Economic Analysis of Individual Actions Recommended for Detailed Analysis

For: California Department of Water Resources and Borrego Water Coalition

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Summary

This memo provides estimates of costs and water quantities for selected actions intended to reduce Borrego Valley groundwater overdraft. A list of about 40 potential actions was reviewed and 19 were carried forward for more detailed analysis (RMann Economics 2014). The cost and water quantity estimates developed are considered to be somewhat subjective and fairly uncertain, and a range of results is provided. Still, results are believed to be representative, and these general findings can be provided.

1. There are no water import projects that appear to be feasible, primarily due to conveyance costs (the region is highly isolated from significant water supplies in other regions), source water quality, and because conveyance through Anza-Borrego State Park, which completely surrounds Borrego Valley, may not be legally feasible.
2. Projects to capture more local inflow may be feasible, but such projects appear to have high unit costs compared to most actions, and the potential amount of cost-effective water supply would not contribute substantially to reducing overdraft. Most potential supply comes very infrequently in large events that last one or a few days. The flows provided by these events would be expensive to capture. Additional hydrology and engineering studies are advised. Economics may hinge on flood damage reduction and the ability to market sand and gravel that would frequently accumulate.
3. Without actions to reduce irrigated area there is not enough potential overdraft reduction to substantially reduce existing overdraft.
4. There appears to be cost-effective potential in all three water-using sectors; municipal, recreational and agricultural.
5. The most cost-effective overdraft reduction from agriculture is by voluntary land retirement, primarily, purchases from willing sellers of land currently in citrus production. Palm and nursery lands might contribute but no recent land sales are known that could suggest what price may be. There must be willing sellers, and there would be some adverse regional economic effects.
6. In golf, significant turf and non-turf irrigated lands could be converted to non-irrigated use, but there are legitimate concerns about how to accomplish such conversions without a significant effect on golf revenues and regional economics.
7. Selective removal of Athel pine, a tamarisk species, appears to be quite cost-effective. The potential amount of water savings is not well-established, but the amount of potential savings is small relative to overdraft.
8. Some outdoor water use efficiency measures appear to have potential, but most efficiency actions appear to be relatively expensive. The fraction of applied water that is not consumed and returned to the aquifer is very important for water use efficiency savings and economics. In the Borrego Valley, this fraction may be close to zero. Irrigation efficiency improvements can create real water savings in this situation, but most irrigation efficiency actions analyzed are not

cost-efficient compared to land retirement. Water use efficiency measures, taken together, cannot substantially reduce overdraft even under the most optimistic of hydrologic assumptions.

9. Additional research on water use requirements of crops and citrus, potential water savings from irrigation efficiency actions, and the fate of applied water, is advised. Water use estimates for crops used in this study may be low given the extreme desert conditions in the Borrego Valley. The general findings of this study should not be affected by more accurate water use estimates.

Table ES-1 and Figure ES-1 provides results for a default set of hydrologic and economic assumptions. The least expensive options appear to be conversion of 175 acres of golf course irrigated turf and non-turf area to native landscape, managing tamarisk (reducing Athel pine acreage), and retirement of up to 75 percent of citrus acreage. These actions could reduce overdraft by almost 8,988 acre-feet per year (AFY) at a total cost of about $25.8 million dollars in net present value terms. Eighty-six percent of this reduced overdraft is from the reduced citrus acreage.[1]

For the remaining actions, unit costs appear to increase quickly and significantly. Total cost to achieve about 13,550 AFY of reduced overdraft is estimated to be over $79 million. The reduced overdraft compares to 19,833 AFY of total pumping based on the analysis water use assumptions. With 5,000 to 7,000 AFY of aquifer recharge, the actions included are approximately enough to eliminate the overdraft.

Table ES-2 provides a summary of water supply and costs by economic sector, being municipal, recreation and agriculture, and additional capture of stormwater, for the default assumptions, and for some alternative assumptions. First, changing the economic discount rate from 3 to 2 percent does not appear to have much effect on total costs, but the present value of costs of some actions that occur in the future are increased (not discounted as much). Second, the default analysis assumed that, under current conditions, none of the difference between applied water and evapotranspiration reaches groundwater. If it is assumed that half of that water, and half of the apparent yield of stormwater projects reaches groundwater, then net savings from all detailed actions are reduced by about 2,029 AFY. Third, if no reduction in irrigated area in municipal, recreation or agricultural use is allowed, then total potential savings are reduced to just about 3,258 AFY. This number would be less to the extent that water applied in excess of evapotranspiration (ET) reaches the groundwater table. Again, some reduction in irrigated areas will be required, or major new water supplies must be imported, to make an appreciable dent in the existing level of overdraft.

The analysis concludes with a qualitative comparison of the regional economic effects of retiring citrus trees and golf holes. The golf and citrus sectors both provide important economic benefits to the Borrego Valley, including direct employment, purchase of inputs, and economic profits that are spent in the region. The two industries appear to generate a similar gross revenue per acre or per acre-foot of water.

[1] An acre-foot is 325,851 gallons or 43,560 cubic feet. An acre-foot year (AFY) means an acre-foot provided every year for a specified duration; in this case, 50 years.

The golf industry, however, appears to support about 5 times the direct employment per acre as the citrus industry. The citrus industry in Borrego Springs does not include important harvest and forward processing industries that, if they existed, might increase the local employment associated with that industry.

More significantly, the local golfing industry provides a substantial base industry that is not provided by the citrus industry. The golf industry attracts many seasonal and part-time residents who contribute important spending in the community. Some of the golf that is provided by irrigation is sold to people who live and spend in Borrego Springs. In addition, the golf courses attract temporary visitors who spend on local goods and services. Almost all of the citrus that is produced is exported, so it does not provide a comparable type of economic base.

The Borrego Valley is economically isolated as well as hydrologically isolated. An important consequence of this economic isolation is that most employees choose to live in the community rather than commute a long distance every day. Also, as compared to a local community in a metropolitan area, resident employees and golfing residents will tend to conduct a larger share of their spending close to home.[2]

Therefore, it appears that retirement of economically viable golf playing turf would be more of a detriment to the regional economy than retirement of a similar acreage of citrus. Retirement of golf holes is not suggested as a way to reduce overdraft; however, some actions that are suggested, if not carefully planned, could diminish the economic viability of golf courses in a way that could significantly harm the larger community.

[2] Since golf brings more people to the region, and these people use water supply, this additional supply requirement should be included in the total overdraft caused by golf. This additional overdraft is not expected to be large relative to the golf turf requirement.

