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**RESULTS OF BASELINE MONITORING OF
EXISTING CONDITIONS AT
BOLINAS LAGOON
AS PART OF MITIGATION FOR THE
HIGHWAY ONE LONE TREE SLIDE REPAIR**

Prepared for

California Department of Transportation

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1.0 EXECUTIVE SUMMARY

As partial mitigation for repairing Highway One at the Lone Tree Slide site the California Department of Transportation is restoring 2.2 acres of intertidal area and habitat within southern Bolinas Lagoon by the excavation and removal of fill at two sites known locally as the Stinson Gulch fill site and the Causeway fill site. This report presents results from physical and ecological pre-construction monitoring conducted in order to document existing conditions at the mitigation site. The results of this monitoring characterize and constitute the existing baseline conditions of the mitigation site prior to excavation and removal of fill. This information will be used as baseline data against which similar, post-construction data can be compared to determine the success of the restoration project.

As a companion to this report, all data collected during the baseline monitoring are included under separate cover in a technical appendix entitled Data Collected During Baseline Monitoring of Existing Conditions at Bolinas Lagoon.

In addition, this report describes the proposed long-term monitoring program which will be implemented after excavation and construction at the site is complete. It is intended that future reports on the physical and ecological monitoring of the mitigation site will be submitted by the end of each monitoring year. The first post-construction report would then be due by December 31, 1993, assuming construction is completed on schedule.

3.0 INTRODUCTION

3.1 DESCRIPTION AND PURPOSE OF MITIGATION AT BOLINAS LAGOON

The repair of the Highway One Lone Tree Slide in Marin County entailed the filling of at least 5 acres of subtidal and intertidal marine habitat. At several meetings during 1991 an inter-agency technical advisory committee established mitigation requirements to compensate for this loss. It identified removal of artificial fill in Bolinas Lagoon and restoration of wetland habitat at Big Lagoon as having the highest priorities.

The mitigation project at Bolinas Lagoon was designed to remove approximately 2.2 acres of intertidal fill from two areas within the southern portion of the Lagoon. The purpose of this project is to restore and maintain the highest natural habitat values for the Bolinas Lagoon ecosystem. Specific objectives of the Bolinas Lagoon restoration are to:

1. Restore as large an area as possible to intertidal or subtidal habitat.
2. Restore as much tidal prism as possible to the lagoon.
3. Restore the natural hydrodynamic functioning of the southern portion of Bolinas Lagoon.
4. Encourage the scouring of deep channels as fishery habitat.
5. Encourage the reversal of the process of conversion of mudflats to salt marsh.
6. Remove toxic fill from the lagoon.

The purpose of this report is to establish both the physical and biological baseline conditions within the study area. This pre-restoration, baseline data will be used as a reference base to determine if the goals of the restoration are being accomplished and to document changes that occur due to implementation of the mitigation plan. The purpose of the physical baseline characterization is to establish information on existing physical conditions so that the improvement in tidal prism resulting from the project can be documented. The purpose of the ecological baseline sampling at Bolinas Lagoon is to provide a characterization of the biological conditions existing prior to excavation of the Causeway and Stinson Gulch fill sites, so that changes in abundance, diversity and habitat use resulting from the project can be documented.

A five-year post-construction monitoring plan has also been proposed and is included in this report as Appendices C and D. Progress reports from this long-term monitoring will enable us

the tidal prism contributed by this portion of Bolinas Lagoon. In addition, the prograding delta at the mouth of Stinson Gulch pushed the tidal channel which drains the southern lagoon to the west and, in places, has contributed to the erosion of about 30 feet of the original Seadrift fill, exposing the 36" outlet pipe for the Seadrift Lagoon.

The 0.6 acres of fill at the Causeway fill site appears to have been placed in the Lagoon in the late 1950's to replace an old bridge and provide access for grading the new Seadrift development. Later, a 50 foot wide channel was breached at the western end of the causeway to reduce flooding in Eskoot Creek and to allow tidal action in the extreme southern corner of the Lagoon. The causeway itself appears to be comprised of sandy gravel overlying the original silty sands or silty clay lagoon bed. Preliminary soil boring logs indicate the base of the fill is at about 0.0 feet NGVD (National Geodetic Vertical Datum, previously known as 1929 Mean Sea Level Datum) in the western three quarters of the causeway, approximately the same elevation as adjacent mudflats. The eastern part of the fill adjacent to Highway 1 was placed in the original tidal channel and its base is as deep as -6.0 feet NGVD (Geo/Resource, 1992). A water main supply for the Seadrift development is buried along the northern edge of the fill and carried across the tidal channel on pilings.

The 2.6-acre Stinson Gulch fill site appears to have been started as a town dump over 60 years ago and consists of mixed sand, gravel, boulder and soil. The base elevation of the fill appears to be between 0 and +1.0 feet NGVD (Geo/Resource, 1992). Stinson Gulch is a short very steep drainage, with a watershed area of about 1 square mile, that conveys high sediment loads and debris flows during prolonged intense rainstorms. Over the last century it has created a deltaic lobe that extends into the lagoon. Highway One traverses the base of this delta for about 1500 feet. Although the delta has several distributary channels, the main flow has been directed through a twin 6 foot x 6 foot box cement culvert under Highway 1 and through an excavated channel through the middle of the fill. At the mouth of this channel a new alluvial delta is developing beyond the well defined margins of the fill and into the lagoon. These deposits tend to impinge upon the north-south trending tidal channel that drains the southern portion of the lagoon, further reducing tidal circulation in the southern portion of the lagoon.

3.2.2 Ecological Setting

The marshland at the southern end of Bolinas Lagoon is contiguous with the main lagoon system. Tidal flow passes through the narrow channel between the water pipe causeway and the Seadrift housing development. Freshwater is carried into the marsh by Eskoot Creek to the south. Eskoot Creek drains the west slope of Mt. Tamalpais and runs north through the town of Stinson Beach. The marsh in this area is primarily brackish to fresh, with the exception of the lower, northern end which is salt.

Barbour, *et al.* (1973), and Barbour and Major (1989) characterized Californian coastal salt marshes. Shuford and Timossi (1989) described those in Marin County, and Giguere (1970) assessed the resources of Bolinas Lagoon. The floral association in the study area was classified

4.0 BASELINE MONITORING PROGRAM AT BOLINAS LAGOON MITIGATION SITE

4.1 METHODS OF MONITORING PHYSICAL BASELINE CONDITIONS

Physical sampling parameters (hydrologic and topographic character) were monitored to define the existing hydrological condition of the mitigation site within the lagoon. Sampling locations were selected to define the hydrologic regime and existing physical topography of the lagoon.

Physical baseline monitoring included tidal monitoring and surveying of existing surface features both above mean tide level (topographic surveys) and below mean tide level (bathymetric surveys). Tidal monitoring was conducted in the lagoon April 6th to 10th, 1993, in order to observe spring tide conditions (maximum tidal range with both the highest high water and the lowest low water) for the month. Topographic and bathymetric surveys were conducted, prior to excavation of the fill sites, on April 9, 1993.

4.1.1 Tidal Monitoring

Three temporary tide staffs were established within Bolinas Lagoon for the purposes of tidal monitoring: 1) near the entrance channel to Bolinas Lagoon (the original NOAA tide gage site), 2) in the main tidal channel immediately north of the Stinson Gulch fill site, and 3) in the main tidal channel immediately to the south of the Causeway fill site (Figure 4.1-1). Tide staff elevations were tied into the National Geodetic Vertical Datum of 1929 (NGVD 1929) by simple land surveying techniques and all water surface elevations discussed in this report shall be relative to NGVD. An automated tidal monitoring was conducted April 6 through April 10, 1993, in order to determine the effects of existing lagoon morphology on tidal circulation within the study area. Automated tide gages were placed at each tide staff location and used to measure synchronous water levels at each site within the lagoon for the three day period of measurement.

4.1.2 Cross-Section Surveys

Elevation transects were surveyed at eight locations within the study area on April 9, 1993. Transect locations are shown in Figure 4.1-1 and include:

- X1: Cross-section of main tidal channel to the north of Stinson Gulch.
- X2: Cross-section at Stinson Gulch excavation site.
- X3: Cross-section at Causeway excavation site.
- X4: Cross-section of main tidal channel to south of Causeway.

4.2 METHODS OF MONITORING ECOLOGICAL BASELINE CONDITIONS

Ecological sampling parameters (vegetation, benthic invertebrates, fish, birds and mammals) were chosen to represent the lagoon ecological communities. Sampling locations were selected to define the four major habitat types (intertidal mudflats and channels, tidal marshes, riparian, and upland) present in the lagoon.

The original scope of work delimited quarterly sampling for benthic invertebrates, twice-yearly sampling for fish and vegetation and every two months monitoring of birds and mammals. Coverage for all surveys exceeded that defined by the workplan in order to present a more thorough picture of existing conditions. In addition, two surveys of the densities of the ubiquitous but non-native snail, *Batillaria attramentaria*, were conducted to augment the description of the marsh community. Species composition of benthic invertebrates is largely determined by the grain size of the sediment in which they live; consequently, grain size samples were taken in conjunction with benthic invertebrate sampling (see section 4.1.3: Physical Baseline Conditions, Grain Size Sampling, above). A schedule of ecological baseline sampling events is presented in Table 4.2-1.

4.2.1 Vegetation

Quantitative Assessment

The salt marsh community was visually assessed and the extent and quality of the three dominant species, cordgrass, pickleweed, saltgrass, were evaluated by a point quadrat method. Transect locations were selected to best represent stands of each of the three species, indicative of elevation—cordgrass lowest, pickleweed higher, then saltgrass highest (Figure 4.2-1). Transect 1 occupies a bench slightly higher than the rest of the marsh and was established to represent the mixed species areas along the edge of the marsh, that is, the highest-elevation salt marsh type. In addition to floral criteria, transect locations were determined by probable influence of increased water flow caused by removal of the causeways. Transects 2, 3, and 4 would be directly and immediately exposed on their northern ends to altered currents when the causeways are removed. Transects 5 and 6 were located farther back and would be protected from direct influence of stronger currents.

Transects were established by setting two permanent polyvinyl chloride (pvc) stakes exactly 20 m apart along the best representative stand of the vegetation to be sampled. Stake locations were noted according to visual landmarks. They were also marked to be visible from the air and are recorded on aerial photographs. Ten points along the transect were selected from a table of random numbers and located with a meter tape stretched between the two stakes. A quadrat of 1/4 meter square area was placed at each point and used to define the area of vegetation to be quantitatively sampled. The pvc quadrat (a square frame, 1/2 meter on a side), was blocked into a 100 square grid by string stretched over the frame. Ten points at string intersections, were selected using a table of random numbers. When the quadrat was set down the plant which

(Figure 4.2-1). Each station encompassed an area of approximately 300 m². Five replicate 0.0625 m² quadrats were placed haphazardly within each of the four stations. All snails on the sediment surface were counted either from photographs of the quadrats (August, 1992) or directly in the field (May, 1993).

4.2.3 Fish

Fishes were collected by beach seine on September 25, 1992, May 21, 1993, and June 24, 1993 between 0800 and 1800 at four locations in Bolinas Lagoon (Figure 4.2-1). To determine the minimum number of tows necessary to describe species composition, a cumulative species curve was plotted against a randomly pooled number of tows. Site 3 was chosen to best represent the Bolinas Lagoon nearshore environment: the month of June was selected because the highest number of species were present, giving a conservative estimate of adequate sample number. The curve indicated that, after 3 tows, there was insufficient data available to describe the fish assemblage, so temporal comparisons could not be made. Cumulative species curves derived after pooling data from all sampling periods suggested at least 4 tows were needed to adequately describe overall abundance and distribution of the most dominant fishes. Six tows were conducted in the tidal creek just south of the Causeway Fill (site 1). Ten tows were done at site 2, a "lake" formed by two landfills. Additional tows were conducted just north of the Stinson Gulch Fill in relatively open water; 10 tows across from the derelict dredge (site 3) and 4 tows across from the school (site 4).

The net was a 30 m x 1.5 m (20 mm stretch mesh) beach seine with a 3 m bag in the center (5 mm stretch mesh). It was deployed from shore and pulled along using two 35 m ropes attached to each end of the floatline. The net seined an approximate area of 1,050 m².

Fishes were removed from the net and placed in 5 gallon buckets. Each fish was identified to species, counted, and measured to the nearest mm. When more fish were caught than could be measured in an hour, a random subsample was chosen. An attempt was made to release all fish alive.

4.2.4 Birds

Seven bird surveys were conducted from June 3, 1993 to July 20, 1993 in southern Bolinas Lagoon. These surveys were completed at least once per quarter within the final two hours of falling low minus tides, and included some or all of the accompanying slack tide. In our initial survey we determined that the low tide in southern Bolinas Lagoon lags behind the published Bolinas Bay low tide (from local tide books) by approximately 2 hours, and adjusted our subsequent surveys accordingly. In some months, (especially September, 1992), there was little overlap between low tides and daylight hours, requiring some deviation from optimal survey time.

low tide to roosting behavior at high tide which has been well-documented for many salt-marsh species (e.g., Page, *et al.*, 1979.).

Species names used in the text are the common names established by the American Ornithological Union (1983).

4.2.5 Mammals

Harbor seals were counted in conjunction with bird counts conducted during low tides on 7 days throughout the sampling period. Three replicate counts were made by an observer using binoculars and a spotting scope. Originally, counts were made from Bird Station 1 of all seals hauled out on a small sand bar, "Near Bank", approximately 400 m to the northwest. However, beginning in February, 1993, the seals appeared to have abandoned this haul-out for an unknown reason, and were only observed at a more distant haul-out, "Town Bar", just east of the town of Bolinas, until July (Figure 4.2-2). Town Bar could only be counted by spotting scope, and was easier to observe from a location approximately 500 m north of the original Station 1 observation site. Therefore, beginning in 1993 all observations were made from this new location and included both the Town Bar and the Near Bank.

The tidal range at TS2, just north of the Stinson Gulch fill site, is slightly less than that at TS1. The maximum tide range measured on April 9, 1993, at TS2 was 4.0 feet with a higher high tide of 3.5 and a lower low tide of -0.5 feet. All of the highest tides measured at TS2 over the three day tidal monitoring period lagged the highest tides measured at TS1 by 12 minutes, and generally reached elevations of up to 0.2 feet higher than those measured at TS1. The lower low tides measured at TS2 were generally 0.5 feet higher than the lower low tides measured at TS1. Modification of tidal waves within estuaries are due to 1) frictional damping of the tidal wave on the lagoon bottom, 2) landward constriction or convergence of the tide within a narrowing estuary or channel, and 3) reflection of the tidal wave on shoals or from the estuary head (Saloman and Allen, 1983). Although frictional damping generally decreases amplitude landward, a decrease in channel cross-section can cause a concentration of energy and thus yield a net increase in amplitude (Nichols and Biggs, 1985).

The tidal range at TS3, south of the Causeway fill site, shows the smallest range measured of the three tide station sites. The maximum tide range measured on April 9, 1993, at TS3 was 2.1 feet (nearly half the tidal range measured at TS1 and TS2). The higher high tide measured at TS3 was 3.4 and the lower low tide was 1.3 feet. The highest tides measured at TS3 over the three day tidal monitoring period lagged the highest tides measured at TS1 by up to 48 minutes, and lagged the highest tides measured at TS2 by up to 36 minutes. The highest tides measured at TS3 reached elevations of up to 0.1 feet higher than those measured at TS1 but were lower than those measured at TS2 by as much as -0.2 feet. The lowest tides measured at TS2 never fell below an elevation of 1.3 feet, being up to 1.8 feet higher than the lowest tides measured at TS2 and up to 2.3 feet higher than the lowest tides measured at TS1.

5.1.2 Cross-Section Surveys

Profiles of thalweg elevations for both the main tidal channel and the Stinson Gulch channel are displayed in plan view in Figure 5.1-3; all values represent elevations and have been corrected to the National Geodetic Vertical Datum of 1929 (NGVD 1929, or just NGVD). Figure 5.1-3 also shows the relationship of the other cross-section locations surveyed within the study area for which elevation data is displayed in Figures 5.1-4 to 5.1-11. These profiles and cross-sections will be used in the future for comparison purposes with post-construction and long-term monitoring surveys.

Cross-section X1, surveyed across the lagoon north of the Stinson Gulch fill site represents the most natural conditions of inter-tidal mudflats and tidal wetland systems within the study area (Figure 5.1-4). Mudflat elevations extend between approximately -0.2 feet and +1.0 feet NGVD. Marshplain elevations, defined by specific indicator species, extend from 0.0 feet NGVD where cordgrass (*Spartina spp*) is growing at the lowest elevations, to approximately +3.5 feet NGVD where saltgrass (*Distichlis spicata*) ends and upland vegetation begins. The dominant vegetation type found on the marshplain is pickleweed (*Salicornia virginica*), the typical indicator plant for the zone between mean high water (MHW) and mean higher high water (MHHW). Pickleweed exists along the X1 cross-section at elevations between 0.0 feet and +1.0 foot NGVD. The

but sediment brought down the creek and deposited in the culverts have nearly closed off the southern culvert and half-filled the northern culvert (to 2.7 feet below the top of the culvert). The channel invert at the downstream end of the southern culvert is 0.2 feet higher than the channel invert at the upstream end. The channel invert at the downstream end of the northern culvert is only 0.3 feet lower than the channel invert at the upstream end. The gradient of the creek downstream of Highway 1 is irregular, with the thalweg profile displaying a pool between Highway 1 and the edge of the emplaced fill. The bottom of the pool exists at an elevation of 1.5 feet NGVD and depths within the pool were observed to be nearly 3 feet. The topographic high that exists at the edge of the emplaced fill has an elevation of 3.7 feet NGVD. Relatively cold water was found pooled in the bottom 1 foot of the pool, and gas bubbles appeared to be being released from the bottom sediments within the pool. From the edge of this pool, the gradient of the creek thalweg to the confluence with the main tidal channel is increased to 1 in 40.

Cross-section X6, surveyed along the thalweg of the main tidal channel from north of the Stinson Gulch fill site to south of the Causeway fill site, shows the elevation of the main tidal channel that runs through the mitigation site (Figure 5.1-9). The thalweg profile extends from approximately 350 feet north of the Stinson Gulch fill site to approximately 500 feet south of the Causeway fill site for a total length of 1,500 feet. Two main topographic high points exist along this profile. The first exists between the tide gates and the southern edge of the Stinson Gulch fill, at nearly +1.0 feet NGVD, and the second high spot exists at the Causeway pipeline crossing (+0.4 feet NGVD), where the Causeway fill constricts the main tidal channel. South of cross-section X4, the channel thalweg increases in elevation as the channel flows through the southern tidal marsh that exists in this area. The tidal channel reaches its lowest elevations between the Causeway fill site and the Stinson Gulch fill site with thalweg elevations of -2.5 feet NGVD, and after the tide drops to levels less than 1.0 foot NGVD, water becomes ponded in this region and does not completely drain before the tide changes and once again begins to rise (see Figure 5.1-1).

Cross-section X7, shows elevations of the main tidal channel and mudflats in the ponded region between the Stinson Gulch fill site and the Causeway fill site (Figure 5.1-10). Although not surveyed across the lowest portion of the main tidal channel, this cross-section displays very gentle slopes between the mudflats and the main tidal channel.

Cross-section X8, surveyed perpendicular to the thalweg of the Stinson Gulch channel upstream of Highway 1, displays the general shape and width of the upper section of Stinson Gulch Creek (Figure 5.1-11). The channel top width at this location is approximately 13 feet. The depth of the channel, from top of bank to thalweg, is only about 0.8 feet.

5.1.3 Grain Size

Percentage of fine sediments in lake, channel, and mudflat sites remained relatively high (>70% in most cases) and fluctuated little between June 1992 and July 1993 (Table 5.1-3, Figure 5.1-

time at those transects. Mud cover did not steadily increase over time at transect 6 and pickleweed was not so strongly dominant.

Changes in plant conditions were evident by season. During the winter sampling period (March) the plants were mostly brown from the die off of the previous year's growth. During summer, plants were green and robust and most species flowered conspicuously. For example, in July and August, cordgrass exhibited showy flowering spikes. However, pickleweed was the exception. It did not flower strongly, a fact emphasizing its probable degraded state.

Aerial photographs taken over the same time period show the strong channelization of the area and high proportion of vegetation-free mud flats. Vegetation patterns indicated on the photographs are consistent with those observed visually, however, detailed plant patterns are not evident. No temporal changes could be readily deduced from the photographs. However, earlier photos from 1991 seem to indicate a more robust growth of the pickleweed patches than later photos or field inspection.

The bulrush communities along the east and west sides of the lower marsh were inspected visually and the plants were in good condition with robust vegetative and reproductive growth. The brackish community at upper, south, edge of the salt marsh was also in good condition. Marsh-rosemary had been noted there during the previous fall, but appeared to be more numerous in August 1993. And the low bulrush (*Scirpus cernuus*) was also growing robustly in August, 1993.

The vegetation associations in the marsh were comprised of either pure stands or simple mixes usually of only two of the three main species: saltgrass, pickleweed, or cordgrass. The sampling technique represented the vegetation accurately when compared with simple visual assessment. However, cordgrass patches may have been slightly under-represented by quantitative sampling. compared to visual estimate because their underground rhizomes were not evident and therefore could not be quantified even though the plants were tall and visually dominant over the lower growing but denser pickleweed. Nonetheless, quantitative techniques provided consistent results of well defined species patches.

Visual inspection of pickleweed in the lower marsh indicated that it was degraded. Plants were thin and straggling and their cover of the mud substrate was incomplete. Quantitative sampling indicated that the percentage of mud cover had increased and that of pickleweed cover had decreased over the last year. While the changes were not dramatic the decline of pickleweed cover appeared to be consistent over the transects. By contrast, cordgrass plants appeared healthy and robust. Even though the quantitative data did not show an increase in cordgrass cover, in fact, cordgrass seemed to be colonizing pickleweed areas. The apparent displacement of pickleweed by cordgrass probably indicates increased exposure to salt water influence. Perhaps elevation of the flat had been lowered slightly by the Loma Prieta earthquake; or perhaps due to reduced water circulation in Bolinas Lagoon salt water residence of the site was slightly greater, due to less complete tidal flushing.

occur in sand and mud bottoms with good tidal currents, since they are primarily suspension feeders.

The only abundant clam in the study area was *Gemma gemma*, which was rarely encountered along the mudflat channel. Otherwise, many of the same benthic invertebrates along the channel also occurred in the other sedimentary habitats. The numerical dominants at the mudflat channel were the crustaceans, *Ampelisca*, *Corophium* (another amphipod), and occasionally the isopod, *Leucon*, and the polychaete worm, *Exogone* (Table 5.2-2).

Mudflat

Sample stations were paired at the mudflat edge and channel with a station in the center of the northern mudflat. Although these mid-mudflat stations were quite near to the channel and in a very similar mud bottom, they did not harbor a large population of *Ampelisca* (Figures 5.2-3 to 5.2-6, Tables 5.2-2 to 5.2-5). *Corophium* and *Exogone* were consistently abundant in the central mudflat (Figures 5.2-4 and 5.2-5). The most distinct temporal pattern was the decline in numbers of the amphipod, *Grandidierella*, another tube dweller related to *Corophium*, and the corresponding increase in the abundance of *Exogone* (the months of March and May; see Table 5.2-3). This site is the most like the mudflat channel in physical setting, except it is located at a slightly higher tidal elevation (about 1 foot higher). *Gemma* clams were abundant in the higher tidal flat, compared to the lower channel (Figure 5.2-6). There were surprisingly few *Gemma* clams in the lake.

