MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TECHNICAL MEMORANDUM 05-01

SURFACE WATER DYNAMICS AT THE CARMEL RIVER LAGOON WATER YEARS 1991 THROUGH 2005

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INTRODUCTION

The Monterey Peninsula Water Management District (MPWMD or District) is a special district created by the California legislature in 1977 and ratified by voters in 1978. Its mission is to "manage, augment and protect water resources for the benefit of the community and environment" of the greater Monterey Peninsula area. The District is responsible for regional water supply planning within a 170-square mile area including the Monterey Peninsula and Carmel Valley **(FIGURE 1)**. The Monterey Peninsula relies entirely on local water resources to meet its water supply needs, primarily surface and ground water from the Carmel River Basin.

In November 1990, the District Board certified the Water Allocation Program Final Environmental Impact Report (EIR) that analyzed the effects of five levels of annual Cal-Am water production ranging from 16,744 acre-feet per annum (AFA) to 20,500 AFA. In addition, the District Board passed a resolution that set 16,744 AFA as the new water allocation limit for Cal-Am Production. Findings adopted by the Board determined that even at the lowest annual production limit analyzed, significant, adverse environmental impacts would occur and must be mitigated for. Thus, the Board adopted a Five-Year Mitigation Program which included biological and hydrological monitoring along the Carmel River and Lagoon. In 1996, the Board voted to continue the District's Five-Year Mitigation Program indefinitely.

This memorandum expands on a previous District report titled: *Surface Water Dynamics at the Carmel River Lagoon, Water Years 1991-1994* (District Technical Memorandum [TM] 94-05) which summarized the District's understanding of the surface water dynamics at the Carmel River Lagoon at that time. Significant, additional data have been collected since TM 94-05 was prepared and the aim of this updated TM is to refine relationships between the lagoon level, river inflow, ocean forces and outflow through the beach berm at the river mouth. This updated TM utilizes available field observations coupled with continuous lagoon level, tidal, buoy and streamflow data for the Water Year (WY) 1991 through 2005 period (i.e., October 1, 1990 through September 30, 2005). These data and observations provide the framework to analyze how the lagoon responds, in terms of size and shape, to various inflows, outflow channel configurations and ocean forces. Issues related to lagoon habitat, water quality, flora and fauna, and sedimentation are not addressed in this technical memorandum. The outline of the discussion section of this report follows the general seasonal progression of the key lagoon, river and ocean processes beginning in the fall.

OBJECTIVE

The overall objective of this technical memorandum is to update and expand on TM 94-05 utilizing new available data. The specific objectives consistent with TM 94-05 are two fold:

- Identify and discuss basic hydrologic and oceanographic processes that occur at the Carmel River Lagoon, and

- Develop basic relationships between lagoon levels, river inflows, ocean forces and outflows through the beach berm at the Carmel River mouth.

The findings presented in this TM are based on selected data from Water Years 1991-2005, and are subject to revision as additional data become available to the District.

SETTING

The Carmel River Lagoon is located at the outlet of the Carmel River, which drains a 255-square mile watershed in the Santa Lucia Range **(FIGURE 1)**. In the upper watershed, the river and its tributaries flow in deep, steep-sided canyons. For its last 15 miles, the river flows across the relatively flat Carmel Valley floor to the Pacific Ocean. The lagoon area and associated wetlands, which are located immediately south of the city of Carmel-by-the-Sea in Monterey County, cover an area of approximately 100 acres **(FIGURE 2)**. The lagoon is a valuable aesthetic and recreational resource to residents and tourists, and provides rich habitat for juvenile steelhead, birds and other wildlife. Most of the lagoon and wetlands area are within the Carmel River Lagoon and Wetlands Natural Preserve which is part of the Carmel River State Beach.

Lagoon morphology (i.e., areal extent, level and form) is strongly influenced by the Carmel River and the Pacific Ocean. In years when fall or winter rains produce sufficient runoff, the Carmel River will advance toward the lagoon and begin to fill it. At this time, the Monterey County Public

Works Department (MCPWD), under contract with the Monterey County Water Resources Agency (MCWRA), will typically use bulldozers to artificially breach the sand bar at the lagoon mouth to avoid flooding residences that are located immediately north of the wetlands. Following this initial, artificial breaching, the beach berm generally remains open and the river flows to the ocean through the winter and early spring. During this period, the lagoon closes and opens (either naturally or by artificial breaching) multiple times depending on variable ocean and river conditions. As inflows recede in spring or summer, the river mouth eventually closes for the remainder of the season until the next significant rainy period repeats the process.

Two major lagoon excavation projects that increased lagoon volume were completed in 1997 and 2004. The 1997 excavation was a Cal-Trans mitigation bank project that included levee removal along portions of the southern bank of the Carmel River near Highway 1, grading downstream of Highway 1, and excavation of the South Arm of the lagoon. Preliminary earthwork estimates (Cal-Trans, 1996) proposed that approximately 25 acre-feet (AF) would be excavated and removed from the South Arm vicinity. As-built drawings that quantify the actual excavation volume are unavailable, therefore, it is uncertain how much additional lagoon volume was created. In 2004, California State Parks implemented the Carmel River Lagoon Enhancement Project that involved excavation of new lagoon, marsh and riparian habitats. This project extended the existing South Arm approximately 3,000 feet eastward to Highway 1. As-built drawings indicate that at the five-foot level (National Geodetic Vertical Datum of 1929 or NGVD), lagoon volume was doubled from 30 AF (based on 1994 volume estimate), to 62 AF, with a total volume gain of 89 AF at the 10-foot level (Dettman, 2005).

PREVIOUS INVESTIGATIONS

Three previous investigations involving the surface water dynamics of the Carmel River Lagoon were conducted by D.W. Kelley & Associates (August 1984), Philip Williams & Associates Ltd. (December 1991), and the District (May 1994). Although not listed, it should be noted that numerous other lagoon reports exist dealing with lagoon water quality, geology, ecology, etc. This report does not list all previous investigations, as only reports specific to surface water dynamics are cited below. Discussion of relationships between river inflow and lagoon level and outflow are limited in both the D.W. Kelly and P. Williams reports. The District's technical memorandum TM 94-05 on Lagoon Surface Water Dynamics was the first attempt to use continuous lagoon level, river inflow and ocean tidal data to develop a basic understanding of the various factors that affect lagoon level, volume and shape.

<u>D.W. Kelley & Associates</u>

Between November 1981 and November 1982, D.W. Kelley & Associates conducted numerous observations at the lagoon and reached the following conclusions that are relevant to this technical memorandum:

- Lagoon inflow and outflow of about 75 cubic feet per second (cfs) is adequate for adult migration into the lagoon. During the winter, flows less than 75 cfs present an increased risk that the sandbar will build up and block the outflow channel leading from the lagoon to the ocean. The precise flow below 75 cfs that results in blockage of the channel is dependent upon swell, tide, wind waves, and the amount of sand moving into and through the lagoon.

- In 1982, storms producing mean daily flows of about 200 cfs were adequate for breaching the sandbar.

- In 1982, outflows of 20 cfs were adequate for smolt migration. At 20 cfs, there was a narrow channel connecting the main body of the lagoon with the ocean.

<u>Phillip Williams & Associates</u>
The conclusions reached in the report prepared by Philip Williams & Associates, *Draft Lagoon Enhancement Plan*, regarding the lagoon hydrology are more general in nature and the reader is referred to the Lagoon Hydrology section of the *Draft Lagoon Enhancement Plan* for this discussion. As noted in the *Draft Lagoon Enhancement Plan*, observations of the response of lagoon morphology to short-term changes in streamflow were limited by the lack of river inflow to the lagoon during the study period.

<u>MPWMD Technical Memorandum 94-05</u>
The main conclusions stated in District Technical Memorandum 94-05 include:

- Ocean swells in the fall and winter can overtop the beach berm and fill the lagoon up to a maximum of about eight feet (NGVD).

- A water-year-to-date total (beginning October 1) of approximately 10 inches of rain at San Clemente Dam are required to advance the river to the lagoon.

- Lagoon inflow rates of 200 and 100 cfs will maintain an open lagoon mouth 100 percent of the time, and 90 percent of the time, respectively. Intermittent lagoon mouth closures can occur below 100 cfs. Below 10 cfs, the lagoon mouth is normally closed.

- Once the lagoon is closed for the season, dynamic equilibrium between lagoon inflow, evapotranspiration, and seepage exists at approximately eight cfs.

AVAILABLE DATA AND METHODS

Lagoon Level In November 1987, the District installed a continuous water level recorder that utilized pressure transducer technology at the Carmel Area Wastewater District (CAWD) effluent pipeline in the South Arm of the lagoon **(TABLE D-1)**. The value of data collected during the first several years of this effort is limited because a consistent gage datum was not established and inflows to the lagoon during Water Years 1987 through 1990 were minimal. In addition, the 1987-1990 records are discontinuous due to periodic equipment failures.

The District engaged in a more rigorous effort to upgrade and maintain the lagoon stage during WY 1992 as survey levels were run from the brass tablet located at the cross atop the knoll on the south side of the river mouth (elevation 59.34 feet NGVD) to the gage, a staff gage was installed, and a regular monthly maintenance routine was developed. Despite improved gage maintenance efforts, a significant period of lost data occurred between February 19 and May 8, 1992, during which time the river mouth closed and the lagoon filled, inundating the data recorder. Because periods of lost data occurred in WY 1991 and 1992, this report focuses primarily on the complete record of water levels obtained for the 1993-2005 period. Water levels were recorded every 30 minutes during WY 1993 and every 15 minutes from WY 1994 to the present. All Lagoon level data used in this TM are referenced to NGVD.

Lagoon level data are normally retrieved from the recorder on a monthly basis, and processed with computer-based software at the District office. Recorded data are compared, and adjusted if necessary, to staff gage readings obtained at the recorder site as verification. The data are then plotted using spreadsheet/graphics software, and assessed.

Lagoon Volume Between September and December 1994, MPWMD staff conducted a topographic survey of the Carmel River Lagoon to develop a topographic map and estimate of the lagoon volume. MPWMD staff obtained approximately 1,100 data points using a total station surveying instrument. The data are horizontally referenced to the California Coordinate System, Zone 4, and vertically referenced to NGVD based on existing monuments in the vicinity of the lagoon. MPWMD retained Graham Matthews & Associates (Matthews, 1997) to provide assistance in developing a topographic map of the lagoon from these field data, and to develop stage-volume and stage-area relationships from this map **(TABLES 1 and 2)**.

Streamflow Streamflow data used to evaluate lagoon surface water dynamics have been collected at the Carmel River at Highway 1 Bridge (HWY 1) streamflow gaging station at river mile 1.1, which is operated by the District. Records at the HWY 1 station are available from October 1992 to the present.

The District collects and processes streamflow data in a manner that is consistent with USGS methods. Instantaneous discharge measurements are collected by the current meter method a minimum of once per month if flow is present. Staff gage readings are obtained to verify recorded stage values. The District utilizes a pressure transducer/data recorder system to measure and record stream stage at the HWY 1 site. Stage data collected at the site are related to a station rating table or stage discharge relation, and mean daily streamflow values are computed and used in this report to approximate lagoon inflow.

Ocean Tides Tidal data used to analyze lagoon level patterns are either taken from predicted tide table readings at Monterey Bay supplied by the National Oceanic and Atmospheric Administration (NOAA), or verified observed tides at Monterey Harbor provided by the NOAA – National Water Level Observation Network (NWLON). NOAA and National Ocean Survey (NOS) tide prediction tables indicate that the tide arrival difference between Monterey Harbor and Carmel Cove (at the lagoon) is less than 5-minutes which is considered negligible for the purposes of this report. It should be noted that tidal data utilized in this TM are referenced to mean-lower-low-water (MLLW), which is the average height of the lower of the daily low tides. At Monterey Bay, a tide level of 2.59 feet equals zero NGVD (National Geodetic Survey, 2005). This is because NGVD of 1929 was originally determined from mean sea levels at 25 stations in the United States and Canada (Atwater et al, 1979). It should be noted that TM 94-05 erroneously stated that tidal datum and NGVD were in close agreement, which is not correct. Refer to **TABLE 3** for further clarification of the MLLW/NGVD relationship.

Buoy Data Buoy data used to define incoming swell height at the lagoon are obtained from NOAA's National Data Buoy Center, Monterey Bay Buoy 46042, located 27 nautical miles west of Monterey Bay. Swell heights in this report are Significant Wave Heights (WVHT) which are calculated as the average of the highest one-third of all of the wave heights during a 20-minute sampling period. Wave heights given in meters have been converted to feet in this report for consistency.

Observations District staff, over the past several years, have documented numerous observations at the lagoon including staff gage readings, lagoon mouth characteristics (e.g., open or closed), outflow channel configuration, surf size, tides, outflows, etc. These observations are an important supplement to the recorded data.

DISCUSSION

SEAWATER INFLOW

General

The summer and fall seasons are relatively static periods at the lagoon, with the exception of occasional filling by ocean waves. As river inflow to the lagoon ceases in late spring or summer, the lagoon mouth closes and the water level gradually recedes until its level has equilibrated with the local water table. Although southerly swells during the summer can occasionally overtop the beach berm and flow into the lagoon, it is the fall and winter seasons when significant west and northwest swells generated by storms over the North Pacific Ocean reach the California coast. These swells, when accompanied by spring tides which occur at full and new moon cycles, will begin to fill the lagoon with seawater. The effects of seawater inflow (also referred to as wave in-wash) to the lagoon are most pronounced in the fall because the initial lagoon level is low and the mouth is closed, resulting in a dramatic increase in lagoon level with no outlet for the seawater to escape. Following the event, the increased lagoon level which has been raised above the local water table, slowly recedes as it recharges local alluvium, seeps through the beach, or evapotranspires.

Coastal Flood Index (CFI)

This memorandum includes an evaluation of seawater inflow using a Coastal Flood Index (CFI) developed by a team of forecasters and managers at the National Weather Service Office (NWSO) in Portland, Oregon. Its purpose is to provide forecasters an operational tool to assess coastal flooding potential and magnitude on oceanic coasts due to high surf and tides. The CFI assumes constant physical beach characteristics (i.e., geographic orientation and beach face slope) and utilizes readily available forecast variables of wave height, wave period, and tide levels to generate a CFI. In addition, computed CFI values included in this memorandum do not account for variations in swell direction which affect wave height at the lagoon beach face. For a given swell height, waves from the west are amplified due to refraction, while waves from the northwest are diminished due to sheltering by the headlands located northwest of the lagoon (Thornton, 2005). Although the CFI units are in feet, it should be viewed as being a unitless, comparative index rather than an absolute measure of the vertical rise on the seawater up the beach (Elson, 2001). A computer program *Surf* (Elson, 2001) that quickly computes a CFI was obtained from the NWSO in Portland. The inputs include wave height and period (Monterey Bay Buoy 46042 was used for this analysis), and observed tide at the Monterey Bay Harbor. **TABLE 4** shows a range of computed CFI values based on various swell and tide combinations. In many cases, due to the comparative magnitude of tides with respect to other variables used in the CFI, tides play a dominant role in the CFI (Elson, 2001).

Fall Events – Lagoon Mouth Closed

In the fall when the lagoon mouth is closed to the ocean, lagoon water level hydrographs indicate that some degree of lagoon filling by ocean waves overtopping the beach berm occurs each year. Long period (wave interval of 17 seconds or greater) ocean swell heights as low as 10 to 12 feet have the potential to significantly fill the lagoon with seawater. Additional factors that influence these seawater inflow events include tidal cycles during the swell, swell direction and beach berm morphology (height and width). **FIGURE 3** shows two similar seawater inflow events that occurred in late September 1995 and September 1997 from long period swells in the 10 to 14 feet range, and a higher high tide of about five feet **(FIGURE 4)**. These September events contributed 120 AF and 130 AF of seawater respectively, to the lagoon over a one-day period, based on the 1994 MPWMD lagoon stage/volume relationship **(TABLES 1 & 2)**. Computed CFI values for these two September events ranged from 11 to 13.

Major seawater inflow events that cause the lagoon level to rise greater than three feet in a 24-hour period have occurred four times in past the 14 years (period of recorded data), or about a three-year return interval on average. The high westerly ocean swells on November 8, 2002 (8NOV) caused the greatest ocean input as lagoon water levels increased from approximately 5 to 9 feet (an estimated 170 AF) in about one day. On 8NOV, swell heights peaked at 28 feet at a 20-second interval (CFI 16), but arrived at the lower high tide (4.49 feet observed tide) early on 8NOV **(FIGURE 5).** Had these swells arrived 12-hours later at the higher high tide (6.71 feet observed tide), it is likely additional seawater inflow would have occurred. On January 11, 2001 (11JAN), high swells of 26 feet did arrive at the higher high tide, accompanied by strong onshore winds and low barometric pressure.

The 11JAN seawater inflow event warrants additional discussion of lagoon, ocean and river conditions as the lagoon reached its highest level of 12-feet NGVD during the period of record **(FIGURE 6)**. Swells were 26 feet at 17 seconds, and coincided with the higher high tide observed at 7.16 feet. It should be noted that the observed higher high tide the previous day of 7.38 feet was the fifth highest tide on record at Monterey Bay Harbor (records begin in 1983). The CFI for this event computes to 17, or the highest CFI found in the 1991 – 2005 data set. Several homes in the Mission Tract along the northern margin of the lagoon and wetlands flooded at the high tide as the ocean inflow was so severe that it was not safe to bulldoze the mouth open at that time. It should be noted that artificial breaches at high tide tend to be ineffective at draining the lagoon due to the lack of lagoon-ocean gradient. Later on 11JAN at the minus tide, bulldozers breached and drained the lagoon, ending the flood risk.

Analysis of the 11JAN event **(FIGURE 7)** suggests that as little as 120 AF of seawater entered the lagoon in less that 6 hours. The 120 AF of seawater inflow is an approximation as the existing lagoon stage/volume curve was extrapolated beyond the 10-foot limit in order to estimate inflow. Curve extrapolation resulted in a lagoon volume of 540 AF at the 12-foot elevation (Dettman, 2001). **FIGURE 7** shows that the lagoon level was about 10.4 feet when waves began to overtop the beach berm. By elevation 11.8 feet the tide began to drop, and the river provided the additional 0.2 foot rise until the breach was accomplished.

There exists some debate whether the 11JAN lagoon flood could have been prevented by breaching the lagoon at the minus tide the previous day. Had the high surf and tide arrived with a lagoon elevation of six or seven feet (instead of 10.4 feet), lagoon volume data indicate that sufficient buffer capacity would have been available to keep levels from topping the 10 foot level. The largest unknown would be the dynamics of the beach berm and outflow channel following a hypothetical breach on January 10, 2001. Perhaps the outflow channel would have created an "avenue" for wave in-wash, or conversely, the presence of an outflow channel could have provided an outlet for lagoon high water. Lagoon hydrographs over the past 14 years indicate that with an open lagoon mouth, high surf in the 20-25 feet range has not resulted in a lagoon level greater than about 10 feet.

Not all high surf events result in waves overtopping the beach berm. According to Stormsurf.com – Pacific Big Wave Events summary, the Swell of November 21, 2001 was the largest swell on record. Significant wave height at the Monterey Bay buoy peaked between 22 and 25 feet. However, the lagoon level remained just above the six-foot level throughout the event, indicating that no significant wave in-wash occurred **(FIGURE 8)**. It is believed that the relatively minor observed higher high tide of 4.36 feet (neap tide phase) that accompanied the swell was not high enough to favor wave in-wash. At peak high tide and swell, waves would likely break and lose energy farther offshore than would be the case with a spring tide (six-foot plus tide), thus reducing wave run-up over the beach berm. Futhermore, the CFI for this event only computed to a 13, indicating the dominant role of tides in CFI computation. Additional potential factors that explain the absence of wave in-wash likely include beach berm height and the swell direction which was 290 degrees.

Winter Events – Lagoon Mouth Open

Once the initial seasonal lagoon breach has occurred, usually in December or January, periodic high long period swells continue. However, their effect on lagoon levels are much different than in the fall, as the river maintains an outflow channel. It is beyond the scope of this report to thoroughly analyze the effects of each large ocean swell and its effect on lagoon level. In general, depending on river flow, the lagoon level will "spike" at the arrival of high swell and the higher high tide, then recede. This "spike" as seen in recent lagoon hydrographs on February 26, 2004 (26 feet at 17 seconds, CFI 15), and on March 9, 2005 (15 feet at 20 seconds, CFI 14) results from a combination of seawater inflow and a backwater effect on the river and lagoon at the ocean/outflow channel interface **(FIGURES A-67 and A-73)**. These were arguably the two largest swells of the past two years. Peak lagoon level on both of these events was about 10 feet, followed by a rapid recession. It should be noted that the swell of March 9, 2005 produced documented 50-60 foot breakers (wave face height) at Pescadero Point located 2.5 miles northwest of the lagoon. This is a good example of size enhancing ocean bathymetry and its interaction with a long period swell.

Another notable high surf event **(FIGURE 9)** which made local press (The Herald, 1/23/1995) occurred on January 22, 1995, when waves washed over the beach berm, and deposited significant sand, logs and driftwood into the lagoon parking lot. The January 11, 2001 event is the only other known instance when waves washed into (and through) the parking lot. Buoy readings at the time of the afternoon observed high tide of 4.41 feet were 24-feet at 20 seconds (CFI 15). Two additional factors that augmented the effects of these high swells were a relatively rare swell direction of 260 degrees (low west swell), and strong onshore winds (reported 40 mile per hour wind gusts in the Big Sur area). Ocean swells of this magnitude are not that uncommon, however, coastal flooding of the lagoon parking lot has been known to occur only twice in the past 15 years. In addition, the high tide during the event was relatively benign. It is speculated that the swell direction of 260 degrees was "well aimed" at the Carmel River mouth due to the geographic orientation of the local coastline, resulting in amplification of breaker height and associated wave run-up at the beach face. Cursory review of the numerous large ocean swells that have reached the lagoon area, indicate that swell directions of 280 to 300 degrees are more typical. It should be noted that, beach berm morphology (unknown) may have been a contributing factor as well.

Critical Values of CFI

Qualitative review of available lagoon, buoy and tidal data suggest that CFI values of 11 to 13 are sufficient to produce significant wave in-wash to the lagoon, but are not associated with property damage. CFI values of 14 to 15 have occasionally resulted in major wave in-wash, moderate coastal flooding, beach erosion, and property damage. Only two high swell events in the 14 years of data were found to compute as 16 or 17. These events occurred on November 8, 2002 (16), and January 11, 2001 (17). The 11/8/02 event, which occurred with a closed lagoon mouth, raised the lagoon level from five to nine feet and added an estimated 170 AF of seawater to the lagoon. Had the 11/8/02 swell coincided with the higher high tide of 6.7 feet (which it did not), the CFI would have computed as an unprecedented 19. The 1/11/01 event had the highest CFI found at 17 and, accordingly, it produced the highest lagoon level in the available data set. Given the limited information above, it appears that predicted CFI values in the 14 to 17 range, have the potential to cause some degree of flooding, beach erosion and property damage at the lagoon. In addition, swells from the west are more likely to cause beach erosion and wash into the lagoon, than swells from the northwest.

RAINFALL AND INITIAL LAGOON OPENING

General

At the lagoon, the late fall/early winter period is characterized by occasional large ocean swells overtopping the beach berm and, in years with normal rainfall and runoff, it is the time of year when Carmel River streamflow reaches the lagoon. In general, a river inflow of 10 cfs or greater will begin to fill the lagoon when it is closed to the ocean. Because the lagoon at the 10-foot level holds only about 300 AF **(TABLE 1)**, even a moderate inflow of 150 cfs is sufficient to fill the lagoon in one day. In some years such as December 1995 **(FIGURE A-18 and TABLE C-4)**, the river reaches the lagoon as a relatively low flow (25 cfs or less) that slowly fills the lagoon. This "slow filling" scenario provides public officials ample time to monitor and assess lagoon flood risk. In other years such as January 1995 **(FIGURE A-14 and TABLE C-3)**, the river reaches the lagoon as a flood flow, and officials must act much more quickly. An example of this would be the January 10, 1995 event, when the lagoon inflow of 25 cfs increased to 10,000 cfs in 12 hours. In anticipation of this flood wave, county officials breached the lagoon the previous day.

Antecedent Rainfall

The amount of rainfall that is necessary to advance the wetted front of the Carmel River to the lagoon depends on the intensity and temporal distribution of the rainfall, antecedent soil moisture conditions, and ground water storage in the Carmel Valley Alluvial Aquifer. It should be noted that, during the drought period between April 1987 and March 1991, no Carmel River inflow to the lagoon occurred. Rainfall at San Clemente Dam for this four-year period was about 60 percent of normal. In contrast, rainfall over the past fifteen water years, 1991 through 2005, has been about 110 percent of average and streamflow has reached the lagoon and ocean each year. **TABLE 5**, which summarizes rainfall and Lower Carmel Valley (LCV) ground water storage data for Water Years 1991-2005, shows how much rainfall was recorded at San Clemente Dam before the lagoon was breached and the river flowed to the ocean. **TABLE 5** indicates that about eight inches of rainfall are required at San Clemente Dam (SCD) before the Carmel River will reach the lagoon forcing an artificial breach. It should be noted that WY 1998 was the only year during the WY 1991 – 2005 period that the inflow to the lagoon never ceased. By October 1998, a steady inflow of 10 cfs was already filling the lagoon, and by November, 3, 1998 the lagoon was breached at the 10-foot level **(FIGURE A-35 & TABLE C-7)**, with only 0.42 inches of rainfall accumulation for WY 1999. Following WY 1995, the second wettest year during the WY 1991 – 2005 period, and the second highest Lower Carmel Valley Aquifer storage, only 3.26 inches of rain had fallen prior to the initial lagoon opening.

Breaching Practice

Once flow in the Carmel River reaches the lagoon, the level begins to rise and artificial breaching of the lagoon becomes necessary to prevent flooding of local roads, private property and homes. Initial lagoon breachings are typically performed by the Monterey County Public Works Department, who begin to mobilize for a river mouth breaching when the water level in the Carmel River Lagoon reaches an elevation of 7.5 feet NGVD[1]. Actual excavation of the sand berm begins when the water level in the lagoon reaches an elevation of 8.78 feet. With high initial lagoon inflows (>500 cfs) similar to what occurred in January 2000, breaching normally occurs the same day the flow arrives **(FIGURE A-42 and TABLE C-8)**. With low initial inflows (< 50 cfs), the lagoon is allowed to fill, sometimes for days, before it is breached (e.g., December 1995). Over the past 14 years, the average and median initial breach levels have been 9.93 and 9.82 feet, respectively. It is interesting to note that the maximum lagoon level on the initial opening date was less than 10 feet for all years during the 1992 – 1998 period (9.06' average), and greater than 10 feet for the 1999 – 2005 period (10.8' average). This apparent change in artificial breaching practice is likely related to the Federal listing of the Carmel River Steelhead as a threatened species in 1997, and the associated, increased involvement of environmental resource agencies (i.e., NOAA Fisheries, CDFG). Inherent to the complexity of lagoon breaching tactics is the fact that each year is different requiring public officials to adapt to variable rainfall, river and ocean conditions, while considering species protection mandates.

Lagoon outflows associated with breachings are slow at first and become more rapid as the beach berm quickly scours. Once this scouring has occurred, a large portion of the lagoon volume is released to the ocean in a few hours with instantaneous flow rates as high as 10,000 cfs (Dettman, 2001). It should be noted that following a breaching event, the minimum lagoon level is between 2.5 – 3.0 feet NGVD. There exists some uncertainty at to why the lagoon level generally does not drop below 2.5 feet. Due to the relationship between tidal datum and NGVD **(TABLE 3)**, the approximate minimum 2.5 foot lagoon level equates to a 5-foot high tide, which rules out the ocean as the controlling factor, as ocean tides drop much lower than five feet. The simplest and perhaps the best explanation is the fact that the lagoon body at this low level is reduced to a mere stream channel flowing past the South Arm of the lagoon (where the lagoon gaging station is located) and out to the ocean. Any beach berm scour at the river/ocean interface under this low level condition is too far down gradient to affect water levels recorded at the lagoon gage. In other words, the presence of streamflow past the South Arm prevents recorded lagoon levels at the South Arm from dropping below 2.5 feet (open lagoon).

This theory is supported by a June 16, 2005 MPWMD survey at three of the four established lagoon cross sections **(FIGURE 2)**, conducted under conditions where the lagoon body was defined by a shallow braided river channel flowing through the lagoon and out to the ocean. The lagoon gage read 3.30 feet during the survey which was fairly consistent with a surveyed water level of 3.40 feet

[1]Interim Plan and Criteria for Emergency Breaching of the Carmel River Mouth, dated September 1, 1992, by Monterey County Public Works.

at cross section 3 (XS3). At XS1, the surveyed water level was approximately 2.90 feet indicating significant channel gradient as the river flowed through the lagoon. These survey data provide a fairly good explanation of why the lagoon does not drop below 2.5 feet. Discussion in TM 94-05 stated that the minimum lagoon level (of about three feet) represents the elevation of the granitic bedrock at the mouth, which controls minimum lagoon level. However, it is now believed that this is not a likely explanation given the above discussion.

OPEN LAGOON DYNAMICS

General

Once the initial opening of the lagoon occurs, the river mouth remains open 85 percent of the time (13 years of data). In some years like the extremely wet WY 1995, the lagoon mouth was open nearly 100 percent of the time, while during the critically dry year of WY 1994, the lagoon was open only half of the time **(FIGURE 10)**. Ocean energy and river inflow are the two major factors that determine whether the lagoon will stay open or closed. In general, low wintertime river flows favor frequent periodic closures and subsequent breaches (e.g., November 1998) as wave and tidal action are the dominant forces **(FIGURE A-35)**. Inflows greater than 100 cfs maintain an open lagoon nearly all the time as river flows are sufficient to scour out beach sand. If the lagoon does close, it will fill in day or two until it is either breached by crews, or breached naturally as the lagoon level eventually spills over the low point of the beach berm. Recorded data and field observations indicate that lagoon inflow rates greater than 100 cfs will maintain an open lagoon mouth 95 to 100 percent of the time. Inflows of 20 cfs maintain an open lagoon about 50 percent of the time, and the lagoon mouth normally will close at 10 cfs or less **(FIGURE 11)**, even under the most benign surf and tidal conditions. These thresholds supersede findings contained in TM 94-05 as they are based on analysis of 13 years of data, rather than four. Basically, the lagoon remains open a higher percentage of the time than previously thought a decade ago.

Intermittent Lagoon Mouth Closures

In order to understand how often the lagoon mouth is open or closed, continuous lagoon hydrograph data were analyzed to identify each likely closure event of the 1993 - 2005 data set and quantify its duration **(FIGURE 11 and TABLE 6)**. It is beyond the scope of this report to determine the cause of each and every closure event. However, limited analysis reveals two classes of intermittent lagoon mouth closures, these include closures lasting several days, or brief mouth closures lasting less than 24 hours. Lagoon inflow rate, tide, wave energy and outflow channel location and shape are all factors that determine the likelihood and duration of a closure event. As previously mentioned, above 200 cfs, the lagoon mouth essentially does not close. Closures lasting less than 24 hours seem to occur in the 75 – 200 cfs range, at the higher high tide, particularly during the spring tide phase when the highest tides of the month occur. Although high surf increases the likelihood of a closure in this flow range, it is not a requirement as illustrated in **FIGURES 12 and 13** when wave heights were only in the 6 – 10 foot range. These figures provide a good example of the brief closure process. With an open lagoon mouth, higher high tide and wave action back up the lagoon and deposit sand at the mouth of the outflow channel. As the tide turns, this newly deposited sand is perched above the lagoon level, temporarily blocking the outflow channel. Subsequently, in a matter of hours, the river fills the lagoon to the low point of the beach berm resulting in a breach. Note that in **FIGURE 13** the brief closure pattern ends by February 19, 1996 as the highest runoff event of WY 1996 reached the lagoon (peak flow of 4,300 cfs). In fact, a storm hydrograph can be seen embedded in the February 1996 lagoon plot **(FIGURE A-19)** as the river discharge exceeded 1,000 cfs for about five days.

Once lagoon inflow falls into the 25 to 75 cfs range, the lagoon capacity is sufficient to accommodate at least a day or two of filling before a breach occurs naturally or becomes necessary to prevent flooding. At these flows, wave and tidal action overcome river forces causing more frequent mouth closures. An exception, would be during wet years such as 1995 and 1998, when river flows greater than 25 cfs persisted well into the summer. In these years, typical small summer surf was ineffective at closing the mouth until flows dropped to about 10 cfs. The longest intermittent closure on record lasted eight days over the November 11 – 19, 1998 period **(FIGURE A-35)** when river inflow averaged 20 cfs.

T**ABLE 6** provides the numerical analysis of lagoon mouth closures for the 1993 – 2005 period at selected inflow ranges. The table was completed by first identifying closure events in the lagoon hydrographic record. The width of these closure events were measured in centimeters and converted to days at the selected inflow ranges. **FIGURE 10** shows the percentage of time that the lagoon was open to the ocean for the water years indicated and is based on **TABLE 6**. As might be expected, the wetter years such as 1995, 1998 and 2005 maintain an open lagoon a higher percentage of time, while the drier years such as 1994 and 2004 are closed a higher percentage of time.

FIGURE 14 summarizes the total number of identified closure events lasting more than 24-hours for each water year shown. Brief closures lasting less than 24 hours are more difficult to clearly identify and rarely observed because they do not last very long. In addition, the brief closures do not last long enough to generate a high lagoon level and significant breach. Therefore, the main focus regarding closure events are the ones lasting several days usually ending with a significant breach. As stated previously, mouth closures lasting several days are most common in the 10-75 cfs range. This is further supported by **FIGURE 14** that shows WY 1999, 2002, 2003 and 2004 as exhibiting the most closure events. In these four years, 50, 74, 42 and 58 percent of the days, respectively, were between 10 and 75 cfs for the total days the lagoon was open. No other years in the data set show these high percentages of relatively low flow days, except for 1994, as flows that year were short lived (39 days between initial opening and final closure) explaining the low number of closure events. Conversely, during WY 1995 (the one year with no identifiable closures) only 19 percent of the total 202 days the lagoon was open were in the 10-75 cfs range, as high river flows persisted throughout the year and well into the summer maintaining an open lagoon. In conclusion, flows in 10-75 cfs range, particularly in the winter (Dec-Mar) when wave heights are at their highest (NDBC/NOAA, 1987-2001), will often result in closures lasting several days, followed by a breach.

Lagoon Water Levels During Flood Flows

Once the initial lagoon mouth opening has occurred, the lagoon seems to pass flood flows without inundating streets and residences surrounding the lagoon. Clearly, the two highest floods during 1991 – 2005 period were on March 10, 1995 and February 3, 1998 with river peaks of 16,000 cfs and 14,000 cfs, respectively. Lagoon levels topped out at approximately nine feet for both of these events **(FIGURES A-14 and A-31)**. Although, the February 3 peak river flow at the lagoon did not coincide with higher high tide, the river was flowing about 10,000 cfs (and rising) at the observed higher high tide of 6.95 feet. Despite this very high tide and river flow, the lagoon remained below flood level. The March 10, 1995 event reached the ocean during an approximate 5-foot tide, and still did not exceed the nine-foot level, despite the high flow (highest recorded flow on the Carmel River since 1957 when stream gaging began). Given the dynamics of these two major flood events, it is postulated that flood flows maintain a relatively deep and wide outflow channel at the mouth that in these instances maintained the lagoon level below flood level (approximately 10-feet), even at high tide.

Effect of Lagoon Outflow Channel Location on Water Level Patterns

The location of the lagoon outflow channel through the beach berm has a profound effect on lagoon water level fluctuation patterns. In most years (excludes WY 2005), the initial artificial breach by MCPWD has been straight out to the ocean forming a channel that trends approximately due west of the MPWMD Surface Water Quality Site shown in **FIGURE 2.** The initial breach typically results in a large cut through the beach berm which allows the lagoon level when open to fluctuate with ocean tides. Occasionally in late winter or early spring, the lagoon outflow channel will migrate north or south, developing into an elongated channel as long as 1,500 feet with an associated sand spit. Although likely related to swell direction and prevailing ocean currents, the formation process of the elongated outflow channel is uncertain.

An elongated outflow channel at the lagoon has formed in about 50 percent of the years based on available data **(APPENDIX B).** The significance of the elongated channel is that it maintains a relatively high lagoon level of predominantly fresh water, and increases dune erosion potential, particularly in the region between the lagoon parking lot and Stewart's Cove. In at least three of the years that the elongated channel formed to the north including 1993, 1997 and 2005, the MCPWD relocated/reconfigured the outflow channel to prevent undermining of Scenic Road which semi-circles around the north margin of Stewart's Cove. The elongated outflow channel whether it be north or south, tends to flow across bedrock along portions of its length which limits down cutting. Although high tides cause slight fluctuations in lagoon level under this scenario, the lagoon does not drain at the lower low tide as the bedrock channel bottom dictates minimum lagoon level. Essentially, lagoon levels are relatively unaffected by low to medium ocean tides, as the now higher lagoon is perched above the tidal zone. Surface readings of specific conductance (units of micro-siemens [mS]) taken at the MPWMD Surface Water Quality Site **(FIGURE 2)** generally remain below 500mS or fresh water. The elongated arm typically forms in the spring, February being the earliest, after the heaviest of seasonal storms have passed. Water Years 1993 and 2005 would be exceptions, as flows of 2,000 to 3,000 cfs flowed through the elongated arm, but as stated above, artificial channel reconfigurations were necessary in these years.

When the lagoon outflow channel follows a trace immediately north of the knoll, straight out (due west) to the ocean (the path following a typical artificial breach), the lagoon level pattern is characterized by daily upward fluctuations of two to four feet from a base level of 2.5 to 3.0 feet NGVD, in direct response to ocean high tides. It is postulated that these fluctuations should be viewed as more of a backwater effect due to high tide and wave in-wash, rather than a rush of ocean water into the entire lagoon quickly filling it. This is supported by specific conductance (SC) readings at the surface that indicate lagoon water generally less than 1,000mS, still in the fresh water range. Due to the higher density of ocean water compared to fresh water, it should be noted that a salt water lens could exist at the lagoon bottom. In addition, the SC readings are instantaneous readings on a weekly basis, and therefore do not represent all conditions.

It is also important to understand how tidal datum relates to lagoon datum (NGVD), which provides additional support to speculation that ocean water is not rushing into the lagoon at high tide. NGVD29 at Monterey is 2.59 feet above mean-lower-low-water (MLLW or 0.00 reference on a tide chart). Based on this relationship, a spring tide of 6.0 feet (assuming a flat ocean) would equate to a lagoon level of 3.41 feet **(TABLE 3)**. However, lagoon levels commonly reach 6-8 feet during spring tides (**FIGURE A-19** mid March 1996) indicating that either backwater is occurring or significant wave action is entering the lagoon or a combination of these two factors. Conversely, a typical minus tide of -1.0 would equate to a lagoon level of -3.59 feet NGVD, well below the minimum lagoon level. As previously stated the minimum (open mouth) lagoon level of about 2.5 feet (NGVD) is likely controlled by the presence of river flow past the South Arm lagoon gage. Additionally, the above tidal datum/NGVD relationship indicates that even an ocean tide of five feet (MLLW datum) under flat ocean conditions is adequate to maintain a "drained" lagoon level of 2.5 feet (NGVD) under the "straight out" channel pattern. An excellent example of this is the March 15-19, 1995 period when the lagoon level remained around 3 feet or less for several days **(FIGURE A-14)**, despite daily high tides of 5.0 feet. In addition, wave height remained relatively low (< 6 feet), limiting lagoon backwater.

WY 1995 was a year when the lagoon outflow channel and mouth remained "straight out" for the majority of the winter. Although the lagoon was open to the ocean more often than any other year **(FIGURE 10)**, it also drained to the 2.5 foot level on a daily basis, resulting in a lower than average lagoon level **(FIGURE 15)**. **FIGURE 15** is somewhat misleading from an ecological standpoint as two of the driest years 1994 and 2004 had high average lagoon levels. This is due to lower than normal lagoon inflow that resulted in numerous mouth closure/filling events that arithmetically compute to a relatively high lagoon level. **FIGURE 10** supports this as the lagoon mouth was open to the ocean a relatively low percentage of the time in 1994 and 2004. Median lagoon water levels were also determined for each year in **FIGURE 15** and were within 20 percent of the average levels showing a similar trend. In general, when viewing the entire season during which the lagoon mouth is open, there appears to be an inverse relationship between the percentage of time the lagoon mouth is open and average/median lagoon level for the season.

CLOSED LAGOON DYNAMICS

General

With the exception of seawater inflow, the period of time during which the lagoon mouth is closed is relatively uneventful. As river inflow recedes to 10 cfs in the spring or summer, the mouth will close for the remainder of the dry season until the following winter's flow returns. Once the final seasonal closure has occurred at the lagoon, there is a final filling by dwindling surface inflows, followed by a gradual water level decline that reaches a minimum in August or September. By September or October ocean swells often overtop the beach berm and contribute seawater to the lagoon, sometimes in large volumes by extraordinarily large swell and surf. By December or January enough rain has fallen to advance the river to the lagoon. The lagoon begins to fill, and eventually it must be breached, usually resulting in an open lagoon for the remainder of the winter and spring runoff season.

Final Seasonal Closure

The final seasonal closure (FSC) can happen any time when spring flows have dropped below 20 cfs, but is often triggered by a higher than usual tide and/or ocean swell. Once closed, receding spring flows are not sufficient to fill the lagoon to a level that would necessitate a breach, and it remains closed for the rest of the dry season. The exact day of the FSC of the lagoon mouth must be interpreted from lagoon hydrographs, and can be identified with plus or minus one day error. **FIGURE A-26** illustrates a good example of a typical FSC that occurred on May 13, 1997, on which day surface inflow to the lagoon was 17 cfs and receding. This receding inflow initially is high enough to increase water levels in the now closed lagoon, but by the time lagoon has reached seven feet several days later the inflow had dropped to 10 cfs. At this flow level, the lagoon has approached an equilibrium level (discussed in detail below) with respect to net inflow and outflow.

The FSC is significant as it represents the final opportunity to store a pool of fresh water in the lagoon that will sustain various biological resources through the dry season (e.g., Carmel River Steelhead, Red-Legged Frog). A direct relationship exists between lagoon inflow at the time of the FSC, and the maximum level that the lagoon will attain before the water level recedes (**FIGURE 16**). This is not expected to be a good relationship as the recession of lagoon inflow, weather and water table elevation are variable from year-to-year. Based on **FIGURE 16** and ignoring outlying data points for 1991 and 2003, the lagoon would be expected to close during a period of receding spring baseflow between 10 and 20 cfs. In all years except 2003, the lagoon had closed for the season once the river inflow dropped to 10 cfs. It should be noted that two projects that increased lagoon volume were completed in 1997 (South Arm dredging) and 2004 (South Arm extension) that could also have an effect on the relationship shown in **FIGURE 16.**

Lagoon Level Equilibrium

Once the lagoon mouth has closed for the remainder of the dry season, there is a specific surface inflow rate at which the lagoon water surface elevation will remain static. At this flow rate, which is approximately eight cfs, inflow is equally offset by lagoon seepage and evapotranspiration. The eight cfs value was determined by visual inspection of available lagoon level hydrograph data for the 1991 – 2005 period, which are included in **APPENDIX A**. The highest level reached following the FSC represents the equilibrium level which usually remains static for several days, until the water level gradually recedes in response to declining inflows of less than eight cfs. It should be noted that this relationship between lagoon inflow and static level will be affected by various environmental factors including, but not limited to, potential evapotranspiration, lagoon volume, and local water table elevation. Refer to **TABLE 7** for more detailed numerical data on lagoon equilibrium level, FSC, and maximum level attained following the FSC.

Seasonal Low Lagoon Level

Lagoon level equilibrium discussed above is followed by a three to four foot decline in lagoon water level over a one to two month period. The seasonal low during the period the lagoon is closed usually occurs in August or (less often) September and averages about 3.0 feet, with 2.5 feet as the lower limit **(TABLE 7)**. This minimum level cannot be easily explained by the presence of river flow (as it is with an open lagoon), as the river is dry at this time. It is hypothesized that local water table elevation and associated subsurface inflow are the primary factors limiting further decline. Additional factors that may explain this closed lagoon-minimum level phenomenon include daily high tides that seep through the beach berm, or the presence of bedrock at the mouth which may act as a barrier retaining lagoon waters. By September, some degree of wave in-wash occurs at the beach berm, allowing lagoon levels to begin a variable upward trend that lasts until the initial seasonal breach occurs in December or January.

CONCLUSIONS

The Carmel River Lagoon is a dynamic interface influenced by seasonal ocean and river forces that act on the beach berm at the mouth. A wealth of available lagoon level, river flow, ocean tidal and swell data have been analyzed to prepare this memorandum in order to improve the current understanding of the physical processes that occur at the lagoon. Because of the highly variable lagoon environment, and lack of quantitative beach berm data, defined relationships provided in this report should be viewed as general guidelines, not absolutes.

SEAWATER INFLOW As the summertime closed lagoon reaches its seasonal low level in August or September, a several month period of lagoon filling by ocean tides and surf ensues. By the end of September, some wave in-wash is evident in all years during the 1991 – 2005 period. During the fall, about once every three years on average, a significant high surf event and associated waves will overtop the beach berm and cause a sudden three to four foot increase in lagoon level equivalent to 110 to 170 AF of seawater. The high surf, tide and moderate river inflow on January 11, 2001 resulted in the highest recorded lagoon level at 12 feet, high enough to cause flooding of adjacent homes. A coastal flood index (CFI) computer program that uses swell height, swell period and tide, was obtained from the National Weather Service in Portland, Oregon, to analyze various high surf events, particularly events that caused major wave in-wash or a higher than normal levels at the lagoon. In the fall, swell and tide conditions that compute to a CFI value between 11 and 13, were sufficient to cause significant wave in-wash at the lagoon. CFI values of 14 to 15 have occasionally resulted in major wave in-wash, moderate coastal flooding, beach erosion, and property damage.

Only two high swell events in the 14 years of data were found to compute as 16 or 17. On November 8, 2002 (CFI 16), waves overtopped the beach berm at high tide, raised the lagoon level by 4 feet, and contributed an estimated 170 AF of seawater to the lagoon (highest seawater input found in data set). The January 11, 2001 (CFI 17 – highest index found) event resulted in the highest lagoon level at 12 feet. However, it should be noted that the lagoon level was over 10 feet before the high surf actually overtopped the beach berm. Critical CFI values occur in the 14 to 17 range, and have the potential to cause some degree of flooding, beach erosion and property damage at the lagoon, especially if the swell direction is due west.

RAINFALL AND INITIAL LAGOON OPENING Each winter after sufficient rains have fallen, the Carmel River wetted front, usually located about 6 miles upstream in summer and fall, will advance downstream to the lagoon. Initial lagoon inflows of 10 cfs or greater will begin to fill the lagoon. Approximately eight inches of rain at San Clemente Dam (SCD) are required to advance the river front to the lagoon. In 1998, lagoon inflow never ceased and a mere 0.42 inches of rain had fallen at SCD before a lagoon breach became necessary. In general, a rising lagoon level of 10 feet or greater will necessitate an artificial breach as lagoon high water is very close to homes at this level. The initial lagoon opening usually occurs in December or January and is typically performed by the Monterey County Public Works Department (MCPWD) using bulldozers. In recent years, the lagoon has been allowed to fill to a higher level than in the past. Over the 1992 – 1998 period, the average maximum lagoon level reached prior to the initial breach was about 9 feet. Over the 1999 – 2005 period, the maximum lagoon level averaged just less than 11 feet. This is likely related to alternate breaching tactics put forth by state and federal environmental resource agencies in their efforts to carry out threatened species mandates. In addition, these agencies are in direct conflict with MCPWD's public safety goals, as the environmental agencies maintain that an artificial emptying (breach) of the lagoon is harmful to the threatened species that live in and around the lagoon.

