

DROUGHT PROTECTION FROM AN IN-LIEU GROUNDWATER BANKING PROGRAM

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ABSTRACT

The framework is provided for a drought preparedness plan (Drought Plan) for the Orange Cove Irrigation District (District) located in the Central Valley of California. The Drought Plan will improve water supply reliability for the District, which needs a firm water supply to support permanent plantings that cover over 90 percent of the District. The District uses a combination of surface and groundwater and has surplus surface water in some years, but the local geology is not favorable for direct recharge using ponding basins. The District therefore investigated several options for drought protection including water purchases, out-of-District groundwater banking, and in-lieu groundwater recharge in their own service area. In-lieu groundwater recharge was found to be the most economical alternative and would be under the full control of the District. Under the program, some District growers would be sold surplus surface waters at reduced rates, and this would allow groundwater levels to rise and groundwater storage to increase. In dry years, these growers would meet most or all of their demands with groundwater, and would transfer their surface water to areas with low groundwater yields. Details of the program were developed with considerable input from local growers through a public outreach program. A pilot program was outlined with the intention of testing the feasibility of the program on a smaller scale. Other topics discussed include incentives for growers to participate, groundwater level monitoring, project benefits and impacts, and project economics. The California Department of Water Resources funded development of the program.

INTRODUCTION

The Orange Cove Irrigation District (OCID or District) is an agricultural water district encompassing approximately 28,000 acres in the Central Valley of California. Growers in OCID are dependent on surface water and groundwater supplies. Some use groundwater exclusively while others use a combination of surface and ground water. Total average crops demands are roughly 80,000 acre-feet (AF) per year. Typically, about 32,000 AF of surface water and 48,000 AF of groundwater are used to meet this demand.

The District has a Class 1 Central Valley Project surface water contract with the United States Bureau of Reclamation. Although Class 1 water is classified as “firm” water, its delivery has

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historically been reduced in some drought years. The District must rely on groundwater to augment surface supplies, and the groundwater supplies can be stressed in dry years when surface water deliveries are reduced. Although the District encompasses 28,000 acres, only about 9,000 acres has a sustainable groundwater supply (see Figure 1). In addition, permanent crops comprise over 90 percent of the cropped area, so the District has little flexibility in reducing their water needs during droughts without sustaining crop or tree loss. At this time, the District has no long-term agreements with other agencies for banking and/or exchange of water between wet and dry years, which places the District at risk of not being able to supply adequate water in a drought.

The District's distribution system was rehabilitated and expanded in the early 1990's to allow delivery to all District growers. However, some growers still decline some or all of their surface water allocation due to the lower prices and greater convenience of using groundwater. As a result, only about 32,000 AF of the District's 39,200 AF surface water entitlement is normally used. This practice is typically short sighted and uses resources that could be reserved for a dry year or, more importantly, during an extended drought in the future. OCID wants to encourage landowners to use all of their surface water so that groundwater storage can increase and be available during droughts. As a result, OCID developed an in-lieu groundwater banking program. The program encourages landowners to use surplus surface waters 'in-lieu' of groundwater. This reduces groundwater pumping, allows groundwater levels to rise, and increases groundwater storage for use in dry years. The development of this program was funded with a grant from the 2000 Local Groundwater Management Assistance Act (Assembly Bill 303) administered by the California Department of Water Resources.

This paper discusses the District's plan for an in-District groundwater-banking program, which will from hereon also be called the District's 'Drought Plan'. This paper provides background information on past efforts to develop the Drought Plan, and planned future efforts to implement the Drought Plan. The remainder of the paper discusses anticipated benefits and impacts from implementing the Drought Plan.

ALTERNATIVES FOR DROUGHT PROTECTION

OCID evaluated numerous alternatives for drought protection and water reliability, including unique and innovative programs to meet their specific needs and situation. Some alternatives for providing drought protection include: 1) water purchases; 2) groundwater banking outside of the District; and 3) in-District groundwater banking. All three of these options are discussed below.

