southern Delta. Freshwater in the Delta is also important to wildlife and recreation. In addition, the levee system protects land use on the islands in the Delta, most of which are below sea level (Figure 5). These islands are used mainly for agriculture, but also contain small communities and their associated infrastructures. In light of these varied uses and benefits, federal, state, and local agencies have an interest in preserving the system of levees and islands.

Less than 150 years ago, the 700,000 acres of the Delta were sea level freshwater and tidal marsh. Through marsh reclamation and damming and diverting of the Sacramento and San Joaquin rivers, the Delta has gradually been transformed from a natural, fluctuating environmental system into an artificially maintained one. Today the Delta contains roughly 60 islands protected by 1100 miles of levees. These islands and levees are constructed mostly of the Delta's indigenous peat, sand, and silt soils. Wind erosion, oxidation, compaction, and consolidation of these soils have reduced the land surface of almost all of the islands to below sea level (Figure 5). Levee failures are common occurrences; since original reclamation, each of the 70 islands and tracts in the statutory Delta (defined in Section 12220 of the California Water Code) has been flooded at least once. Over 100 levee failures have occurred since the early 1890s.

The Delta Problem

Simply stated, the Delta islands are threatened with catastrophic degradation due to sea level rise, land subsidence,

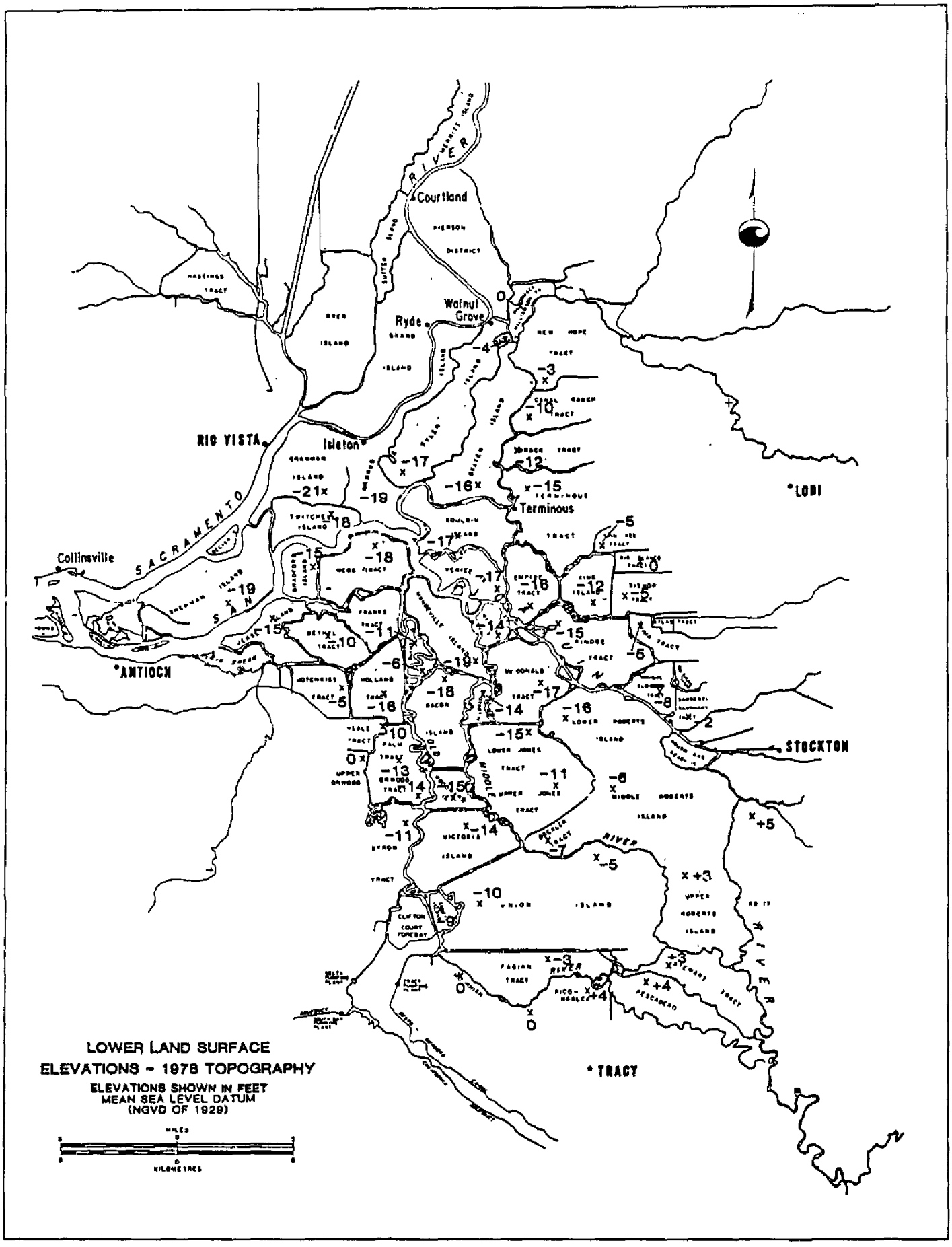

FIGURE 5
DELTA LAND ELEVATIONS SHOWING LANDS BELOW SEA LEVEL (minus values)

wave and current action, and levee deterioration. Also, any changes in freshwater inflow to the Delta or outflow to San Francisco Bay, due to climate change or to consumptive changes, affect Delta water quality. Thus, in addition to being a valuable component in the state's water supply system, the Delta may also be viewed as the "weak link" in that system. The Delta problem is particularly complex because of the many public and private interests with a stake in the issue. The key question raised by the climate threat is, simply, how much effort (and with what policy mechanisms) is to be committed to maintaining the Delta in the face of physical threats.

