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BEFORE THE STATE WATER RESOURCES CONTROL BOARD

OF THE STATE OF CALIFORNIA

In the Matter of **Periodic Review of the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary**	**TESTIMONY OF SAN JOAQUIN RIVER EXCHANGE CONTRACTORS WATER AUTHORITY: TESTIMONY OF CHARLES BURT ON ISSUES 4 AND 5: SOUTHERN DELTA ELECTRICAL CONDUCTIVITY AND SALINITY IN THE SAN JOAQUIN RIVER BASIN** Hearing Date: April 22, 2009 Time: 10:00 a.m.

Dr. Charles Burt testifies as follows:

1. My resumé is attached to this testimony. I am a professor in the BioResource and Agricultural Engineering Department, California Polytechnic State University, San Luis Obispo, California, since 1978; where I have also served as Founder/Director/Chair of the Irrigation Training and Research Center (ITRC) since 1989, and as Chairman of the Board since 2000.

2. I am a registered professional engineer - Civil (California RCE 28995, July 1978); Agricultural (California AG 430 March 1979); Irrigation (Utah 5662, August 1981).

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3. I am certified through the Irrigation Association as an Ag Irrigation Manager, and an Irrigation Designer (drip, surface, and sprinkler irrigation systems).

4. A wide variety of agricultural crops are grown in the lower San Joaquin River watershed. Salts are imported from the Delta through the federal Central Valley Project and disbursed through applied irrigation water. Return flows that eventually drain to the San Joaquin River through drainage channels, in addition to ground water accretions containing naturally occurring salts in San Joaquin soils, M&I discharges and natural tributaries, are the source of salinity in the irrigation water diverted by downstream users. Salts contained in irrigation water may, when applied to an agricultural field, accumulate in the root zone to the point that they cause a reduction in yield.

As recognized in the Staff Reports of the SWRCB submitted as part of the 2005-2006 Water Quality Control Plan Periodic Review and the reports and materials utilized by the Central Valley Project Regional Water Quality Control Board in adopting salt and boron TMDL standards for the San Joaquin River, elevated salinity in the southern Delta is caused by low flows, salts imported in irrigation water by the State Water Project and Central Valley Project, and discharges of land-derived salts, primarily from agricultural and wetland drainage. This Board recognized in its Decision D-1641 that "the actions of the CVP are the principal cause of the salinity concentrations exceeding the objectives at Vernalis." (D-1641, p. 83). This Board found that the United States Bureau of Reclamation, "through its activities associated with operating the CVP in the San Joaquin River Basin, is responsible for significant deterioration of water quality in the southern Delta." (D-1641, p. 83).

The planners of the irrigation projects and the policymakers that wanted increased and more reliable agricultural production (and a stronger economy) understood that drainage was necessary for the irrigation projects. In spite of what everyone would like, it is important to realize that standards cannot reasonably be based upon wishful longing that the San Joaquin River attain the same water quality as that of a naturally flowing water body – thinking and a longing for conditions that cannot scientifically occur. It is essential for all the stakeholders that

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unrealistic regulatory standards not be implemented - standards that would unintentionally destroy the benefits of irrigated agriculture and an efficient food supply for our increasing population, and throw millions of society dollars at a condition that cannot be reversed but can be efficiently managed. The San Joaquin River will be a man-created drain for salts until and unless reverse osmosis (and disposal of the extracted salt) becomes economical for non-point discharges, or a drainage system for physically removing those salts is built and operated. A sustainable drainage water quality objective (e.g., for the San Joaquin River) cannot possibly be maintained at the same or better quality than the salinity objective established for the source water (at the Delta intakes of Delta-Mendota Canal and California Aqueduct) – yet the proposed salinity standard for the San Joaquin River upstream of Vernalis could do just that.

Even the salinity of the Delta-Mendota Canal (DMC) water equals or exceeds the maximum allowable salinity target in the San Joaquin River (see the table below) during some months. Yet almost all DMC water is successfully used to grow beans, lettuce, almonds, and numerous other salt-sensitive crops. The months highlighted in **bold** in the table are when the mean monthly EC of DMC water at Check 21 (Mendota Pool) exceeded the proposed water quality objective of 0.70 dS/m in the summer and 1.0 dS/m in the winter.

