WATER OPERATION AND MAINTENANCE

BULLETIN NO. 99

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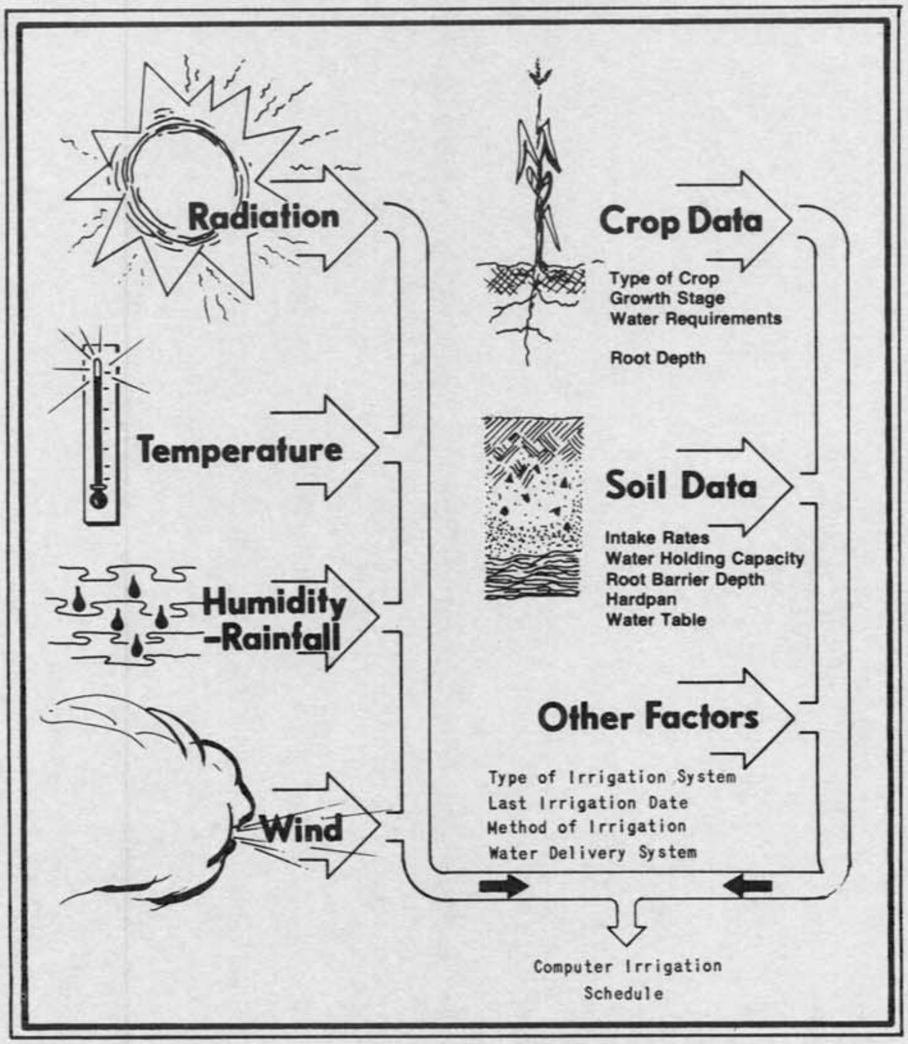

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UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water-supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the reports herein concerning laborsaving devices and less costly equipment and procedures will result in improved efficiency and reduced costs of the systems for those operators adapting these ideas to their needs.

To assure proper recognition of those individuals whose suggestions are published in the bulletins, the suggestion number as well as the person's name is given. All bureau offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

Any information contained in this bulletin regarding commercial products may not be used for advertisement or promotional purposes and is not to be construed as an endorsement of any product by the Bureau of Reclamation.

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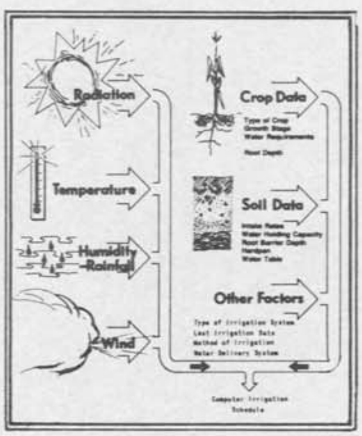

COVER PHOTOGRAPH:

This graphical sketch illustrates some of the factors which are taken into account by the computer in the irrigation scheduling program designed to assure efficient use and conservation of irrigation water.

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

WATER OPERATION AND MAINTENANCE
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INTRODUCTION

Proper irrigation scheduling for optimum use of water is important to those who operate water-supply systems, as pointed out in the first article beginning on page 1. Irrigation scheduling helps the farmer in many ways: increased income through greater yields and improved crop quality, lower production costs, and reduced drainage needs. Scheduling of water throughout the distribution system enables the operating entity to utilize the project water supply in an efficient manner.

As described in the article on page 11, 90 percent of the energy used on some irrigated farms is used in pumping; therefore, the growers should be getting maximum efficiency from their pumps instead of the 51 percent most of them are now experiencing.

A simple solution for the control of pondweeds is explained in an article on page 20.

How to build an entrance gate on a steep grade is described in the short article on page 22.

A listing of current safety color designations recommended by OSHA can be found on page 24.

Some biological methods for the control of aquatic and terrestrial weeds are given in the article starting on page 26.

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CONSERVING IRRIGATION WATER[1]

At present, there are more than 20 million hectares (50 million acres) of land under irrigation in the 17 Western States. Continuing development of irrigation projects along with improved irrigation methods, such as sprinkler and drip irrigation, has brought land under irrigation which previously was considered unsuitable. In some cases, this has resulted in the allocation of all the water available for irrigation. This extensive use of water for irrigation coupled with the increasing demand imposed by municipal and industrial development, including the more recent fossil-fuel resource development, has made efficient use of available water a necessity. But efficient use of water implies efficient storage, efficient distribution of water through a series of canals, laterals, and farm ditches, and efficient application of that water to the field.

It has been estimated that the irrigation of crops accounts for approximately 80 percent of the water used in the Western States. Most of this agricultural use occurs in the arid and semiarid West. Therefore, it stands to reason that a great potential, as well as need, exists for better water utilization in the irrigated areas of the West.

> The purpose of the program is to assure effective use of our natural resources by irrigated agriculture.

