SECTION 4

COST ANALYSIS OF AGRICULTURAL WATER USE MEASUREMENT ALTERNATIVES

Analysis Approach

Regional and statewide cost estimates were developed for ten agricultural measurement alternatives. Each measurement alternative is defined by two parameters: (1) generic measurement location and (2) potential measurement improvement. Measurement location refers to the generic location of water use measurement. Five measurement locations are addressed by the analysis: (1) surface water diversions; (2) return flows; (3) groundwater use; (4) farm-gate deliveries; and (5) crop water consumption.[1] Potential measurement improvement refers to the accuracy with which measurements are made. Three measurement intensities are defined for the analysis: (1) basic[2]; (2) high[3]; and (3) highest technically practical.

Starting from an estimate of baseline measurement conditions, the analysis estimates the incremental cost for each measurement location to move up to the next measurement intensity. For example, given the current distribution of measurement levels (basic, high and highest technically practical) for agricultural surface water diversions, what would be the incremental cost to move all diversion points to at least high? Similarly, what would be the incremental cost to the highest technically practical level of measurement for all surface water diversions in a given region or statewide? The analysis assumes (and available data strongly indicate) that existing infrastructure and practices already are capable of achieving the basic measurement for each of the five measurement locations identified by the analysis. Therefore, in total, there are ten measurement alternatives considered by the cost analysis: two measurement intensities (high and highest practical) times five measurement locations.

[1] Initially the cost analysis also included stream and water quality measurements. These locations were dropped from the analysis, however, due to insufficient data on current measurement conditions. It should also be noted that the analysis of return flow measurement costs contains a high degree of uncertainty because of limitations in existing knowledge of baseline conditions.

[2] The definition of basic measurement ranges from once per day to once per year depending on the measurement location and therefore cannot be simply summarized here. Specific definitions of measurement level at different locations are presented in Section 1.

[3] As with infrequent measurement, the definition of periodic measurement depends on the measurement location.

Analysis Regions

Cost estimates were produced for six regions: (1) Sacramento Valley; (2) Delta; (3) East San Joaquin Valley; (4) West San Joaquin Valley; (5) South San Joaquin Valley; and (6) Rest of State. Table 1 shows the correspondence between the five Central Valley regions and irrigated land area within Central Valley counties.[4] Figure 4.1 displays the geographic regions used in the analysis.

Table 1
Analysis Region's Share of County Irrigated Acreage

Region	100% of County's Irrigated Acreage	Less than 100% of County's Irrigated Acreage
Sacramento Valley	Butte, Colusa, Glenn, Placer, Sacramento, Shasta, Sutter, Tehama, Yolo, Yuba	
Delta	Contra Costa, Solano	San Joaquin (50%)
East San Joaquin	Madera	Fresno (30%), Merced (60%), San Joaquin (30%), Stanislaus (60%)
West San Joaquin		Fresno (40%), Merced (40%), San Joaquin (20%), Stanislaus (40%)
South San Joaquin	Kern, Kings, Tulare	Fresno (30%)

[4] The region Rest of State is not included in Table 1 because by definition it includes all other counties not included in the table.

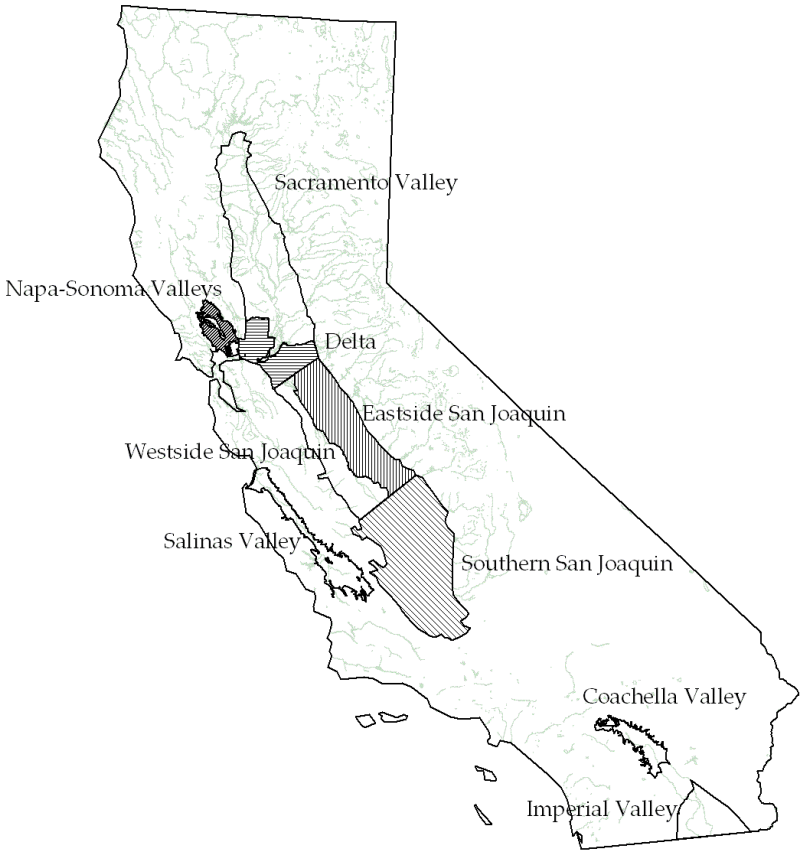

Figure 4.1. Analysis regions.

Definitions of Measurement Intensity

Measurement level definitions used by the cost analysis are reproduced in Table 2.

Table 2
Measurement Definitions

Measurement Location	Measurement Level	Definition of Potential Measurement Procedure
Surface Water Diversion	Basic	Estimate flow rates for water delivery structures once per year. Track delivery duration and use flow estimates to calculate volume delivered.
	High	Inventory and rate structures. Measure flow rates, on average, three times per structure use.
	Highest Practical	Inventory and rate structures. Install flow totaling devices, data loggers, and telemetry where needed.
Groundwater Use	Basic	Closure factor after estimating crop water consumption, surface water deliveries and surface return flows.
	High	Continuous regional characterization of groundwater volume using two methods: hydrologic balance and water table method.
	Highest Practical	Totalizing flow meters or pump testing coupled with an estimate of the surface runoff or deep percolation of the pumped water. Install flow totaling devices, data loggers, and telemetry where needed.
Crop Consumption	Basic	Based on an rolling (every five years) inventory of crop acreage, CIMIS and existing crop coefficients.
	High	Remote sensing (LANDSAT 7) based on a monthly time step with a 30m resolution during the growing season.
	Highest Practical	Remote sensing based on a 16 day (highest frequency of LANDSAT 7 flyover) time step during the irrigation season with a 30 m resolution.
Return flow	Basic	Estimate flow rates for water delivery structures once per year. Track delivery duration and use flow estimates to calculate volume delivered.
	High	Inventory and rate structures. Measure flow rates, on average, three times per structure use.
	Highest Practical	Inventory and rate structures. Install flow totaling devices, data loggers, and telemetry where needed.
Farm-gate deliveries	Basic	Estimate flow rates for turnout structures once per year. Track delivery duration and use flow estimates to calculate volume delivered.
	High	Inventory and rate structures. Measure flow rates, on average, three times per structure use
	Highest Practical	Inventory and rate turnout structures. Install flow totaling devices, data loggers, and telemetry where needed.

Baseline Measurement Levels

In order to estimate the incremental cost of achieving a given measurement level for a given location it was necessary to have an estimate of existing measurement capability. Table 3 summarizes baseline measurement capability assumed by the cost analysis. These estimates were developed using two primary sources of information:

(1) The assumed distributions of current measurement capability for district surface water diversions, return flows and farm-gate deliveries were derived from water district data compiled by University of California researchers in the early to mid 1990's and updated in 2002 by Provost & Pritchard Engineering. While the data indicates the type of measurement technology used by each district in the sample for surface water diversions and return flows, it does show the number of diversion or return points per district. The cost analysis assumed one major diversion point and three return points per district. This assumption, though based on general expert opinion, is somewhat speculative and merits further review particularly with respect to it uniform application across all analysis regions. Regional estimates of the number and distribution of measurement devices were developed using a simple acreage scaling.

