REPORT
ON
DRAINAGE
NAGLEE-BURK IRRIGATION DISTRICT
SAN JOAQUIN COUNTY
CALIFORNIA

AUGUST 1924

ENGINEERING OFFICE
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SAN FRANCISCO, CALIF.

MAPS

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NAGLEE-BURK DISTRICT,
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AUGUST-1924.

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REPORT ON DRAINAGE
NAGLEE-BURK DISTRICT.

The Naglee-Burk Irrigation District lies north of Tracy in the land much of which was formerly overflowed by the San Joaquin River at flood stage. The land is now protected from overflow by levees and is irrigated by pumps which lift the water to the level of the highest lands in the district. In recent years a thorough system of drains has been installed to carry off excess subsurface water.

The district is made up of lands of good quality which under irrigation are productive of large crops. The region promises to be productive continuously if irrigation and drainage are attended to. Neglect of either will jeopardize much land in the district and will undoubtedly result in destruction of large areas.

When the land was first protected from overflow by levees, the distance to underground water was more than 10 feet except for the lowest lands. An open drain was built in the lowest area when the irrigation system was constructed, and the water levels were maintained in the lowest part of the district at a satisfactory depth. In 1918 the West Side District, irrigating higher lands, started operating and, as frequently happens, lower lands - those in the Naglee Burk

District - were menaced by a rising water plane and increase of alkali in the soil and subsoil. This condition has steadily increased in seriousness and has placed a large burden upon these lower lands.

This report is written to describe the conditions and to suggest remedies before great damage is done. An investigation has been made in the field to determine the cause of the present menace, and to suggest methods of prevention of further damage. A plan of cooperation between the two districts is outlined, as it is only by cooperation that lower lying lands can be protected from the menace of seepage originating in higher lands.

Drainage is essential in all irrigated regions. It is not possible to supply the soil with exactly enough water to supply plant needs and soil evaporation - an excess usually is supplied. This excess application besides insuring the full absorptive capacity of the soil serves to flush out the waste products and alkali, and acts to cleanse the soil much as the removal of sewage serves to cleanse a town.

Irrigated land at a higher level produces seepage water which menaces lower lying land. The difficulty of estimating the amount of this seepage makes it difficult to determine the exact part paid by the higher district in the necessity for drainage in the lower land.

There are no court decisions in California which deal with the case we are considering. Drainage suits have usually been between land owners in an irrigation district and the district or between individuals. The doctrine laid down by our Supreme Court in such cases is clear and establishes the principle that any damage done to an individual by the acts of a district in carrying out the public duties of the district must be paid for. The same principle applies to individuals.

The case before us, however, is different. Here two separate quasi-municipal corporations are concerned. There are no court cases, known to the writer, involving two districts. If the land in the West Side and Naglee Burk districts were all in one district drainage work would be assessed against the entire acreage. By so doing all users of water would pay a part of the drainage costs. In some states (Nevada for example) drainage laws are so worded that all users of water who contribute to the necessity of drainage can be assessed the costs.

This is a very just provision, for it is true that every user of water and every irrigation ditch lying above an area are contributors to the necessity of drainage on the lower lands. When, however, the higher lands and the lower lands are in different districts, there is no way of assessing cost on the higher land for drainage work on the

lower land even though it may be proved that the seepage water from the high land is the cause of the need of drainage on the low land.

Recourse to litigation is the only means of forcing payment upon the upper district. It is thought that the case of West Side and Naglee-Burk districts is so easily understood and so patent that some mutual arrangement can be made which will be fair to both.

The details of the reasoning as to the problem are given below.

HISTORY OF IRRIGATION AND RECLAMATION AROUND TRACY.

The writer made investigations of irrigation around Tracy in 1910. At that time there was practically no land irrigated west of the San Joaquin River. Levees had been built to protect the bottoms but they were not effective. Cross levees were not in existence and high water breached the levees and flooded the bottom lands almost invariably whenever large floods occurred. In the winter of 1911 the Naglee-Burk lands were flooded by a break above the head of Paradise cut. Improved levee construction has served to protect these lands since that year and although floods were high in winters of 1914, 1916 and the summer of 1921 no breaks occurred in these years. Cross levees now have greatly reduced the menace, as the length of river levee

which protects the area is shorter than in 1911."

