significant.

PAIRWISE was designed to improve the quality of decisions in multiple-alternative, multiple-criteria problems. The method breaks down complex problems into a structured and manageable set of pairwise comparisons. Using proven and tested procedures found in the operations research literature on decisionmaking, PAIRWISE takes the results of these comparisons and produces an overall ranking of the alternatives. The decisionmaker's judgmental path to this final ranking is highly traceable and documentable--qualities not present in many other methods.

Of equal importance to Forest Service Engineers is PAIRWISE's ease of use. The model is structured as an interactive, menu-driven computer program available for use on the Data General. Once PAIRWISE is installed at a local computer facility, PAIRWISE is easily accessed and used. The user is prompted to provide the comparative judgments necessary to arrive at a final ranking. The model can factor in the judgments of one or more decisionmakers. Installation of PAIRWISE also is straightforward and uncomplicated; the program simply is imported to any Forest Service Data General computer facility using simple "IS" commands. Procedures for acquiring PAIRWISE for your computer facility are listed below.

If you have any comments or questions, address them to Robert Hrubes at FTS-449-3306 or DG: R.HRUBES:S27A or to George Lippert, FTS 235-8020 or DG., G. Lippert:W01B.

INSTALLING PAIRWISE

The PAIRWISE programs can be retrieved via IS from the PSW computer installation. We recommend that the programs be installed in either a staff or public IS drawer, depending on the class of potential users for the software.

Contact your IS information manager for your staff and request that he or she create a drawer and folder in IS's staff or public area with the following designations:

Drawer: LIBRARY
Folder: 7100=PAIRWISE

This drawer and folder should have 2,000 blocks for maximum size.

- (1) From IS MAIN MENU, select 3. Utilities and press NL.
- (2) From UTILITY FUNCTIONS, select 6. Retrieval and FCCC Access and press NL.
- (3) From Retrieval and FCCC Access, select 1. retrieval and press NL.
- (4) In the IS Retrieval Utility information table, enter the following information:
 - (a) Location of file to be retrieved.

For Host Name:, type S27A and press NL.

Select level 2. Staff type Y and press NL.

For Staff Name:, type MaSS and press NL.

For Drawer Name:, type PAIRWISE_EXPORT and press NL.

For Folder Name:, type PROGRAMS and press NL.

For File Name:, type PAIRWISE.DMP and press NL.
 - (b) Location in which to put the file.

Select level appropriately and press NL.

For Drawer Name:, type LIBRARY and press NL.

For Folder Name:, type 7100_PAIRWISE and press NL.

For File Name:, type PAIRWISE.DMP and press NL.
- (5) After the retrieval request has been completed, return to IS MAIN MENU and access the drawer and folder where PAIRWISE.DMP was stored. You need edit permission for the PAIRWISE drawer to perform the remaining steps in this set of instructions.

- (6) Enter LOAD/V/R PAIRWISE.DMP in the IS command line and press NL.
- (7) If the previous command was executed successfully, PAIRWISE.DMP can be deleted. Enter DEL PAIRWISE.DMP in the IS command line and press NL.
- (8) Edit file PAIRWISE.CLI to include in the SEA CLI command the full pathname of the directory where the PAIRWISE.PR file resides (for example, STAFF:ENG:LIBRARY:7100_PAIRWISE).

USING PAIRWISE for the FIRST TIME

Contact your IS information manager and obtain the pathname of the directory that contains the PAIRWISE programs in your installation.

We recommend that you invoke IS from your personal information area. Therefore, it is necessary to create an IS drawer and folder with appropriate attributes to hold the files created by PAIRWISE. Log on to IS and execute the following steps:

- (1) From IS MAIN MENU, select 2. Filing and press NL.
- (2) From FILING FUNCTIONS, select 1. Drawers and press NL.
- (3) From the DRAWERS submenu, select 3. Create and press NL.
- (4) Type in the name of the drawer (7100_PAIRWISE) and press NL.
- (5) For Change Attributes: type Y and press NL.
- (6) For Change maximum size? type Y and press NL. Type in the appropriate maximum size of the drawer, press NL, and press the EXECUTE function key (F1). Each PAIRWISE problem can take up to 100 blocks depending on the amount of information it contains.
- (7) For Change other user access?, type N and press NL.
- (8) For Change drawer searchlist?, type Y and press NL.

- (9) From the submenu, select 1. Add to Searchlist and press NL.
- (10) Type in the full pathname for the PAIRWISE directory and press NL (for example, STAFF:ENG:LIBRARY:7100_PAIRWISE).
- (11) From the submenu, select 3. Continue and press NL.
- (12) Press the EXECUTE function key (F1) twice.
- (13) Press the CANCEL/EXIT function key (F11) twice to return to the DRAWERS submenu and create a folder that will contain the PAIRWISE files. Select size appropriately.
- (14) From the DRAWERS submenu, select 1. Folders and press NL.
- (15) From the FOLDERS submenu, select 3. Create and press NL.
- (16) Type in the name of the folder (PAIRWISE) and press NL.
- (17) For Change folder size: type Y and press NL.
- (18) Type in the appropriate size for this folder, press NL, and press the EXECUTE function key (F1).
- (19) Press SHIFT/CONTROL/F1 to return to IS MAIN MENU and follow the instructions in Invoking PAIRWISE.

INVOKING PAIRWISE

Before you invoke PAIRWISE, you should create a drawer and folder in your personal information area. Follow the instructions in the previous section. In subsequent PAIRWISE sessions, execute the following steps:

- (1) From IS MAIN MENU, select 1. Access Information and press NL.
- (2) From the Level submenu, select 4. Personal and press NL.
- (3) Type in the name of the PAIRWISE drawer and press NL.

- (4) Type in the name of the PAIRWISE folder and press NL.
- (5) Enter PAIRWISE in the IS command line and press NL.
- (6) After exiting PAIRWISE, press the CANCEL/EXIT function key to return to the IS MAIN MENU.

If you failed to access PAIRWISE following the instructions above, contact the IS information manager for your staff. The PAIRWISE programs are probably not available in the directory you named in the searchlist for your PAIRWISE drawer.

A few variations over the scheme outlined above are possible. You could, for instance, have your PAIRWISE files in the staff information area or access other users' files. Whatever is the situation, make sure you have edit permission for the IS drawer you access.