(2) The current number and distribution of metered and unmetered groundwater wells for each analysis region are derived from a custom data extract from the 1997 USDA Farm and Ranch Irrigation Survey.

Table 3
Baseline Measurement Conditions Used for Cost Analysis

Region	Irrigated Acres 1/	Adjusted Quantity					
		Basic	High	Highest	Basic	High	Highest
Diversions (assumed = 1 major diversion per district)							
Sac Valley	1,623,670	5	5	41	10%	10%	80%
Delta	451,548	0	0	11	0%	0%	100%
East SJ	1,321,948	0	2	15	0%	11%	89%
West SJ	906,329	0	0	12	0%	0%	100%
South SJ	2,305,163	0	14	38	0%	27%	73%
Other	1,556,832	0	2	30	0%	7%	93%
Total	8,165,489	7	29	140	4%	16%	80%
Grand Total		175					
Wells							
Sac Valley	1,623,670		7,900	400	0%	95%	5%
Delta	451,548		2,200	2,200	0%	50%	50%
East SJ	1,321,948		5,000	2,100	0%	70%	30%
West SJ	906,329		3,300	1,500	0%	69%	31%
South SJ	2,305,163		9,500	3,400	0%	74%	26%
Other	1,556,832		5,600	3,500	0%	62%	38%
Total	8,165,489		33,500	13,100	0%	72%	28%
Grand Total		46,600					
Farm Gates							
Sac Valley	1,623,670	7,808	23,423	7,808	20%	60%	20%
Delta	451,548	1,612	3,322	4,813	17%	34%	49%
East SJ	1,321,948	5,285	15,854	5,285	20%	60%	20%
West SJ	906,329	2,957	316	13,485	18%	2%	80%
South SJ	2,305,163	983	38,432	15,579	2%	70%	28%
Other	1,556,832	0	14,654	7,601	0%	66%	34%
Total	8,165,489	5,552	99,406	64,256	3%	59%	38%
Grand Total		169,214					

Unit Costs of Measurement

Unit costs of measurement for each measurement level are summarized in Table 4. Appendix A provides more detail on the basis and source of these unit costs. The costs shown in Table 4 are total annual costs per device or measurement point and consist of the following cost elements:

(1) Capital cost of measurement structures annualized over their average useful lives.[5]

(2) Capital cost of measurement and data logging equipment annualized over their average useful lives.

(3) Annual costs to operate and maintain the measurement structures and equipment.

(4) Annual costs to compile, process, report, and archive measurement data at the district level.

Based on these unit costs, an estimate of current expenditure on measurement given baseline measurement conditions was made for each measurement location. These estimates are shown in Table 5.

[5] All annualized costs used in the analysis are based on a 5.5% discount rate.

Table 4
Annual Unit Costs of Measurement by Location ($/Unit/Yr)

Measurement Location	Unit	Basic	High	Highest Practical
SW Diversion	Div. Point	2,110	8,385	9,428
Ground Water Well Meter	Well	NA	NA	669
GW Regional Estimate	Statewide[6]	1,010,832	2,952,066	NA
Return Flows	Return Point	1,340	6,561	7,603
Crop Consumption	Statewide[7]	1,200,000	1,710,000	2,370,000
Farm-gate Deliveries	Turnout	340	1,554	2,313

Table 5
Current Annual Measurement Expenditures Including Annualized Cost of Physical Structures (Mil. $)

Measurement Locations	Statewide	Sacramento	Delta	East SJ	West SJ	South SJ	Other
SW Diversions	1.6	0.4	0.11	0.2	0.1	0.5	0.3
Metered Ground Water 1/	8.8	0.3	1.47	1.4	1.0	2.3	2.3
Regional Groundwater Estimate 2/	1.0	-	-	-	-	-	-
Return Flows 3/	1.1	0.50	0.1	0.1	0.1	0.1	0.2
Crop Consumption 2/	1.2	-	-	-	-	-	-
Farm-gate Deliveries	305.0	73.0	16.8	46.0	32.7	96.1	40.4
Total	321.8	74.2	18.5	47.7	33.9	98.9	43.2

Notes:
1/ Cost is based on annualized cost of meter equipment and annual O&M.
2/ Estimates are produced by DWR, are based on staff FTEs, and are not region specific.
3/ Estimate assumes an average of 3 major return flow points per district. This estimate entails significant uncertainty and should be viewed as a very rough first-order approximation.

[6] The table shows the aggregate cost for all regions. Costs for each region are broken out for the analysis presented in the next section.

[7] See previous footnote.

Summary of Results

The figures on the following pages summarize the results of the agricultural water use measurement cost analysis. The reader should note the following about the information contained in the figures:

(1) The figures show the incremental cost to achieve specific measurement levels given the assumed baseline state of measurement. The figures do not show the total cost of measurement, which would incorporate both the baseline and the incremental cost of measurement. The technical team considered the incremental cost of moving to different measurement levels the most relevant to deliberations on measurement policy.

(2) Pairs of measurement locations and levels are ranked from lowest to highest incremental cost in the figures. This was done to make the figures easy to interpret. However, the figures should not be read to imply a recommendation regarding the appropriateness of specific measurement location/level pairs. While incremental costs are highly relevant to such a recommendation, incremental benefits must also be taken into account.[8]

(3) Incremental costs shown in the figures are cumulative of all lower cost measurement location/level pairs. The cost of a given location/level pair can be gauged by comparing the difference between its cumulative cost and the cumulative cost of the pair immediately to its left in the figure. Table 7 also shows the cost of individual location/level pairs rather than cumulative costs.

(4) The figures show cumulative incremental costs in two ways: (1) aggregate cost for the region and (2) per acre cost for the region. Per acre cost is based on the total irrigated acreage for the region reported in the 1997 Census of Agriculture. The reader should note that this approach results in costs being averaged across all irrigated acreage regardless of baseline measurement conditions for particular acreage. An alternative would be to show per acre cost only for acreage affected by the change in measurement level. This was done in Table 7, which summarizes the cost analysis results in tabular form, but was not done in the figures because it would invalidate the cumulative per acre incremental costs shown in the figures.[9]

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[8] Underscoring this point is the understanding that it is always possible that a measurement location/level pair with a low incremental cost has an even lower incremental benefit, while one with a high incremental cost has an even higher incremental benefit.

[9] The cumulative per acre incremental costs would be invalid because the number of affected acres in a region varies according to measurement location. For example, if a change in surface water diversion affects half a region's acreage while a change in groundwater measurement affects only a quarter of it, it would be incorrect to add the two per acre costs together to get a per acre cost of both measurement

(5) Per acre farm cash returns from the 1997 Census of Agriculture are used to benchmark the magnitude of the calculated incremental costs as well as to show how the cost burden of measurement would vary by region.

(6) The pairs are denoted in the figures according to the nomenclature shown in Table 6.

