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EARLY RECLAMATION *and* ABANDONMENT *of the* CENTRAL SACRAMENTO-SAN JOAQUIN DELTA

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For over 130 years the central islands of the Sacramento-San Joaquin Delta have been flooding, often without warning. In June 2004, for instance, the two Jones Tracts were inundated, nineteen square miles of intensively farmed land being submerged. The tracts flooded in 1980, too, when about thirty-four square miles of farmland were inundated. The Webb and Holland tracts were flooded that year, as well. Since 1900, former wetland islands of the central Delta have been submerged an aggregate of seventy times. While destruction of crops, dwellings and other structures, the tools of farming, and livestock, together with displacement of residents, have always occurred, it used to be that the losses were absorbed by the immediate victims alone. Increasingly however, public funds are committed to emergency, recovery, and remedial efforts. Within a year of the 2004 flooding at the Jones Tracts, for instance, official estimates held that $45 million were expended – well beyond the means of the immersed pair of reclamation districts and fifteen landowners. The stakes for public interests mount because the artificial levees that keep tidal and flood waters out of the farmlands of the central Delta are the banks of the labyrinth of channels that convey fresh water from northern California to aqueducts that serve the San Joaquin Valley, the Los Angeles area, and eastern and southern parts of the San Francisco Bay area.[1]

Flooded barn and field in the Lower Jones Tract, October 24, 1980.
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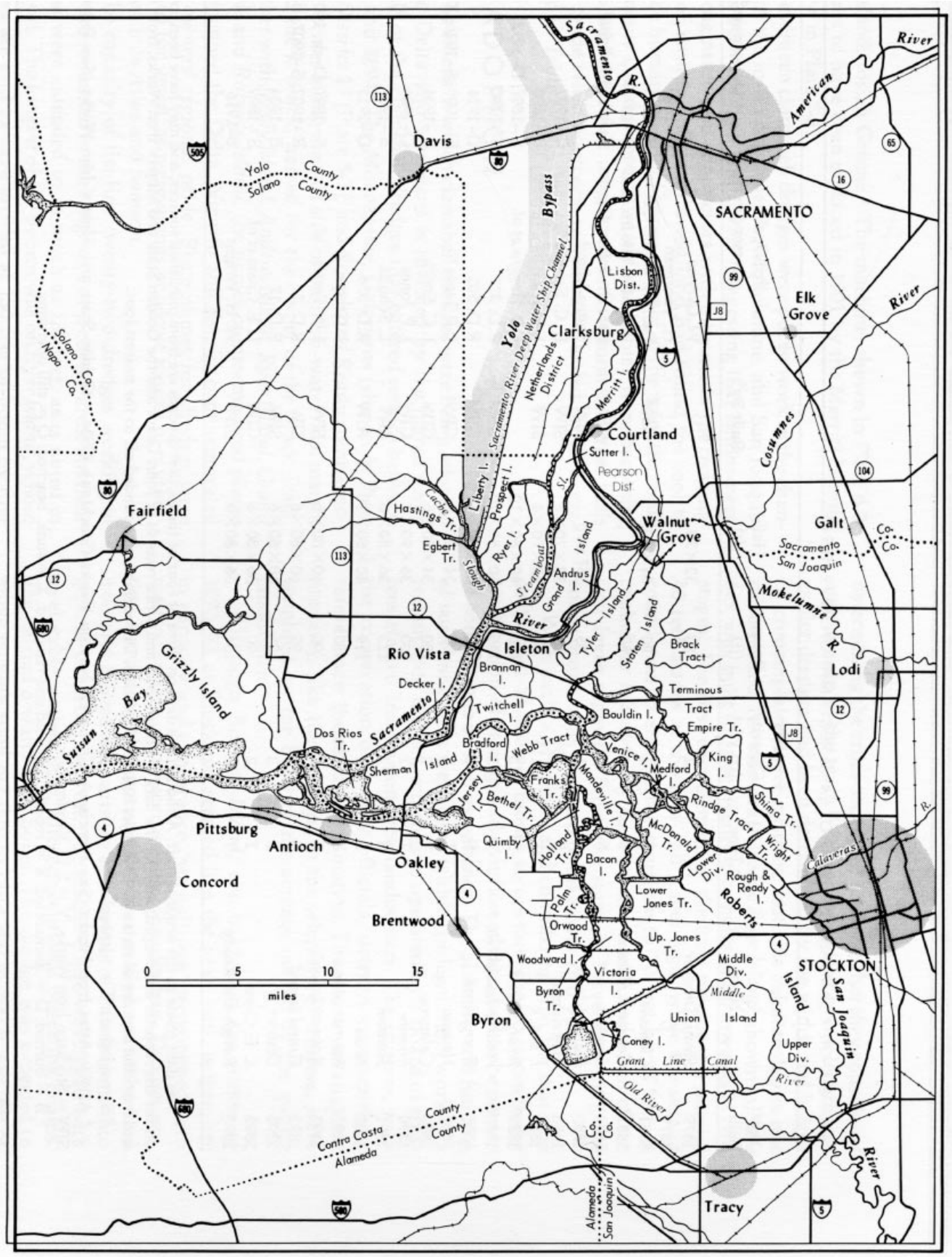


Map of the Sacramento-San Joaquin Delta.

Courtesy John Thompson.

This account is about the earliest activities and technology used to transform the central Delta's pristine tidal wetlands and underlying peat into a domesticated landscape. The efforts to levee and drain the wetlands for commercial agriculture in the 1860s and 1870s[2] initiated changes in the relationships of land and water that burden individuals and society at large whenever nature's wiles disrupt the process and achievements in domesticating the wetlands. The technology used to reclaim the fresh water tidal marshes originally, and prepare the land for crops, depended upon manual labor, mostly Chinese, who ". . . will work in water without a murmur, and dig (their) way through mud and slime where a white man couldn't be induced to enter for love or money." A bit of steam-powered machinery was used, but iron spades and forks, wheelbarrows and wheeling planks, were the principal tools provided for the Chinese builders and maintainers of early levee systems and drainage ditches. The carpenters who framed structures to dam sloughs, built flumes with tide-gates, and shored-up the inner side of some levees with bulkheads, were Caucasians. Superintendence of all work was by farm hands and practical and trained engineers whose callings began in land surveying.[3]

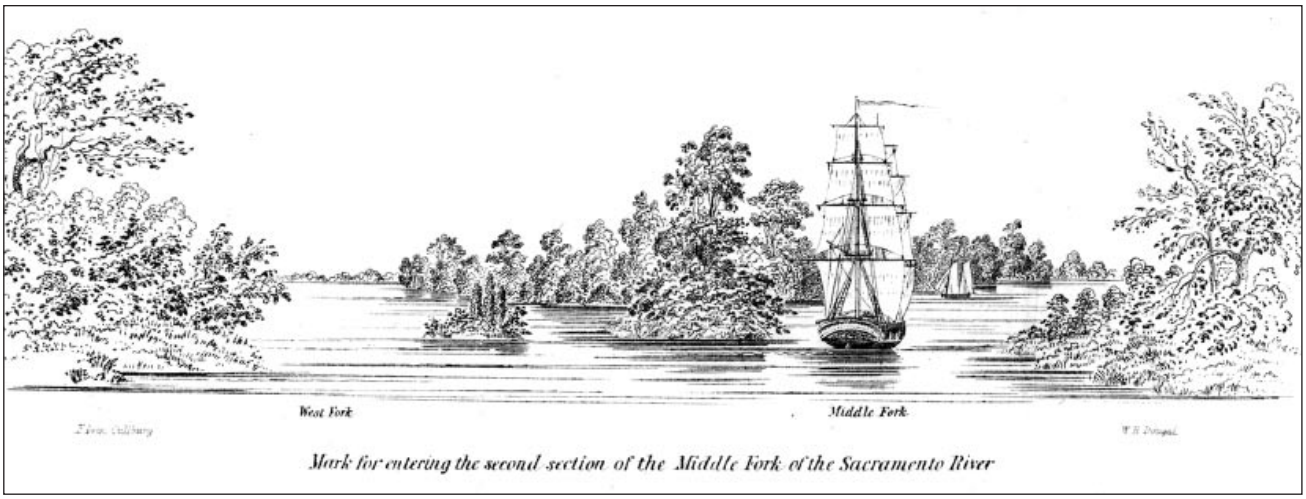
The levee systems made of peat and erected on peat in the central Delta during the 1860s and 1870s all but disappeared by the 1890s. What the tides and waves did not destroy, was buried when long-boom clamshell dredges were used to amass levee systems with material taken from adjacent channel bottoms and sides. The channel-floor materials were tough clays and tractable alluvium located well beyond the reach of men with spades. For that matter, the earliest dredges (akin to floating steam shovels) had too little reach with their long-handled single scoop to discharge directly onto a levee from the channel without undermining levee stabiliy, as occurred at Bacon Island in 1873.[4] The alternative was to dump into scows that laborers or an endless belt conveyor unloaded onto levees. The alternative methods cost $0.40 to $0.50 per cubic yard, whereas levees built by manual labor alone cost $0.12½ per cubic yard, sometimes less, in the 1870s.[5]

The bellwether sites for early ventures to reclaim tidal wetlands of the central Delta for agriculture were Sherman and Twitchell islands, which lie between converging master channels of the Sacramento and San Joaquin rivers. While the present focus is on these and other islands where thick beds of peat underlie the former wetlands, the larger setting of the Sacramento-San Joaquin Delta is described to provide context. It is the area bound by Sacramento, Stockton, Tracy, and where the waters of the Central Valley converge and enter the system of salt water bays that extends westward to the Golden Gate.