All files created under PAIRWISE will show as objects in the IS folder. These are the types of files:

"Problem ID".PRW	Contains PAIRWISE data.
"Problem ID".PRW.BU	Contains PAIRWISE data before the last editing session. You can delete any of this file without loss of essential data.
"Problem ID".WRD	Contains PAIRWISE Report. These files have to be imported into CEO before the report can be printed. They can be deleted without loss of essential information.
\$PAIRWISE.DEFAULT	Contains PAIRWISE default information for a particular user. This file can be deleted without loss of essential information.

PRINTING a PAIRWISE REPORT

The PAIRWISE print function generates a report file in a CEO format. This file must be imported into CEO and can be treated as any other CEO document. The report file already includes headers and footers and can be printed immediately after

importing. Follow the following instructions to transfer the report file into CEO:

- (1) Access PAIRWISE according to the instructions in Invoking PAIRWISE.
- (2) Print a PAIRWISE report for a selected "Problem ID".
- (3) Exit PAIRWISE.
- (4) Enter CEO in the IS command line and press NL.
- (5) From CEO's MAIN MENU select 5. Filing and press NL.
- (6) From Filing Functions select 7. Import and press NL.
- (7) For Filename: enter "Problem ID".WRD and press NL.
- (8) Fill out the entries in Filing Menu with the appropriate drawer, folder, and document names.
- (9) Enter the summary information for the new document and return to CEO's Main Menu.

Heart Bar Hybrid Photovoltaic System

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San Bernardino
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San Bernardino National
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INTRODUCTION

Two Region 5 Forests have installed hybrid photovoltaic-generator systems at remote stations where commercial electricity is not available. The systems are at Heart Bar Station on the San Bernardino National Forest and at Nacimiento Station on the Los Padres National Forest. This article is a report on the Heart Bar installation.

HYBRID SYSTEMS

A hybrid system combines a photovoltaic generation system with a conventional engine-driven generator, resulting in a system with some very desirable characteristics: the generator can be smaller than it would be without the photovoltaics (if the battery bank is sized to carry short-term peak loads), and it runs far fewer hours than it would if it were the sole source of power. When the generator does run, it does so efficiently at near-full load. Because the generator runs comparatively few hours, the time period between replacement or overhaul is longer than with a conventional system. Because routine repairs can be scheduled for periods when sunny weather is expected, a backup generator is not normally required, and the generator is available when the photovoltaic system is being serviced or is inoperative for any reason.

A hybrid system makes electricity available 24 hours a day without the inefficiency of a generator running under light load, and without the constant noise of a generator.

A hybrid system does, however, have some very serious drawbacks. The initial cost is very high

because of the high costs of photovoltaic panels and batteries. Another disadvantage is that the batteries must be replaced approximately every 5 years. Photovoltaic technology is new and changing very rapidly. Few designers or contractors are fully up to date, so the time from inception of a project to completion of construction usually is much longer than for a conventional system.

HEART BAR STATION

Heart Bar station is located in a remote site and consists of an office, barracks, and two residences. The station is intended to be occupied and used year-round. A 17.5-kilowatt, diesel-fueled generator previously provided the electricity to the station. The generator was acquired as military surplus and required constant maintenance and costly repairs.

Contract preparation and contract administration were provided by Robert Ota and Audie Nishida, Civil Engineers on the San Bernardino National Forest. The contract was awarded to Henry Radio of Los Angeles at a cost of \$38,054. Work began in summer 1985 and was completed in May 1986. The contract consisted of furnishing and installing a complete photovoltaic system to be used in conjunction with a 10-kilowatt Onan generator installed by the Forest Service. The Forest Service also constructed a 12- by 18-foot wood-frame building to house all photovoltaic equipment and the generator (figures 1 and 2).

The schematic diagram in figure 3 shows the operation of the Heart Bar system. When the sun shines on 40 Arco Solar M53 panels, which make up the photovoltaic array (number 1 on the diagram), each panel produces a nominal 43 watts peak at approximately 17 volts. A Photron PP-20-LC Photovoltaic Source Combiner (number 4 on the diagram) combines the output into a nominal 1,680 watts peak at a nominal 48 volts. The electricity then is routed through a Photron Source Center (5) to the batteries (7). The source center serves as an interconnection center for all direct current (DC) components as well as a main DC disconnect and overcurrent protection device. It also allows for simplified photovoltaic array testing and isolation of failed modules within the array.

Energy is stored in 24 heavy-duty 2-volt lead-antimony batteries (7) manufactured by Industrial Battery Engineering. The batteries store enough

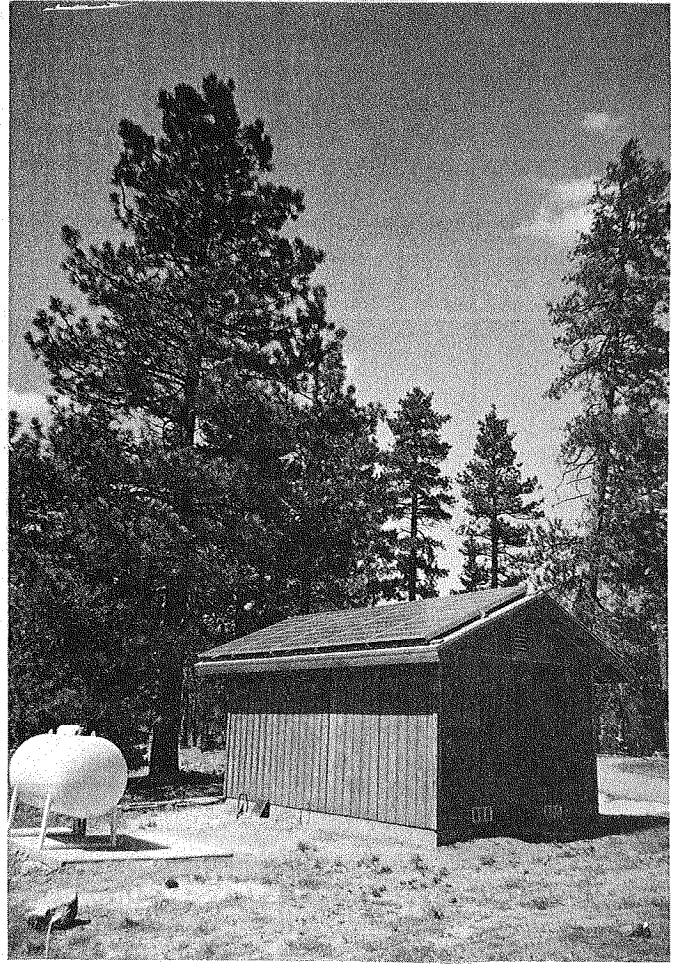


Figure 1.--Heart Bar building exterior showing photovoltaic panels on roof.

energy for approximately 2 days use without unacceptable drawdown.