Lake Site

The lake stations were characterized by the polychaete worm, *Streblospio*, and oligochaete worms (Table 5.2-4). This station also harbored the greatest numbers of highly opportunistic polychaete species, *Capitella*. *Capitella* and oligochaetes are well known indicators of aquatic pollution and of many natural disturbances to muddy bottoms. The lake bottom is apparently disturbed periodically by dense growths of macroalgae, especially the large green algae, *Ulva*. The plant sheets lay on the bottom or in the sediment. The most abundant crustacean in the lake *Leucon*, a surface active animal that only burrows into surface sediments and is less tied to the bottom.

Marsh

This habitat was also characterized by *Streblospio* and oligochaete worms. Also like the lake stations, *Exogone* was rare along the marsh channel compared to all other habitats (Figure 5.2-6). Among the crustaceans, *Corophium* and *Leucon* were periodically abundant. Throughout the study area, including the lake stations, *Leucon* increased in abundance in the last sampling periods, this spring. Among the crustaceans, *Corophium* and *Leucon* may be the most tolerant of variable physical environments on the mud. But *Grandidierella* may be just as flexible,

and sampling stations located in waters partially enclosed by landfills had less diverse fish assemblages than those sites located in the relatively open waters north of the Stinson Gulch fill. The removal of the fills should cause a shift in the fish community towards the more diverse assemblage found in the main lagoon.

5.2.4 Birds

A total of 48 bird species were observed in all stations between June 3, 1992 and July 20, 1993 (Table 5.2-8). All species seen are relatively common to the region (Point Reyes National Seashore Field Checklist of Birds, Page et. al. 1979); at least 8 species are likely to breed within a five square mile area of the Lagoon (Chaffered, in press).

The greatest abundance of individuals and species was recorded during the November and February surveys (Figures 5.2-10, 5.2-11a,b). This broad trend was better defined by categorizing species according to foraging type (Table 4.2-2; Figure 5.2-12). The fall-winter peak represented large numbers of benthic invertebrate-feeders (primarily Dowitchers, Willets and Marbled Godwits), as well as waterfowl feeding on submerged vegetation (primarily American Widgeons and Northern Pintails). This peak in species abundance for shorebirds and waterfowl is a well-documented regional phenomenon (Page et. al. 1979; Gerstenberg 1979; Hands et. al. 1991). The large fall-winter increase in shorebird and waterfowl species was countered in southern Bolinas Lagoon by a somewhat less dramatic summer peak composed of piscivorous species (primarily Snowy and Great Egrets) and species foraging on insects and vegetation occurring near, but not submerged in, the lagoon (primarily Cliff and Barn Swallows). The absence of a strong migratory spring peak in individuals and species abundance may reflect a preference by migrating birds for habitats outside the survey area; it is also possible that the peak may simply have occurred between the February and May surveys.

Individual and species abundance varied by month and by station. At all mudflat stations (Stations 1 through 4; Figure 5.2-11a), individual and species numbers peaked during fall or winter (i.e. September, November and February surveys). Interestingly, an anticipated decrease in abundance was not consistently observed along a north-south gradient (i.e. from greatest to least tidal influence). Individual and species abundance at stations south of the artificial fill (i.e. Stations 5-8: the "lake" station and 3 marsh stations; Figure 5.2-11b) stayed consistently low throughout the year except for a winter peak in species number at the "lake" station (Station 5).. due to the use of this area by four waterfowl species.

Species composition varied by season at four stations representing the range of habitat types in the study area (Figure 5.2-13). Stations 1 and 4 (figures 5.2-13a, 5.2-13b) represent the northern- and southernmost mudflats surveyed; Station 5 (Figure 5.2-13c) is the subtidal "lake" station, and Station 7 (Figure 5.2-13d) is the middle of the three marsh stations. The two mudflat stations were dominated by benthic invertebrate-feeding species in fall-winter and to a lesser extent by piscivorous species in summer-fall. In contrast, Stations 5 and 7 were characterized by fall-winter peaks in waterfowl species and a spring-summer peak in species feeding on wetland-

6.0 COORDINATION WITH LONG-TERM MONITORING PROGRAM

In order to determine the success of this mitigation project and its restoration goals, a five-year, long-term monitoring plan is being proposed for five years immediately following fill removal and reconstruction. Long-term ecological and physical monitoring surveys will be conducted at the same sites as those established during this initial, baseline monitoring so that any changes or trends occurring in or to the ecosystem at Bolinas Lagoon can be determined and accurately measured.

Physical monitoring of the mitigation site will allow us to determine the following parameters:

- The amount of sediment accumulating at the mouth of Stinson Gulch
- The presence of obstructions to anadromous fish migration on Stinson Gulch.
- The change in tidal prism to determine whether the goal of an increase of 5.7 acre ft is achieved.
- The aerial extent of created intertidal/subtidal habitat (up to MHHW).

The general ecological monitoring of the mitigation site permits a thorough assessment of restoration success focussed on the following issues:

- The extent and type of vegetational changes reflecting the conversion of marsh to mudflat.
- The changes in the benthic invertebrate community structure as a reflection of altered hydrologic regime and increased tidal prism into the lagoon.
- The changes in the composition and abundances of the fish community as an indication of the creation of deep channels and improved fisheries habitat.
- Shifts in the bird and mammal community structure as the ecological health of lower trophic levels of the lagoon ramifies up the trophic chain.

The scope of work for the long-term physical monitoring of the Bolinas Lagoon restoration site is detailed in Appendix C of this report. The long-term physical monitoring work will be

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TABLES

Table 4.2-1. Schedule of surveys for ecological baseline data collection.

Bolinas Lagoon

Survey Log 6/92 - 8/93

Moss Landing Marine Laboratories

DATE	SURVEY	TIME	PERSONNEL
6/3/92	Invertebrates	0800-1500	Oliver, Guerrero,
6/3/92	Birds/Mammals	0800-1500	Guerrero
8/15/92	Vegetation	0800-1700	Slattery
9/25/92	Invertebrates	0800-1600	Oliver, Guerrero
9/25/92	Fish	0800-1800	Bennett, Bockus
9/24/92	Birds/Mammals	0800-1300	Guerrero
11/9/92	Birds/Mammals	0800-1300	Guerrero
2/3-4/93	Vegetation	0800-1700	Slattery
2/5/93	Birds/Mammals	0800-1300	Guerrero
3/4/93	Inverts	0800-1600	Oliver, Carney, Bretz
5/4/93	Inverts	0900-1300	Oliver, Carney, Bretz, McDermott
5/21/93	Fish	0800-1700	Oxman, Bockus
5/24/93	Birds/Mammals	0900-1300	Guerrero
6/24/93	Fish	0800-1800	Oxman, Bockus
7/20/93	Inverts	0900-1500	Oliver, McDermott
7/20/93	Birds/Mammals	0900-1300	Guerrero
8/5/93	Vegetation	0800-1700	Slattery

Table 4.2-2. Bird species categorized by habitat use in Bollinas Stations 1-8.

B Benthic Invertebrate-feeding	P Piscivorous	S Waterfowl feeding on submerged insect/ vegetation	W Wetland-associated Insect/vegetation-feeding
1 Willet 2 Marbled Godwit 3 Unidentified Dowitcher sp. 4 Western Gull 5 Killdeer 6 Ring-billed Gull 7 California Gull 8 Unidentified Gull sp. 9 Black-bellied Plover 10 Long-billed Curlew 11 Lesser Yellowlegs 12 Glaucous-winged Gull 13 Whimbrel 14 American Avocet 15 Unidentified Yellowlegs sp. 16 Herring Gull	1 Snowy Egret 2 Great Egret 3 Double-crested Cormorant 4 Great Blue Heron 5 Belted Kingfisher 6 Red-throated Loon 7 Black-crowned Night-Heron 8 Brown Pelican 9 Horned Grebe 10 Caspian Tern 11 Western Grebe	1 Northern Pintail 2 American Widgeon 3 Bufflehead 4 Mallard 5 American Green-winged Teal 6 Northern Shoveler 7 Common Goldeneye 8 Greater Scaup 9 Canvasback	1 Cliff Swallow 2 Barn Swallow 3 Brewer's Blackbird 4 Red-winged Blackbird 5 Tree Swallow 6 Unidentified Blackbird sp.
N Non-feeding occupation of wetland vegetation (esp. roosting)	I Incidental (no apparent association with wetland flora/fauna)		
1 Common Bushlark 2 Purple Finch 3 Song Sparrow	1 American Crow 2 European Starling 3 Rock Dove 4 Turkey Vulture 5 Mourning Dove 6 Band-tailed Pigeon		

Table 5.1-1. Tide Levels at Bolinas Lagoon, Bolinas Bay, California.

Tide	Bolinas Lagoon NOS 941-4958 (ft NGVD)
Mean Higher High Water	2.82
Mean High Water	2.20
Mean Tide Level	0.71
Mean Low Water	-0.78
Mean Lower Low Water	-1.47

Table 5.1-2 Tide Levels at Bolinas Lagoon, Measured April 6th - 10th, 1993.

Tide	TS1 near entrance of Lagoon (ft NGVD)	TS2 north of Stinson Gulch (ft NGVD)	TS3 south of Causeway (ft NGVD)
Higher High Water	3.31 at 13:36 4/9/93	3.46 at 13:48 4/9/93	3.41 at 14:24 4/9/93
High Water	1.77 at 14:00 4/8/93	1.82 at 15:12 4/8/93	1.74 at 15:12 4/8/93
Low Water	-0.35 at 19:48 4/9/93	-0.08 at 20:12 4/9/93	1.31 at 22:36 4/9/93
Lower Low Water	-1.00 at 10:48 4/9/93	-0.51 at 11:00 4/9/93	1.30 at 13:48 4/9/93

Table 5.1-3.

Grainsize characteristics for Bolinas lagoon sediments during 1992-1993. Percentage of fine sediments (silt, clay, and colloids, particle diameter $< 63 \mu\text{m}$) is shown, as well as mean and standard deviation for each station over the entire sampling period. $n = 1$ for each sampling date; $n = 5$ for calculation of yearly mean (except for channel 2 and mudflat 2 stations, where $n = 4$).

Date	Marsh			Lake			Channel			Mudflat		
	1	2	3	1	2	3	1	2	3	1	2	3
6/3/92	10.38%	15.10%	55.35%	80.64%	95.73%	91.02%	95.03%	85.20%	75.96%	76.31%	85.63%	55.31%
9/24/92	37.50%	66.30%	36.39%	73.36%	96.72%	90.72%	86.29%	91.89%	58.79%	84.57%	98.79%	54.27%
3/4/93	60.40%	24.30%	9.17%	66.33%	95.56%	95.41%	87.44%	77.81%	49.47%	0.784	0.9495	0.5351
5/4/93	65.74%	49.72%	16.02%	81.79%	84.21%	93.73%	98.25%	95.62%	69.56%	90.51%	93.12%	56.70%
7/20/93	11.26%	37.88%	52.61%	75.19%	97.45%	94.07%	98.61%	-	75.65%	78.18%	-	53.18%
Mean 92-93:	37.06%	38.66%	33.91%	75.46%	93.93%	92.99%	93.12%	87.63%	65.89%	81.60%	93.12%	54.60%
SD:	26.20%	20.30%	20.90%	6.22%	5.49%	2.04%	5.89%	7.84%	11.51%	5.88%	5.52%	1.43%

Table 5.2-1a. Snail (*Batillaria attramentaria*) counts from photoquadrats taken August 27, 1992 in Bolinas Lagoon.

Station	Replicate					Mean	SD
	1	2	3	4	5		
1	3	0	3	20	3	6	8
2	17	13	17	21	14	16	3
3	9	2	9	30	20	14	11
4	19	6	11	1	10	9	7

Table 5.2-1b. Snail (*Batillaria attramentaria*) counts from quadrats taken May 4, 1993 in Bolinas Lagoon.

Station	Replicate					Mean	SD
	1	2	3	4	5		
1	102	62	69	77	98	82	18
2	12	16	20	23	39	22	10
3	84	46	42	31	49	50	20
4	9	28	52	34	25	30	15

Table 5.2-2. Assemblage of principal benthic invertebrate species in the Bolinas Lagoon Channel stations during the four sampling seasons. Data are in mean number of individuals per core. n=6 replicates per station per season.

CHANNEL	June 1992			September 1992			March 1993			May 1993		
Station #	1	2	3	1	2	3	1	2	3	1	2	3
Species												
Ampelisca	27	49	46	38	43	48	17	11	6	56	52	1
Grandidierella	3	14	24	11	9	11	0	0	2	1	4	12
Corophium	63	63	122	22	25	76	9	20	30	58	47	23
Leucon	0	2	6	2	6	2	2	14	42	5	12	61
Total Crustaceans	105	120	198	72	84	138	50	46	86	187	116	98
Capitella	0	0	0	0	0	0	0	0	0	0	0	0
Exogone	4	8	49	24	11	21	58	70	70	68	58	21
Oligochaete	1	2	10	3	1	7	4	1	5	2	2	10
Streblospio	0	0	1	0	0	3	0	0	1	0	0	27
Total Worms	5	9	51	24	12	26	59	70	72	68	58	56
Total Mollusc (Gemma gemma)	0	0	0	0	0	0	0	0	1	0	0	1
Total Animals	111	130	259	100	97	171	114	117	163	258	176	166

Table 5.2-3. Assemblage of principal benthic invertebrate species in the Bolinas Lagoon mudflat stations during the four sampling seasons. Data are in mean number of individuals per core. n=6 replicates per station per season.

MUDFLAT	June 1992			September 1992			March 1993			May 1993		
Station #	1	2	3	1	2	3	1	2	3	1	2	3
Species												
Ampelisca	32	6	6	31	2	0	14	5	0	28	22	1
Grandidierella	19	25	41	14	46	17	1	3	2	4	6	6
Corophium	48	27	62	42	53	51	20	27	38	55	48	36
Leucon	3	4	6	4	0	2	4	24	49	4	29	32
Total Crustaceans	106	68	116	94	130	76	40	60	89	93	105	74
Capitella	0	9	0	0	28	2	0	0	1	0	0	0
Exogone	36	19	39	36	14	14	77	65	147	106	92	86
Oligochaete	0	8	0	1	25	0	1	4	6	1	0	2
Streblospio	0	85	0	1	108	16	0	11	2	0	0	1
Total Worms	37	118	40	41	151	33	78	76	150	108	92	89
Total Mollusc (Gemma gemma)	0	0	108	0	29	96	0	0	52	0	0	28
Total Animals	144	193	265	136	338	218	120	140	297	201	198	232

Table 5.2-4. Assemblage of principal benthic invertebrate species in the Bolinas Lagoon Lake stations during the four sampling seasons. Data are in mean number of individuals per core. n=6 replicates per station per season.

LAKE	June 1992			September 1992			March 1993			May 1993		
Station #	1	2	3	1	2	3	1	2	3	1	2	3
Species												
Ampelisca	1	12	6	4	3	5	1	0	4	1	4	5
Grandidierella	2	0	1	13	44	10	0	0	0	0	0	0
Corophium	5	8	4	23	3	5	2	6	4	4	27	9
Leucon	1	8	6	4	2	5	106	52	15	55	98	69
Total Crustaceans	8	28	18	45	53	34	110	58	24	60	130	83
Capitella	36	3	3	8	5	8	3	26	33	3	6	4
Exogone	0	0	0	0	0	0	0	0	0	0	2	0
Oligochaete	46	57	51	52	45	44	62	93	68	53	119	84
Streblospio	17	55	24	67	43	68	32	34	23	12	25	23
Total Worms	53	64	31	76	49	77	36	60	57	17	42	33
Total Mollusc (Gemma gemma)	0	0	2	5	0	10	2	4	6	2	3	4
Total Animals	108	148	102	184	147	166	209	214	154	132	294	204

Table 5.2-5. Assemblage of principal benthic invertebrate species in the Bolinas Lagoon Marsh stations during the four sampling seasons. Data are in mean number of individuals per core. n=6 replicates per station per season.

MARSH	June 1992			September 1992			March 1993			May 1993		
Station #	1	2	3	1	2	3	1	2	3	1	2	3
Species												
Ampelisca	0		1	0	1	0	0	0	0		0	0
Grandidierella	4		2	1	2	6	3	4	2		3	1
Corophium	48		35	0	98	21	12	9	0		14	11
Leucon	3		33	4	2	6	70	54	10		57	96
Total Crustaceans	56		72	6	102	34	91	81	13		78	116
Capitella	0		2	0	5	12	3	4	3		1	2
Exogone	0		0	0	0	1	0	0	0		0	0
Oligochaete	41		46	26	148	113	53	104	113		118	64
Streblospio	59		58	48	64	98	30	32	13		24	6
Total Worms	72		63	57	77	111	35	36	16		27	8
Total Mollusc (Gemma gemma)	156		3	128	233	6	31	70	4		38	1
Total Animals	326		183	217	575	282	209	291	147		261	189

Table 5.2-6. Mean number per tow, standard error (in parentheses), and relative abundance (%) of fish species caught by beach seine at four locations in Bolinas Lagoon. Overall relative abundance and rank are indicated. Dash (--) indicates species not collected.

Taxon	Site 1		Site 2		Site 3		Site 4		Rank
	Mean (S.E.)	%	Mean (S.E.)	%	Mean (S.E.)	%	Mean (S.E.)	%	
<i>Atherinops affinis</i>	171.00 (91.23)	71.05	87.60 (35.77)	20.92	179.20 (47.36)	74.39	161.50 (86.33)	75.20	1
<i>Clelandia</i> sp.	67.83 (67.03)	28.19	319.90 (189.21)	76.40	35.50 (11.07)	14.74	25.00 (6.98)	11.64	2
<i>Leptocottus armatus</i>	0.17 (0.17)	0.07	3.60 (2.17)	0.86	22.70 (9.03)	9.42	5.50 (4.21)	2.56	3
<i>Engraulis mordax</i>	--	--	0.10 (0.10)	0.02	0.80 (0.61)	0.33	16.75 (9.66)	7.80	4
<i>Syngnathus leptorhynchus</i>	1.67 (1.12)	0.69	3.90 (1.73)	0.93	0.90 (0.28)	0.37	2.00 (1.08)	0.93	5
<i>Acanthogobius flavimanus</i>	--	--	2.00 (0.95)	0.48	0.10 (0.10)	0.04	1.00 (1.00)	0.47	6
<i>Gasterosteus aculeatus</i>	--	--	1.20 (0.81)	0.29	--	--	--	--	7
<i>Triakis semifasciata</i>	--	--	0.10 (0.10)	0.02	0.80 (0.29)	0.33	0.75 (0.48)	0.35	7
<i>Morone saxatilis</i>	--	--	0.30 (0.30)	0.07	0.10 (0.10)	0.04	0.25 (0.25)	0.12	9
<i>Clupea harengus</i>	--	--	--	--	0.10 (0.10)	0.04	1.00 (1.00)	0.47	9
<i>Myliobatis californica</i>	--	--	--	--	0.50 (0.17)	0.21	--	--	9
<i>Hypsopsetta guttulata</i>	--	--	--	--	0.10 (0.10)	0.04	0.75 (0.25)	0.35	12
<i>Cymatogaster aggregata</i>	--	--	--	--	--	--	0.25 (0.25)	0.12	13
<i>Mustelus californicus</i>	--	--	--	--	0.10 (0.10)	0.04	--	--	13

Table 5.2-7. Summary of diversity, dominance, and abundance of fishes captured by beach seine at four sites in Bolinas Lagoon

	Site 1		Site 2		Site 3		Site 4	
# of species	4		9		12		11	
Dominance index	0.58		0.63		0.58		0.59	
Total #	1444		4187		2409		859	
Mean # / tow (S.E.)	240.67 (157.66)		418.70 (210.59)		240.90 (46.39)		214.75 (101.14)	
# of tows	6		10		10		4	

Table 5.2-8. Bird species observed at Bollinas Lagoon Stations 1-8, June 1992 - July 1993.
Total 48 species*

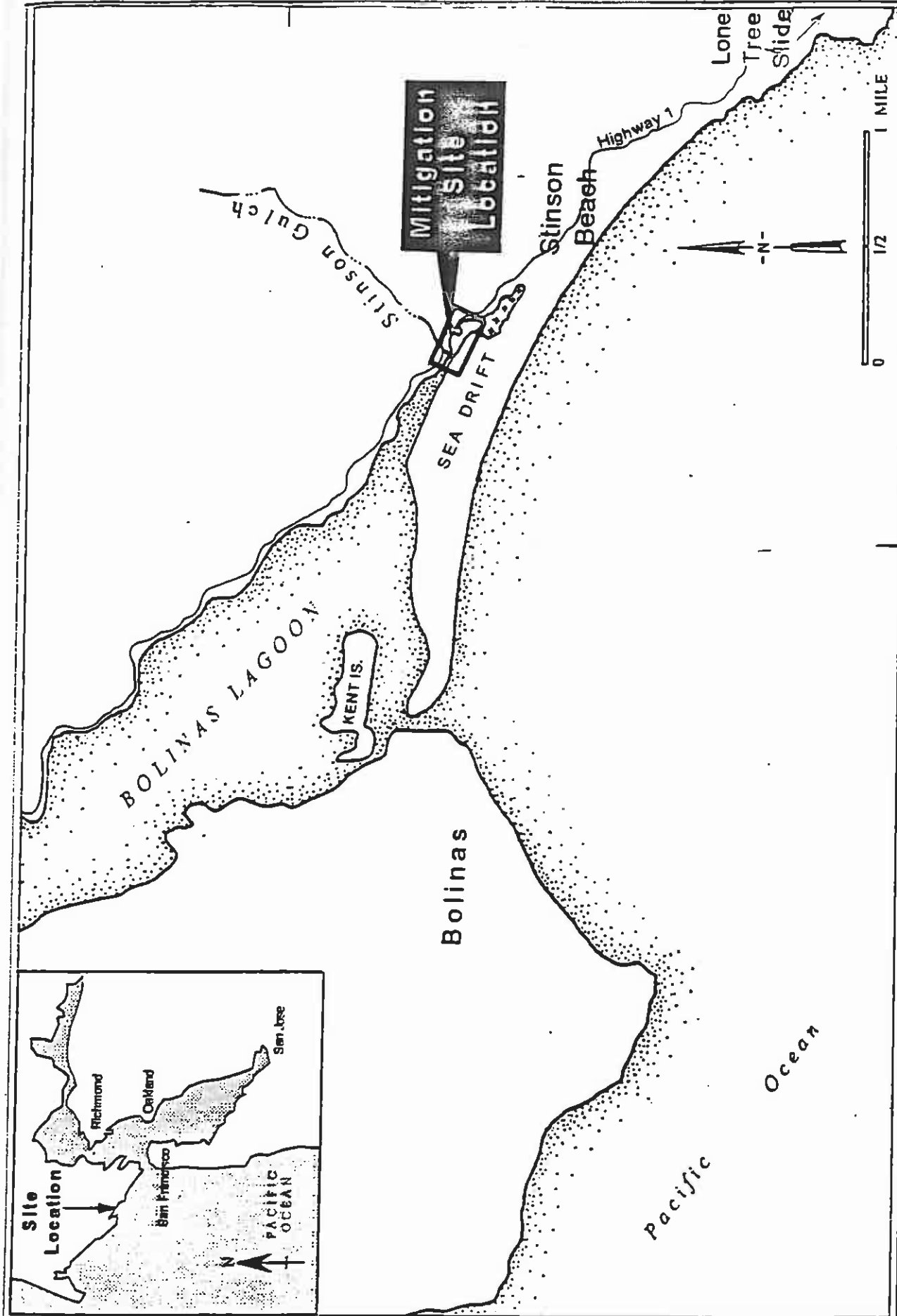
species name	species code	species name	species code
American Green-winged Teal	AGWT	Killdeer	KILL
American Crow	AMCR	Long-billed Curlew	LBCU
American Widgeon	AMWI	Lesser Yellowlegs	LEYE
Band-tailed Pigeon	BTPI	Marbled Godwit	MAGO
Barn Swallow	BARS	Mallard	MALL
Black-bellied Plover	BBPL	Mourning Dove	MODO
Black-crowned Night-Heron	BCNH	Northern Pintail	NOPI
Belted Kingfisher	BEKI	Northern Shoveler	NOSH
Brewer's Blackbird	BRBL	Purple Finch	PUFI
Brown Pelican	BRPE	Ring-billed Gull	RBGU
Band-tailed Pigeon	BTPI	Rock Dove	RODO
Bufflehead	BUFF	Red-throated Loon	RTLO
California Gull	CAGU	Red-winged Blackbird	RWBL
Canvasback	CANV	Snowy Egret	SNEG
Caspian Tern	CATE	Song Sparrow	SOSP
Cliff Swallow	CLSW	Tree Swallow	TRSW
Common Bushitit	COBU	Turkey Vulture	TUVU
Common Goldeneye	COGO	Unidentified Blackbird sp.	UNBL
Double-crested Cormorant	DCCO	Unidentified Dowitcher sp.	UNDO
European Starling	EUST	Unidentified Gull sp.	UNGU
Great Egret	GREG	Unidentified Yellowlegs sp.	UNYE
Great Blue Heron	GTBH	Western Grebe	WEGR
Greater Scaup	GRSC	Western Gull	WEGU
Glaucous-winged Gull	GWGU	Whimbrel	WHIM
Herring Gull	HERG	Willet	WILL
Horned Grebe	HOGH		

*total excludes unidentified gull, blackbird and yellowlegs categories

Table 5.2-9. Harbor Seal counts for near bank and town bar, Bolinas Lagoon.