The Pristine Delta

The pristine delta consisted of some 500,000 acres. These tule lands or fresh water tide lands of the Argonauts and immediate successors had a cover largely comprised of bulrush thickets

and grass. However, the higher bank lands on island margins and scattered mounds supported clumps and strips of shrubs, predominantly willows, in the central Delta. Where the natural levees gained height and breadth headward in the area, especially along the Sacramento River, they supported a woodland, with a brush understory of diverse species. The wooded bank lands



This detail from the "Chart of the Sacramento River from Suisun City to the American River by Cadwalader Ringgold, 1850," provides a snapshot of the pristine delta.
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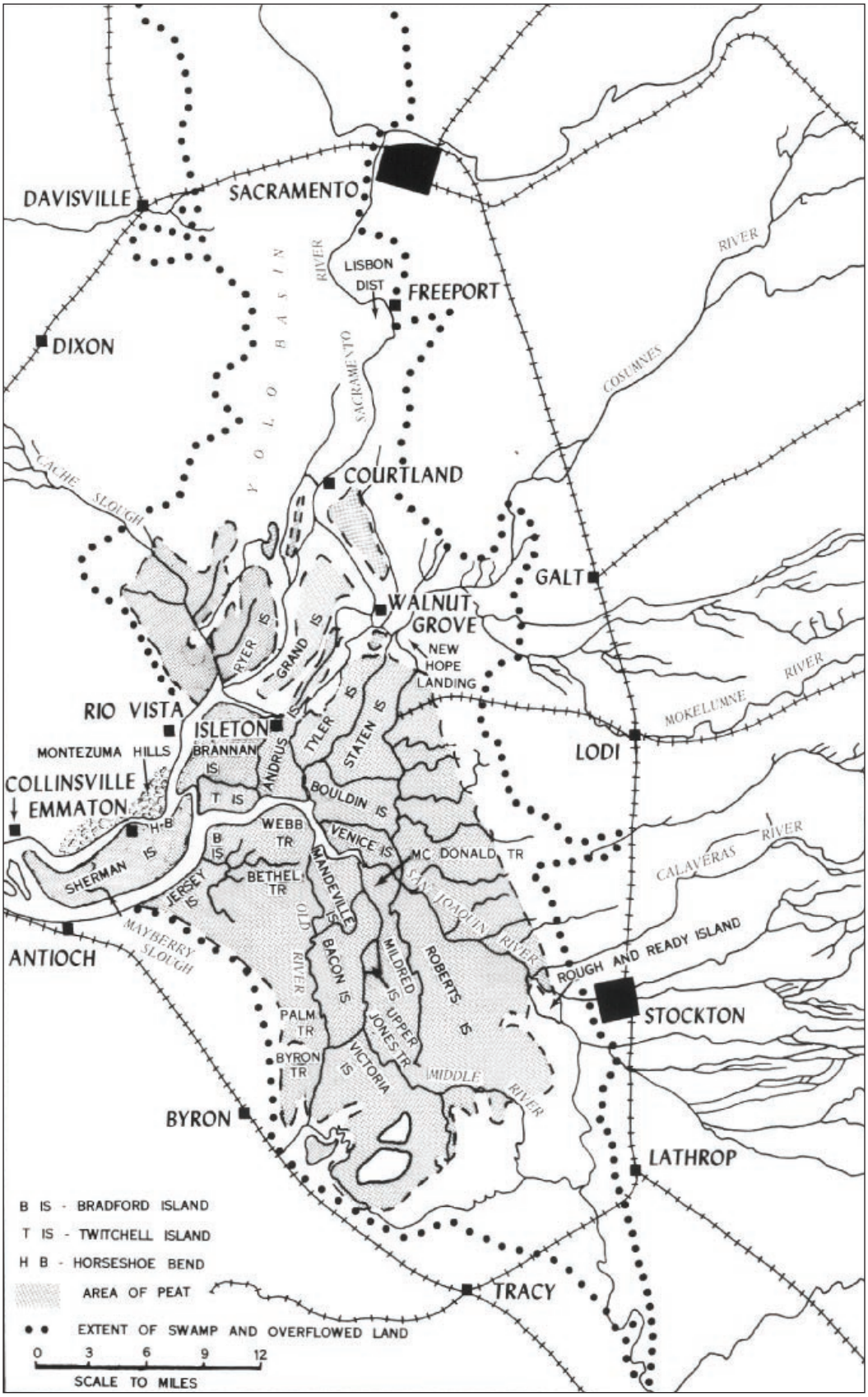
1982/004/0100

attracted settlers during the Gold Rush and thereafter from Brannan Island upstream, and at the upper end of Roberts Island and the mainland opposite, to the south of Stockton. The material deposited by overbank flows of the San Joaquin River formed relatively high natural levees and broad interior areas of sandy soils that extended into northerly tule marshes.[6]

The Delta's tidal wetlands were rooted in beds of fibrous plant material that graded downward into peat, which was thickest under the west-central islands. The beds of peat underlay tule thickets wherever tidal waters penetrated islands and the peripheral tracts at the edge of the valley plains. But, the beds of peat merged into mineral soils toward the Delta's dry-land periphery, and towards the alluvial bank lands of islands and tracts in the northern and southern thirds of the Delta. The peat evolved in the course of sea-level rises of the past 10,000 years. Underlying the peat were compact sediments and fields of aeolian sands.[7]

By and large, island surfaces in the central area were like broad shallow saucers, overbank deposition of fine sediments having contributed to the slightly elevated rims. As the natural levees gained height and breadth headward along master channels and distributaries of the Sacramento, Mokelumne, and San Joaquin rivers, they all but enclosed marshes of tules. Tidal and flood-stage waters penetrated these elongated interior marshes through sloughs that branched



This map illustrates the "pristine delta" of the 1880s before largescale reclamation. Note the changes to Sherman Island, as seen in the map on page 42.

Courtesy of John Thompson

in dendritic fashion. While the tides occurred twice daily, flood-stage penetrations preceded overbank flows of winter and spring. It was during the rainy season, too, that great flows of water from the north moved through the broad Yolo Basin to its outlet between Rio Vista and Grand Island. The greatest of such seas of water surged across the island and Brannan, lower Andrus, and Twitchell Islands, into the San Joaquin River. Grand Island, like smaller Sutter and Merritt Islands, to the north, and the islands and tracts to the east of the Sacramento River, had well-defined natural levees of loam enclosing their interior tidal wetlands.[8]

The finger of elevated bank land flanking the Sacramento River at Sherman Island was no more than 50 to 200 feet wide, and a foot or two above mean high tide. The banks stood seven or eight feet high at the upper end of Andrus Island, and ten or more feet high near Freeport. Upstream of Walnut Grove, the sedimentary bank lands were several hundred feet across. Beyond the interior wetlands rose very modest alluvial banks that faced a trough where wetlands extended southward from the edge of Sacramento. The trough, flanked on the east by the dry lands of the valley plains, drained into the Mokelumne River's distributaries, where the bank lands of upper Tyler and Staten islands were about seven or eight feet high – as at Andrus Island, to the west. The bank lands of the former two islands diminished southward to mere rims about two feet higher than mean high tide and the wetlands adjacent. Thus, the two islands at their southern ends, like lowermost Andrus Island, were akin to the central Delta's Bacon Island, nine or ten miles to the south. Such lands were underlain, for the most part, by twenty to thirty feet of peat, more in some places.[9] Their saucer-like interiors were covered with slough-fretted thickets of tules and ponded areas, which high tides covered by six to twelve inches of water for one-half to two hours, twice a day. About two feet of water covered the island interiors during ordinary flood stages of the main rivers.[10]

Early Central Delta Settlement

Perhaps a half-dozen settlers occupied high ground adjacent the main river channels between Stockton and Suisun Bay in the early 1860s. Settlement on Sherman Island began at Horseshoe Bend in 1855, a few years after occupation of the higher and broader bank lands to the north. The pioneer settler at Twitchell Island located in 1860 on the relatively high bank land adjacent Sevenmile Slough. Already, men who tended ranging cattle and sheep probably occupied ephemeral shelters on greater Webb Tract, Venice Island, and greater Union Island, as they did much of the Delta and the plains beyond. At least by 1863, proprietors of the grazing lands were damming minor sloughs and raising low and short levee segments to counter high tides. The levees, commonly made by stacking peat blocks along island rims, were as much as three to four feet high, eight feet at the toes, and a foot or two across the crowns. Similar dimensions marked levees built on the banks of upper Roberts and Union Islands, and on the bank lands of the Sacramento River from Brannan Island to the north. However, the friable loams and sandy soils of bank land could be shaped into artificial levees with plows and scrapers, as well as by hand. By and large, the underbrush and trees were removed in the process. At least along the Sacramento River, cordwood chopping to serve steamboats was a sort of cash crop.[11]

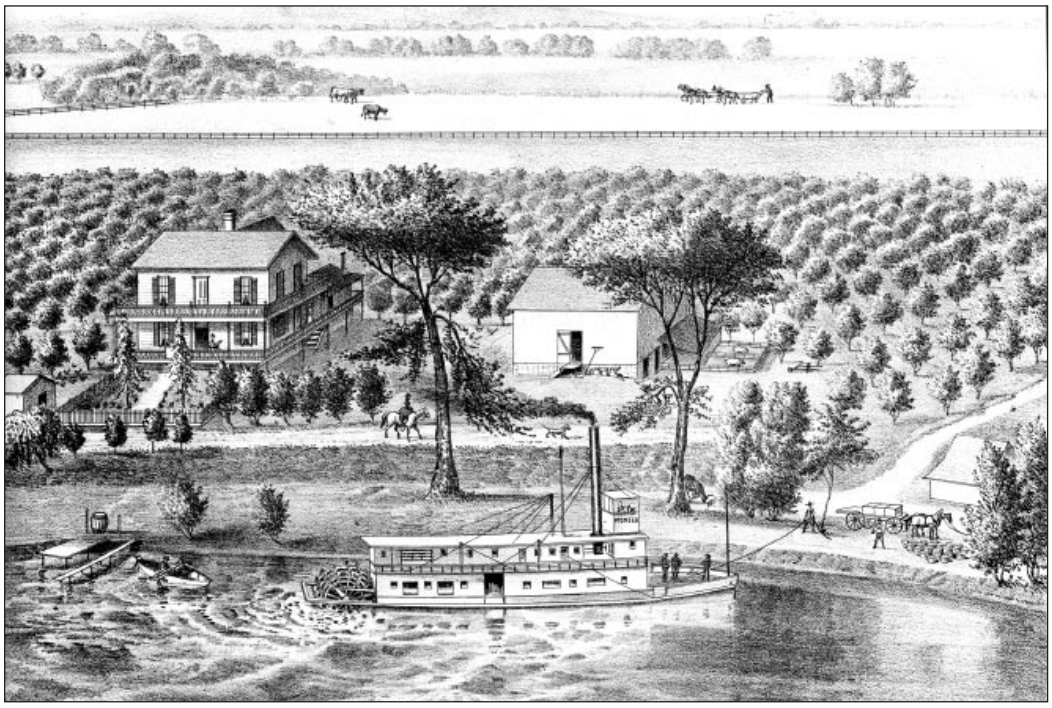


Illustration of Frederick Myers' fruit ranch on Grand Island, formerly part of the overflow and swamp lands that made up much of the Delta, now reclaimed and turned into a productive seventy-two acre farm along Steamboat Slough.

