Canal, which is located on the east side of the By-pass. If such a cross-connecting channel is ever built, the Tule Canal will need to be completely reconstructed. The Canal has very little flow capacity within its banks. The capacity has been reduced over the years by a lack of maintenance, since no person or agency is responsible. In addition, construction projects have left their mark. In the vicinity of the railroad and Old River Road, east of Woodland, concrete rubble, old piles and other material have never been removed, and sediment from dredging operations for the construction of Interstate 5 have clogged the canal in several places. At the lower end of the Tule Canal, abandoned bridge abutments, temporary farm crossings and the Southern Pacific railroad trestle are definitely encroachments. If this channel is ever used to convey Colusa Basin Drain water, even at controlled flows, the entire Tule Canal would need reconstruction and removal or modification of the encroachments.

E. TOE DRAIN ENCROACHMENTS:

The last channel below the Tule Canal extends south from just below the Interstate Highway 80 Causeway. It is within the Yolo By-pass along its east side and extends to Cache Slough just above Rio Vista. What used to be called the West Cut was replaced during construction of the Deep Water Ship Channel and is now called the Toe Drain. Near the lower end of the drain, a pontoon bridge to the Little Holland Tract is in use. If this bridge is not removed during the winter, upstream trash collects on it and causes overflow, sometimes when the By-pass is not even flooded. Near the Lisbon Tide Gauging Station, below West Sacramento, a tidal structure was built to maintain the upstream water surface for irrigation purposes. This is the only permanent structure in the Drain. The entire length of the Toe Drain is in tidal action. Almost all of the irrigation diversion structures are offset in side canals from the Toe Drain and are not detrimental to channel flow. The only factor that has reduced the flow in the Toe Drain from its original design and construction in the 1950's has been sedimentation. Additional information on the Toe Drain is contained in the summary of the report prepared by Gerald H. Jones on page 55.

4) ANALYSIS OF COLUSA BASIN DRAIN FLOW CAPACITY AND CHANNEL CONDITION

A. UPPER COLUSA BASIN DRAIN AND WILLOW CREEK

The upper Colusa Basin Drain and Willow Creek extend from a point near Willows on the north to the narrows near College City on the south.

Plates 30 and 31 show the water surface profiles for the maximum January 1970 winter flow and the April 1971 irrigation flow. The elevations are referenced to U.S.G.S. datum and are based upon actual water level measurements taken along the entire 41 mile run. It is apparent from the drawings that the slope of the drain tends to flatten out at convergence of Willow Creek and the Colusa Drain about three miles south of Norman Road. At that point the drain cross section enlarges as the velocity decreases. The banks are built up higher and the high water surface elevation is, in general, above the adjacent fields preventing gravity drainage during periods of high flow.

The upper reaches of Willow Creek are blocked with vegetation which restricts flow and need to be cleaned. Several structures limit the capacity and therefore are the controlling factors. The structure just upstream from County Road "P" has a capacity of about 2,000 c.f.s. before it is overtopped causing water to flow into adjacent drains and fields. The bridge 0.6 miles and diversion structure 1.5 miles below County Road "P" have capacities of about 1,900 c.f.s. each. A bridge located 1.75 miles south of County Road 61 has an apparent capacity of 2,000 c.f.s. The Lurline Road Bridge has an approximate capacity of 2,400 c.f.s. before the superstructure is submerged. The Highway 20 Bridge is reported to have a flood capacity of 2,100 c.f.s.

When the capacities of these structures are exceeded, the water leaves the banks and spreads over the adjacent fields. It can be seen on the profiles that these restrictions cause a backwater effect upstream that can and often does result in over topping of the banks. In addition, the backwater does impede the gravity drainage of adjacent fields. Modification and enlargement of these restrictions will lessen this backwater effect and help the natural runoff of adjacent lands. This is particularly true of the Maxwell Irrigation District Structure between Norman and Maxwell Roads which probably has capacity but due to its physical shape restricts both summer and winter flows. The effects of the obstruction are apparent at Station 260,000 on the profiles. (plate No. 31)

Below the Lurline Road Bridge, the biggest restriction in flow capacity is the vegetation in the channel within the Colusa National Wildlife Refuge. These restrictions could easily be removed and would greatly improve the channel conditions.

In general, the upper reaches of the drain including Willow Creek, have adequate capacity for normal summer flows with the exceptions noted above. Winter flow capacity is not adequate to handle normal winter flows above 2,000 c.f.s. in most cases. The winter flooding of adjacent lands is usually not serious, if the water will run off the land in a timely manner after the Drain recedes. Spring and summer flooding can be reduced with modifications to the facilities and structures mentioned.

B. LOWER COLUSA BASIN DRAIN

As mentioned previously, the upper and lower Colusa Basins are separated by a narrowing of the Basin northeast of College City.

Some of the narrowing is caused by the ridge that was built up by Sycamore Slough overflow deposits. This area, which sometimes is referred to as the Colusa Basin Narrows, is the upper or northerly limit of the lower Colusa Basin Drain.

The drain from Tule Road south to the Knights Landing Outfall Gates, some 23 miles downstream, is an artificial channel created from the borrowing of material for the construction of the back levees of Reclamation Districts 108 and 787.

Except for the upper 3 miles of channel below Tule Road the channel is fairly uniform. There are some locations where the bottom is slightly shallower but at these points it is also wider. The upper mile of the drain, just below Tule Road, rises to meet the bottom of the unimproved section of the natural upstream channel of the Drain. This portion of the drain is called the riffles. The drain is narrow compared to further downstream, however, the channel slope steepens because of the rather abrupt drop in elevation from the natural swale to the bottom of the borrow area. Over the years many comments by upstream landowners have been made, such that the riffle should be removed or smoothed out, since many of the landowners believe the riffle is the cause of upstream flooding.

Actually, there is no way to remove the riffle. It is a drop in the channel caused by the dredgers when they stopped their work for the levee construction. The riffle area of the channel could be widened, the transition could be flattened out to be less abrupt or the riffle could be moved upstream by further dredging from the downstream direction. Improving the channel in the riffle area would drop the water surface elevations locally but would not increase the downstream flow materially or relieve the upstream flooding of land presently used for crops.

In an effort to observe the existing channel bottom conditions and banks, the landowners, through the Knights Landing Water Users Association, requested that the Department of Water Resources allow the water to drain to a much lower elevation at Knights Landing Outfall Gates than is normal for the fall season in October 1980.

Plate No. 32 shows the water surface profiles for the near maximum September flow for 1979 and 1980, along with the west bank and the thalweg (bottom low point) profiles. The profile elevations are referenced to level runs of the United States Geological Survey (U.S.G.S.) of 1970 and the more recent level run of the Department of Water Resources in the spring of 1980.

Water surface elevations were determined many times, sometimes daily, throughout the irrigation season and especially as the maximum fall or late summer rice drainage flow occurred. Plates 33, 34 & 34 in the appendix give the flows for the drain at the following locations: Highway 20, Davis Weir, below Tule Road, Yolo County Road 99E, and the Knights Landing Outfall Gates. Current data for the 1979-80 years are not complete or published, but the important flows, ones relating to the profiles are as follows:

	State Highway 20	Below Tule Road	Yolo Co. Rd. 99	Knights Landing Outfall Gates
9/ 4/79	1,560 c.f.s.	1,940 c.f.s.	1,150 c.f.s.*	2,080 c.f.s.
9/ 2/80	1,775 c.f.s.*	2,370 c.f.s.	2,000 c.f.s.	2,040 c.f.s.

* Estimated from flow data nearest date

When observing the profiles (Plate 32) one should be aware that the elevations are in relation to U.S.G.S. datum and that three (3.0) feet must be added to obtain United States Engineers Datum (U.S.E.D.) Another item that should be noticed is that the vertical scale is out of proportion to the horizontal scale, 1/4 inch vertical is equal to 1.0 foot in elevation and 1/4 inch in the horizontal equals 1000 feet. This was done in order to display the minor changes in elevation and for convenience of plate size.

The maximum flows observed both years are also very close to the capacity of the channel without water leaving its west banks. The west bank referred to is the road pad that follows most of the channel on the west edge of the channel. The road pad prevents minor flooding. Although in most cases the flooding of fields is prevented, the water at this stage is high enough in the channel to prevent gravity drainage from many of the adjacent rice fields.

There are several obvious conclusions that can be drawn from the profiles. For the flow conditions shown, the outfall gates do not restrict flow to the river. From Jacobs Point to the gates the water surface slope increases, indicating such a condition. Another primary reason for the slope change is the change in the channel itself from this point downstream. This section of channel was not constructed until 1919 and is known as the Knights Landing Ridge Cut Extension. Until that time the lower channel was further to the west.

If the above conclusion is correct, for the flows shown, then it can be concluded that the channel flow is restricted by the size and condition of the channel upstream of Jacobs Point. In addition, within reasonable limits, the water surface at the outfall gates could be increased without affecting upstream flow under the conditions described. It must be understood that the river was low enough so as to not restrict flow from the outfall gates. As previously mentioned, in October 1980 with the full cooperation of the Department of Water Resources, the water in the channel was allowed to drain below the normal established elevation. This was done at the request of the landowners on the lower end, believing that any restrictions in the channel could be observed. There were no major blockages observed. There was some debris at two of the bridge crossings, old wood piles and concrete rubble, and some minor sediment buildup where tributary streams enter the channel. These items are discussed in more detail under "Encroachments". Many fallen trees and snags are in the channel along the west bank between Clarks Ditch and Tule Road, this type of restriction could easily be removed and would improve channel conditions in this reach.

Hydraulic characteristics of the lower channel are being studied by Ahmad Mirbagheri, at the University of California, Davis for his Ph.D. thesis. Flows, cross-sections and channel characteristics used by Mirbagheri were portions of the base information obtained in the field for the University E.A.P. study. However, the thesis has not been completed at this date.

Preliminary review of recent measured flows by various individuals and agencies do not appear to be in total agreement. In addition the method of calculating the flow through the Knights Landing Outfall Gates also needs to be reviewed, especially when there is not free flow. Therefore, it is suggested that before any proposed projects involving the construction of water control structures, channel extensions or enlargement, the question of channel flow capacity and structure capacities be resolved by the agencies.

The hydraulic characteristics of the Colusa Basin Drain are not static. Changes are being caused by encroachments, suspected subsidence, and sedimentation. Therefore, any proposed hydraulic studies should not be undertaken until such information could be integrated with some project that would be implemented within a reasonable time of conducting such a study and analysis.

Another important factor that must be recalled, is that when the Yolo Bypass is flowing, backwater conditions are sometime present at the mouth of the Knights Landing Ridge Cut. When this condition is present, the outflow from the Knights Landing Ridge Cut is severely reduced or even reversed until the water surface in the Yolo Bypass recedes. This usually happens during the Winter and Spring.

In summary, when the Sacramento River stage at Knights Landing is low enough to allow the Outfall Gates free flow to the River, the gates appear to have enough capacity when opened full to pass all the water the channel can carry upstream from the vicinity of Jacobs Point. At the maximum flows observed during the rice drainage period of 1979 and 1980, the downstream channel water surface if monitored properly in relation to upstream conditions, could be raised at the Outfall Gates enough to still allow those diverters using water along the Knights Landing Ridge Cut to operate under better water surface conditions and not effect upstream lands.

5) EFFECTS OF IRRIGATION OUTFLOW AND AGRICULTURAL DEVELOPMENT ON THE COLUSA BASIN DRAIN

A. WATERSHED MODIFICATION BY AGRICULTURAL DEVELOPMENTS

Normally when the term "watershed" is used, one thinks of foothills or mountain slopes. However, the valley floor is also part of the watershed as a whole. To distinguish between the two regions, reference will be made to the upper watershed, meaning the foothills and mountain slopes, and to the lower or agricultural watershed, meaning the cultivated lands of the valley floor that are capable of irrigation in the present or future. Therefore, when the effects of agricultural development are being discussed, the agricultural watershed is referred to.

In both the lower and upper watersheds of the Colusa Basin, precipitation is the primary factor determining runoff and stream flow. Runoff lags behind the precipitation producing it, with the amount of the lag depending upon the characteristics of the drainage area. Some of the basic and important characteristics of a drainage area are surface slopes and lengths of overland flow, surface retention, density of vegetal cover, and soil infiltration capacity.

Most of the precipitation that falls during the first part of a storm is stored on the vegetal cover as interception and in ground surface puddles or local low spots as depression storage. If the storm lasts long enough and the soil surface becomes covered by the interconnected puddles, overland flow then starts. This time lag between precipitation and flow depends upon surface characteristics such as the soil infiltration rate and the slope. Overland flow down a field or hill slope will continue until the water enters a defined channel, where the flow then becomes surface runoff.

During the winter, agricultural land prepared for spring planting normally does not have any vegetal cover, unless it is planted to a cover crop or a weed cover develops later in the season. Therefore, vegetal cover is usually not an important factor in the lower watershed. The soil surface preparation or overwintering condition is a factor, however, if the fields are not furrowed out.

Fall furrowing for spring planting and the raising of beds for wheat production will be discussed in more detail when changing farming practices are cited.

In the upper watershed, vegetal cover interception is a regulating factor of overland flow, but the soil surface, because of non-cultivation and steeper slopes, may reduce retention. However, vegetal cover and depression storage are important for small storms or storms of low intensity. After such storage capability is exhausted, substantially all of the succeeding rainfall will run off into water courses common to the watershed. The interception storage capacity is unimportant in storms of high intensity, long duration or short storms accompanied by high winds. High wind speeds tend to increase total interception during long storms and to decrease it during short storms. A detailed inventory of cover density and surface conditions must be at hand before any statements can be made regarding the effectiveness of these two watershed characteristics. Water intercepted or held in depressions at the end of a storm is either evaporated or absorbed by the soil through infiltration. Generally, interception and depression storage are not part of the effective precipitation. Stock ponds, farm return system sumps, terraces, and overwintering water retention structures (rice contours) all tend to moderate the runoff hydrograph by increasing depression storage, while land leveling and drainage improvements reduce depression storage.

For a given rainfall in a given time period, the total surface runoff from a pervious, sandy watershed will be less than that from another watershed by the difference in water required for saturated or near saturated conditions. During the rainy season, soils generally carry almost the maximum amount of capillary water between rains. Under these conditions, the absorptive capacity of sand before saturation is about four times that of a heavy clay. Therefore clay soils become saturated and permit surface runoff much sooner than sandy type soils.

Infiltration is another characteristic of the drainage area that must be considered in the runoff phase. Infiltration is the passage of water through the soil surface into the soil, while percolation is the movement of water within the soil profile. These two terms, while closely related, should not be interchanged. Once the pore spaces are filled by capillary forces with gravity water, the downward movement is diminished until an equilibrium is established for existing soil surface and subsurface conditions. When heavy rains continue for some time, all but the sandy and gravelly watershed areas become temporarily impervious because of the soil saturation. The rate of infiltration in the early stages of a storm is less if the capillary pores of the soil are filled from an earlier storm or from residual irrigation water. The antecedent conditions of the soil profile are very important when trying to estimate runoff quantities from any watershed.

The steeper the slope of a watershed, the greater the surface runoff will be within a given period of time. However, the total surface runoff may not be substantially changed by adjusting the surface slope (such as by landleveling). Reducing or flattening the slope will lengthen the runoff time period. Generally speaking, when agricultural land is leveled, the slope is reduced. Land under cultivation will, in the spring and fall, absorb considerable rain and thus reduce the surface runoff for short-duration, low intensity storms, provided that antecedent conditions do not prevent infiltration.

Land usage and its effect upon infiltration have been studied for many years. Investigators have stated that the commonly observed higher infiltration and lower runoff for virgin soils, native grass, forest or rotated crop land, in contrast to low infiltration and high runoff for intensively cultivated, is fully in harmony with well known effects of practices upon soil structure. When accepting the above statement, one must realize that the condition and type of soil must be similar for comparison. In the course of land development for agricultural purposes, local stream channels and drains are straightened, relocated, or adjusted to (temporarily at least) alter the channel conditions. In relocating a channel, such as around the boundaries of a field, the usual lengthening reduces the slope. If the channel is straightened, the slope is increased within the limits of work, which may be several thousand feet. The channel grade upstream and downstream of the work is not normally changed during construction.

A relocated stream or drain channel which has substantial flow will try to adjust its dimensions to the controlling hydraulic characteristics of the flow. In the first several years after construction, flow conditions, depending upon channel design, could be accelerated or retarded with resultant overflow. However, after several seasons the channel will adjust or heal and many of the earlier objectionable changes in flow will disappear. This is not to say that channel modifications do not effect long term downstream conditions. The flow and type of storms that occur right after channel modifications are probably the most important factors during the first few rainfall seasons in downstream adjustments until healing takes place.

In addition to the adjustment process, most agricultural drain channels are not regularly maintained after construction. In short order, most vegetative growth becomes re-established. After channel adjustment and re-vegetation have taken place it is very difficult to determine whether channel modification results in more runoff per period of time. In studying the effect of agricultural drainage on flood runoff, one report states that construction of tile drains, open ditches, and some straightening of stream channels had a negligible effect on the total flow or on the maximum discharge from a watershed. However, it should be noted that the agricultural drainage development was less than 5% of the total area observed. Contrary to the above statement another investigator reminds us that, in general, the intensity of rainfall varies inversely with the duration. From this it follows that a reduction in the time of concentration of a watershed increases the rate of runoff, but not necessarily the total runoff.

The conversion of dry-farm and row-crop land to orchards, vineyards, and other perennials is taking place at an accelerated rate. Once the orchard or other perennial crop is developed and established, agricultural practices such as non-tillage, irrigation after harvest and frost control leave the soil in a different condition as the fall-winter rainfall season approaches. This conversion of land is taking place rapidly in southern Colusa and northern Yolo counties. Some of the areas are land newly developed for irrigation but, a large portion has been developed and under irrigation for a long period of time and incorporates a local drainage system.

Farming practices have been gradually changing, especially since the so-called "horsepower war" has been taking place. With the large-wheeled tractors that are now being used and improved implements that use auxiliary power such as the "Incorporator" and "Plantivator" (both trade names), overwintering field conditions are now different from those in the past. Depending upon fall weather conditions, many row-crop fields are bedded up in the fall for overwintering. During the process of shaping, the beds are rolled or compacted and the furrow bottoms are sometimes glazed by shaping skids or by the wheel tracks. Because of these mechanical alterations of the soil surface the infiltration rate is reduced, so there is field runoff earlier in a storm and for a longer period of time. Some fields have been observed that until recently never had any large amounts of runoff except in severe storms.

The practice of planting wheat on beds is becoming more common. This is generally done for drainage on lower, heavier ground or if spring irrigation is planned. The runoff rate from these wheat fields is greater than a wheat field not planted on beds. The overwintering of sugar beets, other winter row crops such as garlic, and seed crops has also changed runoff characteristics of row-crop land.

The practice of working up rice fields in the fall, pulling checks, and installing water control boxes tends to retard early surface runoff and appears to counteract practices that permit early runoff.

Another item that is many times overlooked when evaluating a watershed like the Colusa Basin is the large acreage devoted to duck clubs and bird refuge ponds. This acreage is already flooded and early in the rainy season the supply systems are still in operation. Almost all rainfall on these areas goes to direct runoff. It is estimated that there are over 15,000 acres of ponds in the Basin. If one inch of rainfall occurred there would be approximately 1,200 acre feet of runoff in a very short time interval during and after the rain period.

From the above discussion on the hydrology and the modification of the agricultural watershed, which by no means is all-inclusive, the reader should realize that conditions are not static. One watershed characteristic, if modified, may amplify the impact of another, and, perhaps two characteristics may equalize or nullify their individual effects when considered together.

The most important items to recognize when discussing the effects of a storm or series of storms in relation to the Colusa Basin are the antecedent conditions of the upper and lower watershed. For example, refer to the section on sedimentation, where the storms of January 16, 1978 and February 19, 1980 are compared, and to plate No. 19. Residual irrigation water, applied to crops but not entirely used before harvest, and after-harvest orchard irrigation water should certainly be included when considering antecedent moisture conditions of a watershed.

Because of the multitude of conditions, many of which are changing from day to day, no general statement can be made about the effect of agricultural modifications to the watershed caused by newly-developed irrigated crop land. It must also be remembered that many of the items discussed apply to the already-developed land adjacent to the Colusa Basin Drain. These include changing agricultural practices, stream and drain modifications, and field conditions at the start of a rainfall season.

B. SEDIMENTATION:

Current studies by the University of California at Davis (UCD) and by the Soil Conservation Service (SCS) are still in the data collection and preliminary report stage; however, most of the following data is from these studies.

The eroded material carried to the Colusa Basin Drain from its tributaries has two general sources, that of the bottom land or farming areas and that of the upper watershed. The upper watershed is the source of coarse sands and gravels that ultimately reach the Drain during winter. This is especially true in the lower Colusa and Yolo areas. The finer material, clays, silts and fine sands, are from the cultivated areas that are normally irrigated.

Large quantities of the clays, silts and fine sands are deposited in field drains and local stream channels during the irrigation periods and accumulate throughout the season. This accumulated material is then flushed out or moved downstream by the winter storms and ultimately to the Drain. Of course there is also material coming from the fields during the winter months with the surface runoff following storms of any magnitude.

Tables 1 and 2 (as shown on plates No. 19 and 20) from the University study provide useful and current data for understanding the sediment-carrying capacity or loading of the Drain.

As stated in the University progress report for the winter and spring of 1980, "Table 1 shows that the sediment load was only about half that of 1978 because the concentration of suspended solids (SS) was lower. In addition, the 1980 measured storm water runoff was 75% of the average precipitation in the valley floor in contrast to 49% for 1978. These differences in percent runoff of precipitation and sediment loading may be largely attributed to antecedent conditions. For instance, in 1978 winter precipitation fell on land which had suffered two years of drought and concentration and loads were higher in the winter of 1978 because of poorer condition of ground cover than in 1980 and consequently greater erosion."

The report further states that, when comparing peak tributary channel flows of Buckeye and Stone Corral Creeks to the Colusa Basin Drain for the winters of 1978, 1979 and 1980, collected data supports the findings reported in Table 1. The impact of antecedent conditions is a very important consideration when discussing runoff and sedimentation. For example, again referring to the report, "the January 16, 1978 flood flows contained a higher suspended solids concentration than on February 19, 1980 although the peak flows were nearly the same, with reference to weekly flows and sediment load in the Drain proper, Table 2." (plate No. 20)

Plate No. 20 presents the 1980 winter flood runoff data for the lower reaches of the Colusa Basin Drain based on weekly or smaller time intervals of measurements. The peak flows in January and February reflect heavy rainfall events during the week of January 11th and

February 16th. At CBD-1 the areawide outflow station, the high flow of water persisted into mid March since the surrounding area was flooded for about one month. It should be stressed that the data presented in Table 2 represent measured flows and noes not include overflow, which could not be estimated. It is of interest to note that while the volume of water increased with downstream travel, the mass (tons) of suspended sediments decreased with downstream travel. It appears that substantial amounts of suspended matter were deposited in the reach between CBD-2 and CBD-1" Table 2 indicates 163,510 tons or approximately 100,000 cubic yards of material."

The reach referred to is that section of the Drain between Yolo Co. Road 99E and County Line Road between Yolo and Colusa Counties, a distance of about 12.6 miles. The statement that substantial amounts of suspended material was deposited in the channel, in part, can be attributed to back water conditions caused by flood waters in the Yolo By-pass during the same period. This backwater effect reduces the outflow or at ce-tain stages reverses the flow which in turn reduces the velocity and sediment load carrying capacity of the water.

Not always, but generally, it is the last large winter storms in January and February and sometime later into March that the long durations of flooding of the Colusa Basin and flow into the Yolo By-pass occur that cause the back water conditions and sediment drop-out in the lower Basin. The major portion of the deposits are of a temporary nature and are localized at various locations such as the entrance point or the overflow areas of the tributary streams, channel locations where there is an abrupt change in channel velocity or at several of the bridge structures.

These locations can be identified on plate 32 which shows the profile of the thalweg (channel low point). The reach below the riffles is an area of sedimentation, as is the area upstream of Jacobs Point. This downstream area shifts from storm to storm or winter season to winter season, depending on where the backwater conditions effect the sediment dropout.