Delta-Mendota Canal Mean Monthly EC (Check 21)
Mean Monthly EC values computed from daily data provided by USBR
Bold indicates exceedance of San Joaquin River salinity targets
(All values are in dS/m)

	1993	1994	1995	1996
Jan	**1.10**	0.73	0.49	0.65
Feb	0.88	0.41	0.61	0.48
Mar	0.81	0.81	**1.30**	0.36
Apr	0.65	**0.89**	0.63	0.42
May	**0.72**	**0.88**	**0.73**	0.38
Jun	0.65	**0.77**	0.20	0.39
Jul	0.48	**0.79**	0.21	0.36
Aug	0.25	**0.69**	0.36	0.37
Sep	0.43	**0.70**	0.35	0.39
Oct	0.45	0.62	0.24	0.37
Nov	0.56	0.49	0.42	0.44
Dec	0.65	0.70	0.44	0.51
Average	0.64	0.71	0.50	0.42

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The Central Valley Regional Water Quality Control Board's (Regional Board) position has consistently been that an out-of-valley drain is needed to remove salts from lands irrigated on the west side of the San Joaquin River. In effect, requiring that the salts be reapplied to the lands to meet unrealistic standards will eventually destroy productive farm land and make it economically impossible to produce food and fiber needed by our growing urban populations. Moreover, in the long term, the salt that the TMDL attempts to have retained in the soil will eventually reach the San Joaquin River in any case.

Given the fact that the USBR has not provided drainage to the San Luis Unit lands as required by this Board and the courts, this Board is presented with little alternative other than to provide for the drainage of the region's farmlands through the San Joaquin River.

5. Leaching, the process of applying water over and above the evapotranspiration (ET) requirements of the plants irrigated, is a necessary on-going or annual irrigation management practice used to flush a certain fraction of water below the root zone to maintain an acceptable, constant salt concentration in the root zone. On a long-term basis, the amount of salts removed by leaching (deep percolation) must be equal to or greater than the salts imported with irrigation water or salts will build up and eventually impact crop yields.

The water needed to provide the leaching requirement is a beneficial use of irrigation water. (Irrigation Performance Measures: Efficiency and Uniformity. Burt, C.M., et al. ASCE Journal of Irrigation and Drainage Engineering. 123(6) Nov/Dec 1997). Technically, we have formulas that allow us to compute the Leaching Requirement (LR) – which enables us to compute how much deep percolated irrigation water or rain water is required to achieve the desired salt concentration in the soil at the point in the field that receives the least amount of water.

6. Little has changed since 2005 when this testimony was first prepared. The regulators continue to long to regulate that which only nature and gravity control. In July 2004, ITRC staff and I prepared a report for the San Joaquin Valley Drainage Authority that did the following:

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- Examined the proposed San Joaquin River water salinity standards by the Regional Board for the reach of the San Joaquin River from the Mendota Pool to Vernalis.
- Examined previous, related studies.
- Updated ITRC information on cropping patterns and the recent flow models for the San Joaquin River, and provided a scientific basis for determining reasonable numerical salinity targets that will provide reasonable protection of irrigated agriculture use of water from the San Joaquin River, which is the most sensitive beneficial use of water diverted from the lower San Joaquin River.

I have summarized the major points from these tasks in the sections below.

7. The Proposed Alternatives

The proposed salinity standards of the Regional Board and State Board are relatively restrictive by comparison to historic conditions, especially in terms of the water quality of water supplies imported to the watershed from the Bay-Delta.

The SWRCB set a river water quality objective of 0.7 mmhos/cm (a.k.a. 0.7 dS/m) during the summer irrigation season (April 1 through August 31) based on the salt sensitivity and growing season of beans and an objective of 1.0 mmhos/cm during the winter irrigation season (September 1 through March 31) based on the growing season and salt sensitivity of alfalfa during the seedling stage. (SWRCB Staff Report Periodic Review, September 30, 2004, page 28). The source of these water quality criteria apparently originates in the 1987 Technical Committee Report entitled "Regulation of Agricultural Drainage to the San Joaquin River (SWRCB Order No. WQ 85-1). Due to the significant role in the 85-1 Technical Committee Report and subsequent policy decision making about salinity in the San Joaquin River, I note several of the key aspects of the criterion of 0.7 mmhos/cm (415-430 ppm TDS) as described in the report:

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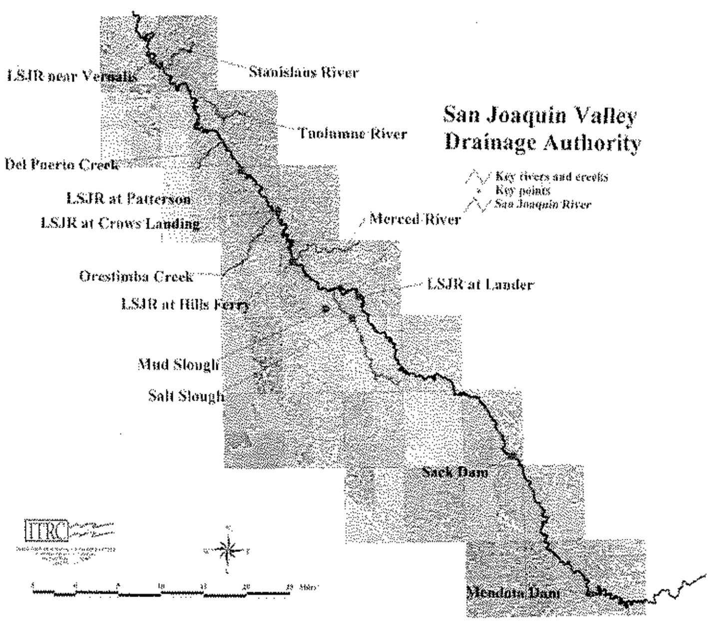
(1) Irrigated agriculture is deemed the most salinity-sensitive beneficial use.