The Bureau of Reclamation has developed a program which will provide the tools and concepts for improving irrigation efficiencies and project operation for effective utilization of irrigation water with an improved economic base to the irrigation enterprise. This program, using the principle of irrigation scheduling, is called the Irrigation Management Service program, or IMS. The principal thrust of the IMS program is to direct and assist irrigation and water districts toward more effective and efficient use of water. The results are increased net returns to the farmer/irrigator through greater yields and improved crop quality with lower production costs, reduced irrigation project operation and maintenance requirements, improved criteria for irrigation planning and development, and more favorable environmental impact of the water resource development for irrigation.

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[1] This article was prepared especially for this publication by the Irrigation Management Service Team at the Engineering and Research Center, Denver, Colorado.

IRRIGATION MANAGEMENT SERVICES: Irrigation Management Services (IMS) is offered to farmers or individuals who request it through irrigation districts and associations. It provides in-the-field advisory service and timely data designed to improve your water management. The program is provided with the cooperation of the Bureau of Reclamation and other Federal, State, and local agencies.

The IMS program is the outgrowth of a study made a few years ago by the Bureau of Reclamation on some 300 farm fields on 18 study areas throughout the irrigated West. We wanted to know what was going on out there in the water user districts and on the farms where the water was being delivered. These studies were very revealing and showed that even though more water was being applied throughout the entire season than was necessary to produce good crops, oftentimes during the critical growing period, the crops suffered from a lack of moisture because they did not have enough water.

IRRIGATION SCHEDULING - WHEN TO IRRIGATE AND AMOUNT TO APPLY

IMPORTANCE

Proper scheduling for optimum use of irrigation water is important to the farmer, the irrigation district, the community, and the Nation.

The studies further revealed that as a general rule the irrigator did not know when he should apply irrigation water or how much water he should apply to fill the rooting zone of the soil. It was also apparent that deficiencies related to applying water efficiently on the farm had an effect on the efficient management of water throughout the distribution system. Probably the most important conclusion drawn from the study was that before any substantial change in present irrigation and water delivery practices could be expected, the irrigator will need to have better information as to when he should irrigate a particular crop and how much water he should apply when he does irrigate. Along with this information, he often needs technical assistance in the preparation of his land for irrigation and in distributing the proper amount of water uniformly over the field.

Recognizing this need, the Bureau of Reclamation set about to develop a program which would supply the irrigator with information on when he should irrigate and how much water he should apply. At the same time, the program would provide the farm-water demands to the operating personnel of the water district to allow them to more effectively schedule water throughout the distribution system.

> HOW IMS WORKS:
>
> Field sampling and laboratory analyses determine soil moisture-holding capacity. Then, through careful measurement of local daily temperatures, wind, humidity, rainfall, and solar radiation, crop water needs can be determined. With this information, an irrigation schedule can be tailored to your specific farm situation. By combining irrigation schedules for several farms, a delivery schedule can be developed for a distribution system.

Basically, the program involves keeping a water budget on each field under irrigation. The amount of moisture in the soil at the start of the growing season will be measured. Figure 1 shows water being

Figure 1

measured and distributed to a field. As the season progresses, the amount of moisture used or "withdrawals" by the crop will be computed from climatological data such as temperature, solar radiation, and wind movement. "Deposits" to the water budget will be effective rainfall and irrigation water stored in the rooting zone. At any time, a budget analysis will provide the amount of moisture in the rooting zone of a particular crop and with current "withdrawals," it will predict when an irrigation should be applied. The analysis will also indicate how much water should be added to the field when the irrigation is applied. The water user will be kept advised of the time for irrigating and the amount of water to apply. First, an estimate, based on crop development and climatological data from past years, will be made of the irrigation date considerably in advance of the actual date. This estimate will be reconfirmed or updated once or twice a week with current climatological data so that the proper irrigation date is selected.

BECAUSE OF THE LARGE AMOUNT OF DATA PROCESSED, COMPUTERS ARE BEING USED

Because of the large amount of data required on many fields and the need for frequent updating, modern computers and data handling systems are being utilized. The use of the computer makes it possible to carry out the program on a large number of fields. Once irrigation scheduling is developed on the farm, these farm irrigation demands are combined into a schedule for water deliveries throughout the distribution system and on to the storage system. Thus, the IMS program is integrated into the regular ongoing operation and maintenance program of the water users district.

The Bureau is currently providing two levels of irrigation scheduling assistance to the irrigator - the "Irrigation Guide," and "Field Irrigation Schedule." Both levels delegate to the irrigator the final decision of when and how much water to apply. They are briefly outlined as follows:

The Irrigation Guide gives irrigation intervals for principal crops in an area based on daily evapotranspiration rates and average water-holding capacities for several soils in the area. The guide is updated weekly with current climatic data from a central location in the area. It gives the average daily water use and the total water use for the week, the seasonal water use to date, and forecasts crop water use for the next week. This information is provided for crops with either an early, average, or late planting date and a corresponding stage of growth that is general for the update period in the area. The Irrigation Guide is proving very effective as a supplemental service along with the other irrigation scheduling approaches. Where the data base and experience enable accurate definitions of the general conditions of the area, the recommended irrigation intervals are quite accurate.

BOOKKEEPING:

Modern computers are used as "bookkeepers." They keep records of all information and provide printouts, recommending irrigation dates and application amounts for each crop grown on your farm.

The Field Irrigation Schedule provides the irrigator or farm manager with the up-to-date soil moisture status of each of his fields in the program. It gives him recommended optimum irrigation dates and amounts to apply at each irrigation. If adequate input data are available, application rates and set times can be included. One field technician is needed for every 2000 to 4000 hectares (5,000 to 10,000 acres) served by this program. Techniques and equipment being developed will ultimately expand the area that one person can serve.

Figure 2 shows the Irrigation Management Service field man visiting a farm to check field and crop conditions. He may also be able to advise on such matters as fertility, insect and disease control, and other aspects related to irrigation.

Figure 2

The Field Irrigation Schedule program provides the irrigator with a computer printout once or twice weekly which is an "update" of his irrigation program. This update or schedule incorporates the measured climatic parameters during the period of elapsed time since the last update. Evapotranspiration potential, based on long-term historic data, can be modified by a short-term (5 days or less) adjustment for anticipated climatological anomalies occurring during the forecast period. A listing of the various fields that make up a farm or operational unit is included on the printout. Data also included are the soil moisture status for each field at the end of the update period. Other items included are the water-holding capacity for the effective rooting zone, the recommended allowable depletion, the date of the last irrigation, and the recommended date for the next irrigation on each field. A Field Irrigation Schedule is shown in figure 3.