These temporary deposits may be as much as several feet thick; however, most of the deposits are slowly moved out during the irrigation season and during the first fall or early winter high flows. Studies related to the University data by Mirbagheri indicate that the net deposit in the lower Colusa Basin Drain, mainly of coarse sand and fine gravel, on a seasonal basis for the last three years was about one tenth of a foot at the several site locations observed.

C. SUBSIDENCE:

During the summers of 1979 and 1980, bench levels were run from known and assumed reliable bench marks near the Sacramento River. These bench marks were established by the U.S. Army Corps of Engineers and the State Department of Water Resources over the years. This level work was performed to establish measuring points for the Colusa Basin Drain water surface profiles shown on plates 30 through 32. The newly established elevations did not agree with previous level runs or with other established bench marks along the Colusa Basin Drain. Bench levels were also run in from the west and south to the same water surface measuring points. All new elevation information was internally adjusted, within the runs, but the adjustments still did not account for the total discrepancies.

From previous data and observations, other problems of the Drain area were reviewed, including the several large irrigation distribution canals which are known to be losing flow capacity despite the fact that the canals are well-maintained and obstruction free. Another continuous problem has been the back levee failures assumed to be due to foundation problems.

It is a well-known fact that the ground water in the area west of the Colusa Basin Drain (Yolo-Zamora and Dunnigan) and north of the Cache Creek fan has been overpumped. The Tehama-Colusa Canal and its extension have been planned to serve this area and relieve the ground water overdraft.

In searching for background data, a 1973 report by B.E.Lofgren and R.L.Ireland was reviewed. The authors reported in their study, "Preliminary Investigation of Land Subsidence in the Sacramento Valley" (U.S.G.S. open file report), that subsidence is presently occurring throughout the Yolo-Zamora-Dunnigan area and the area further to the north. The investigators reported a general subsidence of over 2 feet in the Zamora area and to the east along Yolo County Road No. 13 between the years of 1949 and 1973. This road is only two miles south of one of the areas reporting flooding problems greater than in the past, even though the flooding was caused by storms of lesser magnitude. Refer to Map Plate No. 37. Since 1973, there has been reported additional regional and local subsidence of more than 3.4 feet in the same general area. Several protruding well casings with concrete pump pads have been observed. This shows indications of land settlement or adjustment. However, it is difficult to determine if this was caused by farming operations such as land leveling, by general subsidence, or by localized pumping of sand from the aquifer adjacent to the wells.

These locations can be identified on plate 32 which shows the profile of the thalweg (channel low point). The reach below the riffles is an area of sedimentation, as is the area upstream of Jacobs Point. This downstream area shifts from storm to storm or winter season to winter season, depending on where the backwater conditions effect the sediment dropout.

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It has been assumed that this suspected subsidence has been caused by the local overextraction of groundwater and not by the extraction of natural gas. However, there are now gas wells present in the problem areas and these could contribute to deep subsidence. Lowering of the groundwater level, either by man's activities or some natural cause, will disturb the equilibrium that has been established within the aquifers and confining strata (or aquicludes). Compaction of these confining strata and compression of the aquifers then takes place. It has been noted that compaction of clay-type confining strata is much greater than gravel and sand aquifer compression. If the clay-type strata are thick and abundant the potential for continuing subsidence because of overextraction is present and will continue.

Subsidence caused by groundwater overdraft in areas with limited recharge and thick confining strata results in a general or regional settlement of the land surface. It is difficult to measure such settlement without precise level controls over a rather long period of years. Plates No. 7 and 8 of Appendix show subsidence or elevation relationships between years 1949 and 1973.

In response to local concerns about increased flooding along the Colusa Basin Drain and the suspected subsidence, the State Department of Water Resources is presently conducting (January, 1981) field studies aimed at verifying existing data to determine the existence, rate, degree and hopefully the limits of the suspected subsidence.

D. PROBLEMS RELATED TO UPSLOPE IRRIGATION AGRICULTURE DEVELOPMENT

All agricultural water users, individuals, and districts should be made aware of the fact that preserving the land is important to them. Many of the reasons for land loss have been known to us for a long time, including wind and water erosion, urbanization and so on. Irrigable lands are lost through waterlogging, seepage or other means resulting in a loss of crop production, reduced income, which also includes inability to pay taxes and other dictated costs associated with land ownership.

Historical evidence of the need for drainage as a result of irrigation can be found on every continent of the world. The decline and disappearance of some ancient civilizations can be attributed to their failures to heed this hazard.

Development of upslope land for irrigated agriculture, such as the lands adjacent to the Tehama Colusa Canal, will cause waterlogging (higher water tables) and inherent salinity problems to the downslope lands if precautions are not taken. Efficient drain systems must ultimately be provided in all irrigated agricultural areas where natural conditions are inadequate to remove applied water that exceeds crop needs.

Plans for a drainage system should be initiated the same time as planning for a water distribution system is developed. The drainage system should be constructed and available for use before associated drainage problems become acute.

In most areas of irrigated agriculture there are two types of drainage problems which are related directly to the application of water, both surface and subsurface. Surface drainage, although sometimes not provided for in entirety, is usually included in water development planning. The surface drainage provision is normally overshadowed by efforts expended to obtain a water supply and distribution system, and therefore, somewhat neglected. Some water supply agencies both local and federal, maintain that they have no responsibility for irrigation water after it has been delivered to the user. Because of this "tunnel vision" it is becoming more important for individual water users to be responsible for their own irrigation wastewater. But drainage problems, although they might be the individual's responsibility, when combined over an extensive area cannot usually be undertaken by an individual or even a small group.

In response to the question, "What will be the effects of agricultural expansion on water quality returned to the Sacramento River?" the University of California Agricultural Extension Service of Colusa, Glenn, Tehama and Yolo counties, compiled a brief report assessing future drainage problems of the Colusa Basin Area. These problems in turn would determine the quantity and quality of return water to the Sacramento River at Knights Landing.

For the estimate of the drainage problem, assumptions were made on the future development of the four county area and are as follows:

1.) "Full agricultural development of the area to its maximum potential using the State Department of Water Resources Nine (Ten) Counties Investigation as to the general cropping pattern for the projections."

2.) "Full utilization of groundwater supplies along with surface water supplies from the Glenn-Colusa, Tehama-Colusa and Corning Canals."

3.) "Exclusions of soil areas which by location or soil conditions are reserved for rice or field crops."

4.) "That such water tables will be drained by tile or open drains and the drainage water will be returned to the river as additional agricultural return flows that would not otherwise be included in the river accretions."

Accretion Summary by County, year 2020, via the Colusa Basin Drain.

Glenn County

Acreage projected as needing subsurface drainage = 26,000 acres.

Quantity of subsurface drainage waters = 67.0 c.f.s.

Salinity range, EC = 1.0 to 3.0 mmho.

Colusa County

Acreage projected as needing subsurface drainage = 16,270 acres.

Quantity of subsurface drainage water = 55.0 c.f.s.

Range of salinity, EC = 0.5 to 5.0 mmho.

Yolo County

Acreage projected as needing subsurface drainage = 9,400 acres.

Quantity of subsurface drainage water = 37.7 c.f.s.

Salinity range, EC = 0.5 to 5 mmho.

Totals - Colusa Basin Drainage

Acreage projected as needing subsurface drainage = 51,670 acres

Quantity of subsurface drainage water = 159.7 c.f.s.

Range of salinity, EC = 0.5 to 5 mmho.

The above summary was based upon the four main assumptions already listed, estimated irrigation efficiencies, crop consumptive use, drainage coefficients and salinity levels that are now found in existing perched water tables to depths of about eight feet from the surface. The estimated flow of 159.7 cubic feet per second of subsurface water is the flow during the period of peak consumptive water use by the crops.

Much of the acreage projected, 41,540 acres, is at the lower fringes in areas downslope from newly developed land. The remaining acreage of 10,130 acres, about 5,000 acres from each of the two counties of Colusa and Yolo, was projected as having high water table problems caused by seepage from the Sacramento River. The 10,130 acres would not be the total acreage with seepage problems but only that acreage that would convey its drainage water to the Colusa Basin Drain.

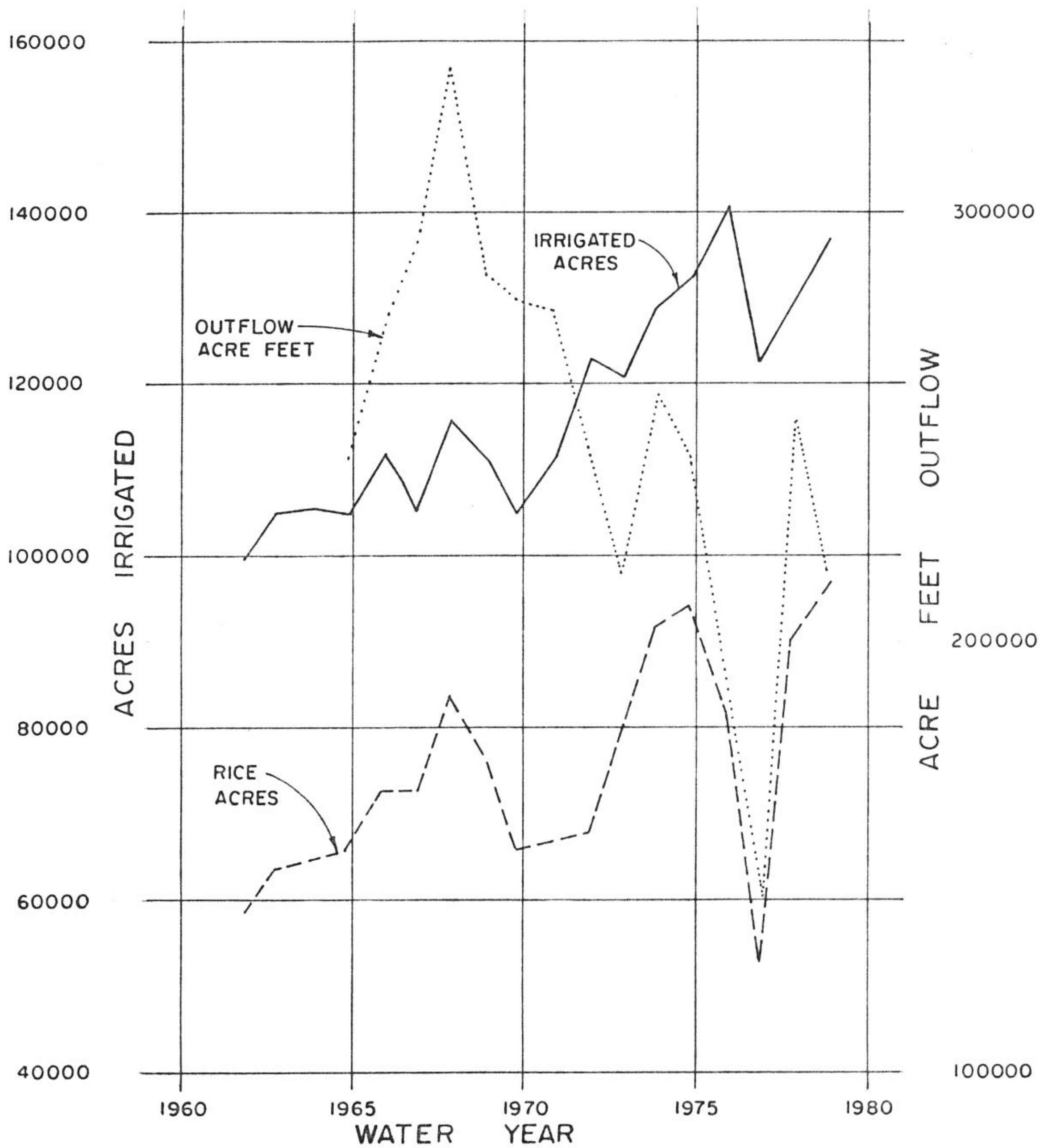
E. INCREASED SURFACE DRAINAGE (IRRIGATION WASTEWATER) FROM WEST SIDE DEVELOPMENT

An analysis of the impact of the Tehama-Colusa Canal water imports and groundwater development on the Colusa Basin Drain outflows prepared by the U.S.B.R. and Plate 10 was based upon assumptions of ideal efficiencies and field management practices. With these assumptions, the estimated peak outflow (in July) of surface drainage water was 181 cubic feet per second in the year 2000 including flow from the Yolo-Zamora Unit of approximately 10 cubic feet per second. Several of the factors or efficiencies assumed by the U.S.B.R. appear to be those desired rather than those that might be obtained in actual practice.

By adjusting the "on the farm efficiency" to 60% from 70% (60% is the figure used by the U. C. Agricultural Extension Service) and reducing the recapture factor from 60% to 40%, the outflow to the Colusa Basin Drain will increase materially from 181 cubic feet per second to 261 cubic feet per second, or a seasonal volume of 75,700 acre feet as opposed to the 52,500 acre feet shown on Plate 11. However, a 261 cubic feet per second outflow is not a large figure for a service area of 183,710 acres of crop land. The maximum monthly flow was assumed to be 21.7% of the seasonal volume, which appears reasonable.

One might question the rationale for lowering the recapture factor, most of the developing service areas will not have master drain collection systems with some sort of central recapture and return network. Instead, any water recapture would be done within the farm unit, and would be small and scattered throughout the areas. It is also likely that some recapture systems would not be developed or operated properly when installed. In addition, since it is possible the irrigation wastewater will have a high salt load, the recapture

GLENN COLUSA IRRIGATION DISTRICT



GLENN COLUSA IRRIGATION DISTRICT
SUMMER WATER IRRIGATION FLOWS-ACREAGE

Figure 12

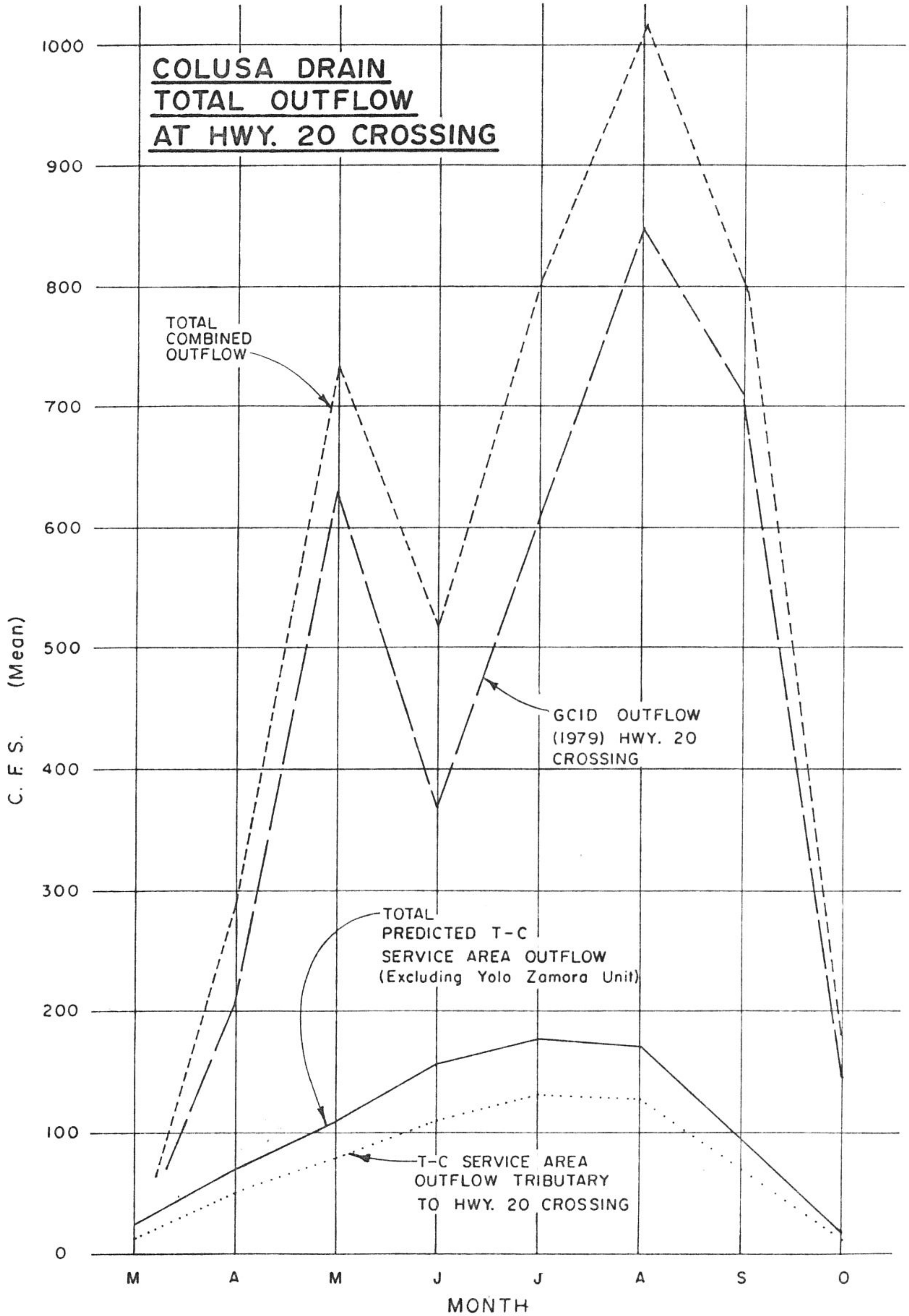
factor used by the U.S.B.R. would be too high for any long term period. The 15,000 acre Kanawha Water District near Willows, in operation for 5 years, has had a good experience with pump-back systems. Very little water escapes the District and to date it has not experienced any groundwater or salt problems.

Expanded agricultural developments within existing service areas, other than ones served principally by the Tehama-Colusa Canal, are showing a changing effect on the Colusa Drain system. Since 1962, Glenn-Colusa Irrigation District records show that total acreage in rice has increased 54% to 90,600 acres while the total acreage under irrigation has increased 38% to 137,000 acres, as shown on Figure 12. In the same time period, district outflow has decreased 25% due to more efficient drain recapture management practices. Drain outfall in 1979 was 212,000 acre feet with two peak flows occurring during May and August due to the methods of irrigation practiced in rice production. These mean flows of 631 cubic feet per second in May and 842 cubic feet per second in late August make up most of the total flow in the drain at the Highway 20 crossing.

Using the tributary area of the U.S.B.R. report applicable to the drain at the Highway 20 crossing, total summer volume of irrigation outflow will increase 17.5% under full development with the volume increasing 20.1% during the spring rice irrigation releases in May and 15.5% during the August releases. (See Figure 13)

Approximately 72% of the total predicted U.S.B.R. report outflow will be tributary at this crossing location, with the exception of the Yolo-Zamora Unit area. The balance of the predicted outflow will enter the drain at various locations between the Highway 20 crossing and Oat Creek in Yolo County.

It follows that the spring rice irrigation releases will not be



SUMMER OUTFLOWS AT HIGHWAY 20 COLUSA DRAIN CROSSING

Figure 13

substantially affected by the increase in outflow generated by expanded agricultural development in the Tehama-Colusa Canal service areas. The maximum effect would be felt during the months of maximum crop water use, usually during July and August.

Under properly managed flow conditions, the additional outflow could be incorporated into downstream irrigation requirements of Drain irrigation users, which in turn would decrease river and groundwater supply requirement. Of the total ultimate 183,710 irrigated acres of newly developed land approximately 7%, or 13,000 acres, is predicted to be planted in rice, which should not substantially affect summer outflow volumes.

The predicted estimated summer outflows from the Tehama-Colusa service areas are shown on the study area maps at locations where existing drainage facilities are available.

6) MANAGEMENT OF COLUSA BASIN DRAIN

A. EXISTING MANAGEMENT

The existing management of the Colusa Basin Drain facilities is at this time under the jurisdiction of several agencies: The State of California Department of Water Resources controls the Knights Landing Ridge Cut and Knights Landing Outfall Gate structures. The California State Reclamation Board has jurisdiction over the Designated Floodway of the Drain which includes encroachments and improvements.

An agreement in 1953 between what is basically the Glenn-Colusa Irrigation District, Provident Irrigation District, Princeton-Codora-Glenn Irrigation District, Maxwell Irrigation District and Reclamation District No. 2047 provides for the maintenance of the drains that are within their respective boundaries. In consideration for the continued right to divert out of the drain, install, operate and maintain the necessary diversion works, structures and pumping plants to accomplish the diversions, the irrigation districts agreed to continued and maintain all drains located within their District and to protect all landowners from drainage from the drains backing up as a result of the diversions or installation of facilities in the drains.

Management on the balance of the Drain is minimal except for what is maintained by the adjacent landowners and other public agencies, such as County Department of Public Works near existing bridges.

B. FUTURE MANAGEMENT REQUIREMENTS

Management can be the primary means by which drainage can be regulated and non-structural flood control can be implemented to protect the drain as a dual purpose conveyance facility. Coordination of flows between various entities could result in less spring and fall flooding due to rice draining. Funding of improvements and maintenance projects should be the responsibility of the various entities and districts using the drain and the counties which the drain serves.

Future management requirements should be responsive to the following areas of concern:

1.) Local Drain Management

a. Outflow from the various irrigation districts and private land owners should be coordinated in order to minimize excessive downstream flows.

b. Routine clearing of trees and vegetation should be performed in cooperation with Fish and Wildlife Agencies, landowners and others.

c. Maintenance of existing levees, channels and structures.

d. Removal of existing encroachments and obstructions which impede winter runoff and are not required for irrigation diversions.

e. Promote the completion of the Yolo Bypass channel improvements and related controlled low flow water level outlet structure. Any major work, new or maintenance along the Drain, must take into consideration the downstream effects. Therefore, it is recommended that all proposed work that might increase downstream flows be carefully analyzed for channel capacity, trespass and damage. Downstream corrective measures should be completed before any upstream improvements.

f. Review and respond to State Reclamation Board permit applications and requirements.

2.) Regional Basin Management

a. Upslope development and drainage system planning to minimize excessive increases in summer drainage and winter flows by way of drainage return systems and improved farming practices.

b. Work with the Tehama Colusa Canal water users to implement protective measures to prevent groundwater perching and related salt accumulation on lands adjacent to the drain.

c. Work with entities within the Basin to alleviate the problem caused by ground water overdrafting and the resulting subsidence which is a suspected cause for flooding problems in some areas adjacent to the drain.

d. Establishment of watershed planning and management to promote and implement sedimentation control throughout the basin, water conservation, storage and control.

3.) Cooperation With Other Agencies

1. Work with Federal and State Agencies in implementing policies that have to do with the flows in the Sacramento River system as they relate to the amount of and durations of flow which could impede the operation of the Knights Landing Outfall Gates and potential seepage problems.

2. Work with Federal and State Agencies to encourage further involvement in the protection of agricultural investments within the total Colusa Basin Drainage Area.

The Colusa Basin Drainage Action Group should continue to serve as the entity to implement, oversee, or participate in these management requirements to protect the continued function of the Colusa Basin Drain system.

The above management requirements are summarized from input by the Colusa Basin Drainage Action Group. Many other problems or future problems were mentioned in the text of this report. The Group expressed the opinion that they should form a permanent entity before indexing all the basin problems and establishing priorities for implementation.

7) SUMMARY

The local drainage and flood water problems of the Colusa Basin Drain have long been recognized. Reports and limited studies were conducted as early as the 1870's. However, detailed investigations were not performed until after the 1907 and 1909 floods of the Sacramento Valley. Much of the earlier technical data that had been used for engineering purposes was revised after these floods made the need for revision obvious.

The Sacramento River Flood Control Project, authorized in 1917 , the basic system of flood control in the Sacramento Valley. It has since been amended but not materially changed from the 1917 concept.

Early reclamation and development projects adjacent to the west bank of the Sacramento River took place before those in the so-called lower basin lands. These early reclamation projects reduced the basin areas in size to such an extent that flood waters encroached further to the west. Several court decisions required those responsible for the encroachment to provide relief. Several temporary measures were devised until the Knights Landing Ridge Cut Project was completed. The overall Ridge Cut project was constructed in two phases. First the ridge that had been built up by the overflow of Cache Creek was cut by excavating a channel through the ridge. From the ridge, a levied channel was constructed through Reclamation District No. 730 to connect with the Yolo Bypass. Except for the cut through the ridge, most of the carrying capacity of the channel was above existing natural ground. The levees acted as training levees. The design capacity for winter flood flows was 20,000 cubic feet per second.