(2) A standard based on irrigated agriculture use is lower than the criteria to protect other beneficial uses, and therefore should protect fish and wildlife.

(3) The 85-1 Technical Committee Report also includes a mention of work done by the Regional Board that had determined that a water quality objective of 1.0 mmhos/cm during the winter irrigation season for the San Joaquin River in the area immediately downstream of Hill's Ferry would provide reasonable protection to these crops on the soils in the areas (P. VIII-15). Further there is discussion of the difficulty of achieving this objective in dry and critical water year types and how this may necessitate blending with better quality water during periods of higher river salinities.

(4) Figure 1 (below) identifies the key points along the San Joaquin River that are relevant to this next point. Quite correctly, as discussed in the 1985 85-1 Technical Committee Report (TCR), there are only a few agricultural diversions between the confluence with Salt Slough and Hills Ferry, mainly for salt-tolerant pasture. The TCR authors state the following:



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> "An objective of 3.0 mmhos/cm EC (3.0 dS/m) supports the existing uses in Salt Slough and areas downstream to Hills Ferry consistent with the historic water quality and present agricultural practices. Therefore, an objective of 3.0 mmhos/cm EC is recommended as the water quality objective for this limited area."

This citation is offered to illustrate that alternate water quality objectives for the lower San Joaquin River have been proposed previously in a manner that recognized existing agricultural practices, specifically the use of higher water salinity threshold standards for irrigation of crops, and which also recognized the reality that Salt Slough, Mud Slough and the San Joaquin River will inevitably serve as a drainage system until a man-created system for removing salts from the watershed is developed and operated economically.

8. <u>Review of Some Technical Points</u>

Allow me to amplify/repeat some of technical details in a more orderly fashion before continuing:

a. It is a physical fact that the salt that is imported into the region must be exported, or else stored in the region.

b. The idea of meeting a "leaching requirement (LR)" from an agronomic standpoint means that irrigation is managed to continually remove salt from the soil as quickly as it is applied. It is not a concept of "storing" salt.

c. Storage of salt in the plant root zone will inevitably cause a buildup of salt levels that will eventually eliminate agriculture, which in turn can have tremendous negative consequences on air quality, recreation, and local and state economies.

d. It is possible to temporarily store salt in the soil for the next 10 years and see a *temporary* beneficial impact on river water quality in *some* reaches of the river. But the eventual consequences, which cannot be debated from a scientific standpoint, are:

i. Agricultural production would seriously decline or be eliminated in some areas as the soil salinity levels increase.

ii. Ultimately, if agricultural is to survive, some of the salt would need to be removed. The removal rate, measured in tons/year of salt, would be approximately the same as

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if the soil was maintained at a lower salinity level . . . meaning that all of the temporary efforts were to no long-term benefit.

e. The only long-term solutions that we know of for the salinity problem are:

i. Import less water, which requires a reduction in cropped acreage.

ii. Utilization of the San Joaquin River for drainage with reasonable water quality standards.

iii. Reverse osmosis (with subsequent salt disposal/storage questions and a very high cost).

f. Sometimes there is confusion about the basics of an "EC" measurement and what it means. "Soil water salinity" is different from "saturated soil past extract (ECe)" is different from "irrigation water salinity".

Although the irrigation water salinity impacts the soil salinity (ECe), the ECe is also impacted by the leaching fraction (the percentage of deep percolation of both rainfall and irrigation water). The importance of the relationship between these different "EC" values – as related to SJ River water quality standards - should become apparent in later sections.

g. Maas (1990) defines salt tolerance as "the plant's capacity to endure the effects of excess salt in the medium of root growth." Although a plant's capacity to endure salts is not an absolute value, salt tolerance is usually expressed in terms of the yield reduction associated with specified concentrations (ECe) of saturated soil past extract – a value that is very different from the irrigation water EC. The amount of salts in soil water tolerated by a specific crop depends on the variety, as well as being a function of the interactions between soil, fertility, climate, irrigation method, growth stage, and other environmental stresses.

h. The relative salt tolerances for agricultural crops are fairly well understood. Research on various different varieties has found differences in salt tolerances; however, the values for most crops grown in the San Joaquin Valley fall approximately into one of the categories listed in Table 1 (see next page). It is important to note the values listed on the table

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are soil salinity values, **not irrigation water salinity.** There is a large range in the salt tolerance of agricultural crops - up to tenfold in some cases. For example, cotton, a tolerant crop, has a salt tolerance nearly eight times as great as beans, a sensitive crop. The precise effect of salinity on yield depends on the timing of the stress effect and the growth stage.

i. The crop tolerances for soil salinity at yield potentials of 100% correspond to qualitative groups as defined by Maas (1984). The numerical divisions for relative soil salinity tolerance ratings are summarized in Table 1 included for the reader's convenience.

