Petition to De-List the Lower San Joaquin River

For

Impairment by Salt and Boron

EXHIBIT O

SDWA Bay-Delta Exhibit-07
Statement, Outline of Testimony of Alexander Hildebrand on Southern Delta Agriculture

Submitted By:

SAN JOAQUIN RIVER GROUP AUTHORITY

OUTLINE OF TESTIMONY OF ALEXANDER HILDEBRAND
ON SOUTH DELTA AGRICULTURE

QUALIFICATIONS

My qualifications as an expert witness are set forth in SDWA Exhibit No. 1.

INTRODUCTION

Dr. Orlob has testified regarding the degradation of the South Delta's in-channel water supply that is caused by upstream development and by the operation of the export pumps.

My testimony will address the in-channel water supply needed for full crop yields, and the extent to which crop yields and crop versatility have been degraded by the degradation in the water supply which Dr. Orlob identified. I will then discuss proposals regarding water supply objectives for the South Delta.

You are already aware from evidence submitted of the effects of salts on plant performance by both osmotic and toxic ion effects, and also of the fact that there are threshold levels of soil-water salinity above which the growth of different varieties of established plants is reduced. You are also aware that the relationship between the soil-water salinity in the root zone of each plant and the salinity of irrigation water applied to that plant is a function of both the applied water salinity and the achieved leaching fraction.

There is little controversy over the maximum soil-water salinity which will permit a full yield of each variety of established crop plant, except that the figures should be given as within a probability range rather than as fixed numbers. However, substantial uncertainties and limitations arise when one addresses the effect of salinity on germination and the survival and vigor of plant seedlings. There are also wide differences in different situations in the physical and economic feasibility of controlling the relationship between the applied water salinity and the soil-water salinity throughout commercial fields. Soils that are difficult for water to penetrate rapidly, or that vary from spot to spot within a field can cause non-uniform or inadequate soil leaching. Mr. Terry Prichard (see also FAO Report, SDWA Exhibit No. 105, page 4 and elsewhere) has discussed the importance of adequate leaching of salts; the limitations on commercially practicable leaching in some situations; and consequent limitations on the maximum applied water salinity which is compatible with adequate control of soil-water salinity. I shall discuss the nature and scope of these limitations as they occur in the South Delta. (Refer also to Preface of FAO report, SDWA Exhibit No. 105, 3rd paragraph; and page 6, 1st paragraph; and page 7, 2nd paragraph).

INFORMATION SPECIFIC TO SOUTH DELTA SOILS AND CROPS

First, let us examine the source and nature of the technical information which is needed in order to make a valid application in the South Delta of generalized data on applied water quality versus crop yield. You have heard a lot about peat soils, but ours are mineral soils. Some are below sea level, but most are above summer mean levels.

In 1981 the SDWA, the Bureau, and the DWR jointly requested that a panel of three well-known soil and water consultants provide the best available information on the maximum salinity of soil-moisture that would permit full yields of various crop plants. (See SDWA Exhibit No. 103, Table 2). They were also asked (1) to indicate the loss of crop yield that would occur as a result of incrementally higher soil-water salinities with each crop variety; and further, (2) to indicate the irrigation water salinity required to provide a given soil-water salinity as a function of leach fraction; and, also, (3) to provide information on the soil varieties, the soil variability, and the soil permeabilities (i.e., percolative capacities) of South Delta soils, together with available data on measured leach ratios in commercial practice. The Report of these consultants is dated December 22, 1981, and is submitted as SDWA Exhibit No. 103. Table 5 and Figures 1 and 2 of the Report, show crop yield as a function of irrigation water salinity and leach fraction for each of eight different crops, all of which are grown in the South Delta. The consultants also cited, by reference (on page 4 and Table 3 of the Report) another study which measured actual leach fractions determined by field measurements of commercial practice in the South Delta, including the variations in leach fractions for different sites in each field. This study is submitted as SDWA Exhibit No. 104.

They further cited a similar study in the Imperial Valley which they felt added credence to the values in the South Delta study. (Page 4 and Table 4 in SDWA Exhibit No. 103). SDWA Exhibit No. 104 also references Irrigation and Drainage Paper #29, Food and Agriculture Organization, United Nations, 1976. That reference also contains salinity tolerance data and soil-water versus applied water salinity relationships. The 1985 revision of that Paper is presented as SDWA Exhibit No. 105.