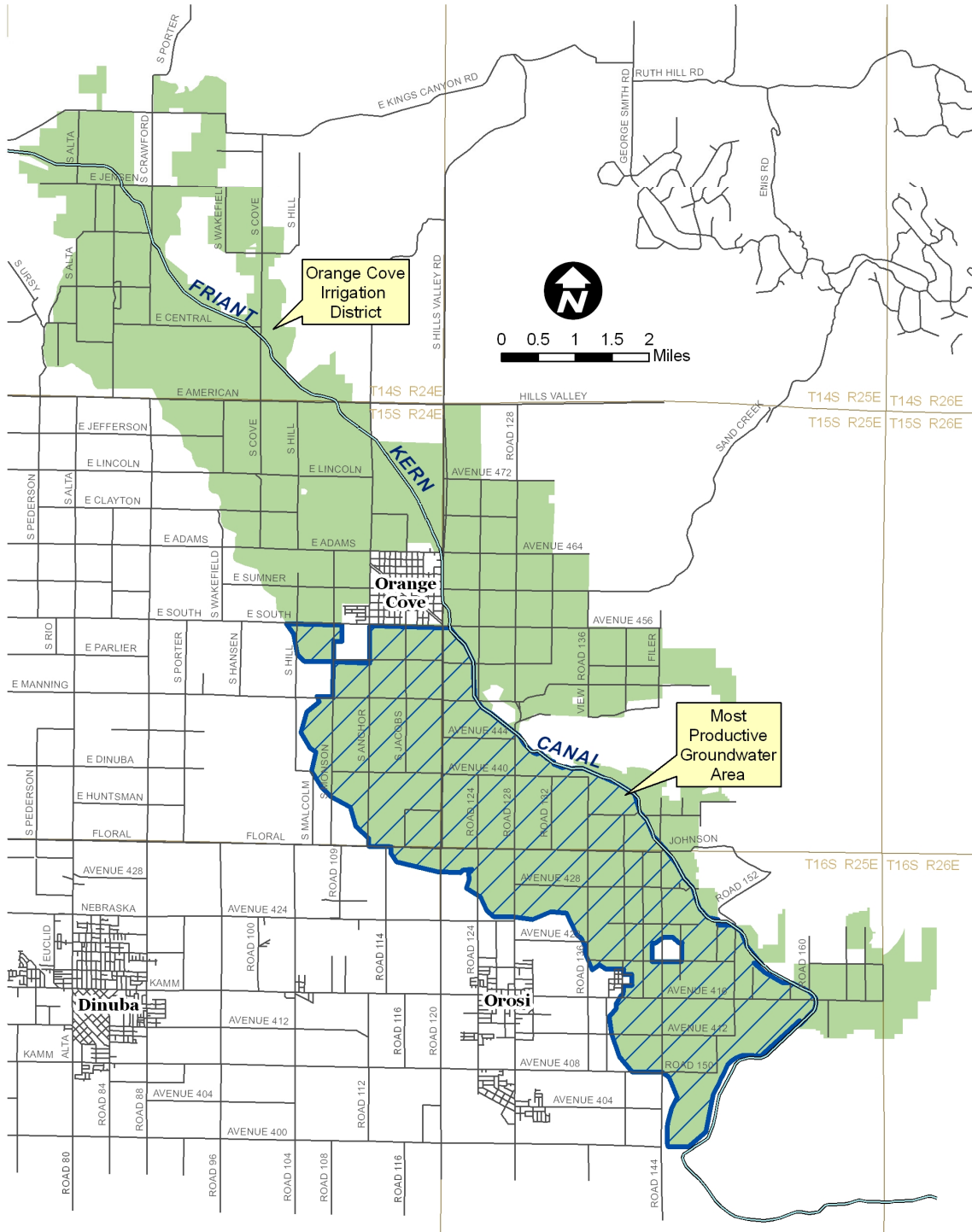


Figure 1. District Service Area including Most Productive Groundwater Area

Water Purchases

Water purchases are a common way for agencies to improve water reliability in dry years. Water markets are typically based on spot market pricing unless prearranged purchase plans or long-term agreements are in place. Dry year water supplies in California are estimated to cost about \$100 to \$500 per AF. These prices are considered high for agricultural uses, and open market water purchases will become increasingly more difficult for agriculture when placed in direct competition with urban users. Given the urban growth in the region and increasing regulatory uncertainty as to the availability of surface water, the pricing of future spot market water purchases is very likely to increase.