"The levee thrown up by the barge canal at the sugar factory, 2 miles east of the Naglee-Burk District, now effectively protects the region from levee breaks further upstream." "The levee thrown up by the intake canal to the West Side District protects from breaks in the river levee below that point." "The river levee between these cross levees is in good condition and of section strong enough to protect the district from any flood which has occurred in historic times. There are no streams entering this leveed area from the hills to the west and south."

About 1911 an irrigation ditch was put in operation on the Naglee-Burk property. It was later enlarged and a new pumping plant built and irrigated area greatly extended in 1913.

The area watered increased until the entire area in the district (3346 acres) was watered.

"In 1918 the West Side Irrigation District was completed and placed in operation. This district joins the Naglee-Burk on the south and west. It has an area of 11,811 acres." "All of it has been irrigated at some time since 1918 and most of it is watered every year." Much of the land is in alfalfa. "The highest land in the Naglee-Burk District is between 20 and 25 feet." "The West Side extends from that level to slightly over 100 feet."

SOILS OF THE NAGLEE-BURK AND WEST SIDE DISTRICTS.

The soils of the Naglee-Burk and West Side Districts are heavy. The Bureau of Soils in the "Reconnaissance Soil Survey of the Lower San Joaquin Valley" shows three types in the district: Yolo clay loam, Yolo adobe and Sacramento clay loam. These types do not differ to any great extent in their absorption of water and in the problems of drainage. The two Yolo types lie on the slopes and extend from the foothills to the edge of the bottom land formerly flooded at times of overflow. They are soils formed from sediments washed down from the coast range; fine materials predominate, consequently the soils are heavy. They, being formed by streams coming from the mountains, are arranged in areas following the direction of flow of these streams - from the hills toward the river. Lenses of porous material follow this same plan.

The surface of the Yolo soils is heavy - clays or clay loams-to a depth of 2 to 4 feet. Below this is another layer of clay, but more sandy and open to the passage of water. This subsoil is many feet deep. Deeper strata contain gravel and water-bearing material as far as wells have been bored, over 300 feet.

The Sacramento clay loam is a sedimentary soil deposited by the rivers when in flood. It is a heavy, black soil underlain at from 2 to 3 feet by slightly more porous subsoil.

"So far as drainage is concerned these soils are noticeable in having subsoils which transmit water more readily than the surface." This is especially noticeable when borings are made, as it is common to find water in the subsoil under pressure even though the surface soil is dry. Borings frequently encounter water under pressure sufficient to raise the level of water one or two feet above the place water is encountered.

"The movement of water through the surface soil is very slow but much more rapid through the subsoil." The result of this condition is that drainage from irrigation and seepage from irrigation canals which gets into the subsoil moves with considerable rapidity." It may affect lands at some distance from the point at which the drainage water originates and it may act with rapidity. When water was first turned into the ditches of the West Side District wells in the town of Tracy - though not near any irrigated land - were quickly affected by underground seepage. In some cases the raise in water level was several feet." In the Southern Pacific wells in Tracy the pumps have been raised four times." In the well at the Tracy High School water raised and drowned out the pumps over night.

"It is the condition of a heavy soil and a more porous subsoil which affects the drainage conditions and causes the underground water to move such long distances. The heavy surface soil is of very slow capillarity." It

does not draw the water to the surface fast enough to remove the excess forced into the subsoil. It acts as a seal or impervious blanket and forces the subsoil water to flow down the slope until it accumulates enough pressure to force its way through this seal. "The Naglee-Burk lands lie so low that the pressure of water from the West Side irrigation now causes wells to flow above the surface. The slow percolation from this artesian zone underlying the low lands will damage these lands, if the condition is not corrected at once."

ALKALI IN THE SOILS.

