McMullin Groundwater Recharge Area Farmer Survey Report

Executive Summary

This report summarizes the findings of a survey of 12 farmers who manage 8,000 acres of high value crops in the lower Kings River Basin of the San Joaquin Valley in California. The survey was designed to assess the perceived benefits and risks of capturing seasonal peak flood flows from the Kings River and holding this water on actively farmed lands to increase groundwater recharge.

Survey results indicate a strong interest in accepting floodwater as long as the farmers have control over quantity and timing, and if it can be demonstrated that crop health and yields will not be compromised by temporary flooding of farmland. We also found that farmers with larger farms are more likely to accept floodwater since they have more flexibility in where to direct the water. However, some farmers would need to upgrade flood irrigation pipelines and other irrigation infrastructure to distribute surface water in quantities sufficient to achieve recharge. Farmers expressed concern about their on-farm costs of these upgrades as well as the potential water management fees associated with collectively administering and delivering floodwater to their farms from the river.

Survey Purpose

This survey was developed to evaluate landowner and farmer willingness to participate in dispersed groundwater recharge opportunities on active croplands with high recharge potential. This on-farm recharge approach is modelled on the success of the Terranova Ranch On-Farm Flood Capture and Recharge Demonstration Project in the lower Kings River basin. The Demonstration Project was able to capture over 3,000 acre-feet of flood water on 1,000 acres of farmland in 2011 without any negative impact on crop yield. This survey evaluated the interest of Terranova's neighbors located in the remainder of the 16,000 McMullin On-Farm Flood Capture and Recharge Project Area (McMullin Area), but offers insights into farmers' views about on-farm recharge on agricultural land throughout the greater Kings River basin.

The success of an expanded on-farm flood flow capture program to recharge the aquifer in the Kings River basin depends on acceptance of the concept by farmers and landowners. Although it is hydrologically feasible to distribute flood flows on farmland, there is still much to consider regarding compatibility with crop management practices and the economic costs and risks associated with taking flood water and spreading it across active farmland for recharge.

Survey Methodology

The agronomic and economic factors assessed though the farmer survey were identified through a review of the Terranova Ranch Demonstration Project. We developed questions to assess the perceived impact of applying floodwater for recharge on crops and the compatibility of this type of water application with current crop irrigation methods, other management practices, and soil type. Questions for an expanded farmer survey were also informed by the work of Toby O'Geen at UC Davis, as well as our contacts at water districts, and technical agencies. Critical topics that emerged included crop sensitivity to flooding, duration of flooding, compatibility with farm operations, weed and crop disease risk, cost of adapting irrigation systems, farmer control of floodwater application, and nitrate leaching.

We developed a draft survey questionnaire of barriers and incentives to farmer acceptance of floodwater for recharge on their farms and distributed to 10 of our farmer, academic, consultant, water agency, and technical partners. We received comments on the draft survey from Don Cameron, Anthony Saracino, and Dave Krietemeyer at the Natural Resources Conservation Service (NRCS) and refined the agronomic and economic questions as a result of their responses.

The Kings River Conservation District (KRCD) provided us with a list of all the growers and landowners in the region and the parcel numbers and we identified 20 grower entities within the 16,000 acre McMullin Area in addition to Terranova Farm. We sent letters to all of the farmers on October 24, 2014, and followed up with phone calls to schedule in-person appointments. 16 of the 20 farmers (80%) responded and we ultimately interviewed 12 of the 20 (60%) (see Table 1 below). The remainder were unresponsive to multiple contacts.

	Number	Percentage
Total farmers in McMullin Area (excluding Terranova Farms)	20	100%
Farmers that responded to request for interview	16	80%
Farmers that completed survey interview with Sustainable Conservation	12	60%
Acres in McMullin Area (excluding Terranova Farms	10,000	100%
Acres managed by farmers that completed survey interview (excluding Terranova Farms)	8,000	80%

Table 1: Survey population and response rate for farmers within McMullin Recharge Area

Joseph Choperena, Senior Project Manager at Sustainable Conservation, conducted in-person interviews with 12 of the 20 farmers on the 10,000 acres adjacent to the Terranova project in the McMullin Area between November 2013 and January 2014. Participating farmers grow grapes, almonds, pistachios, corn silage, and alfalfa on 8,000 acres within the McMullin area and none of these farms currently have access to river water. Several of these farmers grow crops on additional acreage elsewhere in the region where they do have access to surface water but these acres were not included in the findings.

