ANALYZING COST EFFECTIVENESS FOR KINGS BASIN FLOOD FLOW RECOVERY

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Introduction

This report summarizes the economic modeling approach and resulting cost estimates for a set of project configurations to capture floodwater in the Kings River Basin for groundwater recharge. The cost models include all infrastructure and operating costs over the lifetime of the project, as well as probable floodwater availability to arrive at estimates of total cost, annualized total cost and total cost per expected acre-foot (AF) per year of groundwater recharge. The remainder of this report outlines specific cost assumptions used in the model and presents results across the set of project configurations for comparison.

Project configurations covered in this analysis include a dedicated recharge basin as well as multiple on-farm recharge set ups—(i) temporary infrastructure, (ii) permanent infrastructure with purchase of a new pump, and (iii) permanent using an existing surface supply or booster pump. Specific assumptions for each of these configurations are outlined in the following section.

The model was initially constructed based on assumptions made in the Summers Engineering report that booster pumps would be required to flood the entire field area. However, based on field interviews with growers Sustainable Conservation determined that pumps may not be necessary to flood the fields. This analysis therefore includes additional scenarios for the temporary and permanent infrastructure cases where no pumps are used and the fields are gravity fed.

The report first describes the underlying assumptions and data for each of the configurations evaluated. Then the costs per acre-foot recovered are calculated for each configuration. These costs are compared to assess the break-even point at which differences in flood flow probabilities favor one configuration over another. These comparisons are shown in three different ways.

Finally the cost estimates presented here are compared to a similar one prepared using data from Terranova Farms for the same configuration. That comparison shows that the Terranova costs are in fact quite comparable with those prepared in this report, ranging between $90 and $120 per acre-foot.

Based on the analysis presented here and using a common flood flow probability of 38%,[1] the cost per acre-foot recovered per year ranges from $60 to $120 per year. The range is narrow

[1] While 38% was used as a common assumption for the entire basin, flood flow availability varies considerably from the east to the west side of the basin. This parameter can be adjusted in the model to look at individual situations.

enough and the uncertainty of construction costs sufficiently large that these costs probably overlap with each other across different settings. Yet notably, the costs are fairly similar with different data sources indicating that a rough estimate of $100 per acre-foot recovered per year is a useful heuristic for planning purposes.[2]

Summary Table: Annualized Cost per Acre-Foot

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
NPV Total Cost per AF per Year	$119	$107	$99	$96	$89	$61

Model Assumptions and Data

This section explains specific parameter assumptions for each project configuration covered in this analysis. Assumptions cover the costs of constructing and operating the project, the size and operating limitations of the project, and probable floodwater flows that are likely to be available for each project.

In general, the model is constructed to allow these assumptions to be changed easily (e.g., field size, infiltration rate, flood flow probability) based on the improved estimates or changes in project design. By searching for the specific assumption outlined below in the 'Parameter Assumptions' portion of the spreadsheet model, and entering a new value in the corresponding cell, users can explore how changes to project assumptions affect overall cost estimates. For ease of use the parameter assumptions that are input directly into the model and may be adjusted are highlighted in yellow in the accompanying Excel spreadsheet. The model is not yet structured to scale infrastructure costs

On-Farm Configuration Assumptions

In the on-farm configurations, infrastructure would be put in place to implement flooding of cropland for groundwater recharge. This set of models uses criteria for typical farms in the Kings River Basin as identified in the Summers Engineering Report for Sustainable Conservation.

1. **Field size**
   Initial calculations have been carried out for the 160-acre field configuration, based on the configurations outlined in the Summers Engineering report.
2. **Desired flood depth**
   This parameter is set at 12 inches, according to the value used in the Summers Engineering Report. This value can be varied directly in the model if desired, however changes to flood depth are accompanied by changes in infrastructure and operating costs (see Table 1 of the Summers Engineering Report) that are not automatically scaled in the model. Therefore making changes to flood depth in the cost model should be done with caution.
3. **Infiltration rate**
   This parameter is set at 3 inches/acre/day but can be varied in the model if desired.
4. **Days to desired flood depth** (12 inches)

[2] See the comparison with Bachand analysis using data from Terranova Farms which arrives at costs in a similar range.

