Appendix A

DETAILS OF SUBSIDENCE STUDIES

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Mandeville Island was chosen by DWR to be studied in detail to learn about possible subsidence control methods. Methods and information gained on Mandeville Island could then be applied to the subsidence problem in remaining Delta areas.

Information on the thickness of organic soils can be obtained from Plate 1, as it was for Mandeville Island. By using this and estimated subsidence rates, depletion times for various organic deposits can be calculated. Some difficulties may be encountered in differentiating organic from mineral soils where soils mapping is lacking or is not as detailed as that for Mandeville Island. However, until more accurate delineations of organic soil deposits can be obtained, the same method will allow generalized depletion time estimates for other Delta areas.

Subsidence rates found on Mandeville Island compared closely with those of earlier studies at various locations within the Delta. Based on all the studies, it is estimated that the majority of Delta organic soils are subsiding at a rate of from 7.1 to 7.6 cm (2.8 to 3.0 inches) per year.

Mandeville Island Study

Organic and mineral soils were differentiated using Soil Conservation Service (SCS) soils mapping and aerial photography and rates of subsidence on Mandeville Island were determined by calculating changes in ground elevation over known periods of time. Changes occurring in areas of predominately organic soils were then compared with those in areas of mineral soils.

The thicknesses of organic soils on Mandeville Island were estimated from the Thickness of Organics Map (Plate 1), which is based mainly on exploration hole logs and partly on an organic isopach map prepared for another study[1] An electrical resistivity survey was made to supplement the information.

Differentiation of Soils

Organic soils were differentiated from mineral soils for the purpose of calculating relative elevation losses for each general soil type. (Organic soils include peat, organic silt, organic clay and mineral soils containing greater than 25 percent organics by weight, according to the Unified Soil Classification system.) Using the SCS mapping units, the soils were grouped as follows:

Mineral Soils -
- Egbert mucky clay loam
- Piper sandy loam
- Ryde silty clay loam
- Ryde silty clay loam with organic substratum
- Ryde-Egbert complex
- Valdez silt loam

Organic Soils -
- Ringe muck
- Ringe muck overwash
- Venice and Shima muck
- Venice muck overwash

[1] Department of Water Resources, Division of Design and Construction, Organic Isopach Map, October 1976.

The soils groups were delineated on a map of Mandeville Island (Figure A-1) and were compared with aerial photographs to identify characteristics of surficial features for each soil type, thus establishing criteria for organic and mineral soils in Delta areas where detailed soils mapping is not available.

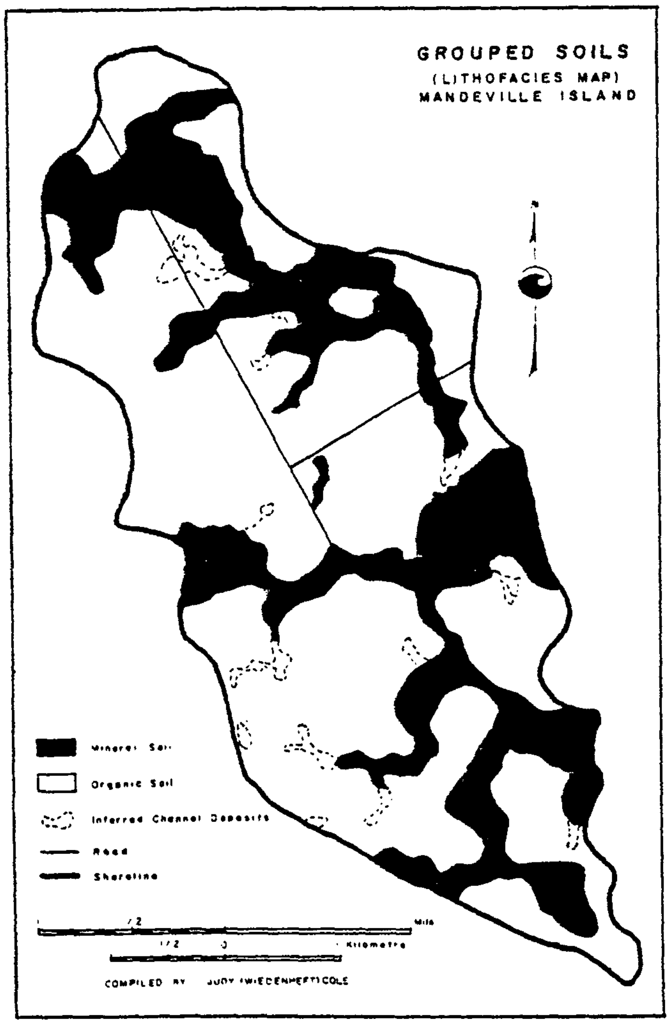

Figure A-1. GROUPED SOILS, MANDEVILLE ISLAND

Calculation of Subsidence Rates

Subsidence rates on Mandeville Island were determined by calculating changes in ground elevation over known periods of time. Changes occurring in areas of predominately organic soils were compared with those in predominately mineral soils.