Survey Findings

The survey was divided into the following sections:

- Irrigation Water Availability, Costs and Sources
- Irrigation Delivery Systems, Engineering & Crop Type
- Soil Water Management Issues
- On-farm Groundwater Recharge
- Nutrient Management

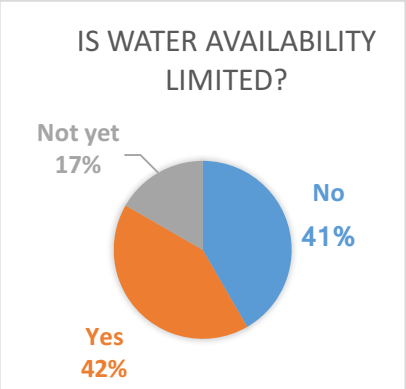
The findings for each section are presented below.

Irrigation Water Availability, Costs and Sources

These questions first explored farmers' general impressions about the availability and reliability of groundwater to meet their agricultural needs. The subsequent questions refine the types of limitations in terms of timing, depth to groundwater, costs of pumping, and water quality.

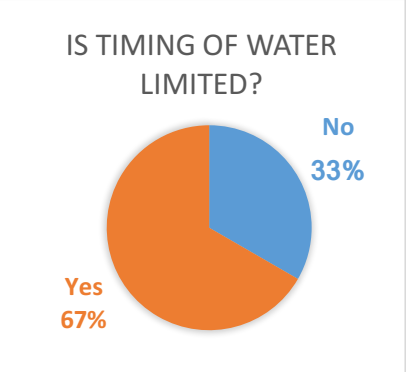
1. Source of Irrigation Water: 100% of the farmers in the survey area rely on groundwater for irrigation purposes. Only Terranova Farms currently has access to river water during flood flows.

2. Limitations on Quantity of Groundwater Available: Five farmers don't have any general limitations on quantity of water available to meet their crop production needs; five do have limitations; two don't currently have limitations but expect they will soon. This dichotomy is even evident with the same grower and on the same ranch. For example, most growers have multiple wells on the same ranch, and while one or two of those wells may have diminishing flow, the other wells may be producing fine. It is fair to say that the majority of growers know that groundwater overdraft is occurring and the problem will continue to worsen. However, some of them still feel that the water is "always there" as long as they can afford the pumping costs.



3. Uncertainty of Groundwater Availability: The farmers were very mixed in their outlook about whether they could rely on groundwater into the future. Only two respondents were confident in the supply of water. Three replied that water availability is definitely uncertain, and three others said it will become uncertain. Uncertainty was noted to be both due to groundwater supply but also as a result of future regulatory restrictions on pumping. Several noted that they could manage uncertainty by drilling deeper.

4. Limitations on Timing of Groundwater Availability: Four farmers always have the water they need; nine have seasonal limitations during summer months. Of the 67% of growers that have supply limitations, some have to pump from greater depths, or reduce use in summer, or manage with less pressure. One farmer has been on his farm for 23 years and the water always recovers after the summer. One has minor supply issues but "can always drill deeper."

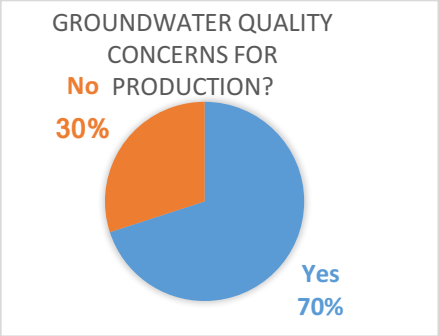


5. Depth of Well: Ten farmers pump from depths of 200 to 250 feet and one farmer is pumping from 980 feet.

6. Need to Drill Deeper Wells: Eight growers (67%) have needed to drop the bore of their current wells or drill new wells in the past five years.