This is calculated based on the infiltration rate and pump rate. The pump rate is held constant at 4.2 inches per day, the rate that would be needed to achieve a 12 inch flood depth in 10 days under the base configuration used in the Summers Engineering Report. The model constrains the total amount of time that fields are flooded to 14 days (the time that has been determined by previous studies to have no detrimental effect on the land). Therefore the 'days to desired flood depth' value is constrained to 14 days minus 'days to drain down to desired flood depth'.

5. **Days to drain down desired flood depth** (12 inches)
   This is calculated based on the infiltration rate. For the 3 inches/acre/day scenario, it takes four days to drain down 12 inches of flood depth. This will vary with changes in the infiltration rate.
6. **Days per cycle**
   Total days per cycle are calculated as the days to desired flood depth and the days to drain down the desired flood depth. In the base case 10 days and 4 days result in a total of 14 days per cycle.
7. **Number of cycles per flood year**
   According to the Summers Engineering Report, an average of 3 cycles can be completed in years that floodwater is available.
8. **Probability of flood flows**
   The probability of flood flows being available in a given year is 38%, based on information in the Summers Engineering report that historically flood water releases on the Kings River have been made in 23 of the last 60 years. This value can be varied to reflect different hydrological data.
9. **Available flood flows per flood year**
   Flood flow assumptions are based largely on assumptions in the Summers Engineering report and are the same for both temporary and permanent configurations. Fields can be flooded up to three times per year, with an infiltration rate of 3 inches per day.[3] Total flood flow capture in years when flood water is available is then calculated as the infiltration rate (3 inches per day) times the area (160 acres), number of days of infiltration (14 days), and the number of cycles (3), or 1,680 acre-feet. With an expected flood water availability probability of 38%, this implies that such a facility would capture an average of 638 acre-feet or four acre-feet per acre over the extended period.
10. **Berm construction**
    Temporary berm construction is assumed to be necessary in both the temporary and permanent configurations and costs are based on assumptions in the Summers Engineering report. Berm construction falls under operating costs, which only take place in flood years. Berm construction cost is assumed to be $1,200. We assume that berms will be constructed from scratch at the beginning of each season when flood flows occur and that approximately one-half of berms will require reconstruction twice throughout the season (once after each of the first two cycles). To simplify these assumptions, we assume that total berm construction occurs twice.
11. **Irrigator Labor**
    These costs are based on assumptions made in the Summers Engineering report. Labor was assumed to be $15/hour (including benefits) and one man-hour of labor is required per acre. The irrigation block refers to the area within the temporary berms constructed

[3] This is equivalent to 0.25 AF per acre per day

in item 10, and is a subdivision of the 160 acre field that would have its own berm and flood water application management. Therefore 3 cycles per year for a 160 acre block amounts to $7,200.

12. **Ripping and Gypsum Costs**
Ripping and Gypsum costs were taken from assumptions made in the Summers Engineering report. These costs were estimated at $80/acre based on actual expense records from a local farm deemed to be representative and take place once per year only in flood years.
13. **Discounted Cash Flows and Net Present Value**
The net present value (NPV) of streams of future costs over 20 years are annualized to an equivalent annual payment using a discount rate of 4.4% from the 10-year average return on assets as reported by the USDA. To compute the cost per acre-foot recovered, the NPV of the annualized cost is divided by NPV of the expected annual flood flows per season, as calculated in assumption #9 above (e.g., 1,680 AF/year * 38% probability).[4]

Temporary Cost Assumptions

In the temporary on-farm configuration, pipe and pump infrastructure is rented, with no permanent construction taking place at the project site.