Soils formed from sediments originating in the Coast Range Mountains contain alkali in small quantities. This alkali is dissolved by and moves with the water. Whenever water accumulates near the surface of the ground, so that it can by capillarity be drawn to the surface and evaporate, alkali will accumulate.

Before irrigation was practiced in this region no alkali was present in the surface soil in quantity large enough to affect vegetation except in the narrow marginal area just above the high water line of overflow. This margin was from a few hundred feet to half a mile wide. It extended around the upper edge of the Naglee-Burk District and entered into the West Side and Tracy-Clover districts. The alkali was all of the white variety, and was not present in large quantity. It was readily washed out and the land made good for any crop.

Small quantities of alkali were present in the subsoil of all of these heavy soils in the Yolo series, both upland and lowland. This alkali, harmless where originally located, is capable of doing serious damage when leached out and accumulated on lower lands. The seepage water from the West Side District carries this alkali with it and wherever that water approaches the surface it will do damage to the land if it stands long enough for the water to evaporate and the alkali accumulate. The presence of alkali in all the subsoil of this region is shown by the fact that surface water in all wells in this region is of poor quality due to alkali and has to be cased out.

If the drainage water from higher lands is allowed to accumulate under the low lands, the amounts of alkali thus deposited will without doubt damage the land. The longer the condition exists the greater the damage.

Land along the north side of the West Side District, where water now stands less than 4 feet from the surface, will become alkaline in time if no drainage relief is provided. Lands lower down the slope in the Naglee-Burk District are more seriously menaced, not only from the drainage waters coming from the West Side District but also from the drainage of higher lands in the Naglee-Burk District. Drainage must be provided to protect these lands. The menace exists in both districts and it is a problem of mutual concern.

EARLY RECORDS OF GROUND WATER LEVELS.

Records of ground water levels were collected by the U. S. Geological Survey and published in Water Supply Papers 222 (1908) and 398 (1916).

In these papers are reported records collected by field agents from a large number of wells in the region around Tracy. The following table shows records from such of these wells as can be identified now. To these records has been added the level to standing water in summer of 1924 collected by Mr. Harrington.

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RECORD OF WELLS AND DEPTH TO WATER

1906 - 1912

FROM WATER SUPPLY PAPER 398.

Name	Location Sec.	T.	R.	Depth to Water	Depth to Water 1924
Hansen	10	2	4	34	26
Toomey	11	2	4	30	
Luhrsen	14	2	4	45	
Oil Co.	13	2	4	12	
Fabian	30	2	5	28	
Deane	20	2	5	15	4.5
Parker	20	2	5	24.5	4.1
Krohn	30	2	5	28	7.0
So. Pacific	28	2	5	30	
Grunauer	22	2	5	29	9
Chrisman	22	2	5	31	12.5
Batterman	24	2	5	30.5	23 in 1922 15 " 1924
Rathjen	36	2	5	40	
Buschke	33	2	5	100	
Tracy Cemetery	28	2	5	57	29.4
Frerichs	32	2	5	80	
Carroll	4	2	5	40	
Droge	23	2	5	18' in 1922	12' in 1924

The table shows that in years previous to irrigation by the West Side Irrigation District water level was deep in the entire region now occupied by the West Side District. A comparison of depth to water with the ground level at the well, as shown on the U. S. Geological Survey topographic maps, shows that the level of water is only slightly above the level of water in the San Joaquin River. As examples, the water level in the Southern Pacific well in Tracy was about 5 feet above San Joaquin River level and in the Buschke is at approximately the same level. In a few wells water was 10 to 15 feet above river level;in more wells it was lower. In only one well, the Carroll well, was the water much above river level (here it was about 60 feet).

Very different conditions are found in 1924. Water level has raised in all the wells and there are indications that the raise has not stopped. Continued irrigation will cause water to raise still higher. Records are not available as to when the first raise occurred,(though it is known that it occurred soon after irrigation commenced) or at what rate the increase in levels took place. Some information on this subject can be obtained from wells in Tracy where observations of water levels have been made at various times. The Southern Pacific pumping plant in Tracy is a 14" stove pipe cased well about 225 feet deep. A reciprocating pump with capacity of 20,000 gallons per hour (330 gallons per minute) has been installed and operated for many years. The pump was

located in the pit a few feet above water level. Since irrigation was started in the West Side District it has been necessary to raise the pump three times, the last time in April of this year.