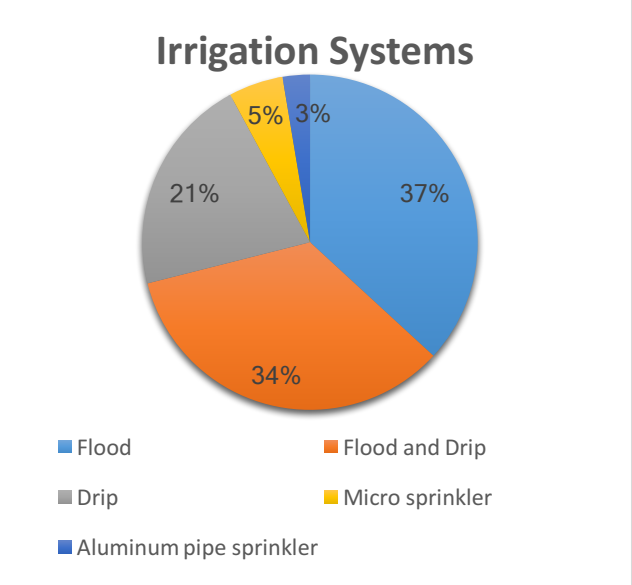
7. Water Pumping Expenses: The cost of pumping is going up as the depth to groundwater increases due to overdraft. Eleven of the interviewees stated that water is a significant portion of their production expenses, ranging from 10% to 30% of their total cost of production. One of the larger ranches in the region cited that their annual utility bill for groundwater pumping alone is over $1M (more than $770 per acre), and that $500,000 is spent on well maintenance every 2.5 years.

8. Groundwater Quality: Seven growers have concerns about the quality of the groundwater they are receiving from their wells and its impact on crop production. Only three farmers do not have these concerns, and one of them thinks problems are coming. The water quality constituents of concern are salts, boron, and pH. The groundwater quality was so poor for one farmer that he had to pull out his almonds due to salt concentrations. Some farmers noted that the water quality has declined as they have pumped from deeper depths.



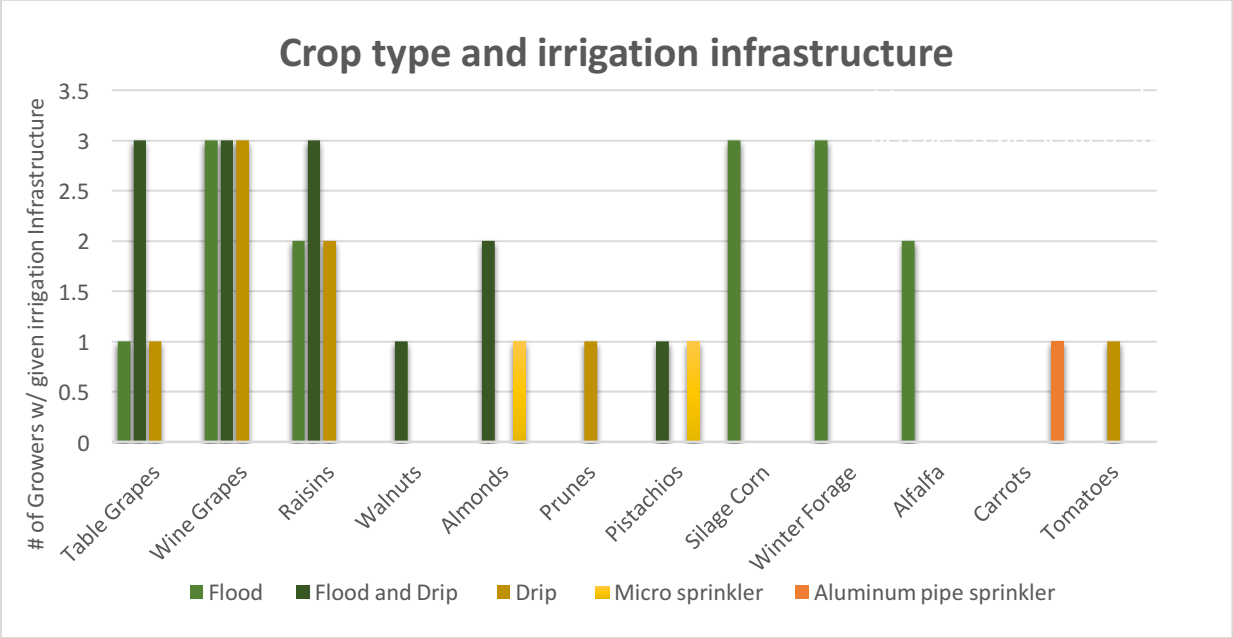
Irrigation Delivery Systems, Engineering & Crop Type