FARM NO. 1　　MR. I.M. NOBODY　　DATE: JUL 23
ROUTE # 1
SOMEWHERE,
ALASKA 99911

FIELD IRRIGATION SCHEDULE

FIELD-CROP-ACRE			PLANT DATE OR ID	RT ZN FT	AVE DAY USE INS	USE BETWN IRR INS	TO-DAYS DEPL INS	DAYS INTERVAL PCT-REFILLED 50	75	100	LAST IRR. DATE	NEXT IRRIGATION DATE	AMT INS
1	WHEAT	20	ID413	4.0	.23	1.7	12.8$	4	6	9			2.2
2	POTATOES	60	ID226	1.9	.25	1.0	.7	2	3	4	JUL 20	JUL 24	1.3
3	CORN	30	ID311	3.6	.24	1.2	1.2◆				JUL 17	JUL 22◆	1.6.
4	BEETS	40	ID124	2.7	.24	1.5	1.1#	2	3	5	JUL 19	JUL 24◆	2.0

◆ FIELD HAS NOT BEEN CHECKED
\# INCLUDES CARRYOVER DEPLETION
$ ACCUMULATED IRR.REQ.TO DATE

Figure 3

Neutron probes for measuring soil moisture and water use rate shown in figure 4, is both consistent and accurate.

Figure 4

The neutron probe is being used in several areas to measure soil moisture and water use rate to enhance the IMS program. A metal tube is placed in the soil shortly after the crop is planted and is used throughout the irrigation season as an access tube. When moisture levels are desired, the neutron source and counting device are lowered to the desired depth within the access tube. The reading obtained in a unit of time is proportional to the moisture content of the soil at that depth.

The speed and direction of neutrons emitted from the source are altered by hydrogen present in the water. Any neutrons which reach the counting device are recorded. The greater the number of neutrons registered by the counting device the greater the water content of the soil. Through the use of the neutron probe, the quantity of water available to the plant may be determined accurately. The neutron probe data are utilized by the computer to develop an irrigation schedule or may be graphically plotted to determine the irrigation requirements. In both cases, the closer the observation is to the scheduled irrigation date, the greater the accuracy.

SCHEDULING OF WATER DELIVERIES THROUGHOUT THE DISTRIBUTION SYSTEM

Scheduling onfarm demands throughout the distribution system is an integral part of the IMS program.

Scheduling of water to fields for optimum crop yields must take into consideration the constraints and limitations imposed by the farm delivery system as well as those of the project distribution system. The compilation and organization of water delivery schedules for the farms on a lateral are referred to as system scheduling. Optimum delivery schedules to farms on the laterals are compiled and adjusted, thus allowing the scheduling of water deliveries throughout the entire distribution and storage system in such a manner as to make the most effective and efficient use of the total water supply. Printouts of farm delivery schedules on a lateral are utilized by the ditchrider or other operating personnel to enable them to schedule and utilize water in the lateral in an efficient manner.

In most cases, system scheduling can be utilized with a minimum of change in present delivery procedures. However, scheduling provides for the allocation of water for delivery in accordance with the actual and projected crop water use, modified by rainfall, cultural practices, delivery system carrying capacity, and field irrigation characteristics, which may result in changes in the water delivery systems of some projects.

System scheduling computer programs have been developed to accommodate either gravity or sprinkler irrigation systems. The system scheduling programs use the forecasted farm irrigation events to determine the optimum delivery demand at each turnout. Adjustments are made in these optimum turnout delivery demands to reflect constraints imposed by the capacity of the distribution system. Daily flow requirements for each turnout are adjusted as necessary and totaled to determine the lateral diversion requirement and its demand on the main distribution system.

An IMS program has been developed to assist an irrigation district in forecasting their seasonal water demands. The program determines this seasonal demand from the consumptive use of the acreage of crops grown within the district. The program may be used to compare the consumptive use with the district's water delivery records. On a regular basis throughout the season, the program may compare the district current water delivery records with the consumptive use determined from the field or system scheduling programs. This program may be run on any or all segments of the district conveyance system.

For example, it may include all the irrigated lands below a given turnout (lateral, canal, or reservoir). The program's "printout" will tabulate the total water diversions and deliveries to date, the crop consumptive use to date, and will also project forecasted water demands for the next day, week, and month.

THE PRESENT PROGRAM INVOLVES 126 650 HECTARES (313,000 ACRES) AND 25 DISTRICTS

The IMS program is economically worthwhile and environmentally sound to the irrigator, the water-user district, and to the Nation.

From 1969 to 1976, the Bureau's IMS program has expanded to 25 different areas in 14 states. The present IMS program involves more than 126 650 hectares (313,000 acres). As a general assessment, the anticipated benefits of the IMS program have been divided into three categories reflecting their beneficiaries. All impacts have not been studied, but some benefits have been documented. Generally, trends and studies support the following ideas:

FARMER - BENEFITS

- Increased income
- High-quality crops
- Higher yields
- Save fertilizer
- Save labor
- Reduce drainage needs

An increase in crop quality and yield is most important. Irrigation scheduling provides for better use of labor and water with fewer restrictions on water deliveries during periods of peak water use. By proper management the farmer can reduce leaching of soil nitrogen and other soluble plant nutrients.

IRRIGATION DISTRICT - BENEFITS

- Control deliveries
- Reduced water demands
- Water savings
- Reduced drainage problems
- Computerized water records

Scheduling will improve the economic base associated with the irrigation enterprise in that an operational program enables better use of reservoir storage and reduces the load on the delivery system during periods of peak water use. With the use of the computer, the district will have the capability of forecasting delivery requirements and computerizing water storage and delivery records. IMS may reduce drainage requirements and associated problems. By controlling field and farm runoff, some of the district's maintenance requirements would be reduced.

NATIONAL - BENEFITS

- Improved agriculture economy
- Reduced environmental impacts
- Improved use of natural resources

An irrigation management program helps reduce adverse environmental effects from irrigated agriculture, such as salt loading of a river, while improving the utility of the natural resources, particularly where chemical fertilizer and pesticides are used. Irrigation management improves the economics of irrigated agriculture and provides needed information for planning and operation of irrigation systems.

* * * * *

MEASURING FLOW RATES CALLED MUST
FOR
ENERGY CONSCIOUS GROWERS[1]

A while back, in the August 1975 issue of Arizona Farmer-Ranchman, readers were let in on a little secret for finding the efficiency of their pumping units. All that's involved is dividing the output of the pump, in gallons per minute, by the energy input, in horsepower.

And according to University of Arizona Irrigation Specialist, Al Halderman, the same irrigation specialist going around the state holding meetings on improving irrigation efficiencies for both man and machine, you're likely to come up with an irrigation efficiency of 51 percent for your pumps if you're like most Arizona growers. According to Halderman, these are shocking figures in the face of energy shortages and the fact that 90 percent of the energy used on a farm is used for irrigation pumping.

