Public Comment
**Crop Salt Tolerance**
Deadline: 9/14/09 by 12 noon


## *San Joaquin River Group*

- Modesto Irrigation District
- Turlock Irrigation District
- South San Joaquin Irrigation District
- San Joaquin River Exchange Contractors

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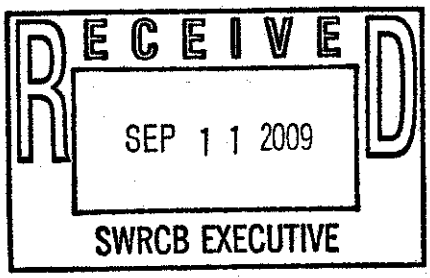
- Merced Irrigation District
- Oakdale Irrigation District
- Friant Water Authority
- City and County of San Francisco


September 11, 2009

*Submitted via email: commentletters@waterboards.ca.gov*

Mr. Charles R. Hoppin, Chair
State Water Resources Control Board
c/o Ms. Jeanne Townsend, Clerk to the Board
P. O. Box 100
1001 I Street, 14th Floor
Sacramento CA 95812-2000




Subject: Crop Salt Tolerance Study Report Comments

Dear Chairman Hoppin:

Enclosed you will find 5 copies of comments from the San Joaquin River Group Authority and the State Water Contractors on the July 14, 2009 Draft Report entitled *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta* (Study Report) prepared by Dr. Glenn Hoffman for the State Water Resources Control Board, Division of Water Rights. These comments are submitted according to your Notice of Availability of the Draft Study Report dated 14 July 2009 indicating that five (5) copies of written comments and attachments are to be submitted prior to 12 noon on Monday, September 14, 2009.

We are summarizing our main points in this letter and attaching a more detailed write-up on these and other points. In summary, we feel the report is well done but there are issues that must receive further analysis. These include:

- The Study Report needs to clarify the location, timing and cultural practices used for dry bean production in the South Delta to reflect present-day practices. Three issues are critical to this analysis:
  1. Dry-beans are not planted before May 15th yet they are assumed to be planted as early as April 1st. The planting dates were verified by comments from the South Delta Water Agency during the 13 August SWRCB workshop.
  2. Present-day cultural practices include pre-irrigations, which minimize or eliminate any potential salinity impacts during germination and seedling emergence.
  3. A major portion of dry bean production in the South Delta is in areas served by water from the Central Valley Project (Fig 3.5) and this acreage should be eliminated from the analysis.

- The analysis needs to evaluate other factors that may be limiting dry bean yields, such as soil boron levels and high water tables, rather than assuming a 100%-yield potential with salinity being the only limiting factor.

- The present water quality objective uses a 100%-yield potential based on the 1977 Mass and Hoffman analysis that established crop tolerance curves for major crops. Unfortunately, the dry bean data used for this analysis is now over 50 years old and does not represent more salt tolerant varieties used today and is likely over conservative. It is recommended that the

Study Report strongly advise against the continued use of these data and it recommend that a new curve be established for dry beans.

- The Study Report needs to take a closer look at actual leaching fractions (LF) in the Delta. The tile drainage data presented in the Study Report shows that it may be 25% or higher and this is consistent with findings in the New Jerusalem Drainage system (we are providing these data with these comments). The South Delta interests acknowledged at the 13 August workshop that leaching was high in the South Delta to prevent saline groundwater from being pushed back up by the constant tides. If this is true, this high leaching fraction should be used in the analysis and modeling as it will likely be continued into the future. This is reinforced by the fact that the predominant surface flood and furrow irrigation practices are also likely to continue into the future as there is little room for improved efficiency from these irrigation methods.

- A major omission in the Study Report is the analysis to show the basis for the winter irrigation season objective and the role of effective rainfall during the winter irrigation season. This needs to be reconsidered and a full evaluation presented, especially the role of rainfall in leaching and salt control.

- The SJRGA and SWC support the development of a transient model for South Delta conditions but in its absence the Study Report should recommend the use of the exponential steady state model over the 40-30-20-10 steady-state model. The 40-30-20-10 model does not represent the present state of knowledge regarding crop water uptake and would only compound the Study Report shortcomings since present crop tolerance data used in the model is over 50 years old.

Please feel free to call us at the above number if you have any questions or need any additional information.

Sincerely,

Dennis W. Westcot
Project Administrator
San Joaquin River Group

Terry L. Erlewine
General Manager
State Water Contractors

Enclosure (5 Copies of Written Materials and Comments)

cc: Frances Spivy-Weber, Vice Chair, SWRCB
Arthur G. Baggett, Jr, Member, SWRCB
Tam M. Doduc, Member, SWRCB
Dorothy Rice, Executive Director, SWRCB
San Joaquin River Group Authority
Les Grober/Tom Kimball/Mark Gowdy, Division of Water Rights, SWRCB

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September 11, 2009

Subject: San Joaquin River Group Authority and State Water Contractors Comments on the State Water Resources Control Board Draft Report Entitled "*Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*" dated July 14, 2009 By Dr. Glenn J. Hoffman (Study Report)

The report in well done, but there are issues that must receive further analysis. The issues that the SJRGA and the SWC feel are important are summarized here in the bullet points followed by a more extensive write-up on each. The issues include:

- The background information on timing and cultural practices of dry beans in the South Delta needs to be changed to reflect present day practices and that information utilized in the analysis. Of critical importance is that dry-beans are not planted before May 15th yet they are assumed to be planted as early as April 1st. The planting dates were verified by comments from the SDWA during the SWRCB 13 August 2009 workshop.

- The Study Report assumes that salinity is the only factor limiting dry-bean yield. In the South Delta there are likely other factors, especially soil boron, that are likely limiting yields to a greater extent than salinity. The assumption of a 100% yield of dry beans needs to be reconsidered as it is a key assumption in the modeling and may not be valid.

- The present water quality standard uses a 100%-yield potential based on the 1977 Mass and Hoffman analysis that established crop tolerance curves for major crops. Unfortunately, the analysis for dry beans is not based a strong data set and is likely over conservative. It is recommended that the report strongly advise against the continued use of this data and recommend that a new curve be established for dry beans.

- A review needs to be conducted of cultural practices presently being used to limit the potential for salt sensitivity of dry beans at germination such as major pre-irrigations.

- There is a need to clarify the salt leaching potential of rainfall in the "applied water" definition.

- There is a need to expand the discussion of actual leaching fraction by using presently available field data. The Study Report needs to take a closer look at actual leaching fractions (LF) in the Delta. The tile drainage data presented in the Study Report shows that it may be 25% or higher and this is consistent with our analysis of data from the New Jerusalem Drainage system (we are providing this data with these comments). The South Delta interests acknowledged at the 13 August workshop that leaching was high in the South Delta to control a fluctuating saline groundwater. If this is true, this high leaching fraction should be used in the analysis and modeling as it will likely to be continued into the future. This is reinforced by the fact that the predominant surface flood and furrow irrigation practices are also likely to continue into the future and there is little room for improved efficiency from these irrigation methods.

- Mandated water conservation by agricultural users will not likely change some of the basic water management practices being used for present day dry bean production. Production returns on dry beans will not allow the investment needed for improved irrigation practices therefore it is unlikely that there will be a reduction in the high leaching fractions being found on dry bean production today. If a water conservation modeling effort is undertaken, similar high leaching factions on dry bean production should be assumed.

- The analysis to show the basis for the winter irrigation season objective and the role of effective rainfall during the winter irrigation season has been left out of the report. This analysis needs to be conducted and the impact of winter rains on leaching and salt control needs to be fully evaluated.

- Both steady-state and transient models are available for use in development of a water quality objective. We support the development of a transient model for South Delta conditions but in its absence the Study Report should recommend the use of the exponential model over the 40-30-20-10 model. The 40-30-20-10 model does not represent the present state of knowledge regarding crop water uptake and would only compound the shortcomings in the analysis since the only crop tolerance data available is over 50 years old.

**BACKGROUND INFORMATION ON DRY BEAN PRODUCTION[1]:**

Bean production in western Stanislaus and San Joaquin Counties is largely dry lima beans (*Phaseolus lunatus*). Bean production in this area began during WWII and flourished for the three decades following. The market for lima beans and other dry beans however continues to decline as it is no longer considered a diet staple. Beans are now grown as a rotational crop with processing tomatoes and specialized crops such as onions, carrots and peppers. The reason is that beans are a legume and are considered a soil builder by releasing nitrogen into the soil. In addition, the present furrow irrigation practices have a very low efficiency and therefore accomplish a strong salt leaching prior to rotating back to processing tomatoes. These factors are often a stronger consideration than the monetary return from the bean crop[2].

Dry lima beans or other types of dry beans are rarely planted before May 15th. Harvest normally occurs from late August to late September. This was verified by Mr. Alex Hildebrand of the South Delta Water Agency (SDWA) during the 13 August 2009 SWRCB Workshop on the Study Report. All dry beans are furrow irrigated and pre-irrigated one week or less prior to planting. Pre-irrigations are done to ensure 1) a high moisture seedbed, 2) deeper profile moisture, and 3) a low-salinity seeding bed. Pre-irrigations are not done with sprinklers as it is not cost effective. Crop water use[3] ranges from 1.5 – 2 acre-feet/acre depending upon yearly weather conditions[4]. Water applications however are much higher and range up to 4 ac ft/acre. The high water use results from all bean production being done with furrows and the need to pre-irrigate. The use of furrows results in the need to run water for extended periods of time in order to get adequate deep percolation in the mid-furrow zone and this results in serious over applications at the head and tail end of the furrow network. This high water use results in a very low irrigation efficiency compared to other cropping systems in the same area.