Table 1. Tolerance of various crops to soil salinity, after germination.

Portion of Table 3-2 from BRAE 331 text by Dr. Charles Burt, BioResource and Agricultural Engr. Dept., Cal Poly, San Luis Obispo, CA. (Adapted from Maas and Hoffman, 1977).

Crop	Threshold ECe (ECe at initial yield decline) dS/m	Crop	Threshold ECe (ECe at initial yield decline) dS/m	Crop	Threshold ECe (ECe at initial yield decline) dS/m
Alfalfa	2.0	Corn, sweet	1.7	Plum	1.5
Almond	1.5	Cotton	7.7	Potato	1.7
Apricot	1.6	Cowpea	1.3	Radish	1.2
Avocado	1.3	Cucumber	2.5	Rice, paddy	3.0
Barley (grain)	8.0	Date	4.0	Ryegrass, perennial	5.6
		Fescue, tall	3.9		
Bean	1.0	Flax	1.7	Sesbania	2.3
Beet, garden	4.0	Grape	1.5	Soybean	5.0
				Spinach	2.0
Bermudagrass	6.9	Grapefruit	1.8	Strawberry	1.0
Blackberry	1.5	Harding grass	4.6	Sudangrass	2.8
Boysenberry	1.5	Lettuce	1.3	Sugarbeet	7.0
Broadbean	1.6	Lovegrass	2.0	Sugarcane	1.7
Broccoli	2.8	Meadow foxtail	1.5	Sweet potato	1.5
Cabbage	1.8	Onion	1.2	Tomato	2.5
Carrot	1.0	Orange	1.7	Trefoil, Big	2.3
Clover;ladino red, strawberry	1.5	Orchardgrass	1.5	Trefoil, birdsfoot narrow	5.0
Clover, berseem	1.5	Peach	1.7	Wheat	6.0
Corn (forage)	1.8	Peanut	3.2	Wheatgrass, crested	3.5
Corn (grain)	1.7	Pepper	1.5	Wheatgrass, fairway	7.5
				Wheatgrass, tall	7.5

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j. For a given irrigation water salinity, a farmer can manage irrigation for a wide range of soil salinities (which is what the plants respond to – not to the irrigation water salinity, itself). The generally accepted formula that defines this relationship is:

$$LR = \frac{ECw}{5(ECe) - ECw}$$

where LR = Leaching Required = the fraction of applied water that must deep percolate at a point in the field to maintain the desired ECe

ECe = The saturated soil paste extract salinity, dS/m (the average of the whole root zone salinity)

ECw = The average salinity of the irrigation water, dS/m

This formula is applied below to show how a ***very*** sensitive crop such as beans can be grown with an irrigation water ECw of 2 dS/m *as long as sufficient leaching water is provided.*

Example: The maximum ECe for beans with no yield decline = 1.0 dS/m
ECw = 2.0 dS/m

$$\text{The required LR} = \frac{2.0\ \text{dS/m}}{5 \times (1.0\ \text{dS/m}) - 2.0\ \text{dS/m}} = .67$$

For other sensitive crops, such as deciduous trees, the LR is only half as great as for the extreme example of beans. And if the crops are irrigated on a frequent basis, they can withstand higher salinities than the published threshold values.

It is noteworthy that beans only represent about 5% of the crops downstream of Vernalis. It is also noteworthy that the needed fraction of deep percolation of irrigation water would be less than 0.67 because (i) rainfall contributes some of the water, and (ii) one would not expect an ECw of 2.0 dS/m for the complete year.