One of the solutions Halderman suggested in the article is that of knowing your flow rates and keeping careful checks on them. This could be done, according to Halderman, by installing various devices to give you this information. Devices such as a critical depth flume, for instance, or any of many such water measuring devices. According to Halderman, the uses of water measuring instruments is the best way to get the output or the numerator of the efficiency equation. To get the denominator, it's best to consult your local power company.

At the September 10 "Cost of Pumping" meeting held in the Maricopa County Extension Center, and organized by Halderman, water measurement devices were discussed at great length by John Replogle, a hydraulic engineer with the U.S. Department of Agriculture Water Laboratory in Phoenix, Arizona.

According to Replogle, the measurement of water is one of the most important and one of the least expensive things a grower can do to improve his water irrigation efficiency. "In the measurement of water," said Replogle, "there are many standard devices which are commonly used. Among them are:

- Weirs
- Parshall flumes, conventional and modified
- Submerged orifices
- Current-meter gaging stations
- Commercial meters.

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[1] Reprinted by special permission of the Editor, from a recent issue of the Arizona Farmer-Ranchman.

"The weir is the most serviceable and economical measuring device," said Replogle, "where there is sufficient available fall in the canal or channel, and the quantity of water to be measured is not too large. It is also one of the simplest and most accurate devices when used under favorable conditions. The submerged orifice is applicable where the available head is limited and the amount of floating debris is a minimum.

"The Parshall flume," said Replogle, "may be used to advantage in many cases in place of weirs or submerged orifices. In addition to several advantages in operating characteristics, the Parshall flume will accommodate discharges much larger than those practicable with a weir, and with less head loss.

"And the current-meter gaging station may be the most practical means of measurement where the quantity of water is large and operating conditions and installations costs are not favorable for the use of weirs, Parshall flumes, or submerged orifices."

<u>The Weir Box</u>

Replogle stated to the growers in attendance at the meeting that weirs are one of the oldest, simplest, and most reliable structures that can be used to measure the flow of water in canals and ditches. The critical parts are easily inspected, and any improper operations can be easily detected and quickly corrected. Weirs can be used most effectively whenever there is a fall of about 150 mm (0.5 ft) or more available in the canal, lateral, or ditch. In certain cases they may be used with even less fall. A Cipolletti weir (named after the man who designed it) in full operation is shown in figure 5.

Figure 5

A weir, Replogle continued, may be defined as an overflow structure built across an open channel, usually to measure the rate of flow of water. Weirs are acceptable measuring devices because, for a weir of a specific size and shape with free-flow, steady-state conditions and proper weir-to-pool relationships, only one depth of water can exist in the upstream pool for a given discharge. The discharge rates are determined by measuring the vertical distance from the crest of the overflow portion of the weir to the water surface in the pool upstream from the crest, and referring to computations or tables which apply to the size and shape of the weir.

For standard tables to apply, the weir must have a regular shape, definite dimensions, and be set in a bulkhead and pool of adequate size so the system performs in a standard manner.

Depending upon the shape of the opening, weirs may be termed rectangular, trapezoidal, triangular, etc. In the case of rectangular or trapezoidal weirs, the bottom edge of the opening is the crest and the side edges are called sides or weir ends. The sheet of water leaving the weir crest is called the nappe. Weirs operate best when they discharge freely into the atmosphere. In certain submerged conditions, the under-nappe airspace must be ventilated to maintain near-atmospheric pressure.

Installation of the Weir

"If you as a grower wish to install a weir, you may either install it in an earth channel or a lined irrigation ditch," said Replogle. "For earth channels, the weir may be made from a piece of steel sheet metal cut approximately in the shape of the cross sections of the channel but somewhat larger, and having a carefully cut weir notch in the top edge. To set this weir, the metal plate is forced firmly into the soft bottom and sides of the channel, normal to the direction of flow, and the crest is adjusted to a level position by tapping down the higher side.

"If you wish to make water measurements in lined tunnels or for making measurements of small discharges in ditches, a weir plate may be installed in a wooden or other bulkhead that has been sandbagged and sealed in place. The opening for the weir notch should be cut about 76 mm (3 in) longer than the crest length to allow for insertion of angle irons, metal strips, or a plate to form the sharp crest and sides of the weir and to insure that the nappe will spring clear of the bulkhead.

"For best operating conditions, the weir structure should be set in a straight reach of the channel, perpendicular to the line of flow. The weir crest must be level and the bulkhead plumb. Adequate cutoff walls well tamped in place should be used on the weir structure to prevent undermining or washing by erosion around it. The banks and bottom of the channel should be trimmed to conform approximately to the shape and size of the box for a distance of 3 to 6 m (10 to 20 ft) upstream for the smaller structures, and from 15 to 21 m (50 to 70 ft) or more for the largest structures."

Replogle continued by telling the growers that "the weir box may accumulate sand and silt to such an extent that discharge measurements will be considerably in error. For sluicing silt and sand deposits, an opening may be provided in the weir bulkhead at the floor line beneath the weir notch. This sluiceway should be provided with a suitable cover to prevent leakage. Frequent trimming of the channel and cleaning of the weir box structure with shovel or scraper are necessary to maintain proper operating conditions. It does little good," said Replogle, "to carefully select and build an accurate weir station if it is then permitted to fill with sediment and the approach channel to deteriorate. Such neglect can only result in erroneous discharge determinations."

Care of Weirs

According to Replogle, the care of the weirs should be as follows:

The weir and weir pond should be freed of weeds and trash at each visit of the canal rider, and the weir pond should be cleaned of sediment as it accumulates. The weir pool banks should be trimmed as required to maintain at least the minimum distance from the notch of twice the maximum weir head. The bottom of the pool must be kept low enough to maintain at least the minimum distance from the crest of twice the maximum head on the weir.

The level of the crest should be checked periodically and should also be checked with reference to the elevation of the zero of the gage. Inspection should be made to determine whether there is leakage around the weir and, if such leakage occurs, the structure should be immediately repuddled and carefully rechecked to see that the weir is level and at the elevation of the zero of the gage.

Great care must be taken to avoid damaging the weir notch itself. Even small nicks and dents can reduce the accuracy of an otherwise good weir installation. Any nicks or dents that do occur should be carefully dressed with a fine-cut file or stone, stroking only in the plane of the weir upstream face, the plane of the weir crest or sides, or the plane of the chamfers. Under no circumstances should the upstream corners of the notch be rounded or chamfered. Nor should any attempt be made to remove completely an imperfection with the result that the shape of the weir opening is changed. Instead, only those portions of the metal that protrude above the normal surfaces should be removed.

