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# ELIMINATION OF HAZARDOUS OPEN CANALS

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## HEARING

BEFORE THE

### SUBCOMMITTEE ON WATER AND POWER RESOURCES

OF THE

### COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

NINETY-SECOND CONGRESS

SECOND SESSION

ON

### S. 3472

A BILL TO AUTHORIZE FEDERAL COST SHARING IN PROMOTING PUBLIC SAFETY THROUGH THE ELIMINATION OF HAZARDOUS OPEN CANALS BY CONVERTING THEM TO CLOSED CONDUITS AND BY FENCING

JUNE 5, 1972



Printed for the use of the Committee on Interior and Insular Affairs

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1972

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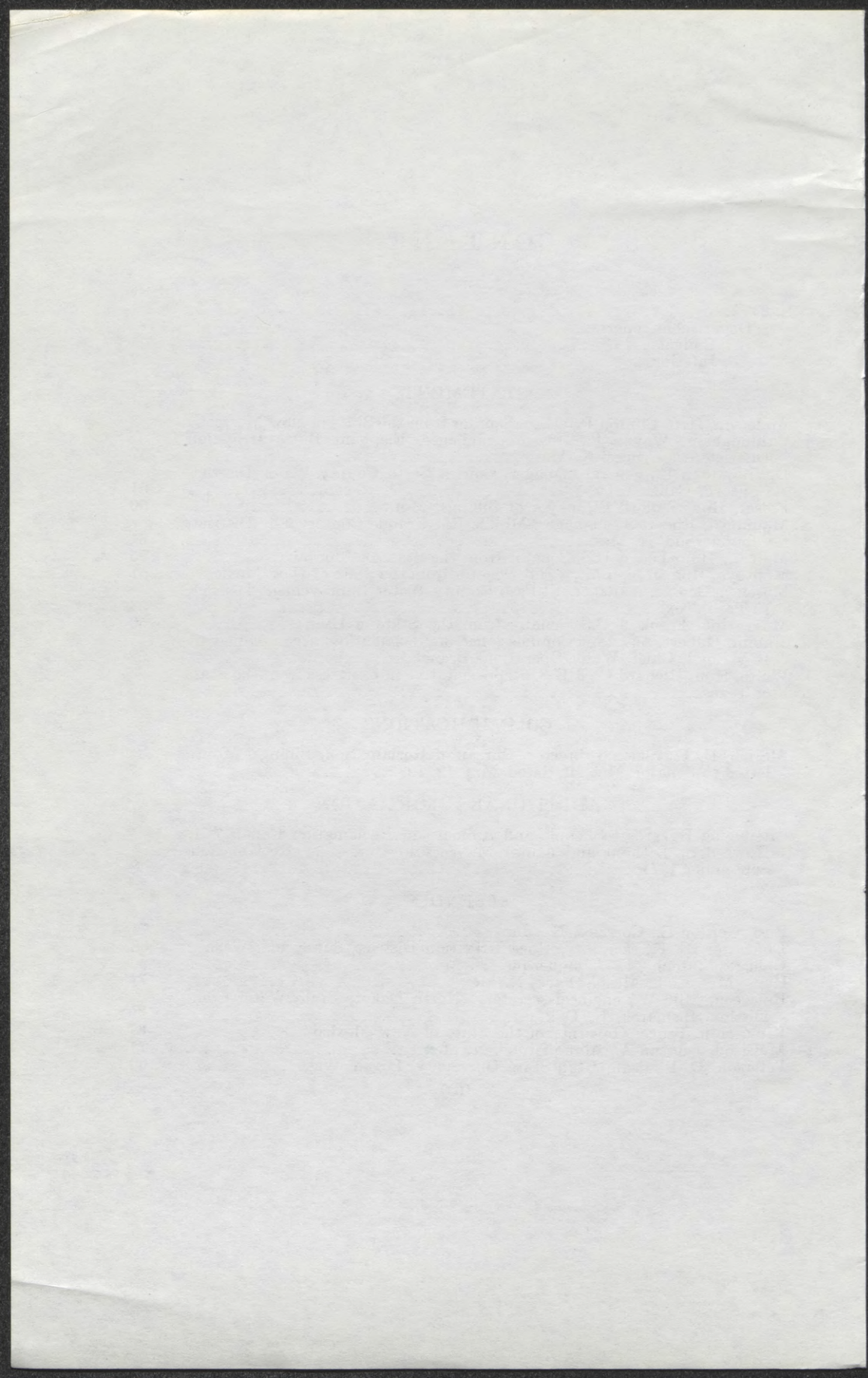
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## ELIMINATION OF HAZARDOUS OPEN CANALS

MONDAY, JUNE 5, 1972

U.S. SENATE,  
SUBCOMMITTEE ON WATER AND POWER RESOURCES  
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,  
Washington, D.C.

The subcommittee met at 10 a.m. in room 3110, New Senate Office Building, Hon. Clinton P. Anderson presiding.

Present: Senators Metcalf and Anderson.

Also present: Jerry T. Verkler, staff director; William J. Van Ness, chief counsel; Daniel A. Dreyfus, professional staff member; and Thomas Nelson, assistant minority counsel.

Senator ANDERSON. Good morning.

The purpose of this hearing before the Water and Power Resources Subcommittee this morning is to take testimony on S. 3472, a bill introduced by Senator Anderson "to authorize Federal cost sharing in promoting public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing."

The hazards to public safety which are presented in the West by large water conveyance canals passing through populated areas have been recognized for many years. In each of the years 1969, 1970, and 1971, there were more than 50 drownings recorded in canals. In facilities operated by the Bureau of Reclamation alone there have been about 30 drownings each year despite active and imaginative programs of water safety and public information.

A high proportion of the lives lost in canal drownings are those of children, which are particularly tragic occurrences, and difficult to prevent by warnings alone.

The purpose of S. 3472 is to establish a program of Federal cost sharing to assist the water using entities in financing protective measures for hazardous canals adjacent to urban areas. The Secretary of the Interior would be authorized to contribute up to 50 percent of the costs of enclosing such canals in conduits or providing safety fencing for them.

The text of S. 3472 and the legislative reports on the bill will be printed in the record at this point.

(The documents referred to follow:)

[S. 3472, 92d Cong., second sess.]

(A BILL To authorize Federal cost sharing in promoting public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing)

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it is the intent of Congress that the United States encourage safety to the public in urban areas by sharing in the cost of converting open canals to closed conduits and of safety fencing of large canals which are economically infeasible to enclose in conduits.*

SEC. 2. (a) The Secretary of the Interior may provide funds not to exceed 50 per centum of the cost of converting existing open canals in or adjacent to urban areas to closed conduits or of providing for safety fencing of large canals in or adjacent to urban areas. Except as provided in subsection (b), the assistance provided under this Act shall be under terms and conditions satisfactory to the Secretary of the Interior.

(b) The portion of the cost of projects described in subsection (a) not provided by the United States may be provided by labor and materials, as well as by money. The costs of labor and material so provided shall be determined by their fair market value.

SEC. 3. There are hereby authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act.

U.S. DEPARTMENT OF THE INTERIOR,  
OFFICE OF THE SECRETARY,  
Washington, D.C., June 2, 1972.

HON. HENRY M. JACKSON,  
*Chairman, Committee on Interior and Insular Affairs,  
U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your request for this Department's views on S. 3472, a bill "To authorize Federal cost sharing in promoting public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing."

We recommend that the bill not be enacted.

S. 3472 would authorize the Secretary of the Interior to provide funds in order to share in the cost of converting open canals to closed conduits or of constructing safety fencing around large canals. The Federal share of the cost is not to exceed 50 percent. The bill applies only to canals in urban areas and would authorize the necessary appropriations to execute the proposal.

Each year a number of people are drowned by falling into canals. Information available to this Department pertains primarily to canals under the jurisdiction of the Bureau of Reclamation. A recent Bureau of Reclamation study of this problem entitled "Reducing Hazards to People and Animals on Reclamation Canals", states that during the years 1962 to 1968, 152 people were drowned in Reclamation canals. The study states:

"The Bureau has had an aggressive canal safety program for many years. It is Bureau policy to include reasonable safety devices when these waterways are constructed. Yet the drownings persist. Why? There are many reasons. The rapid increase in population, and its mobility, has increased exposure of the public to the hazards of open canals. The construction of urban areas adjacent to canals and the granting of access to these canals for recreational uses in the absence of safety facilities and supervision also contribute to these drownings. Many drownings occur on the canals of older projects that were not considered a hazard when constructed because of their then remote locations."

A more recent study of drownings on Bureau of Reclamation and Bureau of Indian Affairs irrigation systems covering the 5-year period 1967 through 1971 indicated that 247 persons drowned. About 20% were 10 years old and younger.

The Bureau continues to work to improve its safety program. It now requires that all new canals be designed according to specified safety standards which include fencing of canals in urban areas. On existing canals the Bureau has installed safety devices on hazardous structures such as chutes and drops. At the same time State and local governments are being encouraged to utilize their regulatory authority to promote canal safety.

The Bureau of Reclamation charges the water users for the cost of maintaining the Bureau's canals and for installing safety devices. The users have also borne the expenses for any legal settlements when persons have drowned in the canals. We feel that the basic responsibility for canal safety should remain with the principal beneficiaries of the canals, which in the case of the Bureau's canals are the water users. S. 3472 would shift this responsibility and the one-half of its cost to the Federal Government and we oppose it for that reason.

A major deficiency in the bill is its failure to define "open canals". The Bureau of Reclamation maintains about 1,000 miles of canals in what may be defined as urban areas. These canals are used primarily for irrigation. We estimate that there are at least 4,000 miles of urban irrigation canals maintained by other governmental or private entities. In addition to irrigation canals there are many thousands of miles of other man-made waterways which could be considered "canals" under the terms of the bill.

We doubt that it would be necessary to fence or enclose all open canals in rural areas as the bill proposes. It is improbable that all open canals in urban areas are hazardous. Furthermore, it may actually be a disservice to residents in urban areas to enclose all open canals. Some canals in these areas are used extensively by the public for fishing and other forms of recreation. In these areas there may be a need to encourage rather than discourage public access to canals. The decision whether to enclose a canal or a stretch of canal should be made by the local community where the advantages and the risks can best be weighed.

We estimate that the cost of enclosing the 1,000 miles of Reclamation canals could be as much as \$360 million which would entail a Federal cost sharing of \$180 million under the bill. The estimated cost does not include maintenance expenses. The estimate would allow for approximately 700 miles of canals to be converted to closed conduits and the remaining 300 miles of larger canals to be surrounded with fencing. However, because the cost of construction of closed conduits is at least ten times greater than fencing, our estimate of \$360 million would, of course, be less if more canals were fenced rather than converted to closed conduits. Nevertheless, in locations of high hazard, the additional expense of closed conduits would be preferable.

The estimated Federal share of the cost for enclosing the other 4,000 miles of irrigation canals in the United States could be as much as \$720 million.

The Office of Management and Budget has advised that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Sincerely yours,

HARRISON LOESCH,  
*Assistant Secretary of the Interior.*

---

EXECUTIVE OFFICE OF THE PRESIDENT,  
OFFICE OF MANAGEMENT AND BUDGET,  
*Washington, D.C. June 5, 1972.*

HON. HENRY M. JACKSON,  
*Chairman, Committee on Interior and Insular Affairs, U.S. Senate, New Senate  
Office Building, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your request of April 28, 1971, for the views of the Office of Management and Budget on S. 3472, a bill "To authorize Federal cost sharing in promoting public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing."

In its report to your Committee on S. 3472, the Department of the Interior recommends against enactment of the bill and indicates in detail the reasons for their opposition. We concur in the views expressed by the Department, and accordingly, the Office of Management and Budget recommends against enactment of S. 3472.

Sincerely,

WILFRED H. ROMMEL,  
*Assistant Director for Legislative Reference.*

Senator ANDERSON: I have a statement of my purposes in introducing this bill which I will insert in the record at this point, and Senator Metcalf will preside for the remainder of the hearing.

Senator METCALF. Thank you. I also have a prepared statement to be inserted in the record.

STATEMENT OF HON. CLINTON P. ANDERSON, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

I have introduced S. 3472 in the hope of solving a major safety problem which now exists in New Mexico and in other areas where open irrigation systems are in operation.

Between 1959 and 1968, 41 persons drowned in the canals of the Middle Rio Grande Conservancy District. Twenty-one of the victims were little children under the age of seven, and, just recently, two more children were drowned in one of these canals in Albuquerque.

Accentuating the tragedy in each instance is the sure knowledge that most of the drownings could have been avoided if simple safety measures had been taken. Fencing the canals, placing their water in underground pipes and discontinuing the use of those canals which serve only a few farms would have saved the lives of most of the children. It would also have saved the lives of many of the older victims, many of whom were apparently intoxicated when they stumbled into the waterways. By now, the public is justifiably aroused over this continuing loss of life.

I do not approach these hearings with any set notions of what should be done. Certain solutions present themselves as almost self-evident. The fencing of the canals is one of these. But there may be reasons why fencing is inappropriate in some regions and there may be other solutions. I hope these hearings will bring some of these to light.

Nor am I set in my thinking on how these safety measures should be paid for. My bill suggests that the Federal government should bear 50% of the cost of the safety measures, but I am not wedded to that figure. Perhaps the Federal government should pay more.

Various groups bear differing degrees of responsibility for providing safety measures. It would be easy to suggest that the users of the water should pay the entire cost of safety, but this is not a realistic solution. In New Mexico, the users of the water of the Middle Rio Grande Conservancy District are mostly small farmers. If the costs they incur in raising their crops go up, they will be put out of business because they cannot pass the increased costs on to their consumers. Indeed, it has been estimated that if safety measures recommended in a report prepared by the Bureau of Reclamation were installed and their entire cost assessed against the water users, the water users' costs would double.

It seems to me that the localities through which the canals pass have some financial obligation here, as does the Federal government. I hope that one result of these hearings will be the discovery of a formula which will fairly allocate the costs of these safety measures among the responsible groups.

On another point, some persons have written to me recently in opposition to this bill. They contend that the safety of the children who live near the canals is the responsibility of the childrens' parents. I do not deny that the parents have a very definite responsibility, but I do think there is a community responsibility as well.

No parent, no matter how conscientious, can realistically expect to follow his child every moment from the time he is born until he is old enough to understand the dangers these canals present and mature enough to respect those dangers. I invite those who suggest that canal safety is a matter only for the parents to think back to their own childhood and to remember their own explorations and dangerous experiences. We all had them. We were just fortunate enough to survive them.

Moreover, the children represent only half of the victims. The other victims have been older than 17 years old and a good number of them were intoxicated at the time they drowned. Who is to protect these persons from themselves?

Canal safety is no different from swimming pool safety, pedestrian safety, highway safety or any other kind of safety. It is a clearly recognizable community responsibility, and it is the genesis of this bill.

Perhaps we cannot make the canals perfectly safe in one step, but it is past the time when we should have begun.

In closing, I would like to make an additional point. I am very disappointed in the poor response of the Bureau of Reclamation toward this program. Five years ago, in 1967, the Congress appropriated \$50,000 to the Bureau to study the problem of canal safety in the Middle Rio Grande Conservancy District. This study was completed in July 1969 and was revised in March of 1970.

I expected the Bureau to send legislative proposals to the Congress based on the findings of the study, and I repeatedly urged the Bureau to do so once the study had been released. On August 27, 1970, I thought progress was being made because Commissioner Ellis L. Armstrong of the Bureau of Reclamation wrote to me saying, "We are preparing a draft of proposed legislation which would provide federal assistance to improve safety conditions on existing systems."

This has proved to be an empty promise, however. To date, no legislation has been forthcoming.

I am disappointed because there have been more drownings since the Commissioner promised his proposals and also because an administration bill on this subject would have easier passage than will my bill. Nonetheless, we cannot wait any longer for the Bureau of Reclamation.

I urge enactment of a suitable canal safety bill.

---

STATEMENT OF HON. LEE METCALF, A U.S. SENATOR FROM THE STATE OF MONTANA

Mr. Chairman, it is a pleasure to open these hearings today on S. 3472, by the distinguished Senator from New Mexico whose bill is before us. I have joined him in sponsoring it.

Irrigation and reclamation canals are principally a Western states phenomenon and therefore their hazards for children are best known to those of us who come from the West. In each of our States, there are annually deaths by drowning that might have been prevented had there been proper protection.

Senator Anderson would eliminate this unnecessary danger, and his bill therefore deserves prompt approval, though with his concurrence, I should like to suggest a few modifications.

I suggest financial assistance should be made available to any agency, public or private, which is concerned with providing safety measures around canals in populated areas. Specifically, I suggest such aid should be available either to the municipalities or the counties affected, so that in cooperation with irrigation companies, safety may be achieved.

Second, I suggest such assistance should be provided to every irrigation or reclamation project which has come into being because of action by the Federal government. I would specifically refer to those canals and irrigation ditches enabled by the Desert Land Act of 1877 as amended in 1888 and the Carey Act of 1894.

In supporting this bill, hopefully with the broadened provisions I suggest, I should like to call your attention specially to the Billings Bench Water Association canal that flows through Billings, Montana.

When it was constructed in 1904 as a Carey Act project, Billings had a population of about 5,000. Most of the community was a respectable distance from the canal that then flowed through open countryside.

By 1970, the population had grown to over 61,000 and was increased by 2,000 only last year. Houses now line the BBWA canal on both sides both within the city limits of Billings and beyond in the urban area.

Since 1965, the community has sought safety measures.

The Bureau of Reclamation, which undertook a study, said its policy at the time was to construct closed conduits for the sections of canals passing through populated areas and, for pre-existing canals, to encourage the water users to erect fences and safety nets at dangerous points.

However, the Bureau rejected fencing for Billings because it was deemed inadequate to provide safety. This is not to suggest that enclosed conduits are always preferable, only that it was best in this particular instance.

According to the 1967 Bureau of Reclamation study, seven children had drowned in this canal since 1950.

In 1967, it would have cost \$5.4 million to enclose the canal. Costs have soared since then, and the community has grown, so that roughly another half mile of enclosure would be needed, adding further to the cost.

The Bureau of Reclamation at that time was unable to measure the cost-benefit ratio, though in a nation-wide study, the Bureau was able to produce cost figures into the one billion dollar range to achieve the purposes of this bill. The Bureau pointed out in both studies what I know we all feel: how does one measure the value of even one child's life? It should not be necessary to devise a dollars and cents figure in determining the cost-benefit ratio of measures undertaken to safeguard children.

However, there are cold, calculating ways to achieve some dollar figures, for those who might question spending over \$1 billion to safeguard human lives.

One way is to estimate the value of a human life against probable lifetime earnings. Just that method is often used in courtcases seeking damages stemming both from disability and from death.

Referring again to the BBWA canal, if we estimate that the average person will earn in the vicinity of \$250,000 in his lifetime, we could say that this ditch in the space of 20 years has cost our national economy \$1,750,000 or roughly a third the 1967 construction cost of enclosing the canal.

There is seepage through unlined sections of the canal into the sewage system of Billings, adding one and one-quarter billion gallons of unwanted water a year. The Mayor of Billings estimates the cost of treating that unwanted water in the "tens of thousands" of dollars a year. To remedy the sewage system to exclude that unwanted water would cost \$3 million or more.

On that basis of knowable figures, the cost-benefit ratio of enclosing the BBWA canal as it flows through Billings at least approaches a one to one ratio: \$5.4 million construction cost against at least \$4,750,000 benefits—and I stress that "at least" because there simply is no way to place such benefit figures on the life of any child. However, I submit if we must concern ourselves with a dollars and cents approach to cost-benefit ratios, then in this instance, we may argue that this canal should be enclosed.

It shouldn't be necessary to seek justification beyond safeguarding the lives of children, but the conservation of water that is now lost through seepage, the improvement of sanitary conditions with elimination of seepage and mosquito breeding areas, the removal of potential flood hazards and an increase in adjacent property values are benefits that would result from enclosure of the canal.

The Bureau of Reclamation in its nation-wide study reports approximately 30 deaths a year in Bureau constructed canals alone. In a five year period, there were 152 drownings, 40 percent of them children, from 1964 to 1968. The grisly toll has continued since. In Region 6 of the Bureau of Reclamation, there have been six more drownings. On the basis of past history, at least one person will drown in a Bureau of Reclamation associated canal within Region 6 this year, and the odds suggest that person will be a child.

No one has kept figures on all the deaths by drowning in unprotected canals. The above figures concern only the Bureau of Reclamation canals. If we add other canals, as I suggest we must do, the death toll soars.

These deaths are a concern for the Federal government. They occur in canals and ditches that simply would not be there had it not been for the action of the Federal government at some time in the past.

Neither the Billings Bench Water Association nor the City of Billings is in a position to bear the costs of the project to enclose the BBWA canal in the populated areas of Billings, however desperately needed such action is. Certainly, the City that would realize a dollar savings should assume some responsibility for it. A low-interest, long-term Federal loan would greatly assist the City of Billings.

As Senator Anderson has pointed out, the Committee can best determine what matching formula is best from the testimony to be taken in these hearings.

Mr. Chairman, for the most part, I have discussed only one canal. There are several others in Billings that have claimed the lives of children, but they are but a small percentage of the total number in this nation which, if they were to be built today, would be enclosed or fenced to provide safety for little children.

Mr. Chairman, I would be grateful if certain statistics and studies assembled by the Bureau of Reclamation may be filed with the Subcommittee to illustrate only part of the problem. I believe they may well indicate the extent of the problem nationwide.