[1] Personal Communications with Bean Growers in Western Stanislaus and San Joaquin Counties
[2] Personal Communications with former grower representatives for the California Bean Growers Association.
[3] California Department of Water Resources, Bulletin 113
[4] University of Nebraska Extension Bulletin, Crop Water use by Growth Stage – Dry Beans

## BORON AND OTHER FACTORS THAT MAY BE LIMITING YIELDS FOR DRY BEANS:

Control of cultural practices is significantly different from the greenhouse to field conditions. Throughout the Study Report it is assumed that a 100% yield of a bean crop can be obtained based upon some maximum yield that was obtained under controlled experimental conditions where salinity was the only factor limiting yield. In reality under field cultural practices, other factors such as pests, soil conditions, weather, irrigation timing, and water tables may limit yield even with an excellent quality water supply. Two of the greatest limiting factors in Western Delta Soils would be high soil boron and fluctuating water tables. As a result, it may not be realistic to assume a 100%-yield potential due to uncontrolled factors that are encountered under field production and a lower level should be assumed.

As the Study Report points out, the present distribution of bean production in the South Delta is on soils that are derived from Marine sediments (Montoya, 2007)[5] from the Diablo Range. These and similar soils that developed in other areas of the west side of the San Joaquin Valley are known to be high in salts and boron. The Study Report looked at the present salinity and boron levels in the water supply and concluded that boron does not present a threat to production. Although likely correct if water supply is the only factor considered, this conclusion fails to consider that the soils where bean production occurs are high in natural boron and may be limiting bean yield to a greater degree than salinity. A review by Mass, 1984[6] showed that several types of beans, including lima beans, which make up a large portion of the dry bean production in the South Delta, were sensitive to boron and that yield losses resulted when soil boron levels were in the range of those found in the soils derived from the Diablo Range.

The continued presence of boron is demonstrated by monitoring of tile drains that have been in continuous operation for over 30 years. These tile drains are located in the South Delta where dry bean production predominates and these tile drains show boron levels continually exceeding 2-3 mg/l. The tile drain data supporting this conclusion includes the citation in the Study Report[7] and data from the New Jerusalem Drainage District[8] which is made an attachment to these comments. Because of the continued presence of boron in South Delta soils in the locations where dry bean production predominates, an analysis needs to be conducted to determine if the soil boron levels have the potential to limit bean yields to less than the presently assumed 100%, even in the presence of excellent quality water.

The SJRGA and SWC agree with the statement on page 45 that "The relationship between crop water use and the depth and salt content of groundwater are not well understood." This is unfortunate as it is also known that high water tables or fluctuating water tables can impact crop yields, especially for sensitive crops. It leads to a basic question about whether it is wise to continue to assume a 100% yield for a salt and boron sensitive crop, such as lima or other dry beans, when the crop is being grown in a marine sediment known to be high in salt and boron

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[5] Montoya, B. 2007. Memorandum Report "Sources of Salinity in the South Sacramento-San Joaquin Delta." California Department of Water Resources, Environmental Assessment Branch, Sacramento, CA.

[6] Maas, E.V., 1984. Salt Tolerance of Plants. In Handbook of Plant Science in Agriculture. B.R. Christie (ed). CRC Press, Boca Raton, Florida.

[7] Chilcott, J., D. Westcot, K. Werner, and K. Belden. 1988 Water quality survey of tile drainage discharges in the San Joaquin River Basin. California Regional Water Quality Control Board, Unpublished Report, Sacramento, CA. 65 p.

[8] Central Valley Regional Water Quality Control Board Files on New Jerusalem Drainage District, San Joaquin County

and is compounded by the fact that it also has a high water table known to be high in salt and boron? Any of these factors could be limiting yield regardless of the supply water quality.

**PRESENT CROP TOLERANCE CURVES FOR DRY BEANS MAY BE OVER CONSERVATIVE DUE TO THE DATA BASE BEING USED:**

The present water quality objective of 0.7 mmhos/cm during the irrigation season is set based upon the salt sensitivity of dry beans. The objective is established primarily on the Mass and Hoffman, 1977[9] threshold limit (100% yield) that is shown in Figure 3.6 on page 20 of the Study Report. As stated in the Study Report, this threshold was established using only 5 data points and as shown in Figure 3.6, three of these data points had an experimental design that was set up with the lowest salinity level significantly below the threshold limit and the remaining two show that a 100%-yield level was obtained at a higher salinity level than the threshold value. Because the original experimental design was not set up to establish the threshold value, it has become necessary to extrapolate between these two extremes. This introduces a significant error as the next nearest data point upon which to develop a slope to the relative yield line is with a yield less than 50%. We find it unfortunate that there are no data points in between these two relative yield levels upon which to refine the threshold point and slope of the line. The Study Report also points out several other deficiencies in the data base that make the threshold value very conservative. One of the most important is that the studies are over 50 years old and the varieties used in the testing are no longer in existence[10]. Because of this, we strongly support Recommendation # 1 and # 2 (page 77) to conduct additional testing to determine the actual tolerance of beans varieties being grown in the Delta and the experiments conducted under growing conditions of the western slope of the Delta where beans are primarily grown.

**SALT SENSITIVITY AT GERMINATION IS NOT LIKELY A LIMITING FACTOR:**

The Study Report reviews the potential for increased salt sensitivity at germination of dry beans. According to the Study Report "Except for the relatively salt tolerant crops of barley, sugar beet, and wheat, all of the crops reported that are important in the South Delta have a higher salt tolerance at emergence than for yield." This conclusion was based on data reported in Table 3.2 (page 22) that included *Phaseolus vulgaris* (bean). In addition to this data, the bean growers all pre-irrigate to leach and provide a high moisture - low salt environment for the emerging bean crop[11]. This additional safety factor for dry bean production and the resulting high leaching fractions being used for bean production need to be recognized in the document. We would recommend that the statement on page 22 be modified to say "Thus, it appears that salt tolerance at emergence may not be a concern if more tolerant cultivars are ~~chosen~~ being used and/or present cultural practices are continued."

**CLARIFYING THE LEACHING POTENTIAL OF RAINFALL IN THE "APPLIED WATER" ASSUMPTIONS:**

In the leaching fraction equation, "applied water" includes both rainfall and irrigation water (page 49). It appears to treat each of them the same but it is well known that rainfall, especially intermittent rainfall is very efficient in leaching and much more efficient than irrigation water application. How are these separated since one is clearly more effective than the other?

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[9] Maas, E.V. and G.J. Hoffman. 1977. Crop Salt tolerance - Current Assessment. Journal of Irrigation and Drainage Division, ASCE 103 (IR2): 115-134.

[10] Personal Communications with former grower representatives for the California Bean Growers Association.

[11] Personal Communications with Bean Growers in Western Stanislaus and San Joaquin Counties.

**ACTUAL LEACHING FRACTION MAY BE HIGHER THAN ASSUMED:**

The Study Report looks at actual leaching fractions (page 50) utilizing a series of small tile drainage systems within the western portion of the Delta but not in the area where a major portion of the dry bean production occurs. Using this data, the Study Report rightfully concludes that the leaching fraction (as defined on page 49) exceeds 20%. By comparison, data from a 1976 field study estimated leaching fractions at the sites measured ranging from 5 to more than 15%. This latter analysis however was conducted in 1976, a drought year when extreme water conservation were likely being used throughout the Delta as was being done throughout the state. Unfortunately the locations in relationship to the dry bean production are not presented for this 1976 study.

It would have been useful if the Study Report had access to the data from a large drainage system directly within the area where the majority of the dry bean production occurs. Such data is available. The New Jerusalem Drainage District covers continuously a 13,000-acre area directly in or just below the major portion of the dry bean production in the southeast corner of the SDWA. The drainage system discharges an average of 25 – 30 cfs during the irrigation season and 10 cfs during the winter period. The salinity level of the drainage system has been monitored periodically[12] since its inception in the mid 70s and that data is attached to these comments. The median salinity level of the drainage water is approximately 2.8 dS/m[13]. Using the techniques used on page 50, the leaching fraction would be close to 25% which closely agrees with what the Study Report found for the isolated tile drainage systems in the western portion of the Delta. This value supports using the LF=0.20 or higher in the analysis for both figures 5.5 and 5.6. This is further supported by observations of the bean farmers that show that dry bean production is done with low water use efficiency[14].

**WATER MANAGEMENT PRACTICES FOR DRY BEAN PRODUCTION WILL NOT CHANGE AS WATER CONSERVATION MEASURES ARE INTRODUCED**

One of the factors of that the SWRCB will need to consider in reviewing the water quality objectives for Vernalis and the Interior Delta is the State mandate for increased water conservation by both urban and agricultural users.

Mandated water conservation needs will not likely change the water management practices for dry bean production. The present production returns on dry beans will not allow the level of investment needed for improved irrigation practices. As dry beans are planted for various reasons, including soil fertility improvement, it is unlikely that farmers will switch to a higher income cropping pattern.

