WATER OPERATION AND MAINTENANCE BULLETIN

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IN THIS ISSUE. . .

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

This *Water Operation and Maintenance Bulletin* is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Reclamation personnel and water user groups in operating and maintaining project facilities.

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***Cover photograph*:** Locked out inlet gate valve.

UNITED STATES DEPARTMENT OF THE INTERIOR Bureau of Reclamation

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A SAFETY PROGRAM TO LIVE BY

by Denver Safety and Health Services, D-7600

When most private companies and Federal agencies cringe at the sound of an Occupational Safety and Health Administration (OSHA) inspection, the Bureau of Reclamation employees at the Elephant Butte Field Division have welcomed the opportunity. They have "invited" the OSHA team members to come and evaluate their work site and safety programs. Crazy? Not on your life. This is an effort by the Elephant Butte employees to become the first Federal agency in the U.S. Government to be admitted into the Voluntary Protection Program (VPP).

The VPP is an employee-driven safety program committed to reducing accidents in and around the workplace, increasing safety awareness, and establishing a cooperative partnership with OSHA. Who better to run a safety program and ensure that coworkers are complying with procedures than the employees themselves? These are the people who work in the so-called "trenches" everyday. The program is geared towards meeting, exceeding, and maintaining the safety standards set forth by OSHA regulations. Being accepted in the VPP is no easy task. It requires a level of dedication and commitment from management and employees that not every organization can achieve. It also requires guidance (mentoring) from an already established VPP participant. The employees at Elephant Butte were mentored by the City of Scottsdale, Arizona, which was mentored by Motorola from Phoenix, Arizona. The City of Scottsdale provided assistance and advice with the application process and performed on-site inspections prior to the OSHA evaluation.

Currently, there are approximately 300 VPP sites in the United States, all of which are private organizations. Since the Elephant Butte Field Division is the first government agency accepted into the VPP, OSHA had to establish a new application process which applied to Federal agencies. This, in itself, is an achievement for OSHA and the Elephant Butte Field Division employees. This provides a stepping stone for the Federal Government which will allow other Federal agencies to apply for the VPP in the future.

Benefits that result from becoming a VPP site include improved employee motivation, positive community recognition and interaction, reduced workers compensation, and other injury- and illness-related costs. Lost workday case rates are generally 60 to 80 percent below the average for their industry. The increased safety awareness brought about by the Elephant Butte employees in the VPP has reduced the number of injury- and illness-related costs from 6 in 1997 to 1 in 1998. The average cost of an injury on the job is nearly $30,000. With the reduction of injury- and illness-related incidents, the employees at Elephant Butte have saved the taxpayers $150,000.

TUNNELS!

by Jim Meredith, Occupational Safety and Health Manager, MP Region

Did you know that the Bureau of Reclamation (Reclamation) has more than 235 miles of them throughout the western United States? Did you know that they are generally considered confined spaces and can be permit-required confined spaces (PRCS) under the definitions contained in the Occupational Safety and Health Administration's (OSHA) Permit-Required Confined Space Standard, 29 CFR 1910.146?

The Mid-Pacific Region and its South Central California Area Office (SCCAO) recently learned more than they wanted to know about the PRCS tunnels during a periodic Reclamation operation and maintenance examination of the Tecolote Tunnel near Santa Barbara, California. The tunnel, completed in 1956, is part of the Cachuma Project, is 33,557 feet long but only 7 feet in diameter. It is operated by the Cachuma Operations and Maintenance Board (COMB), conveying water from the Cachuma Reservoir to other parts of the project.

The tunnel is inspected about every 6 years, with the most recent previous examination taking place in March 1993, just before OSHA's current PRCS Standard went into effect. Because of its relatively small diameter and means of access into the tunnel, the examinations are conducted on foot, with any support equipment carried in a customized "Red Ryder" wagon that the examination team members take turns pulling or pushing as they progress. The tunnel has a powered ventilation system (12,400 cfm capacity) but has no internal lighting or communications system.

Though examined a number of times since its construction, the 1993 "walk" was the first and only one where air monitors were used to check for contaminants and oxygen deficiency. During that exam, carbon monoxide (CO), hydrogen sulfide (H_2S), oxygen (O_2), and explosive gases were monitored (abnormal readings were identified for the latter three). Air temperature was also recorded since there is a tendency for the air temperature to rise (because of geothermic activity in the area) following the cutoff of water in the tunnel.

Planning for the March examination began well before the activity took place. SCCAO, COMB, and the MP Regional Safety Office worked cooperatively to address the safety and health issues related to the examination activity. Though previous examinations had gone well—and had been well planned from a safety standpoint—considerably more thought had to be put into this effort in order to comply with the PRCS Standard and its CalOSHA equivalent (COMB operates under CalOSHA).