We approach this question by first describing the policies and institutions that affect the Delta--particularly in the event of climate change or sea level rise. Once this "policy landscape" is laid out, it is possible to discern likely response to near-future climate change.

Institutions and Policies Affecting Delta Maintenance

The Delta and levee problem comes under the purview of several public institutions, each with different responsibilities and concerns. Indeed, this issue may eventually prove more controversial than water supply and flood control. Thus, an analysis of the policy implications of climate threats to the Delta must take a somewhat different approach than a simple study of supply. In this section we focus on those policy trends and mechanisms which point to a continuing effort to protect the Delta at any cost.

The U.S. Army Corps of Engineers (USACE) and regulatory policies. The USACE plays a regulatory (rather than its typical construction and operation) role in Delta levee maintenance. Although the USACE has built some Delta levees, the maintenance and upkeep of the privately owned, "non-project" levees (Figures 6 and 7), which comprise 95% of the Delta levee system, is the responsibility of the individual owners. However, if a levee owner (or local reclamation district, which serves as representative of individual levee owners) wishes to make repairs or improvements on a levee, they are required to obtain a permit from the USACE.

But the USACE has a blanket mechanism for permitting levee construction and maintenance, called a "nationwide permit", that authorizes broad categories of activities like dredge and fill for water resources management throughout the country. In the Delta case, a commonly used nationwide permit is a "No. 3", which allows for "repair, rehabilitation, or replacement of a structure or fill which was previously authorized and currently serviceable." If this repair does not deviate from the structure's original plans, no additional permit must be obtained to carry out the work.

In cases of major work on a levee that changes its original design, the owner may have to obtain a "Section 10" permit. Section 10 of the Rivers and Harbors Act of 1889 requires approval prior to any work in or over navigable waters or affecting the course, location, condition, or capacity of such