Groundwater Banking with Others

Groundwater banking outside of OCID is also a viable alternative. Typically, OCID would need to buy shares in a banking facility already owned and operated by another entity(ies). OCID would deliver water to the facility or entity for recharge during wet years, and retrieve the water as needed in dry years. Typical costs for “buying” into banking projects currently range from \$150 to \$300 per AF of retrieved water plus an upfront one-time capital expenditure of \$500 to \$1,500 per AF of retrieval capacity. Groundwater banking can provide a fairly firm water supply in dry years, and is considered much firmer than spot market water purchases. However, there is an element of risk relying on the facilities and programs owned by others even under the best-intentioned agreement. When extraction and conveyance facilities are in high demand at banking projects in dry years, even the best laid projects can be stressed to perform.

In-District Groundwater Banking

The use of in-District groundwater storage capacity is essentially a banking program within OCID. Under this scenario, the District would bank water by either actively recharging the groundwater basin or by providing surface water in-lieu of groundwater pumping. In both cases, there would be a net increase in the quantity of groundwater stored and available for future pumping by either the District or their water users. Few if any areas within OCID are conducive to direct groundwater recharge due to fine-grained surface soils. However, OCID could implement an in-lieu groundwater banking program. This would involve the use of surplus surface water ‘in-lieu’ of groundwater, which would allow groundwater levels to rise and increase groundwater storage for later use in droughts.

Since the program will only involve parties internal to the District it may be more economical than water purchases or banking agreements that ultimately offer some benefit to third parties, at the expense of the District. It also would provide greater assurance relative to future performance. In addition, no new facilities would need to be constructed to implement the program. As described later in this paper, this in-lieu groundwater banking program could be implemented for as low as \$90/AF, which is considerably cheaper than water purchases or banking outside of OCID.

The balance of this paper focuses on the development of the in-lieu groundwater-banking program (Drought Plan). However, in order to have a diversified range of options for acquiring drought water, OCID plans to pursue all of the options described above to some degree.

DESCRIPTION OF IN-LIEU GROUNDWATER BANKING PROGRAM

This section provides a description of the in-lieu groundwater-banking program including incentives for landowners, administrative details, and a hypothetical example of Drought Plan operations.

Participation Requirements

Landowner participants would need to meet the following requirements:

- Uses surface water supplies on a routine basis, but does not typically use surface water to meet all crop demands;
- Located within the 9,000-acre “banking area” (most productive groundwater area);
- Willing to relinquish all or a portion of their surface water supply in dry years; and
- Be able to meet all, or at least a majority, of their crop water demands by groundwater pumping in dry years.

Incentives for Participants

The Drought Plan would require the voluntary participation from many landowners so sufficient incentives to encourage participation are crucial. As a result, a program was developed with input from local growers to ensure that the project benefits are sufficient and equitable. Developing appropriate incentives required a large portion of the time needed to develop the overall Drought Plan. Nevertheless, the monetary incentives and program costs discussed throughout this paper are preliminary and were developed during planning-level analysis. They may ultimately need to be revised based on actual costs and grower’s ultimate reactions to the program.

Growers will be asked to participate in two phases: a banking phase and a recovery phase. These phases could be several years apart so it was necessary to develop a two part incentive program. During the banking phase growers will use surplus surface water in place of groundwater pumping. OCID first attempted to understand why some users do not use all of their surface water allocation. The primary reasons included:

- Surface water purchases are more expensive than groundwater pumping. The difference varies for each grower, but it is estimated that groundwater typically costs less than half of the cost for surface water (in areas with a sustainable groundwater supply, depth to groundwater ranges from about 10 to 60 feet);
- Groundwater pumping is more convenient than receiving surface water since the landowner has direct control over the timing and flowrate of pumping; and

- Surface water supplies are low in minerals, limiting water penetration in most soils in the District without the addition of amendments. Whereas the local groundwater contains higher levels of salts which aid in water penetration. The local groundwater also contains a high level of nitrogen that is beneficial to the crops and offsets the need to apply equivalent units of commercial fertilizer.