Table 6
Correspondence between figure labels and pairs of measurement locations and levels

Figure Label	Location	Measurement Level
Divers-Hi	Surface Diversion	High
Return-Hi	Surface Return Flow	High
Gwater-Hi	Groundwater	High
FarmGt-Hi	Farm Gate Delivery	High
Crops-Hi	Crop Water Consumption	High
Divers-Highest	Surface Diversion	Highest Practical
Return-Highest	Surface Return Flow	Highest Practical
Gwater-Highest	Groundwater	Highest Practical
FarmGt-Highest	Farm Gate Delivery	Highest Practical
Crops-Highest	Crop Water Consumption	Highest Practical

Figure 1: Statewide Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity – Cumulative annual and cumulative average per acre costs are arrayed from lowest to highest cost alternative. The results show that all measurement alternatives considered with the exception of highest practical measurement of farm-gate deliveries could be achieved at a cumulative per acre cost of under $7 per year. The incremental cost of moving to the highest practical level of measurement for farm-gate deliveries is significant, increasing per acre cost by about $17 per acre. Thus looking at the entire array of measurement options, approximately 75% of the estimated cost is associated with moving to the highest practical level of measurement of farm-gate deliveries. The cumulative annual cost to achieve all measurement alternatives would be approximately $220 million per year.[10] Stopping short of the highest practical level of measurement of farm-gate deliveries, the cumulative annual cost would

changes. In this circumstance there would not be one cumulative per acre cost but two. The relevant per acre cost for a given piece of land would depend on its baseline condition.

[10] Annual costs are based on the annualized value of up-front capital costs plus anticipated annual O&M expenses. Capital costs were annualized using estimates of usfeul life and a 5.5% discount rate.

be approximately $54 million per year. As discussed previously, these costs are incremental to the baseline costs shown in table 5. The incremental cost of moving all measurement locations to highest practical level of measurement would equal about 12% of farm net cash returns (including government income support payments).[11] The incremental cost of achieving the highest practical level of measurement at all locations except farm-gate deliveries would equal approximately 3% of farm net cash returns. [12]

Figures 2-7: Regional Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity – Cumulative annual and cumulative per acre costs are arrayed from lowest to highest cost alternative for each region included in the analysis. These figures replicate Figure 1 for each region included in the analysis.

Table 7: Summary of Results – Results of the cost analysis for each measurement location, intensity, and region are presented in this table. These data were used to construct Figures 1 – 7. However, note that while the figures report cumulative costs from lowest to highest, Table 7 shows only the incremental cost to achieve each measurement location/level pair. The costs in the table are not cumulative. As discussed previously, Table 7 shows per acre costs in two ways. The first is based on total irrigated acreage for the region. The second shows the average per acre cost only for the acreage that would be affected by the change in measurement. This is referred to in the table as the average cost per affected acre. It shows the average cost per acre assuming the affected acreage would bear the full cost of the change in measurement practice. The reader should note that costs per affected acre should not be added together to get cumulative cost per affected acre for reasons discussed in footnote 9.

[11] Farm net cash returns are from the 1997 Census of Agriculture.

[12] Additionally, the reader should note that incremental costs for high and highest practical levels of measurement of farm-gate deliveries may be understated by the figures to some extent. This is because the baseline condition reflects an assessment of the physical capability of turnouts to achieve these levels of measurement but does not take into account whether turnout measurement capability is actually being utilized. If the capability is unutilized there may be some initial cost to put it in service which the analysis does not capture.

