UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION II

GEOLOGIC STUDY OF THE LINDMORE IRRIGATION DISTRICT

Tulare Basin District
Fresno, California

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SUMMARY

Purpose of the Geologic study of the Lindmore Irrigation District is to develop basic geological information on ground-water supplies and storage.

The district includes parts of four physiographic divisions: (1) The foothill area underlain by igneous and metamorphic rocks of the Basement Complex rocks; (2) a flanking belt of smooth slopes consisting of weathered outwash from the foothills; (3) a piedmont formed by the Old Alluvium of the Kaweah and Tule Rivers; and (4) the lower-lying and younger alluvial fans and stream bottoms.

The Basement Complex, which lies at a depth of approximately 1,000 feet under the district, is assumed to have no effect upon the ground-water table, but does restrict the downward percolation of surface water near its outcrop. The sediments of late Tertiary and Quaternary age, which rest upon it, are water-bearing. They comprise the Kern River series which is herein divided into the Old Alluvium or Delano beds above, and Kern River formation below. The Delano beds are, in turn, overlain by the recent Young Alluvium and the Porterville clays.

Detailed studies were made of the logs of 133 wells, 61 of which are in the district, to determine specific yield of the sediments from the low-water level of 1921 to the low of 1944 or 1946. Specific yields thus determined vary at individual wells from 2.9 to 29.7 percent, averaging 7.4 percent for the entire Lindsay cone area.

Most of the available ground water within the Lindmore District depends on rechargo by influent seepage from the Kaweah and Tule Rivers and their diversion ditches. Lewis, Yokohl, and Frazier Creeks contribute minor amounts.

It is concluded that completely confined water zones do not exist, although there may be some partial confinement under low pressure heads. There is no concrete evidence indicating permanently perched water zones, but temporarily perched zones result locally from slow downward percolation after heavy pumping drafts. Water contact is never lost between the semi-perched water and "low" watertable.

Large scale spreading methods for storage of water underground should be on the loose, open-textured soils which occur chiefly outside of the district. Over-irrigation might conceivably be successful where the hardpan of the older soils does not inhibit percolation of surface water to the free watertable. The lack of favorable spreading area within the district points up the need for further investigation into the feasibility of spreading through wells, pits, or shafts.

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GEOLOGIC STUDY OF THE LINDMORE IRRIGATION DISTRICT

INTRODUCTION

1. Purpose and scope. - This Geologic Study developes basic information for a "Report for contractual purposes between the United States and the Lindmore Irrigation District providing for water service and for the construction of a distribution system, Central Valley Project, California." This study is one of several that have been made in the district, the others covering Water Supply, Land Use, Economics, and Irrigation Distribution System Design and Cost Estimate.

2. This study reviews topographic and geologic conditions in the area, specific yield of the sediments, effect of geology on the occurrence of ground water, possibilities of perched water tables and confined water bodies, and sources of water supply. Together, these form a basis for computing the quantity of supplemental irrigation water needed and for determining the size of distribution system required for this district.

DESCRIPTION

3. Location. - The Lindmore Irrigation District is in Tulare County, California, about 60 miles southeast of Fresno and 14 miles

east of Tulare, occupying portions of Tps. 19, 20, and 21 S., Rs. 26 and 27 E.; Mt. Diablo Base and Meridian. The district, with gross area of 27,478 acres, extends from 2 miles north of Lindsay southward to 1½ miles south of Strathmore, a distance of about 9 miles. A branch line of the Southern Pacific Railroad forms the eastern boundary for 7 miles, the southeastern portion of the district lying east of the railroad. The district's greatest width east and west is about 10 miles. Neither Lindsay, the site of district headquarters, nor Strathmore is inside the district boundaries which include no incorporated towns. General location of the district is shown on Plate 1 of this study.

4. The Friant-Kern canal location traverses the southeastern portion of the district for 1.6 miles, entering it near Strathmore at a point 93 miles from Friant Dam. Approximately 2,472 acres (9 percent) of the district's gross area are above the canal.

5. History. - Before 1880 this area was used primarily for cattle raising, but after that time wheat growing became an important industry. The Southern Pacific Railroad completed its branch line from Fresno to Porterville, which is about 3 miles southeast of the district, in 1888, extending it to a junction with the main line at Famoso in 1890, the year in which the first orange trees were planted in the vicinity. First development of water wells for irrigation purposes in the area occurred in 1895. Intensive pumping since that time has resulted in a serious lowering of the water table. The district was organized under its present name in 1937, for the purpose of obtaining a supplemental water supply from the Friant-Kern canal.

6. Population. - Present population of the district is estimated at 3,600, all rural. An increase to about 4,000 is anticipated under ultimate development. Some land is classified as residential because

it is occupied by suburbs of Lindsay and Strathmore although not included in the limits of either town.

7. Climate. - The climate in the region of which the Lindmore Irrigation District is a part is semiarid. Average annual precipitation at Lindsay has been 10.95 inches over a 33-year period. Average monthly temperatures range from about 45.5 degrees in January to 80.8 degrees in July. Average frost-free period is 238 days, occurring ordinarily between March 20 and November 12. Prevailing winds are from the northwest. About half the district has thermal protection attributed to drainage of cold air from higher elevations toward the valley floor. This facilitates citrus culture, which is the predominant agricultural activity.

8. Soils. - Predominant soils of the District are referable to the San Joaquin, Exeter, and Madera series. These are typical hardpan soils which, when located in the thermal belt, are well adapted to citrus, olives, and grapes. Smaller areas are occupied by the Foster, Chino, Greenfield, Hanford and Cajon soils. ~~These are all young, deep alluvial~~ soils well adapted to a great variety of crops. Most of the hardpan soils were characterized originally by hog wallow micro-relief, little of which remains due to extensive land leveling.

9. Transportation. - Rail transportation for the district is furnished by the Southern Pacific and Santa Fe Railroads. The principal shipping points and market outlets are Lindsay and Strathmore, at average truck hauls of about 6 miles from points in the district. Roads include two main State routes and a system of improved County roads.

10. Industries. - Most of the industrial activity serving the district is centered in the two towns adjacent to it, but not within its

boundaries. Industries inside the district include two large olive packing plants and one spray company plant.

TOPOGRAPHY

11. The Lindmore Irrigation District lies on the floor of the San Joaquin Valley in an area covered by the Cairns Corner, Lindsay, Woodville, Exeter, Rocky Hill, and Porterville quadrangles and extends one-half mile into the Lemon Cove quadrangle, of the United States Geological Survey. It is bounded on the east by the Lindsay-Strathmore Irrigation District, their common boundary being generally the Southern Pacific Railroad. To the northeast are the Sierra Nevada foothills, which project into the district only in its southeastern corner. The Friant-Kern canal will skirt the outer foothills and cross the district only in the southeastern corner.

12. The Lindmore District and adjacent Lindsay-Strathmore Irrigation District form a ground-water and geologic unit. Its most conspicuous feature is a great "cone of depression" of the water table and for this reason the entire unit will be called the "Lindsay cone" or simply, "the cone" in this study. The cone is bounded on the north by Kaweah River and on the south by Tule River. The accompanying maps and sections extend to the north and south to include these rivers.

13. The land surface has a westerly slope averaging 15 feet to the mile at the eastern edge of the district and less than 10 feet to the mile at the west edge. In the southwest portion where it includes part of the fan of Tule River, the land slopes northwesterly. North of the district, southwest slopes prevail on the Kaweah River fan.

14. The accompanying geologic map (Plate 2) indicates four main physiographic divisions of the Lindsay cone. Division 1 consists of the

foothill area and is underlain by crystalline rocks of the Basement Complex. Division 2 consists of smooth slopes underlain by weathered outwash from the foothills. The slopes vary greatly, averaging probably 100 feet per mile.

15. Division 3 consists of the Old Alluvial piedmont formed by Kaweah and Tule Rivers and smaller streams between them. In this and adjacent districts, the Old Alluvium occupies interfan at the positions relative to the young alluvial material. In the Lindmore District, it outcrops between the Tule and Kaweah fans. Its westerly sloping surface is characterized by a hummocky micro-relief of mounds and basins, locally known as "hog wallow" land. Differential relief of the hog wallow varies from 1 to 3 feet. The origin of this prominent topographic feature is not generally agreed upon.

16. The Old Alluvium represents a former apron of coalescing fans initially continuous along the east edge of the San Joaquin Valley from Bakersfield northward. This apron now forms a discontinuous belt with characteristic relief.

17. Division 4 includes the lower lying and young alluvial fans and stream bottoms of Kaweah and Tule Rivers and Yokohl, Frazier, Lewis and Mehrten Creeks. The Kaweah and Tule Rivers fans are large and extend far into the valley. Those of Yokohl and Lewis Creeks are small. The district is mainly in the inter-fan area between the Kaweah and Tule Rivers, but includes a southwestern portion of the recent fan of the latter. The Kaweah River, on leaving the foothills, occupies a channel 50 to 200 feet wide and 10 to 15 feet deep. Its gradient north of Lemon Cove is about 15 feet to the mile, but to the west it divides into several distributaries with average gradients of 7 to 8 feet to the mile.

The channel of the Tule is 100 to 300 feet wide near Porterville and from 5 to 10 feet below the general land level. Its gradient is about 10 feet to the mile. West of Porterville, it also splits into a system of distributaries.

18. Frazier Creek is the only stream that lies within the Lindmore District. Its runoff is negligible and as a result it has an insignificant channel. A former channel north of the present one may be seen on the Lindsay quadrangle. Its depth is five feet below the general level where it enters the district at Strathmore, diminishing to about two feet at the western district boundary.

19. The present channel of Lewis Creek north and east of the district follows the topographic "low" between the Kaweah and Tule fans. It is 2 to 3 feet below the general level and slopes 6 feet to the mile in the area immediately north of the district.

20. Yokohl Creek flows northwest from the foothills toward the Kaweah in a channel about 5 feet deep, with a gradient of 17 feet to the mile, about the same as in its lower valley. Two former channels may be seen in the distribution of Young Alluvium on the accompanying geologic map. Both of these are to the south of the present drainage; one flowed west, and the larger southwest.

REGIONAL GEOLOGY

21. Mountains were first formed in the area of the present Sierra Nevada at the end of the Paleozoic geologic time by uplift and folding of a vast series of sediments. The folded sediments were intruded in Jurassic times by great masses of granitic magma forming the Sierra batholith. Some of the pre-existing sediments were assimilated following

magmatic stoping,[1] and subsequent erosion has removed the larger portion of the remaining sediments overlying the granite.

22. The San Joaquin Valley has been marginal to one or another trough at least since mid-Jurassic. During much of this time some part of the valley has been receiving sediments from the east and to a lesser extent from mountains to the west.

23. The Sierra Nevada took on their present general outline in late Miocene geologic time. The northern Sierra was tilted to the west and faulted on the east. The southern third of the range is a complex horst[2] with low westward tilt. The Sierras have been uplifted several times since the Miocene. Erosion has been active, constantly removing rock and depositing it as sediments in the San Joaquin Valley.

24. Up until Pliocene time most of the sediments were marine deposits; since then they have been predominently continental, and were deposited layer upon layer in broad, often coalescing alluvial fans, lake beds, and some marine deposits. Sand, sandy clay, and clay were laid down in a complex assemblage of discontinuous lenses, stringers, and pockets. At present, great fans cover almost the entire floor of the San Joaquin Valley.

25. The bedrock surface of the Sierra Nevada dips westerly 4 deg. to 6 deg. beneath the valley sediments. Geophysical evidence indicates the alluvial fill reaches a maximum thickness of 25,000 feet or more just east of the Coast Range foothills. Oil well and wildcat drilling south of Tulare Lake establishes the presence of 2,500 feet of nonmarine

(1) Magmatic stoping is a process by which large blocks of rock overlying an advancing magma are broken off and sink into the molten mass. These blocks are usually melted and become assimilated into the magma.
(2) A horst is an upthrown block of the earth's crust bounded by high-angle faults.