Farmers surveyed in the McMullin survey area use a variety of irrigation systems on the different crops they farm. Of the 38 crop-irrigation system combinations on the 12 farms surveyed, 13 (34%) have capacity to apply water through both drip irrigation and flood irrigation[1]. These dual systems were concentrated in grape production and nut trees. The remaining 25 crop-irrigation system combinations (66% of the total), have irrigations systems set up to irrigate only through one delivery system. but 14 of these (37%) currently use flood irrigation as the primary system for water delivery. These farms will be able to use flood irrigation systems to distribute floodwater from the river for recharge. For seasonal river floodwater to be applied for recharge on all of the acres in the McMullin area, only 11 crop-irrigation system combinations (29%) will need to have new flood irrigation distribution infrastructure installed. Those that currently use flood



[1] *Flood irrigation* in this report refers to the method of applying pumped groundwater through furrows on annual row crops or across the field for alfalfa and between tree and vine rows. This is distinct from the application of river *floodwater for recharge*, though the water conveyance infrastructure can serve both functions. Also, flood irrigation applies water at optimal agronomic rates whereas river floodwater distribution for recharge is intended to apply greater quantities to the field.

irrigation may still need to upgrade the capacity of the ditches and head gates to make full use of river flood flows.



Soil Water Management Issues

The McMullin Area offers good recharge potential due to the predominantly fine sandy soils that occur on more than 90% of the 16,000 acre area. To assess whether these soils could pose agronomic problems when additional floodwater is applied for recharge, farmers were asked several questions to assess whether current conditions indicate excessive soil moisture problems.

1. Fungicide or Pesticide Use for Soil Pathogens: The farmers were asked if they apply fungicides or pesticides to address crop pathogens as a result of excessive soil moisture. None of the growers interviewed typically apply fungicides or pesticides due to effects of excessive soil moisture.

1. Mealy Bug Problems: Mealy bug infestations are considered an indicator of excessive soil moisture or humidity. Nine of the 11 growers (81%) that responded to this question did not have problems with mealy bugs in 2011, a year of heavy rains. Several of the growers have had mealy bugs effect their crops, but not in 2011. It is worth noting that the growers interviewed do not think the mealy bugs are related to excessive water/flooding conditions, but that they were brought into the area through machinery and laborer's clothing. Varieties of this pest have been found in both vineyards and pistachios orchards. Farmers assert that falling of trees by wind may be a better indicator of excessively wet soil.

2. Economic Concerns: Farmers had two categories of economic concerns. Two-thirds of respondents were concerned with the added costs of distributing water across fields (including the cost of pumps, ditches, dikes, and labor), and said that these costs would need to be equal to or less than their current costs of pumping water. The other economic concern was with reduced yields if they were required to apply the water at inappropriate times for

their crop or field operations. If they could control the timing, the majority were not concerned about declines in crop yield or quality.

3. Motivating Factors: The farmers in the McMullin Recharge Area are very motivated to implement a groundwater recharge program, and they responded positively to the motivating factors presented in the survey. The majority of the interviewees stated that if the following benefits could be assured as a result of increased groundwater recharge, they would very likely be motivated to participate in an on-farm recharge program:
    - Sustained groundwater availability for use by farmers;
    - Improved water quality for irrigation of crops through dilution of salts and minerals;
    - Reduced pumping costs due to raised water table;
    - Improved groundwater quality through dilution of nitrates; and
    - Less regulatory scrutiny of farming activities.