Tecelote Tunnel is identified as a PRCS, based on the identified hazards (water, atmospheric) within the tunnel. This is where the fun began—trying to make a tunnel entry that did three things: get the job done, protect the entry team, and comply with the OSHA standard. Dealing with the last item first, it was clear from the outset that entry under full PRCS compliance was not possible for one principal reason—communications. OSHA requires full communications between the entry attendant and the entry personnel at all times, something that isn't possible in most tunnels, at least with current technology. So, it was necessary to look at the two alternative approaches allowed under the standard—alternate entry and reclassification. Again, it was easy to eliminate the reclassification option since it is only available where no atmospheric hazard potential hazard exists, leaving the alternate entry procedure as the only possible method of compliance.

Locked out inlet gate valve.

Under the alternate entry procedure, atmosphere is the only hazard that can be posed by the PRCS. After reviewing the air monitoring data from the 1993 examination, it was determined that the existing mechanical ventilation system, operated for an extended period prior to entry with continued operation during entry, would maintain the safe atmosphere necessary for this examination. The engulfment hazard posed by water was not considered an issue because the tunnel intake could be isolated through its double gate valves. OSHA, in its June 1, 1995, interpretation letter addressing a hydropower sluice tunnel question, stated that "potential engulfment by water held back by the double sluice gates should not be an issue" in PRCS since the situation is a "form of isolation."

With the compliance issue settled, the planning could begin. A full job hazard analysis and an examination work plan were developed. This included the identification of certain emergency use safety equipment. Though there was a high confidence level that a safe atmosphere could be maintained, it was also realized that the tunnel existed in a natural environment where conditions could change unexpectedly, and that the time to discover that respiratory protection or emergency breathing air was needed was not 3 miles into the tunnel! The decision was made to carry this equipment on the examination.

Gas masks and H_2S canisters.

The greatest concern was with H_2S. H_2S is a colorless gas, also known as sewer gas, with a pronounced rotten egg odor. It affects the ability to smell, so after a few minutes of exposure, you can't smell it even though it still may be present. Extended exposure or exposure to high concentrations can lead to serious injury or death. The 1993 examination had identified a single "hot spot" in the tunnel where the concentration exceeded that permitted under Reclamation safety and health standards but below OSHA's permissible exposure level. This created a possible situation where the entry team could be required to don respiratory protection under the RSHS but still not have a hazardous atmosphere under OSHA that would terminate the alternate entry of the PRCS. To address this possible situation, a decision was made carry to respiratory protection, both air purifying and supplied air.

Self-contained self-rescue unit.

Most air purifying respirators for H_2S are for escape use only. Because of the possible extended time to clear the area (possibly up to 45 minutes) and the need to continue the examination if possible, it was decided to provide canister-type gas masks. MSA Super Size Gas Masks with end-of-service-life indicating canisters were identified for this purpose. Team members were instructed to don the masks if H_2S concentrations exceeded 10 parts per million (ppm) (Reclamation limit) but would be permitted to continue with the examination. If readings exceeded 20 ppm (OSHA permissible limit), they were to discontinue the activity immediately and proceed to the nearest point of egress (either the access at the intake structure or the tunnel outlet).

An extended ventilation period prior to entry was to address any possibility of oxygen deficiency in the tunnel. At one point in the 1993 examination, a low O_2 alarm sounded. At that time, the team suspected a faulty sensor and continued with the examination. They were probably correct, since O_2 sensors can be "soured" in the high humidity environment of the tunnel. But that was the wrong action to take; so, for the 1999 examination, in addition to the primary gas monitor, a standby monitor was carried in a sealed bag to protect it from humidity. If the O_2 alarm sounded, the team was to confirm the reading with the second monitor. If the reading was confirmed, the team was instructed to don self-contained self-rescue devices (SCSR) and to exit the tunnel by the fastest means. SCSRs are used in the mining industry for emergency escape purposes. They contain a small

Tunnel examination pre-brief and safety meeting.

Entry attendant checks air flow at the entry portal.

oxygen supply or oxygen-generating source and a chemical filtering system which converts CO_2 back to O_2. For this purpose, Ocenco EBA 6.5 SCSRs were provided. These devices were certified to provide at least 90 minutes of breathing air and were lightweight and small enough to be carried on the wagon without difficulty.

In preparation for the examination, all team members were given physicals, to include clearance to use respirators, and fit tested for the MSA masks. All entrants completed a confined space training course.

One day before the examination, all involved personnel met at the entrance portal for an examination pre-brief and safety meeting. During the meeting, the final JHA was reviewed, and training in the use of the safety equipment was conducted. The roles of all personnel, both on the examination team and support team, were discussed.