The 48-volt direct current arriving at a Westec W500-48 inverter (8) is converted to 120/240 volts alternating current (AC) for use in the administrative site.

The control enclosure (3) contains several components that monitor the system and provide appropriate responses to various indicators: a Photron BVR-50 Battery Voltage Regulator, a Photron "Brain," a Photron "Gen Wizard," and a generator exercise timer.

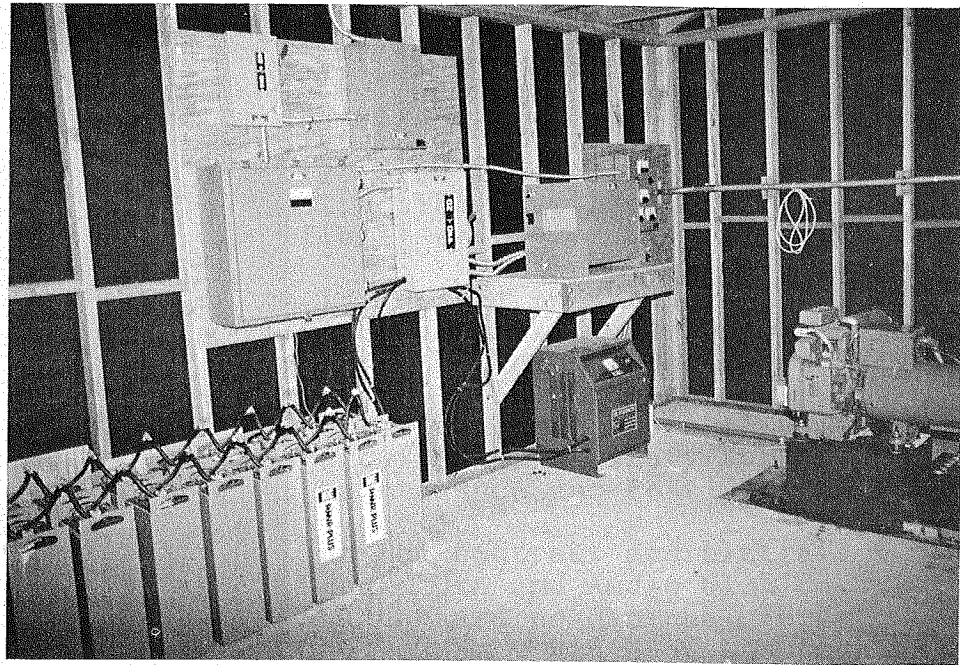
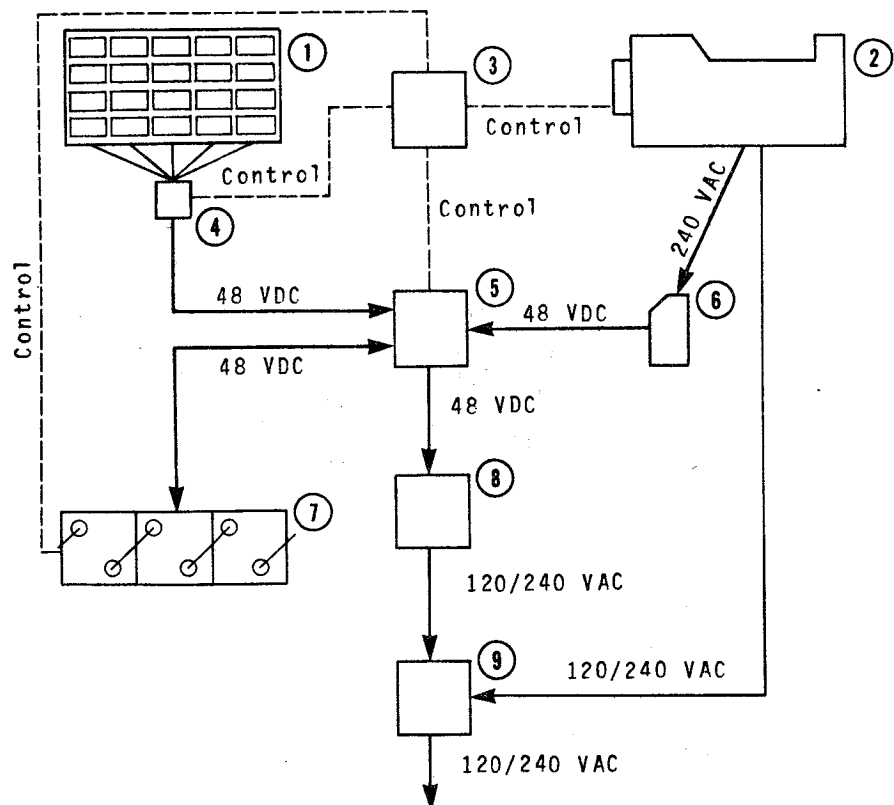


Figure 2.--Building interior. Batteries on left, generator on right.

The Photron battery voltage regulator regulates the voltage supplied to the batteries and disconnects the photovoltaic panels when the batteries are fully charged. It also disconnects the batteries from the photovoltaic panels when no output is available from the panels (for example, at night), thus preventing battery discharge through the array that would otherwise occur.

The Photron Brain senses battery voltage. When the battery voltage drops to a critical level, indicating that charging is needed, a signal is sent to the Photron Gen Wizard, which converts the Brain's two-wire system to the Onan generator's three-wire start system and starts the generator. This happens during prolonged cloudy weather or whenever the daily output of the photovoltaic array cannot keep up with the daily consumption of electricity. The brain also stops the generator when the batteries have been fully charged.