I also submit for the record a statement on behalf of the bill by Willard Fraser, Mayor of Billings, Montana.

In conclusion, Mr. Chairman, I believe this is a valuable piece of legislation. I am delighted to give it my full support. I hope the Committee will promptly approve it with the broadening features I have suggested.



## United States Department of the Interior

BUREAU OF RECLAMATION  
Regional Office, Region 6  
P. O. Box 2553  
Billings, Montana 59103

IN REPLY REFER TO: 110  
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MAY 12 1972

Mr. Roger Hawthorn  
c/o Senator Lee Metcalf  
U. S. Senate Office Building  
Washington, D. C.

Dear Mr. Hawthorn:

In response to your telephone request, following are the statistics  
on drownings in canals on Federal-financed projects in Region 6:

1967 - 0  
1968 - 1  
1969 - 1  
1970 - 3  
1971 - 2

If we can be of any further service to you, please advise.

Sincerely yours,

Regional Director

REC-ERC-71-36

# REDUCING HAZARDS TO PEOPLE AND ANIMALS ON RECLAMATION CANALS

## Open and Closed Conduit Systems Program

Howard S. Latham  
and  
James M. Verzuh  
Bureau of Reclamation

September 1971



MS-230 (8-70)  
Bureau of Reclamation

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. REC-ERC-71-36	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE REDUCING HAZARDS TO PEOPLE AND ANIMALS ON RECLAMATION CANALS - Open and Closed Conduit Systems Program		5. REPORT DATE September, 1971	
		6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) Howard S. Latham and James M. Verzuh		8. PERFORMING ORGANIZATION REPORT NO. REC-ERC-71-36	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Engineering and Research Center Bureau of Reclamation Denver, Colorado 80225		10. WORK UNIT NO.	
		11. CONTRACT OR GRANT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS Same		13. TYPE OF REPORT AND PERIOD COVERED	
		14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES			
<p>16. ABSTRACT</p> <p>The Bureau of Reclamation and others engaged in water resource management are concerned with increasing the safety of people and animals exposed to open waterways. An indepth study of the nature and extent of the hazard presented by canals together with an evaluation of preventive measures is given. A survey of human drownings in Bureau canals and a review of protective devices and safety practices currently in effect are presented. A detailed review of the problem of animal drownings is presented. The relative effectiveness and comparative cost of right-of-way fencing, conveying water in buried conduits, and covering canals are presented. These and other proposed solutions, such as installing stepped or corrugated canal linings, are examined and illustrated. The study presents much information related to the problem of public safety and preservation of animal life which will be of assistance to waterway planners, designers, and operators.</p>			
<p>17. KEY WORDS AND DOCUMENT ANALYSIS</p> <p>a. DESCRIPTORS--/ *animals/ benefits/ canals/ canal linings/ *safety/ water users/ closed conduits/ accidents/ economics/ *hazards/ *personnel/ thin shell structures/ construction costs/ indirect benefits/ fences/ project planning/ irrigation operation &amp; maintenance/ irrigation systems/ public relations/ prestressed concrete/ reimbursable costs/ *drowning</p> <p>b. IDENTIFIERS--/ canal covers/ Open and Closed Conduit System Prog/ safety equipment/ humans</p> <p>c. COSATI Field/Group 13L</p>			
18. DISTRIBUTION STATEMENT Available from the National Technical Information Service, Operations Division, Springfield, Virginia 22151.		19. SECURITY CLASS (THIS REPORT) UNCLASSIFIED	21. NO. OF PAGES
		20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. PRICE \$3.00

**REC-ERC-71-36**

**REDUCING HAZARDS TO PEOPLE AND  
ANIMALS ON RECLAMATION CANALS**

**Open and Closed Conduit Systems Program**

by

**Howard S. Latham, Division of Safety  
Engineering and Research Center  
Denver, Colorado**

and

**James M. Verzuh, Division of Design and Construction  
Regional Office  
Billings, Montana**

**September 1971**

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**UNITED STATES DEPARTMENT OF THE INTERIOR**  
Rogers C. B. Morton  
Secretary

\*

**BUREAU OF RECLAMATION**  
Ellis L. Armstrong  
Commissioner

**ACKNOWLEDGMENT**

This investigation was conducted under the Bureau of Reclamation's Open and Closed Conduit Systems Program. The study group conducting these investigations was headed by G. N. Thorsky, Chief, Division of Engineering Support, and included R. L. Berger, Division of Planning Coordination; H. S. Latham, Chief, Division of Safety; W. P. Simmons, Division of General Research; all of the Engineering and Research Center, Denver, Colorado; J. V. Walker, Regional Supervisor of Water and Land Use, Boise, Idaho; and J. M. Verzuh, Division of Design and Construction, Region 6 Office, Billings, Montana. Designs were prepared by the Division of Design; cost estimates were prepared by the Division of Engineering Support. The survey of drownings represents the joint efforts of the Chief, Division of Safety, and staff members of all regional offices. Much of the information in this report concerning animal losses was contributed by staff members of regional and project offices. Many others provided assistance in the study and preparation of this report. These were too numerous to list herein, but their assistance is gratefully acknowledged.

## PREFACE

An investigation leading to this report was initiated at the request of the Commissioner of the Bureau of Reclamation. Although the Bureau has an excellent public safety program, people and animals are continuing to drown in canals, which prompted a study of all aspects of the problem.

This report includes conclusions of the investigation. It contains a detailed survey of drownings of people and a brief review of current safety practices and policies. For a complete study of Bureau safety policy and practices relating to Bureau reservoirs and waterways, the reader is referred to USBR General Design Standards, Chapter 3, Safety Design Standards, and the bulletin entitled Canal Safety. A more detailed review of the problem of animal drownings is presented herein because much of this information has never before been published. This report also includes a discussion of both the costs and some of the benefits of placing canals in buried conduits, covering canals, and fencing canals. In addition, other safety considerations, such as using stepped or corrugated canal linings, allowing canals and rights-of-way to be used for recreational purposes, constructing canals with flatter side slopes, and attaching cleats to linings of existing canals, have been investigated and are included in the report.

A detailed economic study of the costs and benefits of reducing or eliminating the hazards of open canals was not made because of the many variables involved in this broad study of the problem. Land costs throughout Bureau projects may vary by 1,000 percent, and can even have a wide range within a project. The value of water varies greatly, and operation and maintenance costs differ from project to project. The size and cost of facilities required will depend extensively upon local conditions. For example, the cost of conveying a given quantity of water by pipe will vary in accordance with the topographical characteristics of each Bureau project. Thus, developing typical costs and benefits would result in meaningless comparisons. However, information is presented herein, related to the problem of public safety, that will be of assistance to waterway planners, designers, and operators.

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Frontispiece — Safety fence and float at inlet to siphon on the San Luis Canal. Photo P.805-236-14106

## INTRODUCTION

The loss of a human life is a tragedy which affects the immediate family of the deceased forever. It is also an economic loss to the nation. Unfortunately, this tragedy occurs approximately 30 times every year on Bureau-constructed canals. In the past 5 years there have been 152 public drownings on these waterways. Even more tragic is the fact that 40 percent of the victims were children.

The Bureau has had an aggressive canal safety program for many years. It is Bureau policy to include reasonable safety devices when these waterways are constructed. Yet the drownings persist. Why? There are many reasons. The rapid increase in population, and its mobility, has increased exposure of the public to the hazards of open canals. The construction of urban areas adjacent to canals and the granting of access to these canals for recreational uses in the absence of safety facilities and supervision also contribute to these drownings. Many drownings occur on the canals of older projects that were not considered a hazard when constructed because of their then remote locations. As a result there are both Bureau-operated and privately operated projects which do not include adequate safety features. A contributing factor is the lack of financial assistance by others to the irrigation district for construction of safety features required because of such increased exposure.

In addition to the drowning of people in Bureau-constructed canals, many animals are also lost annually. These consist mainly of big game animals, mostly deer. Although the number of big game animals lost is not tabulated herein, it is estimated that approximately 1,000 to 2,000 deer are drowned annually in Bureau waterways. Although this is a small percentage of the nation's total deer population, these drownings are concentrated in specific canals, resulting in significant depletion of local deer herds. For example, 45 deer were lost in the first 30 days of operation of the Howard Prairie Canal in Oregon. When a condition such as this exists, severe pressure is exerted upon the Bureau to reduce these losses.

### REDUCING HAZARDS TO PEOPLE ON RECLAMATION CANALS

There is ample evidence that unguarded and unprotected open canals and laterals present a serious hazard to people, particularly children. Since 1962 the Bureau has maintained a detailed record of

drownings on Bureau-constructed facilities, including canals and laterals. Tables 1A through 1D, entitled "Survey of Drownings in Bureau-constructed Canals" contain pertinent information from accident investigation reports relating to the 152 public drownings in Bureau-constructed canals and laterals for the 5-year period from 1964-1968. This survey covers all Bureau-constructed canals and laterals including those operated by irrigation districts, state and local agencies.

#### 1. Survey of Open Waterway Hazards to People

The survey sheds considerable light on the nature and extent of the hazard to people from Bureau-constructed canals and laterals. Fortunately, it also serves as a guide to steps which can be initiated to reduce public drownings in these waterways. The information in the accompanying tables can be summarized as follows:

- a. The type of construction, lined or unlined, has had little influence on the number of drownings. Large hard-surface lined canals are more hazardous due to the difficulty in escaping from them. There is greater exposure to young children to the relatively small unlined canals and laterals in the vicinity of their homes. For approximately equal lengths of canal, the 5-year survey shows that 69 drownings occurred in lined canals and laterals compared with 67 in unlined canals and laterals.
- b. The survey discloses that canals and laterals of all sizes and depths must be considered as potential hazards. For example, 45 drownings or approximately one-third of the total occurred in waterways with a capacity of 100 cubic feet per second or less. Similarly, 27 drownings or 18 percent occurred in water depths of 30 inches or less, and 77 or over 50 percent of the drownings occurred in 5 feet or less of water. The survey indicates that both lined and unlined canals and laterals, regardless of size or flow, constitute very real hazards, particularly to children. Consequently, all canals, regardless of size, flow, or type of construction must be included in considering solutions to the hazards to people.

c. Pertinent to the hazards to people, and to its solution, is the fact that almost all of the drownings occurred in urban and rural populated areas (Class A\* and B exposure). Conversely, drownings in canals and laterals located in isolated areas with only occasional exposure to persons, do not present a problem. By far the greatest number of drownings occurred in rural areas (Class B).

\*See Table 1C for exposure classification.

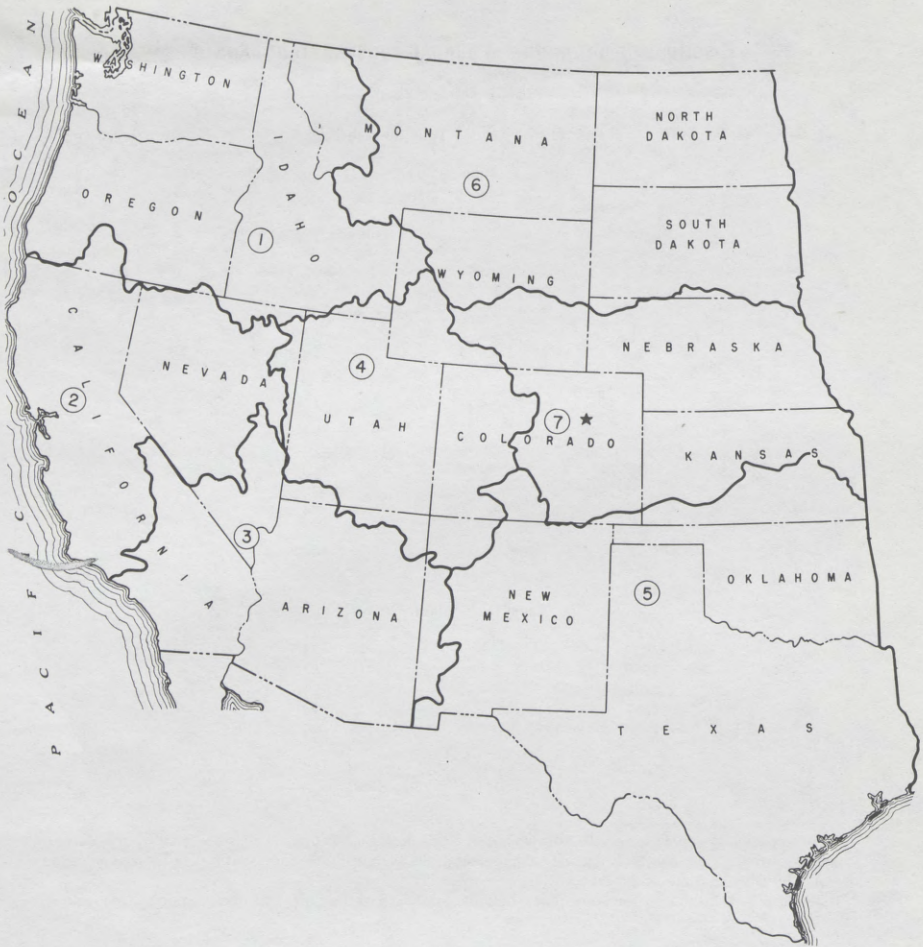


Figure 1. Bureau of Reclamation regional boundaries

Table 1A

## SURVEY OF DROWNINGS IN BUREAU-CONSTRUCTED\* CANALS

(By Region and Year)

Period: Five Years - 1964 through 1968

Bureau-Wide

Region**	Number of drownings
1	22
2	39
3	26
4	5
5	53
6	3
7	4
Total	152

## Canal Drownings by Year

1964	31
1965	31
1966	27
1967	24
1968	39
Total	152

\*The accompanying survey covers 152 drownings in Reclamation-constructed canals operated by the Bureau, irrigation districts, state and local agencies. Of this total, 85 were in Bureau-operated canals; 67 were in canals operated by District, State, and local agencies

\*\*Refer to Figure 1 showing the geographical boundaries of each of the Bureau of Reclamation's seven regions.

Table 1B

**SURVEY OF DROWNINGS IN BUREAU-CONSTRUCTED CANALS**  
(by canal type, capacity, and water depth)  
Years 1964 through 1968

## A. Number of drownings related to canal capacity and type

Type	Canal capacity, cubic feet per second					5-year total	Annual rate
	0-100	101-500	501-1,000	1,001-5,000	Over 5,000		
Lined canals and laterals	14	14	8	30	3	69	13.8
Unlined canals and laterals	18	27	9	11	2	67	13.4
Other (Drains, wasteways, etc.)	13					13	2.6
Total drownings	45	41	17	41	5	*149	29.8

## B. Number of drownings related to depth of water and type of canal

Type	Water depth					5-year total	Annual rate
	0-30 in.	31 in.-5 ft.	6-10 ft.	11-15 ft.	Over 15 ft.		
Lined canals and laterals	12	12	26	6	13	69	13.8
Unlined canals and laterals	6	36	18	5	2	67	13.4
Other (drains, wasteways, etc.)	9	2	2			13	2.6
Total drownings	27	50	46	11	15	*149	29.8

\* In three drownings the capacity and water depth are unknown.

Table 1C  
**SURVEY OF DROWNINGS IN BUREAU-CONSTRUCTED CANALS**

(by type of exposure)  
 Years 1964 through 1968

	Vehicular	Other	5-year total	Annual rate
<b>A. Exposure classification*</b>				
Class A	3	42	45	9.0
Class B	26	77	103	20.6
Class C	3	1	4	0.8
Totals	32	120	152	30.4
<b>B. Site of drowning</b>				
Bank	26	77	103	20.6
Bridge	6	6	12	2.4
Siphon		2	2	0.4
Turnout		1	1	0.2
Check		11	11	2.2
Chute or drop		4	4	0.8
Undetermined		19	19	3.8
Totals	32	120	152	30.4
<b>C. Protective fencing</b>				
Fenced site	9	20	29	5.8
Unfenced site	23	100	123	24.6
Totals	32	120	152	30.4

\*Class of Hazard Exposure (Paragraph 3.5, Chapter 3, Safety Design Standards)

Class A—(Urban)—Locations and sites readily accessible to the public from an adjacent or nearby city or school and subject to numerous and frequent visits by the public.

Class B—(Rural)—Locations and sites removed from any population concentrations but subject to infrequent visits by the public from nearby farms or public highways.

Class C—(Remote)—Locations and sites far removed from any dwelling which would be visited by operating personnel and sportsmen.

Table 1D

## SURVEY OF DROWNINGS IN BUREAU-CONSTRUCTED CANALS

(by age, sex, type, and activity)

Years 1964 through 1968

A. Age, years	Sex		5-year total	Annual rate
	Male	Female		
0-5	36	10	46	9.2
6-10	14		14	2.8
11-15	3	1	4	0.8
16-20	12	4	16	3.2
21-60	54	7	61	12.2
Over 60	9	2	11	2.2
Totals	128	24	152	30.4

B. Type of drowning	Cause				5-year total	Annual rate
	Fell	Own volition	Pushed or thrown	Vehicle		
Accidental	60	26		27	113	22.6
Apparent suicide		2			2	0.4
Suspected homicide			1		1	0.2
Undetermined				5	36	7.2
Totals	60	28	1	32	152	30.4

C. Activity of deceased	Age group						5-year total	Annual rate
	0-5	6-10	11-15	16-20	21-60	Over 60		
Fishing				1	3	1	5	1.0
Swimming			2	3	10	1	16	3.2
Hunting		1					1	0.2
Walking	5	3		1	4	4	17	3.4
Playing	34	6					40	8.0
In vehicle	1	1		4	25	1	32	6.4
Undetermined	6	3	2	7	19	4	41	8.2
Totals	46	14	4	16	61	11	152	30.4
(Under the influence of alcohol)				2	16	4	22	4.4

d. Two-thirds of the drownings, or 103, occurred along the bank of the canal or lateral. Drownings from bridges and check structures claimed 23 lives. The fact that 32 drownings (21 percent) involved vehicles points up the mounting hazard from this source. These incidents involved vehicles entering canals from adjacent public highways, vehicles traveling O&M roads alongside canals where access was permitted for recreational uses, and vehicles traveling O&M roads where access was not permitted and trespassing was involved. In several cases, it was determined that the driver was under the influence of alcohol.

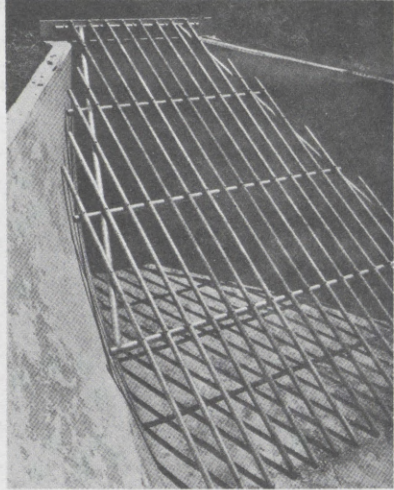
e. Not considering vehicular accidents, only a total of 20, or 4 drownings per year, occurred in reaches of canals or laterals protected by fencing. In most instances trespassing was involved and the fencing varied from simple barbed wire to more elaborate chain link and barbed wire. Significant is the fact that 100 of the 120 drownings, not including vehicular, occurred along unfenced reaches of Bureau canals and laterals.

f. Indicating the danger that open waterways present to children is the tragic fact that 60 were under 11 years of age.

g. The study indicates that almost all the drownings were accidental although 22 or 12½ percent of the drowned persons were known to be under the influence of alcohol at the time. Only 16 drownings involved persons swimming in the canals, compared with 57, mostly young children, who fell in while walking or playing along the waterways.

From the accompanying survey, shown in Table 1D, it is concluded that the greatest single incidence of drownings involves children playing or walking along open canals or laterals. Further, that while lined canals and laterals are potentially the most hazardous, the incidence of drownings is equally great in unlined canals and laterals. The survey indicates that protective fencing is effective in reducing the number of drownings. Conversely, a review of the specific locations where drownings have been prevalent, as listed below, disclosed the absence of fencing or perimeter guarding:

Delta-Mendota Canal	1.8 drownings per year
Yuma Main Canal	1.2 drownings per year
Rio Grande Project	4.8 drownings per year
Middle Rio Grande Project	4.6 drownings per year



Photograph 1. Safety rack installed in inlet transition of siphon. Photo P328-701-9467

In many areas the Bureau's public image has suffered as a result of these tragic drownings of children. Additionally, law suits against the Bureau resulting from drownings in Bureau-operated canals and laterals are becoming more prevalent.

## 2. Present Practice in Protecting the Public Along Existing Waterways

The Bureau, for some years, has been thoroughly aware of the need to protect the public along existing waterways. In an effort to reduce drownings in canals and laterals an aggressive public safety program, incorporating the following actions, has been initiated:

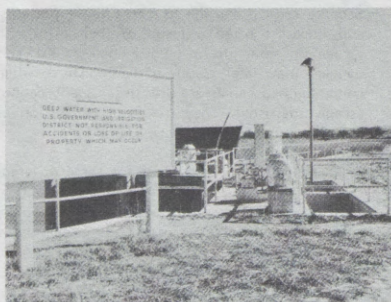
- a. Design. — Current Bureau safety design criteria dictate that all open canals and laterals over 30 inches deep, located in Class A exposures, be protected with either a 4- or 6-foot chain link or wire mesh perimeter fence topped with barbed wire. This protection has also been extended to rural areas depending upon the degree of exposure. All concrete-lined canals with sides more than 30 inches in height are equipped with escape ladders installed at 750-foot intervals. In addition, other escape devices are provided upstream from all

hazardous canal structures (such as checks, turnouts, drops, and chutes). These escape devices include suspended cables with droplines, floats or booms across canals, escape nets, safety racks, and trashracks. All inlets to siphons over 30 inches in diameter and all inlets to tunnels are protected with these escape devices and a fence or guardrail. In urban areas, it is the Bureau's policy to construct closed conduits wherever practical.