It is unlikely that water conservation will significantly change the leaching fraction. The primary reason is the continued need to pre-irrigate and the continued use of furrow irrigation. In water conservation efforts, the first and easiest water losses to control are those of surface water runoff. As these are a big component of the irrigation practices in the South Delta, these

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[12] California Department of Water Resources (DWR). May 2007. Sources of Salinity in the Sacramento-San Joaquin Delta, Memo Report, p. 3, 5, 24
http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/comments040609/dwr_appendixc.pdf (Accessed August 2009)

[13] Central Valley Regional Water Quality Control Board Files on New Jerusalem Drainage District, San Joaquin County

[14] Personal Communications with Bean Growers in Western Stanislaus and San Joaquin Counties.

are likely to be the first to be controlled. This will leave deep percolation in the same range as it is now, in the range of 20-25%. This is the leaching fraction that should be assumed in future modeling when water conservation is assumed to occur.

NEED TO FURTHER CONSIDER THE BASIS FOR THE WINTER IRRIGATION SEASON OBJECTIVE:

A major omission is that the entire Study Report focuses on the summer irrigation season objective which is based on the salt sensitivity of dry bean (lima) production and does not evaluate the crop sensitivity basis for the winter irrigation season objective. On page 1 it states "an objective of 1.0 mmhos/cm EC during the winter irrigation season (September through March) based on the growing season and salt sensitivity of alfalfa during the seeding stage." There is no further discussion of the basis for this objective. Considering the basis for the winter irrigation season objective is of utmost importance since alfalfa production covers almost 36% of the presently irrigated lands in the South Delta (Tables 2.2 and 3.7). For the evaluation of the winter season objective, we recommend the following sections to the Study Report be considered for revision:

1. *Water Quality(Section 2.2):*
   Salinity should be considered since alfalfa is classified as a moderately sensitive crop[15].
   The author's sodicity conclusion should be sufficient for the winter irrigation season analysis.
   Boron does not need to be considered as alfalfa is classified as a "Tolerant" crop[16].

2. *South Delta Soils and Crops (Section 2.3):*
   The author's discussion in this section should be sufficient as alfalfa is adapted to a wider variety of soil conditions than the more sensitive bean crop.

3. *Factors Affecting Crop Responses to Salinity (Section 3.1):*
   This section needs to be modified to consider salt tolerance under cooler temperatures and lower evaporative demand for alfalfa production during the winter irrigation season. If possible a comparison to alfalfa production in the cooler periods in the Imperial Valley of California and the Fallon-Lahontan and Lovelock Basins of Nevada should be discussed. Also if possible, a discussion of the semi-dormancy of alfalfa during the coolest months (Dec-Jan) should be discussed in relation to salinity, if any information is available. In addition the timing and specific cultural practices of alfalfa production in the South Delta should be defined especially in relation to seeding of new fields during the fall-winter irrigation season.

4. *Crop Salt Tolerance at Various Growth Stages (Section 3.2):*
   This is a very important section as the objective is set based on "salt sensitive during the seedling stage." In particular, the Study Report should discuss the relevance of the data in Table 3.2 which shows that alfalfa does not appear to be any less sensitive during the emergence stage

[15] Maas, E.V. and G.J. Hoffman. 1977. Crop Salt tolerance - Current Assessment. Journal of Irrigation and Drainage Division, ASCE 103 (IR2): 115-134.
[16] Maas, E.V., 1984. Salt Tolerance of Plants. In Handbook of Plant Science in Agriculture. B.R. Christie (ed). CRC Press, Boca Raton, Florida.

5. *Saline/Sodic Soils (Section 3.3):*
There should be no need to modify this section as alfalfa is adapted to various soil types and would not be limited in scope.

6. *Bypass Flow in Shrink-Swell Soils (Section 3.4):*
The Study Report's conclusions reached in this section should be sufficient for the analysis of alfalfa production as alfalfa is a major crop in many similar soil types in the Central and Imperial Valleys of California.

7. *Effective Rainfall (Section 3.5):*
This section requires a major modification to include a discussion of effective rainfall during the winter irrigation season. From Table 3.6, it is clear that a significant amount of effective rainfall occurs in the winter irrigation season (>8 inches). This is not only effective in meeting ET demand but from the literature it is shown that winter rainfall is very effective in leaching salts from the profile[17], especially the upper portion of the profile[18] where seedlings would be most affected. This same characteristic was seen in the Imperial Valley in leaching salt during reclamation[19], especially if the application rate could be intermittent and the application rate kept below the soil infiltration rate[20].

   The analysis shown in Table 3.6 assumes an average condition and does not consider storm intensity and frequency. In the Central Valley most storms come in waves of several back-to-back storms with dry periods in between. This characteristic should allow for considerable recharge, leaching of salts and will be a significant factor in eliminating seedling exposure to salts. A discussion of how they germinate and grow seedling alfalfa under the Imperial Valley conditions would be useful since they do this with water of an EC of 1.4 dS/m and without the benefit of winter rainfall.

8. *Irrigation Methods (Section 3.6):*
Few changes are needed to this section other than discussing pre-irrigation and irrigation practices during the emergence and seedling stages of alfalfa.

9. *Leaching Fraction (Section 3.13):*
This section needs to be updated to describe the potential leaching that will occur with winter irrigation of alfalfa seedlings or for germination of alfalfa and then consider the winter rainfall and its effectiveness in providing for deep leaching of salt from the upper portion of the root zone.

   In this section or in Section 3.9 (Crop Water Uptake Distribution) there needs to be an analysis of crop water uptake distributions under winter irrigation patterns and winter

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[17] Stylianou, Y. and Orphanos, P.I. 1970 Irrigation of Shamouti Oranges with Saline Water. Technical Bulletin No 6, Cyprus Agricultural Research Institute, Nicosia (as shown in Ayers and Westcot, 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper #29 (revised))

[18] Aziz, M.H.A. Crop Water Requirements and Water Quality: Salinity Control in Kuwait. (as shown in Ayers and Westcot, 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper #29 (revised))

[19] Hoffman, G.J. et al. 1980. Guidelines for Reclamation of Salt-Affected Soils. Proceedings of the Inter-American Salinity and Water Management Technology Conference. Juarez, Mexico, Dec 1980. Pages 49-64.

[20] Oster, J.D., Willardson, L.S. and Hoffman, G.J. 1972. Sprinkling and Ponding Techniques for Reclaiming Saline Soils. Transactions ASCE 15(6): 1115-1117.

rainfall especially if the exponential model for salinity impacts is used because it better represents actual water uptake distribution patterns.

10. *Miscellaneous Sections:*
    Few changes are needed to the following sections other than updating the discussions to include the non-irrigation season and determine if any factors in these sections would have a significant impact during the emergence and seedling stages of alfalfa during the winter irrigation season. The sections are:
    - ***Sprinkling with Saline Water (Section 3.7)***
    - ***Irrigation Efficiency and Uniformity (Section 3.8)***
    - ***Crop Water Uptake Distribution (Section 3.9)***
    - ***Climate (Section 3.10)***
    - ***Salt Precipitation or Dissolution (Section 3.11)***
    - ***Shallow Groundwater (Section 3.12)***

**NEED TO RECOMMEND THE USE OF THE EXPONENTIAL MODEL:**

Several models are available for analysis of the data under South Delta conditions. The original models were steady-state and based on the 40-30-20-10 pattern of water uptake which was assumed in the 1970s to be approximately correct. Based on the modeling skill level at that time this was a valid assumption as other errors in the modeling exceeded the error introduced by using the 40-30-20-10 water uptake pattern. Since that time however, it has been shown that the water uptake pattern is weighted stronger to the upper portion of the rootzone. Therefore the exponential model was developed with an updated water uptake pattern. As this model better reflects the present state of knowledge, it seems reasonable that it should be used in the Study Report's analysis. Using the 40-30-20-10 model would place the analysis in the same light as the data limitations on the crop tolerance curves; completely out of date. The Study Report should recommend the use of the exponential model if the SWRCB uses a steady-state model in the future and we would support that recommendation.

The obvious choice is the use of a transient state model over the steady-state model. The shortcoming however is that such a model that can be applied to the South Delta is not presently available, has not been verified for the South Delta conditions, and requires extensive data. Because of this, we recommend that the Study Report recommend that efforts be made to develop a transient model and verify the amount and quality of data needed to make such a model valid. We also recommend that the Study Report recommend that an Exponential Steady-State Model be used in the interim as it best imitates field conditions.

# Attachment # 2

# New Jerusalem Drainage District Data

LAW OFFICES OF

**SOUZA, COATS, MCINNIS & MEHLHAFF**

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June 10, 1992

Central Valley Regional
Water Quality Control Board
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Re: New Jerusalem Drainage District: Information for Inland Surface Water Plan for California

Gentlemen:

I am the attorney for the captioned drainage district and the enclosed information is submitted in an attempt to comply with your too-numerous requirements for the Inland Surface Water Plan for California. Please know that the district is small and lacks funds to employ an engineer to draw the maps and gather the data necessary for full compliance with your demands. What follows is the best we can do on short notice.

The New Jerusalem Drainage District (NJDD) consists of 12,300 acres of agricultural land in the Vernalis area, southeast of Tracy. We enclose an area map with the district's location highlighted.