DATE	REPLICATE COUNTS			
	NEAR BANK		TOWN BAR	
		# pups included		# pups included
6/3/92	32	1	NA	
	34	1	NA	
	33	1	NA	
9/24/92	50		NA	
	49		NA	
	51		NA	
11/10/93	46		NA	
	54		NA	
	46		NA	
2/4/93	0		20	
	0		22	
	0		25	
5/24/93	0		32	2
	0		31	2
	0		33	2
6/22/93	0		106	5
	0		109	5
	0		101	5
7/20/93	3		160	
	3		157	
	3		164	

FIGURES

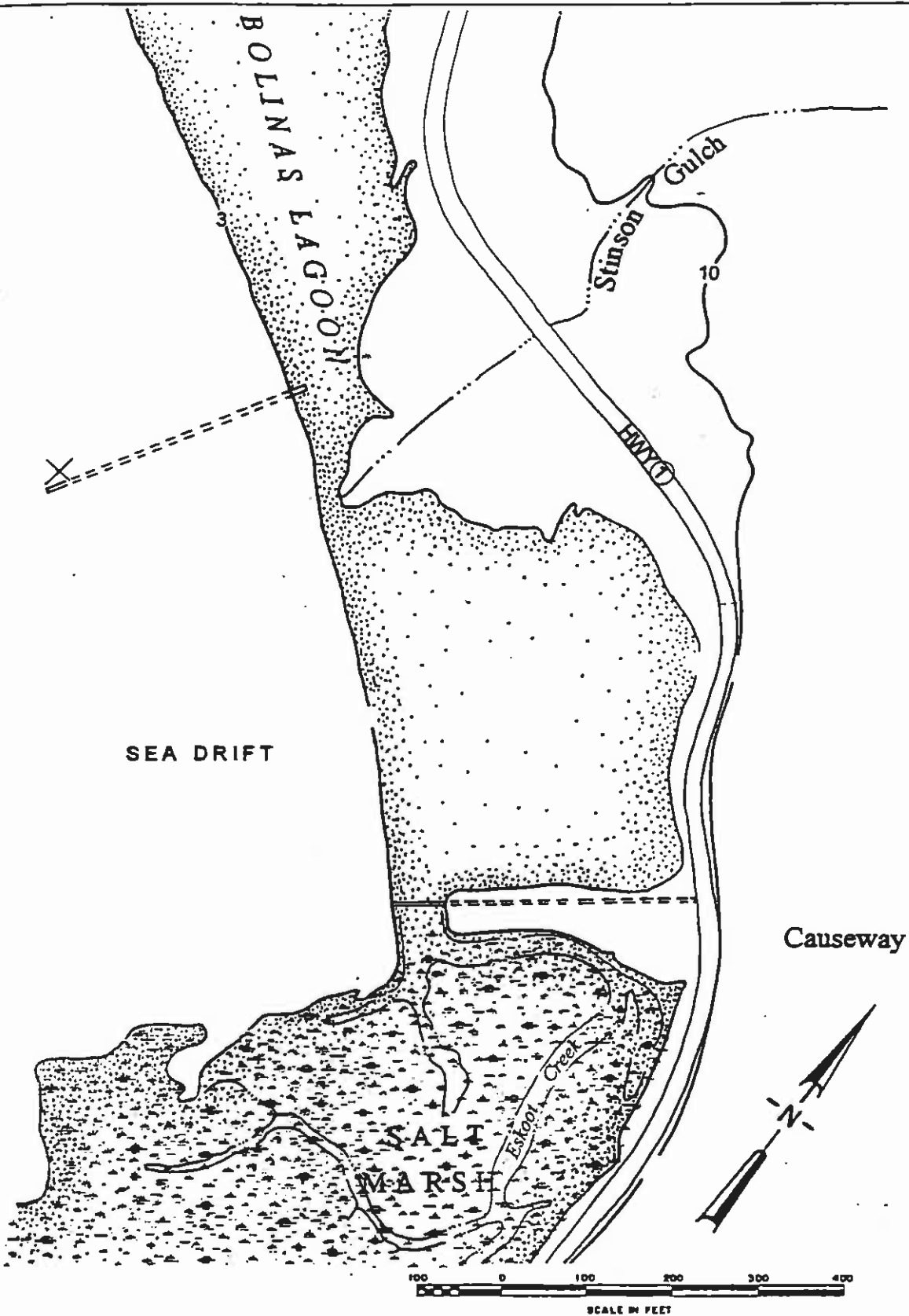


Site Vicinity Map

Figure
3.1-1

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Consultants in Hydrology

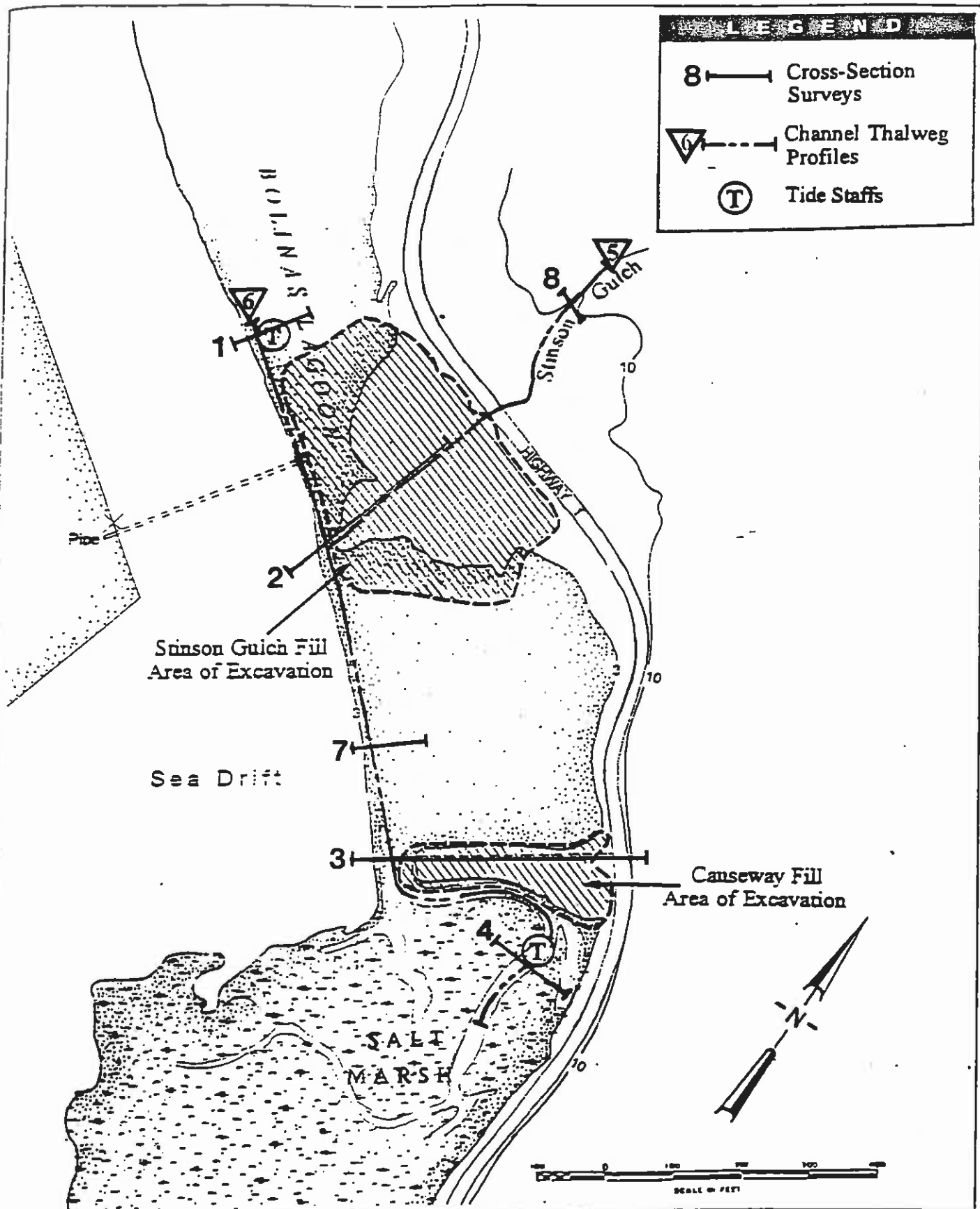




Philip Williams & Associates, Ltd.
Consultants in Hydrology

Site Location

Figure
3.1-2



Philip Williams & Associates, Ltd.
Consultants in Hydrology

Mitigation Site
Physical Monitoring Locations

Figure
4.1-1

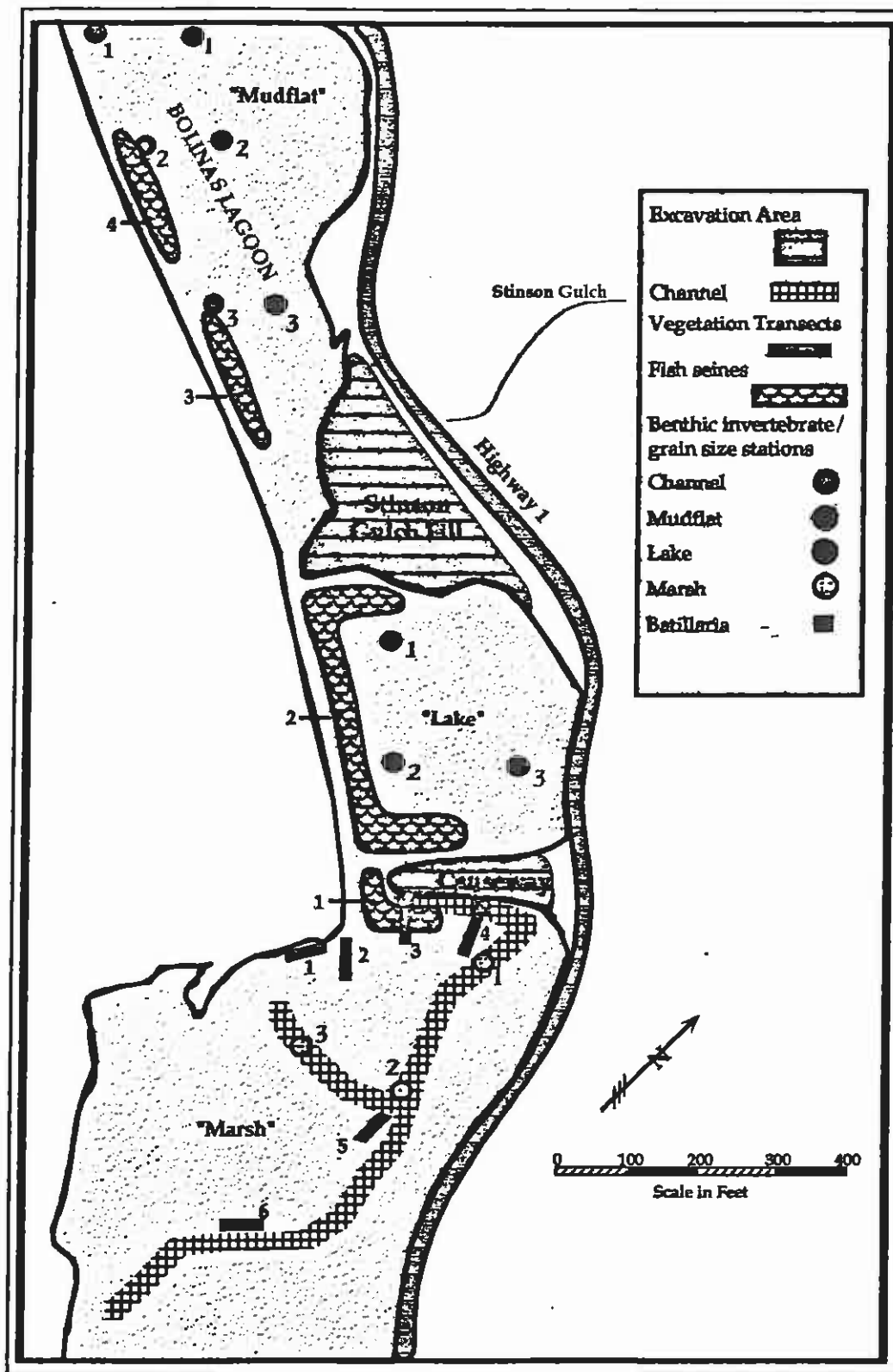


Figure 4.2-1. Excavation sites and biological sampling station locations in Bolinas Lagoon.

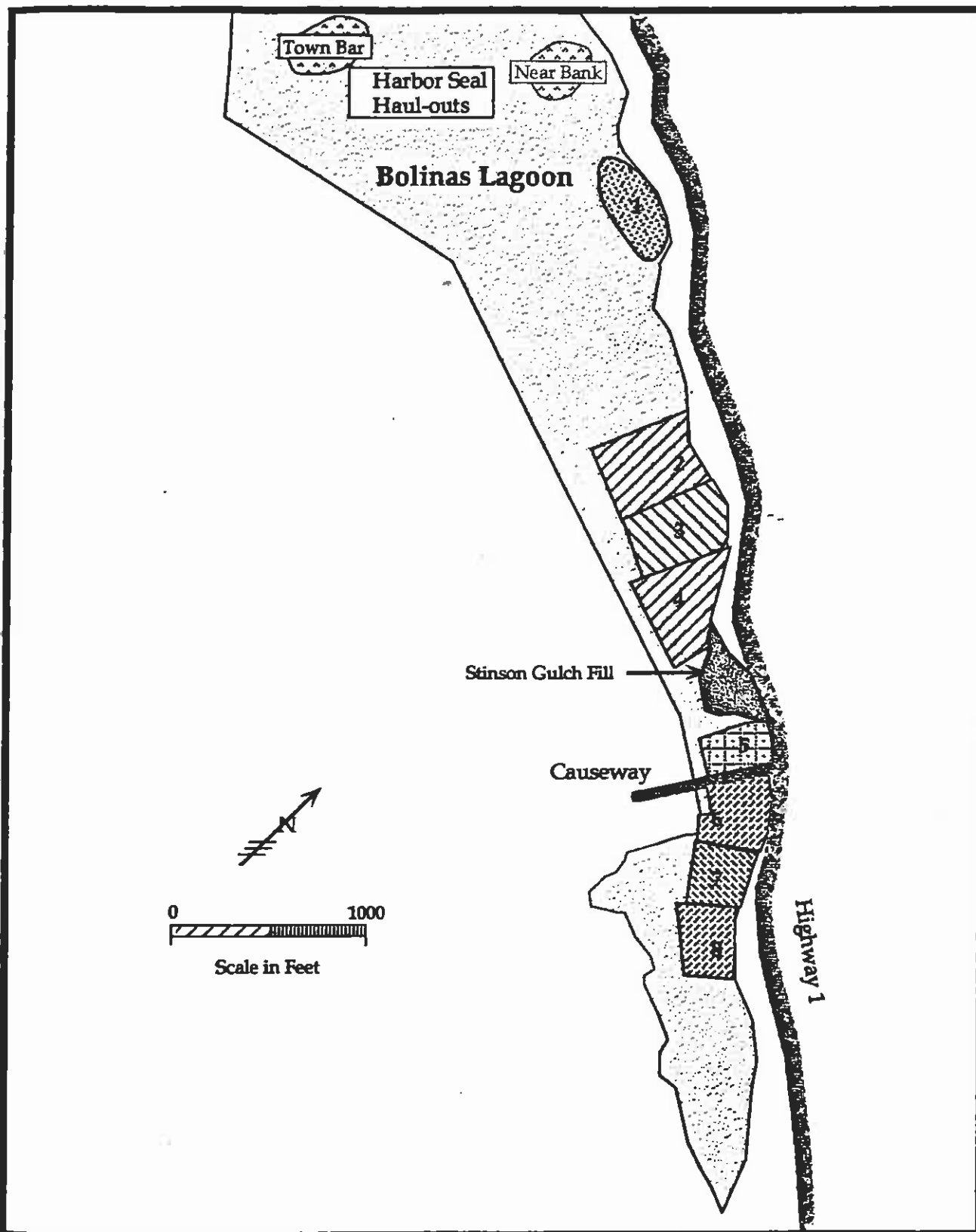
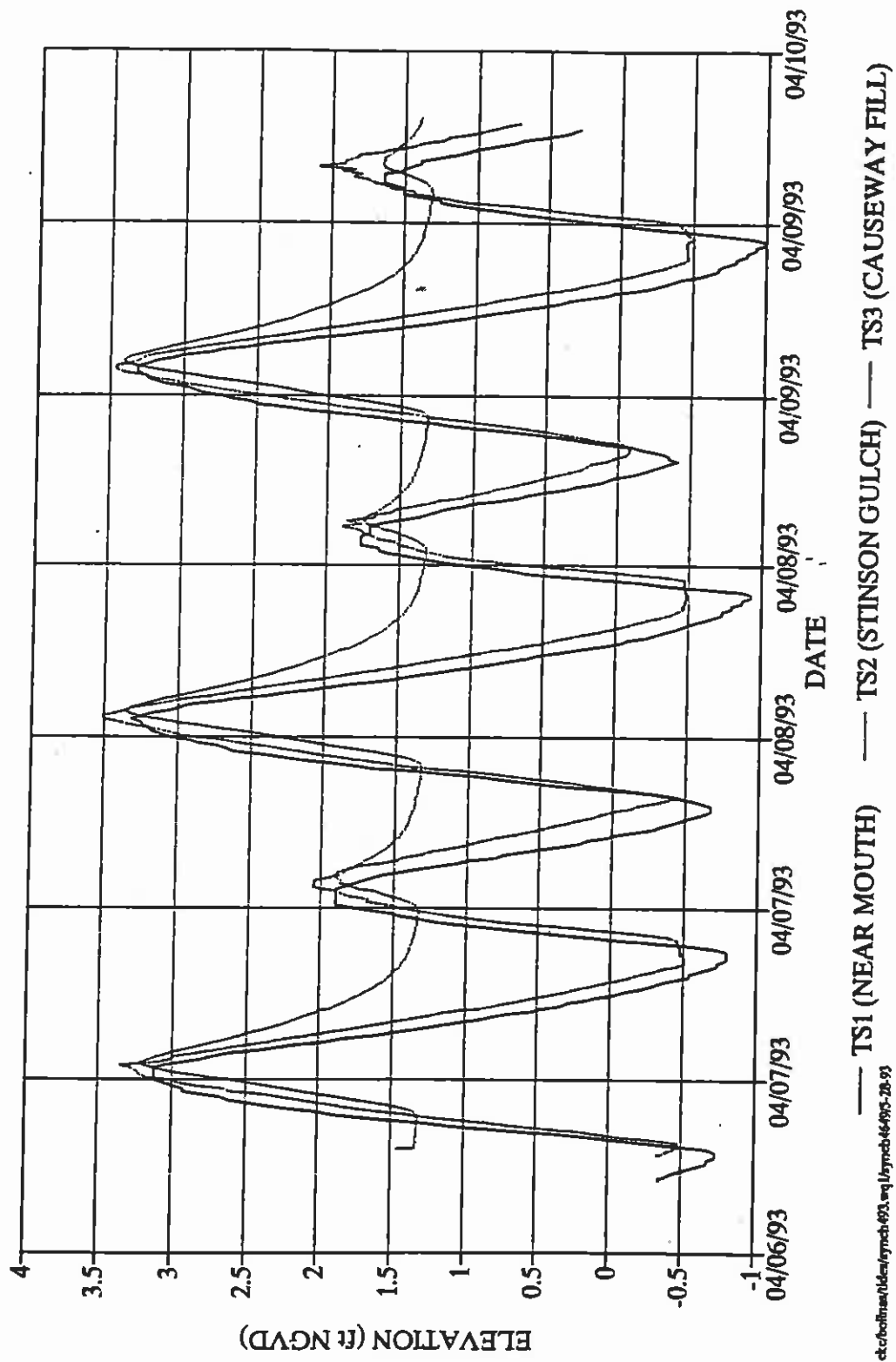


Figure 4.2-2. Bird and mammal survey station locations in Bolinas Lagoon.