Table ES-1.
Detailed Actions, Net Supply to Aquifer, Million $ Cost, Cost/AF, and Accumulated Supply and Cost

No	Action Description	Net AFY Overdraft Reduction	Million $ cost	$/AF	Accumulated Net Supply	Accumulated Cost, Mil $
16	Manage tamarisk	350	$0.56	$63	350	$0.6
10	Retire old citrus, 50% of citrus acres, $10K per acre	5,183	$13.13	$98	5,532	$13.7
7	Replace 85 acres golf irrigated turf with native landscaping	478	$1.53	$124	6,011	$15.2
11	Retire mid-aged citrus, 25% of citrus acres, $14K per acre	2,591	$8.91	$134	8,602	$24.1
8	Replace 90 acres golf irrigated non-turf area with native landscaping	386	$1.62	$163	8,988	$25.8
13	Retire 75% of palm acreage, $15K per acre	2,147	$10.36	$187	11,134	$36.1
2	Reduce municipal irrigated landscape area	317	$2.70	$331	11,451	$38.8
4	Reduce HOA landscaping	66	$0.56	$331	11,517	$39.4
12	Maximize citrus irrigation efficiency	264	$2.52	$371	11,780	$41.9
9	Stop golf winter over-seeding on 300 acres	154	$1.54	$391	11,934	$43.4
19	Percolation ponds and wastewater recovery wells below sewer evaporation ponds	50	$0.60	$465	11,984	$44.0
5	Golf irrigation system management (physical and operational)	41	$0.51	$483	12,025	$44.5
15	Irrigation efficiency on remaining palm, potato and nursery	101	$1.40	$541	12,126	$45.9
18	De Anza Country Club storm water project, 24 acres	154	$2.21	$557	12,280	$48.1
6	Rehabilitate golf irrigation systems on remaining acres	304	$5.76	$737	12,584	$53.9
14	Retire 75% of potato acreage, $15K per acre	512	$10.54	$800	13,097	$64.5
3	Improve HOA irrigation efficiency	26	$0.78	$1,153	13,123	$65.2
1	Municipal landscape audits	127	$3.80	$1,167	13,249	$69.0
17	Viking Ranch storm water project, 150 acres	300	$10.32	$1,338	13,549	$79.4

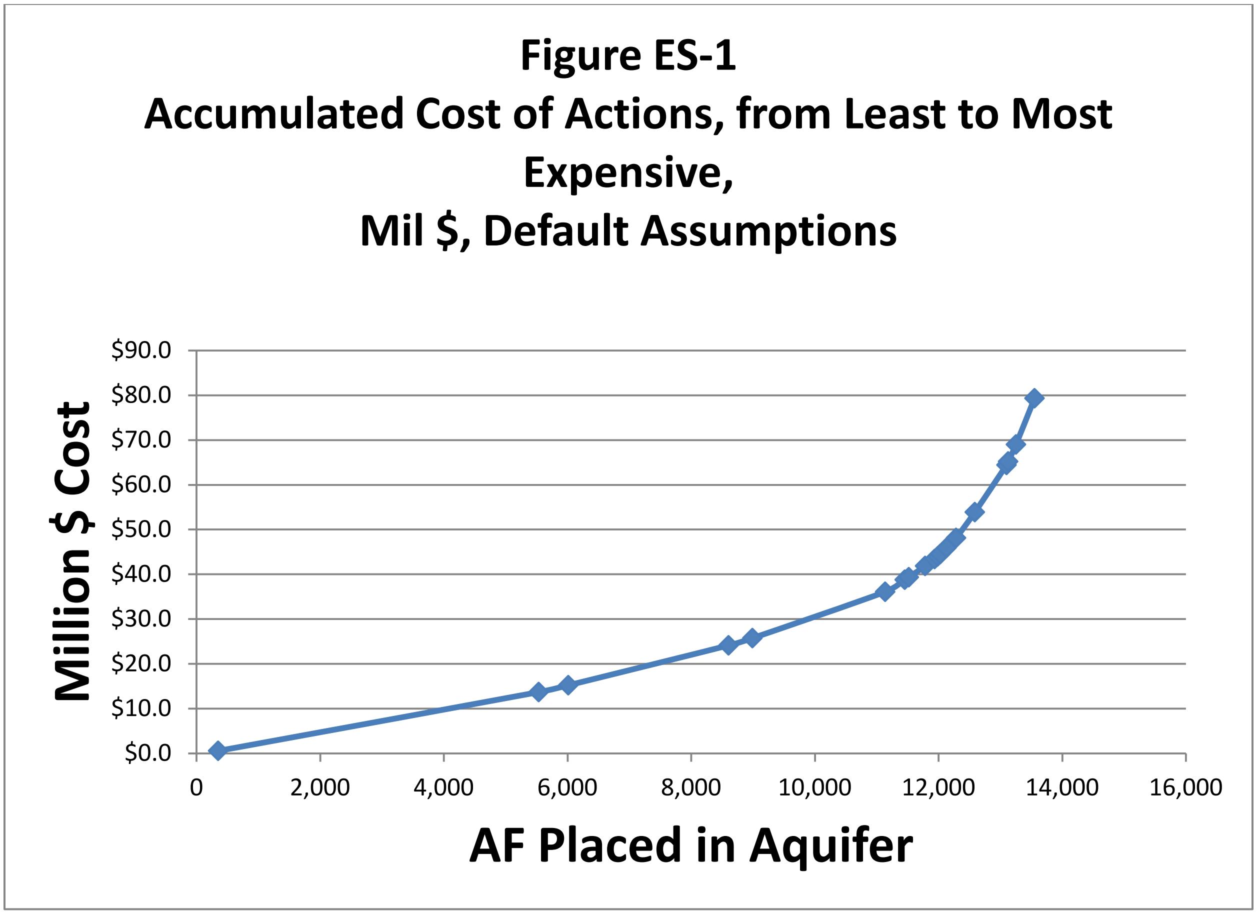
Figure ES-1
Accumulated Cost of Actions, from Least to Most Expensive,
Mil $, Default Assumptions
$90.0
$80.0
$70.0
$60.0
$50.0
$40.0
$30.0
$20.0
$10.0
$0.0
Million $ Cost
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
AF Placed in Aquifer

Table ES-2.
Comparison of results under alternative assumptions (each considered separately)