OPEN LAGOON DYNAMICS Once the initial lagoon opening has occurred, the river mouth will remain open 85 percent of the time until its final closure. During this period, inflows of 200 cfs, 100 cfs and 20 cfs will maintain an open lagoon 100, 95 and 50 percent of the time, respectively. The lagoon mouth will close given inflows less than 10 cfs. Flows in the 10 – 75 cfs range, particularly in winter (Dec-Mar) when the highest wave heights occur, will often result in periodic closures lasting several days followed by a breach. Accordingly, wet years favor an open lagoon, while dry years such as 1994 and 2004 exhibit relatively more closures. Flood flows, provided the lagoon is already open to the ocean, seem to pass through the lagoon without flooding residences around the surrounding wetland. The two largest floods during this reporting period were on March 10, 1995, and February 3, 1998, with peak flows of 16,000 cfs and 14,000 cfs, respectively. Lagoon level during these two events reached about nine feet. It should be noted that on February 3, 1998, a very high tide of nearly seven feet was present with about 10,000 cfs of lagoon inflow and no flooding occurred around the lagoon. It is postulated that as flood flows pass through the lagoon and beach berm, the dominant river forces maintain a deep and wide outflow channel that prevents lagoon back-up to flood levels. The lagoon outflow channel location has a profound effect on lagoon water level fluctuations. An outflow channel "straight out" (due west of the MPWMD

Surface Water Quality Site in **FIGURE 2**) causes the lagoon to back-up and/or fill at high tide, and drain to the 2.5 or 3.0 foot level at low tide. An elongated outflow channel forms to the north or south in 50 percent of the years, usually in late winter or spring. The elongated channel configuration creates a relatively high lagoon level that does not drain at low tide. A northerly flowing elongated arm has been associated with erosion below Scenic Road, and artificial channel reconfigurations were necessary in 1993, 1997 and 2005. Specific conductance readings at the surface indicate that lagoon waters at the surface remain fresh with both the "straight out" and "elongated" pattern.

CLOSED LAGOON DYNAMICS In the spring or summer, as river inflow to the lagoon recedes to 10 cfs, the mouth will close for the remainder of the season (referred to as the final seasonal closure [FSC]). The FSC can happen any time once receding springtime flows have dropped into the 10 - 20 cfs range. The FSC is followed by a brief rise in lagoon water levels that reach a maximum at which point net inflow equals net outflow. This equilibrium level occurs with a river surface inflow of 8 cfs, as surface and subsurface inflow are in balance with lagoon seepage and evapotranspiration. Lagoon level equilibrium is followed by a three to four foot decline in water level over a one to two month period, depending conditions during a particular year. Eventually, the lagoon reaches its seasonal low, usually in August or (less often) September of around 2.5 – 3.0 feet. By September, some degree of wave in-wash occurs at the beach berm allowing lagoon levels to begin a variable, but upward trend that lasts until the next year's initial seasonal breach occurs, usually in December or January.

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FIGURE 1

Monterey Peninsula Water Management District

Carmel River Basin and Vicinity

Carmel River Watershed Boundary

MPWMD Boundary

FIGURE 2

Monterey Peninsula Water Management District

Carmel River Lagoon Area

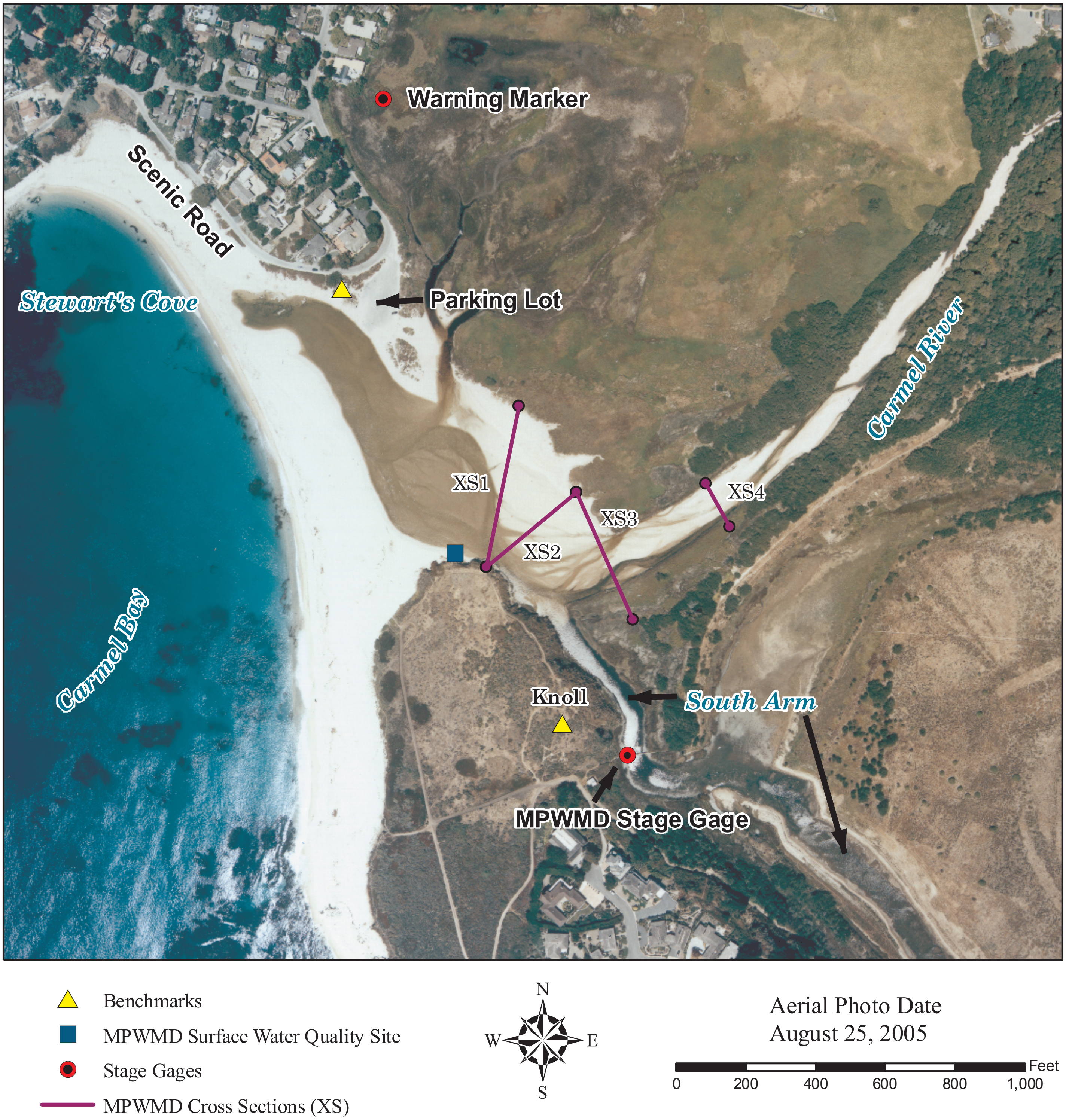


FIGURE 3

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Carmel River Lagoon
Similar Seawater Inflow Events
September 1995 and September 1997

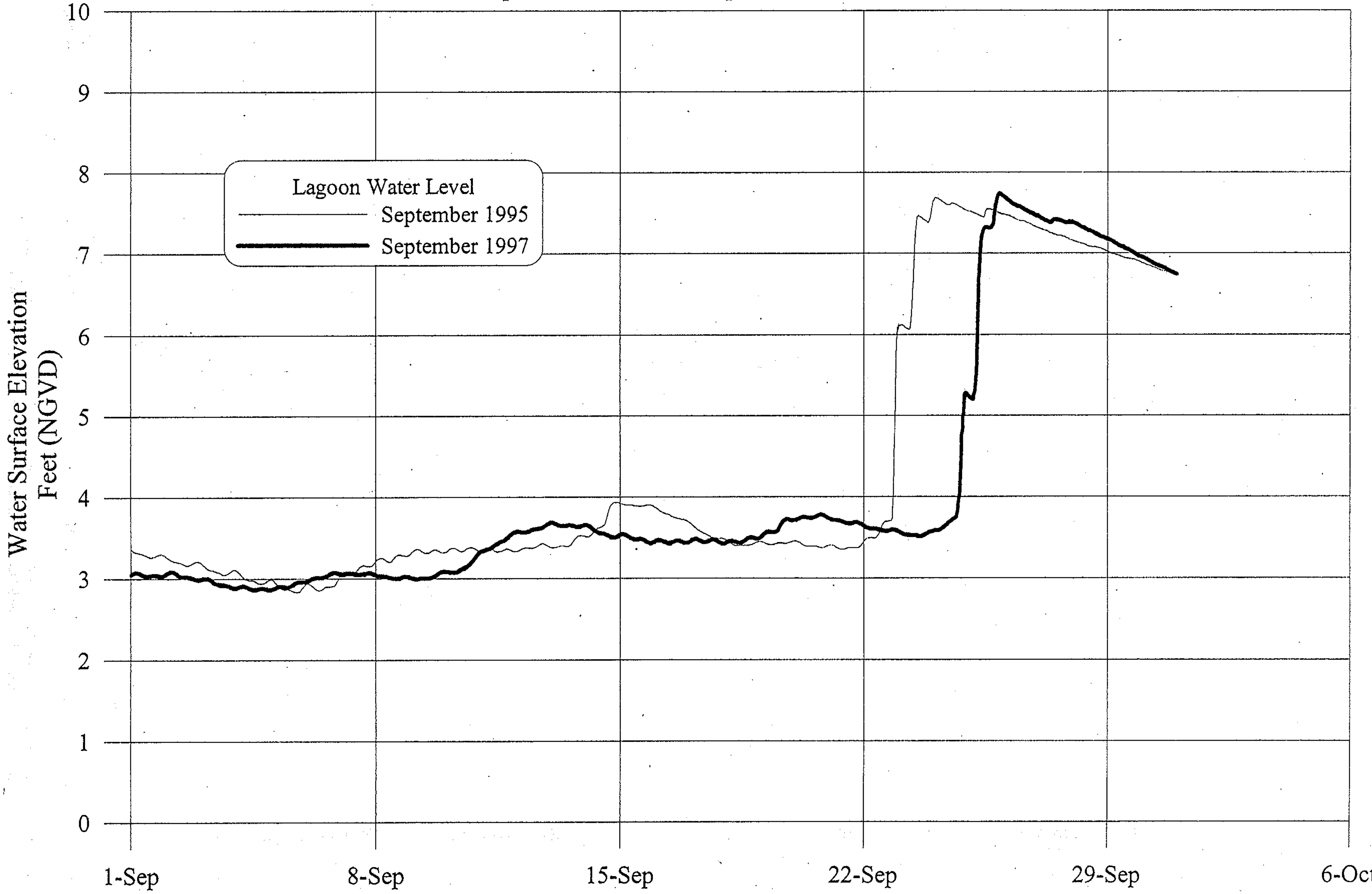
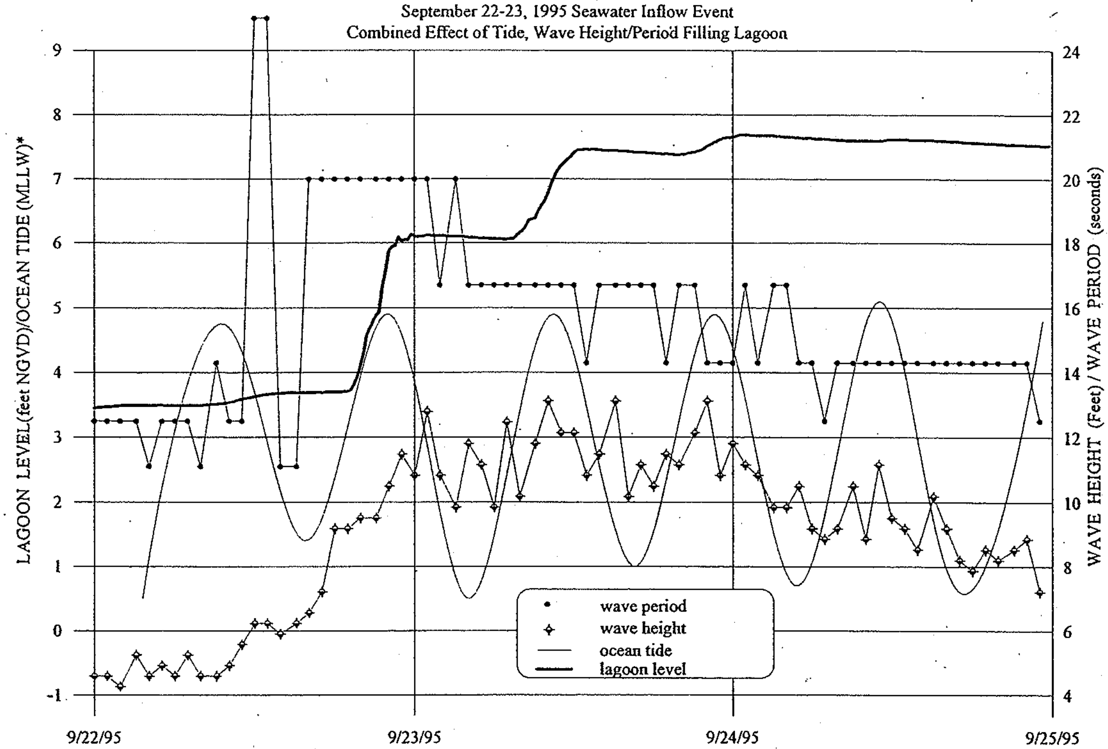


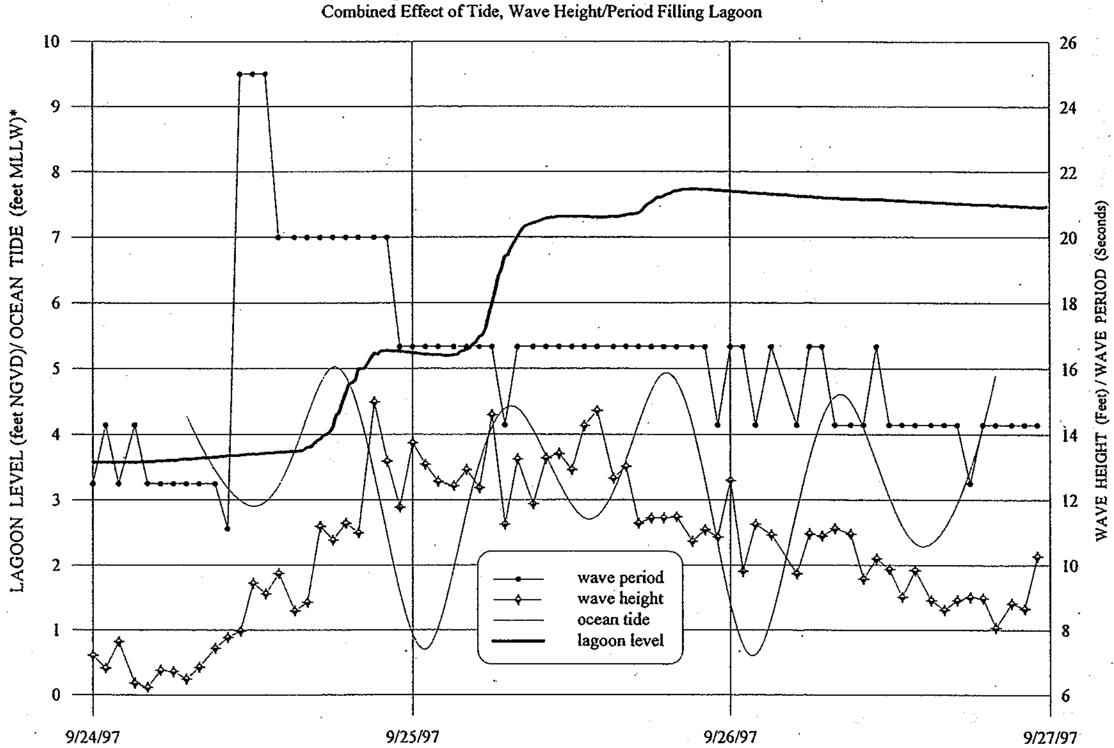
FIGURE 4

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Carmel River Lagoon
September 22-23, 1995 Seawater Inflow Event
Combined Effect of Tide, Wave Height/Period Filling Lagoon



Carmel River Lagoon
September 24-25, 1997 Seawater Inflow Event
Combined Effect of Tide, Wave Height/Period Filling Lagoon



* Lagoon level based on 1929 NGVD, Tide level based on mean-lower-low-water (MLLW)
Tidal data when adjusted to match NGVD would be 2.59 feet lower than shown on plot.

FIGURE 5

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Carmel River Lagoon
November 8, 2002 Seawater Inflow Event
Combined Effect of Tide, Wave Height/Period Filling Lagoon

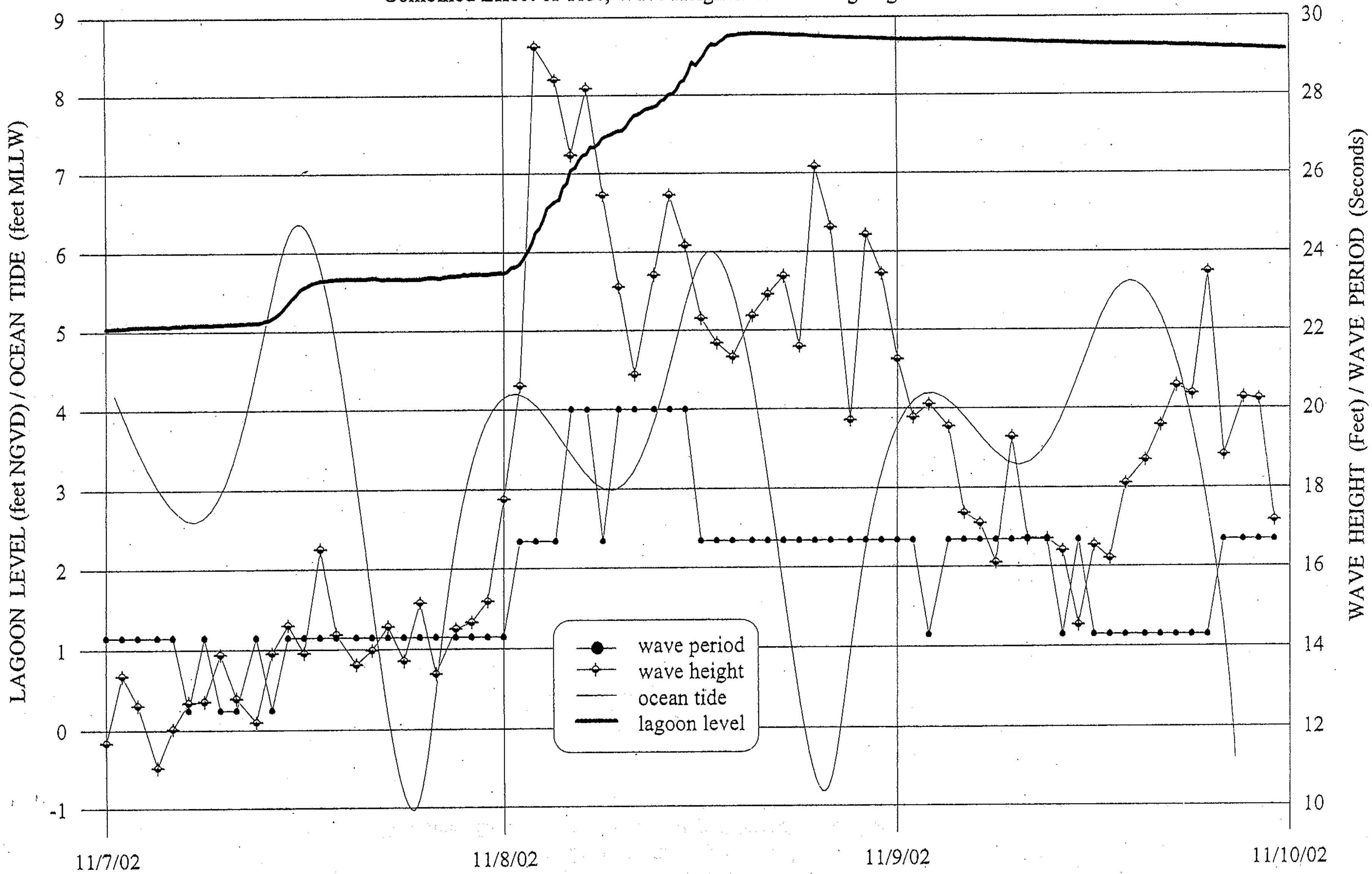


FIGURE 6

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Carmel River Lagoon
Flood Event of January 11, 2001
Combined Effect of Tide, Wave Height/Period Filling Lagoon

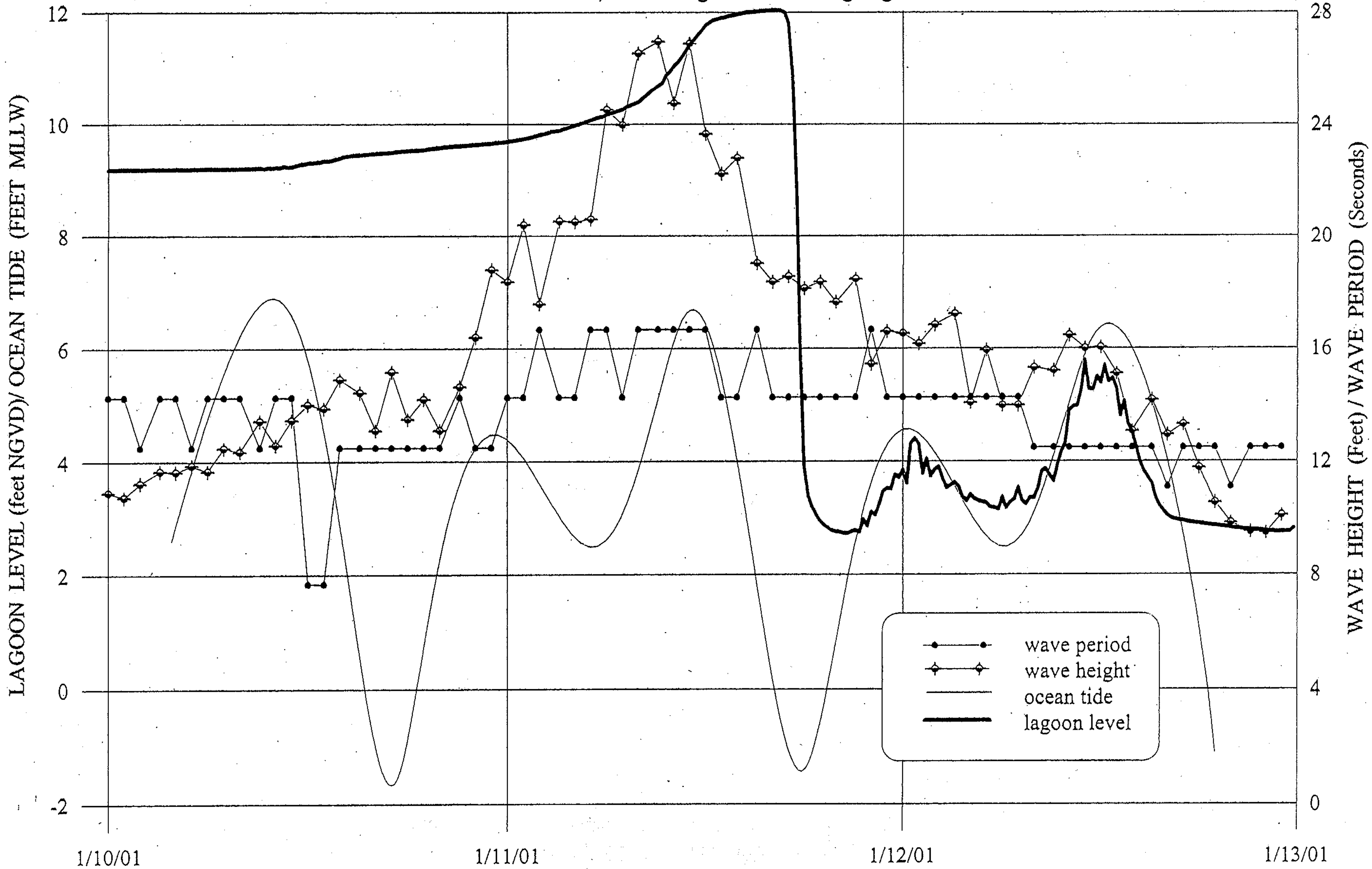


FIGURE 7

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

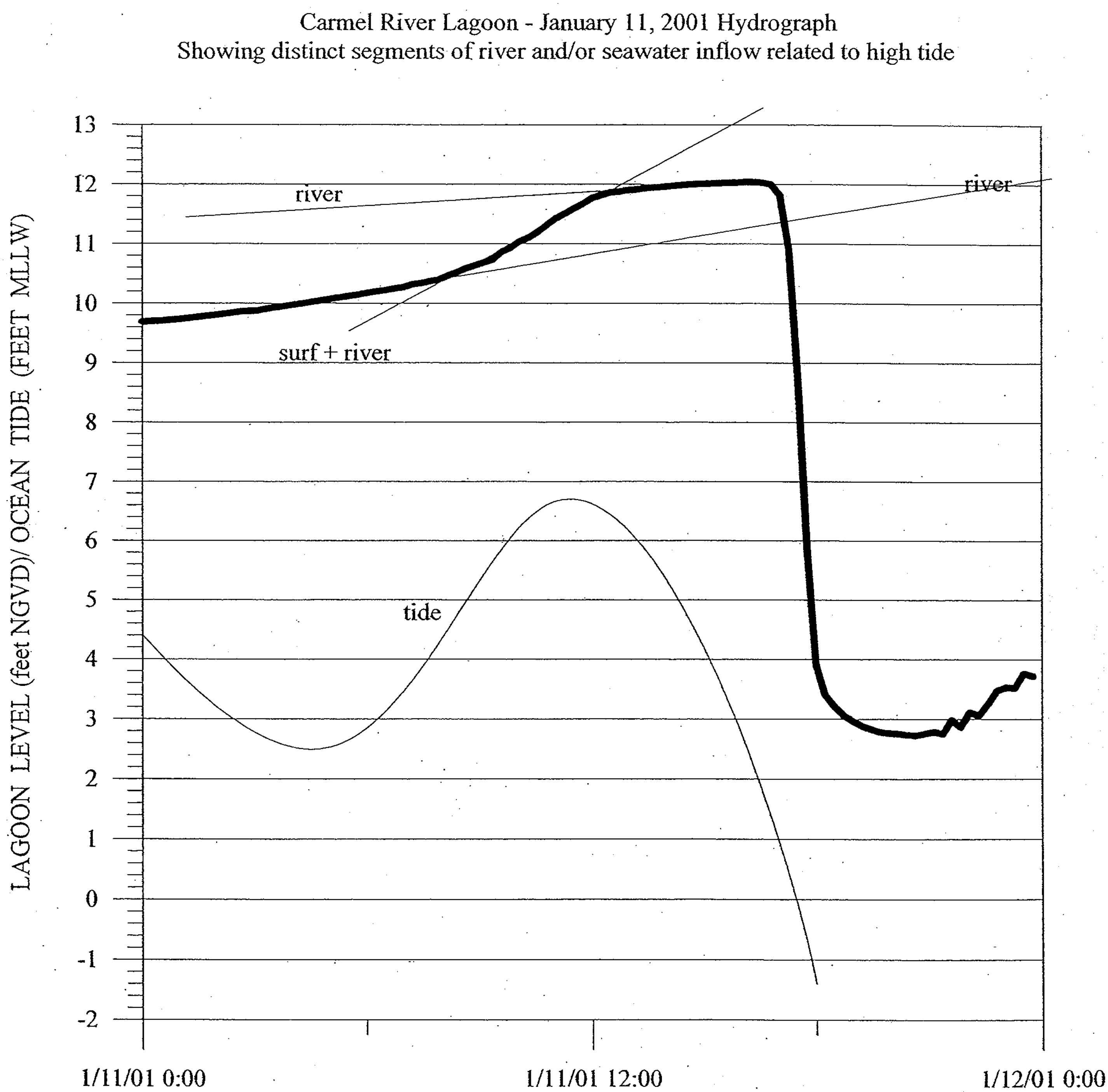


FIGURE 8

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Carmel River Lagoon - November 21, 2001
High Swells and Moderate High Tide Having No Effect on Lagoon Level

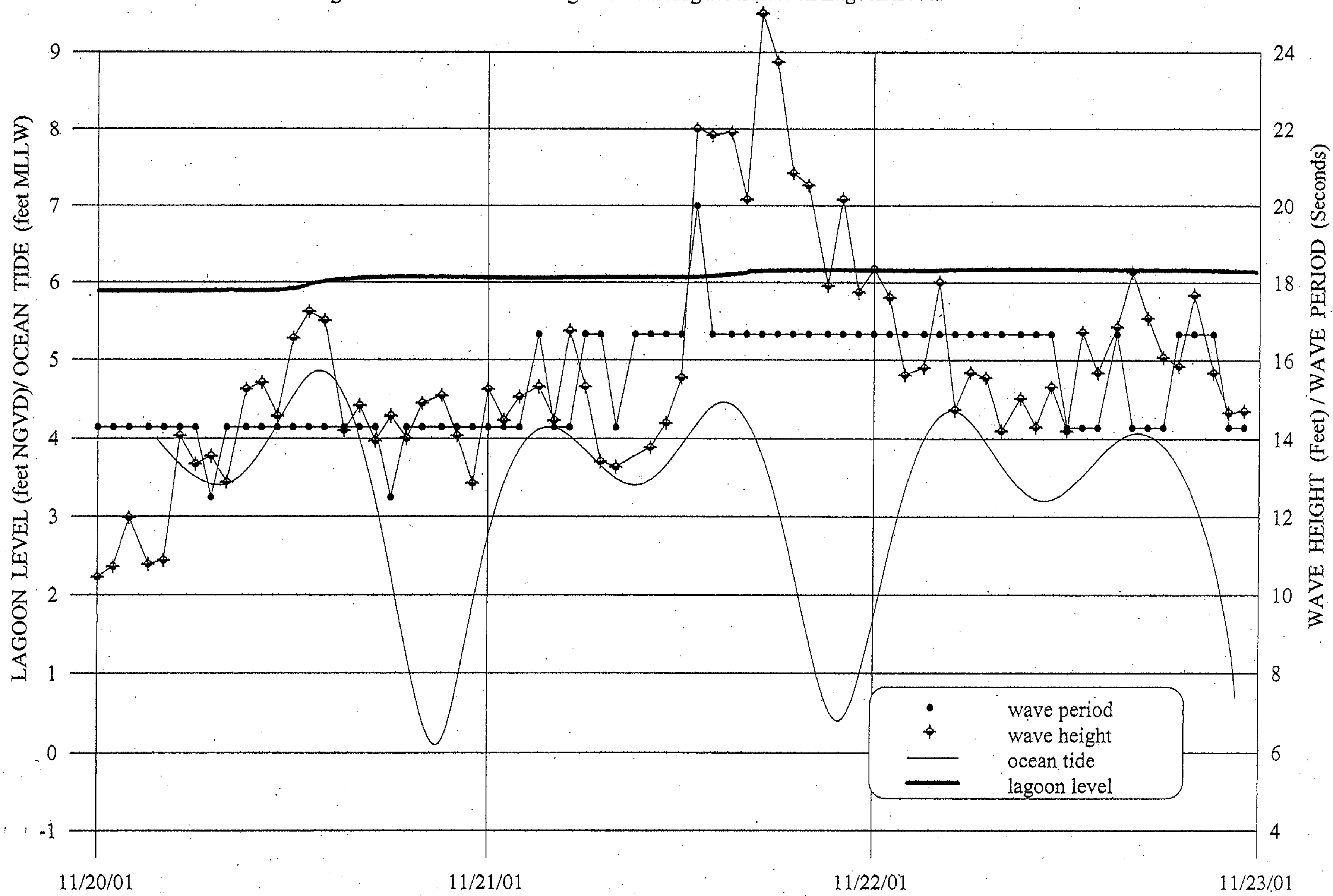


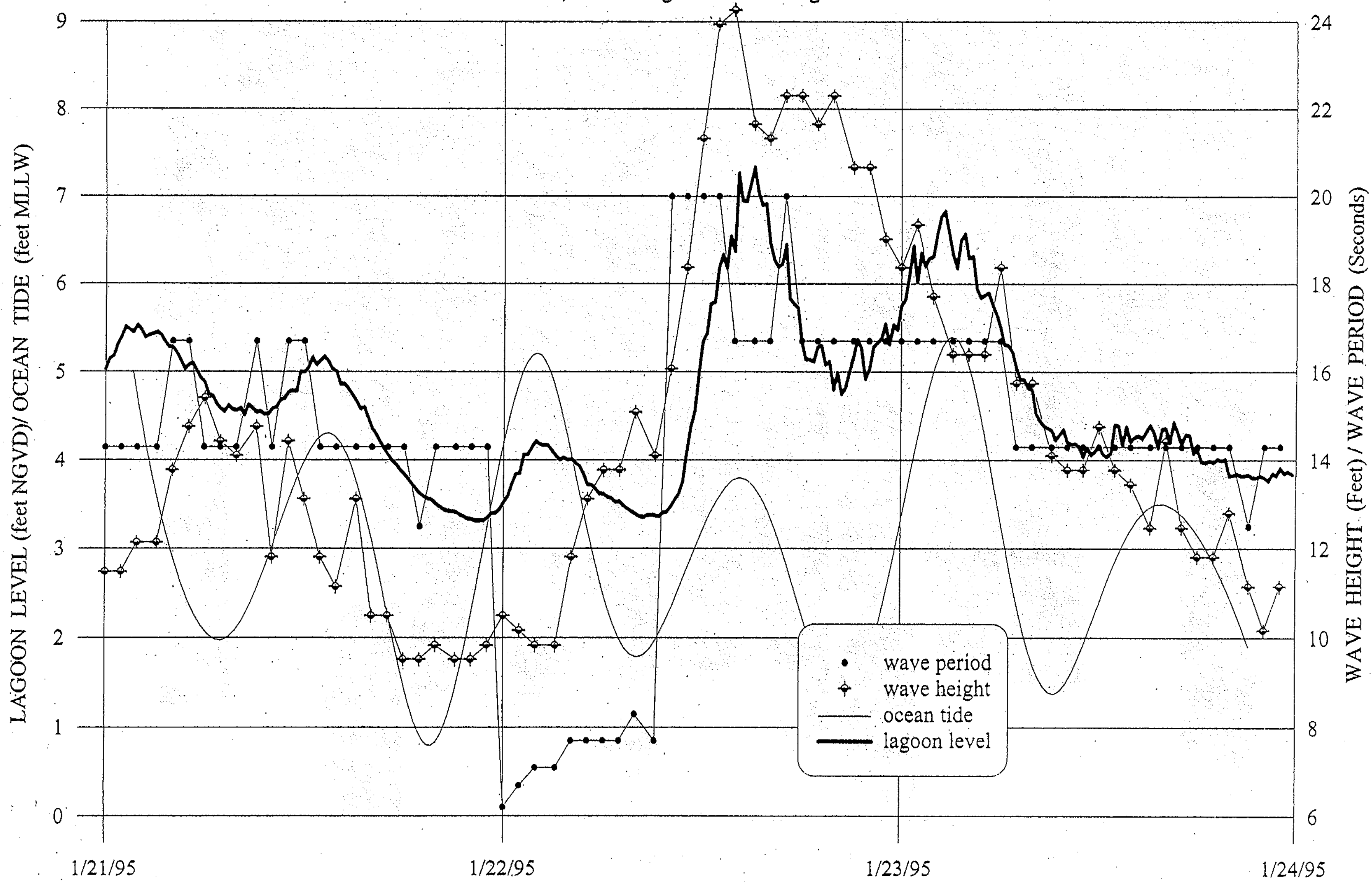
FIGURE 9

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Carmel River Lagoon

January 22, 1995 High Surf Event that Flooded Lagoon Parking Lot

Interaction of Tide, Wave Height/Period on Lagoon Levels

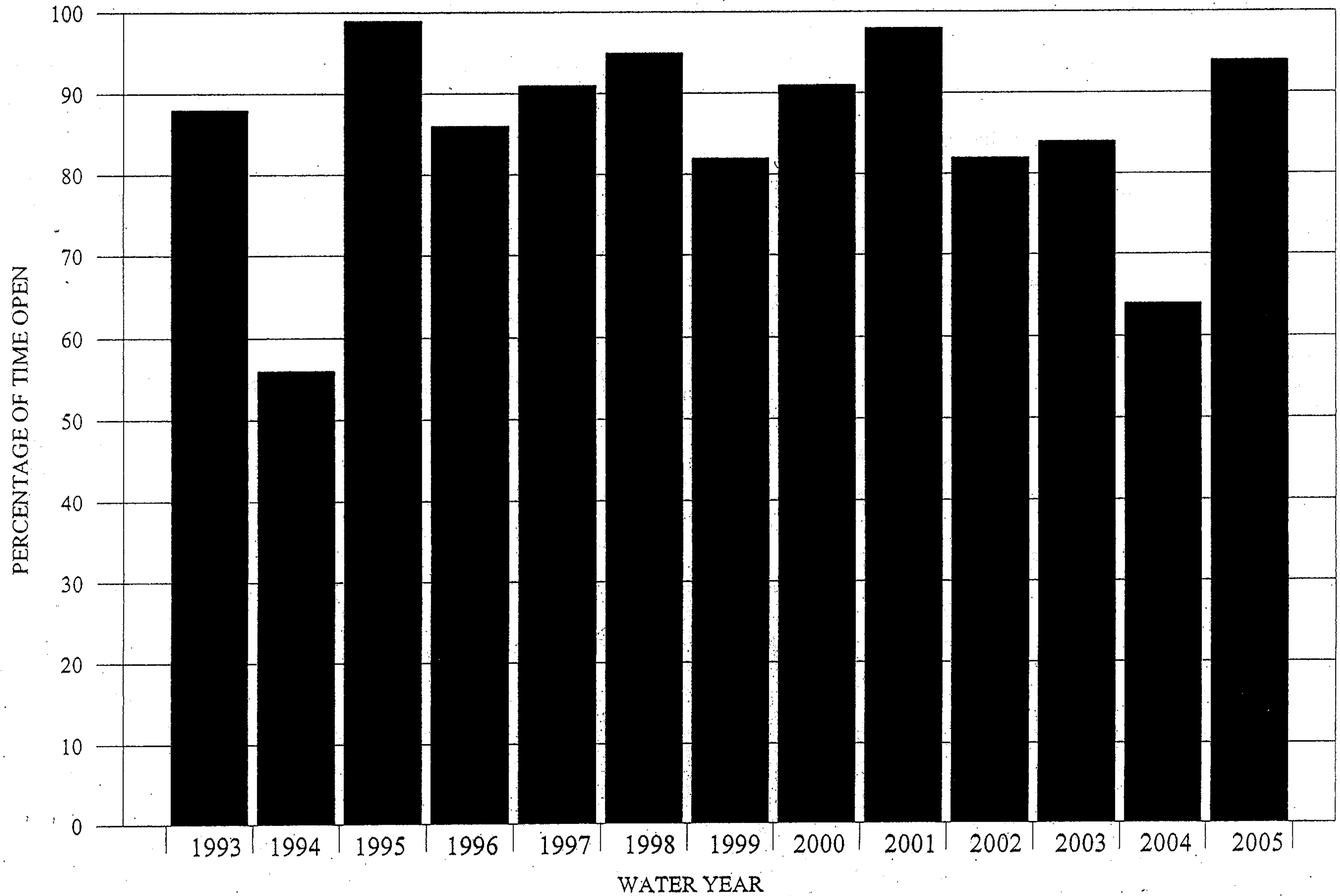


Notes: Tide levels are predicted tides for Monterey Bay. Observed high tide at 2 pm on 1/22/95 was 4.41 feet meas. at Monterey Harbor.

FIGURE 10

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON
PERCENTAGE OF TIME THE LAGOON MOUTH WAS OPEN TO OCEAN*

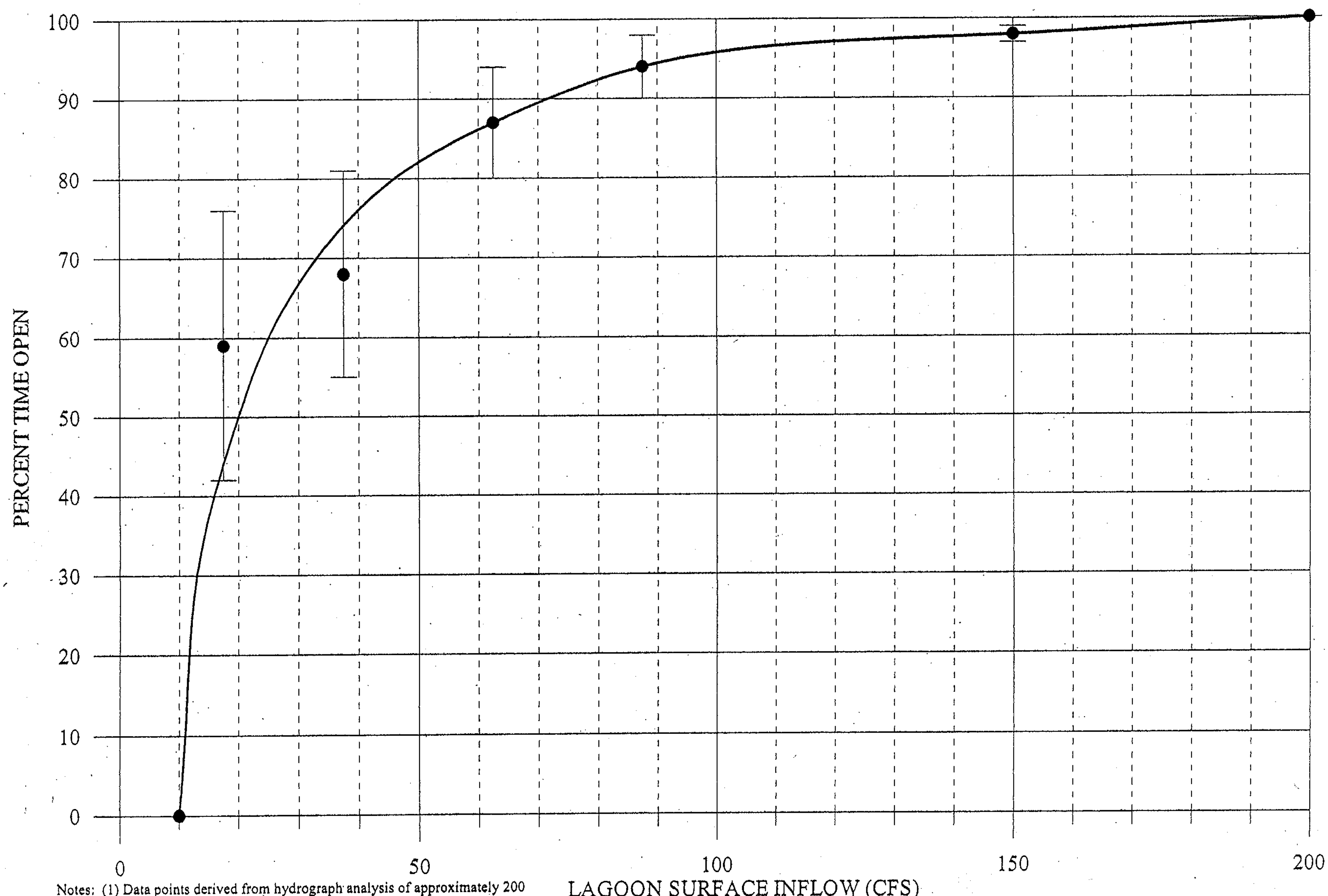


*Period includes day after initial breach through day of final seasonal closure.

FIGURE 11

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON - WATER YEARS 1993 - 2005
SURFACE INFLOW VS. PERCENTAGE OF TIME LAGOON MOUTH IS OPEN

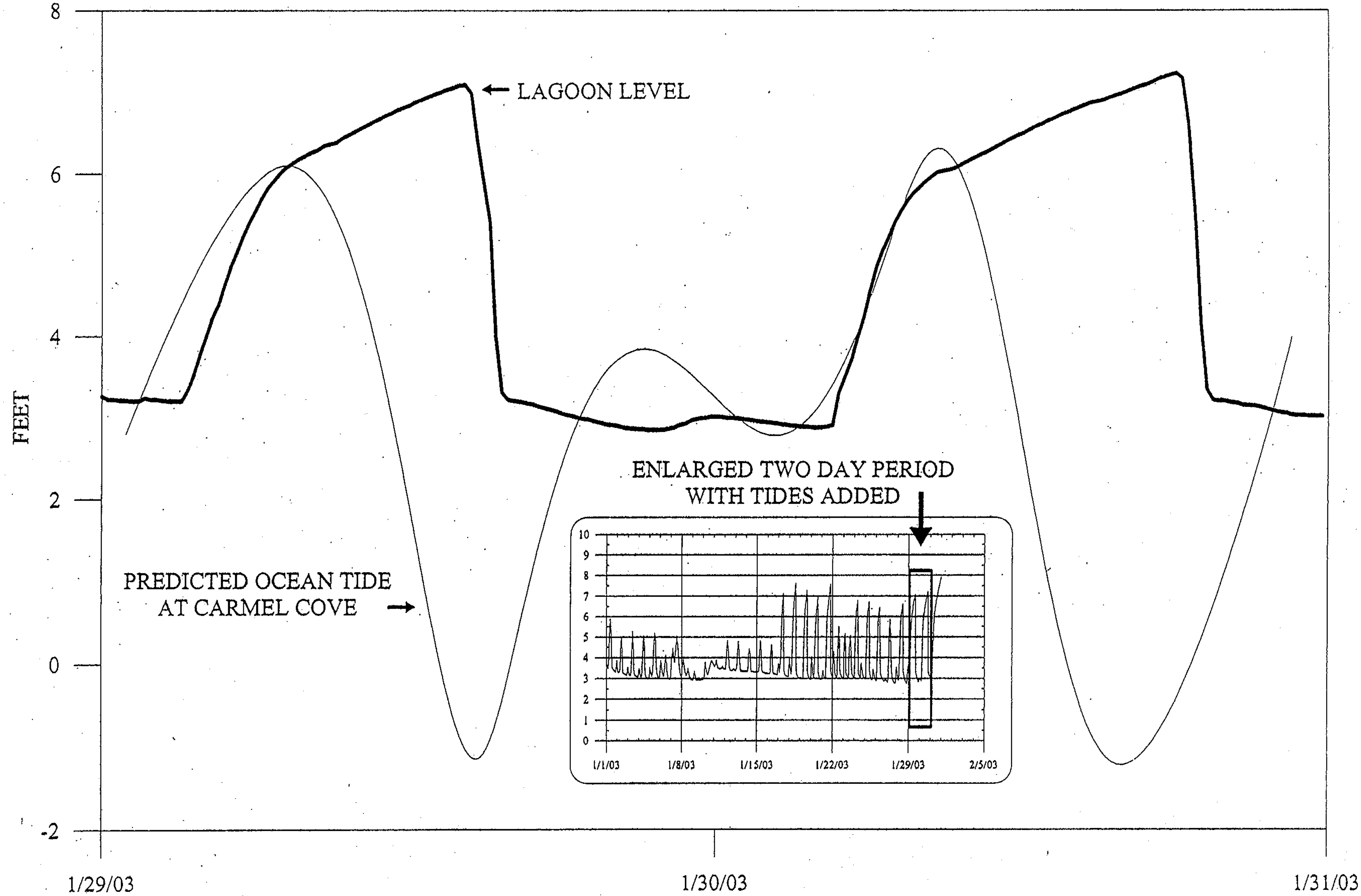


Notes: (1) Data points derived from hydrograph analysis of approximately 200 identified lagoon mouth closure events during the 1993-2005 period
(2) Error bars indicate 95% confidence limits.
(3) Inflow measured at Carmel River at Highway 1 Bridge gage.