Measuring the Discharge

Growers who follow Replogle's advice and construct a weir can measure the discharge over the crest as follows:

"Before you begin to measure discharge," said Replogle, "you must be aware that as the stream passes over the weir the top surface curves downward. This curved surface, or drawdown, extends upstream a short distance from the weir notch. The head, called 'H' must be measured at a point on the water surface in the weir pond beyond the effect of the drawdown. This distance should be at least four times the maximum head on the weir, and the same gage point should be used for lesser discharges. A staff gage is then placed at the same elevation as the crest upstream at this point and the measurements are usually taken from there. The depths of the water over this post will be the head on the crest. After this head is determined, the rate of flow, or discharge may be found by referring to prepared tables."

Limited Use

Replogle told the audience that although weirs are easy to construct and convenient to use, they are not accurate unless properly installed and maintained. They require considerable drop between the upstream and downstream water surfaces (loss of head) often not available in ditches with flat grades.

Parshall Flumes

Replogle turned next to the second popular form of water measurement among growers - the Parshall flume, named for the late Ralph Parshall. Figure 6 shows a Parshall flume set to record return flows.

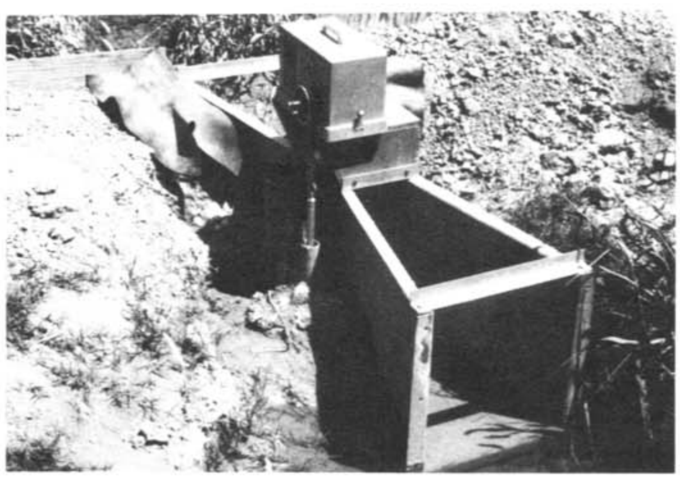

Figure 6

"A Parshall flume is a specially shaped open channel flow section which may be installed in a canal, lateral, or ditch to measure the rate of flow of water. The flume has four significant advantages:

- It can operate with relatively small head loss.
- It is relatively insensitive to velocity of approach.
- It has the capability of making good measurement with no submergence.
- Its velocity of flow is sufficiently high to virtually eliminate sediment deposition within the structure during operation."

Said Replogle: "The constricted throat of the flume produces a differential head that can be related to discharge. The crest followed by the downwardly sloping floor, gives the Parshall flume its ability to withstand relatively high degrees of submergence without affecting the rate of flow. The converging upstream portion of the flume accelerates the entering flow, thereby essentially eliminating the deposition of sediment which would otherwise reduce measurement accuracy."

Exact Throat Width

"Important construction features of the Parshall flume," said Replogle, "are a throat of exact dimensions, a proper drop in the throat section, correct rise in the diverging section and gage wells placed at proper positions. In addition, the size of the flume is the same as the throat width of the flume. For example, a 76-mm (3-in) flume has a 76-mm throat width.

"When installing the flume, it is important to place it in a straight section of the ditch and to keep it clear of obstructions which may interfere with the even approach of the water. The floor of the converging section of the flume must be absolutely level lengthwise and crosswise. It is generally necessary to set the flume with floor (or crest) elevated above the ditch bottom to prevent excessive submerging. Submergence occurs when the elevation of the water surface downstream from the flume is high enough to retard the flow. Conversely, when the upstream flow elevation is higher than downstream, the water moving through the flume is called 'free flow.' When water is of this type, only one measurement need be taken. This would be at what we call the converging section. But when submergence occurs, two measurements must be taken: at the converging section and at the diverging section. Of course, reference must be made to flow tables for accuracy."

As a footnote, Replogle warned that submergence and flows are not desirable for standard conditions and, except in unusual cases, should be avoided.

Submerged Orifices

Combining some of the same elements of the weir box and the flume is the submerged orifice which, according to Replogle, is used when the available head is insufficient or when conditions are not satisfactory for weirs. Many irrigators use relatively flat irrigation ditches which facilitate handling large heads of water. Weirs often cannot be used to measure water in flat ditches, but measurements can be taken with a submerged orifice.

"A submerged orifice," said Replogle, "discharges under water so that the downstream water surface is above the top of the orifice or opening in the structure. The orifices can be built of wood, metal, or concrete. The essential features of the structure are: a smooth, vertical face of sufficient size; an orifice with smooth, sharp edges and of accurate dimensions; and provisions for measuring the head.

"The head on a submerged orifice is the difference in elevation between the water upstream and downstream from the orifice. Often, two stakes are set in the ditch with the tops at the same elevation, one a few feet upstream from the orifice and the other a few feet downstream. The distances from the tops of these stakes to the water surfaces are measured with a rule. The measurements should be made at points where the water surfaces are fairly quiet or smooth." Figure 7 is a single-barrel constant-head orifice turnout.

Figure 7

Replogle added that in the early days of irrigation the orifices usually discharged into the air, in which case the orifices were said to be free. After weirs became more generally adopted for measuring irrigation water, free orifices were practically abandoned as their use required considerable fall and resulted in excessive loss of head.

To overcome excessive head loss, the orifices were lowered in the structures and the submerged orifice, so-called because it discharges under water, was developed. The submerged orifice conserves head and it's therefore used where there is insufficient fall for a weir, and where a Parshall flume is not justified because of cost or some special field condition. A disadvantage of the submerged orifice is that accumulations of submerged debris or of sand and sediment upstream from the orifice may prevent accurate measurements.

Deflection Meters

According to Replogle, a deflection meter consists of a wand or vane that projects into the flowing fluid, and a sensing element that measures the deflection caused by the force of the flow against the vane. Portable meters of this type are commercially available and can give fairly accurate service. Interchangeable, calibrated scales can be supplied to indicate cubic metres per second (second-feet), litres/minute (gallons per minute), or other units of flow.