TABLE 1 - Geologic history of Sierra Nevada and San Joaquin Valley

ERA	PERIOD	EPOCH	MILLIONS OF YEARS	EVENTS IN SIERRA NEVADA	EVENTS IN SAN JOAQUIN VALLEY	STRATIGRAPHY East Side	STRATIGRAPHY West Side
CENOZOIC	QUATERNARY	Recent	.02	Renewed slight tilting.	Continued deposition of continental sediments.	Young Alluvium	
		Pleistocene	2	Renewed great uplifts and tilting, followed by 3 or 4 periods of glaciation. Extreme canyon cutting to 2,000'--still in progress. Canyon Stage	Continued continental deposition including occasional lake beds.	KERN RIVER SERIES: Old Alluvium (Delano); (Kern River formation	Tulare
	TERTIARY	Pliocene	9	Continued downcutting--slow rate; valleys widened.	Deposition of continental sediments on east side, interrupted by marine Etchegoin during middle Pliocene, and marine deposition in middle and west side throughout.	Etchegoin; Chanac	San Joaquin; Etchegoin; Jacalitos
		MIOCENE Late		Major uplift and tilting by faulting; stream cutting. Sierra assumes present form. Inner Gorge stage of mountain canyons	Sea covered most of valley south of Fresno, except for large alluvial fans at base of Sierra near Bakersfield near end of period.		Reef Ridge
				Volcanic activity--andesitic lavas. Stream courses altered, particularly in northern Sierra.		Santa Margerita	McClure
		MIOCENE Middle		As below	Sea more extensive	Temblor	Temblor
		MIOCENE Early	21	As below	Deposition restricted to shallow marine and continental beds in vicinity of Bakersfield.	Vaqueros (Friant)	Vaqueros
		Oligocene	37	Quiet period; erosion of rhyolites and bedrock.	Seas are restricted; marine deposition on south and west sides.	Walker (?)	Pleito; San Emigdeo; Tumey

SOURCES: Matthes, Francois E. - "Geologic History of Yosemite Valley". U. S. Geol. Survey, Prof. Paper 160. 1930.

Reed, Ralph D. - "Geology of California". American Association of Petroleum Geologists, 1933.

Geologic Formations and Economic Development of Oil and Gas Fields of California, Pt. II, "Geology of California and Occurence of Oil and Gas". California Division of Mines Bulletin 118, 1941.

TABLE 1 - Geologic history of Sierra Nevada and San Joaquin Valley (Continued)

ERA	PERIOD	EPOCH	MILLIONS OF YEARS	EVENTS IN SIERRA NEVADA	EVENTS IN SAN JOAQUIN VALLEY	STRATIGRAPHY East Side	STRATIGRAPHY West Side
CENOZOIC		Late	37	Beginning of intermittent volcanic outbreaks mostly along western edge, and north of area of this report, rhyolitic lavas filled stream channels. Lava flows and erosion periods alternated Sierra intermittently uplifted and tilted to the west.	Deposition in seas of various depths. Shoreline fluctuated several miles east and west of present mountain base.	Ione Walker (?)	Tejon - Kreyenhagen Domengine Maganos Martinez
		EOCENE Early	60	First upwarping--moderate uplift. Topography--the remnants of the Cretaceous mountains, sloping to the sea on the west. Mild humid climate. Broad-Valley stage, continuing to nearly the end of the Miocene.			
MESOZOIC	CRETACEOUS	Late		Period of extensive erosion; region worn down. At beginning of Tertiary only NW-SE ridges of moderate height remain. Most sediments removed by erosion; granite exposed over large areas.	Shallow sea on west side of valley and over Coast ranges.		Asuncion gr. Santa Lucian gr. Pacheco gr. Shasta group
		Early	135				
	JURASSIC			In area north of that here considered, deposition of sands, silts, clays, lime and many volcanics, followed by new upheaval and folding in late Jurassic and complex intrusion of Sierran granitic batholith in latest Jurassic.		Mariposa Amador	Knoxville Franciscan
			175				
	TRIASSIC			Much erosion, then region sank below sea; new series of sediments deposited.		Mineral King beds Kaweah series (?)	
			215				
PALEOZOIC	PERMIAN			Uplifting and folding of great series of shales and sandstones.			
	PENNSYLVANIAN AND OLDER			Sedimentation of clay, silt, sand and lime muds with many volcanics in area of present Sierra, derived from land mass west of present continent and laid down in arm of Pacific Ocean.		Calaveras series	

sediments beneath which are 2, 500 to 4,000 feet of alternate marine and nonmarine deposits which are mostly soft siltstone, sometimes clayey or sandy.

26. Table 1 outlines the geologic history of the Sierra Nevada and San Joaquin Valley since Paleozonic time.

STRATIGRAPHY

27. The Lindsay Cone is underlain by (a) a nonwater-bearing series of rocks and is developed in (b) a water-bearing series of sediments.

28. Nonwater-bearing series. - The nonwater-bearing series comprises the Basement Complex and crops out throughout the foothills and mountains east of the area. These igneous and metamorphosed rocks are relatively impervious and inhibit ground-water recharge and are not further considered. Streams flowing on the Basement Complex lose little or none of their original flow by influent seepage, since downward percolation of the ground water is restricted at the contact between the Basement Complex and the alluvial sediments.(3) The Basement is assumed to be deep enough to have no significant effect upon the ground-water supply and conditions beneath the Lindmore Irrigation District.

29. Late Tertiary and Quaternary water-bearing sediments form a huge wedge, thickest near the western edge of the San Joaquin Valley and thinnest along the mountain front to the east. The generalized stratigraphic sequence is shown in Table 2. For the purpose of this

(3) The marine sediments of Miocene geologic age, which outcrop farther south, have apparently been completely eroded or were never deposited in this area, and the alluvial sediments rest unconformably upon the Basement Complex.

report, the Kern River series has been divided into the lower "Kern River Formation," and an upper portion, "Old Alluvium" (4) or "Delano beds."

30. This water-bearing series, consisting of alluvial fans of Late Tertiary and Quaternary geologic age, form the ground-water reservoir of the Lindsay cone. The Kern River formation has been included in Table 2, although it does not crop out north of Tule River. Possibly the Kern River series represents essentially continuous deposition in the Lindsay cone.

31. The Basement Complex consists of ancient sedimentary and volcanic rocks, now greatly metamorphosed, and the granitic rocks which intruded them. These were involved in the late Jurassic deformation and form a unit that underlies the valley fill at varying depths - probably not less than 1,000 feet below the Lindmore District. On the accompanying geologic map, Plate 2, the granitic rocks are differentiated from the remainder of the Complex.

32. The metamorphosed sedimentary and volcanic rocks comprise the Kaweah series, which were folded and altered at the close of the Jurassic. This series underlies most of the foothills east of the district. The Kaweah series is possibly of Triassic age. The plutonic rocks, ranging from hornblende gabbro to granite, intruded the Kaweah series.

33. Water-bearing series. - The Kern River formation includes all known or suspected local sediments older than the Delano beds. Sediments of the Kern River formation probably occur beneath the area, since they crop out just south of Tule River where they disappear beneath the Old

(4) "Old Alluvium" named "Delano beds" in report on Southern San Joaquin Municipal Utility District.

Alluvium. Aquifers of this formation presumably contribute water to the deeper wells. The lithology is similar to Old Alluvium or Delano beds described below; no means of separating the two by use of water well logs is known at this time.

34. The Delano beds crop out as a belt of varying width between the Tule and Kaweah fans and the foothills. Sediments shown in the accompanying cross-sections belong largely to this sequence, which is the most prominent in the area.

35. The Delano beds consist of fluvial sands, silts, sandy clays, and clays, with a few thin lenses of gravel. The sands are generally arkosic, angular to subangular, friable to loose, poorly sorted and of various shades of reddish-brown, tan and gray. The clay and silt fractions, varying widely in amounts, form the only cementing material observed. They are often deeply stained by iron oxides resulting from weathering, accounting for the common reddish-brown color of the sands. These finer materials are decomposition products which occupy pore spaces between the grains and reduce permeability. Various types of silts form the bulk of the formation and generally are of low permeability. Clays, also, are common in the formation. They are usually brown or reddish-brown. In the clay and silt beds, sand grains of fine, medium, and coarse grades are usually present, as well as scattered granules and small pebbles. The clays and silts are frequently calcareous and consist largely of subangular grains of granitic rocks with minor amounts of metamorphic material. Pebbles larger than 10 mm. are often rather well rounded.

36. The hardpan soils of the San Joaquin, Madera, Exeter [5] and Yokohl series have been developed on the Old Alluvium fans. Brown and

(5) The hardpan underlying the Exeter soil is not properly a part of that formation, but of an older, shallowly buried soil profile.

reddish-brown surface soils are characterized by siliceous and iron-oxide, or by calcareous, hardpans. Slight differences in soil types developed on the Old Alluvium can be attributed to local differences in relief, parent materials, and elevation of the ground-water table. Relief, and excess or deficiency of water, have been the controlling factors in the development of these soils.

37. Soils in the area between the fans of the Kaweah and Tule Rivers along the outer stretches of Lewis Creek are characterized by high saline content and by many subsoil clays and calcareous concentrations. The latter often give rise to lime-cemented hardpans. These are the "Lewis soils," developed where alluviation has not occurred for some time and where there was formerly a high water table due to restricted drainage. Soils of this type are wide-spread along Lewis and Frazier Creeks. They have the same age and parent material (Old Alluvium) as the normal non-saline soils of neighboring areas.

38. Porterville clays occur in a nearly continuous belt of varying width between the Basement Complex outcrops of the foothills and the Old Alluvium of the valley floor. While dominantly clay, there are frequent scattered angular grains of sand and gravel. Locally, boulders of basic igneous rocks up to one foot in diameter are abundant on the surface and throughout the soil mass. The surface horizon is a black to dark chocolate brown adobe, which fractures characteristically on drying. Beneath the dark surface materials the clays become various shades of reddish-brown and are abundantly calcareous in pebbly nodules and stringers, often concentrated in distinct horizons. The Porterville soils represent weathered outwash from the foothills, transported by "creep" and run-off. They veneer the other materials probably to a depth of not over 40 feet; and may still be forming.

39. Young Alluvium forms the fans, flood plains and channels of the present streams. It resembles Old Alluvium, but being younger is not so deeply weathered. As a consequence, heavy subsoils and hardpans have not developed and the materials are generally loose and porous. Sands of various grades predominate. They are usually gray to grayish-brown, and arkosic. Sandy silts occur in the Young Alluvium within the district in the Tule fans and the small fan formerly built by Lewis Creek near Lindsay.

40. Sedimentary material comprising the Delano beds underlies the Young Alluvium. In many places, hardpans developed on the Old Alluvium have not since been eroded and are present beneath the flood plains and fans occupied by Young Alluvium. In the present bed of Yokohl Creek, in sec. 24, T.18S.,R.26E., an iron oxide hardpan of the San Joaquin soil series protrudes through the gravelly stream wash.

GEOLOGIC STRUCTURE

41. Water-bearing series of the Lindsay Cone. - Sediments of the Lindsay cone were built by deposition from Kaweah and Tule Rivers, with minor assistance from Lewis Creek. Judging by the predominance of fine silts, silty clays, and sandy silts within the area considered, the original slopes of the Kaweah and Tule River fans were gentle and deposition sufficiently slow to allow complete weathering and breaking up of coarser materials. Each constituent alluvial fan of the piedmont had its own set of built-in aquifers, elongate and radiating from its canyon mouth in rude beds approximately parallel to the surface of the fan. Cross-bedding, excessive textural variation, and discontinuous layering of sand lenses of varying thickness are characteristic. The cross-sections, Plates 6, 7, 8, 9, 10, and 11 are intended to show

TABLE 2 - Generalized stratigraphy of water-bearing series
Lindsay-Strathmore-Lindmore ground-water unit

~~Age~~ Period	Epoch	Geologic formation	Description
Quaternary	Recent	Hill wash	Mainly clay with scattered angular grains of sand and gravel. Locally, boulders of basic igneous rocks to 1 ft., found in abundance. Clay, various shades of brown, highly calcareous.
		Young alluvium	Loose, porous, unconsolidated sediments derived from granite rocks; sands of various sizes predominate with a high percentage of silt.
	Upper Pleistocene	Old alluvium or Delano beds	Arkosic sand, angular to subangular, poorly sorted various shades of reddish-brown, tan and gray. Clay and silt present in varying amounts. Local unconformity?
Tertiary	Pliocene	Kern River formation	

trends and the proportion of permeable and relatively impermeable layers. It is not possible to correlate individual beds, but groups of beds or lenses can be correlated for some distance. The cross-sections illustrate the lenticular character of the deposits and the principal aquifers. The aquifers are sandwiched between less permeable materials, of clays, sandy clays, silts, and sandy silts, that permit a slow, steady migration of ground water from sand lens to sand lens. No impervious sediments that would act as absolute ground-water barriers are known to exist within the Lindmore District. The geologic sections illustrate the structure as explained above and are separately discussed below.