1. **Infrastructure Costs**
Pump and surface pipe infrastructure rental cost assumptions are taken from the Summers Engineering Report.
2. **Pump Operation**
In the temporary configuration pumps are assumed to be diesel operated. Pump fuel costs are based on current 2015 diesel cost estimates from EIA, converted from $/MMBTU to $/gallon. It is assumed under the temporary configuration that the entire field is fed by pump and that each pump can serve 40 acres, requiring 4 pumps for the entire 160-acre field. The pumps are operated a total of 120 pump-days per flood year (3 cycles * 10 days of pumping * 4 pumps). It is assumed that the pumps operate for 24 hours during the pumping periods. Assuming a 13 HP pump, a fuel consumption rate of 3.27 gal/hr. is calculated. This yields a total pumping fuel cost of $32,423 in the first year of operation.
3. **Gravity Fed**
The gravity-fed case includes all assumptions from the other temporary scenarios, but with zero pumping costs for both infrastructure and operations.
4. **Present Value Calculations**
Annualized costs are calculated by escalating current (2015) cost estimates over the 20-year period, using a cost escalation factor of 2.5% in the case of temporary infrastructure costs, and 2.6% in the case of temporary operating costs (reflecting diesel fuel prices). Escalation rates were derived as weighted averages of the subcomponents of labor, construction and energy prices.[5] The net present value of this stream of future

[4] This is the same method used to calculate the monthly payment on a home mortgage: the NPV of a house payment divided by the NPV of the years of the term of the loan.

[5] Labor and construction escalation are based on the implied inflation rate in the U.S Treasury TIPS bonds plus 0.5% in real escalation. The diesel fuel price escalation is taken from the U.S. Energy Information Administration's 2014 *Annual Energy Outlook*.

costs is then annualized to an equivalent annual payment using a discount rate of 4.4% from the 10-year average return on assets as reported by the USDA.

Permanent Cost Assumptions

In the permanent on-farm configurations all necessary infrastructure is constructed at the project site rather than rented annually.

1. **Infrastructure Costs**
   Permanent infrastructure costs are taken from the Summers Engineering Report. For the two different permanent configurations—one with purchase of a new pump and one that makes use of an existing pump, infrastructure costs are identical for removing the existing irrigation system, furnishing and installing a 24” canal gate, furnishing and installing PVC pipe and furnishing and installing irrigation valves. However, only the configuration with a new pump purchase includes the cost of the pump, lift pump stands and F&I electrical service and control panel. Under the configuration where an existing pump is used these costs are zero.
2. **Lift Pump Power**
   The permanent configuration model assumes that half of the total acreage uses gravity-fed flood irrigation, while the other half of the total acreage will require pumping water onto the fields. The cost of operating the pump is identical between the existing pump and new pump configurations. As in the temporary cost model, pump energy is calculated as the energy to raise the total volume of water used 10 ft., where the total volume used is calculated as the infiltration rate (3 inches per acre in the base case) times the area (0.5* 160 acres), and number of days of infiltration (14 days total in the base case) over the three cycles.[6] We then apply to this total energy usage an average winter electricity rate based on current PG&E electricity rates for small agricultural users (AG-4). We calculated the winter average electricity rate[7] based on the following parameters and a 21 kW pump. We assume a 60% pump efficiency rate, which can be varied in the model.

Summer usage:	65%
Winter usage:	35%
Summer capacity factor:	45%
Winter capacity factor:	70%

3. **Gravity Fed**
   The gravity-fed case includes all assumptions from the other permanent scenarios, but with zero pumping costs for both infrastructure and operations.

[6] As noted previously, the model can vary the infiltration rate, holding period, flood depth and other parameters to arrive at different values. This analysis is based on one set of parameters provided by one study.

[7] Winter season runs from October 31 to May 1. We assume little on-farm flooding would occur in May because that would impinge on the growing season. PG&E may shorten the season to run from June 1 to September 30.

4. **Present Value Calculations**
   Annualized costs are calculated in a similar manner as temporary costs above from weighted averages, using a cost escalation factor of 2.5% and 1.9% for infrastructure costs and operating costs (reflecting electricity prices), respectively.[8] These escalation factors differ from those used in the temporary configuration because the temporary configuration operates on diesel fuel while the permanent configurations operate on electricity. The prices of these two inputs are expected to escalate at different rates.