    The majority also said they would be very motivated if they could be provided with:
    - Reliable information addressing their concerns; and
    - Cost share payments for constructing water conveyance systems.

    Regarding governmental financial support, some of the farmers feel that recharging the aquifer is a public good and therefore the costs should be incurred by a broad range of stakeholders like communities, environmental groups, and farmers.

4. Control of Time and Duration of On-farm Recharge: Farmers were asked if they would be dissuaded from participating in an on-farm recharge program if it required them to take storm/floodwater at unspecified times and durations during the flood season. This requirement could occur if funding was secured from a public flood prevention program and required flood easements in order to secure use of the water. Eleven (92%) of the farmers interviewed do not want to be required to take storm/floodwater at unspecified times and durations during the flood season. This is because such an agreement could influence their farming practices and potentially eliminate an entire growing season, or permanently damage or kill perennial crops. The only ranch that did not object to this is a dairy that has a lot of annual crop acreage. The dairy owner stated that he would sacrifice growing corn silage (a lower value crop) in order to maximize the amount of water recharged to the aquifer, and would purchase feed grown elsewhere. Another farmer stated that their ranch is large enough that they could move the water around and not have to sacrifice their cultural practices or experience decreased yields.

5. Terms of Management: The farmers were asked if they would be more likely to participate in an on-farm recharge program if they had various types of control over the amount, timing, and placement of floodwater delivery.

More likely to participate if you could:	**YES**	**NO**
Specify maximum amount of floodwater grower is willing to use per flood event?	12	0
Specify certain fields for recharge any time floodwater is available?	10	2

Specify the number of acres for recharge any time floodwater is available but retain choice of which fields?	9	3
Dedicate land as permanent recharge basin rather than flooding cropland?	0	12

All the farmers surveyed said they would be most likely to participate if they could specify a maximum amount of floodwater they would be willing to receive for recharging their cropland per flood event or per year. The options of specifying certain fields or the number of acres were slightly less popular. All interviewees stated that they would not devote land on their ranches to be permanently converted to dedicated recharge basins. Even the dairy operator that said he would sacrifice an entire growing season to maximize recharge, stated that he was not interested in permanently converting land to a recharge basin, because he would prefer to still grow crops on that land during dry years. However, it is worth noting that one grower stated that he would consider pulling out half of his 80 acre vineyard and converting it to a dedicated recharge basin, if it would ensure long-term water sustainability for his ranch and the local area. This landowner is additionally motivated because multiple generations of his family live on the ranch and he is very interested in their farm's long term viability for his children and grandchildren.

6. Funding Incentives: Although there are not currently any funding incentives available to encourage on-farm recharge, the farmers were asked if they would be willing accept any of the following incentives to help motivate them to participate:
   - Annual easement payment in exchange for using crop land for recharge in wet years;
   - One time easement payment to convert some acreage to a dedicated recharge basin;
   - One time easement payment to dedicate some of your land for conveyance canals to transport water to other properties with other soils suitable for recharge;
   - Payment for actual yield loss in flood years;
   - Payments from migratory bird conservation groups to hold water on field for more than two weeks.

   Eight of the 12 farmers are "likely" and "very likely" to be motivated by annual easement payments in exchange for using cropland for recharge in wet years. This is the most likely incentive to motivate participation. There were very mixed opinions among these farmers about whether they would be motivated by a one-time easement payment to dedicate some of their land for conveyance canals to transport water to other properties with other soils suitable for recharge. There was also a strong split amongst the group on receiving payments for actual yield loss in flood years. About half the group is not interested in this because they grow permanent crops and wouldn't want to accept a one-time crop loss payment if the flooding could potentially cause long-term effects to their trees or vines. The other half of the group would appreciate payments for yield losses as long as long-term crop health issues were not expected, or if payments were for impacted annual crops.

   This group of farmers would not at all be motivated by payments from migratory bird conservation groups for holding water on their fields for more than two weeks, or at the prospect of receiving a one-time easement payment to convert some acreage to dedicated recharge basins.