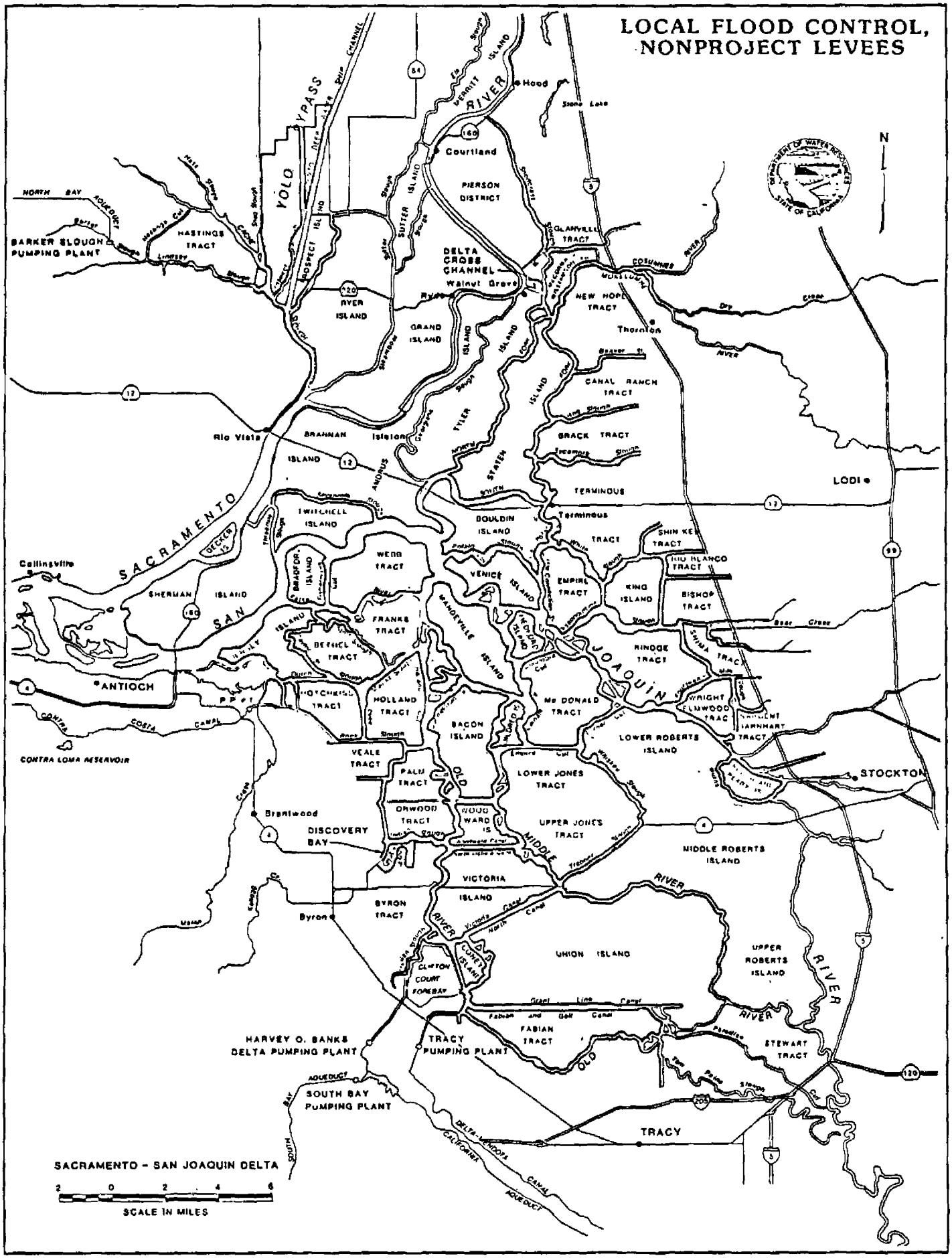

FIGURE 6

NON-FEDERAL LEVEES IN THE DELTA

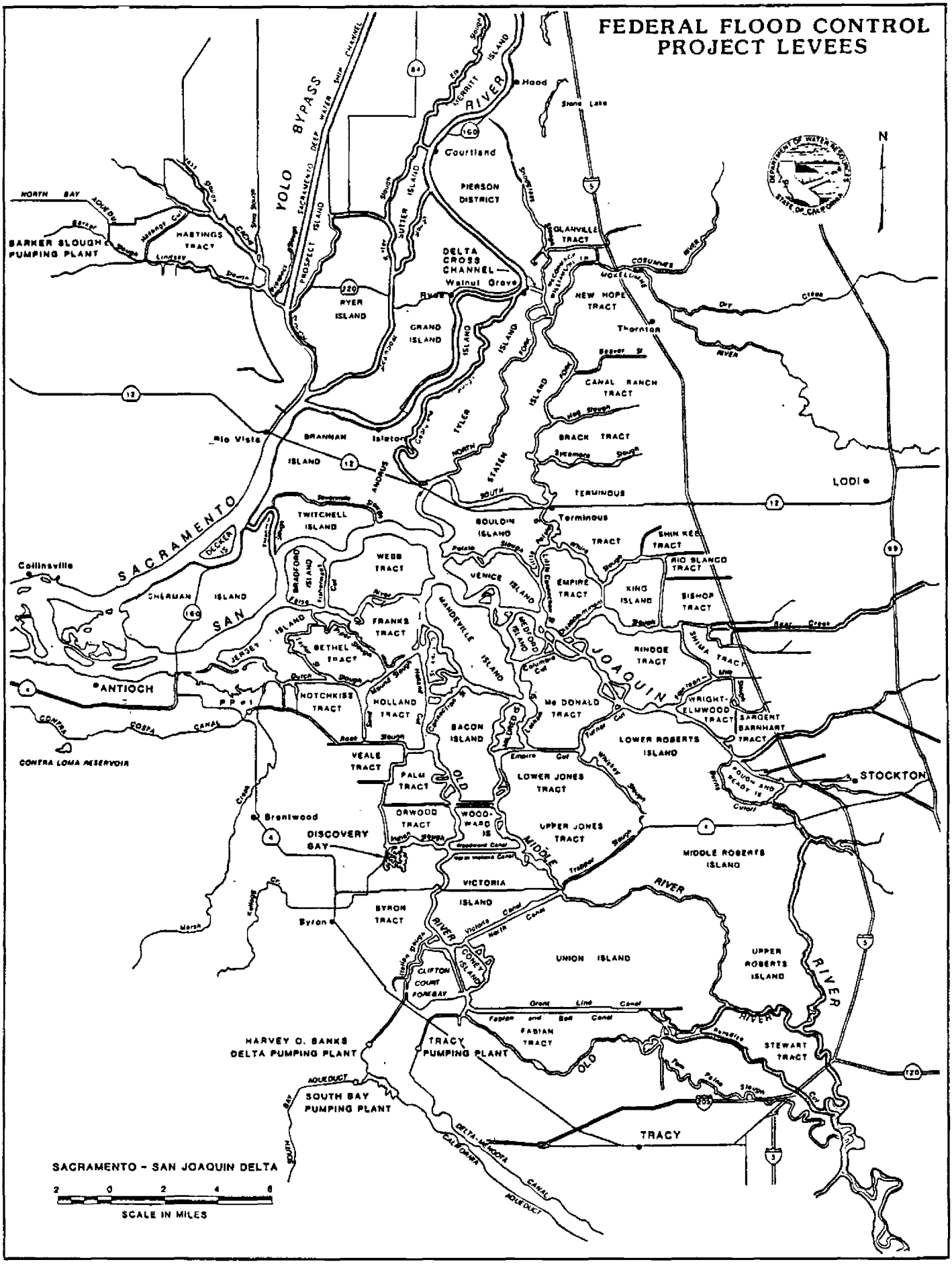

FIGURE 7

FEDERAL LEVEES IN THE DELTA

waters (all tidal waters are considered navigable; all Delta waters are tidal and, hence, navigable). Typical activities requiring Section 10 permits are the construction of piers, wharves, marina ramps; dredging; and excavation.

Construction or maintenance activities which result in some material being deposited onto wetlands or into existing water bodies, require a "Section 404" permit (pursuant to Section 404 of the Clean Water Act). Typical 404 permit activities include deposition of dredged or fill material, as well as construction of levees, dams, and dikes.

These permitting processes are used today mostly for environmental protection, and they might, in theory, result in delayed or reduced maintenance, or even in the consideration of alternatives to continued maintenance. However, the USACE can also issue a permit for "Emergency Bank Rehabilitation" (General Permit No. 35--GP-35). This permit is issued under the authority of Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act, and <u>is available only in the Sacramento and San Joaquin drainage basins</u>. The purpose of this permit is to allow emergency repair of eroded levees and stream banks by the DWR or its authorized representative (usually the local reclamation district). The intent of GP-35 is to authorize work on severely eroded levees when there is a threat to levee integrity which poses a hazard to life or property.

Thus, federal regulatory mechanisms for maintaining the status quo, and fighting physical degradation of the Delta due to

climate change, are in place. A similar set of state policies also support maintenance in the face of physical threat.

The Reclamation Board. The Reclamation Board was established in 1911 to help oversee flood control efforts in the Central Valley. The board also has jurisdiction over all project levees in the Delta. It thus assures the federal government that Delta levees will be properly maintained. The actual maintenance is usually carried out either by a local reclamation district or the DWR. The law governing the Reclamation Board is codified in the California Water Code, Part 4, Sections 8520-9377. Other parts of the code, especially Sections 8340-9577 and 12878-12878.45, inclusive, assign responsibilities to the board regarding the maintenance of flood protection works. Since 1956, the board has been administratively part of the DWR. However, by statute, it continues to function as a separate agency in exercising its responsibilities for flood management on the Sacramento and San Joaquin rivers and their tributaries.