The powered ventilation system was turned on approximately 13 hours prior to entry, 10 hours earlier than in 1993. Mechanical ventilation was required for the alternate entry method under which the tunnel was being entered, and it had been estimated that it would take that long for the system to achieve the 7.5 air changes necessary to ensure fresh air was in the tunnel prior to entry. Greater ventilation was, in fact, achieved. The water flow was not locked out until 3 hours prior to entry, and the smaller cross-section of air to be exchanged resulted in a much higher number of air changes taking place during that period.

On a cool, rainy morning in late March, the entry and support teams assembled at the north portal of the tunnel. The atmosphere at the tunnel portal was checked to ensure that it is nonhazardous and safe for entry. After the equipment wagon was lowered into the tunnel, the team entered and was on its way. After all the planning and preparation, the actual event was almost anticlimactic. The team had a 6-hour time limit to complete the examination; if not out by then, outside rescue teams were to be called. Because of the inability to communicate with the team while in the tunnel, communications were limited to telephone calls at regular intervals between the support teams at the entrance and exit portals.

Finally, shortly before 1 p.m. (the end of the 6-hour entry period), the team emerged from the exit portal. Everyone was tired but safe. The transit through the tunnel was uneventful (that is, except for the fish that swam past someone's foot, scaring their socks off!). There were no abnormal readings or alarms from the air monitor—the H_2S readings peaked at 8 ppm. The worst had been planned for, and the best had resulted!

The next day, in the post-examination debrief, the team members expressed their appreciation for the safety planning and preparation that had taken place. Even though no one had expected to have to use the respiratory equipment, they were glad that it was available and was worth having to pull it along for 6 ½ miles. They felt the lack of communication was a handicap, one which Reclamation needs to address (a pair of 900-MHZ radios used in a Technical Service Center tunnel communications study conducted in 1997 was used by the team during this examination. Contact with the outside support team was lost less than 1 mile from the portal). Entrants in future examinations should use head-mounted miner's lamps to keep hands free.

In this case, all objectives were met: get the job done, protect the team, and comply with OSHA standards. However, this will not be possible in all Reclamation's tunnel entry situations, and so it is an issue that needs top priority attention by the organization if we are to continue to maintain our reputation as the premier safety and health organization within the Department of the Interior and the Federal Government.

Post Script Note: The gas masks and self-contained self rescuers mentioned in this article are available for use by other Reclamation offices. Requests should be directed to the MP Region Office of Safety, Health, and Security; (916) 978-5575.

AGRICULTURAL DRAINAGE ENGINEERING PRACTICE

by Glen D. Sanders[1] and Lowell Ploss[2]

Abstract

Science, sound engineering, and proper operation and maintenance (O&M) are keys to successful drainage systems. The past 50 years have taken the art of agricultural drainage and made it into a science; still, there is much to learn about drainage. Some soils do not fit the conventional wisdom of how soil, water, and salts are handled. Installation practices are changing, and with them, the economics of installation. Social attitudes and policies are changing. We can no longer indiscriminately drain lands without considering the environmental consequences outside the limits of the drain system. At the same time, we cannot arbitrarily preclude drainage as a management practice. This paper suggests a sampling of the many areas where research is needed to keep the science of agricultural drainage from falling behind as we enter the next millennium. The paper will also introduce a new task committee whose mission is to provide information and guidelines which can be used by management and staff personnel involved in the design, construction, operation, and maintenance of agricultural drainage systems.

Introduction

For several thousand years, man has understood that successful irrigation ventures required removal of excess water and salts through natural or manmade drainage systems. For most of that time, drainage engineering was limited to "let's put it here and see if it works." Still, we have not moved much beyond the "let's wait and see where it is needed" approach.

Operation and maintenance of a subsurface drainage system usually involved replacement after the system failed—if the entire irrigation venture had not already failed because of lost production. Around the middle of the 20th century, subsurface drainage of agricultural lands was developed into a science. Engineers can now design drainage systems that provide adequate drainage while minimizing risk of failure and optimizing economics.

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Needed Studies

Problem Soils

Vertisols are soils that invert themselves over time by developing cracks during dry seasons. The cracks fill with surface soils then swell shut when the soils are wetted. Typically, these soils are judged to be unsuitable for irrigation because they display permeability values that are much too low to provide adequate drainage. Nevertheless, there are documented cases of vertisols being irrigated over long periods of time with no apparent ill effects. One example is the Bedoin Clay soils along the Milk River in Montana. The primary crop grown is wild hay, a low value crop. If we knew enough about the process to be able to apply it to rice or wheat, similar soils in Somalia could possibly be managed in a manner to relieve the famines of that country.