The second phase of construction was the relocation of the back levee of Reclamation District No. 787. The levee location was moved east several thousand feet. The levee relocation eliminated previous restrictions on flow to the Knights Landing Ridge Cut.

The Knights Landing Outfall Gates were built prior to the Knights Landing Ridge Cut Project. The first structure was similar to a "dry-dock" gate. This gate was able to swing open and allow floating dredgers to enter from the Sacramento River. These floating dredgers were used in constructing the back levees of the Reclamation District Nos. 108 and 787 and along the levee system of the Knights Landing Ridge Cut. Gates for water flow control were also a part of the "dry-dock" type timber gate.

The borrow pits created by removing the earth material required for the back levee construction now form the channel for the Colusa Basin Drain from Tule Road near College City south to the Knights Landing Outfall Gates. This portion of what is now the Drain did not require further enlargement to serve the drainage system of Reclamation District No. 2047 except for some minor work near the river outlet.

In the 1920's the District Engineer for Reclamation District No. 2047 presented a drainage plan to the District Trustees. The plan described a comprehensive drainage system for the entire District, covering approximately 200,000 acres of land to be irrigated. Of the above total, 101,000 acres would be devoted to rice and require system capacity to serve this acreage. The main drain, now called the 2047 Drain or the Colusa Basin Drain, varied inflow capacity from 60 cubic feet per second at the northern end near Jacinto to 1,450 cubic feet per second in the lower reaches. This drainage system was designed and constructed to convey agricultural drainage waters during the rice growing season. The system, along with the down-stream levee construction, was completely financed by private funds. Since only short portions of the Drain at several locations make use of natural channels, the major portion of the Drain is essentially an artificial drainage channel. Lower Sycamore Slough was the only natural outlet for the entire Colusa Basin area, and emptied into the Sacramento River at Knights Landing. This outlet was closed off annually by sand and debris after the winter storm waters receded. Because of this natural closure the outlet was dynamited, almost annually, to create a new opening and thus allow the lower Basin to drain more rapidly.

A brief statement on each local reclamation district that is still active has been included in the preceding text. Other items that relate to the districts and the drainage of the Colusa Basin Drain have also been included.

Also, short synopses of studies and reports prepared by various individuals, local organizations, and State and Federal agencies have been included. Comments, where appropriate, have been made on some of the contents, especially if they relate to the Colusa Basin Drain's past or future.

The section of text that relates to changing agricultural conditions caused by new developments and physical conditions of the Colusa Basin Drain proper have been discussed so that individual subjects can be combined for an overall viewpoint.

A. CONCLUSIONS

During discussions with the Colusa Basin Drainage Action Group it became apparent that there were several kinds of drainage problems within the Colusa Drain study area. Winter flooding, spring flooding, and irrigation drainage were all of concern to various individuals and entities represented. Winter flooding problems were considered to be beyond the scope of the investigation because many previous studies and reports have shown that a project to control winter floods was not economically feasible.

Spring runoff and irrigation return waters were the primary concern of the Group, since they affected agricultural interests the most. Prolonged releases to the Sacramento River by Shasta Dam and the proposed Glenn Complex will result in higher downstream river levels and backwater conditions at Knights Landing. This condition would extend the time period required for the Colusa Basin drainage to leave the Basin. Also, increased drainage runoff from newly developed lands served by the Tehama-Colusa Canal will increase the amount of water the drain will be required to convey. Estimates of total accumulated outflow range from 181 cubic feet per second by the United States Bureau of Reclamation to 500 cubic feet per second by the Department of Water Resources. Encroachments and obstructions within both the channel and the Reclamation Board's Designated Floodway impede the flow and contribute to recurring spring and irrigation outflow problems.

B. PROBLEMS AND CONCERNS

To best describe or categorize the existing and potential problems related to the agriculture interests of the Colusa Basin, three rather distinct areas can be identified.

First, we can define those problems that cannot be solved on a local level, but could be relieved by regional management of the Drain by those locally involved. The actual management requirements are fully discussed in Section 6, including such methods as water outflow coordination during rice field draining periods, local clearing and channel maintenance, and small projects like water level control structures where appropriate. Another regional possibility might be a controlled-flow outlet and channel across the Yolo Bypass from the Knights Landing Ridge Cut as shown on map plate 37 as A.B. and C., and as recommended in State Department of Water Resources Bulletin No. 109, perhaps only to a capacity that could be accommodated downstream with minor channel improvements. A note of caution, downstream channel modifications must be accomplished prior to any major upstream corrective work is done that might increase channel flows. To accomplish any of the local activities just described, some type of managing entity for the entire area should be organized and become active.

The second type of problems that are developing are those created by changing upslope agricultural development and practices, such as increased irrigation and drainage. These are problems within the Colusa Basin Area but cannot be attributed directly to the land adjacent to the Drain. Expanded upslope irrigation development increases requirements for drainage. In order to guarantee investments made in an irrigation system there must be an adequate and permanent area-wide drainage system. So far, upslope developers have not shown any concern or desire to consider such a system. The overall effect assumed by most downslope landowners has been a potential for increased summer drainage flows and larger winter floodings. Landowners also assume that shorter periods of time now elapse between storms and subsequent flooding of Colusa Basin low lands. The data presented and limited field observation do not completely bear out these local assumptions. Development of upslope lands is by no means complete, additional land leveling will take place, and construction of drainage return systems and establisment of certain beneficial farming practices for the area are still lacking. The overall upslope development effects need to be monitored in more detail to pinpoint those that are detrimental to the lowlands of the Colusa Basin.

Relating to the overtaxing of the Drain by surface drainage waters from upslope agricultural development, the U.S. Bureau of Reclamation "Colusa Basin Study-Flood Prevention and Drainage" Work

Team Report of 1974 states the following: "Since additional return flows will be generated by the Tehama-Colusa Canal, and facilities of the Colusa Trough or Reclamation District No. 2047 drain may be overtaxed by such additional return flows at certain seasons, it is recommended that the possibility be explored by the Bureau and by the districts involved of an exchange of the use of the Reclamation District No. 2047 drain for summer irrigation return flows from the Tehama-Colusa Canal service area in return for the right on behalf of those having jurisdiction over the canal to make use of the return flow drainage water from the Tehama-Colusa Canal service area." Although this suggestion would not relieve any potential flooding problem along the Drain, it would provide some compensation for the trespass of these additional upslope return flows.

Two other situations that will develop and should be of major concern to the entire agricultural community of the Colusa Basin are the changes that will take place in the ground water elevations and the accumulation of salts in the lower areas. Salt buildup will take place if corrective measures are not implemented to ensure a permanent agriculture. At the present time an equilibrium or salt balance has been established within much of the lower Colusa Basin land, especially those that have been devoted to rice culture.

Another category of items that are of importance to the entire Colusa Basin are those created by man's activities or natural phenomena within the Basin and elsewhere in the region. One would be the groundwater extraction that is causing subsidence, which in turn, because it is more pronounced in some areas than in others, has caused increased flooding in some areas adjacent to the drain.

Another item of concern that should be placed in this category is the proposed increase in flows in the Sacramento River to transport water south. Several of the reports that have been reviewed suggest that the high river stages will impede the operation of the Knights Landing Outfall Gates during summer months. One report (D.W.R. Bul. 125) further states that any prolonged flow above 9,000 cubic feet per second in the Sacramento River between Colusa Weir and Fremont Weir could cause seepage in the top 4 feet of soil. It seems logical that the Federal and State Agencies that are involved would be concerned before these problems are serious enough to cause damage to agriculture.

There are still other regional programs that would be a benefit to the Colusa Basin. Watershed planning and management should be encouraged. Although development of foothill reservoirs for flood control only, does not appear to be feasible, their development potential when combined with water conservation measures, wildlife enhancement, hydro power, and other watershed benefits should be explored. Reports have also suggested that sedimentation is taking place in the Colusa Basin Drain, and that the major source of this eroded material is the foothills and upper watershed to the west of the Basin. Watershed planning, which is receiving more attention in recent years, should include managed sediment control basins near the source of the material. The Cache Creek Settling Basin, constructed in 1937 is a good example of sediment management. For smaller streams the basins could be located near the base of the foothills. They must be managed and, when filled, be relocated or enlarged. The Corps of Engineers reports the Cache Creek Settling Basin has reached its capacity and the heavy sediment load is now being carried unimpaired into the Yolo ByPass. This deposition in the Yolo ByPass is resulting in a reduction of the flood flow capacity of the Bypass and could conceivably cause backwater effects at the mouth of the Knights Landing Ridge Cut.

It is the problems that are mentioned in this last category that require further involvement by the already established and responsible Federal and State agencies. They need to be encouraged to carry out the tasks and responsibilities entrusted to them, and work in harmony for simultaneous action on mutual problems or projects.

Finally, although this report has put under one cover the physical problems of the Colusa Basin Drain and the adjacent areas, there still appears to the observer at least one more problem.

Besides providing for the funding of this report, the Colusa Basin Drainage Action Group has other accomplishments. The Group opened up a dialogue between landowners and farmers of the upper and lower ends of the Colusa Basin Drain. They have already made efforts to coordinate or at least become informed about the drainage practices of each other and predicted water releases. Successful management however, would not be a term to describe their efforts. The activity of the Group has also resulted in an educational fulfillment for all those that attended the many meetings. Even at the risk of destroying a client-engineer relationship, there must be some comments made by the report writers on their observation of the Group. There has always been the outward appearance of cooperation of everyone, that is until there is a problem that one landowner thinks is his only, then this item becomes his main concern (it could be flooding, crop loss, lack of irrigation water or what have you). When this happens, and it has several times during the course of this study, what appeared to have been a cooperative effort as mentioned earlier quickly disappears.

Until members of the Group and the people they represent can act and think in concert as one body, they will not move forward to accomplish any of their desired goals or objectives. Therefore, in order to continue as a group and move forward, some type of permanent organization must be formed. This organization should have funding and area control capabilities. The membership should consist of perhaps districts but, be mainly made up of the landowners who will end up paying for any expenses and receiving the benefits. It then follows that people with the problems and receiving the benefits should be making the decisions. At the present time there are many established means or vehicles available to form any type of organization desired. First the Group must decide what type of organization and area coverage it wants. Legal assistance and leadership is necessary and certainly desirable from this point forward to guide the decision making sequence and select the most desirable form of organization.

After permanently establishing an organization, priorities and an operating plan should be established as to what should be done to at least maintain the Drain in its present condition. If work by other agencies or groups would be beneficial to the area then support them and encourage their projects. However, past experience has shown, even within the Colusa Basin Drain area, that waiting for someone else to develop and fund a project is a time wasting and frustrating exercise.

If you want something done, develop a capable organization with good leadership and go after it. This is better than making rumbles and hoping someone else will do it for you and pick up the tab, those days if ever here are certainly past.

The only way state or federal agencies or their monies will be able to help the area is that they may have created or aggravated the problems that are being currently assessed. The Colusa Basin Area and the entire westside of the Sacramento Valley are of statewide importance and perhaps a different or unconventional project analysis may be justified or certainly should be reviewed.

APPENDIX
A

Plates

Plate No. 1 outlines the plan of the U.S.B.R. for storage and regulation of the westside streams as shown. the State Department of Water Resources in Bulletin 76, 1978, proposes a similar plan and is described as follows. In comparing the Glenn Complex and the proposed Southerly Colusa Reservoir, the Colusa Reservoir could be constructed in stages. Actually it is an expanded version of the the Sites Reservoir. The Colusa and Glenn Reservoir plans would depend on nearly the same supply, therefore both should not be constructed to their maximum described size. However, a combination of the reduced plans is conceivable. The Bulletin also states that the Colusa Reservoir would provide some flood protection to the Willows and Colusa areas. The proposed Colusa Reservoir data is summerized below and is located as shown on Plate No. 1c.

COLUSA RESERVOIR—RIVER DIVERSION DAM AND RESERVOIR DATA SUMMARY

Drainage area	383 square kilometres (148 square miles)
Elevations	
Dam crest:	163 metres (535 feet)
Maximum pool:	158 metres (520 feet)
Top of flood reservation:	Not applicable
Top of conservation pool:	158 metres (520 feet)
Minimum pool:	98 metres (320 feet)
Streambed:	
Willow dam:	114 metres (375 feet)
Logan dam:	85 metres (279 feet)
Hunters dam:	81 metres (265 feet)
Funks dam:	73 metres (240 feet)
Sites dam:	73 metres (240 feet)
Dam height	
Willow dam:	49 metres (160 feet)
Logan dam:	78 metres (256 feet)
Hunters dam:	82 metres (270 feet)
Funks dam:	90 metres (295 feet)
Sites dam:	90 metres (295 feet)
Capacities	
Flood reservation:	None
Conservation storage:	3824 cubic hectometres (3100 thousand acre-feet)
Inactive, dead, sediment:	74 cubic hectometres (60 thousand acre-feet)
Gross:	3898 cubic hectometres (3160 thousand acre-feet)
Area	
Reservoir at gross storage:	12 100 hectares (30,000 acres)
Total land required:	16 200 hectares (40,000 acres)

COLUSA RESERVOIR—RIVER DIVERSION CONVEYANCE FACILITY DATA

Tehama-Colusa Canal (Under Construction)

Type: Concrete-lined
Length, Red Bluff to project diversion:
90 Kilometres (56 miles)
Capacity of project diversion:
90 Cubic Metres/Second (56 cubic feet/second)
Maximum water surface elevation at project diversion:
59 Cubic Metres/Second (2,100 cubic feet/second)

Glenn-Colusa Irrigation District Canal (Existing)

Type: Unlined
Length, Sacramento River to project forebay:
37 Kilometres (23 miles)
Capacity at forebay (with planned improvements):
59 Cubic Metres/Second (2,100 cubic feet/second)
Maximum water surface elevation at forebay:
39 Metres (129 feet)

Colusa Forebay

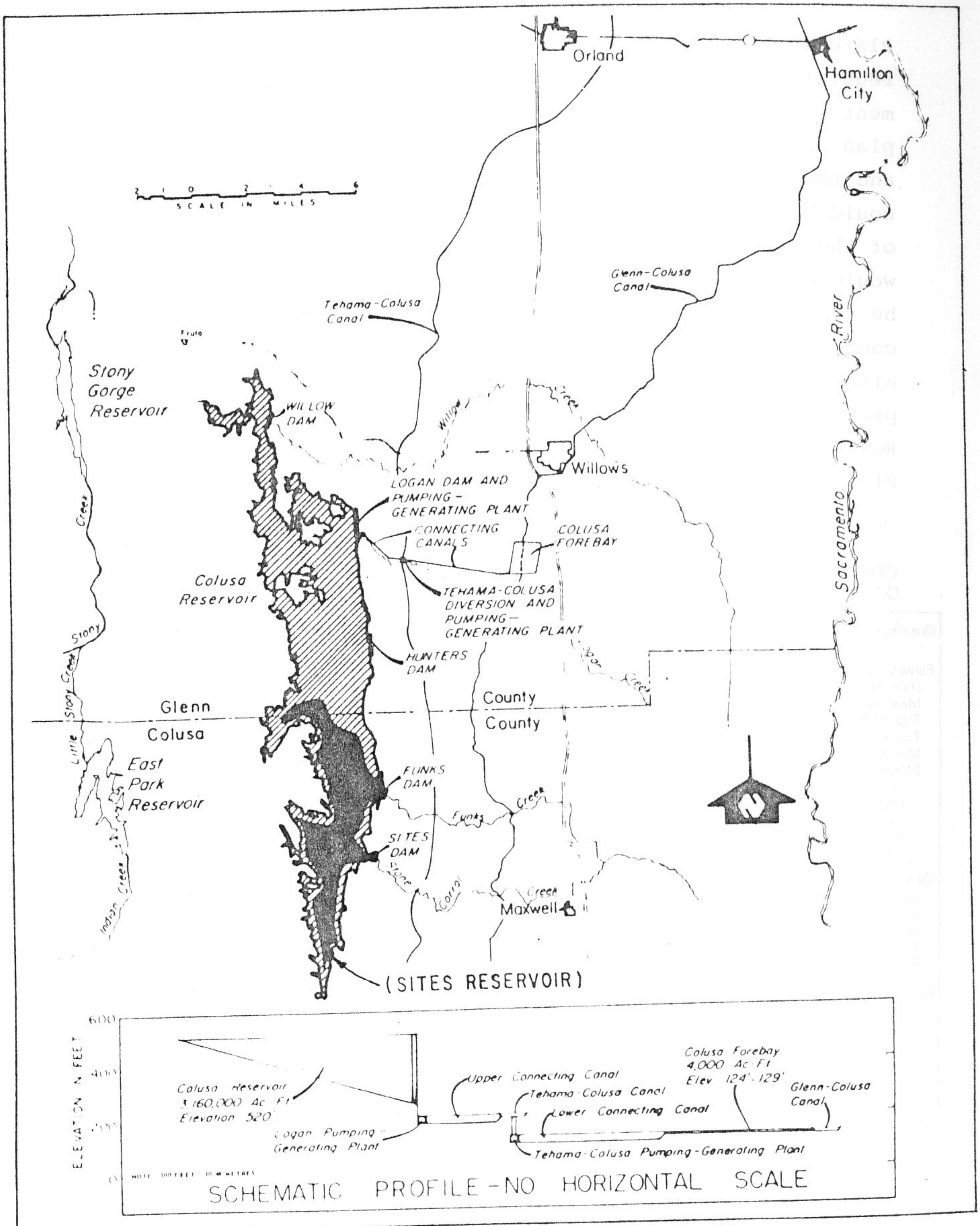
Active storage capacity:
5.2 Cubic Hectometres (4,200 acre-feet)
Operating water surface elevation:
38 to 39 Metres (124 to 129 feet)
Maximum area: 340 Hectares (840 acres)

Lower Connecting Canal (Forebay to Tehama-Colusa Canal)

Type: Unlined, level bottom
Length: 6.1 Kilometres (3.8 miles)
Capacity: 178 Cubic Metres/Second (6,300 cubic feet/second)

Plate No. 1b

Delta Water Facilities
Bulletin No. 76
Department Water Resources
1978



Colusa Reservoir - River Diversion Plan.

Plate No. 1C

Delta Water Facilities
Bulletin No. 76
Department Water Resources
1978

SENATE CONCURRENT RESOLUTION NO. 79--RELATING TO A STUDY OF THE "COLUSA BASIN."

"WHEREAS, There exists in the Counties of Glenn, Colusa, and Yolo inadequate drainage and flood control facilities that are necessary for the general area located therein which is known as the 'Colusa Basin'; and

"WHEREAS, This condition of inadequate drainage and flood control has annually resulted in great damage to the agricultural crops in the area amounting to many thousands of dollars each year; and

"WHEREAS, The agricultural and economic development of the area is greatly impeded by these conditions; and

"WHEREAS, The creation of new irrigation and soil conservation districts in this area will compound the damages now being suffered; and

"WHEREAS, It is necessary for an overall plan to be developed for this area to alleviate the damages caused by drainage, seepage and storm water disposal, giving due consideration to the established water rights existing in the area; now, therefore, be it

"Resolved by the Senate of the State of California, the Assembly thereof concurring, That the Department of Water Resources is hereby requested to make a comprehensive study of the 'Colusa Basin' for the purpose of determining the best manner for alleviating the problems resulting from inadequate drainage and flood control facilities, seepage and storm water disposal giving due consideration to the protection of established water rights in the area; and be it further

"Resolved, that the Secretary of the Senate is directed to transmit a copy of this resolution to the Department of Water Resources."

Date
1959

Plate No. 2

SUMMARY OF FOOTHILL RESERVOIR PROJECT

Reservoir location	Drainage area above dam site, in square miles	Reservoir storage capacity, in acre-feet	Once-in-50-year flood discharge, in second-feet		Capital costs of dam and reservoir, in dollars
			Uncontrolled	Controlled 1/	
Wilson Creek	13.5	2,200)			1,305,000
French Creek	69.2	11,000)	16,400	3,500	3,865,000
Unnamed Creek	13.7	2,200)			1,619,000
South Fork Willow Creek	79.0	12,600)			2,452,000
Logan Creek	20.4	3,300)	3,900	550	888,000
Hunter Creek	15.8	2,500)			1,088,000
Funks Creek	47.5	7,600)	8,300	900	1,516,000
Stone Corral Creek	36.5	5,800)			1,317,000
Freshwater Creek	32.8	7,000)	4,300	540	1,414,000
Salt Creek	10.5	2/)			392,000
Spring Creek	16.9	2,700	1,700	200	2,205,000
Cortina Creek	33.5	5,300	3,400	450	2,760,000
Salt Creek	18.9	3,000	1,900	250	2,082,000
Petroleum Creek	6.0	1,000	600	60	1,212,000
Buckeye Creek	31.3	5,000	3,100	350	2,200,000
Bird Creek	8.0	1,300	800	150	1,040,000
Oak Creek	27.0	4,300	2,700	350	1,405,000
	480.5	76,800	-----	----	28,760,000

1/ Controlled release following flood. No releases made during high flood inflow.
2/ Salt Creek Dam diverts up to 1,000 second-feet into Freshwater Creek Reservoir.

Colusa Basin Investigation
Bulletin No. 109
Department Water Resources
1964

Analysis of Sacramento and Feather River

Selected Flow Conditions

River Gaging Stations	Condition 1 Flow CFS	Condition 1 Stage USGS 1)	Condition 2 Flow CFS	Condition 2 Stage USGS 1)	Condition 3 Flow CFS	Condition 3 Stage USGS 1)
Sacramento River						
at Colusa	10,000	42.6	14,000	46.1	18,000	49.4
below Wilkins Slough	10,000	30.2	14,000	34.7	18,000	39.0
* at Knights Landing	10,000	18.8	14,000	21.5	18,000	24.5
at Verona	17,300	14.5	21,300	16.3	25,300	18.1
at Sacramento	18,300	5.8	22,300	7.2	26,300	8.6
near Freeport	---	----	22,300	5.2	26,300	6.4
at Snodgrass Slough	---	----	22,300	3.4	26,300	4.2
Feather River						
at Nicolaus	6,500	22.8	6,500	22.8	6,500	23.4

Flow Condition No. 1 assumes the importation of approximately 5,000 second-feet. Condition No. 2 is based on an importation of about 9,000 second-feet, and Condition No. 3 assumes an importation of approximately 14,000 second-feet.

1) Add 3.0 feet to U.S.G.S. river stages to obtain Corps of Engineers Datum.

* Above elevations for normal operations of Knights Landing Outfall Gates.