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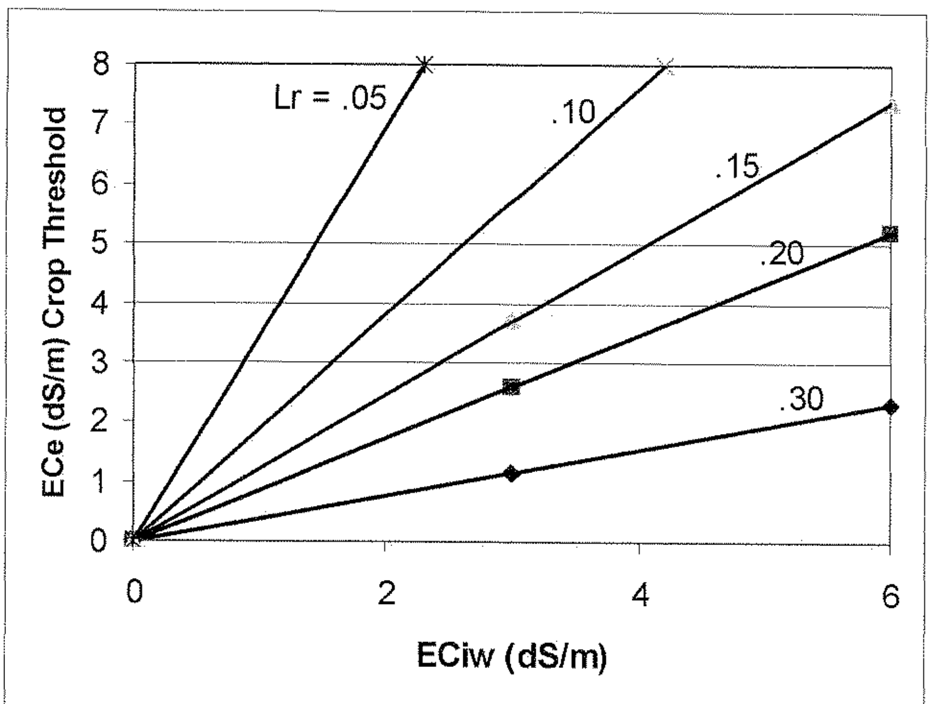
9. Context of "LR" Equation

Two very important points must be made to put "LR" even more into context:

(1) The standard "LR" equation is meant to be applied to the spot in the field that receives the least amount of water. This means that if the LR is not met or achieved, the vast majority of the field will still have no yield decline because of extra deep percolation caused by non-uniformity of irrigation water application.

(2) There are a number of formulas available to predict the relationship between LR, water ECiw, and soil saturated past ECe. The "Agricultural Salinity Assessment and Management" book (ASCE EP No. 71, K. Tanji (ed), 1990) is probably the most common reference for salinity. The figure below illustrates the recommended relationship.



Leaching Requirement (Lr) as a Function of the Salinity of the Applied Water and Salt-Tolerance Threshold Value (after Hoffman (1983); Tanji (ed), 1990.)

The figure above shows that with an ECiw of 2.o dS/m, the required LR would be about 0.28 to achieve an average root zone ECe of 1 dS/m. This is much less than the 0.67 value computed earlier – and upon which this testimony is based. The analysis for this

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testimony estimated no problem with higher ECiw, and the Hoffman relationship only strengthens that argument.

10. **Deverel and Schmidt Drainage Study**

I have reviewed related work done by Steve Deverel and Kenneth D. Schmidt. Dr. Deverel has developed a ground water flow model for Firebaugh Canal Water District and surrounding Water Districts and looked at the flux, or flow, across the common boundary between Firebaugh and upslope water districts in the San Luis Unit of the CVP. Dr. Schmidt, in 1987, conducted pump tests right at the boundary of Firebaugh Canal Water District with upslope water districts to calculate the movement of water in the subsurface across the common boundary. In Dr. Deverel's work, he came up with a number of around 235 acre-feet per year per mile of boundary. The movement of poor quality drainage water into Firebaugh is caused by the failure of the government to provide drainage service to the lands in the San Luis Unit.

a. The TDS of this water moving across the boundary is about 5142 EC.

b. I also reviewed Dr. Deverel's work where he determined a quantity of load of the poor quality water that moves outside of Firebaugh originates from areas other than the Firebaugh Canal Water District. Dr. Deverel calculated that load to be 50%. In other words, 50% of the poor quality water discharged from Firebaugh, which ultimately ends up in the San Joaquin River is attributable to activities other than Firebaugh's farming actions.

11. The Firebaugh study points to the regional nature of the problem and is a reason that this Board should be establishing standards as part of its Periodic Review to manage the San Joaquin River to allow for the drainage of salts from agricultural lands, given the fact that the government is not acting to construct a drain or otherwise provide drainage service to the region.

12. The reasonableness of achieving water quality conditions is one of the factors that the Regional Board and this Board must consider when setting salinity objectives. (Water Code §13241). The Regional Board has apparently recognized that significant reductions in salt discharges will be needed to meet the objectives that they have proposed. A major point I will now make is that the reduced surface discharges may not result in reasonable impacts. Put

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another way, the impacts of retaining salt or productive farm land because of an ill-conceived regulatory goal can be detrimental.

13. Examination of River Sections Between the Mendota Pool and Vernalis

The 130 mile reach of the lower San Joaquin River from the Mendota Pool to the airport way bridge at Vernalis was divided into 10 sections for analysis, corresponding to the primary tributary inflow points or major hydraulic feature. The Regional Board can set, with justification, water quality objectives that vary by river section and by the time of year. And the State Board's Periodic Review of Delta Estuary standards must in its standard setting for that area recognize that salinity standards can preserve beneficial uses without attempting to idealize San Joaquin River water quality to a near natural state. The San Joaquin River has undergone extensive hydromodification. Realistically, this is a man-altered system, even though the body of water is called a "river" as contrasted with a "drainage canal"

Based on historical data sets of water quality indicating significant differences in salinity concentrations by river sections and the fact that different water agencies and private water users divert and/or drain to different river sections, it is reasonable to divide the distance between the Mendota Pool and Vernalis for the purpose of varying the salinity objectives.