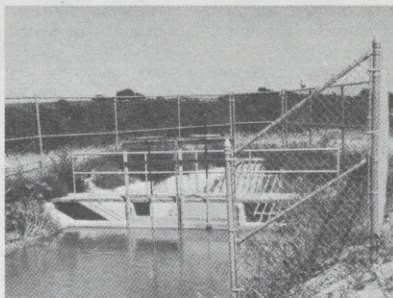
b. Current practice on existing canals. — During the past 5 years the Bureau has installed siphon protection on Bureau-operated canals and has encouraged water districts to do likewise. Also, safety devices have been installed on other hazardous canal structures on most Bureau-operated canals. Very little perimeter fencing has been installed on existing canals or laterals, regardless of the exposure or the incidence of drownings. However, in cooperation with the districts and state agencies, the Bureau has encouraged local legislation requiring land developers to fence adjoining canals and laterals.

c. Safety maintenance. — Routine inspection and maintenance programs are carried out by all operating offices to ensure that required fencing and protection devices are installed and adequately maintained.

d. Public education. — Since 1961 the Bureau, in cooperation with the American Red Cross, has sponsored and actively participated in an aggressive public water safety program. The program, widely known as "Operation Westwide," currently



Photograph 2. Safety sign, life buoy and fence at canal headworks. Photo P-328-701-7145



Photograph 3. Checked siphon inlet with safety rack, fencing and guardrail. Photo P-328-700-103NA

is composed of 30 community water safety councils promoting water safety on or adjacent to Bureau irrigation projects.

### 3. Potential Improvements for Reducing Waterway Hazards to People

In view of the hazards that open canals present to people, the following steps are proposed to reduce drowning in these waterways:

a. Future fence construction. — Bureau design standards should be revised to provide for construction of protective right-of-way fencing on all reaches of open canals or laterals designated as Class A or Class B exposure. For Class A exposure the fencing should be 5 feet high, constructed of 4 feet of chain link and three strands of barbed wire on metal posts. Adjacent to schools or public playgrounds the fence should be 7 feet high, constructed of 6 feet of chain link and three strands of barbed wire on metal posts. Class B exposures should meet the Class A design criteria except that wire mesh shall be substituted for chain link fencing material on the 5-foot fence. Also, wooden posts may be used in lieu of metal posts.

b. Existing facilities. — Reaches of existing canals and laterals classified as Class A or B, operated by the Bureau, should be either placed in underground conduits or fenced in accordance with the design criteria set forth in a. above. A priority should be established for the fencing of these canals based upon the degree of hazard to the public and upon the incidence of drowning. Irrigation districts operating Bureau-constructed

canals and laterals should be encouraged and assisted in an effort to provide similar protection.

c. Safety. — The current safety maintenance and public education programs carried out by the Bureau should be intensified.

d. Increased consideration for use of underground conduits. — In future planning studies for water conveyance structures, more consideration should be given to reducing hazards through the increased use of underground conduits in lieu of fenced, open waterways.

### REDUCING HAZARDS TO ANIMALS ON RECLAMATION CANALS

Concrete-lined canals present a very serious hazard to animals. Because of the high water velocities and slick, steep side slopes normally associated with these canals, it is virtually impossible for animals to escape from them unassisted. If they do not die of exhaustion, they drown when swept through siphons. Canals with earth banks do not present as great a hazard because animals can generally escape from them unassisted.

Relatively few domestic animals are drowned in Bureau-constructed canals annually but these can be greatly reduced by the construction and maintenance of cattle guards, gates, and right-of-way fences. The present policy of providing barbed wire or wire mesh fences wherever canals present a hazard to domestic animals is successful and should be continued.

The loss of big game animals in canals is another matter. Limited attempts have been made to reduce the many drownings of these animals. Approximately 95 percent of the big game animals lost are deer, although losses of elk, bear, antelope, and desert bighorn sheep have been recorded. Just how many animals are lost in Reclamation canals is not known because complete records have never been kept. Table 2 is a summary of available data and is presented to give some idea of the number of animals lost.

It can be seen from Table 2 that the problem of big game drownings is primarily a problem of one species, namely deer. These reports cover about 2,200 miles of the 7,000 miles of canals the Bureau has constructed. The data are too incomplete to establish the total number of deer drowned annually on Bureau-constructed canals.

Table 2 reveals that the loss of deer is a problem in only a few canals. The Charles Hanson Feeder Canal in Colorado has annual losses of approximately six deer per mile of canal. The Delta-Mendota Canal in California apparently has annual losses of one deer for every 10 miles of canal. Canals that are in suitable deer habitat usually have annual losses of one or more deer per mile. Thus, the location of a canal will determine the hazard the canal presents to wildlife.

Table 3 shows canal properties of the canals mentioned in Table 2. All canals tabulated are either partially or completely concrete lined, and deer losses were significant only in the lined portions. Also noteworthy is the fact that concrete-lined canals with sideslopes as flat as 2:1 (2 horizontal to 1 vertical) are a hazard. The size of a canal does not appear to be significant, nor does water depth.

#### 1. The Basic Problems of Canals to Big Game

A listing of the basic problems that canals present to big game are:

a. A canal located in an area normally inhabited by deer or other big game can act as an obstacle or barrier that must be crossed. In extreme cases canals may reduce or eliminate access to valuable habitat.

b. Canals may be in resident, summer or winter range or in a transition area. They often intersect normally traveled game trails. They may intersect major migration routes.

c. The danger of canals to deer is threefold: First, deer enter the canal, are unable to find a suitable place to escape, become exhausted, and drown. Second, critical damage to deer's hoofs, pasterns, and knees is often a result of their efforts to escape on concrete- or gunite-lined banks. This damage may later result in death. Third, when concrete-lined canals are dry, deer usually cannot escape unassisted. They die from exhaustion or injury incurred trying to escape.

d. Deer may enter the canal for three different reasons: First, the animal may be attempting to cross to the opposite bank. This is especially compelling if the canal crosses daily or seasonally traveled game trails. A deer might be attracted to something on the opposite bank, such as another deer or feed, and be tempted to cross. Second, deer may be forced to jump into the canal when frightened or chased by people, dogs, or predators. Third, deer might fall or slip into a canal when trying to drink from it. Canals are an attraction to

Table 2  
SUMMARY OF BIG GAME LOSSES IN BUREAU-CONSTRUCTED CANALS

Canal—Project	State	Animals lost*	Period involved	Miles of canal involved	Comments	Source of information
Ainsworth Canal— Ainsworth Unit	Nebraska	23	1965	52		(1)
		45	1966			
Charles Hansen Feeder Canal— Colorado—Big Thompson Project	Colorado	25	1957	8.5	Project Manager's letter of February 20, 1969 Average loss for 12-year record is 49 deer per year	(5)
		23	1958			
		58	1959			
		37	1960			
		30	1961			
		33	1962			
		61	1963			
		43	1964			
		41	1965			
		70	1966			
38	1967					
32	1968					
Columbia Basin Project	Wash.	36	1953		Losses on 40 miles of concrete-lined canal on Main Canal and West Canal; 25 rough gravel-asphalt escape ramps constructed in March 1955	(2)
		54	1954			
		27	1955			
		13	1956			
Columbia Basin Project	Wash.	171	1952-59		About 10 percent died in dry canals after close of irrigation season	

Table 2—Continued

Canal—Project	State	Animals lost*	Period involved	Miles of canal involved	Comments	Source of information
Delta-Mendota Canal	Calif.	13	1954-55	120	Fenced against livestock; no escape ramps	(3)
		10	1958-59			
Friant-Kern Canal	Calif.	12	Per year	153		(3)
Gateway Canal, Weber Basin Project	Utah	2	July 1957		33 removed from canal. Canal not carrying full flow	(3)
Howard Prairie Canal Talent Division Rogue River Basin Project	Oregon	55	7-21-59 to 8-31-59	17	55 deer lost in first 40 days of canal operation USBR constructed 18 deer catchers, 5 drinking bays, and 207 deer crossings in 1960. Average loss for 8 years is 24 deer per year	(4)
		42	1961			
		33	1962			
		26	1963			
		21	1964			
		18	1965			
		14	1966			
		25	1967			
11	1968					
Robles-Casitas Canal Ventura River Project	Calif.	Over 100	1957	8	After 9 ladders and 2 bridges constructed, 9 deer were taken from canal in September 1959	(3)

Table 2—Continued

Canal—Project	State	Animals lost*	Period involved	Miles of canal involved	Comments	Source of information
Robles—Casitas Canal Ventura River Project	Calif.	None	1959—60	—	Since 9 ladders and 2 bridges constructed	(3)
Toketee Project North Umpqua River	Oregon	57 deer 3 elk	1952—59	—	Resident population of deer small; no migration of significance. Decreasing loss over period attributed by Company to bridges	(3)
Wellton—Mohawk Project	Arizona	Many deer Several desert bighorn sheep		Over 50		(3)

\* Animals lost are deer unless otherwise indicated

Source of Information

1. Nebraska Game, Forestation, and Parks Commission
2. State of Washington, Department of Game
3. Bureau of Sport Fisheries and Wildlife (see bibliography reference No. 3)
4. Talent Irrigation District
5. Bureau of Reclamation

Table 3  
SUMMARY OF CANAL HYDRAULIC AND PHYSICAL PROPERTIES

Canal	Lining	V	S:S	d (ft)	b (ft)	H <sub>L</sub> (ft)	Q
Ainsworth Canal Reaches 1, 2, 3 Reaches 4, 5, 6, 7	Concrete	3.40	2:1	7.22	9.0	8.40	580
	Concrete	6.20	2:1	5.30	7.0	6.50	580
	Concrete	4.41	1-1/4:1	8.79	13.0	10.50	930
Charles Hansen Feeder Canal	Concrete	3.91	1-1/4:1	8.17	7.0	8.67	550
Delta Mendota Canal Typical unlined section, 2 miles Typical concrete-lined section, 96 miles Typical earth-lined section, 18 miles	Not lined	2.26	2-1/2:1	14.27	50.0	—	4,600
	Concrete	3.81	1-1/2:1	16.56	48.0	18.08	4,600
	Earth	2.41	2-1/2:1	13.90	62.0	—	3,310
Friant-Kern Canal Typical concrete section, 152 miles Typical earth-lined section, 25 miles	Concrete	3.90 to 5.10	1-1/4:1	17.00 to 18.30	36.0	—	5,000 to 3,500
	Earth	3.20	1-1/2:1	15.20	64.0	—	3,500
	Concrete	4.99	1-1/2:1	6.90	10.0	8.33	700
Gateway Canal Howard Prairie Canal Howard Prairie Bench Flume	Concrete	3.38	1-1/4:1	2.99	2.2	3.50	60
	Concrete	3.34	Vertical	2.99	6.0	3.75	60
Robles Castias Canal	Concrete	5.86	1-1/2:1	5.56	7.0	6.80	500

V = velocity, feet per second

S:S = side slope ratio

d = normal water depth

b = canal bottom width

H<sub>L</sub> = height of lining

Q = design capacity, cubic feet per second



Photograph 4., Male mule deer attempting to escape from the Ainsworth Canal. The deer was unable to escape until it reached the deflector escape structure further down the canal (see Photograph 6). Photograph courtesy Nebraska Game, Fish and Parks Commission.

deer because they offer a source of drinking water. This is especially important in areas where water is scarce. Drinking from a canal can be difficult if the water surface is well below the top of the canal. Deer, in attempting to reach this water, may slide into the canal.

e. The steepness, slickness, and height of the canal bank influence a deer's ability to escape. The depth and water velocity apparently affect the animal's behavior in the canal.

f. Concrete-lined canals present a major problem to big game because the walls are too steep and slippery to allow an animal to get out. Even small concrete-lined canals are a hazard to adult animals as well as fawns.

g. In most cases, canals with earth banks offer few problems to adult deer but may be a hazard to fawns.

The behavior of deer trapped in a canal is not entirely predictable. Normally, they attempt to escape at the point they entered the canal. They continue to try to escape until they become exhausted. Then they swim or float downstream until swept through a siphon and are drowned or until they reach some barrier in the canal where they die. Deer will swim either upstream or downstream searching for an escape point. Normally they will not swim upstream in a canal if the velocity is greater than 4½ feet per second.

The loss of a deer in a Bureau-constructed canal does not result in monetary loss to the Bureau or to its water-users; however, when significant numbers of big game animals are lost in a canal, measures are undertaken to reduce or eliminate these losses. These measures are usually endorsed by conservation organizations, sportsmen's organizations, and the communication media. Directly interested are the state game departments, the Bureau of Sport Fisheries and Wildlife, and state and Federal officials.

In addition, state game departments and the Bureau of Sport Fisheries and Wildlife are requesting that hazards to wildlife be reduced on future canals. For example, on the Fryingpan-Arkansas Project the Bureau will provide 33 miles of deerproof fence and 16 deer crossings at a cost of approximately \$350,000 on three concrete-lined canals. This is being done at the request of the Colorado Game and Fish Department. In addition, the State of Nebraska has stated that all future concrete-lined canals should be fenced completely.

On existing canals operated by water districts the problem of deer loss can be complex. Expenditures for animal protective devices can range from very minimal to a large amount. Usually large expenditures for such protective devices may be beyond the financial capabilities of the districts. Cooperative efforts by both the water users and conservationists are needed to find a solution to the problem.

## 2. Present Practice in Reducing Deer Losses on Existing Canals

Presently there are several measures being taken on different projects to reduce deer losses in existing canals. These include elimination of access by fencing, installation of deer crossings, construction of drinking bays, and installation of escape devices. Escape devices used consist of deflectors, floating log booms, snow fence laid on canal sides, airplane landing mat laid on canal sides, metal cleat steps attached to canal lining, rough gravel-asphalt escape ramps, reinforcing bar grids laid on canal sides, escape steps at siphon inlets, and temporary escape devices for use during the nonirrigation season.

Generally, stock fences have not been effective in reducing deer losses; however, installation of such fencing along canal rights-of-way has been credited with reducing losses on some projects. A conventional stock fence is 4 feet high with four strands of barbed wire. Deerproof fence is 7½ feet high with 6 feet of woven wire and three strands of barbed wire and will almost completely eliminate deer access. Fencing costs are included in this report in the portion entitled "Fencing."

Deer crossings are bridges constructed across canals and their use is limited to animals. They provide a means of animal movement across canals and reduce incidents of animals entering the canal. They should be at least 8 feet wide and have a cover of 4 inches of earth. The effectiveness of these structures has been proven on the Colorado-Big Thompson and Rogue River Projects. Any plan to reduce deer losses in a canal should consider the use of crossings. Crossings should be provided for deer movement if a canal is to be fenced. They present few or no O&M problems if properly constructed. The following tabulation gives estimated costs (May 1969) of deer crossings constructed of timber:

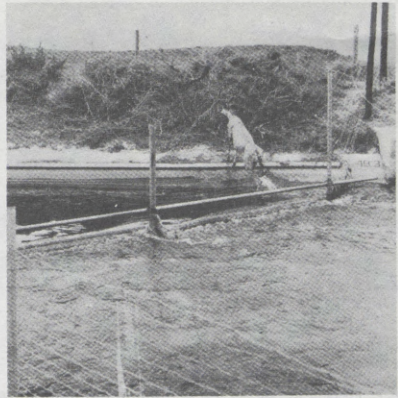
Span of crossing	Width of crossing	Estimated cost per crossing
15 feet	8 feet	\$1,650
20 feet	8 feet	2,200
30 feet	8 feet	3,300
40 feet	8 feet	4,400

Installation of drinking bays will reduce incidents of deer entering canals in areas where water is scarce. They are credited with reducing deer losses on the Howard Prairie Canal. Drinking bays can be constructed inexpensively, with the use of natural materials and corrugated metal pipe, and present few O&M problems.

Deflectors are barriers placed in the canal to shunt or force a swimming or floating deer to the sides of the canal where some means of escape is provided. Deflectors can be constructed of metal pipe, wood, or metal pipe and reinforcing bars. They can be floating or stationary.



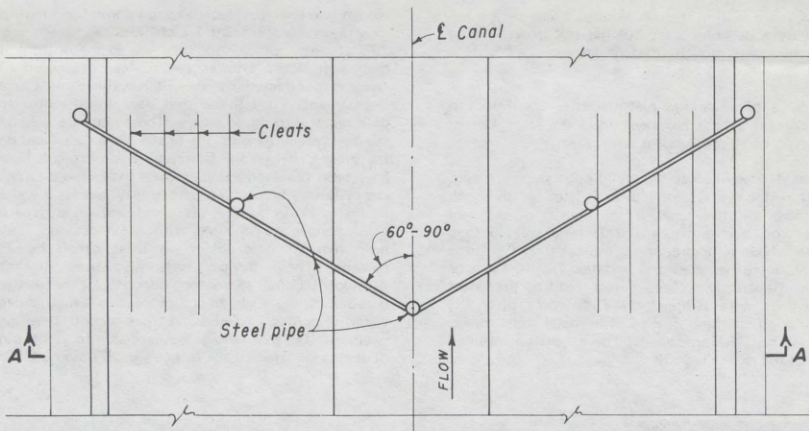
Photograph 5. Canal deer crossing (or bridge) on the Charles Hanson Feeder Canal. Tracks show deer usage. Photo P-245-713-4111 NA



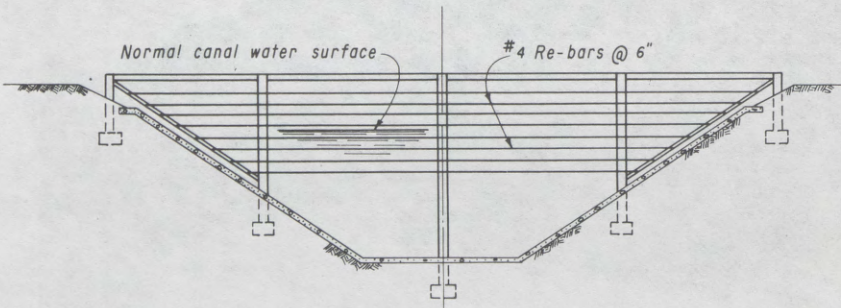
Photograph 6. Deer escaping Ainsworth Canal at deflector escape structure. Note cleats attached to canal lining assisting the animal's escape. Photograph courtesy Nebraska Game, Forestation and Parks Commission.

On small canals they are usually placed diagonally across the canal and anchored to the canal bank. On larger canals they are usually V shaped in plan (see Figure 2). Wooden or angle iron cleats attached to the canal lining, concrete steps, or flattened canal side slopes have been used to aid the escape of deer from the canal. Floating deflectors constructed of wood have been used on the Southern Okanogan Lands Project in British Columbia where they were credited with reducing deer drownings from 30 to 3 annually. Stationary deflectors constructed of pipe have been used experimentally on the Ainsworth Canal. Their effectiveness has not been fully determined, but it has been concluded that they do aid in reducing deer losses. To be effective, these devices should be placed upstream from all in-line canal structures and at approximately ½-mile intervals along the canal. The structures present several problems and are not popular with irrigation operators. They cause loss of head in the canal, require annual maintenance, and periodic cleaning when the canal is in operation. They present the possibility of causing the canal to overflow when they become plugged. The estimated cost of the deflector for a 20-foot-wide canal is \$900, and for a canal 40 feet wide, the estimated cost is \$1,200.

The log boom consists of floating logs attached to a chain or cable anchored to the canal bank. Some means of animal exit at the canal sides should be provided. Deer have been observed going over and under them in the canal. They are not used extensively for reduction of deer losses.



PLAN



SECTION A-A

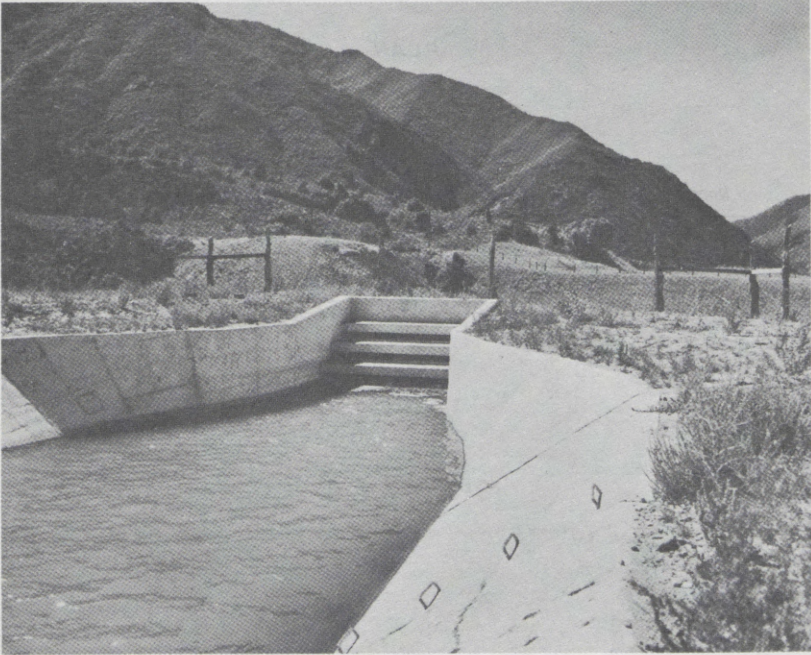
Figure 2. Typical animal deflector on canal.