Elevation differences were obtained by comparing spot elevations shown on 1974 U. S. Geological Survey (USGS) field table boards with estimated elevations at a corresponding location on a published 1952 USGS topographic quadrangle map. The estimates from the 1952 map were made from elevation contours or from spot releveling points near the earlier spot elevation locations. Elevation decrease rates for each pair of elevations were estimated by dividing 22 years (1952-1974) into the elevation differences (Table A-1).

Estimates were also made for 1918 to 1952 (34 years) and for 1918 to 1974 (56 years) assuming that initial cultivation on Mandeville Island, when ground surface elevation was at sea level, was in 1918. Estimates for the 1918-52 period were based on a comparison of elevations on a 1910 topographic map with those of a 1952 topographic map. Estimates for the 1918-74 period also used elevations from the 1910 map as compared to spot elevations on the 1974 field table board. Differences for the pairs of elevations and respective elevation decrease rates were then computed as for the 1952-74 period.

The elevation decrease (apparent subsidence) in the mineral soil areas of Mandeville Island is primarily due to land leveling. As adjacent organic soils subside, an elevation differential occurs between the mineral and the organic soils. This requires frequent releveling of the mineral soils, according to SCS.[2] The elevation decrease of the mineral soils is thus a result, rather than a cause, of subsidence.

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[2] Soil Conservation Service, Stockton Soils Survey Office, Preliminary Soil Survey Report, Bouldin Island Quadrangle, 7-1/2 minute scale, Stockton CA, 1975.

TABLE A-1

ESTIMATED ELEVATION DECREASE RATES ON MANDEVILLE ISLAND
(in centimetres (inches) per year)

Soil Type	Primary Reason	1952-74 (22 yrs)	1918-52 (34 yrs)	1918-74 (56 yrs)
Organic Soils	Subsidence	7.1 (2.8)	8.9 (3.5)	7.6 (3.0)
Mineral Soils	Land Leveling (apparent subsidence)	5.3 (2.1)[a]	8.4 (3.3)	7.1 (2.8)[a]
Undifferentiated	---	---	9.0 (3.54)[b]	---

[a]This apparent subsidence of Mineral Soil is primarily due to land leveling practices on Mandeville Island (see text).
[b]Subsidence estimate by Lao (1965).

Lao Study

While employed by DWR in 1965, Lao estimated subsidence rates for Mandeville Island by comparing elevation contours of topographic maps for the period 1906 to 1964.[3] He also compared Coast and Geodetic Survey bench mark elevations for the period 1957 to 1964. He assumed the beginning of reclamation to be 1918 as a basis for his subsidence rate computations, and also assumed the land surface to be at sea level in 1918.

The approach used in this current study on Mandeville Island was similar in some respects to that used by Lao. Differences are that the more recent method:

1. Provides rate information for the additional period of 1952-74, which may be more indicative of present rates.

2. Used elevations based on spot elevations from USGS field table boards for 1974, which are more accurate than estimates based solely on topographic contours.

3. Used the SCS soils mapping not previously available, which allows more accurate photo interpretation, resulting in a differentiation of organic soils from mineral soils.

4. Did not use the two USGS bench marks on the island perimeter in making rate calculations because such bench marks may be more indicative of levee movement than of island subsidence.

5. Used a thickness of organic soils map (Plate 1) not previously available, which allows a more accurate estimate of thicknesses and the calculation of depletion times for organic soil deposits.

6. Included drilling of exploratory holes and laboratory analyses of boring samples.

Results of the two approaches (Mandeville Island and Lao) produced estimated annual subsidence rates of 8.9 and 9.0 cm (3.50 and 3.54 inches) respectively for 1918 to 1952.

[3] Department of Water Resources, Land Subsidence Study, Incomplete Draft of Office Report by Chester Lao, 1965.

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Weir Study

Weir[4] estimated subsidence by establishing a leveling network (transect) that crossed parts of Lower Jones Tract, Bacon Island, and Mildred Island. His work has resulted in calculations of subsidence amounts along the transect for 1922 to 1964 (Figure A-2).

All horizontal distances were measured by stadia and the transect lines were maintained by sighting on objects such as power poles or warehouses. There were no attempts in succeeding years to take elevations at exactly the same points. Instead, elevations were taken at intervals of about 60 to 120 metres (200 to 400 feet) within a 6-metre (20-foot) wide strip and were read to the closest 3 millimetres (0.01 foot). Many such readings were averaged to obtain a single elevation for each island traversed.

Only a generalized comparison can be made between Weir's study and the latest study by DWR because Weir's transect did not cross Mandeville Island. Weir's estimates of 7.6 and 7.5 cm (3.0 and 2.95 inches) per year on Bacon and Mildred Islands for 1922 to 1964 are close to the 7.1 cm (2.8 inches) per year for 1952 to 1974 estimated by DWR. On the other hand, his estimates for 1958 to 1964 range as low as 2.5 cm (1.0 inch) per year.