The district was organized in 1966 to construct and operate a subsurface tile collector-line system designed to eliminate a very high water table of poor quality that plagued the area. Thereafter NJDD installed about 30.8 miles of loosely-jointed concrete pipe, bedded in gravel and designed to collect subsurface percolation from surrounding lands. The pipe varies in size from 12 in. to 42 in. at the outfall. The system is not designed to collect surface drainage. Attached is Table 3A from the Watershed Workplan Report which lists the various collector lines that make up the system and states their lengths, sizes, etc. Also attached is a map of NJDD showing the location of the various lines.

In addition to the district's system there are several connecting, private on-farm subsurface systems. These are shown on the attached map. There are also a number of shallow drainage wells, some operated by the Banta-Carbona Irrigation District, that pump into the NJDD system. Time has not permitted us to locate and mark these wells on the map.

All of the system--including the private drain lines and drainage wells--is manmade and no natural streams or water bodies of any kind are involved save for the San Joaquin River, into which our effluent flows.

The system was designed to discharge about 40 cfs into the river, but flows are not that high. A flow meter on the district's outfall pipe indicates flows of about 25 cfs during the irrigation season and about 10 cfs during the winter.

The system requires very little maintenance and the repairs themselves do not cause any water quality problems.

We think that--relatively speaking-- the quality of NJDD's river discharge is good, and certainly better than that coming from Mud and Salt sloughs and other points further south. But this is a matter on which the CVRWQCB staff has much better data than we, and you can judge the effluent quality for yourself.

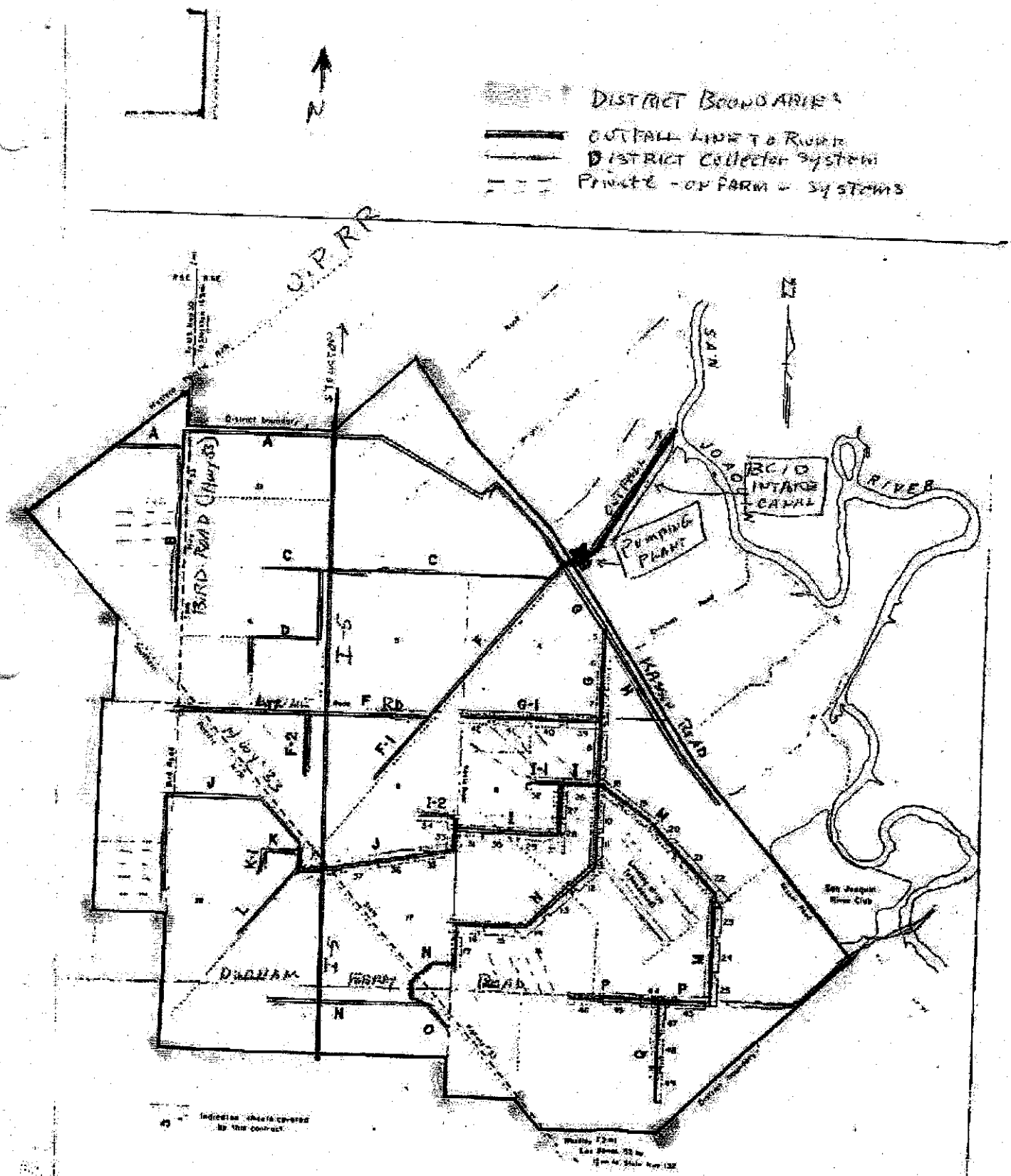
The district will be happy to work with CVRWQCB to develop whatever additional information is required, but we lack the money to employ engineering assistance.

Very truly yours,

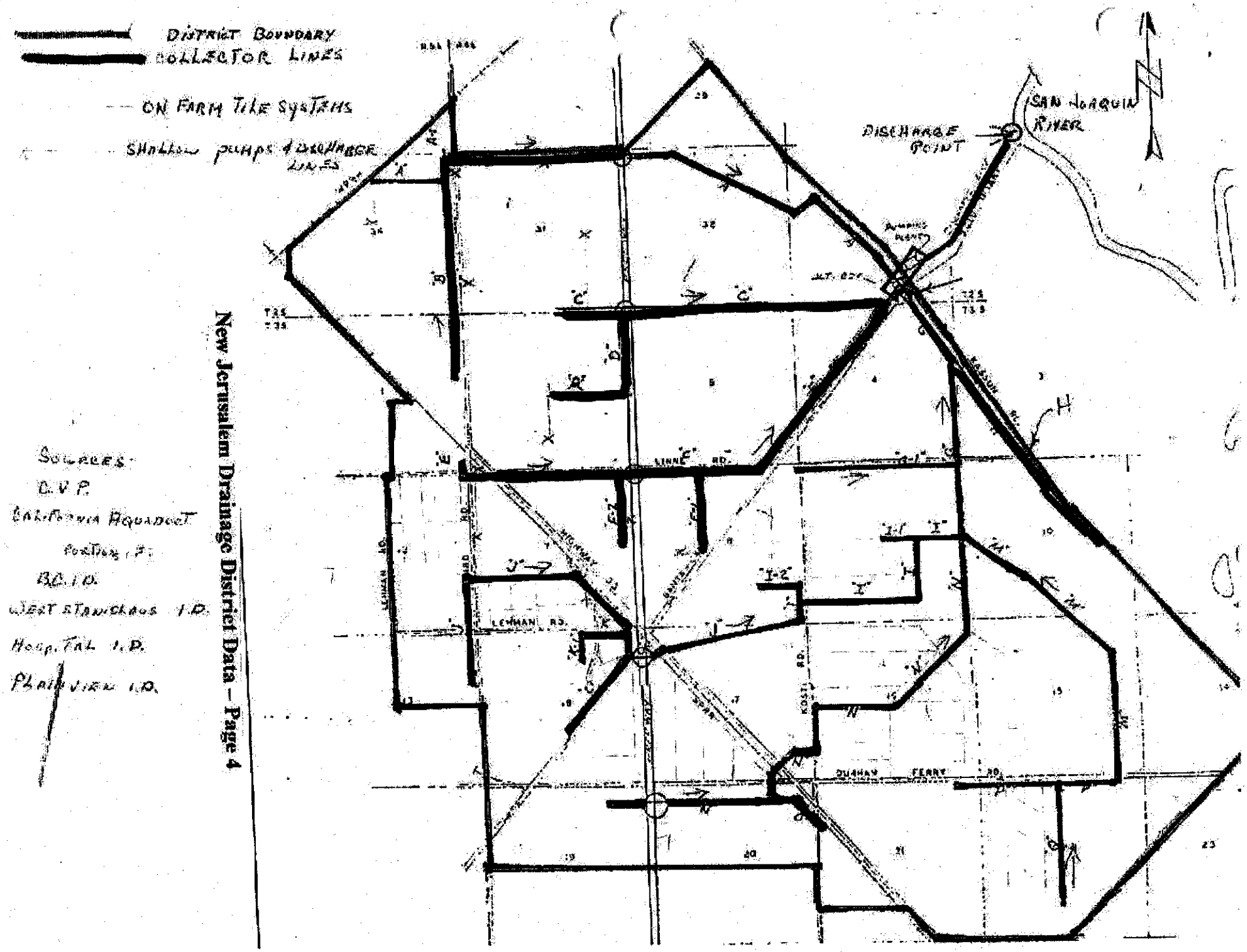
Walter J. McInnis

WJM:td

cc: Board of Directors




**LOCATION MAP** SHOWING ALL NJDD COLLECTOR LINES ~~EXCEPT~~ INCLUDING PUMPING PLANT & DISCHARGE LINE




New Jerusalem Drainage District Data – Page 4

## New Jerusalem Drainage District

### Various Water Quality Data in the Regional Board Files

| Year | TDS (mg/L) | EC (dS/m) (calculated from TDS/0.64) |
|---|---|---|
| 1977 | 1,666 | 2,603 |
| 1978 | 2,048 | 3,200 |
| 1979 | 1,920 | 3,000 |
| 1980 | 1,664 | 2,600 |
| 1982 | 1,408 | 2,200 |
| 1983 | 1,536 | 2,400 |
| 1984 | 1,280 | 2,000 |