The exercise timer automatically starts and runs the generator for an hour or so every week.



- | | |
|------------------------|-------------------|
| ① P.V. Array | ⑥ Battery Charger |
| ② Generator | ⑦ Batteries |
| ③ Control Enclosure | ⑧ Inverter |
| ④ PV Source Controller | ⑨ Transfer Switch |
| ⑤ DC Source Center | |

Figure 3.--Heart Bar photovoltaic system schematic diagram.

The generator is an Onan 10-kilowatt model fueled by liquefied petroleum gas. It charges the batteries by means of a Photron Gencharger (6), which is similar to many large commercial battery chargers.

The generator also is connected to the Photron Tranzac transfer switch (9). This switch automatically transfers loads directly to the generator whenever it is running, and returns the loads to the

batteries and inverter as soon as the generator stops. The switch also can be used in a manual mode.

A hybrid system ideally is a balance between photovoltaic array size, battery bank size, and generator size. At Heart Bar, this balance was compromised because of the amount of money available. The battery bank is large enough to provide 2 day's storage for current needs, but there are only enough photovoltaic panels to provide 8.6 kilowatthours of the total 10.4 kilowatthours of current daily consumption. Additional panels could be added to increase the system's daily output with no modifications to other components, but for now there is a slight shortfall in the photovoltaic panels output. It is not yet known exactly how much generator time will be needed; a preliminary estimate is an average of a half-hour per day.

ECONOMIC ANALYSIS

The system was constructed under the Federal Photovoltaic Utilization Program, which was intended to demonstrate the technical feasibility of photovoltaics, but not necessarily economic feasibility. No economic analysis was made before construction. The accompanying analysis (figure 4) was made after construction, with rather surprising results considering the high initial costs of the photovoltaic system and the current low costs of diesel fuel and liquefied petroleum gas.

The total present worth of the conventional system is just slightly less than that of the photovoltaic system. The photovoltaic system cannot be justified strictly on the basis of economics, but perhaps it might still be appropriate because of its other advantages, such as less noise and 24-hour-per-day availability of electricity.

Economic Analysis of Heart Bar Hybrid System Versus Generator-Only System

Life of project: 25 years
Discount Rate: 7 percent, as prescribed for energy-related projects.
Present Worth Factors (PWF) for fuels as determined by Department of Energy, November 1985.

Maintenance costs for both hybrid and generator-only systems are estimated to be approximately equal and are therefore not included in this comparison.

Hybrid System

Construction of Building (Force Account)	\$ 8,400	
Cost of 10 kW Generator	\$ 4,500	
Cost of PV System (Contract)	\$38,054	
Total First Cost		\$51,000

Replace batteries every 5 years
\$4,224 materials + \$420 installation = \$4,700

Year	Cost	PWF	Present Worth	
5	\$4,700	0.7130	\$3,351	
10	\$4,700	0.5083	\$2,389	
15	\$4,700	0.3624	\$1,703	
20	\$4,700	0.2584	\$1,214	
Total Present Worth of battery replacement				\$8,700

The generator will need replacement or major overhaul once during the life of the project, say at year 12.
\$4,500 x 0.444 (PWF) = \$2,000

Fuel Costs

Generator is estimated to run an average of a half-hour per day year-round.

Cost of LPG
2.75 gal/hr x 183 hr/yr x \$0.72/gal = \$362/year
Present Worth of liquefied petroleum gas = \$362 x 15.88 = \$5,700

Total Life Cycle Cost of Hybrid System (rounded to nearest \$1,000) \$67,000

Generator-Only System

Construct building to house generator	\$6,500
Cost of 12kW generator	\$5,000

Replace generator every 10 years

Year	Cost	PWF	Present Worth	
10	\$5,000	0.5083	\$2,542	
20	\$5,000	0.2584	\$1,292	
Total Present Worth of Generator Replacement				\$3,800

Salvage Value at year 25

PW = \$5,000/2 x 0.1842 = -\$500

Fuel Cost

12 kW diesel generator; 1.2 gal/hr fuel consumption
Estimated use: 6:00 AM to 9:00 AM and 5:00 PM to 10:00 PM daily
8 hr/day x 365 days/yr x 1.2 gal/hr x \$0.87/gal = \$3,048/yr
Present Worth of diesel fuel = \$3,048 x 16.77 = \$51,100

Total Life Cycle Cost of Generator-only System (to nearest \$1,000) \$66,000

The life cycle cost of the generator-only system is approximately 2 percent less than that of the hybrid system.

Figure 4.--Economic analysis, made after construction.

Rehabilitation of Hume Lake Dam—First Concrete Multiarch Dam in the United States

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Region 5*

INTRODUCTION

Hume Lake Dam, built in 1908, was the first concrete multiarch dam in the United States. The lake is the most heavily used lake on the Sequoia National Forest. Recreation, the primary use, serves a large population of people. The dam needed renovation to preserve its life and structural integrity so that the lake and recreational uses could continue.

HISTORY

The dam, originally designed and constructed by John S. Eastwood in 1908 for the Hume-Bennet Lumber Company, was used for the harvest of the giant sequoia redwood trees. It is now considered the last remnant of that era. The sawmill, constructed directly below the dam, used the lake as the millpond. A 67-mile-long V-shaped flume floated the sawed boards to Sanger, California, the nearest railhead.

The 87-acre lake has a 1,411 acre-feet capacity. The dam is 51 feet high and 677 feet long (including the wing walls). It has 12 arches, each having a 50-footspan, and 13 buttresses. The dam had three outlets--a 24-inch outlet at the lowest point in arch 6 for draining the lake, a 12-inch outlet about 10 feet higher in elevation in arch 5 to supply water to the mill and flume, and a 12-inch outlet in arch 4 to supply water to the mill and flume. The main spillway comprised twelve 5-foot by 8-foot windows in arches 5, 6, and 7 with flashboards for raising and lowering the lake level; water also could flow over the top of arches 4, 5, 6, 7, 8, and 9. It took 114 days to construct the dam, which cost \$46,000.

Figure 1 shows the dam and part of the constructed mill just after completion in 1908. Figures 2 and 3 show plan and elevation views and typical cross sections of the dam.



Figure 1.--Completed dam in 1908.