FIGURE 12

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TYPICAL BRIEF WINTERTIME LAGOON MOUTH CLOSURE
DUE TO HIGH TIDE (SPRING TIDE PHASE) AND WAVE ACTION
JANUARY 2003

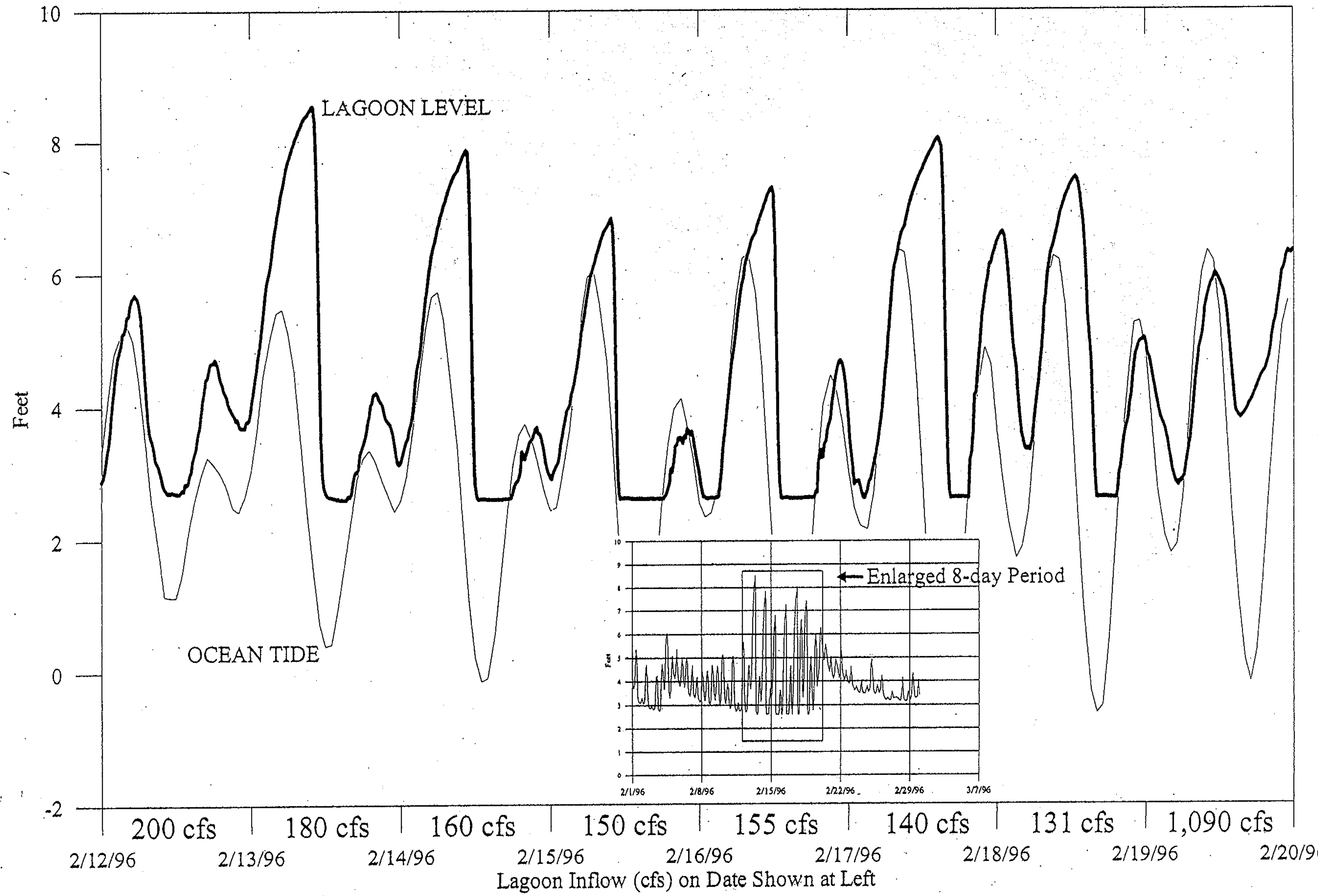


Notes: Lagoon inflow approximately 100 cfs for above two day period.
Significant wave height at the Monterey Bay Buoy approximately 6-feet.

FIGURE 13

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

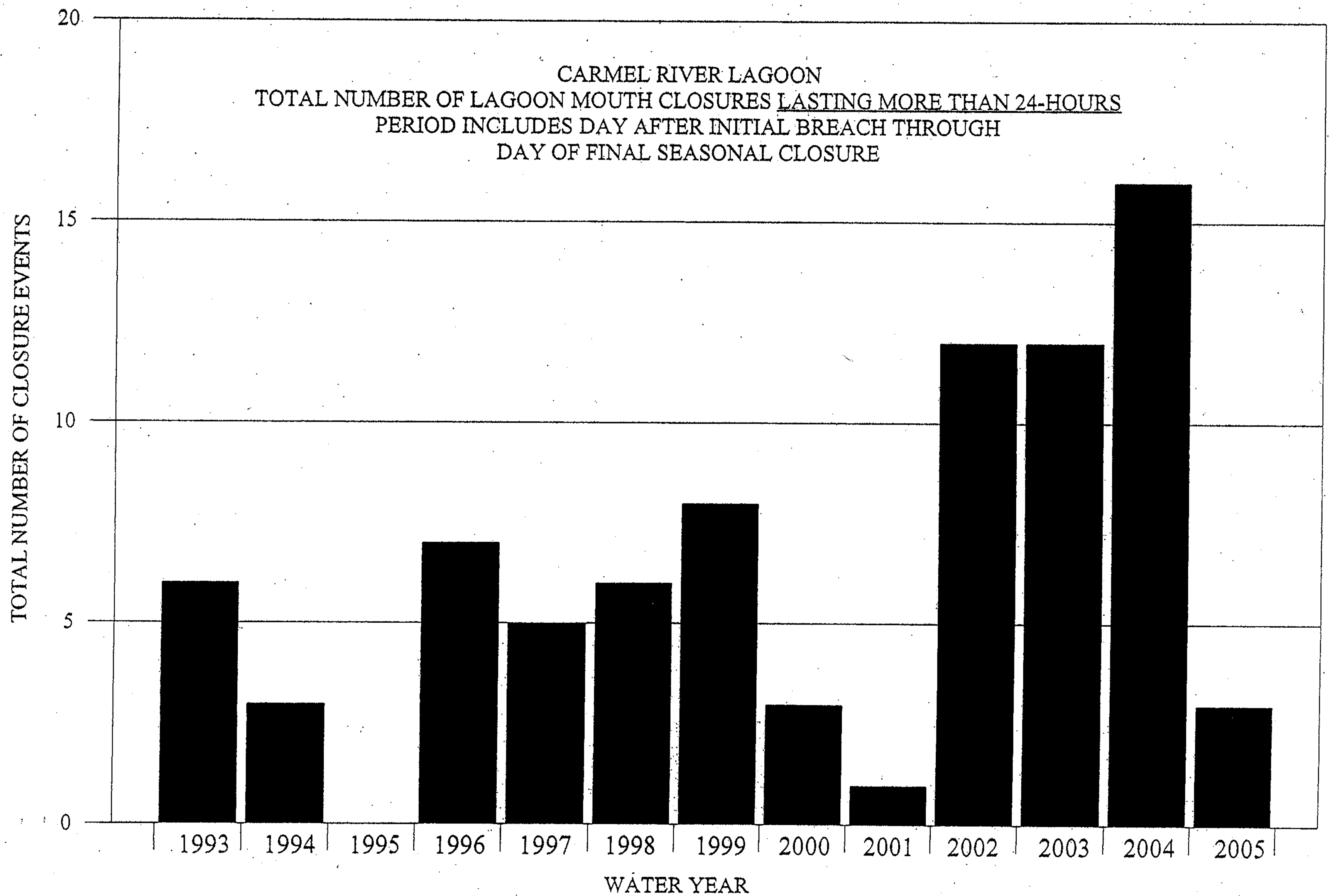
TYPICAL BRIEF WINTERTIME LAGOON MOUTH CLOSURE
DUE TO HIGH TIDE (SPRING TIDE PHASE) AND WAVE ACTION
FEBRUARY 1996



Notes: Significant wave height at the Monterey Bay Buoy in the 6-10 foot range through above period.
Highest runoff event of WY 1996 arrived on 2/19/1996 ending the brief closure pattern.

FIGURE 14

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

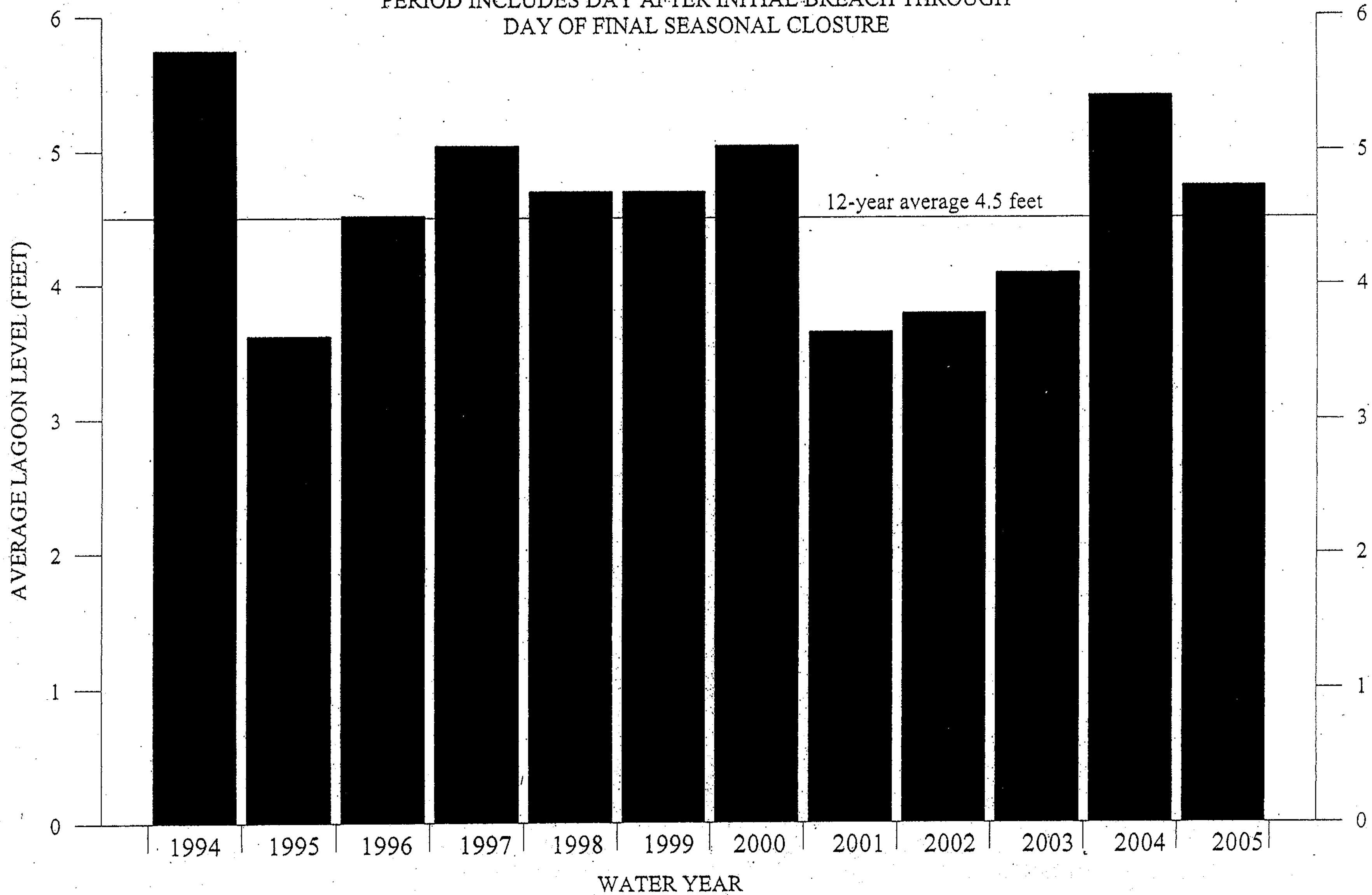


Note: Closure events were identified in the hydrographic record and totaled for each year. The final seasonal lagoon mouth closure is not included in closure totals above.

FIGURE 15

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

AVERAGE LAGOON WATER LEVEL BY WATER YEAR PERIOD INCLUDES DAY AFTER INITIAL BREACH THROUGH DAY OF FINAL SEASONAL CLOSURE



Note: Averages represent the numerical average of 15-minute lagoon water level readings.

FIGURE 16

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

RELATIONSHIP BETWEEN CARMEL RIVER LAGOON INFLOW ON DAY ON FINAL SEASONAL CLOSURE AND MAXIMUM LAGOON LEVEL REACHED PRIOR TO RECEDING WATER YEARS 1991 - 2005

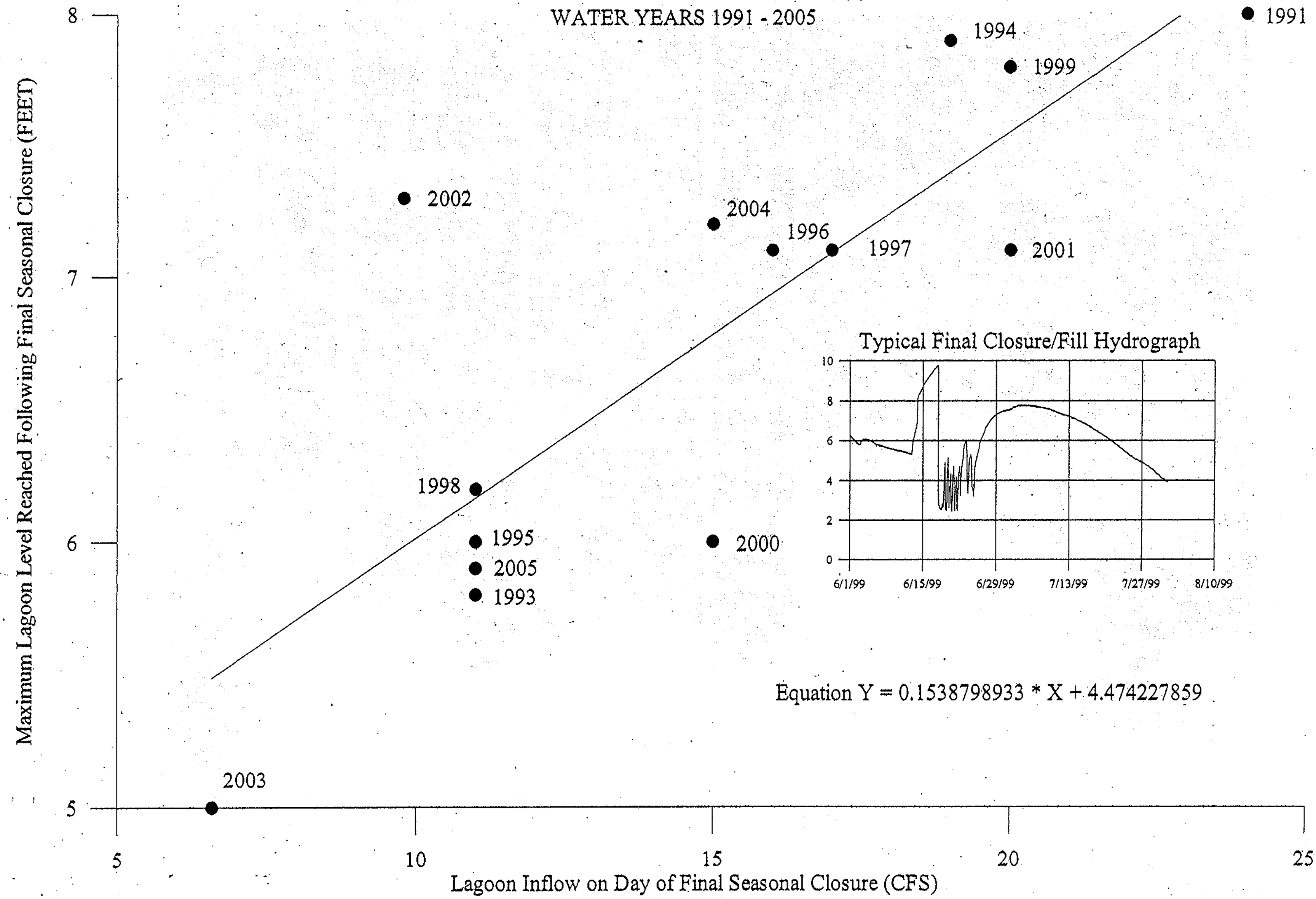


TABLE 1

Carmel River Lagoon Stage/Volume Relationships Based on 1994 MPWMD Survey Data
(All Values in Acre-Feet)

Lagoon Stage (feet)	Tenths of Feet									
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
-2	0.002	0.001	0.0004	0.00						
-1	0.043	0.034	0.027	0.022	0.018	0.015	0.000	0.007	0.005	
-0	0.191	0.170	0.150	0.131	0.115	0.100	0.086	0.073	0.061	0.052
0	0.191	0.215	0.240	0.266	0.294	0.323	0.354	0.388	0.425	0.464
1	0.504	0.547	0.597	0.661	0.737	0.826	0.931	1.05	1.19	1.34
2	1.50	1.67	1.87	2.09	2.34	2.62	2.93	3.28	3.66	4.09
3	4.57	5.10	5.69	6.34	7.05	7.81	8.63	9.51	10.46	11.47
4	12.55	13.74	15.07	16.54	18.13	19.84	21.66	23.61	25.67	27.86
5	30.18	32.62	35.19	37.89	40.73	43.70	46.80	50.04	53.43	56.94
6	60.58	64.38	68.35	72.43	76.61	80.86	85.20	89.61	94.10	98.66
7	103.31	108.11	113.02	118.03	123.13	128.34	133.66	139.07	144.55	150.11
8	155.77	161.60	167.52	173.51	179.56	185.68	191.86	198.10	204.41	210.79
9	217.25	223.88	230.57	237.32	244.12	250.96	257.84	264.77	271.73	278.73
10	285.77									

Notes: Lagoon stage is 1929 national geodetic vertical datum, based on brass tablet at knoll and brass tablet at restrooms.
See map for locations and elevations.
Volumes computed by Softdesk DTM surface comparison using 20'x20' grid.

TABLE 2

Carmel River Lagoon
Stage/Area Relationships Based on 1994 MPWMD Survey Data

Lagoon Stage (feet, NGVD 1929)	Lagoon Surface Area	
	Square Feet	Acres
-2.0	460	0.011
-1.0	3,870	0.089
0.0	9,887	0.227
1.0	18,874	0.433
2.0	78,646	1.805
3.0	220,987	5.073
4.0	500,465	11.49
5.0	1,037,829	23.83
6.0	1,611,538	37.00
7.0	2,054,235	47.16
8.0	2,326,745	53.41
9.0	2,848,719	65.40
10.0	3,403,278	78.13

Note: Based on 1994 MPWMD field surveys and 1988 photogrammetry data where required to complete field survey data.

TABLE 3

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Relationship between Ocean Tidal Datum of Mean Lower Low Water (MLLW) and National Geodetic Vertical Datum of 1929 (NGVD) at Monterey, California

(Values in Feet)

Ocean Tide (MLLW)	NGVD Equivalent or Corresponding Lagoon Level
7.00	4.41
6.00	3.41
5.00	2.41
4.00	1.41
3.00	0.41
2.59	**0.00**
2.00	-0.59
1.00	-1.59
0.00	-2.59
-1.00	-3.59
-2.00	-4.59

Note: Ocean tide values span the approximate range of tides expected in the Monterey area.
Source: National Geodetic Survey, 2005.

TABLE 4

EXAMPLE OF COASTAL FLOOD INDEX (CFI) VALUES
AT VARIOUS WAVE HEIGHTS (WVHT), TIDES AND SWELL PERIODS

WVHT	TIDE	CFI AT PERIOD 17 SEC	CFI AT PERIOD 20 SEC
10	4.0	9	10
	4.5	10	10
	5.0	10	11
	5.5	10	12
	6.0	11	12
	6.5	12	12
	7.0	12	13
	7.5	12	14
15	4.0	12	12
	4.5	12	12
	5.0	13	13
	5.5	14	14
	6.0	14	14
	6.5	14	14
	7.0	15	15
	7.5	16	16
20	4.0	13	13
	4.5	14	14
	5.0	14	14
	5.5	14	14
	6.0	15	15
	6.5	16	16
	7.0	16	16
	7.5	16	16
25	4.0	14	15
	4.5	14	16
	5.0	15	16
	5.5	16	16
	6.0	16	17
	6.5	16	18
	7.0	17	18
	7.5	18	18
30	4.0	16	16
	4.5	16	16
	5.0	17	17
	5.5	18	18
	6.0	18	18
	6.5	18	18
	7.0	19	19
	7.5	20	20
35	4.0	16	18
	4.5	16	18
	5.0	17	19
	5.5	18	20
	6.0	18	20
	6.5	18	20
	7.0	19	21
	7.5	20	22

Source: National Weather Service, Portland, Oregon, Surf Computer Program (Elson, 2001).

TABLE 5

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

LAGOON OPENINGS, ANTECEDENT RAINFALL, AND GROUND WATER STORAGE CONDITIONS FOR WATER YEARS 1991 THROUGH 2005

Water Year	Date of First Lagoon Opening	Maximum Level on Opening Date (Feet)	Antecedent* Rainfall at San Clemente Dam (Inches)	October 1 Usable Storage Lower Carmel Valley (Sub-units 3 & 4) (Acre-Feet)	(% Usable Capacity)
1991	March 18, 1991	No Data	11.77	11,000	50%
1992	February 11, 1992	8.99	12.28	17,800	81%
1993	January 3, 1993	8.51	7.43	17,700	81%
1994	February 17, 1994	8.95	9.38	18,200	83%
1995	January 9, 1995	8.85	9.27	16,700	76%
1996	December 13, 1995	8.94	3.26	20,700	95%
1997	December 9, 1996	9.60	5.31	19,700	90%
1998	December 6, 1997	9.62	8.57	18,400	84%
1999	November 3, 1998	10.01	0.42	21,200	97%
2000	January 24, 2000	11.31	6.56	19,800	90%
2001	January 11, 2001	12.04	7.48	19,800	90%
2002	December 3, 2001	10.65	6.16	19,000	87%
2003	December 16, 2002	10.81	9.71	18,600	85%
2004	December 30, 2003	10.48	7.97	19,300	88%
2005	December 30, 2004	10.29	9.96	18,300	83%
AVERAGE		9.93	7.70		
MEDIAN		9.82	7.97		

*Total water year rainfall up to and including rain recorded on the day of first initial lagoon opening.

TABLE 6

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TABULATION OF NUMBER OF DAYS THE CARMEL RIVER LAGOON MOUTH WAS CLOSED
AT SELECTED INFLOW RANGES FOR WATER YEARS 1993 - 2005

Water Year	total days	days closed	total days	days closed	total days	days closed	total days	days closed	total days	days closed	total days	days closed	Days between Initial Opening and Final Closure	Total Number of Days the Lagoon Mouth was Closed	Percentage of Time the Lagoon Mouth was Open
Flow range	>200		100-200		75-100		50-75		25-50		10-25				
1993	88	0	20	0	10	0	12	2.2	28	11.1	15	7.7	173	21	88%
1994	5	0	4	0.3	3	0.5	6	1.7	9	5.8	12	8.9	39	17.2	56%
1995	98	0	53	0.8	13	0.3	11	0	10	0	17	0	202	1.1	99%
1996	58	0	43	1.4	13	0.2	18	0	48	23.4	5	1.6	185	26.6	86%
1997	71	0	25	0	10	0	17	2.3	25	9.3	7	3	155	14.6	91%
1998	143	0	45	1.7	13	0.7	20	3	27	9.1	22	0	270	14.5	95%
1999	28	0	74	0.7	15	0	28	0	48	12.6	41	29.8	234	43.1	82%
2000	47	0	35	0.7	16	0.5	19	1.6	24	7.2	9	3.7	150	13.7	91%
2001	32	0	30	0.9	32	0.5	21	0.9	15	0.9	11	0	141	3.2	98%
2002	8	0	20	0	18	1.1	55	12.1	53	6	24	12.3	178	31.5	82%
2003	29	0	56	3.3	28	4.2	47	13.3	22	6.7	12	3.7	194	31.2	84%
2004	18	0.5	21	0.9	11	0.5	22	5.8	36	26.3	12	9.8	120	43.8	64%
2005	95	0	43	0	8	1.6	18	0	13	1.9	18	8.8	195	12.3	94%
totals	720	0.5	469	10.7	190	10.1	294	42.9	358	120.3	205	89.3			
%closed		0%		2%		5%		15%		34%		44%			
%open		100%		98%		95%		85%		66%		56%			

NOTES:
1. Closure events in Appendix A were identified with the width of the event measured in centimeters and converted to days.
2. Flow ranges based on daily flows measured at the MPWMD Carmel River at Highway 1 Bridge gaging station.

TABLE 7

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

DRY SEASON/CLOSED LAGOON MOUTH SUMMARY DATA

Lagoon level equilibrium with closed mouth and associated river inflow on date shown.		Date of final seasonal closure and river inflow on date shown.			
Equilibrium Date	cfs	Final Seasonal close date	cfs	max level attained	seasonal min. mouth closed
5/4/1991	10	4/29/1991	24	8.0	no data
5/17/1991	9				
5/13/1992	9				
5/14/1992	8	no data			2.5
5/15/1992	8				
6/28/1993	8	6/25/1993	11	5.8	2.6
6/29/1993	7				
6/30/1993	5				
7/1/1993	4				
7/2/1993	4				
7/3/1993	3				
4/2/1994	8	3/28/1994	19	7.9	2.7
4/3/1994	7				
8/1/1995	10	7/30/1995	11	6.0	2.9
8/2/1995	10				
8/3/1995	9.2				
8/4/1995	8.1				
8/5/1995	8.5				
8/6/1995	8.1				
8/7/1995	7.4				
6/20/1996	10	6/15/1996	16	7.1	3.0
6/21/1996	9.7				
6/22/1996	11				
6/23/1996	11				
6/24/1996	9.9				
6/25/1996	11				
6/26/1996	11				
6/27/1996	9.4				
6/28/1996	8.7				
6/29/1996	9.1				
6/30/1996	7.8				
5/18/1997	8.8	5/13/1997	17	7.1	3.0
5/19/1997	7.9				
5/24/1997	6.9				
5/25/1997	7.3				
5/27/1997	6.6				
9/6/1998	7.2	9/2/1998	11	6.2	4.5
9/14/1998	5				
9/15/1998	4.6				
9/18/1998	5.6				
9/19/1998	5.7				
9/26/1998	7.7				
10/5/1998	9				
10/6/1998	8				
10/16/1998	10				
10/19/1998	9.7				
10/20/1998	9.5				
10/22/1998	8.5				
7/3/1999	8	6/25/1999	20	7.8	2.7
7/4/1999	7.6				
7/5/1999	7.8				
6/25/2000	10	6/22/2000	15	6.0	3.0
6/26/2000	9.7				
6/9/2001	7.6	6/1/2001	20	7.1	3.1
6/10/2001	6.7				
6/11/2001	6.9				
6/12/2001	7.1				
6/13/2001	6.6				
6/3/2002	9	5/30/2002	9.8	7.3	2.7
6/4/2002	7.6				
6/5/2002	6.6				
7/7/2003	4	7/1/2003	6.6	5.0	2.7
5/6/2004	9.9	4/28/2004	15	7.2	2.5
5/7/2004	9.5				
5/10/2004	8.7				
5/11/2004	8.5				
5/12/2004	9.6				
5/13/2004	8.7				
7/19/2005	5.8	7/13/2005	11	5.9	3.0
7/20/2005	5.8				
average	8.0				
median	8.0				

NOTES:

Lagoon mouth closure dates are inferred from water level hydrographs and are plus or minus one day.
Maximum level attained and seasonal minimum following the final seasonal closure are estimated to the nearest tenth of a foot by visual inspection of lagoon hydrographs.

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TECHNICAL MEMORANDUM 05-01

SURFACE WATER DYNAMICS AT THE CARMEL RIVER LAGOON
WATER YEARS 1991 - 2005

APPENDIX A

LAGOON WATER LEVELS

FIGURE A-1

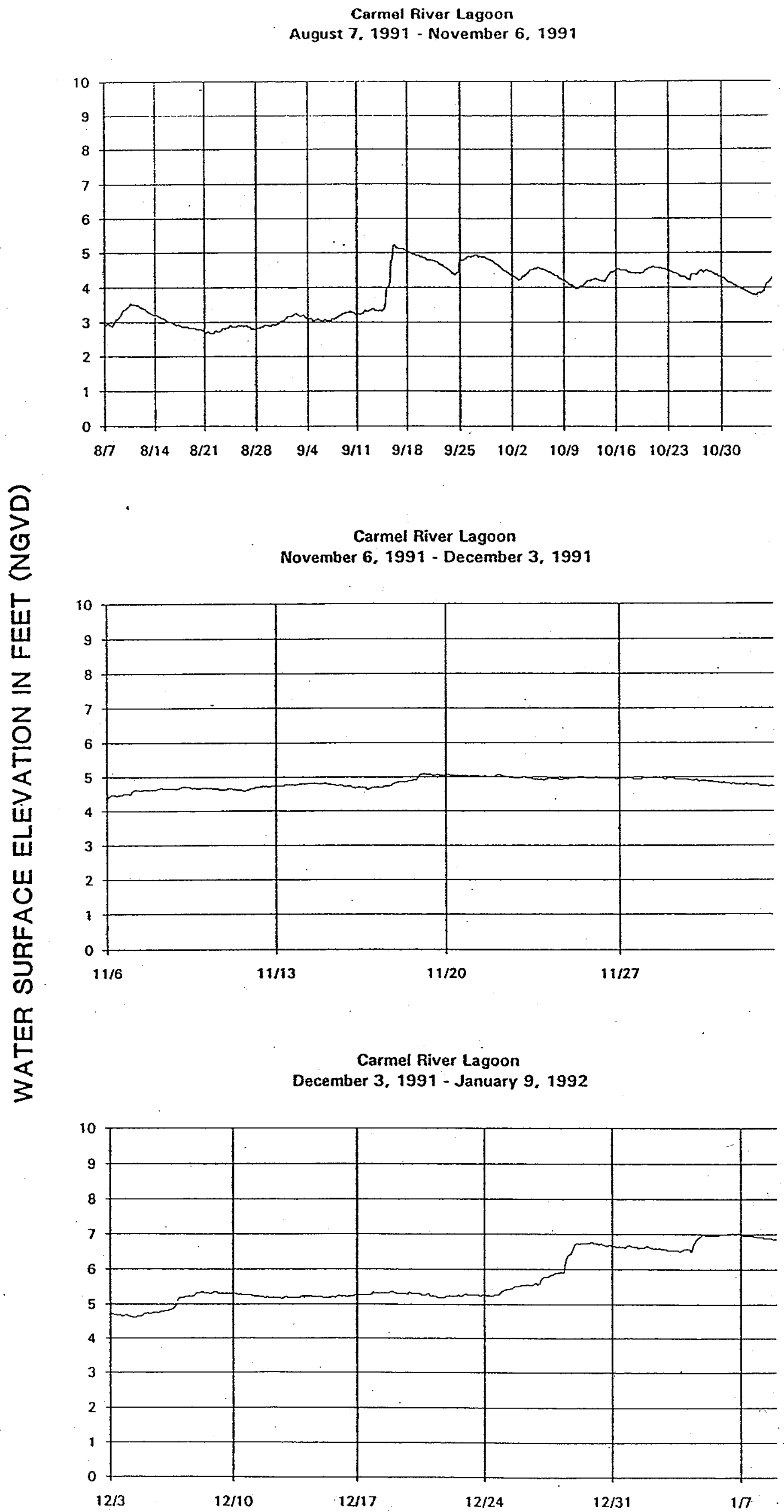
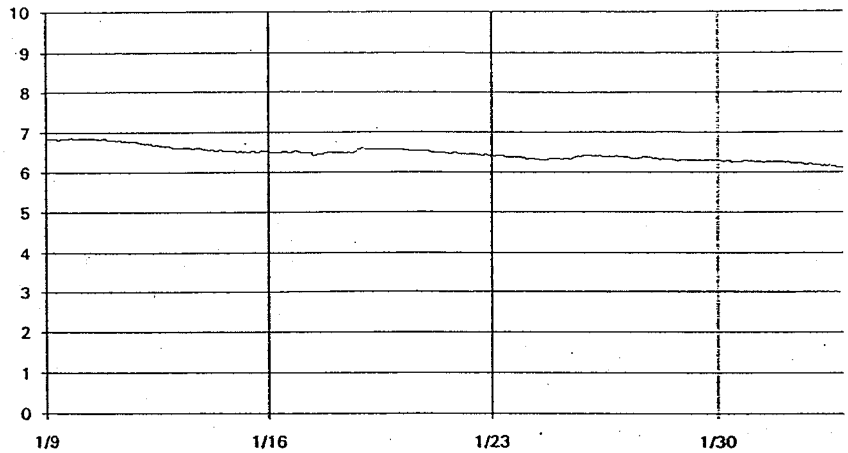

WATER SURFACE ELEVATION IN FEET (NGVD)
Carmel River Lagoon
August 7, 1991 - November 6, 1991
0 1 2 3 4 5 6 7 8 9 10
8/7 8/14 8/21 8/28 9/4 9/11 9/18 9/25 10/2 10/9 10/16 10/23 10/30
Carmel River Lagoon
November 6, 1991 - December 3, 1991
0 1 2 3 4 5 6 7 8 9 10
11/6 11/13 11/20 11/27
Carmel River Lagoon
December 3, 1991 - January 9, 1992
0 1 2 3 4 5 6 7 8 9 10
12/3 12/10 12/17 12/24 12/31 1/7

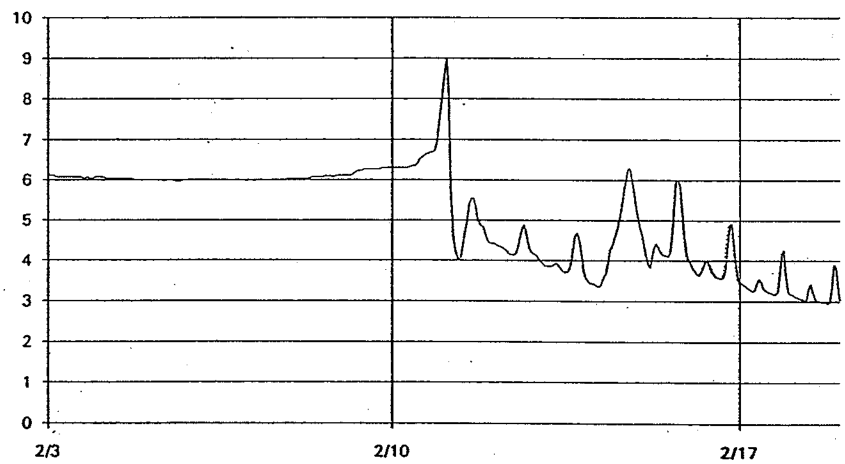
FIGURE A-2

WATER SURFACE ELEVATION IN FEET (NGVD)

Carmel River Lagoon
January 9, 1992 - February 3, 1992



Carmel River Lagoon
February 3, 1992 - February 19, 1992



Carmel River Lagoon
May 8, 1992 - May 27, 1992

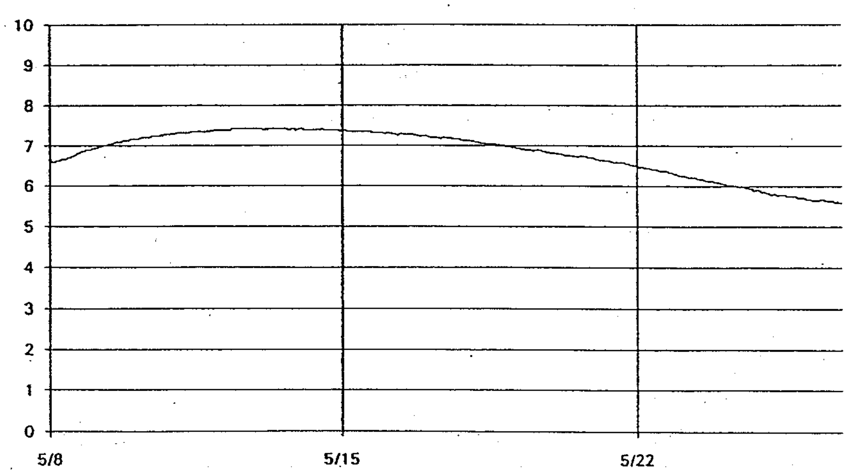


FIGURE A-3

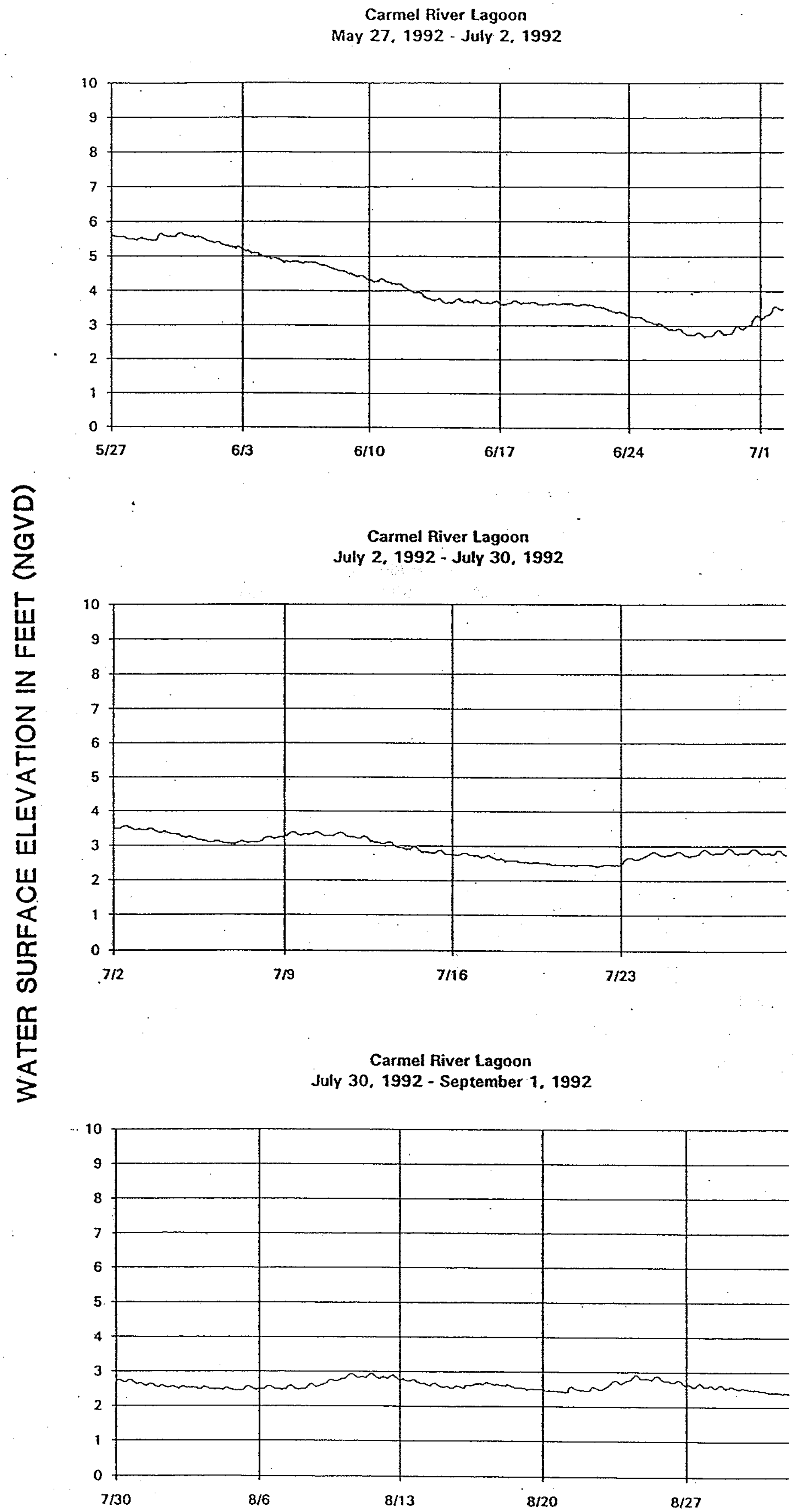

Carmel River Lagoon
May 27, 1992 - July 2, 1992
10
9
8
7
6
5
4
3
2
1
0
5/27
6/3
6/10
6/17
6/24
7/1
WATER SURFACE ELEVATION IN FEET (NGVD)
Carmel River Lagoon
July 2, 1992 - July 30, 1992
10
9
8
7
6
5
4
3
2
1
0
7/2
7/9
7/16
7/23
Carmel River Lagoon
July 30, 1992 - September 1, 1992
10
9
8
7
6
5
4
3
2
1
0
7/30
8/6
8/13
8/20
8/27

FIGURE A-4

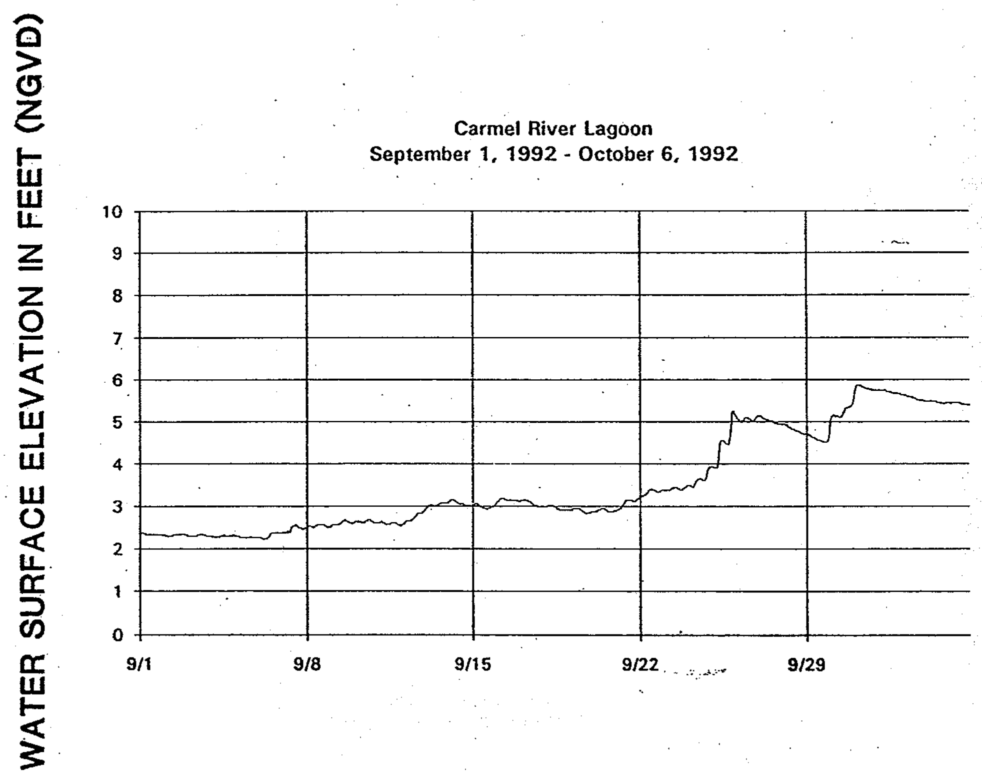
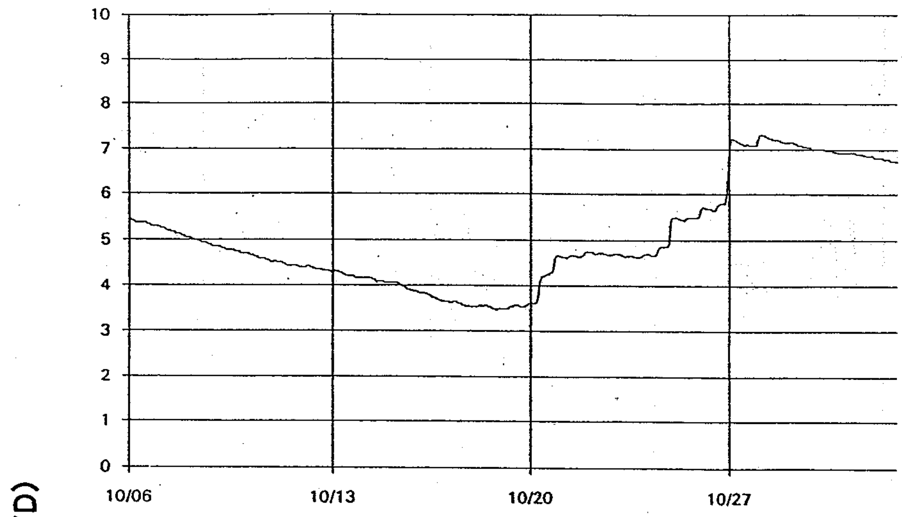
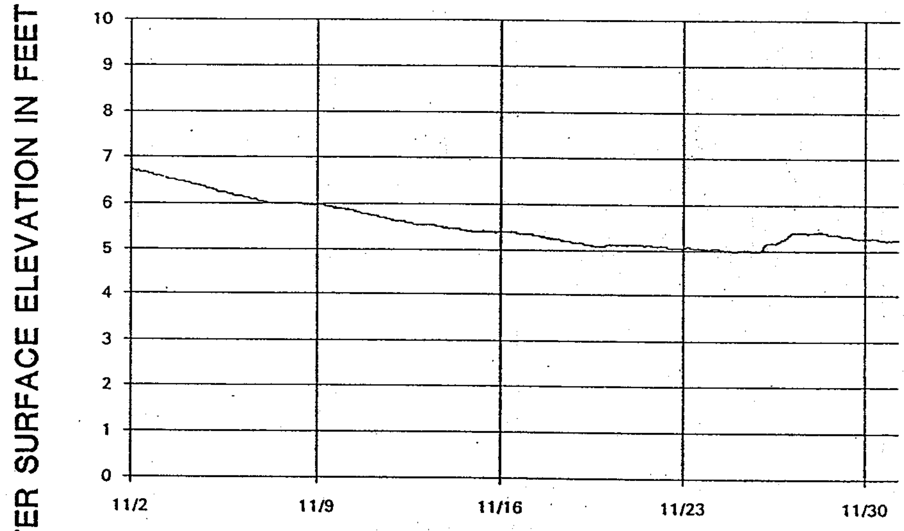

WATER SURFACE ELEVATION IN FEET (NGVD)
Carmel River Lagoon
September 1, 1992 - October 6, 1992
10
9
8
7
6
5
4
3
2
1
0
9/1
9/8
9/15
9/22
9/29

FIGURE A-5

Carmel River Lagoon
October 6, 1992 - November 2, 1992



Carmel River Lagoon
November 2, 1992 - December 1, 1992



Carmel River Lagoon
December 1, 1992 - January 8, 1993

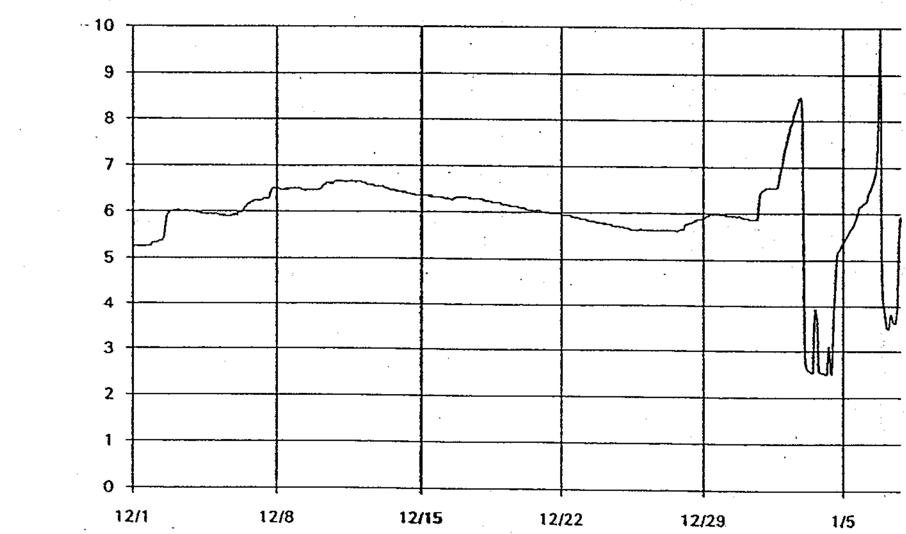
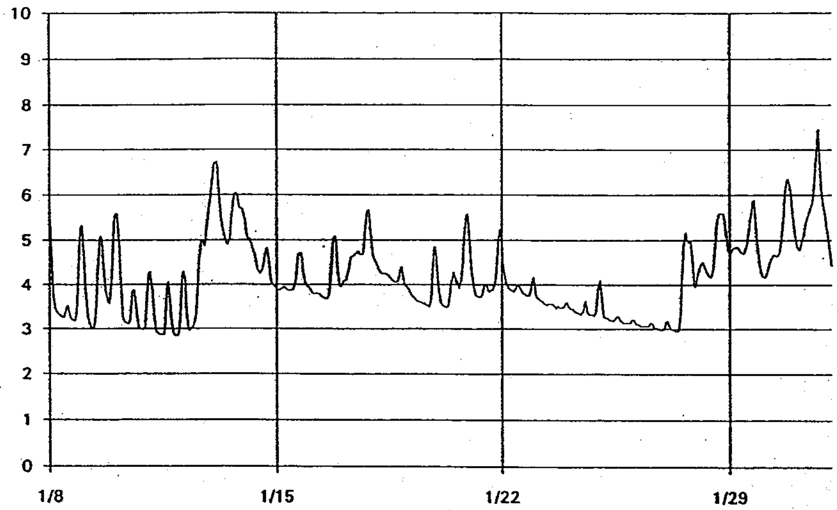


