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# Engineering Field Notes

## Engineering Technical Information System

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### 1981 Field Notes Article Awards

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# Engineering Field Notes

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## 1981 Field Notes Article Awards

The material in Forest Service Manual 7113 formally establishes and provides for cash awards and service certificates to be awarded to the authors of three Field Notes articles in each calendar year. The awards will be distributed based on responses of Field Notes readers.

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If the answer to any of these questions is "yes," complete the article rating sheet on the following page. Select the three articles that were "most beneficial and useful"; rate these articles from 1 (highest) to 3; do not rate more than three articles. Wherever applicable, indicate the amount of money that was saved as a result of the article.

Cut out the page as indicated, fold carefully, and staple both ends of the folded sheet. The rating sheet must be received in the Washington Office by October 15, 1982, for your selections to be considered.

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If you have a new way of accomplishing a job or a better idea for handling problems, share your ideas and problem solutions or new methods. Write an article for Field Notes, and you may win a \$100 cash award and certificate for 1982.

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1981 Field Notes Article Rating Sheet

| Article                                                                                                                       | Author                                                                 | Choice<br>(1, 2, 3) | \$ Saved |
|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------|----------|
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| <u>February</u>                                                                                                               |                                                                        |                     |          |
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| Vertical Spar Guying: A Brief Examination<br>of Forces                                                                        | John J. Warner, R-10<br>Dennis J. Caird, R-3<br>Virgil W. Binkley, R-6 | _____               | _____    |

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# Aerial Tramways

Charles F. Dwyer, Chief Aerial Tramway Engineer,  
Washington Office (Denver, Colorado)

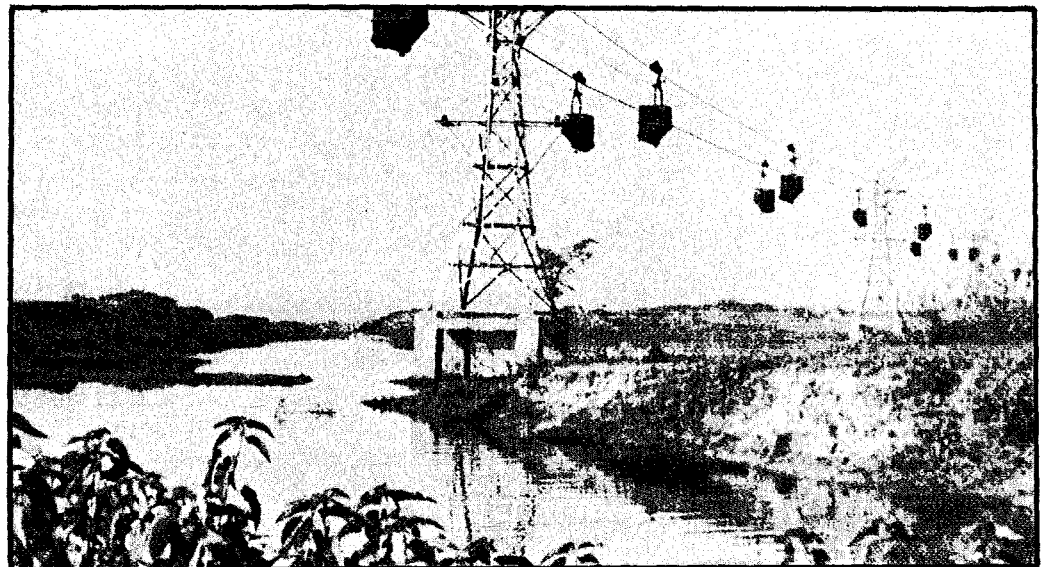
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## Materials Transport

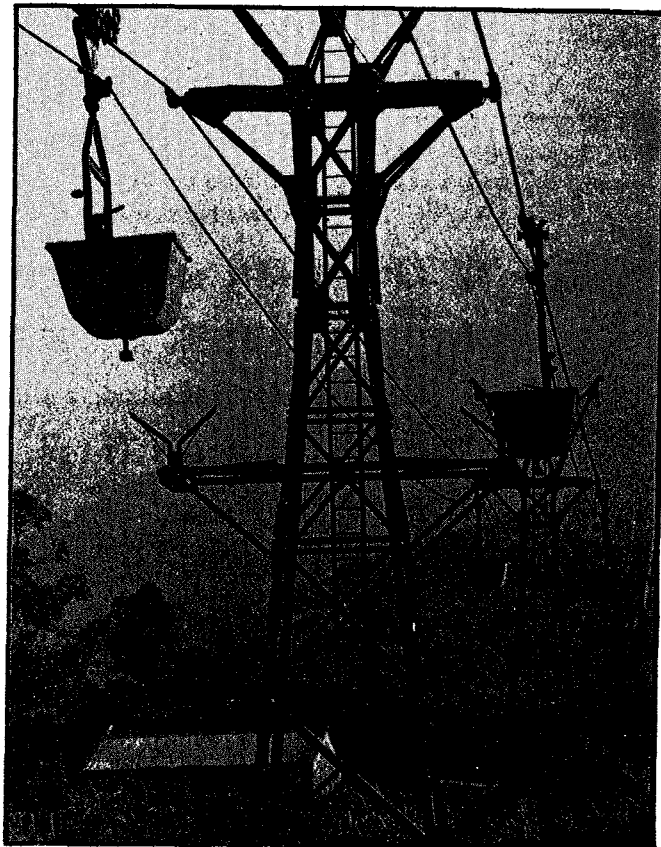
During the late 1800's and until World War I, hundreds of aerial tramways operated in mining areas of the Western United States. The tramways were an essential and integral part of mining in steep, rugged mountain terrain. Aerial tramways also had other industrial applications and were always considered as an alternative when selecting materials transport systems. But the decline in mineral mining and the introduction of alternate transport systems, principally motor vehicles and conveyors, in the early 20th century, resulted in the virtual elimination of material tramway systems in the United States.

The recent upturn in mining and energy exploration activities, particularly in rugged (and scenic) mountain areas of the Western States, has brought about renewed interest in aerial tramways for materials transport. Fortunately, the aerial

Figure 1.--This ropeway in India transports 400 tons of coal per hour over a distance of 62 kilometers, from the mine to the steel works. The ropeway has several sections, each of which has a circulating hauling rope with drive and tension device.



*Figure 2.--Steel trestles of a bicable ropeway. PHB ropeway trestles--whether steel, concrete, or wood--are always provided with erection gallows to facilitate erection as well as occasional maintenance.*



tramway principle remained valid, and virtually identical facilities remained on the scene; hundreds of aerial passenger tramways, serving tourists and winter sports enthusiasts, operated in the very same area.