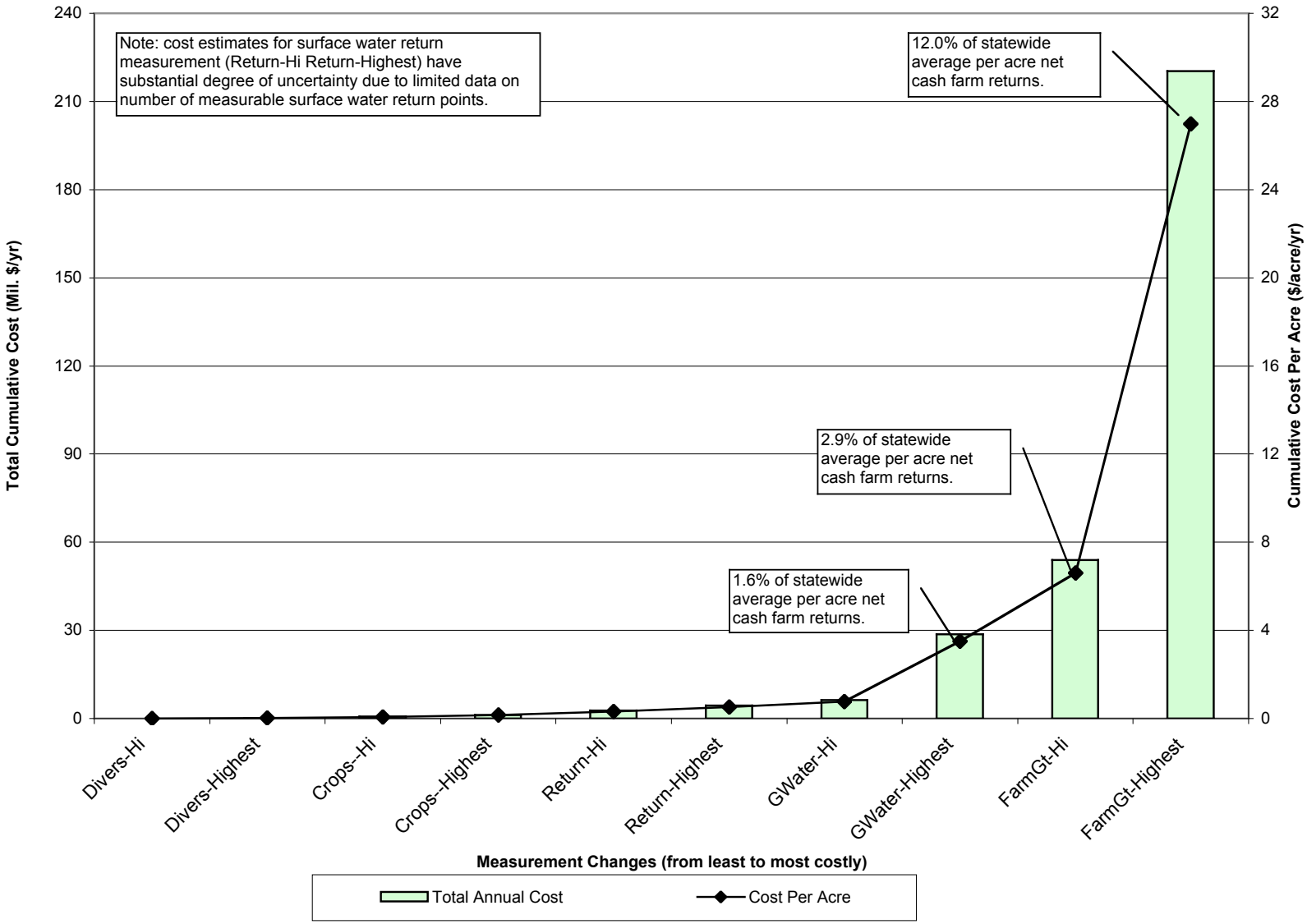

Figure 1. Statewide Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

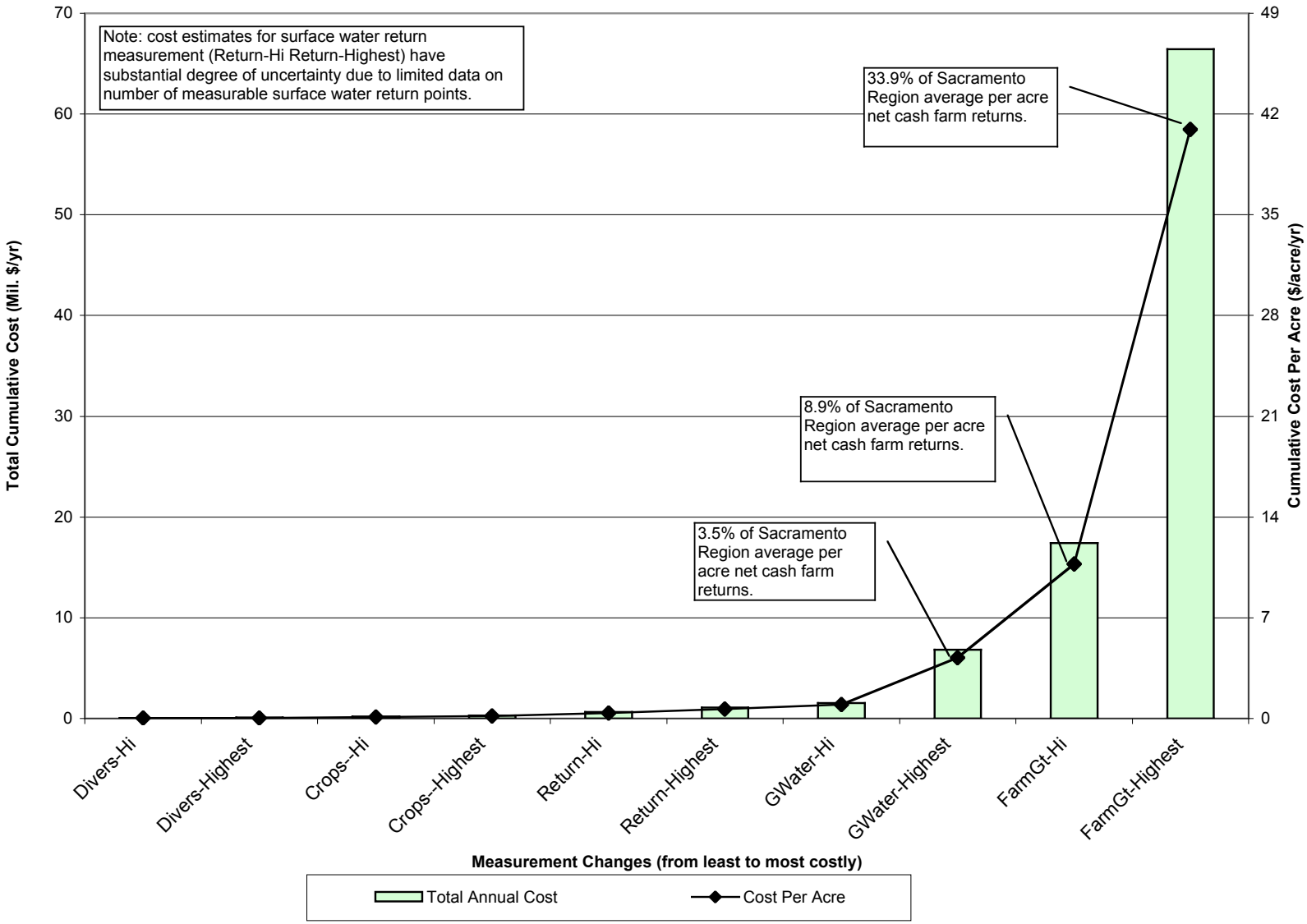

Figure 2. Sacramento Region Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

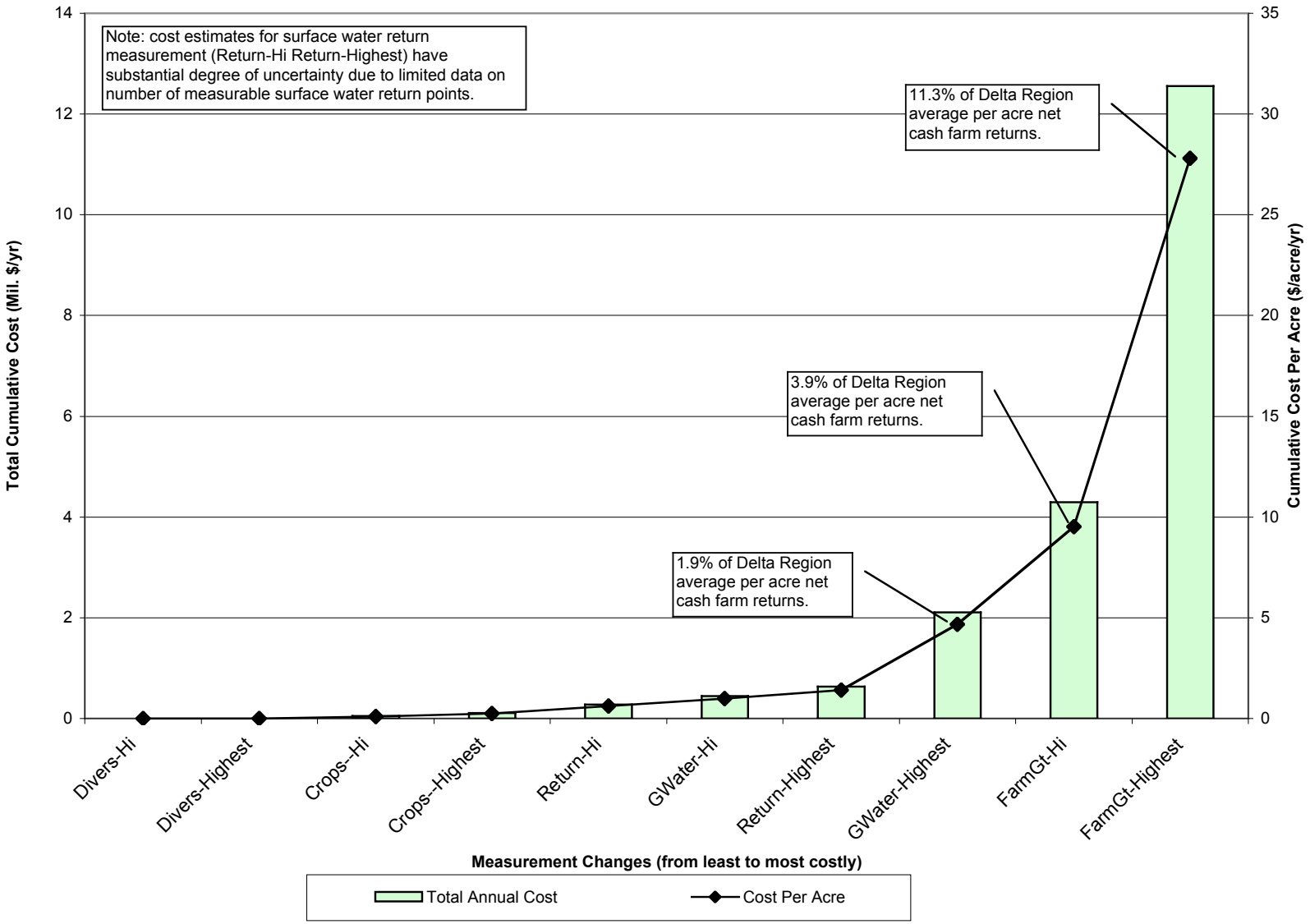