Snow fence laid on the canal side as a deer escape has been used in some areas but has not proven to be effective. It is thought that its appearance frightens deer.

Surplus airplane landing mat placed on canal sides to aid deer in escape has been used on some canals; however, its effectiveness is not known.

To assist deer in escaping, metal cleat steps are used on the Mohawk Canal, Yuma Project, at all check structures on the canal. These consist of steps of angle iron placed on canal sides and welded to a frame which is anchored to the canal bank. These devices were designed and installed by the Arizona Game Department. The project reports that deer drownings were reduced by 75 percent after the installation of these devices. The metal steps should present no O&M problems. The estimated installed cost of the device is \$500.

Rough gravel-asphalt escape ramps consist of a mat of rough gravel and asphalt 1 inch thick, approximately 20 feet wide, applied from the top to the bottom of the canal sides. This escape device is a result of research conducted by the Washington State Game Department. They found that deer are attracted to dark areas in trying to escape. These mats are used on the concrete-lined portions of the Main Canal and on the West Canal of the Columbia Basin Project. Deer have been observed escaping from the canals on these ramps both when canals were empty and with water in them. Project O&M personnel and game department people are satisfied with these devices. They have reduced deer losses on these canals by 75 percent. These devices were also used on the Ainsworth Canal and were found to be ineffective because of the high velocities of this canal. When water velocities exceed 5 feet per second, deer are swept off the mat before they are able to climb out of the canal. This escape device should pose no O&M



Photograph 7. Stepped siphon inlet, Gateway Canal. The concrete steps allow humans and animals to escape from the canal. Conventional reinforcing bar steps for human escape shown in right foreground. Photo 526-400-4213

problems. Their estimated cost is \$100 per ramp. At present this device appears to offer the best means of aiding deer in escaping from concrete-lined canals.

Reinforcing bar grid consists of a mat of concrete reinforcing bars welded into a grid placed on the canal sides and anchored to the canal bank. These grids were used on the North Branch Canal, Yakima Project, but were found to be ineffective and their use has been discontinued.

Stepped siphon inlets, consisting of reinforced concrete steps, extend below the canal water surface. They are a monolithic part of the siphon inlet. These steps require an inlet transition of special design, eliminating their use on existing canals. They were developed in the hydraulic laboratory of the U. S. Bureau of Reclamation. Stepped siphon inlets were constructed on the siphons of the Gateway Canal, Weber Basin Project. They are effective when the canal is at or near design capacity. They are completely ineffective when the canal has low flows or is dry. They are credited with reducing deer drownings on the Gateway Canal where deer have been observed using them to escape from the canal.

Baled hay placed in canals after close of the irrigation season is an effective temporary escape device. This has been used successfully on the Tieton Division of the Yakima Project and has eliminated losses of deer and elk during the nonirrigation season.

The degree of effectiveness of all measures and devices reviewed is in some part based on judgment. For some there is little or no data available to make a scientific determination of their effectiveness.

Measures that have been found to be effective in reducing deer losses include deer crossings, drinking bays, and escape devices. None of these alone will prove satisfactory, but an intelligent application of a combination of some of these devices should reduce deer losses significantly. Escape devices that have been found effective are deflectors, metal cleat steps, rough gravel-asphalt escape ramps, and stepped siphon inlets. Escape devices used should be in accordance with canal characteristics and must take into account the conditions peculiar to the locality. These conditions include canal properties, terrain canal traverses, habits of deer, and availability of food and water for deer.

Deer losses can be eliminated by covering canals, conveying water in pipe rather than in open canals, and by fencing open canals with deerproof fence (see bibliography references 1, 3, 5, 6, 7, and 8).

### 3. Potential Improvements for Reducing Waterway Hazards to Animals

After reviewing the animal drowning problems, experienced by the Bureau on existing canals, it is obvious that future canals should be planned to

minimize these hazards. Of first importance in planning is recognizing those areas where wildlife losses are likely to be a significant problem. Then all plans under investigation for water utilization should include adequate measures to protect wildlife. Some measures that should be considered for wildlife protection are conveying water in pipe in lieu of concrete-lined canals, conveying water in earth-lined or buried membrane-lined canals in lieu of concrete-lined canals, fencing concrete-lined canals, provision for animal crossings and drinking bays, and/or escape devices in concrete-lined canals.

## SELECTION OF PROTECTIVE FACILITIES TO REDUCE HAZARDS

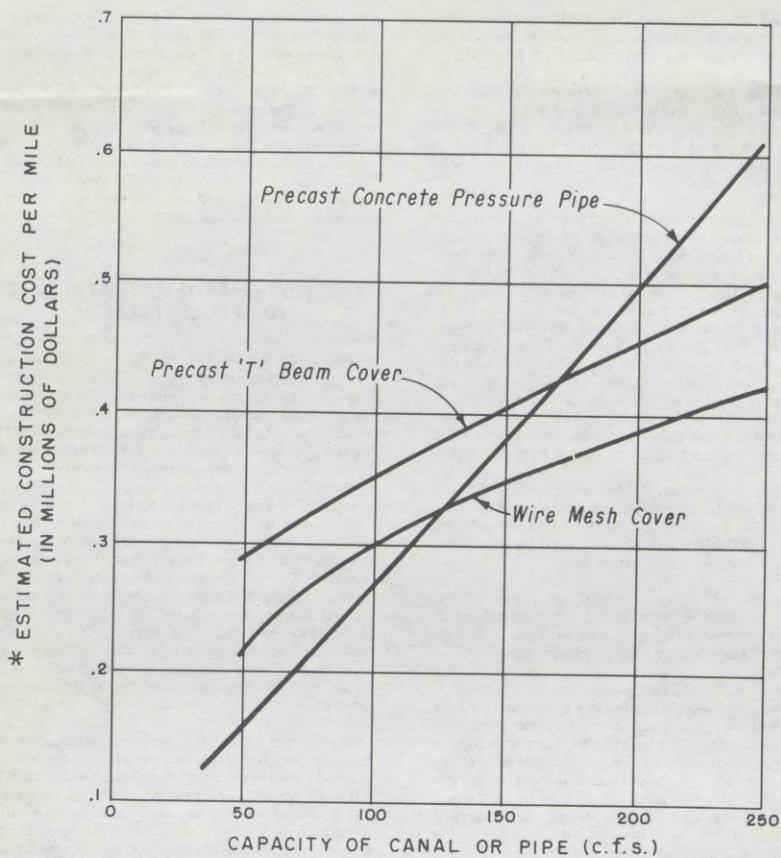
### 1. Economic Procedures for Selecting Appropriate Waterway Safety Features

Engineering economy is involved in the selection of the most appropriate methods, materials, and types of structures to serve the project purposes. Project plans for proposed projects or for rehabilitation and betterment of existing projects should include facilities for minimizing hazards to people and animals. The safety features to be included in each plan should be based on a determination of the potential hazards to people and animals. Basic facilities for public health and safety must be provided for in the plans. Methods for reducing hazards discussed in the preceding sections should be studied concomitantly with all other project purposes. For example, the alternatives of fencing waterways or placing them in buried underground conduits for safety purposes will also affect the total costs and benefits associated with the irrigation function.

The separable costs for each purpose must be less than the benefits from that purpose. In general, the selected plan should produce the greatest net benefits but must provide necessary safety features. However, other economic constraints such as the total construction cost per acre of irrigated land, the amount of amortization provided by the water users, and the amount of basin fund assistance required must also be given consideration in selection of the appropriate type of facilities to be provided.

Procedures for making economic comparison of alternative facilities are available in other documents and are not presented herein. A report entitled "Economic Justification for Canal Lining in Irrigation Distribution Systems," available from the Bureau of Reclamation, is one illustration of these procedures.

Costs and benefits for various safety features are discussed in the following sections. Comparisons of construction costs for pipe and canal covers are presented in Figure 3 and of pipe and fenced



\* Costs are as of May, 1969

Figure 3. Comparison of construction costs of covering canals and conveying water in pipe for various capacities.

concrete-lined laterals in Figure 4. Figure 4 indicates that construction costs for a pipe lateral will generally exceed those for a fenced, lined lateral when the lateral capacity is greater than 11 cubic feet per second. However, an economic comparison of these alternatives, considering all related costs and all related benefits, would generally indicate that pipe can be justified for laterals of greater capacity than 11 cubic feet per second.

## 2. Closed Conduits

Normally open canals are the most economical means of conveying large quantities of water. It can be assumed that the capital cost per lined foot of underground conduits exceeds the cost of open waterways except for those of very small capacity. Comparisons of underground conduits with fenced, open waterways for a proposed project should give consideration to such economic factors as:

### a. Comparative Costs

(1) Construction costs, as affected by compactness of area served, alignment of waterways, drainage requirements, right-of-way severance etc.

(2) Operation and maintenance costs, considering weed, rodent, and vector control; drain and waterway cleaning; operating requirements, pumping; energy; etc

### b. Comparative Benefits

(1) Net irrigation benefits from water conserved, comparing relative items such as evaporation seepage, operational waste, etc. These benefits may also be evaluated in terms of water use for such purposes as power generation, municipal and industrial supply, quality control, fish and wildlife enhancement, and recreation.

(2) Increased intangible benefits, considering such items as hazards to human lives and animals, esthetics, environment, and ecology.

Table 4 presents an estimate prepared in 1967 of the cost to enclose 982 miles of existing Reclamation canals that constituted a serious safety hazard (see bibliography Reference 11). Although the costs shown in the table may be conservatively high, they indicate the magnitude of costs to convert open canals to closed conduits.

Estimated construction costs for pipe and lined canals are also shown in Figures 3 and 4. These costs are presented for general information only. Construction costs for buried conduit vary greatly with location, pressure in pipe, etc.

For instance, Table 4 shows a construction cost of \$457,000 per mile for converting an existing canal of

100 cubic-feet-per-second capacity to a pipe system; while Figure 3 shows a cost of only \$270,000 per mile, assuming new work, for a pipe system of the same capacity. This points up the merit of including closed conduits in new work — so that economic water velocities may be used — rather than trying to convert existing canal to pipe systems.

## 3. Canal Covers

To determine whether existing canals could be covered economically, estimates were made for several types of canal covers. Reconnaissance grade design and estimates were prepared for thin-shelled, reinforced-concrete arches; precast concrete, double T-beams; and chain link fencing supported by pipe arches. See Figures 5 and 6. Obviously canal covers also could be constructed of a variety of other materials. A comparison of the construction costs of covering canals versus the construction costs of conveying water in pipe is shown in Figure 3.

The advantage of covering canals is mainly the elimination of the hazards of open canals. In some instances, the covered canal right-of-way might be used for other purposes such as park or recreation areas. Other benefits might include reduction in canal weed problems and improvement of winter operating conditions. Disadvantages might include increased hazard to animals where wire mesh covers were involved, increased maintenance costs for such items as silt removal, canal prism inspection and repair, etc. It would also be necessary to prevent vehicle access to flat canal covers.

## 4. Fencing

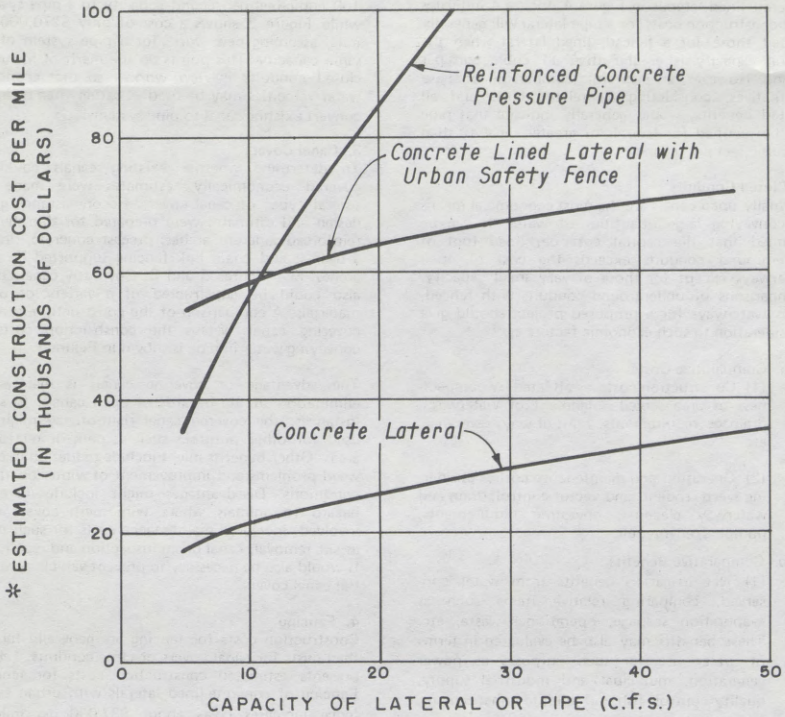
Construction costs for fencing are generally far less than costs for canal covers or close conduits. Table 5 presents estimated construction costs for fencing. Fencing of concrete-lined laterals with urban safety fence increases costs about \$37,000 per mile as shown in Figure 4. The costs shown in Table 5 are based upon the following design criteria:

a. School safety fence. — Fence 7 feet high with 6 feet of chain link and three strands of barbed wire. Steel posts at 10-foot centers with top rail. (Also known as cyclone fence.)

b. Urban safety fence. — Fence 5 feet high with 4 feet of chain link and three strands of barbed wire. Steel posts at 10-foot centers with top rail. (See Figure 7).

c. Proposed rural safety fence. — Fence 5 feet high with 4 feet of wire mesh and three strands of barbed wire supported by posts of metal or wood at 10-foot centers.

d. Barbed wire stock fence. — Fence 4 feet high with four strands of barbed wire and posts at 12-foot centers.



\* Costs are as of May, 1969 and do not include Right-of-Way costs

Figure 4. Comparison of construction costs of fenced laterals and conveying water in pipe for various capacities in urban areas.

Table 4

**TABULATION OF ESTIMATED COST TO PLACE EXISTING  
OPEN CANALS IN CLOSED CONDUITS\***  
(Pipes and boxes)

Capacity, cfs	Estimated miles to be enclosed	Estimated total cost of enclosure	Estimated cost per mile of enclosure**
50 or less	468	\$ 79,092,000	\$ 169,000
50-100	116	53,012,000	457,000
100-500	271	400,267,000	1,477,000
Subtotal	855	532,371,000	
500-1,000	74	240,352,000	3,248,000
1,000-3,000	23	117,162,000	5,094,000
3,000-10,000	30	230,700,000	7,690,000
Total	982	\$1,120,585,000	

\* Reconnaissance grade estimate, costs are as of October 1967.

\*\* Costs based on pipes or boxes placed on the same grade as the existing canal. Low velocity of flow, between 2 and 3 feet per second, results in large-diameter structures and relatively high-cost systems.

So that the size of open canals may be visualized, the following tabulation gives approximate dimensions of typical canal sections for capacities that correspond with the capacities shown in Table 4:

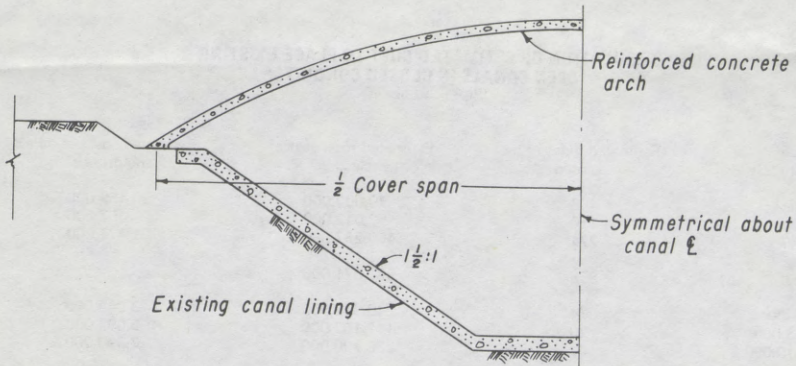
Capacity (cfs)	Canal bottom width (ft)	Canal top width (ft)	Canal depth (ft)
50	4	14	3.5
100	9	20	4.0
500	16	40-45	9.0
1,000	20	50-60	10.0
3,000	60	100-120	12.0

Table 5

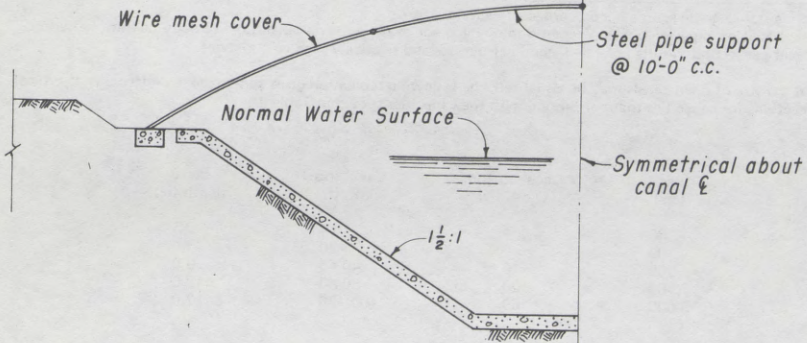
**ESTIMATED CONSTRUCTION COSTS OF FENCING**

Fence	Exposure class	Cost per linear foot of fence	Cost per mile of canal*
USBR school safety fence	A	\$4.00	\$41,200
USBR urban safety fence	A	3.50	36,800
Recommended rural safety fence	A&B	1.05	11,200
USBR barbed wire stock fence	B&C	—	4,800
USBR woven wire stock fence	B&C	—	7,200
Recommended deer fence	—	—	20,000
Highway safety fence (6-foot chain link)	A	3.75	40,000
Highway safety fence (4-foot chain link)	A&B	3.25	34,000

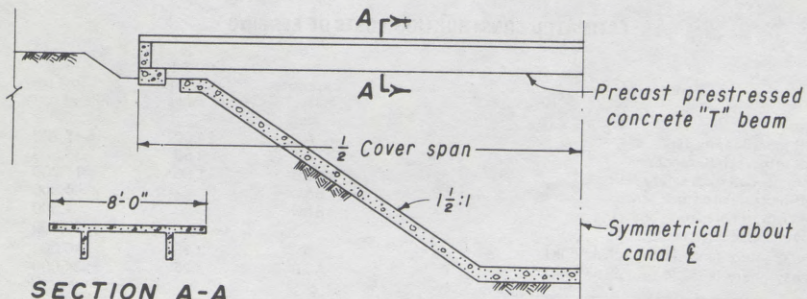
\* Assuming each side of the canal is fenced.



**CONCRETE ARCH CANAL COVER**



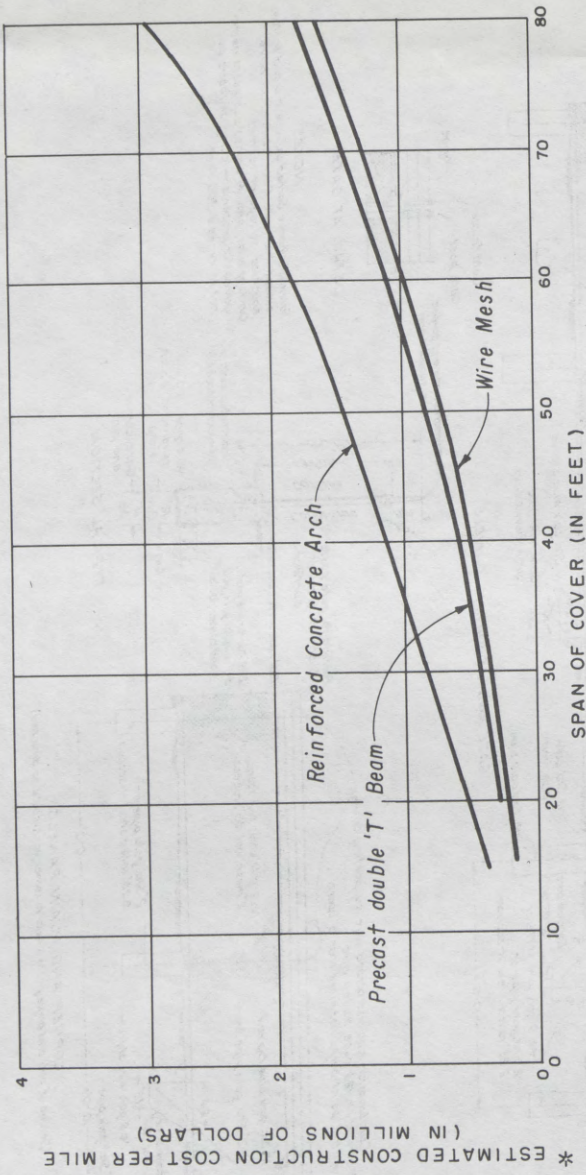
**WIRE MESH CANAL COVER**



**SECTION A-A**

**PRECAST "T" BEAM CANAL COVER**

Figure 5. Typical canal covers.



\* Costs are as of May, 1969

Figure 6. Estimated construction cost of canal covers.