Detailed actions in Sector	2009 AFY Baseline	Gross AFY Savings	Net AFY Savings	Net as % Base	Million $ NPV Cost
Default assumptions					
Municipal	2,621	585	585	22.3%	$8.43
Golf	3,889	1,363	1,363	35.0%	$10.97
Agriculture	14,217	11,147	11,147	78.4%	$47.42
Stormwater		454	454		$12.53
TOTAL	20,727	13,549	13,549		$79.36
Discount rate 2%, not 3%					
Municipal	2,621	585	585	22.3%	$9.42
Golf	3,889	1,363	1,363	35.0%	$11.43
Agriculture	14,217	11,147	11,147	78.4%	$48.32
Stormwater		454	454		$12.77
TOTAL	20,727	13,549	13,549		$81.94
Share of (AW-ET) and stormwater reaching groundwater is 50%, not 0%					
Municipal	2,621	585	426	16.3%	$8.43
Golf	3,889	1,363	984	25.3%	$10.97
Agriculture	14,217	11,147	9,883	69.5%	$47.42
Stormwater		454	227		$12.53
TOTAL	20,727	13,549	11,520		$79.36
No reduction in irrigated areas, maximize efficiency					
Municipal	2,621	279	279	10.7%	$5.18
Golf	3,889	794	794	20.4%	$7.82
Agriculture	14,217	1,730	1,730	12.2%	$17.58
Stormwater		454	454		$12.53
TOTAL	20,727	3,258	3,258		$43.11

Introduction

This memo provides estimates of costs and water quantities for selected detailed actions intended to reduce Borrego Valley overdraft. Descriptions and estimates of costs and water amounts are provided. Water amounts are calculated relative to 2013 conditions. Different combinations of actions that might eliminate overdraft are displayed to show how costs are affected.

This memo does not evaluate all actions that might help reduce overdraft. Many actions were evaluated at a scoping level and were not included in this analysis because either they would not contribute much water, or because of cost, hydrologic, or legal issues (RMann Economics 2014). The actions that have been considered but were not carried forward were:

- Modify indoor water heaters: relocate heaters or add recirculating pumps
- Low-flow toilets
- Low-flow showerheads
- Water efficient clothes washing machines
- Swim pool covers
- Gray water systems
- Cisterns to capture gutter water or other flows off structures.
- Golf courses: reduce lake area
- Convert existing crop acreage to water conserving crops
- Add up to 400 homes to existing wastewater system and treat up to 200,000 gpd of wastewater.
- Recycle most wastewater generated by indoor water use
- Import Colorado River Surface Water through Imperial ID
- Import Colorado River Surface Water through Coachella ID
- Transfer groundwater supply from Clark Dry Lake property
- Transfer groundwater supply from Dr. Nel property
- Transfer groundwater supply from Allegretti Farms property
- New wells for groundwater outflow, SE corner of basin
- Reduce BWD delivery system paper losses
- Floodwater capture: Henderson Canyon
- Floodwater capture: Palm Canyon
- Floodwater capture: San Felipe Creek

There may be other possible actions that have not be considered, and changing technology and economics might change the set of possible actions in the future. The economic analysis provided in this memo is still characterized as scoping level. For most actions, additional analysis is recommended before investing in implementation.

The detailed actions are shown within water use categories. The categories are important because the amount of water provided by an action depends on the amount of water provided by other actions within that category. That is, actions within each category are not normally mutually exclusive in terms of water savings.

For each category of water use, the analysis starts with a description of total applied water use in that category under 2009 and 2013 planned conditions. 2013 planned conditions include water savings since 2009, and they allow for additional residential development based on Viking Ranch water credits. The estimated baselines include water use estimates from multiple sources; the choice of sources, preferred method of calculation, and the resulting baseline numbers might change in the future.

Then, the assumptions about implementation of each detailed action and its costs are described. It is generally assumed that no applied water returns to groundwater, and costs per unit savings reflect this assumption unless stated otherwise. While some applied water does return to the aquifer, the amount is unknown and there are substantial time lags. Sensitivity analysis is provided where assumptions about costs, water savings and the fate of applied water are varied.

Economic discounting is used to compare and sum costs that occur at different times in the future. The discount rate is a real (inflation-free) interest rate that allows costs occurring in future years to be combined into one net present value (NPV) cost, or a current cost or NPV cost can be expressed as an annualized cost. Unless stated otherwise, the discount rate is 3 percent and costs are annualized over a planning horizon of 50 years. With discounting, future costs count less than present costs. For example, a dollar 50 years in the future is worth only \$0.23 in NPV terms (\$1 times $1/1.03^{50}$).

Water Use Category: Utility Distribution

There are no detailed actions included for the category of BWD pumped but not delivered (207 AFY in 2009 or 2013). Most of this water amount probably represents an accounting error related to inaccurate BWD meters.

Water Use Category: Residential/Commercial/Multi-family/Public Agency Indoor

Water use in the Residential/Commercial/Multi-family/Public Agency indoor category is estimated from BWD records for residential, public agency, multiple units, and commercial categories, plus Borrego Air Ranch and individual domestic wells. It is assumed that 30 percent of total use in this category is indoor.

Residential use is about two-thirds of the use within this category. Normalized residential 2009 use of 0.86 AF per account per year was estimated as the average of 2005 through 2008 data. By 2013, average use per residential account had declined to 0.59 AF per account per year. These savings are believed to be caused by metering and volumetric pricing. The analysis estimates that these savings reduced 2013 total residential use (indoor and outdoor) by about 493 AF per year relative to 2009 levels. The water savings from recent metering for the other account types (public agency, multiple units and commercial) are not as substantial as for residential. This relative lack of improvement suggests potential for savings.

2013 planned residential use allows for the eventual additional use for 306 residences, based on Viking Ranch water credits, each using the 2013 average water use per residence of 0.59 AF per year. These residences will increase total residential demand by about 181 AF (0.59 times 306) relative to 2013 demand. With this additional use, and assuming the 30/70 indoor/outdoor split, 2013 planned Residential/Commercial/Multi-family/Public Agency indoor use is 543 AFY as compared to 646 AFY in 2009.

1. Percolation ponds and water recovery below sewer evaporation ponds

This action would add new percolation ponds to increase recharge from the existing wastewater treatment plant. Water would be recovered by existing wells. It is assumed that 10 acres of new percolation ponds would be developed at a cost of $500,000, annual maintenance costs would be $200 per acre, and new supply would be 50 AFY. Current wastewater flow to the treatment plant is estimated to be 77 AFY. The 50 AFY allows for 27 AFY of evaporation losses from percolation ponds.