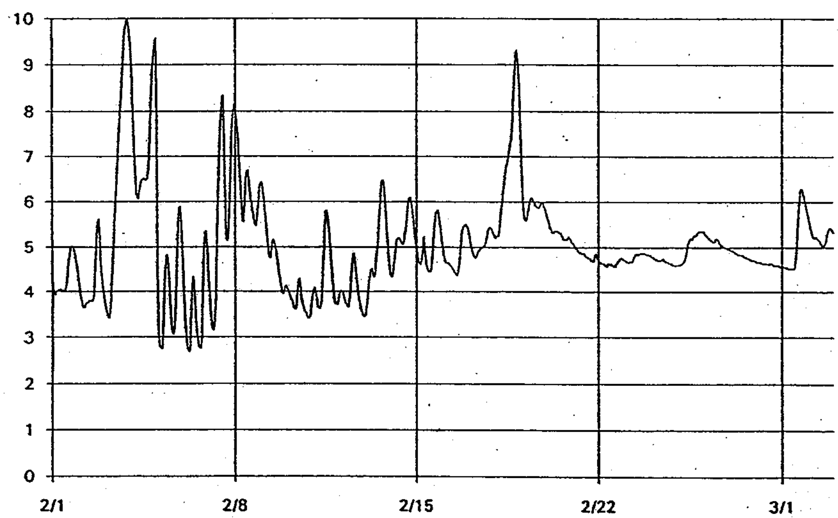
FIGURE A-6

WATER SURFACE ELEVATION IN FEET (NGVD)

Carmel River Lagoon
January 8, 1993 - February 1, 1993



Carmel River Lagoon
February 1, 1993 - March 3, 1993



Carmel River Lagoon
March 3, 1993 - April 1, 1993

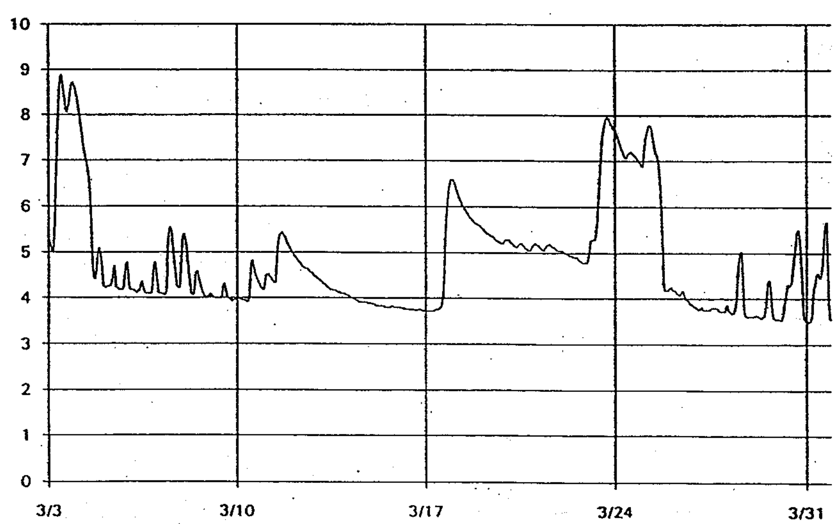


FIGURE A-7

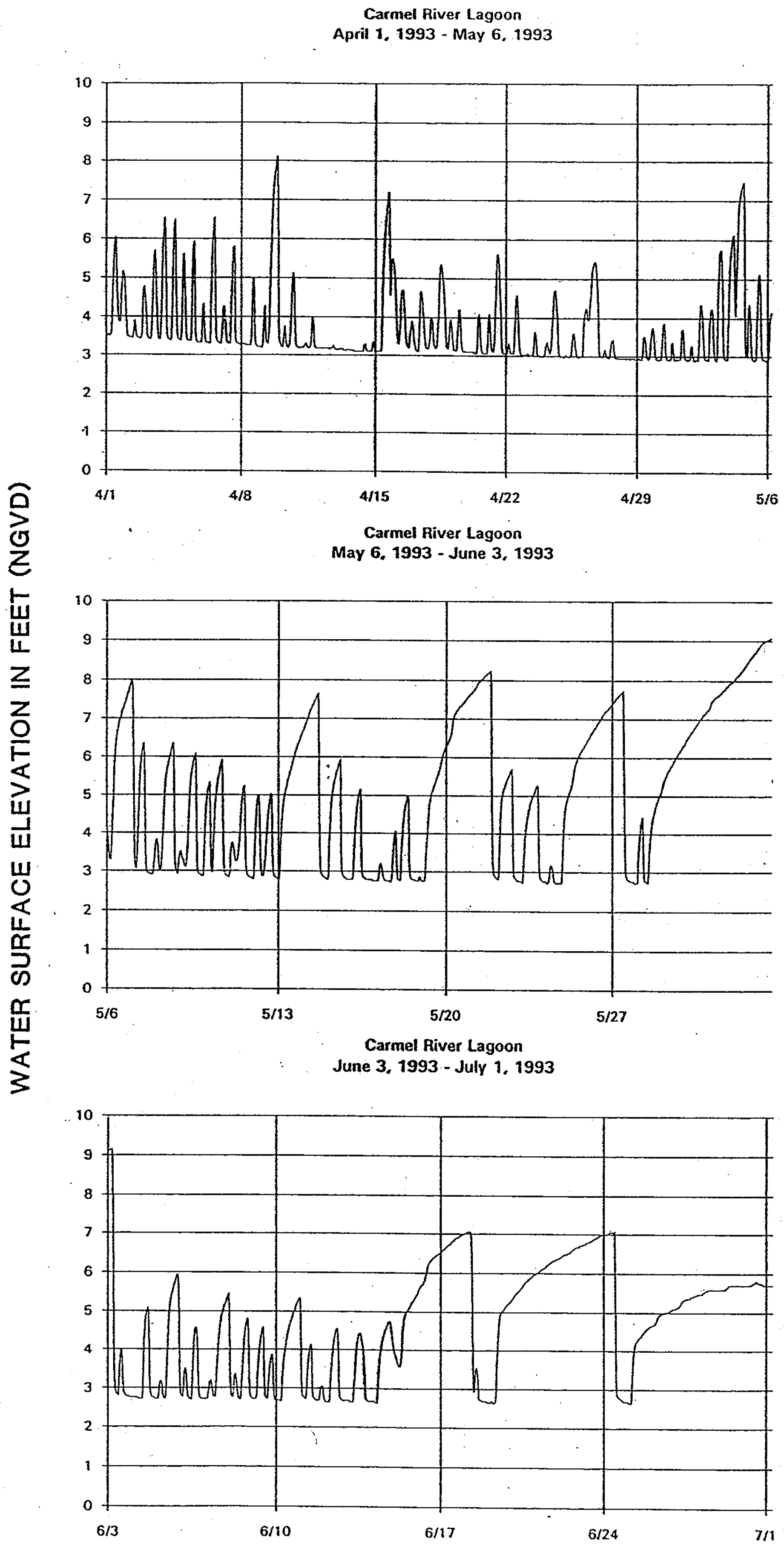
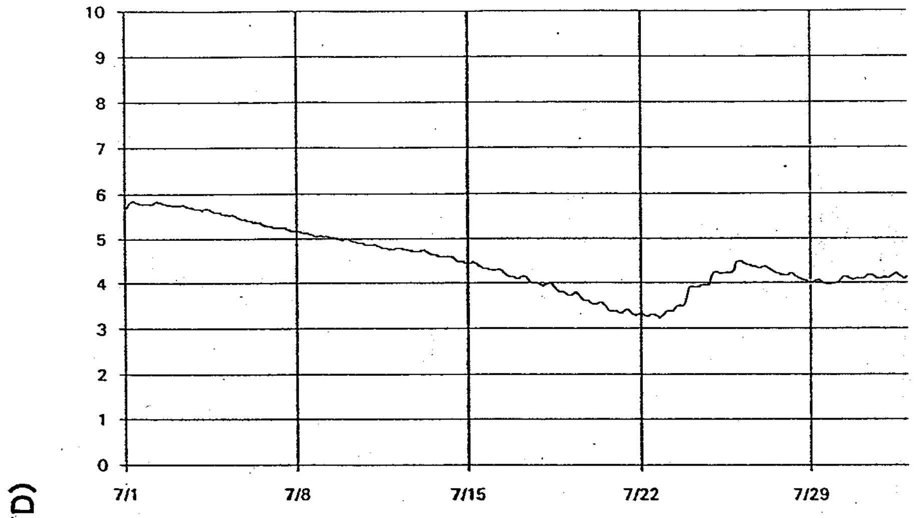
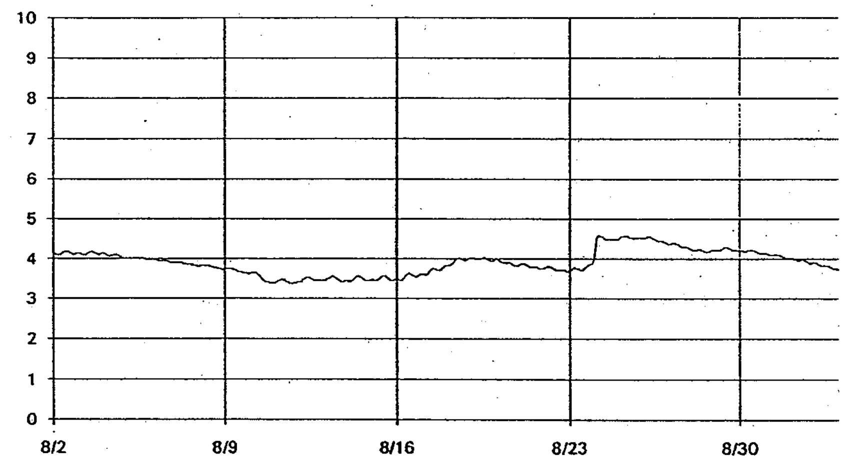

Carmel River Lagoon
April 1, 1993 - May 6, 1993
10
9
8
7
6
5
4
3
2
1
0
4/1
4/8
4/15
4/22
4/29
5/6
WATER SURFACE ELEVATION IN FEET (NGVD)
Carmel River Lagoon
May 6, 1993 - June 3, 1993
10
9
8
7
6
5
4
3
2
1
0
5/6
5/13
5/20
5/27
Carmel River Lagoon
June 3, 1993 - July 1, 1993
10
9
8
7
6
5
4
3
2
1
0
6/3
6/10
6/17
6/24
7/1

FIGURE A-8

Carmel River Lagoon
July 1, 1993 - August 2, 1993



Carmel River Lagoon
August 2, 1993 - September 3, 1993



Carmel River Lagoon
September 3, 1993 - October 4, 1993

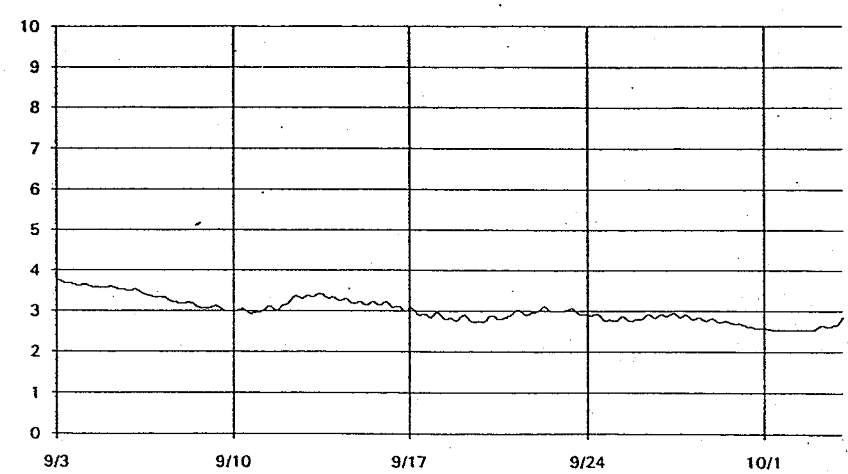


FIGURE A-9

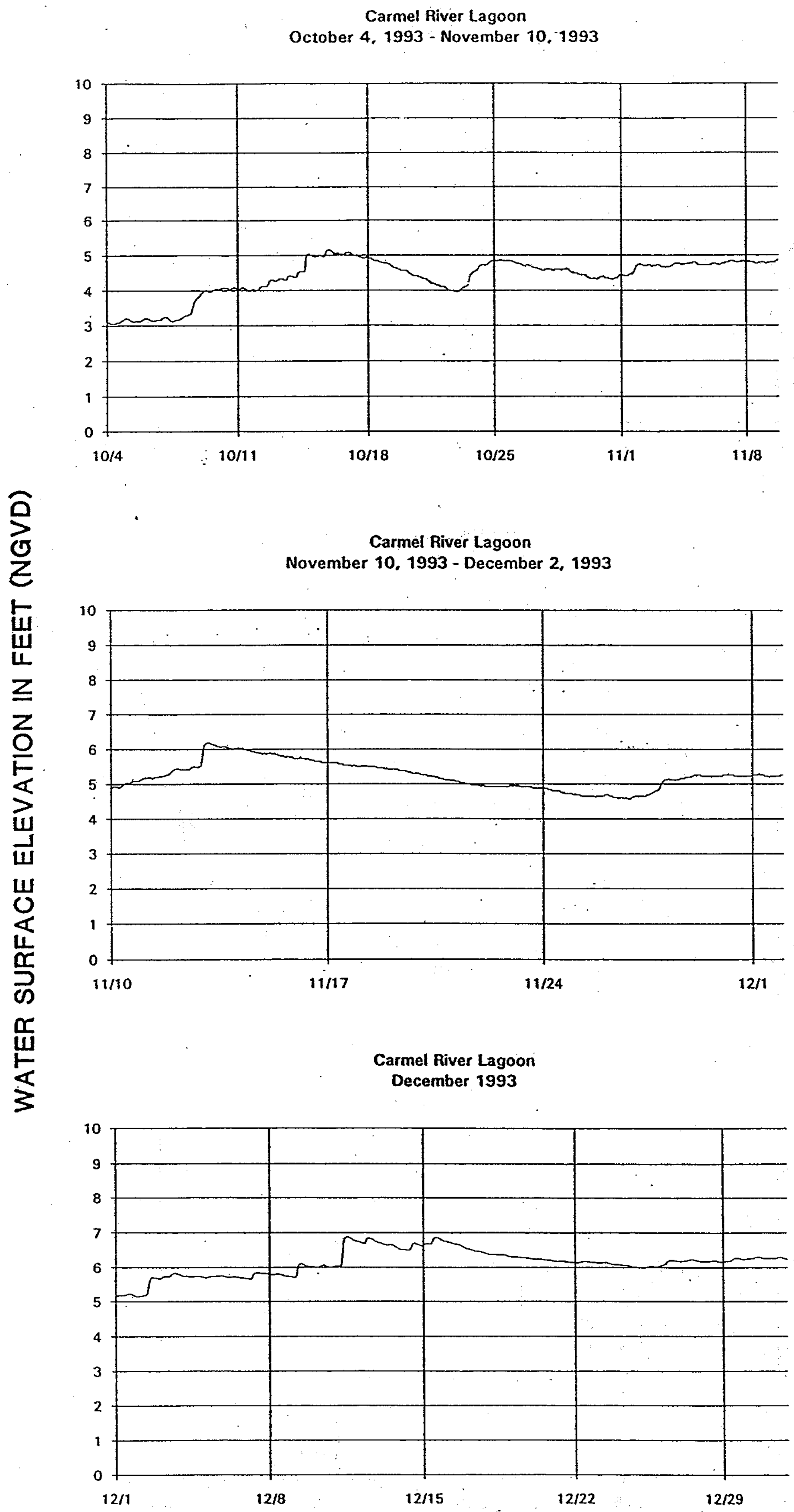

Carmel River Lagoon
October 4, 1993 - November 10, 1993
10
9
8
7
6
5
4
3
2
1
0
10/4
10/11
10/18
10/25
11/1
11/8
Carmel River Lagoon
November 10, 1993 - December 2, 1993
10
9
8
7
6
5
4
3
2
1
0
11/10
11/17
11/24
12/1
Carmel River Lagoon
December 1993
10
9
8
7
6
5
4
3
2
1
0
12/1
12/8
12/15
12/22
12/29
WATER SURFACE ELEVATION IN FEET (NGVD)

FIGURE A-10

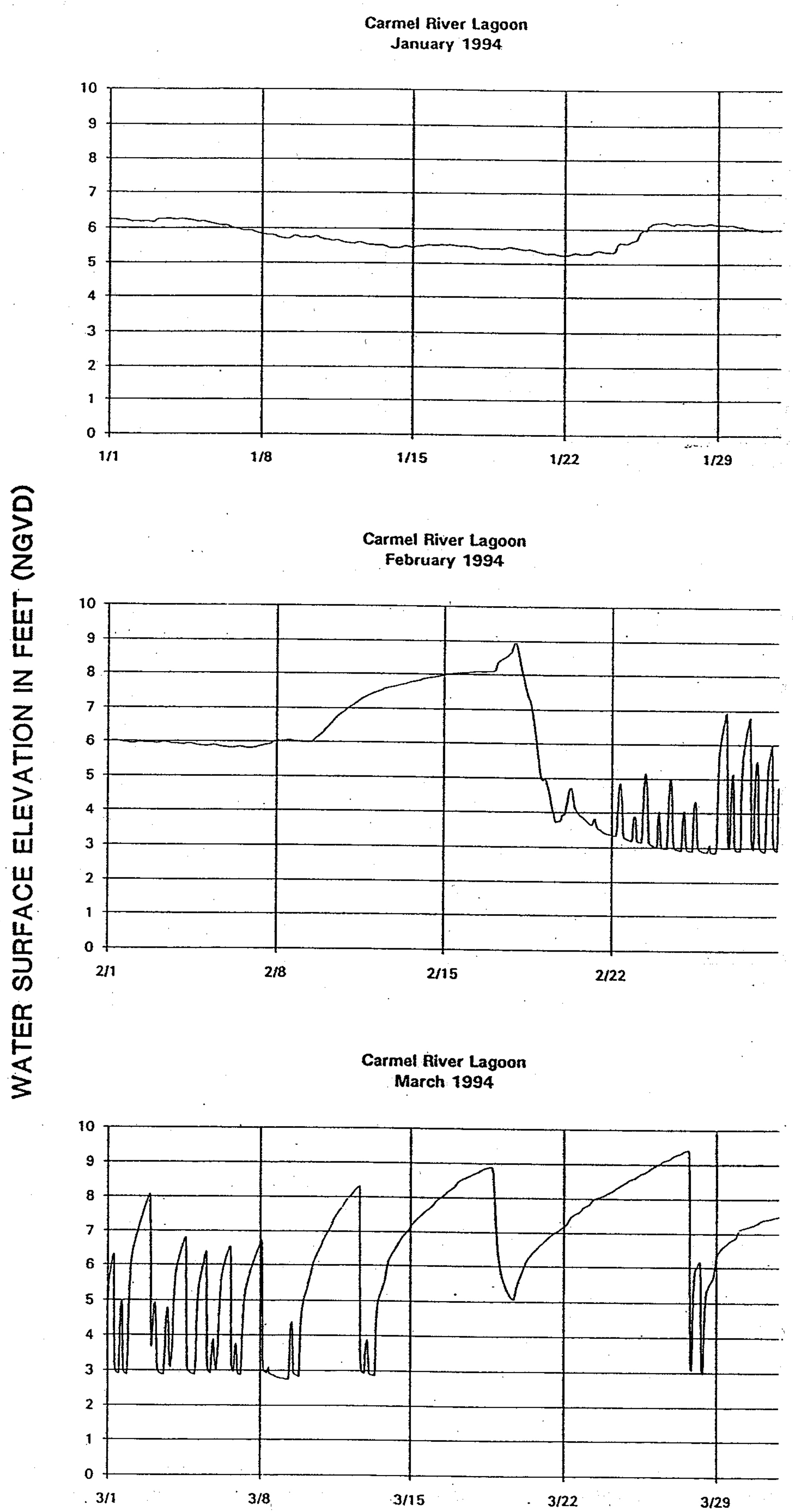

WATER SURFACE ELEVATION IN FEET (NGVD)
Carmel River Lagoon
January 1994
10
9
8
7
6
5
4
3
2
1
0
1/1
1/8
1/15
1/22
1/29
Carmel River Lagoon
February 1994
2/1
2/8
2/15
2/22
Carmel River Lagoon
March 1994
3/1
3/8
3/15
3/22
3/29

FIGURE A-11

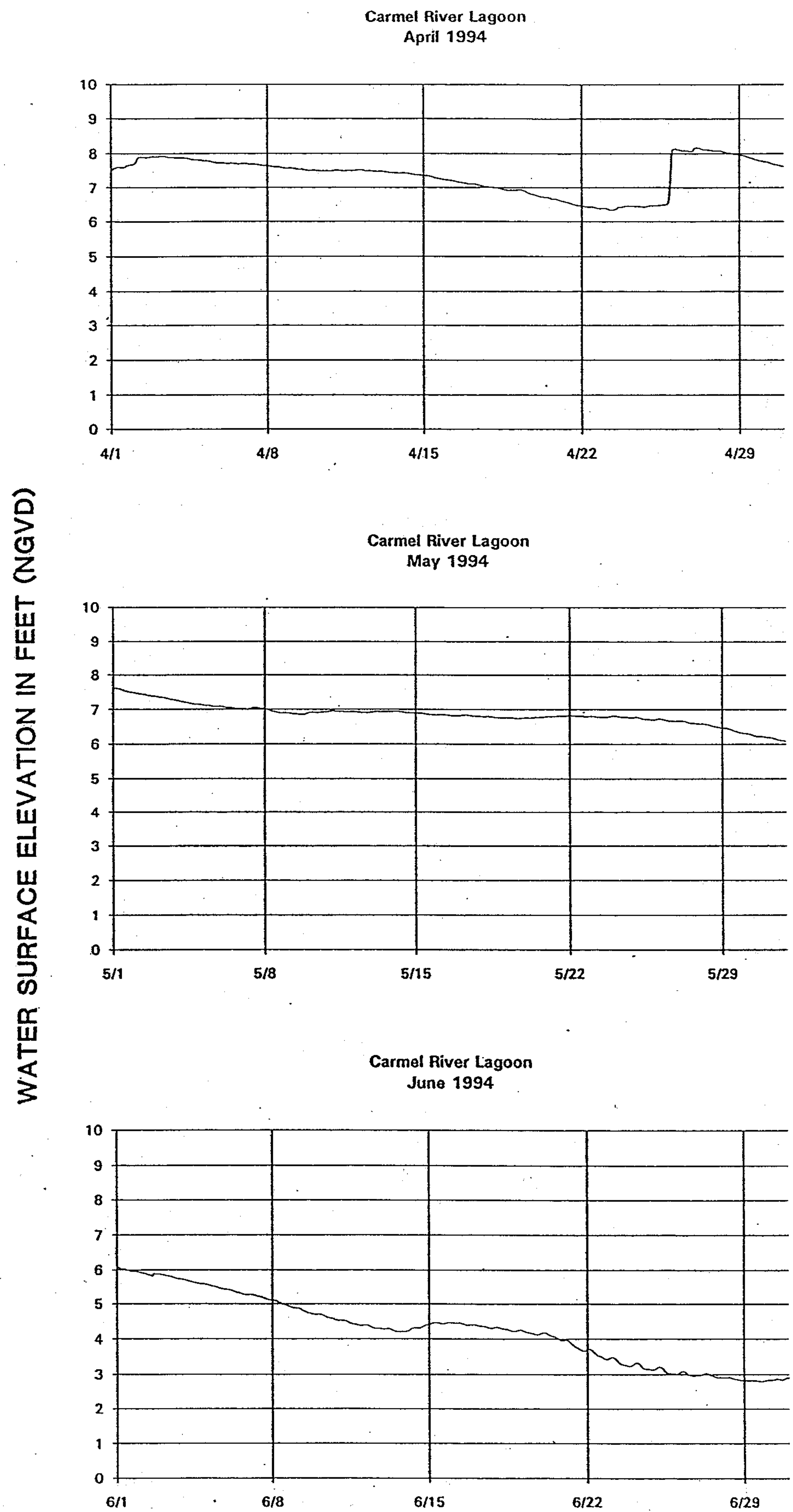
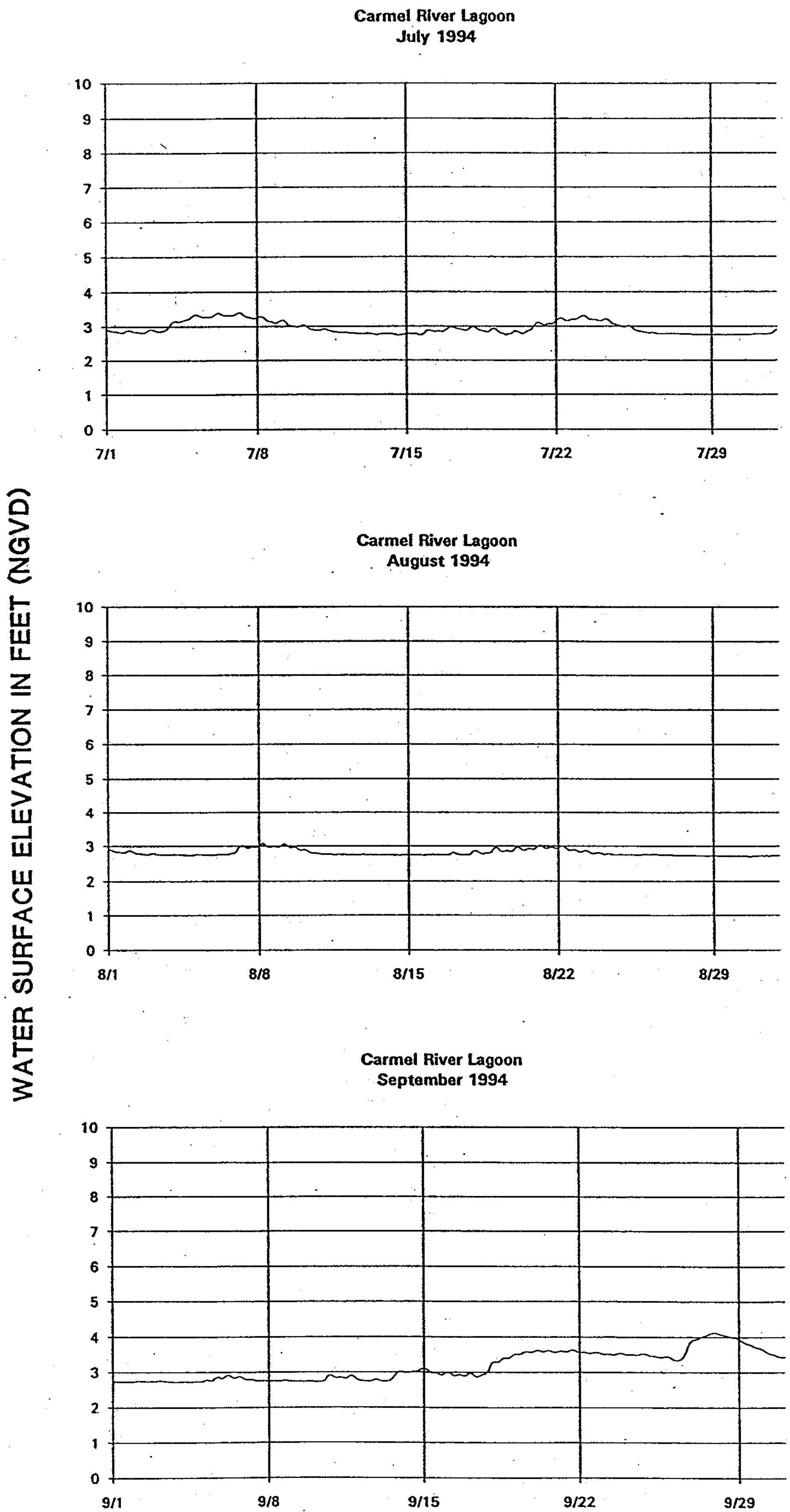
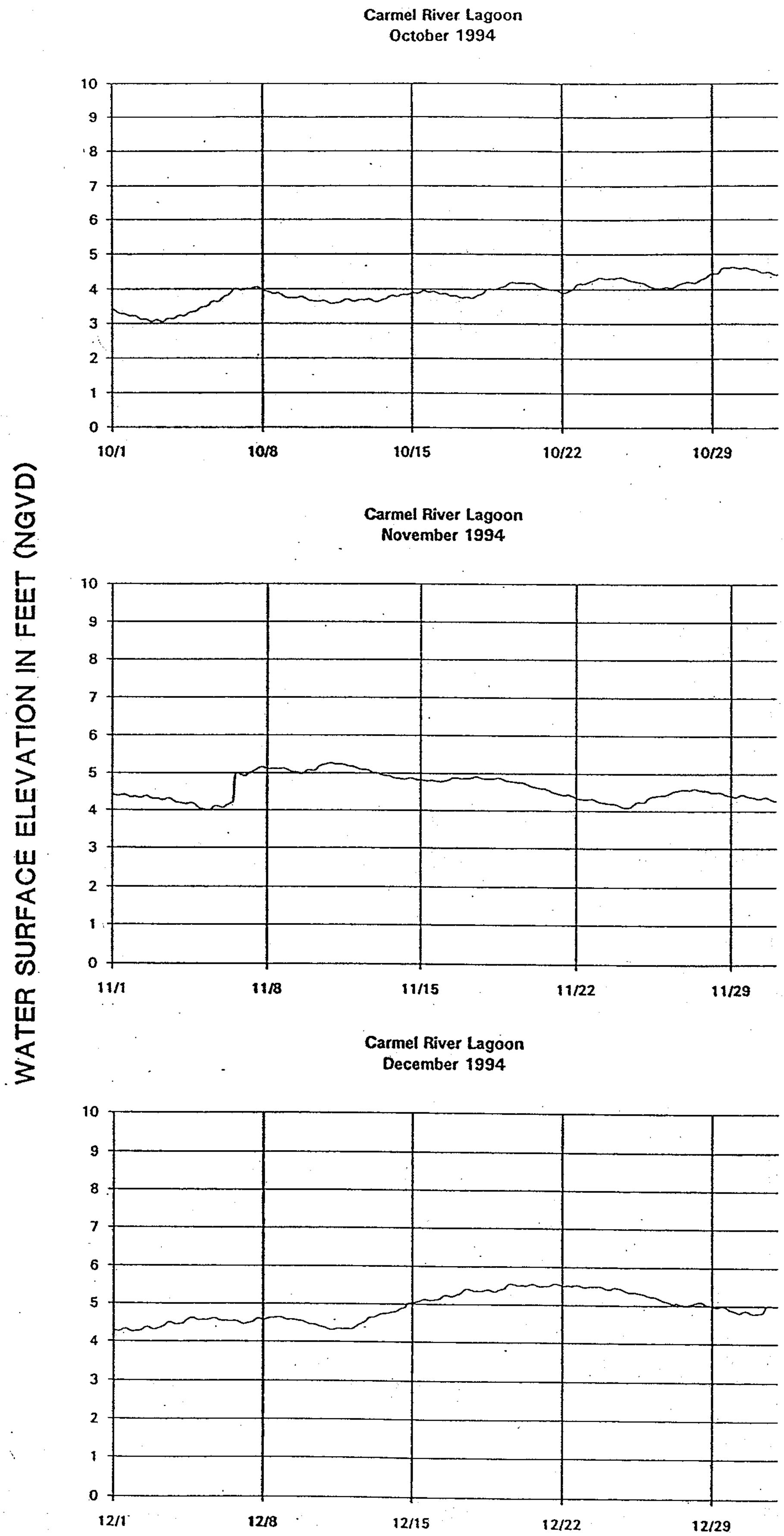

Carmel River Lagoon
April 1994
Carmel River Lagoon
May 1994
Carmel River Lagoon
June 1994
WATER SURFACE ELEVATION IN FEET (NGVD)
0
1
2
3
4
5
6
7
8
9
10
4/1
4/8
4/15
4/22
4/29
5/1
5/8
5/15
5/22
5/29
6/1
6/8
6/15
6/22
6/29

FIGURE A-12



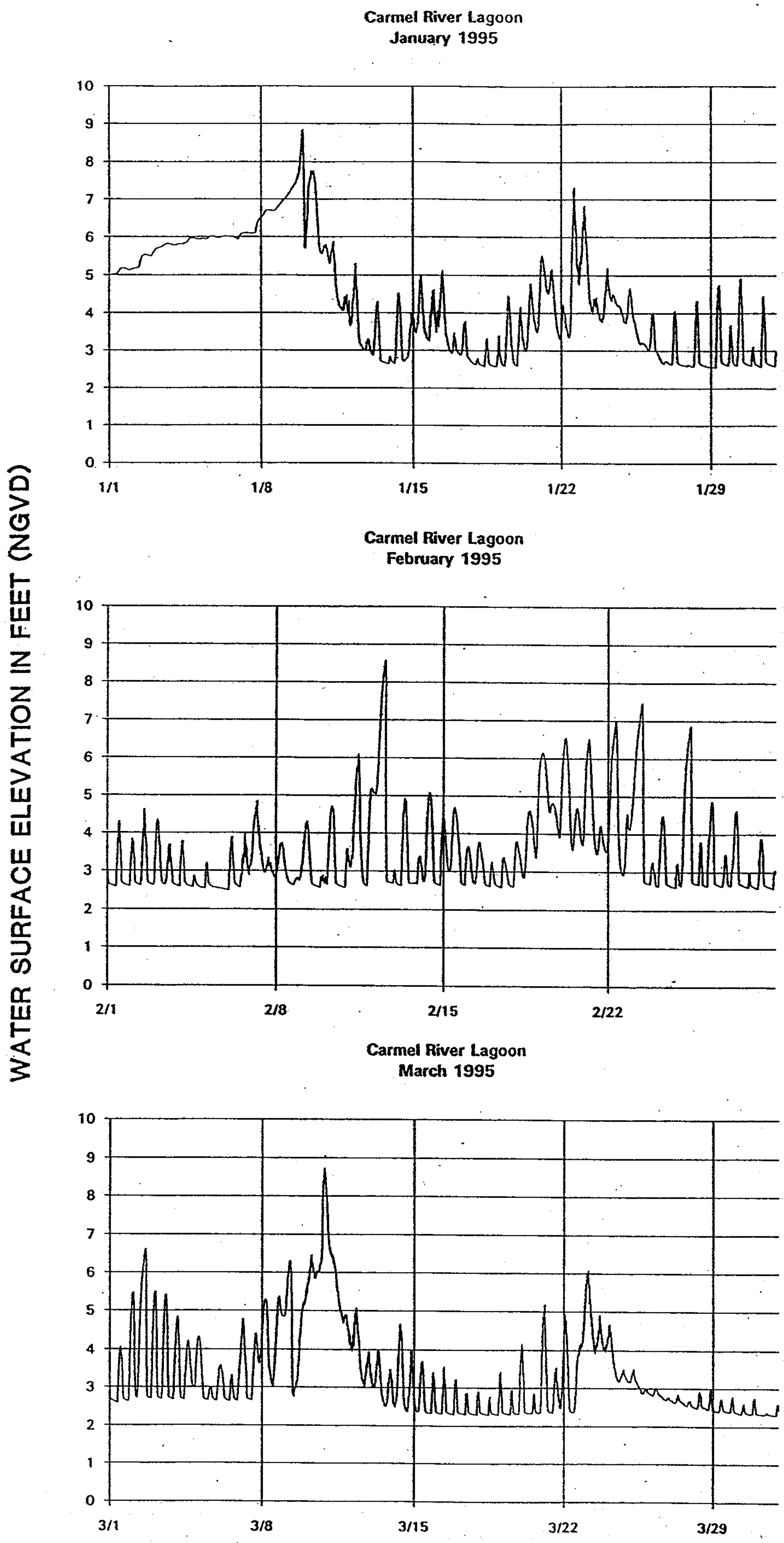
Carmel River Lagoon
July 1994
Carmel River Lagoon
August 1994
Carmel River Lagoon
September 1994
WATER SURFACE ELEVATION IN FEET (NGVD)
0
1
2
3
4
5
6
7
8
9
10
7/1
7/8
7/15
7/22
7/29
8/1
8/8
8/15
8/22
8/29
9/1
9/8
9/15
9/22
9/29

FIGURE A-13



Carmel River Lagoon
October 1994
Carmel River Lagoon
November 1994
Carmel River Lagoon
December 1994
WATER SURFACE ELEVATION IN FEET (NGVD)
0
1
2
3
4
5
6
7
8
9
10
10/1
10/8
10/15
10/22
10/29
11/1
11/8
11/15
11/22
11/29
12/1
12/8
12/15
12/22
12/29

FIGURE A-14



WATER SURFACE ELEVATION IN FEET (NGVD)
Carmel River Lagoon
January 1995
0
1
2
3
4
5
6
7
8
9
10
1/1
1/8
1/15
1/22
1/29
Carmel River Lagoon
February 1995
2/1
2/8
2/15
2/22
Carmel River Lagoon
March 1995
3/1
3/8
3/15
3/22
3/29

FIGURE A-15

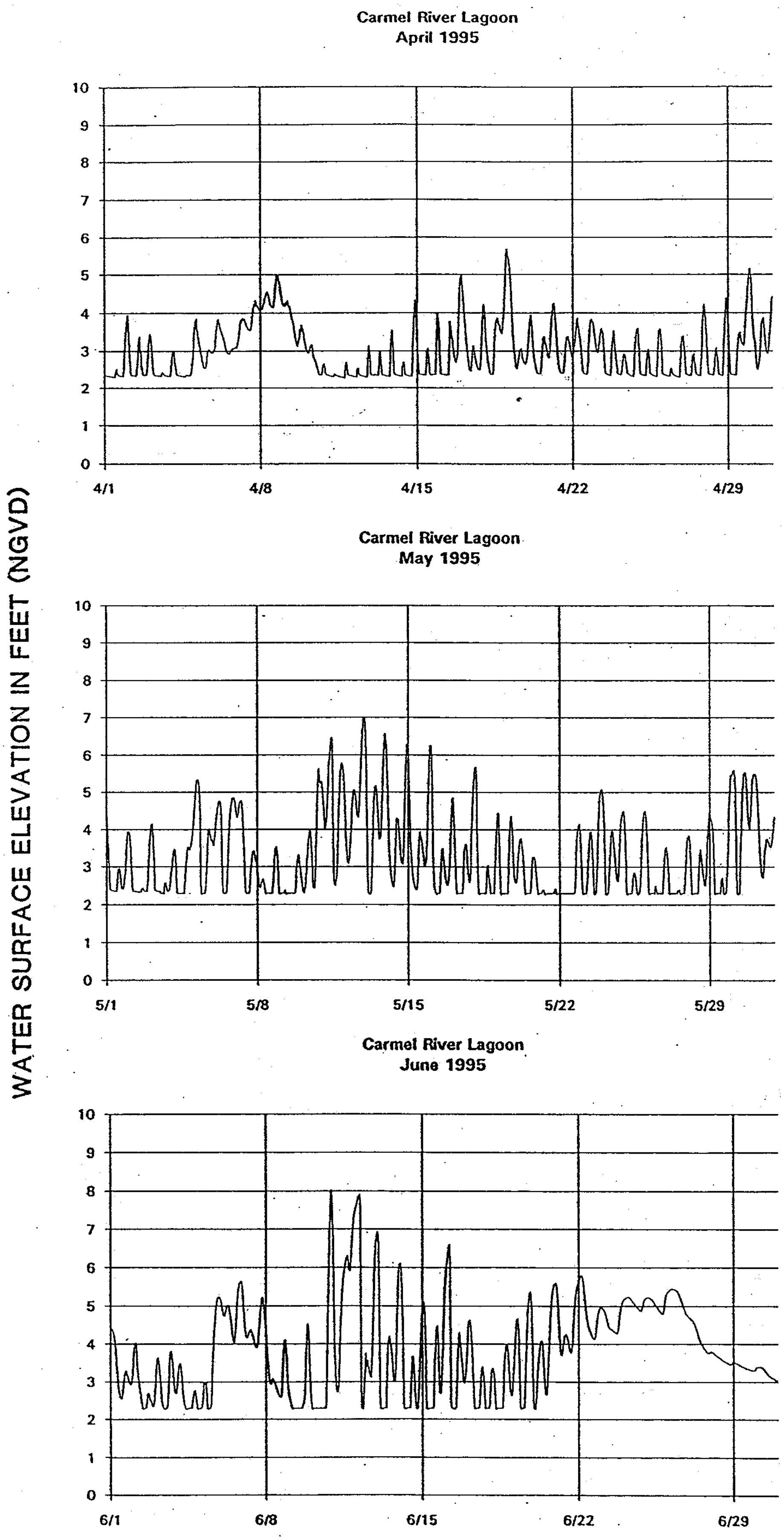

Carmel River Lagoon
April 1995
Carmel River Lagoon
May 1995
Carmel River Lagoon
June 1995
WATER SURFACE ELEVATION IN FEET (NGVD)
0
1
2
3
4
5
6
7
8
9
10
4/1
4/8
4/15
4/22
4/29
5/1
5/8
5/15
5/22
5/29
6/1
6/8
6/15
6/22
6/29

FIGURE A-16

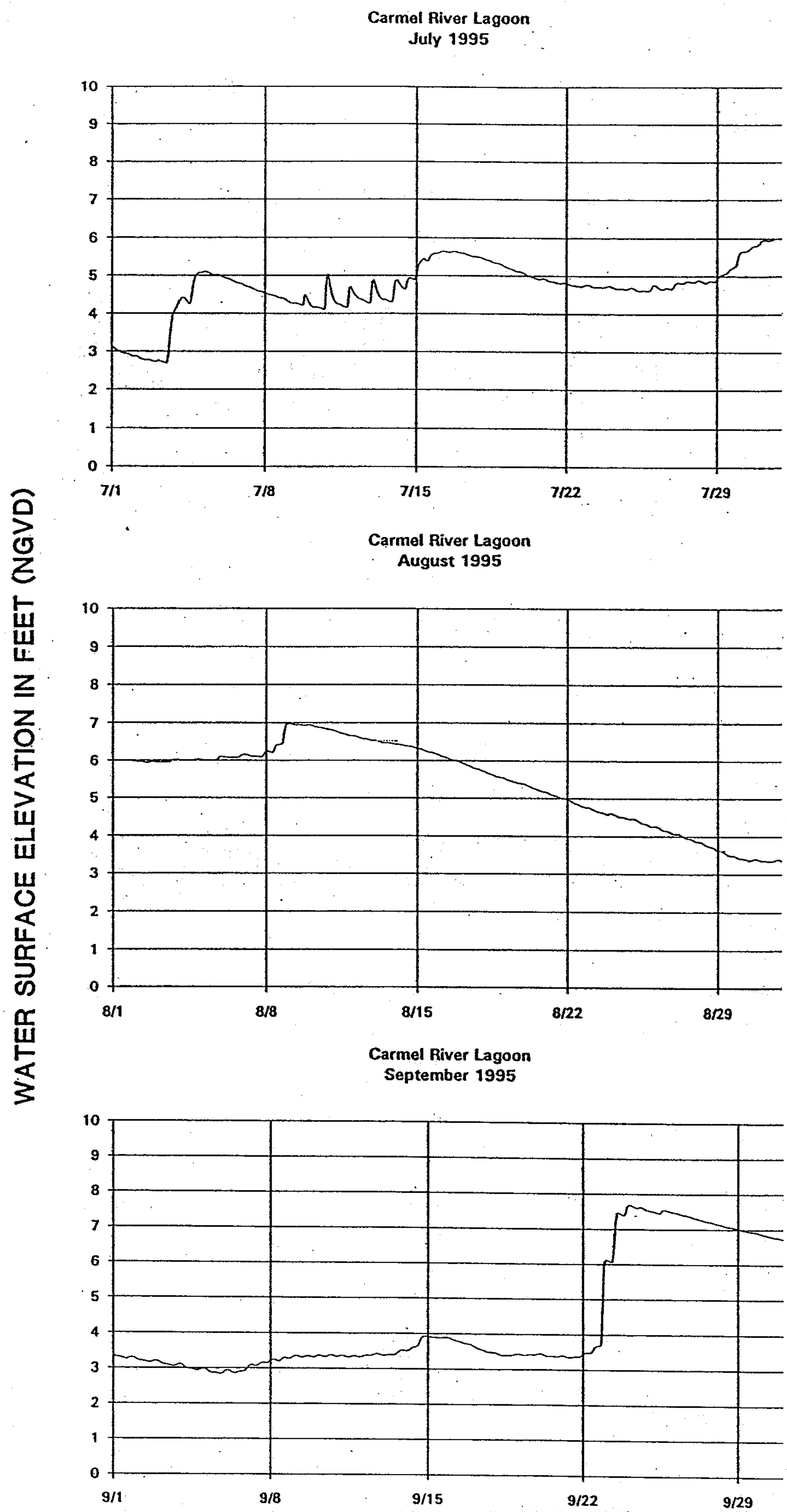

Carmel River Lagoon
July 1995
0 1 2 3 4 5 6 7 8 9 10
7/1 7/8 7/15 7/22 7/29
Carmel River Lagoon
August 1995
0 1 2 3 4 5 6 7 8 9 10
8/1 8/8 8/15 8/22 8/29
Carmel River Lagoon
September 1995
0 1 2 3 4 5 6 7 8 9 10
9/1 9/8 9/15 9/22 9/29
WATER SURFACE ELEVATION IN FEET (NGVD)

FIGURE A-17

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

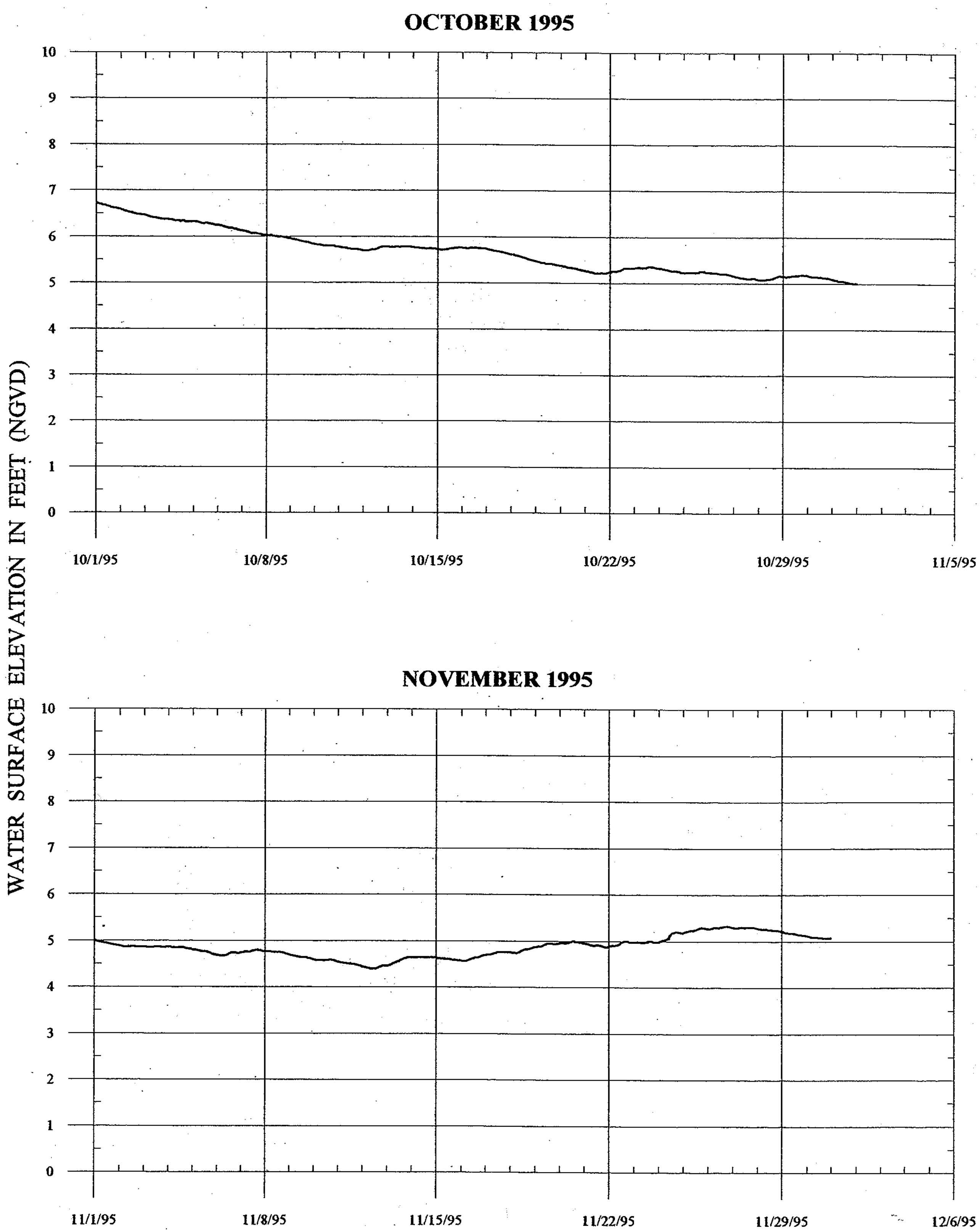
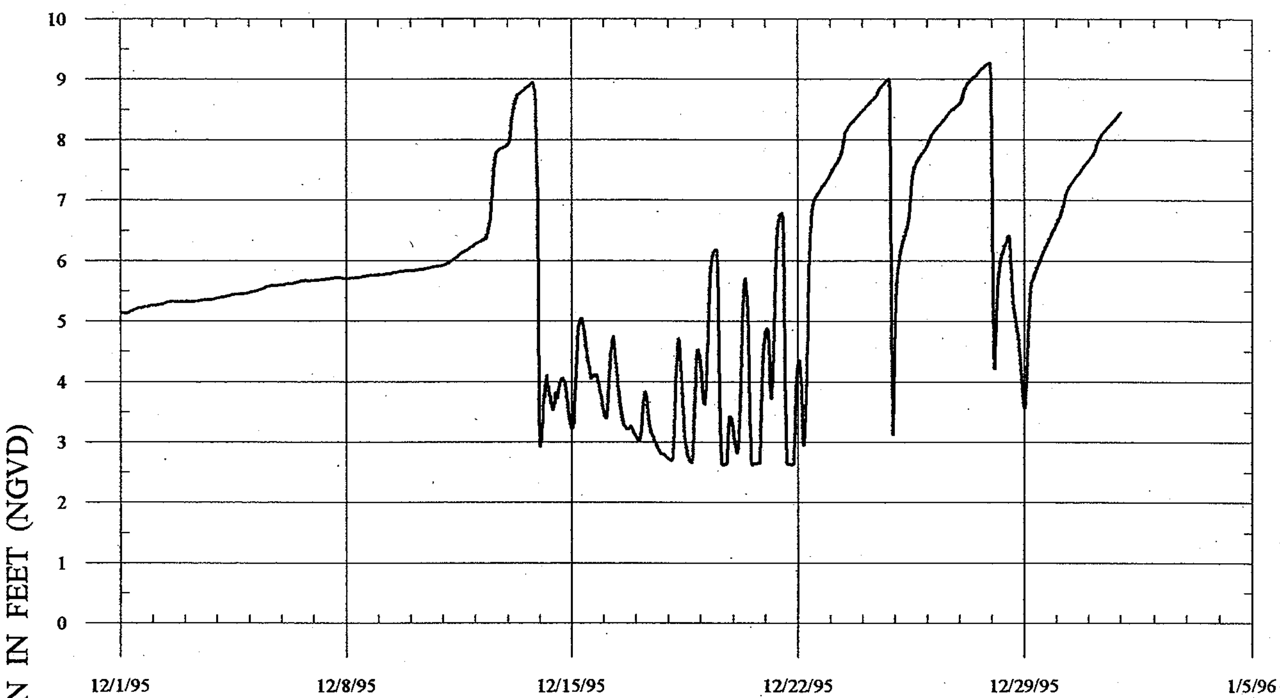