A parallel story can be told about glacial till soils that are predominant across the northern tier of the United States, Canada, northern Europe, and northern Asia. By the best science we have, most of these soils will not economically support irrigation when all costs of development are considered. Again, there are many instances of apparent success which are attributed to a wide range of factors. The most common explanation lies in an intricate pattern of "joints" as described by Hendry (1982) which impart a secondary permeability to the soil matrix. Even this secondary permeability does not adequately answer the question of the eventual fate of salts that are imported with the irrigation water.

Filters and Envelopes

Drainage engineers have been using graded gravel envelopes as filters around pipe drains for a very long time. Recently, the Bureau of Reclamation experienced a drain failure as a result of envelope material clogging the perforations in the drain pipe. This may be an isolated incident or it may be a phenomenon that occurs often but goes undetected because the entrance area of drains is typically overdesigned. The size and shape of the gravel particles, the degree of curvature and degree of uniformity, and the geometry of the holes may all be contributing factors. Another possible contributing factor is the fact that the drain was thoroughly dewatered for construction and the gravel envelope was slowly saturated from the bottom up.

It is possible that significant differences in permeability exist between crushed or angular gravel and rounded gravel of the same gradation. If so, this should be taken into account in the design stage. There may be significant differences in segregation during handling or in the ability of the gravel to flow through a trenching machine. Many instances of problems have been attributed to the shape of the gravel, but little solid research has been done on the subject.

The use of filter fabrics around drain pipes has become commonplace. A few studies have been done comparing these envelopes to gravel envelopes, but what are the true hydraulic consequences of wrapping the pipe in a filter? Some designers advocate wrapping a coarse sand/gravel envelope in a filter fabric. Is this a sound practice?

Disposal Problems

Drain effluent has long been a cause for concern because of the salt load that is often carried. These problems are still with us, but they become less significant when compared to the problems that arise from even minute concentrations of certain trace elements. Research is needed to fully understand the transport mechanisms. Understanding how soil concentrations of heavy metals relate to concentrations in drain outflow, developing economical methods of treating the drain outflow, and developing management practices that will allow irrigation development to take place in an environmentally responsible manner are some of the areas that need to be addressed.

The experience with Kesterson Wildlife Refuge in the Central Valley of California is an example of how the trace element selenium fueled a conflict between irrigation and ecological interests that has gone on for more than a decade and is still not fully resolved. Death and deformity of waterfowl attributed to selenium in drain effluent resulted in closure of the reservoir, a moratorium on the installation of new drainage systems in the area, and a suspension of plans for completion of a valley drainage outlet. Hundreds of thousands of acres of productive farmland on the west side of the San Joaquin Valley are threatened by the lack of an affordable, environmentally acceptable means of disposal of drainage effluent.

Biological Clogging

Biological clogging of drains is a problem that sporadically occurs under certain conditions that are favorable to the biologic clogging agent. In general, the causes of the problem are known, and treatment techniques are available. However, little has been done in the line of preventive techniques. Maintaining a drain that has severe biological clogging is a formidable task involving frequent flushing with pressure sewer cleaners and possibly the use of strong chemicals. Treatment of the drain pipe or the envelope material that is placed around the pipe may offer better and more permanent solutions. Research in this area could also be beneficial to the water well industry as well as those charged with maintenance of relief wells on dams.

Open Drain Maintenance

Maintenance of open drains has become more and more difficult with increasing controls placed on pesticides of all kinds. Weed control, including woody plant growth, is made more difficult by environmental controls. Alga is a never-ending problem in certain environments.

Generally, the drains are designed to run freely, and any obstructions to free flow require additional hydraulic head to move water through the same length of drain. The additional head required transfers to the ground water outside the drain, and the design criteria is no longer met. The water table is not controlled at the depth that was intended. Many innovative solutions have been developed to meet these challenges but more needs to be done. In some instances, the solutions are not publicized, so maintenance personnel do not have access to them.

In many instances, open drains can be very beneficial to waterfowl, fish, and other wetland beneficiaries. Research needs to be done on what the real differences are between an environmentally friendly drain and a hydraulically efficient drain. We need to find the common ground and begin designing, building, and maintaining drains that address both causes in a satisfactory manner.

Drain Spacing Procedures for Two-Layer Aquifer

A two-layer aquifer system as it relates to spacing of agricultural drains means that a very permeable aquifer unit underlies a slowly permeable formation at a depth that is not conducive to placing of subsurface drains. The problem may be the elevation of the terminal outlet or limitations of the construction equipment available to install the drains. In any case, we know that the permeable layer influences the optimum drain spacing and that it is related to the relative permeabilities of the layers, the depth of the upper layer, the depth that drains can be placed, and possibly other factors. Two-layer aquifer spacing procedures have been developed but none adequately field tested.