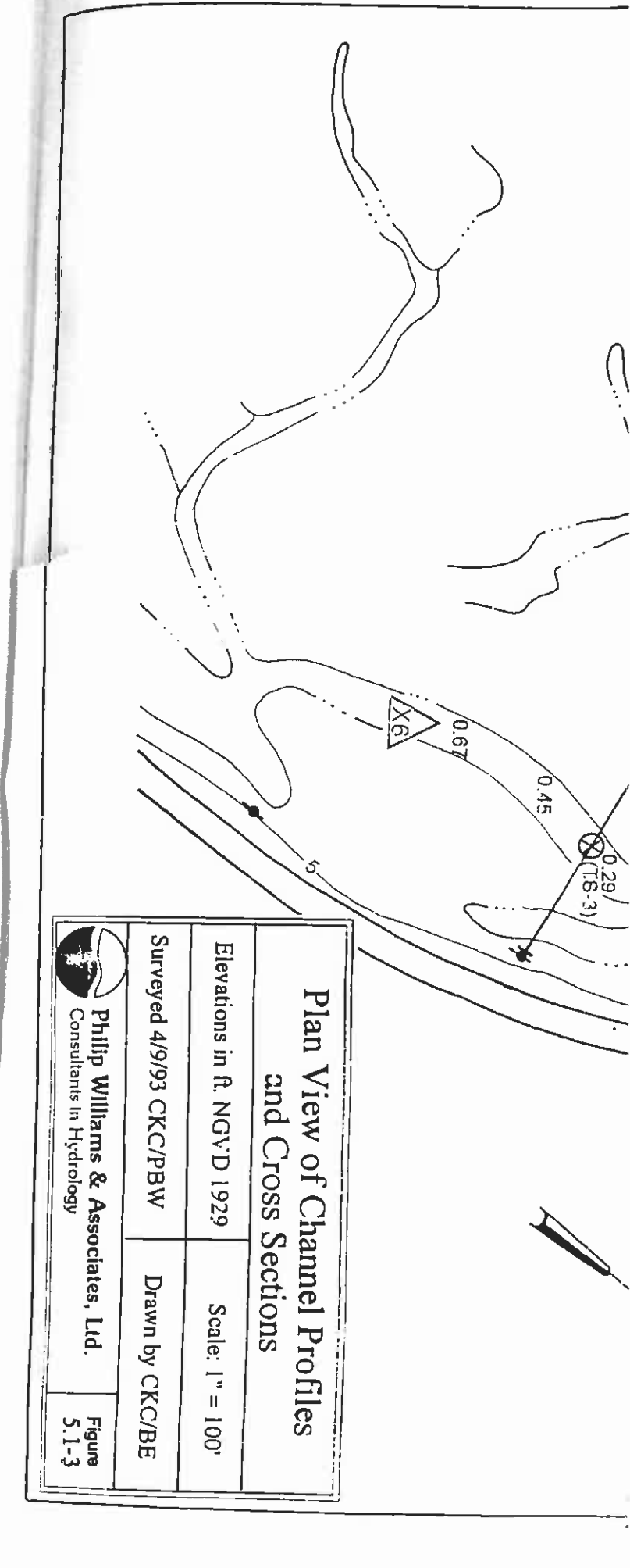


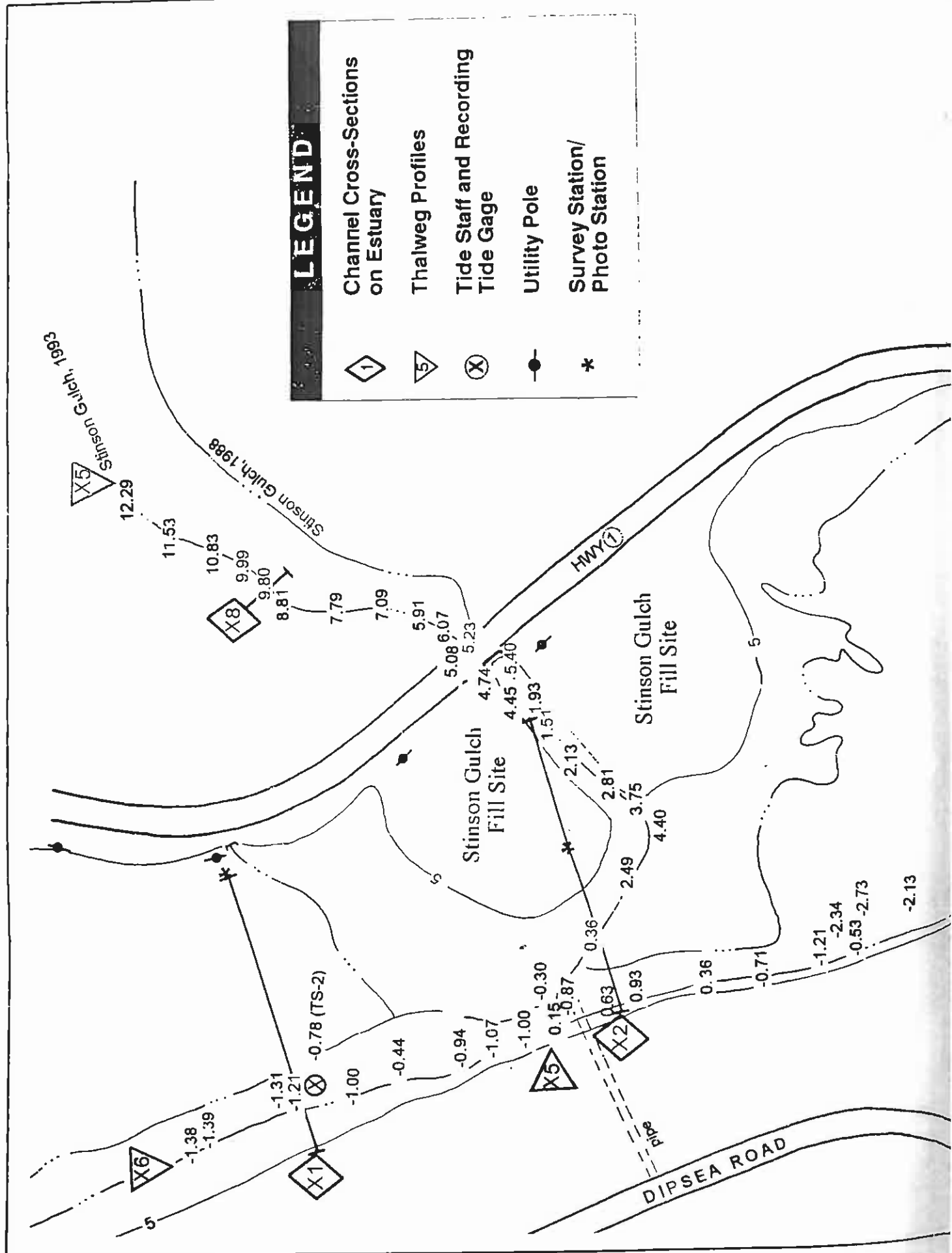
Philip Williams & Associates, Ltd.
 Consultants in Hydrology

BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
 SYNCHRONOUS TIDE LEVELS IN BOLINAS LAGOON 4/6-4/9/93

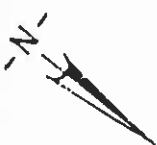
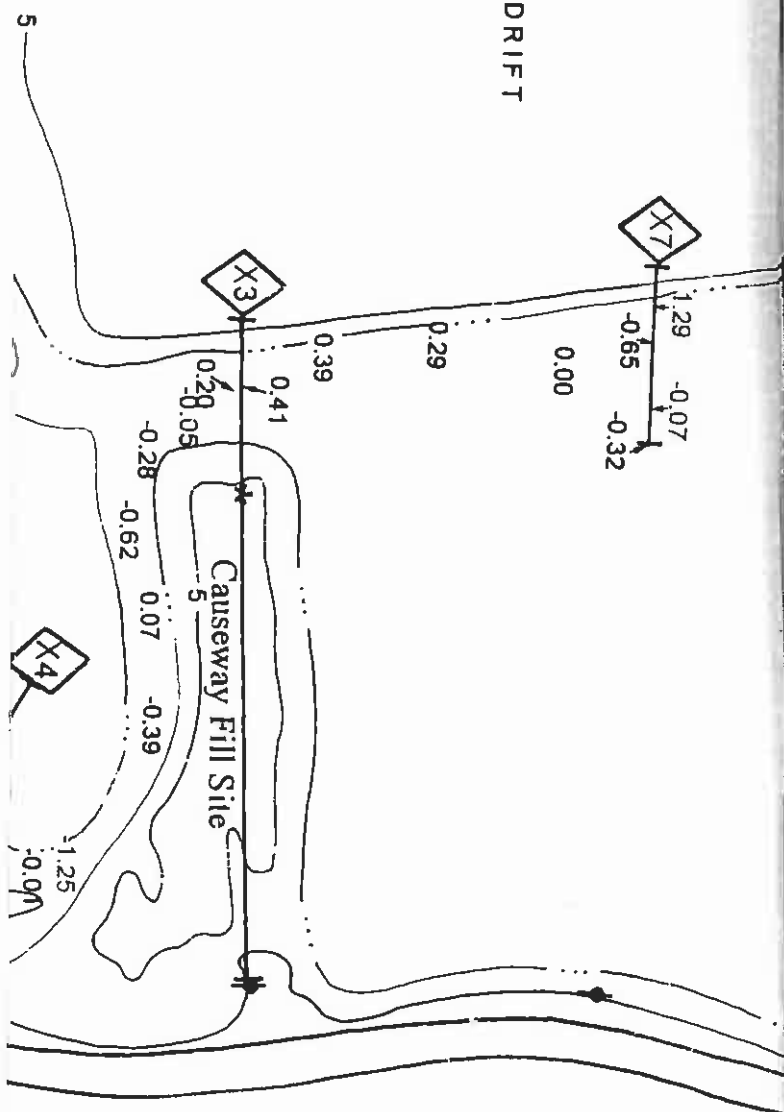
Figure
 5.1-1

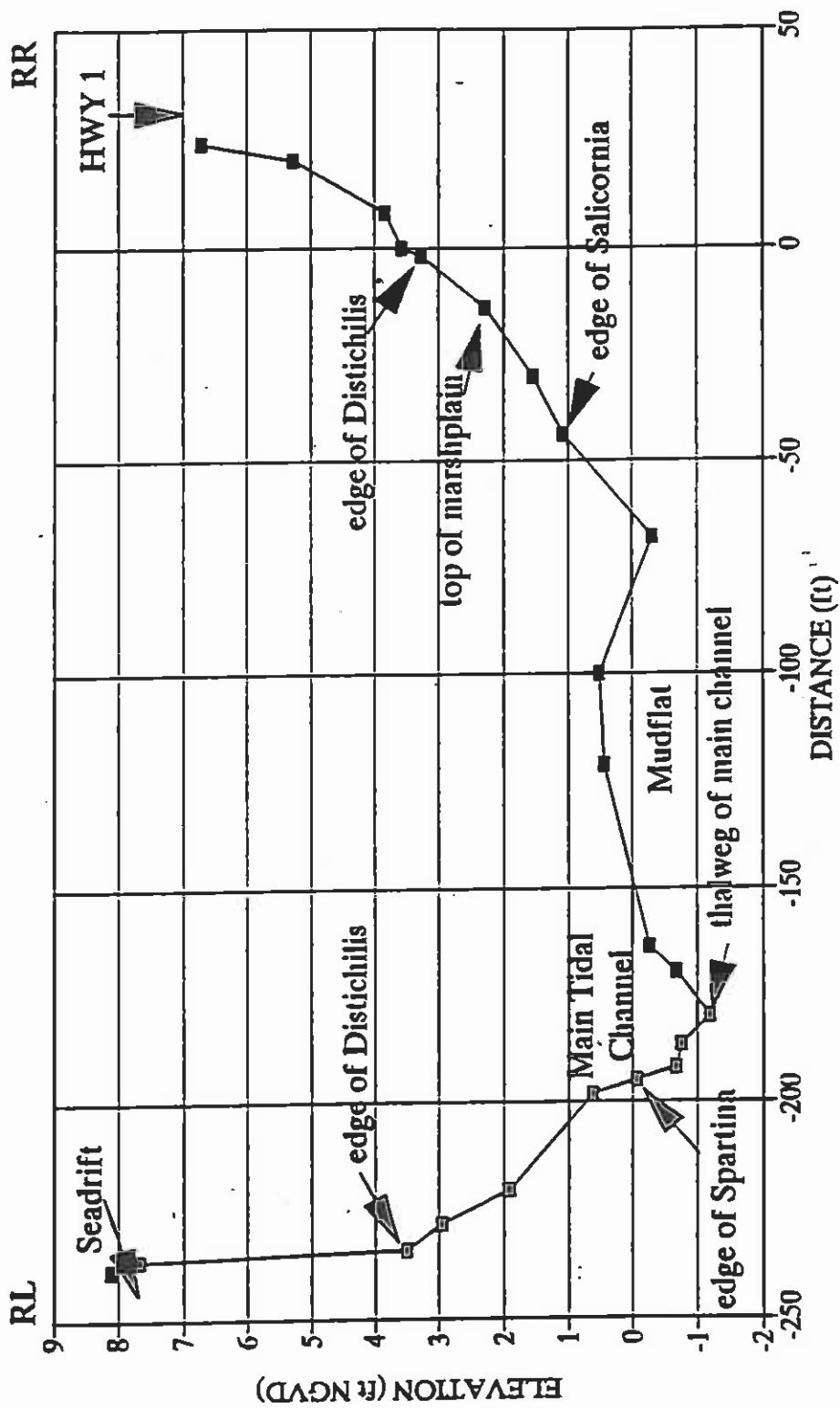
Plan View of Channel Profiles and Cross Sections		
Elevations in ft. NGVD 1929	Scale: 1" = 100'	
Surveyed 4/9/93 CKC/PBW	Drawn by CKC/BE	
 Philip Williams & Associates, Ltd. Consultants in Hydrology	Figure 5.1-3	





SEA DRIFT





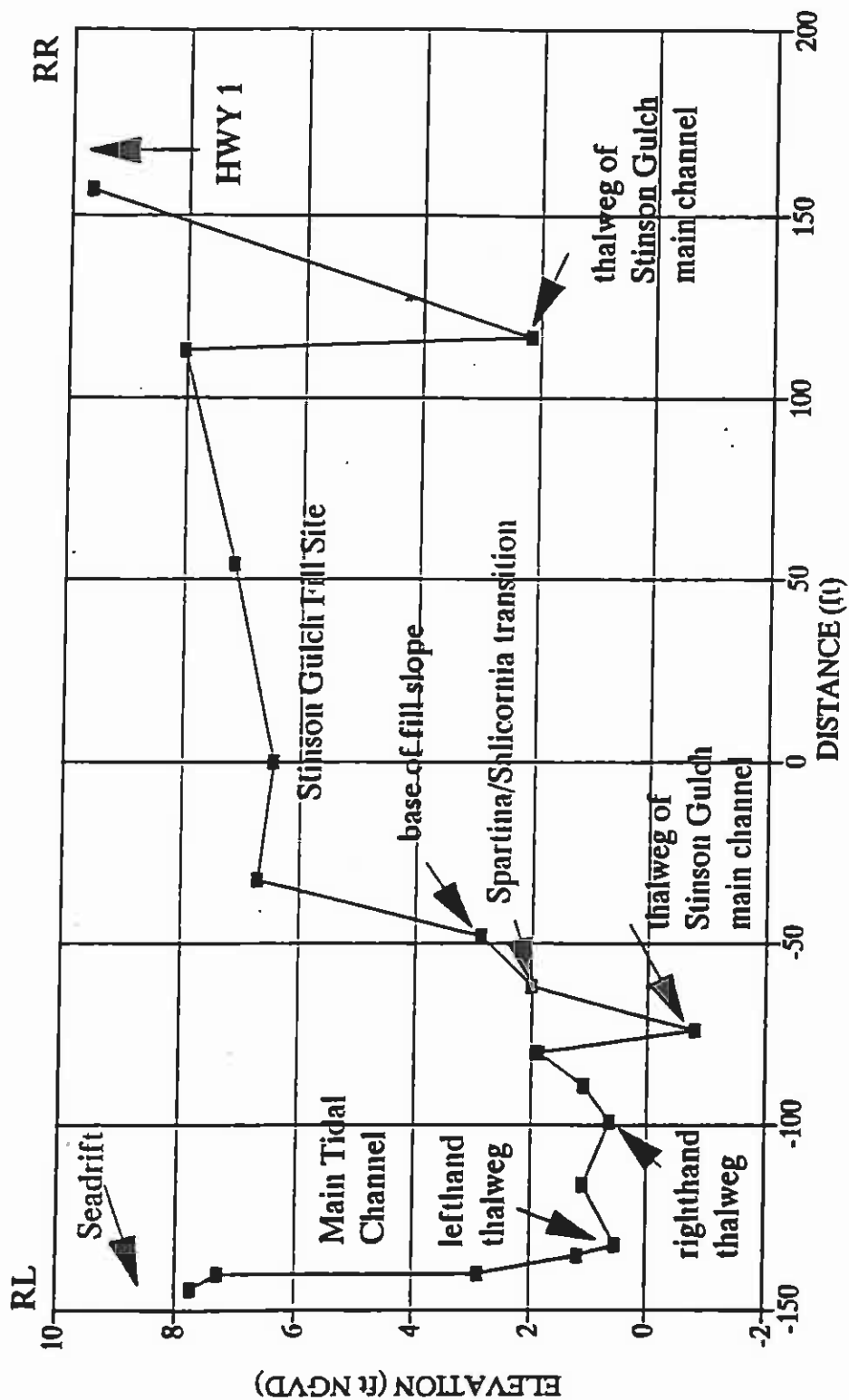
ct/bolinas/mitigation/0493.mxd 10/4/93/4-18-93



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BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X1 (N OF STINSON GULCH FILL) 4/9/93

Figure
5.1-4



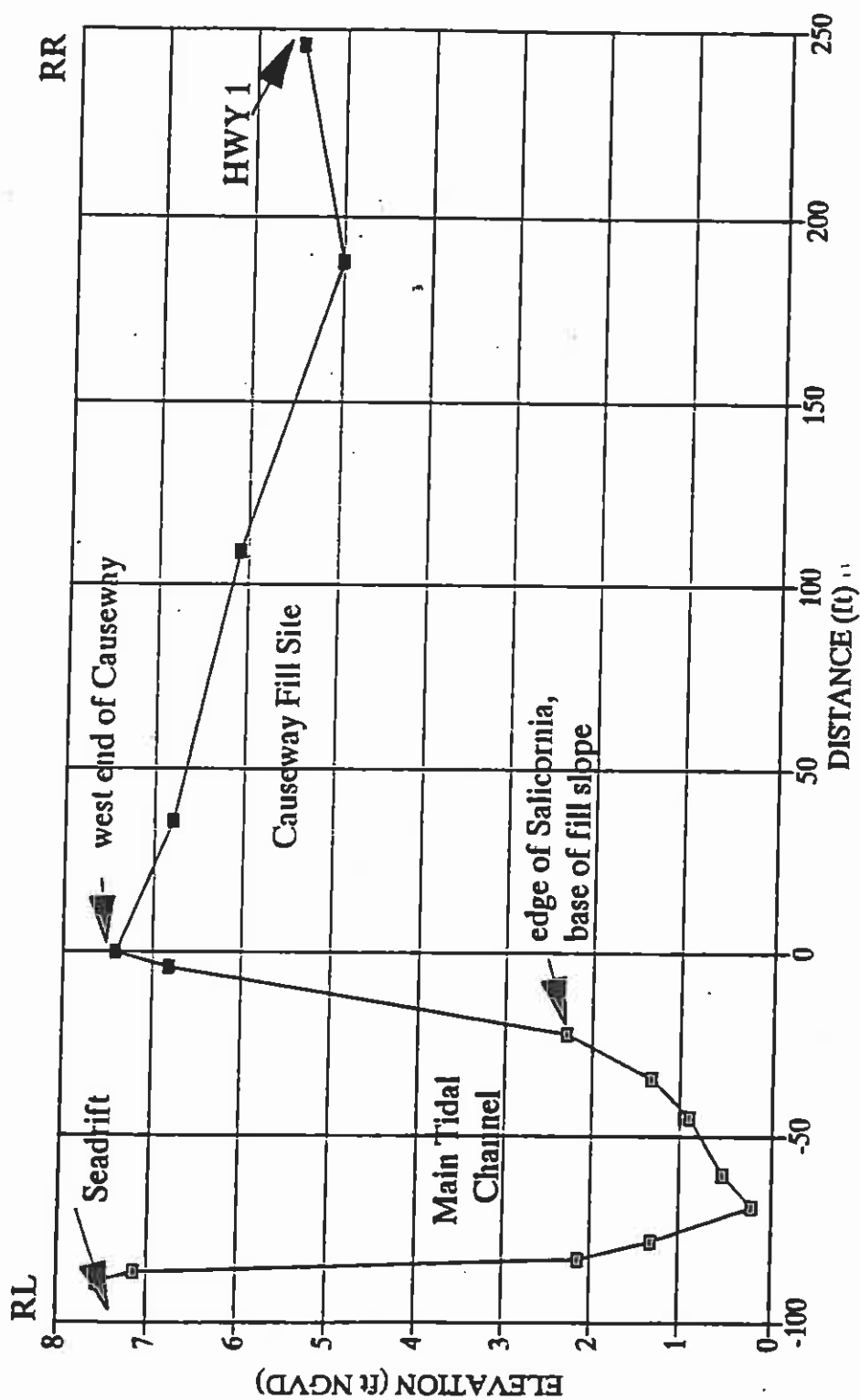
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Consultants in Hydrology

BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X2 (AT STINSON GULCH FILL) 4/9/93

Figure
5.1-5



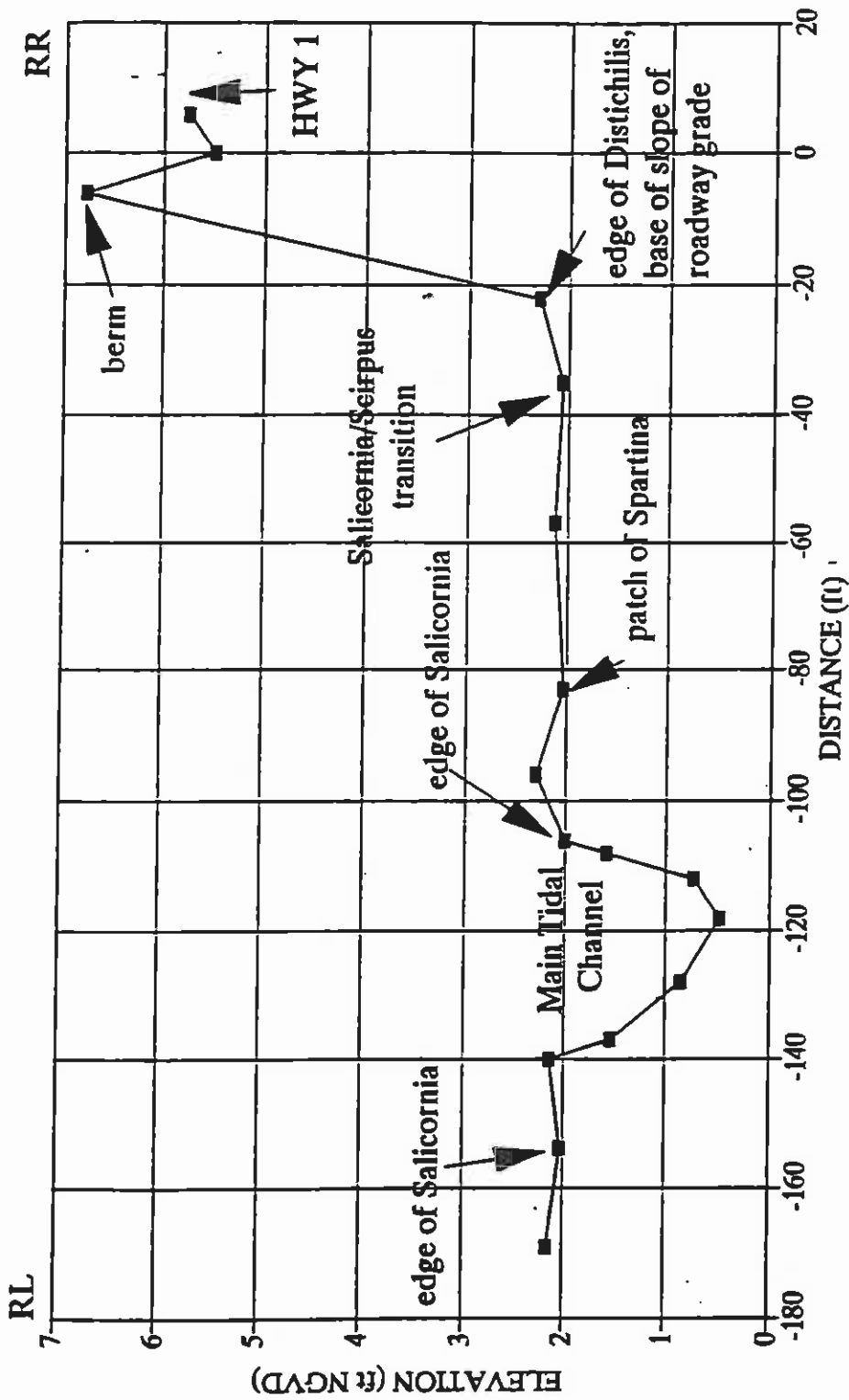
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Consultants in Hydrology

BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X3 (AT CAUSEWAY FILL) 4/9/93

Figure
5.1-6



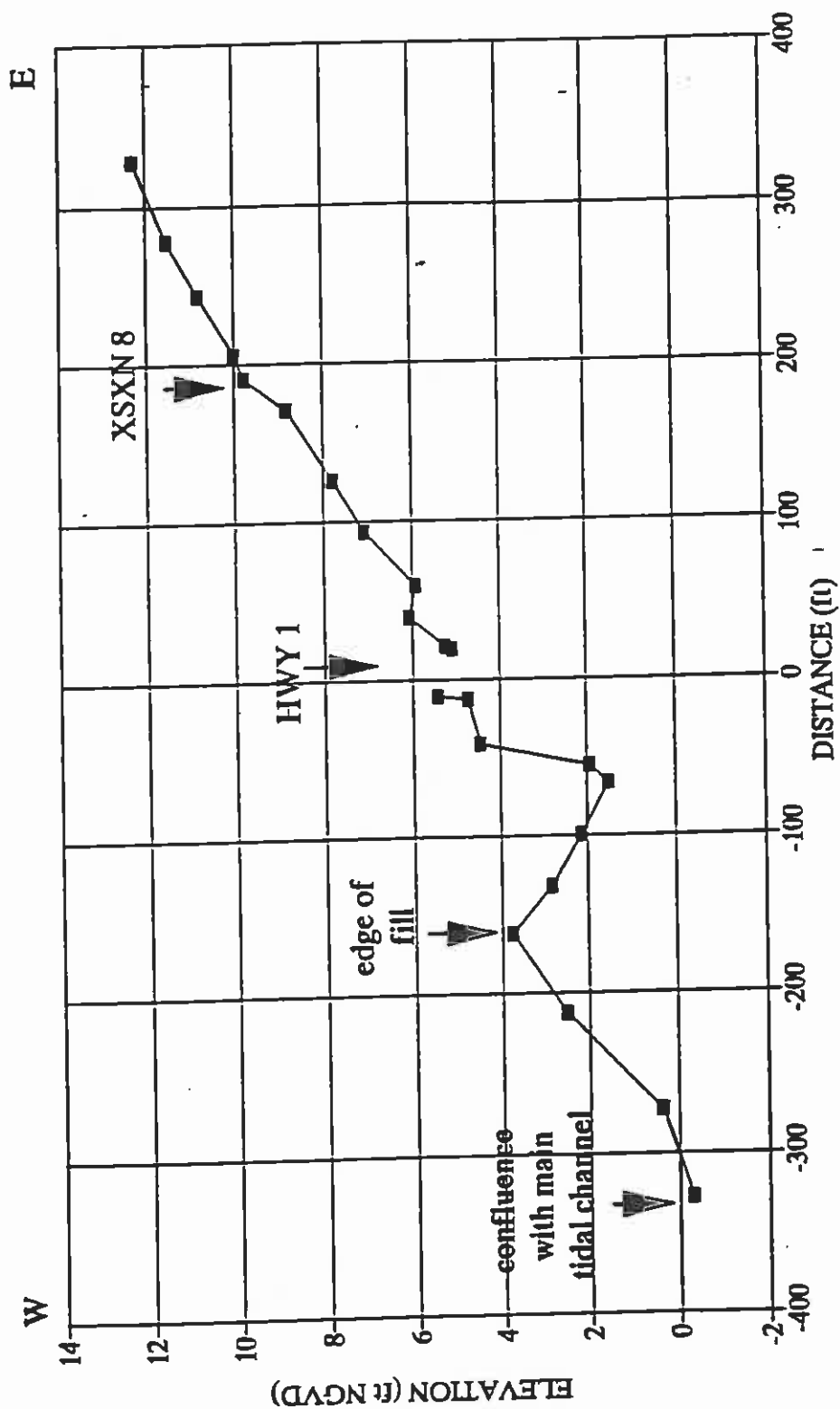
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Consultants in Hydrology

BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X4 (S OF CAUSEWAY FILL) 4/9/93

Figure
5.1-7

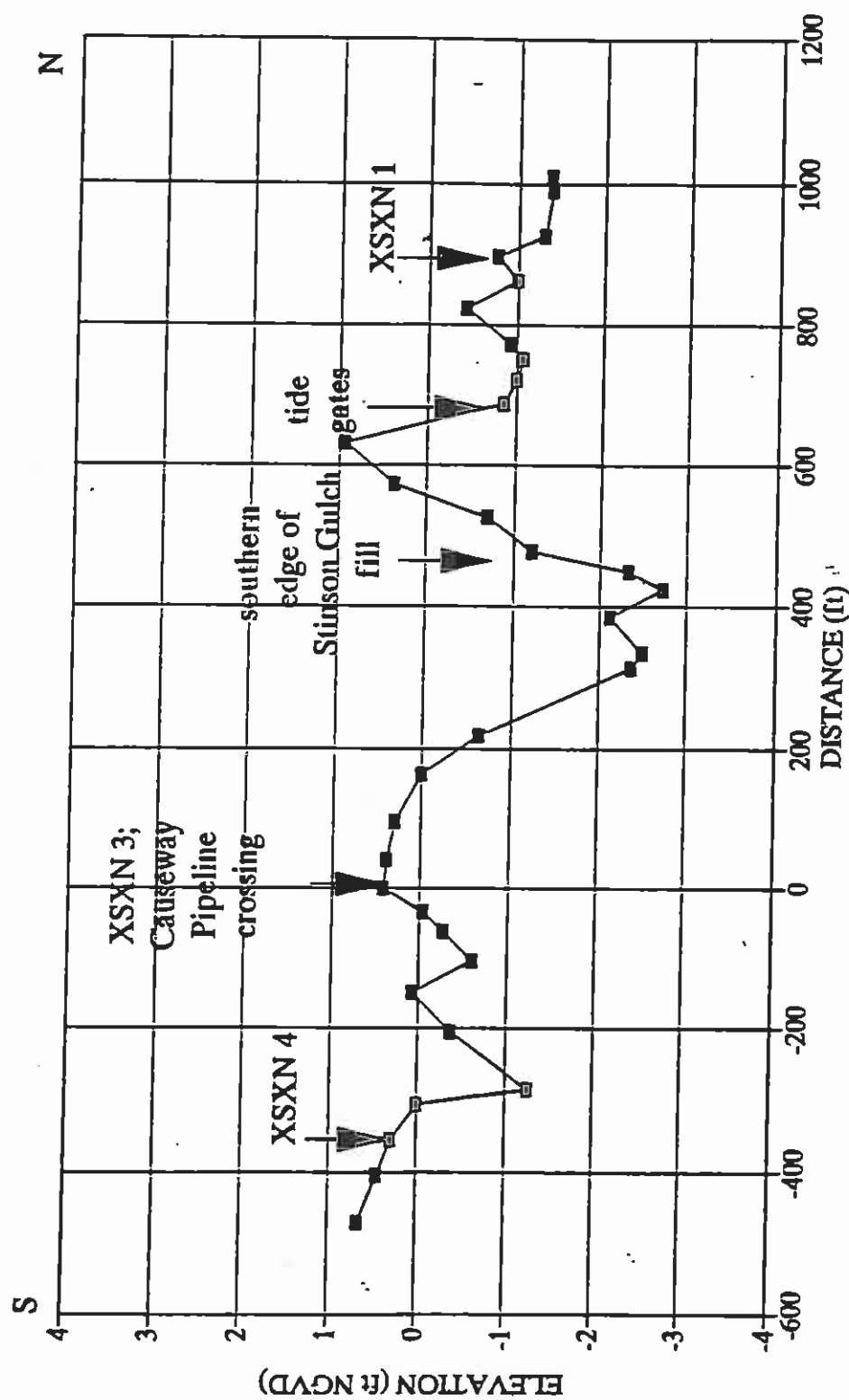


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BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X5 (STINSON GULCH THALWEG) 4/9/93

Figure
5.1-8



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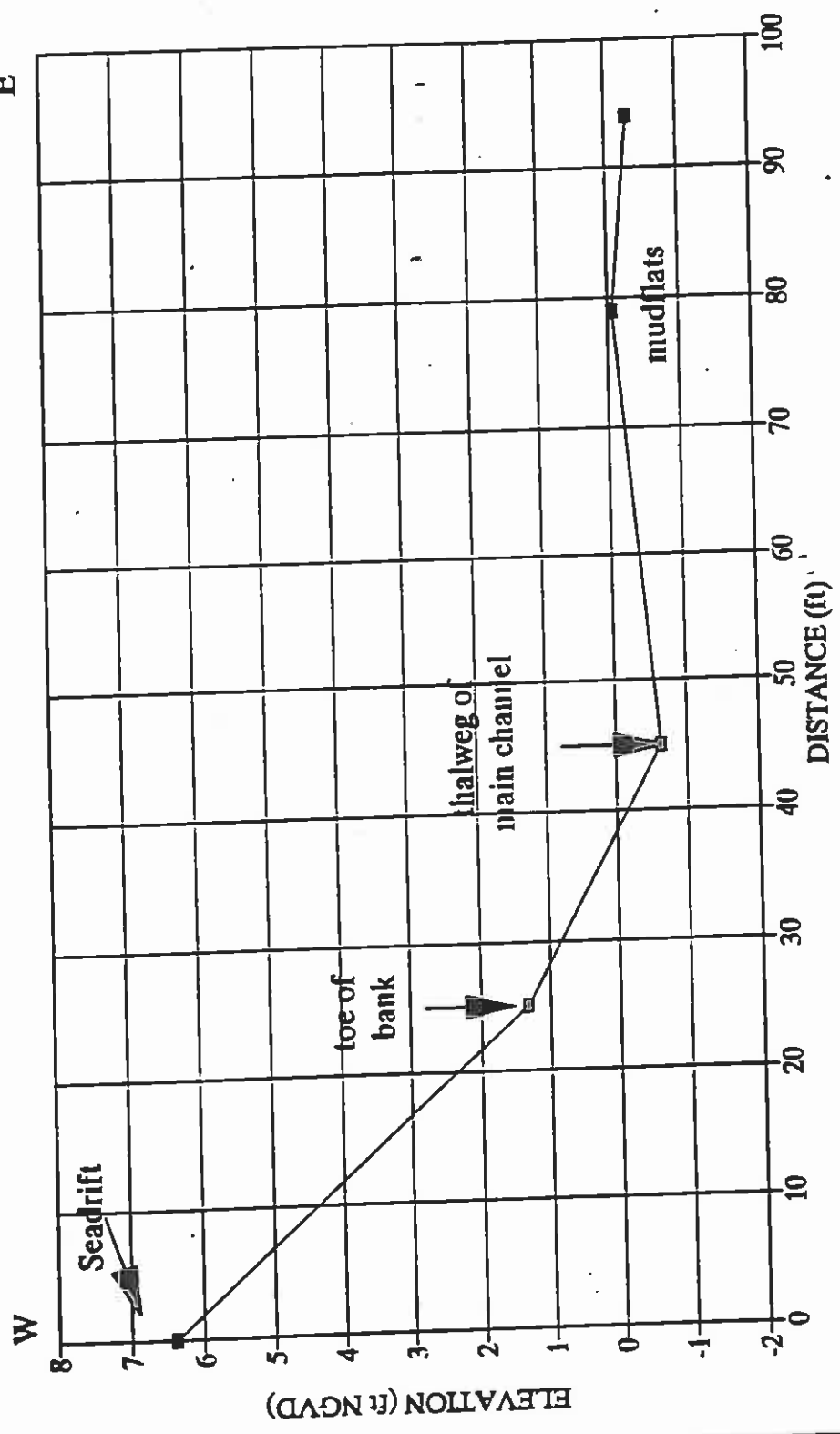


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BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X6 (THALWEG OF MAIN TIDAL CHANNEL) 4/9/93

Figure
5.1-9

E

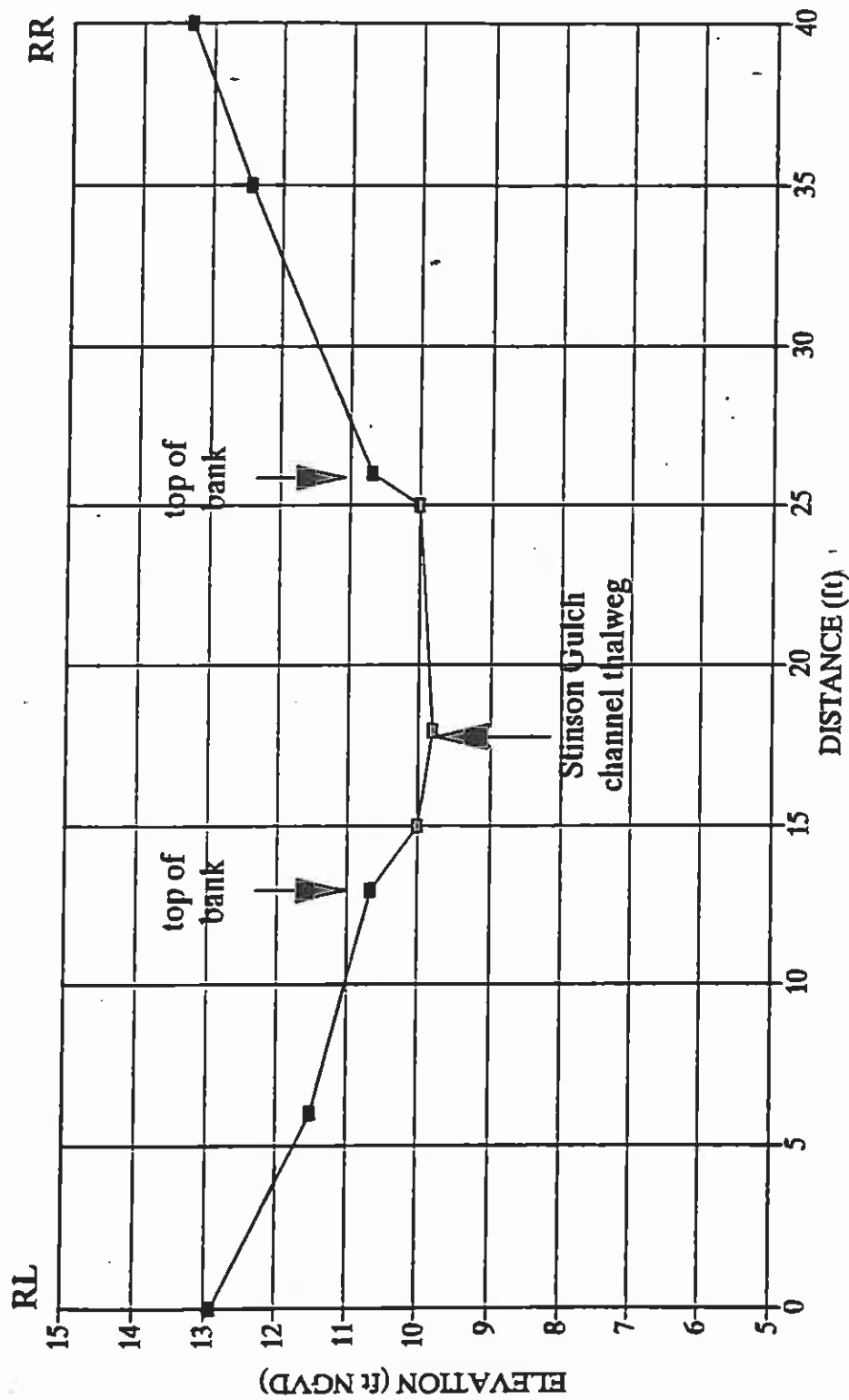


ct/bolinas/lagoon/0493.eq (2/20/09) 5.1-10

Figure
5.1-10

BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X7 (BETWEEN STINSON GULCH AND
CAUSEWAY FILL SITES) 4/9/93


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Consultants in Hydrology

BOLINAS LAGOON MITIGATION SITE - BASELINE MONITORING
CROSS-SECTION : X8 (STINSON GULCH) 4/9/93

Figure
5.1-11

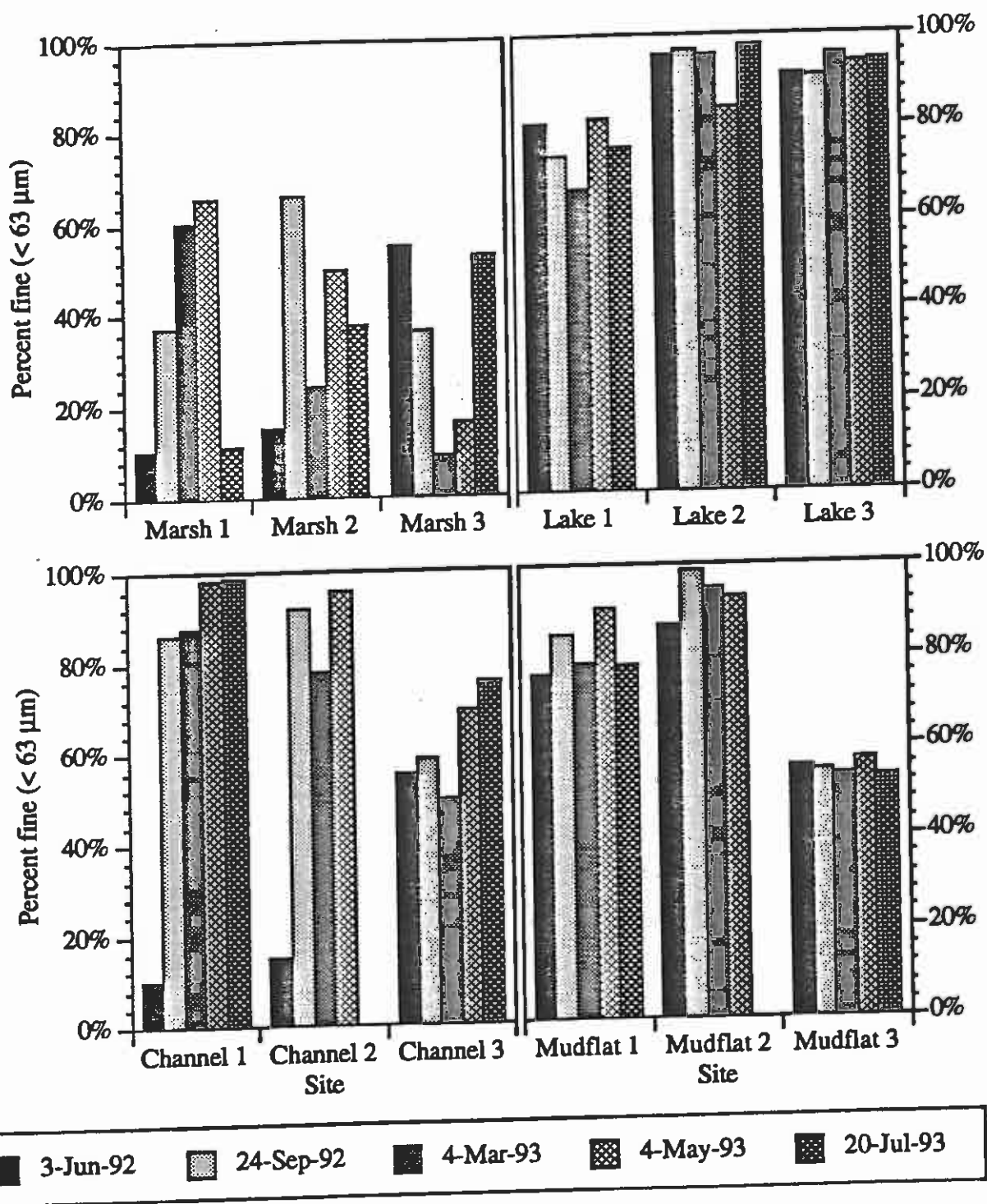


Figure 5.1-12. Grainsize characteristics for Bolinas lagoon sediments during 1992-1993. Percentage of fine sediments (silt, clay, and colloids, particle diameter < 63 μm) is shown. $n = 1$ in all cases.

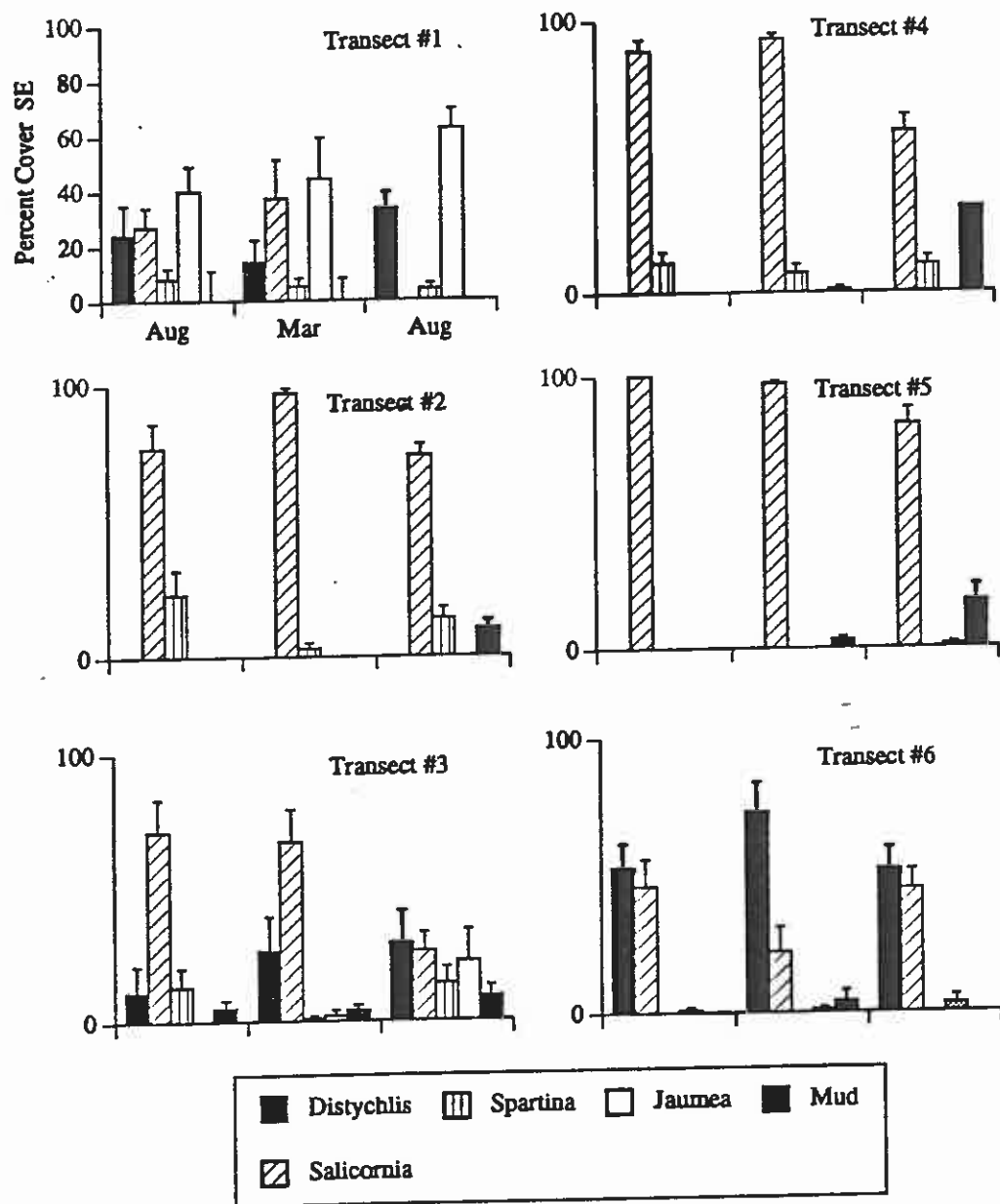


Figure 5.2-1. Percent cover + standard error of plant species at six permanent transects in Bolinas Lagoon over three sampling times - August 1992, February 1993 and August 1993.