The District needs to offer the landowners sufficient incentives to overcome these obstacles. This will be achieved by subsidizing surplus surface water so it costs no more than groundwater pumping. Groundwater pumping costs are estimated to be about \$20/AF and surface water presently costs about \$60/AF. Therefore, all surface water above and beyond a grower's average annual usage would be sold to the grower for \$20/AF (a \$40/AF reduction).

During the recovery phase the growers would be paid \$50/AF to relinquish their surface water supplies for that year. The grower profit would be the \$50 payment minus the cost to pump groundwater (approximately \$20), minus any additional costs they incur to participate, such as amendments or new facilities. The incentive needs to be large enough to convince growers that they will at least make a slight profit on the program and are not exposing themselves to any unnecessary risks.

To help participants evaluate the economics of the Drought Plan the District prepared a participant worksheet (Figure 2). The worksheet helps determine whether a grower has enough groundwater pumping capability to participate and estimates the financial incentives for the grower. A copy of the worksheet is included as Figure 2.

Groundwater Outflow Losses

To account for groundwater outflow the District would leave behind 5 percent of the banked water. Thus, for every 100 AF banked by a grower, the District will retrieve (ask the grower to reduce their future surface water use by) only 95 AF. Groundwater levels will be monitored with shallow observation wells during the pilot project to help determine whether other loss adjustments are necessary. Based on a preliminary hydrogeologic evaluation groundwater outflow is not expected to exceed 5 percent of banked supplies over the anticipated bank and retrieval operation cycle, but this needs to be confirmed and will depend on how long the water is banked.

Other banking projects provide 10 percent or more to account for losses. However, these projects differ because the losses account for conveyance seepage and evaporation, basin evaporation, and phreatophyte transpiration, which are not present in this project. In addition, such losses are sometimes used as partial payment for banking facility infrastructure, which are also not needed for this project.

Banking Limitations

The participants would be limited in the quantity of water they could bank and return in a given year. The total quantity banked by a participant should not exceed more than two (2) years worth of the participant's average annual use during a 5-year base period. This is to ensure that the landowner does not bank such a large quantity of water that OCID cannot retrieve it in a reasonable time or before it flows out of the District. The quantity of water returned in a drought should not exceed the grower's average annual surface water use.

Safety Net

Landowners will probably not participate unless they have a safety net to account for unforeseen problems. As a result, OCID will allow participants to buy back their water on an emergency basis or be relieved of their commitment under extenuating circumstances.

The participants will be able to buy back their water for the higher of: 1) the spot market price for the District to buy water plus 10 percent; or 2) the District's nominal cost to buy water plus the District's initial investment in the banking program (on a per acre-foot basis) plus 10 percent. Alternatively, the banking participant could temporarily be relieved of these penalties if they petition the District. This could be possible, for instance, if a grower's pump fails and they are not able to get replacement parts for several days or weeks. In addition, the participant could be permanently relieved of their contract if it can be shown that the groundwater they have banked has flowed out of the District or away from their property.

This safety net also protects the District from delinquent landowners. The District can impose these fees on landowners that refuse to relinquish their surface water in dry years. Without this clause, a landowner could bank water at District outlay and never choose to give the water back. This alternative clearly lays out the damages the District would suffer and increases the likelihood that the District would be kept whole financially.

Triggers for Implementation

OCID would probably declare a drought and implement the retrieval part of the program when their surface water allocations are 85 percent or less of their maximum CVP contract entitlement. An 85 percent allocation would correspond to 32,300 AF of surface water, which is the average surface water demand in OCID. Therefore, there should be demand for some of the banked water in a year with an 85 percent or lower surface water allocation.