The river Salinity Standards must recognize that if poor quality water is "stored" in the soil profile upstream the stored salts may come down the river at times when beneficial uses will be more severely impacted. As poor quality water stored within the soil profile and tile sumps operated by individual growers or water agencies are shut off to meet the TMDLs, it increases the lateral subsurface flows of salty water to the surrounding grounds and actually tends to increase discharge from some of the other surrounding tile sumps and from accretions which reach the San Joaquin River in an uncontrollable fashion. In other words, to a degree, TMDLs or an artificial and inflexible Vernalis Standard will cause a shutdown of tile sumps in a drainage area and this will result in an even larger problem for the landowners and users of water from the San Joaquin. The problem exists due to the failure of the government to provide drainage service to the region.

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a. I directed an analysis to determine what the salinity concentrations would be in the lower San Joaquin River with no salt loading from agricultural discharges through surface drainage or surface canal spills. In other words, one way of assessing the reasonableness of the proposed salinity objectives is to first quantify the salinity concentrations that would have occurred in the river using historical data, assuming that water users on both the east and west sides of the river did not dispose of drain water or canal spill in the river or in the major tributaries and instead ground water accretion flows were the means of salts entering the river.

b. The results of my analysis indicate that under the proposed actions, the estimated EC (water salinity) in the River from Bear Creek (north of Mud and Salt Sloughs joining the River) to Del Puerto Creek (9 miles above the Tuolumne confluence with the San Joaquin River), a total reach of 43 miles, during August 2002 would have been over 100% higher than the most lenient proposed objectives proposed by the Regional Board. The value used in the numerical analysis for the ground water accretion rate had a significant influence on the predicted EC and flow rate at Vernalis under a no agricultural discharge condition indicating higher EC at Vernalis. This limited analysis of historical conditions indicates that the removal of all surface discharge, by itself, cannot be reasonably expected to bring the river into compliance with the proposed salinity objectives. In a simple logical extension, Vernalis standards that drive agricultural users to eliminate surface water drainage flows or canal spillage can require more, not less, New Melones flows.

The bottom line is that it seems unreasonable to put a regulation into place if the unintended impact will be an increase in EC at Vernalis caused by uncontrolled salt-laden ground water accretion flows into the river.

c. Using this analysis, it is seen that the unfortunate impact of a well-intentioned EC standard applied to regulate discharges is that the mean EC in the reach of the river between Bear Creek and Del Puerto Creek was actually elevated over historical conditions when agricultural surface discharges were removed. In particular, in the section of river between Salt Slough and Mud Slough, the estimated EC in August 2002 was 80% higher than with surface

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discharges and the flow rates decreased by over 60%. The analysis for salinity concentrations occurring during March 2002 with no surface discharge (drain water disposal and canal spills) follows a similar pattern, with the exception that the mean EC downstream of the Merced River was about half as high due to the assimilative capacity of the natural flows of that tributary.

d. I also directed an analysis to estimate the additional instream flows that would have been required under historical conditions in order to meet the salinity objectives proposed by the Regional Board. The Regional Board's proposed alternative salinity objectives range from 700 to 1000 microseimens per centimeter (μs/cm) (0.7 – 1.0 dS/m). As discussed immediately above, there would need to be some additional instream flows provided to the river in order to provide enough assimilative capacity depending on flow conditions. I do not understand the rationale behind a regulation prohibiting surface drainage into the river, which then requires the addition of artificial surface flows to meet the water quality standards that the first steps were intended to meet.

I performed an analysis to determine reasonable salinity objectives for different sections of the lower San Joaquin River from the Mendota Pool to Vernalis using our most current knowledge of crop needs.

e. A wide variety of agricultural crops are grown in the lower San Joaquin River watershed. The analysis computed the irrigated acreage of the agricultural fields in each of the delineated river sections from Mendota Pool to Vernalis using GIS mapping with field boundary layers obtained from the Department of Water Resources. In addition, comprehensive field work done by the Regional Board was used to estimate private acreage that is presently being irrigated with San Joaquin River water.

f. Salts are imported from the Delta and disbursed through applied irrigation water.

g. The salt tolerance of various crops in various sections of the river was computed, along with the gross water requirements by month (2002) that included leaching requirements.

h. The results indicate that a soil salinity objective of 2,000 μs/cm (2 dS/m) for the San Joaquin River from the Merced River to Vernalis would provide reasonable protection of the agricultural supply beneficial uses in that region – especially because some of the river

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stretches have no agricultural diversions. For example, because of the lack of agricultural diversions between Sack Dam and the Merced River, higher salinities are acceptable in this reach.

i. Figure 2 illustrates a worst-case August 2002 scenario for additional diversions required to avoid crop loss, as compared to available river flows. A key point to be made is that the concept of "leaching requirement" states that the required leaching does not need to be done every month, but instead can be done once/year for most crops.