FIGURE A-18

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

DECEMBER 1995



JANUARY 1996

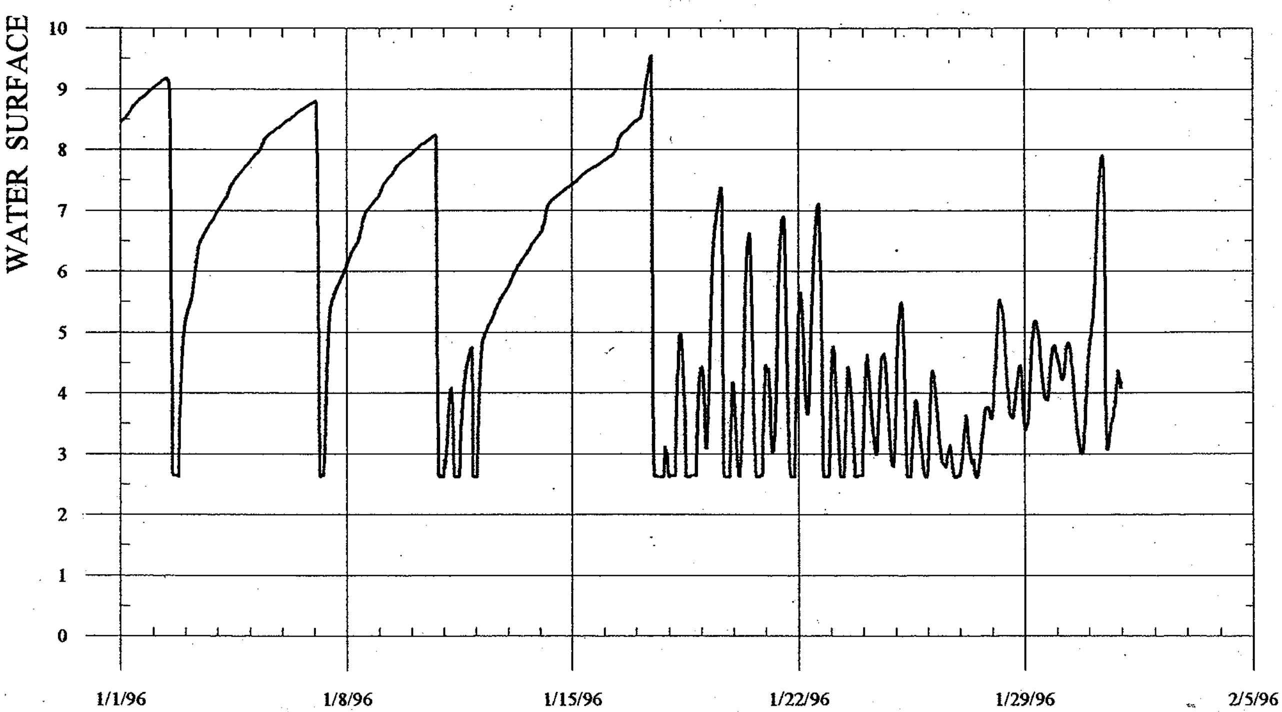
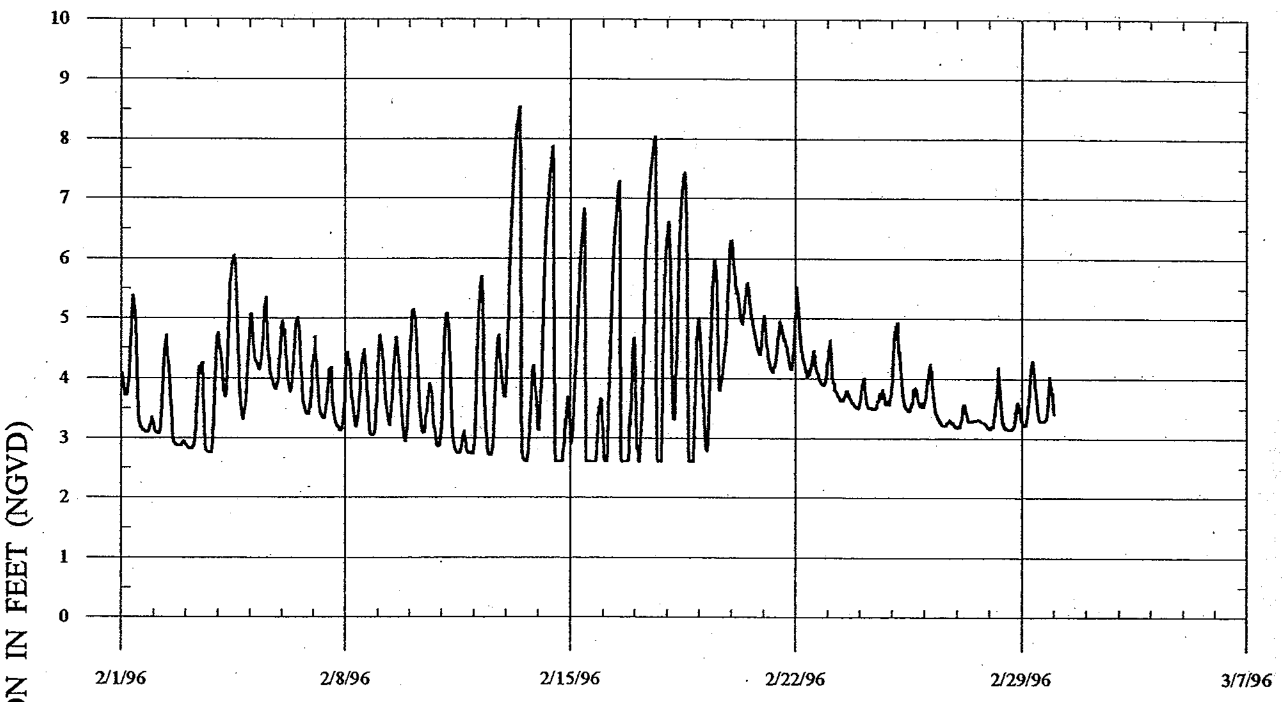


FIGURE A-19

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 1996



MARCH 1996

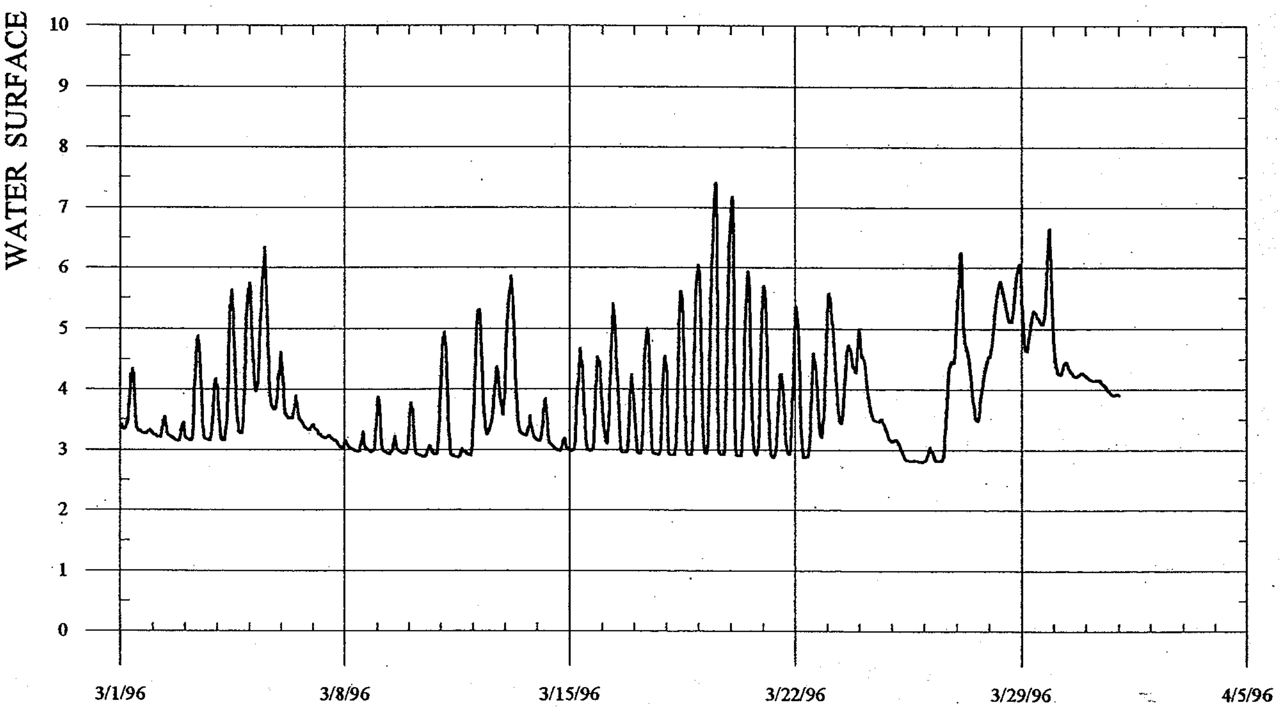


FIGURE A-20

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

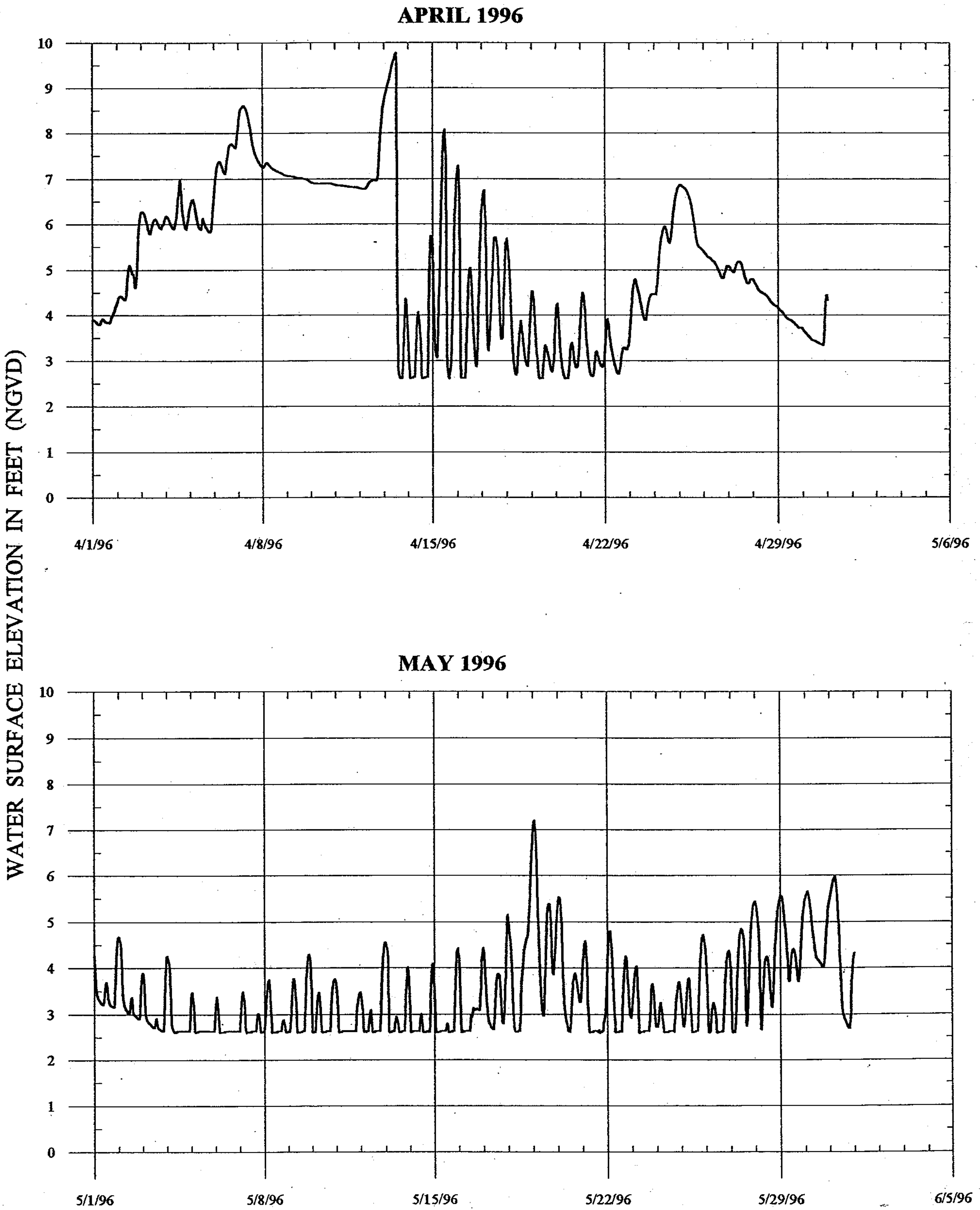
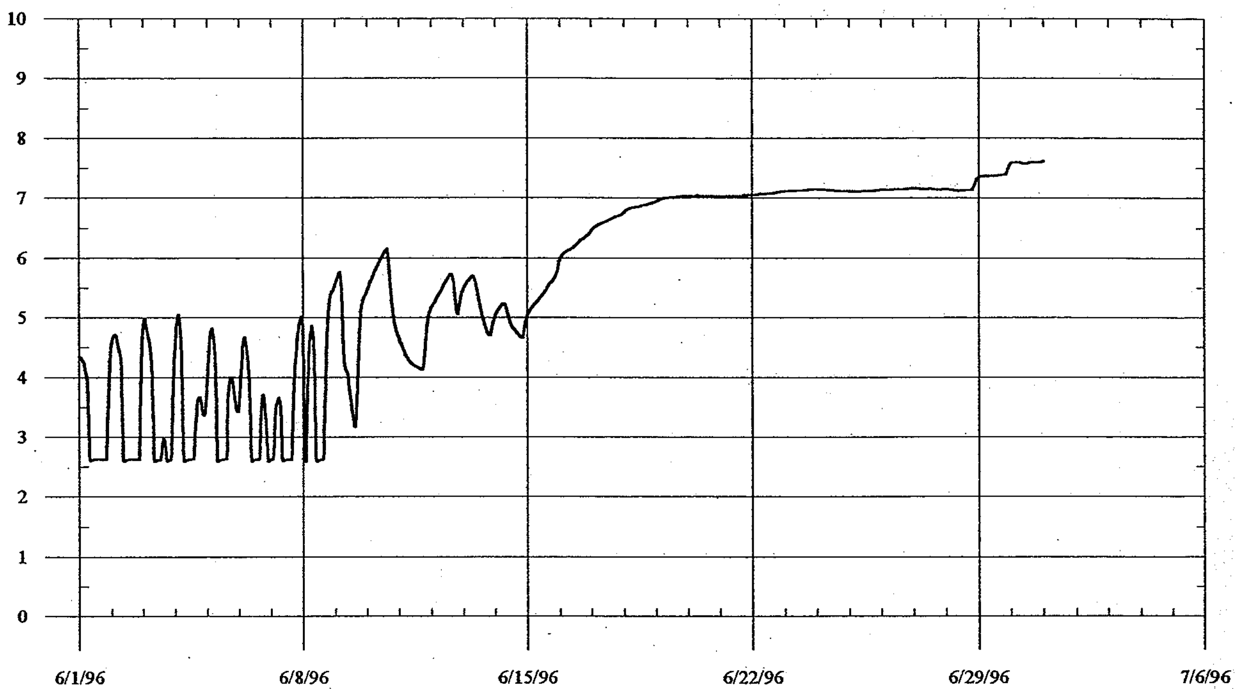


FIGURE A-21

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

JUNE 1996



WATER SURFACE ELEVATION IN FEET (NGVD)

JULY 1996

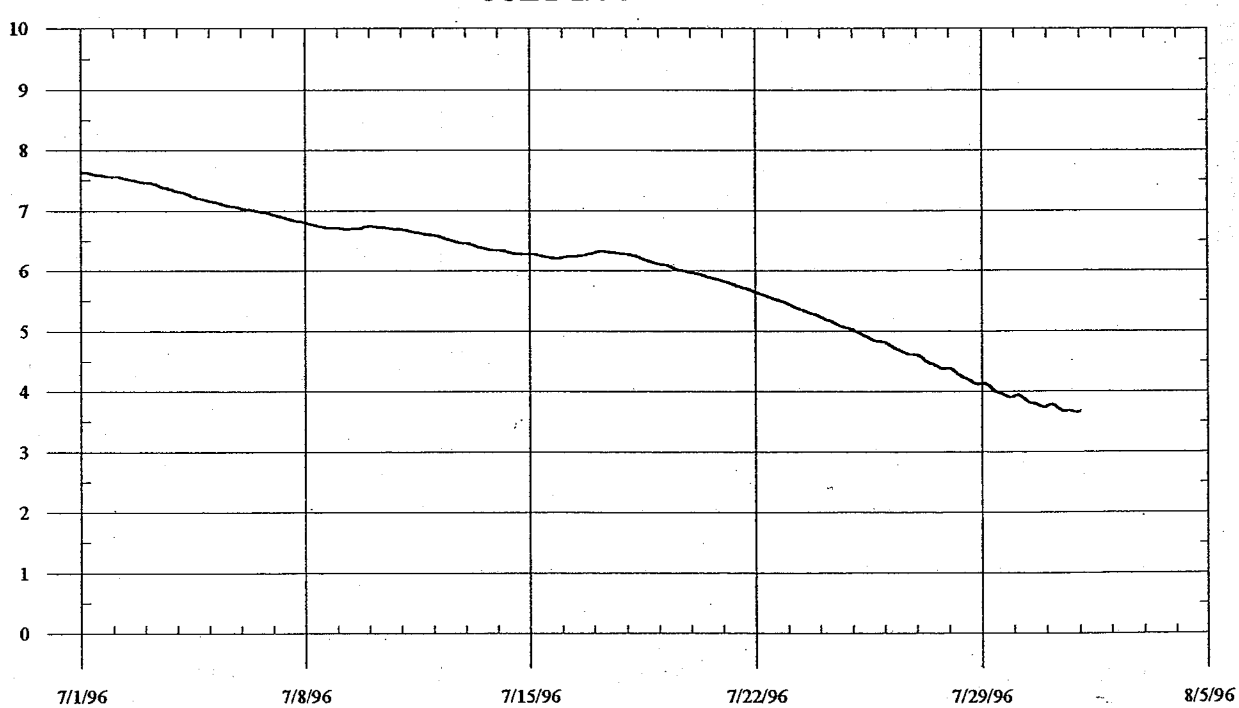
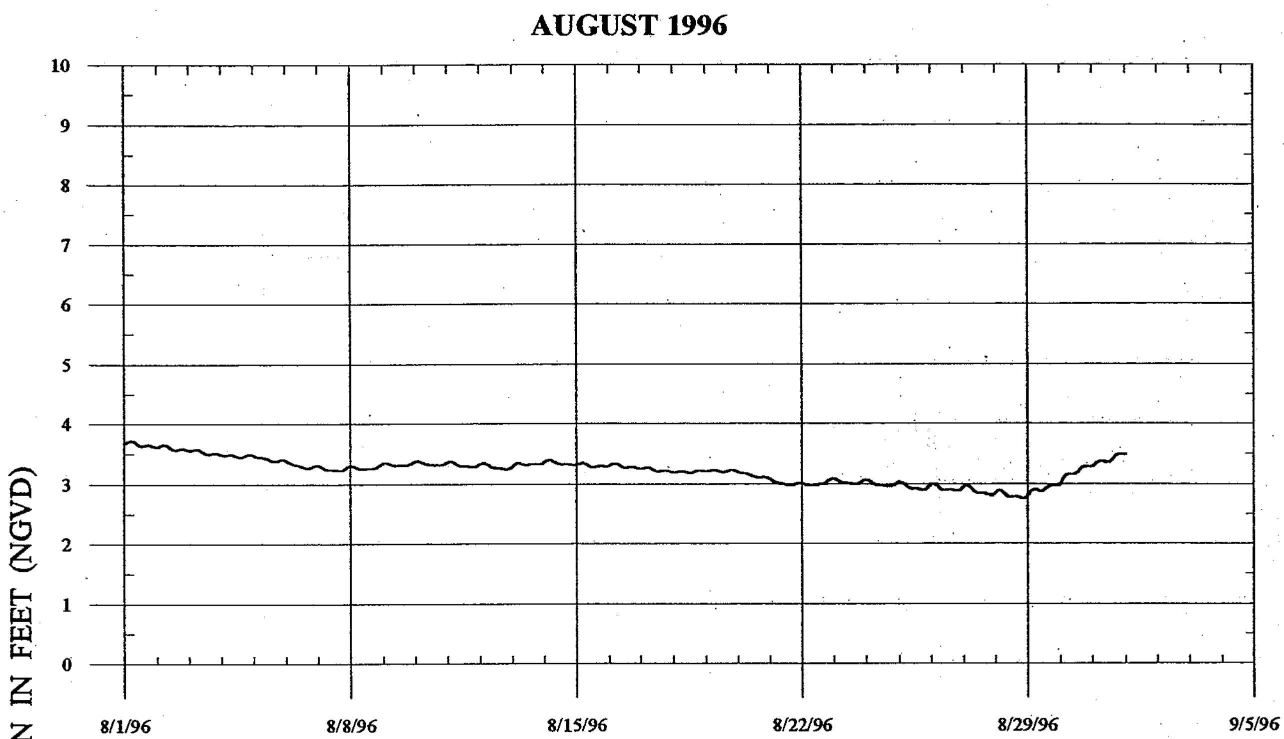


FIGURE A-22

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



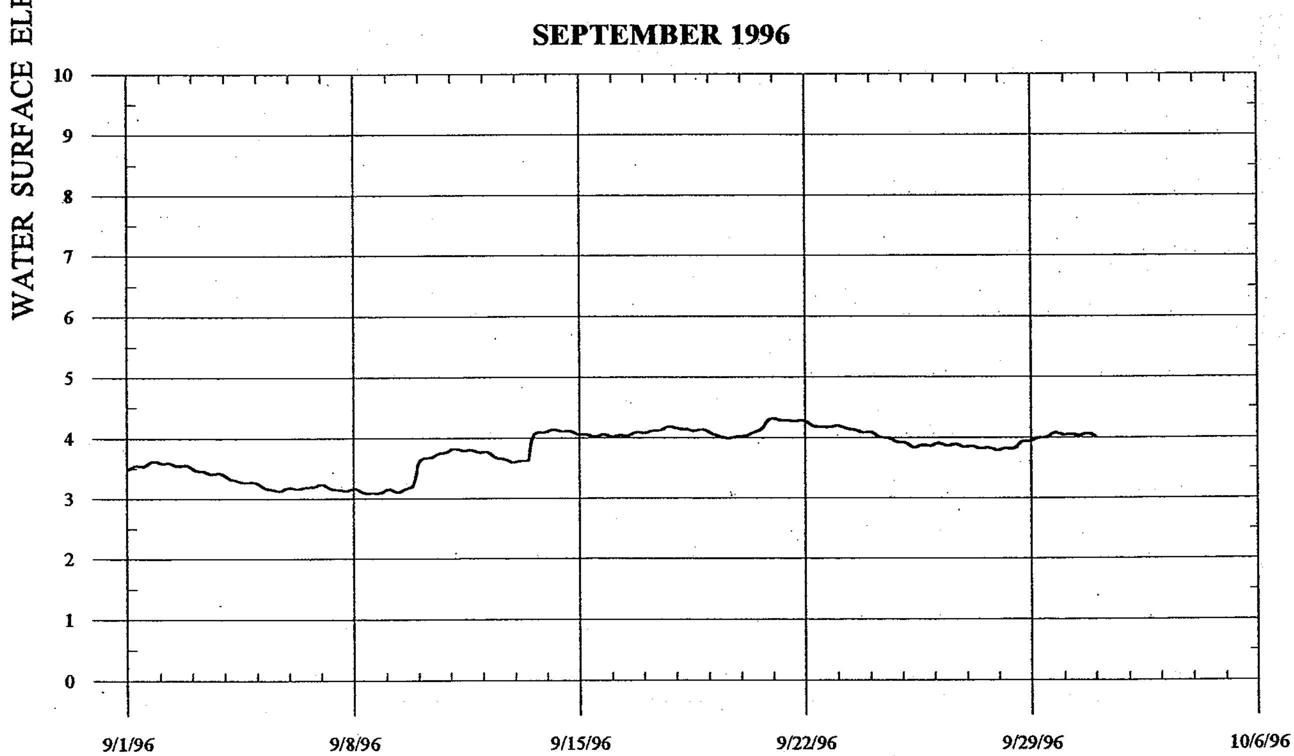


FIGURE A-23

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

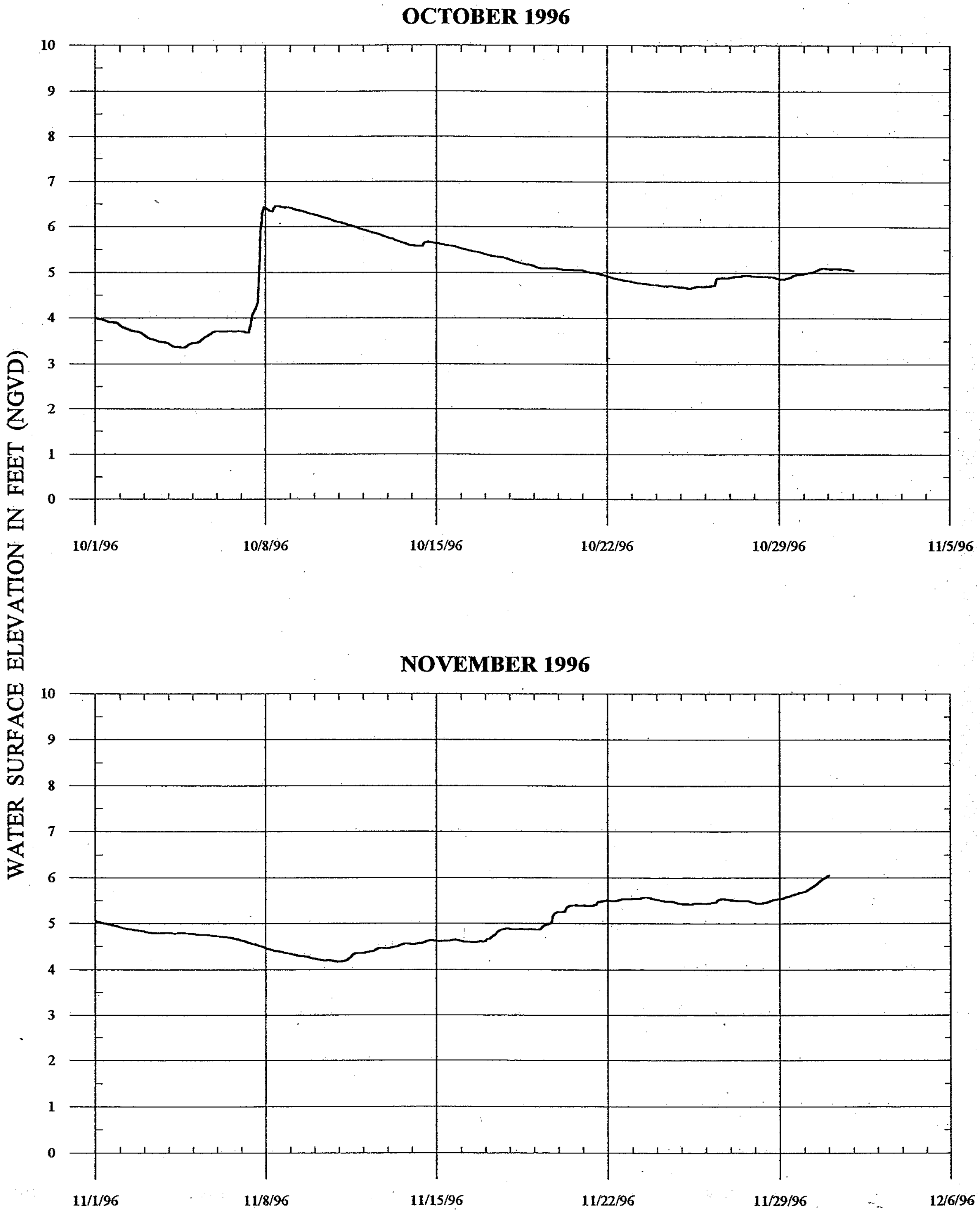
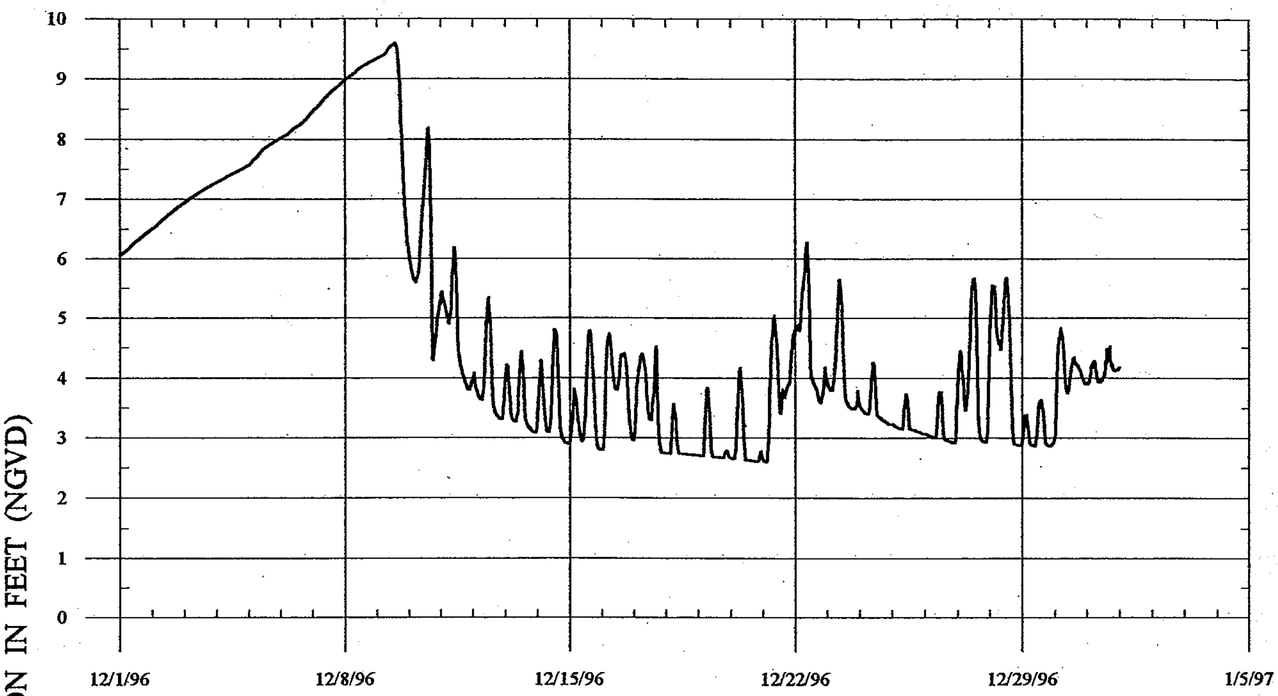


FIGURE A-24

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

DECEMBER 1996



JANUARY 1997

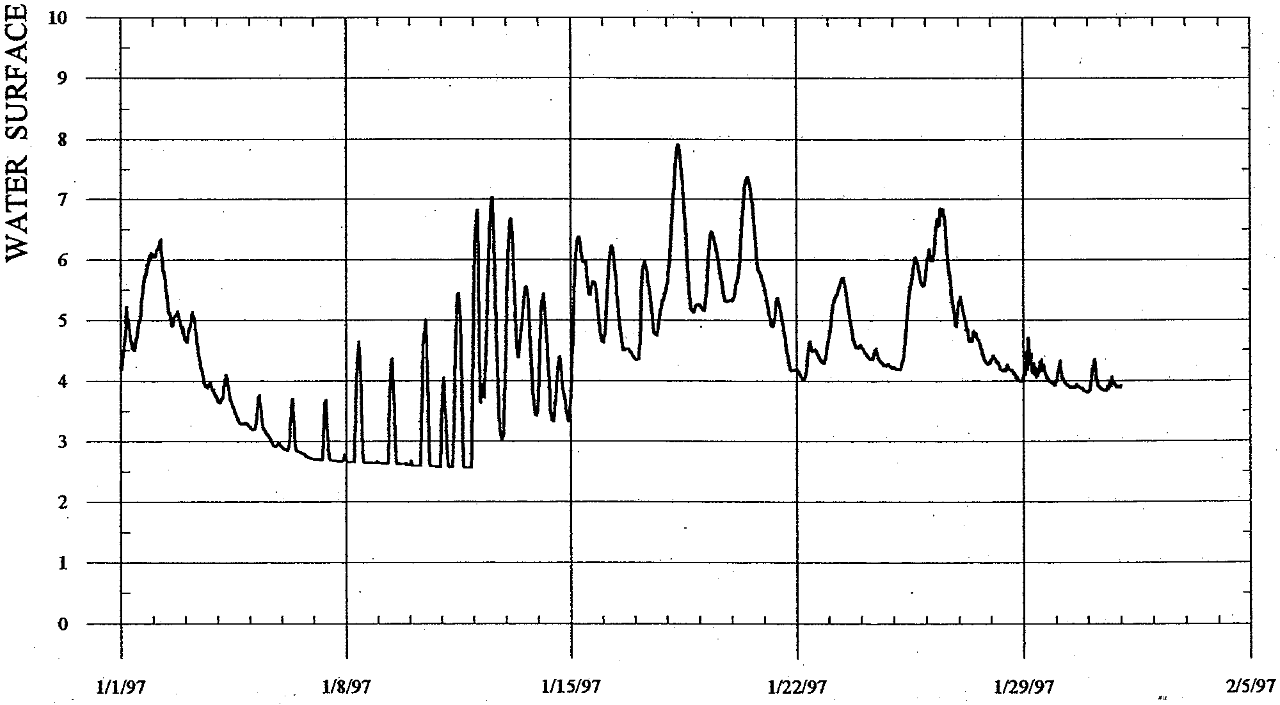
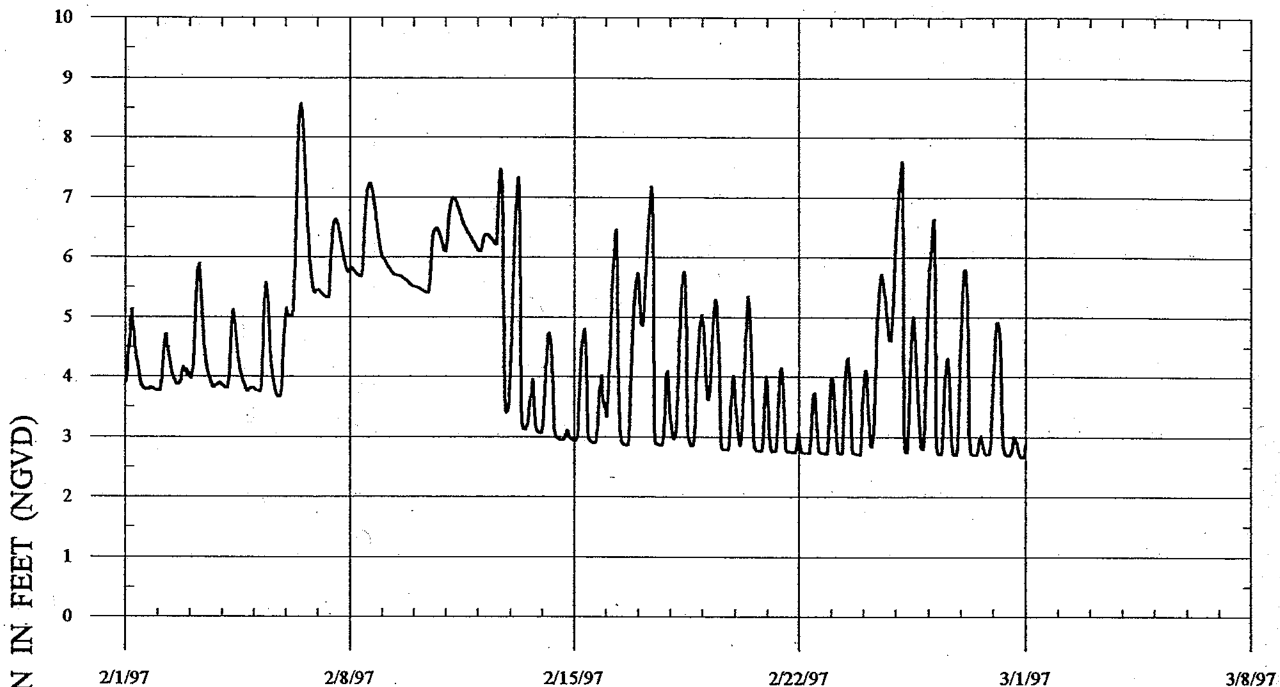


FIGURE A-25

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 1997



MARCH 1997

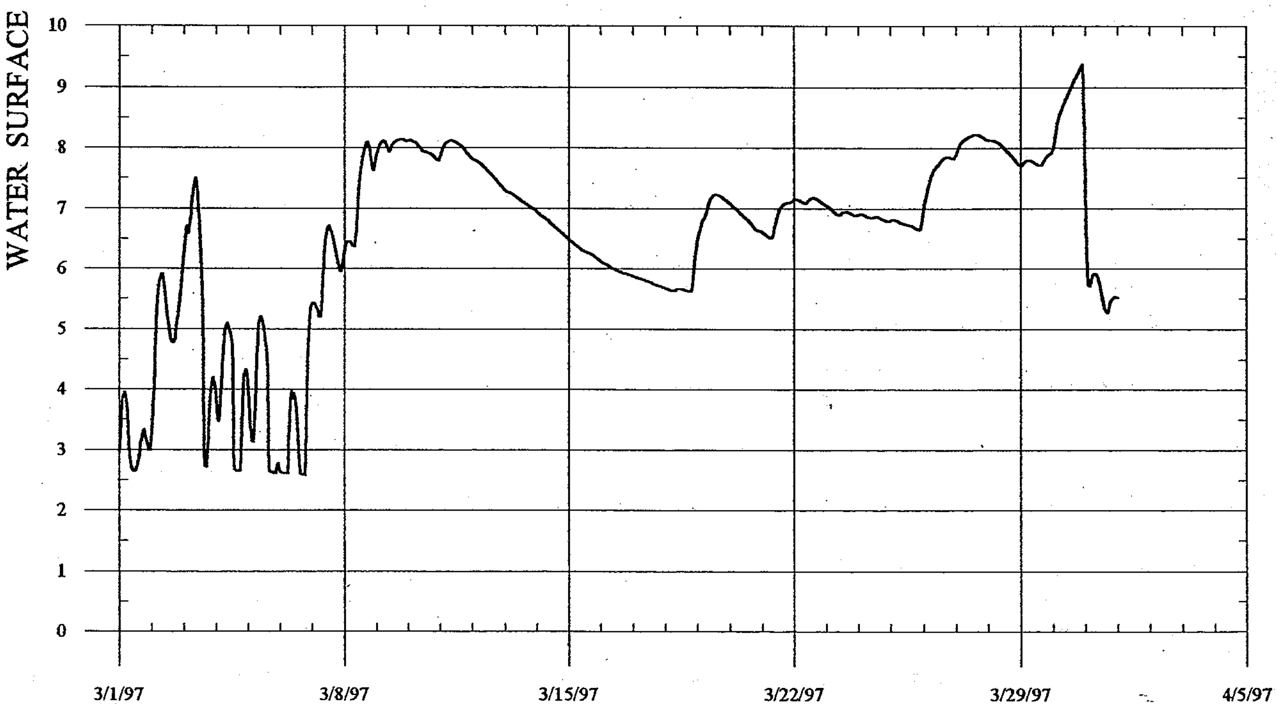
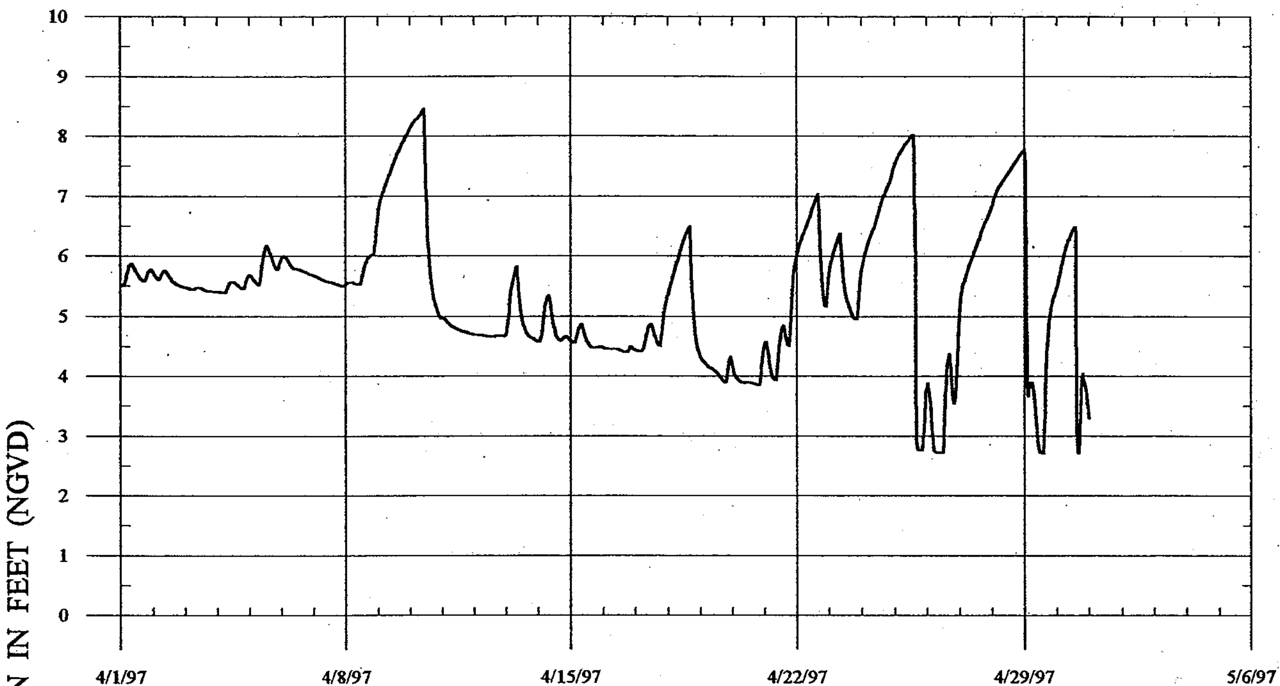


FIGURE A-26

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 1997



MAY 1997

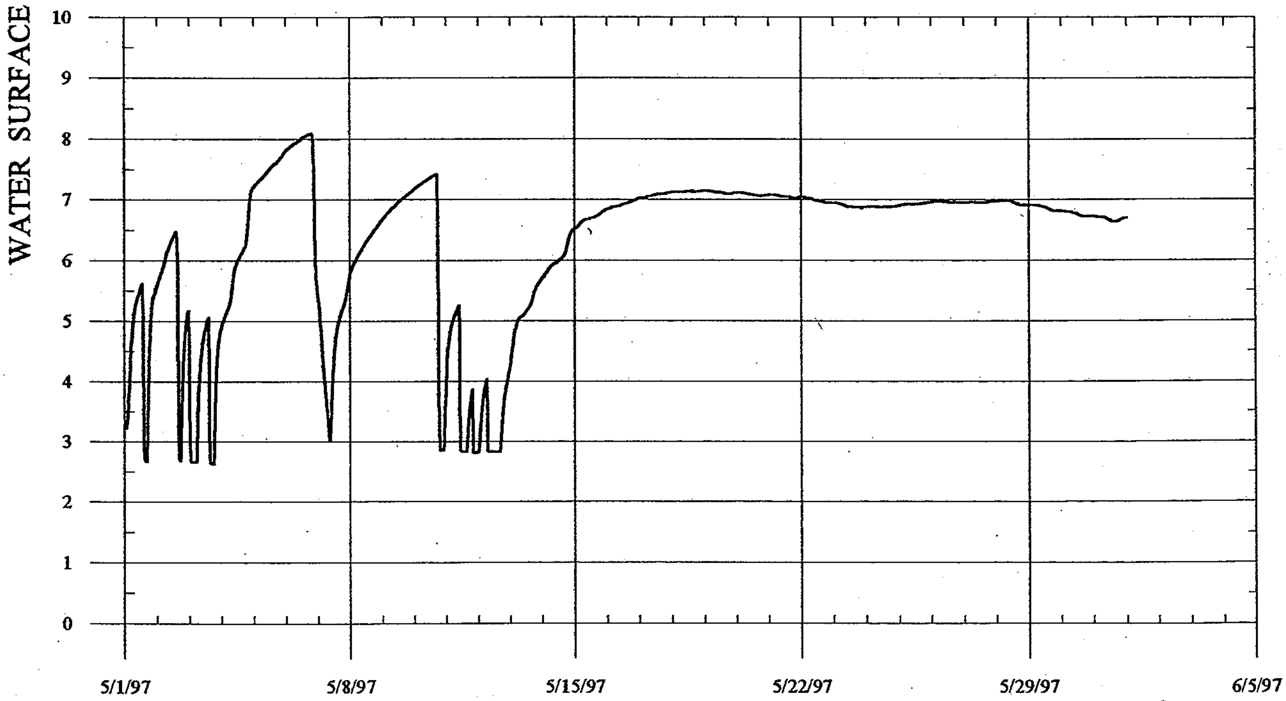
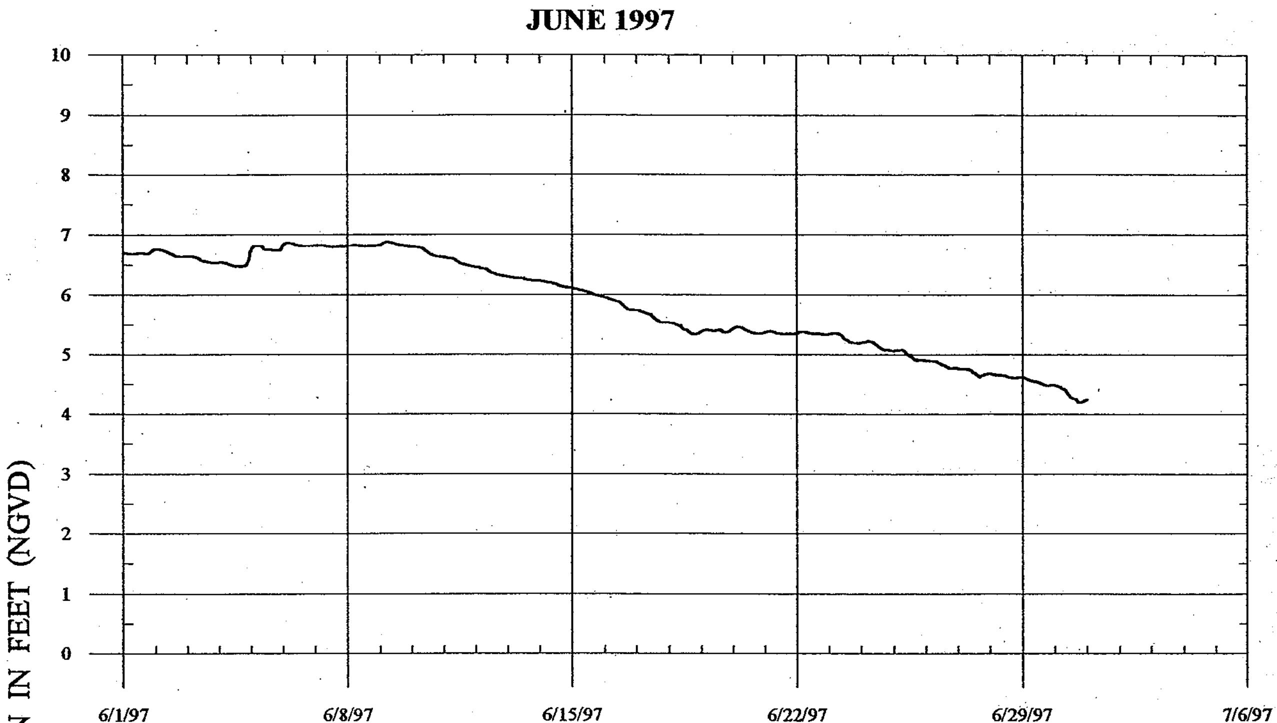