The soil types and permeabilities of South Delta soils are shown on the soil map that was submitted by the consultants along with the Consultants' Report and which was derived from a Soil Conservation Service survey (SDWA Exhibit No. 106). SDWA Exhibit No. 107 illustrates the variability of soils in a portion of SDWA as shown on that soil map. Note that there is a 100 fold variation in permeability, much of which can occur in a single field.

Typical ranges of leach fraction within commercial fields are shown in the South Delta Salinity Status Study (SDWA Exhibit No. 104), which was referenced in the Consultants' Report (SDWA Exhibit No. 103) and summarized on Table 3 of that Report. These leach fractions can be correlated with the soil types and permeabilities at the test fields as shown on the consultants' map. This correlation indicates the South Delta acreage for which the soils at each test field are approximatel representative and the achievable leach fraction for that soil type. There were 51 measurement sites in ten fields. From SDWA Exhibit No. 104, a rough estimate of the variation in leach fraction over a typical field may be derived.

The San Joaquin County Agricultural Commissioner supplied crop acreages, crop yields, and on-farm unit crop values for each of the major crops grown in the South Delta in 1981. This material is submitted as SDWA Exhibit No. 108.

I will expand on the relevance of some of this data before we proceed to the use of this information to estimate crop yield losses versus South Delta in-channel water quality.

PERCOLATION TIME LIMITATIONS

The reason why soils with low permeability require better water for full crop yield can be illustrated by considering the crop alfalfa, which has been the crop with the largest acreage and the second largest value in the South Delta. It is grown largely in support of the County's large dairy industry.

Table 1 in the Consultants' Report, (SDWA Exhibit No. 103), shows that alfalfa consumptively uses about 41 inches of applied water depth per year. Page 8 of that Exhibit shows that 40% of the South Delta's soils have percolation rates of less than 0.2 inches of water per hour. Furthermore, the operations of mowing, baling, and bale hauling compact the near surface soil and further reduce percolation rates. With 0.15 inches per hour of water percolation, the time required to percolate 41 inches of water is 273 hours even with a uniform distribution of applied water (i.e. 41 inches ÷ .15 inches per hour = 273 hrs.).

No salt flushing can take place unless that time is exceeded.

With six hay harvests per year, the time required to mow, cure, and bale the hay makes it very difficult to get more than two irrigations per cutting, or twelve irrigations during the crop season. More than one extra irrigation in the fall is risky on tight soils because of the possibility of an early rain after a late fall irrigation which could drown or water damage the crop. On the other hand, if the winter turns out to be dry, most of the 41 inches has to be percolated by irrigation. This then requires about 21 hours of soaking time per irrigation in a dry year with no effective rainfall (273 hours ÷ 13 irrigations) or 17 hours in a normal year (with 8.4" effective rainfall- per SDWA Exhibit No. 103, Table 1) before any leaching takes place. This soaking time is long enough to cause serious water damage to the alfalfa plants on a tight soil. This is why the 0.04 leach fraction shown on Table 3 of the Report is a plausible leach fraction for alfalfa on the tight soils. Figures 1 and 2 of the Report show that alfalfa crop loss occurs in this case with water salinities over 275 or 325 mg/L TDS depending on rainfall. Table 5 shows a 480 ppm TDS requirement for full yield with a .07 leach fraction in a dry year.

My own measurements with tensiometers in one of my fields demonstrated that it was difficult to get any leach fraction in the low permeability areas when growing alfalfa.

It is somewhat more feasible to get a larger leach fraction with an annual crop having a shallower root system and less surface soil compaction and an opportunity for leaching between crops. However, a 0.11 leach fraction is needed for full yield with beans with a 400 mg/L TDS water supply, as shown in Figure 1 in SDWA Exhibit No. 103. Even on those soils where a 0.15 leach fraction can be obtained, the irrigation water quality requirement for beans is 520 TDS in a dry year or 580 TDS in a year with "normal effective rainfall" (Table 5 of SDWA Exhibit No. 103).