7. Program Administration: Capturing floodwater from the river and managing distribution to farmers in the McMullin Area would require an entity to administer the on-farm recharge program. Farmers were asked what type of organization they would prefer to run the program.

   The vast majority of farmers interviewed feel that a third party, local group, or agency that is responsive to local grower's needs and that will keep their best interests in mind, would be best suited to administer an easement or payment incentive program for on-farm recharge. Approximately five growers stated that KRCD could play this role and one mentioned NRCS. It should also be noted that two farmers specified that a local, existing irrigation district (ID) would be better suited than KRCD. The reasoning for this is that the ID would be just focused on the recharge group's territory and specific needs, whereas KRCD's view would be much broader, incorporating numerous districts, due to their regional objectives. One of these growers specifically mentioned Raisin City ID for this role. This grower said that Raisin City ID was originally created to convey surface water throughout the district, should surface water someday become available.

Nutrient Management

These questions assess farmers' concerns about the potential impact of on-farm recharge on nutrient levels in groundwater which have become a significant issue in recent years in the San Joaquin Valley and Tulare Lake Basin. Increased movement of water through the soil profile has the potential to leach current and legacy nitrates into groundwater, though preliminary modelling suggests that the net effect of floodwater application will dilute nitrate concentrations in groundwater (Bachand et al 2012. The questions here also assess the potential effect of on-farm recharge on farmers' current nutrient management practices.

1. Nutrient Leaching to Groundwater: Nine (75%) of the growers interviewed do not have concerns about nutrient leaching to groundwater from their current farming operations. One of the farmers did express concern because he owns a dairy and is familiar with the Water Board's stringent Dairy General Order, which limits the amount of nitrogen that dairies can apply to their fields. However, the other dairy in the MRA is not concerned, because he has a sufficient cow to land ratio and needs to supplement his manure nitrogen with commercial fertilizer. Another grower expressed concern about nitrogen leaching because he uses a lot of manure in his vineyard. He realizes that the organic nitrogen in the manure is not available to the vines when applied to his fields, and it could leach later in the year when the vines are not taking up nitrogen. Finally, one grower is not concerned because the depth to groundwater ratio is so great, approximately 230'.

2. Irrigation Management to Reduce Nutrient Leaching: Seven (64%) of the 11 growers that answered this question said that they manage their irrigation water to reduce nutrient leaching to groundwater. These growers attributed this to not overly applying irrigation water and nutrients, whether through the use of drip irrigation, soil moisture probes, or just closely managing water and nitrogen because they're valuable resources.

3. Soil and Tissue Sampling to Determine Fertilizer Needs: All of the farmers interviewed take soil samples to determine fertilizer needs and timing. However, they rely much more heavily on plant tissue sampling to meet their crop's nutrient requirements. The majority of the growers interviewed take soil samples every couple of years, whereas they have tissue analysis conducted at least annually, and often more frequently. One of the farmers explained that the salts in the soil at McMullin can tie up the micro- and macro-nutrients, making soil analysis not as informative as plant tissue sampling.

   All of the farmers also test for salts along with a whole range of other nutrients and minerals as part of their overall soil and crop fertility management systems.

4. Nitrate Leaching with On-farm Recharge: Ten (83%) of the growers interviewed stated that they do not have any concerns about increasing nutrient leaching to groundwater should they apply floodwater to their land to increase recharge. The few detailed responses to this question justified this by again stating their nutrient application efficiencies.

5. Loss of Residual Nitrogen: Eleven (92%) of the farmers interviewed said they do not have concerns about losing residual nitrogen in their soil when recharging water. Some of the justification for this was that grapes, one of the primary crops in this region, do not require much nitrogen, and that with fertilizer efficiency, nitrogen is not building up in the soil. They also feel that being able to capture the water would be worth the risk of losing a small amount of fertilizer.

6. Loss of Fertilizer vs. Groundwater Contamination: The farmers were asked if they were more concerned with the potential impacts of nutrient leaching on groundwater or the loss of valuable fertilizer for their crops. Seven (64%) of the 11 farmers who responded stated that they are more concerned about impacts on groundwater quality than the loss of a valuable fertilizer source. Two farmers (18%) said that they are concerned about both factors, and two (18%) stated they are not concerned about either.