42. Plate 6. - Plate 6 is a north-south cross-section showing general position of the sand lenses, areas of high and low specific yield, and areas where the Young Alluvium rests upon the Old Alluvium. Here the decreasing specific yield from Tule River northward and from Kaweah River southward is clearly demonstrated. The surface breaks of the Young Alluvium are barely noticeable, suggesting that the sediment forms only a thin layer over the Old Alluvium. The section indicates that specific yield percentages will be higher below the 1946 ground-water level than those which appear on Plate 3.

43. Drillers' and geologists' well logs do not indicate any completely impervious barriers that would stop the flow of ground water. The difference in elevation between water tables of 1921 and 1946 indicates drawdown in the cone of water-table depression in the plane of this cross-section in 26 years of irrigation water use. Distance from the recharge areas, low specific yield, and a crop pattern demanding large supplies of water are the three principal factors that have produced the cone of water-table depression.

44. Lewis Creek occupies the topographic low of the interfan area. The fans of the two rivers would be expected to overlap one another erratically at depth, because of past varying flood conditions, sediment load, and the directions of flood-flows during deposition.

45. Plate 7. - The north-south geologic cross-section shows the drawdown in the deepest part of the cone of pumping depression and clearly demonstrates the value of this type of section for comparison of the permeable and relatively impermeable sediments. At depth the cone is almost lacking in sands where clays, silts, sandy clays, and sandy silts predominate. The comparatively low storage capacity of the area combined with slow recharge and heavy irrigation requirement are again clearly indicated as the three major factors that have combined to accentuate the cone of water-table depression.

46. Plate 8. - This north-south cross-section shows a buried ridge of the basement complex which restricts ground-water flow from Tule River. Plate 4 shows that this basement ridge affects only that small portion (1,920 acres) of the Lindmore District, east of the Southern Pacific railroad. This area is poorly situated for recharge except from Frazier Creek, which has an average annual run-off of 900 acre-feet. South of the buried ridge, presence of numerous beds of sand and gravel to depths of 100 feet in sections 26, 27, and 34 indicate former active deposition by Tule River.

47. Plate 9. - This east-west cross-section illustrates the northern part of the cone of water-table depression. As the area of deeper ground water is approached from the west, the proportion of coarser sediments, and hence the ground storage capacity, steadily decreases. The surface of the basement complex dips approximately 150 feet per mile at this point. In contrast, the sediments dip 10 to 15 feet per mile.

48. Plate 10. - This east-west geologic cross-section transects the southern part of the cone. Sand and gravel predominate towards the west due to proximity of Porter Slough. Specific yields decrease steadily eastward to a low of 4 percent near the basement complex outcrops. The section suggests that the former Tule River distributaries responsible for the coarser sediments to the west, at no time swung northerly against the foothills. The finer sediments of the eastern portion of the section are of interfan character.

49. Plate 11. - This east-west cross-section passes through the deepest part of the cone. The specific yield varies between 4 and 6 percent in the area of the greatest pumping drawdown. Clays, silts, and sandy clays predominate.

SPECIFIC YIELD

50. Available determinative methods. - In order to establish storage capacity of the underground reservoir, it is necessary to determine specific yield of the sediments. O. E. Meinzer (6) has outlined seven methods of estimating this property. All seven methods require extensive field study and the use of specialized laboratory equipment. The Bureau of Reclamation is not at present equipped or staffed to utilize any of these methods with sufficient accuracy to obtain worthwhile results. Therefore, it has been necessary to apply the results of investigations in other areas to the local problem.

51. One such investigation was carried on in the Mokelumne area, 115 miles to the northwest, by Piper and others. (7) Numerous tests

(6) O. E. Meinzer, The Occurrence of Groundwater in the United States, with a Discussion of Principles: U. S. Geol. Survey Water Supply Paper 489, pp 67 - 76; 1923.

(7) Piper, A. M.; Gale, H. S.; Thomas, H. E.; Robinson, T. W.; Geology and Groundwater Hydrology of the Mokelumne Area, California: U. S. Geol. Survey Water Supply Paper 780, 1939.

were made by measuring the volume of material saturated and unwatered by the addition and withdrawal of measured volumes of water from columns of undisturbed soil and also by determining the difference between porosity and specific retention of samples of undisturbed material after drainage for periods as long as 390 days. The average specific yield resulting from both of the above methods were as follows:

Material	Percent
Gravel and coarse sand	34.8
Medium and fine sand	24.2
Sandy silt	7.5
Fine sandy silt	5.8
Very fine sand, silt and clay	4.2
Clay, impermeable	2.9

52. A second investigation was carried on in the South Coastal Basin by the California Division of Water Resources.(8) Methods used were similar to those used in the Mokelumne area. Since the results obtained in two such widely separated areas are comparable, it may be assumed that specific yield is a function of the grain size and sorting of the sediment. Therefore, it seems justifiable to apply the specific yield values obtained in the Mokelumne area to similar sediments farther south.

53. Methods used in this study. - Specific yield of the groundwater reservoir was estimated by segregating into one of the six classifications of materials mentioned, all of the sediments recorded in each water well log, either between depths of water surfaces in the

(8) Geology and Groundwater Storage Capacity of Valley Fill: State of California, Division of Water Resources, Bul. 45, 1934.

fall of 1946 and in the fall of 1921, or, where that interval was too small to be used, from the surface to a depth of 50 feet. The footage of each type of material in a well was reduced to feet-per-hundred and multiplied by the respective specific yields assigned to the different grades of materials. The sum of these weighted figures gives an estimate of specific yield for the portion of the hole under consideration.

54. Specific yields figured from sediment percentages of individual wells varied considerably because of the erratic occurrence of the sediments and of inconsistence in the drillers' descriptions. In order to obtain a synoptic specific yield map, all wells after plotting were combined into natural (proximity) groups of two to ten and an average specific yield of each group was determined. This value was then used at the center of the group in drawing specific yield contours. Average specific yield for any desired area can be determined by planimetering the contours.

55. It is emphasized that specific yield figures in this report are based on correlations of sediment texture and specific yield made in another area. While it seems justifiable to apply these correlations to similar sediments here, it cannot be said with certainty that the figures are accurate. A further contribution to inaccuracy is the nature of the drillers' logs of water wells, in which depths are approximate and terminology inaccurate. Accurate specific yield determinations can be based only on local exhaustive tests of sediments. Results obtained by the method used herein agree well with results obtained by groundwater inventory in the Lindmore Irrigation District.

56. Discussion of results. - Specific yield contours are shown on Plate 3. Average specific yield for the Lindmore District is 7.4

percent, for the portion of the Lindsay cone outside the district 8.4 percent, and for the entire cone 8.1 percent. Areas of low specific yield are concentrated in the Lindmore and Lindsay-Strathmore Irrigation Districts, which unfortunately roughly coincide with an interfan area where fine grained sediments, sandy silt, silts, and clays, would be expected. Higher specific yields are found near the Kaweah and Tule Rivers.

SOURCES OF GROUND WATER AND DIRECTIONS OF FLOW

57. Sources of ground water. - The principal ground water sources of the Lindmore cone, from north to south:

Stream	Average annual run-off Ac.-ft.
Kaweah River	403,000
Yokohl Creek	9,000
Lewis Creek	2,000
Frazier Creek	900
Tule River	139,000

The tabulated run-off figures indicate that the beds of Tule and Kaweah Rivers are the principal intake areas for ground water in this district.

58. The Lindmore District is situated within the inter-fan area of the Kaweah and Tule Rivers. Its northern section is supplied with underground water from the Old Alluvium of the southern portion of the Kaweah River fan. Its southern section is similarly supplied from the Old Alluvium of the northern part of the Tule River fan. Plate 3 demonstrates a progressive decrease in specific yield percentage southward from Kaweah River and northward from Tule River. The resulting zone of minimum values coincides, roughly, with the cone of water-table depression, underlying the Lindsay-Strathmore and Lindmore Irrigation Districts (Plate 4). Progressive lowering of specific yield southward from the

Kaweah and northward from the Tule is modified somewhat by local sands and gravels deposited by Yokohl, Lewis, and Frazier Creeks.

59. The areas of influence of Kaweah and Tule Rivers and Lewis, Yokohl, and Frazier Creeks can be seen by the direction of the water-table contours. Ground waters of northern and southern derivation meet in sections 34, 35 and 36 of T.20 S, R.25 E., and sections 13, 23, 27, 28, 32 and 31 of T.20 S., R.26 E.

60. For approximately 7 miles downstream from McKay Point the channel and diversion ditches of Kaweah River contribute to the ground water of the Lindsay cone, by southward and eastward migration. This ground water from the Kaweah intermingles with the water that has Yokohl Creek at its source.

61. For approximately 12 miles westerly from sec. 36, T.21 S., R.27 E., the Tule River channel recharges the underground reservoir. Apparently equal amounts of water migrate to north and south. Influence of Tule River on the present water table is shown by the slope of the water table north, northwest, and northeast from the river in Plate 4. In sediments below present heavy pumping depth, seepage from the Tule may well be effective much farther to the north into the belt in which the Tule and Kaweah fans intertongue.

62. Lewis Creek probably contributes water to the underground reservoir, although this is not suggested by Plate 4. Paucity of control points may be sufficient explanation for the apparent absence of a ground-water ridge under Lewis Creek. A little water is contributed to the underground supply by Frazier Creek.

63. The inner area enclosed by the ground-water divide west of the cone has apparently been a closed basin for over 25 years, during which

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63. The inner area enclosed by the ground-water divide west of the cone has apparently been a closed basin for over 25 years, during which

there has been no disposal of entering water except by irrigation and evaporation. All salts carried by waters migrating into this closed basin are still there. The cone of water-table depression should be built up to reinstitute normal westward migration so as to keep salt concentration low.

64. The cone is not likely to spread farther north or south, but is currently extending itself to the southwest as shown by a "tear-drop" outline on that side. Low specific yield and distance from recharge determine the shape of growth of the cone.

65. Plate 5 shows the relation of irrigation demand and specific yield to ground-water elevation. The most striking feature of this map is the location of the bottom of the ground-water cone. Tables 1A and 1B of the preliminary ground-water report (9) indicate that Kaweah River contributes about 44,320 acre-feet annually to the total water supply of the cone, while Tule River contributes 34,980 acre-feet. However, the Kaweah supplies water for an area of 130 sections with average irrigation requirement of 1.9 acre-feet per acre per year, while the Tule supplies an area of 68 sections with average requirement of 2.02 acre-feet. Thus the Kaweah supplies less than one and one-half times as much water as the Tule to meet approximately twice the demand. It would appear, therefore, that the bottom of the cone of depression should be considerably further north than it is. The only apparent explanation for the present location of the bottom is the fact that the specific yield in the Kaweah unit is higher than that near the base of the cone. Therefore, more water can be withdrawn from storage without much deepening of the water

(9) Preliminary Report, Lindmore Irrigation District Water Supply, Visalia, Calif., June 13, 1947

table. The surface supply provided by the two rivers to the area is about equal and therefore does not have much effect on the problem.

66. The general shape of this cone for the next two to three years can be predicted from a study of Plate 5. The areas of northern and southern influence of the cone have comparable pumping demands, fairly high specific yields and good sources of recharge from the Kaweah and Tule Rivers, respectively. The area of southwestern influence of the cone has a low pumping demand but a generally low specific yield and is poorly situated for recharge. It is apparent that the cone is now enlarging in this direction. If the present pumping demand within the area of influence continues for the next two to three years, the cone will inevitably continue to steepen and extend toward the southwest. The northern, northwestern, and southern margins will probably remain in their present positions for some time.