FIGURE A-27

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



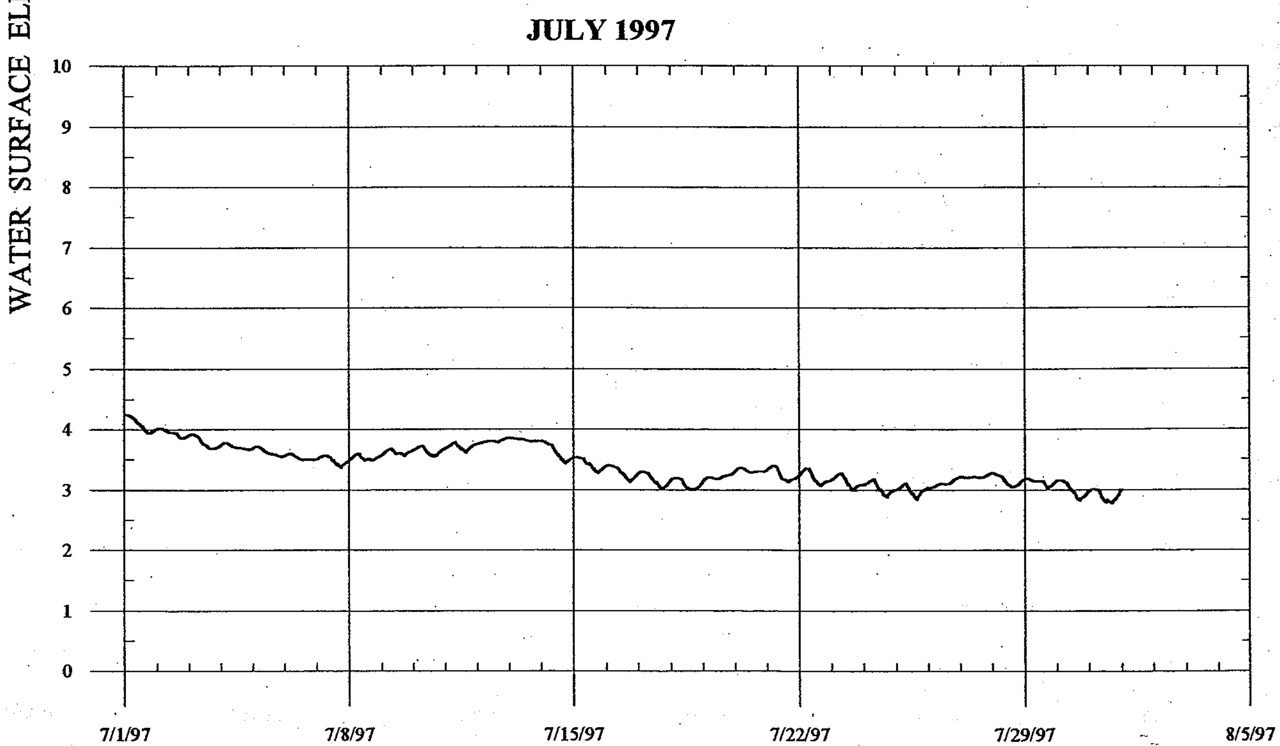


FIGURE A-28

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

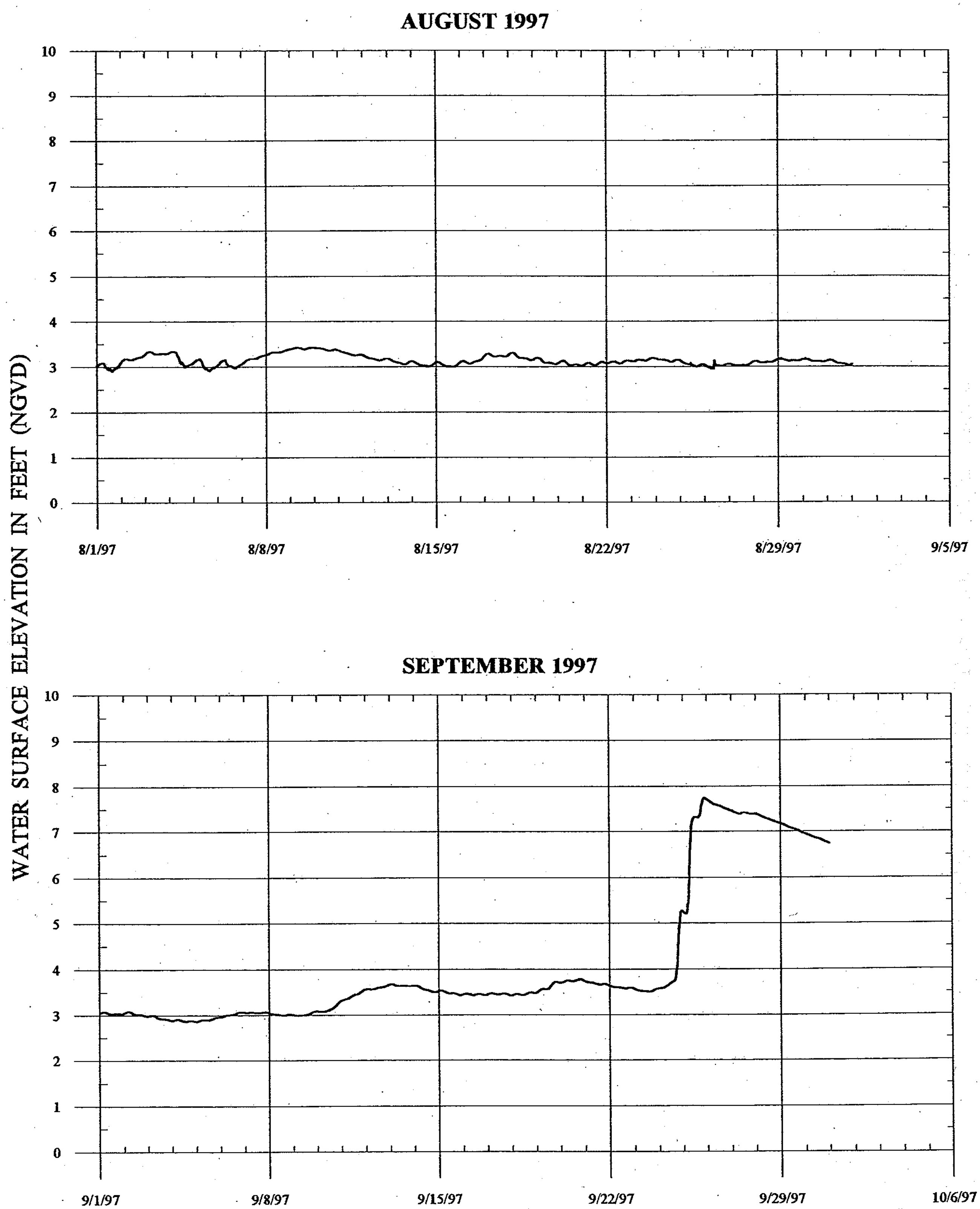
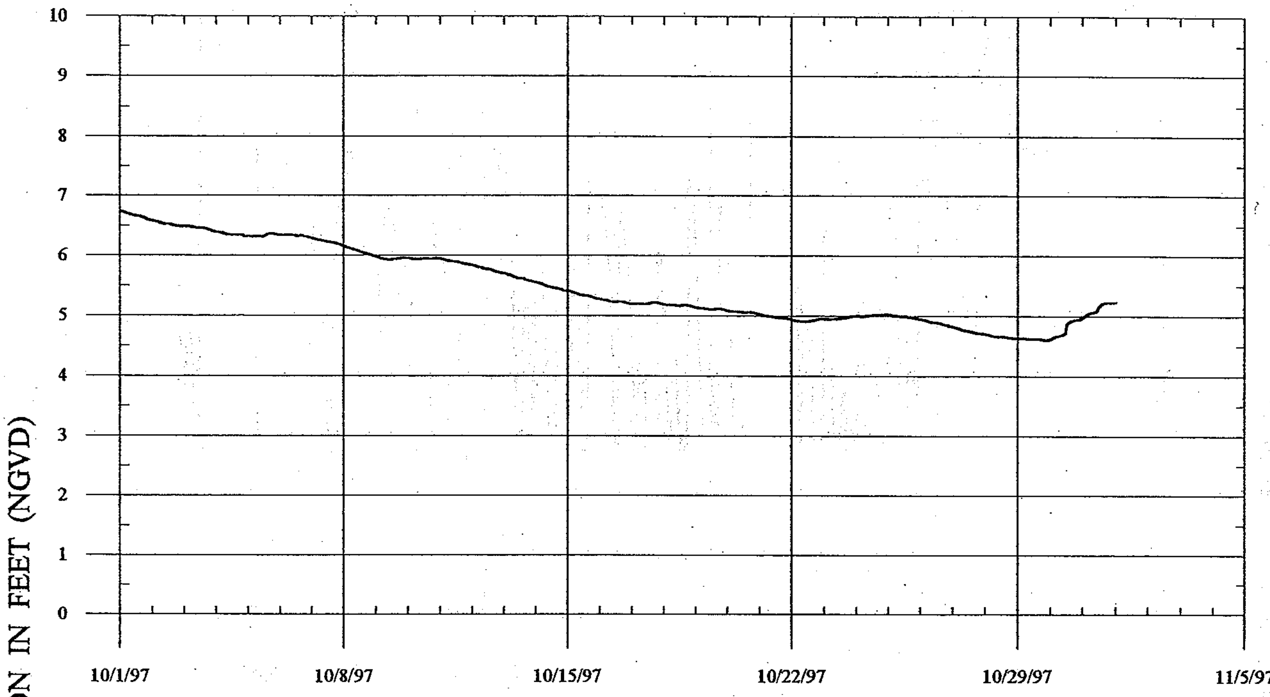


FIGURE A-29

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

OCTOBER 1997



NOVEMBER 1997

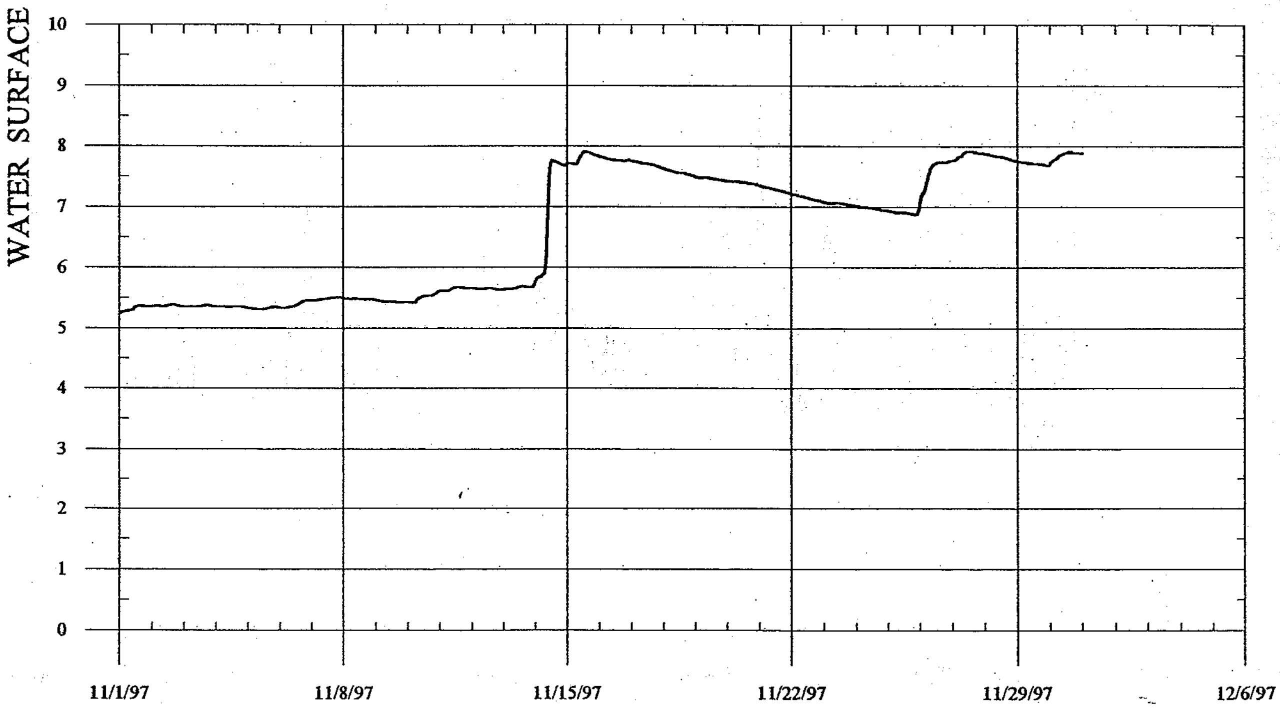


FIGURE A-30

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

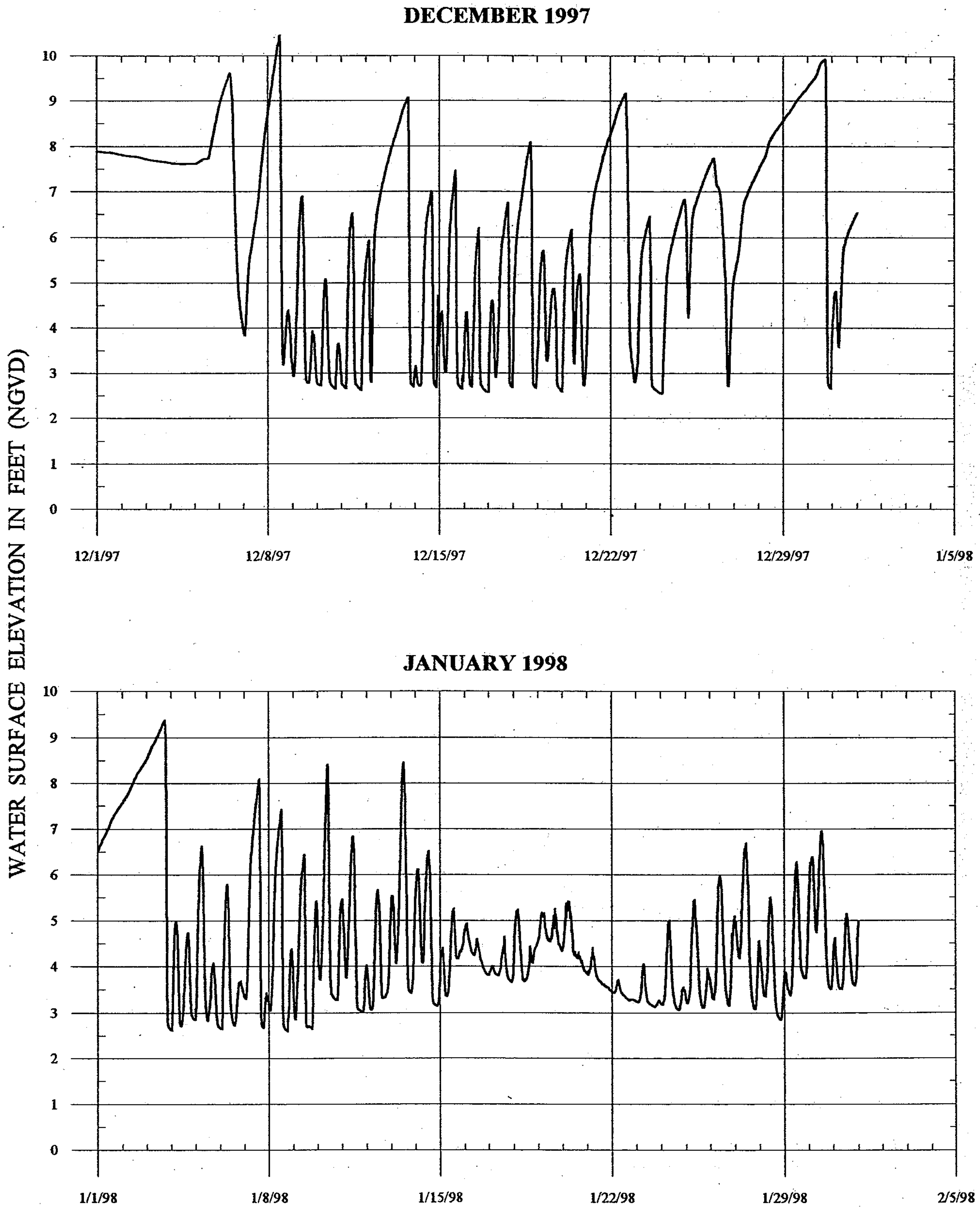
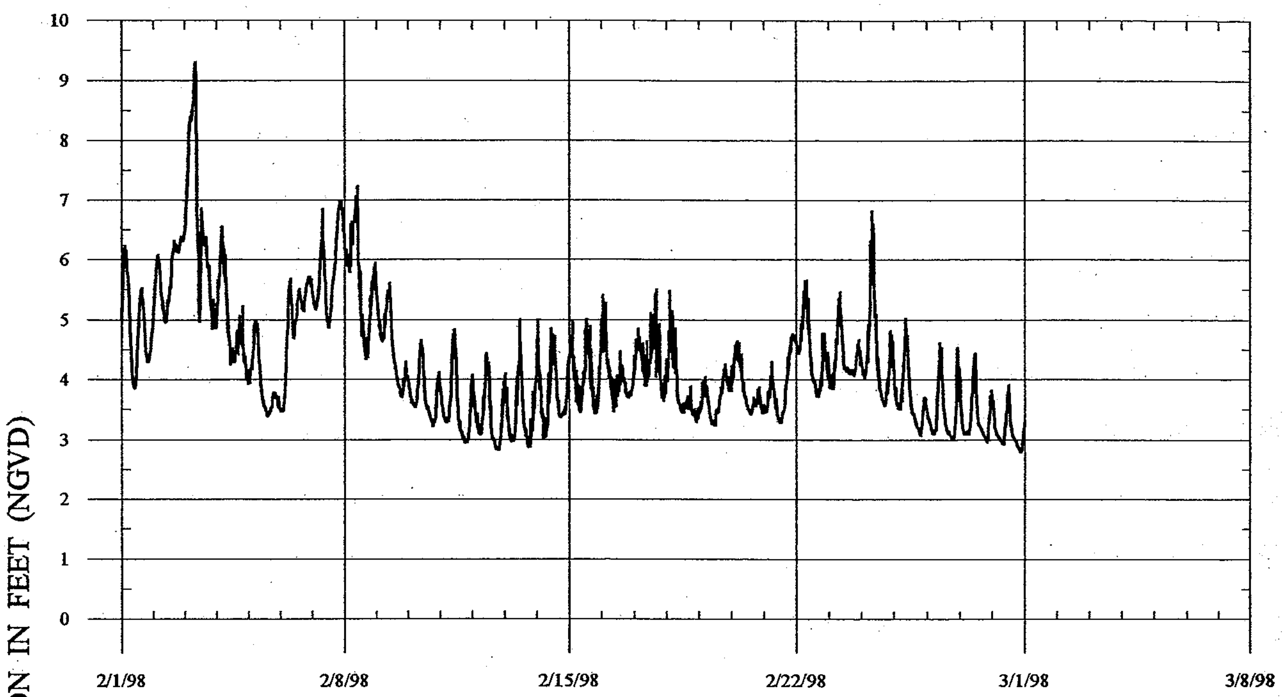


FIGURE A-31

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 1998



MARCH 1998

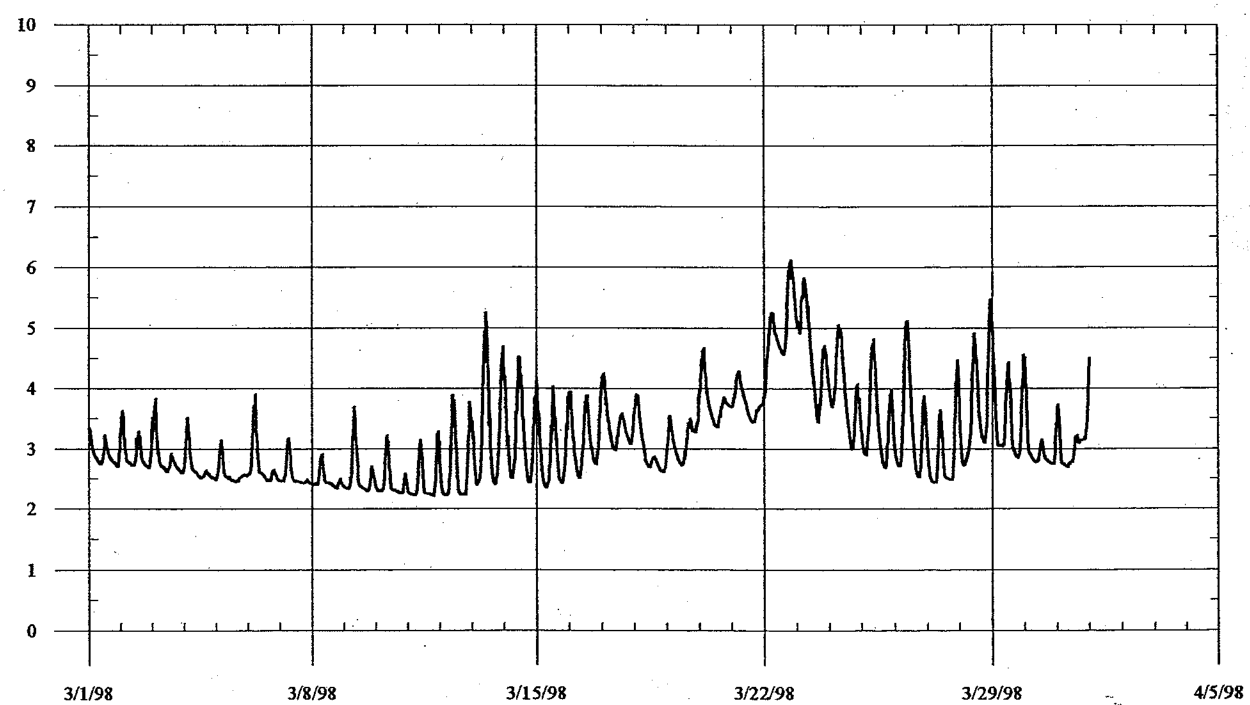
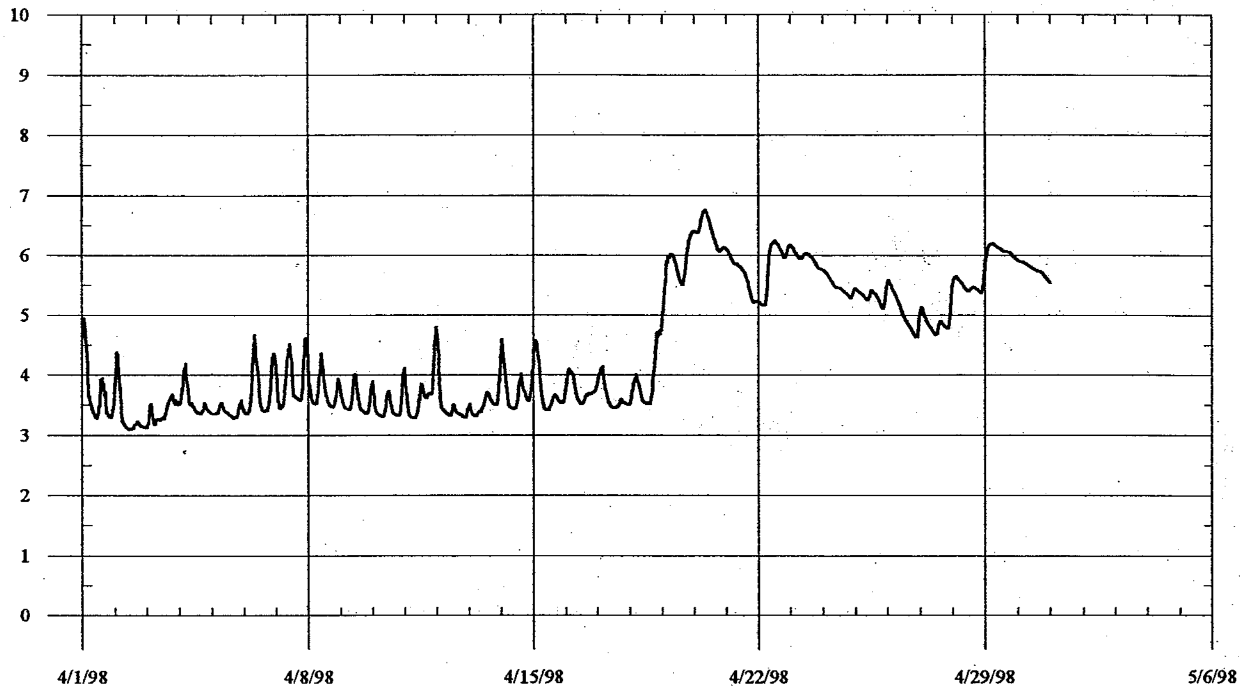


FIGURE A-32

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 1998



WATER SURFACE ELEVATION IN FEET (NGVD)

MAY 1998

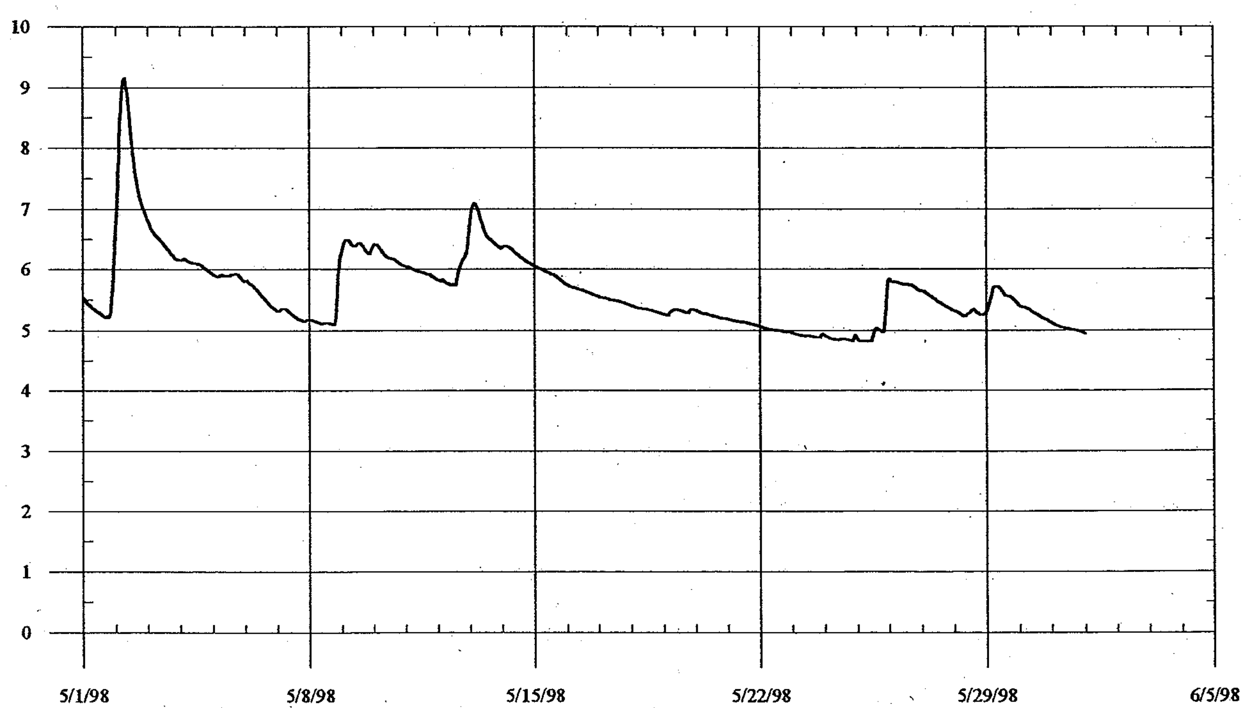
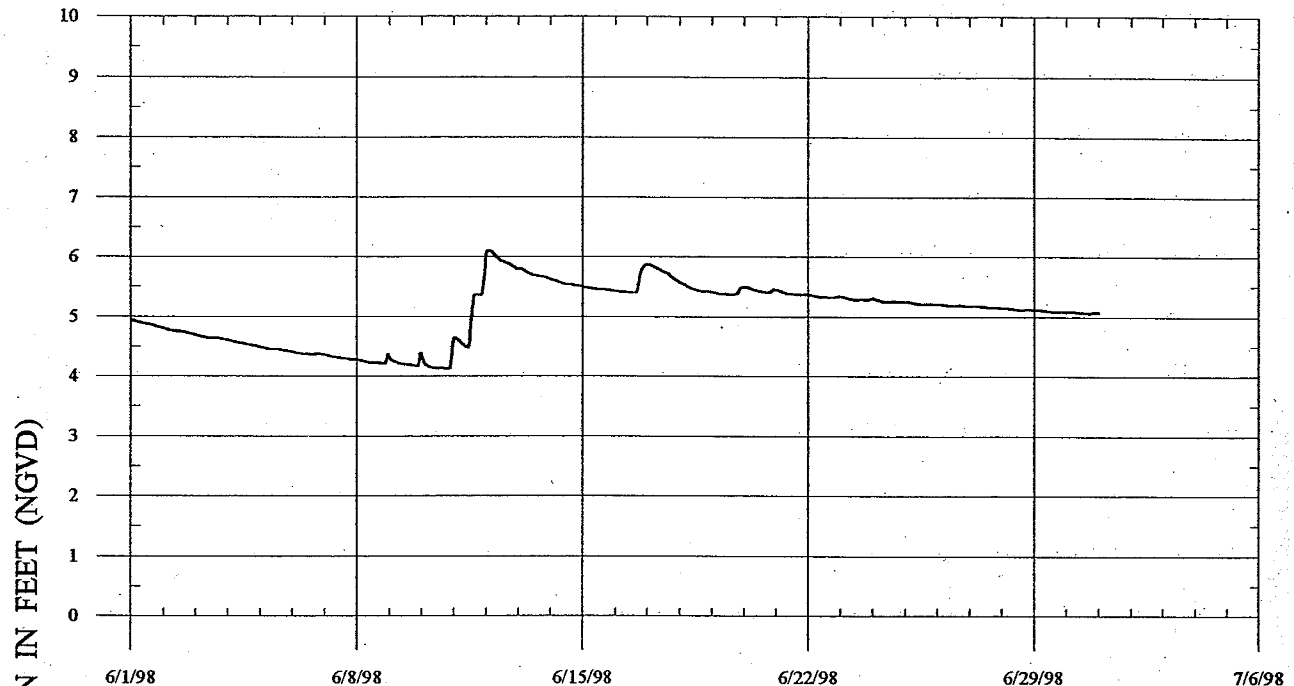


FIGURE A-33

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

JUNE 1998



JULY 1998

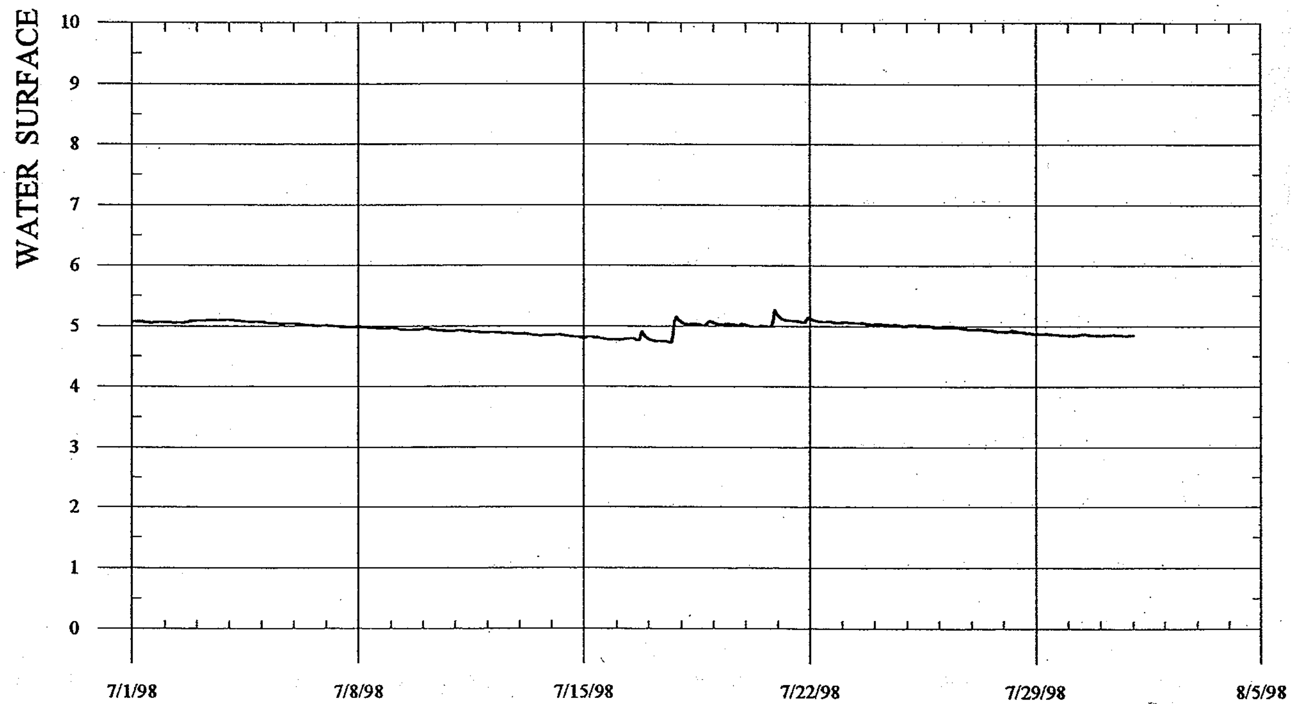
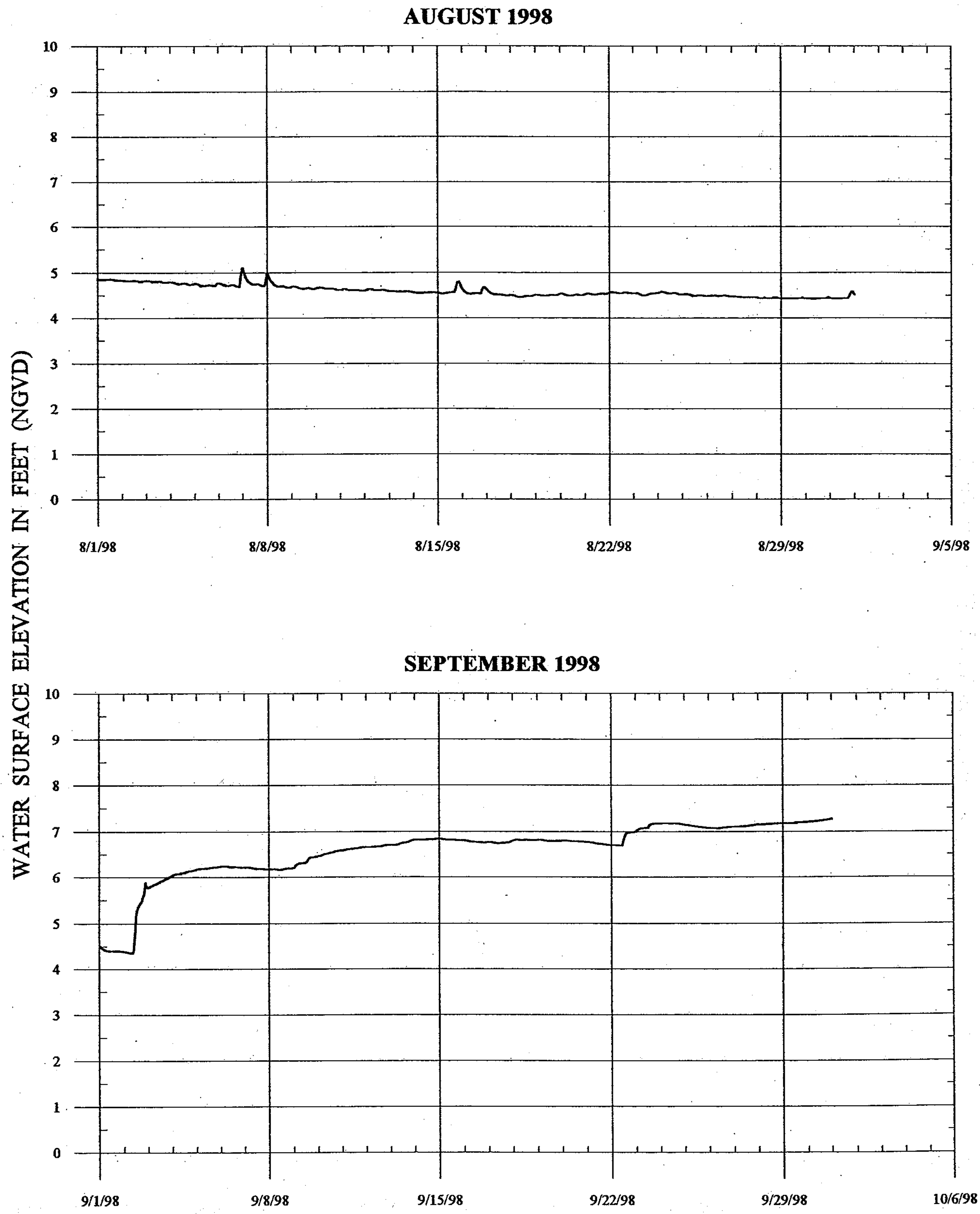


FIGURE A-34

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

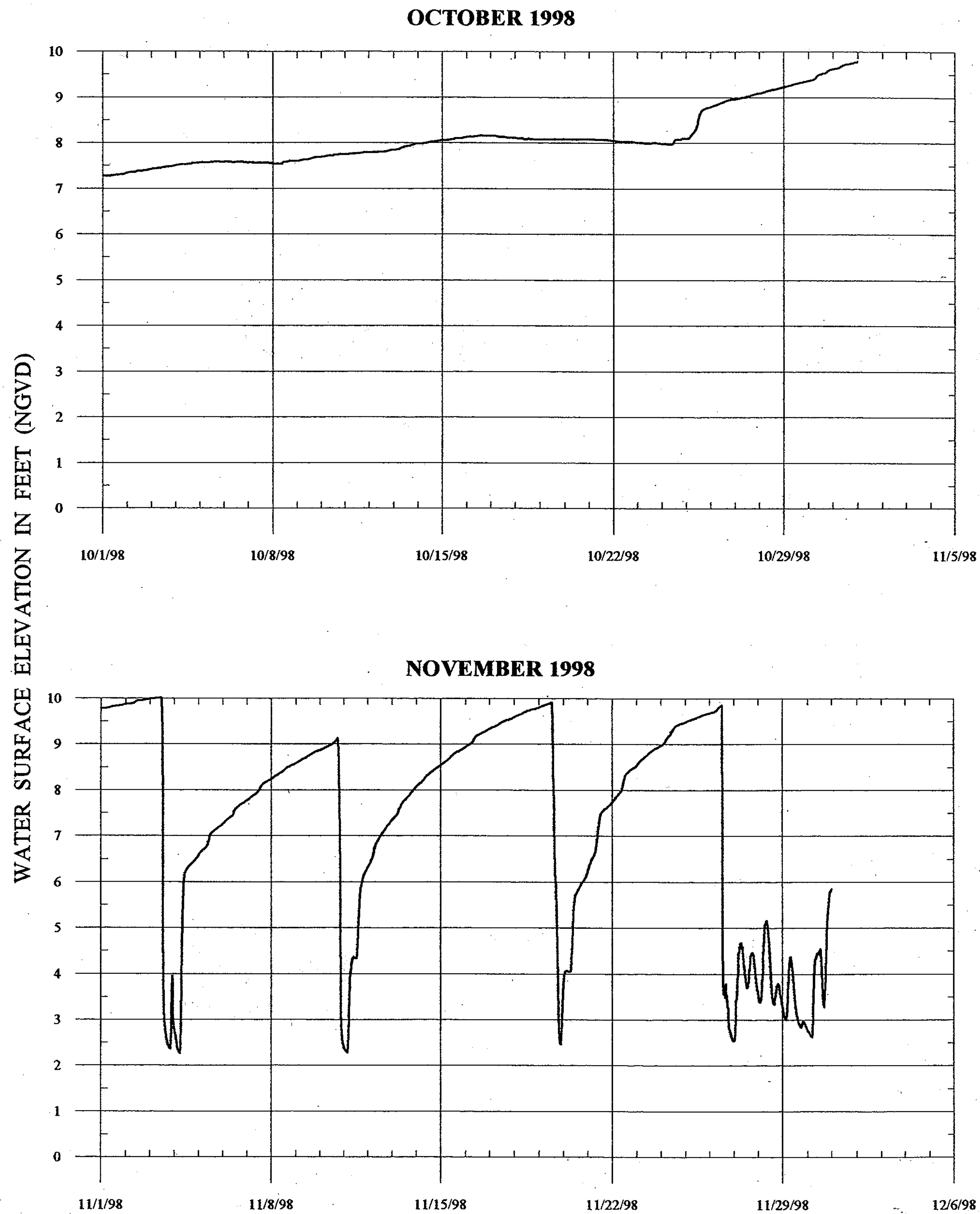
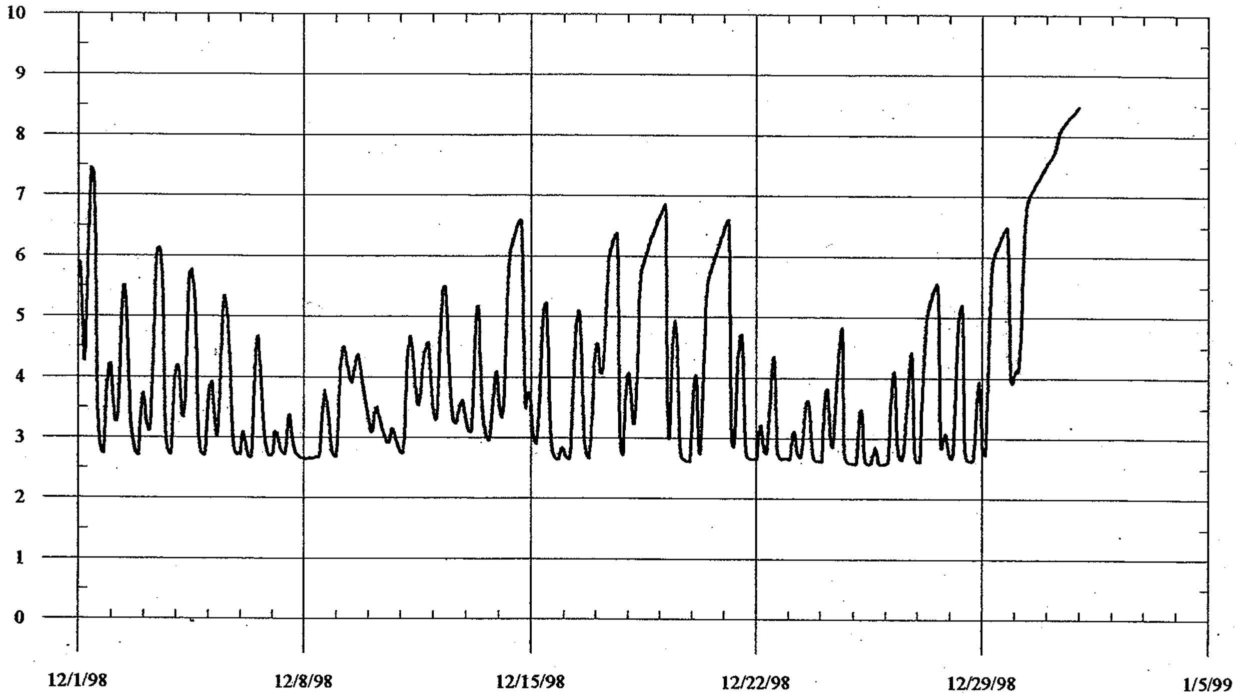


FIGURE A-36

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

DECEMBER 1998



WATER SURFACE ELEVATION IN FEET (NGVD)

JANUARY 1999

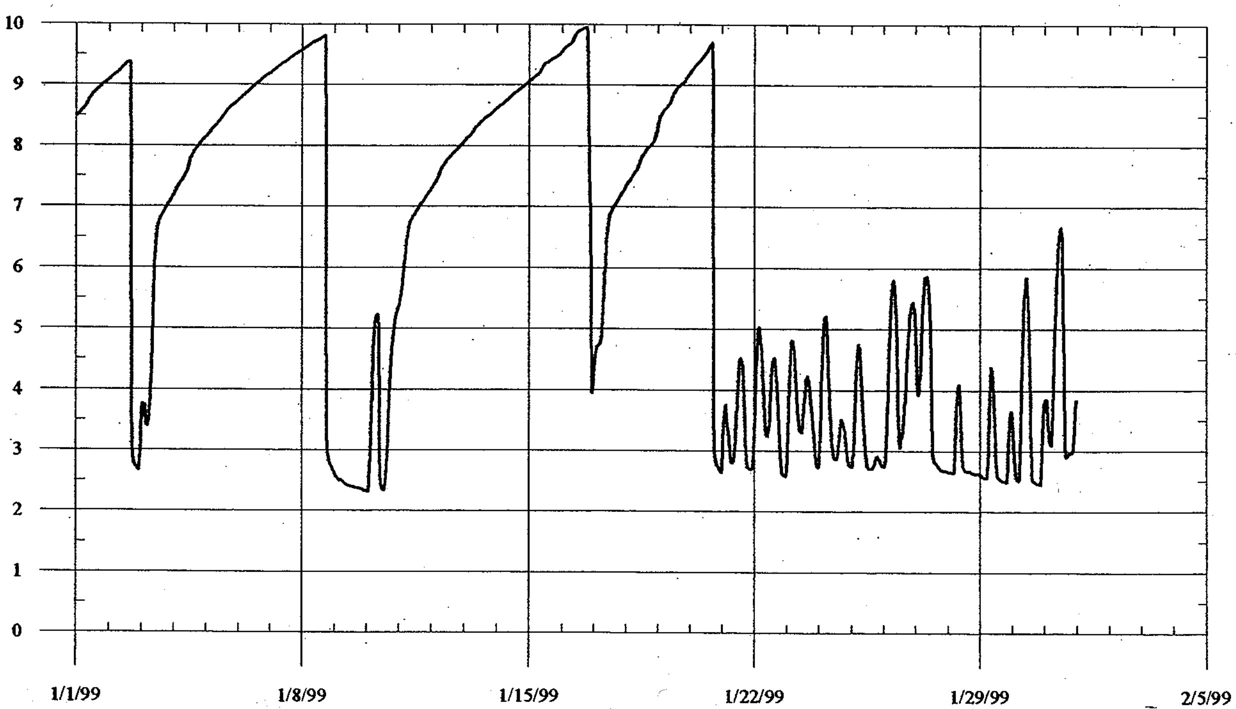
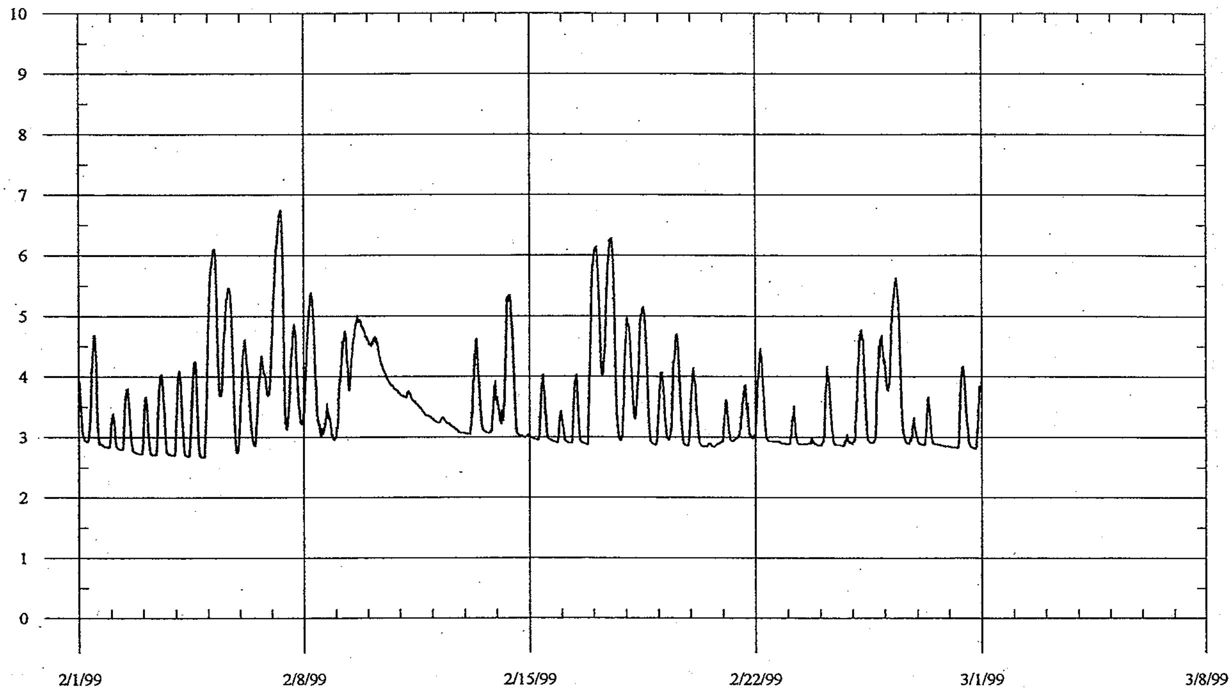