12,000+ Acres Drained

| | |
|---|---|
| Discharge (Design) | 40 cfs |
| Actual Discharge | 25-30 cfs (Irrigation Season) |
| | 10 cfs (Winter Season) |
| Discharges at Mile 63.4 | (9.1 Miles downstream of Vernalis)<br>(7.5 Miles Upstream of Mossdale) |

# QUALITY OF AGRICULTURAL DRAINAGE DISCHARGING TO THE SAN JOAQUIN RIVER AND DELTA FROM THE WESTERN PORTION OF SAN JOAQUIN COUNTY, CALIFORNIA APRIL 1986 TO MAY 1988

California Regional Water Quality Control Board
Central Valley Region
3443 Routier Road
Sacramento, CA 95827-3098

July 1989

Table 3. Water Quality Data for sites monitored in Western San Joaquin County.

| Date | Temp | pH | EC | Se | Mo | B | Cl | SO4 | Ca | Mg | Na | K | Total Alk. | Hdns | TDS | Cu | Cr | Ni | Pb | Zn | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | deg F | | umhos/cm | ...ug/L.... | | | | | | | mg/ | | | | | | | | ug/L | | |

SJC001 New Jerusalem Tile Drain

Latitude 37 42' 32", Longitude 121 17' 55". In NE 1/4, NE 1/4, NW 1/4, Sec. 34, T.2S, R.6E.
New Jerusalem Tile Drain at San Joaquin River.

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/11/86 | 66 | | 2500 | | 4 | 2.5 | 360 | 480 | | | | | 230 | | | 1 | 7 | <5 | <5 | 3 | |
| 10/23/86 | 67 | | | | <5 | 2.4 | 410 | 500 | | | | | 280 | | | 6 | 26 | <5 | <5 | <1 | |
| 12/22/86 | 64 | 7.8 | 2200 | | <5 | 2.4 | 290 | 430 | | | | | 270 | | | <1 | 25 | <5 | <5 | <1 | |
| 04/07/87 | 66 | 7.5 | 2500 | 6.2 | | 3.0 | 290 | | | | | | | | | | | | | | |
| 06/12/87 | 64 | | 2350 | 4.9 | | 2.8 | 444 | 560 | | | | | | | | | | | | | |
| 08/26/87 | 67 | 7.6 | | 3.6 | | 2.4 | 320 | 450 | | | | | 96 | | | | | | | | |
| 02/19/88 | 61 | 7.0 | 2300 | 3.7 | | 2.8 | 260 | 400 | | | | | 290 | | | | | | | | |
| 03/30/88 | 65 | | 2550 | 5.2 | | 3.1 | 270 | 550 | | | | | 280 | | | | | | | | <.5 |
| 04/22/88 | 64 | 7.2 | 2650 | 4.6 | | 2.8 | 275 | 475 | | | | | | | | | | | | | <.5 |
| 05/25/88 | 66 | 6.5 | 2650 | 4.3 | | 2.5 | 350 | 470 | | | | | 130 | | | | | | | | |

SJC002 Tracy Boulevard Tile Drain Sump

Latitude 37 46' 47", Longitude 121 26' 15". In SE 1/4, NE 1/4, NE 1/4, Sec. 8, T.2S, R.5E.
1.1 mile north of Interstate 205, 150-200 feet west of Tracy Blvd.

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04/22/86 | 60 | 6.9 | 2500 | | | 0.9 | 430 | 630 | 186 | 99 | 284 | 0.4 | 276 | 850 | 1800 | | | | | | |
| 08/11/86 | 69 | | 2800 | | 28 | 1.2 | 440 | 460 | | | | | 260 | | | 2 | <1 | <5 | <5 | 1 | <.5 |
| 10/23/86 | 67 | | | | <5 | 1.6 | 270 | 700 | | | | | 300 | | | <1 | <1 | <5 | <5 | <1 | |
| 12/22/86 | 60 | 7.2 | 3100 | | 16 | 0.8 | 400 | 320 | | | | | 350 | | | <1 | <1 | <5 | <5 | <1 | |
| 06/12/87 | 65 | | 3050 | 3.2 | | 1.1 | 615 | 580 | | | | | | | | | | | | | |
| 08/26/87 | 71 | 7.5 | | 2.3 | | 1.0 | 270 | 320 | | | | | 184 | | | | | | | | |

SJC003 Grant Line Road Tile Drain Sump

Latitude 37 45' 29", Longitude 121 30' 9". In NW 1/4, NW 1/4, SE 1/4, Sec. 14, T.2S, R.4E.
0.6 east of Hansen Rd., south of Grantline Rd.

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/12/86 | 67 | | 2800 | | <5 | 2.9 | 490 | 370 | | | | | 280 | | | 1 | <1 | <5 | <5 | <1 | |
| 10/23/86 | 68 | | | | <5 | 3.0 | 550 | 340 | | | | | 290 | | | <1 | <1 | <5 | <5 | <1 | |
| 12/22/86 | 64 | 7.6 | 2600 | | <5 | 3.0 | 420 | 210 | | | | | 270 | | | <1 | <1 | <5 | <5 | <1 | <.5 |
| 06/12/87 | 65 | | 2700 | 2.7 | | 2.8 | 541 | 335 | | | | | | | | | | | | | <.5 |
| 08/26/87 | 69 | 7.4 | | 1.5 | | 2.6 | 590 | 409 | | | | | 110 | | | | | | | | <.5 |

**Appendix A-1.** **Summary of constituent ranges for U.S. Bureau of Reclamation Water Quality Data. (U.S. Bureau of Reclamation, 1987; U.S. Bureau of Reclamation, 1989)**

| | EC umhos/cm | HCO3 mg/L | N mg/L | Ca mg/L | Mg mg/L | Na mg/L | K mg/L | Cl mg/L | SO4 mg/L | B mg/L |
|---|---|---|---|---|---|---|---|---|---|---|
| | SJC001 New Jerusalem Tile Drain | | | | | | | | | |
| Minimum | 2100 | 280 | 1.0 | 40 | 42 | 280 | 1.0 | 270 | 221 | 0.76 |
| Median | 2770 | 354 | 9.8 | 159 | 89 | 330 | 2.1 | 420 | 540 | 2.8 |
| Maximum | 3720 | 466 | 98 | 193 | 93 | 389 | 3.0 | 3600 | 830 | 4.2 |
| Data Count | 42 | 6 | 22 | 10 | 10 | 10 | 10 | 16 | 11 | 33 |
| | SJC002 Tracy Boulevard Tile Drain Sump | | | | | | | | | |
| Minimum | 2660 | 230 | 1.0 | 170 | 84 | 1 | 0.4 | 440 | 500 | 0.75 |
| Median | 3488 | 390 | 4.1 | 210 | 123 | 348 | 1.0 | 610 | 600 | 1.5 |
| Maximum | 3920 | 434 | 18 | 277 | 361 | 420 | 700 | 3500 | 720 | 3.6 |
| Data Count | 38 | 5 | 21 | 9 | 9 | 9 | 9 | 14 | 10 | 32 |
| | SJC003 Grant Line Road Tile Drain Sump | | | | | | | | | |
| Minimum | 2690 | 208 | 8.2 | 64 | 60 | 281 | 1 | 525 | 320 | 0.64 |
| Median | 3000 | 346 | 12 | 85 | 62 | 421 | 1 | 560 | 331 | 3.0 |
| Maximum | 3580 | 364 | 44.5 | 156 | 68 | 455 | 2 | 625 | 348 | 3.9 |
| Data Count | 12 | 5 | 11 | 5 | 5 | 5 | 5 | 5 | 5 | 10 |

| | Ag ug/L | As ug/L | Cd ug/L | Cr ug/L | Cu ug/L | Fe ug/L | Hg ug/L | Mn ug/L | Mo ug/L | Ni ug/L | Pb ug/L | Se ug/L | Zn ug/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SJC001 New Jerusalem Tile Drain | | | | | | | | | | | | |
| Minimum | <1 | <1 | <1 | 22 | <1 | 30 | <0.1 | <10 | <1 | <1 | <1 | <1 | <10 |
| Median | <1 | <1 | <1 | 36 | 3 | 160 | 0.1 | <10 | 2 | 9 | <1 | 5 | <10 |
| Maximum | <1 | 2 | 2 | 46 | 5 | 670 | 0.3 | 30 | 7 | 33 | 7 | 8 | 20 |
| Data Count | 20 | 18 | 20 | 22 | 24 | 21 | 22 | 21 | 24 | 24 | 19 | 25 | 23 |
| | SJC002 Tracy Boulevard Tile Drain Sump | | | | | | | | | | | | |
| Minimum | <1 | 2 | <1 | <1 | <1 | <10 | <0.1 | 50 | 4 | <1 | <1 | <1 | <10 |
| Median | <1 | 3 | <1 | 3 | 2 | 30 | <0.1 | 95 | 12 | 8 | 2 | 3 | <10 |
| Maximum | 1 | 4 | 1 | 8 | 6 | 210 | 0.1 | 480 | 24 | 31 | 7 | 5 | 40 |
| Data Count | 17 | 18 | 19 | 21 | 23 | 20 | 19 | 20 | 23 | 23 | 18 | 24 | 20 |