67. Perched water tables and confined water zones. - In some local areas perched water tables are present, but downward percolation is not absolutely prevented. The specific yield of the sediments directly affects fluctuations of the water table. It is within the cone of water-table depression, where specific yield is the lowest and irrigation requirement the greatest, (Plate 5), that temporarily perched water tables occur. Low storage capacity of the sediments and high pumping demand combine to lower the water level in and near wells. Adjacent saturated sediments are then unwatered, both by cascading down wells and by slow percolation through relatively tight sediments. This drainage may take some time, but actual water contact between the perched zone and free water table is never lost.

68. Water table determination within the cone of depression is unsatisfactory. The "high" measurement in February or March is made before downward seasonal percolation has fully drained the surficial layers. Measurements made during the seasonal low are not accurate because of the cone of depression developed around each well. Thus the "replenishment" indicated by the fluctuations between seasonal "highs" and "lows" is in part caused by drainage from the area outside of the cone of depression into those areas after seasonal pumping has ceased.

69. Even when the above errors are considered, the annual replenishment to the cone seems to be proportional to the total flow of the Kaweah and Tule Rivers of the same year. This indicates a migration of water from the rivers to the bottom of the cone within a period of four months. Such a rapid migration cannot be entirely explained by simple movement migration down the ground-water slope. The usual explanation for such a phenomenon would be transfer by artesian pressure. This requires confined aquifers. Such confined zones would have to have a stratum of very high permeability confined by impermeable beds. The evidence at hand indicates that such aquifers do not exist.

70. It appears, therefore, that water transfer takes place by a combination of migration down the ground-water slope and by the action of slight pressure effects through "semi-confined strata". By semi-confined is meant a system of permeable lenses and "shoestrings" with interrupted and devious continuity, in a poorly permeable to permeable mass of sediments.

71. Typical well characteristics as shown on hydrographs in the district depend upon the nature of the sediments and the degree and continuity of over-pumping. Both total movement of the water table and its

rate of rise and fall are greatest near the bottom of the cone, and least near the streams. (10) Thus, the water level drops quickly when a large water demand is made upon sediments of low specific yield. As an example, the hydrographs of well 20-26-12B (11) show that a large pumping demand in the latter part of April 1946 caused a sharp drop in water level, lasting until the latter part of May. Probably as great a demand continued until the middle of September, but the rate of fall of water level diminished sharply after the first month. The initial drop was caused by the drawing down of the water level in the conduit and slow inflow in an area of low specific yield. After the first sharp drop, the adjacent, poorly permeable sediments began to drain, holding the dropping water level at a fairly smooth gradient for four months. Cessation of pumping in September and October resulted in a sharp upward gradient since all water draining from the sediments contributed directly to the rise in water level. There are possibly some confined zones within the Lindmore Irrigation District, but there are no wells of sufficient depth to prove the existence of a large confined zone of ground water.

ARTIFICIAL REPLENISHMENT - ABSORPTIVE AREAS

72. Any attempt at spreading water for storage underground by the use of basins, furrows or ditches, or by flooding, should be limited to areas of loose, porous, open-textured soils. Such soils occur in the Lindmore Irrigation District only on the recent alluvial fans of Lewis Creek, Frazier Creek, and the Tule River. Outside the district, the Kaweah fan offers similar possibilities. Spreading by the Lindmore District on either the Tule or Kaweah fans is not feasible because of the large amount of water that would be lost to the district.

(10) Preliminary Report, Lindmore Irrigation District Water Supply, Visalia, California, June 13, 1947, p 15.
(11) Idem. Typical Well Hydrographs, following p 15.

73. Tule River fan. - Water spread on the Tule River fan in sections 28, 32, 33, 34, 35, T.20 S., R.26 E., and sections 1, 2, 3, T.21 S., R.26 E. (Plate 2), would eventually migrate into the deeper part of the cone of water-table depression. However, migration would be slow through the tight sediments which characterize the cone. Here the principal disadvantages of artificial recharge are the small area available for spreading, the distance from the main cone, and the low permeability of the sediments through which the water would have to migrate. The disadvantages of using this area for spreading water for storage underground far outweigh the advantages, and its use for that purpose is not recommended.

74. Frazier Creek fan. - Most of the alluvial fan of Frazier Creek lies east of and above the Friant-Kern canal location (Plate 2). The portion of the fan that lies below the canal is small and apparently covers the Old Alluvium with a thin layer of porous soils. The surface soil of the area is favorable, but the geological structure, surface drainage, location, and size of the area make it unsuitable for water spreading.

75. Lewis Creek fans. - The recent alluvial fan of Lewis Creek (Plate 2) is the largest in the Lindmore District, and most of it lies below the line of the Friant-Kern canal. The most recent part, approximately 2½ square miles in extent, surrounds the town of Lindsay, and is centered over the deepest part of the cone. Citrus fruit yields here are among the highest in the area. The location, cost of land, topography, and small area covered preclude any possibility of any large scale spreading operation by the basin, furrow or ditch, or flooding methods.

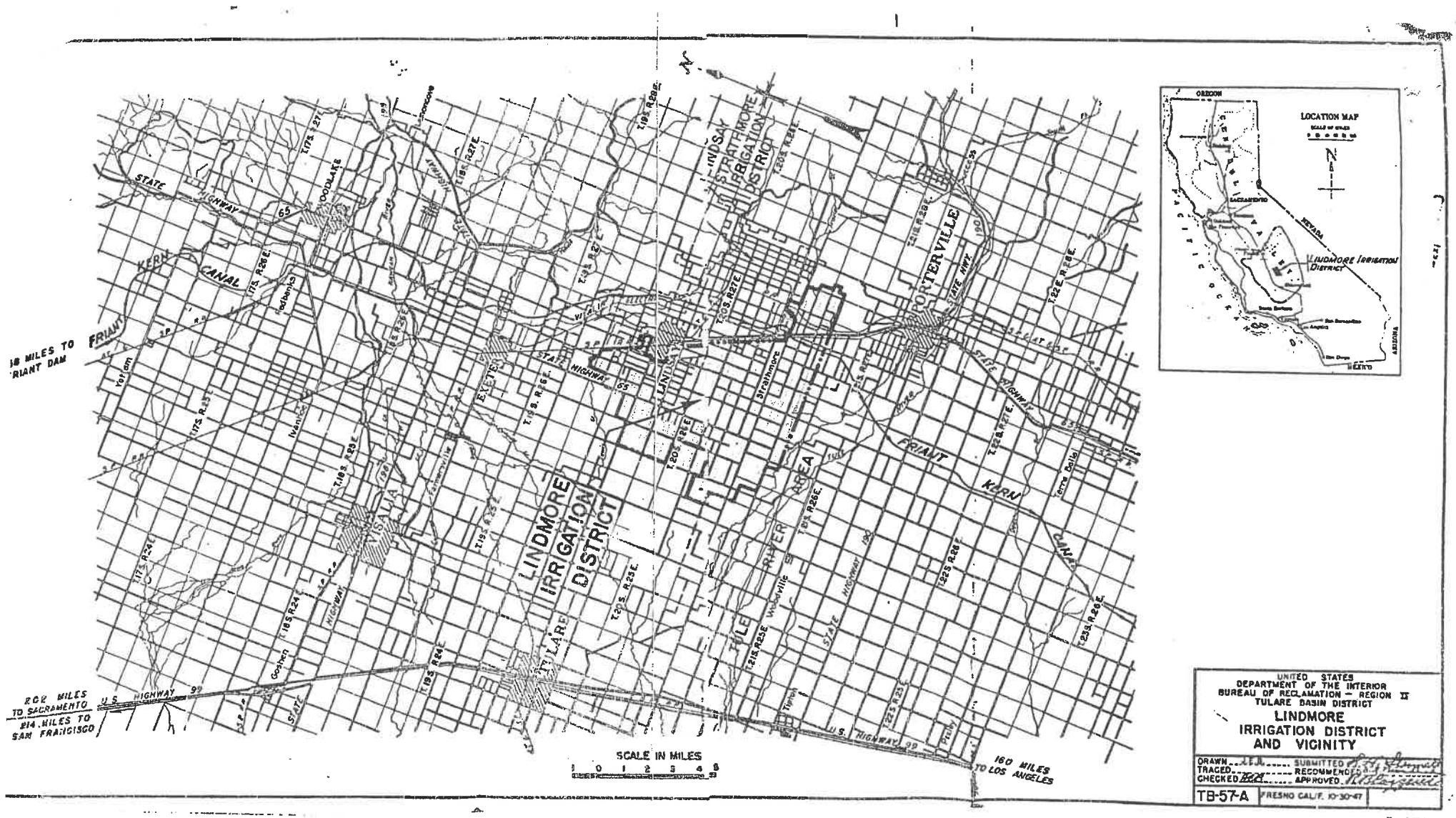
76. It is possible that most of the Young Alluvium in this area is underlain by the hardpan of the Exeter, Madera, and San Joaquin soil series. If so, free downward movement of percolating water must be restricted, and the upper surface soils, which are in the root zone of citrus groves, would, if water were locally spread, tend to become partially saturated. Thus, no large addition of water to the underground reservoir should be attempted, except in areas where the hardpan is not present or is sufficiently cracked to allow the downward movement of percolating water.

77. Other areas for spreading water. - All other areas within the Lindmore District are underlain by San Joaquin, Madera, and Exeter soil series. The impervious nature of their characteristic hardpan layer necessitates a careful study before any large scale water spreading is started. Danger of permanent damage to citrus groves and other crops caused by a saturated surface condition is always present where this hardpan layer is found. Water spreading by the basin, furrow or ditch, or flooding methods cannot be practiced, unless a careful experimental drilling program shows that the hardpan layer does not exist or is found to be discontinuous and sufficiently cracked to allow free movement of water between the ground surface and the underground water reservoir.

78. Other methods of spreading water for storage underground. - Pits and shafts are not widely used for spreading water, but in the Lindmore District no other large scale method is possible without an extensive exploratory drilling program, as noted in the preceding paragraph.

79. A high percolation rate could possibly be obtained in pits or wells in the Old Alluvium, but because of the limited surface areas wetted, relatively little water could be spread by this method. Although

initial cost and upkeep are high in recharge pits and shafts, possible crop damage due to saturated surface conditions would be avoided. If suitable areas for other methods cannot be found, the pit, shaft or well method should be considered as a possibility for recharge of underground storage in the Lindmore Irrigation District. It was applied successfully in the Lindsay-Strathmore Irrigation District when water was introduced through existing water wells in the spring of 1926. Another possibility for disposal of second class water is the method of spreading underground by over-irrigation. Areas where the hardpan is sufficiently pervious to allow deep percolation would be suitable for local spreading by this method.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION — REGION II
TULARE BASIN DISTRICT

LINDMORE IRRIGATION DISTRICT AND VICINITY

DRAWN ..... SUBMITTED .....
TRACED ..... RECOMMENDED .....
CHECKED ..... APPROVED .....