Sacramento Valley
Seepage Investigation
Department Water Resources
August 1967

PROBABLE RANGES OF MAXIMUM SUMMER STAGES OF SACRAMENTO RIVER
(Feet)
(1970-2000)

Reach	Location of Gage	Datum of Gage	Corresponding Gage Heights (Feet)
Upper			
(12,000 - 16,000 cfs)	Below Wilkins Slough	USED	35 - 39
	Near Rough & Ready Bend	USED	27 - 32
	At Knights Landing	USED	22 - 27 *
Middle			
(16,000 - 20,000 cfs)	At Verona	USED	16 - 19
	At Elkhorn Ferry	USED	13 - 16
Lower**			
(18,000 - 22,000 cfs)	At Sacramento	USED	9 - 14
	Near Freeport	USED	3 - 7
	At Snodgrass Slough	USED	5 - 9*

Notes:

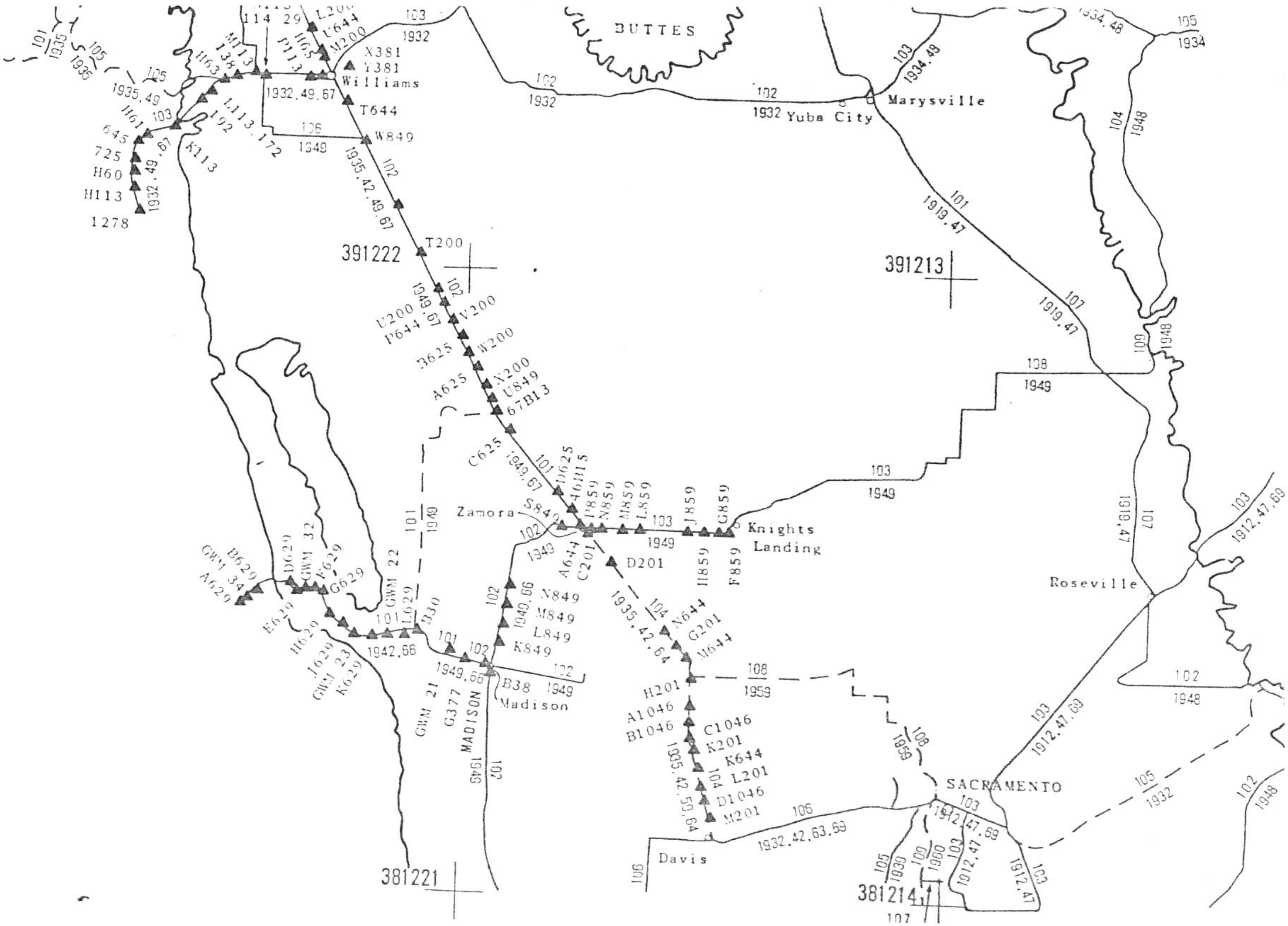
* : May be reduced by operation of Peripheral Canal
** : Affected by tides
USED: U.S. Corps of Engineers (Department)
USGS: U.S. Geological Survey

Add approximately 3 feet to USGS gage heights to convert to USED gage heights.

1) Based upon upstream projects planned in 1970.

* Above elevations for normal operations of Knights Landing Outfall Gates.

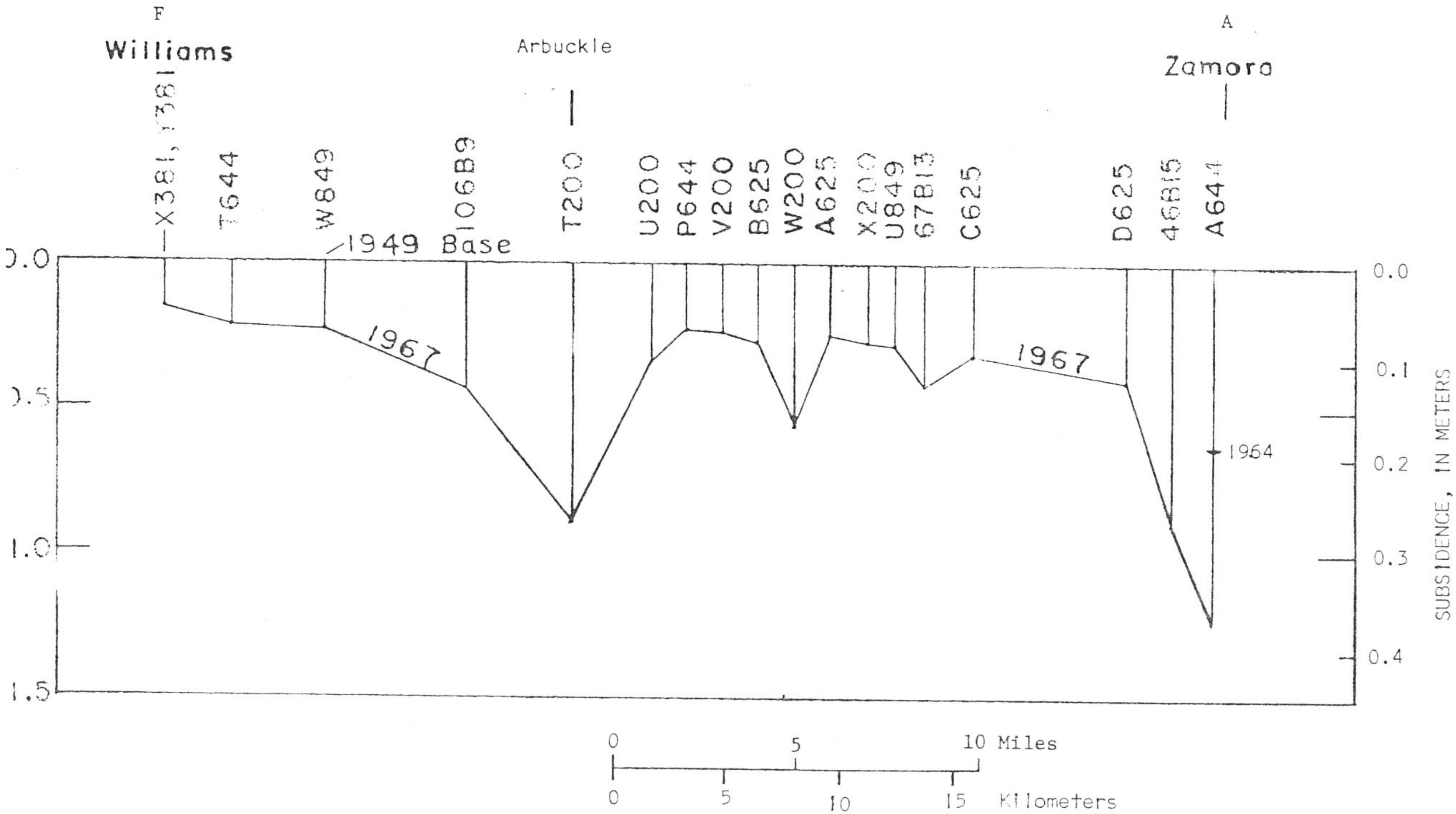
Sacramento River Flows
and
Potential Seepage in Yolo County
Kaiser Engineers, February 1972



Years of leveling by the National Geodetic Survey and location of bench marks for which repeated leveling indicates change in land-surface elevation, Sacramento Valley, California

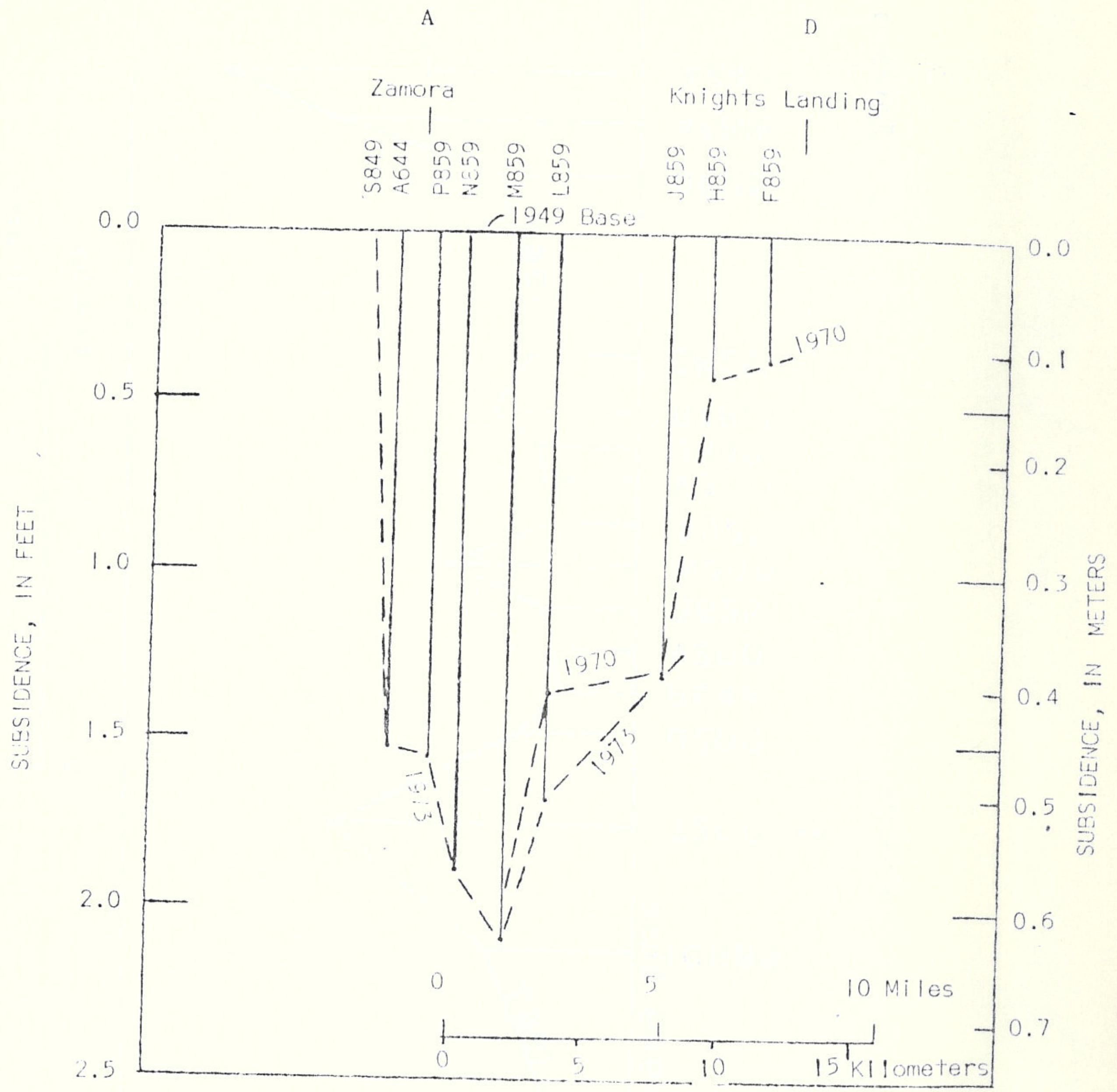
Preliminary USGS
Sacramento Valley
Subsidence Investigation
1973

Plate No. 6



Preliminary
USGS Sacramento Valley
Subsidence Investigation
1973

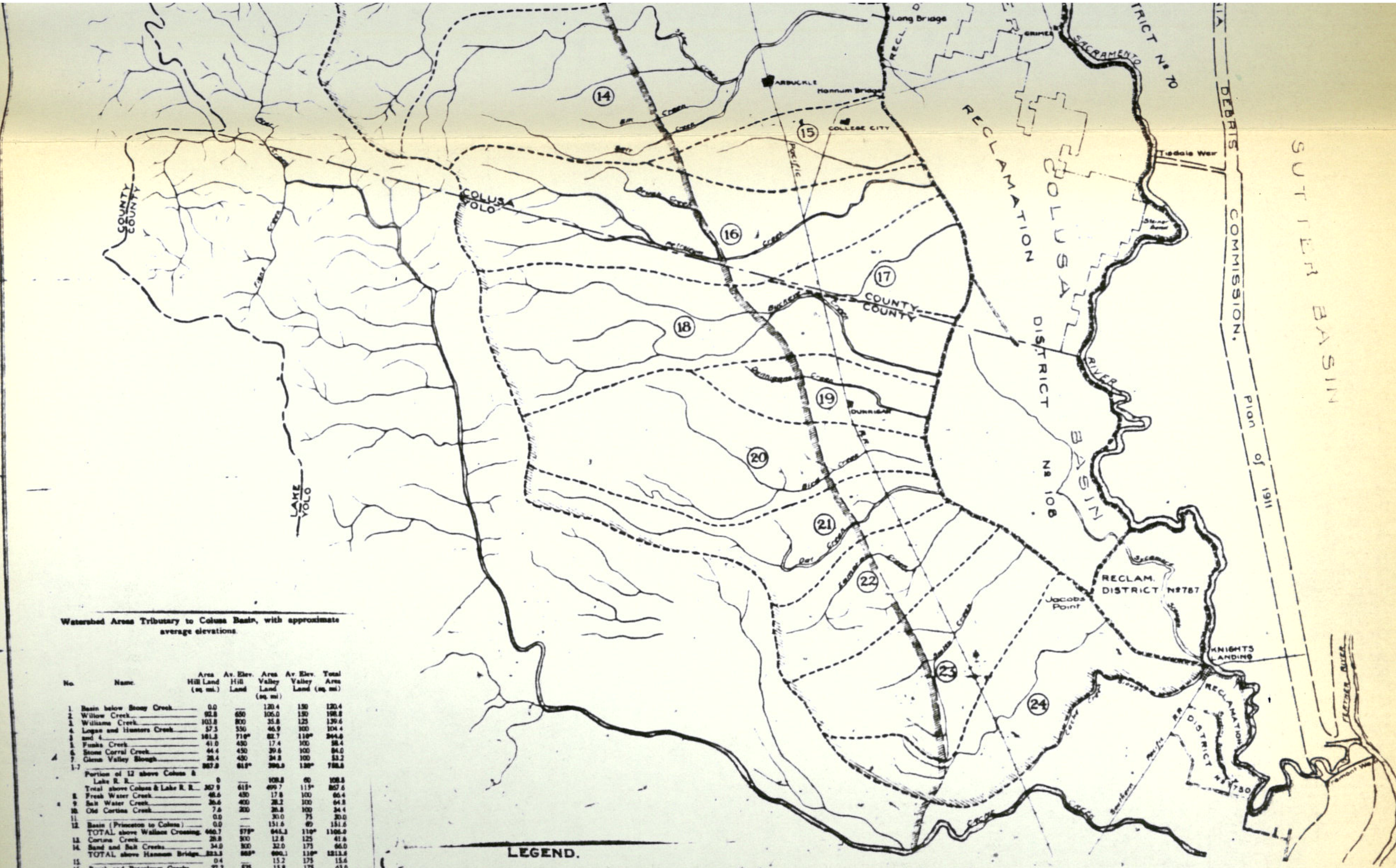
Profiles of apparent land subsidence, F-A, 1949 to 1967, from Williams to Zamora. For location, see plate 6.



Profiles of apparent land subsidence, A-D, 1949 to 1970 and 1973, from Zamora to Knights Landing. (1949 leveling by National Geodetic Survey; 1970 and 1973 second-order leveling by U.S. Geological Survey.) For location see plate 6.

Preliminary
USGS Sacramento Valley
Subsidence Investigation
1973

Plate No. 8



Watershed Areas Tributary to Colusa Basin, with approximate average elevations.

No.	Name	Area Hill Land (sq. mi.)	Av. Elev. Hill Land	Area Valley Land (sq. mi.)	Av. Elev. Valley Land	Total Area (sq. mi.)
1.	Basin below Stony Creek	0.0	—	120.4	150	120.4
2.	Willow Creek	92.8	650	106.0	150	198.8
3.	Williams Creek	103.8	800	35.8	125	139.6
4.	Logan and Hunters Creek	57.3	550	46.9	100	104.4
3	and 4	161.1	710*	82.7	110*	244.8
5.	Funks Creek	41.0	450	17.4	100	58.4
6.	Stone Corral Creek	44.4	450	39.6	100	84.0
7.	Glenn Valley Slough	28.4	450	24.8	100	53.2
1-7		367.9	615*	390.9	130*	758.8
	Portion of 12 above Colusa & Lake R. R.	0	—	108.8	60	108.8
	Total above Colusa & Lake R. R.	367.9	615*	499.7	115*	867.6
8.	Fresh Water Creek	48.6	450	17.8	100	66.4
9.	Salt Water Creek	36.6	400	28.2	100	64.8
10.	Old Cortina Creek	7.6	200	26.8	100	34.4
11.		0.0	—	30.0	75	30.0
12.	Basin (Princeton to Colusa)	0.0	—	151.6	60	151.6
	TOTAL above Wallace Crossing	460.7	575*	645.3	110*	1106.0
13.	Cortina Creek	28.8	500	12.8	125	41.6
14.	Sand and Salt Creeks	34.0	300	32.0	175	66.0
	TOTAL above Hannum Bridge	523.5	565*	690.1	110*	1213.6
15.		0.4	—	15.2	175	15.6
16.	Brush and Petroleum Creeks	27.2	525	15.8	175	43.0
17.		0.0	—	13.2	90	13.2
18.	Buckeye Creek	29.3	300	11.4	125	40.7
19.	Dunnigan Creek	7.2	300	4.8	65	12.0
20.	Bird Creek	20.8	450	5.2	80	26.0
21.	Oat Creek	16.3	200	5.0	40	21.3
22.	Zamora Creek	10.0	150	7.4	30	17.4
23.	Smith Creek	12.0	150	14.6	30	26.6
24.		4.3	150	22.3	30	26.6
	5 to 24 inclusive	466.8	425*	495.8	90*	962.6
	GRAND TOTAL 1 to 24 inclusive	641.0	525*	805.0	110*	1446.0

* Weighted according to area at each elevation.

LEGEND.

- Levees.
- Railroads.
- Watershed Boundaries.
- Line between Foothills and Valley.
- Proposed Government By-Pass.
- Reclamation District Lines.

KNIGHTS LANDING CUT PROJECT

WATERSHEDS TRIBUTARY TO COLUSA BASIN

Compiled from County Maps of Yolo, Colusa, Glenn and Tehama Counties

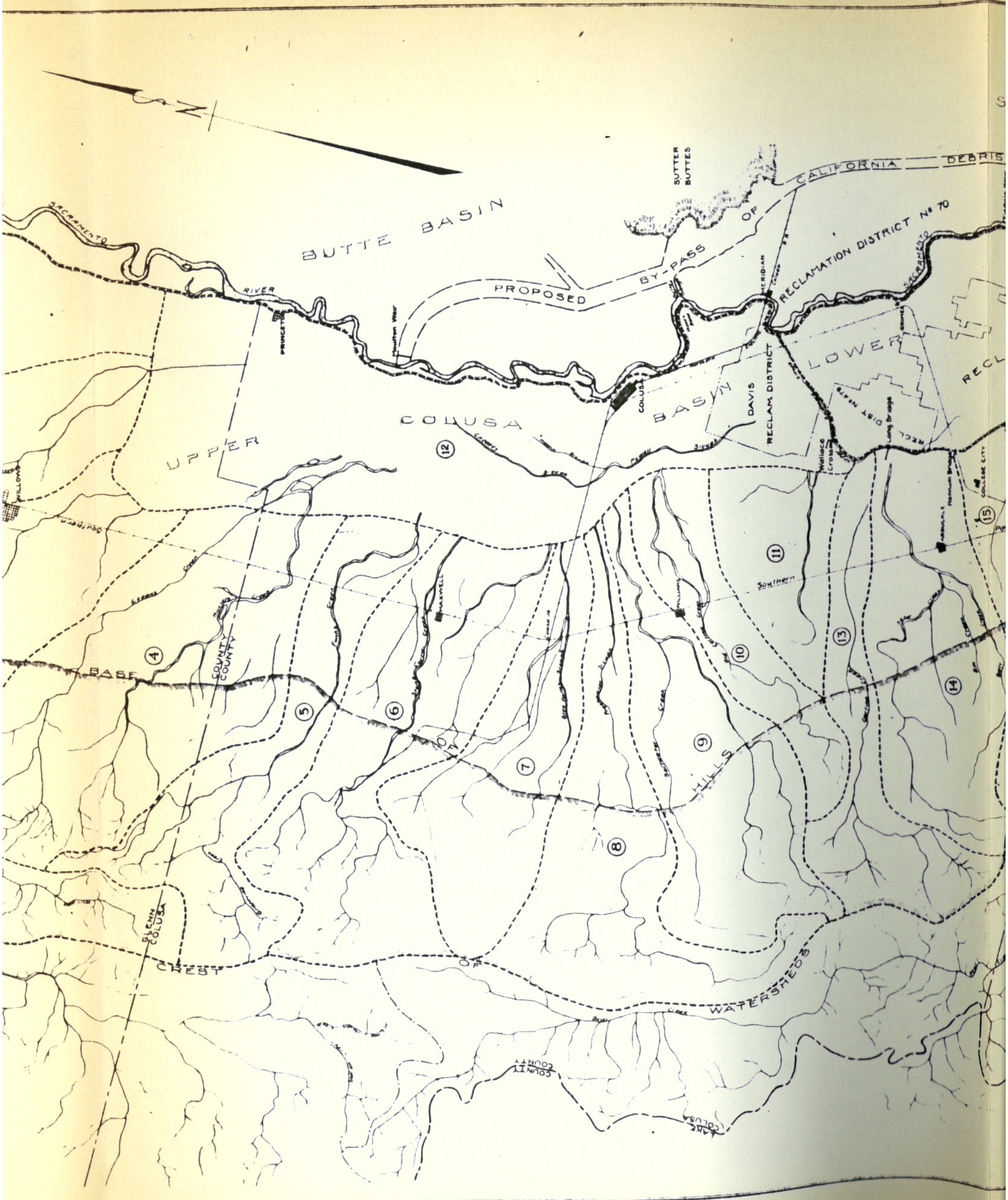
NOVEMBER 1912

Haviland & Tibbetts Civil Eng'rs
San Francisco, Cal.