FIGURE A-37

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 1999



WATER SURFACE ELEVATION IN FEET (NGVD)

MARCH 1999

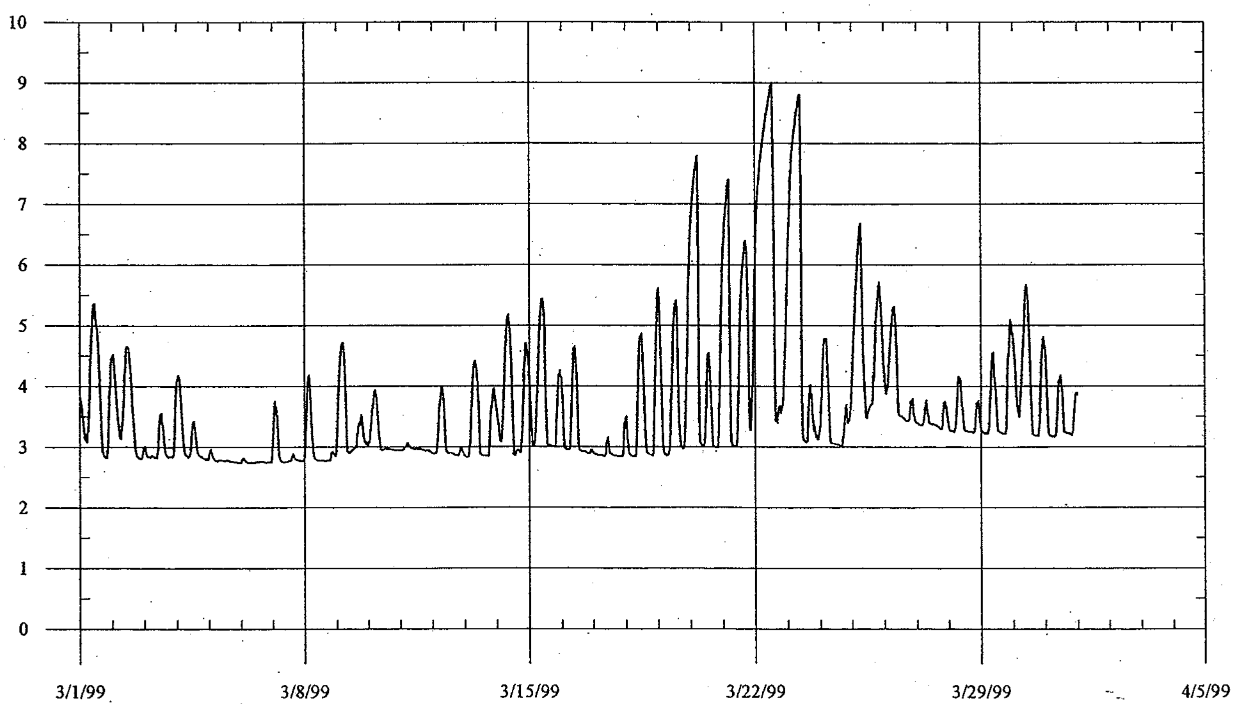
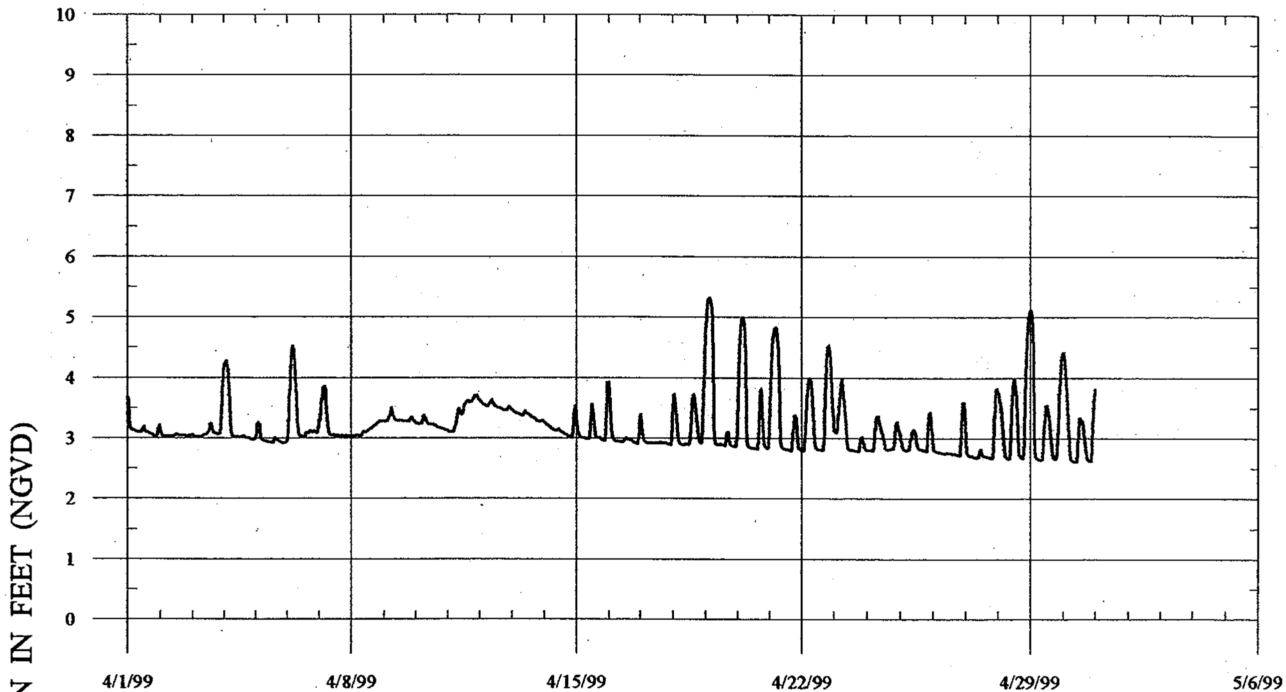


FIGURE A-38

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 1999



MAY 1999

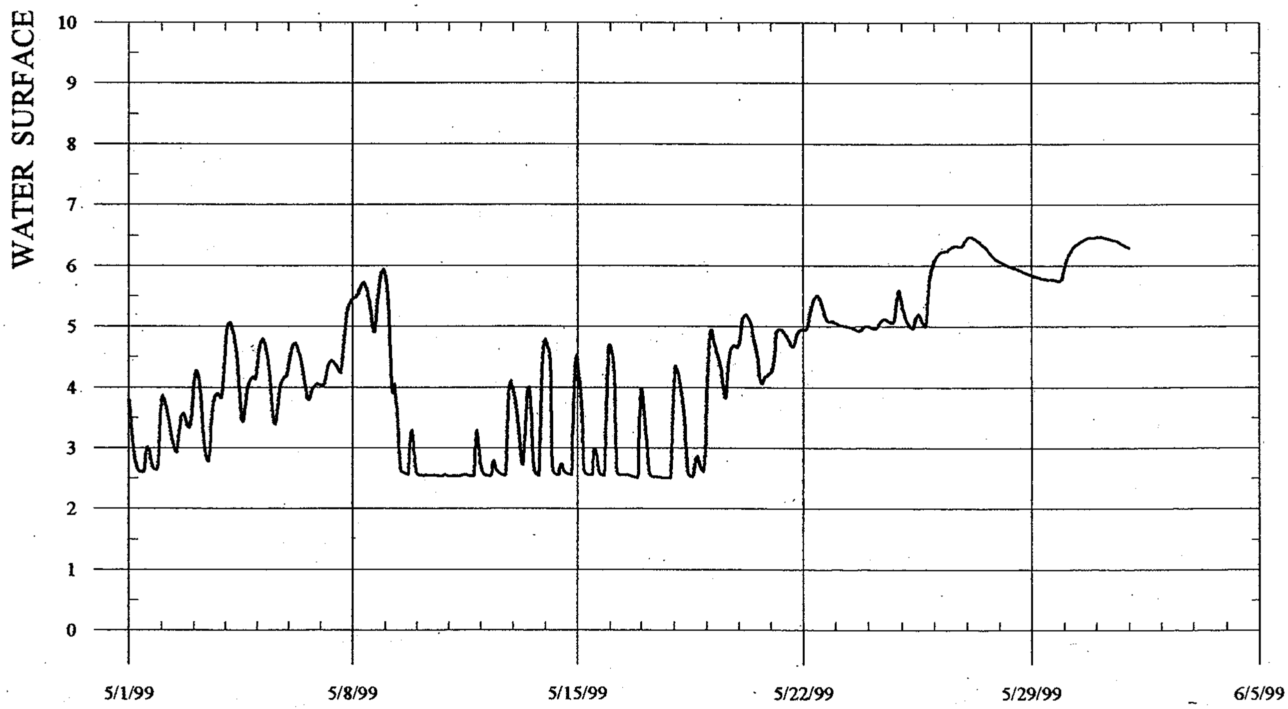
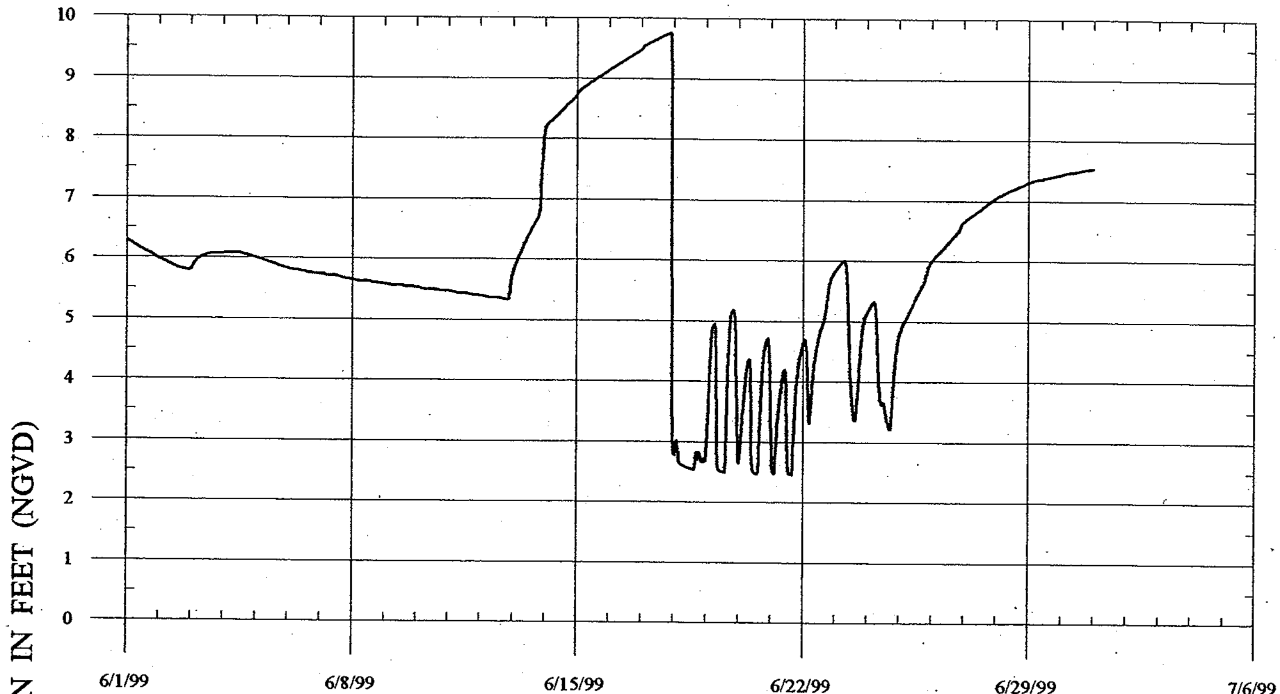


FIGURE A-39

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

JUNE 1999



JULY 1999

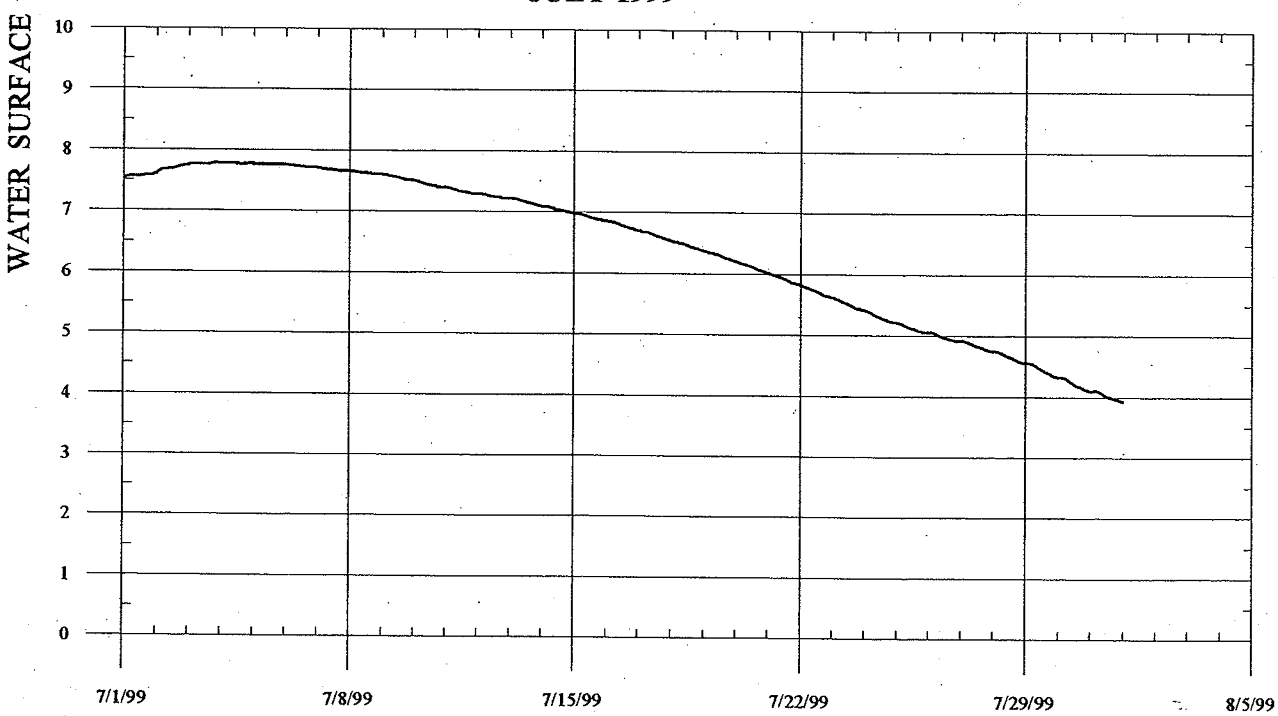


FIGURE A-40

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

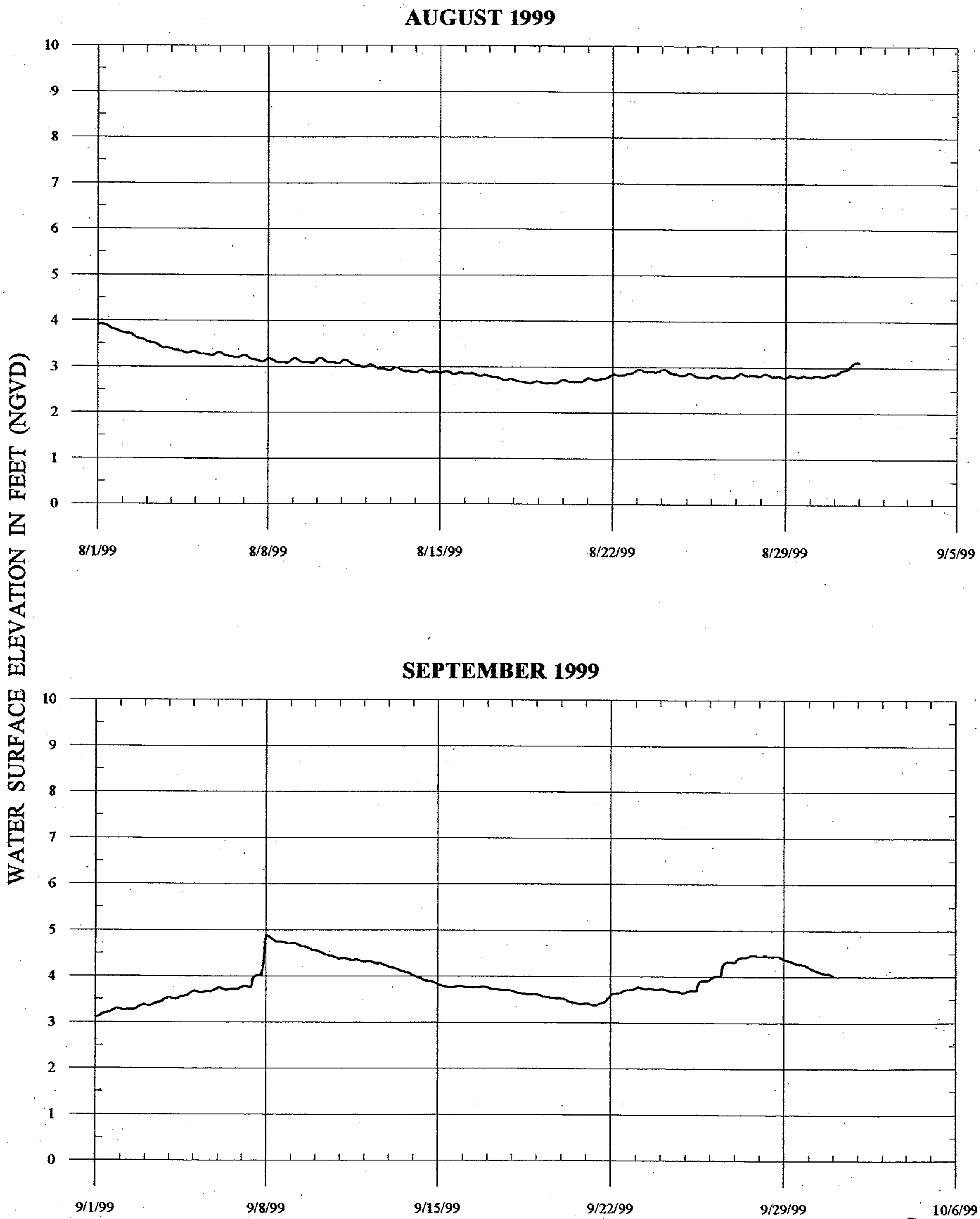
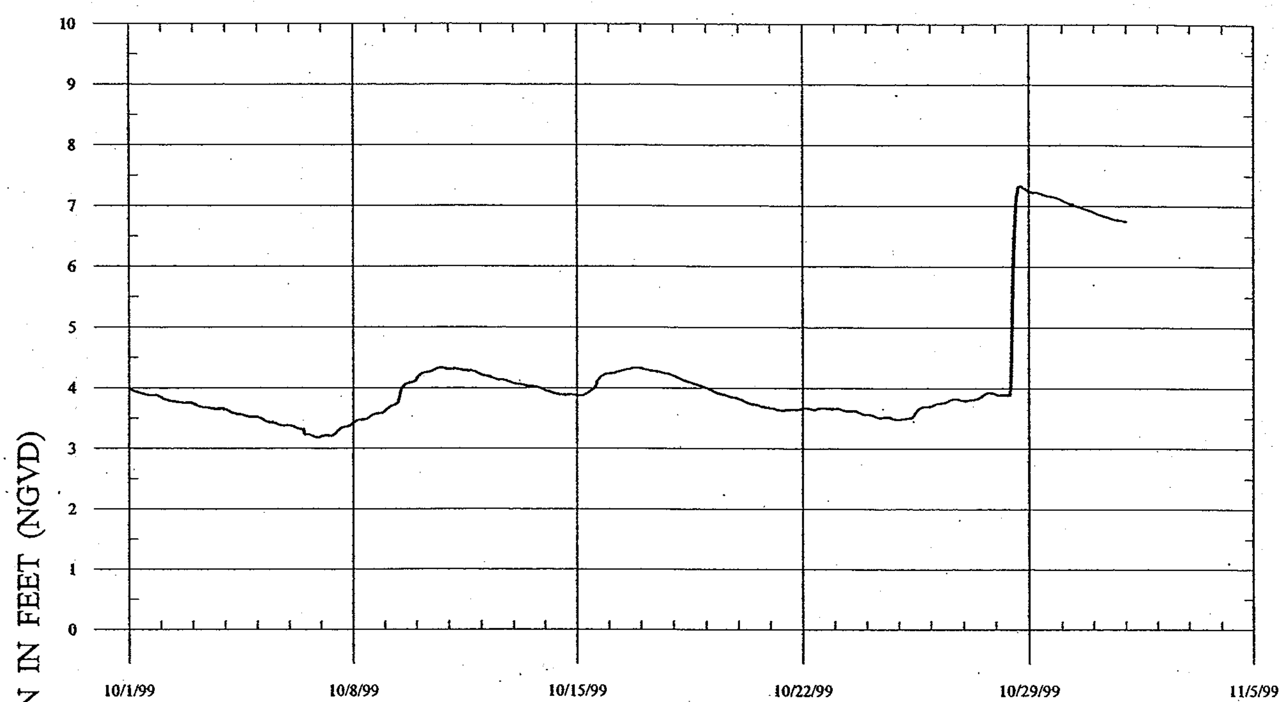


FIGURE A-41

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

OCTOBER 1999



NOVEMBER 1999

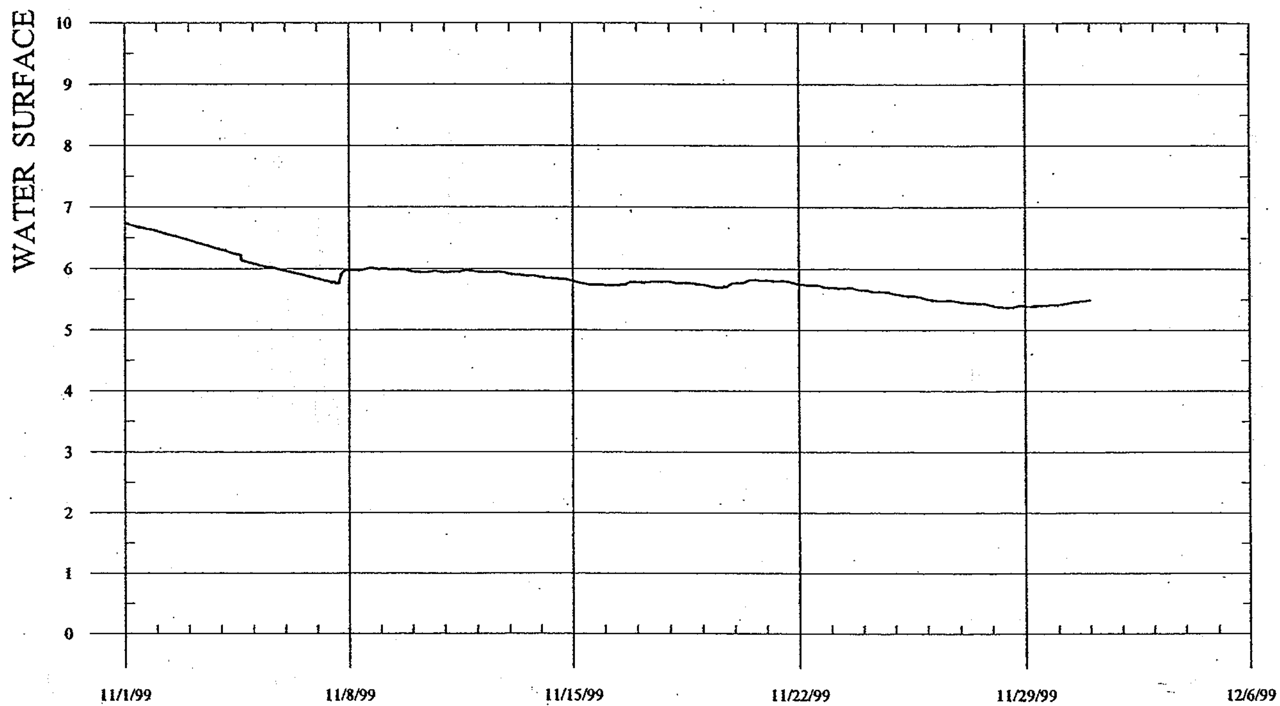


FIGURE A-42

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

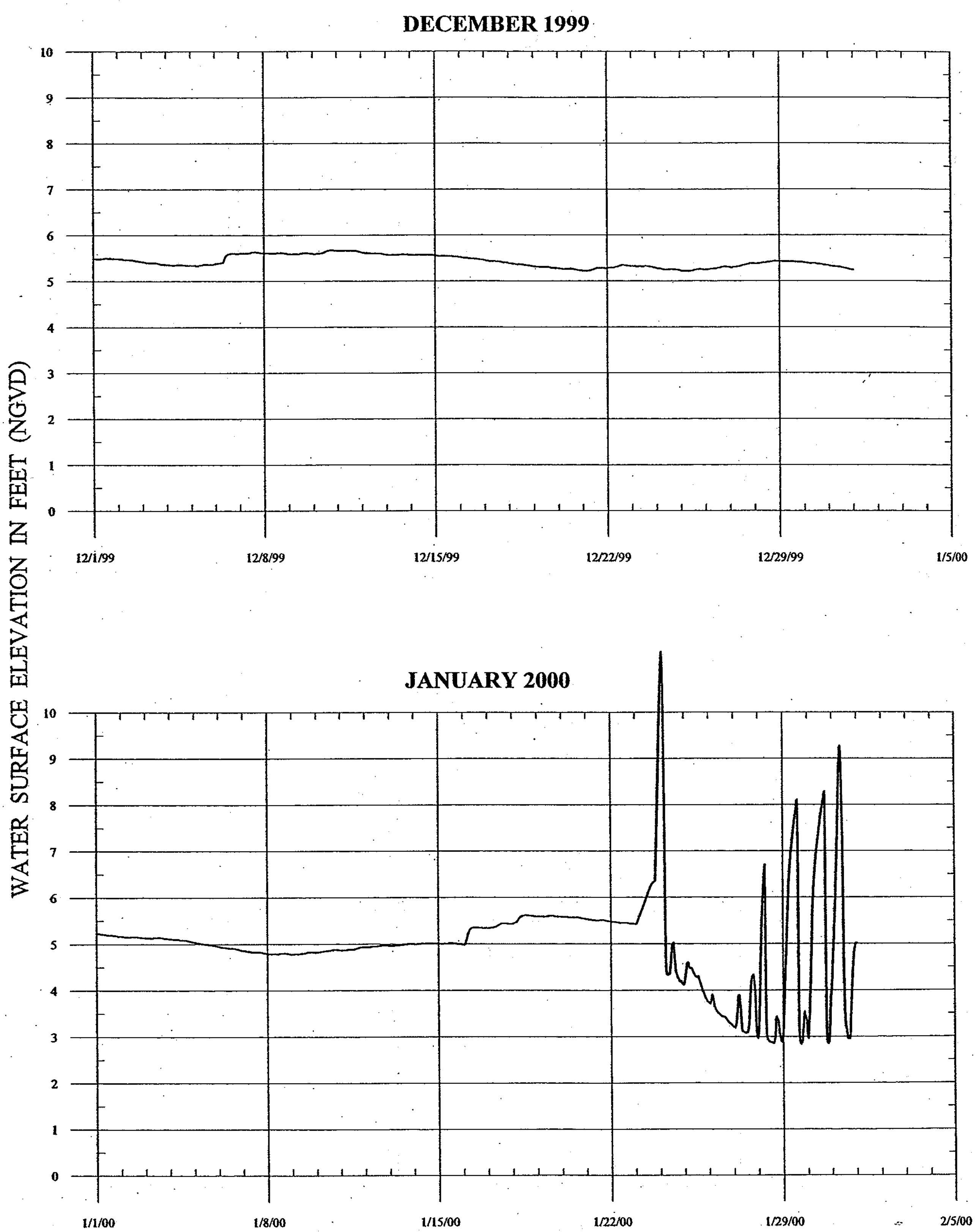


FIGURE A-43

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

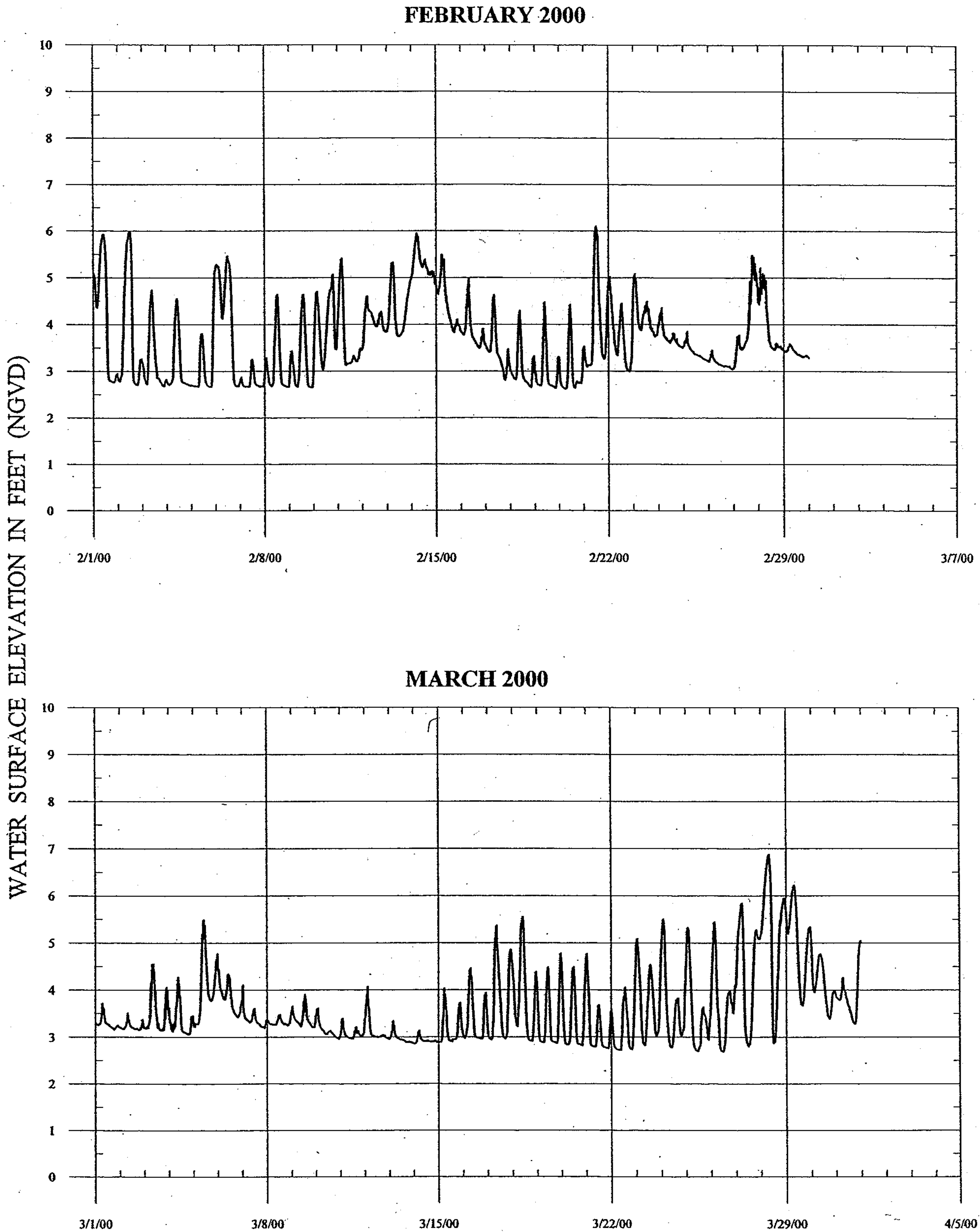
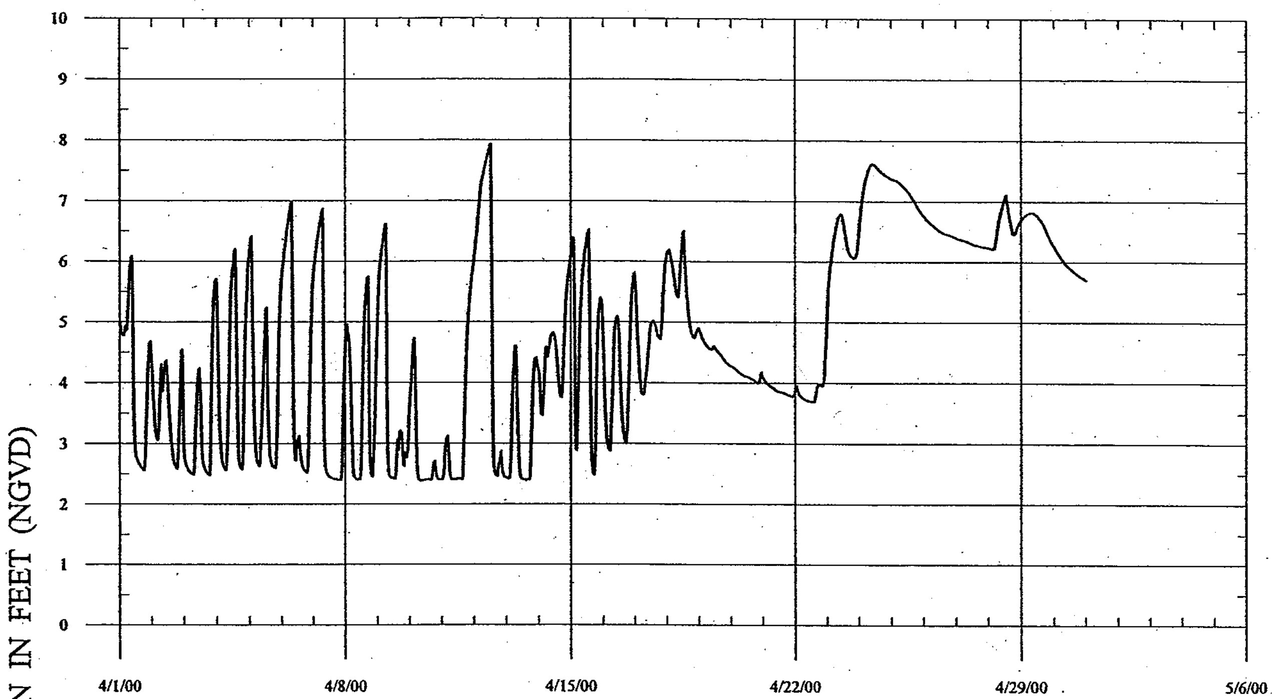


FIGURE A-44

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 2000



MAY 2000

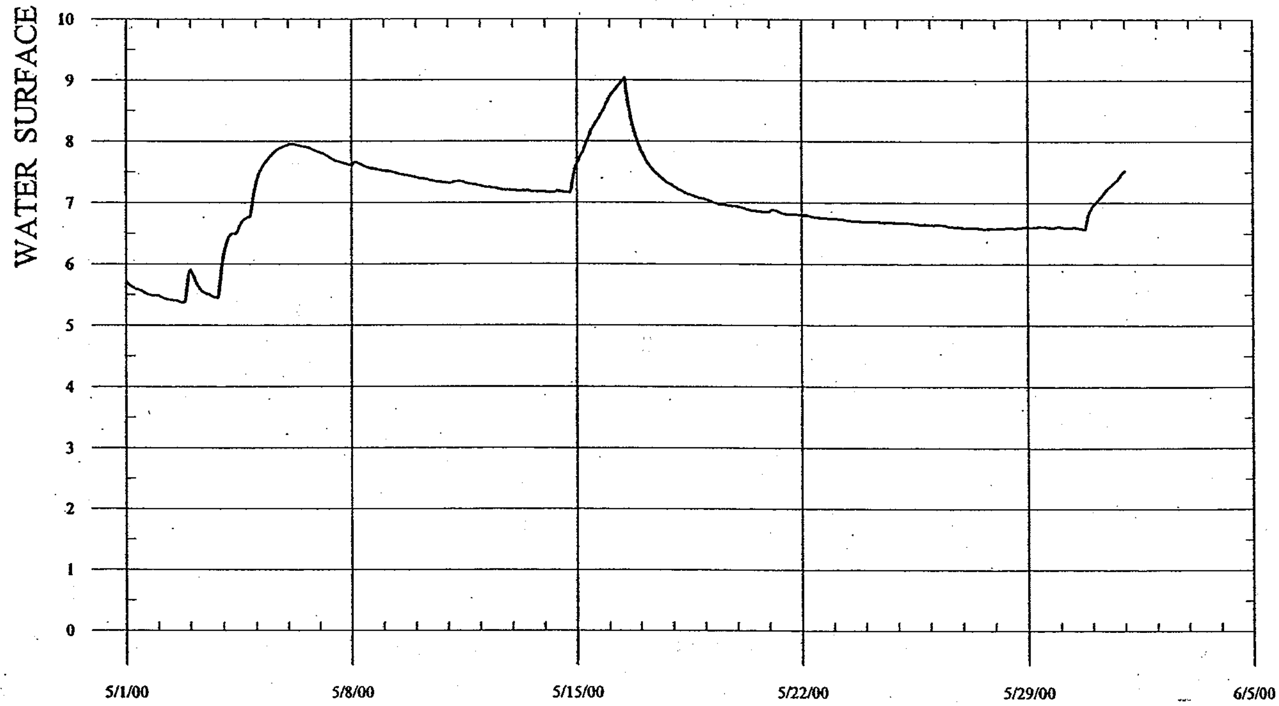
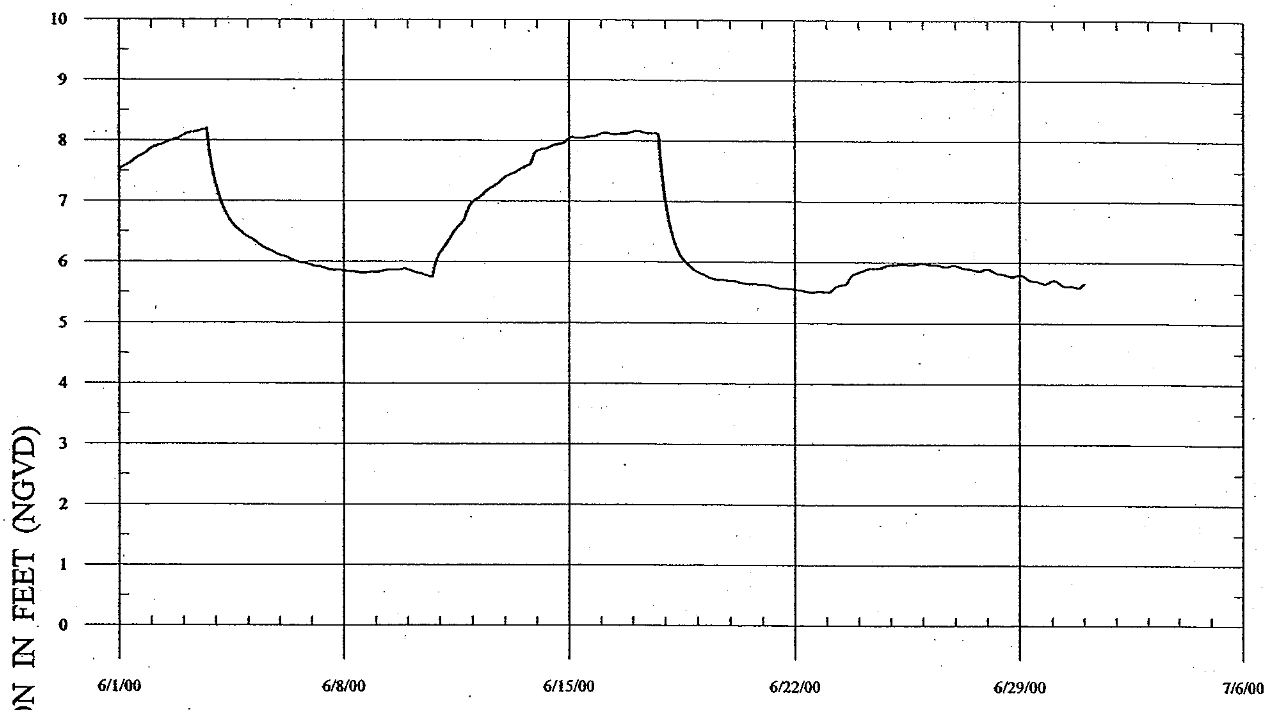


FIGURE A-45

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

JUNE 2000



JULY 2000

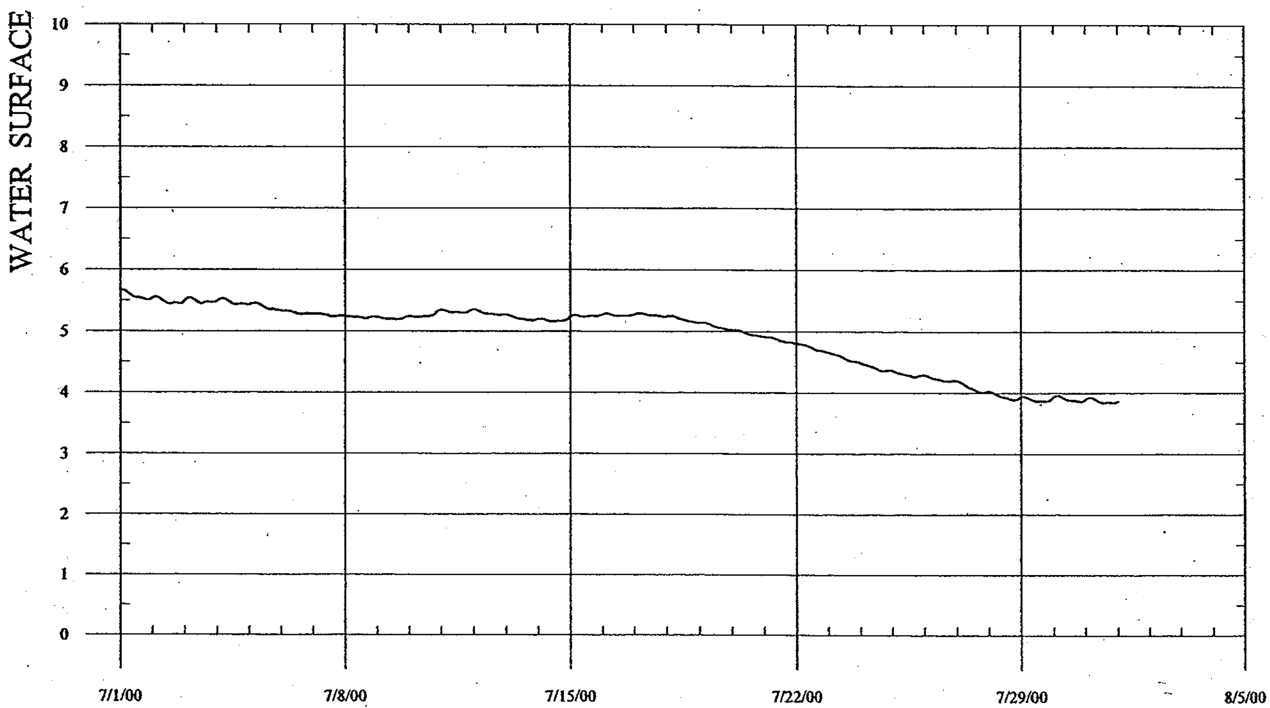
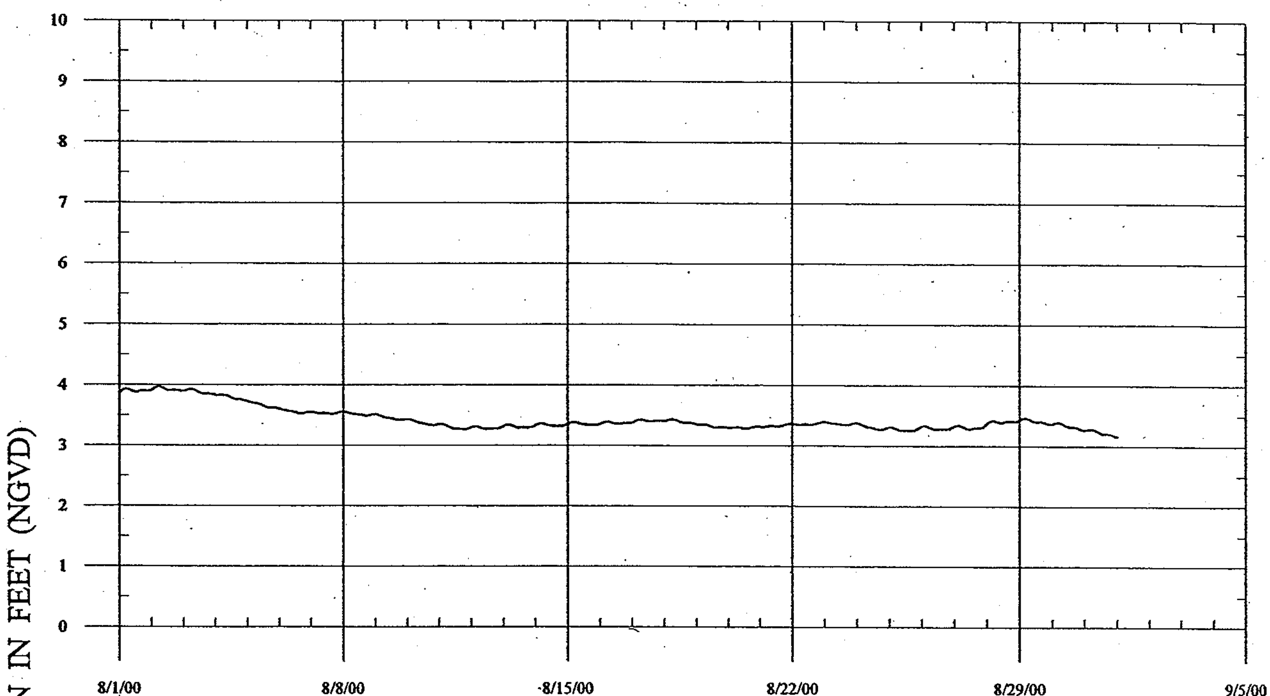