A table on page 17 of the March-April 1987 issue of "California Agriculture", (SDWA Exhibit No. 109) indicates that salinities of less than 450 mg/L TDS are needed for unrestricted use, but even this is qualified (page 16) for tight soils. The FAO report (SDWA Exhibit No. 105, p. 8, Table 1) also lists a requirement of less than 450 mg/L TDS for unrestricted use, but this assumes a 15% leach, and clay-loam permeability or better and good drainage capability (page 9).

IRRIGATION MANAGEMENT AND SOIL VARIABILITY

South Delta farmers have compelling incentives to achieve leach fractions that are adequate for full crop yields, as is the case with farmers elsewhere, and they do not have the disincentive of high water costs. It is, therefore, reasonable to conclude that when South Delta farmers have leach fractions that are inadequate for the poor quality of available water, that inadequacy is typically due to the problems discussed above which limit soaking time on tight soils. Ponding for winter leach is not feasible where the land is not flat or where the water drains through permeable areas without leaching areas with very low permeability.

There are several reasons why no general assessment of farm management can be made in the South Delta on the basis of either excess or inadequate water application. Many South Delta fields have highly variable permeability (see SDWA Exhibit No. 107). The more permeable portions of a field, therefore, often have to be over-irrigated in order to strive for an adequate leach fraction in less permeable areas. Where permeability is variable, this leads to high average leach fractions. Furthermore, in dry and below normal years there is now no way to know how saline the channel water will get as the irrigation season progresses because there are no enforced water quality standards sufficient to protect most southern Delta areas. It is, therefore, prudent to irrigate heavily, where crop limitations permit, in order to keep soil salinity low early in the season. The fields with high permeability are typically located where excess subsurface drainage seeps back into the channel from which it was diverted, and can, therefore, be recaptured at little cost. Furthermore, excess drainage from South Delta soil does not significantly affect channel salt loads. There is, consequently, much less incentive to avoid excess field-average drainage as contrasted to other farm regions where water costs are high, and where drainage causes increased salt loads in the river or groundwater, or where seepage may be lost from the water supply system.

However, excess drainage does involve increased pumping costs and leads to high water tables in some locations. Where a high field-average leach is needed to achieve an adequate leach in tight areas,the overall excess drainage can become substantial, whereas in more uniformly tight fields there is insufficient drainage. Any increase in channel water salinity necessitates increased leaching. (SDWA Exhibit No. 105, page 4, paragraph 1)

The use of sprinklers, where feasible, can partially offset the in-field water distribution problem. However, the irregular shapes of fields along the channels do not lend themselves to self-propelled sprinklers, and even at best, sprinklers involve substantial energy, capital, and labor costs which should not be imposed on South Delta farmers so that upstream users can benefit by degrading the water supply. No significant saving in consumptive water use would result from the use of more expensive water application systems.

With appropriate allowance for the nature of our constraints, irrigation management in the Southern Delta compares favorably to other areas in California. Cropping patterns require cultural operations which do not provide an adequate opportunity on South Delta soils to attain the leach fractions required to prevent yield reductions when high quality water is not available. A major factor limiting production on these types of slowly permeable soils is the inability to prevent disease organisms from reducing crop plant survival when irrigation water is kept on the ground long enough to obtain large leach fractions. High quality water minimizes this problem.

CROP VERSATILITY

An important economic asset for an agricultural region is the capability of growing many varieties of crops and of changing crops to meet changing market demands. The South Delta has this capability when it can count on good quality water.

For example, large acreages of many varieties of dry beans were once grown in the South Delta. However, beans are very salt sensitive. As the water quality became unreliable and the demand for corn grew, most of this bean acreage converted to corn. Now, corn is in oversupply and other crops, including beans,should displace corn. In my own case, I am growing beans this year on land that was in corn last year. This is made possible by the interim USBR-SDWA agreement on San Joaquin River flow and quality maintenance for 1987. Some of my neighbors are growing onions, which are also very salt sensitive.

Our assessment of crop loss due to increases in salinity does not attempt to quantify and include the financial impact of lost crop versatility, but that loss is serious.