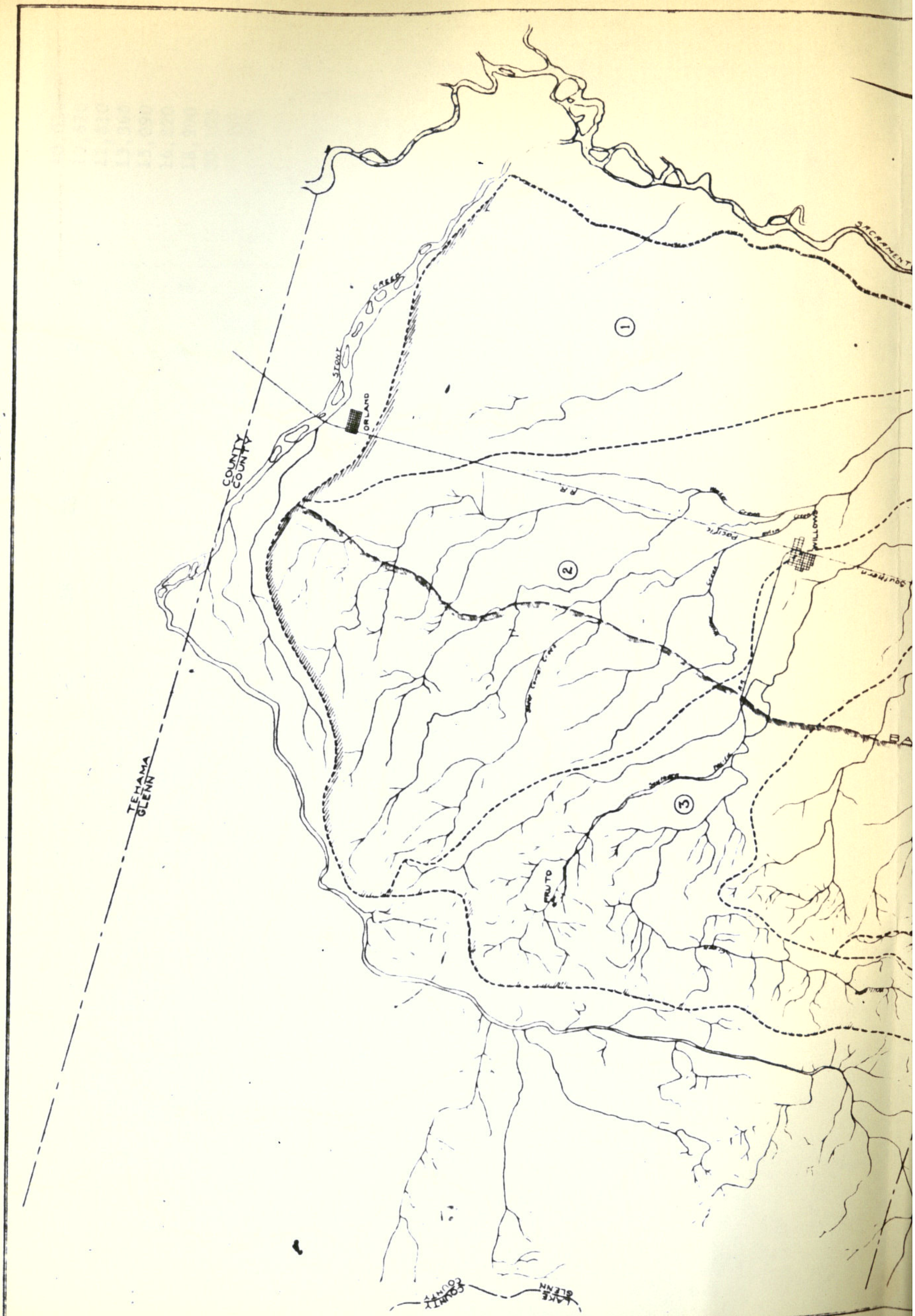
Dr. T&H Tr. GWT

10 13

PLATE 9



N
SUTTER BUTTES
BUTTE BASIN
PROPOSED BY-PASS OF CALIFORNIA DEBRIS
RECLAMATION DISTRICT No 70
SACRAMENTO RIVER
SACRAMENTO
PRINCETON
MERIDIAN
COLUSA
UPPER COLUSA BASIN
LOWER
RECL
DAVIS RECLAM DISTRICT
WILLOWS
MAXWELL
WILLIAMS
ARBUCKLE
COLLEGE CITY
Southern
Wallace Cross
Long Bridge
BASE OF HILLS
CREST OF WATERSHEDS
GLENN COLUSA
COUNTY COUNTY
COLUSA COUNTY
LAKE COLUSA
4
5
6
7
8
9
10
11
12
13
14
15


TEHAMA COUNTY
GLENN COUNTY
STONY CREEK
ORLAND
SACRAMENTO
WILLOWS
R R
1
2
3
FRUTO
LAKE COUNTY
GLENN COUNTY

Total Annual Agricultural Drainage Outflow - Cubic Feet Per Second
Tehama-Colusa Canal Service Areas 3B, 3C, 3D, 4, 5, 6, and Yolo-Zamora Units

Year	Drainage outflow to Colusa Drain by months - cubic feet per second												Acre-feet per year
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1													9,800
2													10,020
3	0	0	5	15	24	34	40	38	23	4	0	0	10,870
4													11,810
5													13,360
6													15,090
7													16,820
8	0	0	8	26	41	59	69	67	40	7	0	0	18,990
9													20,105
10													24,290
11													26,390
12													28,660
13	0	0	13	44	69	98	114	112	67	12	0	0	31,380
14													33,510
15													35,310
16													37,090
17													38,790
18	0	0	17	56	89	126	148	144	86	16	0	0	40,490
19													42,040
20													43,540
21													44,850
22													45,965
23	0	0	20	66	103	147	172	167	99	18	0	0	47,120
24													47,820
25													48,590
26													49,400
27													50,050
28	0	0	21	67	105	149	175	170	102	19	0	0	50,610
29													51,110
30													51,690
31													51,790
32													52,090
33	0	0	22	69	108	154	181	176	105	19	0	0	52,210
34													52,240
35	0	0	23	69	108	154	181	176	105	19	0	0	52,500

Flood Prevention and Drainage - Work Team Report, USBR
October 1974

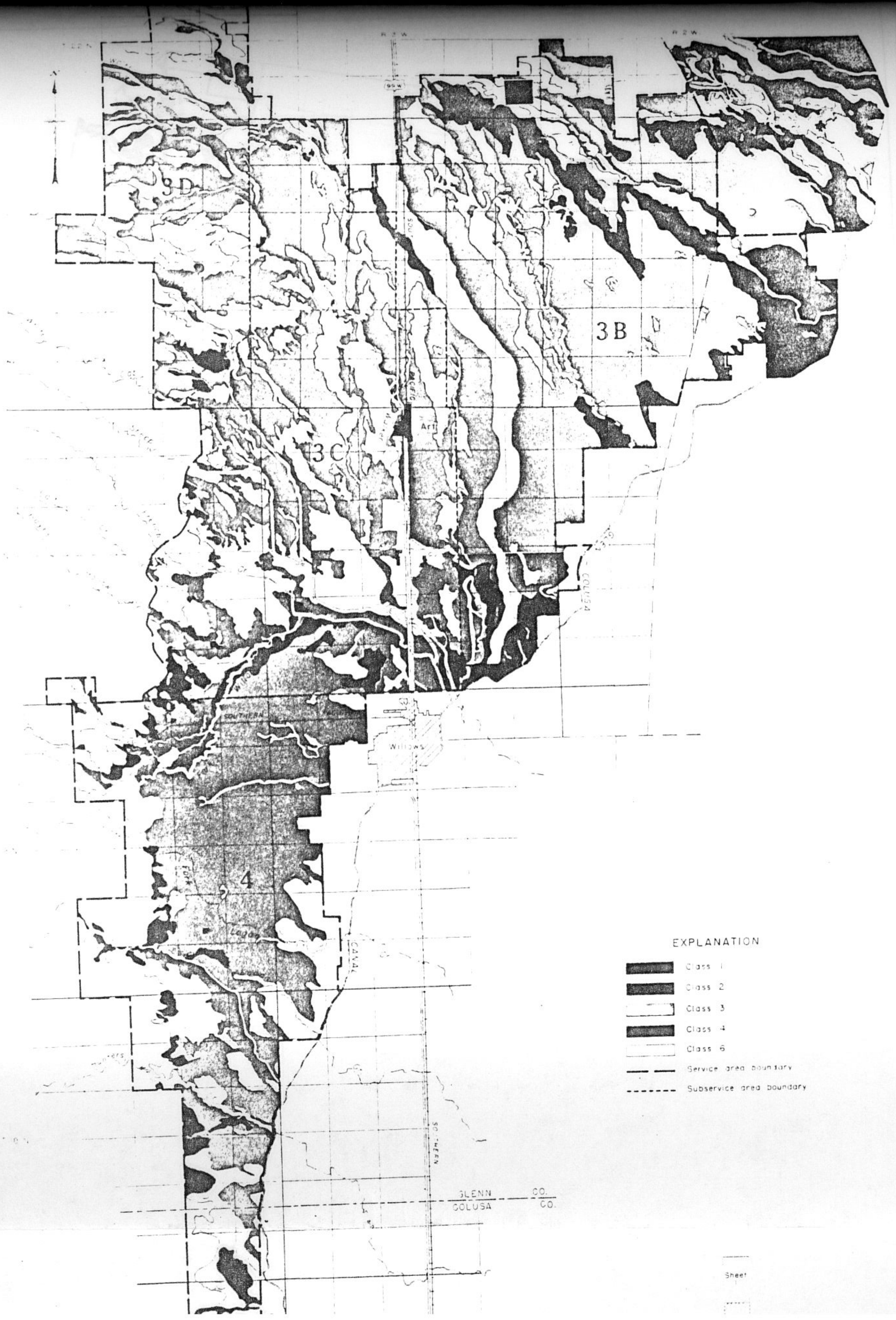


Plate 10 a

(Drainage Ar

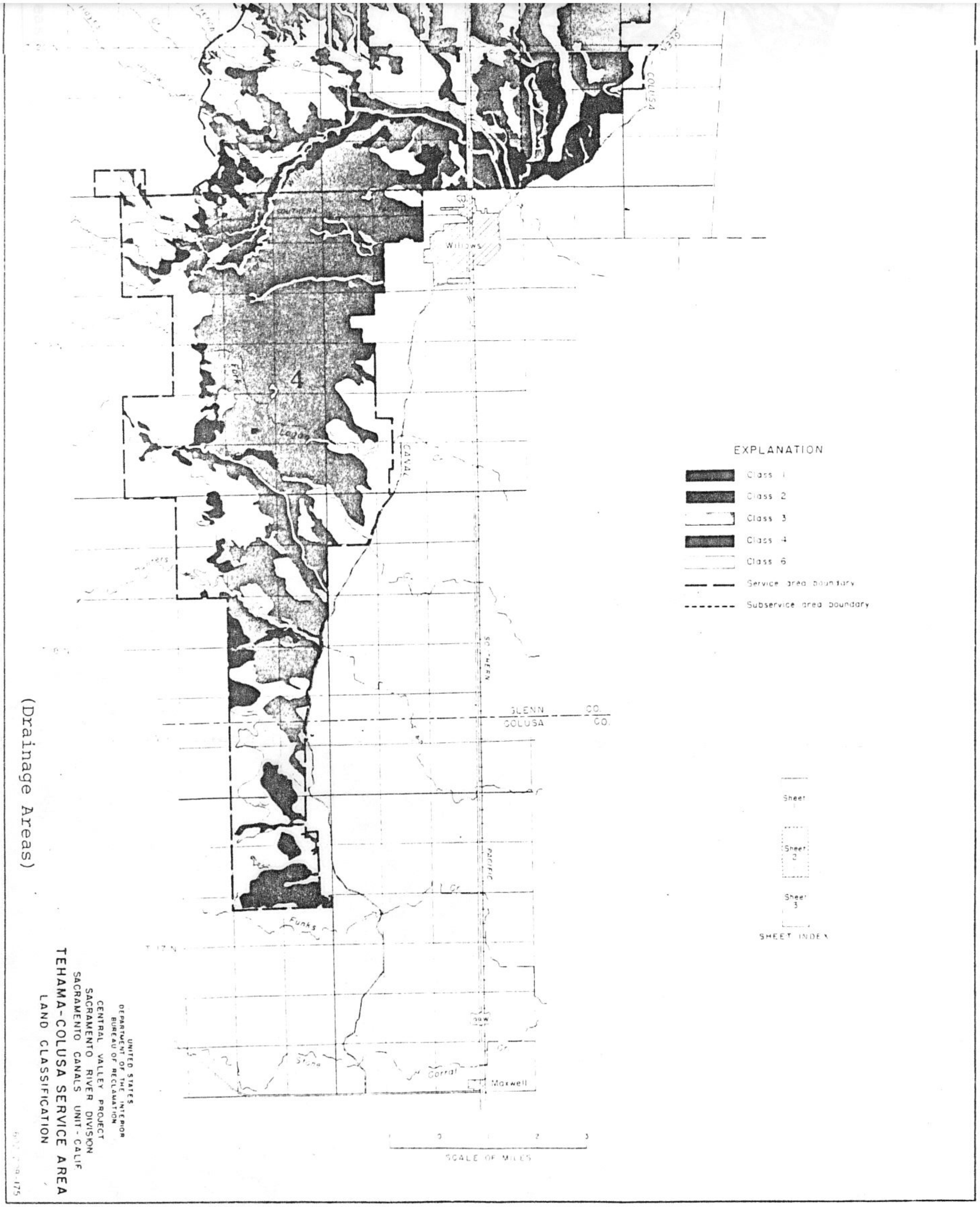
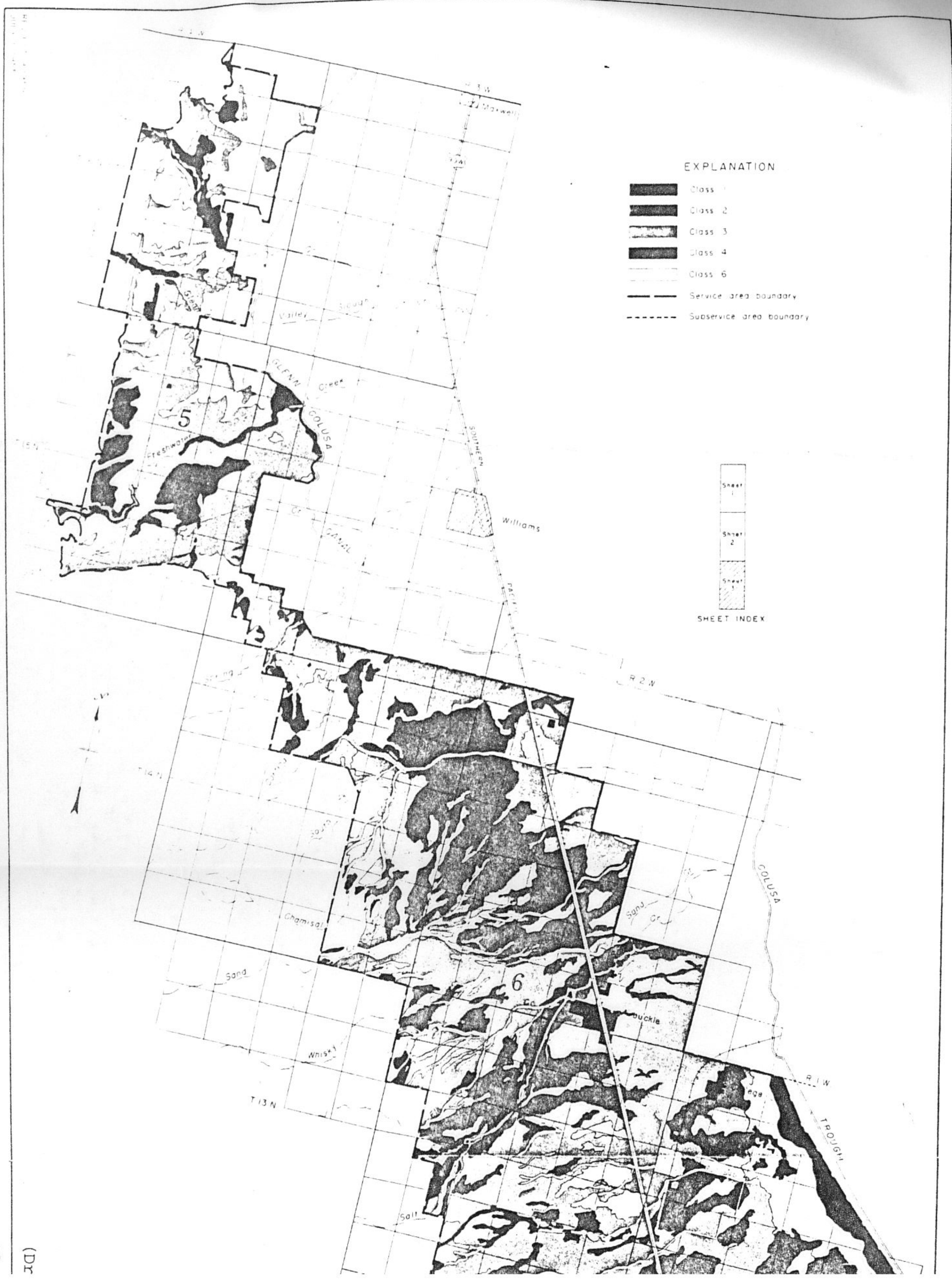


Plate 10 a

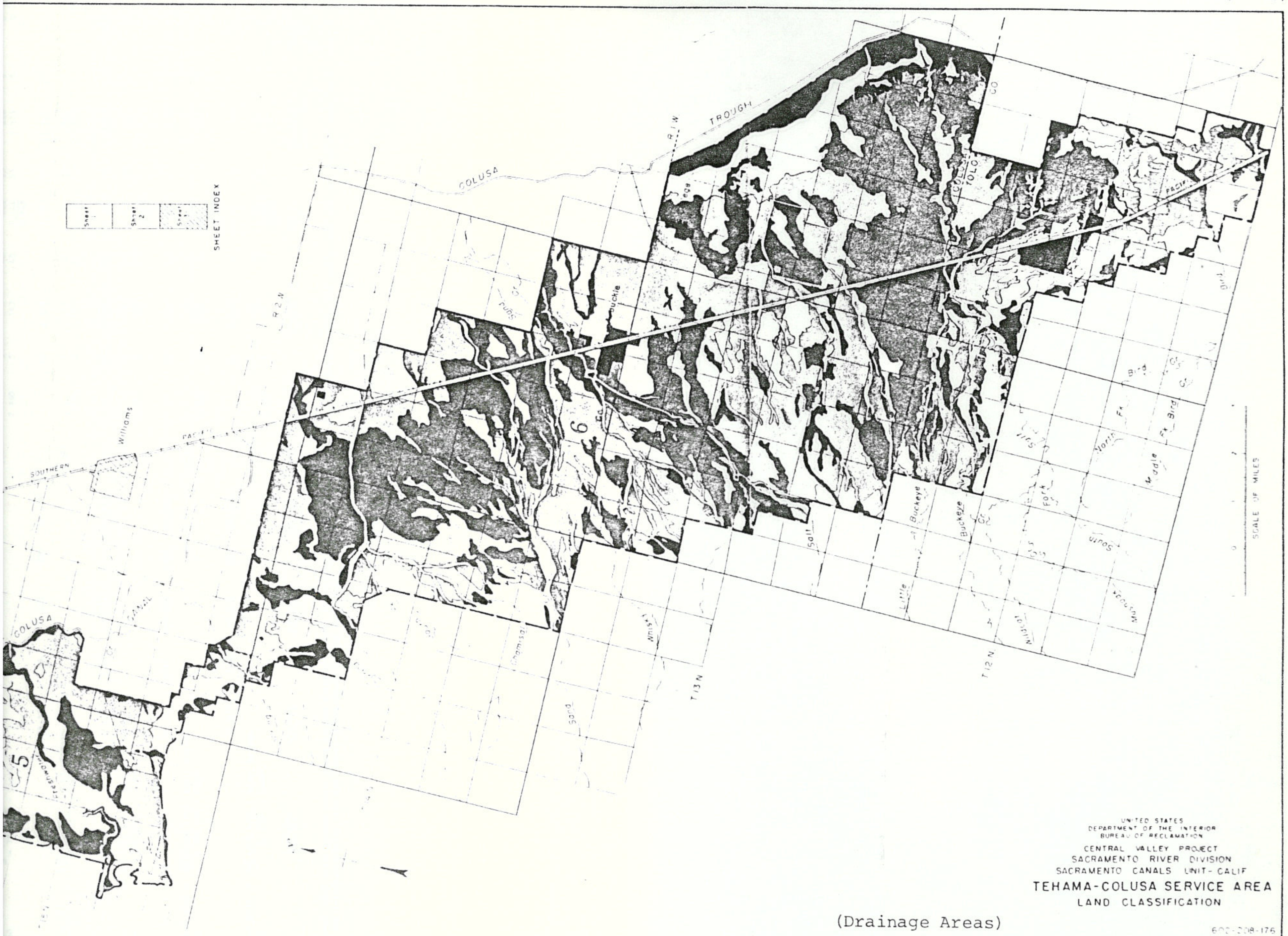
PLATE I (Sheet 2)


EXPLANATION
Class 1
Class 2
Class 3
Class 4
Class 6
Service area boundary
Subservice area boundary
SHEET INDEX
Sheet 1
Sheet 2
Maxwell
Williams
5
6
Freshwater
Glenn
Colusa
Canal
Valley
Southern
Pacific
R 2 W
T 14 N
T 13 N
R 1 W
Sand Cr.
Chamisal
Sand
Salt
Colusa
Trough
Arbuckle

Pla

(Dr

PLATE 1 (Sheet 3)



(Drainage Areas)

Plate 10 b

Colusa Basin Drain Unit

Tehama-Colusa Service Areas 3; 4; 5; 6 and Yolo-Zamora Unit
Losses and Projected Drain Flows - Year 2000

Area	Tehama-Colusa Canal and Distribution System Water Delivery Calculations a/	Irrigated Land acres	Water Req. AF/Ac.	Farm Delivery Demand (F.D.D.) AF	Farm Applic. Losses	Farm Applic. AF	Canal & Dist. System Losses: Dist. System (acre-feet)	Canal & Dist. System Losses: Main Canal (acre-feet)	Distribution of Losses: Evapo-trans. %	Evapo-trans. AF	Deep Perc. %	Deep Perc. AF	Surface Runoff %	Surface Runoff AF	Distribution of Surface Runoff: Recapture of Surface Runoff %	Recapture AF	Runoff via Colusa Drain %	Runoff via Colusa Drain AF	Distribution of Deep Percolation: Pumped in Service Area (acre-feet)	Increase in G.W. Outflow (acre-feet)
3B	Stony Creek Flood Plain	29,374	3.68	108,096	30%	32,428			15	4,864	50	16,214	35	11,350	60	6,810	40	4,540		
	[(108,098-59,000-11,674)+ .98] =(38,185) - Dist. System						765		5	38	50	383	45	344	0	0	100	344		
	38,185 + 1,100 = 39,285 - Canal							1,100	5	55	50	550	45	495	0	0	100	495		
												17,147						5,379	4,100	4,940
3C & 3D	Willow-Walker Creek Area	34,734	3.65	126,779	30%	38,034			15	5,705	10	3,803	75	28,525	60	17,115	40	11,410		
	[(126,779-36,000-17,115) + .98] =(75,167) - Dist. System						1,504		5	75	40	602	55	828	0	0	100	828		
	75,167 + 2,860 = 78,027 - Canal							2,860	5	143	40	1,144	55	1,573	0	0	100	1,573		
												5,549						13,811	1,700	3,849
4	Area 4	21,180	3.56	75,401	30%	22,620			15	3,393	10	2,262	75	16,965	55	9,331	45	7,634		
	[(75,401-2,000-9,331) + .98] =(65,378) - Dist. System						1,307		5	65	40	523	55	719	0	0	100	719		
	65,378 + 3,960 = 69,338 - Canal							3,960	5	198	40	1,584	55	2,178	0	0	100	2,178		
												4,369						10,531	0	4,369
5	Area 5	14,780	3.30	48,774	30%	14,623			15	2,193	10	1,462	75	10,967	55	6,032	45	4,935		
	[(48,774-6,032) + .98] =(43,614) - Dist. System						873		5	44	40	349	55	480	0	0	100	480		
	43,614 + 3,740 = 47,354 - Canal							3,740	5	187	40	1,496	55	2,057	0	0	100	2,057		
												3,307						7,472	0	3,307
6	Area 6	61,962	2.62	162,340	30%	48,702			15	7,305	40	19,481	45	21,916	60	13,150	40	8,766		
	[(162,340-51,000-13,150) + .98] =(100,194) - Dist. System						2,010		5	100	50	1,005	45	905	0	0	100	905		
	100,194 + 5,940 = 106,134 - Canal							5,940	5	300	50	2,970	45	2,673	0	0	100	2,673		
												23,456						12,344	20,000	3,456
Yolo-Zamora Unit		21,680	3.00	65,040	30%	19,512			15	2,927	60	11,707	25	4,878	60	2,927	40	1,951		
	[(65,040-43,350-2,927) + .98] =(18,763) - Dist. System						377		5	19	70	264	25	94	0	0	100	94		
	18,763 + 2,640 = 21,403 - Canal							2,640	5	132	70	1,848	25	660	0	0	100	660		
												13,819						2,705	13,819	0
TOTALS	361,541	183,710		586,430		175,919	6,836	20,240		27,743		67,647		107,607		55,365		52,242 say, 52,500	39,619	19,921

a/ Farm Delivery Demand (FDD) minus ground water, minus surface water recapture, divided by distribution system loss factor equals distribution system requirements. Distribution system requirements plus main canal losses equals amount diverted from the Sacramento River into the Tehama-Colusa Canal for the six areas.