#### ADVANTAGES of MATERIALS TRAMWAYS

Aerial tramway systems are highly competitive with other materials transport systems and offer distinct advantages in locations and applications where cable suspension and propulsion of carriers are most appropriate. For example, tramway systems are being considered and selected over other systems, even those that are more cost-effective, for areas where minimal impact upon adjacent resources and environment is a primary consideration.

Modern materials tramways offer high capacity and extremely reliable transport at competitive ton-mile costs. The system is increasingly competitive in areas with steep and difficult terrain, adverse operating altitudes and climatic conditions, and natural or manmade obstacles. Length of haulage and route of travel are flexible and virtually unlimited with the options of interconnected sections operating in tandem.

The systems are fuel efficient. Economical, pollution-free electrical power is most often used; when predominantly downhill transport is involved, the tramway may generate power for its own use and related uses. The systems also save labor because of increased use of automation in terminal loading and discharge areas. Electronic surveillance has reduced operating personnel requirements, and manufacturing quality-control advances and technical progress have minimized the need for maintenance personnel.

The systems are socially and environmentally advantageous. Noise levels are low, and air pollution may be nonexistent. Visual impacts in scenic terrain are minimal, and the intrusion is temporary. Small and dispersed permanent foundations, helicopter construction, and adaptability to existing grades also contribute to minimal impact on the terrain traversed.

#### The MODERN MATERIALS TRAMWAY

The design of aerial tramways for materials handling has advanced with modern technological and industrial development. Whereas passenger tramways in the early 1940's were patterned after materials tramways, materials tramways today reflect advances developed for passenger systems.

Tramway capacity has increased markedly; the rate of 500 tons per hour is now commonplace, and a rate of 2,500 tons per hour has been achieved. Operating line speeds have increased, and the speed of 4.5 meters per second has now been proven satisfactory.

Tramway structures are now exclusively prefabricated steel designed to accommodate construction needs and allow for minimum maintenance. Terminal housing structures facilitate the materials handling and the tramway operation. Drive machinery is more powerful, compact, efficient, and dependable. The increased use of standard industrial components has facilitated initial installation, replacement, and repair. Advances in electronics are reflected in the increased use of alternating-current-supplied, thyristor-controlled direct current motors. Increased automation has improved reliability and reduced the need for skilled operators and attendants. Improved communications and control circuitry permit monitoring the tramway operation at night and during bad weather.

Carrier loading and discharge, and carrier handling in terminal areas have become much more efficient. The loading and discharge operations

are automatic and virtually without time or capacity limitations. Carriers are decelerated, moved through the terminal, and relaunched mechanically. High-capacity systems are most frequently the continuous circulating type, in which the carriers are either permanently attached or are detachable with a provision for automatic recoupling to the continuously moving haulage rope. Special carrier designs, including provisions for cleaning and covering, can accommodate virtually all materials to be transported.

The ENGINEERING CHALLENGE  
of the MATERIALS  
TRAMWAY

Use of aerial tramways for materials handling should be considered by project proponents, land-use administrators, and engineers. Proponents of mining or related activities--either voluntarily or by direction--should consider this alternative for materials transport. When a tramway system is the most cost-effective alternative and meets all project requirements, its use is obvious; when such a system is competitive--but not necessarily the most economical--and offers distinct ecological, visual, and other advantages, its use should be seriously considered. Otherwise, the system should not be imposed.

Aerial tramway design, construction, operation, and maintenance are engineering problems. Increasingly, the ecological, visual, and other factors, as well as economics, are of concern to the engineer. Aerial tramway design requires the talents of civil, structural, mechanical, electrical, and electronic engineers. A designer must either have uniquely-diversified engineering qualifications, or have access to these individual specialties and the ability to combine these efforts to produce a functional system. Tramway engineering is a specialized field, and designers should take advantage of the experience gained over nearly 100 years of aerial tramway operations in materials handling.

The young engineer is at a disadvantage when working independently on materials tramways. Up-to-date texts and technical publications on the subject are virtually nonexistent. Information which is developed by those relatively few companies that supply materials tramways is understandably well guarded. There is no National Standard, and few State codes apply to aerial tramways for materials transport. The problem posed by lack of standards is complicated, rather than relieved, in cases where a tramway accommodates transport of both materials and personnel. In that instance, the requirements of National

Standards and/or State codes for passenger tramways are applicable, and impose restrictive requirements on design and operation; reasonable and enlightened interpretation of these requirements is the problem that presents itself to the engineer acting for an authority exercising jurisdiction.

Until aerial tramways for materials transport again become commonplace, heavy reliance must be placed upon the relatively few engineers and suppliers of this specialized equipment. A few U.S. suppliers, and a slightly larger number of foreign firms, can provide excellent service in support of proposals in which use of aerial tramways for materials transport is contemplated.

#### FOREST SERVICE APPLICATIONS

##### New Impacts on Forest Service Engineering

The recent upturn in mining and energy exploration activities, particularly in the Western Regions and Alaska, will certainly involve Federal lands and will affect Forest Service administration. Concern here is with the impact involving Forest Service Engineering, particularly the engineering of aerial tramways strictly for materials or for materials and personnel transport.

The Forest Service will increasingly receive proposals for mining and related projects where use of aerial tramways is proposed or, of more importance, proposals where this alternative has not been considered. In both cases, engineering should be involved in evaluating the proposals regarding this type of transport. Under a policy statement of the new Manual 7320.3-4, the Forest Service is expected to have technical expertise available to carry out management objectives and policies and to communicate effectively with industry interests. Engineering should be available to assist authorized officers in their review of applications and EA/EIS Development (7321.2 and 36 CFR 251.54). Where projects materialize and installation of tramways is contemplated, design will be by the proponent's engineer, and approval will follow much the same procedure as for passenger tramways in ski areas. Evaluating and establishing criteria for more complex installations will be accomplished as provided in 7321.31-2, Design and Construction Approval, by use of a qualified engineer specialist "employed, retained, or recognized by the Forest Service" (emphasis added).