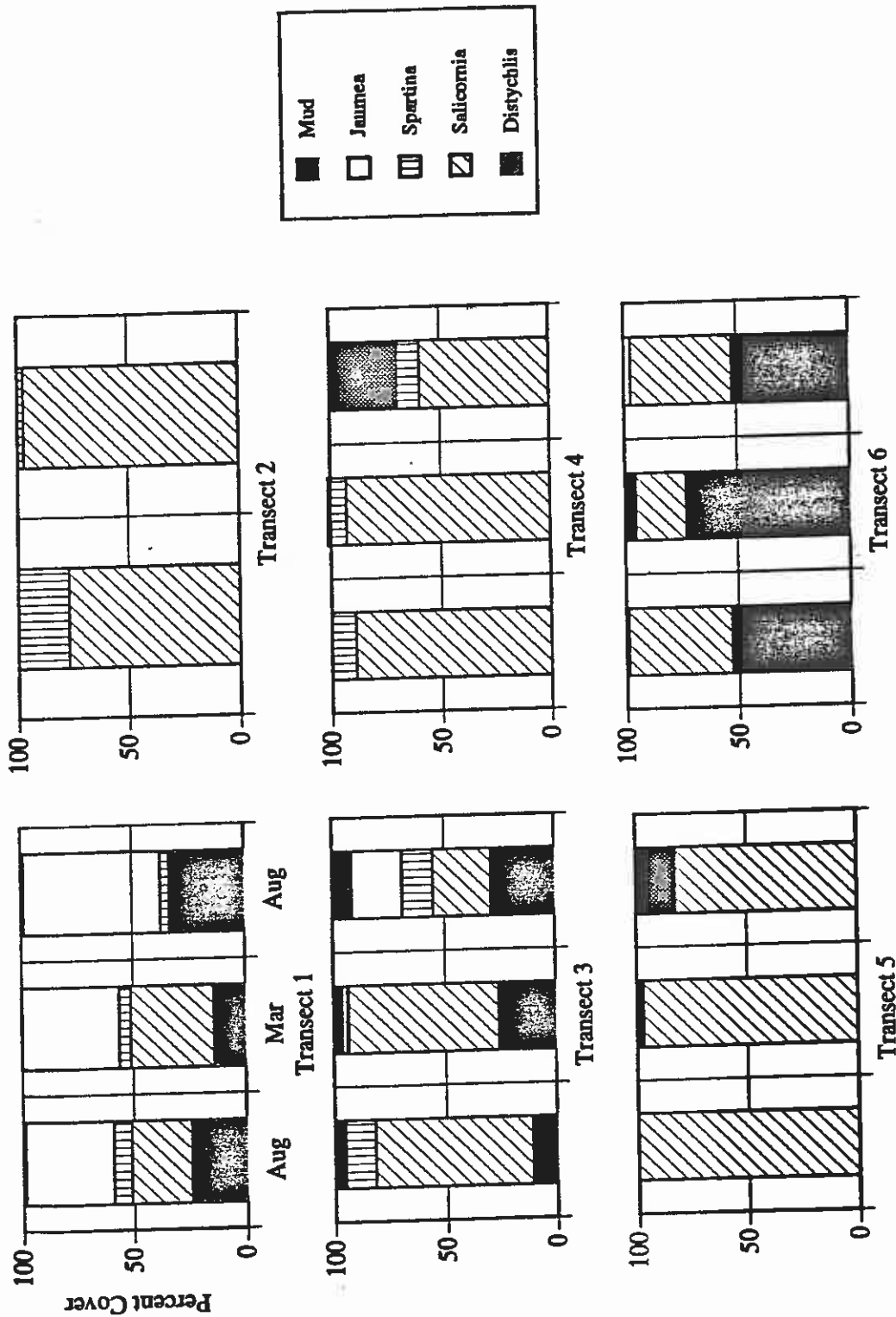


Figure 5.2-2. Percent cover of plant species at six permanent transects in Bolinas Lagoon over three sampling times- August 1992, February 1993 and August 1993.

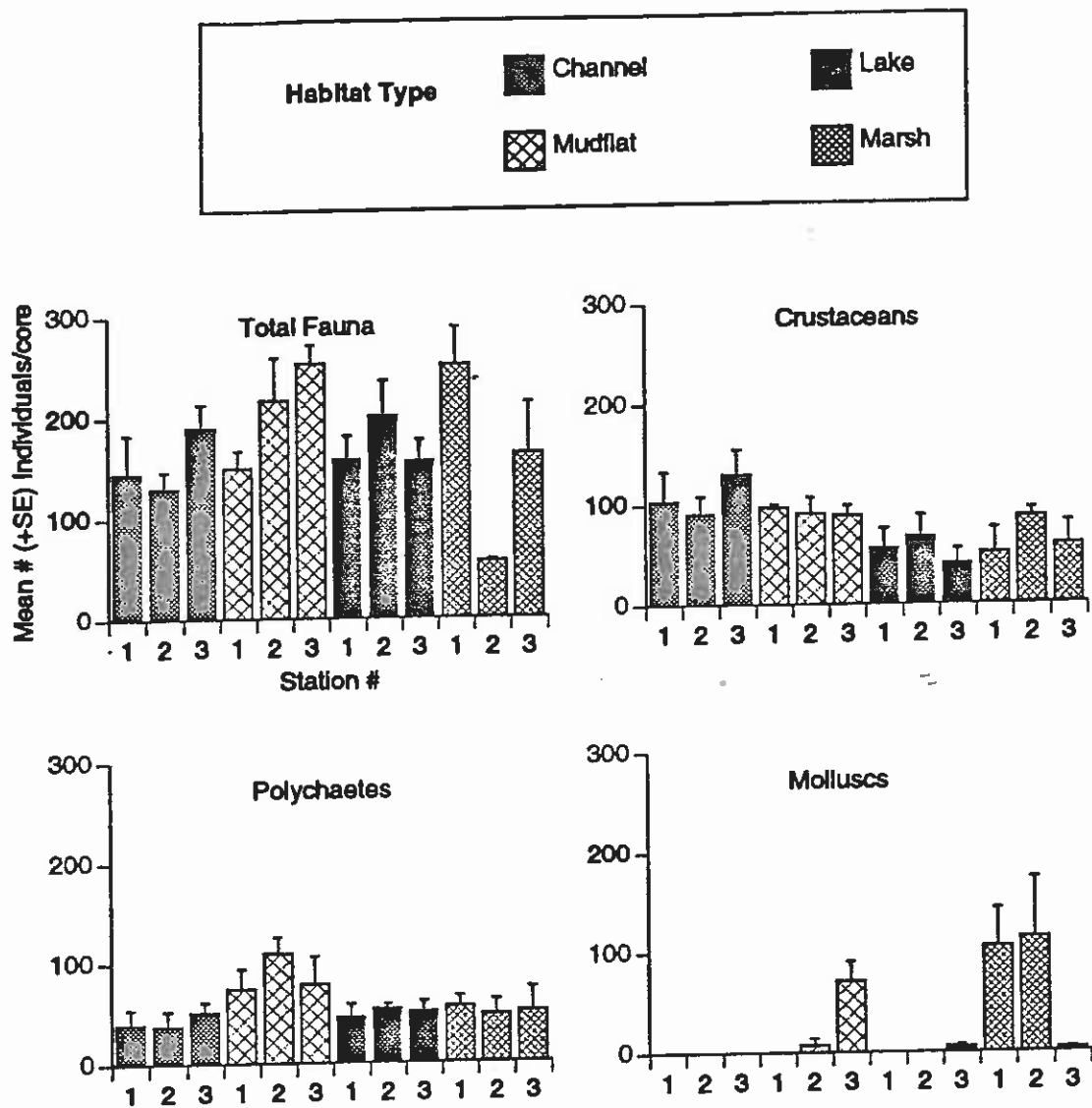


Figure 5.2-3. Total fauna as well as assemblages of major invertebrate groups (polychaetes, crustaceans and molluscs) in four Bolinas Lagoon habitats in mean number of individuals per core. $n=6$ replicates per station. Data are pooled over four sampling periods between June 1992 and May 1993.

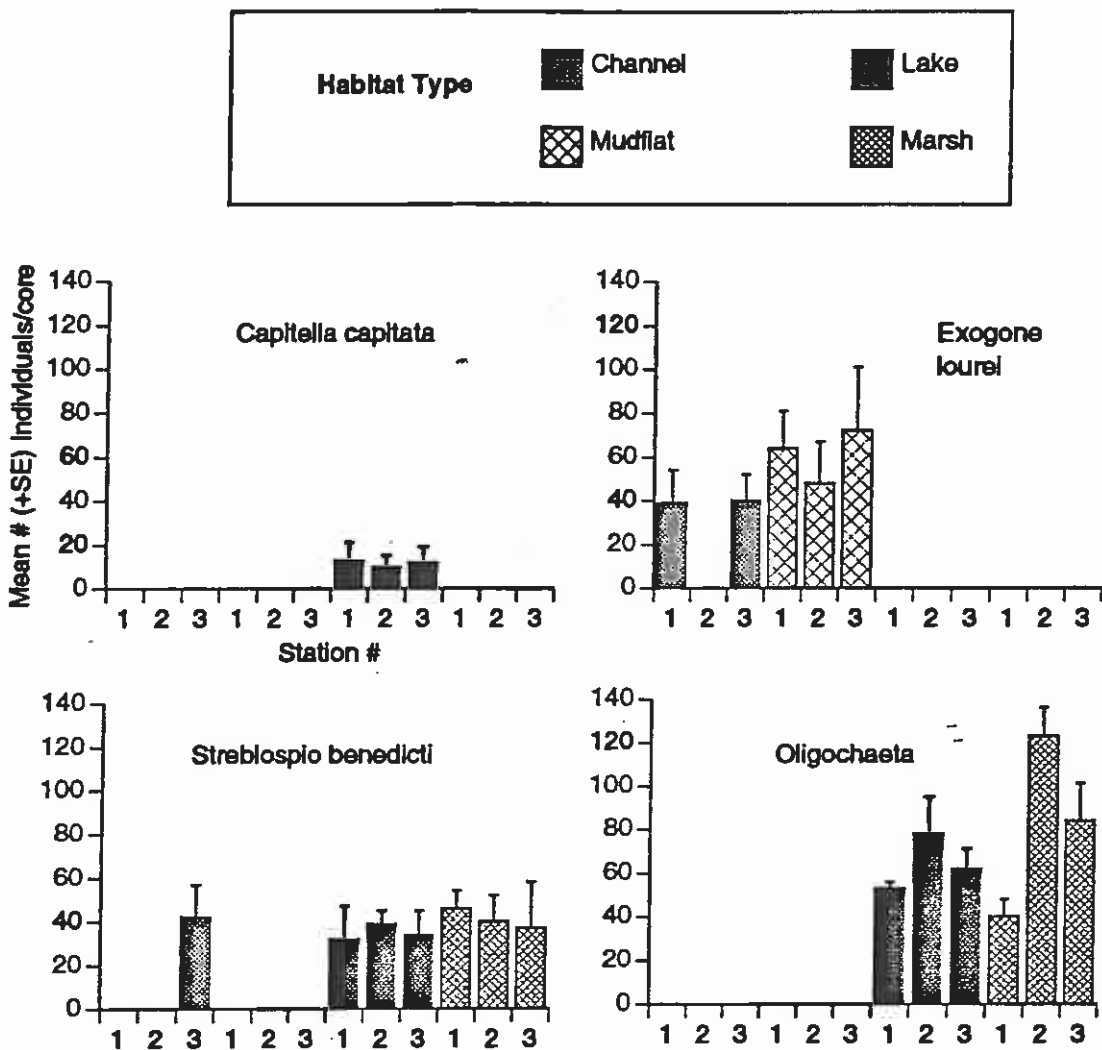


Figure 5.2-4 . Principal worm taxa in four Bolinas Lagoon habitats in mean number of individuals per core. $n=6$ replicates per station. Data are pooled over four sampling periods between June 1992 and May 1993.

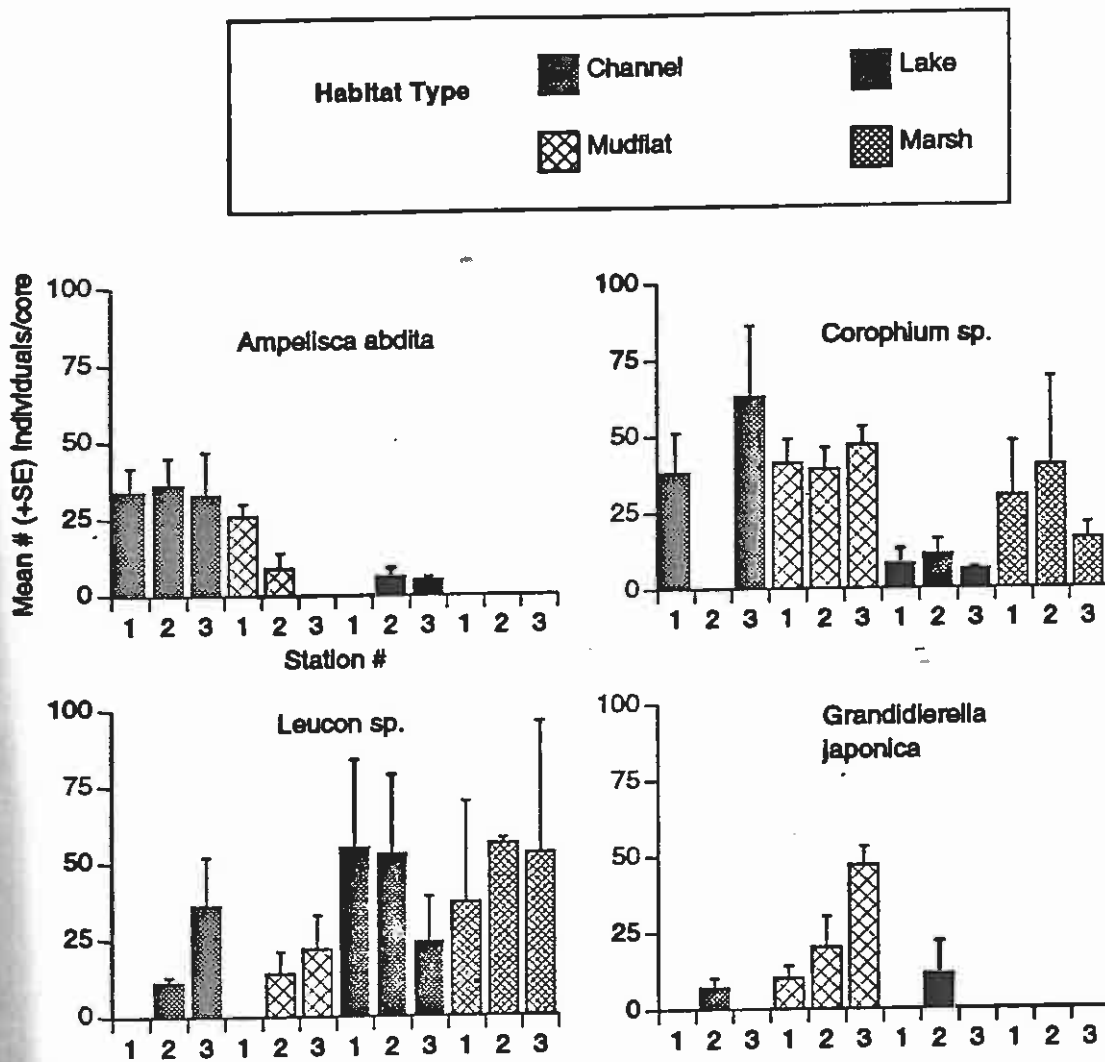


Figure 5.2-5. Principal crustacea taxa in four Bolinas Lagoon habitats in mean number of individuals per core. $n=6$ replicates per station. Data are pooled over four sampling periods between June 1992 and May 1993.

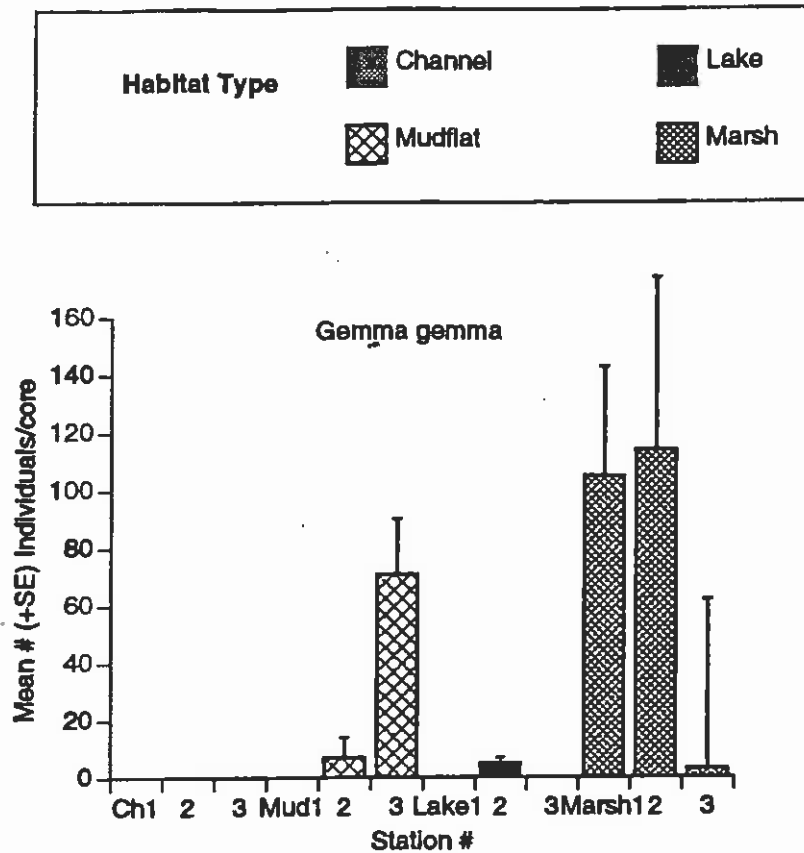


Figure 5.2-6. Principal mollusks in four Bolinas Lagoon habitats in mean number of individuals per core. $n=6$ replicates per station. Data are pooled over four sampling periods between June 1992 and May 1993.

Figure 5.2-7. Length - frequency histogram for arrow goby (*Atherinops*) captured at four sampling stations in Bolinas lagoon.

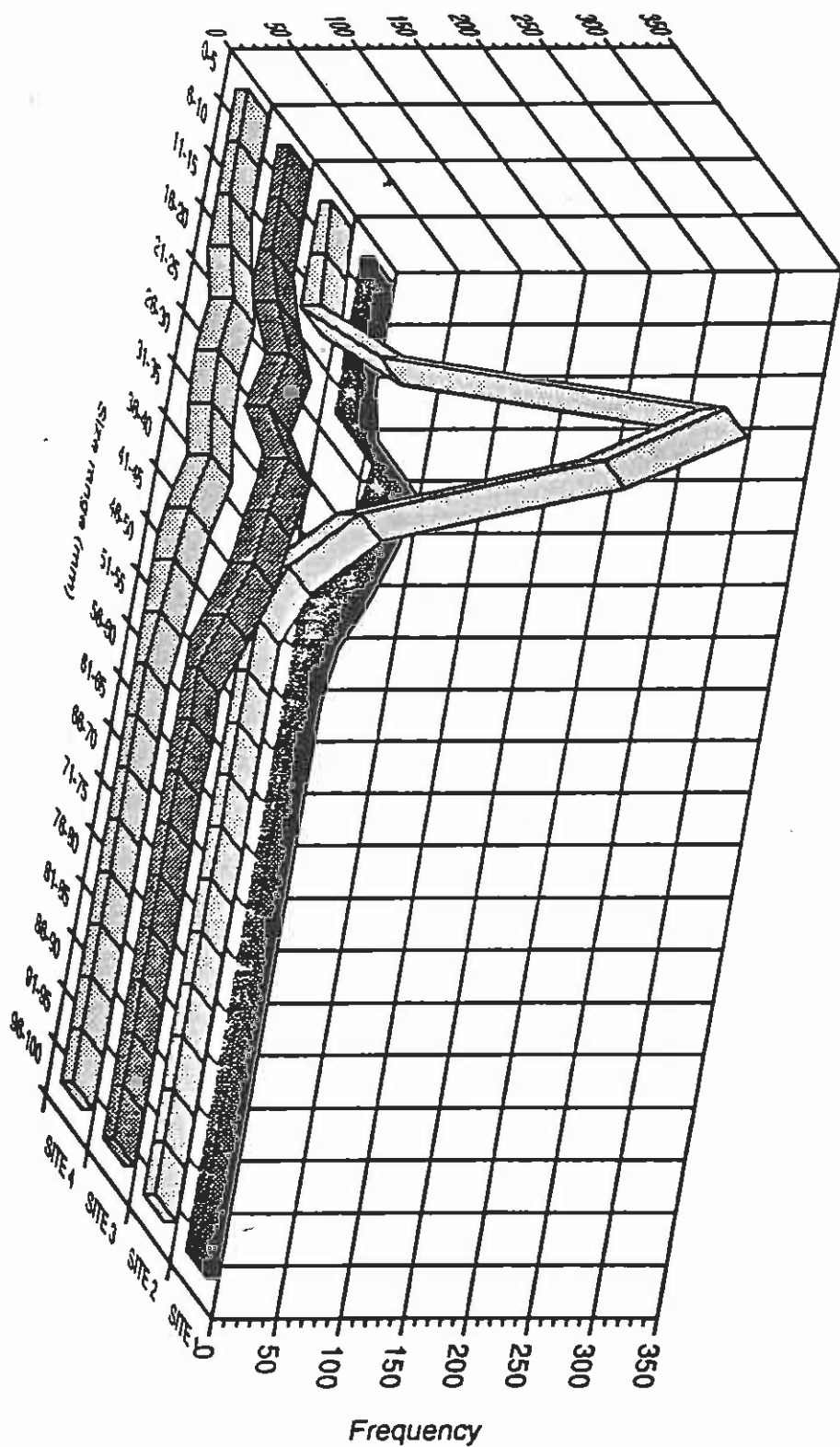


Figure 5.2-8. Length - frequency histogram for topsmelt (Clevelandia) captured at four sampling stations in Bolinas lagoon.