Dedicated Basin Configuration Assumptions

The dedicated basin configuration consists of permanent construction of a groundwater recharge basin for the sole purpose of recharging excess floodwaters. Once again the model is constructed to allow assumptions to be changed easily (e.g., field size, infiltration rate, flood flow probability, etc.). The model is not yet structured to scale infrastructure costs.

1. **Basin Size**
   This analysis relies on two projects. The first is the recently completed Laguna Irrigation District Groundwater Recharge Project 168. The gross site acreage used is 52 acres, and the basin floor acreage used for actual recharge activity is 41 acres. The second is the Tulare Irrigation District's Swall Basin. The footprint is 135 acres but the recharge portion was not provided. The costs per acre are close for these projects ($132 for TID and $146 for LID), so the average of these costs are used here to compare to the other configurations..
2. **Flood Flow Probability and Availability Assumptions**
   Flood flow assumptions are based largely on the project description document for LID; we did not have similar parameters for TID so we assumed similar conditions. According to the study by Provost and Pritchard, in wet years floodwater is available 121 days on average. Based on the same study, floodwater is available in 35% of years based on historical data from 1954 to 2011. However, for ease of comparison the initial model uses a 38% probability of flood flows according to the assumptions for the on-farm configuration. Note that this probability can be varied in the model.
   An infiltration rate of 18 inches per acre per day is identified in the project description. In order to be conservative and based on advice from Sustainable Conservation, we use an infiltration rate of 6 inches per acre per day[9], which is based on average percolation rates for Fresno Irrigation District basin projects. Total flood flows are then calculated as 6 inches per day infiltration rate * 41 acres basin floor * 121 days, or 2,481 AF per flood year. Based on a 38% chance of any given year being a wet year, this yields expected flood flows per year of 951 AF.
3. **Construction Costs**
   Construction Costs are actual costs provided for each project. Where unit costs are appropriate and available from the engineering report, these are included in the cost estimation model and can be varied in the model as necessary.
4. **Operating Costs**

[8] Labor and construction escalation are based on the implied inflation rate in the U.S Treasury TIPS bonds plus 0.5% in real escalation. The electricity rate forecast is taken from the California Energy Commission's *California Energy Demand 2014-2024*.

[9] This is equivalent to 0.5 AF/acre/day.

Operating costs are based on historical basin operation costs in Laguna Irrigation District and applied to the TID basin as well. Operating costs include mechanical weed control, chemical weed control, earthwork, and operations. Historical costs across six basins and gross basin acreage were used to calculate an average historical cost per acre. For all cost categories except for operations, all six basins were used to calculate average costs. However, for operations, costs vary significantly depending on whether the basin is operated annually as a regulation basin (based on average 90 day water run) or used only during excess water events (based on 30 days average). Operating costs used in the model are the average across those basins used only during excess water events as these are more similar to the way the Laguna ID basin would be operated.

5. **Gross Site Acreage**
   Operating costs are calculated on a per acre basis, using gross site acreage as opposed to basin floor acreage. Note that the distinction between gross and basin floor acreage was not available for the TID project.
6. **Discounted Cash flows and Net Present Value**
   The net present value of streams of future costs over 20 years are annualized to an equivalent annual payment using a discount rate of 4.4% from the 10-year average return on assets as reported by the USDA. To compute the cost per acre-foot recovered, the NPV of annualized total cost is divided by the NPV of expected annual flood flows per season, as calculated in assumption #2 above (i.e., 2,481 AF/ flood year * 38% probability).

Cost Calculations

Total costs across all six configurations: (1) Dedicated basin, (2) Permanent with purchase of a new pump, (3) Permanent with use of an existing pump, (4) Permanent gravity fed, (5) Temporary pump rental, and (6) Temporary gravity fed are calculated both as the NPV of the total stream of costs over the 20-year period, taking into consideration how costs are likely to escalate over time, as well as the equivalent annualized cost. Both of these calculations are presented in Table 1 below. Total costs range from $540,000 in the temporary configuration with gravity-fed flooding to $1.5 million in the dedicated basin configuration. These are equivalent to a range in annualized costs from $39,000 under the gravity-fed temporary configuration to $113,000 under the dedicated basin configuration.