Summary and Conclusions

The growers in the McMullin Recharge Area are very interested in receiving flood water for recharge or for irrigation in lieu of pumping groundwater. However, they have several significant concerns that must be addressed in the development and administration of a flood water distribution system.

1. Control of amount and timing of water received:
   - They are only willing to participate if they have control over the amount of water and timing of floodwater applications.
   - All farmers will gladly accept river water for agronomic rates of irrigation in lieu of pumping scarce groundwater and many will take more if they have control.

2. Uncertain risk to crop yield and plant health:
   - They will not risk short-term yield declines or their financial investment in permanent crops by over applying floodwater, despite how desperate they are to replenish groundwater.

- Acceptance of higher volumes of water to accelerate recharge will require greater certainty about the threshold for potential yield reduction or plant damage.

3. Lack of flood irrigation infrastructure:
   - Some of the farms have converted to high-efficiency irrigation systems and no longer have the infrastructure for flooding their fields, so this would be an additional set-up and management cost.

4. Program administration and future requirements:
   - All of the growers want to ensure that the program is administered with the farmers' best interest in mind, and some were concerned about future unforeseen regulations that could develop.
   - Farmers are interested in incentives that compensate them for the use of their land to recharge groundwater in wet years but only if they retain control of where and when they accept water. They feel that their recharge efforts will benefit others and there should be some mechanism for compensation.

We have learned from the farmers we interviewed that they will need greater information about the following issues before they can make the critical decision about whether to flood their land.

1. Crop Compatibility: Available research on this issue has not evaluated well-drained sandy soil conditions typical of high-recharge potential areas of the Kings Basin. Farm Advisors discourage flooding of cropland during the growing season despite the experiences of Terranova Farms and other farmers who have experienced flooding of their crops.

2. Nitrate Leaching Risk: Research now underway with financial support of the California Department of Food and Agriculture to model the leaching and dilution effects of on-farm recharge and provide assurances to farmers that they will not increase their regulatory liability by participating in an on-farm recharge program.

3. On-Farm Water Infrastructure and Management Costs for Different Crops: Some farmers will need to invest in setting up floodwater distribution infrastructure, and are concerned that the return on their investment may not pay off if water availability is infrequent.

4. Flood Water Delivery Costs: Growers in the McMullin Recharge Area need to know how much it will cost to get water from the river to the field's edge. This includes the cost of canals, pipes, and pumps to deliver floodwater to the farms.

5. Water Rights and Grower Requirements: Farmers will need greater certainty from KRCD and KRWA about the terms of a floodwater delivery program.

These survey findings about farmer interest in adopting this water management strategy will be combined with a growing body of information being collected by Sustainable Conservation and other California Water Foundation grant recipients:

- Hydrologic assessments of flood water availability and recharge potential (RMC, UC Davis, and HydroMetrics/KRCD);
- An engineering cost study of the needed on-farm irrigation infrastructure for flood flow dispersal (Sustainable Conservation);
- A literature review and expert recommendations on crop compatibility with flooding (Sustainable Conservation);
- An analysis of nitrate leaching risk to groundwater (TetraTech, UC Davis, LSCE, KRCD and Sustainable Conservation).

This information will inform a regional economic assessment of costs and benefits of alternative groundwater recharge strategies including on-farm flood flow capture. Widespread engagement of landowners, farmers, and irrigation districts to better manage groundwater resources through recharge on farmlands and dedicated recharge basins will hinge on several factors. One will be the availability of data on the potential return on investment for farmers' participation in the program. They will also need specific guidance to assist in their decisions to invest in infrastructure and flexible irrigation management systems.

References

Bachand P.A.M., W.R. Horwath, S. Roy, J. Choperena, and D. Cameron, Implications of Using On-Farm Flood Flow Capture To Recharge Groundwater and Mitigate Flood Risks Along the Kings River, CA. 2012. Bachand & Associates