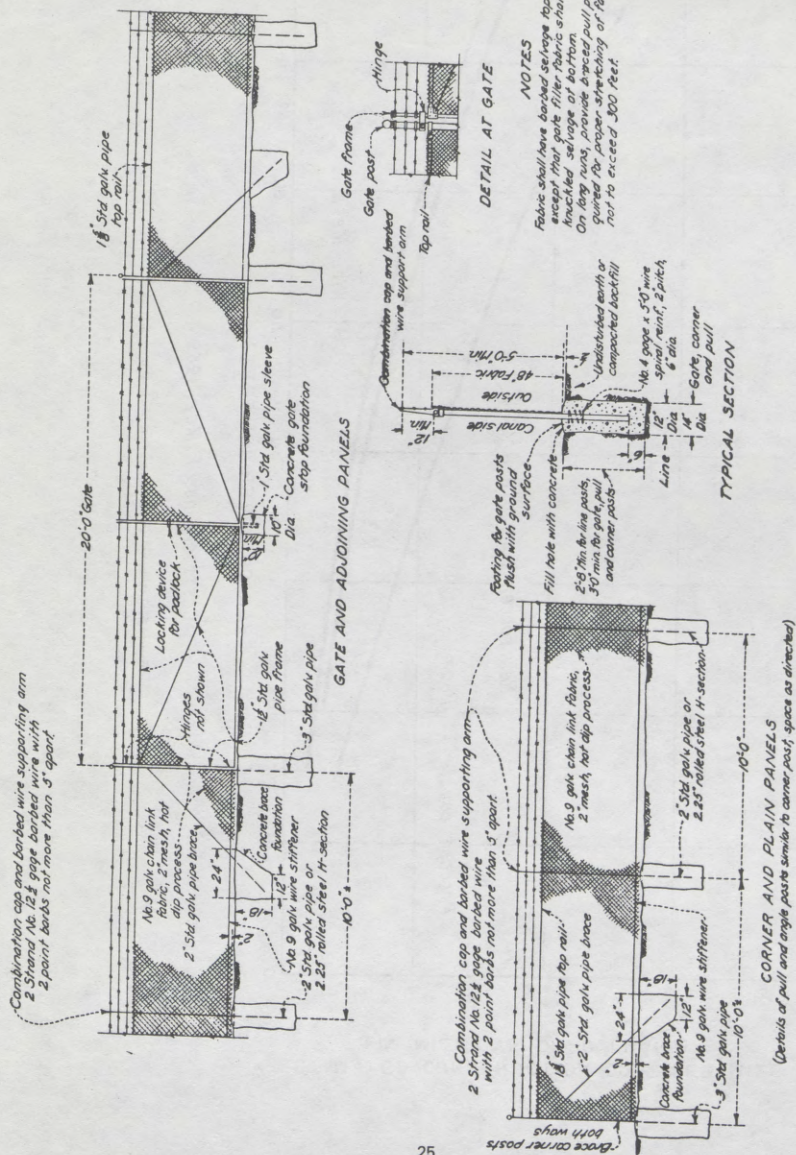


Figure 7. Typical urban safety fence.

e. Woven wire stock fence. — Fence 4 feet high with 2½ feet of woven wire and three strands of barbed wire. Posts are at 12-foot centers.

f. Proposed deer fence. — Fence 7½ feet high and 6 feet of wire mesh and three strands of barbed wire supported by wooden or metal posts at 8-foot centers.

g. Highway safety fence, 6-foot. — Fence 6 feet high, chain link, along all freeways in urban areas.

h. Highway safety fence, 4-foot. — Fence 4 feet high, chain link, in sparsely populated urban areas; or a 4-foot-high barbed wire fence or wire mesh fence where highways are a hazard to domestic animals.

The benefits of fencing are primarily the reduction of hazards to people and animals. In addition to the costs, fencing has another disadvantage — its detracting from the local landscape. To retain its effectiveness, fencing requires particular attention to maintenance. It has been estimated that the average annual maintenance cost for a stock fence is about \$50 per mile of fence. Maintenance costs for the various types of fencing will vary considerably with the type of fence and its location.

#### 5. Other Solutions

Among the other possible methods of reducing the hazards which canals present to people and animals are stepped concrete-lined canals, corrugated concrete linings for canals, flattened canal side slopes, attachment of cleats to concrete canal linings, animal repellents, and animal frightening devices. Figure 8 illustrates three of these possible methods. Because of the construction costs for and problems involved in construction of the stepped or corrugated linings as compared to those for fencing conventional concrete-lined canals, no further consideration has been given to these two proposals.

Cleats attached to canal linings would need to be installed the total length of the canal to prevent frightening animals or in connection with the deflectors discussed in earlier sections. Two or more

cleats would be required on each side of the canal depending upon the canal depth. The following tabulation gives estimated costs for various types of cleats.

Comparison of construction costs for continuous canal cleats with costs of deerproof fencing indicates fencing to have less first costs. Because of maintenance problems associated with deflectors and the wide variety of designs that have been suggested, no estimates were prepared for deflection structures.

No determination has been made of the maximum angle of concrete linings which people or animals could safely negotiate. Continuously flattened canal side slopes would result in unacceptable hydraulic efficiency and would result in a larger, more expensive canal. When compared with the effectiveness of fencing, this solution is considered infeasible for any but the smallest of canals.

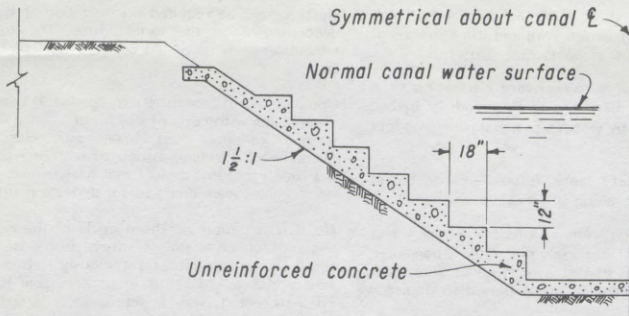
Costs for animal chemical repellent developed by the Bureau of Sport Fisheries and Wildlife in the amount required for effectiveness are such as to make this method infeasible.

The Bureau of Sport Fisheries and Wildlife reports that no deer-frightening devices have proven effective over periods of prolonged use. Therefore, no further consideration has been given to such devices.

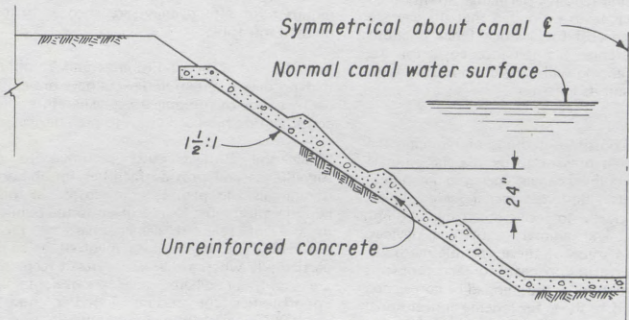
While the Bureau must continue to maintain surveillance and provide facilities for the protection of animals and people, as discussed in this report, consideration must also be given to the public interest in use of selected canal areas for recreational purposes. The high values involved in some areas, particularly where other water-based recreation areas are scarce or where canal areas contain unusual opportunities for certain activities, have already resulted in establishment of public use areas on Reclamation canals. It is anticipated that public interest in similar uses in other canal areas, particularly those near towns and cities, will accelerate in the future. Where encountered they should be considered on their individual merits. Care

### ESTIMATED INSTALLED COST OF VARIOUS CLEATS

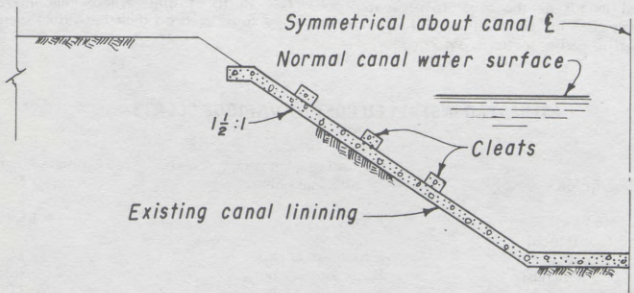
Cleat description	Method of anchoring to canal lining	Estimated installed cost per linear foot of cleat
Unreinforced concrete block (2 by 4 inches by 2 foot 0 inch)	Epoxy	\$1.25
Precast reinforced-concrete beam	Expansion anchor	3.00
Redwood timber (2 by 4 inches)	Expansion anchor	2.25
Galvanized steel angle irons	Expansion anchor	3.00
Aluminum angle iron	Expansion anchor	3.00



**STEPPED CANAL LINING**



**CORRUGATED CANAL LINING**



**CLEATS ATTACHED TO CANAL LINING**

Figure 8. Other proposed canal escape solutions.

must be taken to avoid interference with primary project functions. Any resulting alterations in canal alignment or other characteristics would be limited to relatively small locations and would not call for any general redesigning of canal sections. Prerequisites to recreational development and use of such canal areas

are arrangements with a responsible local or state agency or organization to provide recreational, sanitation, and related facilities, and to supervise public recreational use. Through such arrangements the substantial recreational values of Reclamation projects can continue to be extended.

## CONCLUSIONS

1. The Bureau of Reclamation is aware of the safety hazards associated with open waterways and incorporates protective features in the design of new facilities and modifies existing irrigation features for the protection of the public. Similar preventive measures have been undertaken for animals but on a smaller scale. Aggressive water safety programs to educate and protect the public have assisted in reducing the number of drownings in some areas.

2. The rapid growth of a highly mobile population, particularly in areas adjacent to Reclamation canals, is increasing the exposure of the public, thereby increasing the number of drownings and the need for implementing additional protective measures.

3. Exposure to both people and animals is virtually eliminated by using pipe in place of open canals; however, the initial cost of pipe is expensive and may be prohibitive. In those cases, fencing of the canals appears to be the most feasible alternative. Right-of-way fencing is comparatively inexpensive and has proven to be an effective deterrent to drownings in Reclamation canals if maintained properly. Financing modifications may require assistance from adjacent land developers, irrigation districts, or other sources.

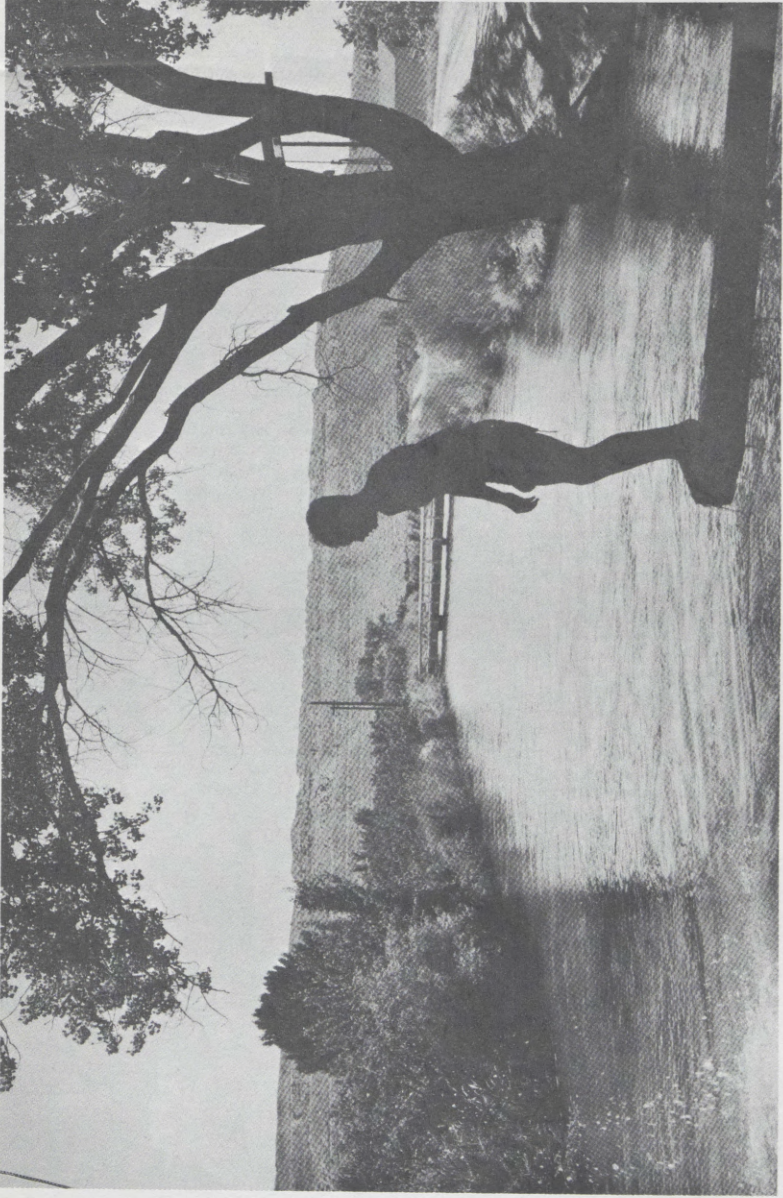
4. Drownings now occur most often along unfenced rural canals and laterals.

5. A high percentage of human drownings in canals and laterals involve children.

6. Protective devices including guardrails on structures, escape ladders, float lines, and siphon guards are effective in reducing human drownings.

7. Large concrete-lined canals present the greatest hazard to animals. Effective animal escape devices include various types of deflectors, cleats, rough gravel-asphalt mats, and stepped siphon inlets. Constructing stepped, corrugated, or flatter canal sides appears impractical and in most cases financially prohibitive.

8. Recreational use of Bureau waterways has always occurred, even in areas where such use has not been officially recognized or permitted, particularly where recreational values for such activities as fishing and swimming were unusually attractive. Such use will undoubtedly continue. Maximizing the attendant recreational values at specific and limited locations through appropriate development and adequate supervision appears more consistent with the public interest than attempting the impossible task of prohibiting all recreational use of Bureau canals and other waterways.



Photograph 8. This photograph gives witness to the popularity of canals for recreational use. Photo P8-400-694

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7. Report, Follow-up report for Talent Division, Rogue River Project, Oregon, March 1965, Bureau of Sport Fisheries and Wildlife, Portland, Oregon
8. Report, Deer Losses in Concrete-lined Canals, prepared by Bureau of Sport Fisheries and Wildlife, Bismarck, North Dakota, January 1967, for the Garrison Diversion Conservancy District
9. Letter, Project Manager, Yuma, Arizona, dated May 31, 1968, on hazards to animals and people from concrete-lined canals
10. Letter, Regional Director, Region 4, dated June 27, 1968, on hazards to animals and people from concrete-lined canals
11. Report, letter from Acting Commissioner dated November 9, 1967, on converting open canals to closed conduits to reduce hazardous conditions
12. Cost estimates prepared by Estimates and Analyses Branch, Division of Construction, Office of Chief Engineer; prices are as of May 1969

7-1750 (3-71)  
Bureau of Reclamation

### CONVERSION FACTORS—BRITISH TO METRIC UNITS OF MEASUREMENT

The following conversion factors adopted by the Bureau of Reclamation are those published by the American Society for Testing and Materials (ASTM Metric Practice Guide, E 380-68) except that additional factors (\*) commonly used in the Bureau have been added. Further discussion of definitions of quantities and units is given in the ASTM Metric Practice Guide.

The metric units and conversion factors adopted by the ASTM are based on the "International System of Units" (designated SI for Systeme International d'Unites), fixed by the International Committee for Weights and Measures; this system is also known as the Giorgi or MKSA (meter-kilogram (mass)-second-ampere) system. This system has been adopted by the International Organization for Standardization in ISO Recommendation R-31.

The metric technical unit of force is the kilogram-force; this is the force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 9.80665 m/sec.<sup>2</sup>, the standard acceleration of free fall toward the earth's center for sea level at 45 deg latitude. The metric unit of force in SI units is the newton (N), which is defined as that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/sec.<sup>2</sup>. These units must be distinguished from the (inconstant) local weight of a body having a mass of 1 kg, that is, the weight of a body is that force with which a body is attracted to the earth and is equal to the mass of a body multiplied by the acceleration due to gravity. However, because it is general practice to use "pound" rather than the technically correct term "pound-force," the term "kilogram" (or derived mass unit) has been used in this guide instead of "kilogram-force" in expressing the conversion factors for forces. The newton unit of force will find increasing use, and is essential in SI units.

Where approximate or nominal English units are used to express a value or range of values, the converted metric units in parentheses are also approximate or nominal. Where precise English units are used, the converted metric units are expressed as equally significant values.

Table I  
QUANTITIES AND UNITS OF SPACE

Multiply	By	To obtain
LENGTH		
Mil . . . . .	25.4 (exactly) . . . . .	Micron
Inches . . . . .	25.4 (exactly) . . . . .	Millimeters
Inches . . . . .	2.54 (exactly) * . . . . .	Centimeters
Feet . . . . .	30.48 (exactly) . . . . .	Centimeters
Feet . . . . .	0.3048 (exactly) * . . . . .	Meters
Feet . . . . .	0.0003048 (exactly) * . . . . .	Kilometers
Yards . . . . .	0.9144 (exactly) . . . . .	Meters
Miles (statute) . . . . .	1,609.344 (exactly) . . . . .	Meters
Miles . . . . .	1.609344 (exactly) . . . . .	Kilometers
AREA		
Square inches . . . . .	6.4516 (exactly) . . . . .	Square centimeters
Square feet . . . . .	*929.03 . . . . .	Square centimeters
Square feet . . . . .	0.092903 . . . . .	Square meters
Square yards . . . . .	0.836127 . . . . .	Square meters
Acres . . . . .	*0.40469 . . . . .	Hectares
Acres . . . . .	*4,046.9 . . . . .	Square meters
Acres . . . . .	*0.0040469 . . . . .	Square kilometers
Square miles . . . . .	2.58999 . . . . .	Square kilometers
VOLUME		
Cubic inches . . . . .	16.3871 . . . . .	Cubic centimeters
Cubic feet . . . . .	0.0283168 . . . . .	Cubic meters
Cubic yards . . . . .	0.764555 . . . . .	Cubic meters
CAPACITY		
Fluid ounces (U.S.) . . . . .	29.5737 . . . . .	Cubic centimeters
Fluid ounces (U.S.) . . . . .	29.5729 . . . . .	Milliliters
Liquid pints (U.S.) . . . . .	0.473179 . . . . .	Cubic decimeters
Liquid pints (U.S.) . . . . .	0.473166 . . . . .	Liters
Quarts (U.S.) . . . . .	*946.358 . . . . .	Cubic centimeters
Quarts (U.S.) . . . . .	*0.946331 . . . . .	Liters
Gallons (U.S.) . . . . .	*3,785.43 . . . . .	Cubic centimeters
Gallons (U.S.) . . . . .	3.78543 . . . . .	Cubic decimeters
Gallons (U.S.) . . . . .	3.78533 . . . . .	Liters
Gallons (U.S.) . . . . .	*0.00378543 . . . . .	Cubic meters
Gallons (U.K.) . . . . .	4.54609 . . . . .	Cubic decimeters
Gallons (U.K.) . . . . .	4.54596 . . . . .	Liters
Cubic feet . . . . .	28.3160 . . . . .	Liters
Cubic yards . . . . .	*764.55 . . . . .	Liters
Acres-feet . . . . .	*1,233.5 . . . . .	Cubic meters
Acres-feet . . . . .	*1,233,500 . . . . .	Liters

Table II—Continued

Multiply	By	To obtain
<b>WORK AND ENERGY*</b>		
British thermal units (Btu)	0.292	Kilogram calories
British thermal units (Btu)	1,055.056	Kilogram calories
Btu per pound	1,055.056 (exactly)	Joules per gram
Pounds	1.35582	Joules
<b>POWER</b>		
Horsepower	745.700	Watts
Btu per hour	0.293007	Watts
Foot-pounds per second	1.35582	Watts
<b>HEAT TRANSFER</b>		
Btu in./hr ft <sup>2</sup> degree F (k. thermal conductivity)	1.442	Milliwatts/cm degree C
Btu in./hr ft <sup>2</sup> degree F (k. thermal conductivity)	0.1240	Kg cal/hr m degree C
Btu/hr ft <sup>2</sup> degree F (C. thermal conductance)	1.4880	Kg cal/m <sup>2</sup> degree C
Btu/hr ft <sup>2</sup> degree F (C. thermal conductance)	0.568	Milliwatts/cm <sup>2</sup> degree C
Thermal conductance (21 degree F thermal resistance)	4.862	Kg cal/hr m <sup>2</sup> degree C
Btu/hr ft <sup>2</sup> degree F (C. thermal resistance)	1.761	Degree C m <sup>2</sup> /milliwatt
Btu/hr degree F (c. heat capacity)	4.1868	J/g degree C
ft <sup>2</sup> /hr (thermal diffusivity)	1,000	Cal/gram cm <sup>2</sup> sec
ft <sup>2</sup> /hr (thermal diffusivity)	0.092900	M <sup>2</sup> /hr
<b>WATER VAPOR TRANSMISSION</b>		
Grains/hr ft <sup>2</sup> (water vapor transmission)	16.7	Grams/24 hr m <sup>2</sup> perm (permeance)
Pounds per inch (permeability)	0.659	Metric perm
Pounds per inch (permeability)	1.67	Metric perm-centimeters