Flood Prevention and Drainage
Work Team Report, USBR
October 1974

ALTERNATIVES	COMMENTS	CONCLUSIONS
COLUSA DRAIN FLOODING		
1. Construct foothill reservoirs with combined flood storage of 50,000 acre-feet	Could provide irrigation water supply and recreation use depending on sizing and operation of reservoirs. Downstream channels may have to be enlarged to carry reservoir releases after large storm.	Does not appear economically justified.
2. Restore flow capacity of Knights Landing Ridge Cut	Would evacuate water in Colusa Drain quickly when Yolo Bypass flows decrease; but in late spring may be detrimental to bypass agriculture. Thus additional construction may be required in the bypass. Improving Ridge Cut channel would cause adverse wildlife impact requiring mitigation.	Does not appear economically justified.
3. Divert north basin streams to Stony Creek or Sacramento River	Would reduce floodflows in lower portion of basin. Possible legal entagelements resulting from increasing floodflows into Butte Basin via Moulton and Colusa Weirs. Would worsen seepage problem.	Does not appear feasible due to legal and economic considerations.
4. Increase flow capacity of Colusa Drain	Add new levee along west bank to protect west side of drain against flooding. Approximately 6,000 acres of land would fall within the leveed area. Wildlife mitigation measures should be incorporated. Consideration should be given to providing an adequate outlet capacity.	Does not appear economically justified.
5. Pump from Colusa Drain at various locations to the Sacramento River	Reversible pumps could be used for irrigation if necessary. High construction and operating costs. Would increase seepage problem.	Does not appear economically justified for either spring or winter flooding.
6. New drain at higher elevation than Colusa Drain	To provide "50-year" flood protection to the Colusa Basin. A 25,000 ft^3/s canal would be required. Could possibly be used also as an irrigation canal.	Does not appear economically justified.

Sacramento River Drainage
and Seepage Utilization
USBR, February 1977

ALTERNATIVES	COMMENTS	CONCLUSIONS
COLUSA DRAIN FLOODING (Cont'd)		
7. Divert streams to Tehama-Colusa Canal and thence to Cache Creek.	Would help to reduce flood peaks. Would increase floodflows in Cache Creek and sedimentation in Tehama-Colusa Canal. Canal capacity only 10 percent of floodflow.	Does not appear economically justified.
8. Extend Colusa Drain to Suisun Marsh	Would reduce spring flooding in Yolo Bypass, enhance Sacramento River water quality, serve as treated waste effluent outlet and agricultural return flow conveyance, provide irrigation water, and provide wildlife enhancement to Suisun Marsh.	Consider further if Solano Water Reclamation Project planning is terminated.
9. Extend Colusa Drain to proposed Solano Water Reclamation Project conveyance facility	Would provide benefits similar to those in the preceding alternative. Short time frame in which to complete interface planning/design and obtain funding if changes in the Reclamation Project are required.	Appears economically justified but further analysis is necessary.
10. Flood retention reservoirs on National Wildlife Refuges	Low dikes would be formed around fallow land to make a combination flood retention reservoir and marshland. Flood waters would be diverted from nearby drainage channels.	Merits further evaluation to determine engineering and economic feasibility.
TEHAMA-COLUSA CANAL RETURN FLOW		
1. Pump back for reuse in Tehama-Colusa service area	Tailwater drains and pumps on individual farms would recirculate water. A final collector drain parallel to Glenn-Colusa Canal may also be required.	May be desirable for area south of Glenn-Colusa Canal.
2. Pump into Glenn-Colusa Canal for reuse	Not practical for area south of Glenn-Colusa Canal. Plan would require construction of collector drain parallel to Glenn-Colusa Canal and installation of pumps at various points along collector drain.	May be best overall alternative. Probably most cost-effective solution for portion of area.

ALTERNATIVES	COMMENTS	CONCLUSIONS
TEHAMA-COLUSA CANAL RETURN FLOW (Cont'd)		
3. Route to Colusa Basin Drain	Possible supplemental water supply for downstream irrigators. Possible increase in late spring flood problems in lower Colusa Drain.	If extend drain to Yolo and Solano Counties, may be desirable alternative. May be a necessary option south of Glenn-Colusa Canal.
4. Pump back to Tehama-Colusa Canal for reuse	Water could be reused in Tehama-Colusa service area or conveyed to Oat Reservoir for use south of the canal terminus.	Desirability will depend on comparative economics and water supply needs.

Sacramento River Drainage
and Seepage Utilization
USBR February 1977

Total Monthly Discharge in Acre-feet from
Colusa Basin Drain and Knights Landing Ridge Cut
(period of record and estimates - 1947 through 1966)
Return flow from irrigation

	April	May	June	July	Aug.	Sept.	Oct.
1947 to 1966 av.	24,100	47,800	35,400	27,200	47,800	68,100	25,600
High flow 1947-1966	44,200	81,700	65,500	50,800	62,800	95,100	40,500
Low flow 1947-1966	10,000	5,000	21,100	9,100	27,100	46,300	10,000

Total Flow - April through October (1947 to 1966 Ave.) = 276,000

Total High Flow " " " " " " " = 434,000

Total Low Flow " " " " " " " = 128,600

Flood Prevention and
Drainage - Work Team
Report, USBR, October 1974

Flow of Colusa Trough at Colusa-Williams Highway - 1954 Daily Mean

Date	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Daily Mean Flow in Second-Feet											
1	86	150	200	212	735	593	212	500	1620	661	275	181
2	74	148	194	183	516	601	189	527	1500	697	262	596
3	76	156	184	203	343	595	215	607	1380	753	307	1200
4	76	156	198	470	237	631	227	609	1260	697	334	1300
5	73	150	189	459	164	719	201	625	1230	607	345	1170
6	74	151	183	350	176	753	167	707	1170	569	345	1000
7	74	151	178	266	131	747	215	717	1110	593	374	859
8	63	148	178	242	102	843	206	741	1100	657	440	669
9	64	155	215	206	66	1060	269	769	1090	542	849	601
10	96	158	215	167	34	1250	284	733	1160	519	1200	1030
11	178	155	198	147	6.0	1390	298	695	1140	491	1200	1220
12	249	181	186	139	58	1310	320	715	1190	449	1080	993
13	198	712	176	135	33	1150	330	759	1240	428	955	647
14	131	804	172	134	9.0	996	356	817	1380	377	823	540
15	88	679	169	230	8.0	853	320	896	1530	338	1140	468
16	76	498	172	205	7.0	687	348	961	1630	348	1640	397
17	472	696	176	200	48	639	361	1010	1740	359	1630	372
18	905	1400	179	167	222	546	388	977	1800	383	1540	345
19	643	1390	188	184	166	472	410	947	1760	350	1310	336
20	375	1110	285	210	271	388	397	965	1740	334	1020	325
21	230	760	307	213	422	339	392	1010	1710	309	781	307
22	[illegible]	535	455	276	478	276	350	1060	1670	293	585	309
23	249	422	487	330	293	240	293	1040	1590	285	472	294
24	261	345	361	268	225	208	305	983	1350	291	404	291
25	210	302	266	341	230	167	341	935	1160	273	356	276
26	174	268	307	374	311	167	379	977	1020	240	314	261
27	147	237	298	483	446	167	444	1060	957	251	273	244
28	137	217	237	639	508	156	485	1320	845	232	254	227
29	137	—	213	645	533	169	535	1660	745	210	210	205
30	153	—	271	677	556	166	525	1700	673	245	181	194
31	153	—	266	—	529	—	476	1720	—	252	—	208.
Mean	197	437	236	292	254	609	330	927	1316	420	697	550
Ac-Ft	12120	24270	14480	17360	15600	36250	20310	57010	78330	25650	41450	33850
Maximum Discharge	Calendar year 1810 c.f.s. September 15, 1954								Total Runoff In Acre-Feet	Calendar Year / Water Year	376880 / 327248	

Division of Water Resources station located 37.0 miles above the mouth of Back Borrow Pit of Reclamation District 108. This station is also known as Colusa Trough at Highway 20 and Colusa Trough at Tahoe-Ukiah Highway. The flow is return water flowing in the main drain of Reclamation District 2047; it is drainage chiefly from lands irrigated by Glenn-Colusa, Provident, Princeton-Codora-Glenn, Compton-Delevan, Maxwell, and Jacinto Irrigation District. Flow reaches Sacramento River, at Mile 34.15R, through the Knights Landing Outfall Gates via Back Borrow Pit, (see Table 60). Period of record 1924 to date.

Source of data: **State of California report on Sacramento-San Joaquin Water Supervision.**

Water Supply and Water Rights
Work Team Report, USBR
December, 1973

Flow of Back Borrow Pit (Colusa Basin Drain) Near College City - 1954 Daily Mean

Date	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Daily Mean Flow in Second-Feet											
1				300	682	688	189	526	1760	888	300	186
2				277	589	739	202	556	1700	916	297	414
3			•225	292	355	698	194	604	1600	990	313	1120
4				547	292	717	199	625	1500	963	352	1480
5			204	553	252	814	186	662	1430	837	368	1280
6				403	186	916	156	723	1360	752	362	1120
7				331	134	905	152	807	1330	733	384	865
8				303	86	929	172	841	1300	810	448	669
9				234	70	1150	216	902	1290	714	767	559
10			•270	212	•57	1410	269	902	1360	650	1180	926
11				226	•44	1570	295	861	1360	634	1260	1230
12				226	•31	1590	326	824	1390	583	1180	1060
13				234	•17	1420	342	875	1450	559	1040	672
14				179	•4.0	1240	365	933	1550	514	905	577
15				352	•30	1030	355	1020	1700	459	1030	628
16				352	•55	895	326	1100	1770	440	1510	499
17				266	•80	787	339	1180	1850	434	1700	398
18				216	•105	742	373	1170	1910	440	1600	339
19				216	130	592	395	1130	1930	440	1620	310
20			•335	229	154	544	400	1130	1940	392	1410	295
21				236	284	479	389	1150	1920	395	964	292
22				274	583	423	392	1220	1900	365	628	290
23				373	366	406	323	1230	1860	378	465	290
24				303	209	344	310	1200	1760	375	392	287
25			336	360	204	321	342	1140	1580	412	355	282
26			355	389	229	214	373	1130	1420	362	332	279
27			381	529	352	242	445	1230	1310	336	290	272
28			334	662	505	170	529	1420	1150	300	259	264
29			321	637	553	163	574	1690	1010	259	254	239
30		—	352	502	610	165	604	1790	933	272	196	209
31		—	373	—	625	—	547	1810	—	287	—	232
Mean			299	340	255	743	332	1045	1545	545	739	567
Ac-Ft			18390	20260	15680	44240	20390	64230	91960	33500	43960	34880
									Total Runoff in Acre-Feet	Calendar Year Water Year		

Division of Water Resources station located on Back Borrow Pit of Reclamation District 108 at Mile 22.7. This is return water derived chiefly from lands irrigated by Glenn-Colusa, Provident, Princeton-Codora-Glenn, Compton-Delevan, Maxwell, and Jacinto Irrigation Districts. Period of record 1946 to 1952 and 1954 to date. Recorder installed March 5, 1954.

• Estimated.

Source of data: State of California report on Sacramento-San Joaquin Water Supervision.

Water Supply and Water Rights
Work Team Report, USBR
December, 1973

Flow of Colusa Basin Drainage to Sacramento River at Knights Landing - 1954 Daily Mean

Date	Daily Mean Flow in Second-Feet											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	137				0	464	0	263	1750	866	347	237
2	134				0	513	0	250	1780	866	361	243
3	115				0	505	0	*240	1630	878	358	0
4	129				388	493	0	*250	1550	1180	382	0
5	134				528	505	0	*268	1510	1100	416	0
6	135				494	556	0	*324	1470	952	445	0
7	143				220	707	0	*403	1330	906	449	0
8	161				0	782	0	491	1180	892	478	0
9	155				0	808	0	537	1190	900	646	0
10	153				0	1120	0	593	1220	830	982	0
11	181				128	1350	0	589	1240	788	980	0
12	279	N	N	N	0	1430	*62	555	1240	752	1060	0
13	335	O	O	O	0	1450	103	553	1260	720	980	0
14	322				0	1240	105	564	1320	683	764	546
15	254				0	801	122	597	1500	634	824	644
16	192				0	591	120	681	1730	571	318	634
17	290	F	F	F	0	568	111	803	1780	549	0	634
18	0	L	L	L	0	574	109	847	1790	530	0	644
19	0	O	O	O	0	441	118	823	1830	538	862	534
20	0	W	W	W	0	373	131	813	1840	527	1220	455
21	0				0	174	138	805	1850	497	1230	428
22	0				0	77	136	821	1850	479	498	386
23	0				0	85	130	883	1840	486	454	362
24	0				50	80	113	895	1800	456	331	364
25	0				72	76	97	867	1680	456	325	265
26	0				66	60	99	849	1480	482	300	259
27	0				73	48	114	865	1250	445	300	248
28	0				181	32	149	951	1130	416	302	245
29	0				316	7.7	228	1270	1120	375	300	230
30	0	—			350	0	330	1520	944	341	251	204
31	0	—		—	362	—	325	1600	—	338	—	202
Mean	105	0	0	0	104	532	91.6	702	1504	659	539	250
Ac-Ft	6444	0	0	0	6403	31660	5633	43180	89520	40530	32060	15400

Total Runoff in Acre-Feet		
	Calendar Year	270830
	Water Year	252096

This is the drainage from Colusa Basin passing down the Back Borrow Pit of Reclamation Districts 108 and 787 and entering the Sacramento River at Mile 34.15R, just above the Knights Landing gaging station. Flows are controlled at the Knights Landing outfall gates and a portion of the flow of the Back Borrow Pit is diverted to the Knights Landing Ridge Cut, (see Table 59). Total flow to Sacramento River is sum of Tables 50 and 51. Period of record is 1924 to date. Records for 1954 computed by Division of Water Resources.

*Estimated

Source of data: State of California report on Sacramento-San Joaquin Water Supervision.

Water Supply and Water Rights
Work Team Report, USBR
December, 1973

Plate No. 17

Flow of Ridge Cut at Knights Landing - 1954 Daily Mean

Date	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Daily Mean Flow in Second-Feet											
1	0	286	167	258	443	72	41	54	117	49	0	0
2	0	299	135	211	459	69	44	55	64	49	0	0
3	0	299	116	190	398	68	•47	•53	58	53	0	8.2
4	0	302	96	195	267	66	•50	•55	58	45	0	331
5	0	277	93	299	138	68	•54	•58	53	18	0	857
6	0	214	87	331	63	95	•57	•62	47	6.3	0	923
7	0	172	74	256	50	90	•60	•66	45	1.5	0	862
8	0	135	68	299	43	64	•64	77	47	1.8	0	770
9	0	112	66	318	32	68	•67	75	54	2.1	0	674
10	0	91	82	270	24	96	•70	70	56	0	0	720
11	0	74	101	208	19	92	•87	65	59	0	17	887
12	0	66	526	153	5.4	79	•96	60	60	0	24	933
13	0	235	520	104	0	68	101	60	65	0	19	826
14	0	549	322	72	0	58	106	61	70	0	19	504
15	0	593	219	70	0	56	114	66	92	0	9.4	221
16	0	674	162	100	0	57	98	79	69	0	62	119
17	0	826	122	95	0	52	85	87	64	0	862	62
18	63	1140	88	72	0	53	80	80	66	0	1130	44
19	434	1650	72	68	0	49	95	69	70	0	852	27
20	424	1690	83	67	0	50	100	68	79	0	325	12
21	350	1540	119	67	0	51	98	67	83	0	64	0
22	286	1170	150	65	11	62	95	69	87	0	23	0
23	356	826	203	70	45	65	83	70	75	0	0	0
24	312	501	242	79	58	63	67	67	67	0	1.0	0
25	302	386	221	82	55	62	65	64	58	0	0	0
26	261	341	187	98	52	55	68	62	52	0	0	0
27	229	261	184	143	59	49	68	64	55	0	0	0
28	209	193	187	264	70	46	129	70	52	0	0	0
29	206	—	177	411	68	39	135	111	47	0	0	0
30	219	—	213	443	67	38	132	92	41	0	0	0
31	254	—	274	—	69	—	96	70	—	0	—	0
Mean	123	532	173	180	80.4	63.3	83.0	68.6	63.7	7.3	115	284
Ac-Ft	7551	29560	10620	10690	4950	3769	5101	4217	3788	448	6516	17450

Total Runoff In Acre-Feet	
Calendar Year	104960
Water Year	80387

Knights Landing Ridge Cut diverts water from the Back Borrow Pit of Reclamation District 108, at a point above the outfall gates, into the Yolo By-Pass above Elkhorn. Winter flows are uncontrolled. Summer flows for irrigation are controlled at the outfall gates and at the junction with Yolo By-Pass by weir boards and gates. Period of record 1933 to date. Records for 1954 computed by Division of Water Resources.

• Estimated

Source of data: State of California report on Sacramento-San Joaquin Water Supervision.

Water Supply and Water Rights
Work Team Report, USBR
December, 1973

Plate No. 18

Areawide storm-runoff data for the January through March period for 1978, 1979, and 1980 in the Colusa Basin Drainage Area.

	1978	1979	1980
Precipitation[1]			
Monthly precipitation, (inches)			
January	8.80	4.61	3.20
February	6.95	3.85	7.14
March	3.38	1.47	1.80
Total precipitation, (inches)	19.13	9.93	12.13
Colusa Basin Drain Outflow[2]			
Monthly storm water discharge, (ac-ft)[3]			
January	>334,930	98,310	216,290
February	311,020	156,100	>363,560
March	179,750	75,180	222,220
Total storm water discharge, (ac-ft)	>825,700	329,590	>802,070
, (ac-in/ac)[4]	>9.35	3.73	9.09
, (% of precip.)	>49	38	>75
Monthly average sediment concentration, (ppm)			
January	574	134	137
February	302	291	303
March	247	100	139
Monthly sediment discharge, (tons)			
January	>261,490	17,890	40,400
February	127,590	61,700	>150,050
March	60,430	10,190	41,940
Total sediment discharge, (tons)	>449,510	89,780	>232,390
, (lbs/ac)	>850	170	>439

1/ Pecipitation gauging stations at Dunnigan, Williams, Sacramento National Wildlife Refuge, and Willows. Precipitation in the watershed area is typically 1.5 times the valley floor.

2/ Drain discharge as measured at CBD-1 (Roads 99E and 108) above Knights Landing; based on weekly or smaller time intervals of measurements.

3/ Symbol > denotes bank overflow; values given are those measured within the drain channel.

4/ Based on 1,059,200 acres of watershed and valley floor.

University of California, Davis, 1980

(Table 1)

Plate No. 19

Summary of weekly flows and sediment loadings for the January through March, 1980 quarter in the lower reaches of the Colusa Basin Drain (see Fig. 2 for sampling locations).

1980	CBD-3 (Tule Road)			CBD-2 (County Line Road)			CBD-1 (Roads 99E and 108)		
sampling period	Flow	Ave. SS	SS	Flow	Ave. SS	SS	Flow	Ave. SS	SS
(mo/day)	(ac-ft)	(ppm)	(tons)	(ac-ft)	(ppm)	(tons)	(ac-ft)	(ppm)	(tons)
1/1 - 1/7	28,940	70	2,760	35,640	52	2,520	25,650	61	2,130
1/8 - 1/13	48,800	901	59,810	48,630	456	30,170	31,550	136	5,850
1/14 - 1/21	123,880	220	37,070	78,190	141	15,040	99,460	203	27,410
1/22 - 1/30	30,680	44	1,840	32,500	48	2,120	38,080	61	3,160
1/31 - 2/4	12,820	44	770	20,320	56	1,550	21,550	63	1,850
2/5 - 2/11	9,110	34	420	11,870	55	890	16,750	37	840
2/12 - 2/19	66,140	519	46,670	88,480	499	60,070	68,780	330	30,900
2/20 - 3/3	172,020	970	227,160	191,960	981	256,100	278,030	313	118,310
3/4 - 3/10	58,900	205	16,420	63,880	174	15,120	56,630	111	8,550
3/11 - 3/17	35,520	182	8,790	36,750	120	6,000	123,150	148	24,800
3/18 - 3/25	17,160	118	2,750	17,640	195	4,680	31,670	156	6,740
3/26 - 4/1	7,880	90	960	8,060	150	1,640	10,770	126	1,850
Total or Ave.	611,850	487	405,420	633,920	459	395,900	802,070	213	232,390

University of California, Davis
1980

(Table 2)

Plate No. 20

IRRIGATION SYSTEMS

Assumptions: Planned irrigation systems in which all facilities are installed for the efficient application of water to crops or pasture. Includes pipelines, ditches, valves, emitters, structures, land preparation, etc., all meeting standards for quality of materials, workmanship and design. Includes surface, sprinkler and drip systems. Assumes that facilities are needed and used to achieve Irrigation Water Management. System selected is that appropriate to the terrain and crop.

ECONOMIC EFFECTS

BENEFICIAL

1. Permits most efficient use of water supply
2. Systems are labor efficient, particularly sprinkler and drip, which can be made automatic
3. May increase area available for production (pipelines) and minimize obstacles to movement

ADVERSE

1. Requires initial investment for facilities
2. Sprinkler and drip systems have continuing costs for power

ENVIRONMENTAL EFFECTS

BENEFICIAL

1. Distributes water with minimum seepage, reduces local wetness problems
2. Can facilitate reduction of erosion and sediment, or other agricultural pollutants

ADVERSE

1. May result in loss of variety and "picturesque" aspects of the landscape (leveling, pipe-lining canals, etc.)

SOCIAL WELL-BEING EFFECTS

BENEFICIAL

1. Greater efficiency allows higher living standards for irrigators (pay, hours, security) who adopt system use

ADVERSE

1. Automated systems lessen employment opportunities for untrained workers

Recommended Plan of Best Management Practices, Central Valley Region
USDA Soil Conservation Service
June 1979

IRRIGATION SYSTEM--TAILWATER RECOVERY

Assumptions: Includes the facilities to collect, store and transport irrigation tailwater for re-use in the farm irrigation system. Used with surface irrigation methods. Includes pickup ditches, sumps, pumps and pipeline constructed to standards.

ECONOMIC EFFECTS

BENEFICIAL

1. Saves water for on-farm irrigation use
2. Pumping costs for recovered water are less than for well or surface delivered water
3. Saves lower end of fields from scald and wet spots
4. Reduces spread of weed seeds, insect pests, diseases, herbicides, etc.

ADVERSE

1. Considerable expense for facilities construction
2. Storage facilities may take some land out of production
3. System may concentrate weed seeds, insect pests, diseases, herbicides and salts in an area
4. Can lead to inefficiencies when used to prevent visible flooding from over-irrigation
5. Some annual costs for maintenance and cleaning of sumps

ENVIRONMENTAL EFFECTS

BENEFICIAL

1. Reduces flooding of rural roads from escaping tailwater
2. Reduces mosquito sources at foot of fields
3. Sump will intercept sand and recirculate silt from row crop to close growing crops (hay, pasture, etc.) for "filtering" of sediment
4. Some sump designs provide for aquatic and wildlife habitat

ADVERSE

1. Reduces water supply to users dependent on tailwater
2. Could have basin-wide effect; i.e., water quality in delta could deteriorate due to sea water encroachment with lessened flow from tailwater into San Joaquin
3. Some designs are eyesores

SOCIAL WELL-BEING EFFECTS

BENEFICIAL

1. Elimination of bleeding sources lessen vectoring of mosquito-born diseases (malaria, encephalitis)

ADVERSE

1. Some sump designs are unsafe for children
2. Some sump designs are a hazard to farm machinery operations

IRRIGATION WATER MANAGEMENT

Assumptions: Water is applied in the proper amount, rate and intervals to maximize crop yield without waste of water, erosion or causing wet soil conditions. Assumes irrigator has facilities necessary to achieve objectives. Primary goal is maximum return (profit) per unit of water applied.