In 1917, the sawmill burned down and was not rebuilt in its original location. In 1935, because of declining logging industry, the area became National Forest land.

1949 INSPECTIONS

Subsequent dam inspections found serious deterioration of the concrete around the window spillways. As a result, sometime in the 1940's the windows were plugged with concrete, leaving only a shallow spillway over the top of arches 4, 5, 6, 7, 8, and 9 for a depth of 1 foot before water flows over the entire length of the dam.

In 1949, the inspections also indicated some progressive foundation leakage in arches 9, 10, 11, and 12. Leakage through the dam itself also was increasing. Water overflowing arches 1, 2, 3, and 12 was eroding the foundation on the backside of the dam.

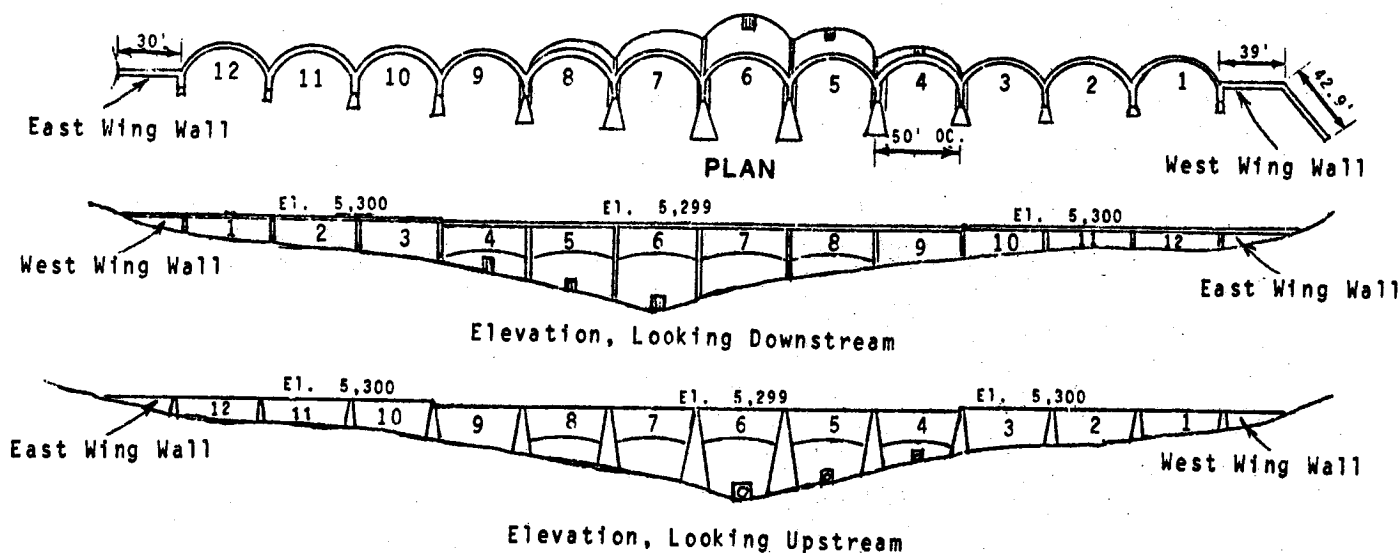


Figure 2.--Plan and elevation views of dam.

In 1954, because of these findings, a contract was awarded to Ted Schwartz for \$64,905 to repair the dam. The work consisted of the following items:

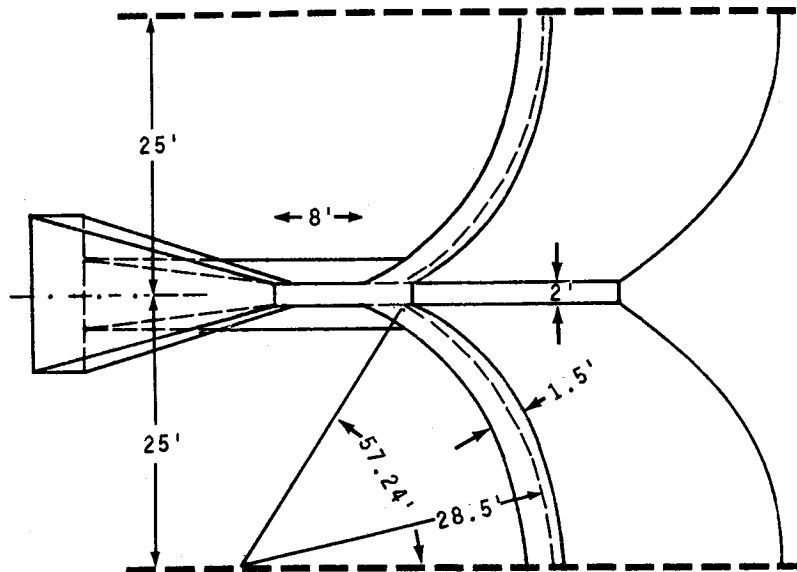
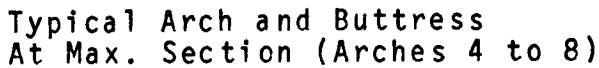
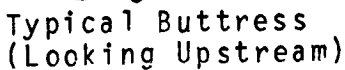
- (1) Foundation grouting.
- (2) Placing 6 inches of gunite with reinforcing steel on the upstream face.
- (3) Placing a 2-foot concrete high parapet wall on top of arches 1, 10, 11, and 12.
- (4) Plugging the 12-inch outlet in arch 4 with concrete.
- (5) Repairing the outlet valves and trash racks in arches 5 and 6.

Figure 4 shows a sample of the condition of the dam before the guniting process in 1954.

1978 INSPECTIONS

In 1978, under the National Dam Safety Program, the dam was again inspected by a Regional Office Specialist. The following were inspections concerns:

- (1) Questionable spillway capacity.