Routine Maintenance of Subsurface Drains

One of the most asked questions by irrigation district maintenance personnel is, "What do we have to do to maintain this drain and how often?" Even more disconcerting is when the question is not asked. Winger addressed this problem in 1973, and Sanders and Crooks explored it in a little more detail in 1985. Considerable progress has been made since then in developing new methods and techniques, but little has been published. The result is that many owners of pipe drainage systems do not have ready access to the best information available to maintain these multimillion-dollar systems.

Surface Return Flow Quality Considerations

The quality of surface return flows is a subject of considerable interest in the drainage field. Irrigation return flows and storm runoff carry pesticides, herbicides, nutrients, and silt loads to the receiving streams. Many meaningful studies have been conducted and published on the subject in recent years. Perhaps the time has come to review this body of work and report on the overall findings.

Other Considerations

Irridrainage systems, slope stabilization systems, and toe drains for dams and canals represent areas that have ample room for research and development. This is not intended to be an exhaustive list but rather a representative overview that demonstrates the need for work in the field of drainage and the need to produce a single reference that will provide information and guidance which can be used by management and staff personnel involved in the construction, operation, and maintenance of agricultural drainage systems.

Conclusion

The purpose of this paper has been to briefly examine some of the problems that remain unsolved in the world of agricultural drainage. It is certainly not an exhaustive list, and it sheds little, if any, light on the problems that were discussed. We hope that we have stirred some interest in this vital issue by isolating a few of the problems that need to be addressed.

We would like to conclude by introducing a new task committee which has been funded for the current and one additional fiscal year. The committee name is "Design, Construction, and O&M of Drainage Systems." We are inviting members to participate in committee activities and to contribute papers for publication in a monograph which will include the latest technology in the field of agricultural drainage as we enter the 21st century.

References

Delamore, M., personal contact, March 1998.

Hendry, M.J., Hydraulic Conductivity of a Glacial Soil in Alberta, Ground Water, vol. 20, No. 2, pp. 162-169, 1982.

Sanders, G.D., and T.J. Crooks, You Need More Than a Plumber's Helper, ASCE, Irrigation and Drainage Specialty Conference, 1985.

Winger, R.J., Construction and Maintenance Techniques for Subsurface Pipe Drainage Systems in Irrigated Lands, International Drainage Workshop, 1978.

BANK STABILIZATION EXPERIENCE ON THE MIDDLE RIO GRANDE

by Drew C. Baird (ASCE member)[1]

Abstract

The Middle Rio Grande has been aggrading with an unstable channel, causing rising water tables in nearby agricultural lands and flooding problems during this century. Since the early 1930's, channel improvements have been made along with the construction of large storage reservoirs. The Bureau of Reclamation's (Reclamation) area of channel-improvement works extends for nearly 300 miles (483 km). Bank stabilization works have been constructed over a 45-year period in reaches with gravel-cobble bed and steep slopes and reaches with fine sand beds and large sediment loads. Bank stabilization works include Kellner jetties, riprap revetments, groins, toe revetments, and habitat improvement structures. Geomorphic river conditions and past and present river channel stabilization works are reviewed. A summary of local design guidelines and methods is presented.

Introduction

The alluvial Rio Grande has long been recognized for its striking characteristics. The surrounding desert lands, large snowpack, and summer thunderstorms produce wide ranges of water and sediment flows. As the river flowed from the mountainous region to the flatter Middle Rio Grande Valley, sediment was deposited, resulting in river bed aggradation. The Middle Rio Grande Conservancy District (MRGCD) constructed soil levees along the river channel in the 1930's, but these levees were not engineered to be effective against erosion resulting from direct flows of the river. MRGCD installed sediment fences and encouraged vegetation growth in an effort to stabilize the river banks. Later, Reclamation and the U.S. Army Corps of Engineers performed various bank stabilization activities. Among the channel rectification measures, use of Kellner jetties became the primary means of providing bank protection. The purpose of this paper is to briefly review river channel geomorphology before and after reservoir construction, review past and present river channel stabilization works, and present a summary of local design guidelines and methods.

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River Geomorphology

The location of the works described in this paper is the central portion of the Rio Grande Valley in New Mexico from Velarde, New Mexico, to Caballo Reservoir. Figure 1 shows the general location, the various river divisions, and the reservoirs constructed.

The Middle Rio Grande has one of the highest sediment loads of any river in the world. According to Janson et. al. (1979), the four major rivers with the highest sediment concentrations are: (1) Hwang Ho (Yellow River) (China) 15,000 mg/1, (2) Waipapa (New Zealand) 7,500 mg/1, (3) Ganges (India) 3,600 mg/1, and (4) Missouri (USA) 3,200 mg/1. The sediment concentration flowing into Elephant Butte was as high as 24,000 mg/l from the 1950's to the middle 1960's, about 13,000 mg/1 from 1966-1977, and currently is about 5,000 mg/1. Individual years' average sediment concentrations were as high as about 200,000 mg/l.