Appendix A-... U.S.Bureau of Reclamation Water Quality Data for Selected Monitoring Sites. (U.S. Bureau of Reclamation, 1987; U.S. Bureau of Reclamation, 1989)

| Date | Time | EC | HCO3 | CO3 | N | Ca | Mg | Na | K | Cl | SO4 | B | Ag | As | Cd | Cr | Cu | Fe | Hg | Mn | Mo | Ni | Pb | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | umhos/cm | | | | | | | mg/L | | | | | | | | | | ug/L | | | | | | |
| SJC001 New Jerusalem Tile Drain (continued) | | | | | | | | | | | | | | | | | | | | | | | | | |
| 08/09/85 | | 2810 | | | | | | | | 400 | 500 | 2.8 | <1 | 2 | <1 | 29 | 1 | <30 | 0.1 | <10 | 1 | 7 | <1 | 2 | <10 |
| 09/13/85 | | 2840 | | | | 180 | 78 | 330 | 1.9 | 400 | 630 | 3.0 | <1 | 1 | <1 | 46 | 3 | 80 | 0.2 | <10 | 4 | 3 | <1 | 5 | <10 |
| 10/11/85 | | 2240 | | | | | | | | | | 2.6 | | | | 37 | 2 | | 0.2 | | 1 | 6 | | 4 | |
| 11/08/85 | | 2230 | | | | | | | | | | 2.4 | | | | 40 | 2 | | <0.1 | | 1 | 1 | | 4 | |
| 12/06/85 | | 2100 | | | 9.5 | 120 | 51 | 280 | 1.4 | 270 | 420 | | <1 | | <1 | 34 | <1 | 36 | 0.2 | 14 | 2 | 9 | <1 | 4 | <10 |
| 01/10/86 | | 2250 | | | | | | | | | | | <1 | | <1 | 43 | <1 | <60 | <0.1 | <10 | 1 | <1 | | 3 | <10 |
| 05/09/86 | | 2940 | | | | 180 | 69 | 330 | 1.9 | 370 | 550 | 2.5 | | | | | <4 | | | | <4 | <5 | | 5 | <10 |
| 08/08/86 | | 2850 | | | | 160 | 68 | 310 | 2.2 | 380 | 500 | 3.0 | | | | | | | | | | | | 4 | <10 |
| SJC002 Tracy Boulevard Tile Drain Sump | | | | | | | | | | | | | | | | | | | | | | | | | |
| 09/23/82 | 1220 | 3350 | 390 | 0 | 3.6 | 277 | 127 | 361 | 1 | 700 | 678 | 1.3 | | | | | | | | | | | | | |
| 11/22/82 | 1115 | 3480 | 380 | 0 | 1.4 | 251 | 361 | 1 | 700 | | 696 | 1.3 | | | | | | | | | | | | | |
| 12/14/82 | 0840 | 3690 | | | 5.8 | | | | | | | | | | | | | | | | | | | | |
| 01/21/83 | 0805 | 3510 | 230 | | 1 | 227 | 130 | 348 | 5 | 710 | 610 | 0.78 | | | | | | | | | | | | | |
| 02/22/83 | 1150 | 3800 | | | 10 | | | | | | | | | | | | | | | | | | | | |
| 03/28/83 | 1005 | 3720 | | | 18 | | | | | | | | | | | | | | | | | | | | |
| 04/18/83 | 1005 | 3496 | 424 | | 10.7 | 175 | 123 | 397 | 1 | 700 | 590 | 1.2 | | | | | | | | | | | | | |
| 05/16/83 | 0920 | 3650 | | | 9 | | | | | | | 1.1 | | | | | | | | | | | | | |
| 06/13/83 | 0850 | 3140 | | | 5.3 | | | | | | | 1.4 | | | | | | | | | | | | | |
| 07/18/83 | 0950 | 3660 | | | 4.8 | | | | | | | 1.5 | | | | | | | | | | | | | |
| 08/15/83 | 0855 | 3470 | 434 | | 6.4 | 191 | 123 | 420 | 1 | 613 | 532 | 2.1 | | | | | | | | | | | | | |
| 09/12/83 | 1000 | 3430 | | | 3.6 | | | | | | | 3.5 | | | | | | | | | | | | | |
| 10/17/83 | 0910 | 3660 | | | 3.3 | | | | | | | 1.5 | | | | | | | | | | | | | |
| 01/23/84 | | 3330 | | | 3.7 | | | | | 561 | | | | | | | | | | | | | | | |
| 03/12/84 | | 3600 | | | | | | | | | | 1.1 | <1 | 2 | <1 | 3 | 3 | 30 | <0.1 | 120 | 14 | <1 | 2 | 5 | <10 |
| 05/21/84 | | 3560 | | | 4.1 | | | | | 3600 | | 1.2 | <1 | 2 | 1 | <2 | 4 | 20 | <0.1 | 90 | 24 | 11 | 2 | 2 | |
| 06/18/84 | | 3220 | | | 6 | | | | | | | 1.1 | <1 | 2 | <1 | 3 | 3 | 40 | <0.1 | 110 | 15 | 1 | 1 | <1 | 30 |
| 07/23/84 | | 2810 | | | 7.6 | | | | | 460 | | 1.1 | <1 | 3 | <1 | <1 | <20 | <30 | <0.1 | 53 | 12 | 12 | <1 | 3 | <5 |
| 08/20/84 | | 3450 | | | 4.1 | | | | | 600 | | 1.4 | <1 | 3 | <1 | <1 | <20 | 68 | <0.1 | 120 | 4 | 28 | 1 | 2 | 8 |
| 09/24/84 | | 3620 | | | | | | | | | | 1.6 | <1 | 2 | <1 | 8 | <1 | 60 | 0.1 | 50 | 12 | 12 | <1 | 2 | <10 |
| 10/18/84 | | 3540 | | | 2.3 | | | | | 610 | | 1.7 | <1 | 3 | <1 | 2 | 4 | 20 | <0.1 | 100 | 12 | 31 | 3 | 2 | <10 |
| 11/12/84 | | 3390 | | | 1.6 | | | | | | | 1.5 | <1 | 3 | <1 | 3 | 1 | <10 | <0.1 | 110 | 12 | 5 | <1 | 2 | 10 |

Appendix A-2. U.S.Bureau of Reclamation Water Quality Data for Selected Monitoring Sites. (U.S. Bureau of Reclamation, 1987; U.S. Bureau of Reclamation, 1989)