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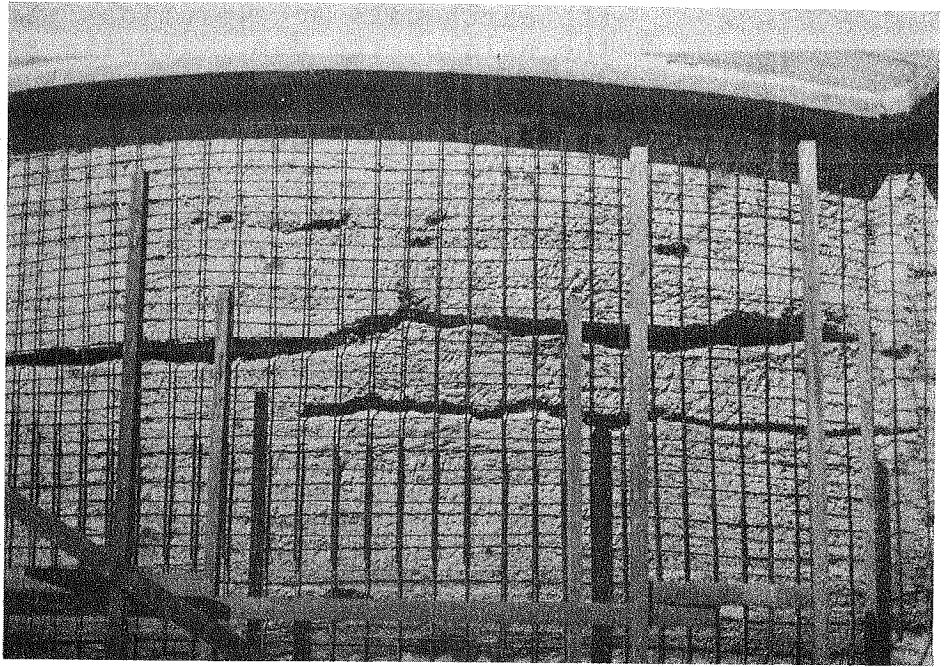


Figure 4.--Arch 1 before gunite application in 1954.

- (2) Inoperable 24-inch valve in arch 6.
- (3) Foundation seepage.
- (4) Questionable capacity to withstand seismic activity.
- (5) Recommendations for a Phase I and II investigation.

The Army Corps of Engineers conducted the Phase I investigation and found that the maximum probable flood (MPF) would overtop the spillway (crest of dam) by 5.5 feet for a $4\frac{1}{2}$ -hour period and by 2 feet during a flood equal to half the MPF.

In 1979, the Forest Service awarded an A & E contract to Leeds, Hill and Jewett, Inc. for \$42,493 to make a Phase II investigation and safety evaluation of Hume Lake Dam. The contract included a study, an investigation, and a pseudostatic analysis to evaluate the structural safety of the dam.

The results of the pseudostatic analysis indicated that portions of the dam could be overstressed when the earthquake accelerations were acting parallel to the axis of the dam. Tensile stresses also could develop between the buttresses and foundation, which under earthquake conditions could overturn or collapse the buttresses.

The contractor divided the recommendations into three categories: Category I, those measures that would restore the dam and its appurtenances to its original condition and structural integrity; Category II, work that would increase the structural strength of the dam to enable it to withstand critical earthquake loadings; and Category III, those measures that should be considered but were not mandatory. Individual remedial recommendations are listed below. However, because of the limitations of the pseudostatic analysis in predicting seismic loadings, additional dynamic analysis was recommended, such as a time-history finite element analysis.

(1) Category I.

- (a) Repair or replace the 24-inch outlet to enable emergency drawdown and to prevent overtopping of the dam.
- (b) Resurface the downstream face of the dam and the buttresses with concrete to prevent continued deterioration.
- (c) Grout the foundation at the upstream toe of the dam in arches 8, 9, and 10 and beneath buttresses 1, 2, 10, and 11.
- (d) Repair any cracks on the upstream face of the dam that are visible after the lake is drained.

(2) Category II.

- (a) Reinforce the arches to avoid excessive tension stresses.
- (b) Reinforce the buttresses to prevent side-sway and possible overturning or collapse of the buttresses.

(3) Category III.

- (a) Raise the ends of the dam to ensure the MPF overflow would be confined to the center portion of the dam.
- (b) Remove all vegetation and brush on the downstream side of the dam.
- (c) Remove water pools at the toe of the downstream face of the dam.
- (d) Monitor seepage through the foundation.

Following the recommendation of Leeds, Hill & Jewett, another A & E contract was awarded to Converse Consultants for \$59,869 to conduct a seismic dynamic analysis. They were to perform the analysis, evaluate the results, and report their findings with recommendations as to any structural corrections needed.

Converse Consultants reevaluated Hume Lake Dam by conducting a series of stress analyses of a three-dimensional finite element (3-D FEM) model of the dam. The analyses determined the static and dynamic response of the dam, the deformations, and the stress distributions in the dam under the design Maximum Credible Earthquake (MCE) loading (Richter Magnitude 8.25 at Owens Valley, California).

They analyzed the dam assuming full reservoir conditions. The dynamic loads included cross-valley, upstream-downstream, and vertical time histories of motion. The maximum combined stresses included full reservoir static loads, 10 °F temperature changes, and dynamic loading; these combined stresses did not exceed the strength of the concrete. A sample of the stresses developed are shown in figures 5, 6, and 7. They concluded that Hume Lake Dam would perform adequately when subjected to an earthquake with similar characteristics.

Converse Consultants recommended the Category I remedial corrective measures as stated by Leeds, Hill & Jewett. Since the stresses in the dam did not exceed the strength of the concrete, Category II corrective measures were not necessary.