The well at the Tracy Union High School is a 12" one, 210 feet deep, built in 1917. A 24 foot pit was dug to hold the pump. Water was originally 13 feet below the bottom of the pit. Water is now 11 feet deep in pit, or a rise of 24 feet. The first rise occurred three to four weeks after irrigation commenced and was so rapid as to drown out the pump in the bottom of the pit over night. Water has risen, slowly, about 6 feet since the first rapid rise.

There is no irrigation close by either of these wells and it is probable that water level conditions in them represent the general ground water levels around Tracy.

All wells in the West Side District and lower in elevation outside the district have followed the same history. Rise of water level has occurred in all of them - in fact some wells between the West Side District and the San Joaquin River have raised so that water now flows above the surface of the ground.

CHANGES IN GROUND WATER CONDITIONS SINCE IRRIGATION COMMENCED.

In July and August, 1924, a study was made of water conditions in the Naglee-Burk Irrigation District and in the immediately adjoining portion of the West Side District. Information was first obtained by measuring the depth to water in wells and later a series of borings was made to determine the depth to ground water.

The examination of the wells showed that water levels had raised in all regions in recent years. In many parts of the Naglee-Burk District wells would flow above the ground surface. Some of these wells were along the Grant Line Road - the boundary of the two districts - others were further north.

// The fact that artesian conditions are found along the highest part of the district is conclusive evidence that the water does not come from the irrigation in the Naglee-Burk District but from higher land. The West Side District is the only other possible source of such water. //

Important information on water levels was collected by a series of borings made with an 1½ inch soil auger. Four lines of borings were made:

1. A line west along the Grant Line Road from the Deane corner to the S.P. track.

2. A line north along the Fremont Road from the Grant Line Road.

3. A line north along the Lammers Ferry Road from the Grant Line Road.

4. A line south from the Grant Line Road along the east side of the Grunauer property.

Record of the borings is shown on the sheets attached; in all 36 borings were taken. Levels were run to these holes and the elevation of ground and water above sea level was determined. The attached profiles show the records of water levels.

WELLS ALONG GRANT LINE ROAD.

The upper profile shows the record of wells along the Grant Line Road. The line was run a few feet south of the road on the Grunauer property. The profile shows that water is found less than four feet from the surface all along this road from the Deane Ranch to about three-quarters of a mile west; it is deeper under the land about the junction of Lammers Ferry Road with the Grant Line Road. When water was encountered in these borings it rapidly raised from 1 to 3 feet, indicating considerable pressure. The line to which water raises is in many places within a foot of the ground surface.

This condition, with ground water so close to the surface, is menacing to the overlying lands; if it is allowed to continue it will result in the accumulation of alkali at the surface and damage to the land. It shows that the source of water is from higher land - in the West Side District - and that it is not only menacing to the Naglee-Burk District but is menacing to the West Side District lands.

Few crops except grain can make the best growth with water table this high. Fruit trees would be seriously damaged and would be killed unless drainage was provided and alfalfa would be reduced in yield and in period of usefulness. It would have to be plowed up and replanted more frequently. If this condition continues alkali will rise and damage the land.

PROFILE ALONG EAST LINE GRUNAUER PROPERTY.

The profile along the East line of the Grunauer property shows similar conditions. The water plane is high, about 4 feet below the land surface throughout the length of the profile, nearly 3/4 of a mile, and the water is under sufficient pressure to raise it nearly a foot nearer the surface of the ground. The slope of this water plane is 18 to 20 feet to the mile. The slope shows the direction of movement which is from the south to the north, or from the West Side District toward the Naglee-Burk District.

This profile shows that the menace of high water plane is present under the lower part of the West Side District as well as in other regions. The fact that the soils are so heavy as to make the upward movement by capillarity very slow is the reason that the rise of water is not more evident on the surface of the ground.