ECONOMIC EFFECTS

BENEFICIAL

1. Maximum crop yields
2. Minimum cost for water, pumping, etc.
3. Minimizes loss of crop nutrients
4. Protects soil structure and internal aeration
5. Water resources available for other users
6. Minimizes need for water and electric power supply facilities

ADVERSE

1. Additional time and care needed in the field
2. Requires skilled labor
3. May require higher investment in irrigation equipment

ENVIRONMENTAL EFFECTS

BENEFICIAL

1. Controls erosion and sediment from irrigation
2. Minimizes nutrients and salts in return flows
3. Reduces perched water tables and subsurface salinity problems in downslope areas
4. Reduces mosquito breeding places
5. Less opportunity for contamination of rural domestic water supplies

ADVERSE

1. Reduces recharge of underground aquifers
2. May reduce marsh habitat for wildlife

SOCIAL WELL-BEING EFFECTS

BENEFICIAL

1. Provides employment opportunity for skilled irrigators
2. Generally healthier environment where irrigation water is carefully applied

Recommended Plan of Best Management Practices, Central Valley Region
USDA Soil Conservation Service
June 1979

LAND LEVELING

Assumptions: Reshaping the land to planned grades for irrigation. Includes rough grading known as "land smoothing"--does not include touch-up "land planing."

BENEFICIAL	ADVERSE
ECONOMIC EFFECTS	
1. Increases efficiency of surface irrigation methods	1. Can be costly installation
2. Reduces labor requirement for irrigation	2. Requires periodic "touch-up" maintenance
3. Reduces inefficiencies related to short rows	
4. Reduces machinery problems with wet spots, loss of productive areas.	
ENVIRONMENTAL EFFECTS	
1. Reduces erosion from steep areas of field	1. Generally produces much dust in initial application
2. Reduces mosquito production from wet spots	
SOCIAL WELL-BEING EFFECTS	
1. Reduces time required for irrigation, more time for recreation	1. May reduce employment opportunities for irrigators

Recommended Plan of Best Management Practices, Central Valley Region
USDA Soil Conservation Service
June 1979

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

SPKED-P

17 January 1969

NOTICE OF INITIATION OF INVESTIGATION
FOR COLUSA BASIN DRAINAGE PROBLEM
COLUSA AND YOLO COUNTIES, CALIFORNIA

C O P Y

Under the provision of Section 205 of the 1948 Flood Control Act, as amended, the Chief of Engineers has authorized the district to prepare a Detailed Project Report on a possible major drainage project in the lower Colusa Basin, Yolo County, California. The report will be considered by the Chief of Engineers for possible authorization of a project.

Damaging floods in the lower Colusa Basin and Yolo Bypass are caused by inadequate drainage facilities to convey spring floodflows and return flows from irrigation.

Preliminary studies indicate that new channel construction from the mouth of Knights Landing Ridge Cut across Yolo Bypass to the existing Tule Canal and improvements to Tule Canal, including replacement of two existing check structures, would provide an economical and feasible solution to the drainage problems of the area. However, during detailed project studies, other alternatives will be investigated.

It is requested that you furnish an expression of your interest in this investigation; a statement of pertinent data you may have, or have knowledge of, which can be made available for use in this study; and any comments or suggestions you may wish to make. A reply within 30 days would be appreciated.

George B. Fink
GEORGE B. FINK
Colonel, CE
District Engineer

1 Incl
Sketch Map

Plate No. 25

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

SPKED-P

23 December 1970

The Reclamation Board
Resources Building, Room 1335
1416 Ninth Street
Sacramento, California 95814

C O P Y

Gentlemen:

I regret to inform you that detail studies indicate it is not economically feasible to provide a major drainage project for the southern Colusa Basin and the Yolo Bypass in Colusa and Yolo Counties, California, at the present time. Our study under the small flood control project program authorized by Section 205 of the 1948 Flood Control Act, as amended, has been terminated. The investigation is briefly described in the following paragraphs.

The Colusa Basin has a drainage area of approximately 1,700 square miles, a length of about 70 miles, and a maximum width of about 25 miles. The basin extends from the Sacramento River on the east to the crest of the foothills on the west, with Stony Creek and Cache Creek the approximate northerly and southerly boundaries, respectively (see attached map). The lands of the basin are used primarily for agriculture; about 100,000 acres are devoted to rice production.

The lands on the west bank of the southernmost reach of the Colusa Basin Drain are often flooded between April and June. The flooding is caused by irrigation return flows from rice fields along the Colusa Basin Drain and also from runoff caused by early spring rains. The flows from the drain usually discharge through the Knights Landing Outfall Gates into the Sacramento River during this period; however, high stages in the Sacramento River prevent discharge through the outfall gates. When sufficient stage has been reached in the drain, the flow is discharged via the Knights Landing Ridge Cut into the Yolo Bypass causing inundation of agricultural lands of the Yolo Bypass downstream from the mouth of the ridge cut to Tule Canal and along Tule Canal and the Toe Drain.

23 December 1970

The Department of Water Resources, State of California, published a report on the Colusa Basin in May 1964. This report generally dealt with high flow winter flooding; however, construction of a new channel across the Yolo Bypass was recommended to control spring flooding in the southernmost reach of the Colusa Basin Drain. At the request of the State Reclamation Board and the Boards of Supervisors of Colusa, Glenn, and Yolo Counties, the Sacramento District initiated preliminary study of the Colusa Basin drainage problem. The reconnaissance report, completed in June 1968, and based largely on data contained in the report by the Department of Water Resources, concluded that new channel construction across the Yolo Bypass would provide an economically justified solution to the problem and recommended preparation of a Detailed Project Report.

The detailed studies revealed that the capacity of the Toe Drain was considerably less than previously believed. This also led to the conclusion that sedimentation of a new canal across the bypass would be substantially greater than had been included in the Reconnaissance Report. Considering this additional information, several plans providing various degrees of flood protection to the southern Colusa Basin and the Yolo Bypass have been investigated in detailed studies. Alternative plans included: (a) new channel from Knights Landing Ridge Cut to Tule Canal and enlarging Tule Canal to the Toe Drain with enlargement of the Toe Drain to Cache Slough, or a gravity diversion to the Sacramento Deep Water Ship Channel, or a pumping plant discharging to the ship channel; (b) pumping plant at Knights Landing Outfall Gates discharging to Sacramento River; (c) new channel from Knights Landing Ridge Cut along west side of Yolo Bypass to Cache Slough.

Although the Reconnaissance Report concluded that new channel construction from Knights Landing Ridge Cut and enlargement of Tule Canal to the Toe Drain was a viable plan and was economically justified, identification of the sedimentation problem in detailed project studies indicated that additional enlargement of Tule Canal and enlargement of the Toe Drain to Cache Slough would be required and that channel maintenance costs should be increased considerably. In addition, the Federal interest rate has risen from 3-1/4 percent at the time of the Reconnaissance Report to the current 5-1/8 percent. Under present conditions none of the various plans of improvement studied is economically justified.

23 December 1970

I would appreciate hearing any comments you may have on our findings and, if we can be of further assistance, do not hesitate to contact us.

Sincerely yours,

JAMES H. [illegible]
Lieutenant Colonel, CE
Acting District Engineer

C
1 Incl
Map

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DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814

REPLY TO ATTENTION OF
SPKED-W

5 May 1980

Mr. Richard L. Hurni, Chairman
Colusa County Board of Supervisors
County Courthouse
Colusa, CA 95932

Dear Mr. Hurni:

We have completed our reconnaissance studies of the flood problems in Colusa Basin under the Northern California Streams Investigation authority, as requested by the Colusa County Board of Supervisors on 27 June 1978.

Our studies indicate that it is not economically feasible to provide a major flood control project for the northern, non-project portion of the Colusa Basin, but it may be economically feasible to rebuild portions of the existing project levee system which have been subject to slippage failures in the past.

Several plans to provide increased flood protection in Colusa Basin were considered, including: (a) nonstructural measures, such as increasing the size of the existing designated floodway to control further encroachment within the flood plain; (b) a levee setback system along the Colusa Basin Drain from Willows to Knights Landing and enlargement of the Knights Landing Ridge Cut; (c) a diversion for Willow Creek to flow into the Sacramento River; a levee setback plan from Maxwell-Colusa Road to Knights Landing and enlargement of the Knights Landing Ridge Cut; and (d) rebuilding the existing project levees on the Colusa Basin Drain system which have required emergency work to repair partial embankment failures in the past. Under present conditions, alternatives a, b, and c are not economically justified. Alternative d may be economically justified depending upon the work needed to eliminate the slippage problems and associated maintenance in the lower reaches of the project levee system.

We plan to conduct a field exploration program this year to obtain soil and foundation information for the existing levees from levee mile 0.0 to 12.0. This information will then be used to determine the cause of levee slippage and to develop and evaluate measures needed to prevent future levee failures.

Sincerely,

GEORGE C. WEDDELL
Chief, Engineering Division

1978
Irrigation Season Weekly Flows

Colusa Basin Drain
(cubic feet per second)

[Preliminary Data: Subject to Revision]

Date	Knights Landing Outfall Gates- Sacramento R. (1)	Yolo County Roads 99E & 108 (CBD-1) (3)	County Line Road (CBD-2) (3)	White Road (CBD-2A) (3)	U.S.B.R. Sta. below Tule Rd. (2)	Tule Road (CBD-3) (3)	Davis Weir (CBD-4) (4)	Highway 20 (CBD-5) (1)
4- 4-78	0	1,908			625			486
4- 6-78	0	1,275			428			261
4-11-78	0	1,275	635		403	417		292
4-18-78	0	1,275	635		401	408	200	262
4-25-78	552	1,275	556		423	420	200	410
5- 2-78	0	608	656	639	348	335	240	279
5- 8-78	0	1,277	523	115	17	14	0	64
5-16-78	578	455	584	775	771	750	676	882
5-23-78	869	1,226	708	984	1,210	1,190	840	1,240
5-30-78	1,060	610	644	740	1,030	1,000	750	875
6- 6-78	134	610	312	492	333	329	291	314
6-13-78	96	584	351	339	319	319	200	400
6-20-78	263	466	484	735	602	602	490	574
6-27-78	116	608	565	763	561	561	454	546
7- 5-78	588	608	565	763	968	968	500	500
7-11-78	238	608	565	763	630	633	688	603
7-18-78	289	774	644	735	725	725	680	594
7-25-78	236	643	516	677		987	647	622
7-31-78	528	774	672	998		1,119	670	844
8- 8-78	602	706	626	882	1,060	1,016	687	864
8-15-78	709	863	960	1,168	1,200	1,305	730	974
8-22-78	923	941	960	1,198	1,320	1,399	605	1,100
8-29-78	1,780	2,039	1,933	2,197	1,860	2,261	1,100	1,480
9- 7-78	1,970	2,039	2,315	2,312	2,040	2,509	1,150	1,630
9-12-78	2,170	3,129	2,911	3,011	2,220	3,118	1,230	1,710
9-19-78	483	692	530	521	973	748	535	649
9-26-78	407	571	465	481	503	497	375	347

Maximum fall irrigation flows:
Highway 20; 1,770 c.f.s. 9/11/78
Davis Weir; 1,230 c.f.s. 9/12/78
U.S.B.R. Sta. Below Tule Rd; 2,220 c.f.s. 9/12/78
Outfall Gates to Sacramento R.; 2,170 c.f.s. 9/12/78

(1) Department of Water Resources - mean daily flow
(2) U.S. Water and Power Resources Service - mean daily flow
(3) Univ. of California, Davis, E.P.A. Grant No. R 805462 Report - instantaneous flow
(4) Glenn Colusa Irrigation District - daily flow

1979
Irrigation Season Weekly Flows

Colusa Basin Drain
(cubic feet per second)

[Preliminary Data: Subject to Revision]

Date	Knights Landing Outfall Gates- Sacramento R. (1)	Yolo County Roads 99E & 108 (CBD-1) (3)	County Line Road (CBD-2) (3)	White Road (CBD-2A) (3)	U.S.B.R. Sta. below Tule Rd. (2)	Tule Road (CBD-3) (3)	Davis Weir (CBD-4) (4)	Highway 20 (CBD-5) (1)
4- 5-79	263	547	440		250	230		162
4-12-79	433	547	490		431	381	150	373
4-19-79	132	403	319		232	206	224	153
4-26-79	378	547	302		591	206	400	517
5- 4-79	-0-	588	502		249	230	112	128
5-10-79	361	588	502		896	414	650	880
5-14-79	648	419	490	510	1,360	748	950	1,190
5-21-79	1,030	588	734	1,170	1,200	1,305	1,000	1,080
5-28-79	413	776	565	550	800	497	476	463
6- 4-79	-0-	403	440	360	110	206	80	109
6-11-79	-0-	300	264	250	220	206	102	207
6-18-79	192	776	734	650	673	497	330	701
6-25-79	433	776	734	692	705	678	931	647
7- 2-79	352	750	734	690	763	678	550	761
7- 7-79	481	750	734	678	870	678	550	847
7-16-79	226	750	710	680	664	678	490	598
7-22-79	417	1,183	1,162	1,005	857	1,119	500	836
7-30-79	825	1,352	1,349	1,290	1,180	1,301	670	1,050
8- 6-79	961	1,352	1,162	1,290	1,190	1,301	1,300	1,080
8-13-79	961	1,352	1,162	1,290	1,210	1,301	910	1,080
8-20-79	1,320	1,183	1,532	1,560	1,470	1,682	720	1,280
8-27-79	1,520	1,183	1,532	1,590	1,560	1,682	500	1,340
8-28-79	1.740	1,183	1,532		1,600	1,682	450	1,390
9- 5-79	2,060	1,137	2,411	2,480	1,860	2,509	1,300	1,540
9-10-79	1,900	4,994	4,114	4,550	1,600	4,675	1,100	1,270
9-17-79	1,390	776	1,330	1,380	1,240	1,399	800	982
9-24-79	850	313	490	568	688	678	530	552

Maximum fall irrigation flows:
Highway 20; 1,690 c.f.s. 9/2/79
Davis Weir; 1,500 c.f.s. 9/2/79
U.S.B.R. Sta. Below Tule Rd; 2,040 c.f.s. 9/2/79
Outfall Gates to Sacramento R.; 2,080 c.f.s. 9/4/79

(1) Department of Water Resources - mean daily flow
(2) U.S. Water and Power Resources Service - mean daily flow
(3) Univ. of California, Davis, E.P.A. Grant No. R 805462 Report - instantaneous flow
(4) Glenn Colusa Irrigation District - daily flow

1980
Irrigation Season Weekly Flows

Colusa Basin Drain
(cubic feet per second)

[Preliminary Data: Subject to Revision]

Date	Knights Landing Outfall Gates - Sacramento R. (1)	Yolo County Roads 99E & 108 (CBD-1) (3)	County Line Road (CBD-2) (3)	White Road (CBD-2A) (3)	U.S.B.R. Sta. below Tule Rd. (2)	Tule Road (CBD-3) (3)	Davis Weir (CBD-4) (4)	Highway 20 (CBD-5) (1)
4- 1-80	Not Available	776	580	Not Available	Not Available	567		Not Available
4- 8-80		776	734			678	700	
4-15-80		419	530			493	300	
4-22-80		356	580			493	300	
4-28-80		456	319			20	20	
5- 5-80		1,226	734			2,509	220	
5-12-80		1,256	2,411			2,106	1,200	
5-19-80		1,226	1,943			2,485	900	
5-27-80		1,270	2,721			1,905	1,150	
6- 2-80	776	1,226	960			1,905	800	
6- 9-80	1,010	1,185	950			789	700	
6-16-80	457	950	710			789	400	
6-23-80	25	950	544			748	200	
6-30-80	30	950	615			578	175	
7- 7-80	484	850	750			720	250	
7-14-80	594	850	750			720	375	
7-21-80	592	850	970			920	375	
7-28-80	632	850	950			1,050	650	
8- 4-80	831	900	1,060		1,320	1,500	750	
8-11-80	1,290	700	1,500		1,630	1,250	1,100	
8-18-80	1,330	700	1,500		1,620	1,550	1,300	
8-25-80	1,400	950	1,550		1,680	1,600	1,400	
9- 2-80	2,040	2,000	1,750		2,370	1,850	1,800	
9- 8-80	2,020	2,000	1,700		2,230	1,800	1,600	
9-15-80	1,900	1,750	1,550		1,890	1,600	1,000	
9-22-80	1,030	750	650		949	700	600	
9-29-80	542	740	630		448	500	200	

Maximum fall irrigation flows:
Highway 20; 1,790 c.f.s. 8/30/80
Davis Weir; 1,850 c.f.s. 9/1/80
U.S.B.R. Sta. Below Tule Rd; 2,390 c.f.s. 9/1/80
Outfall Gates to Sacramento R.; 2,060 c.f.s. 9/3/80

(1) Department of Water Resources - mean daily flow
(2) U.S. Water and Power Resources Service - mean daily flow
(3) Univ. of California, Davis, E.P.A. Grant No. R 805462 Report - instantaneous flow
(4) Glenn Colusa Irrigation District - daily flow

APPENDIX B

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(2) Sources of Sediment
(3) Alternative Management Practices
(4) Comparison of Alternative Management Practices
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APPENDIX C

State of California
Reclamation Board Rules and Regulations

October 1973

(Designated Floodway)

802

ADOPTED BY THE RECLAMATION BOARD
ON
JULY 27, 1973

STATE OF CALIFORNIA
The Resources Agency

THE RECLAMATION BOARD
Room 335, 1416 Ninth Street
Sacramento, California

RULES AND REGULATIONS

for

DESIGNATED FLOODWAYS AND FLOODWAY ENCROACHMENT LINES

OCTOBER 1973

REGULATIONS
FOR ADMINISTRATION OF
DESIGNATED FLOODWAYS
AND
FLOODWAY ENCROACHMENT LINES

The regulations printed herein are those set forth in Title 23, California Administrative Code, Sections 45 through 95.

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Article 6 - General Provisions On Designated Floodways and Floodway Encroachment Lines

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Article 8 - Notifications of Hearings for Adoption of Designated Floodways and Floodway Encroachment Lines

Article 9 - Extent of Improvements Within Designated Floodways

Article 10 - Existing Encroachments Within Designated Floodway

Article 11 - Extent of Improvements Outside of Designated Floodways

Article 6 - General Provisions on Designated Floodways and Floodway Encroachment Lines

SECTION

45 Purpose of Rules and Regulations. These rules and regulations are adopted as a means of establishing designated floodways and floodway encroachment lines for flood control projects adopted or authorized by the United States or plans of flood control adopted or authorized by the State.

SECTION

46 Definitions. As used in these regulations, the terms listed below shall have the meanings noted:

(a) Design Flood. "Design Flood" shall mean the flood against which protection is provided or may eventually be provided by means of flood protective or control works; or, as determined by the Board, to be compatible with future developments.

(b) Designated Floodway. "Designated Floodway" shall mean the channel of the stream and that portion of the adjoining flood plain required to reasonably provide for the passage of the Design Flood, or the floodway between existing project levees.

(c) Floodway Encroachment Lines. "Floodway Encroachment Lines" shall mean the exterior limits of the designated floodway.

(d) Obstruction. "Obstruction" means any encroachment such as a dam, wall, wharf, embankment, levee, dike, pile, pump, abutment, projections, excavation, bridge, conduit, culvert, building, fence, rock, gravel, refuse, fill, house, barn, storage building, or other analogous structure or matter which may unduly impede, retard, or change the direction of the flow of water, either in itself or by catching or collecting debris carried by such water, or that is placed where the flow of the water would carry the same downstream to the damage or detriment of either life or property.

(e) Parties. "Parties" means any individual, firm, partnership, association, corporation, any agency of the State, municipal corporation, political subdivision of the State, or any other legal entity.

(f) Permitted Uses. "Permitted Uses" shall mean structures, improvements and land uses in the designated floodway that in the judgment of the Board will not unduly impede the free flow of water in a stream.

(g) Stream. "Stream" shall mean natural or regulated water flowing in any channel natural or artificial. Streams can be perennial, flowing continuously; intermittent or seasonal, flowing only at certain times of the year; and ephemeral, flowing only in direct response to precipitation.

(h) Encroachment. "Encroachment" shall mean the use for any purpose of either flood control project works, the waterway area of such project works or the area covered by an adopted plan.

(i) Conforming Existing Encroachments. "Conforming Existing Encroachments" shall mean an existing facility or use that is consistent with all the provisions of Sections 75 and 76 of these Rules and Regulations.

(j) Non-conforming Existing Encroachment. "Non-conforming Existing Encroachment" shall mean an existing facility or use that is not consistent with all of the provisions of Section 76 of these Rules and Regulations.

(k) Board. "Board" shall mean The Reclamation Board of the Resources Agency of the State of California.

(l) Recreational Vehicle. "Recreational Vehicle shall mean a travel trailer, camp car, motor home, tent trailer, with or without power which is designed or used for human habitation and which may be moved upon a public highway without a special permit, chauffer's license or both, without violating any provision of the Vehicle Code.

SECTION

47 Plans and Applications for Approval on Existing and Proposed Structures and Improvements.

The Board will follow the application approval procedure as provided in 23 Cal. Adm. Code 16 through 23 and 8700, et seq., of The California Water Code. The necessary forms can be obtained from The Reclamation Board in Sacramento, California.

Normally, all applications for encroachments will be referred to appropriate Federal, State and local agencies for review and comments before action by the Board.

Article 7

Studies to Support Regulations on Designated Floodways and Floodway Encroachment Lines

SECTION

55 Responsibility of the Board

The Board, after appropriate studies have been made, will delineate on an aerial mosaic or map the designated floodway and the floodway encroachment lines. The Board will further determine allowable uses in the designated floodway and will establish criteria therefor.

SECTION

56 Priorities

The Board will establish and follow a priority list of areas to be studied and establish the order in which studies shall be made. In establishing and revising the priority list, the Board will consider:

(a) Existing and projected Federal, State and local flood control improvements and regulations affecting the flood plain.

(b) The degree of danger from flooding to life, property, public health and welfare.

(c) Rate and type of development taking place upon the flood plain.

Article 8

Notifications of Hearings for Adoption of Designated Floodways and Floodway Encroachment Lines

SECTION

65 Responsibility of the Board

The Board will notify local interested parties, thirty days prior to any hearing or hearings on designated floodways and floodway encroachment lines. Hearings will be held in areas convenient to the majority of interested parties. The Board will hold one hearing prior to initiation of the study, and at least one hearing after the study has been completed and prior to adoption.

SECTION

66 Comments of Interested Parties

Prior to the adoption of a designated floodway, interested parties will be given the opportunity to be heard at one or more public hearings to obtain views and recommendations for desirable modifications to the proposed designated floodway and the floodway encroachment lines. The Board will make the final determination as to the exact encroachment lines to be adopted.

SECTION

67 Recording

After a designated floodway and the floodway encroachment lines are adopted by the Board, an aerial mosaic or map showing the designated floodway and the floodway encroachment lines will be transmitted to the appropriate county or counties for recording.

SECTION

68 Availability of Maps

The Board will also furnish a copy of the map or maps showing the limits of the designated floodway to the county engineer, the county planning department, and other interested parties.

SECTION

69 Future Changes

If at some future date, after the adoption of the designated floodway and floodway encroachment lines, the Board feels that conditions have changed sufficiently to necessitate altering the said lines, the Board may make such modifications as it deems to be appropriate.

Article 9

Extent of Improvements Within Designated Floodways

SECTION

75 Structures and Improvements

The following uses may be permitted in the designated floodway if a combination of such uses in a specific reach of the stream will not materially increase the flood height or the velocity of the design flood when confined within the Encroachment Lines.

SECTION

76 Permitted Uses in Designated Floodways

(a) Open space uses not requiring a closed building, such as agricultural cropland, orchards, livestock feeding and grazing or open type public and private recreation areas.

(b) Fences, fills, walls, or other appurtenances which do not constitute an obstruction or debris catching obstacle to the passage of floodwaters.

(c) Storage yards for equipment and material; if said equipment and material can be either securely anchored or removed upon notice.

(d) Railroads, streets, bridges, and public utility wires and pipelines for transmission and local distribution.

(e) Commercial excavation of materials from pits, strips, or pools providing that no stockpiling of materials, products or overburden shall create an obstruction to the passage of floodflows.