| Date | Time | EC | HCO3 | CO3 | N | Ca | Mg | Na | K | Cl | SO4 | B | Ag | As | Co | Cr | Cu | Fe | Hg | Mn | Mo | Ni | Pb | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | umhos/cm | mg/L | | | | | | | | | | ug/L | | | | | | | | | | | | |
| SJC001 New Jerusalem Tile Drain | | | | | | | | | | | | | | | | | | | | | | | | | |
| 08/19/82 | 1330 | 2440 | 466 | 0 | 12.5 | 40 | 42 | 360 | 2 | 440 | 221 | 3.5 | | | | | | | | | | | | | |
| 09/23/82 | 1100 | 2670 | 348 | 0 | 9.8 | 176 | 78 | 290 | 3 | 440 | 564 | 3 | | | | | | | | | | | | | |
| 11/22/82 | 1150 | 2400 | 326 | 0 | 9.6 | 157 | 62 | 306 | 3 | 340 | 540 | | | | | | | | | | | | | | |
| 12/14/82 | 0940 | 2730 | | | 9.8 | | | | | | | | | | | | | | | | | | | | |
| 01/21/83 | 0850 | 2990 | 280 | | 19.5 | 144 | 68 | 385 | 3 | 420 | 605 | 0.78 | | | | | | | | | | | | | |
| 02/22/83 | 1315 | 2910 | | | 5.3 | | | | | | | | | | | | | | | | | | | | |
| 03/28/83 | 1115 | 3720 | | | 10 | | | | | | | | | | | | | | | | | | | | |
| 04/18/83 | 1130 | 2980 | 360 | | 10.4 | 128 | 71 | 380 | 3 | 500 | 513 | 2.8 | | | | | | | | | | | | | |
| 05/16/83 | 1100 | 2960 | | | 1 | | | | | | | 3.2 | | | | | | | | | | | | | |
| 06/13/83 | 1025 | 3180 | | | 7.5 | | | | | | | 4.1 | | | | | | | | | | | | | |
| 07/18/83 | 1050 | 3060 | | | 9.8 | | | | | | | 2.6 | | | | | | | | | | | | | |
| 08/15/83 | 1050 | 3190 | 372 | | 24.2 | 193 | 83 | 389 | 1 | 450 | 542 | 4.2 | | | | | | | | | | | | | |
| 09/12/83 | 1120 | 2680 | | | 9.6 | | | | | | | 3.7 | | | | | | | | | | | | | |
| 10/17/83 | 1100 | 2600 | | | 9.4 | | | | | | | 2.9 | | | | | | | | | | | | | |
| 01/23/84 | | 2420 | | | 8.8 | | | | | 340 | | | | | | | | | | | | | | | |
| 03/12/84 | | 2620 | | | | | | | | | | 2.5 | <1 | <1 | <1 | 44 | 4 | 670 | <0.1 | 30 | 2 | 6 | <1 | 4 | 10 |
| 04/02/84 | | 2500 | | | | | | | | | | 2.3 | <1 | <1 | <1 | 43 | 5 | 180 | <0.1 | <10 | 2 | 11 | 2 | 5 | 10 |
| 04/23/84 | | 2840 | | | | | | | | | | 2.8 | <1 | <1 | <1 | 36 | 3 | 180 | <0.1 | 10 | 2 | 6 | <1 | 5 | 20 |
| 05/21/84 | | 2930 | | | 14.3 | | | | | 3600 | | 2.9 | <1 | <1 | 2 | 24 | 3 | 190 | <0.1 | 20 | 3 | 23 | 2 | 4 | <10 |
| 06/18/84 | | 3050 | | | 10 | | | | | | | 2.8 | <1 | <1 | <1 | 36 | 4 | 270 | <0.1 | 20 | 2 | <1 | <1 | <1 | <10 |
| 07/23/84 | | 3010 | | | 11 | | | | | 460 | | 2.8 | <1 | <1 | <1 | 33 | <20 | 160 | <0.1 | 16 | <1 | 17 | 6 | 6 | <5 |
| 08/20/84 | | 2620 | | | 10 | | | | | 420 | | 2.7 | <1 | 1 | <1 | 22 | <20 | 190 | 0.1 | 14 | <1 | 33 | 5 | 4 | 5 |
| 09/24/84 | | 2670 | | | | | | | | | | 2.9 | <1 | <1 | <1 | 28 | 1 | 120 | | 10 | 2 | <1 | 1 | 4 | <10 |
| 10/09/84 | | 2960 | | | 98 | | | | | 430 | | 3.0 | <1 | <1 | <1 | 45 | 3 | 220 | 0.2 | <10 | 7 | 30 | 2 | 5 | <10 |
| 11/12/84 | | 2300 | | | 8.6 | | | | | | | 2.4 | <1 | <1 | <1 | | 3 | 80 | 0.1 | <10 | 1 | 11 | 1 | 4 | <10 |
| 12/10/84 | | 2300 | | | | | | | | | | 2.4 | <1 | <1 | <1 | 38 | 3 | 130 | 0.1 | <10 | 5 | 18 | <1 | 5 | <10 |
| 02/14/85 | | 2240 | | | | | | | | | | 2.4 | <1 | <1 | <1 | 31 | 2 | 30 | <0.1 | <10 | <1 | 12 | <1 | 5 | <10 |
| 03/14/85 | | 2250 | | | | | | | | | | 2.4 | <1 | <1 | <1 | 30 | 2 | 40 | 0.2 | <10 | 2 | 10 | <1 | 6 | 10 |
| 04/11/85 | | 2650 | | | | | | | | | | 3.0 | <1 | <1 | 2 | 45 | 3 | 190 | 0.2 | <10 | <1 | 12 | 7 | 5 | 20 |
| 05/09/85 | | 2810 | | | | | | | | | | 2.6 | <1 | <1 | 1 | 36 | 2 | 430 | 0.3 | 10 | 3 | 23 | <1 | 8 | <10 |
| 06/06/85 | | 2880 | | | | | | | | | | 2.9 | <1 | 2 | 2 | 30 | 3 | 90 | 0.3 | <10 | 3 | 9 | 4 | 5 | 20 |
| 07/12/85 | | 2820 | | | | | | | | | | 3.0 | | | | 37 | 3 | 400 | 0.2 | <10 | 2 | 5 | | 5 | 10 |

# Surface Water Ambient Monitoring Program Data for New Jerusalem Drainage District from the Central Valley Regional Board Files