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2004/076/0001

The first levees raised along the bank of the Sacramento River at Sherman Island in 1859-62 were ineffective. Horses, cattle, and sheep did well during most years, but nearly all were drowned during high water of 1861-62. Tilled bank land was flooded every winter between 1864 and 1869, and most land did not dry out enough in summer for crops to flourish. A settler recalled in mid-1868, "we had not three garden spots dry enough to work."[12]

Whereas few people occupied the islands of the central Delta, the riverside lands adjacent the Sacramento River downstream of Sacramento had become a populous and prosperous rural corridor by the 1870s. There were thrifty truck and dairy operations of smallholders and tenants in the Freeport vicinity and the Lisbon District, opposite. And, the scene from about six miles above Courtland to about nine miles downstream of Walnut Grove revealed belts of flourishing orchards, fields, and gardens, where homes of the gentry and other Caucasians were interspersed with China camps. Larger clusters of frame structures marked villages here and there. Beyond the new town and wharf of Isleton and the orchards and gardens of northern bank land on Brannan Island were the tracts of freshly leveed and broken wetlands of lower Brannan and Andrus Islands, Sherman Island, and Twitchell Island. Off to the south of the San Joaquin River were Webb Tract, Mandeville, and Bacon Islands. These tidal wetlands of nascent development were akin to the interiors of the populous tracts and islands upstream of Isleton, where burned and plowed land and drainage ditches were being extended from bank lands into the wetland pastures for dairy and other stock.[13] The spirit of the times, albeit somewhat enhanced, was captured by a resident observer:

> Until a few soulless speculators and bloated monopolists reclaimed these lands in large masses, the only way possible, and by selling them in small tracts on long credit, made it possible for men of limited means to establish homes upon them, they were regarded by the general public as merely an expanse of valueless mud, and permanently covered by water, inhabited only by mosquitoes, and supporting no growth but that of undeservedly despised tule. Through the enterprise of George D. Roberts, the soul of the Tide Land Reclamation Co., the tule lands of California have already reached so satisfactory a degree of appreciation, that it is within the bounds of moderation to say, that every overland train to this State brings here from one to a dozen parties to examine the tule lands for the first time, or to settle upon parcels of from two hundred to a thousand acres, purchased on a former visit.[14]

Selling the Wetlands of California

The wetlands of California were sold by the State as swamp and overflowed lands, in accordance with an obligation to the national government created by the Arkansas Act of 1848. Although land sales were limited by the General Assembly to 320 acres (1855), then 640 acres (1859) per individual, the limit was removed in 1868. At the same time, the organization of assessment districts to reclaim wetlands was transferred from the State's Board of Swamp and Overflowed Land Commissioners to the auspice of county boards of supervisors.[15] Consequently, the Delta's fresh water tidal wetlands, regarded as "barren wastes" in the mid-1860s, began "to be understood and appreciated by some of the capitalists of the State" by 1869:

> The wonderful results of the reclamation of the tract of land known as Sherman Island, have stimulated the enterprise of our most public-spirited citizens to embark in a large enterprise of a similar character, and, in consequence, a Company has been formed, entitled the 'Tide Land Reclamation Company', with the view of solving the problem of practicability of reclaiming overflowed lands on a large scale.[16]

The Models for Reclaiming Islands in the Central Delta

The earliest large-scale reclamation of tracts in the central Delta occurred at Sherman Island in 1868-69, and Twitchell Island in 1869. About 14,000 acres were enclosed with levees, flumes and tide gates at the former and 3,600 acres at the latter. Already in the southern third of the Delta, 40,680 acres of rangeland were ringed a second time (1876-78) at greater Union Island (included present Victoria and Woodward Islands) with several dams and thirty-seven miles of very large levees composed of sand and peat blocks, the construction of which involved horse-drawn scrapers, 1,000 Chinese laborers, and a hydraulic dredge.[17]

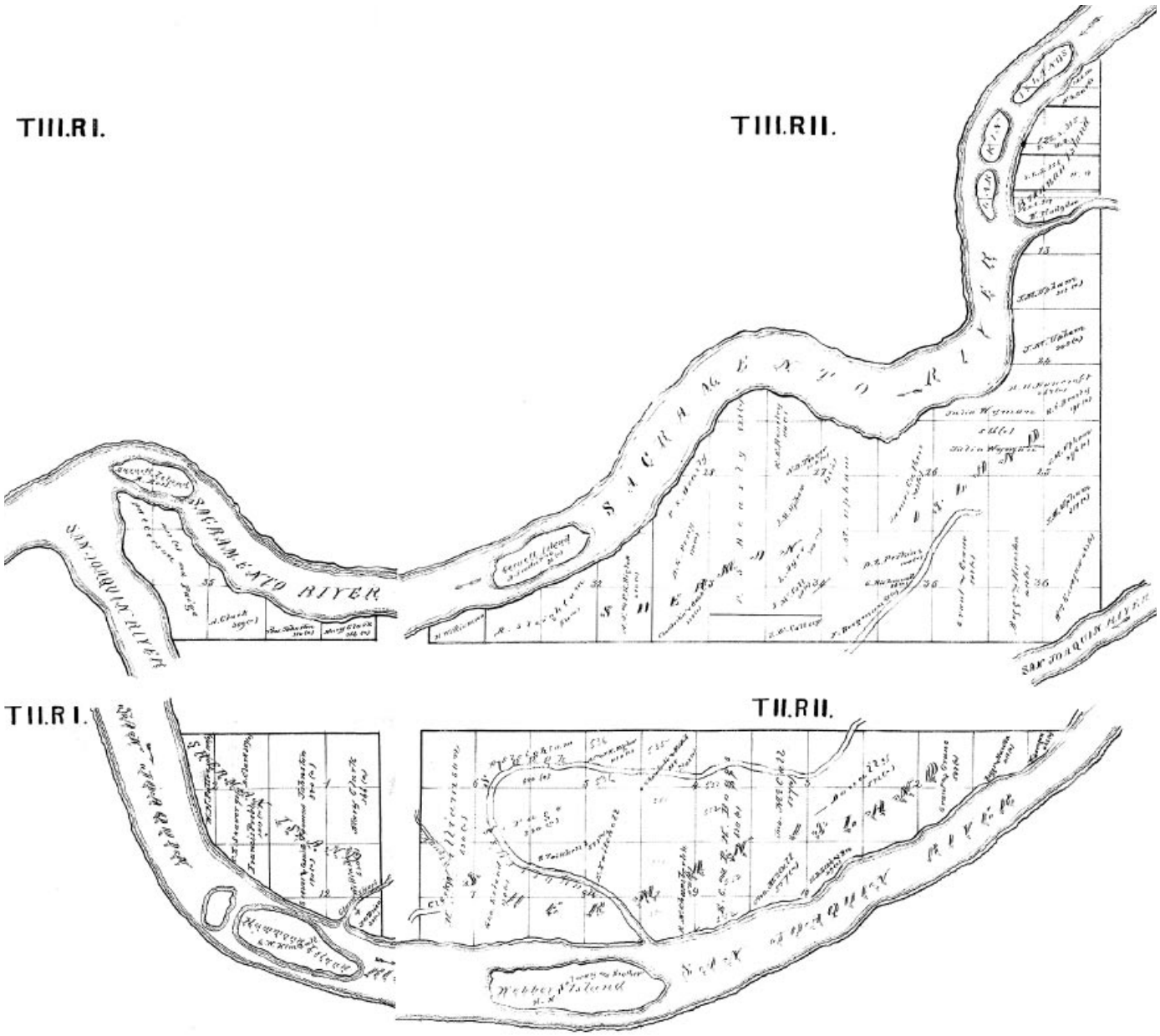
Sherman Island

The plans to reclaim Sherman Island began to take shape in 1865. Three separate groups of landowners, each group representing about half of the acreage within proposed districts, successfully petitioned the State Board of Swamp and Overflowed Land Commissioners to authorize formation of assessment entities, and have the formal reclamation plan prepared by an engineer. Swamp Land District No. 50, authorized in June 1865, embraced the westernmost 7,400 acres of the island. Four months later, District No. 54 was organized to reclaim 4,550 acres located adjacent the Sacramento River, in the upper end of the island. Another handful of landowners, whose 3,000 acres adjoined the San Joaquin River, were persuaded by the Board to affiliate with District No. 54, rather than proceed independently – a rare kind of union. Although Districts 50 and 54 functioned until the late 1870s, there were perennial difficulties with landowners who wished to form independent districts.[18] Such separatist desires were by no means unique to Sherman Island. Generally speaking, separatists resented being coerced into a collaborative enterprise on principle, especially when they owned relatively high land, were interested primarily in raising cattle, had reservations about the local land barons, or lacked resources.

It took eight months to enclose Sherman Island with over forty miles of levees constructed with blocks of peat. They were laid upon the ground and each other, which resulted in leakage during high tides and flood stages as the blocks dried out. The rule-of-thumb was that a third of original volume was lost when peat became dry. The system made of peat blocks was set back from river channels twenty to forty feet, a good deal more than many reclaimers adopted subsequently in order to maximize the area of bank land for crops. The blocks were cut from a ditch located about three feet behind the inner toe of the levee system. They were fitted into a structure that rose four to five feet from a base of eight to fourteen feet, to a crown made three to four feet wide. The levee system was widest and highest along the Sacramento River, and smallest where it flanked Mayberry Slough, which was preserved for some years as a navigable channel into the heart of the island. The Chinese laborers emplaced 250,000 cubic yards of blocks, no mean task for men with spades, forks, wheelbarrows, and wheeling planks. Meanwhile, the flumes and self-acting tide or flood gates that drained the land and sloughs during low tide were built by Caucasians.[19]

The levee system completed in May of 1869, cost $80,000, of which ten percent was expended to restore a breach along the Sacramento River; to counter shrinkage and subsidence along the San Joaquin River, where the underlying peat was exceptionally thick; to dress the system where wave and wind erosion caused damage, especially along the San Joaquin River; and, to stop leakage wherever drying peat lost mass and volume, admitting water. Additions were made to the system's height and width between 1869 and 1873.[20]

On January 8, 1872, a high river stage displaced seventy-five feet of levee into the island about two and a half miles downstream of Horseshoe Bend, producing a large lake that broke through the levee on the San Joaquin River. In the interim, dwellings and sheds were awash, except for



The property owners of Sherman Island as recorded in the 1870 Sacramento County Tax Assessor mapbook.