Figure 3. Delta Region Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

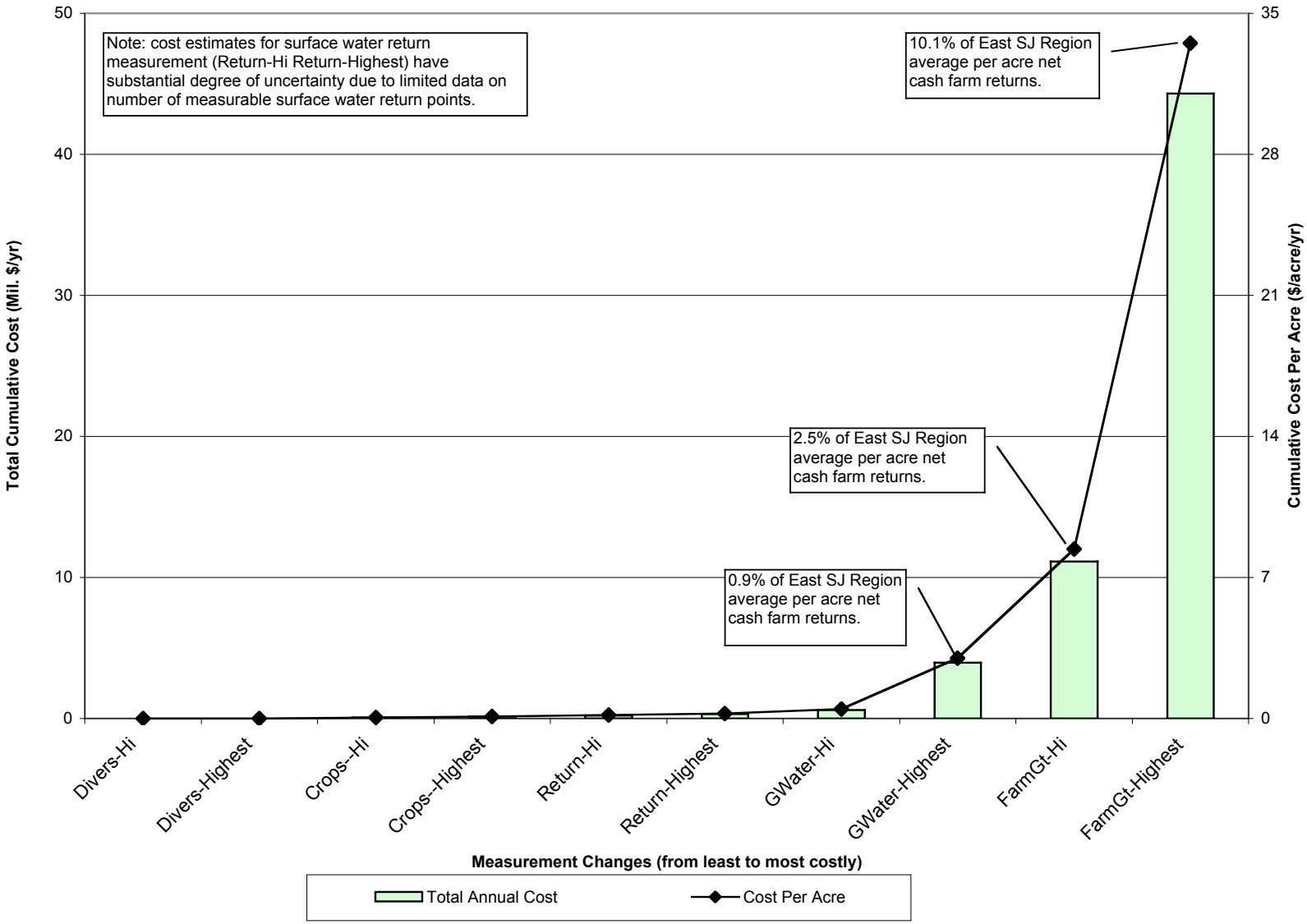

Figure 4. East San Joaquin Valley Region Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

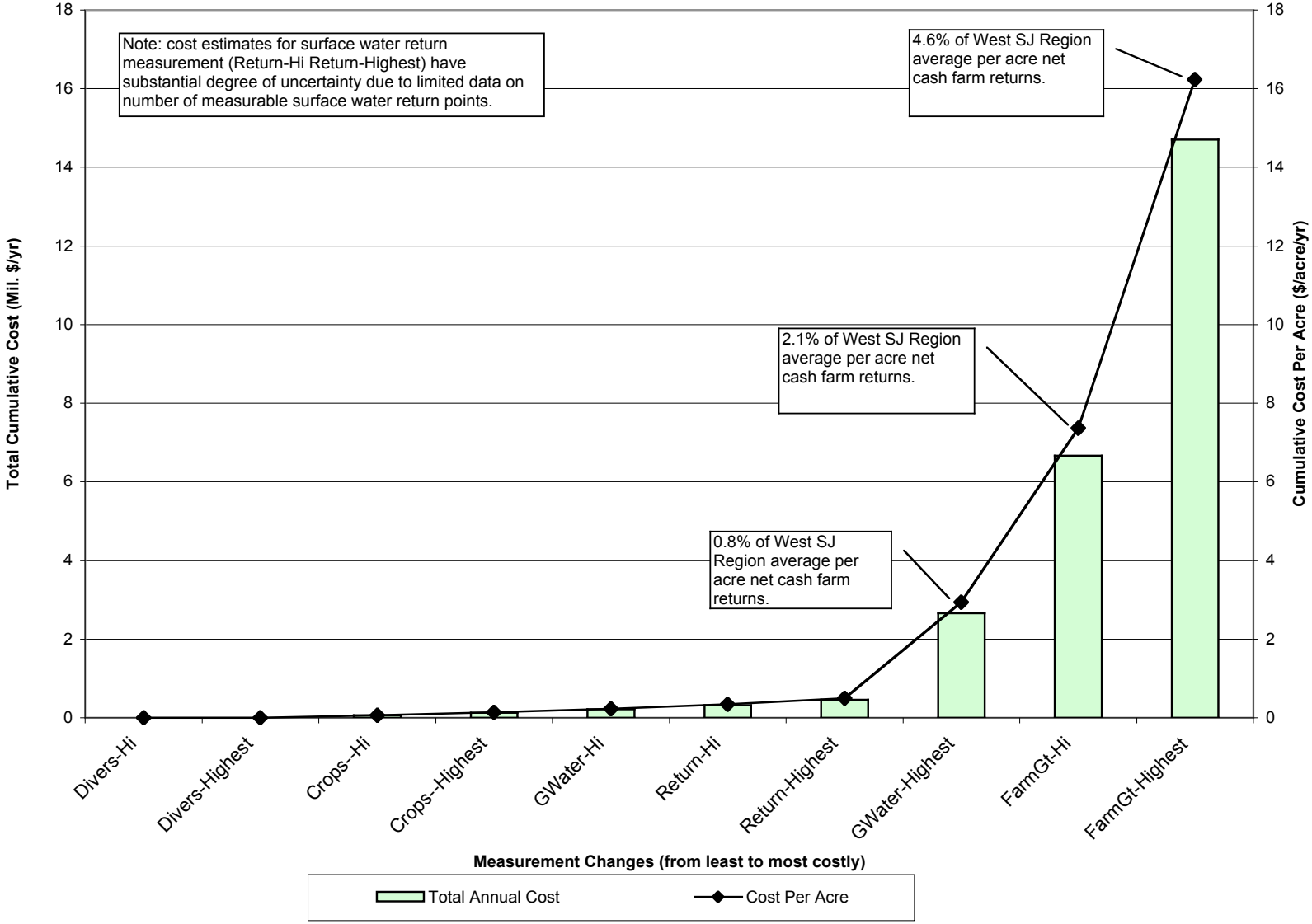

Figure 5. West San Joaquin Valley Region Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