Hypothetical Example

To further elucidate the details of the proposed Drought Plan a hypothetical example is provided below:

District Participating Grower Average Water Uses:

Total Demand: 200 AF
Surface Water: 100 AF
Groundwater: 100 AF

Under Wet Year of Pilot Program:

Total Demand: 200 AF
Surface Water: 150 AF
Groundwater: 50 AF

*50 AF of OCID supply would be sold to grower at approximately \$20/AF (\$40/AF reduction in cost).

*Total of \$40/AF x 50AF = \$2,000 incentive paid by OCID.

*Total of 200 AF could be “banked” over multiple wet years.

Under Dry Year of Pilot Program:

Total Demand: 200 AF
OCID Surface Supply to Participating Grower: 5 AF
Groundwater Pumped by Participating Grower: 195 AF

*OCID would pay \$50/AF incentive on 100 AF (average annual use of surface water) = \$5,000.

*OCID could only retrieve 95 percent of “banked supply.” 5 percent of “banked supply” would be left in aquifer.

IMPLEMENTATION OF IN-LIEU GROUNDWATER BANKING PROGRAM**Drought Plan Simulation**

The Drought Plan was simulated to estimate the long-term yield and benefits from the program. The simulation was based on the hydrology of the Friant Division of the Central Valley Project over the 30-year period of 1975 through 2004. This period includes some of the driest and wettest periods on record. The simulation is shown in Table 1. In the simulation the bank was limited to holding no more than 15,000 AF at any time. The simulation showed that over a 30-year period a cumulative total of 45,000 AF would have been banked, 30,000 AF would have been withdrawn, and 15,000 AF would still be in the bank at the end of the 30-year period.

Table 1. Simulation of Operations
Water Year Supply¹

YEAR	Water Year Supply ¹		Put	Take ²	Available for Take	Costs	
	Class I	Class II				Put-\$40/AF	Take-\$50/AF
1975	100%	59%	5,000	0	5,000	\$200,000	
1976	75%	0%	0	5,000	0	\$250,000	
1977	25%	0%	0	0	0	\$0	
1978	100%	100%	5,000	0	5,000	\$200,000	
1979	100%	63%	5,000	0	10,000	\$200,000	
1980	100%	100%	5,000	0	15,000	\$200,000	
1981	100%	6%	0	0	15,000	\$0	
1982	100%	100%	0	0	15,000	\$0	
1983	100%	100%	0	0	15,000	\$0	
1984	100%	50%	0	0	15,000	\$0	
1985	100%	14%	0	0	15,000	\$0	
1986	100%	100%	0	0	15,000	\$0	
1987	91%	0%	0	0	15,000	\$0	
1988	78%	0%	0	5,000	10,000	\$250,000	
1989	98%	0%	5,000	0	15,000	\$200,000	
1990	68%	0%	0	10,000	5,000	\$500,000	
1991	100%	0%	5,000	0	10,000	\$200,000	
1992	83%	0%	0	5,000	5,000	\$250,000	
1993	100%	90%	5,000	0	10,000	\$200,000	
1994	80%	0%	0	5,000	5,000	\$250,000	
1995	100%	100%	5,000	0	10,000	\$200,000	
1996	100%	58%	5,000	0	15,000	\$200,000	
1997	100%	30%	0	0	15,000	\$0	
1998	100%	10%	0	0	15,000	\$0	
1999	100%	20%	0	0	15,000	\$0	
2000	100%	17%	0	0	15,000	\$0	
2001	100%	5%	0	0	15,000	\$0	
2002	100%	8%	0	0	15,000	\$0	
2003	100%	5%	0	0	15,000	\$0	
2004	100%	18%	0	0	15,000	\$0	
Total			45,000	30,000		\$3,300,000	

Notes: 1 - Class I supplies are usually fully allocated in normal and wet years. Class II supplies are typically only allocated in years with above average precipitation or with significant carryover storage from the previous year.

2 - Take includes both losses and return water.