SEEDLING SURVIVAL

Another important loss which we have been unable to quantify is the loss in seedling survival and seedling vigor caused by increased salinity. A critical stage of crop growth is the seedling stage. Seedlings are generally more salt sensitive than established plants. Even some salt tolerant plants like barley have salt sensitive seedlings (See U. C. "California Agriculture", October 1984, page 9). (SDWA Exhibit No. 110)

The seedling root zone is very shallow. It is, therefore, fairly well leached by rain in a normal winter, but this is not the case in a dry year. Furthermore, the seedling zone tends to dry out after the seed is planted. As it dries, the soil-water salinity increases. (See also FAO report, SDWA Exhibit No. 105, page 43, paragraph 4; and page 44). Our mineral soils cannot retain the high volumes of soil-water that are retained by peat soils. If moisture is restored with sprinklers, crusting occurs. If it is restored from furrow irrigation there is, at best, some concentration of salt from the applied water. Either method also increases costs and can cause seedling damage from excess moisture. These are problems that occur and increase with higher salinity of applied water.

High salinity can also retard seed germination and, thereby, give more time for loss of moisture by evaporation from the soil. If the loss is too great, it can stop the germination. Slow germination also gives more time for salt tolerant weed growth to crowd the seedlings and deprive them of moisture and nutrients; and more time for pest problems, such as cut worms on corn seedlings. (Refer also to FAO Report, SDWA Exhibit No. 105, page 39, last paragraph).

The "Report on the Salt Tolerance of Corn in the Delta" by the U.S. Salinity Laboratory, et al, was based on peat lands. It, therefore, has limited applicability in the South Delta. It did, however, include germination and seedling tests which illustrate the fact that germination can be delayed by high salinity and that the seedlings are substantially more salt sensitive than established plants.

In dry years the problem of seedling survival and vigor has sometimes been substantial in the South Delta. Three slides of 1976 photographs show examples of this damage. (SDWA Exhibits No. 111, 112, 113)

WATER LEVELS AND PUMP DRAFT

A third loss which is difficult to quantify is the loss which has occurred in some channels because of inadequate water depth for pump draft. Dr. Orlob has discussed the physical extent of this problem as it is caused by export pump drawdown. The impact on agricultural operations includes increased costs for pump maintenance, energy, and labor, and more important, the crop losses due to inability to irrigate in a timely fashion. The drawdown affects Old and Middle River channels in the South Delta. It also affects the adequacy of pump draft in the San Joaquin channel between Vernalis and Paradise Cut when it is combined with very low San Joaquin River flows at Vernalis. These pump draft problems are expected to be reduced this year by the terms of the interim agreements among SDWA, USBR, and DWR. However, the permanent corrective measures which we will outline are essential.

CROP LOSSES BY SALINITY IMPACTS ON ESTABLISHED CROP PLANTS

We will now proceed with Dr. Orlob's presentation of the calculation of crop yield losses as a function of the salinity of applied water on established crop plants in the South Delta. I remind you that these calculated losses do not include the other serious losses previously discussed which are difficult to quantify.

The methodology for this calculation of crop yield loss is provided by the expert consultants' and the FAO reports which we have cited. The data comes from the data sources I have cited and from the in-channel water salinity information previously presented by Dr. Orlob. We are not introducing any new concepts. We are merely applying accepted principles to a specific situation which differs from the more ideal situations covered by familiar tables of the tolerance of crops to applied water quality. In other words, we are accounting for the caveats usually mentioned in fine print under such tables and which are discussed in the FAO report, SDWA Exhibit No. 105,particularly the qualifications on page 9 which apply to the Table 1 Guidelines.

After Dr. Orlob's presentation, (SDWA Exhibit No. 114), I will discuss our conclusions on reasonable levels of protection for agricultural uses in the South Delta, and on the objectives and monitoring which will be needed.

WATER QUALITY NEEDS AND OBJECTIVES

It is evident from our previous testimony that optimum crop yields in the South Delta would require at least:

a) Adequate pump draft in all channels at all times, and

b) 400 ppm TDS or better throughout all channels at all times, or a 400 ppm TDS seasonal average with somewhat better quality through June and somewhat poorer quality after July.

Dr. Orlob's testimony has shown that prior to upstream development and export pumping there was adequate pump draft at all times in all SDWA channels. This would still be the case if upstream development were now eliminated except for rare late season occasions when the flow at Vernalis might be inadequate for pump draft at some points between Vernalis and Paradise Cut. However, the occasional inadequacy in that reach would even in that event not then occur if the reduced flows, previously caused by upstream development, had not permitted a large accumulation of silt since the 1930's. This siltation has raised the bottom of the channel substantially and it is now above low tide level (SDWA No. 4, 2nd page of Fig. VII-1).