(f) Improvements in stream channel alignment, cross-section, and capacity.

(g) Structures that are designed to have a minimum effect upon the flow of water and are firmly anchored to prevent the structure from flotation, provided that normally no structures for human habitation shall be permitted.

(h) Recreation vehicles and related service facilities that are either floodproofed or are removed during the flood season of the particular stream involved.

(i) Other uses of a type not appreciably damaged by floodwaters.

Article 10

Existing Encroachments Within Designated Floodway

SECTION

85 Existing Encroachments Under Board Order

The existing facility or use shall be allowed to continue as at present. The facility or use shall not be changed, extended or expanded without a new application to and approval by the Board.

SECTION

86 Existing Encroachments Not Under Board Order

(a) Conforming Existing Encroachments:

An approved Board Order will be automatically issued for all conforming existing facilities and uses. The facility or use shall not be changed extended or expanded without a new application to and approval by the Board. If the facility is abandoned, it shall be removed at the expense of the owner.

(b) Non-conforming Existing Encroachments That Do Not Have a Major Detrimental Impact.

The existing facility or use shall be allowed to continue under an automatically issued Board Order until abandoned or until it is destroyed or damaged, by any cause, to the extent of more than fifty percent of its market value or its physical usefulness. The facility or use shall not be changed, extended or expanded without a new application to and approval by the Board. If the facility or use is destroyed or damaged to the extent of more than fifty percent it shall not be reconstructed without a new application to and approval of the Board. If the facility is abandoned, it shall be removed at the expense of the owner.

(c) Non-conforming Existing Encroachments That Have a Major Detrimental Impact.

If the facility or use has been in existence prior to the adoption or authorization of a project by the United States or prior to the adoption or authorization of a plan of flood control by the State, it shall be removed, abandoned or suitably modified at no cost to the owner. Facilities or uses not falling in such category shall be removed, abandoned or suitably modified as directed by the Board, all at the expense of the owner, and within a period of time to be specified by the Board.

(d) Determination of Extent of Impact of Existing Encroachments

The Board will make the final determination as to whether the facility or use has or has not a major detrimental impact within the designated floodway or on project facilities and will advise the owner thereof of any action that he must take.

Article 11

Extent of Improvements Outside of Designated Floodways

SECTION

95 Undesirable Changes in Channel on Flow Regimen

All uses or combinations of uses in a specific reach of the stream will be permitted if such use or combination of uses will not result in an undesirable change in the channel or in the flow regimen. Applications to and Orders by the Board will be required outside the limits of the designated floodway only for uses or activities that might result in such changes. Existing activities of the foregoing nature will be handled by the Board on a case by case basis.

APPENDIX D

Written Responses To Basin Problem Inquiries

Date: February 28, 1979

To: Ad Hoc Committee on Colusa Basin Drain

From: Twyla J. Thompson, Secretary

Subject: Response to Basin Problem Inquiry

Questionnaires were sent out to the various agencies within the Colusa Basin Drain area. Four replies were received back as of this date.

Although the defined problems varied, a distinct similarity was found to be in the area of drainage and flooding in all four seasons of the year.

A determination is needed in the area of drainage and/or tail water ownership.

There is no single and/or group of entities presently empowered with the jurisdictional and/or financial capability to undertake the responsibilities of resolving these problems.

Attached are the replies which delineate the problems in detail.

A possible course of action would be to obtain a consultant's services to further catalog and outline the type and location of the problems and to recommend appropriate solutions.

DATE: 02/22/79

TO: Twyla Thompson, Committee Secretary
Ad Hoc Advisory Committee on Colusa Basin Drain

FROM: Robert D. Clark, Manager & Secretary
Glenn-Colusa Irrigation District

SUBJECT: Response to Questionaire

1. This District believes that the greatest problem in the Colusa Basin Drain area is the lack of overall comprehensive planning needed to coordinate drainage improvement and development activities.

2. The area lacks any entity or entities to accept responsbility for flood protection and control in those specific areas where it may be ecomonically justified. This may be accomplished by use of one overall entity improvement agency or individual entities coordinated by some form of basin wide authority.

3. Capacities of reaches of the present irrigation drainage system are limited in certain areas and need reexamination to determine if they are of sufficient size to serve the present service area.

4. Impacts from changes in operating conditions both on the Sacramento River and the Yolo bypass that affect the outlet drainage of the Basin need examination to determine what might be done and how it might impact the drainage problem.

5. Maintenance of natural and man made channels for the passage of flood control run off does not presently fall under the specific responsibility of any agency except in areas where agencies have been formed to provide this service. This problem should be addressed as an overall issue or as a coordinated local effort.

6. Attached is a copy of a letter sent to each of the three County Boards of Supervisors by the Glenn-Colusa Irrigation District in May of last year expressing the District's concerns which may be of interest to members of the committee.

DIRECTORS

President
RALPH A. NISSEN
Williams

Vice President
PETER R. MIRANDE
Willows

BEN JOHNSON
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CHARLES O. WISCHROPP
Delevan

ROY W. OTTERSON
Willows

GLENN-COLUSA IRRIGATION DISTRICT

SERVING 170,000 ACRES
SITUATED IN GLENN AND COLUSA COUNTIES

ASSOCIATION OF CALIFORNIA WATER AGENCIES MEMBER

OFFICERS

ROBERT D. CLARK,
Manager & Secretary

S.W. DUNLAP
Assessor-Collector-Treasu

MINASIAN, MINASIAN, MINASIAN, SPRUANCE & BABER
Attorneys

344 EAST LAUREL STREET
POST OFFICE BOX 150 AREA CODE (916) 934-4695
WILLOWS, CALIFORNIA 95988

May 4, 1978

Board of Supervisors
County of Colusa
County of Glenn
County of Yolo

Dear Sirs:

The Glenn-Colusa Irrigation District is the largest water supplier in the Colusa Basin, and their experience in the providing of irrigated agricultural water supply has lead them to the realization that providing irrigation drainage is every bit as essential to the area as the water supply.

First we want to address the background and development of the existing drainage system of the Colusa Basin. The development of the irrigated agriculture preceded any consideration toward adequate drainage to accomodate the impacts of the agricultural water supply. The vast growth in irrigated rice after World War I and in the 1920's put a tremendous impact on the natural drainage which created unbearable conditions downstream and eventually lead to the formation of an irrigation drainage entity, for the upper portion of the Basin, Reclamation District #2047. This entity was preceded by other efforts particularly in the lower Colusa Basin to provide drainage such as the Knight's Landing Ridge Cut and others. The increasing value and productivity of lands, particularly in the lower Colusa Basin has heightened the interest in that area to provide year around flooding protection on what had normally been flood plain.

Reclamation District #2047 was a well designed plan to provide for irrigated agriculture anticipated at that time. Here we are 50 years hence with more than twice the irrigated agriculture in the Colusa Basin than was envisioned by the developers of the Reclamation District. It is certainly not arguable that the facilities constructed by Reclamation District #2047, the Knight's Landing Ridge Drainage District, Reclamation District #108 and others are insufficient for the purposes they were intended for the Tri-County area. The problem in irrigation drainage has arisen due to the increase in the irrigated agriculture within the Basin. Over the years many of the drain channels have been further encumbered by their use as water conveyance facilities. This has substantially increased the complexity of the solutions which must be sought. In addition, further development to be brought about from the impacts of the Tehama-Colusa Canal will even more greatly increase the load on the existing facilities.

The efforts to delineate responsibilities among the many irrigation supply entities and individuals in the Basin probably complicates the efforts to arrive at a solution, to the point where the problem becomes almost insolvable, without the establishment of an overall entity to apportion the responsibility based on benefits. To do so would require the creation of a multi-county drainage entity to apportion benefits and establish priorities in order to attack the problem effectively. Such an entity would of course, also have to be structured in order to assume responsibility for other needs of the Basin such as the firming of water supply to those areas dependent on infirm supply and an effort to attack what can best be described as the flood control problem.

Every major study made in the past in the Colusa Basin in regard to flood control protection has substantially ended in the conclusion that the flood control cost to benefit ratio was not favorable. Although the project was not feasible for the overall area it may be possible for an entity to develop areas of benefit where protection works, rerouting facilities, or channel improvement projects might provide protection for limited areas. In these cases the benefit would have to be high enough to offset the cost of these projects.

The Glenn-Colusa Irrigation District entered into a contract with Reclamation District #2047, commonly known as the "Five Party Agreement". This agreement involved other irrigation districts within the Colusa Basin and within the service area of Reclamation District #2047 and provided that those districts would maintain the irrigation drainage facilities owned by the Reclamation District #2047 within their respective boundaries. This arrangement between the Districts has worked reasonably well. The development of the irrigation districts along the Tehama-Colusa Canal has raised the problem of what to do with their drainage and the impacts of their land development. Glenn-Colusa lying parallel and east of the Tehama-Colusa Canal will have to accept a substantial portion of the drainage of these newly developed lands in Glenn and Colusa counties. It is apparent from these development plans that there will be problems arise as to the delineation of the point of responsibility or custody of the drainage as it falls into the hands of the Glenn-Colusa Irrigation District and subsequently other entities. This is the type of problem that probably best lends itself to the solution of an overall drainage entity, with the responsibility to apportion costs and benefits. The best solution that can be offered to the tax-payer is long range planning and regulation of changes in drainage.

We hope that the three counties can see fit to develop a locally controlled in-Basin solution rather than being confronted with State or Federal agency domination. The Glenn-Colusa Irrigation District is interested in participating in a local solution to the overall Basin problem.

Sincerely,

GLENN-COLUSA IRRIGATION DISTRICT

Ralph A. Nissen
President

cc: Keith Hansen
Ed Ross
Harold Peterson
Dave Barton

RAN/kap

DIRECTORS
WALTER CALVERT, Princeton, President
RUSSEL KENNEDY, Willows
ROBERT JONES, Willows

PROVIDENT IRRIGATION DISTRICT

258 SOUTH BUTTE STREET • TELEPHONE 934-4801
WILLOWS, CALIFORNIA 95988

OFFICERS
E. L. ROGERS, Secretary-Manager
BILLIE G. JOHNSON, Treasurer
D. H. MINASIAN, Attorney

Willows, Ca. 95988
Feb. 20, 1979

Twyla J. Thompson
11 Court Street
Woodland, Ca. 95695

The Provident Irrigation District does not have a summer time flooding problem, in winter in flood conditions the district has a back up of water from road 57 (glenn county) to three miles in to Colusa county along the willow creek and Colusa drain.

WESTSIDE WATER DISTRICT
P. O. BOX 1079
717 BRIDGE ST.
COLUSA, CALIF. 95932

February 9, 1979

Twyla J. Thompson
Committee Secretary
11 Court Street
Woodland, CA 95695

Dear Mrs. Thompson:

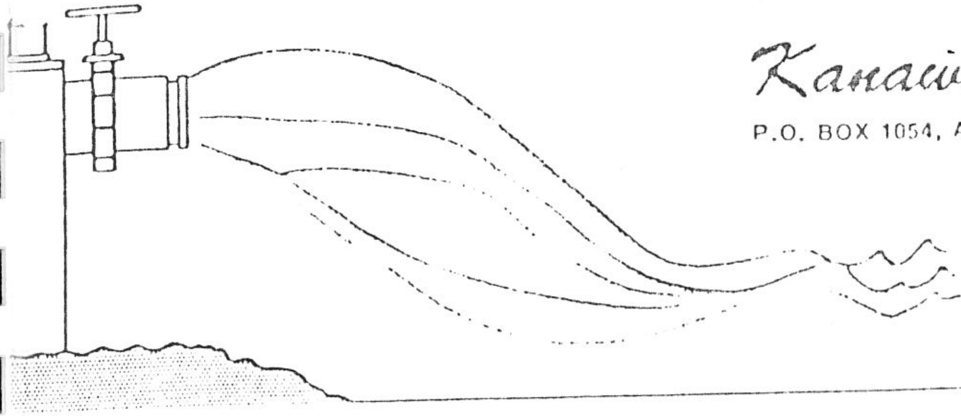
Upon receipt of the Memorandum Questionaire, the Board of Directors discussed the Colusa Basin Drain problem as requested.

The Board concluded that the major problem concerning our area is the winter drainage of Freshwater Creek, Salt Creek, and Spring Creek. We hope this information will be of assistance in identifying the total drainage problem.

Very truly yours,

Mary S. Pennebaker

Mary S. Pennebaker
Secretary



Kanawha Water District

P.O. BOX 1054, AIRPORT ROAD • WILLOWS, CA. 95988
(916) 934-5476

February 16, 1979

Twyla J. Thompson
Committee Secretary
11 Court Street
Woodland, CA 95695

Dear Mrs. Thompson:

Enclosed find our District's listing of problems on 2047 as we view them.

Yours very truly,

John C. Campbell

JOHN C. CAMPBELL
Secretary-Manager

JCC/jb

1. Increase of rice acreages and resulting drainage overtaxing existing drain.

2. Encroachments in drain for irrigation block effective drainage.

3. Purpose of drain was for drainage not irrigation ∴ maintained as a canal.

4. River return flows not maintained by pumping out of drain as originally intended.

5. Lack of cooperation of Federal entities esp. Fish and Wildlife U.S.B.R. with local agencies (2047). U.S.B.R. study claims 50,000 a/f drainage - not a factual report but even if so, U.S.B.R. would have a responsibility.

6. 2047 landowners apparently unwilling to assume responsibility of maintaining existing drain.

7. Consistent history of flooding in the Colusa Basin during water months - flood zone but not recognized as such as yet.

8. Great diversity of interests on 2047. Example:
   a/ Some want a constant flow maintained during irrigation season for irrigation - not consistent with good water conservation practices - encourages water wasting upstream.

   b/ Spring, Fall drainage difficult to manage when tail water disposed of in drains.

   c/ Can't please all users of drain.

   d/ Seem to expect Tehama-Colusa water users to accept responsibilities of conditions in existence for several years and to manage water to please 2047 landowners.

   e/ Water rights not an issue - not part of the study.

9. Much misinformation as to amount of drainage from Tehama-Colusa Districts U.S.B.R. drainage studies indicated 50,000 a/f not realistic.

Suggestions for Study of Problems

1. Spring - Summer - Fall
   a/ Monitor all laterals (meter) and identify from which source water comes.

   b/ Identify crops and acreages - water use and amount of tail water and when in excess. Who is responsible for Fall, Spring drainage.

   c/ Identify congested areas and reasons for congestion.

DATE: 2/22/79

TITLE: Ad Hoc Advisory Committe on Colusa Basin Drain

OBJECTIVE: To develop a statement of the problems associated with the drainage and flood control within the overall basin. To advise the consulting engineers engaged in developing the scope of such a study to catalogue and list the specific problems encountered. To act as a sounding board for questions and proposals of the consulting engineers. To develop a reasonable formula for sharing costs of such a study among the counties; water and drainage districts; individuals; or others the committee feels should be asked to assist in funding such a study.

MARCH 10, 1977

COLUSA BASIN DRAINAGE PROPOSALS

Submitted by: Eugene M. Massa, Trustee
Reclamation District 2047
Advisory Committee Member
Colusa & Glenn County Landowner/Farmer

As a solution to help with some of the problems of the Colusa Drain, the following suggestions would need immediate attention:

1. Take whatever steps necessary to clean and improve the Ridge-Cut, so that the water may get away faster; and as a long range program, continue with the Colusa Drain extension to Solano County.

2. By starting with the Ridge-Cut, continue to work North, cleaning and improving as necessary.

3. Check that all bridges and diversion dams are not holding back water flows, which could cause flooding.

4. Study and improve present floodway on the West side of the drain. Get roads, leeves and ditchbanks lowered so that floodwater may get away faster.

5. Clean the channels where necessary in the upper reaches, especially Willow Creek, from where it flows to the Main Channel North to the Highway 99 near the Blue Gum Lodge.

6. A more thorough study should be made of the impact of the Tehema-Colusa Canal on the Drain, and on winter flooding; as well as from irrigation water and seepage.

7. As the Reclamation District 2047 is a drainage district, and the drain is on private land, all studies and planned improvements, etc.., should come before the Board of Trustees of the drain.

8. If we could correct the problems due to winter flooding on the drain, our summer problems would not be as large. Therefore, funding for these projects should come as flood control funds.

9. As the Tehema-Colusa Canal will have some impact on the drain, funding could come for drainage and flooding from this project also; or perhaps an alternate drain at a higher elevation than the Colusa Drain should be considered.

10. Westside river seepage in summer should be pumped and given to irrigation districts and farmers for irrigation. Any excess water should be pumped back into the river as a short range program, so as not to burden the Colusa Drain.

11. By correcting the winter flooding problems along the drain, numerous advantages would be gained, such as better farming, which now comes to a halt during prolonged flooding seasons. Wildlife and game refuges would be helped, as well as improved fishing conditions. Therefore, uncontrolled flooding seems to be the main problem; funding should come as a flood control measure.

CARL E. RODEGERDTS (1903-1971)
E. L. MEANS
FREDERICK R. ESTEY

MICHAEL D. REED
DAVID MICHAEL YOUNG

RODEGERDTS, MEANS & ESTEY
ATTORNEYS AT LAW
618 COURT STREET
WOODLAND, CALIFORNIA 95695

(916) 662 7367

MAILING ADDRESS:
P. O. BOX 610

March 6, 1979

Mrs. Twyla Thompson
Ad Hoc Advisory Committee
11 Court Street
Woodland, California 95695

Re: Ad Hoc Committee on Colusa Basin Drain

Dear Supervisor Thompson:

In accordance with your request, representatives of the Knights Landing Ridge Cut Water Users Association have met in an attempt to delineate specific areas of concern in regards to drainage problems. Generally speaking, our primary drainage problem occurs in the lower reaches of the Colusa Drain from the College City riffles to Knights Landing. During the winter, the West side of the canal in this area is generally inundated. Over the years the severity and duration of the flooding has progressively increased. The Knights Landing Ridge Cut is the sole outlet for the Colusa Basin when the outfall gates at Knights Landing are closed during high stages on the Sacramento River. When the gates are closed, all of the water coming down the drain must pass down the Ridge Cut across the Yolo Bypass and into the Tule Canal. In order to eliminate the flooding problem on the lower reaches of the Colusa Basin Drain it will be necessary to increase the rate of flow through the Knights Landing Ridge Cut as follows:

1. Consideration should be given to the need to clean the Colusa Basin Drain and the Ridge Cut to remove vegetation, sediment, and obstructions which impede the flow of water.

2. The obstruction at the terminex of the Knights Landing Ridge Cut should be eliminated and replaced with a control structure which would permit the rapid flow of drain water from the Colusa Basin during winter, and control summer water levels.

3. It will be necessary to channelize the flow of water from the Knights Landing Ridge Cut across the Yolo Bypass to the Tule Canal.

4. The capacity of Tule Canal must be investigated to check it for conformance with the proposed channel across the Yolo Bypass.

5. Likewise, the capacity of the toe drain serving the Tule Canal must also be evaluated in terms of the effect of increased flows from the terminex of the Knights Landing Ridge Cut.

As has been previously pointed out by other respondents, common sense dictates that any attempt to clean or improve the drain to increase the flow of water should start at the bottom of the drainage system. This achieves the maximum cummulative benefits of improved drainage and flood control and minimizes any possible exacerbation of existing flooding problems to downstream owners which would result if the cleaning or improvement were not started at the bottom of the effected drainage system.

If you require any additional information or details concerning any of these items, please do not hesitate to contact our office.

Very truly yours,

RODEGERDTS, MEANS, ESTEY & REED

By
MICHAEL D. REED

MDR:rcw

cc: George Youngmark
Layton Knaggs
Ken Lerch

COMMISSIONERS
KENNETH BALSDON PRESIDENT
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KNIGHTS LANDING RIDGE
DRAINAGE DISTRICT

YOLO AND COLUSA COUNTIES
CALIFORNIA

ATTORNEYS
DOWNEY, BRAND,
SEYMOUR AND ROHWER
SACRAMENTO, CALIFORNIA

ENGINEERS
LAUGENOUR AND MEIKLE
P.O. BOX 828
608 COURT STREET
WOODLAND, CALIFORNIA
95695

MAR 12 1979

March 7,

RECEIVED
LAUGENOUR AND MEIKLE
WOODLAND, CA 95695

Twyla J. Thompson
Committee Secretary
11 Court Street
Woodland, California 95695

MAR 9 1979

Dear Mrs. Thompson,

I have looked through some material concerning the Colusa Basin Drain which has been prepared during the last fifteen years. Apparently, discussions since then (and probably before) have uncovered no new problems. The same situations exist now, as then. Only the degree seems to have altered.

Listed here are a few of those problems.

1) Ridge Cut is inadequate to discharge flows. It needs an outlet to tidewater.

2) Elevation of water in Ridge Cut must be maintained at an elevation high enough to provide water for irrigation.

3) Drain, throughout its length, has many blocks - both natural and man made. These impede drainage flow capability.

4) Drain is used for irrigation water supply.

5) Grading of land for irrigation changes surface runoff patterns, generally accelerating the arrival of water in the Drain.

6) Tehema-Colusa Canal construction dictates to landowners that they must grade their land for irrigation.

7) Rice culture is of paramount importance to the area served by the Drain.

8) Much land served with Tehema-Colusa Canal water will be used for crops other than rice.

I have used these few examples to demonstrate what, in my opinion, is the greatest hindrance to making headway in any solution to problems along the Colusa Basin Drain.

In meetings and discussions I have read of or participated in, the conditions occuring at various seasons of the year are never kept separate. I believe that in our discussions, these physical differences and needs during these seasonal periods must be defined, considered, and solved independently. Then, and only then, can these solutions be discussed as a whole and the necessary compromises be made.

I noted at our meeting in Colusa the other day, the same line of discussion to which I allude. Summer, winter, spring and fall problems all seem to enter willy-nilly.

I believe any physical solution will require funding over and above local resources. The program we recommend must take this into consideration. Cooperation between State and Federal agencies currently leaves something to be desired. But if we have a good plan, supported by local interests, which can be promoted at the right time politically, I am sure many of the problems we discuss can be remedied. I hope so!

Sincerely,
KNIGHTS LANDING RIDGE DRAINAGE DISTRICT

David P. Granicher, Manager

DPG:dd

cc Ken Lerch - Laugenour & Meikle

RECEIVED
LAUGENOUR AND MEIKLE
WOODLAND, CA 95695

MAR 9 1979

MAR 16 1981

Woodland, Calif
March 12, 1981

Mr. Ken Lerch,
Woodland, Calif.

Dear Ken,

In answer to the letter of Feb. 24, 1981 which I received from you and Tom Landon I wish to submit my comments and recommendations that you requested.

Having been a rice grower in the lower Colusa Basin drain area since 1930, which is 50 years, I have attended many water meetings and have seen many changes and problems on the 2047 Canal. Problems become greater and more numerous and it makes organization very important. This we must have if we are to be heard, especially by the State and Federal groups. We have that organization now in the Colusa Basin Drainage Action Group which represents members from three counties Yolo, Colusa and Glenn. This area represents many people and a large acreage which is very important when you wish to present your problems.

(1) Therefore, I recommend that the Colusa Basin Drainage Action Group stay in force as a tri-county planning group for a united push for the benefit of all.

(2) Start solving the drainage problems at the lower end of the 2047 Canal and Knights Landing Ridge-Cut first. I mean cleaning the part of the canal

from Knights Landing south to the Yolo By Pass.

(3) Keep our projects small as possible to make them feasible. Feasible seems to be a big word now.

(4) One of the first projects to consider is a water control weir at the lower end of the Ridge-Cut, so when the Sacramento River is high and the out-fall gates at Knights Landing are closed or inadequate to handle the flow, the flood waters then can be released into the Yolo By-Pass. This structure could and should be managed by the Department of Water Resources who now operate the Knights Landing out-fall gates.

(5) Since it has been stated that land subsidence of 1 to 3 feet has occured in the area between Knights Landing and College City, it now appears more necessary than ever to make an outlet for these flood waters.

(6) Finally I recommend to do first things first for the good of all. Our problems will become greater and more complicated, but as a group working to-gether I know that they can be solved without causing unnecessary damage to any-one.

Sincerely,

George Youngmark