Limited Hydrogeologic Evaluation

The rate of groundwater movement under OCID was estimated to be about 500 feet/year. As a result, most banked water would require at least 5 to 10 years to flow out of the recoverable range. However, these estimates are only approximate since limited data was available on aquifer parameters. Information will be collected in a pilot program (described below) to help refine aquifer parameters values. Parameters of interest include specific yield and transmissivity to determine the storage capacity and groundwater outflow, respectively.

Groundwater depths in the southern portion of the District range from 30 to 70 feet. Assuming an average groundwater depth of 45 feet, and a specific yield of 0.04 in the sand and clay aquifer (based on the stratigraphy encountered during the recent installation of monitoring wells), then storage under a unit area of land would be $(45 - 20 \text{ feet}) \times 0.04 = 1.0 \text{ feet}$. This would only equate to 9,000 AF of storage over the 9,000-acre sustainable groundwater area. This falls short of the District's goal to ultimately bank 15,000 AF of water.

Limited Financial Analysis

The Drought Plan is estimated to be the least expensive option for the District to firm up dry year water supplies. Costs are minimized since no new facilities need to be constructed and no fees are paid to outside entities. Fees are paid to local growers for their participation, but the monies stay within OCID and benefit the local farming economy.

The cost to pump groundwater in OCID is estimated to be about \$20/AF. The cost for surface water deliveries is about \$60/AF. So the District will need to subsidize the balance of \$40 per acre-foot to encourage landowners to use more surface water. When retrieving water, the District would pay the participants \$50/AF to relinquish their surface water. Thus, the cost per acre-foot of water banked and retrieved would be \$40 plus \$50 or a total of \$90/AF. This represents a minimum cost, as it does not include administrative costs, consultant costs, or the loss of 5 percent of the banked water to account for groundwater outflow. In addition, it is possible that larger incentives will be needed to encourage sufficient participation from landowners or, if OCID so decides, to fund groundwater well improvements to enable more growers to participate.

Pilot Program

In order to evaluate the Drought Plan on a smaller scale, the District plans to implement a pilot project. The District has proposed their Service Area 9 for the pilot project. This area covers 3,345 acres and is located within the 9,000-acre most productive groundwater area (see Figure 1). The pilot project will allow OCID to evaluate the administrative aspects of the plan, effectiveness of the incentives, willingness of participants, appropriate contractual requirements, impacts to participant operations, and impacts to groundwater levels. The District would need to bank about 2,000 to 3,000 AF and operate the pilot program for several years to get enough data for a meaningful evaluation. The pilot project would be based initially on the concepts described in the previous sections.

PROJECT BENEFITS

Drought Protection

The primary benefit of the in-lieu groundwater banking program is an improvement in the District's dry-year water supply. Without an effective plan some growers may suffer from reduced yields or total crop losses during droughts. The Drought Plan will also provide dry year water at a considerably lower cost than other options such as water purchases and groundwater banking outside of OCID.

Financial Incentives for Landowners

The Drought Plan was developed with incentives to encourage landowner participation. In fact, most participants should realize some profits from participating. The financial benefits would be the price paid to relinquish their surface water (currently proposed at \$50/AF) minus the costs to pump groundwater and costs for any necessary facility modifications or amendment applications. For most growers this should equate to a safe and financially positive arrangement.

The cost of the Drought Plan will probably be financed through slightly higher water fees charged to all surface water users. However, this will result in long-term savings since the District will not have to eventually buy dry-year water for exorbitant prices that would be passed on to the water users.

An additional benefit is that any money expended by the District would be kept local. Thus, the exchange of money would be kept within the boundaries of the District and would benefit the local water users and economy, and not an outside or distant entity.

Local Control

The in-lieu groundwater-banking program would remain under the control of OCID. As a result, they would not be dependent on outside agencies to store or retrieve water, or decisions by outside agencies to increase costs, suspend projects, or not renew contracts.