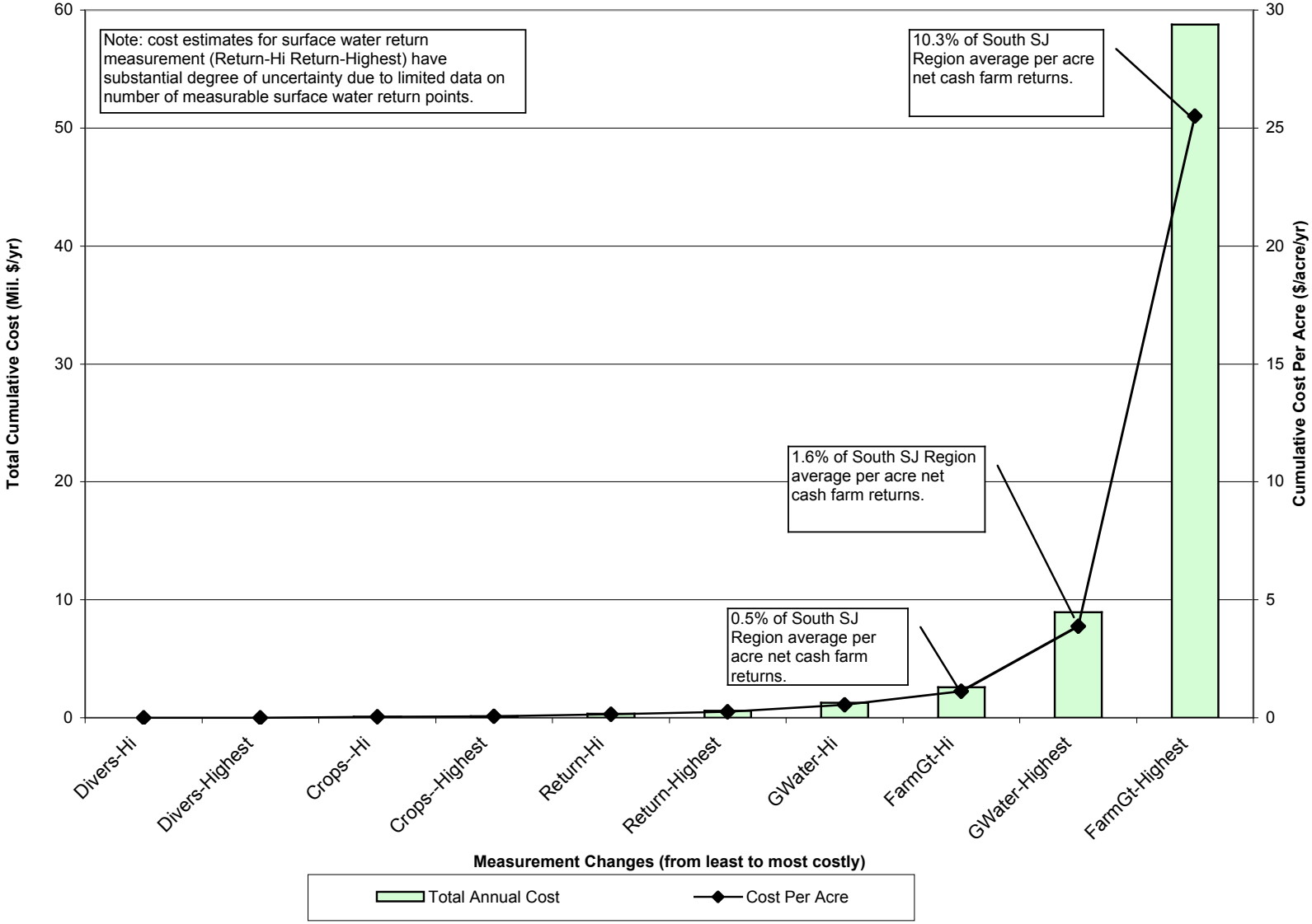

Figure 6. South San Joaquin Valley Region Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

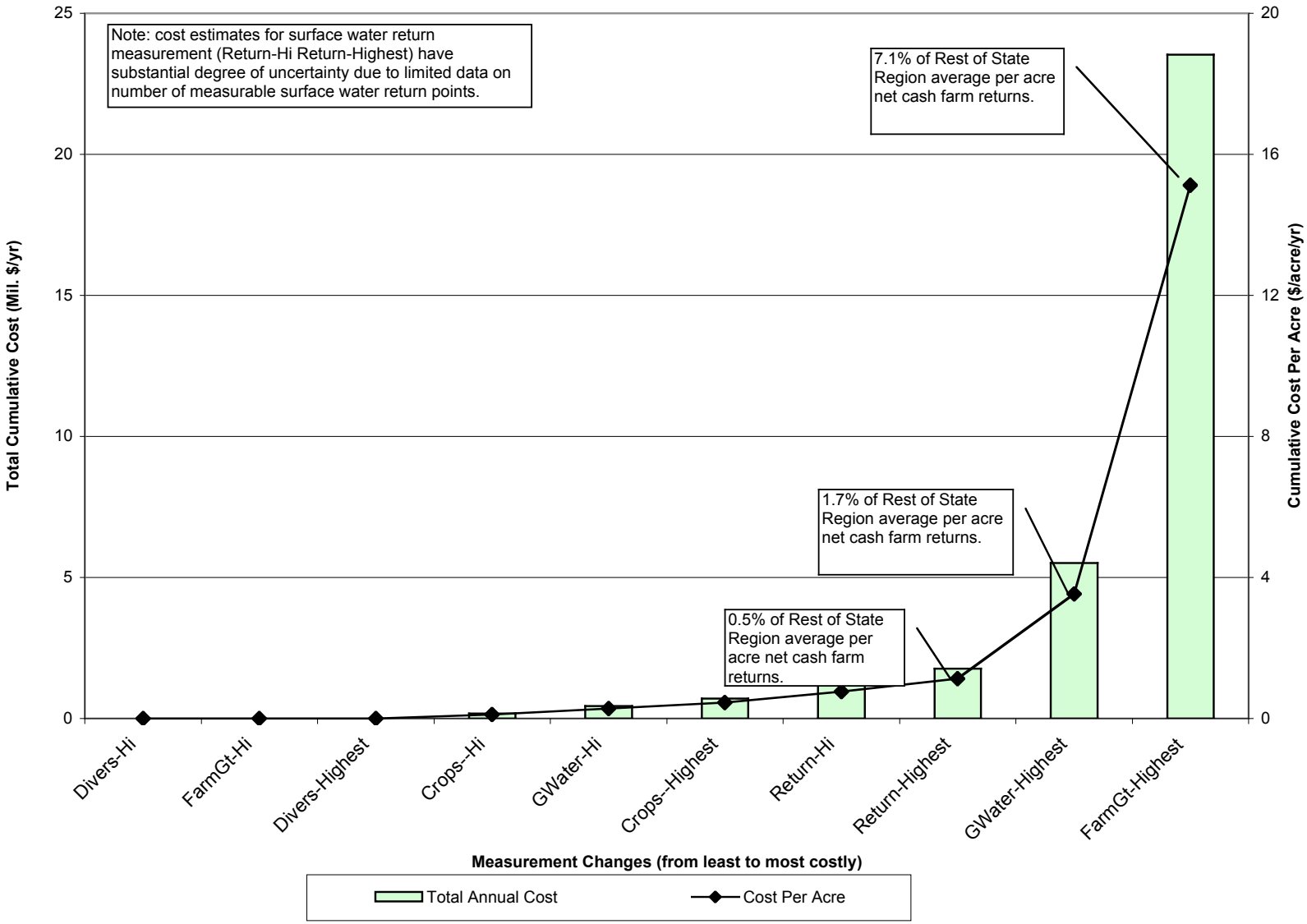

Figure 7. Rest of State Region Cumulative Cost of Agricultural Water Use Measurement by Location/Intensity

Table 7. Regional Incremental Costs of Measurement by Location/Intensity[13]