There are no other detailed actions for economic analysis within this use category. Some actions might be economical, but were judged unlikely to provide enough water to make much difference for aquifer overdraft. Two recycled water options were judged to be too expensive to include at this time (RMann Economics, 2014). Gray water systems, home plumbing that allows for reuse of some indoor wastewater, have recently come on the market that might be economical for homeowners (Moxham 2014). These excluded actions may prove to be cost-effective, but the potential supply will not contribute substantially to reducing current overdraft.

Water Use Category: Residential/Commercial/Multi-family/Public Agency Outdoor

Water use in this category is estimated from BWD records for residential, public agency, multiple units, and commercial categories, plus Borrego Air Ranch and individual domestic wells, all times 70%, the fraction of use that is outdoor. 2009 outdoor water use is estimated to be 1,506 AFY. The analysis estimates that 2013 total residential use (indoor and outdoor) was reduced by about 493 AF per year relative to 2009 levels. 2013 planned outdoor water use, with 70 percent of these savings and 306 additional residences, is 1,267 AFY. The analysis estimates that, even with 306 new homes, residential outdoor use will decrease by 239 AFY per year relative to 2009 levels.

2. Landscape audits.

This action would provide outdoor water use audits for existing irrigated landscaping to identify and implement opportunities for improved efficiency and landscape conversions (Action #2).

Audits would include an invited site visit by trained staff who (1) solicit information on current water use practices; and (2) make recommendations for improvements in those practices. The scope of this action could range from an intensive outdoor water efficiency study (turf audit, catch can test, and written recommendations for irrigation scheduling or landscape changes) to simple provision of a brochure on outdoor watering practices. For this analysis, landscape acreage is estimated from outdoor use divided by average use per acre.

A&N Technical Services (2005) reports on conservation costs reported by landscape customers in southern California. Costs for timer adjustments, equipment upgrades, irrigation system repairs, external audits and other amounted to $1,834 initial and $656 annual costs per acre. It is assumed that the initial cost would be required every 10 years. In addition, costs for landscape audits and related

BWD costs are assumed to be $50,000 per year. The analysis assumes that half of irrigated landscape would use landscape audits, incur the additional implementation costs, and savings would be 20 percent of applied water.

3. Reduce irrigated landscape area or change type.

Irrigated landscape that could be converted to non-irrigated land, or to lower water requirement vegetation types, would be identified during landscape audits. During audits, staff would work with willing property owners to identify irrigated landscape areas that might be converted at least cost. Also, property owners could propose irrigated areas for inclusion. An incentive payment, $1.00 per square foot of irrigated turf, would be provided. The rate of payment has been used by BWD in the past (Rolwing, 2014). The payment would be proportionately less for lower water requirement vegetation types according to their relative applied water rate. The analysis assumes that 25 percent of irrigated landscape areas would be converted to non-irrigated use. Since half of acreage is improved by landscape audits, it is implicitly assumed that the remaining 25 percent of landscape acreage is not changed relative to existing conditions.

Category: BWD Irrigation Accounts

Water use in this category, measured by BWD, is primarily for irrigation of landscape areas in home owners associations. 2009 and 2013 planned use are both estimated to be 262 AFY.

4. Improve HOA irrigation efficiency

This action would be the same as 2. landscape audits, but applied to Home Owners Association landscapes. The analysis assumes that half of irrigation account landscapes would use landscape audits, incur the additional implementation costs, and savings would be 20 percent of applied water. Additional BWD costs are assumed to be $10,000 per year.

5. Change HOA landscaping

This action would be the same as 3. Reduce irrigated landscape area or change type. An incentive payment, $1.00 per square foot of irrigated turf, would be provided, and 25 percent of irrigation account landscape would be converted.

Category: Recreation

Water use in this category is from information provided by BWD and golf course operators. Most water use data are based on the July 2010 through June 2011 period. Under current conditions, water use has been reduced compared to 2009 conditions by the expectation that Ram's Hill will reduce annual water use from over 1095 FY to 800 AFY. Borrego Springs CC is currently not irrigating 9 of 27 holes. It is assumed that those 9 holes will be returned to irrigation in the future, so no permanent water savings are included in the baseline.

For water savings potential, water use per acre estimates and savings potential are from BWD (2013). Reference ET is 5.97 feet per acre, crop coefficients for warm-season turf and warm-season turf with overseeding are 0.60 and 0.66, respectively, and irrigation efficiency is 70%. The formula used to calculate total water use is

1. Annual Groundwater Consumptive Use (acre-feet/yr) = [Reference Evapotranspiration (feet/year) x Plant Factor] / Irrigation Efficiency

Note that this formula presumes that any applied water that is not transpired is consumed. In total, 2009 water use is estimated to be 3,889 AFY on 659 acres. 2013 planned use is less, 3,338 AFY, because one golf course reduced use from about 1,300 to 800 AFY.

6. Less turf area

This action would convert golf course turf, primarily roughs and non-play turf areas that receive little or no play, to non-irrigated land. A high quality of replacement is proposed at a cost of $18,000 per acre.

The amount of potential turf reduction is estimated in two ways; from information provided by a subset of operators, and by application of a turf standard per golf hole. The turf standard is allowed to be 5 acres per hole or 45 acres per 9 holes. Total 2013 planned area irrigated by the golf courses is estimated to be 659 acres, including non-turf irrigated areas. Total turf requirement for 90 holes is then 450 acres, except a few courses already have less than 45 acres per 9 holes, so the turf requirement is 428 acres. Therefore, there are 231 irrigated acres (659-428) that could be converted to non-irrigated use without reducing turf below the turf standard of 45 acres per 9 holes.

In consideration of information provided by operators, it is assumed that 85 acres of irrigated turf could be replaced with native landscaping and 90 acres of irrigated non-turf could be replaced with non-irrigated landscape for a total of 175 acres of 231 replaced. The remaining 56 irrigated acres, about one-quarter of the 231, are assumed to remain in irrigation.

The BWC Recreation Working Group (2014) noted that driving ranges could be reduced from 10 acres of irrigated turf to 12,000 square feet with artificial turf target greens and non-irrigated grasses. Cost of conversion to artificial turf, based on informal estimates, is assumed to be $10 per square foot, or $436,500 per acre. This sub-action is not carried forward because it is not cost competitive.

7. Replace irrigated non-turf area with native landscaping where appropriate

Golf courses include some irrigated landscape areas that could be converted to native landscape or other non-irrigated areas. From the discussion above, 90 acres are assumed to be converted at a cost of $18,000 per acre.