Reduced Pumping Costs

The Drought Plan will temporarily raise groundwater levels and reduce groundwater-pumping costs for participating landowners. While groundwater is being stored the local groundwater levels will be higher resulting in lower pumping lifts and pumping costs. In addition, OCID plans to leave 5 percent of the banked water in the aquifer to account for groundwater outflow. This amount left behind will also produce higher groundwater levels until this water eventually flows away from the District.

PROJECT IMPACTS

Environmental Concerns

The program will be developed and implemented so there are no significant environmental impacts including long-term and short-term groundwater overdraft. Specifically, additional groundwater pumping in drought years will not exceed the added groundwater storage (resulting from fuller utilization of surface supplies). No permits are known to be necessary to implement the program. Consideration would be given to the location of participating growers so as to minimize the potential for increasing well interference with neighboring wells from short-term higher intensity well usage.

Impacts to Banking Participants

Participating landowners could experience some adverse impacts, but sufficient incentives would be offered to offset the impacts and even make participation financially attractive. Nevertheless, it is important to identify possible impacts so that landowners can consider them when making their decision to participate. Participant impacts could include the following:

- 1) Cost to purchase amendments to use with surplus surface waters. These would include amendments to improve infiltration and commercial fertilizers to replace the higher nitrogen levels of local groundwater. These would be needed due to the differences in surface and ground water quality.
- 2) Costs to construct new facilities (i.e. connection to the District's distribution system, larger well pump) needed to participate in the program.
- 3) Loss of surface water supply in a drought. The participant will agree to relinquish their surface water rights in a drought year. However, this would be accompanied by an increase in groundwater storage to help meet their demands. In addition, the Drought Plan includes a safety net allowing them to default on their agreement either due to extenuating circumstances or by paying a fee.

The impacts will differ for each landowner based on their facilities, water needs, historic water uses, and other factors. The proposed incentives may not make the Drought Plan attractive for all growers, but OCID expects that they will be sufficient for most growers.

Waterlogging

A potential impact could be higher groundwater levels that rise to the point of adversely impacting crops. OCID plans to restrict banking so that groundwater levels do not rise higher than 20 feet below ground surface. In fact, waterlogging does not occur until groundwater levels are less than 10 feet from the surface, but 20 feet was selected so there is a comfortable buffer zone. The District has an existing groundwater level monitoring program, and they recently installed six shallow wells to monitor groundwater levels for the pilot program.

PUBLIC PARTICIPATION

The Drought Plan was developed with input from a Groundwater Advisory Committee (GAC) comprised of District growers and several members of the District's Board of Directors. The GAC played a vital role in the development of the Drought Plan. In the future, the GAC will also assist District staff in overseeing the Drought Plan operations and monitoring.

A public outreach program was also implemented to educate landowners and solicit their comments on the Drought Plan. The public outreach program was not included in the original scope for developing the Drought Plan. Rather, the public outreach program was recommended by a GAC member, who, being a grower, recognized the importance and value of educating landowners on the intricacies and benefits of the program. Three meetings were held with local growers to discuss the project. Several handouts were given to all attendees including: list of Frequently Asked Questions (FAQs), informational brochure, participant worksheet (see Figure 2), and a PowerPoint Presentation summarizing all aspects of the Drought Plan. Results from the outreach program were generally positive, and OCID will probably perform more public outreach to garner further input and support.

CONCLUSIONS AND RECOMMENDATIONS

An in-lieu groundwater-banking program can offer the Orange Cove Irrigation District increased protection from droughts by increasing groundwater storage for use in dry periods. The details of the program will be evaluated and refined during a pilot program. Simulation of the Drought Plan shows that it could provide up to 15,000 AF of water in dry years. However, this quantity of water could not be banked in the local aquifer without causing potential waterlogging problems. The District will only be able to bank up to 9,000 AF of water, which is short of their goal of 15,000 AF of drought protection. While the in-lieu groundwater banking program cannot provide all of the District's needed drought protection, it is the most promising alternative from the standpoint of economics and being under local control. OCID plans to also implement other drought protection alternatives in combination with in-lieu groundwater banking to provide diversified and comprehensive drought protection.

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