Table 1. Total Cost and per Acre-Foot Cost Calculations

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
NPV Total Cost	$1,545,000	$944,000	$871,000	$850,000	$784,000	$540,000
Annualized Cost	$113,000	$69,000	$64,000	$62,000	$57,000	$39,000
Annualized Cost per AF	$119	$107	$99	$96	$89	$61

Annualized present value per acre-foot cost estimates range from $61 for the temporary, gravity-fed configuration to $119 for the average of the dedicated basin configurations. The estimates for the other permanent and temporary configurations are in the middle of the range from $89 and $107.[10] An important observation is that this range is sufficiently narrow that one

[10] Per acre-foot cost estimates can be calculated in two different ways, which result in equivalent values. One is by dividing the total annualized cost by the annual probability-weighted calculation of flood flows ((a) 1680 acre-feet multiplied by 38% probability of

option does not dominate over the others in all situations. These relative costs will change with differing circumstances.

Total costs presented in Table 1 are calculated as the sum of infrastructure construction costs and operating costs. A breakdown of infrastructure and operating costs that make up the total costs presented above is shown in Table 2.

Infrastructure costs are upfront construction costs. Calculations of NPV and annualized payments take into consideration financing this cost of construction over the 20-year period. Operating costs take place only in years when flood flows actually become available. Therefore the initial annual operating costs are calculated as probability-weighted costs or the expected value of costs based on a 38% chance of flooding in a given year. That probability-weighted initial cost is then escalated over the 20-year period according to the assumptions listed above to arrive at the NPV and annualized total operating costs.

Infrastructure costs range from $398,000 to $1,426,000 for the temporary configuration and the dedicated basin configuration, respectively. Permanent on-farm configurations have infrastructure costs in the middle of this range at $781,000 for the permanent configuration with a new pump and $708,000 for the permanent configuration with an existing pump. These are equivalent to an annualized cost of $57,000 and $52,000 for the permanent configurations with and without an additional pump. For the temporary and dedicated basin configurations, annualized infrastructure costs are $29,000 and $124,000 respectively. Operating costs are actually higher in the temporary configuration because we assume that the rented pump runs on diesel, which is more expensive to operate than electric pumps under the permanent configurations and that four pumps will be needed to cover the 160-acre field. Permanent configurations have the same operating costs since we assume that costs of operation are the same whether a new pump or an existing pump is used to move water onto the field. The dedicated basin configuration has the lowest operating costs. Operating cost estimates therefore range from nearly $120,000 in the dedicated basin configuration to nearly $386,000 in the temporary configuration. These are equivalent to annualized costs of nearly $9,000 in the dedicated basin configuration and over $28,000 in the temporary configuration.

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flooding in a given year or 644 acre-feet in the permanent and temporary scenarios; (b) 2481 acre-feet multiplied by 38% probability of flooding in a given year or 951 acre-feet in the dedicated basin scenario). The other is by dividing the NPV of total costs by the NPV of total flood flows over the lifetime of the project. The NPV of the flood flows calculation assumes that water stored in the current year is more "valuable" than water stored in the future and discounts those future flows. This is based on the premise that dollars do not have real value on their own—they represent value embedded in other things such as labor, land and water, so each of those should be discounted in the same fashion. The two approaches yield equivalent estimates of total cost per AF of water recharge.