The following description of the historical Middle Rio Grande geomorphology is slightly modified from Crawford et. al. (1993).

> "Prior to measurable human influence on the system, up to the 14th century (Biella and Chapman, 1977), the river was an aggrading channel with a shifting sand substrate. Its pattern was, as a rule, braided, relatively straight, or slightly sinuous. The river would migrate across the floodplain, the extent being limited only by the valley terraces and bedrock outcroppings. The Rio Grande's bed would aggrade over time; then, in response to a hydrologic event or series of events, it would leave its elevated channel and establish a new course at a lower elevation in the valley. This process is called river avulsion (Leopold et al., 1964). Although an aggrading system, there were periods of stability that allowed riparian vegetation to become established on riverbanks and islands alternating with periods of instability (e.g., extreme flooding) that provided, by erosion and deposition, new locations for riparian vegetation."

The constructed river channel works throughout the basin have initiated channel degradation and improved water and sediment transport efficiency, a major goal of the Congressional authorizations. After construction of Cochiti Dam and resulting degradation, the river changed from a sand bed to a gravel and cobble bed channel. The channel has sought to become longer through bank erosion and meandering in many areas as degradation has progressed over time. Current river bed slopes range from about 0.001 near Velarde, New Mexico, to about 0.0005 in the headwaters of Elephant Butte Reservoir. The bed of the river changes from gravel to sand in the northern part of the Albuquerque Division. The Socorro Division from a point 10 miles (16 km) south of San Acacia Diversion Dam to the headwaters of Elephant Butte is still an aggrading channel, with fine sand bed material, low banks, and a relatively straight alignment with low sinuosity. The average bed material sizes range from a high of 85 millimeters near Velarde, New Mexico, to 0.2 millimeters in the headwaters of Elephant Butte Reservoir.