8. Irrigation system management (physical and operational)

This action includes changes to management of existing irrigation systems as well as partial replacement of irrigation system components as needed to improve irrigation efficiency. Changes in management might include installation of tensiometers (measures soil moisture tension), real-time management in response to measured soil moisture and evapotranspiration (ET), changes in irrigation scheduling, more irrigation labor, and partial changes in sprinkler types and operations. It is assumed that 50 acres would cost $400 per acre per year more to manage, providing an applied water reduction of 0.82 AF/A.

9. Rehab irrigation systems

This action is major rehabilitation of irrigation systems, and the future operation of those systems, to achieve maximum practical efficiency. Complete updating of irrigation systems might include new distribution and application systems, plus remote soil moisture sensing, highly efficient water application, electronics, computer software, and real-time management. It is assumed that 180 acres would be converted at a cost of $4 million, new operations and maintenance costs would be $200 an acre, and water savings would be 30% of applied water.

10. Reduce over-seeding

This action would reduce over-seeding for cool-season play. Over-seeding Bermuda grass with rye grass is a common practice in the region to improve quality of winter play. Costs without over-seeding would include painting or other management of the warm-season turf.

Potential cost savings, and potential revenue losses from reduced green fees and memberships are important. Rams Hill estimated potential cost savings of $187,000 annually and De Anza estimates cost savings of $150,000 annually (BWC Recreation WorkGroup, 2014). It is assumed that these cost savings would be offset by lost revenues. If over-seeding can be reduced without reducing revenues, this action could have a net benefit even before considering the water savings. Paint or dye is applied to 300 acres of playing turf each year, saving 0.51 AF per acre (AFA). This savings follows from a crop coefficient of 0.60 as opposed to 0.66 with over-seeding. The cost of paint or dye, $200 per acre per year, is assumed to be the net cost of this action. The potential costs of this action in terms of lost revenues are very unclear.

Category: Agricultural irrigation, citrus

A variety of citrus is produced commercially in the region. The estimated water use for 2009 or 2013 planned conditions is 10,365 AFY based on 4.91 AFA applied water and 79 percent irrigation efficiency on 2,110 irrigated acres of trees.

For water savings potential, water use per acre estimates and savings potential are from BWD (2013). Reference ET is 5.97 feet per acre, the crop coefficient for citrus is 0.65, and irrigation efficiency is 79%. The formula used to calculate total water use is

Annual Groundwater Consumptive Use (acre-feet/yr) = [Reference Evapotranspiration (feet/year) x Plant Factor] / Irrigation Efficiency

Note that this formula assumes that any applied water that is not transpired is consumed.

11. Retire acreage, instead of re-establishment, by purchasing lands from willing sellers

This action would purchase citrus land by purchase at fair market prices when existing trees are past their economic life; typically, at an age of 30 to 40 years. Costs of land restoration are included. The amount of irrigated land bought and retired is 90 percent of the amount of land purchased because some orchard land such as roads and storage areas is not irrigated.

Information on irrigated land values is from California Chapter American Society Farm Managers and Rural Appraisers (CCASFMRA, 2013) and local sales. The CCASFMRA publication provides a range of recent sales prices for San Diego county land in citrus trees. The most recent price data, for 2012, shows a price range of $10,000 to $20,000 per acre. One recent sale in the local area reportedly resulted in a price of less than $8,000 per acre; this may have been a distress sale that may not reflect long-run average conditions. BWD purchased 125 acres of Viking Ranch property for $12,000 an acre in 2010 (BWD 2010a). The analysis includes costs of land restoration that would be required. Based on experience with the Viking Ranch property, an additional cost of $1,200 per acre is assumed for land restoration.

The analysis assumes that land with fully depreciated citrus trees would sell for $10,000 an acre. In sensitivity analysis, a range of $8,000 to $12,000 is assumed. The water provided by the land is based on a calculated ET of 3.88 AF per irrigated acre and irrigation efficiency of 79 percent resulting in 4.91 AFA of applied water. The ET and applied water calculations used for this study intends to match the assumptions and results from BWD (2013). Average water savings from retiring citrus that would be planted to young trees might be less because the land uses less water per acre during the establishment years.

The estimated ET and applied water in this study may be less than actually experienced in the field (Seley, 2014). Additional field research may result in new water use estimates and changes to the water credit system. Under the approach used for this study, larger ET and applied water estimates would increase the apparent amount of overdraft, but the cost to eliminate the overdraft using land retirement would be unaffected because the amount of water pumped, overdraft, and the potential amount of water saved per acre are all estimated using the same per-acre water use.[3] Still, it may be useful to reconsider irrigation water use estimates in the future to ensure comparability with other overdraft-reducing actions.

12. Retire acreage, mid-aged trees, by purchase from willing sellers

This action would purchase citrus land at fair market prices while existing trees are within their economic life of about 30 years. Costs of land restoration are included. Average water use is 4.91 AFA. The analysis assumes that land with middle-aged citrus trees would sell for $14,000 an acre. In sensitivity analysis, a range of $12,000 to $16,000 is assumed. Land restoration costs are $1,200 per acre.

13. Maximize irrigation efficiency by irrigation improvements including soil moisture monitoring, and real-time management.

This action would improve irrigation efficiency by real-time soil moisture and ET monitoring, water application in response to this information, and irrigation system improvements as needed to obtain maximum efficiency. Costs are based on estimates provided by a local contractor; $9,120 per 100 acres for the first 3 years, and $780 a year thereafter, for tensiometer services, plus additional labor of $10,000 per 100 acres per year is assumed. These costs work out to $4,300 per year in NPV terms (3%, 50 years). Water savings are 0.50 AFY per acre based on a reduced ET (3.88 to 3.75 AF) and improved efficiency (79% to 85%).

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[3] For example, if 1,000 acres are estimated to use 4 AFA and land cost is $10,000 per acre, then $10 million is required to eliminate 4,000 AF of depletion. If the acreage actually uses 6 AFA, then $10 million is required to eliminate 6,000 AF of depletion.

Category: Agricultural irrigation, other

The estimated water use for palm for 2009 or 2013 planned conditions is 2,862 AFY based on 3.73 AFA applied water and 70 percent irrigation efficiency on 767 irrigated acres of trees.

The estimated water use for potato for 2009 or 2013 planned conditions is 683 AFY based on 0.88 AFA applied water and 80 percent irrigation efficiency on 781 irrigated acres of potatoes. The low water use per acre reflects a rotation in which only 1 in 3 acres is irrigated each year.