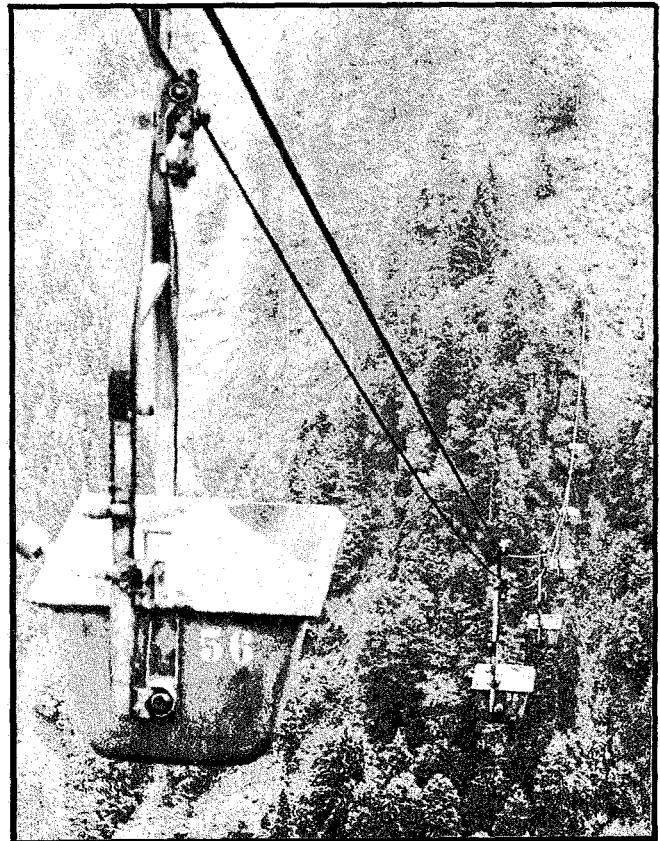
##### Qualifying Forest Service Engineering Personnel

The numbers of proposals or actual installations involving materials tramways will never approach that of ski lifts and passenger tramways. Therefore, it will not be necessary to develop and

maintain engineering competence at Region and Forest levels for materials tramway involvement as is done for passenger tramways. Certainly the technical expertise expected to be maintained (7320.3-Policies 4) should be available at Washington Office level in order to respond to Regional Foresters' requests for assistance (7320.42-8). The extent to which the Forest Service develops and maintains technical expertise at Regional levels should depend upon demand and interest among engineers at that level.

There are several factors regarding the opportunities and the availability of information to help develop and maintain competence and technical expertise in the materials tramway field. Whereas early personnel-carrying tramways used much of the design construction and operational criteria developed for materials tramways, today the reverse is true, and modern materials systems are following practices established for personnel transport systems. Engineering principles involved in wire rope, machinery, electric controls, and structures are much the same for both types. However, texts and other publications on materials tramways are limited. The old standard, Mining Engineers Handbook by Peele (3d ed.,

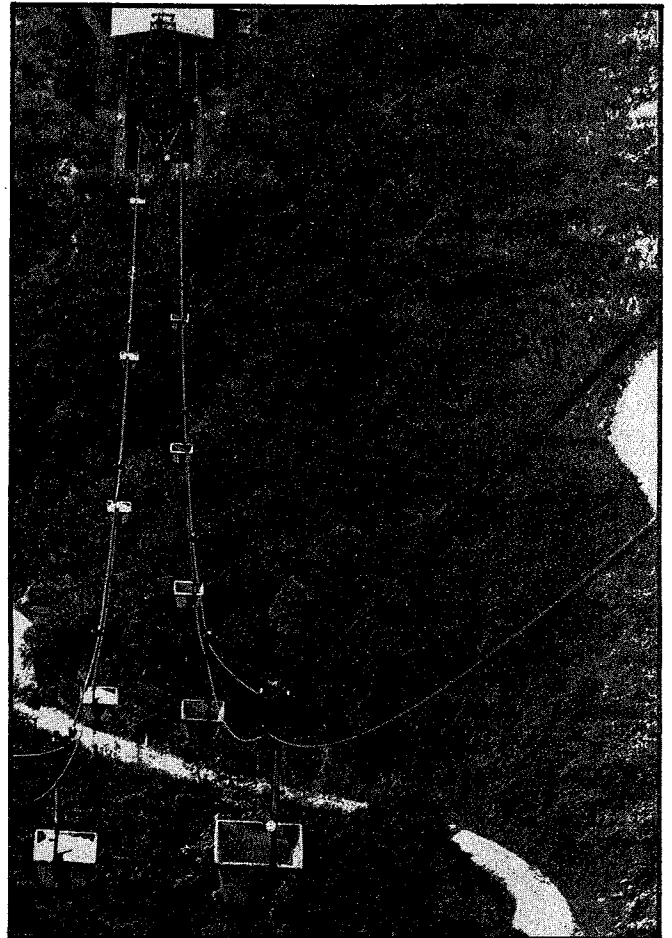
*Figure 3.--Another example of the adaptability to extremely difficult terrain conditions. This ropeway at Hochfilzen, Austria, transports 300 tons of magnesite per hour and crosses, without using a trestle, a valley that is 1,050 meters wide.*



vol. 11, 26-02 to 26-50) and Aerial Tramways and Funicular Railways by Z. Schneigert, are the only publications available in most libraries. Periodicals carry some articles about recent installations, but they are very general and contain little of engineering value. Information developed by the relatively few companies supplying materials tramways is difficult to acquire.

Problem Areas  
for Forest  
Service  
Engineers

There are two principal areas of concern for Forest Service Engineers regarding materials tramways. First, there is no national standard and few, if any, State codes or other regulatory criteria for materials tramways. Administration and engineering cannot be handled as simply as with personnel carriers, wherein a permittee or proponent is required to "meet ANSI." The Forest Service will be required to establish and to set forth limiting criteria for design, construction, operation, maintenance, quality control, testing, and related considerations that it expects to require and to enforce. The second area of concern involves problems created when a materials tramway is used concurrently for transporting personnel. This problem often arises when a tramway is



*Figure 4.--Difficult conditions are no handicap for a ropeway. Spans of 1,000 meters pose no problems, nor do extreme weather conditions in high mountain areas, arctic regions, or the tropics.*

required to serve a project completely and exclusive of roads or other transport for personnel, construction, building equipment, operating machinery, and other uses. Determinations are demanded regarding the extent to which design limitations and "safety" requirements associated with personnel transport must be met by what is essentially a materials tramway. Even where standards established for passenger tramways are imposed, there remains a matter of interpretation of performance standards for this application. This problem will require the highest level of engineering involvement and is not one easily assigned or delegated to others.

Engineering will most often be involved in evaluating costs of materials tramways and relative costs with other transport systems. It is difficult to develop representative figures that are valid for a particular project. A study of this nature is being considered at the University of West Virginia in Morgantown. This study, it is hoped, will involve initial installation costs, operating costs, depreciation, and other factors. Engineering will be expected to provide information concerning tramway feasibility other than cost, particularly data on environmental impact.