PROFILES ALONG FREMONT AND LAMMERS FERRY ROADS.

The profiles along Fremont and Lammers Ferry Roads show conditions much the same as on the other profiles. These two profiles are in the Naglee-Burk District and show a cross section of the district from the boundary of the West Side District to the lowest ground toward Old River branch of the San Joaquin River.

An examination of these profiles shows that water is closest to the ground at the boundary between the two districts - at the Fremont Road the hydrostatic pressure raises water to less than 2 feet of the surface and at the Lammers Ferry Road to between 4 and 5 feet. Lower down the slope of the water plane is deeper. It is in this region that the Naglee-Burk District has recently constructed drainage canals. At the bottom of the slope the land flattens and the water plane again is closer to the ground surface.

Throughout the length of the profiles the slope of the water plane is toward the north - no effect of the

river levels is shown in these profiles, in fact the entire movement is toward the river."

ADDITIONAL DRAINAGE NECESSARY.

The records given above show that the seepage and under-drainage from the West Side Irrigation District ditches and irrigated lands has caused water to raise under both the lower lands in this district and the adjacent parts of the Naglee-Burk District. In fact the effect of this water is no doubt felt on all lower lying lands toward Old River.

Conditions reached such a state in the Naglee-Burk District that drainage had to be provided or a large part of the land abandoned to pasturage. The success of the drainage has been nearly complete and indicates that further damage from high water plane need not be feared so long as drainage works are maintained. The Naglee-Burk District is still menaced by drainage from the West Side Irrigation District and the lower lands of the West Side District are menaced by seepage from the higher parts of the same district.

"A deep drainage canal should be built along the Grant Line Road to intercept the water from the higher lands and such additional drains as are needed to protect the lands of the West Side District should be dug." Intercepting drains are not altogether efficient in their

the boundary between West Side & Naglee Burk Districts

operation, as water sometimes passes underneath to appear lower down on the slope. "Drains higher than the Grant Line Road may be advisable."

PUMPING OF DRAINAGE WATER.

"Drainage water collected by these drains must be pumped into the San Joaquin River. At present the Naglee-Burk District is bearing nearly the entire cost. It is pumping the drainage which originates in the Naglee-Burk District and that which comes from the West Side District. The Tracy-Clover District also uses this drainage outlet and there is no doubt that the drainage water from this district in part originates in the West Side District."

"It is clearly the duty of the Naglee-Burk District to endeavor to have the West Side District bear a part of this drainage cost. This should consist of the construction of deep drainage canals along the boundary and in the lower parts of the West Side District and of a contribution toward the annual cost of pumping and main drainage canal maintenance, and interest on cost of main works heretofore constructed."

COOPERATION BETWEEN DISTRICTS.

There is so little doubt about the fact that the expenses of drainage by the Naglee-Burk District are increased by the seepage waters from the West Side District that there should be no hesitance on the part of the West Side District in entering into negotiations concerning the

matter. If, however, it is found that the willingness to cooperate is lacking, there will be little difficulty in establishing the facts in court. It is to be hoped that court action will not be necessary, for the cost of such action will be heavy and if this amount of money is used in construction of drains a great deal can be accomplished toward the solution of the problem.

It is suggested that the problem be submitted to the West Side District and an endeavor made to come to some amicable adjustment.

NAGLEE-BURK BORINGS.

ALONG BOUNDARY LINE GRANT ROAD.

#1. Adobe 4 feet, water at 4¼, sandy at water, raises to 3'. Op Pole $\frac{39}{23}$

#2. Adobe 4 feet. Op. Pole $\frac{39}{18}$

#3. Op. Pole 12 adobe, water at 4 ft. Water raised to 3.2 - sounding taken in hollow.

#4. Op. E. line Fremont Road.

#5. Adobe 2 ft. Light clay and alkali. Water 4.2 raised to 1.5.

#6. Op. Pole $\frac{38}{35}$ adobe 2 ft., light clay and alkali water 4.0 ft. raised to 2.0 ft.

#7. Op. Pole 31 adobe 2 ft., clay and alkali water at 3 ft., raised to 1.75 ft.