The estimated water use for nursery for 2009 or 2013 planned conditions is 306 AFY based on 4.88 AF per acre applied water and 70 percent irrigation efficiency on 68 irrigated acres.

All of these estimates are from BWD (2003). Resulting ET and applied water may be less than actually experienced in the field. Additional field research may result in new water use estimates and changes to the water credit system. In the default analysis, none of the difference between ET and AW returns to groundwater.

14. Retire palm acreage by purchase from willing sellers

This action would purchase and retire 75 percent of palm acreage. Reference ET is 5.97 feet per acre, the crop coefficient for palm is 0.50, and irrigation efficiency is 80% so applied water is 3.72 AFA. Costs of land restoration ($1,200 per acre) are included. No recent sales are known. Land price is assumed to be $15,000 per acre, so total cost is $16,200 per acre.

15. Retire potato acreage by purchase from willing sellers

This action would purchase and retire 75 percent of potato acreage. Potato ET is 2.09 feet per acre, irrigation efficiency is 80%, and only one of three potato acres is grown each year, so applied water is 0.87 AFA. Costs of soil stabilization ($1,200 per acre) are included. No recent sales data are known. The California Chapter of the American Society of Farm Managers and Rural Appraisers (2013) cites a price for San Diego County cropland of $40,000 to $55,000 per acre. The land in Borrego Valley is cropped only once every 3 years. $15,000 per acre is assumed, and total cost is $16,200 per acre.

16. Improve irrigation efficiency on palm, potato and nursery acreage

This action would assist palm, potato and nursery operators to achieve maximum practical efficiency from irrigation water use on their producing acreage. This action is included because 1) there is nothing else proposed for nursery acreage, and this category could grow in the future, and 2) palm, potato, and nursery account for much water use, but no irrigation efficiency improvements are included anywhere else. It is applied only to any acreage of these crops remaining after acreage retired. Potential applied water savings are 0.34, 0.37, 0.05 AFA for palm, nursery and potatoes, respectively, where only 1 of 3 potato acres is irrigated each year. Costs per acre are as described for citrus, detailed action 13.

17. Manage tamarisk

Athel Tamarisk (T. aphylla) is used extensively to reduce wind speeds for developed and agricultural properties in the region. This action would reduce tamarisk ET by eliminating large athel tamarisk where it is not providing an important wind reduction benefit, managing the size of tamarisk windbreaks, and replacing tamarisk with windbreaks that use less water and have other benefits that can help to offset the costs.

This action is included under the agricultural use category because water use by athel tamarisk may subtract from water available for agricultural crops, and some of the water consumed may be provided by the fraction of applied water that is not evapotranspiration. At this time, these effects are not included in any water use or supply estimates.

The Tamarisk Coalition (2008) provides a cost for tamarisk removal of $1,500 to $5,000 an acre, the higher cost being for “heavily infested areas.” The $5,000 per acre is similar to costs for land clearing of forest land which would probably apply for these large athel tamarisk trees. Additional costs, for root plowing and hand application of herbicide, are from Zavaleta (2000). Total cost per acre, updated to 2013 using the GNP implicit price deflator, is $6,265.

The amount of water being consumed by athel tamarisk, and the amount of potential savings is uncertain. Google Earth was used to estimate that there are 7 miles of dense athel tamarisk rows, and another 5 miles of broken or thin rows in the valley. The dense rows are assumed to be 40 feet wide, and the thin rows 20 feet wide. This results in an estimate of 46 total acres of tamarisk.

Potential water savings are estimated using two methods. In method 1, use per acre is assumed to be the same as reference ET, 5.97 feet per acre. Total ET is estimated to be 275 AF per year. Method 2 recognizes that, with a tree height to 50 feet, and with windy desert conditions, the athel pine might consume more than reference ET. In method 2, each tree consumes 200 gallons per day, and there is one tree for every 400 square feet. Total ET is estimated to be 1,123 AF per year. The average of these, 700 AF is assumed, and it is assumed that treatment of all 46 acres would be required to obtain half of the consumptive use, or 349 AF. Total cost for treating all acres once is $289,000. It is assumed that half of this cost would be required every 10 years thereafter to maintain the savings. The NPV of the total cost is $563,000.

Stormwater/local water source

There is no baseline water use associated with this category. Stormwater is available occasionally during winter rain events or during summer monsoon or tropical storm events frequently associated with thunderstorms. There is currently no municipal stormwater system, but some stormwater is captured by golf courses. Stream flow enters the Borrego Valley from a number of canyons and draws and flows over the valley in a broad channel. If flow is sufficient, water can fill the Borrego sink and overflow into San Felipe Creek and out of the basin. The amount of flow out of the canyons that reaches the groundwater aquifer is unclear. The vast majority of recharge to the groundwater system comes as flow from the adjacent mountains. Some of this is overland flow that seeps in mainly near the mountain fronts, and some is from underflow. In large storms, much of the potential supply is lost as outflow or ground surface evaporation (Faunt 2014). In the valley, precipitation averages about 6 inches a year and does not contribute much to groundwater.

18. Viking Ranch stormwater

This project would provide increased capture of storm water by building a water retention basin on the Viking Ranch property. Water would be diverted from Coyote Creek. Villalobos (2007) studied a facility with a diversion using a weir, two- 36 inch pipelines having 75 cfs of capacity, and 151.5 acres of groundwater infiltration basin. With infiltration rates of 1.0 foot per day for the first 20 days and 0.5 feet thereafter, the maximum infiltration rate would also be 75 cfs for 20 days and 37.5 cfs thereafter. The SWRCB (2007) estimated an average annual supply added to groundwater of 307 AF using 1951 to 1983 records. Over the same period, annual average inflow from Coyote Creek was estimated to be 1,834 AF.

Three hundred AF of new supply is assumed for this study. Villalobos (2006) reworked the estimates to obtain an estimate of 240 AF of new supply. Therefore, the 300 AF is considered generous. BWD purchased 125 acres of the Viking Ranch in 2010 (BWD, 2010a). Approval from the BWD Board would be required for this project. Given its history, this seems unlikely (Rolwing, 2014). However, it is assumed this project could be constructed.