Sacramento Region						Delta Region				
Measurement	Irrigated Acres		Annual Measurement Costs			Irrigated Acres		Annual Measurement Costs		
Loc./Intensity	Total	Affected	Total	Per Acre	Per Affected Acre	Total	Affected	Total	Per Acre	Per Affected Acre
Divers-Per	1,623,670	159,183	36,371	0.02	0.23	451,548	-	-	-	-
Divers-Con	1,623,670	318,367	46,793	0.03	0.15	451,548	-	-	-	-
Crops--Per	1,623,670	1,623,670	100,000	0.06	0.06	451,548	451,548	50,000	0.11	0.11
Crops--Con	1,623,670	1,623,670	120,000	0.07	0.07	451,548	451,548	60,000	0.13	0.13
Return-Per	1,623,670	752,068	324,585	0.20	0.43	451,548	423,315	163,656	0.36	0.39
Return-Con	1,623,670	1,623,670	449,157	0.28	0.28	451,548	451,548	194,689	0.43	0.43
FarmGt-Per	1,623,670	324,742	10,586,305	6.52	-	451,548	74,680	2,185,509	4.84	29.27
GWater-Con	1,623,670	1,545,421	5,288,798	3.26	3.42	451,548	225,774	1,472,830	3.26	6.52
FarmGt-Con	1,623,670	1,298,928	49,019,117	30.19	37.74	451,548	228,565	8,256,670	18.29	36.12
East San Joaquin Valley Region						**West San Joaquin Valley Region**				
Measurement	Irrigated Acres		Annual Measurement Costs			Irrigated Acres		Annual Measurement Costs		
Loc./Intensity	Total	Affected	Total	Per Acre	Per Affected Acre	Total	Affected	Total	Per Acre	Per Affected Acre
Divers-Per	1,321,948	-	-	-	-	906,329	-	-	-	-
Divers-Con	1,321,948	142,149	1,933	0.00	0.01	906,329	-	-	-	-
Crops--Per	1,321,948	1,321,948	60,000	0.05	0.05	906,329	906,329	60,000	0.07	0.07
Crops--Con	1,321,948	1,321,948	70,000	0.05	0.05	906,329	906,329	70,000	0.08	0.08
Return-Per	1,321,948	617,325	87,141	0.07	0.14	906,329	475,609	103,345	0.11	0.22
Return-Con	1,321,948	1,116,173	115,150	0.09	0.10	906,329	906,329	138,354	0.15	0.15
FarmGt-Per	1,321,948	264,670	7,165,551	5.42	-	906,329	159,920	4,008,974	4.42	25.07
GWater-Con	1,321,948	930,950	3,347,340	2.53	3.60	906,329	623,101	2,209,245	2.44	3.55
FarmGt-Con	1,321,948	793,960	33,179,166	25.10	41.79	906,329	177,004	8,036,378	8.87	45.40
South San Joaquin Valley Region						**Rest of State Region**				
Measurement	Irrigated Acres		Annual Measurement Costs			Irrigated Acres		Annual Measurement Costs		
Loc./Intensity	Total	Affected	Total	Per Acre	Per Affected Acre	Total	Affected	Total	Per Acre	Per Affected Acre
Divers-Per	2,305,163	-	-	-	-	1,556,832	-	-	-	-
Divers-Con	2,305,163	613,007	14,300	0.01	0.02	1,556,832	113,682	2,480	0.00	0.02
Crops--Per	2,305,163	2,305,163	60,000	0.03	0.03	1,556,832	1,556,832	180,000	0.12	0.12
Crops--Con	2,305,163	2,305,163	70,000	0.03	0.03	1,556,832	1,556,832	270,000	0.17	0.17
Return-Per	2,305,163	2,062,686	197,600	0.09	0.10	1,556,832	1,311,454	482,784	0.31	0.37
Return-Con	2,305,163	2,305,163	236,856	0.10	0.10	1,556,832	1,311,454	568,607	0.37	0.43
FarmGt-Per	2,305,163	41,222	1,333,381	0.58	32.35	1,556,832	-	-	-	-
GWater-Con	2,305,163	1,697,600	6,359,947	2.76	3.75	1,556,832	958,050	3,749,021	2.41	3.91
FarmGt-Con	2,305,163	1,652,161	49,838,552	21.62	30.17	1,556,832	1,025,131	18,033,152	11.58	17.59

[13] Whereas Figures 1-7 show cumulative costs of measurement, building from the lowest to highest cost measurement activity, Table 7 shows just the cost for each individual measurement location/intensity pair. These are not cumulative costs. Also note that the costs in both the figures and Table 7 are incremental in the sense that they do not include the costs already incurred for current levels of measurement.

Appendix A – Unit Costs of Measurement Detail Tables

The tables in Appendix A provide the basis for the unit cost estimates shown in Table 4.

Table A-1
Unit Cost Components by Measurement Location/Level

	Flow Structure				Data Collection/Storage/Delivery				Total	
	Capital			O&M	Capital			O&M		
Location	($)	Life (yr)	($/yr)	($/yr)	($)	Life (yr)	($/yr)	($/yr)	($/yr)	Unit
Measurement Level - Basic										
SW Diversion	13,500	50	797	1,200	0	0	0	113	2,110	Site
Ground Water	0	0	0	0	20,000	2	10,832	1,000,000	1,010,832	Statewide
SW Return	6,500	50	384	900	0	0	0	56	1,340	Site
Crop Cons.	0	0	0	0	0	0	0	1,200,000	1,200,000	Statewide
Farm Gate	1,000	20	84	200	0	0	0	56	340	Site
Measurement Level - High										
SW Diversion	37,000	50	2,185	1,200	[illegible]	[illegible]	[illegible]	5,000	8,385	Site
Ground Water	0	0	0	0	15,242,031	20	1,275,443	1,676,623	2,952,066	Statewide
SW Return	9,500	50	561	1,000	[illegible]	[illegible]	[illegible]	5,000	6,561	Site
Crop Cons.	0	0	0	0	0	0	0	1,710,000	1,710,000	Statewide
Farm Gate	4,100	20	343	600	20	2	11	600	1,554	Site
Measurement Level – Highest Practical										
SW Diversion	37,000	50	2,185	1,200	26,700	10	3,542	2,500	9,428	Site
Ground Water	1,300	10	172	200	[illegible]	[illegible]	[illegible]	300	672	Well
SW Return	9,500	50	561	1,000	26,700	10	3,542	2,500	7,603	Site
Crop Consumption	0	0	0	0	0	0	0	2,370,000	2,370,000	Statewide
Farm Gate	6,800	10	902	1,200	20	2	11	200	2,313	Site

Measurement of Surface Water Diversions and Return Flow at the Basic Level of Measurement: Conversion of Existing Control Structures to Measuring Structures

Description: Use existing water surface control facilities, such as check structures and radial gates in delivery canals and check structures and flashboard risers in drainage channels to measure flow rate. Metal plates can be added to the top boards of check structures and flashboard risers to convert them into a sharp crested weir. Likewise, radial gates can be rated for flow according to the gate opening and upstream/downstream water surface. To maximize measurement accuracy, a stream gauging bridge or similar facility should be constructed at larger measuring stations to allow calibration and regular stream gage measurements.

Table A-2
Capital & O&M Costs for Measurement of Surface Water Diversions & Return Flows at Basic Level of Measurement

	Capital Cost	Useful Life	Annual O&M
Main Canal (500 cfs)			
Convert Exis. Struc.	$ 13,500	50 yrs	$ 1,200/yr
District Drain (20 cfs)			
Convert Exis. Struc.	$ 6,500	50 yrs	$ 900/yr

Source: Provost & Pritchard Engineering

Measurement of Surface Water Diversions and Return Flow at the High Level of Measurement: Long Throated (Replogle) Flume

Description: A long throated flume is a contraction in the canal prism consisting of a single obstruction coming up from the floor of the channel in a known cross-sectional area. This contraction forces the water profile to reach critical depth, so that a single upstream measurement is required to determine discharge. Long-throated flumes can be easily fitted into complex channel shapes as well as simple shapes and can be installed in nearly any size channel. These flumes can be used for district delivery system measurement, drain flow measurement and turnout delivery measurements.