This study on Mandeville Island and that by Weir indicate a possible slight decrease in subsidence rates as time increases. For instance, the Mandeville Island study indicated a decrease from 8.9 to 7.1 cm (3.5 to 2.8 inches) per year.

Correlation between Crop Use and Soil Loss

No study has been done using crop use and tillage practices data to correlate with soil loss in the Delta. However, crop use data were included in field notes during the Weir transect measurements, and are reportedly on file at the University of California at Davis. In addition, DWR files contain detailed crop use data that may be correlated with soil losses. Future cooperative studies with UCD may yield information on relative soil losses that may be caused by growing certain crops or by certain tillage practices.

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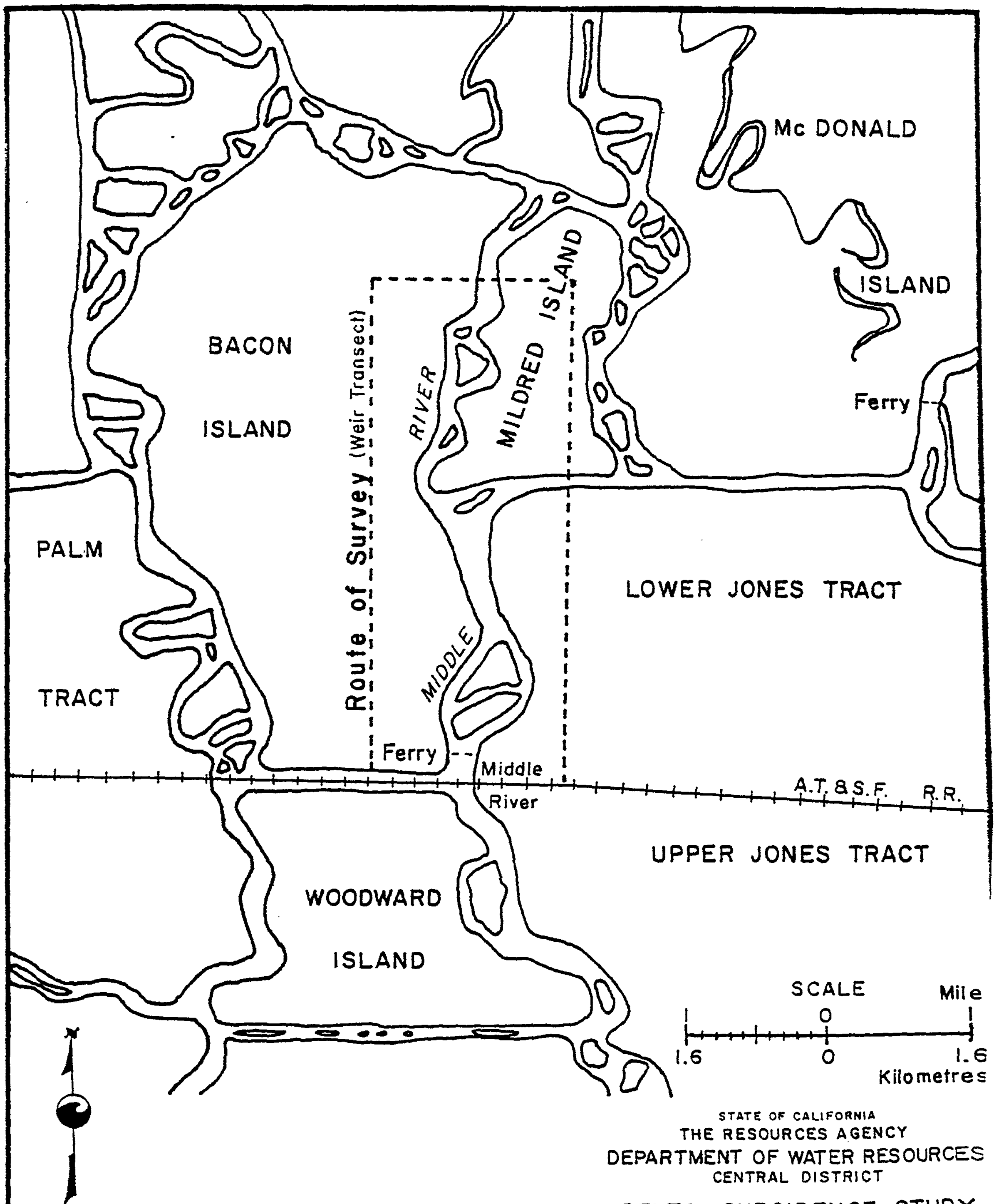
[4] Walter W. Weir, Subsidence of Peat Lands of the Sacramento-San Joaquin Delta, Summary, Agricultural Extension Service, Stockton, CA, Reprinted 1971, p. 10.



SOURCE: Walter W. Weir, Subsidence of Peat Lands of the Sacramento-San Joaquin Delta, California, Summary by Agricultural Extension Service (Stockton CA, reprinted 1971).

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT

DELTA SUBSIDENCE STUDY

WEIR TRANSECT

Figure A-2. WEIR TRANSECT