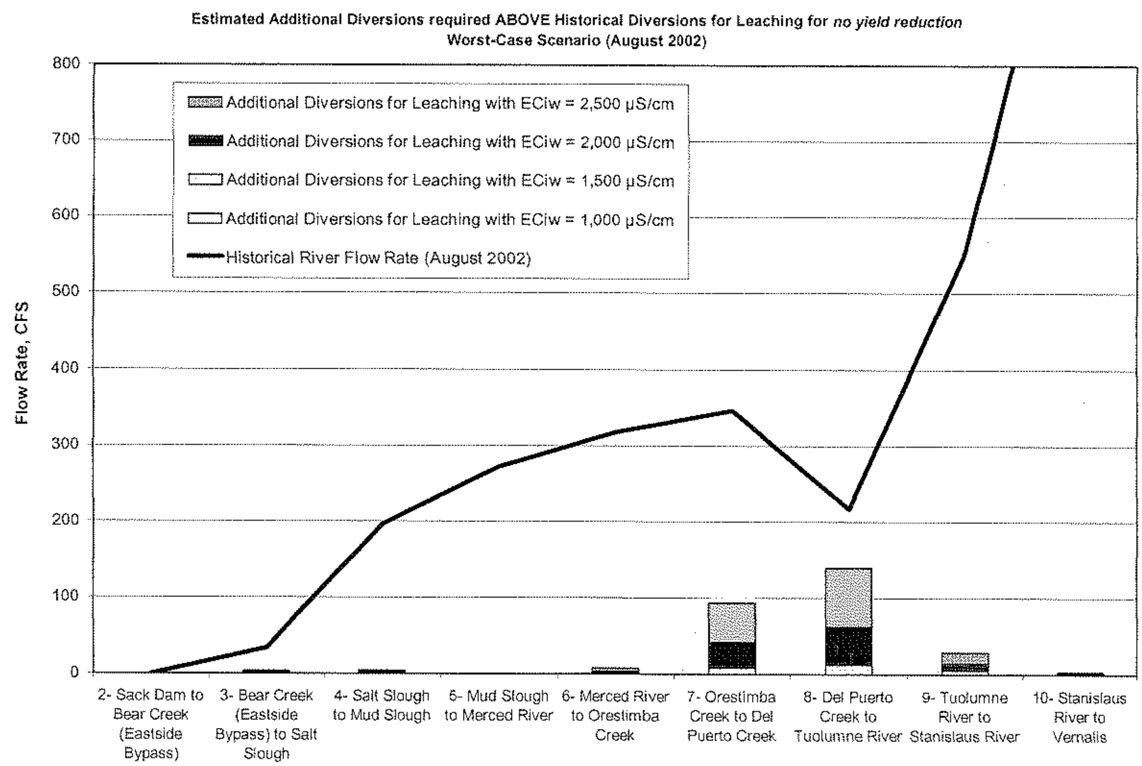

Figure 2. Additional diversions needed to avoid yield decline, in various reaches of the San Joaquin River.

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j. The crop acreages for each river section according to salt tolerance ratings are summarized herein for the reader's convenience. The analysis indicates that sensitive crops represent about 1/3 of the crop acreage downstream of Sack Dam, while the majority of acreage can be classified moderately sensitive.

Table 2. Acres of crops of different qualitative salt tolerance ratings by river section in the Lower San Joaquin River

Sect.	Description	Salt Tolerance Rating[1]			
		Sensitive	**Moderately Sensitive**	**Moderately Tolerant**	**Tolerant**
1	Mendota Pool to Sack Dam	281	20,694	2,083	20,708
2	Sack Dam to Bear Creek	0	4,261	217	2,694
3	Bear Creek to Salt Slough	76	804	20	170
4	Salt Slough to Mud Slough	76	804	37	170
5	Mud Slough to Merced River	0	0	0	0
6	Merced River to Orestimba Creek	153	1,608	41	341
7	Orestimba Creek to Del Puerto Creek	5,908	12,166	1,250	1,074
8	Del Puerto Creek to Tuolumne River	11,223	8,625	1,194	1,160
9	Tuolumne River to Stanislaus River	1,926	1,976	648	1,098
10	Stanislaus River to Vernalis	131	208	45	70
	Total	**19,776**	**51,147**	**5,534**	**27,486**
	(%)	(19%)	(49%)	(5%)	(26%)
	Sub-total downstream of Sack Dam	**19,494**	**30,453**	**3,451**	**6,778**
	(%)	(32%)	(51%)	(6%)	(11%)

[1] Based on the agricultural crop types as listed in Table 5 of Ayers and Westcot (1989)

CONCLUSIONS

Based upon the foregoing it is my opinion that:

1. It is unreasonable from a scientific standpoint to install a drainage water quality standard that requires the drainage water to be as good as, or better than, the incoming irrigation water quality.