Another important function of the board is the co-administration, with the DWR, of the State Delta Levee Maintenance Subventions Program. In 1973, the state legislature passed Senate Bill 541--also known as the Way Bill--which provides state financial assistance to Delta agencies for maintaining and improving non-project Delta levees for flood protection of Delta islands. This program operates pursuant to the California Water Code, Chapter 3, Sections 12980-12991.

Section 12981 of the Water Code states that, "the physical

characteristics of the Delta should be preserved essentially in their present form, and that the key to preserving the delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands." However, this stance has since been softened with the addition of another sentence to Section 12981 in 1985 which states, "However, the Legislature recognizes that it may not be economically justifiable to maintain all Delta islands."

Section 12982 also states:

> The Legislature further finds and declares that while most of the Delta's levees are privately owned and maintained they are being subjected to various multiple uses and serve to benefit many varied segments and interests of the public at large, and that as a result of the varied multiple uses of such levees, added maintenance costs are being borne by adjacent landowners.

Section 12983 adds,

> The state has an interest in providing technical and financial assistance for delta levee maintenance and rehabilitation.

Thus, there exists a formal policy statement in support of maintaining the levees against physical threat. Of course, there is a range in values of the Delta islands. Some islands contain communities and highways, for instance, while others are strictly agricultural. Although the general policy is for maintenance of the present Delta configuration, there is precedence for allowing some inundation to go unreclaimed. In 1983, Mildred Island's 997 acres of strictly agricultural land which had recently sold for roughly $1 million, were flooded by levee failure. Estimated

total costs of its reclamation, including public and private funds, have ranged from $5-$10 million, and, consequently, it has not been reclaimed (Section 12981 was one reason cited for not reclaiming the island), but other islands are certainly more likely to be protected and reclaimed if flooded. In addition to increasing real estate values, islands in the western Delta are important in repelling saltwater intrusion. Failure of one of these islands would undermine water quality in the Delta and would affect upstream water supply and flood control activities.

Currently, the state of California funds the Delta Levee Subvention Program at $2 million annually. Pursuant to Section 12986, these monies are distributed to the local reclamation districts in the following manner:

1) No costs incurred shall be reimbursed if the entire cost incurred per mile of levee is $1000 or less.

2) Fifty percent of any costs incurred in excess of $1000 per mile of levee shall be reimbursed.

Efforts are underway to increase funding of the subventions program. A bill proposed by state senator Boatwright (Senate Bill No. 34, 1986), would, until January 1, 1999, "authorize reimbursement for 75% of any costs incurred in excess of $1,000 per mile of levee and delete the $2,000,000 per year limitation." In addition,

> The bill would, until January 1, 1999, create the Delta Flood Protection Fund, would declare legislative intent to appropriate $12,000,000 each year to the fund through fiscal year 1998-99 from specified tidelands oil and gas revenues, and would declare legislative intent to annually appropriate from the fund $6,000,000 for local assistance for the maintenance and improvement of delta levees...and $6,000,000 for

special delta flood protection projects and for subsidence studies and monitoring.

Thus, the subventions program funding would be increased to $6 million annually and $6 million would be allocated to flood protection projects and subsidence studies and monitoring. Funds allocated for these projects, studies, and monitoring, "shall only be allocated for projects on Bethel, Bradford, Holland, Hotchkiss, Jersey, Sherman, Twitchell, and Webb islands in the delta." These islands are clustered in the western Delta, and here the legislature may be showing more its concern for overall water quality problems rather than a simple commitment to island maintenance. According to many California water management officials, the passage of this bill is imminent.

Local reclamation districts. Local reclamation districts are representatives of the private owners of Delta levees and islands. These districts do most of the maintenance on the levees within the Delta and have the authority to raise funds from three major sources:

1) The California Water Code empowers the districts to create and update assessment rolls of the lands within their boundaries on which the governing board can periodically level assessment.

2) The reclamation districts' governing boards are also mandated by the water code to establish a schedule of charges and fees for services and benefits provided by the districts.