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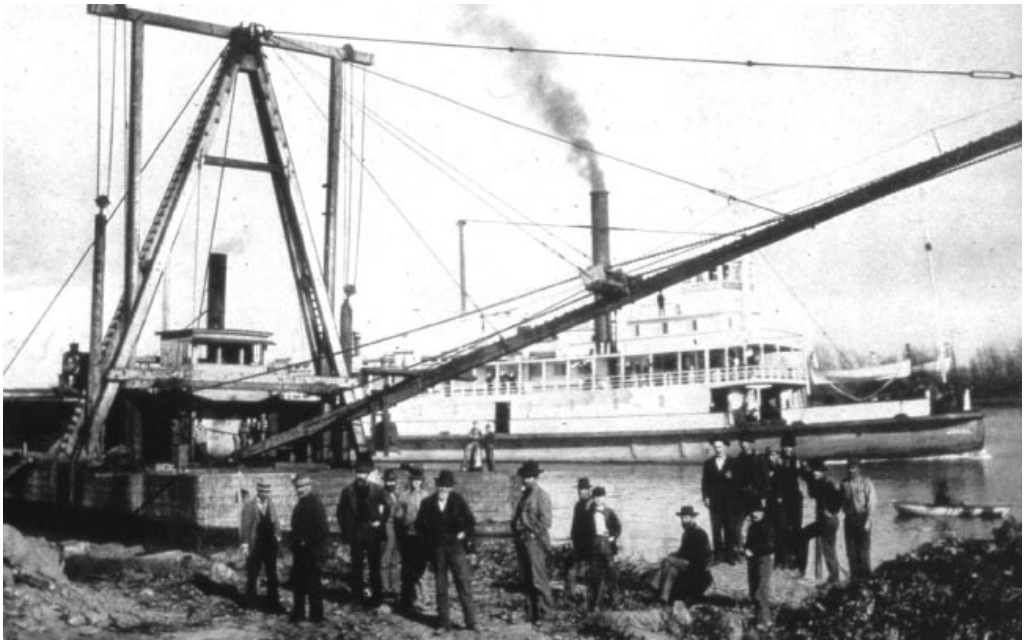
Sacramento County Collection
1980/132

cabins built originally on high-and-dry scows by wary residents. While the levee system was restored and enlarged, the island floor remained too wet for seeding. Lesser levee breaches were repaired quickly, but some land flooded in 1875, 1876, and 1877.[21]

Early in 1872, the landowners considered purchasing drainage pumps. It was apparent that breaking the virgin wetlands by the conventional burning method, together with oxidation of the drained organic soil, was lowering large areas of island floor two or three feet, and by five or six feet in some places. Consequently, gravity drainage through tide gates at low tide was impossible for the most depressed land.[22]

The work of reclaiming the island was seen by many travelers from riverboats that plied the main routes of commerce between San Francisco, Sacramento, and Stockton. By March of 1871, steamers called regularly at the Emmaton wharf, located at the lower end of Horseshoe Bend. Already, Emmaton's ferry to the mainland provided access to Rio Vista, located about six miles to the north. And, by mid-March of 1871, ferries that linked Antioch with Collinsville called at the lower end of Sherman Island. Emmaton consisted of a store and hotel, lumber yard, blacksmith and wheelwright's shop, and school. The number of residences in the community is unknown, but about 400 people, mostly Chinese males, resided on the gardens and farms of the island. The village was built by the major local landowner, J.R. Upham, who added grain and hay warehouses to the service center in mid-1874. Meanwhile, the Sacramento County Board of Supervisors was petitioned to designate thirty miles of county roads.[23]



Travelers on delta riverboats witnessed the ongoing reclamation work as they journeyed between San Francisco, Sacramento, and Stockton.

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1983/146 Portuguese Slideshow, frame 85

The entrepreneurial Upham provided other inducements to attract tenant farmers and buyers of land. A reputable nurseryman was persuaded to take land on which seedling fruit trees and other economic plants were to be raised for sale. Also, Isleton's fledgling California Sugar Manufacturing Company was invited to plant sugar beets on the island, but declined.[24]

Upham and associates were inspired to have orchards, row crops, and market gardens developed because of the exceptional productivity of the land, and the island's location provided advantage over farmland upstream with regards to the San Francisco market. Then, too, hay and grain were in demand in the city. Moreover, suitable land for market gardening was about gone on the peninsula to the south of San Francisco. Ample steamboat and schooner service carried the trade.[25]

Virgin land sold for $30 per acre in 1869, and for $50 to $75 per acre when broken. Cash-tenants paid $15 to $25 per acre per annum, while share-tenants committed a quarter of the harvest to landowners. The investment in developing Sherman Island seemed worthwhile by 1869; the remarkably productive land had been reclaimed for about $5.25 per acre.[26]

In 1869, about 1,000 acres of peat land were burned and seeded in grain:

> Burning the land is the cheapest and quickest method of reduction, and is thus described: Watch the land after drainage, until it becomes dry enough to burn to ten or twelve inches deep (not dryer, lest too much land be consumed and the level reduced). The growth will still be green and very heavy; ignite fires in a multitude of places in the sod; and the fires being well tended, ten acres a day may be reduced. The hay will fall as the roots are burned, and in a few days be dry enough to be consumed by fire. This process leaves a bed of ashes and burned soil some six inches deep, free from seeds of weeds, and in fine tilth for the sower. Grain may be covered, in this culture, by a brush harrow or by driving a flock of sheep over it; the last process costs only thirty-five cents per acre.[27]

Sheep were used, also, to crop newly sprouted wheat and barley in order to check the tendency of growth to become rank. Otherwise, there were crop residues and residual areas of wetlands to be grazed. The availability of feed must have been substantial; as many as 19,000 sheep from the San Joaquin Valley wintered on the island in 1875-76 – until March.[28]

Beginning in 1871, the bulk of Sherman Island was farmed; winter and summer field and row crops were possible. The land seeded in wheat and barley increased from 3,500 acres in 1870, to 7,000 or 8,000 acres in 1871 and 1873, and 10,500 acres in 1874. No grain was seeded in 1872, the soil being too wet. Otherwise, yields of wheat averaged forty to sixty bushels per acre. Sometimes, land was sub-irrigated following the wheat harvest so that a hay crop would develop. Commonly, the crops of small grains served as nurse-crops for clover, alfalfa, or timothy. An aggregate of 4,000 acres of potatoes was raised in 1871, some of the land being double-cropped with plantings in February and June. There were 6,000 acres of the tuber in 1877, the Early Rose variety predominating. Some land was planted in beans, and there were trial plantings of the vine, various berry and row crops.[29]

The potato harvest; some 6,000 acres of the tubers were planted on Sherman Island by 1877.
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Sacramento Valley Photographic Survey Collection
1981/001/1180

In general, grain and hay crops were raised by Caucasian landowners and tenants; Chinese tenants tended row crops. The Chinese numbered between 600 and 800 tenants and field hands in 1878, probably over eighty percent of the island's residents. Some of the field hands were hired between August and October to harvest grain on land too spongy or cracked to permit the use of wheeled headers. Otherwise, harvesting and threshing crews were contracted from adjacent dry-farmed areas on the mainland. The crews baled straw, rather than risk igniting the soil. Soil

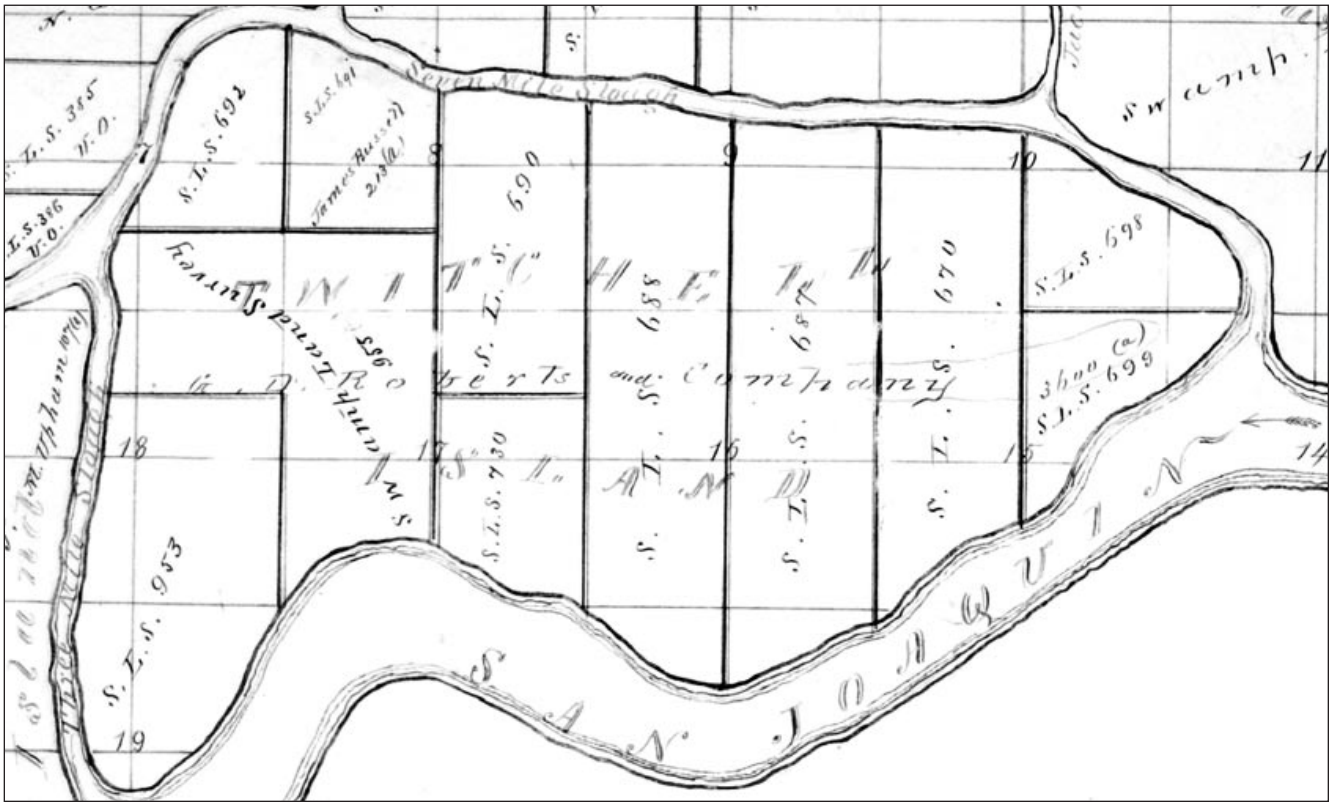
conditions led to improvising over-sized shoes for horses from hardwood blocks, leather, canvas, rubber, and iron. Wagon tires were six or eight inches wide.[30] However, there was no way to compensate for a general loss of two or three feet elevation in the island's floor by 1879.[31]