## Ski Lift Engineering—New Concepts (FSM 7320)

Recently revised FSM 7320 establishes policies and procedures for engineering support of Forest Service authorized officers who have responsibility for special-use administration involving aerial passenger tramway facilities. Authorized officers will be implementing objectives and policies recently established in FSM 2342-- Winter Sports Concessions. The new policies direct a change in the traditionally perceived Forest Service role in winter sports administration and aerial-tramway-related engineering. The change involves, essentially, added emphasis on the charge that permittees are responsible for their operations, and the Forest Service role is one of monitoring and checking to determine that permittees implement and adhere to established standards, systems, and procedures.

Simply put, Forest Service Engineering is charged under the new concept with providing support for authorized officers to assure competent and effective technical decisions and actions in evaluating and administering Special Use Permits involving aerial tramways (2342.5-4, 7320 and 7320.2). Direct engineering support and technical assistance are on an as-needed and as-requested basis at discretion of the authorized officer acting in accord with National Policy and Regional Direction. Forest Service Engineering will be limited to inspecting and monitoring engineering and related efforts by permittees in fulfilling their primary responsibility for installation, construction, operation maintenance, and inspection of aerial passenger tramway facilities (7320.3-3). Indirectly, Forest Service Engineering will provide input and will cooperate in programs to further responsible design, adequate maintenance, and safe operation of the subject facilities (7320.3-5). The programs include (1) developing codes and standards, (2) cooperating with State jurisdictions, (3) encouraging private interests, (4) enforcing industry standards, (5) disseminating information, and (6) training personnel.

### Direct Engineering Support

Revised Manual direction and change in the perceived Forest Service role are not intended to suggest a lesser need for engineering than was provided in the past. It is intended to establish and to require that the permittee retain engineers in private practice to do virtually all engineering. Forest Service Engineers will be involved only in an inspection and monitoring

capacity as needed and as determined by the authorized officer involved. Aerial tramway engineering will continue to be performed in these principal categories: (1) type selection and location, (2) design, (3) construction, (4) operation and maintenance, and (5) inspection.

Type Selection and Location. This category involves the often extensive period of project or ski area development, including early planning; environmental analyses; EA/EIS development; master planning (2342.3); and, specifically for aerial tramway facilities, General Location Approval. Professional planning and engineering are available to the developer or proponent who is responsible for making arrangements and paying for these services. Authorized officers will interact with the proponent or permittee during this planning and developing period. Forest Service Engineering personnel will be involved as deemed necessary by the authorized officer in establishing and explaining engineering-related criteria and requirements. This information, when developed, will be made available to the proponent, with his responsibility for implementation clearly established. Particular emphasis must be given to those considerations that require Forest Service review and approval.

Design. Permittees are responsible for the design (as a preliminary to construction) of aerial passenger tramways, lifts, and tows (7320.3-2). Permittees fulfill this responsibility, initially, by having designs prepared by a qualified design engineer (7320.5-3) who must certify that the design meets requirements (7321.1) of the current National Safety Standard, ANSI B77.1. The authorized officer will reasonably assure himself that the design incorporates technical features reflecting onsite conditions and other specific requirements for the facility. This will be accomplished by review conducted by a qualified engineer employed, retained, or recognized by the Forest Service (7321.31-2a). The Forest Service Engineering review will be general and limited to that necessary to provide the assurance requested by the authorized officer. The prerogative for detailed review is retained and may be exercised at the discretion of the reviewing officer.

Forest Service design and construction approval by the authorized officer constitutes the second stage of approval (7321.31-2) and fulfillment of that requirement in 36 CFR 251.56c. The authorized officer will keep a permanent file

copy of approved drawings, specifications, and conditions (7321.32-5).

Requirements of the submittal for design review will vary for each project at the discretion of the authorized officer (7321.31-2b). Forest Service Engineering may be involved in the design review (7321.31-2a).

Construction. Permittees are responsible for the construction of aerial passenger tramways, lifts, and tows (7320.3-2). Permittees must fulfill this responsibility initially by placing their construction programs under the direction of a qualified construction engineer (7320.5-3) who must be responsible for the construction and must certify that it has been completed in accord with approved plans and specifications (7321.1). The scope of involvement is at the professional discretion of the engineer. The authorized officer may elect monitoring of the construction program by Forest Service Engineers to seek assurance that the engineer selected by the permittee for construction responsibilities (1) meets the requirements (7320.5-3) for qualified construction engineer; (2) is cognizant of all tests and other expectations for certification of construction by State authorities, if any, exercising joint jurisdiction; and (3) is aware of the information expected to be developed associated with field construction and prior to postconstruction inspection, load testing, and operational approval.

Operation and Maintenance. Permittees are responsible for the safe operation and the adequate maintenance of aerial tramways, lifts, and tows (2342.03-5 and 7320.3-2). The permittees are responsible for developing a Winter Sports Site Operating Plan (2342.4 and 7322.1). This plan must be sufficiently detailed and supported by sufficient records and documentation so that it can be periodically monitored to assure the authorized officer that applicable standards, provisions of the Operating Plan, and terms of the permit are being met (2342.5 and 7322.2). This monitoring, particularly as it involves lift maintenance programs and quality-control checks, may be performed by Forest Service Engineering personnel upon request of the authorized officer.

Initiation and implementation of a program capable of being monitored with a systems approach to area operation and maintenance will require

a concerted effort by Forest Service personnel and permittees. This program requires particularly knowledgeable engineering involvement in preparing the Winter Sports Site Operating Plans and their provision for operating and maintenance systems that can be monitored. Forest Service Engineering personnel will perform the spot-checking and quality-control measures called for by the authorized officer (2342.5-3 and .5-4).

Inspection. Permittees are responsible for the internal inspection (2342.5) of aerial tramway, lift, and tow facilities, as required, to (1) redeem their responsibility for safe operation and adequate maintenance of their facilities, (2) meet requirements of the Safety Standard (7320.5-5), and (3) fully implement the Winter Sports Site Operating Plan. Permittees are also responsible for the postconstruction inspection with accompanying load test (7321.31-3) and the periodic safety inspection required by ANSI (7322.2).

Authorized officers are responsible for insuring that permittees conduct self-inspections (2342.5-1). This responsibility most frequently involves Winter Sports administrators, but could involve Forest Service Engineering personnel at the discretion of authorized officers.

The authorized officer is responsible for obtaining from a Forest Service qualified engineer or qualified Forest officer an independent evaluation of postconstruction inspections and the periodic safety inspections (7322.2).

Most frequently Forest Service Engineers are involved in that the inspection (1) most often is highly engineering oriented; (2) has been made by a qualified inspection engineer from private practice; and (3) demands a determination regarding acceptability of the inspection and the recommended action on the deficiencies noted.