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2. It is unreasonable from a scientific standpoint to expect to have sustainable irrigated agriculture by storing more salt in the soil every year.

3. Discontinuing the disposal of west side drain water to the San Joaquin River, by itself, will not be sufficient to meet the least restrictive of the Regional Board's salinity objectives in the reach of river from Salt Slough to the confluence with the Tuolumne River.

4. Meeting the least restrictive salinity objective proposed by the Regional Board would necessitate an additional instream flow of over 100% above historical conditions in the critical river section downstream of Mud Slough. This is equivalent to an additional flow rate of about 125 cfs during the middle of the irrigation season in August.

5. A maximum water salinity objective of 2000 µs/cm for the San Joaquin River from the Merced River to Vernalis would provide reasonable protection of the agricultural supply beneficial use, based on historical conditions.

6. Upstream of the Merced River, it can be argued that a water salinity objective as high as 2500 µs/cm is reasonable within the historical cropping patterns.

7. The Regional Board has defined a formal procedure (Resolution 88-63: Sources of Drinking Water Policy) to de-designate beneficial uses, such as municipal and domestic supply. There is justification to explicitly de-designate municipal and domestic water use as a potential beneficial use on the lower San Joaquin River because there are no urban or municipal users between Mendota Dam and Vernalis, M&I beneficial uses require better water quality than agricultural uses, and the Regional Board has made allowance to de-designate categories of beneficial use.

8. In categories 4 and 5, there are reference to titles of "source control options", "climate change" and "salinity objectives". These words suggest a broad concluding theme in this testimony. Salinity is peculiarly a subject which lends itself to concentration upon short-term measurements rather than long-term planning. As an example, we are in the middle of a drought with extraordinary limits being placed upon exports of surface water from the Sacramento-San Joaquin Delta. This means less salt will be imported. Yet greater amounts of high-salinity groundwater are being pumped in the areas of the San Joaquin Valley draining into

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the San Joaquin River because of the drought conditions, adding additional salt to local irrigation sources but reducing groundwater accretion flows of saline water to the San Joaquin River. The water shortage conditions curtail surface drainage and return flows to the River. All of these conditions combine to result in a short-term reduction of salinity reaching the San Joaquin River.

To a regulator looking solely at salinity concentrations in the San Joaquin River, the changes appear to be a regulatory success. In the long-term, however, salt is retained in the soil profile, groundwater almost always of greater salinity is applied to the soil, and less leaching fraction water is available. The agricultural soils are advanced toward an inevitable unproductive status because drainage of the salts cannot occur. Those stored salts will eventually need to be removed in which case they will migrate toward and reach the San Joaquin River. They are being stored unsustainably until that time.

ITRC conducted a significant study related to long-term accumulation of salinity in soils of the San Joaquin Valley under drip irrigation (Burt, C.M. and B. Isbell. 2005. Leaching of Accumulated Soil Salinity Under Drip Irrigation. Trans of ASABE 48(6): 2115-2121). The results were rather alarming, since they showed that the poor salt leaching around emitters on trees and vines has resulted in large portions of fields being rendered unproductive. Although this accumulated soil salinity does not damage the present crop, it must be removed when the orchard is replanted. Many of these orchards are now reaching their replacement life. ITRC's research also determined the best way to remove this accumulated salt, which of course will result in that salt being washed downward (leached) into the groundwater, in many cases eventually into the San Joaquin River as eccretions. The point is that the short-term visual gains of today do not reflect the long-term sustainability challenges.

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The expanded point is that regulations need to be aimed at maintaining a salt balance over the long-term if we wish to establish policy on a long-term rather than short-term basis. Until a drainage system or physical system for removing salts exists through a physical conduit or through reverse osmosis and physical transport of the salt occurs, we must remove the salts imported and generated by irrigation through the San Joaquin River if we are to have irrigated agriculture. We could think long-term by reducing salinity in the water delivered from the Delta Mendota Canal and State Aqueduct through improved cross-Delta facilities, increasing the quantities of water available through such facilities, and thus reducing the amounts of saline groundwater applied and improving the availability of water for leaching fraction use.

The quoted phrases "climate change", "source control options" and "salinity objectives" suggest long-term planning and thinking, yet our regulatory approach is often the opposite in desiring to see some immediate improvement in "scores" or "pushing water users for innovative solutions" to reduce salinity discharges and driving them to attempt to store salt in soils or groundwater . . . which are short-term measures destined to inevitably fail.

If called to testify in this matter, I could and would testify to each of the above matters, except as to those matters stated upon information and belief, and as to those matters I believe them to be true and correct.

Executed this 6th day of April, 2009 at San Luis Obispo, California.

CHARLES M. BURT