#8. Op. fence line adobe 2 ft., clay and alkali water 3.5, raised to 2.5 ft.

#9. Op. Pole 15 adobe 31, clay and alkali water 5.8, raised to 5 ft.

#10. Op. Lammers Ferry Road adobe 3 ft., clay and alkali soil water at 5.5, raised to 5 ft.

NAGLEE-BURKE BORINGS.
ALONG FREMONT ROAD

ALL SOUNDINGS ON FREMONT ROAD TAKEN IN DITCH.

#11. Location 200 ft. N. of tree on W. side Fremont Road in ditch at foot of 12th pole from gate 1 ft. clay sandy water 2.5 ft. raised to 2.2. El. 16°.

#12. Location at fence corner in ditch west side of Fremont Road 2 ft. of clay - sand and water at 3 ft. raised to 2.8 ft. El. 14.0.

#13. Location 6th post north of gate on west side of Fremont Road .5 adobe, clay 3, water and sand at 3.5, raised to 3.2. El. 10.5

#14. Location west side Fremont Road 25 ft. N. of drainage canal to p.5 adobe, clay 3 ft., lighter clay and water at 4 ft. raised to 3.8. El. 6.3.

#15. N.W. fence cor. of Fremont and Middle road in irrigation ditch, adobe 4 ft., soil changes to lighter color but same formation, no water at 5.8. El. 2.8.

#16. Location at fence cor. of corral on west side Fremont Road across from greenhouse adobe, struck water at 1.5 ft., raised to 1.3. El. 1.5.

#17. Location at fence corner south of white barn sand and fools gold, struck water at 1 ft., no raise.

#18. Fence corner south of main canal. Sounding taken in ditch. Sandy loam and fools gold, struck water at 2 ft., raised to 1.5.

NAGLEE-BURK BORINGS.
LAMMERS FERRY ROAD.

#19. On west side Lammers Ferry Rd. 5th post north of canal, sandy loam 2.5 ft., adobe water at 4.1, doesn't raise.

#20. West side Lammers Ferry Rd. - lot car N. end of gate adobe struck water at 3.5, raised to 3.2.

#21. At intersection of Bethany and Lammers Ferry roads N.W. fence cor. adobe 4 ft. sand water at 5.4, raised to 4.2.

#22. On west side Lammers Ferry Rd. opp. fence cor. in ditch adobe 1.5, sandy loam water 2.5, raised to 2.1.

#23. West side Lammers Ferry Road opp. south cor. of corn field adobe water 2 ft., raised to 1.8.

#24. West side Lammers Ferry Road opp. tel. pole by milk stand, sandy loam water and sand at 4 ft., does not raise.

#25. East side of Lammers Ferry Road, foot of tel. pole near gate 6 ft. no water.

#26. Water level in drain ditch 5 ft. from top of board.

#27. E. side Lammers Ferry Rd. near concrete headgate in center of ditch adobe 2.5, clay and alkali water 3.5, raised to 3.4.

#28. Water level in drain ditch 6 ft. from top of board on E. side where ditch crosses Lammers Ferry Rd.

#29. Op. fence corner Lammers Ferry Rd. in ditch adobe 1.5, clay .5, clay and alkali water 4.3, raised to 4.1.

#30. At fence corner on W. side of Lammers Ferry Rd. 4 ft. adobe, clay 2 ft., no water.

#31. W. side of road by White stake #2 5.8 ft. no water adobe 2.5 clay.

#32. Op. road from east adobe 3 ft. clay water 4.5, raised to 4 ft.

#33. About 350 ft. N. of S.P.R.W. on W. side of rd. in depression in bank adobe 1 ft. sandy loam water at 3.5 ft., doesn't raise.

#34. About 25 ft. north irrigation ditch, adobe 3 ft. clay water 4 ft. raised to 3.5.

#35. Opp. pole $\frac{38}{8}$ adobe 3 ft. clay and alkali to 5.8 no water but muddy.

#36. Pole $\frac{38}{4}$ adobe 2 ft. clay and alkali, no water at 5.8.