Table 2. Total Infrastructure and Operating Costs

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
Infrastructure Cost--NPV Total Cost	$1,426,000	$781,000	$708,000	$708,000	$398,000	$398,000
Infrastructure Cost--Annualized Total Cost	$104,000	$57,000	$52,000	$52,000	$29,000	$29,000
Operating Cost--NPV Total Cost	$120,000	$163,000	$163,000	$142,000	$386,000	$142,000
Operating Cost--Annualized Total Cost	$9,000	$12,000	$12,000	$10,000	$28,000	$10,000

Cost estimates vary somewhat from those made in the original Summers Engineering report. The individual components of temporary infrastructure cost estimates are the same as those in the report, however, applying a 38% chance of flooding in any given year rather than the simplified 33% used in the report and taking the annualized cost of the NPV result in a final estimate that is higher. Temporary operating costs are lower than those estimated in the original report, mainly because the original report overestimates fuel costs by double counting pump-days of operation. In the permanent configuration with a new pump, infrastructure and operating costs are close to those estimated in the original report. The main differences arise from our estimation of lift pump power costs based on EIA fuel price forecasts and our methodology for annualizing total costs based on NPV. Total annualized costs are higher than those estimated in the original Summers Engineering report, $72,000, but only by about $3,000 or about 4.2%.

Break-even Comparisons among Flow Recovery Configurations

The model allows users to vary the probability of flood occurrence to explore the effect on total costs across the various recharge project configurations. Being able to compare cost-effectiveness across flood flow probabilities is important because those probabilities can vary within a basin. Those probabilities vary naturally due to differing watershed topographies and stream capacities. They also vary as acreage moves further up the canal system away from the mainstem. And even taking action to divert floodflows can affect the probability of such flows further downstream and down the canals. In fact, that change in probabilities is one of the ancillary benefits to downstream communities and property owners.

The break-even analysis identifies at which point in a probability distribution one retention strategy is cost-effective over another. The costs shown here are only examples, and these should be tailored to specific settings in each case.

Holding the flood probability for the dedicated basin constant at 38% (based on the historical average of floods occurring in 23 of the last 60 years), we can determine what flood probabilities would be necessary in the on-farm configurations so that on-farm recharge is at least as cost-effective as recharge in the dedicated basin.

At a flood probability of 38.3%, Annualized Cost/AF of recharge water in the dedicated basin is $119. The permanent on-farm configurations are less than or equal to (i.e. more affordable than) this cost across all probabilities. For the temporary on-farm configuration, because there is no permanent infrastructure, costs are incurred only in years when floodwater is available. At these probabilities, total cost/AF is equal across the configurations at $88/AF. If flood probability rises above 52%, temporary on-farm capture becomes more expensive than the dedicated basin scenario. The cost of the dedicated basin falls to $88 as well at that point.

Table 3. Break-even point with dedicated basin as specified flood probability

	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
Probability of flood flows fall below:	100%	100%	99%	52%	77%

This result implies that even when dedicated basins might take a large proportion of available flood flows which then lowers the probable availability of flows to on-farm operations, the on-farm configurations may still have similar costs per acre-foot. A water management agency can develop a portfolio of flow recovery strategies using this approach.

Similarly, we can obtain the flood probabilities that would be necessary for each of the configurations to be cost-competitive with the lowest cost temporary configuration. At a flood probability of 73% the permanent configuration with an existing pump and the temporary configuration with gravity-fed flooding have the same annualized cost per acre-foot at $60. At a flood probability of at least 82%, the permanent configuration with a new pump and the temporary on-farm configuration have the same total cost per acre-foot. The dedicated basin configuration would have to have a flood probability of at least 77% in order to reach a total cost of $60/AF.

Table 4. Break-even point with temporary configuration

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental
Flood flow probability must be at least	77%	82%	73%	70%	N/A

The probability of flood occurrence is likely to vary in different locations. The cost model therefore allows users to explore changes in cost with different flood frequencies. Tables 5 and 6 display the total costs and annualized costs per acre-foot of recharge across the four different recharge project configurations for different flood frequency probabilities ranging from 25% to 45%.

Configurations exhibit lowest costs at higher flood frequencies. For the dedicated basin configuration, costs per acre-foot range from $101 to $181 over the flood frequencies from 25% to 45%. For the permanent configuration, costs range from $94 to $154 with a new pump, and from $87 to $142 with an existing pump. With gravity-fed flooding in the permanent configuration, costs range from $84 to $139. For the temporary configuration, the costs remain constant at $89 per acre-foot with pump rental and $61 per acre-foot with gravity-fed flooding, across the varying flood frequencies.