Project schematics from Villalobos (2007) show that 151.5 acres could store 459 AF. USEPA (2006) provides a typical cost for large stormwater detention facilities of $0.50 per cubic foot. At that rate, the construction cost for the spreading ponds would be about $10 million. In addition, annual costs of $15,000 ($100 per acre) for treatment of percolation ponds, and an annual cost of $10,000 to maintain the weir and diversion works, is assumed. This cost is considered to be highly uncertain at this time; cost engineering is recommended.

19. De Anza Country Club stormwater

This project would improve the existing detention dam and catchment basin to provide water supply and flood control benefits. BWD (2001) reported that a catchment basin of about 96 AF capacity was associated with a 3,000 foot detention dam on 24 acres of land upstream of De Anza Country Club (DACC). Storm flows in 2005 from the Borrego Palm Canyon Creek caused flood damage to residential and recreational property near the DACC (BWD, 2010b). In 2006, DACC excavated a storm water detention basin immediately upstream of their development, removing up to 90,000 cubic yards of silt and sand. In 2013, flood waters damaged about 40 homes in the area around Montezuma Road and De Anza Drive (Borrego Springs Life 2013).

Mills (2007) studied the potential use of the storm water basin as a groundwater recharge facility. He found that

- Average annual flow at the upstream stream gauge was 680 AF
- Recharge rate would be 3 to 5 feet per day.
- With 4 acres “below the outlet structure” daily recharge could be 12 to 20 AF per day.
- Annual average recharge based on monthly average flow data and 3 and 5 AF per day of recharge was 534 and 584 AF per year respectively.
- The facility would have to be cleaned or re-excavated annually
- Given the characteristics of soils, the basin could function as an artificial recharge facility.

The facility would need to be engineered to function and survive the extreme hydrologic events in the region; the 100-year flow for Borrego Palm Canyon has been estimated to be more than 10,000 cfs (San Diego County, 1985). A concrete dam with a spillway is assumed providing 24 acres of submerged area and 96 AF of capacity for percolation when full.

The Mills analysis assumed that "all flows enter the basin at a constant rate each month." An analysis of daily gauge data (10255810) was developed for this project. Assuming the first 10 cfs of daily flow at the gauge is not captured by the facility, and with 24 acres for percolation, and with 3 or 5 feet of recharge daily, then 126 and 154 AF per year of recharge was estimated for the 3 and 5 foot assumptions. For this analysis, 150 AF per year average supply, the high end of the range, is assumed. Based on USEPA (2006) the cost of the facility is estimated to be $0.50 per cubic foot of capacity or $2.1 million. In addition, $100 per acre, or $2,400 annually, is assumed for maintenance. This cost is considered to be highly uncertain at this time; cost engineering is recommended.

The facility would have flood damage reduction benefit. However, because flood flows are so sudden and short, no analysis is possible with the available data. It is not certain that this facility could be built without affecting Anza-Borrego state park lands that are adjacent to the site. No related cost has been included.

Results

This section summarizes results and discusses uncertainty of the estimates.

The analysis suggests that several actions that would convert irrigated land to non-irrigated use are among the most economical. These actions have large up-front costs, but as compared to many efficiency measures where water use per acre is reduced 10 to 30 percent, land retirement eliminates 100 percent of water use. The six most economical options appear to be

- Manage tamarisk, $6,265 per acre, $63 per AF, 350 AFY
- Retire citrus instead of re-establishment, 50% of acreage, 1,172 acres bought, $11,200 per acre, $98 per AF, 5,183 AFY
- Replace golf irrigated turf with native landscaping, $18,000 per acre, $124 per AF, 478 AFY
- Retire citrus, mid-aged trees, 25% of citrus, $15,200 per acre, $134 per AF, 2,591 AFY
- Replace golf irrigated non-turf area with native landscaping, $18,000 per acre, $163 per AF, 386 AFY
- Retire palm acreage, 75%, $16,200 per acre, $187 per AF, 2,147 AFY

These actions taken together cost $36.1 million and they provide 11,134 AF of overdraft reduction for the aquifer. The analysis estimates total water use under 2013 planned conditions of 19,830 AF. If natural recharge averages 7,000 AF, then these six actions could reduce overdraft by 87 percent [11,134/(19,830-7,000)].

In general, the costs and potential water savings in this group are relatively certain. Within this group, the potential overdraft reduction from tamarisk management (350 AFY) is quite uncertain. Also, the price that will need to be paid for palm acreage is uncertain. For citrus, most land would not be purchased until the trees are fully depreciated. The amount of water use per acre for citrus and palm may be understated, but if total water use and overdraft are calculated using the same per acre water use assumptions, the cost of eliminating overdraft is not much affected by these water use assumptions.

As a sensitivity analysis, if citrus land prices are reduced by $2,000 an acre, then the cost of retiring citrus lands is reduced from $22 million to about $18.5 million. If land prices are increased by $2,000 an acre, then the cost of retiring citrus lands is increased from $22 million to about $25.5 million. Given uncertainty in land prices, it appears that the direct cost of retiring 75 percent of citrus acreage and subsequent land management could be $18 to $26 million.

The four next most expensive options jump into the $300 to $400 per AF cost range;

- Reduce municipal irrigated landscape area or change type, $331 per AF, 317 AFY
- Reduce HOA landscaping, $331 per AF, 66 AFY
- Maximize citrus irrigation efficiency, $371 per AF, 264 AFY
- Stop golf winter overseeding on 300 acres, $391 per AF, 154 AFY

In this group, potential water savings and costs are relatively uncertain. Municipal and HOA landscape characteristics are not well-known. It is not clear that citrus irrigation efficiency can be increased much without affecting root zone salinity and yields. The action to reduce golf over-seeding has fairly certain water savings, but net costs, in consideration of player acceptance are uncertain.

Options in the $400 to $1000 per AF range are

- Percolation ponds and water recovery below sewer evaporation ponds, $465 per AF, 50 AFY
- Golf irrigation system management (physical and operational), $483 per AF, 41 AFY
- Irrigation efficiency on remaining palm, potato and nursery, $541 per AF, 101 AFY
- De Anza Country Club stormwater project, 24 acres, $557 per AF, 154 AFY
- Rehab golf irrigation systems, $737 per AF, 304 AFY
- Retire potato acreage, 75%, $15K per acre, $800 per AF, 512 AFY

In this group, the amount of potential water savings and the costs required to obtain stated reductions are both uncertain. Engineering work would be required to verify the feasibility, cost and water supply from the percolation ponds and De Anza stormwater project concepts. The two golf efficiency actions are based on recent local estimates. The amount of water supply benefit is not very certain, but the costs are both relatively certain; both costs are based on recent estimates by private providers. Little is known about how improved irrigation efficiency would be implemented on palm, potato and nursery acreage. Note that the palm and potato irrigation efficiency is applied only to the 25 percent of acreage that remains after land retirement.