The bountiful days were ended by a succession of levee failures. The westernmost part of the island, below Mayberry Slough, was awash so much of the time between 1875 and 1879 that it became a favorite hunting ground for nimrods from San Francisco. The area was sealed off from the rest of the island in 1875 by a massive cross-levee. It had a base 100 feet across and a crown width of ten or twelve feet; it stood seven to nine feet high. The structure marked the part of the island where the bed of underlying peat is the Delta's thickest. Before long, the large cross-levee began to settle, creating fissures in the peat. Filling the cracks contributed to the structure's catastrophic collapse in February of 1878, when 400 to 500 feet sank and broke up at one time. By coincidence, most of Sherman Island was awash beforehand, a high-stage Sacramento River having destroyed about one mile of levee. The resulting lake thrust sectors of the peaty southern levee into the San Joaquin River. The value of destroyed levees, buildings, fences, and crops, was at least $100,000. Levee restoration attempts were interrupted by fresh breaks along Horseshoe Bend in spring of 1879 and 1880, and more of the levee system was destroyed by the Sacramento River in early 1881. Salvage efforts lapsed, close to $40 per acre by then having been expended to reclaim the island.[32]

Thus, the glory-days of reclamation and agriculture on Sherman Island were over. The bulk of the island was not reclaimed again until 1896, when the levee system was renewed with a new order of cross-section by long-boom clamshell dredges. Nevertheless, the levee system was breached in 1904, 1906, and 1909. Restoration of the levee system to the west of Mayberry Slough began in 1907, but was not successful.[33]

Twitchell Island

Levee construction began on Twitchell Island in mid-1869, three years after it was designated Swamp Land District No. 56 by the Board of Swamp and Overflowed Land Commissioners. In the interim, the agency repossessed about a quarter of the 3,600-acre tract from individuals who were in arrears in paying for their parcels. Much of the land was acquired by B.F. Mauldin, a speculator who took advantage of the legislature's act of 1868 that removed the 640-acre limit to an individual's ownership of wetlands. He then sold 2,400 acres to George D. Roberts, the entrepreneur who ultimately acquired over 250,000 acres of wetlands for the Tide Land Reclamation Company. In 1869-70, Roberts erected a levee system about the tract without organizing a reclamation district under auspices of the Board of Supervisors. Although essentially comprised of peat, the island had narrow strips of relatively firm sedimentary soil along the flanking sloughs to the north and west.[34]



George D. Roberts, listed as the owner of much of Twitchell Island in the 1870 Sacramento County Tax Assessor mapbook, made a $40,000 profit when he later sold his island holdings.

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County authorities were concerned that people like Mauldin and Roberts were more interested in making money from the sale of wetlands than in facilitating rural improvements that promised economic growth and revenue. Confirming critics' views, Roberts sold 2,400 acres to a group of investors from California and Louisville, Kentucky, for $68,000, of which Roberts netted about $40,000. However, the first crop raised on the Twitchell Island ranch turned out to be a startling endorsement for large-scale conversion of wetlands to cropland.[35]

To build the levee system, Robert's company recruited 235 Chinese laborers, perhaps more, through contractors in San Francisco. Apparently, too, the company experimented with a steam-powered wheel dredge and a peat excavating machine that rode on planks. Nevertheless, the twelve or thirteen miles of levee system were constructed of peat blocks that were manually cut and placed. The northern and western perimeters provided fairly stable foundations, but four miles of bank land along the San Joaquin River were underlain by peat of considerable depth, which resulted in a lot of trouble.[36]

The levee system's top stood initially from three and a half to five feet high; the crown was two to four feet wide. The wall of peat blocks was eight to twelve feet across the base, the wider sector being along the San Joaquin River. A berm of at least three feet was left unaltered between the outer toe of the levee and the river. Construction was well along by early 1870, when "eastern capitalists" associated with local land developer, Minor, Prather and Company, purchased 2,400

acres at about $28 per acre. There were several small breaks in the riverside levee that spring, but they were quickly repaired during periods of low tide. Sufficient area of the grass- and tule-covered island floor was dry enough to burn, seed to wheat and barley, and "sheep-in," over 1,000 acres. Some planting of truck crops occurred, as well.[37]

The first harvest from the 1,200 acres of wheat was 40,000 bushels, and the yield per acre ran as high as 50 to 80 bushels. A volunteer crop of hay followed. The results were remarkable, given that growers of dry-farmed small grain in the San Joaquin Valley had endured three winters of drought. Twitchell Island's wheat crop, which cost $1.25 per acre to seed, sold for $67,000 in San Francisco, a bonanza outcome attributed to the need for seed grain in the San Joaquin Valley. Impressed in a state where dry-farmed land usually was planted in alternate years, the widely-circulated *Pacific Rural Press* noted that: "As fast as farmers on these islands take off one crop, they put in another and on a piece of ground which had just been mowed for hay, a crop of barley is put in."[38] The outcome prompted Sacramento County's Swamp Land Clerk to concede that large-scale speculative reclamation projects could benefit the commonwealth.[39]

This picture on Elkhorn Slough, taken c.1920, shows the bounty of a delta harvest, as workmen load sacks of barley ready for transport to market.

Sacramento Archives & Museum Collection Center
Sacramento Valley Photographic Survey Collection
1981/001/0757

Although the Tide Land Reclamation Co. had reclaimed Twitchell Island without organizing an assessment district under the auspices of the County Board of Supervisors, the conventional mode, the new owners did in February of 1871 (Swamp Land Dist. No. 117). The group proposed an assessment of $43,200 in order to add two feet to the settling levee's height, and to widen it. Peaty material was removed from the inner edge of the borrow trench that lay behind the levee system to obtain a cubic yard of blocks per linear foot of the defense against high water. By then, 1,500 or 1,700 acres were to be planted, and ranch headquarters and a costly wharf (Kentucky Landing) had been built near the island's southeastern end. The wharf was one of three then in the central Delta. The levee facing the San Joaquin River broke several times during high tides of June and July. Restoration soon followed, and a lot of wheat was seeded in the usual manner. However, in mid-January 1872, a flood stage in the Sacramento River that was increased by the flow out of the Yolo Basin through Cache Slough, broke the dam at the head of Jackson Slough, located just southwest of Isleton. The failed structure and overbank flow resulted in flooding Brannan and Twitchell Islands. While wintering livestock survived, the crops did not. Also, a large sector of Twitchell Island's southern levee floated off into the San Joaquin River.[40]

The Twitchell Island levee system was restored to a "good and substantial" condition by February 1872, at a cost of $30,000. In the process of adding three feet to the levee's height, the crown was widened to six feet and the base to between twelve and twenty feet. As usual, the material came from the interior edge of the borrow trench. Crops faired well over most of the island floor in 1872, by which time experimental plots of jute and ramie were added to the 1,500 to 2,000 acres planted in small grains, potatoes, and truck crops. Only a partial crop was harvested in 1873, apparently because the tract was saturated by winter's rain and by seepage, which cracks in the peat augmented. Nevertheless, the Tide Land Reclamation Co. sponsored an excursion for prospective buyers of reclaimed lands to the island in April 1873. A share-tenant's farm and the Minor, Prather operation were inspected.[41]

Twitchell Island's pioneer farmers on a large-scale found that the tract's fire-modified soil overlay a mass of peat that was 35 feet deep, perhaps more, near the San Joaquin River. The spongy organic matter's fire-modified soil, when not too moist, assured splendid yields. However, the weight of the levee compressed underlying peat, resulting in fissuring that crossed the narrow riverside berm, ran beneath and along the levee for scores of feet, and into the island for 300 to 1,000 feet. The cracks tended to be from two to eight feet across where they did not form a broader honeycomb of fractures, and thirty-five feet deep. They were noticed as early as July 1872. Although Chinese laborers built corral levees to contain them, and filled the fissures with material taken from deposits in and adjacent the sloughs that flanked the island, the fissures provided subterranean avenues through which water moved from the river. The extensive system of cracks that appeared in late 1873 and early 1874 in the southeastern part of the island resulted in flooding the tract. Although the levee was rebuilt, the soil may not have dried out enough to broadcast a late barley crop. In any case, a sizeable segment of the southern levee was pushed into the island by a "tidal wave" in January 1875. Some 800 over-wintering sheep and other stock were drowned, and dwellings were awash.[42]

By the time that Twitchell Island was abandoned in 1875, landowners had expended over $111,000 on works of reclamation. Their levee system had been widened to twenty feet at the toes and eight feet across the crown; at least six feet of peat was placed on top of the continually settling levee sector that faced the San Joaquin River. Expenditures on residences and farm structures, and on cultivating crops, are unknown. In any case, the tract was abandoned to the elements. An Antioch newspaper opined that peat was "unfit for levee purposes".[43]

Except for the very early landowner whose 213 acres included an orchard on slightly elevated land along the northern end of the island, everyone left. Nevertheless, five of the Minor, Prather Co. associates retained title to acreage for at least a decade, and two until 1900. A westerly parcel of 1,136 acres, meanwhile, was acquired by Thomas H. Williams, the developer of wetlands whose extensive holdings included a good part of Grand Island and Union Island, where reclamation was more rewarding, although not without destructive inundations.[44]

For the better part of twenty years, the easternmost 1,600 acres of Twitchell Island were left in volunteer cover and tidal water, as was the westernmost fifty-five percent for another decade. Renewed efforts to reclaim the former tract began in 1894, resulting in the creation of Oulton Island (Reclamation District No. 559). The tract's western wetlands were leveed in 1903-04 as Twitchell Island by a group of established landowners bound by civil contract to pay for the job. The reclamation projects involved the use of long-boom clamshell dredges, which amassed and maintained levee systems of much greater cross-section than theretofore, and pumps. Nevertheless, peat remained a spongy medium on which to build levees, and the Sacramento River continued to sweep in. The island was flooded in July 1906, March 1907, and January 1909.[45]

Survey work amongst the delta waterways and thick tules, c. 1900, was conducted by teams from the U.S. Geological Survey.
Sacramento Archives & Museum Collection Center
Hubert F. Rogers Collection
2006/028/0122

U.S. Geological Survey at work, c. 1900.
Sacramento Archives & Museum Collection Center
Hazel Pendleton Collection

Other Reclamation Ventures in the Central Delta

While the venture in reclaiming Sherman Island involved small groups of landowners who collaborated to transform the wetlands into cropland, albeit lead by a local entrepreneur, enclosure of Twitchell Island was done by the company owned by George D. Roberts, and developed by a company of investors from California and Louisville. The former model was common in the central Delta, but Roberts was not alone in operating a company organized to reclaim large tracts that were to be sold and leased to others.[46]