3) Those districts that use county assessment rolls to levy special taxes for levee maintenance continue to receive an allocation under the post-Proposition 13 tax collection by the county, which includes property revenues and state subventions.

Until 1980, funds made available for levee maintenance and restoration from these sources had been relatively small--less than $1 million per year. However, due to the large number (24) of levee failures since 1980, the local districts were assessed up to their capacity to pay. Because of this trend of increased levee failures, the Federal Emergency Management Agency (FEMA) and other emergency services agencies have played an increasingly important role in the levee maintenance and repair issue.

Emergency service agencies. In the event that a levee failure is part of a flood or storm which becomes a federally declared national disaster, the Federal Emergency Management Agency provides emergency repair funds. These funds are administered pursuant to Public Law 93-288--the Disaster Act. Generally, federal funds are combined with state funds on a 75%-25% basis during federally declared emergencies. The funds provided by FEMA flow through the state of California Office of Emergency Services (OES) to local reclamation districts, counties, and cities.

Due to the recent increase in the number of floods in the region (discussed in the water supply section) and resulting levee failures, FEMA felt they were providing too much money for emergency repairs. They pushed to have Delta levees upgraded to a minimum standard, as stated in the recent Flood Hazard Mitigation Plan (California Office of Emergency Services, 1986). The plan, required in all federal flood disasters, also proposed a levee inspection program to be carried out by the DWR. This

inspection is to be made annually and the results reported to FEMA. The DWR does not have the power to make local districts comply with their recommendations for levee standards or with the inspection plan. However, if the local districts do not upgrade their levees to or above the standards described in the "Short-Term Rehabilitation Plan" (Part 4, Section c, No. 2, of the Flood Hazard Mitigation Plan), they may lose eligibility for FEMA-sponsored emergency funds in the future.

In 1986, FEMA, the OES, and the local reclamation districts signed an amendment to the Flood Hazard Mitigation Plan stating that in order for local reclamation districts to receive federally sponsored disaster aid, they must commit to upgrading levees to at least the minimum standards set forth in the plan (i.e., one foot of levee freeboard above 100-year flood elevations) within a five-year period. Thus, the mitigation plan provides another policy mechanism for fighting climate impacts.

Summary: Delta Protection Has Large Institutional Backing, but Increasing Climate Threat May Eventually Force Alternatives

It is reasonable to expect that the broad array of agencies, policy mechanisms, and interests lined up to protect the Delta islands, even in the face of major threats from sea level rise and other climate change phenomena, will result in substantial public investment if, indeed, the physical threat increases. A range of possible response options is given in Table 3 (see also MacCracken, et al., 1987).

TABLE 3

RANGE OF OPTIONS IN DELTA LAND USE

1) **Inaction:** This would probably result in the formation of a large, brackish inland sea as levees fail and saltwater penetrates farther inland.

2) **Maintenance of status quo:** This will require strengthening and extending the levee system.

3) **Construction of polder levees:** This entails enclosing groups of islands with levees to form large polders. Such a proposal has generally been deemed unsuitable by recreational and wildlife interests.

4) **"Strategic Inundation":** This hypothetical strategy (no agency has formally proposed it) allows for the permanent flooding of islands which have no or little role in repelling saltwater intrusion and have relatively low land values. Efforts could be made to capitalize on the alternative benefits of the open water and marsh created by this, and to create a circum-Delta conduit for water transfers to the California Aqueduct (something like the Peripheral Canal, now referred to as some form of "isolated canal").

It can be argued that, given the importance of the Delta to California's water supply and quality, and the California Legislature's commitment to "preserving the Delta's physical characteristics", inaction is not a likely option. Indeed, the forces for maintaining the Delta in something close to its current configuration are great, and, thus, maintenance of the status quo is the most likely general policy goal over the next several years.

The idea of mega-levees enclosing groups of islands as "polders" in the Dutch tradition is feasible from an engineering standpoint, but, although it has been mentioned, has received little attention. Similarly, some form of "Delta sacrifice" or strategic retreat in Delta land use might be appropriate given the potential for large protective investments that are eventually overwhelmed, but it is probably unacceptable to most Delta interests.