Manual subsections 7321.1 and 7321.31-3b(2) direct that a qualified inspection engineer perform the preoperational postconstruction inspection and observe the load testing of a new lift facility. Forest Service Engineering personnel may or may not be present. Participation is advisable and is expedient in maintaining technical expertise within the Forest Service (7320.2-4).

Indirect  
Engineering  
Support

With decreased Forest Service direct involvement in aerial passenger tramway and ski lift administration, there will be less direct involvement in engineering these facilities. Forest Service policies continue to demand an indirect involvement in programs to encourage responsible design, correct construction, adequate maintenance, and safe operation of these facilities (7320.3-5). This engineering effort will be carried out by involvement and cooperation in various programs described briefly in the following subsections.

Development of Codes and Standards. The importance of a National Safety Standard and enlightened State codes in furthering aerial tramway interests is well established and recognized. The current National Standard (ANSI B77.1) is the applicable reference document for the Forest Service administratively (2342.5) and technically (7320.3-1). The Chief is responsible for arranging responsible participation in developing National Standards (7320.41-1). Regional Foresters are responsible for cooperating with States exercising joint jurisdiction over aerial tramways (7320.42-2); much of this effort involves direct participation in preparation of State codes. Forest Service Engineering is most often involved because codes and standards contain largely technical considerations.

Cooperation with State Jurisdictions. Forest Service policy intends to achieve (1) decreased Federal involvement, (2) increased reliance upon State jurisdiction, and (3) elimination of duplication by authorities having joint jurisdiction. Close cooperation with State authorities should be furthered by a "memorandum of understanding" or similar agreement (7320.5-6). Regional Foresters are charged with meeting this responsibility (7320.42-2). A major portion of the cooperative effort involves engineering-related activities of design approval, construction control, establishing operational and maintenance requirements, inspection of facilities, and accident investigation.

Encouraging Private Interests. Operating within manpower and budgetary constraints, the Forest Service will encourage, to the fullest extent possible, private research, development, operating safety practices, and related work (7320.3-5c).

Enforcement of Industry Standards. The policy statement (7320.3-5d) calling for achievement of safety in aerial tramway design, construction, maintenance, operation, and inspection through an

informed interpretation and enforcement of industry standards is largely administrative. Forest Service Engineering is involved in interpreting technical provisions or requirements as requested by the authorized officer. Whereas the extent of engineering effort involved is limited, the interpretations and determinations made are extremely important, may be controversial, and suggest the necessity for maintaining a high level of engineering competence (7320.3-4).

Disseminating Information. Forest Service Engineering will be actively involved in disseminating information on aerial tramway design, equipment development, operating practices, safety standards, and accident prevention (7320.3-5e). This task will be accomplished, in part, by (1) exchange among Forest Service personnel at training sessions, (2) technology transfer through national and international trade journals, and (3) national and international organizations oriented to this end.

Training Personnel. Forest Service Engineering will assist in training qualified personnel. This includes Forest Service personnel, as needed, and personnel outside the Service who are performing functions vital to Forest Service interests. The Chief is responsible for providing assistance in personnel training for the Regional Foresters (7320.41-4). Regional Foresters are responsible for providing training to Forest personnel (7320.42-6). Sufficient technical expertise and competence will be developed and maintained to perform Forest Service functions and responsibilities and to communicate effectively with industry and independent engineering sources (7320.3-4).

## Dwyer Receives Award

The Rocky Mountain Lift Association (RMLA) awarded Charles F. Dwyer the first Robert F. Lesage Memorial Award for outstanding contributions to the aerial tramway and winter sports industries.

Dwyer is a Forest Service Washington Office Aerial Tramway Engineer who works out of the R-2 Office. He is well known internationally as an expert on aerial cableways and lifts and has represented the U.S. Government at regional, national, and international technical conferences on cable systems.

The award is in memory of Robert Lesage, P.E., aerial tramway designer and Colorado State Tramway Administrator, who died December 24, 1980. The RMLA has a diverse membership but is composed principally of operating and maintenance personnel. To be recognized by the people who run the units--and keep them running--adds significance to this "grassroots" award.

Charles F. Dwyer (right), Chief Aerial Tramway Engineer for the Forest Service, receives Award from Tom Clink (left), master of ceremonies. Others (left to right) are Bob Hartzell, Chairman of the RMLA Board of Directors; Mary Purdy, RMLA Board member; Georgia Lodders, Director of Area Operations, Colorado Ski Country USA; and Jim Branch, President of Sno-engineering, Inc.



Photo courtesy of RMLA.



## P-M:

*M. R. Howlett, Director of Engineering*

In the current climate of limited budgets and personnel ceilings, it seems that maintenance is one of the first activities considered for reduction. Even under expanding operating conditions, the idea of preventive maintenance (P-M) has been difficult to "sell."

The following editorial, reprinted from WATER/Engineering & Management, presents a good case for a well-conceived and carefully managed P-M program. These ideas apply to virtually all of our engineering jobs--roads, bridges, buildings--as well as to water and wastewater systems.

Perhaps the time has come to consider P-M as one of the "NEW" ways for us to do business.

Editor's Desk \_\_\_\_\_WATER/Engineering & Management, January 1982

## A Stitch in Time Saves Nine

The sage who first said that years ago did not realize it, but he or she was defining preventive maintenance. What better way to capture the idea of P-M?

Its importance certainly varies from industry to industry, depending on such factors as complexity, safety and reliability requirements, physical and chemical conditions, etc. However, there seems to be a common denominator of sorts based upon the passage of time. Sooner or later, a P-M philosophy has to become part of the normal way of doing business for most manufacturing or processing industries. Our water and wastewater industry is no exception, and the last decade has brought a growing realization that sound maintenance practices are essential for operational success. This is especially true in the rapidly expanded wastewater treatment area, with many new plants in the picture.

Installing P-M programs can take much effort and a real selling job on the part of middle managers and engineers who believe in them. In

the profit-motivated environment of manufacturing, upper management can profess to recognize the significance and value of the P-M function, but too often prefers to subordinate it in favor of production processes and equipment. There is a tendency to be addicted to the bottom-line syndrome--"get the product in the box and out the back door." Maintenance personnel are often thought of in terms of muscle, not brainpower. Fortunately, this attitude is changing. Upper managers are paying more attention to the intrinsic value of P-M programs--and the need for bright, skilled people to implement them.

In another analogy, think about what would have happened to the airline industry if sophisticated, well-engineered maintenance procedures had not been developed. These probably represent the most advanced, large-scale P-M system in existence. Concern for public safety was the principal stimulus. But the airlines' business also had to have high equipment utilization factors. Sound P-M was the only way to go. Without it, a 747 at today's price of \$60 million will not fly reliably and safely for very long. Similarly, a \$60 million water or wastewater treatment plant--even a perfectly designed example--cries out for P-M attention if it is to do its job.