Barely had early labor-intensive ventures succeeded in reclaiming Sherman and Twitchell islands, when levee-building projects began elsewhere in the 200,000 acres of tracts underlain by deep bodies of peat. Webb Tract and its one-time western sector, Bradford Island, were leveed in 1870 and 1871, respectively. Bacon and Bouldin Island's levee systems were completed in 1871. The first levee system around the southernmost 7,419 acres of wetlands on Brannan and Andrus Islands was built in 1871 and 1872. Mandeville and Venice Islands, and most of the wetlands to the south of the present Webb Tract, were enclosed with levee systems in 1872, as was Jersey Island in the winter of 1872-73. Levee building began at Staten Island in 1873, the year when the Tide Land Reclamation Co. restored the levees around southernmost Brannan and Andrus Islands. Bethel Island was leveed effectively by 1875, and peaty lower Roberts Island in 1876 or 1877. Meanwhile, about 3,000 acres of wetlands located adjacent the Montezuma Hills and Horseshoe Bend were reclaimed for the second time. The dimensions of this levee system were similar to those raised in the northern and southern thirds of the Delta, where alluvial bank lands were well defined, being thirty feet at the toes, five feet across the crown, and ten to fifteen feet high.[47] Systems of peat levees that were erected around the central islands were more remarkable for their extent and the area of some 100 square miles that they enclosed, than for their security against flooding. Nevertheless, the ramparts were considered to be sufficient for

the purpose. In general, new levee systems had from ten to seventeen feet across the base, two to eight feet at the crown, and were three and a half feet to nine feet high. The levee systems of smallest dimensions were expected to prevent high tides from entering tracts where grazing was to continue. By 1878-79, most lines of defense around prospective cropland were broadened by at least eight to twelve feet across the base. Levee crowns were commensurately broad, but were not higher than theretofore. It is likely that project superintendents who had levees built with large cross-sections were allowing for shrinkage (about 33 percent) and subsidence. As a rule, they had men cut peat blocks from a trench located three to ten feet beyond the inner toe of the levee. Invariably, borrow trenches were three feet deep, which facilitated measurement of the volume extracted. The width of the trenches reflected original levee dimensions, plus material borrowed subsequently to restore the outer faces and heights of the systems. There tended to be plenty of room for enlargement, as the levee set-back from channels was from 35 to 100 feet. On the other hand, as superintendents learned,[48] the peat lost substance the further that borrow ditches were widened into island interiors:

> It is well known among 'Tule' men that the first three or four feet of the surface contains all the tenacity and consistency that is of any value for building material for foundation; below this is nothing but a pulpy mass, through which a sounding rod would pass almost by its own weight, down to the 'hardpan', so, that when it becomes necessary to construct an artificial berme, the contingency becomes expensive, through the cost of making additions for several seasons as the materials settle into the pulp, and uncertain, as a seam will always exist when the artificial joins the natral berme.[49]

Among the original and restored levee systems of the central islands, only Bacon, Bethel, and Jersey Islands, and the Webb Tract, are known to have received some material dredged from channel bottoms. The steam machines, operating in 1873 and 1875, dumped the alluvium and clay into scows, which were towed to island perimeters, where Chinese laborers or conveyors dressed the systems. As noted earlier, the costly procedures were adopted because the dredge dipper could not be extended far enough to dump upon a levee without risking destabilizing the structure by excavating too close to the outside of the system.[50]

In the course of the 1870s, several 10,000-acre tracts of tidal wetlands were partially or completely leveed on the Delta's fringes. However, the velocity and volume of water during river flood-stages could be destructive, as on lands to the south of Stockton, where crops flourished on some 8,000 acres between 1869 and 1874, but were drowned out in 1875. The same flood event destroyed 2,000 acres of grain to the west of the Old River distributary of the San Joaquin River. At times, too, the Mokelumne and San Joaquin Rivers spilled across their banks onto adjacent valley plains, before ultimately entering the interiors of leveed areas on the mainland periphery. These flows from inland were infrequent, compared to the seas that the Yolo Basin delivered into the Sacramento River just north of Rio Vista. As noted earlier, the broad and high flows were capable of entering and sweeping over lower Grand Island, and of inundating Brannan, Andrus, and Twitchell Islands. During such events, the Sacramento River's water would back

up to about Courtland, threatening the security of levee systems which had been enlarged for some years with mining debris taken from the river's shoal margins. Meanwhile, the enormous volume of water pouring downstream of Rio Vista encountered a bottleneck at Horseshoe Bend, which caused the stream to rise over and through the levee system at Sherman Island, into the San Joaquin River.[51]

Following enclosure with the first levee systems at Webb Tract, Mandeville and Bradford Islands, some land was burned and seeded with wheat and clover. Nearly all of Bouldin Island's 6,400 acres were burned in 1873, but no crops survived in 1873 or 1874. Webb Tract, which was free of water between 1870 and 1873, had as much as 2,000 acres of small grain and forage crops. Mandeville Island had up to 2,500 acres burned and seeded in 1872-73 and 1873-74. The first seeding of small grain on Bradford Island covered 700 acres by early 1873, when houses, barns, and a wharf were built. Meanwhile, shrinkage and subsidence occurred in the levee systems, and the underlying peat cracked here and there. Some sectors of levee were so buoyant that they shifted with the tides, although not to the point of breaking.[52] Still, every island had to have a gang doing maintenance the year-around.

Many of the reclaimed islands of the delta provided wintering pastures for livestock of Sacramento and San Joaquin Valley ranches. The sheep and cattle, seen here along Elkhorn Slough, often drowned when levees breached.

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Robert Heringer Collection
1985/005/0010

Livestock were ranged on all of the islands and mainland tracts of the Delta's periphery before and after reclamation. Large numbers of sheep and cattle came from as far as the lands of Miller & Lux, in the southern San Joaquin Valley. Venice Island is not known to have been cultivated,

and Jersey Island was not farmed until 1878. As noted for cultivated Sherman Island, Bradford Island carried many sheep, especially in winter. Its owner lost 4,000 sheep to drowning in the course of several floods of the early 1870s, abandoning the island in 1875.[53]

The land drainage venture at Bradford Island was aborted after mid-winter and June floods in 1873 and 1874, and in the spring of 1875. Adjacent Webb Tract and Mandeville Island, and Bouldin Island, were abandoned in 1874, cracks in the peripheral peat admitting water at the high tides of June.[54] The degree to which tule thickets developed again over any abandoned island is unknown.

Brannan and Andrus Islands

The southern halves of Brannan and Andrus Islands were of the central Delta in that they were underlain by peat that was from ten to forty feet thick. The southeastern rim of Andrus Island was but a foot or two above high tide, as were the banks of nearby central islands. There were bands of sedimentary land along the Sacramento River; less so along the eastern (Georgiana Slough) side of the upper half of Andrus Island. The sedimentary soils of bank lands on northern Brannan Island were as much as 500 to 600 feet broad, and high enough to support orchards. The continuity of the bank lands toward Andrus Island was broken just to the southwest of Isleton by the head of Jackson Slough, a small distributary of the Sacramento River that extended southerly between the tule basins of the two islands.[55]

The southern 8,233 acres of wetlands on the two islands (Swamp Land District No. 148) were enclosed with nineteen miles of levee by the Tide Land Reclamation Co. The company built a brush dam at the lower end of Jackson Slough, as did an independent landowner the upper end. The company's peat levee was a little smaller than average along the Sacramento River – four feet high, fifteen feet between the toes, and eight feet across the crown. It was inside a six-foot berm, and backed by a borrow-ditch of twenty-four by three feet. The system cost $3.20 per acre, about $48,000. To the southeast, where the system adjoined the San Joaquin River, persistent settling required additions of one-and-a-half or two feet to the levee's top every year between 1873 and 1878, when it yet was but a foot or two above ordinary high tide. In 1876, to forestall flooding from southernmost Brannan Island, where a separatist owner of 439 acres was inattentive to levee care, the company built a cross-levee of peat between the Sacramento River and Seven Mile Slough. It was unusual in that a trench (puddle ditch) was cut and filled with alluvium to reduce seepage and afford more security for the overlying peat levee. Elsewhere on the sandy and loamy perimeters of the two islands, individual landowners built levees for themselves, spurred on by the major flood event of the winter of 1872-73, when levees were overtopped, but not broken. Material was borrowed from riverside for the structures. Thus, by 1873, both islands were enclosed. Until then, the interior tule marshes had flooded every winter.[56]

By and large, the bank lands on Brannan Island were planted in row crops, like potatoes and other vegetables; also, there were small areas of orchard on the high ground. North of Isleton, along the Sacramento River (or "Old River"), orchards were more in evidence. Whereas tenants who planted row crops paid cash-rent of $20 to $25 per acre, tenants who harvested small grains paid $10 per acre, or a fourth to a third of the harvest. Orchards were managed by landowners.[57]

The cut alfalfa drying in the reclaimed land of the Holland Tract, c. 1920, was only possible behind the area's protective levees.
Sacramento Archives & Museum Collection Center
Robert Heringer Collection
1985/005/0011

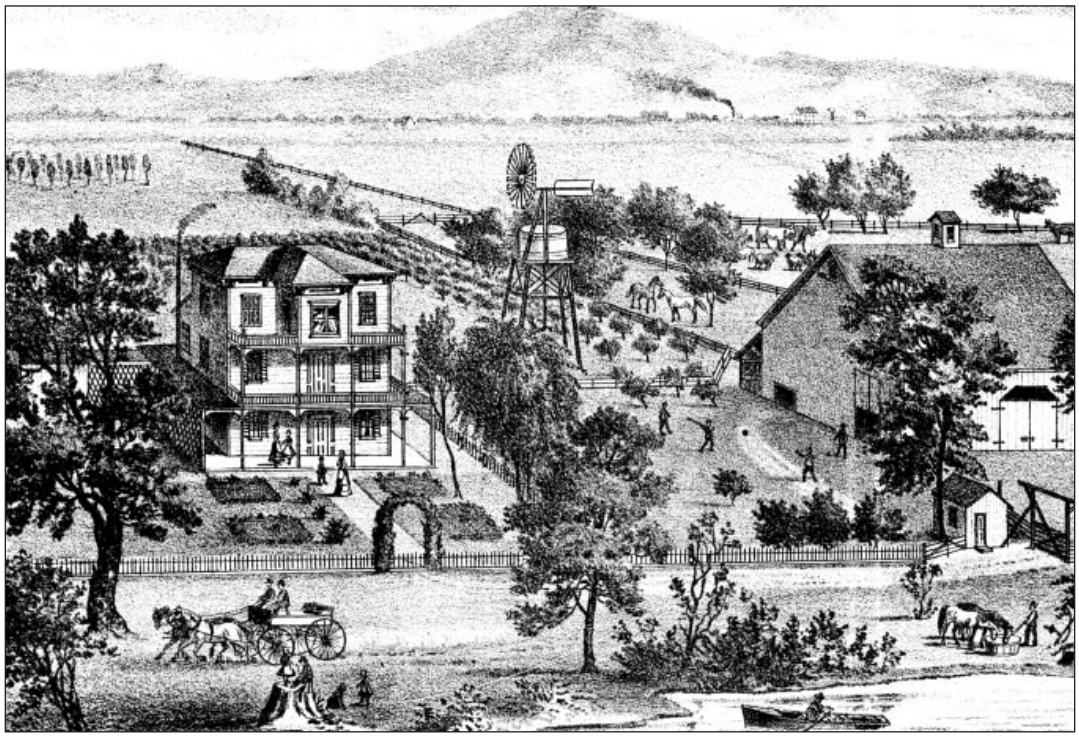
A partial crop of grain was harvested in 1874, and 2,000 acres of wheat and barley did well in 1875, the wheat yielding 30 bushels per acre. By 1876, nearly all of the land had been burned and seeded, or planted. Although rust was a problem in 1876, wheat yielded well in 1877, as did barley and row crops. Potato crops netted about $125 per acre then, and beans $80 per acre. Double-cropping was common. Bank lands were worth $50 to $60 per acre during the late 1870s.[58]