Recently, however, the legislature indicated that it might soften its stance towards Delta island reclamation (see the 1985 addition to Section 12981 of the California Water Code), and it is possible that something approximating a strategic inundation policy might emerge over the next few decades. Sea level rise will increase the frequency of levee failures (Figures 8 and 9). The case of Mildred Island--a relatively low value island that is not required to maintain Delta water quality--is instructive; it has remained flooded since the 1983 levee failure because

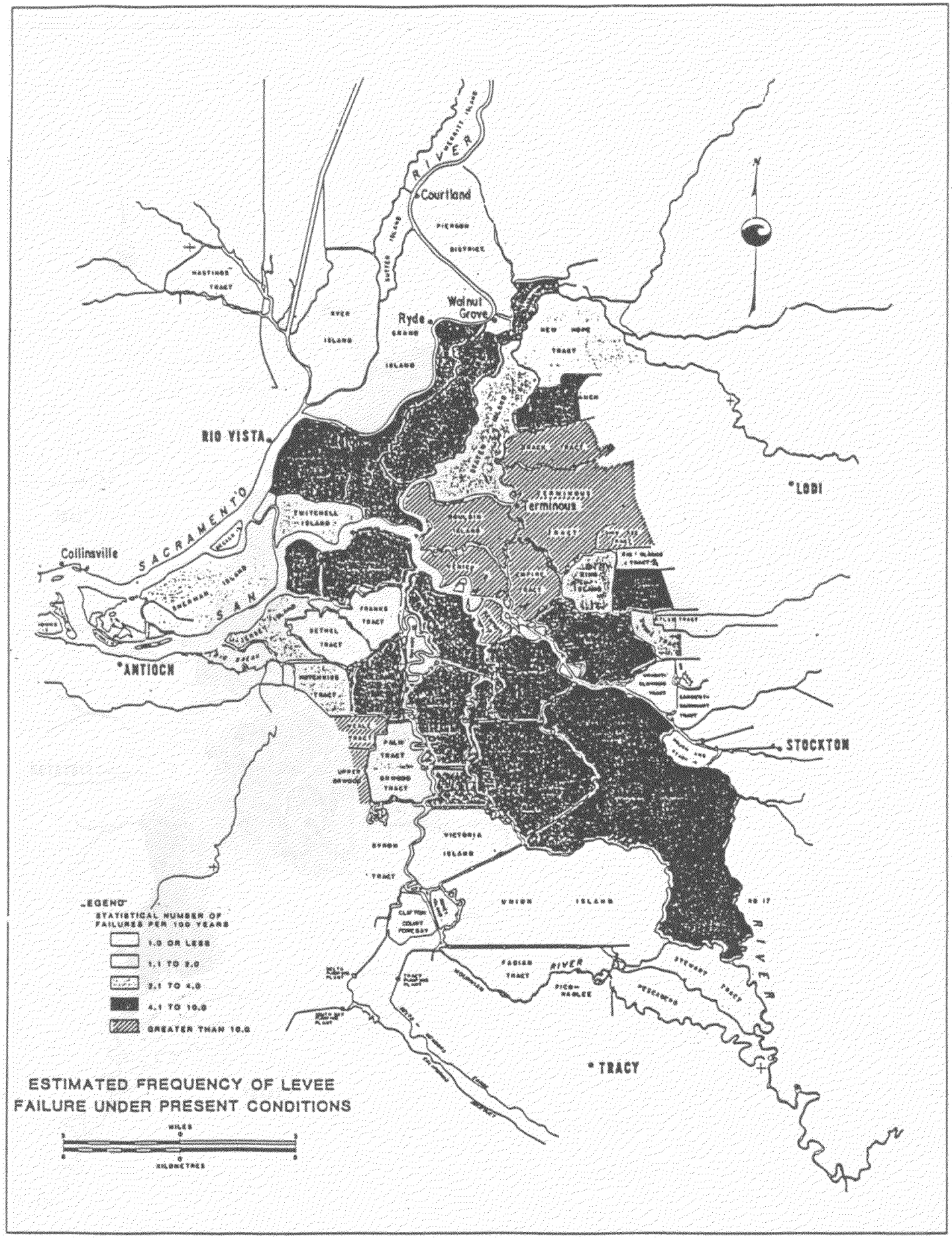

FIGURE 8

CURRENT ESTIMATED FREQUENCY OF LEVEE FAILURE