Table III

Multiply	By	To obtain
Cubic feet per square foot per day (seepage velocity)	*304.9	Liters per square meter per day
Cubic feet per second (velocity)	*4.8824	Kilogram second per square meter
Square feet per second (velocity)	*0.0929003	Square meters per second
Fahrenheit degree (change)	5/9 exactly	Celsius or Kelvin degrees (change)
Volts per mil	0.03937	Kilovolts per millimeter
Lumens per square foot (foot-candle)	0.001093	Lux
Lumens per cubic foot	0.001652	Ohm-square millimeters per meter
Milligrams per cubic foot	*35.3147	Milligrams per cubic meter
Milligrams per square foot	*10.7639	Milligrams per square meter
Gallons per square yard	*4.57219	Liters per square meter
Pounds per inch	*0.17858	Kilograms per centimeter

Table II

Multiply	By	To obtain
<b>QUANTITIES AND UNITS OF MECHANICS</b>		
<b>MASS</b>		
Grains (17,000 lb)	64.79891 (exactly)	Milligrams
Troy ounces (480 grains)	31.1035	Grams
Ounces (avoirdupois)	28.3495	Grams
Pounds (avoirdupois)	0.45359237 (exactly)	Kilograms
Short tons (2,000 lb)	907.18474	Kilograms
Long tons (2,240 lb)	0.897185	Metric tons
	1,016.05	Kilograms
<b>FORCE/AREA</b>		
Pounds per square inch	0.070307	Kilograms per square centimeter
Pounds per square inch	0.089476	Newtons per square centimeter
Pounds per square foot	4.88243	Kilograms per square meter
Pounds per square foot	47.8803	Newtons per square meter
<b>MASS/VOLUME (DENSITY)</b>		
Ounces per cubic inch	1.72959	Grams per cubic centimeter
Pounds per cubic foot	16.0185	Kilograms per cubic meter
Pounds per cubic foot	0.0160185	Grams per liter
Tons (long) per cubic yard	1.28594	Grams per cubic centimeter
<b>MASS/CAPACITY</b>		
Ounces per gallon (U.S.)	7.4893	Grams per liter
Pounds per gallon (U.S.)	6.2992	Grams per liter
Pounds per gallon (U.S.)	119.629	Grams per liter
Pounds per gallon (U.K.)	99.779	Grams per liter
<b>BENDING MOMENT OR TORQUE</b>		
Inch-pounds	0.01821	Meter-kilograms
Inch-pounds	1.12885 x 10 <sup>6</sup>	Centimeter-dynes
Foot-pounds	0.138255	Centimeter-dynes
Foot-pounds	1.38255 x 10 <sup>7</sup>	Centimeter-dynes
Ounce-inches	5.4431	Centimeter-kilograms per centimeter
Ounce-inches	72.008	Gram-centimeters
<b>VELOCITY</b>		
Feet per second	30.48 (exactly)	Centimeters per second
Feet per second	0.3048 (exactly)*	Meters per second
Feet per year	*0.965872 x 10 <sup>-6</sup>	Centimeters per second
Miles per hour	1.609344 (exactly)	Kilometers per hour
Miles per hour	0.44704 (exactly)	Meters per second
<b>ACCELERATION*</b>		
Feet per second <sup>2</sup>	*0.3048	Meters per second <sup>2</sup>
<b>FLOW</b>		
Cubic feet per second (second-foot)	*0.028317	Cubic meters per second
Cubic feet per minute	0.000473	Cubic meters per second
Gallons (U.S.) per minute	0.06309	Liters per second
<b>FORCE*</b>		
Pounds	*0.453592	Kilograms
Pounds	*4.4482	Newtons
Pounds	*4.4482 x 10 <sup>5</sup>	Dynes

## ABSTRACT

The Bureau of Reclamation and others engaged in water resource management are concerned with increasing the safety of people and animals exposed to open waterways. An in-depth study of the nature and extent of the hazard presented by canals together with an evaluation of preventive measures is given. A survey of human drownings in Bureau canals and a review of protective devices and safety practices currently in effect are presented. A detailed review of the problem of animal drownings is presented. The relative effectiveness and comparative cost of right-of-way fencing, conveying water in buried conduits, and covering canals are presented. These and other proposed solutions, such as installing stepped or corrugated canal linings, are examined and illustrated. The study presents much information related to the problem of public safety and preservation of animal life which will be of assistance to waterway planners, designers, and operators.

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REC-ERC-71-36  
Latham, H S and Verzuh, J M  
REDUCING HAZARDS TO PEOPLE AND ANIMALS ON RECLAMATION CANALS  
— OPEN AND CLOSED CONDUIT SYSTEMS PROGRAM. Bur Reclam Rep  
REC-ERC-71-36, Aug 1971.  
Bureau of Reclamation, Denver, 31, p. 7 fig, 7 tab, 8 photo, 12 ref, append

DESCRIPTORS—/ \*animals/ benefits/ canals/ canal linings/ \*safety/ water users/ closed  
conduits/ accidents/ economics/ \*hazards/ \*personnel/ thin shell  
structures/ construction costs/ indirect benefits/ fences/ project planning/ irrigation operation &  
maintenance/ irrigation systems/ public relations/ prestressed concrete/ reimbursable  
costs/ \*drowning  
IDENTIFIERS—/ canal covers/ Open and Closed Conduit System Prog/ safety  
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## STATEMENT OF WILLARD E. FRASER, MAYOR OF BILLINGS, MONTANA

Gentlemen, I am speaking today in support of S. 607 as the duly elected Mayor of the City of Billings, Montana, a City that has a very large, and very dangerous irrigation ditch now flowing through a large section of the residential area of the City of Billings. As Mayor I speak in support of Senator Metcalf's proposal that would bring Federal Assistance to communities such as Billings to aid them in covering such ditch hazards, and thereby prevent the drowning of small children.

Let us realize that irrigation ditches are both givers of life and wealth, but are also, all too often, takers of life, and sometimes inadvertently the destroyers of wealth as well—when ditch banks break and flood. The large irrigation ditch now flowing through the City of Billings has brought great wealth to our community, but it has also brought great sorrow to too many families who have suffered the death by drowning of small children, and it is to prevent such tragedies that I lend the support of my community to Senator Metcalf's measure. On occasion, this ditch has broken from its banks causing great property damage within the City Limits of Billings.

Although the U.S. Bureau of Reclamation conducted an extensive feasibility study a few years ago to determine a way to eradicate this ditch-drowning hazard from our midst, and while this Bureau Study produced the only sensible method of removing our ditch danger, there simply has not been, nor is there now a way for the City of Billings to ever finance same.

An exhaustive study has been previously made as to the feasibility of fencing our ditch banks, but it was determined, and emphatically pointed out, that fencing might well subject the City to the possibility of great legal hazards, as no fence can ever be built that inventive, enterprising small boys of Billings could neither climb over, nor tunnel under, and that when one, after so doing, might have fallen into the water, no adult passers-by could, in all likelihood, ever climb that fence in time to effect a rescue of that drowning child.

This, then, makes the covering of the ditch the only practical safety solution to our ditch danger. But I would point out to the Senators that this solution can only be made possible with Federal Financial Assistance, as would be provided in Senator Metcalf's proposal—S. 607.

Therefore, as Mayor of Billings, Montana, and especially in behalf of the small children of Billings, I now urge that this Sub-Committee of the U.S. Senate Committee of the Interior do approve of S. 607.

Senator METCALF. We also have statements from Senators Moss and Montoya and from Congressman Richard White to be inserted in the record at this point.

(The statements referred to follow:)

## STATEMENT OF HON. FRANK E. MOSS, A U.S. SENATOR FROM THE STATE OF UTAH

Mr. Chairman, every summer those of us who represent the western reclamation States are importuned to do something about the safety hazards of open irrigation canals—particularly about the hazard they represent to children under 10 years of age.

In the country as a whole there have been about 250 drownings in the past 5 years in open canals of Federal reclamation projects—about one fifth of them children under 10. In Utah recently we had a great double tragedy—we lost two children, one 6 and one 8, in an open ditch of the Provo River Project. Last year it was the Ogden River Project. In fact, every year brings its toll—both on projects built by the Federal government and those built by local irrigation companies.

The question has long been argued as to who should pay for the cost of making these canals safe—those who use the water from them, the home owners who buy or build homes close to canals, the cities or towns which urbanize areas once considered agricultural or the subdividers who built in the new areas?

When the project is a Federal one, a further question arises—should the local people bear all of the cost for seeing that those projects already built are made safe, or should the Federal government be partially responsible. And who should see that those now being planned and built by the Federal government have built-in safety factors?

I am glad to have these hearings called this morning to discuss this important question fully, and to decide what action should be taken on S. 3472 which would authorize the Federal government to bear up to 50% of the cost of converting open hazardous ditches to closed conduits or of providing safety fences.

The question at issue is simply this:

"How much is the life of a child worth?"

Of course, there is no price that anyone can pay. Nor does awareness of the hazards compensate for the loss of the life of a single child, or a single adult.

So the question we must work out here today, is not just who will pay, and how much, but how can we move most swiftly to find a solution to this problem, and put it into effect.

The hazards to public health and safety inherent in open canals in urban areas will increase with the years unless action is taken now. Those already built can be closed by fencing, or converted into closed conduits. Underground pipes are safer, of course, but fencing requires maintenance.

The Federal government, through the Bureau of Reclamation, should most certainly participate in funding safety provisions on those Federal projects already constructed. I understand that Reclamation now requires all new canals to be designed according to specified safety standards, and that special safety devices are being installed on hazardous structures such as chutes and drops.

No all irrigation projects are hazardous, of course. In many areas canals are used extensively for fishing and other forms of recreation, and these facts must be taken into consideration.

At the present time, water users are paying the full cost of operating and maintaining the canals, and also have borne the expense of legal suits and settlements when persons drown.

Others in the community have a responsibility, it seems to me, as does the Federal government when the project is a Federally-financed one.

I commend the Chairman for introducing this bill (S. 3472) and I hope its introduction, and the instigations of hearings on the problem here this morning, will lead to early action to protect the safety and well-being of all citizens who live in areas where open irrigation canals pose a constant threat and temptation to both children and adults, and take so many lives of both each year.

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STATEMENT OF HON. JOSEPH M. MONTOYA, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Mr. Chairman, your subcommittee is currently considering a bill introduced by Senator Clinton P. Anderson which is designed to promote the safety and well-being of citizens in densely populated areas where open irrigation ditches and canals pose a constant threat and temptation to adults and children alike. As a cosponsor of this legislation, I urge the subcommittee to give S. 3472 careful consideration and to report it favorably to the Committee on Interior and Insular Affairs.

S. 3472 authorizes Federal cost sharing in promoting public safety through the elimination of hazardous open canals in urban areas by converting them to closed conduits and by fencing. Although this legislation is national in scope, the original impetus for its introduction in the Senate developed in New Mexico. Consequently, I would like to review for this subcommittee the situation in my state that produced S. 3472.

During the past fifteen years, a number of fatalities have occurred in New Mexico which were associated with waterways of the Middle Rio Grande Conservancy District. This district extends along the Rio Grande River from the Cochiti diversion dam north of Albuquerque to the northern boundary of the Bosque Del Apache Grant south of Socorro. It includes the city of Albuquerque, with 331,500 inhabitants (1968), and other large cities and towns.

The growth of population in the Rio Grande Valley has exposed more and more people to open waterways which were originally located in sparsely populated rural areas. During the period 1959-1968, forty-one fatalities occurred in the Middle Rio Grande Conservancy District, thirty-seven of which were drownings. Twenty-one of these deaths were children, 1-7 years of age. The other twenty victims were 16 years of age and older.

In response to the public outcry over these unnecessary deaths, I attempted to have \$500,00 appropriated to the Bureau of Reclamation in Fiscal Year 1968 for the purpose of fencing the extremely hazardous locations in the district where fatalities were frequent. Instead, the Senate Appropriations Committee recommended that a study of the drowning problem be made to see what should be done to improve safety measures in the conservancy district. The House passed a \$50,000 appropriation for the study, and the Senate concurred. In its report dated September 28, 1967 (Report No. 90-574), the Senate Appropriations Committee requested that "Congress be advised as soon as the study is completed in order that appropriate consideration can be given to recommendations which may be made."

The Bureau of Reclamation completed a draft study in July 1969. This report was later revised in March 1970 and released to the public. In a letter to Senator Anderson dated August 27, 1970, Mr. Ellis L. Armstrong, Commissioner of the Bureau of Reclamation, promised that the Department of Interior would submit draft legislation authorizing Federal matching funds to construct safety measures in the Rio Grande area. This legislation was never submitted, and no further action has been taken by the current Administration on the Bureau of Reclamation's safety recommendations. Meanwhile, another twenty-one people have died in the waterways of the Middle Rio Grande Conservancy District during the period 1969-March 1972.

Mr. Chairman, I believe Congress has a responsibility to follow up the safety study it commissioned the Bureau of Reclamation to make in 1968. This study made four recommendations to improve public safety in areas contiguous to Federally constructed irrigation systems. One of these recommendations stated: "Legislation is needed which would authorize the Secretary of the Interior to improve safety conditions on Federally constructed water conveyance systems, allocate costs in relation to benefits and repayment capability of water users, and enter into appropriate cost sharing arrangements."

I believe S. 3472 fulfills this recommendation and should be reported favorably to the Senate. The needless deaths occurring in the Middle Rio Grande Conservancy District and in other Federally constructed waterways in urban areas must end.

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STATEMENT OF HON. RICHARD C. WHITE, A U.S. REPRESENTATIVE IN CONGRESS  
FROM THE STATE OF TEXAS

Mr. Chairman and members of the committee, I am Richard C. White representing the 16th District of Texas. It is my pleasure to testify today in behalf of S. 3472. I would like to inform the committee that I have been joined by Mr. Lujan of New Mexico in sponsoring similar legislation in the House where we are hopeful for speedy and affirmative action. Open and unfenced canals in my district, and particularly the city of El Paso, have long posed a serious problem as they have in other areas of the country. Too often do we read newspaper accounts of small children falling into these open and unprotected channels and being drowned. Numerous incidents of adult drownings are also on the record, but somehow it is the three, four, and five year old tragedies which remain on our minds. I feel that the proposed legislation before the committee today is extremely fair being on a shared cost basis, and I cannot emphasize enough the crying need for this aid to municipalities in their efforts to provide safety to their citizens. Thank you.

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Senator METCALF. Our first witness today is Mr. Gilbert Stamm, Assistant Commissioner of Reclamation.

STATEMENT OF GILBERT STAMM, ASSISTANT COMMISSIONER OF  
RECLAMATION; ACCOMPANIED BY ROY BOYD, CHIEF, WATER  
OPERATIONS BRANCH

Mr. STAMM. Mr. Chairman and members of the committee, we thank you for the opportunity to appear before you today to discuss the Department's views on S. 3472, a bill to authorize Federal cost sharing to promote public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing.

The hazards to public health and safety inherent to open canals in urban areas is a matter of concern to all of us involved in the operation of open ditch systems. During the past 5 years, despite extensive safety programs directed by this Department, about 150 persons drowned on Federal irrigation projects. These projects have been constructed to irrigate approximately 9 million acres of land on reclamation projects and 1 million acres on Bureau of Indian Affairs projects. About 20 percent of these drownings were children under 10 years of age. Irrigation projects administered by the Department of the Interior account for only 20 percent of the total irrigated areas in the United States.

We continue to work to improve our safety program. Reclamation now requires that all new canals be designed according to specified safety standards which include fencing of canals in urban areas. On existing canals, the Bureau has installed safety devices on hazardous structures such as chutes and drops. At the same time State and local governments are being encouraged to utilize their regulatory authority to promote canal safety.

The best solution for elimination of the hazards of existing open canals is the installation of underground pipe. In some instances the water users have installed safety fences. Although fences are much cheaper than closed conduits, they are not as effective in preventing drownings or pollution. Safety fences require continuous maintenance.

For a number of years, Reclamation has urged water-users organizations on irrigation projects to convert open canals to closed conduits in urban areas or to construct safety fencing. Some water-users organizations have cooperated with assistance from local property owners. Some of the organizations are more able to finance such works than are others.

We doubt that it would be necessary to enclose all open canals as the bill might imply. It is probable that not all open canals in urban areas are hazardous. Furthermore, it may actually be a disservice to residents in some urban areas to enclose open canals. Some canals are used extensively by the public for fishing and other forms of recreation. The decision whether to enclose a canal or a stretch of canal should be made by the local community where the advantages and the risks can best be weighed.

We have analyzed only Reclamation projects in estimating the costs that may be involved in the proposed safety program. Approximately 1,000 miles of Reclamation's open canals are located in urban areas where they may constitute a safety hazard. We estimate the cost of enclosing the 1,000 miles of Reclamation canals could be as much as \$360 million, which would entail a Federal cost sharing of \$180 million under the bill. This estimate does not include maintenance expenses, but it would allow for about 700 miles of canals to be converted to closed conduits and the remaining 300 miles of larger canals to be surrounded with fencing. As the construction cost of closed conduits is at least 10 times the cost of fencing, the estimate of \$360 million would, of course, be less if more canals were fenced rather than converted to closed conduits. Nevertheless, in locations of high hazard, closed conduits would be more desirable.

The expense of converting dangerous areas on Bureau of Indian Affairs irrigation projects and on non-Federal projects probably would be similar to those of Reclamation. The total cost involved for non-

Reclamation projects would probably be about four times Reclamation's cost.

The Department believes that the bill does not propose a satisfactory method for reducing the hazards of open canals. By law, the water users are required to pay the full cost of operating and maintaining canal systems for water supply purposes. Also, by means of insurance or direct payment, the water users have borne the expense of legal suits and settlements resulting from persons drowning in canals.

The Department feels that the basic responsibility for canal safety should remain with the primary beneficiaries who are the water users. S. 3472, would permit the Federal Government to bear up to 50 percent of the cost of converting open hazardous ditches to closed conduits or of providing safety fencing. For that reason, the Department opposes the bill.

Senator METCALF. Thank you very much for your statement; for your frank and forthright appearance this morning.

We have, of course, just received the departmental reports, and have had no opportunity to analyze them and it may be that as a result we will have to ask the staff to propound some questions to you on this bill.

Mr. STAMM. Mr. Chairman, I should apologize to you for the Department report arriving here so late. We realize that the rules of the committee are to have those reports up early. There were some differences of opinion and it took some time to get those resolved to the point that the report could be prepared in final form. Therefore, we would be happy to receive any questions the committee might send to us and we will supply the answers for the record.

Senator METCALF. Fine. I know, of course, with your usual cooperation you will be. I am somewhat concerned about your conclusion that the bill does not propose a satisfactory method for reducing the hazards of open canals. In your opinion, what would be satisfactory? Is the method that you suggest that water users pay the full cost?

Mr. STAMM. Well, in some areas the property owners adjacent to the canals have borne a part of the cost. There has been no established pattern for getting the job done. But there are several methods that have been used whereby adjacent property owners, or the folks who live close to a hazardous open canal, have contributed enough, perhaps to buy the pipe required to enclose the ditch and the irrigation district involved has installed the pipe. This is cost sharing between the property owners and the water users or, more accurately, the irrigation district and the property owners who face the hazard.

I think the Department's opposition to this bill is primarily because of the large cost that would be involved, and perhaps because the definition of canals subject to benefit under this bill is not very clear.

Senator METCALF. Could you help us clarify the definition in your subsequent communications with the committee?

Mr. STAMM. I think we could, in consultation with the committee staff find out more clearly what the committee had in mind, and we could then help to provide a definition. As it now stands, any open ditch or canal any place in the 50 States used for any purpose might be interpreted in this draft of legislation as being eligible for the cost

sharing, and we are not sure whether the committee intended it that way or not.

Senator METCALF. There is a curiously contradictory proposition in your statement. You suggested some of these open canals are available for fishing, swimming, recreation, and so forth, and at the same time you suggested probably that they should be completely closed and used for ditch or a pipe or something of that sort.

How do we determine which should be available and kept open and which should be used for underground feeding.

Mr. STAMM. Well, my comments indicated that that decision probably should be made by the local community, where they would—

Senator METCALF. Doesn't this legislation provide that that decision be made by the local community?

Mr. STAMM. Yes sir; it could be.

Senator METCALF. Yes.

Mr. STAMM. The Secretary has enough latitude under this proposed bill that it could be done; yes sir.

Senator METCALF. And then you suggest that by means of insurance or direct payment the water users might bear that expense.

Now, how much is the life of a child worth?

Mr. STAMM. I don't think it is possible to put a price tag on the life of a person.

Senator METCALF. So if we prevent the death of a child or a group of children, we have achieved a significant advance even though insurance and liability provisions, and so forth, are taken care of as far as the water users are concerned.

Mr. STAMM. Yes, sir.

Senator METCALF. Another matter that has come to my attention as I have watched the development of this legislation is that over the years the spread of the urban communities into suburban areas has sometimes spread into adjacent areas to these canals, to do something that the original water users has no opportunity to anticipate and when the original act was passed they were in substantially rural areas. Now, why should the water users pay for that, instead of the Federal Government, and adjacent municipal governments that are involved.

Mr. STAMM. You ask difficult questions, Mr. Chairman. It certainly is true that many of these canals that are hazardous today were far out in rural areas at the time they were built, and they originally did not present a hazard. It is possible for the counties or States or the local communities, through zoning ordinances, to require when the land is subdivided, for example, that the subdivider provide canal protection which could be fences or coverings, the same they are required to extend sewers, build roads, and provide drainage. This would not cure the situation that has already developed, but it could reduce the extent of the problem in the future.

It is true that the nonfarmers are in these areas to a large extent because of the economic base that is generated by the agriculture economy itself, and I presume the Department has in mind that when the people bought the property, the ditches were already there, the people were aware of the hazard, and perhaps that the cost sharing should be on a local basis rather than on a national basis.