TB-57-A | FRESNO CALIF. 10-30-47

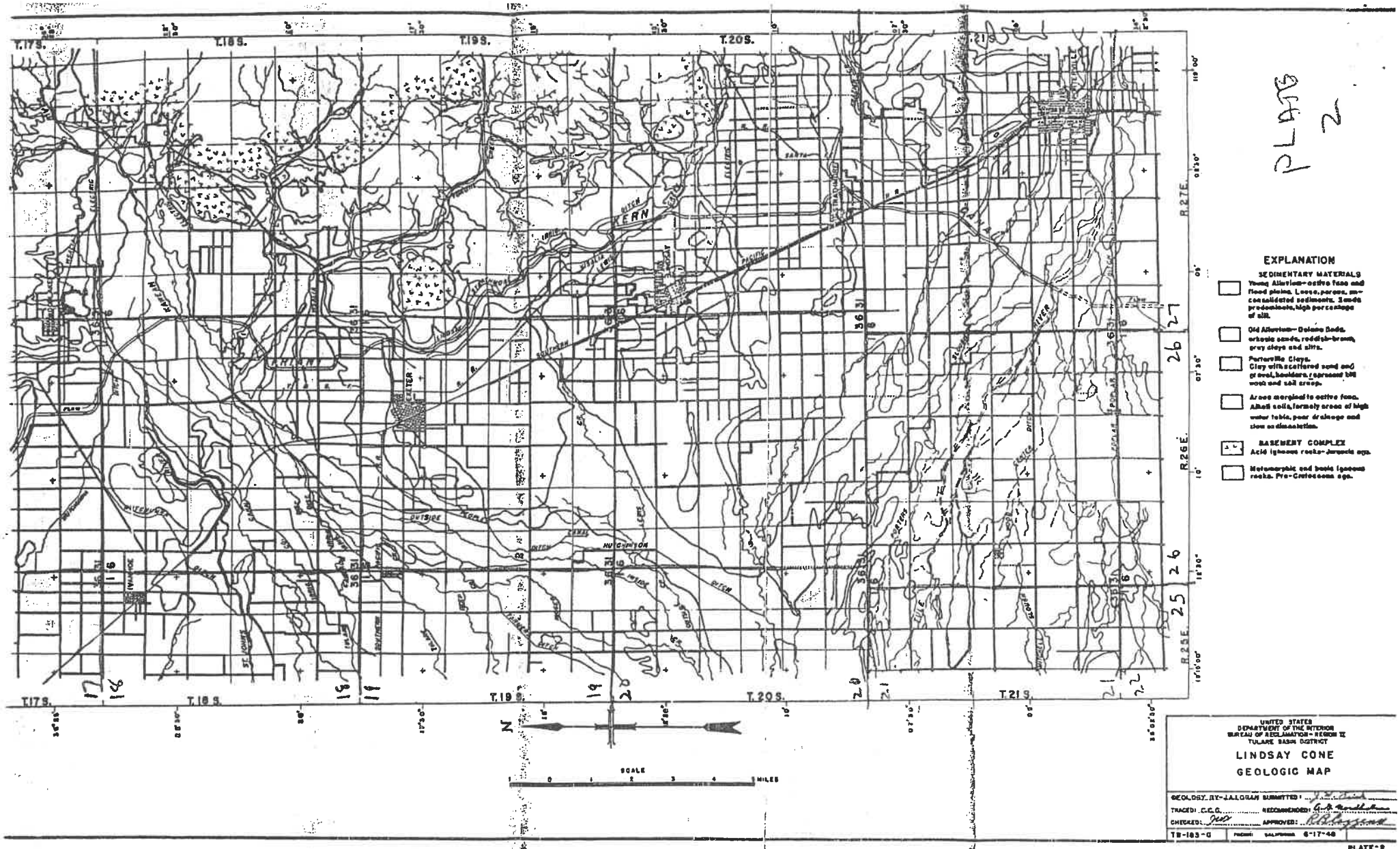

T.17S.
T.18S.
T.19S.
T.20S.
T.21S.
R.27E.
R.26E.
R.25E.
KERN
KHIANT
EXETER
HUTCHINSON
OUTSIDE
DITCH
CANAL
SCALE
MILES
N
EXPLANATION
SEDIMENTARY MATERIALS
Young Alluvium—active fans and flood plains. Loose, porous, unconsolidated sediments. Sands predominate, high percentage of silt.
Old Alluvium—Delano Beds, arkosic sands, reddish-brown, gray clays and silts.
Porterville Clays. Clay with scattered sand and gravel, boulders, represent bill wash and soil creep.
Areas marginal to active fans. Alkali soils, formely areas of high water table, poor drainage and slow sedimentation.
BASEMENT COMPLEX
Acid igneous rocks—Jurassic age.
Metamorphic and basic igneous rocks. Pre-Cretaceous age.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION—REGION II
TULARE BASIN DISTRICT
LINDSAY CONE
GEOLOGIC MAP
GEOLOGY BY—J.A.LOGAN SUBMITTED:
TRACED: C.C.G. RECOMMENDED:
CHECKED: APPROVED:
TB-183-G
6-17-48
PLATE-2

PLATE 2

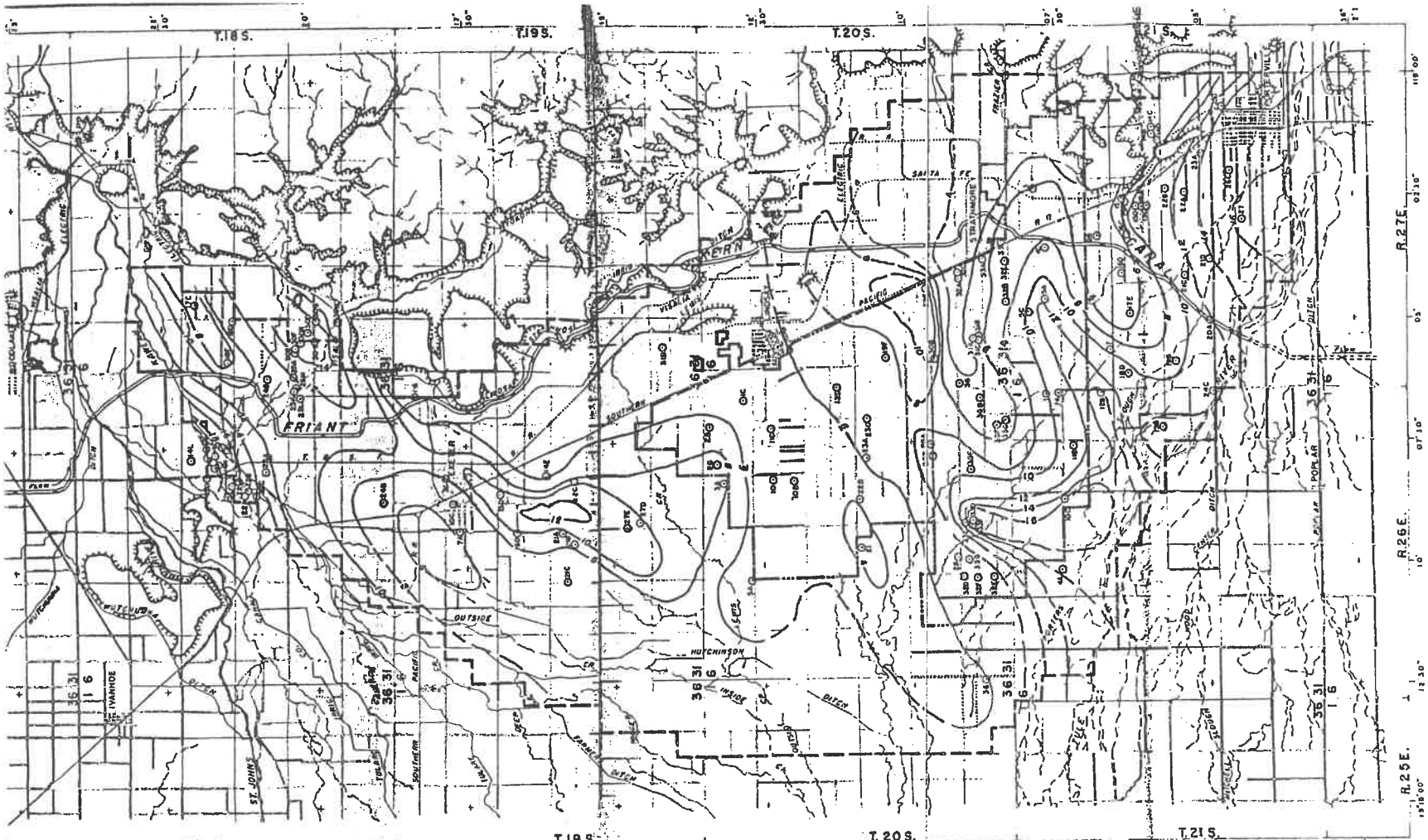


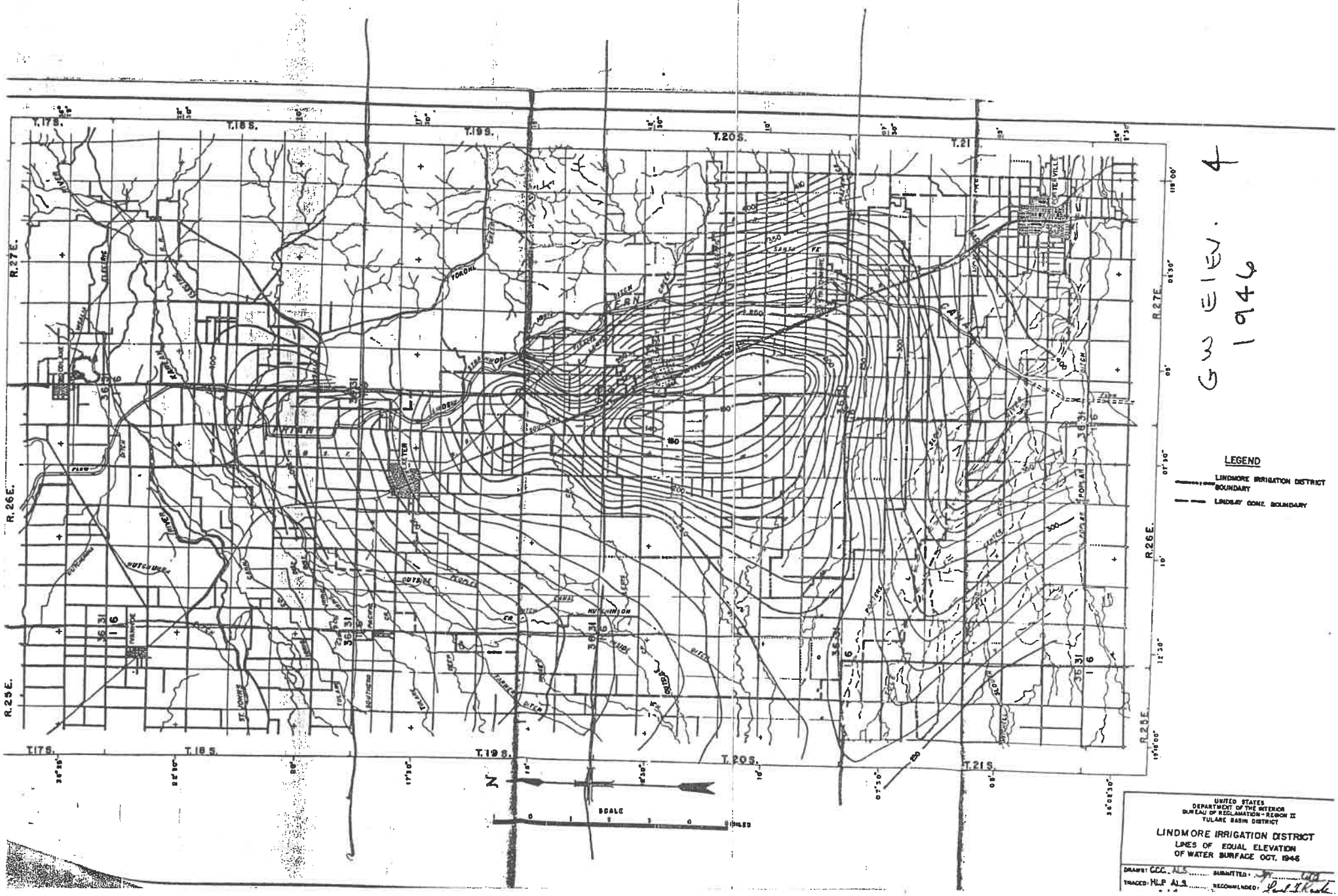
PLATE 3

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION II
TULARE BASIN DISTRICT