The southernmost part of the tract reclaimed by the Tide Land Co. was penetrated by large cracks from Seven Mile Slough in mid-1876. In response, imperiled levee sections were piled high with sedimentary spoil, and the fissures filled. The work fully occupied between 150 and 200 laborers for several months. While the problem was contained, a major flood stage on the Sacramento River inundated all of Brannan and Andrus islands in the winter of 1877-78. Many sectors of levee were broken, as was the dam at the head of Jackson Slough. As a result, a large amount of mining debris filled sloughs and veneered island floors. Before long, floating debris within the ponded tracts included massive blocks of peat, 100 to 500 feet across and four feet thick, that rose from the floor of lower Andrus Island. While chunks of peat invariably rise from scouring crevasses, this was a surprise; and "floats" that settled on the land as the waters spilled into the San Joaquin River were a hindrance to subsequent cultivation.[59]

The levee system that was restored in 1878 by newly organized (1877) Reclamation District No. 317, ranged in height from five to nine feet, higher sectors facing the Sacramento River. The structure was twenty-five to thirty and thirty to forty feet wide at ground level, with crowns three to five feet wide. For the most part, the building material came from outside the system of levees. Since burned peat lands were reduced in elevation by up to three feet, drainage ditches were cut to tide gates, at least on lower Andrus Island.[60]

Isleton, founded in 1874, like the earlier Emmaton, was created to be the local service center. The developer, a "genuine hustler", was Dr. Josiah Pool, who began to farm in 1855 on 146 acres

of bank and tule land in the narrow waist of Andrus Island. He purchased 535 acres located in the southerly tract that was reclaimed by the Tide Land Reclamation Co. The property, together with parcels owned by a brother and two neighbors, was organized in 1875 for reclamation as the Isleton District (Reclamation District No. 215). It ultimately embraced 1,155 acres that were located between the Sacramento River and Jackson Slough, and downstream of the ox-bow on Georgiana Slough, to the east. The successor district (No. 317) was organized to include much of peaty southern Andrus Island in its 3,348 acres. To develop the town and land, Pool borrowed about $29,000 between 1874 and 1877 from a life-insurance company and a bank. A wharf (1875) and warehouse, hotel, grange hall, two saloons, blacksmith's shop, and two or three stores, soon appeared. And, Pool persuaded several Chinese to form a community on the Jackson Slough side of town. By 1880, they comprised about a third of the town's 110 residents. A city hall and water company functioned in 1878. By then, the California Sugar Manufacturing Company (org. 1876) had planted acreage in sugar beets, and built a beef-feeding lot adjacent the $160,000 mill, just to the north of town. Isleton's second hotel and the water system served the site. There was a commercial ferry (1877) to Grand Island and Rio Vista, and one to Sherman Island. Yet another private ferry linked the county roads of Andrus and Brannan Islands with Walnut Grove, and the roads to Sacramento and across Tyler and Staten Islands to New Hope Landing, where the Mokelumne River entered the Delta from the east. Isleton's road to a landing (San Andreas) on the San Joaquin River followed the banks of Jackson and Seven Mile Sloughs. To begin with, Isleton was very well served by steamboats operating between San Francisco and Sacramento.[61]



Hart F. Smith's 600 acre ranch on Andrus Island, lay near the delta service town of Isleton, founded in 1874.

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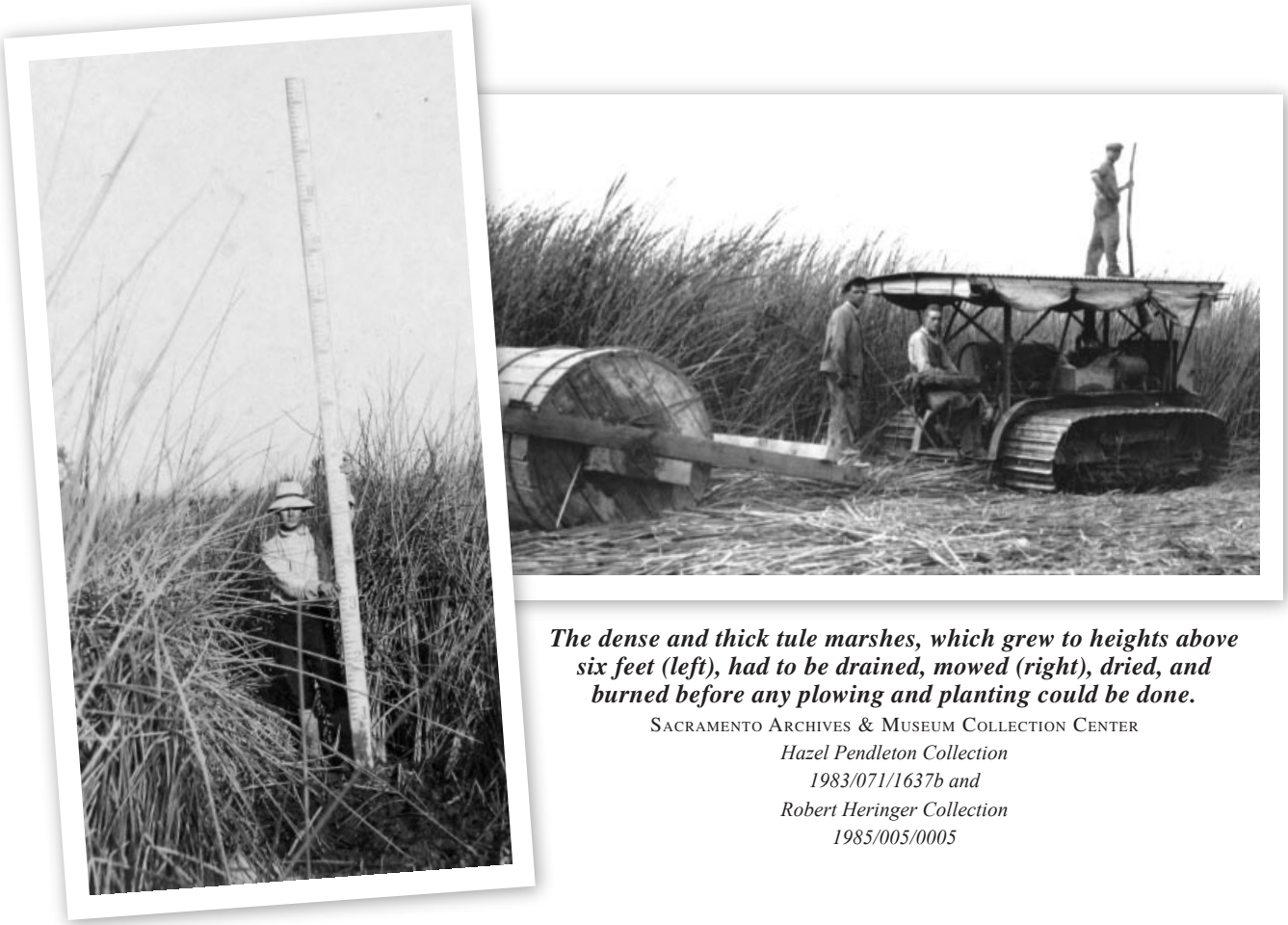
Margaret Casselman Collection

2004/076/0001



The dense and thick tule marshes, which grew to heights above six feet (left), had to be drained, mowed (right), dried, and burned before any plowing and planting could be done.

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Hazel Pendleton Collection
1983/071/1637b and
Robert Heringer Collection
1985/005/0005

In late 1876, the editor of Stockton's *Daily Evening Record* commented about Isleton: "The town and business are both prospering, and the prosperity of both seem to be healthy, solid and permanent, because based upon correct principles of business – on the natural and mutual relations between capital, labor and natural resources."[62]

Nature mounted a devastating flood event in late February 1878, an enormous flow from the Yolo Basin crossing and backing up the Sacramento River to the point of flooding almost every tract and island downstream of Sacramento. Pool and many others were staggered; the prospering sugar beet company never recovered. Nevertheless, once the inundated lands were free of water, as after the flood of 1881, agriculture flourished. Restoration of levee systems began to be effected with long-boom clamshell dredges, which amassed bulwarks of a new order of height and cross-section with mining debris taken from shoals and channel floors. Initially, it was corporate capital that underwrote restoration of levees with clamshell dredges, as at the Isleton District and Bouldin Island.[63]

Except for the project undertaken by the Tide Land Reclamation Co., enclosure of the two islands was accomplished within the lands of eight independent reclamation districts, whose landowners were thoroughly independent as to where, and how large, to build a levee. Nevertheless, the line of levees facing the Sacramento River was on the order of four to eight feet high, three to eight feet across the crown, and fifteen to thirty-five feet wide on the ground.[64] Within the levees, farming resumed as soon as the land was dry enough to plant. On northern Brannan Island, and Andrus Island upstream of Isleton, as with all lands upstream to Sacramento, and where bank

lands flanked the Mokelumne and San Joaquin Rivers, floods were damaging to tenants and landowners, and delayed cropping, but recovery soon followed. However, at flooded islands of the Delta's center, depleted peat floors, disappearing levees, reduced sources of material suitable for levee reconstruction, frustration and strained finances, resulted in abandonment in the late 1870s.