What about design attitudes toward maintenance? Does the design coming off the drawing board reflect "sophistication" without complexity? (Over-design is not always necessary.) Does it take P-M, and emergency maintenance for that matter, into account? Is the designer thinking beyond first cost, start-up, and the early months of a system's life? Is he visualizing the mature plant that has to be run cost-effectively around the clock, and that fires on all cylinders? The buyer should insist that these and other pertinent factors are considered in the design philosophy.

Intelligent training of maintenance personnel at all levels is another essential ingredient of the successful plant operational recipe. Most water or wastewater maintenance people are not process or mechanical engineers. Perhaps their managers are, but they don't have to be. However, they must be taught to spot a problem, communicate with the right individual, and not habitually turn knobs and develop their own solutions without approval. Shortcuts may be

well-intended but can be disastrous. To use another airline analogy, the tragic 1979 DC-10 crash in Chicago was caused principally by a money-saving maintenance shortcut. It had been implemented without a sufficiently detailed analysis of possible structural effects.

There has been much talk about a significant number of poorly operated and maintained wastewater treatment plants of recent vintage. Rehabilitation of water distribution and sewer piping systems is another hot topic. Correcting all the problems is going to take money. To prevent or minimize them in the future we must think long term. A dollar spent on P-M may very well save another nine, for there is probably no more effective mechanism for controlling operational costs than a well-conceived and managed maintenance program.

--*Ian Lisk, Editor*

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# Priorities . . . Priorities . . . Priorities . . .

G. L. 'Scotty' Rome, Editor

From late December until May, we had only one person in the Engineering Publications Unit...yours truly. In addition to work on the Certification Program exams and course books, staff studies, and special reports, the Engineering Publications Specialist is the Staff Coordinator for FS Manual, Handbook, and Forms material--all priority items.

The result of juggling our schedules, with a continuing stream of new "first" inputs, was the long delay in publishing our Engineering Field Notes. With the addition of Dennis J. Carroll as Editorial Assistant, as well as the growing capabilities of our publication services contractor, we are making headway in reducing the backlog. We hope that the Fall of 1982 brings publication schedules that are current and--if we're lucky--improved temperature and humidity readings.

In conversations with field Engineering people, the concern that they expressed about missing the Field Notes included encouraging comments about the content and interest factors, as well as readability. The contributing authors deserve our thanks for their support in these matters. We will continue our efforts to make each issue of Engineering Field Notes a better publication and to justify your cooperation and patience during the difficult half-year that we have experienced. So, keep the articles coming. You're doing a fine job, and you can let others know how to get it done.

...And YOU may get the 1982 Award of \$100 (less your IRS contribution!) for the best article published in Engineering Field Notes.

# Fire Tower to Observation Platform

*Richard D. Wilson, Structural Engineer, Region 9*

## WASHINGTON OFFICE COMMENTARY

*Although the desire to make use of an abandoned facility, such as a fire lookout tower, is understandable, the potential hazards and possible tort claims, redesign costs, and the costs of long-term maintenance and operation should be considered before proceeding with plans to convert unused towers into public observation platforms. The proposed "recreational" uses of these towers often cannot justify the costs involved.*

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## A USE for ABANDONED FIRE TOWERS

Forest Service use of lookout towers for fire detection dates back many years. In the early 1970's, the increasing use of aircraft for fire detection prompted a reevaluation of the use of lookout towers. As a result, many of these towers have been phased out. Region 9 currently has no regularly manned towers.

The unused towers not only left the Forests with a maintenance headache, but often were targets for vandals. Public safety also became a concern, necessitating the locking of cabs and the removal of the lower flights of stairs. Many Forests disposed of towers through exchange, sale, or by dismantling totally.

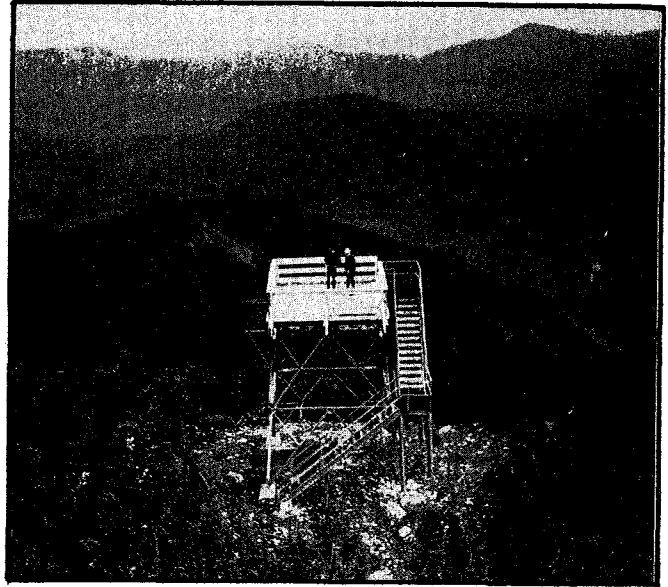
Some remaining towers in Region 9 have been used for communications or have simply been abandoned. However, two Forests in the Region have proposed to use their steel towers for public observation platforms and requested assistance from the Regional Office in designing the necessary modifications.

## DESIGN CONSIDERATIONS

The first completed modification design was for a 20-foot tower on the White Mountain National Forest in New Hampshire. The Forest proposal called for removing the cab, installing an observation platform, a new stairway, and a guard railing system.

Primary design considerations for this project included the following:

*The converted Carrigain Tower,  
White Mountain National Forest.*



1. Design loads; the need to meet Occupational Health and Safety Administration (OSHA); and other safety requirements.
2. Restricted access. The tower is accessible only by trail.
3. Electrical power is unavailable.
4. Construction to be performed by force account crews having little or no experience in steelwork.

OSHA requirements for stairways precluded reuse of the original stair system because it was too steep and narrow. Another design problem was determining the acceptable live load; the Uniform Building Code (UBC) does not indicate the design load to be used for an observation platform. The closest classification--for Assembly Areas, auditoriums, and balconies--listed design live load values ranging from 50 pounds per square foot (psf) to 125 psf, depending on conditions of seating. By estimating the number of people who could stand on the platform and an average weight, we finally selected a live load value of 100 psf.

Because of the restricted access to the platform, a new stair system was designed to be pre-assembled in sections, and lifted to the site by helicopter. The lack of electric power led to selection of bolt-connection designs instead of welds. Supporting the stair system independently on columns eliminated any field drilling into the old tower legs.