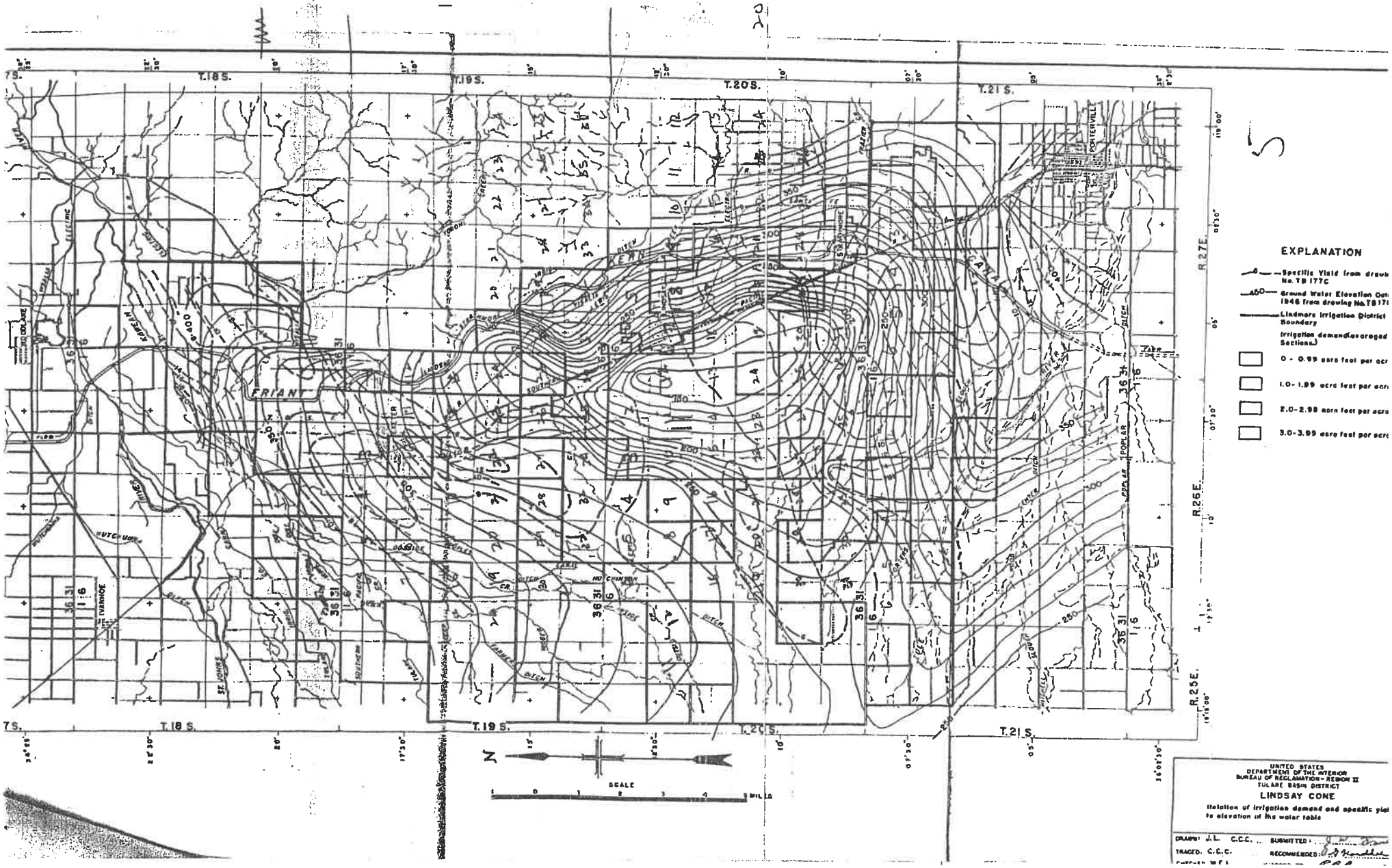
LINDSAY CONE
SPECIFIC YIELD CONTOURS
ZONE OF GROUNDWATER FLUCTUATIONS
1921-1946

DRAWN: J.A.L. — C.C.C.	SUBMITTED:		
TRACED: C.C.C.	RECOMMENDED:		
CHECKED:	APPROVED		
TB 177-C		6-9-48	

PLATE-3



GW ELEV. 4
1946



T.18 S.
T.19 S.
T.20 S.
T.21 S.
R.27 E.
R.26 E.
R.25 E.
FRIANT
PORTERVILLE
IVANHOE
POPLAR
EXPLANATION
Specific Yield from drawi No. TB 177C
Ground Water Elevation Oct 1946 from drawing No. TB 17
Lindmore Irrigation District Boundary
(Irrigation demand (averaged Sections.)
0 - 0.99 acre feet per acr
1.0 - 1.99 acre feet per acr
2.0 - 2.99 acre feet per acre
3.0 - 3.99 acre feet per acre
SCALE
MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION II
TULARE BASIN DISTRICT
LINDSAY CONE
Relation of irrigation demand and specific yie to elevation of the water table
DRAWN: J.L. C.C.C.
SUBMITTED:
TRACED: C.C.C.
RECOMMENDED:

South

North

T19S | T20S

Woodville Quad. | Cairns Corner Quad.

T20S | T19S

Cairns Corner Quad. | Exeter Quad.

LINDMORE IRRIGATION DISTRICT

SPECIFIC YIELD 14% 12% 10% 8% 8% 8% 8% 8%

21-25-13B (Geol.) 1.25mi E. TULE RIVER

21-25-11B (Geol.) 0.25mi E.

21-25-10C (Geol.) 0.00?mi E.

20-25-35E (Geol.) 0.06mi E.

20-25-26A (Geol.) 0.50mi E.

20-25-23A (Geol.) 0.21mi E.

20-25-22R (Geol.) 0.31mi W.

20-25-10A (Geol.) 0.33mi W.

20-25-10 (Geol.) 0.10mi W.

20-25-9A (Geol.) 0.14mi W.

20-25-8R (Geol.) 0.28mi E.

350 300 250 200 150 100

300 250 200 150 100 50 Sea Level -50 -100 -150 -200 -250

1921 Water Level

Water at October 1946

R23E R24E R25E

VISALIA

T19S T19S

T20S T21S

LINDSAY

TULE

Miles

HORIZONTAL SCALE

VERTICAL SCALE

50 0 50 100 200 Feet

Datum Line, Borden Rs. 100.4

GEOLOGIC CROSS SECTION LOOKING WEST

EXPLANATION

20-25-10 (Geol.) 0.10mi E. — Well sampled by Geologist

Distance of well from line of Section

Well Number

Gravel (Very Permeable)

Sand (Permeable)

Silt (Relatively Permeable)

Sandy Clay (of drillers: silt, sandy silt or very fine sand - Relatively Permeable)

Clay (Relatively Impermeable)

This profile was prepared from well logs which were either copies from the records of drillers or made by geologist from samples taken from drillers. The accuracy of the logs varies with the individual drillers and is often open to considerable question. Thus conspicuous and rapid changes in sediment character from well to well along the profile are in part caused by, i.e., due to ignorance and inaccuracy during description. To the inconsistencies extent they are merely a result of inconsistencies - one of descriptive terms by the several drillers.

The 1921 water levels were taken from the California Department of Public Works Groundwater map for that year, and the 1946 water levels were taken from a map by The Bureau of Reclamation.

John Logan

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION 2
TULARE BASIN DISTRICT

"LINDMORE IRRIGATION DISTRICT
Geologic Cross Section two miles West of 25E Range Line

DRAWN: A.A.L. C.C.C. SUBMITTED:
TRACED: C.C.C. RECOMMENDED:
CHECKED: W.F. APPROVED:
T.B. 1003 C FRESNO CALIFORNIA 3-27-47

South

North

T19S

Corns Corner Quad.

T19S | T18S

Exeter Quad.

L.I.D.

Lewis Creek

19-26-27C(Geol)
19-26-27E
.34mi.W.

19-26-22E
.34mi.W.

19-26-22D(Geol)
.32mi.W.

19-25-14E
.01mi.W.

19-25-15D
.25mi.

19-25-3C(Geol)
.01mi.W.

19-25-2AA(Geol)
.34mi.W.

19-25-34C(Geol)
.31mi.W.

19-25-34A(Geol)
.12mi.W.

Old Channel Kaweah River

19-24-7E(Geol)

19-24-2D(Geol)

Private Well

19-24-2E
.12mi.W.

19-24-1C
.12mi.W.

19-24-1E(Geol)
.12mi.W.

Kaweah River

19-24-1A(Geol)
.12mi.W.

Lone Willow

Rancho De Kaweah

Water Level 1923

Water Level October 1945

300
250
200
150
100
50
Sea Level
-50
-100

350
300
250
200
150

Refer to Line Drawing No. T31003C

GEOLOGIC CROSS SECTION LOOKING WEST

Horizontal Scale
1/2 0 Miles

Vertical Scale
50 0 100 150 Feet

VISALIA

Exeter

Lindsay

T18S
T19S

T19S
T20S

T20S
T21S

R25E
R26E
R27E

0 1 2 3 4 5 6 Miles

EXPLANATION

Well sampled by Geologist

19-26-22E
.34mi.W.

Distance of well from line of Section

Well Number

Gravel (Very Permeable)

Sand (Permeable)

Silt (Relatively Permeable)

Sandy Clay (of drillers a silt, sandy silt or very fine sand - Relatively Permeable)

Clay (Relatively Impermeable)

This profile was prepared from well logs which were either compiled from the records of drillers or made by geologist from samples obtained from drillers. The accuracy of the logs varies with the individual drillers and is often open to considerable question. Thin strata and rapid changes in sediment character from well to well along the profile are also in part actual, i.e., due to heaving and channeling during deposition. These indeterminate factors may be merely a result of inconsistencies in use of descriptive terms by the several drillers.

The 1923 water levels were taken from the California Department of Public Works Groundwater map for that year, and the 1945 water levels were taken from a map by The Bureau of Reclamation.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION 2
TULARE BASIN DISTRICT

LINDMORE IRRIGATION DISTRICT

Geologic Cross Section Two miles East of 26E - Range Line

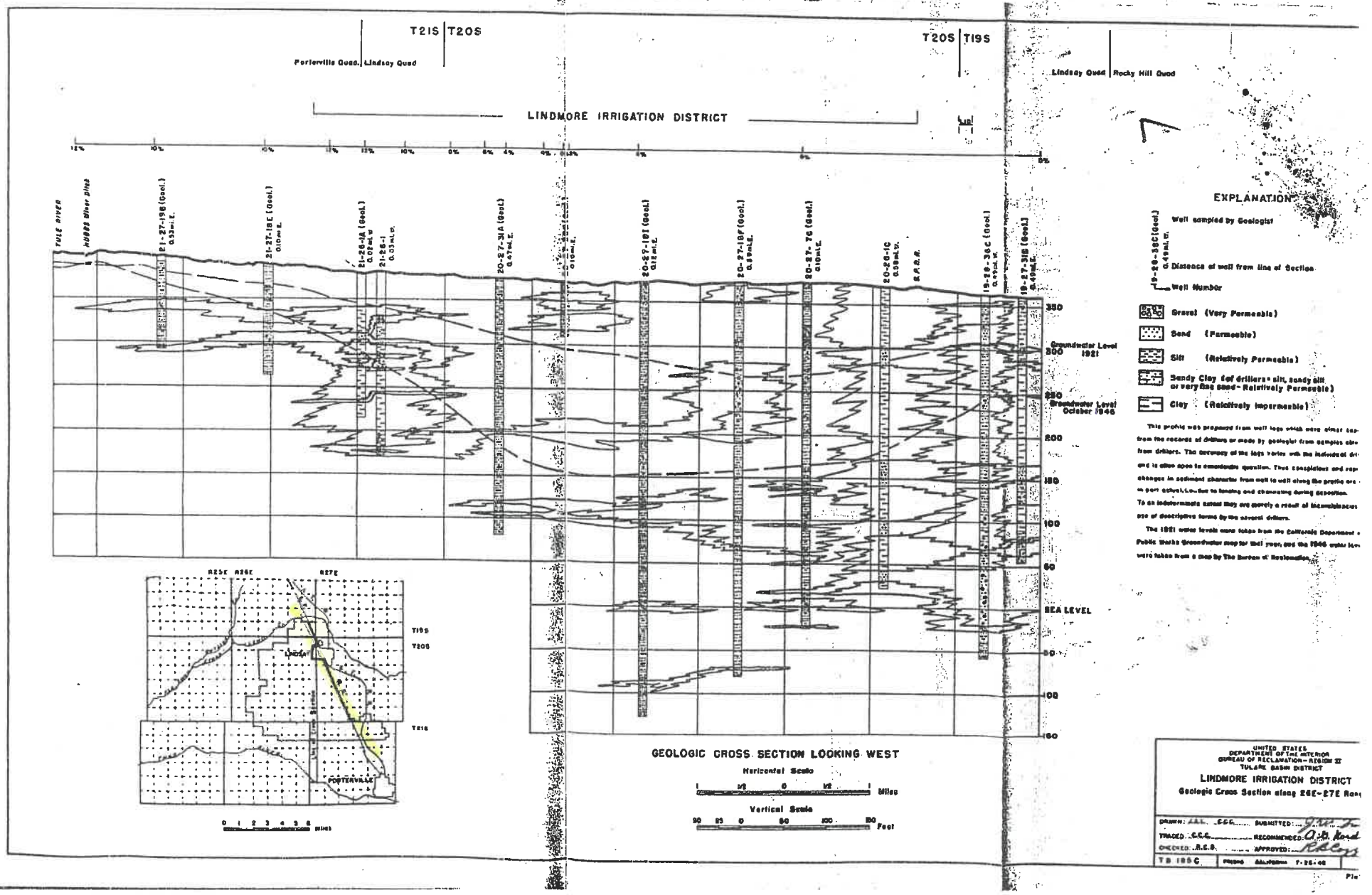
DRAWN: L.A.L. TRACED: S.E.P. SUBMITTED: J. W. Z.
CHECKED: JWZ APPROVED: C.A.C.
T.S. 10004 C DATE COMPLETED: 8-10-48