Retrospect

The aggregate area of wetlands in the central Delta that was planted in crops could have exceeded 19,000 acres in 1873, more than double the area in 1871. About 17,000 acres appear to have been planted in 1874. However, it is doubtful if the total of farmed land exceeded a third of the area of the reclaimed islands. The harvested cropland was substantially less, overtoppings and failures of levees, together with fissuring of underlying peat, resulting in flooding.[65] To what degree fire in the tules and peat damaged crops and levees is unknown. In any case, the experience of the 1870s lead an engineer to observe in 1882, "I know of no peat lands that have been successfully reclaimed. Levees made of peat have proven failures in every instance."[66]

The toll of failed ventures to drain and farm tracts of peat included the Webb Tract and Mandeville Island in 1874, then Twitchell and Bradford Islands in 1875. The western segment of Sherman Island was abandoned to the tides between 1875 and 1879, and again in 1881, when the entire island was lost to farming for about thirteen years. Lower Brannan and Andrus Islands were partially awash between 1878 and 1886. At best, Venice, Bacon, and Jersey Islands functioned as rangeland for livestock.

The islands of the central Sacramento-San Joaquin Delta at mid-nineteenth century were slightly rimmed saucers of wetlands resting on deep beds of peat, and were washed by tidal fresh water. They lay within a fretwork of winding river channels and inter-connecting sloughs. Since about 1900, dredge-made island rims became relatively high and broad levees atop buried earlier levees and compressed beds of peat. Some new levees were on the order of 100 to 125 feet at the base, up to 20 feet across the crown, and at least 5 feet above estimated high-water level. Often, modern levees are armored with riprap to protect them from wave erosion, rather than the alfalfa, bundles of brush, and volunteer cover, adopted long ago.[67] Much of the enclosed areas of the central islands now are ten or fifteen feet below sea level; some places are seventeen to nineteen feet below.[68] The shallow, slightly rimmed, islands of 150 years ago have become bowl-like because of depletion of the peat by natural oxidation, shrinkage, burning, wind erosion, and periodic flooding. Much of the loss of elevation has occurred since 1897-1918, when about 25 tracts and islands comprising over 100,000 acres, were enclosed with levees built by dredges, and kept free of water by pumps.[69] Since then, the island floors have lost elevation at the rate of about three inches per year. The loss of elevation has resulted in increased hydrostatic pressure against the artificial levees and porous underlying peat.[70]

During the 1900-1918 period, waterways of the peaty Delta, notably to the south and east of the San Joaquin River, were extended and greatly altered by dredges. The cuts were made to build levees around newly formed and recovered old islands. Between then and the 1950s, burning and turning under peat soil was a common practice where potatoes were planted. The practice

liberated potash for the crop, and was thought to control weeds, pests, and disease. To what degree the burning preceded planting of 30,000 to 40,000 acres of potatoes per annum between 1908 and 1919 is unknown, but it was common after 1930, when the area planted in the crop was less than 11,000 acres (1938). Such destructive land preparation ended about 1980.[71]

It was common practice early in the twentieth century to dress the fragile levee systems with fresh dredged material at intervals of one to three years. The frequency and extent of levee dressing dropped in the 1930s and 1940s, and have not prevented flooding of many tracts since.[72]

Over the past 125 years, owners of wetlands reclaimed for agriculture adjacent the main river channels of the Delta were among the greatest beneficiaries of the navigation improvement and flood control plans executed by the U.S. Army Corps of Engineers and collaborating state agencies. Especially beneficial was the project to realign, widen, and deepen the Sacramento River downstream of Grand Island, which resulted in cutting through Horseshoe Bend in 1918 with hydraulic dredges.[73] The same owners have benefited from operation of multi-purpose dams built in the uplands of the Central Valley's watershed since the 1930s. However, mitigation of the problems associated with reclaimed islands of peat did not receive significant state attention until the 1960's. Not the least of such programs resulted from the Delta Flood Protection Act of 1988. It was designed to preserve the integrity of eight westernmost islands (Sherman, Twitchell, Bradford, Jersey, and Bethel) and tracts (Webb, Holland, Hothkiss) of the central Delta, in order to protect water quality in the keystone conveyance of water from the north to the aqueducts that serve the populous Los Angeles and San Francisco Bay areas, and irrigated lands in the San Joaquin Valley. Benefiting, too, were the ecological and recreational assets of the Delta, together with its irrigation-dependent agriculture.[74]

Nevertheless, the inherent deficiencies of peat as foundation for levees made of peat, and the rapidity with which drained peat oxidizes and shrinks across island floors continue. Hydrostatic pressure exerted by the tides, and raised when rivers at flood stage enter the Delta, continue. Furthermore, in years of exceptional runoff, as in 1938, 1950, 1955, 1958, 1964, 1986, and 1997, levee systems have been breached adjacent the Mokleumne and San Joaquin Rivers where they enter the Delta. More serious, however, are breaches that occur in the central Delta, where very large areas of island floors lie ten or more feet below sea level. The resulting inrush of water, and subsequent variations in tidal levels, draw brackish and salt water from Suisun Bay toward the channels that convey fresh water to the pumps that feed the aqueducts upon which millions of people and millions of irrigated acres depend. As is widely recognized, strong seismic activity could breach the fragile levee systems. Given trends of subsidence on the islands that rest on thick beds of peat, prospective rises in sea level are sobering to contemplate, as well.

Acknowledgements

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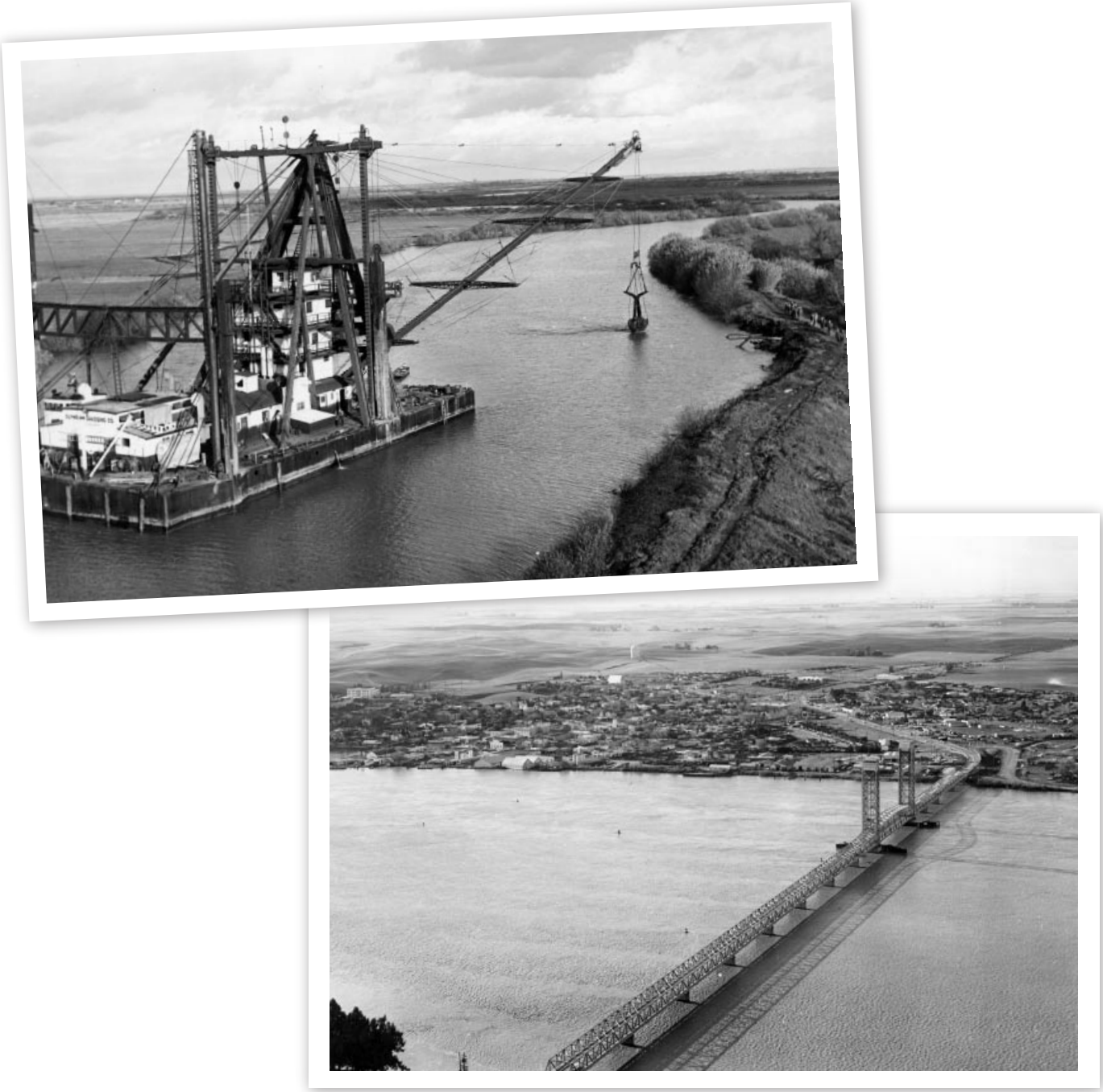

As the peat of the delta levees subsided, dredges like the Neptune became crucial components of keeping the saucer-like islands dry (left); Rio Vista, like many delta towns, is susceptible to rising sea levels and weakened levees (right).

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Sacramento Bee *Collection*

SBPM Sacramento River

ENDNOTES

1. California, The Resources Agency, Department of Water Resources (DWR), Delta Levee Investigations, Bulletin 192-82 (December 1982), 39, _____, Sacramento-San Joaquin Delta Atlas (Sacramento: Department of Water Resources, 1987; reprinted July 1995), 46, 48; cited below as DWR, Atlas, _____, Central District, "Historic Inundations of Delta Islands," unpublished file. Accounts of the floods of 1902, 1904, 1907, and 1909, appear in John Thompson, Flood Chronologies and Aftermaths Affecting the Lower Sacramento River, 1878-1909 (Sacramento: Department of Water Resources, November 1996), 21-54, cited below as Thompson, Flood. "Two Delta Islands Flooded," Stockton Record (SR), January 27, 1980, 1, "200 Flee Delta Flood", September 27, 1980, 1, 8; "New Delta Levee Break – Aqueduct Threatened", San Francisco Chronicle (SFC), October 24, 1980, 1, 16; Cheryl Miller, "Red Tape Snagged Levee Repair Work", SR, June 14, 2004, B 1, Dana Nichols, "Jones Tract Struggles to Recover from Flooding", SR, May 29, 2005, A 23.
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3. A detailed description of the technology of early levee construction is in John Thompson, Discovering and Rediscovering the Fragility of Levees and Land in the Sacramento-San Joaquin Delta, 1870-1879, and Today (Sacramento: Department of Water Resources, February 1982), 7-25, cited below as Thompson, Discovering.
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