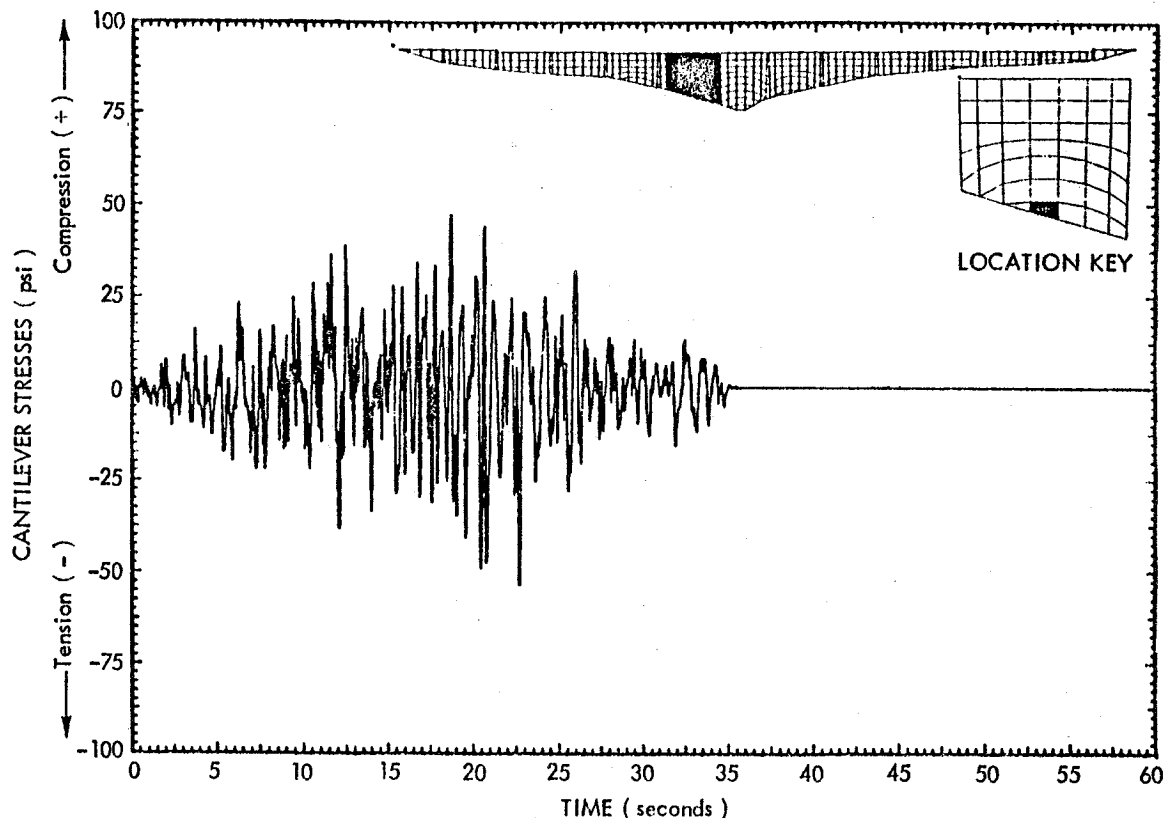


Figure 5.--Cantilever stress history of upstream element.

REHABILITATION in 1984

The Corps of Engineers provided consulting services during the contract development and during the grouting and shotcreting processes to train Forest Service inspectors.

A contract to rehabilitate the dam was awarded to ALL-CON, Dennis Seever. The work was performed during the summer of 1984. Total construction cost was \$448,152. The contract items of work included were as follows:

- (1) Foundation Grouting. Grouting was done at the upstream toe of arches 8, 9, 10, and 11. Drilling depth ranged from 10 to 30 feet. Grouting pressures varied from 5 to 20 psi, depending on the depth of the hole.

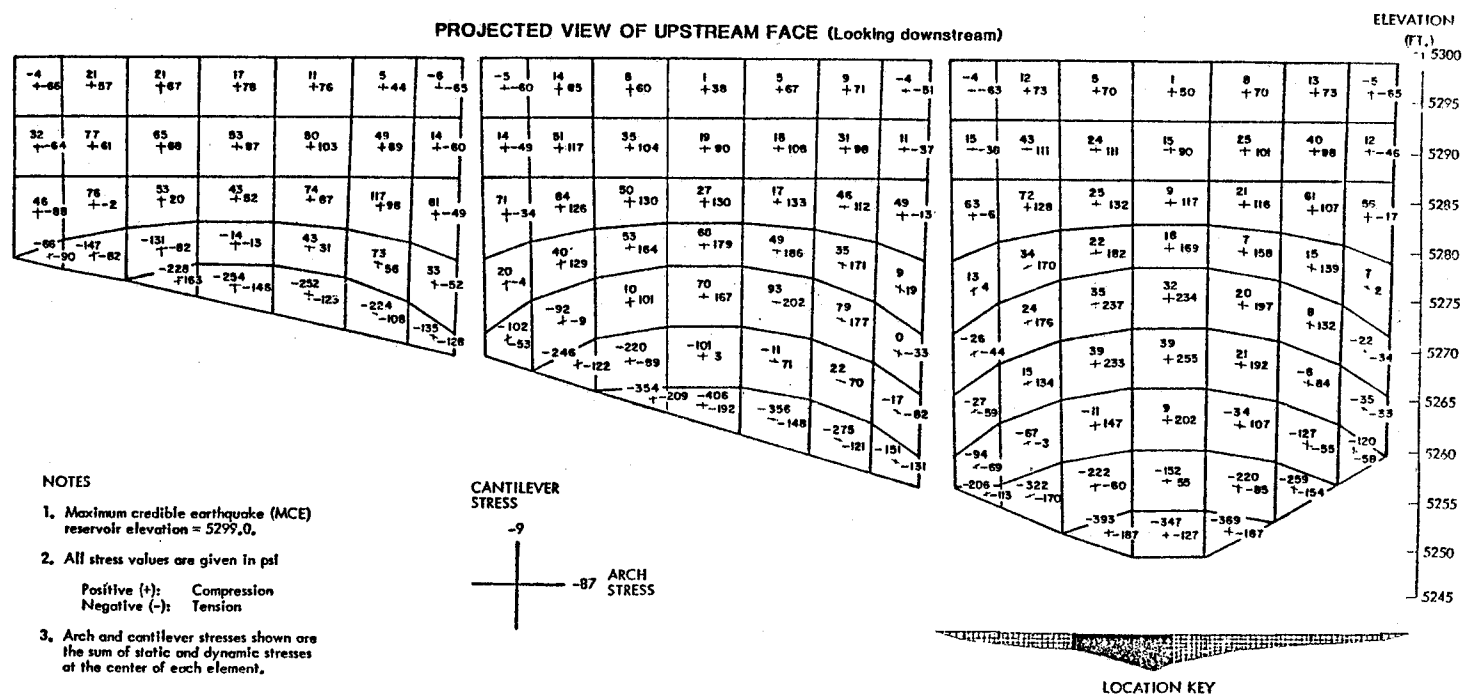


Figure 6.--Static plus dynamic stresses at 22.68 seconds.