PL.6

66

SE

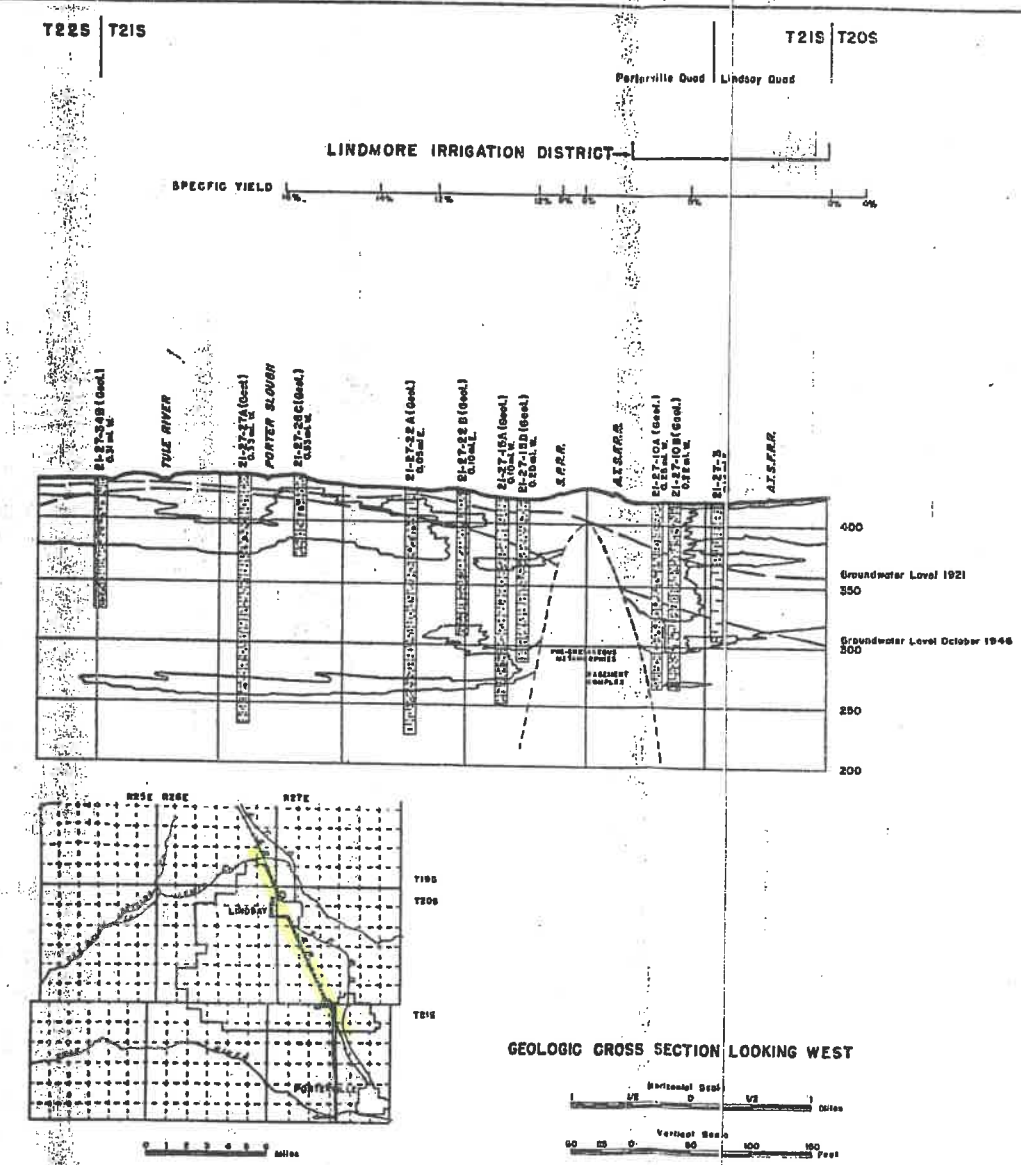
NW



T21S | T20S
Porterville Quad. | Lindsay Quad
T20S | T19S
Lindsay Quad | Rocky Hill Quad
LINDMORE IRRIGATION DISTRICT
TULE RIVER
HUBBS Minor Ditch
21-27-19B (Geol.)
21-27-18E (Geol.)
21-26-1A (Geol.)
21-26-1
20-27-31A (Geol.)
20-27-18I (Geol.)
20-27-18F (Geol.)
20-27-7C (Geol.)
20-26-1C
19-26-36C (Geol.)
19-27-31B (Geol.)
Groundwater Level 1921
Groundwater Level October 1946
SEA LEVEL
EXPLANATION
Well sampled by Geologist
Distance of well from line of Section
Well Number
Gravel (Very Permeable)
Sand (Permeable)
Silt (Relatively Permeable)
Sandy Clay (of drillers = silt, sandy silt or very fine sand - Relatively Permeable)
Clay (Relatively Impermeable)
This profile was prepared from well logs which were almost ... from the records of drillers or made by geologist from samples ... from drillers. The accuracy of the logs varies with the individual dri... and is often open to considerable question. Thus completions and ... changes in sediment character from well to well along the profile are ... in part actual, i.e., due to lensing and channeling during deposition. To an indeterminate extent they are merely a result of inconsistencies ... use of descriptive terms by the several drillers.
The 1921 water levels were taken from the California Department ... Public Works Groundwater map for that year, and the 1946 water levels were taken from a map by The Bureau of Reclamation.
R25E R26E R27E
T19S
T20S
T21S
LINDSAY
PORTERVILLE
Miles
GEOLOGIC CROSS SECTION LOOKING WEST
Horizontal Scale
Miles
Vertical Scale
Feet
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION II
TULARE BASIN DISTRICT
LINDMORE IRRIGATION DISTRICT
Geologic Cross Section along 26E-27E Range
DRAWN: J.A.L. C.C.C. SUBMITTED:
TRACED: C.C.C. RECOMMENDED: A.B. Hard
CHECKED: R.C.B. APPROVED:
TB 185C

South

North



GEOLOGIC CROSS SECTION LOOKING WEST

EXPLANATION

- Well sampled by Geologist
- Distance of well from line of Section
- Well Number
- Gravel (Very Permeable)
- Sand (Permeable)
- Silt (Relatively Permeable)
- Sandy Clay (of drillers = silt, sandy silt or very fine sand - Relatively Permeable)
- Clay (Relatively Impermeable)

This profile was prepared from well logs which were either copied from the records of drillers or made by geologist from samples obtained from drillers. The accuracy of the logs varies with the individual driller and is often open to considerable question. Thus conspicuous and rapid changes in sediment character from well to well along the profile are only in part actual, i.e., due to lensing and channeling during deposition. To an indeterminate extent they are merely a result of inconsistencies in the use of descriptive terms by the several drillers.

The 1921 water levels were taken from the California Department of Public Works Groundwater map for that year, and the 1946 water levels were taken from a map by The Bureau of Reclamation.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION II
TULARE BASIN DISTRICT

LINDMORE IRRIGATION DISTRICT

Geologic Cross Section 2.4 miles West of 27E-28E Range Line

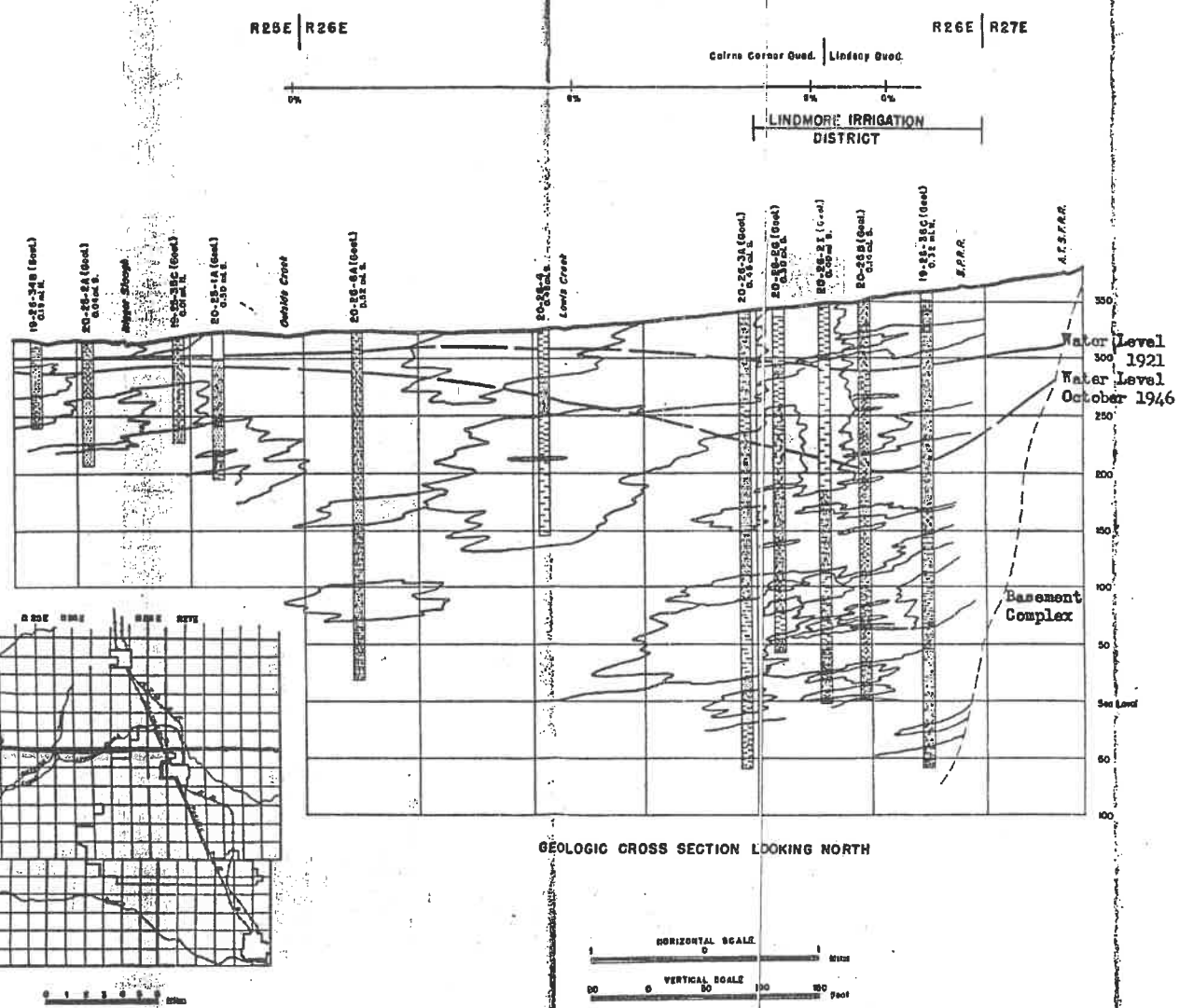
DRAWN: J.A. LEAN SUBMITTED: J. V. Smith
TRACED: C.C.C. RECOMMENDED: O. D. Kendholm
CHECKED: R.C.B. APPROVED: R. Bloggens

TB - 188-C | PRESNO CALIFORNIA 7-27-46

PLATE 8

Wgt

Ent



GEOLOGIC CROSS SECTION LOOKING NORTH

EXPLANATION

Well sampled by Geologist

Distance of well from line of Section

Well Number

Gravel (Very Permeable)

Sand (Permeable)

Silt (Relatively Permeable

Sandy Clay (of drillers = silt sandy silt or very fine sand Relatively Permeable)

Clay (Relatively Impermeable)

This profile was prepared from well logs which were either copied from the records of drillers or made by geologist from samples obtained from drillers. The accuracy of the logs varies with the individual driller and is often open to considerable question. Thus conspicuous and rapid changes in sediment character from well to well along the profile are only in part actual, i.e., due to leaning and channeling during deposition. To an indeterminate extent they are merely a result of inconsistencies in the use of descriptive terms by the several drillers.