Deflection meters are usually portable and may be easily moved from one station to another. In use they rest in permanently placed brackets mounted in a 1.83-m (6-ft) long rectangular or trapezoidal liner section placed in the earth ditch. Thus, a meter head will serve a number of ditches of about the same flow capacity if these ditches have liners and brackets permanently installed. About 30 sizes of meters and ditch liners are available. Meters and liners are made to fit either a trapezoidal or rectangular channel. Each meter handles about a 1 to 15 range of flows in a given size of ditch and automatically compensates for different combinations of velocity and depth. Best accuracy is obtained when the flow in the ditch is neither too deep nor too shallow, that is, when the velocity is not too low or too high. Midrange combinations of velocity and depth provide best measurement accuracy. There is negligible loss of head caused by the ditch liner or meter. Instantaneous discharges are read by estimating the position of a level-type indicator bubble on the calibrated scale. Installation is simple and the cost is reasonable if several ditches can be served with one meter.

Because the meter works on the deflection principle, wind affects the exposed portion of the meter and vane. Serious measurement errors can result unless precautions are taken. A windbreak made from a piece of plywood has been found effective in minimizing wind-caused errors.

Under ideal conditions deflection meters have been found to be accurate within 2 percent. Generally, this accuracy will not be attained because field conditions are seldom ideal. For example, wind can produce errors up to 100 percent. Simple precautions can eliminate much of this type of error.

* * * * *

ONE SOLUTION TO POND WEEDS: A "WEED-WIRE"[1]

Thanks to John Sandige of Camp Verde, Arizona, water users bothered by pond weeds now have another tool to work with, in addition to the usage of chemicals and pond drainage.

Would you believe barbed wire!

That's absolutely right, according to Mr. Sandige. He said they got almost complete weed control when he and a neighbor pulled a long strand of barbed wire through the bottom of his pond, cutting the weeds and floating them to the surface. From there, he said, it was a simple matter of putting the weeds into baskets to be dried and burned. In all, he and his neighbor gathered about 0.7 m^3 (20 bushels) of weeds from the 30.5-m (100-ft) pond.

Figure 8 shows Mr. Sandige and his neighbor working the wire through the pond and the weeds floating to the top. Figure 9 shows the weeds being gathered from the shoreline. When the weeds dry, they take up about one-fifth of their original size and are easily burned.

Figure 8

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[1] Reprinted by special permission of the editor from the July 1976 issue of Arizona Farmer-Ranchman.

Figure 9

Mr. Sandige, who first tried to control the weeds with regular wire, believes his method of using barbed wire would work on cattails and other types of pondweeds, but that larger ponds would necessitate the use of a horse or truck to pull the wire through the pond.

* * * * *

A $6-million Bikeway Demonstration Program aimed at promoting bicycling as a transportation alternative was announced recently by the Federal Highway Administration. The new funds are available only for construction of bicycle facilities, and are to supplement funds already available for bicycle projects under the regular Federal-Aid Highway Program. Funds will be provided to the States and local communities on an 80-percent Federal and 20-percent State or local matching basis. Funding is not available for constructing bicycle facilities in rural areas. An implementing directive was scheduled for publication in the Federal Register in early February 1976.

From a recent issue of the APWA Reporter.

TELESCOPE ENTRANCE GATE

(Reprinted by permission from a recent issue of GRIST, a publication of the National Conference of State Parks, Washington, D.C.)

Faced with a problem of how to build a gate on a steep grade with a 15.2-m (50-ft) wide entrance, Merle Smeltzer, Park Foreman of the Samual S. Lewis State Park, Pennsylvania, found by putting an island