Table A-3
O&M Unit Costs for Surface Water Diversion and Return Point Measurements at the High Level of Measurement

Daily Measurements during Irrigation Season		
Staff Labor		
1 measurement per day		1
200 days per year	x	200
Avg. time to perform measurement is 0.5 hrs.	x	0.5
Hourly staff rate including benefits is $36/hr	x	36
		3,600
Truck Use		
3 measurements per day		1
200 days per year	x	200
Avg. time to perform measurement is 0.5 hrs.	x	0.5
Hourly cost for 1/2 ton pickup is$13.50 (source: UC Extension Farm Equipment Cost Budgets)	x	13.5
		1,350
Calibration and Cleaning		
1 calibration per year		1
Avg. time to perform calibration is 1.5 hrs	x	1.5
Hourly rate for eng. Staff to perform calibration	x	75
		1,12.5
1 clean out per year		1
Avg. time to perform clean out	x	2
Hourly staff rate including benefits is $36/hr	x	36
		72
Hourly cost for back hoe		42.5
Avg. time to use back hoe	x	2
		85
Total cost for 1 diversion/return point measurements per day.		5,220
Rounded to nearest 1,000		5,000
Sources:		
Average labor rate developed by CALFED		
Days of irrigation per year developed by CALFED		
Hourly cost for equipment use from UC Extension Farm Budgets		

Table A-4
Capital & O&M Costs for Measurement
of Surface Water Diversions & Return Flows
at High and Highest Practical Levels of Measurement

	Capital Cost	Useful Life	Annual O&M
Main Canal (500 cfs)			
Replogle Flume	$37,000	50	$1,200
District Drain (20 cfs)			
Replogle Flume	$9,500	50	$1,000

Source: Provost & Pritchard Engineering

Measurement of Groundwater at Highest Practical Level of Measurement: Micro-meter or Equivalent Propeller Meter on Well.

Description: Propeller meters are commercial flow measuring devices used in pipelines and in conduits flowing full and under pressure. The propeller rotates on a horizontal axle geared to a totalizer that displays total volume that has passed the meter. Some meters also display the instantaneous discharge rate. Since the meter head, in effect, counts the number of revolutions of the propeller to indicate the flow rate, any factor that influences the rate of propeller turning can affect the accuracy of the meter.

Table A-5
Meter Read Unit Costs for Groundwater Well Measurements at the Highest Practical Level of Measurement

Labor		
12 reads per year		12
Avg. time to perform measurement is 0.5 hrs.	x	0.5
Hourly staff rate including benefits is $36/hr	x	36
		216
Truck		
12 reads per year		12
Avg. time to perform measurement is 0.5 hrs.	x	0.5
Hourly cost for 1/2 ton pickup is$13.50 (source: UC Extension Farm Equipment Cost Budgets)	x	13.5
		81
Total meter read cost per meter		297
Rounder to nearest 100		300

Table A-6
Capital and Annual O&M Cost for Well Meter at the Highest Practical Level of Measurement

Estimated useful life:	☐	☐	Meter:	10
Description	Quantity	Units	Unit Cost: 12" dia.	Total Costs: 12" dia.
Micrometer (or equivalent) totalizing propeller meter	1	LS	$ 1,000	$ 1,000
Installation* - steel pipe saddle	1	LS	$ 300	$ 300
☐	☐		☐	☐
☐	☐		☐	☐
☐	☐		☐	☐
☐	☐		Total	$ 1,300
Annual O&M Cost	1	LS	☐	$ 200

* Assuming existing steel pump discharge pipe with 10' straight pipe section u/s & 5' straight section d/s of meter location

Table A-7
O&M Unit Costs for Farm Gate Diversion
Measurements at the High Level of Measurement

Periodic measurement during irrigation event		
Staff Labor		
3 measurements per irrigation		3
8 irrigations per year	x	8
Avg. time to perform measurement is 0.5 hrs.	x	0.5
Hourly staff rate including benefits is $36/hr	x	36
		432
Truck Use		
3 measurements per irrigation		3
8 irrigations per year	x	8
Avg. time to perform measurement is 0.5 hrs.	x	0.5
Hourly cost for 1/2 ton pickup is$13.50 (source: UC Extension Farm Equipment Cost Budgets)	x	13.5
		162
Total cost for 3 farm gate measurements per irrigation		594

Inventory and rating of turnout structures cost assumptions		
For the rating and inventory program assume about 0.75 hrs/gate. This would cover collection of rating curves from mfgs and site inspection of turnouts. In the office data would be put into a format and analyzed by a staff engineer and written up. Assume inventory and rating is updated every 15 years.		
Staff Labor		
1 inventory per turnout		1
0.75 hrs per inventory	x	0.75
$75 per hour	x	75
		56.25
Annualized cost @ 5.5% discount rate with 15 year life		$5.60
Total Annual Cost		$599.60
Rounded to nearest 100		$600.00
Sources:		
Average labor rate developed by CALFED		
Days of irrigation per year developed by CALFED		
Hourly cost for equipment use from UC Extension Farm Budgets		

Table A-8
Basis of Costs for Measurement Structures and O&M

Cost Category	Items in Category	Item Cost
Materials:	Reinforced concrete	1000-1200 $/cy
	Concrete lining (hand lining)	12 $/cy
	RipRap	5 $/cy
	Date Recording Equipment	6500 $/each
	Includes:	
	Float, stilling well	
	Data logger, power system	
	Phone and modem, and	
	Programming	
	Stream gauging bridge	
	500 cfs	7000 $/each
	100 cfs	4000 $/each
Data Collection	Data collection includes site visits, calibration, databasing, and calculations	400 $/yr
O&M	Monthly stream gauging	300 $/yr
	Date equip. maintenance	900 $/yr
	Sediment removal	200 $/yr

Table A-9
Measurement Costs Reported by Imperial Irrigation District

Description	Capital Cost 2001 $	O&M Cost 2001$	# of Sites	Capital Cost per Site	O&M Cost per Site
Main canals ; 5,000 - 12,000 cfs	$1,057,700	$98,000	63	$16,789	$1,560
Main supply laterals; 1,000 - 3,000 cfs Laterals; 30 - 250 cfs Drains: 5 - 30 cfs	$5,343,000	$496,328	200	$26,715	$2,480
Farm deliveries; 1 - 18 cfs	$8,100,000	$955,000	1,000	$8,100	$960
TOTAL	$14,500,700	$1,549,328	1,263		

NOTES:

Cost information is based on the IID/MWD Water Conservation Program (Kirk Dimmitt, 2001)

Operations & Maintenance (O&M) based on IID/MWD Water Information System and Conserved Water Verification O&M costs.

Capital costs include equipment/installation, development of measurement process/methodology, data analysis, quality control, & reports.

O&M costs includes O&M of equipment, monitoring/collection of data, data analysis, and reporting.

Farm deliveries, both inflow & outflow, based on installation of over 1000 sites including contingencies for additional equipment to ensure sites, that fail, are back up and running in an expeditious manner.

All costs have been adjusted to 2001 costs using the U.S. Bureau of Reclamation Composite Construction Cost Index where necessary.

Measurement of Crop Water Use at High and Highest Practical Level of Measurement: Remote Sensing Using LANDSAT7 Images

Table A-10
LANDSAT7 Crop ET Measurement Costs

High Level				
Region	Time Pts	Images	Unit Cost	Total Cost
Sac Valley	5	2	10,000	100000
Delta	5	1	10,000	50000
East SJ	6	1	10,000	60000
West SJ	6	1	10,000	60000
South SJ	6	1	10,000	60000
Other	6	3	10,000	180000
Highest Practical				
Region	Time Pts	Images	Unit Cost	Total Cost
Sac Valley	11	2	10,000	220000
Delta	11	1	10,000	110000
East SJ	13	1	10,000	130000
West SJ	13	1	10,000	130000
South SJ	13	1	10,000	130000
Other	15	3	10,000	450000