Senator METCALF. Well I have never believed that that idea of awareness of the hazard compensates for the loss of a child. Most of these—many of these areas—I don't say most of them, but many of these areas are occupied by people immediately adjacent to the canals who are in poverty areas and who cannot afford to pay—and yet it is their children that are drowned as a result of the lack of safety precautions in these canals.

Mr. STAMM. I think that also is true, I think the record shows that a higher percentage of the drownings have occurred in low-income areas, and again this may offer some opportunity in working with the staff to develop language setting up criteria which would assist the Department, if such a bill were enacted in the future, to carry out the desires of the committee, and would be less open-ended than the present form of the bill.

Senator METCALF. Of course I can't speak for the other Members who are the sponsors of the bill, but, as you know, I have long had legislation in for the Billings area which has had all the situations which I have described.

It was largely a rural area when it started. Children have been drowned. Canals now flow through some of the lower income areas of the city of Billings and I would hope that this experience we have had in Billings wouldn't be repeated over the United States. This is why I gladly cosponsored Senator Anderson's bill that provided that water users wouldn't be completely responsible for the growth and expansion of the city, that the municipalities and the Federal Government would try to pick up this needed responsibility. I would hope we could work out with the committee some sort of language that would provide for opportunity for the local areas to make the choice, opportunity for the people adjacent to—if they could afford it maybe—to participate in the construction of safety devices, rather than purchase of insurance, and then approve and give us a favorable report on this legislation.

Mr. STAMM. As the chairman knows, if the committee or the chairman asked us to provide you with draft legislation along those lines or to work with you, we would be happy to do so. I wouldn't be able, at this time, to commit the Department to a position on any revised draft.

Senator METCALF. I know, but I appreciate your willingness and your ability to participate in drafting one that might be satisfactory. Senator Anderson?

Senator ANDERSON. I appreciate the willingness that you have made to give us some sort of start, and as Senator Metcalf pointed out, we must find some answers. I think that the problem is very serious in some areas, and I proposed this legislation to make sure that a study of this thing would be completed.

I appreciate what the Senator said. I think you have been very helpful. I appreciate it, and I appreciate your suggestions in this area.

Senator METCALF. Mr. Stamm, we really aren't wedded to any special language. We are concerned with the situation that you have described, the drowning of a good many people, many of them children, and we welcome any assistance that you, with your experience, and the experience of your Department, can give us in finding the solution other than just saying, well, you can insure against that sort of thing. An insurance payment doesn't bring back a child.

Mr. STAMM. Yes.

Senator METCALF. Thank you very much for your statement.

Our next witness is Mr. Wayne P. Cunningham, treasurer-manager of the Elephant Butte Irrigation District.

Mr. Cunningham, we are very enthused to have you before the committee.

**STATEMENT OF WAYNE P. CUNNINGHAM, TREASURER-MANAGER,  
ELEPHANT BUTTE IRRIGATION DISTRICT, LAS CRUCES, N. MEX.**

My name is Wayne P. Cunningham, I am treasurer-manager of the Elephant Butte Irrigation District of New Mexico.

This is a statement in behalf of the Elephant Butte Irrigation District board of directors and approximately 5,000 water users themselves to testify in support of Senate bill 3472. This is to authorize Federal cost sharing in promoting public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing.

There have been approximately 132 drownings in irrigation canals in the Federal Rio Grande reclamation project since July 1947. The proposed legislation would limit Federal participation to 50 percent and would permit an orderly conversion to closed conduit systems. The proposed legislation, if authorized would eliminate drownings where irrigation districts are in the vicinity of urban areas.

In conclusion, Mr. Chairman, while this statement is extremely brief, is in essence the reason for our support. I wish to express on behalf of the Elephant Butte Irrigation District of New Mexico appreciation of the opportunity to appear before this distinguished subcommittee to urge early favorable consideration in this matter.

Thank you.

Senator METCALF. Thank you, Mr. Cunningham.

When was the Elephant Butte Irrigation District started?

Mr. CUNNINGHAM. It was back in about 1906 the project was finished about 1914.

Senator METCALF. And at that time was your canal through an urban area?

Mr. CUNNINGHAM. In a very small way, sir. It is much like you mentioned to Mr. Stamm that urban areas have encroached upon our rights-of-way.

Senator METCALF. Did you have any anticipation that you would have this urban spread at the time that you entered into agreement to purchase water and build a canal?

Mr. CUNNINGHAM. No, sir; we did not. To reiterate probably what you already said as our irrigation district consisted of 91,000 acres and it is approximated about 106 miles long and for the past several years we have been contemplating trying to modernize our project to enclose a conduit system. As you were talking previously between Mr. Stamm and yourself about insurance, this is not a solution because we have insurance and we were canceled last year and you can only be canceled a certain number of times before no other insurance company will touch you. That is the experience we are dealing with at the present time.

We have people who have children that are drowning every year. And like you say, no insurance check will satisfy this life.

Senator METCALF. 132 drownings is rather a startling number. How many of these are children?

Mr. CUNNINGHAM. I would say probably one-half or three-quarters of them. This takes in that area from the dam to El Paso district. Mr. Moseley is here from the El Paso district and this includes down through his property.

Senator METCALF. Thank you very much for coming here Mr. Cunningham.

Of course, as you know, I am concerned about this. This happened in my own State in, Billings and other areas in Montana, but certainly evidence piles up as these hearings develop that our Montana experience and Senator Anderson's experience in New Mexico is something that we have to do something affirmatively about at this time.

Mr. CUNNINGHAM. Yes, sir; we sure do.

Senator METCALF. Thank you very much.

Mr. CUNNINGHAM. Thank you.

Senator METCALF. Our next witness is Mr. George Moseley, manager of the El Paso County Water Improvement District, El Paso, Tex.

Mr. Moseley, we are very pleased to have you here before the committee. You have a well-documented statement, so you go right ahead in your own way and we appreciate having you here.

Mr. MOSELEY. Thank you, Mr. Chairman. I will go ahead and read my statement here.

Senator METCALF. Please do.

#### **STATEMENT OF GEORGE MOSELEY, MANAGER, EL PASO COUNTY WATER IMPROVEMENT DISTRICT, EL PASO, TEX.**

Mr. MOSELEY. Honorable chairman, and committee members, I am George B. Moseley, general manager of the El Paso County Water Improvement District No. 1, El Paso, Tex.

I am here today representing the board of directors and the more than 12,000 constituents of my water district, in support of S. 3472, Senator Clinton P. Anderson's bill to authorize Federal cost sharing in promoting public safety through the elimination of hazardous open canals by converting them to closed conduits and by fencing.

This district is one of the many Federal reclamation projects of the West which is being encroached upon by city and urban development. This development is intensifying the people population adjacent to much of our irrigation system and the hazards to public health and safety inherent to canals in urban areas, is a matter of extreme concern to the public and the district.

We are one of the districts that each year lose a number of lives, both young and old, to accidental drownings in our irrigation systems, and even though we conduct extensive safety programs along the lines of education, law enforcement, and the installation of protective devices, people are still drawn to the irrigation ditches and water as if by a magnet and some lose their lives.

Districts such as this one were begun in the early 1900's soon after the Reclamation Act was enacted, and have done much to add to the economy of the area and the Nation as a whole, but now we are faced

with partial extinction of our district by the invasion of urban areas which brings with them the many problems of ditch maintenance, water distribution and last but not least, ditch safety.

The responsibility of fencing or converting existing open canals and drains to closed conduits should not, and cannot be, the obligation of the agriculturist who has helped develop the agriculture and economy of the area, now only to find that he is faced with a declining agricultural income and an ever increasing cost of operation, some of which is brought about by urbanization and the cost of trying to protect the people of the urban areas through programs of ditch safety.

Mr. Chairman, legislation such as S. 3472 is needed to authorize Federal assistance to water users organizations so that open ditches in urban areas may be converted to closed conduits or at least fenced. There is no doubt at all among the users of this district that the passage of this bill would eliminate many drownings each year, especially of small children, and should be a responsibility of the general public.

This proposed legislation would permit an orderly conversion to closed conduit systems where participation develops in areas of most critical need and the construction authorized by this legislation would eliminate these problems in the urban areas. Additional benefits which would accrue include reduced water losses, the prevention of seepage, damage to property, elimination of weeds and other unsightly conditions which would enhance the ecology of the areas, all of which naturally will be paid for by the contributions made by water user organizations.

Litigations arising from the drowning of children in open canals are becoming more numerous and it appears that the cost of settlements in these cases will continue to rise. The proposed canal safety program will reduce the number of drownings and enhance our legal position as to liability when drownings do occur.

In conclusion, Mr. Chairman, I have attached herewith a number of press clippings that have appeared in several of the newspapers published in cities along the Rio Grande after the drowning of several small children already this year. Let us not hesitate in passing S. 3472, we may be able to save some lives yet this year.

I would like to express my appreciation and that of the constituents of my district for being given the opportunity of appearing in support of S. 3472. We hope that you will give it favorable consideration.

Thank you.

Senator METCALF. Thank you very much Mr. Moseley. You have, in your statement, anticipated some of the questions I have already asked the other witnesses, and, of course, the material that you have submitted and the newspaper clippings will be incorporated in the record immediately after your statement.

I wonder, if you think that in your district assistance amounting to 50 percent of the cost would be adequate to provide the kind of conduits and underground piping that you feel would be necessary.

Mr. MOSELEY. Mr. Chairman, I don't think 50 percent would take care of the proposition as well as we would like to see it taken care of. Many of our ditches are in urban areas where we have been encroached upon, and that has been pointed out this morning here. It is in a

majority of the low-income area where the ditches are that need to be enclosed in the conduits, and, of course, enclosures—

Senator METCALF. It doesn't make any difference whether it is lower income area or high income areas if the cost is paid by the Federal Government and by the water-users. But if the cost is paid by indigenous landowners then we have a real problem as to the areas through which the canal is operated.

Mr. MOSELEY. The cost of the closing of the conduits is considerably higher than open ditch construction by any means, about four or five times the cost even in cement lines in many instances. So it is very costly, but it certainly could be beneficial to a district such as ours. We are on program at this time which we have a rehabilitation and betterment program taking place, and are expending five and a half million dollars for cementing many of our ditches to take care of our irrigation system. If we would be able to get 50 percent on top of this and put much of our system underground this would greatly reduce the number of drownings in our district.

Senator METCALF. When were your systems started Mr. Moseley?

Mr. MOSELEY. In the early 1900's. As a matter of fact, Mr. Cunningham and myself were under the same project. The Rio Grande Federal Project for New Mexico and Texas. It was completed about 1914.

Senator METCALF. Your system repeats the history—you started a reclamation program for water users in agriculture areas and maybe just barely touched the metropolitan and municipal community, and then the urban spread brought this problem to all of your systems.

Mr. MOSELEY. This is right. I believe at the time our district was formed and established I think we had about 450 constituents in the district. At this time we have more than 12,000. At least 3,000 of those have two acres or less within the district. So it has spread out and it has just been cannibalized actually by people moving out into the rural areas.

Senator METCALF. Can you tell me about how many people have been drowned? You say we are one of the districts that each year loses a number of lives, young and old.

Mr. MOSELEY. We probably lose between eight and 10 a year.

Senator METCALF. Eight or 10 every year. And can you divide them into children, say under 12—10 or 12—and people over that age?

Mr. MOSELEY. Well the percentages of drownings in the area is a little higher in the adult class than it is in the child class. This is principally because it is a bordertown and of course, you have people crossing the border. And they do a lot of this at night and they get in those canals and they just don't get out. But, of course, this is the adult population.

Senator METCALF. That is certainly an unexpected hazard for those people.

Mr. MOSELEY. They don't have any trouble crossing the river at that point. When they get the canal, that's a different story.

Senator METCALF. I see. Well thank you for a very informative and persuasive testimony Mr. Moseley. Thank you for coming and appearing before the committee on this very important matter, very important as the lives are concerned.

Mr. MOSELEY. Thank you very much sir.

Senator METCALF. The next witness is Mr. John E. DeVito, general manager, Contra Costa County Water District, Concord, Calif. We're delighted to have you here. Mr. DeVito doesn't have a prepared statement, but you go right ahead.

Mr. DEVITO. Thank you Mr. Chairman. I would like the opportunity to submit a written statement following the hearing.

Senator METCALF. Without objection, it is so ordered. Do it as promptly as possible.

**STATEMENT OF JOHN E. DeVITO, GENERAL MANAGER, CONTRA COSTA COUNTY WATER DISTRICT, CONCORD, CALIF.**

Mr. DEVITO. My name is John E. DeVito, general manager, Contra Costa County. Contra Costa County is located 25 miles east of San Francisco centrally located in California. It consists of about 101,000 acres, and our district obtains its water supply from the very first unit of the U.S. Bureau of Reclamation's Contra Valley project. The construction started in 1937.

It was designed and constructed as an open trapezoidal concrete-lined canal. The main canal is some 50 miles long to connect the smaller canals of approximately 5 miles each, a total of about 60 miles. Now, as you have expressed, Mr. Chairman, it was principally an agriculture territory in the 1930's. Population at that time was approximately 25,000 people, roughly five cities. Today we have seven cities with 250,000 people. In this same territory—

Senator METCALF. Will you name the cities?

Mr. DEVITO. Yes. Concord is the largest city, approximately 96,000 people. The second largest city is the city of Antioch, then Pittsburg, Walnut Creek, Pleasant Hills, Martinez, Oakley, and Clayton. As I mentioned earlier there were five initially; now we have two more.

Senator METCALF. I want to tell you that I attended Stanford University and that is an area with which I am a little familiar. That is why I asked you to tell us just what the cities were.

Mr. DEVITO. Yes, Stanford, or the farm, as we call it, is 40 miles south of the bay area, the district which I manage. It is really located in the western portion of the Sacramento, San Joaquin Valley, and Stanford, of course, is just south of the San Francisco Bay.

The first years of experience—at first the water was delivered in October of 1940. I might add, too, that our water use is divided in a ratio of 50 percent is delivered to industry, 45 percent today is delivered to municipalities for municipality purposes. Only 5 percent is delivered for irrigation purposes.

I should also mention that of the 110,000 acres in the district, those lands that are zoned for suburban or residential development, only one-fourth of the suburban zoned lands are residential. Those lands are developed as of this date. By way of our own experience, during the first 13 years of operation of the canal, there was something in the order of 26 drownings; our total to date is 48.

Now, in 1954 at the completion of these first 13 years the district asked—not asked—we prepared an ordinance for the board of supervisors' adoption that would compel any developer to provide hideaway fencing at any time the land use made its transition from agriculture

to residential development. At the same time, the district employed three deputized sheriffs to work for the district to patrol the canal during every daylight hour, 7 days a week. I might say that the record shows that although there were 26 drownings in the first 13 years, with the fencing ordinance and the canal patrolled, in spite of a threefold increase in population, the drownings that occurred in the following 19 years were on the order of about 22. We have a total of about 48 drownings in this 32-year period of time that the Contra Costa Canal has been in operation. The district has an extensive educational program. We distributed some 85,000 safety folders to all the schools; in fact, they are going out starting today before school closes and begins its summer session. We have a rather extensive newspaper advertisement program that continues through the summer months and throughout the year. That is carried by the five newspapers in the district. We also use the two radio stations in the district. We invite and coordinate the participation in our safety program of the California Highway Patrol, the police departments of the seven cities, as well as the sheriff's department, along with our personnel and the U.S. Bureau of Reclamation personnel who are currently operating the canal.

I should also mention that under the terms of our new contract with the Bureau of Reclamation, the district that I run this year will assume the responsibility for the operation and maintenance of the canal. Foreseeing this responsibility, last year the district commenced a different fencing program. Instead of that required by ordinance where fencing has been installed along the right-of-way by developers, we find by our own experience that over half of the drownings occurred in fenced areas by youngsters, as well as older—not older adults, but more mature adults. They will get through the fences, under them, and over them.

Our program is to move the fencing—not move it—but to locate fencing at the canal lining, probably install this fencing with a pavement, asphalt or concrete base, to preclude the digging under, and we find that keeping people off the canal is most difficult.

If we can keep them out of the water, we feel that is the way to go. However, we have been aware of the fact that fencing is only an interim measure. The district by way of its consulting engineer has completed a feasibility report for totally converting the system to closed conduit over a period of time. We feel that this will have to be a transition based on local decisions, and consideration for the various problem sectors in our district.

By way of cost comparison, to fence the entire Contra Costa canal system with chain link fence approximately 6 feet high would be on the order of one and one quarter to one and a half million dollars. To convert the system to closed conduit, the visibility report just completed last year would involve something on the order of \$80 million.

I may submit the report to the committee for further study.

We of the Contra Costa County Water District have participated in testimony before this committee on the Small Project Act as well as others.

We feel this bill is a very needed supplement to the various other methods of financing the improvements, the rehabilitations, and converting the conduits of the irrigation system, and urge the cooperation of the U.S. Bureau and your staff—the USBR and your staff.

Thank you.

Senator METCALF. Thank you very much.

You were here and heard Mr. Stamm's testimony?

Mr. DEVITO. Yes, sir.

Senator METCALF. He was rather critical that this bill provided, probably—as the present language consists for fencing and assistance in conduits, other than reclamation projects—now, your project, according to your testimony, is only 5 percent reclamation.

Why do you think it should be included? Am I quoting you correctly, Mr. Stamm?

Mr. STAMM. His project is 100 percent reclamation. Five percent of the water is currently used for irrigation purposes and the remainder is used for municipal and industrial purposes, but it was totally federally built.

Senator METCALF. Well, then, even if we changed the language so that assistance would only be provided by the Department of Interior for reclamation projects, this project would be included even then?

Mr. STAMM. Yes.

Senator METCALF. Then I don't made the point that I was trying to make earlier, that perhaps other projects that weren't originally reclamation projects have the same inherent danger and probably should have some of the same type of support.

Mr. DEVITO. I think that you made the point that loss of life doesn't respect the source of the project.

Senator METCALF. Well, I think you have added to the testimony, Mr. DeVito. You discussed your program that you have underway for safety provisions, and preventing some of these drownings.

If we give you this 50-percent assistance, would this accelerate your program?

Mr. DEVITO. I would say it certainly would. We considered very seriously going out for an \$80 million bond issue 2 years ago, and perish the thought, immediately with a simple polling of the voters in the area, there is no question about it, that a 50-percent assist would do much to enhance an early conversion to closed conduit.

Senator METCALF. Thank you very much for your appearance.

Mr. DEVITO. Thank you very much.

Senator METCALF. Now, is there a representative from the Middle Rio Grande Conservancy District from Albuquerque here?

(No response.)

Senator METCALF. There is no representative present from that district, which is the last witness on my schedule. I want to say that the record is going to be kept open. If any interested person is concerned and hears about this testimony—we would be glad to have written testimony submitted.

(Subsequent to the hearing the statement referred to was received by the committee.)

STATEMENT OF ROBERT S. MANNING, MANAGER, MIDDLE RIO GRANDE  
CONSERVANCY DISTRICT, ALBUQUERQUE, N. MEX.

The Middle Rio Grande Conservancy District was organized under the Laws of 1927, Chapter 45 of the State of New Mexico. It was formed for the purposes of flood control, drainage and irrigation, without the general power given to states, cities or counties of assessment or taxation for the purpose of public safety. It acquired, after its formation, many rights-of-way for drainage ditches and irrigation canals or ditches. It also, by agreement with the Commissioners of the Old Community Ditches in the confines of the District, took over the operation and maintenance of these ditches. The community ditches do not have a defined easement nor has the Conservancy District taken over any right, title or interest in the community ditch other than the right to operate and maintain these ditches. As time has passed, the size of the easement on these community ditches has in many instances increased by virtue of depositing of silt during their operation and maintenance. There are some 1500 miles of drains, irrigation ditches, canals and community ditches within the District. Under a rehabilitation contract between the United States and the Middle Rio Grande Conservancy District dated the 21st day of September, 1951, all works within the District to which the Middle Rio Grande Conservancy District had title, was conveyed to the United States (see Section 29 of that Contract, on page 14.) *Title to all of the works of the District remains vested in the United States until otherwise provided for by Congress.*

There is a present indebtedness of the District to the United States under that Contract of \$10,660,704.66 and an indebtedness to the United States under a contract dated the 25th of June, 1968 for the San Juan Diversion Project. The United States Bureau of Reclamation operates and maintains the works of the District under a fully reimbursable contract which cost the District, during their last fiscal year ending August 31, 1971 \$1,813,282.50. The budget for 1972 for operation and maintenance is estimated at \$1,965,000.00.

The foregoing brief history is given so that the position of the middle Rio Grande Conservancy District on SB 3472 can be more readily understood.

Special features and unique local peculiarities within irrigation and drainage districts are of such varied nature that improvements designed for public safety will of necessity also need to be of a varied nature. Cost sharing programs with individual property owners may be appropriate when one considers fencing of canals or ditches.

On July 20, 1967, from the House Committee on Appropriations, Report #505, 90th Congress, and on September 28, 1967, the Senate Committee Appropriations Report #574, 90th Congress, the Bureau of Reclamation received a grant from Congress to conduct a water course safety study in the Middle Rio Grande Conservancy District. A report was submitted in 1969 and released to the public in 1970. This report took into consideration such improvements as fencing some canals and placing underground others. The abandonment of ditches which were not serving any great number of users was also recommended. The study was recognized by the Bureau as one of the reconnaissance grade which would mean certain refinements would be required prior to initiating any construction work.