Table 5. NPV Total Costs at varying flood frequencies

Flood Frequency	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
25%	$1,535,000	$888,000	$815,000	$801,000	$512,000	$352,000
30%	$1,539,000	$908,000	$835,000	$819,000	$614,000	$422,000
35%	$1,543,000	$930,000	$857,000	$839,000	$717,000	$494,000
40%	$1,546,000	$951,000	$877,000	$855,000	$818,000	$562,000
45%	$1,550,000	$972,000	$899,000	$875,000	$920,000	$634,000

Table 6. NPV Total Costs per AF at varying flood frequencies

Flood Frequency	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
25%	$181	$154	$142	$139	$89	$61
30%	$151	$132	$121	$119	$89	$61
35%	$130	$115	$106	$104	$89	$61
40%	$114	$103	$95	$93	$89	$61
45%	$101	$94	$87	$84	$89	$61

Comparison of M.Cubed/Summers and Bachand/Terranova Results

We compare Bachand's estimate with M.Cubed's temporary configuration, the most comparable one, since the Terranova pilot project was renting diesel equipment temporarily only in flood years. For the temporary structure configuration, M.Cubed estimated a long-run cost of $89/AF, where Bachand estimated a first-year cost of $38/AF. These estimates are highlighted in red below to show the starting points of the analyses.

Between the two projects' costs in a single flood year are comparable, but Terranova used 1,000 acres and recovered 3,100 AF of recharge, whereas the Summers estimate used 160 acres and 1,680 AF of recharge. Terranova shows a recovery of 3.1 AF/acre while Summers shows 10.5 AF/acre.

- If M.Cubed used Bachand's first-year methodology the result would be $68/AF. Beyond that, our cost escalation and annualization methodology increases our cost estimates a bit more to $89/AF.
- If Bachand used M.Cubed's annualized costs, the cost would be $118/AF.

M.Cubed/Summers Data	Method			Bachand/Terranova Data	Method	
Description	**M.Cubed**	**Bachand**			**M.Cubed**	**Bachand**
				One-time infrastructure costs	$28,780	$28,780
Surface pipe	$35,000	$35,000		Conveyance (weirs, irrigation pipe system)	$6,969	$6,969
Lift pumps (4 engines)	$24,000	$24,000		Pump rental (3 engines)	$25,479	$25,479
Total Infrastructure Cost per Flood Year	$59,000	$59,000		**Total Infrastructure Cost per Flood Year**	$32,448	$32,448
Annualized Infrastructure Costs	$29,070			**Annualized Infrastructure Costs**	$42,110	
Build temporary berms 2 times per year	$2,400	$2,400		Labor (land prep, management)	$18,545	$18,545
Diesel fuel for pump operation	$32,423	$32,423		Diesel	$29,986	$29,986
Irrigator labor	$7,200	$7,200		Contracted Services	$1,500	$1,500
				Other operating (taxes, ins., admin)	$6,491	$6,491
Annual ripping or gypsum application	$12,800	$12,800				
Total Annual First-Year Operating Cost per Flood year		$54,823		**Total Annual First-Year Operating Cost per Flood year**		$56,522
Annualized Operating Costs	$28,160			**Annualized Operating Costs**	$10,466	
Total Cost In A Single Flood Year		$113,823		**Total Cost In A Single Flood Year**		$117,750
Annualized Total Cost Frequency Weighted	$57,230			Annualized Total Cost Frequency Weighted	$52,576	
Acre-Feet Per Flood Year	1680	1680		Acre-Feet Per Flood Year	3116	3116
Infiltration Rate (Feet/Day)	0.25	0.25		Infiltration Rate	0.35	0.35
Frequency	38%	38%		Frequency	14%	14%
Cost/AF In A Single Flood Year	$34	**$68**		Cost/AF In A Single Flood Year	$17	***$38***
Cost/AF Adjusted For Flood Frequency	***$89***	$177		**Cost/AF Adjusted For Flood Frequency**	**$118**	$265