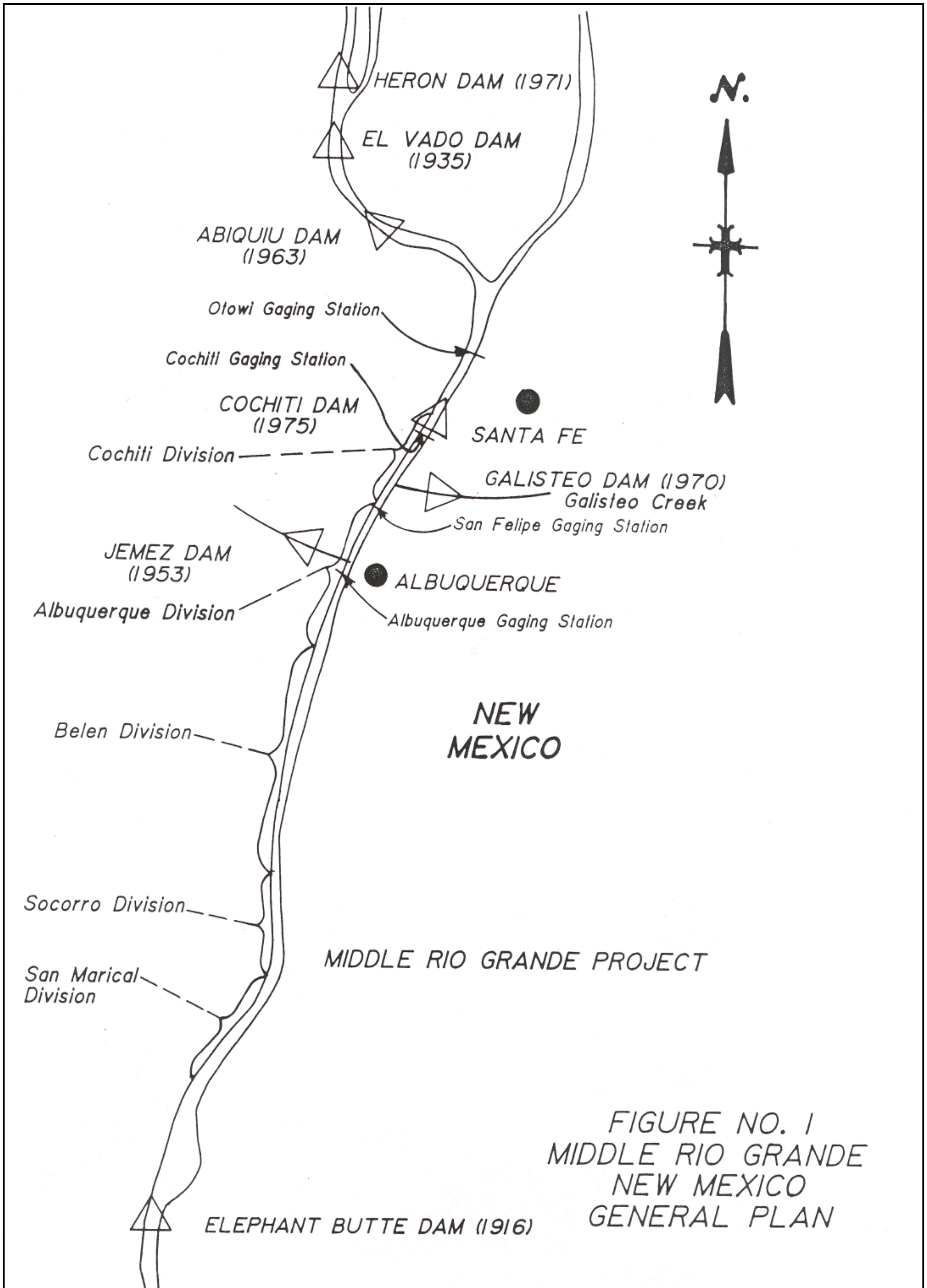

FIGURE NO. 1
MIDDLE RIO GRANDE
NEW MEXICO
GENERAL PLAN

Past River Channel Works

El Vado, Jemez Canyon, Abiquiu, Galisteo, Heron, and Cochiti Dams were completed in 1936, 1953, 1963, 1970, 1971, and 1975, respectively, and provide sediment and flood control upstream of the mouth of the Rio Puerco. In the 98 miles (158 km) from Cochiti Reservoir to above the confluence of the Rio Puerco, channelization consisted of a cleared channel with physical characteristics compatible with hydraulic and sediment transport requirements. The channel is mostly defined by permeable steel jetties in combination with existing native vegetation and natural topographic features.

Kellner jetty systems were investigated by Reclamation (1962). They used a prototype study area on the Middle Rio Grande and a laboratory hydraulic model study to define and develop design parameters. Throughout the Albuquerque and Belen Divisions, channelization works included establishing banks using Kellner jetty lines in the flow area to provide additional resistance to the water passing through the field to reduce the flow velocity. This reduces the sediment carrying capacity of the water, depositing sediment in the jetty field. Sediment accumulates and forms a new bank. Clearer water recirculates back in the main river channel, causing a slight scouring action. Vegetation growth on the sediment deposits further reduces the velocity in the jetty field. Debris lodged on the jetties also can cause additional velocity reductions.

Kellner jetty systems have been found to be effective on the Middle Rio Grande where suspended sediment concentrations are greater than 4-5,000 mg/l, with more than 40 percent sand in suspension, with a sand bed and low banks, bankfull (Q_2)width/depth ratio's ranging from 120 to 200, bankfull depths ranging from 1.5 (0.46) to about 3.5 feet (1.1 m), bankfull width ranging from 420 (128) to 1,200 feet (366 m), bed slopes ranging from 0.0005 to 0.0009, and sinuosities ranging from 1.04 to about 1.17. Kellner jetties have been ineffective on the Middle Rio Grande in reaches with gravel bed material, average annual suspended sediment concentrations less than 3,000 mg/l, bankfull depths greater than 3.5 feet (1.1 m), bankfull widths less than 320 feet (97.5 m), width depth ratios less than 120, and in reaches with sinuosity greater than 1.2. Even with debris lodged on the jetties, they are ineffective in the conditions listed above.

Present River Channel Stabilization

Riprap revetments have been constructed since 1985 to protect the banks on the outsides of river bends. Design considerations include toe scour, riprap size, length of revetments, alignment, and tie-backs. Velocity and scour in bends in the Espanola and Cochiti Divisions have been estimated using the approach documented by Baird and Achterberg (1991). This methodology uses a backwater model with stream tubes and a modified application of the Blench equation. Designs applying this methodology have been implemented at sites where the peak riverflows that have been the design flow or greater, without any failures. Median riprap sizes range from 14 (355) to 24 inches (610 mm). Experience has shown that riprap characteristics in order of importance are: (1) angularity, (2) gradation, and (3) size. Riprap installation thickness is 1.5 times thicker than the median size when measured perpendicular to the slope. A thickened toe section has been used that has the volume of riprap that will launch into a scour hole sufficient to protect the bank through the entire depth of the scour to a thickness of 1.5 times the median riprap size. Well-graded, angular riprap can be placed on slopes as steep as 1:1 to 1.5:1. A discussion of riprap sizing experience is beyond the scope of this paper.