From this study a \$16,411,200.00 estimate for carrying out the improvements was projected. For the Albuquerque area, the estimate was \$13,372,000.00. The figures were calculated on 1968 costs. Our office has updated these costs and based on a \$20,000,000.00 over all cost to carry out the safety recommendations of this study. To pay such sum in cash, if the program was immediately adopted, it would cost Class "B" property owners (generally urban property) approximately \$87 per thousand assessed valuation of their property. It would cost the Class "A" (rural farmland) property owners approximately \$89 per acre. If it were to be funded and paid off in 20 years on a 5% interest rate loan, each "B" property owner would pay 8.11 per year per thousand property assessment valuation and the "A" property owners would pay \$8.81 per acre per year as their share in paying off the loan. Current annual assessments for these two groups of property owners in Class "B" \$10.95 per thousand and Class "A" \$10.30 per acre. Thus, to fund the improvements as recommended by the Waterway Safety Study as prepared by the Bureau of Reclamation from local property owners would virtually double the current assessments. This is cost for initial construction without considering cost of annual maintenance, acquisition of right-of-way, increased operation and maintenance costs. Property owners within the District could not afford this and the financial integrity of the District would be threatened.

Fencing of canals and ditches in the Middle Rio Grande Conservancy District presents several serious problems as follows:

First, in a District which is formed for irrigation, flood control and drainage, the legal question arises as to whether or not assessments can be made against the property owners within the District for a fencing program which is not within the specific purpose for which the District was formed. State, cities and counties are charged with the public health, safety and welfare of the inhabitants, although fencing could be done for the purpose of protecting works of the District.

Second, the type fencing contemplated by the Senate Bill, could be considered a propriety function which would expose the property owners in the District to a liability not in existence in carrying out its governmental functions.

Third, community ditches, as has been stated, do not have a defined right-of-way. Rights of way would have to be secured by eminent domain or purchase for the purpose of establishing fences along these community ditches.

Fourth, the title to the works of the District is in the United States Government and the property owners would be assessed for the purpose of placing improvements on lands that their representative does not own.

Fifth, no estimate has been made of the cost of maintenance of fencing, which based on experience in the metropolitan area of Albuquerque, would be very high. Throughout the District each property owner using irrigation water has a turn-out to secure his water from the canals or irrigation ditches. It would be necessary to have a gate in the fence at each turn-out for each user of water which gate should be kept locked, with the persons desiring access having a key. Operation and maintenance costs of the works of the District would be increased because of the necessity to have equipment passing through locked gates in going from one area to another while conducting work.

Sixth, the District has many requests by citizens and public agencies to use certain of the works of the District for bridal paths, bicycle paths, fishing, hunting and other recreational activities. Fencing of many of these ditches would restrict or prohibit such activities.

The Middle Rio Grande Conservancy District believes that any fencing program established should be so designed that individual property owners (many of whom located near ditches are in low income brackets) who may have need to fence their property to provide protection to those in their family, who are not of such an age as to comprehend the dangers of water, may participate. Such arrangements with private property owners would accomplish several things. The party desiring the protection would receive it, the liability for this type of public safety would not be placed on irrigation districts or other government agencies, and maintenance costs would be properly assessed to the party desiring the protection afforded by the fence.

Another feature on SB 3472 covers underground piping as a safety measure.

In the metropolitan area of Albuquerque, as well as other areas in the District, it would be practically impossible to carry out this type of program due to the high degree of sediment carried in irrigation water. The deposit of sediment by the Rio Grande River and its tributaries in the Rio Grande Valley lead to the creation of the District. The District, several years ago, began a program which hopefully will provide for the abandonment of diversions on the river that transfer sediment laden waters into the system. With modifications of the system, relatively clear water can be secured in certain areas of the District, including the metropolitan area of Albuquerque, which when secured, would make a piping program feasible.

#### CONCLUSION

Though the District wholeheartedly supports a public safety program, the District, based upon the foregoing, believes that SB 3472 is too restrictive in that it limits funding to only fencing and underground piping. By this it eliminates many other more effective measures, such as abandonment of ditches, sediment control measures to enable piping, including drilling of wells and other related improvements which could be accomplished under the program to enable safety measures to be taken at less expense.

In addition, title to the major portion of the works of the Middle Rio Grande Conservancy District is in the United States and will remain there for many years. It would, thus, appear that funding for the protection of people who may be subject to accident on United States property should be the responsibility of the United States.

Also, though no specific stand has been taken by any ecological or environmental group in the area, members of such groups have raised the question of the effect of chain link fencing on the environment with representatives of the district.

Senator METCALF. We are going to have our staff confer with the staff of the Secretary of the Interior, and try to reach some sort of an agreement on this bill that will overcome the objections that have been made this morning.

As one Senator who has experienced some of these disasters in the State of Montana as the result of the growth of an urban community around irrigation canals, I feel that this is important and significant legislation.

Maybe it isn't as significant as stopping the war in Vietnam, but we can save a few lives with this bill, and I hope that we can work out some satisfactory agreement that all of us can get behind. The legislation is important and necessary.

I thank you all for your appearance here this morning.

The subcommittee will be in recess subject to the call of the Chair.

(Whereupon, at 11 a.m., the hearing was recessed, to reconvene at the call of the Chair.)

## APPENDIX

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(Under authority previously granted, the following statements and communications were ordered printed:)

STATEMENT OF HON. BRUCE KING, GOVERNOR OF THE STATE OF NEW MEXICO

Mr. CHAIRMAN, my name is Bruce King. I am Governor of the State of New Mexico. I am most appreciative of this opportunity to present to this distinguished Committee the views of the State of New Mexico on S. 3472, a bill that would authorize federal cost sharing in works to protect the public from the hazards of the open waterways of water projects.

In New Mexico the hazard of open waterways on water projects is most acute in the Middle Rio Grande Valley where the works of the Middle Rio Grande Conservancy District are situated. Since 1958 sixty-two people have drowned in the works of that District. Thirty of those people were under seven years of age—too young to understand or cope with the dangers of open waterways. This spring two infants, a two-year old and a three-year old, drowned in one of the waterways of the Middle Rio Grande Conservancy District.

Bureau of Reclamation data also show that since 1968 six people have drowned in the works of the Rio Grande Project below Caballo Reservoir in New Mexico. The statistics I have given exclude drownings in reservoirs used by the public for recreation. While there are hazardous open waterways on other irrigation projects in New Mexico, the problem is concentrated in the vicinities of Albuquerque and Las Cruces because of rapid and extensive residential development along the irrigation project waterways originally located in rural and sparsely populated areas.

At the urging of the distinguished Chairman of this Committee and his colleague Senator Montoya, the U.S. Bureau of Reclamation undertook a study and in July of 1969 completed its report entitled "Waterway Safety Study—Middle Rio Grande Project New Mexico." That report recommends among other things that cities and towns be encouraged to pass ordinances requiring new subdivisions in irrigated areas to place open ditches in pipe or install fencing. Enactment of such ordinances by appropriate units of government might have saved a number of lives and untold grief.

The works of the Middle Rio Grande Conservancy District are constructed and operated in accordance with New Mexico law and pursuant to contracts between the District and the Bureau of Reclamation. I am advised by competent counsel that careful reading of the applicable statute (Section 75-28-18, NMSA 1953 Comp.) leaves some question as to whether the Conservancy District is empowered to fence its open waterways and undertake other measures to protect the public from drownings. Furthermore, while the District is responsible for the operation and maintenance of the ancient community ditches in the project area, title to these ditches and adjacent rights-of-way remains in the community ditch associations and their members. I am advised that the question is further complicated by the fact that under the 1951 contract between the Bureau of Reclamation and the District for the repayment of reimbursable construction costs, the United States holds title to all of the works of the District and that title must continue to be vested in the United States until otherwise provided by the Congress.

As Senator Anderson said in introducing S. 3472:

"Because of the divided governmental authority the blame for lack of corrective steps cannot be readily pinpointed. But suffice it to say that need for safety measures has long been recognized, especially by those who must live with the daily fear, and that the crucial need now is not for recriminations but quick action."

It is not useful now to consider what might have been done or debate who is responsible for the corrective action needed; it is important to halt the drownings and the sorrows that result from open waterways in densely populated areas. All levels of government and the individuals affected share the responsibility for getting this done.

The Bureau of Reclamation study, which I am sure will be presented to you in some detail, found that the greatest part of the hazard could be eliminated by abandoning or putting underground about 80 miles of the open waterways and fencing another 20 miles of the total of about 1,200 miles of open waterways in the District. The Bureau's reconnaissance grade estimates place the total cost of the work required at \$20,200,000 at 1972 prices.

The Bureau's report says:

"The District is hard pressed to obtain revenue to meet rising costs and cannot support payment for facilities that are not urgently needed to affect more efficient delivery of the irrigation water to the entitled beneficiary. The District has been granted a one-year deferral on construction payments in order to construct facilities to correct serious sediment problems."

In fiscal year 1971 the District assessment for construction, operation and maintenance costs was \$10.60 per acre against Class A, or irrigated land, and \$10.32 per thousand dollars of assessed value against Class B, or all other real property in the District. If the District paid the cost of safety measures estimated by the Bureau of Reclamation using money borrowed for 25 years at 5% interest, it would be necessary for the District to assess annually an additional \$6.35 per acre against Class A lands and an additional \$6.20 per thousand dollars of assessed value against Class B lands. In my opinion this cost is more than the District's taxpayers can manage at this time.

Even if the Federal government paid 50% of the estimated cost, as would be authorized by S. 3472, the financial integrity of the District would still be jeopardized.

I urge this Committee's favorable consideration of an amendment to S. 3472 to provide, with respect to projects constructed, owned or operated by the United States, that the Secretary of the Interior may, under appropriate contract, advance all of the funds required for the needed safety measures with one or more political subdivisions in the benefitted area required to repay, without interest, 50% of the construction costs or that amount which the Secretary finds that the political subdivisions are able to pay, whichever is the lesser.

Mr. Chairman, I am confident that if S. 3472 is enacted with the amendment that I have suggested, state and local governments can and will focus their attention and do whatever must be done to overcome any financial and legal barriers that may remain and cooperate with the Federal government to effect the quick action that you and I agree must be taken.

In conclusion, Mr. Chairman, I urge this distinguished Committee's early and favorable action on S. 3472 to authorize federal cost sharing in protecting the public from hazardous open canals and I express appreciation on behalf of the State of New Mexico for this opportunity to present my views on the bill.

ROZA IRRIGATION DISTRICT,  
Sunnyside, Wash., June 7, 1972.

Senator CLINTON P. ANDERSON,  
*Chairman, Water and Power Resources, Senate Interior and Insular Affairs Committee, New Senate Office Building, Washington, D.C.*

DEAR SIR: The Roza Irrigation District Board of Directors wish to make the following suggestions relative to Senate Bill 3472.

First, they believe it is almost impossible to design pipelines capable of carrying all possible flood waters. If the conduit or pipeline proved to be too small to carry the flood waters then the Irrigation Districts would be blamed and held liable for any resulting damage.

Second, the Board believes that the adjacent land owners, County or Municipal, should pay for the pipeline or fencing. In many cases urban areas have enveloped irrigation canals many years after they were constructed and created the condition which you seek to remedy.

Finally, they wish to point out that bridges across canals would also need fencing. One of our most serious problems arises from people diving off bridges into the canals.

Very truly yours,

By E. F. DONCASTER, *Secretary.*

NORTH DAKOTA STATE WATER COMMISSION,  
Bismarck, N. Dak., June 1, 1972.

HON. CLINTON ANDERSON,  
Chairman, Subcommittee on Water and Power Resources, New Senate Office Building,  
Washington, D.C.

DEAR SENATOR ANDERSON: First, I would like to commend you on the thoughtfulness of submitting S. 3472, which deals with open canals and the dangers that it poses to the public. I am hopeful that it will not result in the extension of the fencing and the installation of pipelines to include areas that are not subjected to public intrusion. Many projects which are financially capable are, of course, using pipelines in place of open canals to conserve water. This, I believe, is commendatory in water-short areas.

Generally fencing, unless the irrigation districts are unable to meet the costs, should be extended in a "U" shape manner on each side of the crossing. The fencing should parallel the canal for a distance of 50 feet where crossings have been installed. Certainly, the parallel fence line should also be connected with guard rails on the bridges or crossings. In those instances, where pipe or conduits are used as crossings, they should be similarly extended so as to avoid traffic to pass with safety. It is assumed that the irrigation districts or the urban areas in which the canals are located will be required to provide the necessary maintenance. I am familiar with the large amount of trash that can be accumulated along protective fence lines. The maintenance would, no doubt, be an added burden to the districts especially if fence lines were extended to completely parallel the open channels.

I am currently President of the National Water Resources Association, but I am making a statement on my own behalf, as I have not had the opportunity to discuss it with the Board of Directors.

Sincerely yours,

MILO W. HOISVEEN,  
Engineer-Secretary.

UTAH STATE UNIVERSITY,  
Logan, Utah, May 31, 1972.

HON. CLINTON P. ANDERSON,  
Subcommittee on Water and Power Resources, Senate Interior and Insular Affairs  
Committee, New Senate Office Building, Washington, D.C.

DEAR SENATOR ANDERSON: My attention has been called to S. 3472 which is concerned with promoting public safety by either converting canals to conduits or fencing them. No doubt the public safety of canals should be carefully evaluated and measures taken to insure that these are not unreasonably hazardous.

There is another aspect of canal use which I believe, in many cases, could have great benefit and that is their multiple use for recreation. This might require some changes in their design and perhaps some reconstruction, but my colleagues and I are convinced that there is a real potential here.

Under a project entitled "Present and Potential Multiple Uses of Canal Systems—Phase 1" an interdisciplinary group at Utah State University will initiate a study of recreational feasibility of canals beginning July 1, 1972 under Office of Water Resources Research funding. I hope that we may eventually have some data which would be of interest to your committee.

Sincerely yours,

D. F. PETERSON, Dean.

ALBUQUERQUE, N. MEX., June 9, 1972.

HON. CLINTON P. ANDERSON,  
Chairman, Subcommittee on Water and Power Resources,  
New Senate Office Building, Washington, D.C.

DEAR SENATOR ANDERSON: S. Bill #3472 and H.R. #14403, "To Authorize Federal Cost Sharing in Promoting Public Safety through Elimination of Hazardous Open Canals by Converting them to Closed Conduits and by Fencing" is of interest to me and my neighbors, as residents; water-users and taxpayers.

The purpose of this document is not to favor or oppose S. Bill #3472/H.R. #14403, but to make information available to you and the honorable and distinguished members of your committee.

This Bill was prompted by the drowning of Theresa Lovato, age 2, Michael Lovato, age 3, in the Arenal Canal on March 22, 1972; the known record of more than 40 such incidents w/in the Middle Rio Grande Project and I am further

moved by the more recent drowning of 3-year-old Malcolm A. Guilar on May 25 at Santo Domingo Pueblo.

### *Feasibility*

The question of Feasibility would not have come up had the drownings (God forbid) had been other than Mexican or Indian children—there is no feasibility question to the fencing of hundreds of miles of R.R. tracks, freeways, Army or Navy bases—the fences are simply there.

Since the inception of the project (Middle Rio Grande Project) these people have been dis-enfranchised by the mere composition of the Management Structure. The Board (Middle Rio Grande Conservancy Board) is appointed by District Court, "The Districts Seven-Member Board is required to have a majority membership—one from each of the four District Counties—of persons who earn 75% or more of their livelihood from agriculture. This means majority representation for the people who contribute only 25% of the Districts Annual Budget." (Alb. Journal 4/14/72).

This Board Budgets the needs of the Conservancy District Operations and Contracts for the Operation & Maintenance of the Project, the Contractor being the Bureau of Reclamation.

The Bureau of Reclamation is Managed out of Amarillo, Texas w/Responsibilities to the Dept. of Interior and their dictates in lieu of the dictates of the taxpayers.

Through legal and prescribed channels we have, time and again, tried to get a project Superintendent, Personnel Officer, Administrative officer an/or management employees w/decision making authority from the local area, from New Mexico or from the taxed area w/out success.

Under the guise of the dictates of the Mobility Program, one Personnel Officer was brought from Wyoming, at great expense to the project; served a short while and transferred out. At an expense of more than \$4,000 (moving only) another was brought from San Francisco. He did not cooperate to the wishes of Management and out he goes. Another is brought from Texas—From Texas via Arizona & Santa Fe—transfers without ending. We should close our universities if we cannot qualify a man for these positions. We are not part or parcel of this operation but subservient to—Any way you see it, it is taxation w/out representation.

Our State representatives have tried time and again to pass legislature to make the board elective, but have been unable to because the same tax monies, governmental authority & cooperation are used to lobby against us, the poor people. We can only turn the other check.

In a legal tie, such as this, where State Trust Funds are expended by Federal Officials, the State should retain accounting and/or auditing priveleges.

Through the years the General Accounting Office has delegated the Audit Function to the Agencies, (Ref Civil Service Journal, Vol 12, #3) the results are atrocious, the financial burden un-ending and trying to break the legal tie impossible.

Our property deeds now read "Subject to the Lien of the Middle Rio Grande Conservancy District" and if we do not protect ourselves it will read "Subject to the Lien of the Bureau of Reclamation, Amarillo, Texas."

Based on my past Contacts w/the Conservancy District, the Bureau of Reclamation and Substantiation at my disposal, I sincerely urge this Committee to recommend:

1. A detailed review of the Past Expenditures of this Project by a Committee composed of General Accounting Office and Taxpayers representatives. Purpose:

(a) To determine whether or not the fencing can be accomplished with the money now available.

(b) To determine whether or not these is a double jeopardy—"Conservancy District"—"Bureau of Reclamation."

(c) To determine how to stop legal torts—their cause.

(d) To determine the availability of Surplus Material & Equipment & review the final disposition of Equipment & Other Assets purchased or acquired with Irrigation monies.

2. A detailed review of Land Acquisitions and Right of Ways, to determine, "How much the Government has infringed on Private Property in the Past and how much it will Trespass if this Bill is Approved."

And finally that this committee seriously consider an operation "Boot-Strap" as follows:

(A) Legislative Action (At the State Level) making the board Elective-Responsible and Responsive to the taxpayers & waterusers.

(B) Finance to be from Direct Taxes and a Federal Grant requiring Community involvement.

(C) Use of Local Contractors for Operation & Maintenance and elimination of the Bureau of Reclamation.

the Purpose: to end "Taxation without Representation," "Double Jeopardy."

Whatever your decision we must remember the purpose, to end the drownings of innocent children.

Sincerely Yours,

JOSEPH M. GALLEGOS.

Albuquerque, N. Mex., June 7, 1972.

SUBCOMMITTEE WATER AND POWER OF  
SENATE INTERIOR AND INSULAR AFFAIRS,  
U.S. Senate, Washington, D.C.

GENTLEMEN: As a resident of North Albuquerque and a father who raised two boys around irrigation ditches, I feel it is not necessary to spend public money for fencing irrigation ditches.

The loss of children's lives is certainly more serious on our streets than in irrigation ditches.

Parents should be responsible to keep children off the streets or out of ditches, lakes and rivers and not the Federal Government.

I would ask that the Committee do not recommend to Congress any expenditure for the fencing of ditches.

Yours truly,

DUNCAN A. McLEOD.

CORRALES, N. MEX., June 6, 1972.

SENATOR CLINTON P. ANDERSON: I wish you would withdraw your bill pertaining to the fencing of irrigation ditches. The majority of your constituents are not in favor of it. Each time someone drowns, the wave of emotionalism is so great that all politicians jump on the bandwagon. When will we cease coddling the irresponsible. The parents of the most recent victim have six more at home and none have ever been cared for. If you fence the ditches then you will have to follow thru with the rivers, then the lakes, then the oceans. How about the streets and highways where more than 41 in 9 years have been killed.

Please talk to the people of New Mexico, none that I have asked are in favor of the fences. Water has been around for a long time and most people have respected the fact that a person can drown. Therefore they teach their children to swim or they watch them. Only the irresponsible will father a dozen and then turn them out in the traffic or in the ditch while they concentrate on TV. Let's deal with the cause (irresponsibility) not the effect (drownings). It would be cheaper to teach these people than fencing the ditches.

Yours truly,

GORDON E. BOSL.

MESILLA PARK, N. MEX., May 26, 1972.

HON. HENRY M. JACKSON,  
Old Senate Office Building,  
Washington, D.C.

Sir: I register a nay vote re Clinton P. Anderson's bill "Canal coverage" to be aired June 5th before the Senate Interior Committee.

I object:

1. We are responsible parents and we expect others to do also.
2. We cannot afford *more* assessments. We love it here, we're struggling to carve our *empire* on two acres—we resent being driven off.
3. We resent C. P. Anderson strapping us while he goes out of office in a blaze of glory. Wouldn't it be beautiful *for him* to have miles of covered canals with his name carved across them!
4. We resent C. P. Anderson believing we're all stupid fools—when he says it will *not cost us!* Let the Federal Government pay fifty percent.

We are the Government and we're paying through the nose now.

Please try and see our point. Water is short this year in the Rio Grande, we're trying to save our pecans by purchasing water. We want to stay, we want to survive, we would like to see canals covered—but we cannot afford it, and we can't see the U.S. go further in debt for one man's inconsiderate, out of touch whims.

Sincerely,

E. J. HANS,  
(Mrs. E. J. Hans).