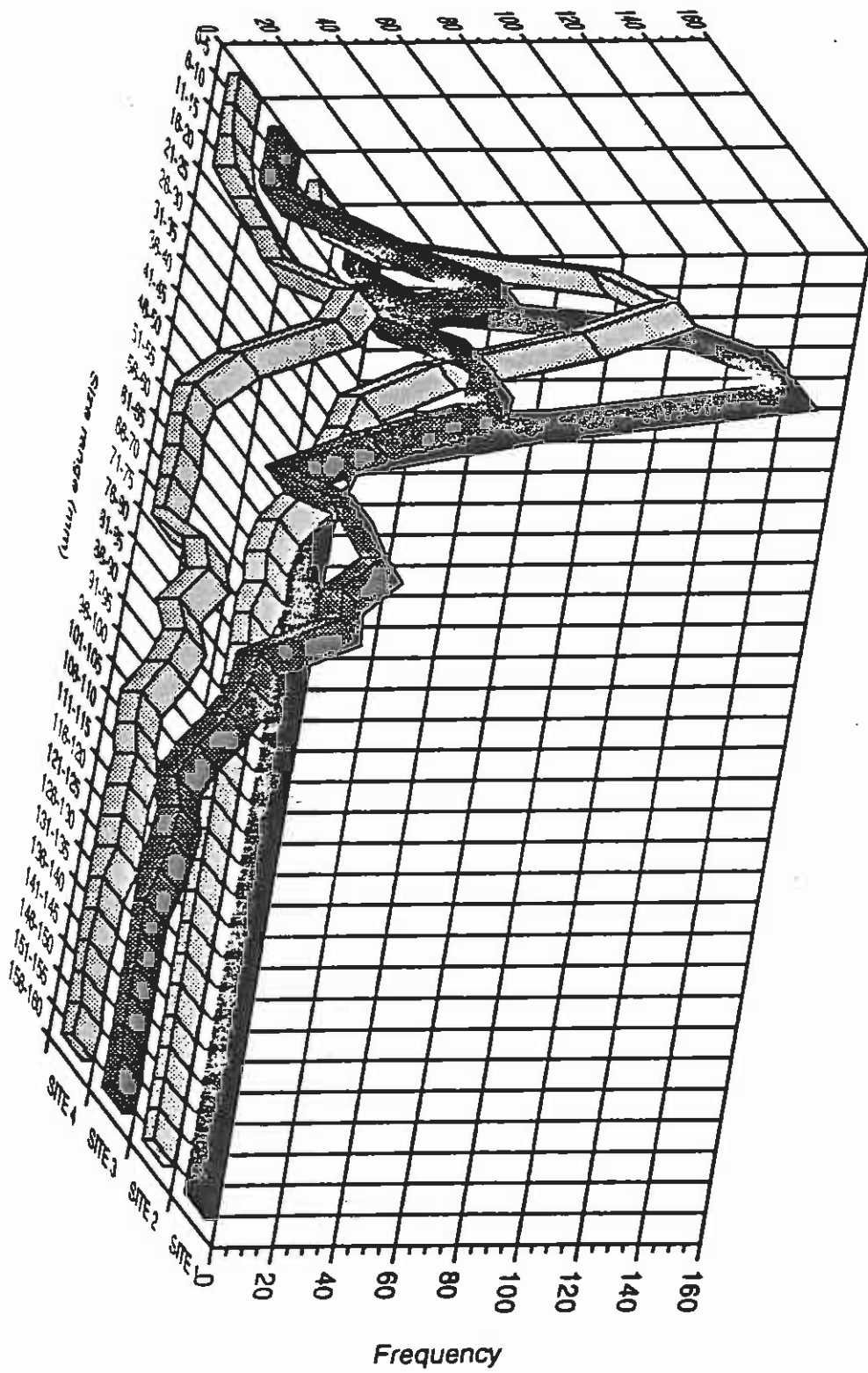
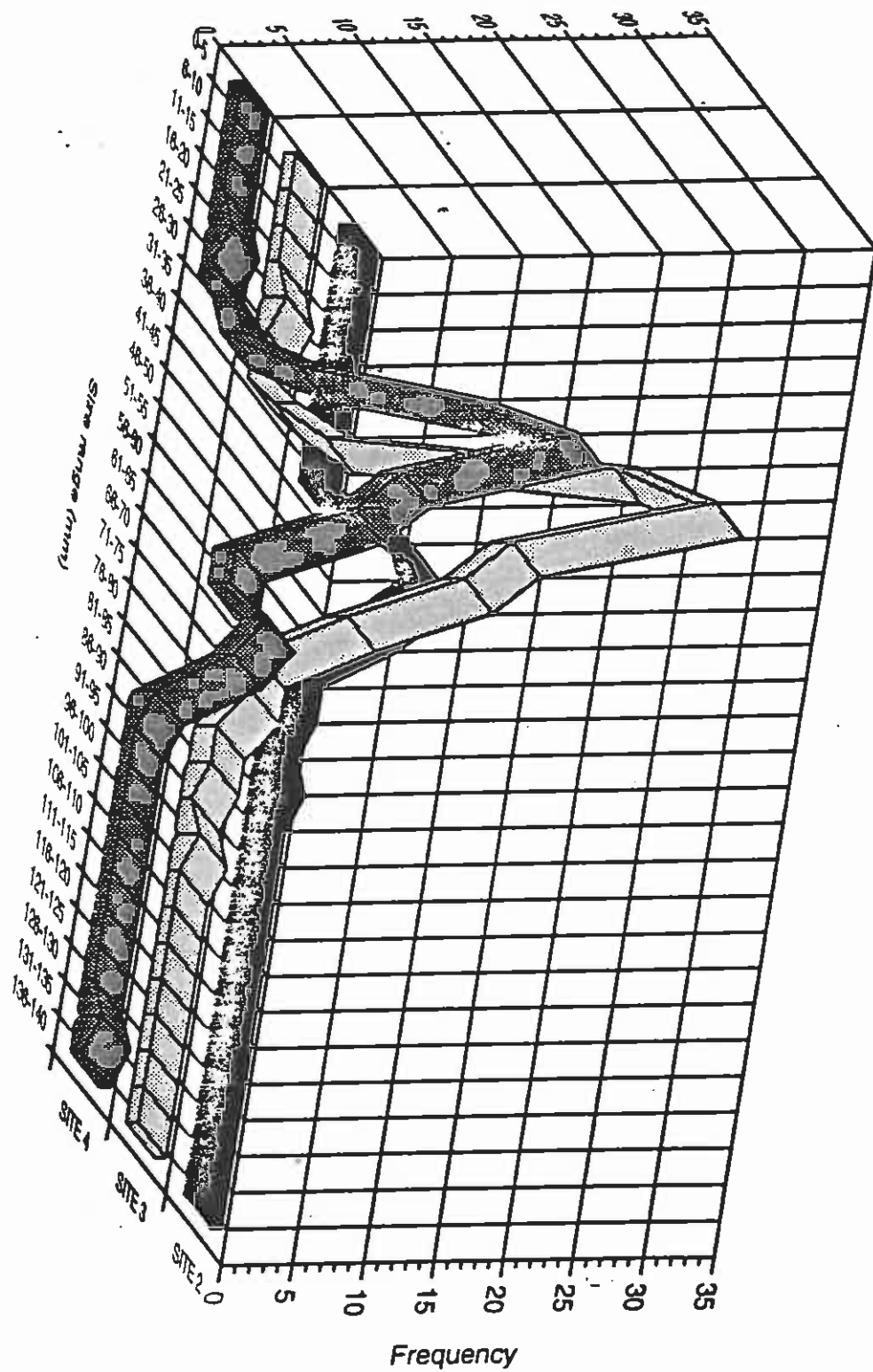


Figure 5.2-9. Length - frequency histogram for slaghorn sculpin (*Leptocottus*) captured at three sampling stations in Bolinas lagoon.



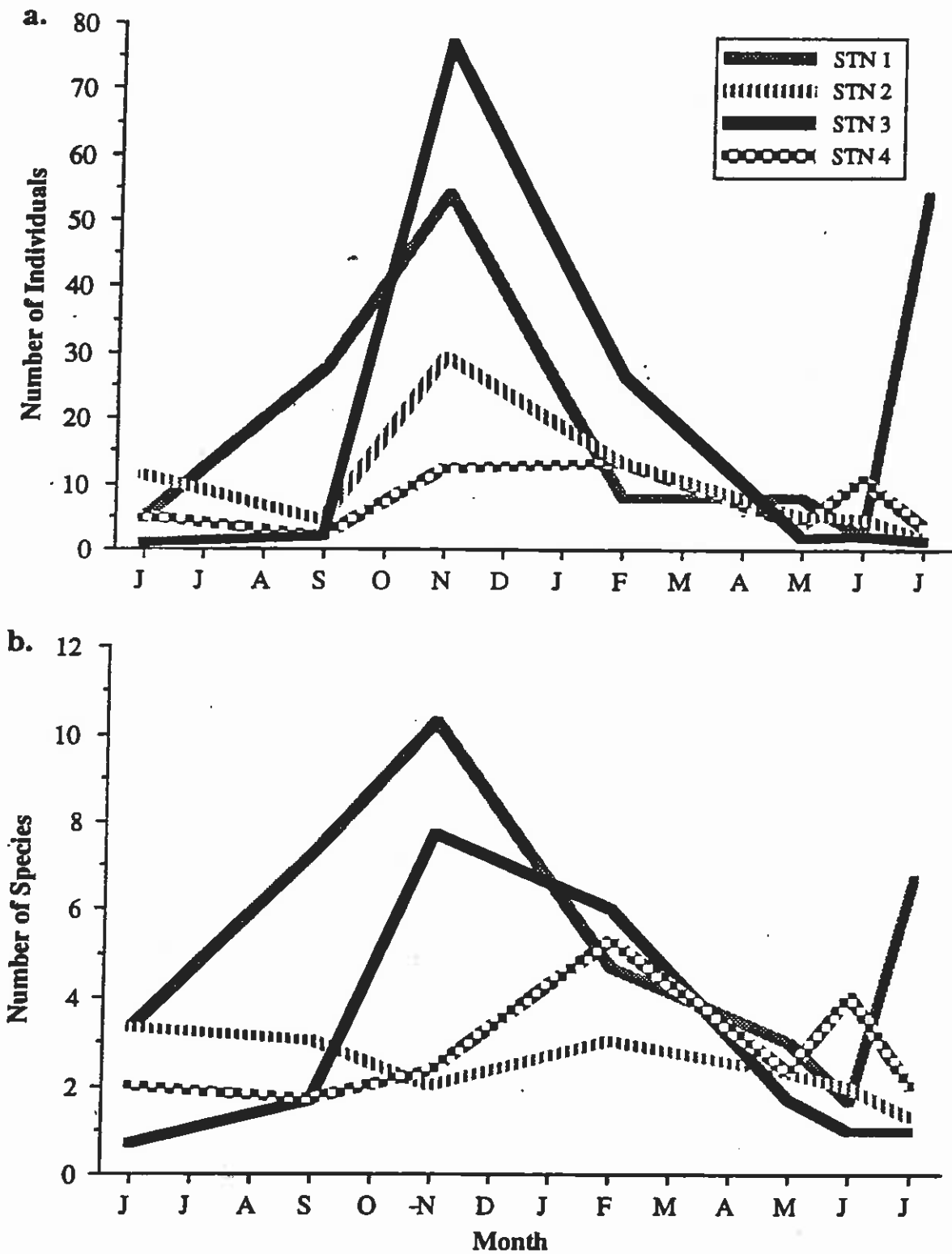


Figure 5.2-11a. Individual (average individual count per replicate) and species abundance of birds in mudflat stations 1 - 4, June 1992 - July 1993.

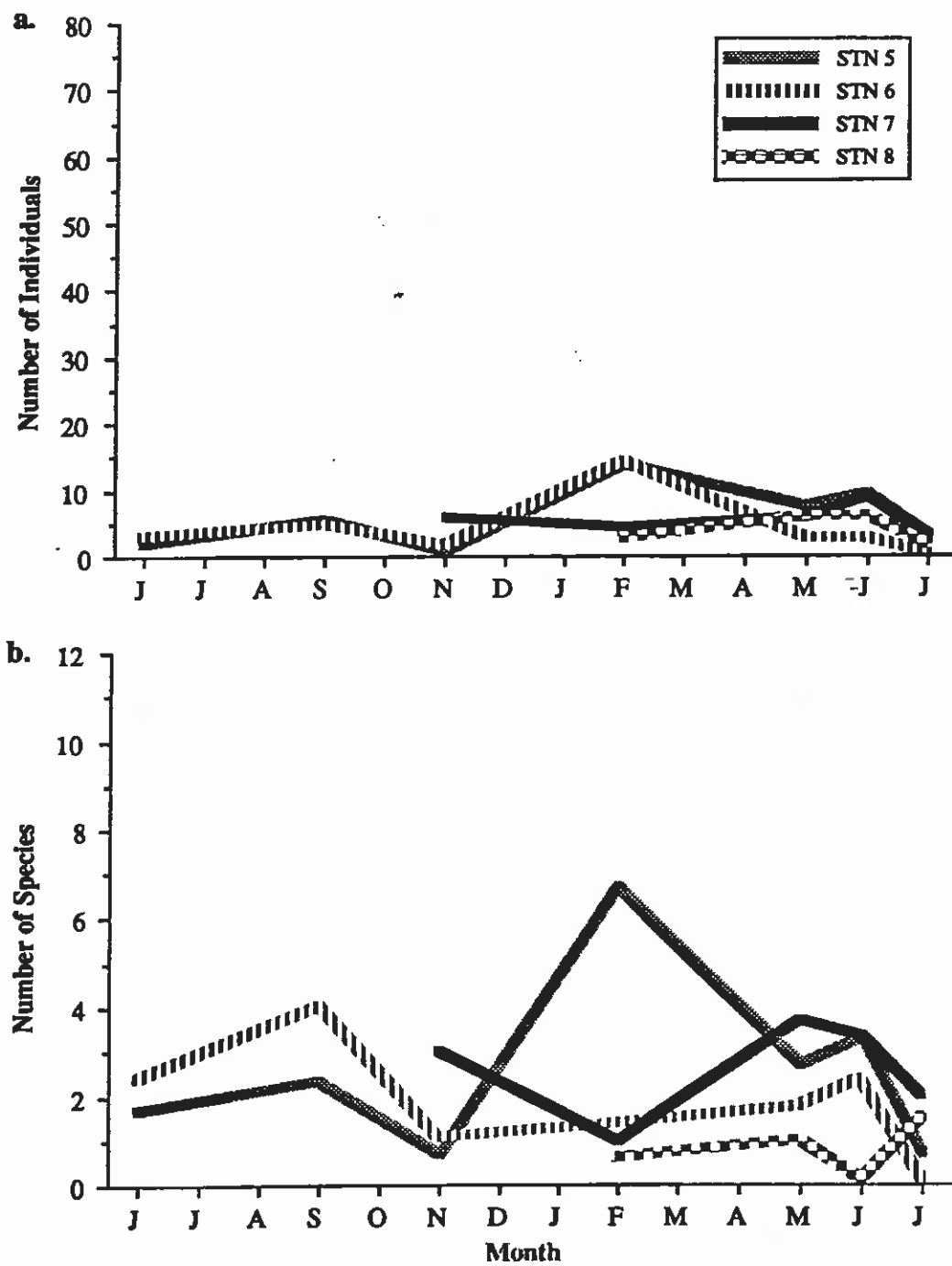


Figure 5.2-11b. Individual (average individual count per replicate) and species abundance of birds in mudflat stations 5 - 8, June 1992 - July 1993.

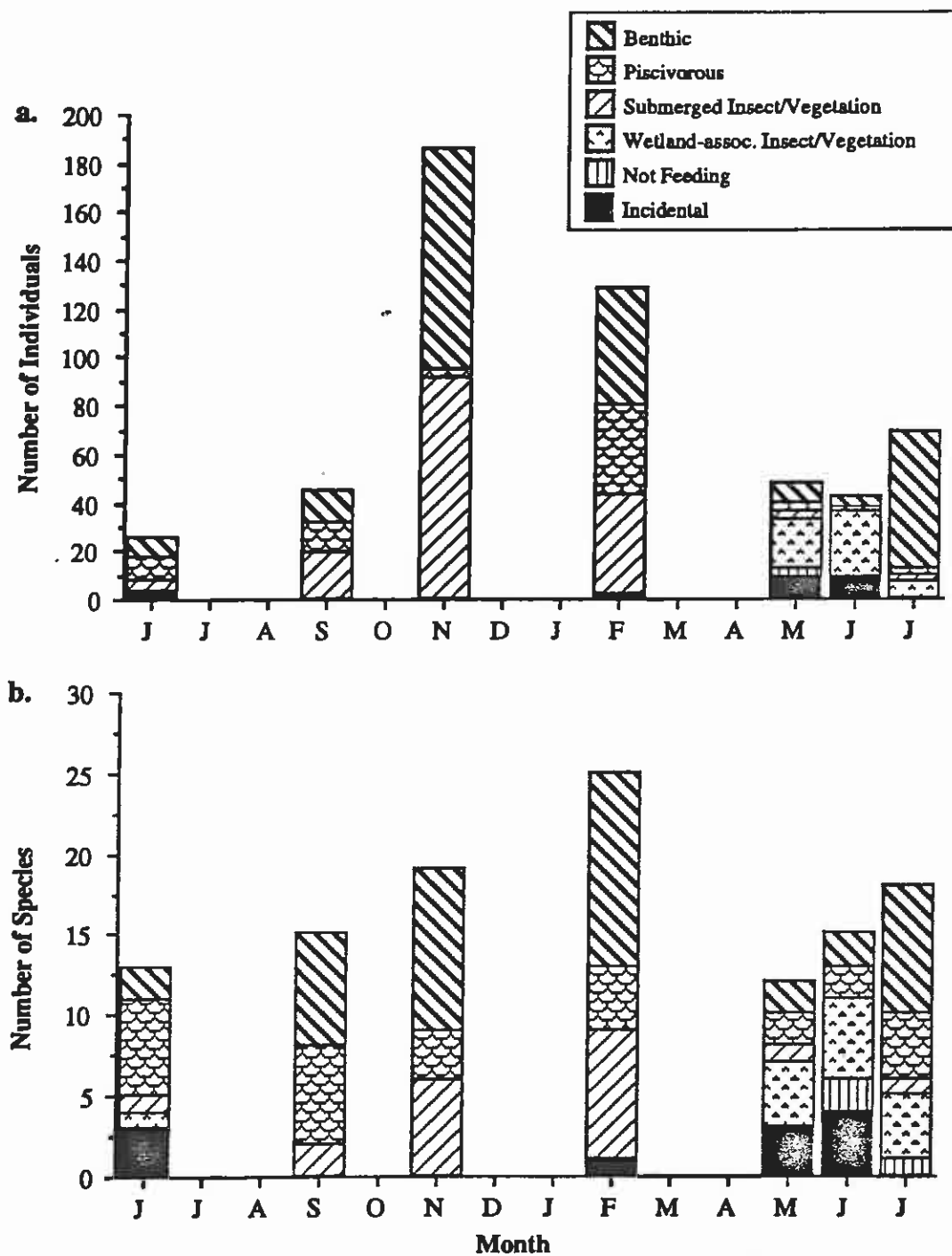


Figure 5.2-12. Individual* and species abundance of birds categorized by habitat use, June 1992 - July 1993.**

* Number of individuals represents sum of average individual counts per replicate for each habitat use type for all stations.

** Number of species represents sum of all species observed for each habitat use type for all stations.

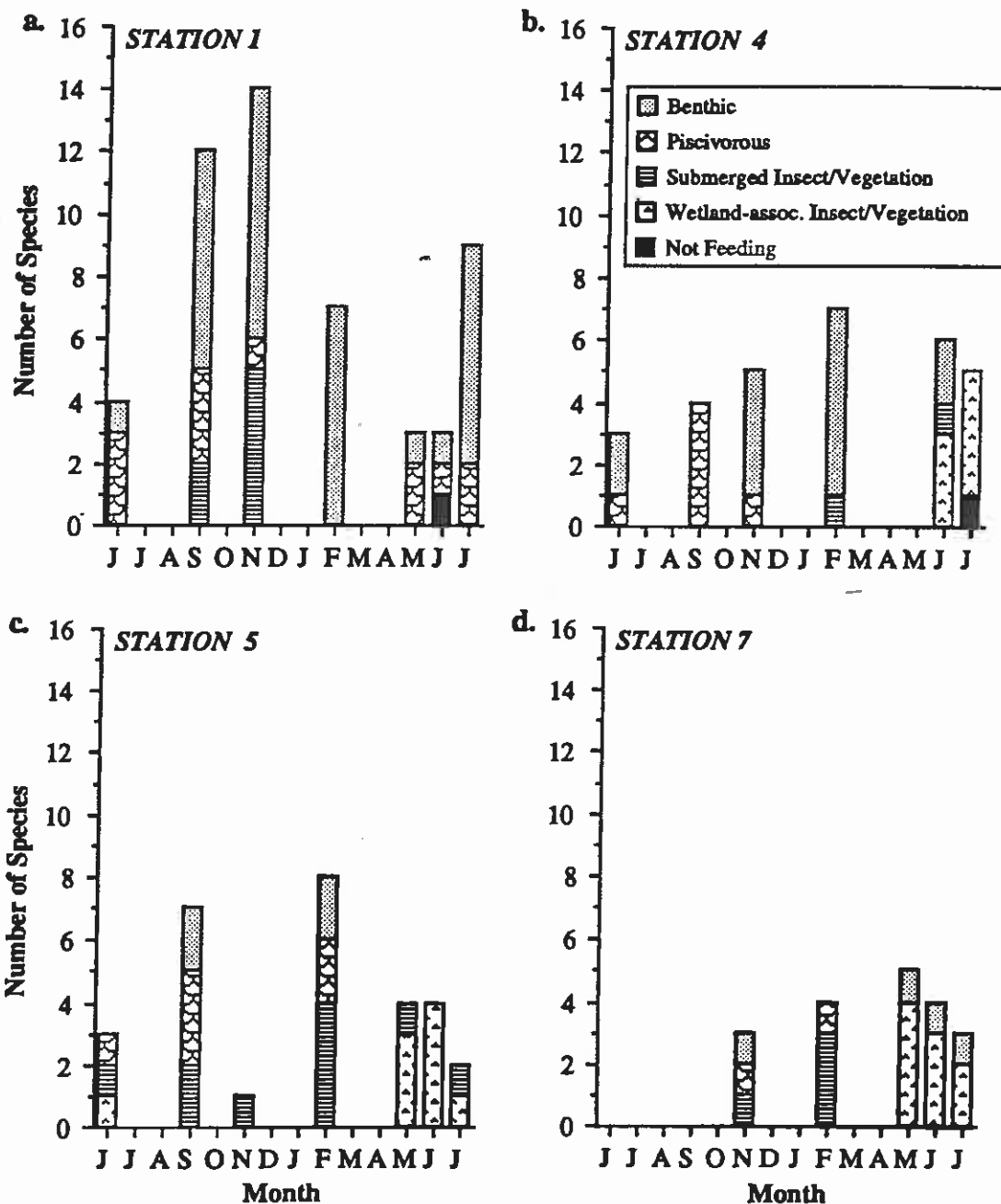


Figure 5.2-13. Species* abundance of birds categorized by habitat use at mudflat stations 1 and 4, lake station 5, and marsh station 7, June 1992 - July 1993.

* Number of species represents sum of species observed for each habitat use type.

APPENDICES

APPENDIX A:

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PROJECT TEAM

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PERSONS AND AGENCIES INVOLVED

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APPENDIX C:

PRELIMINARY LONG-TERM PHYSICAL MONITORING PROPOSAL

PROPOSED SCOPE OF WORK FOR
LONG-TERM, PHYSICAL MONITORING
AT BOLINAS LAGOON
AS PART OF MITIGATION FOR THE
HIGHWAY ONE LONE TREE SLIDE REPAIR

for

California Department of Transportation

by

Philip B. Williams, Ph.D., P.E.
President

and

C. Kelly Cuffe
Hydrologist

July, 1993

P1494

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I. INTRODUCTION

As part of mitigation for the repair of the Highway One Lone Tree Slide, approximately 2.2 acres of intertidal fill is to be removed from two sites within the southern portion of Bolinas Lagoon (Figure 1). The general goal of this project is to restore and maintain the highest natural habitat values for the Bolinas Lagoon ecosystem. Specific objectives of the Bolinas Lagoon restoration are to:

1. Restore as large an area as possible to intertidal or subtidal habitat.
2. Restore as much tidal prism as possible to the lagoon.
3. Restore the natural hydrodynamic functioning of the southern portion of Bolinas lagoon.
4. Encourage the scouring of deep channels as fishery habitat.
5. Encourage the reversal of the process of conversion of mudflats to salt marsh.
6. Remove toxic fill from the lagoon.