On the Middle Rio Grande, leaving curves at or near the natural radius/width ratio of between 2 and 3 has been successful. This approach has significantly reduced the changes to the river channel, the amount of work required, and the cost. At most sites, only the outsides of eroding bends are stabilized and only where there is a direct erosional threat to riverside facilities. In the Cochiti Division, there was one site with nine bends threatening the levee where all of the curves were stabilized along about one-half of the total bankline. Riprap length goes from the upper riffle or crossing through the bend to the lower riffle or crossing. This is essentially the point where the flow lines are about parallel with the bank line. An excavation is made into the bank about 30 feet at the upstream and downstream ends of the revetment and filled with the same volume per unit length of riprap as placed along the bankline. This prevents the revetment from failing should the upstream or downstream bank erode.

Two riprap revetment failures occurred in 1985, one upstream of San Acacia Diversion Dam and one at a similar site. At both sites, the flow was directed between 70 and 90 degrees into the bank line, and the river bed was medium to fine sands. During high flows, the riprap sloughed down the bankline into the scour hole. Depths in the failure area were estimated to be 18 feet (5.5 m), with a velocity of about 15 ft/s (4.6m/s) at the peak flow of about 8,000 cfs (227cms). Failure of the riprap revetments at these sites was attributed to the sand bed material and to the flow being directed into the bankline at such a large angle. In gravel bed areas with a median bed material size of 15-20 mm at flow depths of 15 feet (4.6 m) and a velocity of 8 ft/s (2.4 m/s) with flows being directed into the bank at angles between 30-70 degrees, riprap revetments have remained stable.

Numerous fish habitat structures have been constructed to diversify and enhance existing habitat. This includes boulder groupings, snags (i.e., dead trees), submerged groins or spur dikes, boulder groupings with snags, and backwaters. Aquatic resource monitoring data show significant use of stabilized banks and the other environmental features (Baird et al., 1993).

Several installations of groins have been made recently on the Middle Rio Grande. The designs incorporated groin orientation, length, spacing, scour, crest elevation, side slopes, location within the river reach, riprap size, and local flow conditions (Klumpp and Baird, 1992). The groins were installed about 30 degrees downstream, were spaced 1.5 times the groin length, with a top width of 14 feet (4.3 m), the crest at bankfull elevation, and were constructed with a gravel core protected by 24 inches (610 mm) riprap. The first installation was completed in 1991. During the first spring runoff season, the groins suffered erosional damage. Riprap material dislodged from the groin tips, and some of the core fill material eroded. The riprap erosion was partially attributed to: (1) the riprap volume required to fill the scour hole was larger than the available toe protection riprap, (2) the rounded riprap rolled downstream into the scour hole, (3) the high velocities on the groin tips, and (4) severity of the bend curvature. Repairs were made in 1992, including replacing the dislodged riprap, covering the groins with 6 inch (152 mm) nominal size riprap, adding about 30 percent more riprap to each groin, and making two groins into "T" groins. Since the repairs, these groins have remained stable under several high flows approaching the design discharge. In addition, on the downstream side of each groin, a gravel bar was deposited. These bars have reduced the eddy circulation and velocity between each groin, thereby increasing their effectiveness and creating additional aquatic habitat diversity.

Recommendations for Future River Maintenance Work

It is recommended that more innovative and less structural approaches be used where river maintenance objectives can be met in a manner that contributes to the biological integrity of the river system. However, from an engineering point of view, many of these methods do not have adequate performance data. Reclamation is currently analyzing the performance of non-traditional bank stabilization techniques, including constructing demonstration projects and hydraulic and geomorphic data collection.

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References

Baird, D.C., and D.G. Achterberg, (1991), "Estimating Velocities and Scour Depth in River Channel Bends," Proceedings of the Fifth Federal Interagency Sedimentation Conference, Las Vegas, Nevada.

Baird, D.C., J.P. Wilbur, and R.W. Slater, (1993), "Bank Stabilization with Environmental Features on the Middle Rio Grande," Proceedings of the 1993 Conference on Hydraulic Engineering, ASCE, New York, New York.

Biella, V., and R.C. Chapman (eds.). 1977. Archeological investigations in Cochiti Reservoir, New Mexico. Volume 1: a survey of regional variability. Report submitted to National Park Survey, Santa Fe, for U. S. Army Corps of Engineers, Albuquerque.

Bureau of Reclamation, (1962) Control of Alluvial Rivers by Steel Jetties, Hydraulic Laboratory Report No. Hyd. 503, Denver, Colorado.

Janson, P.P., L. van Bendegom, J. van den Berg, M. de Uries, and A. Zanen, (1979), "Principles of River Engineering," Pitman Publishing Company, San Francisco.

Klumpp, C.C., and D.C. Baird, (1992), "Recent Criteria for Design of Groins," Proceeding of the National Hydraulic Engineering Conference, ASCE, New York.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial Processes in Geomorphology. W.H. Freeman and Co., San Francisco.

Note: This article has been modified from the original version.

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