Maximum Stresses - Static Plus Dynamic Loads

Cantilever Compression	120 psi at 12.44 sec.	225 psi at 22.68 sec.
Cantilever Tension	406 psi at 22.68 sec.	168 psi at 22.68 sec.
Arch Compression	237 psi at 22.68 sec.	211 psi at 22.68 sec.
Arch Tension	209 psi at 22.68 sec.	175 psi at 22.68 sec.

Figure 7.--Maximum stresses on the dam.

- (2) Shotcrete. This consisted of cleaning the concrete surface on the downstream face, placing 6x6x6 welded steel wire fabric, and applying 3 inches of shotcrete.
- (3) Inlet Structure. The inlet structure consisted of a trash rack with an antivortex plate, a 54-inch vertical inlet pipe, a 36-inch steel pipe through the dam, a 36- and a 12-inch ball valve, an electric remote operator for the 36-inch valve, and a 2½-inch vacuum release pipe with valve. See figure 8 for more details.
- (4) Upstream Crack Repair. Cracks upstream were chipped out, cleaned, and shotcreted.
- (5) Waterproof Membrane. They sprayed 16 millimeters of a polymer cementitious coating (Sika 144) on the upstream face of the dam.
- (6) Seepage Tubes. They placed small seepage tubes in known water-bearing cracks on the downstream face.

One of the biggest problems encountered on the project was the poor placement and holding ability of the cofferdam. The silt and debris in the bottom of the lake was worse than expected at the base of the dam and the earth-filled cofferdam continually leaked and sloughed off into the working area. The cofferdam eventually failed, making the job even more difficult. Because of this condition, it was necessary to redesign the inlet structure to a vertical inlet pipe.

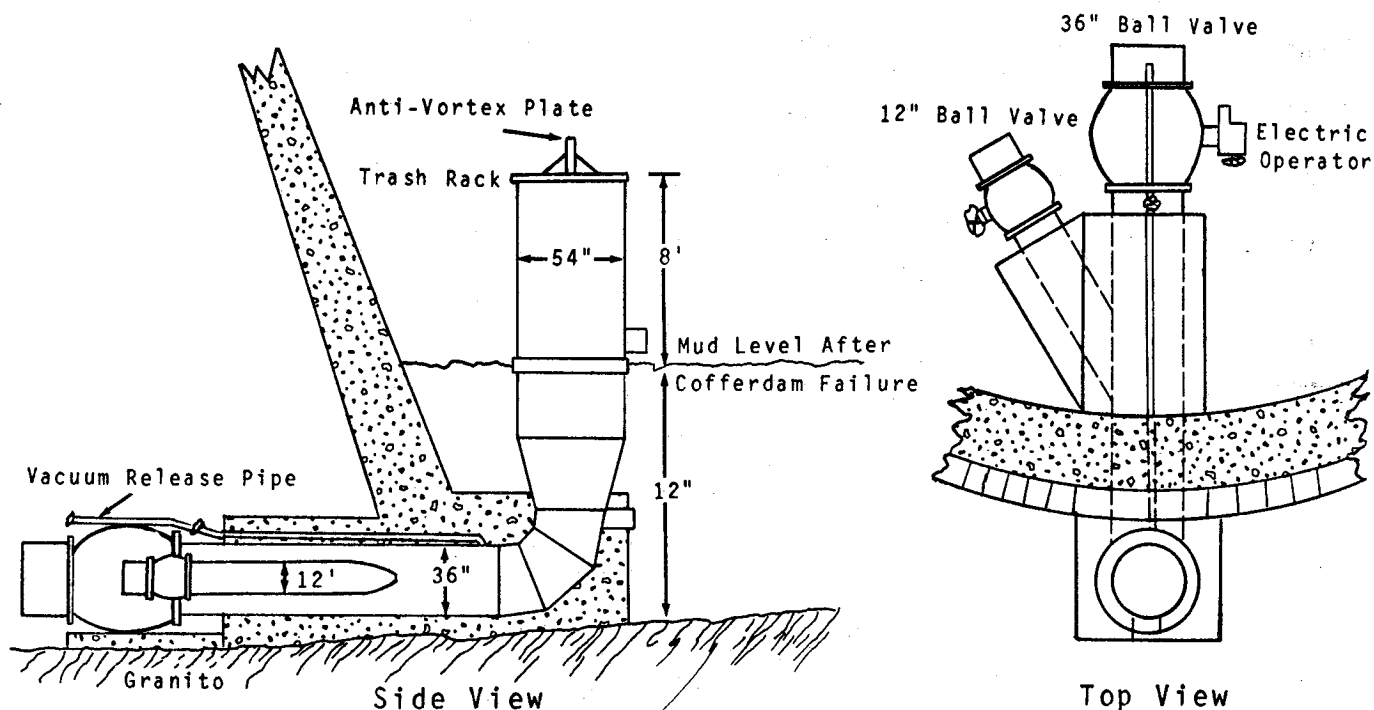


Figure 8.--Pipe inlet structure and valves.

We also found more weathered bedrock in the foundation than expected. The weathered bedrock located in arches 1, 2, 3, 4, 9, 10, 11, and 12 resulted in another contract with Converse Consultants (for \$23,238) to check the foundation more fully and reevaluate their previous analyses. We wanted to be sure the structure was still safe since they had assumed in their original analysis that the foundation and concrete were rigidly connected. They concluded that the distributed combined stresses did not exceed the strength of the concrete in the dam and considered the dam to be safe.

FINAL RESULTS

Based on the recommendations of Converse Consultants, we are monitoring foundation seepage in arches 1, 2, 3, 4, 9, 10, 11, and 12 to detect any increased seepage through the weathered bedrock. We also have surveyed control stations on top of the dam so we can measure and record any horizontal or vertical movement of the dam.

Leakage through the dam itself is minimal and the seepage tubes are functioning as designed, although more weep tubes would have been better.

Even with the vacuum-release valve fully open, we still have some concern that cavitation and dynamic surges may be taking place when the 36-inch valve is fully open. This is being controlled by not opening the valve fully for any long durations and by opening the 36-inch valve only until a vacuum just begins to develop (approximately 80- to 85-percent open). We expected no problem because the 36-inch valve will be fully open only during emergency drawdown, and then only for a short duration. As a precaution, we will inspect the interior of the inlet pipe after operating the inlet structure for a few years.



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