In order to determine the success of these restoration goals, a long-term monitoring plan is being proposed for five years following fill removal and reconstruction. Long-term ecological and physical monitoring surveys will be conducted within the mitigation site at locations previously established during baseline monitoring surveys so that any changes or trends occurring in or to the ecosystem at Bolinas Lagoon can be determined. Areas outside of the direct mitigation site will also be monitored to determine if external changes occurring in other areas of the lagoon have any effect on the success of this mitigation project.

The scope of work for the long-term physical monitoring of the Bolinas Lagoon restoration site is detailed in this proposal. This work will be performed separately from, but in conjunction with ecological monitoring conducted within the study area over the same monitoring period. The scope of work detailed in this proposal generally follows that described in the "Preliminary Design for Fill Removal" report presented to the California Department of Transportation in June of 1992 (PWA Report 821-1).

II. LONG-TERM PHYSICAL MONITORING PROGRAM

A five-year long-term physical monitoring program will be used to document any physical changes that occur within the study area at Bolinas Lagoon after removal of fill is complete at both the Causeway and Stinson Gulch fill sites. Results from monitoring of baseline conditions within the study area will be used to determine the need to refine or amend performance criteria for the study. Physical monitoring will involve monitoring water levels at the study site relative to tides entering the lagoon system as a whole, measuring elevation transects within the lagoon to determine erosion and accretion through time, and monitoring a shoreline erosion transect to measure shoreline change through time. At the end of the 5-year monitoring program, a bathymetric survey will be conducted to determine what affects, if any, this mitigation project has had on the geomorphology of the Lagoon itself.

A. TIDAL MONITORING

A mean diurnal tide will be monitored within Bolinas Lagoon immediately following excavation, and once annually for four years thereafter, to measure tidal lags and amplitudes at the mitigation site and to compare changes in tidal prism at the site over time. Data collected during the long-term tidal monitoring will be compared against similar data collected during baseline (pre-construction) monitoring to determine total change in tidal prism due to the mitigation project. Tidal monitoring locations previously established during baseline monitoring will continue to be used through the long-term monitoring phase of this study (Fig. 2). Tide staffs and automatic water level recorders will be emplaced 1.) at the NOAA tide gage site in Bolinas, 2.) a location in the channel immediately to the north of Stinson Gulch, 3.) a location in the channel immediately to the south of the causeway, and 4.) a location at the north end of the lagoon.

B. ELEVATION TRANSECTS

Fifteen elevation transects will be surveyed immediately after excavation and then annually for the following five years to monitor physical topographic changes at the mitigation site. Cross-section surveys will be conducted along fifteen transects using standard land surveying techniques, and changes in elevations and successional aggradations will be recorded. Elevations will be tied into the National Geodetic Vertical Datum of 1929 (NGVD 1929). The location of transects 1 through 8 are shown in Figure 2 and would be monitored immediately after excavation and then quarterly in the first 2 years and semi-annually in the last 3 years. These transects include:

1. Cross-section of main tidal channel to the north of Stinson Gulch.

2. Cross-section at Stinson Gulch excavation site.
3. Cross-section at Causeway excavation site.
4. Cross-section of main tidal channel to south of Causeway.
5. Thalweg profile of Stinson Gulch.
6. Thalweg profile of main tidal channel from north of Stinson Gulch excavation site to south of Causeway excavation site.
7. Cross-section of main tidal channel between Stinson Gulch and Causeway excavation sites.
8. Cross-section of Stinson Gulch cheek channel upstream of Highway 1.

Transects 9 through 15 are shown in Figure 3 and would be monitored immediately after excavation and then annually for five years. These transects include:-

9. Cross-section of tidal inlet at entrance to Bolinas Lagoon.
10. Cross-section of tidal channel between Bolinas and Kent Island.
11. Cross-section of lagoon near Stinson Beach School.
12. Cross-section of lagoon south of McKinnan Gulch.
13. Cross-section of lagoon south of Kent Island.
14. Cross-section of lagoon near the mouth of Pine Gulch Creek.
15. Cross-section of lagoon south of Pike County Gulch.

C. SHORELINE EROSION TRANSECTS

A 200-foot shoreline erosion transect will be surveyed immediately after excavation and then annually thereafter to monitor shoreline change along the marshfront of the salt marsh at the southern end of Bolinas Lagoon. This marsh, which sits at the mouth of Eskoot Creek, is presently protected from north-easterly wave erosion by the Causeway fill site. It is expected that an equilibrium shoreline will be developed after excavation of the Causeway fill. A shore-parallel baseline transect will be established inland from the marsh edge and

distances to the marshfront will be measured at 20-foot spacings. Annual shoreline change (erosion and/or accretion) rates of the marshfront will be determined from these data.

Physical monitoring of the mitigation site will allow us to determine the following parameters:

- The amount of sediment accumulating at the mouth of Stinson Gulch
- The presence of obstructions to anadromous fish migration on Stinson Gulch.
- The change in tidal prism to determine whether the goal of an increase of 5.7 acre ft is achieved.
- The aerial extent of created intertidal/subtidal habitat (up to MHHW).
- The response of the tidal drainage system downstream of the mitigation site.

D. BATHYMETRIC SURVEY OF BOLINAS LAGOON

A bathymetric survey of Bolinas Lagoon will be conducted in the fifth year of monitoring, in 1998, to assess impacts of the mitigation project on other areas within the lagoon, as well as to determine if changes occurring in other areas of the lagoon affect the success of the mitigation project. A bathymetric map will be produced at a scale compatible with previous bathymetric surveys conducted for the Marin Open Space District in order to compare geomorphic changes within the lagoon over time. If requested, a topographic survey will be conducted, at a scale similar with previous topographic surveys also conducted for the Marin Open Space District to determine how changes in local topography or morphology have or have been affected by this project. The topographic mapping will either be done in-house by CalTrans surveyors or will be sub-contracted out to a reliable service. Previous surveys for the Marin Open Space District, including both topography and bathymetry, were conducted in 1968, 1978 and 1988 by Towill, Inc. The cost of the 1988 Towill survey is used as a basis for estimating the cost of a similar 1998 survey.

III. ASSESSING NEED FOR REMEDIAL ACTIONS

The primary physical habitat restored by the mitigation project is intertidal mudflats and tidal channel area. The exact form and character of the substrate will be dictated by wave and tidal action, as it is in other parts of Bolinas Lagoon. Uneven topography is expected to be naturally smoothed out by erosion and sedimentation. If the cross-section surveys and tidal monitoring indicate inadequate tidal drainage due to local obstructions in the tidal channel, these will be removed or smoothed out.

If monitoring shows that sediment accumulation at the mouth of Stinson Gulch has filled the sediment trap to within three feet of the crest of the training berm, the sediment trap will be reexcavated by equipment working from the training berm.

If obstructions to fish migration are found in the lower part of Stinson Gulch they will be removed. In addition, if the invert of the Highway 1 culvert is completely cleared of sediment and appears to impede fish passage due to high velocity flow, low wooden baffles will be installed to aid in fish migration.

After two years of monitoring, a review of progress will be made by the Technical Advisory Committee following submission of the second fourth-quarter (second year-end summary) report to determine if significant remedial actions are necessary. Any emergency remediation needs will be addressed as they arise.

VI. REPORTING FORMAT AND SCHEDULE

Quarterly reports describing work to date will be submitted to San Jose State University Foundation and CalTrans for the first two years (1994 and 1995) of the five year monitoring. The quarterly reports will consist of a brief, one to two page outline of physical monitoring tasks completed, a brief description of methodology(ies), a summary of results, a discussion section, and any pertinent maps or lists of sampling locations and transects. The fourth quarterly report will summarize all data collected during that year of monitoring. This format is similar to that of the quarterly reports of baseline conditions monitoring. In that the first quarterly monitoring will likely occur in October, 1993, following completion of construction, the first quarterly report will be submitted December 31, 1993. Subsequent quarterly reports due the last day of March, June and September for the first two years of monitoring. Semi-annual reports will be submitted during the last three years of the project (1996, 1997, and 1998) in a format similar to the quarterly reports. Semi-annual reports will be submitted June 30 and December 31. A final report summarizing the five-year monitoring project, synthesizing both the ecological and physical monitoring, shall be submitted in place of the last semi-annual report due December 31, 1998.

V. MEETINGS

PWA staff will attend two meetings per year to discuss findings and present results to date regarding the Bolinas Lagoon long-term physical monitoring project. PWA staff will attend a total of ten meetings over the five year long-term monitoring project.

VI. SCHEDULE

All work will be completed by December 30, 1998 assuming a contract has been executed by September, 1993.

VII. WORK PRODUCTS

See Reporting Format. Five copies of each report and map will be provided; two copies shall be delivered to San Jose State University Foundation and three copies shall be provided to CalTrans.

VII. PERSONNEL AND ORGANIZATION

Physical monitoring work will be carried out under the supervision of Dr. Philip Williams as Principal-in-Charge, who will be assisted by PWA staff as identified in Attachment A through E. Kelly Cuffe, hydrologist, will act as Project Manager.

APPENDIX D:

PRELIMINARY LONG-TERM ECOLOGICAL MONITORING PROPOSAL

Workplan for
Long-Term Ecologic Restoration Monitoring of
Fill Removal at Bolinas Lagoon

12 August 1993

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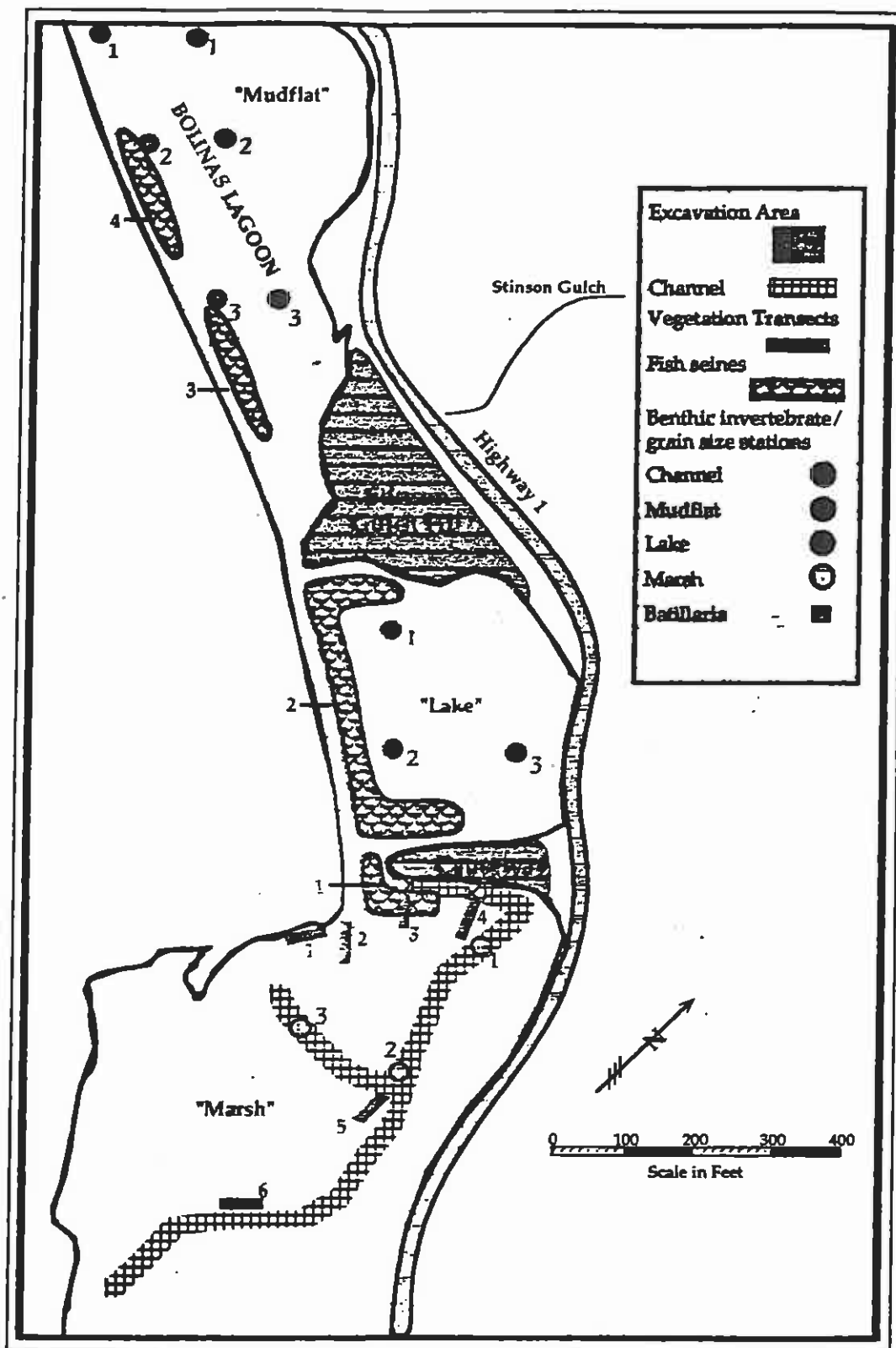


Figure 1. Excavation sites and biological sampling station locations in Bolinas Lagoon.

the baseline sampling, fishes will be sampled with five replicate trawls in the late winter/early spring and in the fall at the same three stations. Relative abundance patterns and size of fish were measured on each date, but these vary greatly over time and cannot be sampled adequately with only two visits. On the other hand, species composition is a good indicator of the development of a natural fish community in the restoration area. Even though relative abundance and size data are not good indicators of restoration success as sampled, these data are easily collected with species composition and permit a more realistic evaluation of success combined with the species lists.

We will also make qualitative surveys of Stinson Gulch and south lagoon creeks for use by salmon and steelhead during their river runs. Although these observations will not be used as success criteria, there could be some surprising changes in stream use related to the increased tidal action and the general opening up of the stream course.

1.4 Plants

The same plant stations will be monitored as in the baseline work, including five transects in the south marsh and five in reference marshes throughout the lagoon. In addition, five more transects will be monitored along the narrow fringe of tidal marsh which will develop in the restoration area. The species composition and relative cover of marsh plants will be surveyed once each year during the period of maximum biomass development, in the late summer or early fall. Qualitative habitat and vegetation surveys will continue at least quarterly in the marshes and along the upland fringe to monitor for erosion of marsh and riparian habitat. The upland plant fringe along the road will also be qualitatively surveyed for invasive non-native weeds which can be controlled by periodic weeding.

2 CONTINUATION OF BASELINE MONITORING

The baseline monitoring program was designed for two purposes: to evaluate the success of the restoration and to monitor ecological differences in a sand and mud sediment. The continuation of the baseline monitoring program accomplishes both objectives. The addition of a sand substrate to the tideflat is

sediment composition is one of the most important factors influencing the development of marine and brackish water wetlands. This is the first restoration project where two different sediment types are provided in the same hydrographic environment. Everything is the same except the type of sediment. The monitoring program will document any increases in sport clam populations as well as differences in tideflat communities that develop on a sand and mud bottoms. As we are attempting with the clams, it may be possible to attract very different species and communities to different sediments in a restoration. This sediment experiment will be monitored as part of the evaluation of restoration success at no extra effort because the baseline sampling was designed to encompass this unique experiment.

2.2 Benthic Invertebrates

The benthic monitoring program is a continuation of sampling at 15 stations sampled in the baseline work. Some station locations will be modified to sample sand and mud bottoms on the new tideflat. The existing program already includes sampling natural mudflats and sandflats in the lagoon, as well as the marsh mudflats at the extreme southern end of the lagoon that may be influenced by improving tidal flow here after the fill removals. Stations will be sampled quarterly for two years, as in the baseline program. Six stations will then be selected for monitoring twice each year for years 3-5. All sampling techniques and procedures will be the same as in the baseline program.

2.3 Birds

As in the baseline program, birds will be monitored monthly at the eight tideflat stations for two years, and quarterly in years 3-5. Monthly sampling in the first two years provides much more detailed and realistic information on the seasonal changes in bird use of the new tideflats. Birds may forage differently on the new sand and mud substrates because they harbor different prey communities. Invertebrate and bird use of the two sediment types may be the most significant outcome of providing two sediment types in the restoration.

The goal of the mudflat restoration is to create habitat that functions similar to natural mudflat ecosystems in the larger lagoon complex. Invertebrate communities, fish communities, and bird use of the new site should be similar to natural mudflats just north of the area. In addition, the baseline monitoring was designed to create both mud and sandflat on the restored tidelands. Although the surrounding areas are muddy, sandy flats were more extensive nearby and once harbored dense populations of large gaper and butter clams, which are now rare throughout the lagoon. The tidal channels created at the edge of the mudflats are essentially an extension of the mudflats, and unless otherwise noted, are treated the same.

3.1.1 Success Criteria

Benthic invertebrate communities are emphasized as the success criteria because they are the best indicator of a healthy and restored mudflat habitat. Success criteria for the benthos were developed from sampling natural mudflat and channel communities and habitats just north of the mitigation site. Success criteria are based on species composition and density of key invertebrate species. We expect a similar species composition and density of important populations to develop within 1-2 years.

Specific success criteria are as follows:

Initial:

The most critical component of the restoration is to get the initial elevation of the mud benches at the proper elevation. The elevation must be within ± 1 foot of -1 ft MLLW. This elevation will allow appropriate invertebrates to colonize. Fine sand will be spread over part of the tideflat to stimulate the recovery of large clam communities.

Spring 1994:

Benthic colonization in the short term is dependent on the timing of construction. Since many benthic invertebrates are episodic spawners, colonization will be influenced by the availability of larvae or benthic young.

including opportunistic and non-opportunistic species, such as the clam *Macoma*, the polychaetes *Streblospio* and *Exogone*, and the crustaceans *Ampelisca* and *Corophium*. After two years there should be normal bird foraging on the mudflats. If proper settlement and survival has not taken place after two years, and the sediment bioassays indicate no problem with sediment toxicity, then the problem is probably related to water circulation patterns and/or water quality.

3.1.2. Remediation

It is unlikely that recolonization of the mudflats will not occur as predicted, provided that the sediment does not contain toxicants. The natural Bolinas Lagoon fauna is very resilient. Although we expect no problems requiring remediation, remediation for possible problems are briefly outlined below as a framework for proceeding if an unlikely event occurs.

Initial: If the mudflat is not at the proper elevation, the only remediation is to re-contour it to the proper elevation.

Spring 1994: If colonization has not taken place, the mudflat restoration areas must first be re-surveyed to determine if there has been a change in elevation. If there has been substantial erosion or sedimentation, it is probably the result of larger-scale circulation patterns. A decision will need to be made about the desirability of re-grading of the restoration area, possibly combined with some manipulations of the circulation patterns in the south end of Bolinas Lagoon.

The restored channels are unlikely to fill with more sediment than adjacent natural channels. This entire mitigation area is probably influenced by the same general patterns of current flow and sedimentation within the lagoon. If the new channels filled at abnormally high rates, the cause could be traced and the channel configuration changed to increase flushing or even dragged to remove excess sediments.

Sediment bioassays should be performed to test for sediment toxicity. These bioassays should include sediment collected from the restoration area, along with control and reference sediments from uncontaminated areas. We

made on successive days and at different tidal heights. Surveys have also been extended to other parts of the lagoon to make the final assessment of success tie into a much broader baseline of bird use patterns.

3.2.1 Success Criteria

Because of the high natural variation in bird numbers and because of the relatively low use of the north tideflats, no specific or quantitative success criteria are recommended for birds. The benthic invertebrates are still the best indicators of success. However, the bird data and observations will be used to fit the restored site into the larger lagoon ecosystem. The bird use of the new flats should fall within this variation- which again is quite large in both time and space. With the addition of a sand substrate on the site, we expect greater variation in the benthic communities and perhaps more birds will be attracted to the area as a result of the difference in prey communities in the adjacent sands and muds. Like the fish, the most important bird data is species composition. We expect the same group of common species using the north flat to use the restoration areas.

3.2.2 Remediation

If remediation is needed for shorebirds, it would be similar to the alternatives discussed in the last section on benthos. The primary evaluation of mudflat success is with the invertebrate communities. If they are not present, the birds may not be present as well.

3.3 Fish

Fish are only sampled twice each year primarily to document species composition. Although at each sampling the relative abundances and sizes of fishes are also measured, they vary so much within the year that a much more frequent sampling program is needed to document these patterns. Since fish also move on and off the tideflats and primarily eat the benthic animals here, they are not a primary target for monitoring or determining the restoration success. Nevertheless, it is important to document the common species present

3.4.1 Success Criteria

Species composition and cover of the five key marsh species will be used as the main success criteria. The criteria were developed from sampling natural marsh communities and habitats just north and south of the mitigation site. The key marsh species include cordgrass, pickleweed, alkali heath, fleshy jaumea and saltgrass.

Fall 1994:

After one year, the main success criteria will be the lack of undesirable exotics. Exotics should be controlled by removal (see remediation). One year is a little premature to expect complete recolonization of the natives. However, all species except cordgrass should be present in the wetland fringe at low densities. If no plant species are present, a selective replanting program should be instituted (see remediation).

Cordgrass does not colonize well from seeds but spreads easily from plugs. Others species will colonize from seeds which easily disperse throughout the entire system, or from the upland borders along the road.

Fall 1995

After two years, the five species should be present and cover should be at least 25% of that found in the control areas. If this cover has not been reached, the best strategy is to give the plants more time. Since this narrow fringe is not a large or important part of the restoration, which is primarily mudflat, we do not recommend restoration planting here, even after two years. One possible exception is that the narrow marsh slope is being eroded by waves and more rapid plant establishment might reduce the erosion. The lack of plant colonization and erosion of the marsh slope are unlikely events, but considered in remediation.

upland species are immediately local. However, seeds or cuttings of some species may not be readily available, e.g. bunch grasses. This material would be best obtained from Larner seeds, a high quality native plant nursery in Bolinas which gathers local seeds and can contract grow specified material.

Along much of the east and west sides of the road restoration will require eradicating non-native, invasive pest plant species, particularly French broom, but also ice plant and annual grasses. Eradication will need to be in stages: removal of large biomass, followed by poisoning or weeding the ensuing recruitment, and perhaps third and fourth steps of dealing with the residual seed bank and/or vegetative remnants which can start reinvasion. The latter two steps need to be applied in concert with planting the desirable species. Removal and control of pest species is necessary to prevent reinvasion which could jeopardize newly established native species. In some cases watering may be required through the dry season of the first year and perhaps occasionally through the second dry season.

3.5.1 Success Criteria

The major success criteria for upland habitat is the lack of dominance by non-native plants. The native species introduced to the site should dominate. The final species composition and cover patterns of the natives can develop into a number of different plant assemblages. Although the general species composition is likely to be similar, the final relative abundance patterns can take on many forms. All are likely to be desirable as long as non-natives do not dominate. The restored plant community will be a mix of native grasses and shrubs.

3.5.2 Remediation

The upland border is the most likely area to be subject to remediation. Planting and establishing native species along the roadsides is cost-effective in the long-run because of their low maintenance requirements, however, initial establishment requires particular effort. Caltrans has done an outstanding job of revegetating the east side of the Lone Tree slide with native plants. The

related to the restoration monitoring and success evaluation, but is being done by our group because of wider interests in the history of the lagoon at no cost to the program. A marine lab graduate student is designing his masters thesis work around these broader ecological questions, adding perhaps an additional 25-30% more effort to the monitoring program at no cost.