| Station Code | Date | Time | Temp (C) | Temp (F) | Field EC (umhos) | Lab EC (umhos) | pH | Dissolved Oxygen (mg/L) | Boron (mg/L) | Salinity | TSS (mg/L) | Turbidity (ntu) | TOC (mg/L) | Total Coli (MPN) | E Coli MPN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Water Year 2001** | | | | | | | | | | | | | | | |
| SJC001 | 10/24/2000 | 12:45 PM | 20 | | 2390 | 2390 | 7.6 | | 2.3 | | <5 | | <1 | | |
| SJC001 | 11/28/2000 | 1:42 PM | 15.0 | | 2380 | 2390 | 7.9 | | 2.4 | | <5 | | <1 | | |
| SJC001 | 12/27/2000 | 12:00 PM | 15.7 | | 2550 | 2600 | 7.9 | | 2.7 | | <5 | | <1 | | |
| SJC001 | 1/23/2001 | 11:45 AM | 14.1 | | 2480 | 2430 | 7.8 | | 2.5 | | <5 | | 1.6 | | |
| SJC001 | 2/20/2001 | 12:05 PM | 16 | | 2600 | 2610 | 8 | | 2.7 | | 15.5 | | <1 | | |
| SJC001 | 3/27/2001 | 12:21 PM | 18.6 | | 2760 | 2830 | 7.5 | | 2.6 | | <5 | | NA | | |
| SJC001 | 4/24/2001 | 2:00 PM | 20.7 | | 2420 | 2450 | 7.4 | | 2.3 | | 12 | | 3.2 | | |
| SJC001 | 5/29/2001 | 12:55 PM | 19.9 | | 2540 | 2560 | 7.2 | | 2.3 | | <5 | | 3.1 | | |
| SJC001 | 6/26/2001 | 1:39 PM | 18 | | 2580 | | 7.5 | 10.5 | | | 33 | | 7.5 | | |
| SJC001 | 7/24/2001 | 11:08 AM | 18.9 | | 2740 | | 7.4 | 9.4 | | | | | 4.8 | | |
| SJC001 | 8/28/2001 | 9:55 AM | 19.1 | | 2340 | | 7.4 | 10.6 | 2.2 | | <5 | | 21 | | |
| SJC001 | 9/25/2001 | 11:47 AM | 19.2 | | 2230 | | 7.6 | 10.8 | 2.2 | | NA | | 21 | | |
| **Water Year 2002** | | | | | | | | | | | | | | | |
| SJC001 | 10/23/2001 | 11:23 AM | 18.6 | | 2440 | | 7.9 | 9.7 | 2.6 | | | | 20 | | |
| SJC001 | 11/27/2001 | 11:35 AM | 18 | | 1340 | | 8 | 9.2 | 2.5 | | | | | | |
| SJC001 | 12/26/2001 | 1:12 PM | 13.6 | | 2670 | | 8.7 | NA | 2.8 | | | | | | |
| SJC001 | 1/29/2002 | 10:41 AM | 17.3 | | 2780 | | 8.1 | 11.2 | 2.8 | | | | | | |
| SJC001 | 2/26/2002 | 10:41 AM | 17.5 | | 2590 | | 8 | 9.3 | | | | | NA | | |
| SJC001 | 3/26/2002 | 12:20 PM | 15 | | 1730 | | 7.9 | 10.1 | 1.8 | | | | 2.1 | | |
| SJC001 | 4/23/2002 | 1:12 PM | 17.1 | | 2570 | | 7.5 | 10.1 | 2.5 | | | | NA | | |
| SJC001 | 5/28/2002 | 11:10 AM | 17.7 | | 2390 | | 7.5 | 11.8 | 2.3 | | | | <1.0 | | |
| SJC001 | 6/18/2002 | 11:18 AM | 17.9 | | 2560 | | 7.4 | 9.1 | 2.6 | | | | 2.1 | | |
| SJC001 | 7/31/2002 | 9:20 AM | 18.5 | | 2550 | | 7.6 | 9.8 | | | | 2.4 | | >2419.6 | 4 |
| SJC001 | 8/27/2002 | NA | 20.3 | | 2370 | 2400 | NA | NA | | | | | 1.7 | | |
| SJC001 | 9/24/2002 | 11:41 AM | 19.3 | | 2430 | | 7.6 | 10.1 | 2.4 | | | | 2.2 | | |
| **Water Year 2003** | | | | | | | | | | | | | | | |
| SJC001 | 10/15/2002 | 9:40 AM | 19.2 | | 2280 | | 7.6 | 9.2 | | | | 0.2 | | 548 | 6 |
| SJC001 | 10/29/2002 | 1:15 PM | 19.2 | | 2260 | | 7.7 | 9.2 | 2.2 | 3.4 | | 0.2 | 1.5 | | |
| SJC001 | 11/19/2002 | 11:01 AM | 19 | | 2260 | | 7.7 | 9.8 | 2.2 | | | | 1.4 | | |
| SJC001 | 12/17/2002 | 10:14 AM | 19 | | 2080 | | 7.9 | 9.5 | | | | 280 | | | |
| SJC001 | 1/15/2003 | NA | NA | | NA | | NA | NA | | | | NA | | NA | NA |
| SJC001 | 1/28/2003 | 10:30 AM | NA | | NA | | NA | NA | | | | NA | | | |
| SJC001 | 2/25/2003 | 10:15 AM | 17.4 | | 2380 | | 7.7 | 10.9 | 2.3 | | | 2.6 | 1.8 | | |
| SJC001 | 4/22/2003 | 10:45 AM | 17.2 | | 2650 | | 7.6 | 11.7 | 2.8 | | | 13.9 | 2.6 | 1990 | 9 |
| SJC001 | 5/27/2003 | 11:29 AM | 17.4 | | 2510 | | 7.1 | 9.6 | 2.7 | | | 38.3 | NA | | |
| SJC001 | 6/24/2003 | 9:34 AM | 17.8 | | 2260 | | 7.4 | 10.1 | 2.2 | | | 355 | NA | | |
| SJC001 | 7/29/2003 | 9:35 AM | 18.8 | | 2410 | | 7.4 | 9.3 | | | | 2.5 | | 1986 | 4 |
| SJC001 | 8/26/2003 | 11:01 AM | 19.1 | | 2650 | | 7.5 | 9.7 | | | | 0.7 | | >2419.6 | 15 |
| SJC001 | 9/23/2003 | 10:42 AM | 19.4 | | 2440 | | 7.7 | 10.7 | | | | 0.9 | | 1120 | 15 |
| **Water Year 2004** | | | | | | | | | | | | | | | |
| SJC001 | 10/28/2003 | 12:27 PM | 19.6 | | 2250 | | 7.9 | 11.2 | | | | 9.7 | | 236 | 1 |
| SJC001 | 11/18/2003 | 11:02 AM | 19.4 | | 2320 | | 8.3 | 12.6 | | | | 6.6 | | 548 | <1 |
| SJC001 | 1/28/2004 | NA | NA | | NA | | NA | NA | | | | NA | | NA | NA |
| SJC001 | 2/24/2004 | 10:55 AM | 15.6 | | 2240 | | 8.1 | 10.3 | | | | NA | | 135 | <1 |
| SJC001 | 5/26/2004 | 10:55 AM | NA | | NA | | NA | NA | | | | NA | | NA | NA |
| SJC001 | 6/23/2004 | 9:47 AM | 18.2 | | 2530 | | 7.5 | 11.9 | | | | NA | | >2419.6 | 6 |
| SJC001 | 7/28/2004 | 10:27 AM | 19.4 | | 2190 | | 7.4 | 11 | | | | NA | | >2419.6 | 18 |
| SJC001 | 8/25/2004 | 10:30 AM | 19.2 | | 2050 | | 7.4 | 9.9 | | | | NA | | >2419.6 | 2 |
| SJC001 | 9/29/2004 | 10:43 AM | 19.1 | | 2240 | | 7.3 | 11.2 | | | | NA | | 1986 | 4 |
| **Water Year 2005** | | | | | | | | | | | | | | | |
| SJC001 | 10/27/2004 | 10:43 AM | NA | | NA | | NA | NA | | | | NA | NA | NA | NA |
| SJC001 | 11/22/2004 | 11:24 AM | <1 | | 2540 | | 8.1 | 10.1 | | | | | <0.20 | 365 | 8 |
| SJC001 | 12/29/2004 | 10:10 AM | NA | | NA | | NA | NA | | | | NA | NA | NA | NA |
| SJC001 | 1/26/2005 | 10:26 AM | 17.5 | | 2550 | | 8 | 9.1 | | | | | >0.20 | 222 | <1 |
| SJC001 | 2/23/2005 | 9:53 AM | 17.4 | | 2620 | | 7.5 | 10.1 | | | | | <0.20 | 52 | 1 |
| SJC001 | 3/29/2005 | 11:09 AM | NA | | NA | | NA | NA | | | | | NA | NA | NA |
| SJC001 | 3/31/2005 | 12:40 PM | 17.1 | | 2550 | | 7.5 | 10.6 | | | | | 2.2 | 548 | 5 |
| SJC001 | 4/26/2005 | 10:50 AM | 17.2 | | 2770 | | 7.4 | 11.3 | | | | | NA | >2419.6 | 12 |
| SJC001 | 5/24/2005 | 10:05 AM | 17.4 | | 2500 | | 7.2 | 9.2 | | | | | NA | >2419.6 | 15 |
| SJC001 | 6/28/2005 | 10:12 AM | 17.9 | | 2450 | | 7.3 | 8.7 | | | | | 1.9 | >2419.6 | 3 |
| SJC001 | 7/26/2005 | 10:08 AM | 18.6 | | 2320 | | 7.3 | 9.2 | | | | | NA | >2419.6 | 22 |
| SJC001 | 8/23/2005 | 10:14 AM | 19.1 | | 2340 | | 7.2 | 9.1 | | | | | 2.2 | 2420 | 1 |
| SJC001 | 9/27/2005 | 10:59 AM | 19.1 | | 2290 | | 7.4 | 14.6 | | | | | 2.4 | >2419.6 | 27 |
| **Water Year 2006** | | | | | | | | | | | | | | | |
| SJC001 | 10/25/2005 | 10:17 AM | 19.2 | | 2220 | | 7.8 | 9.5 | | | | | 1.9 | >2419.6 | 4 |
| SJC001 | 11/29/2005 | 9:26 AM | 18.8 | | 2180 | | 7.3 | 9.2 | | | | | 1.6 | 517 | 4 |

# Surface Water Ambient Monitoring Program Data for New Jerusalem Drainage District from the Central Valley Regional Board Files

| Site Code | Date | Chloride (mg/L) | Sulfate (mg/L) | Hardness (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | TDS (mg/L) | Carbonate (mg/L) | Bicarbonate (mg/L) | Total Alkalinity (mg/L) | Sodium (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Water Year 2001** | | | | | | | | | | | |
| SJC001 | 10/24/2000 | 280 | 420 | 610 | 150 | 60 | 1600 | <1 | 380 | 310 | 290 |
| SJC001 | 11/20/2000 | 310 | 420 | 640 | 150 | 62 | 1600 | <1 | 370 | 300 | 320 |
| SJC001 | 12/27/2000 | 320 | 500 | 660 | 160 | 65 | 1700 | <1 | 370 | 300 | 320 |
| SJC001 | 1/23/2001 | 280 | 420 | 630 | 150 | 61 | 1600 | <1 | 370 | 300 | 310 |
| SJC001 | 2/20/2001 | 310 | 520 | 670 | 160 | 67 | 1700 | <1 | 360 | 300 | 320 |
| SJC001 | 3/27/2001 | 360 | 520 | 740 | 180 | 71 | NA | <1 | 380 | 310 | 330 |
| SJC001 | 4/24/2001 | 280 | 610 | 640 | 150 | 61 | 1600 | <1 | 320 | 270 | 280 |
| SJC001 | 5/29/2001 | 290 | 500 | 660 | 160 | 63 | 1700 | <1 | 360 | 300 | 310 |
| SJC001 | 8/28/2001 | 280 | 410 | 360 | 51 | 56 | 1600 | <1 | 380 | 310 | 290 |
| SJC001 | 9/25/2001 | 280 | 410 | 590 | 140 | 60 | NA | <1 | 350 | 280 | 280 |
| **Water Year 2002** | | | | | | | | | | | |
| SJC001 | 10/23/2001 | 300 | 490 | 620 | 150 | 61 | NA | <1 | 380 | 310 | 320 |
| SJC001 | 11/27/2001 | 290 | 450 | 610 | 150 | 60 | 1600 | <1 | 370 | 300 | 310 |
| SJC001 | 12/26/2001 | 310 | 570 | 660 | 160 | 62 | 1800 | <1 | 360 | 300 | 310 |
| SJC001 | 1/29/2002 | 350 | 590 | 730 | 180 | 71 | 1900 | <1 | 370 | 300 | 330 |
| SJC001 | 3/26/2002 | 220 | 320 | 450 | 110 | 5 | 1100 | <1.0 | 260 | 210 | 210 |
| SJC001 | 4/23/2002 | 300 | 540 | 720 | 180 | 69 | 1700 | <1.0 | 340 | 280 | 320 |
| SJC001 | 5/28/2002 | 340 | 470 | 610 | 150 | 58 | NA | <1.0 | 360 | 290 | 310 |
| SJC001 | 6/18/2002 | 330 | 470 | 720 | 170 | 69 | NA | <1.0 | 360 | NA | 340 |
| SJC001 | 9/24/2002 | 340 | 400 | 680 | 150 | 67 | NA | <1.0 | 370 | 310 | 310 |
| **Water Year 2003** | | | | | | | | | | | |
| SJC001 | 10/29/2002 | 310 | 360 | 590 | 140 | 57 | 1500 | <1.0 | 370 | 310 | 280 |
| SJC001 | 11/19/2002 | 320 | 430 | 580 | 140 | 57 | 1500 | <1.0 | 360 | 300 | 280 |
| SJC001 | 3/25/2003 | 300 | 390 | 590 | 140 | 58 | | | | | |
| SJC001 | 4/22/2003 | 350 | 510 | 720 | 170 | 72 | | | | | |
| SJC001 | 5/27/2003 | 310 | 480 | 680 | 160 | 66 | | | | | |
| SJC001 | 6/24/2003 | 310 | 430 | 600 | 140 | 58 | | | | | |

**Water Year 2004-2006**
No data collected