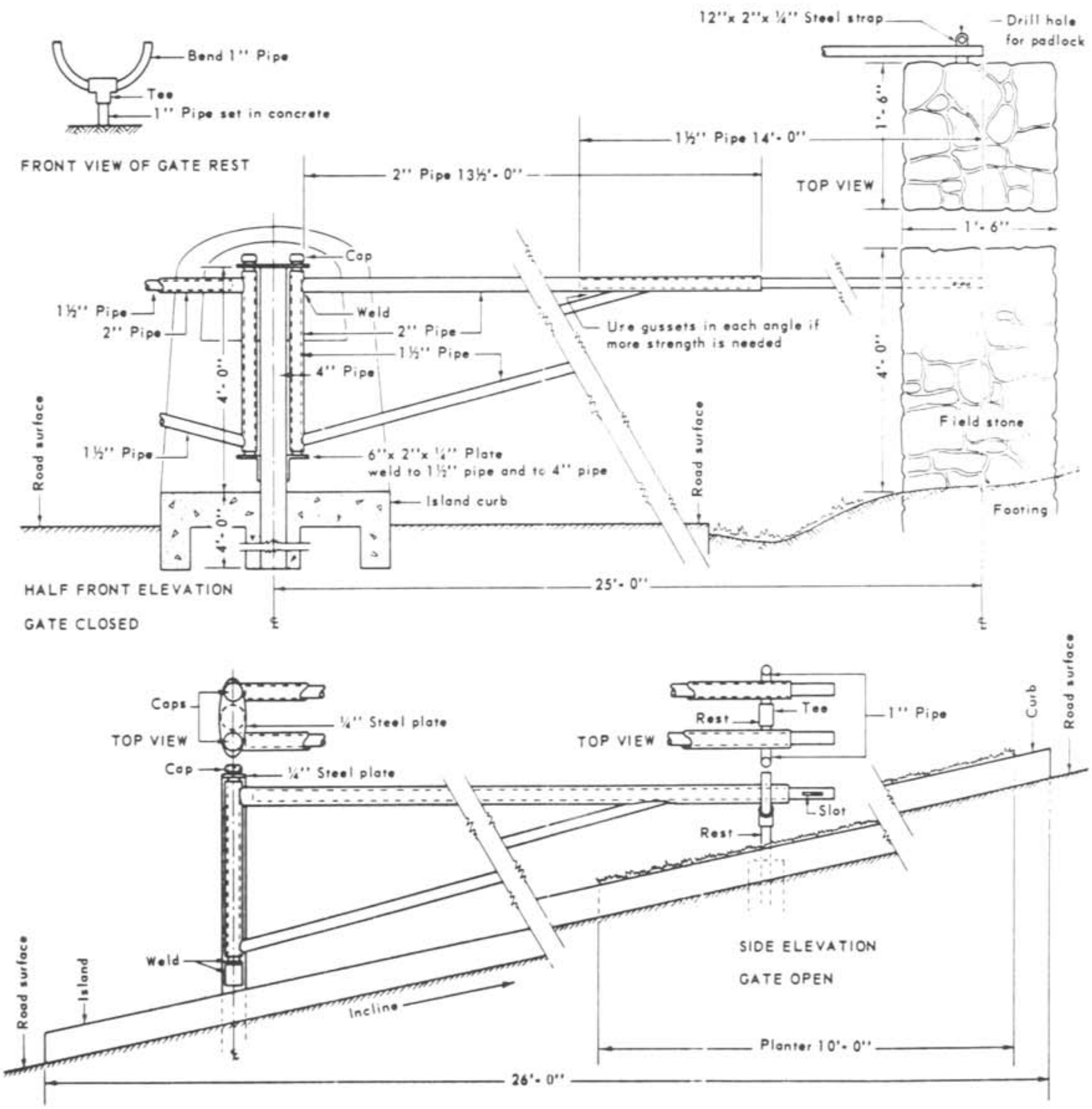

Figure 10

in the center with a short piece of well casing in the middle, two gates could be hung and opened simultaneously from the center. However, this was only half the battle. He discovered much to his surprise that even a 7.6-m (25-ft) gate was too large, so for this purpose he developed two telescoping gates. (See sketch, fig. 10.) This was accomplished by using a 4.1-m (13.5-ft) section of 51-mm (2-in) pipe plus accompanying bracing for the main frame and a 4.3-m (14-ft) section of 38-mm (1-1/2-in) pipe as the telescoping portion for each gate.

In the closed position the telescoping section is extended and in the open position it is retracted.

If further information is desired regarding this telescope entrance gate, please write to GRIST, National Park Service, National Society of Park Resources, Washington, D.C. 20240.

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OSHAct Color Designations[1]

Currently, there are seven colors OSHAct recommends as code indicators for physical hazards or for things pertaining to such hazards. OSHAct lists the colors as follows: Red, Orange, Yellow, Green, Blue, Purple, and also Black and White. These last two are used as one, generally for special identification purposes. Here is a list of the meaning attached to each color.

<u>Red</u>: Three uses for this color: (1) to identify fire protection equipment, (2) to identify "dangerous" conditions or items that might exist, (3) to identify <u>stop</u> controls on machines.

<u>Yellow</u>: Indicator of caution. It warns of possible danger of falling, striking the head, stumbling, catching in between, or similar hazards. Yellow may be used with another color such as black, in a striped or check configuration, for greater emphasis.

<u>Orange</u>: This indicates the exact danger point or hazard: machinery overhang, moving parts, etc. It indicates where there is a chance to be cut, crushed, or encounter electric shock. It is used inside covers or access doors so that it will be visible when they are open.

<u>Green</u>: Green identifies safety equipment, other than fire equipment, and safety locations (first aid, eyewash stations, etc.).

<u>Blue</u>: Warning against starting, moving, or otherwise tampering with a piece of equipment or machine undergoing repair or modification. This hazard warning condition often lapped over into the realm of the Yellow warning. Blue is not often used.

<u>Purple</u>: Radiation hazard including X-ray, gamma ray, etc.

<u>Black & White</u>: These, or combinations of the two, are used for designating traffic lanes, housekeeping, or stacking areas, etc.

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[1] Taken from an article in April 1976 issue of National Safety News.

The confusion found in using colors such as blue and yellow has caused a reevaluation of all warning colors. There is an effort currently in OSHAct to reduce colors to three: Red, Yellow, and Green. Red would then stand for all physical hazards and hazardous conditions, Yellow for all warning functions including radiation warning, and Green for safety devices and locations. This simplified scheme will probably be adopted.

* * * * *

Could There Be Such A Thing As A Universal Fire Extinguisher?

In the Safety Product News for June 1976 (vol. 10, No. 6), there is an item concerning a new fire fighting foam. It is an alcohol-resistant type that combats fires in liquids which normally destroy regular foams. It is effective against ethers, keytones, and similar liquids; also against hydrocarbons such as gasoline, toluene, and benzene. The foam may be used on Class A materials as well. Its wide-range effectiveness, so the manufacturer claims, makes it possible to do away with the usual variety of conventional fire extinguishers and systems. It is a product of 3M Company, Fire Protection Systems Department. More information is available through the publication.

EXCERPTS ON CHEMICAL WEED CONTROL[1]

Herbicide chemicals are an important tool for control of aquatic and terrestrial weed growths on irrigation projects. They often are the only viable alternatives to mechanical methods or they may be integrated with mechanical control. An effort is being made to develop biological control methods to a level of practical application. Much more work needs to be done to achieve this objective.

Herbicide chemicals must be chosen with care. Some factors to consider are:

1. What are the cost comparisons among the various chemical herbicide alternatives?

2. What are the characteristics of the target species to be controlled (annual, perennial, broadleaf, grassy, etc.)?

3. To what degree and how long is a given species to be controlled?

4. What about danger or harm to applicators and to nontarget species (crops, wildlife, etc.)?

All herbicide chemicals produced and sold in the United States must be registered by the Federal Government and must provide fairly specific information on their labeling pertaining to species controlled, dosage levels, directions for use, and precautions to follow to avoid danger to applicators and to the environment. Labeling directions should be closely followed when using any chemical herbicide.

Pertinent information on some herbicide chemicals used by the Bureau of Reclamation and by irrigation districts in the Western United States is given as follows:

Acrolein

It is manufactured by Magna Corporation, EPA (Environmental Protection Agency) Registration No. 201-118. It is registered for control of certain species of algae and floating and submersed pondweeds in irrigation water conveyance and distribution systems. As applied in water, it has little effect on emersed weeds such as cattails and tules. It kills by contact and is rather fast acting. Plant tissue breaks up in

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[1] Article was written by the Bureau of Reclamation, Pest Control Specialist, Division of Water Operation and Maintenance, E&R Center, Denver, Colorado.

relatively small pieces which are less likely to clog or foul structures downstream in the system. It is exempt from residue tolerances in crops and irrigation water when kept at or below 15 mg/l. It is generally used in irrigation canals with flows of 14.2 m^3/s (500 ft^3/s) or greater. It is a lachrymator and is tear gas in gaseous form. It is a liquid and must be applied beneath the water surface with special equipment by trained operators. It is highly toxic to fish and must not be used in waters where fishkills cannot be tolerated.