The 1921 water levels were taken from the California Department of Public Works Groundwater map for that year and the 1946 water levels were taken from a map by The Bureau of Reclamation.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION REGION II
TULARE BASIN DISTRICT

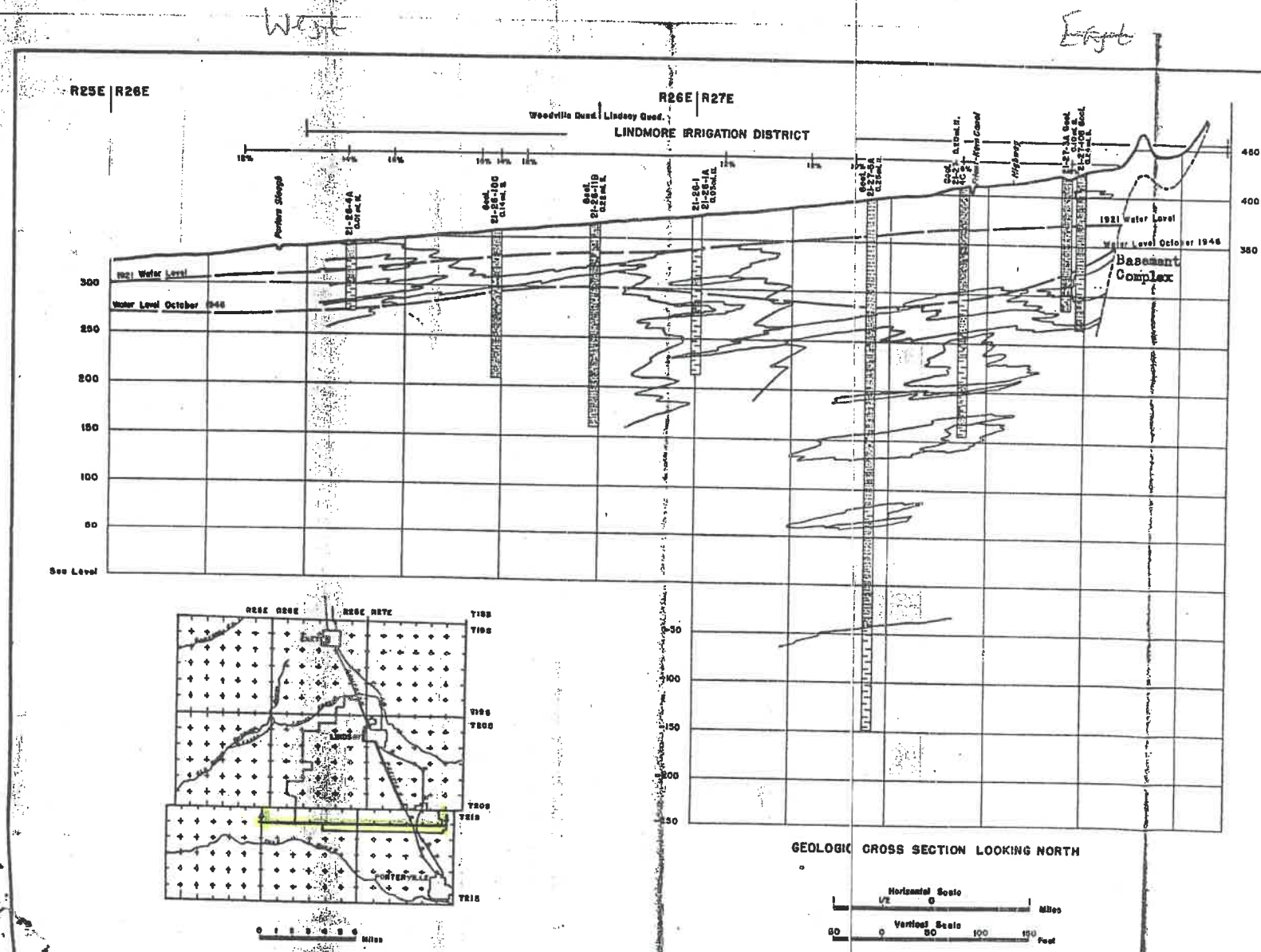
LINDMORE IRRIGATION DISTRICT

Geologic Cross Section Looking North On T19 S – T20 S Line

DRAWN: J.E.L. SUBMITTED:
TRACED: G.C.D. RECOMMENDED: A. G. Kindleberger
CHECKED: J.W.F. APPROVED: R. E. Cyrus

TB 1006C | FRESNO · CALIFORNIA

PLATE 9



EXPLANATION

21-27-3A Geol. 0.10 mi. S.

Well sampled by Geologist

Distance of well from line of Section

Well Number

Gravel (Very Permeable)

Sand (Permeable)

Silt (Relatively Permeable)

Sandy Clay (of drillers: silt, sandy silt or very fine sand – Relatively Permeable)

Clay (Relatively Impermeable)

This profile was prepared from well logs which were either copied from the records of drillers or made by geologist from samples obtained from drillers. The accuracy of the logs varies with the individual driller and is often open to considerable question. Thus conspicuous and rapid changes in sediment character from well to well along the profile are only in part actual, i.e., due to lensing and channeling during deposition. Those indeterminate extent they are merely a result of inconsistencies in the use of descriptive terms by the several drillers.

The 1921 water levels were taken from the California Department of Public Works Groundwater map for that year, and the 1946 water levels were taken from a map by The Bureau of Reclamation.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION – REGION II
TULARE BASIN DISTRICT

LINDMORE IRRIGATION DISTRICT

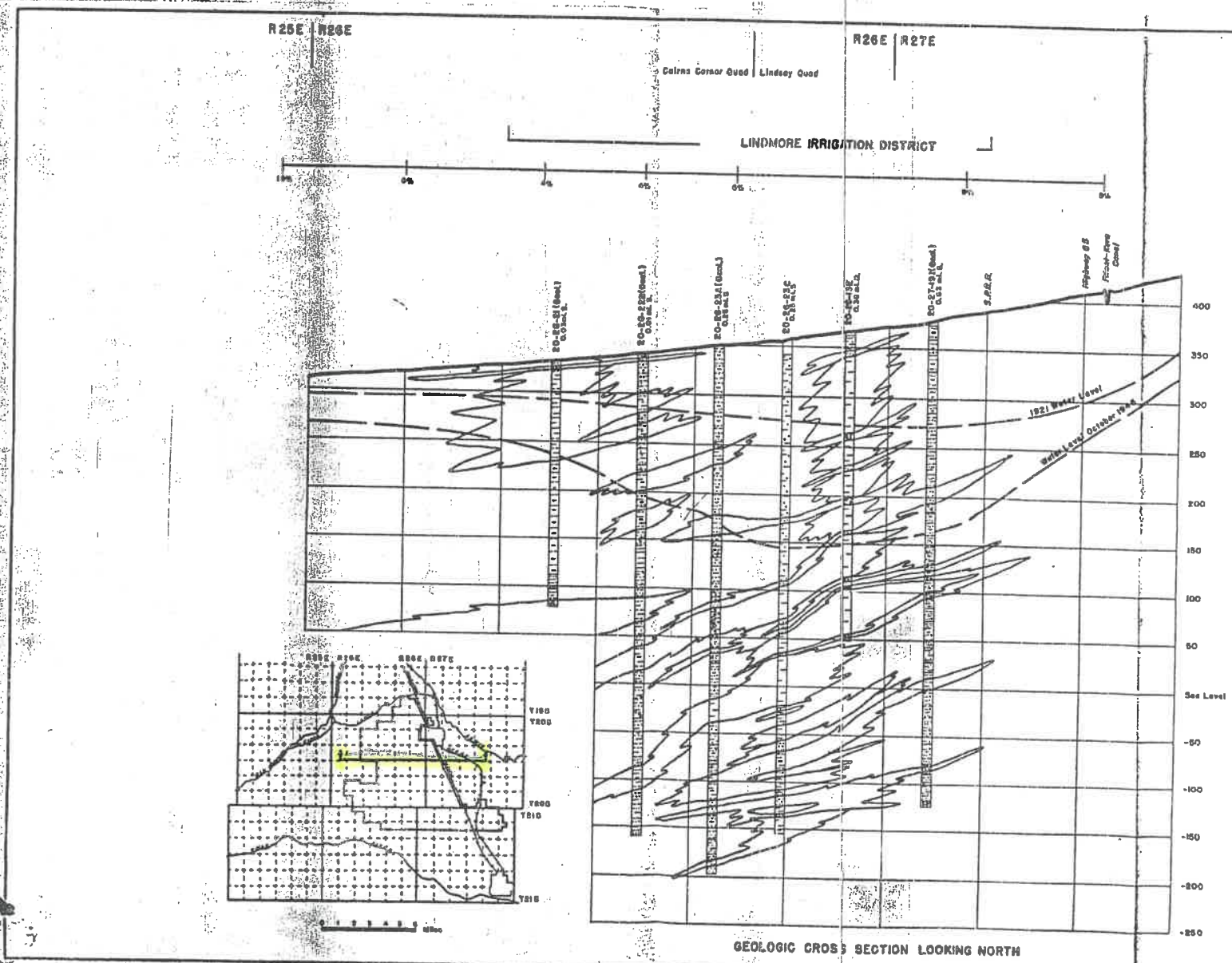
Geologic Cross Section one mile South of T20S–T21S
Looking North

DRAWN J.A.L. C.C.C.	SUBMITTED		
TRACED C.C.C.	RECOMMENDED		
CHECKED R.C.S.	APPROVED		
T.S. 100TC	FRESNO CALIFORNIA 9-8-49		

Wgt

Exst

PLATE 11



GEOLOGIC CROSS SECTION LOOKING NORTH

EXPLANATION

Well sampled by Geologist

Distance of well from line of Section

Well Number

Gravel (Very Permeable)

Sand (Permeable)

Silt (Relatively Permeable

Sandy Clay (of drillers = silt, sandy silt or very fine sand – Relatively Permeable)

Clay (Relatively Impermeable)

This profile was prepared from well logs which were either copied from the records of drillers or made by geologist from samples obtained from drillers. The accuracy of the logs varies with the individual driller and is often open to considerable question. Thus conspicuous and rapid changes in sediment character from well to well along the profile are only in part actual, i.e., due to lensing and channeling during deposition. To an indeterminate extent they are merely a result of inconsistencies in the use of descriptive terms by the several drillers.

The 1921 water levels were taken from the California Department of Public Works Groundwater map for that year, and the 1946 water levels were taken from a map by The Bureau of Reclamation.

HORIZONTAL SCALE

Miles

VERTICAL SCALE

Feet

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION—REGION II
TULARE BASIN DISTRICT

LINDMORE IRRIGATION DISTRICT

Geologic Cross Section three miles South of T19E-T20E Line

DRAWN: J.A.L. C.C.C. SUBMITTED: [signature]
TRACED: C.C.C. RECOMMENDED: [signature]
CHECKED: J.W.F. APPROVED: [signature]
T.B. 1008 C | PRESS | CALIFORNIA 6-21-49