Overall, the design was accomplished with a minimum of connections. By independently supporting the stairs and preassembling the stairway sections, the construction process was simplified so that the relatively inexperienced force account crews had little trouble with steel erection. Timber was selected for the observation platform for ease of construction and its natural appearance.

Since completion of the first design, modifications have been developed (or planned) for two other towers: One was another 20-foot tower on the White Mountain NF; the second was on a 40-foot structure on the Monongahela NF. The second White Mountain project design was similar to the first; however, some materials were substituted to reduce project costs. Supporting columns were also arranged differently, allowing fewer columns and making the design more efficient. Access was easier, permitting equipment to be taken to the site, with advantages of field-drilling opportunities for some of the connections. A lightning rod, omitted on the first tower, was installed.

The Monongahela project was different in several respects. The project site was accessible to equipment, and the work was set up to be contracted. With more skillful workers, more desirable connections were used. With a height of 40 feet, it was not feasible to support the stairway sections separately on columns. The support system consisted primarily of cantilevered sections and struts welded to the existing frame. Again, cost savings were effected from the materials changes that had been incorporated in the second White Mountain design.

On all designs, the effect of the changed loading on the strength of existing tower legs and foundations was checked. In all three cases, the towers were in good condition. The total weight of changes and estimated live load were close to the total estimated weight of the cab and its live loads. Existing tower legs and foundations were found to be adequate without modification for the new loads.

Modifications such as were made to these towers can convert an eyesore to a useful and attractive structure, and eliminate some safety hazards associated with abandoned towers. The use of fire towers for observation platforms provides an opportunity for a unique recreational experience, while taking advantage of an otherwise unused facility.



# Hydropowered Pump Installation

*Don Hillard, Environmental Engineer, Region 1*

Prior to 1974, the McGillivray Campground in the Kootenai National Forest, Montana, had a water system consisting of a well, a 19,000-gallon reservoir, and distribution system; one estimate of its capacity was less than 3 gallons per minute. Water was pumped to the reservoir with a submersible pump powered by a gasoline-engine-driven generator, and gravity flow supplied the distribution system and associated appurtenances. This system was considered temporary for initial development at the campground.

As the campground developed, the need for a more substantial source of water became evident. In 1974, construction was completed on a new water system consisting of an intake system on Jackson Creek, sedimentation tanks, two hydraulic rams and drive pipes, and 8,950 feet of 2-1/2-inch-diameter pipeline to the existing reservoir (figure 1). Problems with the hydraulic rams and the undesirable aspects of a surface source system prompted a new look at the water supply situation.

In 1979, a new well adjacent to the ram building was drilled; it is 100 feet deep and produces about 6 gallons per minute. Although it is a marginal source in terms of quantity, its quality is good and it will supply the immediate demand. The only problem remaining was getting the water from the well to the reservoir. As a temporary measure, a gasoline-engine-driven, deep well centrifugal pump with injector was installed to provide water for the 1980 recreation season.

## DESIGN CONSIDERATIONS

Although it was recognized that this well would not satisfy future water demand if the site were ever developed to ultimate capacity, the 6-gallon-per-minute capacity coupled with the 19,000-gallon reservoir is adequate for the existing 3-day demand of the site. Ultimate demand will require an additional source or more storage capacity, or both. The objective of this project was to supply available water supply to the campground at a low cost. To do so, 14 design parameters had to be taken into account:

1. Existing developments to be used as much as possible.
2. Need for a system with uncomplicated, easy-to-operate components.
3. Design flow to reservoir  $Q = 5$  gpm.
4. Elevation of storage reservoir: elev. = 2,687 feet.
5. Distance from ram building to reservoir = 9,725 feet (2-1/2-inch pipe = 8,950 feet; 4-inch pipe = 775 feet).
6. Pumping water elevation in well: elev. = 2,470 feet.
7. Distance from ram building to well = 40 feet.
8. Elevation of ram building: elev. = 2,569 feet.
9. Elevation of Jackson Creek intake: elev. = 2,648 feet.

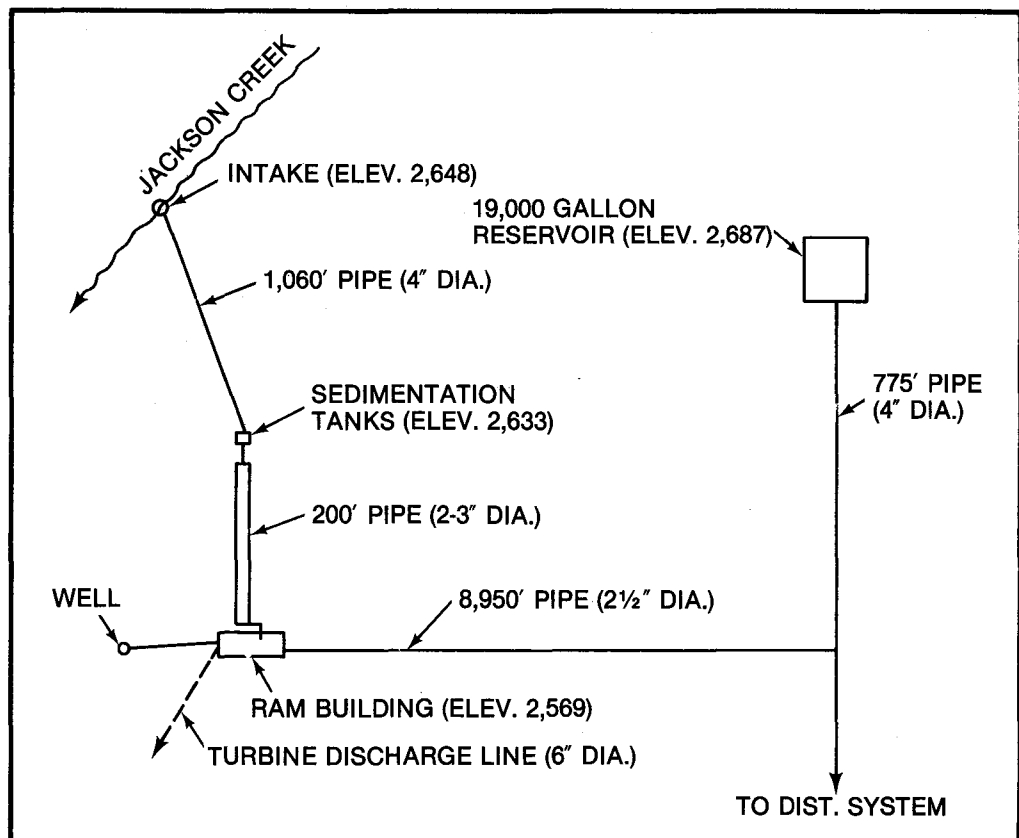


Figure 1.--Flow diagram, McGillivray Campground water system.