Copper Sulfate Pentahydrate

It is distributed by Cities Service Company and by Thatcher Chemical Company, EPA Registration Nos. 1109-1, 1109-20, and 1109-27 (Cities Service) and 9768-35, 9768-36, and 9768-37 EPA registration numbers (Thatcher). It is registered for control of certain species of algae and submersed pondweeds in irrigation and other water conveyance systems (municipal and industrial). As applied in water, it has little or no effect on emersed weeds such as cattails or tules. The copper ion in this product is the active killing agent and kills weeds by systemic action in the plant. It will not harm crops if recommended dosage levels for treated irrigation water are complied with. It is exempt from residue tolerances in eggs, fish, meat, and milk. It has a permanent residue tolerance in potable water of 1.0 mg/l and may be applied in drinking water supplies if residues can be kept at 1.0 mg/l or below. It is generally used in irrigation canals with a flow of 14.2 m^3/s (500 ft^3/s) or greater. It is supplied in various sized crystal forms and one solution formulation and may be applied to water by the slug or continuous method. It is generally not toxic to fish at normal dosage levels. However, particularly in soft, acid waters, normal dosage levels may cause some fishkill. In hard waters, it is necessary to increase the dosage of copper sulfate to achieve control. Though a higher dosage is used, the harder water seems to mitigate the toxicity of the copper sulfate to fish, and fishkill seldom occurs in these situations.

Xylene

It is distributed by Shell Chemical Company, EPA Registration No. 201-384. It is registered for control of certain species of algae and submersed pondweeds in irrigation and drainage ditches. It kills by contact and as applied in water, has little or no effect on emersed weeds such as cattails or tules. It is not soluble in water and an emulsifier must be mixed with it at application time to disperse it in the water. It is exempt from irrigation water and crop residue tolerances and will not harm crops when present in the water at normal dosage levels. It is generally used in small canals and laterals with flows of 14.2 m^3/s (500 ft^3/s) or less. It is not practical to use it in larger canals due to the logistics involved. It is highly toxic to fish and must not be used where fishkills cannot be tolerated.

Aromatic Petroleum Distillate

It is distributed by Chevron Chemical Company, EPA Registration No. 239-409. It is registered for control of algae and submersed pondweeds in irrigation and drainage ditches. Its other characteristics are essentially the same as those previously described for xylene.

Diquate Dibromide

It is manufactured by Chevron Chemical Company, EPA Registration Nos. 239-1663, 239-2279, and possibly other registered formulations. It is registered to control certain species of algae and submersed and floating pondweeds in irrigation canals. It will also control certain species of emersed weeds, such as cattails, if it is sprayed directly on the foliage. It kills by contact. It has been proven to give good control of elodea. It has an interim residue tolerance of 0.01 mg/l in potable water. It is sometimes used on Reclamation irrigation projects, but is not used widely because of certain limitations. It sometimes has a tendency to dissipate quite rapidly from the water which tends to reduce its effectiveness. It is generally effective when used in clear water unless the water is very cold, but is useless when applied to muddy water. The active chemical ion is adsorbed to sediment particles and rendered inactive in muddy water. It is quite toxic to humans and applicators must take adequate safety precautions during application. It is not highly toxic to fish and at normal dosage levels will not ordinarily cause fishkills.

Endothall

It is manufactured by Pennwalt Corporation, EPA Registration No. 4581-174. It is registered for control of certain species of algae and submersed pondweeds in irrigation conveyance systems. It is not widely used on Reclamation irrigation projects because it has never been exempted from water, crop, and animal tolerances in the United States, so treated water cannot be used for irrigation, livestock, or domestic purposes within 25 days following treatment. Since fish have been killed by dosages above 0.3 mg/l, it should not be used where fishkills cannot be tolerated. Pennwalt is in the process of obtaining permanent water, animal product, and crop tolerances so that treated irrigation water does not have to be wasted when the chemical is used in the United States.

Weedar 64, 2,4-D DMA Salt

It is manufactured by Amchem Products, Inc., EPA Registration No. 264-2. It is the only chemical in the United States, other than certain weed oils, which is registered to control growth of broad-leafed terrestrial weeds on the inside banks of irrigation canals, laterals, and ditches in the United States. It will not control grassy weed growth. It is translocated by broadleaf plants and they are slowly killed or their growth is inhibited. Residue tolerances have been established for many crops and permanent tolerances have been established at 0.1 mg/l in potable water and fish and 1.0 mg/l in shellfish. 2,4-D formulations, especially esters, should never be used where spray drift might contact desirable trees, shrubs, or crops.

Dalapon

It is manufactured by Dow Chemical Company, EPA Registration No. 464-402. Although it is a generally effective herbicide for control of grassy weed growth on the inside banks of irrigation canals and ditches, it is not registered for this use in the United States. It will also control cattails growing in canals, ditches, and drains. It is registered for use in drains and on industrial and noncrop areas. It will not control broadleaf weeds. Efforts are being made to obtain registration for use on the banks of irrigation canals and ditches in the United States. It is translocated by grassy plants and they are slowly killed or their growth is inhibited. This chemical is low in toxicity to man and to aquatic organisms, and could probably be used with relative safety on systems where fish are present.

Glyphosate

It is manufactured by Monsanto Chemical Company, EPA Registration No. 524-308. It is nonselective and will control many species of broadleaf and grassy weeds growing on the inside banks of irrigation canals and ditches, but is not registered for this use. Efforts are in process to obtain registration for this use. It is registered for use on several crops and for industrial sites and other noncrop areas. It is effective, but time of application relative to stage of plant growth is sometimes critical. It is not highly toxic to man. Crop and animal residue work is in progress to obtain registration for canal and ditchbank use. Preliminary study does not reveal high toxicity to fish.

Many chemical herbicides may be safely used to control growths of terrestrial weeds on noncropland areas away from water. Some are nonselective and control many varieties and types of weeds. Others are selective, like 2,4-D or dalapon, and will control only broadleaf or grassy weeds. Some act as soil sterilants for a few months up to 2 or 3 years when applied at high dosage levels. Some examples are listed as follows:

Selective and nonselective temporary control		Soil sterilants (High dosages)
2,4-D	Diuron	Chlorates
Dalapon	Sodium TCA	Borates
Glyphosate		Atrazine
Picloram		Simazine
Dicamba		Monuron
Atrazine		Diuron
Simazine		Sodium TCA
2,4,5-T (Woody brusy)		
2,4-5-TP (Woody brush)		
Monuron		

None of the above chemicals should be used where spray drift or leaching through the soil would contaminate irrigation water. If irrigation canals or ditches are dewatered for 3 or 4 months of the year, monuron or diuron may be applied to the dry bottoms and inside banks at the beginning of the dewatering period for nonselective weed control. The first water from such treatments must be wasted when canals or ditches are rewatered.

Special precautions must be taken when using chlorates or borates because they are highly flammable.

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The purpose of this Bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful O&M ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin! So let us hear from you soon.

Prospective material should be submitted through your Bureau of Reclamation Regional office.

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