The remaining actions all have estimated costs in excess of $1000 per AF.

- Improve HOA irrigation efficiency, $1,153 per AF, 26 AFY
- Municipal landscape audits, $1,167 per AF, 127 AFY

- Viking Ranch stormwater, $1,338 per AF, 300 AFY

These actions generally have uncertain costs and uncertain water supply benefits.

Regional Economic Effects of Irrigated Land Retirement Options

This analysis suggests that there is no cost-effective opportunity to bring the Borrego Groundwater Basin into hydrologic balance that does not include substantial retirement of irrigated land use. The largest categories of irrigated land use are agriculture and recreation. Agriculture includes citrus, palm, nursery and potato. Recreational land use is primarily golf turf, but also irrigated landscape features that paying customers enjoy on and off the golf course. Municipal and HOA irrigation water use is relatively small but economical contributions should be possible.

The economic analysis estimates the economic cost of land retirement. The price of land generally reflects the expected profits from use of that land expressed in net present value terms. That is, buyers and sellers have expectations regarding revenues and costs, including water costs, and land prices are set accordingly. Land retirement by land purchase has a cost that includes the price of land, and that cost reflects the lost net benefits from the irrigated land use. Land price is a measure of economic benefits for landowners, but we are also interested in economic benefits for other members of the community, and we are interested in other economic measures that are not the same as economic benefit or cost, but are related.

This section of the report reviews the other regional economic effects of irrigated land retirement by comparison of golf turf and irrigated cropland retirement. Both types of land retirement have these types of regional effects:

- Reduced direct employment in agriculture or golf, and reduced employment income and resulting spending;
- The net incomes from golf or agriculture, including economic rents, are eliminated. The land owner is presumably compensated for these losses, but the owners may leave the region or otherwise take their land sale proceeds and spending elsewhere;
- Spending for services and materials needed for golf or farming are reduced. Some of these purchases are made from other businesses in the region;
- These direct spending reductions have indirect economic effects because people who sell to employees, owners, and golf or farm operations then have less income to spend. These indirect effects can be felt in all sectors of the regional economy that depend on local spending.
- In addition, there may also be price effects, for example, when land prices are reduced by a loss of jobs and local income.
- Local government revenues can be reduced by reduced sales, income and property taxes, and costs of local government services can be increased by unemployment.

The pattern of regional economic losses from land retirement are very location and case-specific, especially in a small economic region like the Borrego Valley. However, it is clear that agriculture and golf are “base” industries; they bring money into the region. The other base industry in the region is tourism, primarily for the State park. Tourism also has water needs, but the amount of water required to support tourism, mostly through accommodations, is much less than for golf and agriculture.

Borrego Springs is physically isolated, and this has implications for regional economic effects. In particular, full-time employees are relatively likely to live in the region, and their spending is likely to have a relatively large effect on the regional economy. “Relatively” in this case means relative to a typical small modern American community where there are many shopping opportunities outside of the community but close by. Consequently, local employment is an important factor affecting local spending in Borrego Springs.

Information on direct revenue and employment were obtained from secondary sources, and directly from regional businesses. For citrus, one lemon and one orange budget from the San Joaquin Valley south region were an analyzed (UCCE, 2009, 2010). Also, data from San Diego County (2011, 2012) were used to augment the crop budgets with information on average per acre revenues and yields. Yields influence harvest labor requirements.

These data suggest that citrus revenues have recently averaged more than $6,700 per acre with lemons ($12,800) and grapefruit ($8,700) providing more revenue than average. Labor requirements for established orchards are 80 to 100 hours per acre including labor required for custom operations and harvest. Discussions with one local grower suggest 4 full-time equivalents per 400 acres, not including harvest and custom operations, and this estimate corresponds well with the “hired” labor estimate from the UCCE crop budgets. Total labor requirement per acre is about 20 to 25 hours of hired labor, 25 to 35 hours of custom labor, and 30 to 50 hours of harvest labor, or 75 to 110 total hours per acre, or 0.04 to 0.055 full-time equivalents per acre. Since there is no packinghouse located in the Borrego Valley, much of the harvest and packing income may be paid to persons who are not Borrego Valley residents.

For golf, a description of the golf economy in San Diego County is available (Cunningham and Bruvold, 2010), and information from local golf courses was obtained. Cunningham and Bruvold estimate that $64.1 million was spent at 90 golf courses having 1,728 holes in the county in 2008. This does not include $191 million of additional spending for lodging, dining and non-golf entertainment. The direct and additional spending amounts to $37,094 and $110,532 per hole, respectively. If these spending rates are applied to the 90 holes in Borrego Springs, then $3.3 and $9.9 million was spent. With 659 acres of irrigated turf and non-turf, direct revenues would be $5,000 per irrigated acre and “additional spending” would be $15,000 per irrigated acre for a total of $20,000 per acre. The golf economy in Borrego Springs is certainly different from the county average. Possibly, more of the revenue is provided by seasonal and part-time residents who spend less on restaurants and entertainment than the average San Diego golf tourist.

Information was provided by a subset of golf course operators in the Borrego Springs area. Direct revenues per irrigated acre were about $8,000 per acre, similar to the direct revenue estimate derived from county averages, and similar to the average direct citrus revenues per acre.

Golf course operators also provided information on employment for a sample of operations. Full-time employment per sample irrigated acre is about 0.26 persons which is 4 to 5 times more than the 0.04 to 0.055 full-time equivalents for citrus. It's hard to say which jobs are higher quality, on average, but it also seems likely that a larger share of the agricultural labor income leaves the region since most harvest and packing labor is not local.

The fact that there are many part-time golfing residents in Borrego Springs means that they provide a different kind of spending in the region. An important share of retail goods and services spending may be provided by the part-time golfing residents. The economic input from part-time residents is appreciable, and for many, golf is a major factor in their maintaining a part-time residency.

It seems likely that the economic benefits provided by golf facility employees, and from part-time residents who would not live there without golf, are much larger on a per-acre basis than the effects provided by citrus. This analysis has proposed that golf courses convert irrigated land in a way that will not reduce the amount of golf play and revenues. This may be easier said than done as many golfers enjoy water features including irrigated landscape that is not used for play. This will be an important challenge as golf course operators contemplate the aesthetics of non-irrigated land use.

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