10. Distance from intake to sedimentation tank = 1,060 feet.
11. Elevation of sedimentation tank outlet: elev. = 2,633 feet.
12. Distance from sedimentation tank to ram building = 200 feet (2- to 3-inch-diameter pipes).
13. Location of commercial electrical power: about 5 miles from the site.
14. Safeguards to prevent pumping the well dry.

#### HYDROPOWERED PUMP

Several alternatives were investigated to pump water from the well: a submersible pump, a line shaft turbine, and a deep well centrifugal pump with injector. Several power sources were also investigated: a powerline constructed from the nearest source (5 miles), a fuel-powered electrical generator, solar power, a hydropowered electrical generator, and a pump that is powered directly from a turbine.

The simplest and most economical system was the deep well centrifugal pump with injector, belt-driven by a hydroturbine. Figure 1 shows how the water to power the hydroturbine installed in the ram building is supplied through the existing intake, sedimentation, and hydraulic ram drive pipe system. Figure 2 shows the finished installation. This installation was assembled using common components from various manufacturers. Figure 2 also shows how flow enters from the ram drive pipes at the right, goes through the flow control butterfly valve, and drives the 17-inch-diameter pelton wheel upon exiting from a 15/16-inch nozzle. Power is transferred from the 18-inch sheave on the turbine shaft to an adjustable (1.9 to 2.9 inches) sheave on the pump shaft by a "V" belt. During tests, the system produced 4 gallons per minute at 55 pounds per square inch at the pump outlet. To provide emergency service, the standby pump (figure 2) can easily be connected using the "Kamlock"-type quick-connect fittings that are the same on both pumps.

To keep from pumping the well dry or operating the pump without water, the injector was installed 70 feet from the top of the well with 25 feet of tailpipe below the injector. This matches pump output to well production whenever the well is drawn down below the injector.

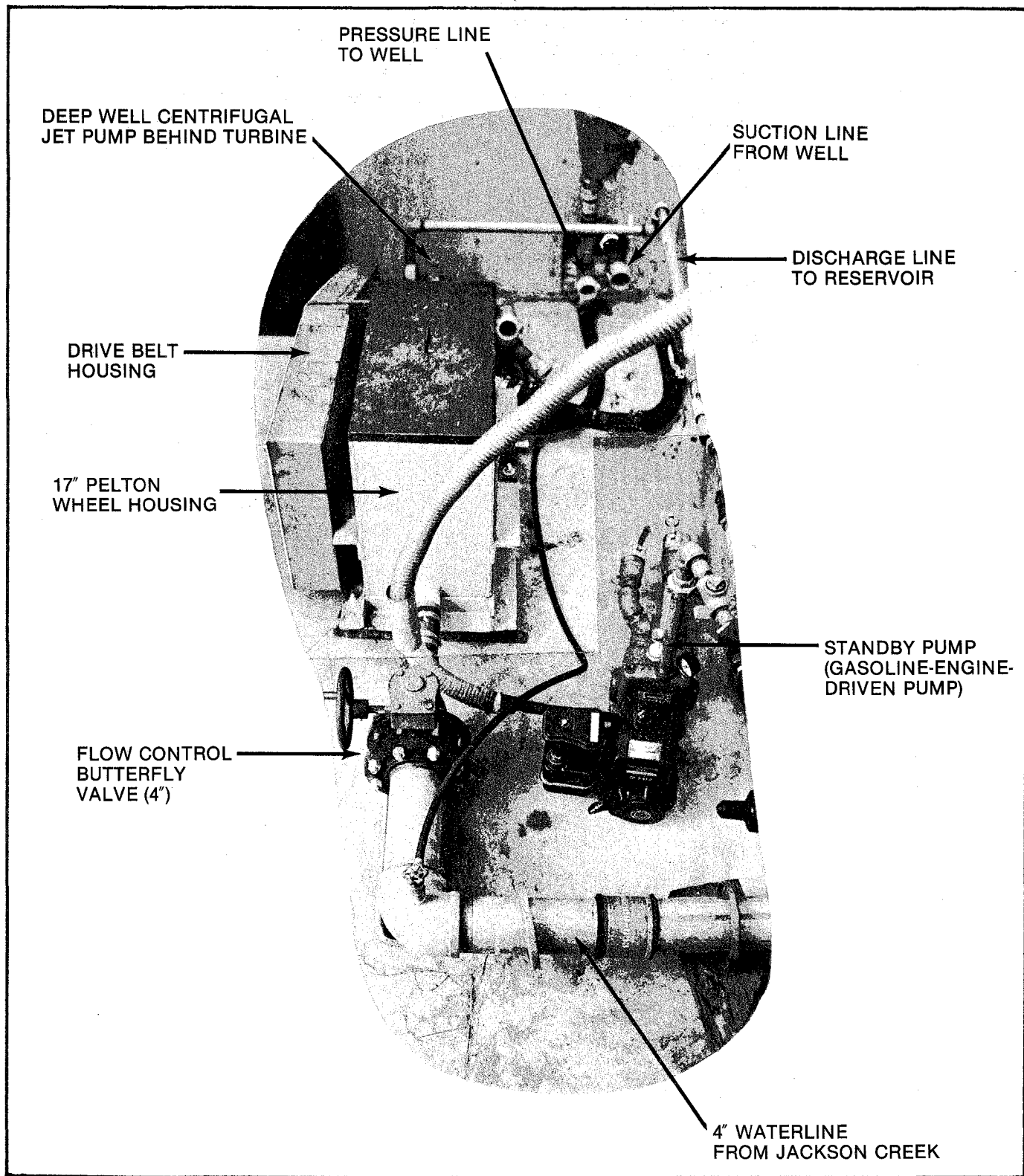


Figure 2.--Hydropowered pump, McGillivray Campground water system.

This system was feasible at this location because almost all components were in place. Starting from scratch, the project would have cost considerably more. Also, if starting from scratch, several components would have been designed differently. For instance, the turbine and pump would have been a "well head" installation, not 40 feet from the well. The pump would have been a positive displacement progressive cavity pump in the well, driven with a line shaft directly from the turbine.

Itemized costs were as follows:

|                                                                                                |              |
|------------------------------------------------------------------------------------------------|--------------|
| 1. Well drilling                                                                               | \$2,430      |
| 2. Temporary system--gasoline-engine-driven pump, injector, pitless well adapter, and plumbing | 2,932        |
| 3. Permanent system--pelton wheel, butterfly valve, pump, and plumbing                         | <u>3,941</u> |
| TOTAL COST                                                                                     | \$9,303      |





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