Dr. Orlob has also shown that prior to upstream development, water quality throughout SDWA channels was always fully adequate to meet water quality needs. Water quality during the early irrigation season was always so good that even an occasional increase in late summer salinity was not serious (except in a few channels that experienced Bay water intrusion in September of 1931). This was because the residual soil-water salinity in mid-summer was sufficiently low after using high quality early season water so that it could tolerate some salt buildup when more saline late summer water was applied. Furthermore, crop plants in late summer were then at their least salt sensitive stage of growth. The FAO report, SDWA 105, page 25, discusses the importance of good water quality early in the irrigation season.

Adequate pump draft is essential. It can be maintained by adequate flow maintenance at Vernalis combined with either adequate export pumping restraint during extreme tides, or by channel water level control devices such as those under study by SDWA, USBR, and DWR.

It is not feasible to maintain a uniform water quality throughout South Delta channels, and it would be impractical to restore the very high quality of San Joaquin River water that existed most of the time in the absence of upstream development. However, the South Delta must be protected from the substantially increased river salt load caused by upstream development. This protection can only be accomplished by providing a net daily unidirectional flushing flow within SDWA through each reach of: Old River, Grant Line Canal, Middle River, and the two reaches of the San Joaquin River (Vernalis to Old River and Old River to Stockton).

The net daily flushing flow would eliminate stagnation in South Delta channel reaches and should be sufficient in quantity to avoid any significant accumulation of the increased incoming river salt load in any South Delta channel reach.

There is very little chance that the increase in river salt load during low flows can be eliminated, and certainly not in the near future. Furthermore, a development such as the Mid-Valley Canal would further increase the salt load due to importation of salt to the east side of the watershed. The Vernalis flow must, therefore, be adequate to supply the net agricultural diversions and other channel depletions from all those channels which receive Vernalis flow, plus enough net flushing flow to maintain adequate quality throughout those channels. The Vernalis flow that is required can be reduced by using seasonally functional tide-gated barriers in Middle and Old Rivers. The design of these barriers, in conjunction with control of the Clifton Court intake schedule, should be such as to provide an adequate net daily unidirectional reverse or upstream flow by tidal cycling of Central Delta water into those two channels.

The other internal channels which would still be fed from Vernalis would rarely have water of as good quality as would be the case in the absence of upstream development. They should, therefore, be protected from salinity higher than we now propose and which might otherwise occur on rare occasions, i.e., the range of fluctuation in water quality in internal channels can be narrowed somewhat and the mean seasonal salinity thereby adequately protected.

It should be noted that extra Vernalis flows can be provided by New Melones Reservoir releases with no loss of CVP project yield, particularly if New Melones is operated to serve eastern San Joaquin County on a conjunctive use basis. Increased releases from New Melones to Vernalis over those previously committed would only be required in about 25 to 30% of the water years unless there are further increases in salt load or in upstream diversions. At those times when flow restoration is needed at Vernalis, the deliveries to eastern San Joaquin County could be substantially reduced while some users returned to wells or to water stored locally from extra New Melones deliveries. These deliveries to storage could be made available, in large part, by increased direct diversions in wetter years. Similar releases from other upstream projects or limitations in upstream diversion schedules should also be considered.

The proposed level of water quality and water level protection could be required and monitored at designated internal channel points. Or, subsequently, if Middle and Old River flow and level control barriers were installed, the standards could stipulate minimum water levels and an adequate salinity control at Vernalis and at each other point of water inflow, and a corresponding minimum inflow quantity at each point of inflow such that the level of protection of internal channels would be shown by model analyses to be the same as with the un-barriered requirements. This subsequent method can not be defined in detail until the location and design of flow and level control barriers is determined and a Clifton Court intake schedule established.

Monitoring points and control standards are proposed in SDWA Exhibit No. 115 for the case with no flow and level control facilities. SDWA Exhibit No. 116 illustrates the approach to possible monitoring and control standards with barriers in Middle and Old Rivers at specified locations and with specified functional designs.