FIGURE A-46

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

AUGUST 2000



SEPTEMBER 2000

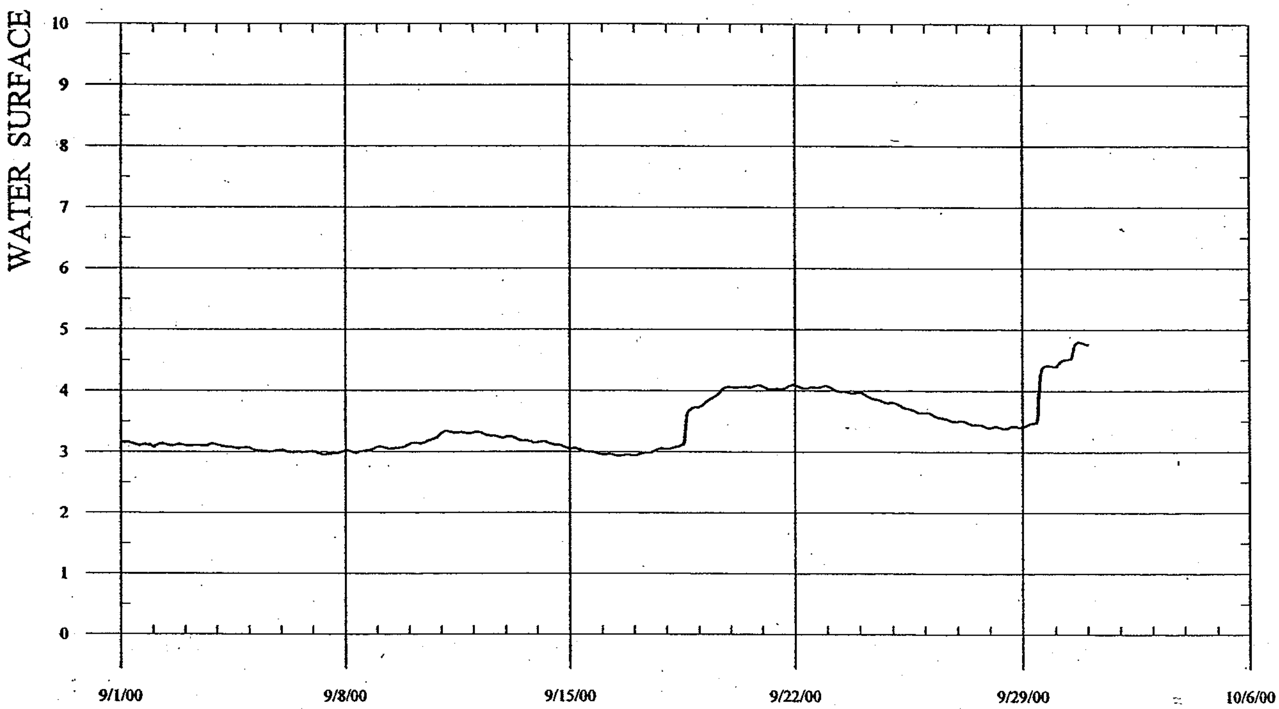
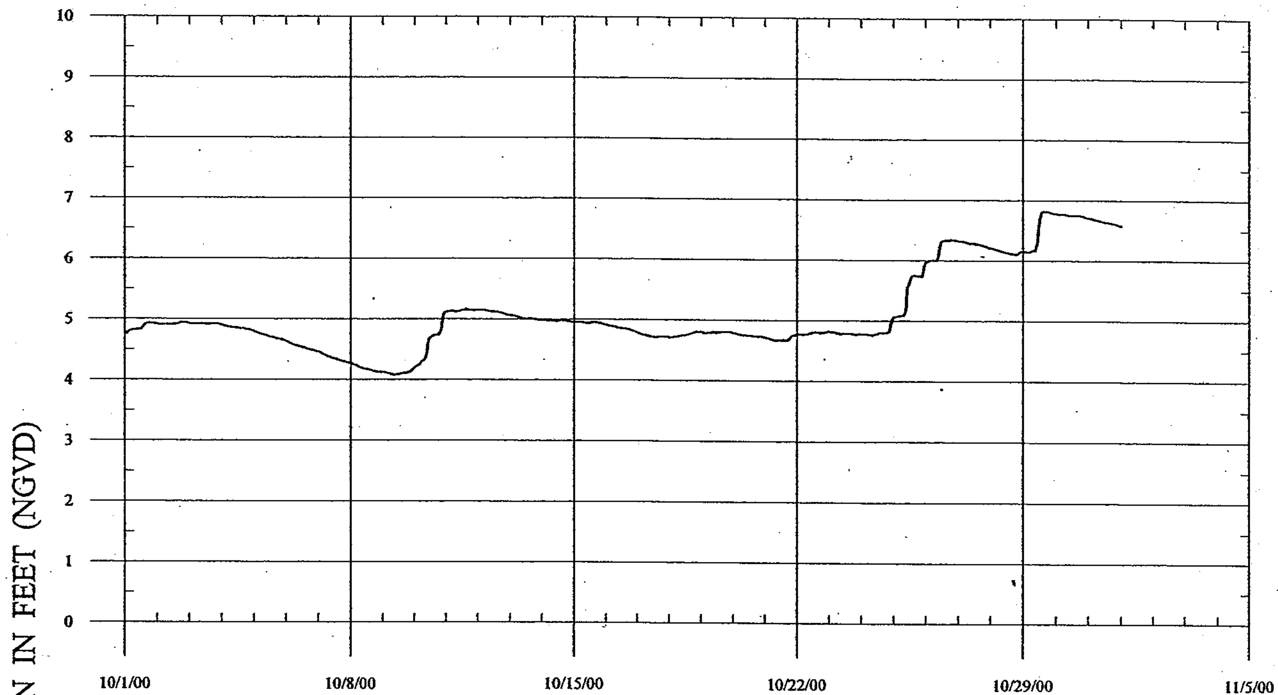


FIGURE A-47

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

OCTOBER 2000



NOVEMBER 2000

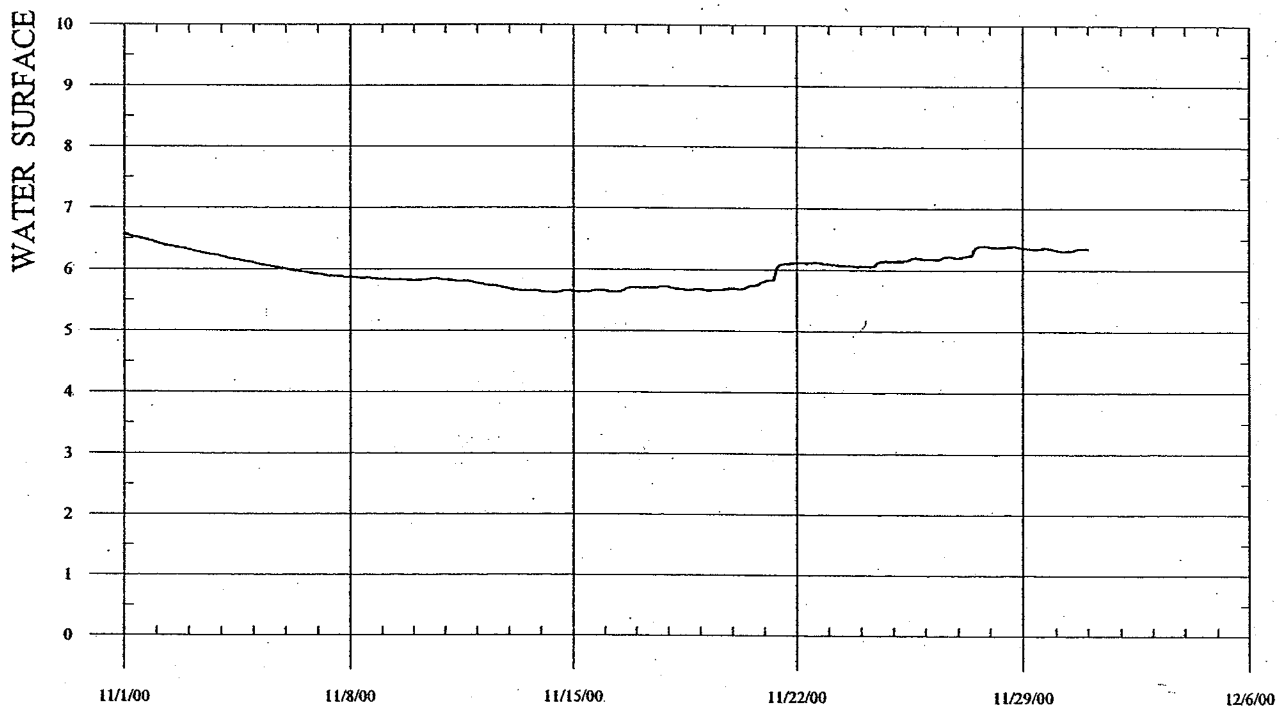


FIGURE A-48

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

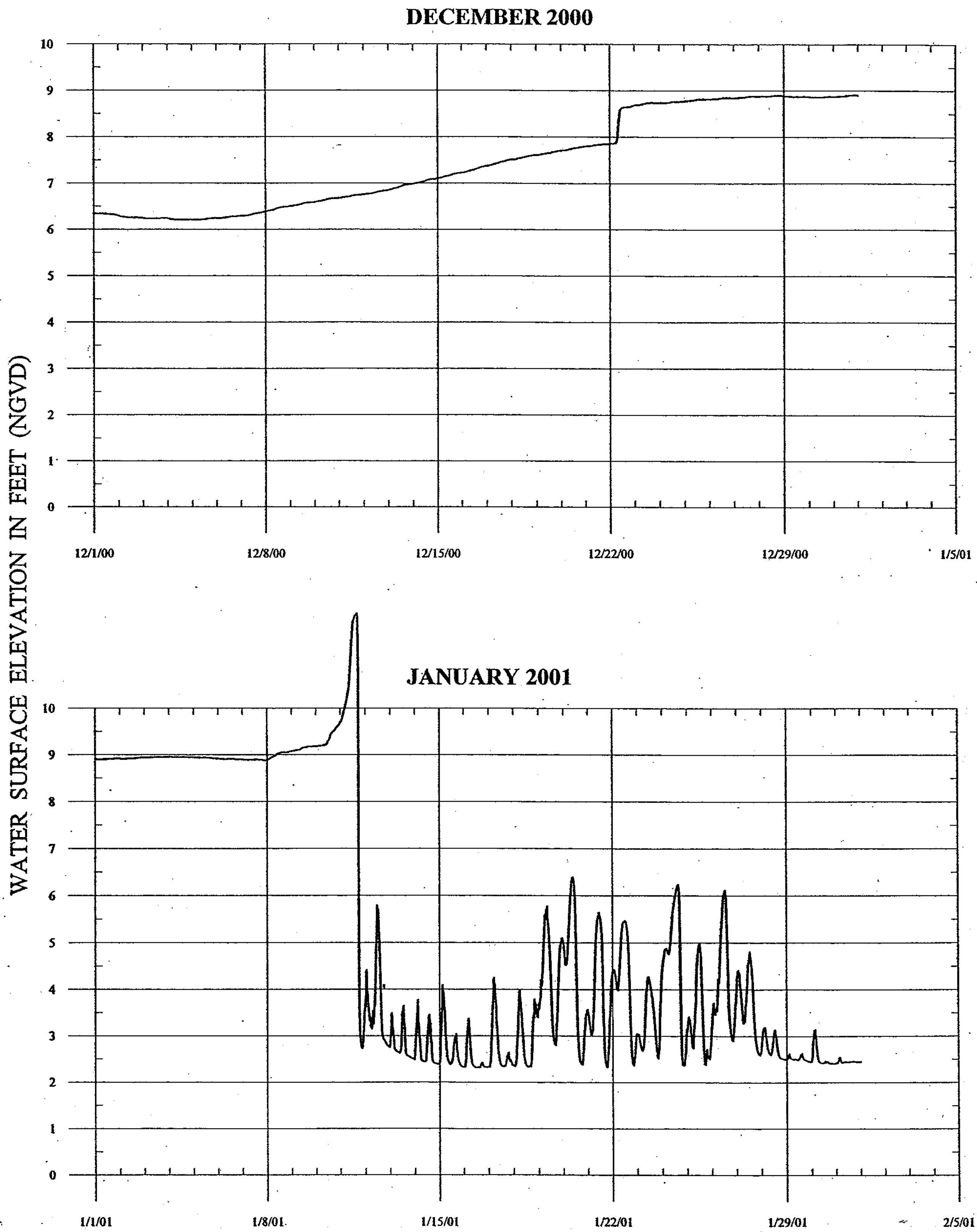
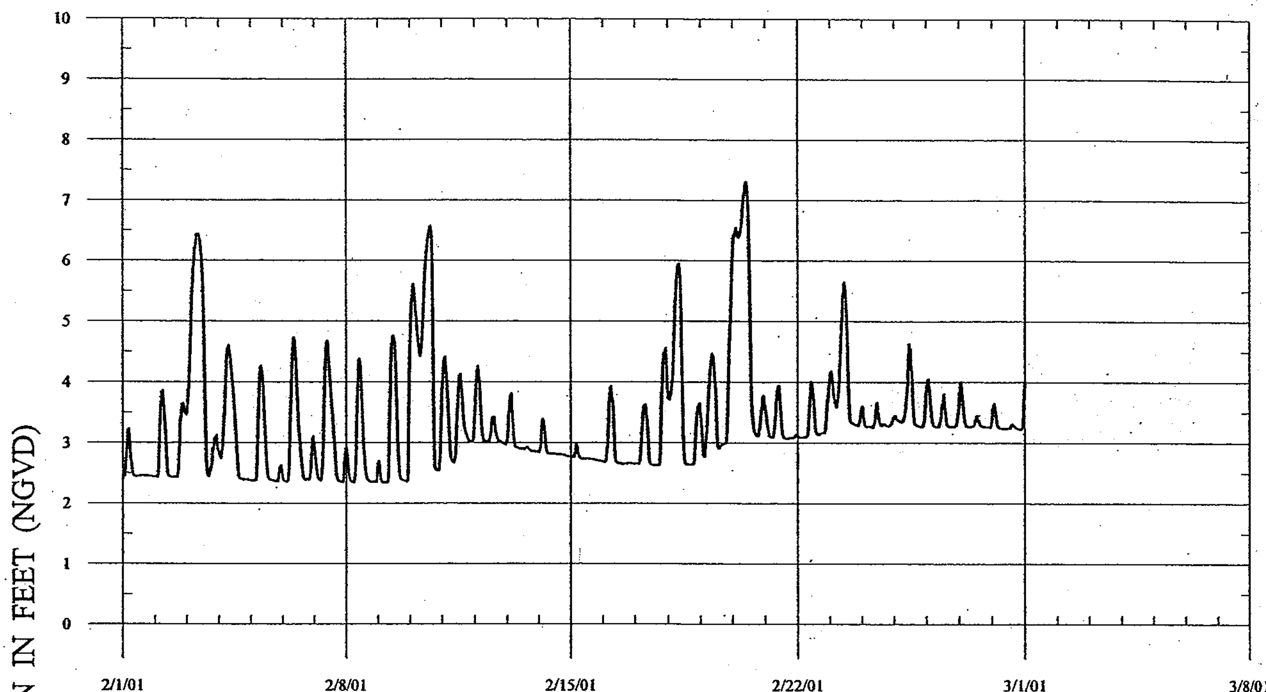


FIGURE A-49

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 2001



MARCH 2001

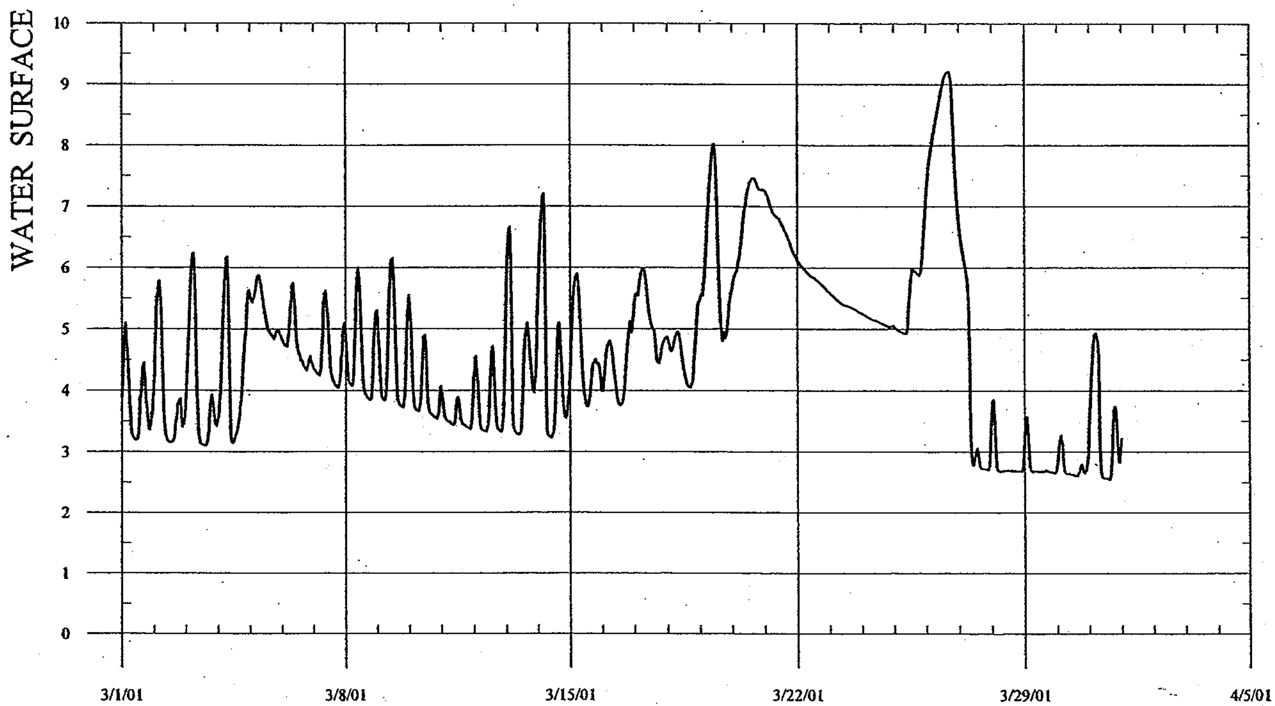
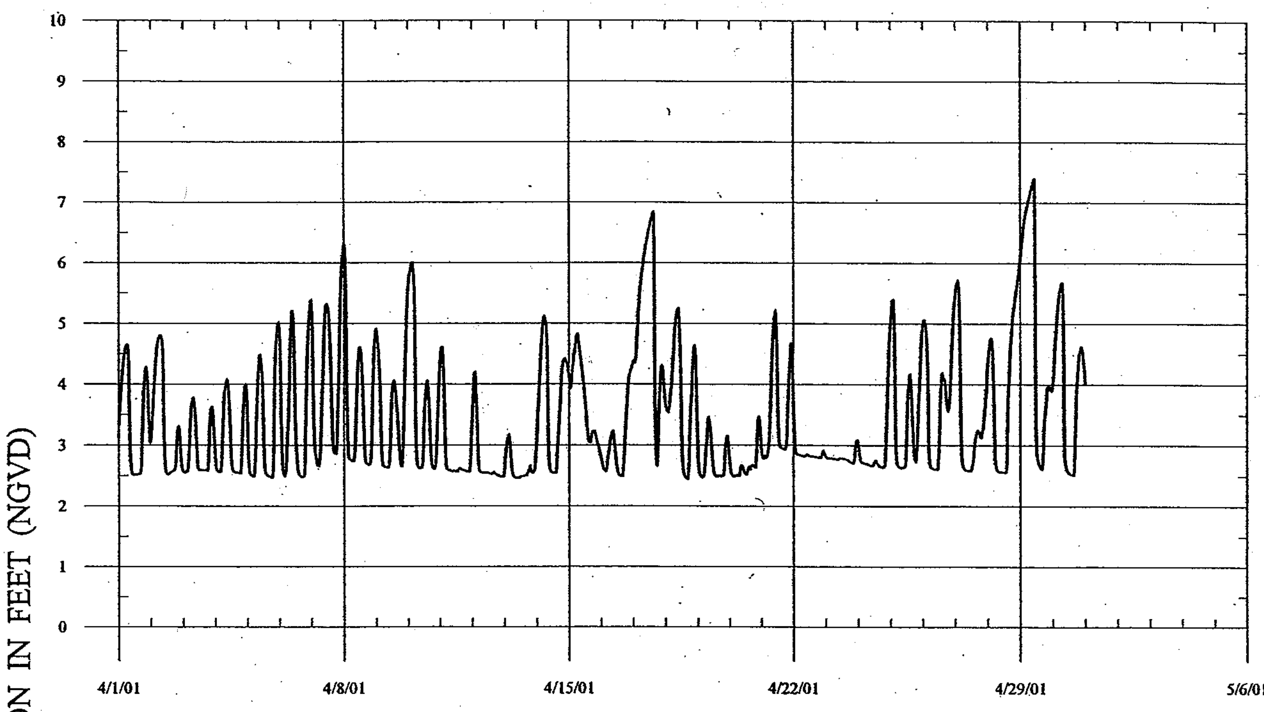


FIGURE A-50

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 2001



MAY 2001

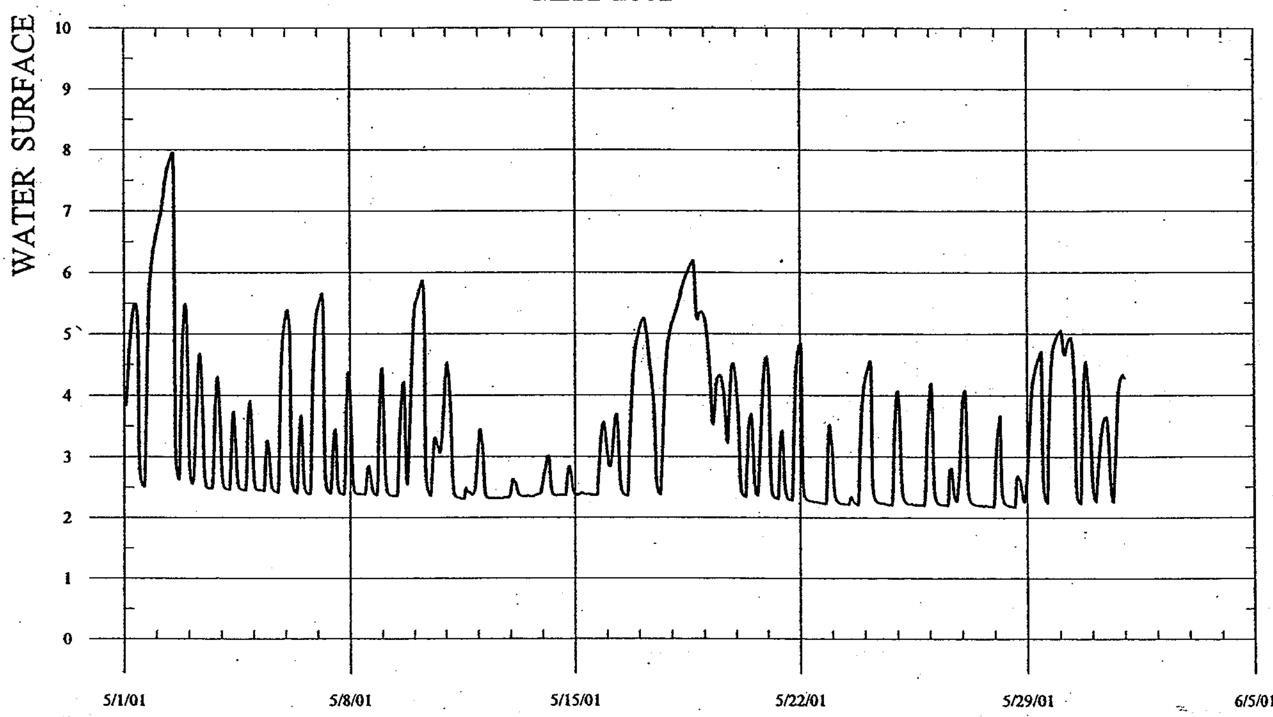
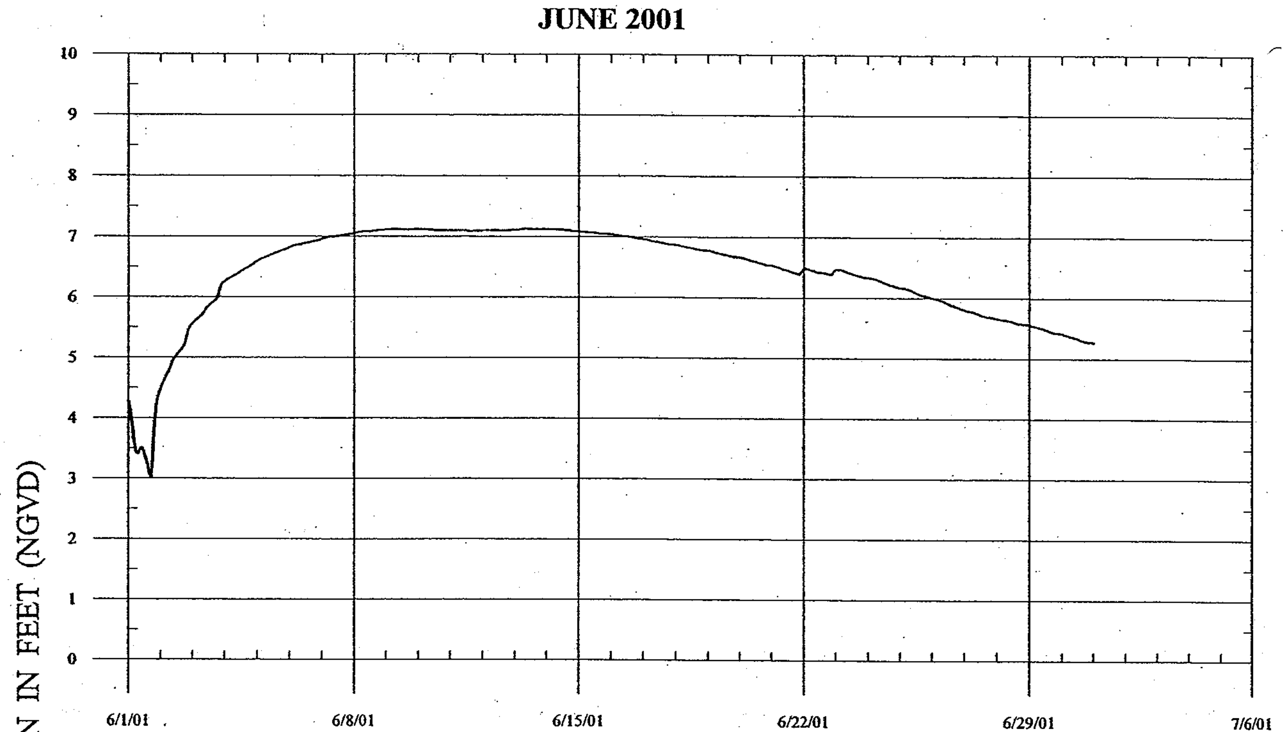


FIGURE A-51

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



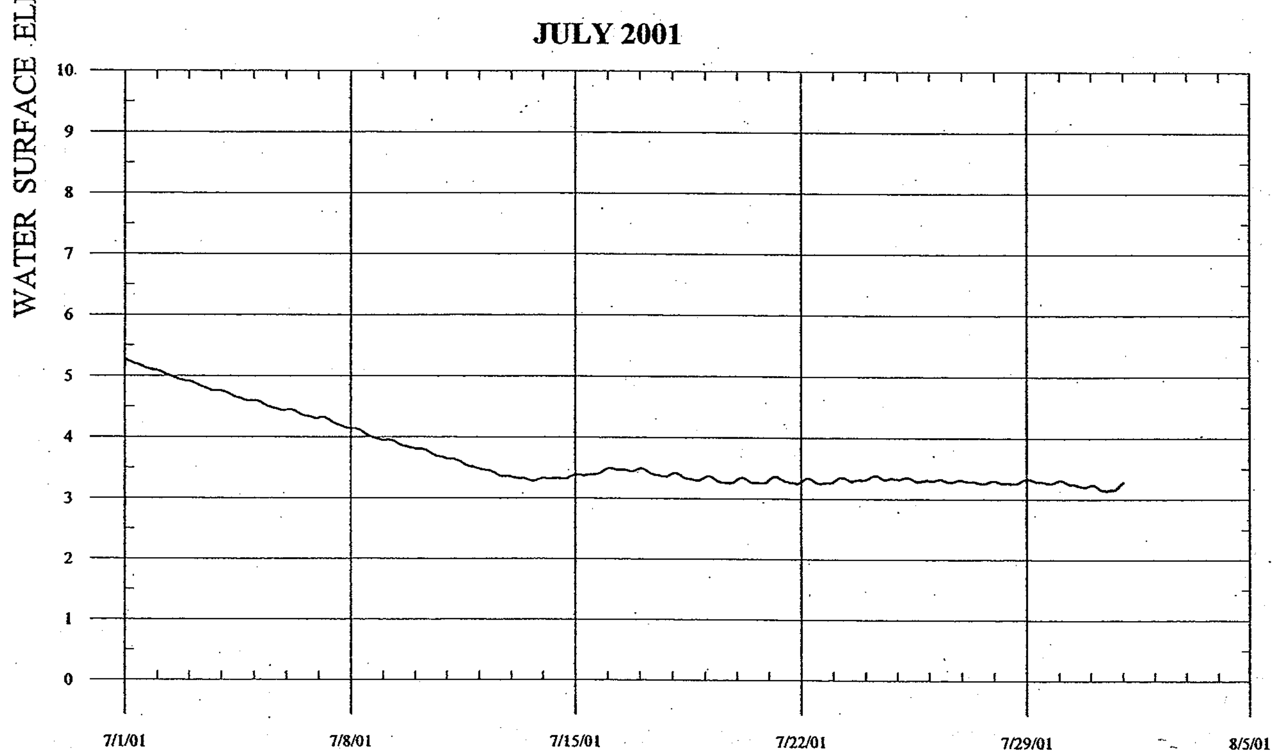
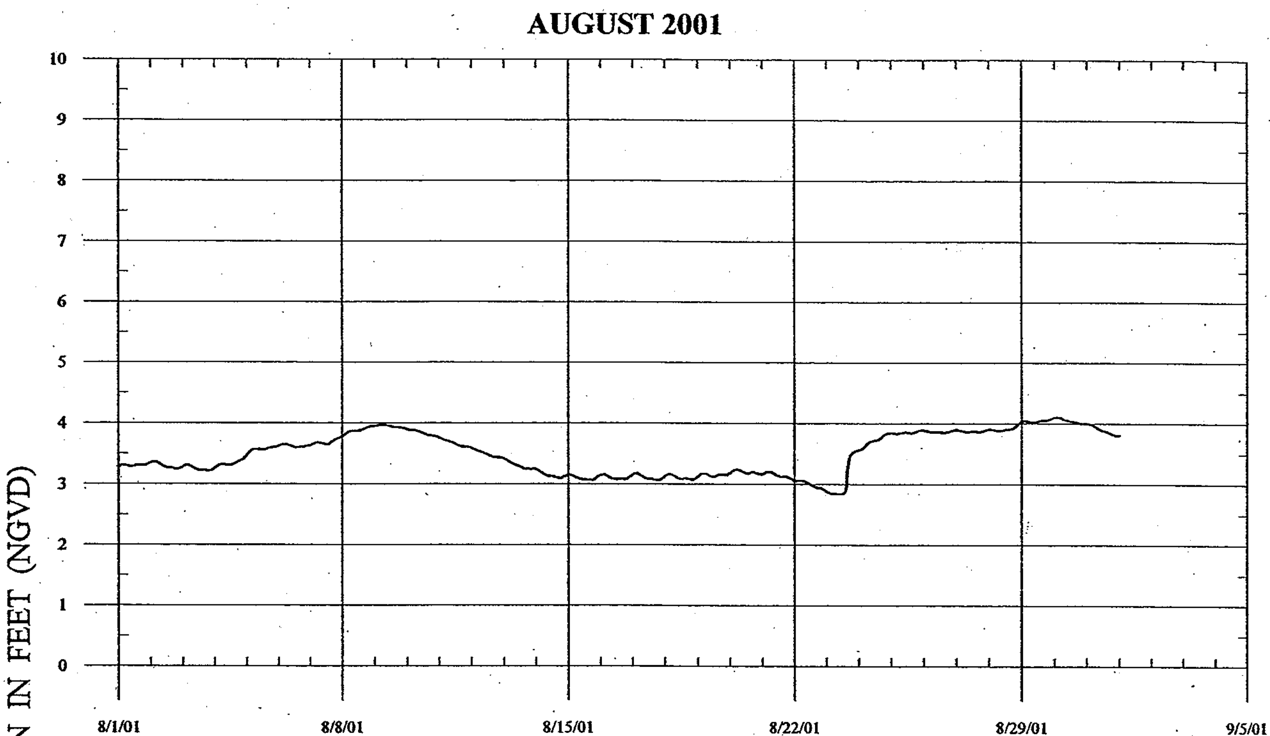


FIGURE A-52

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



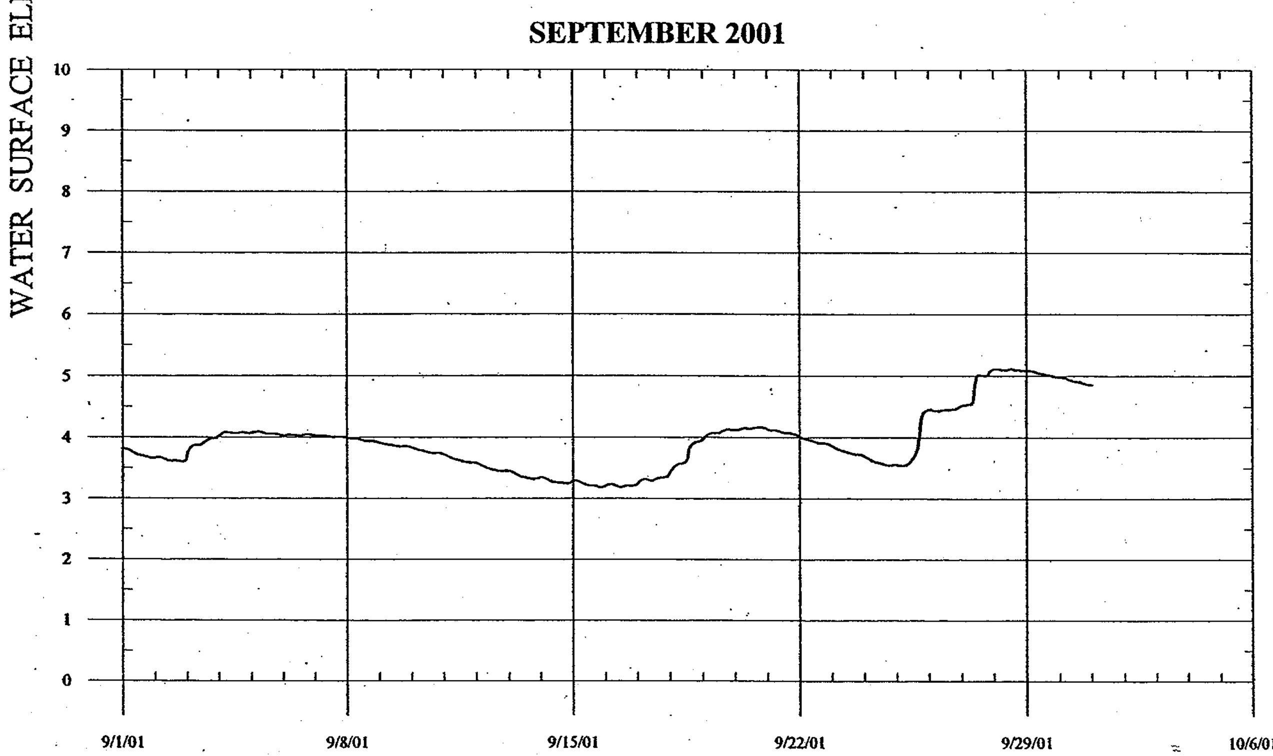


FIGURE A-53

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

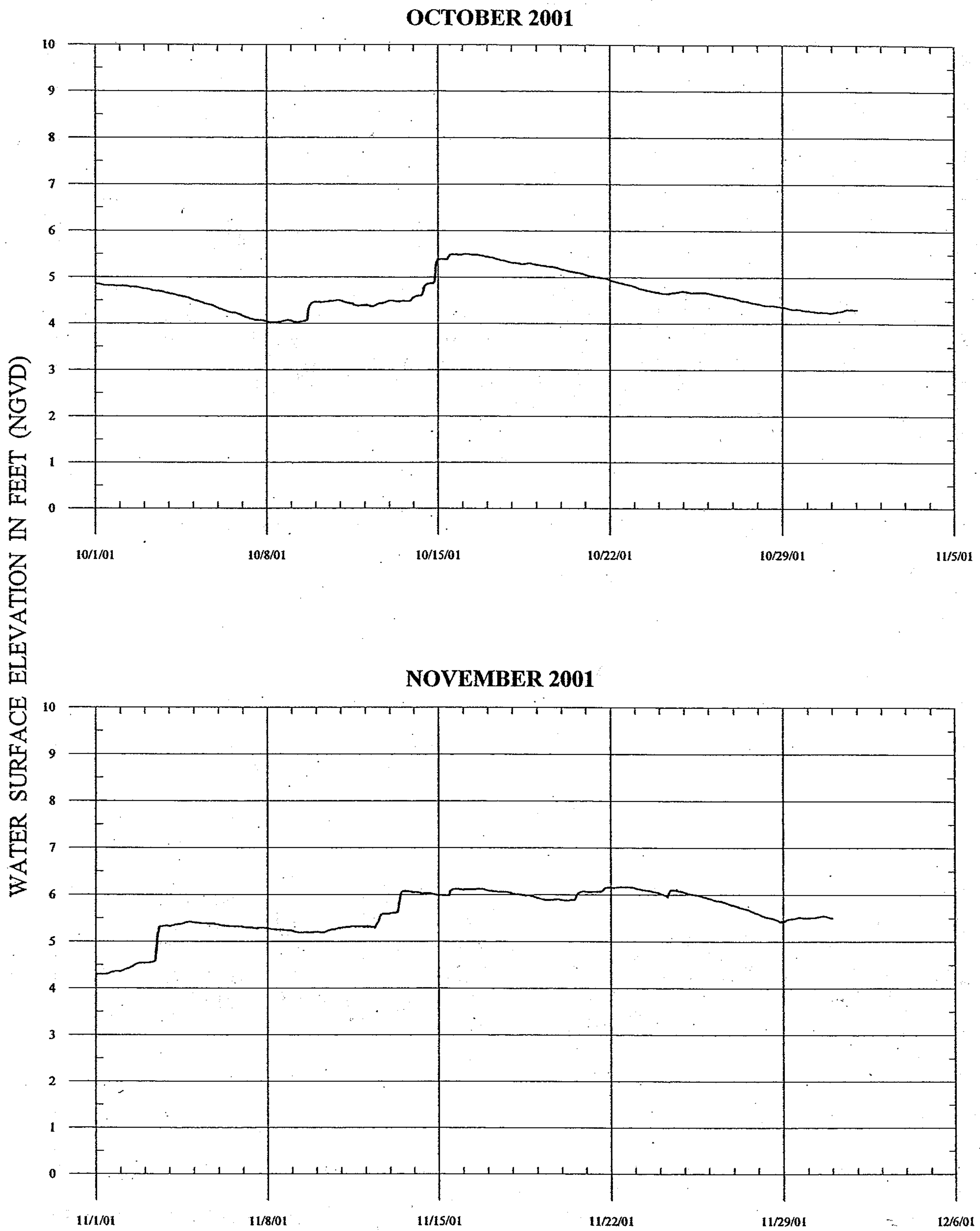


FIGURE A-54

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

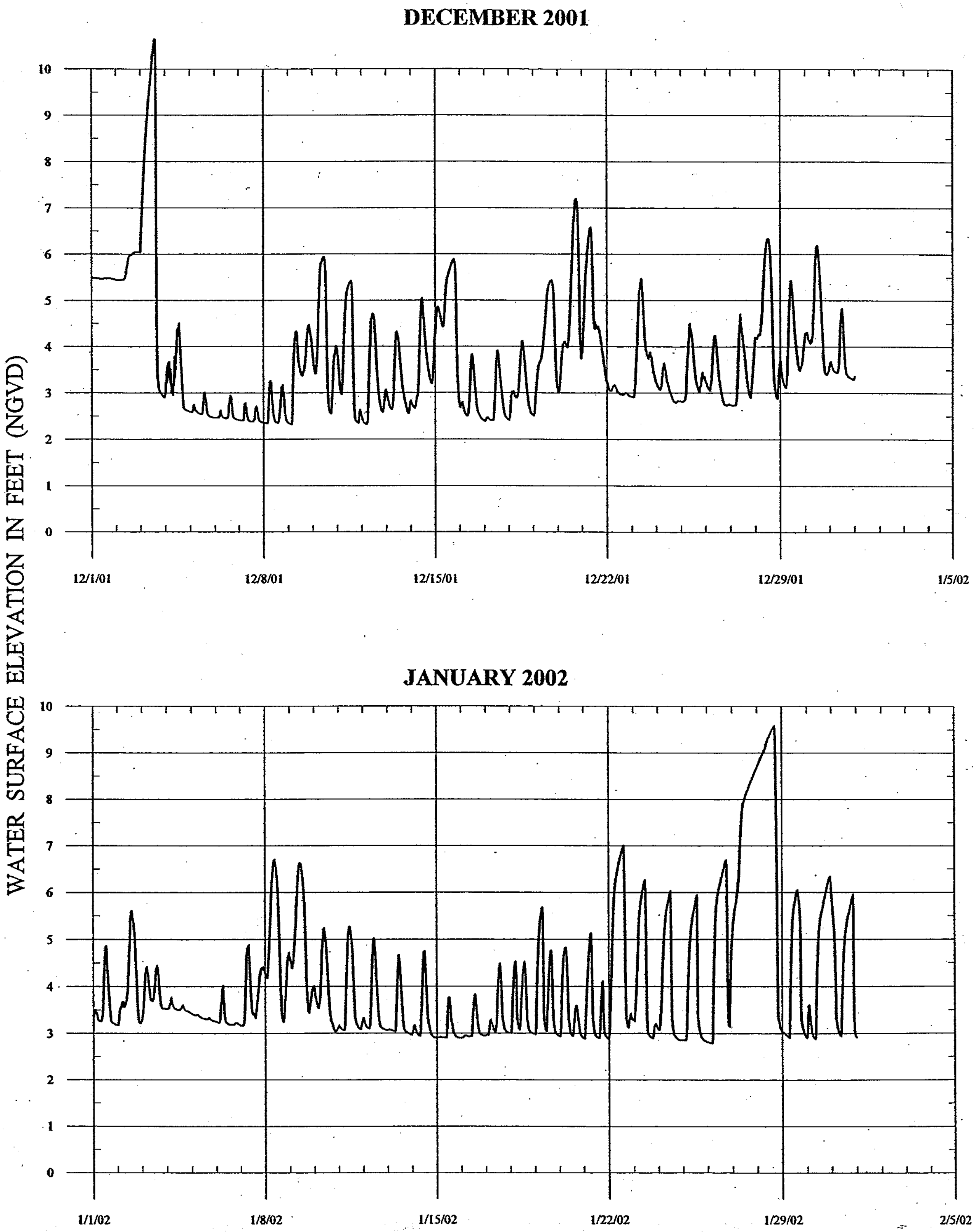
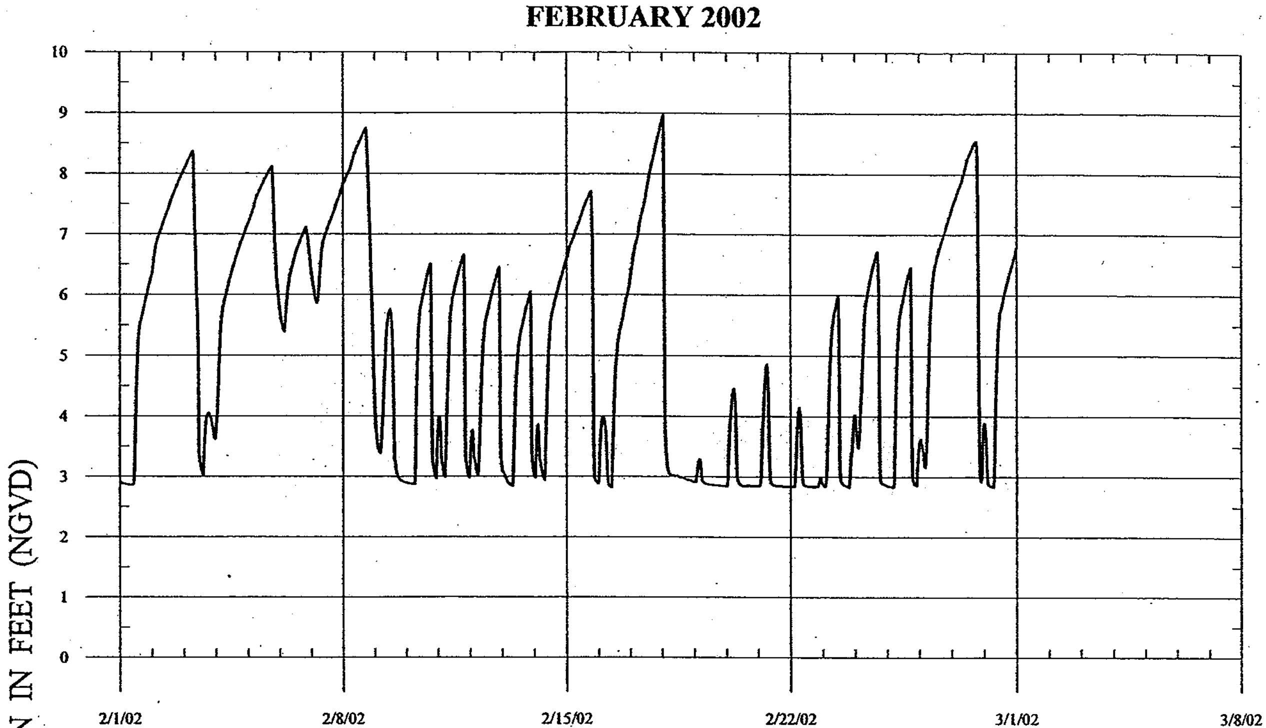


FIGURE A-55

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



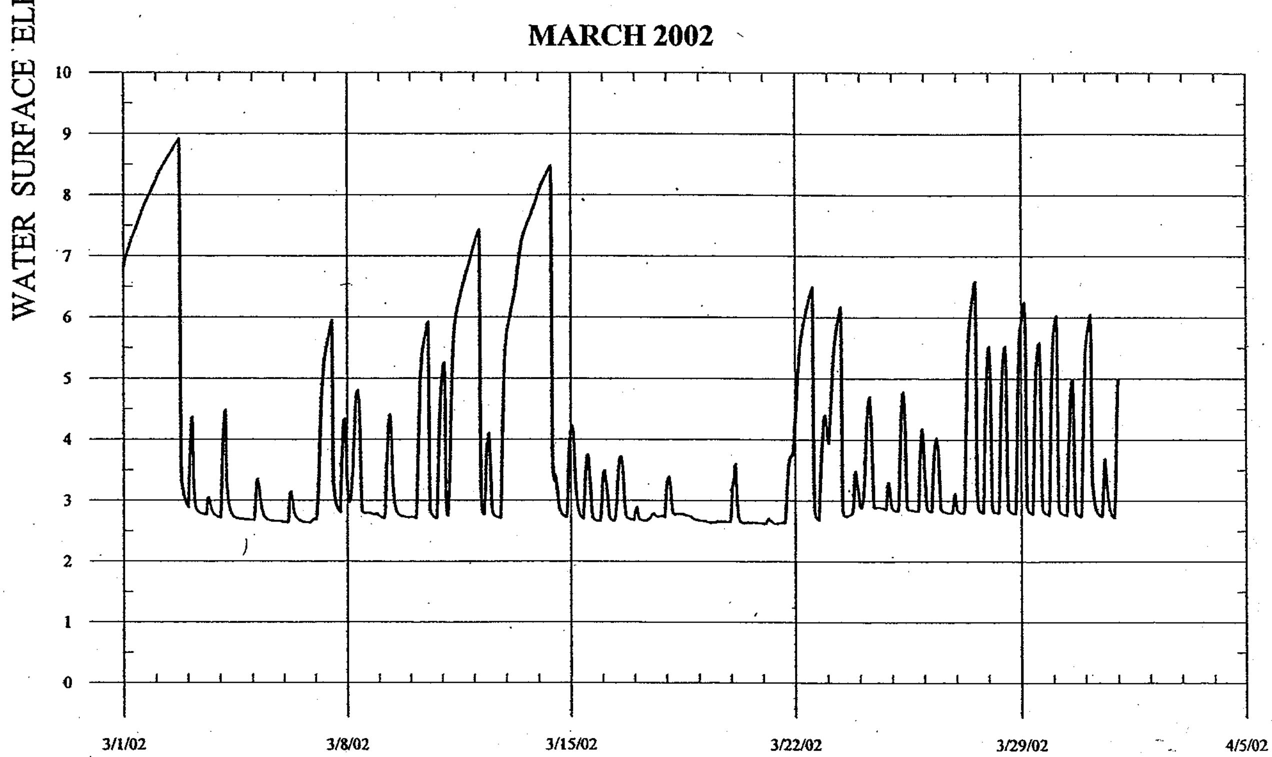
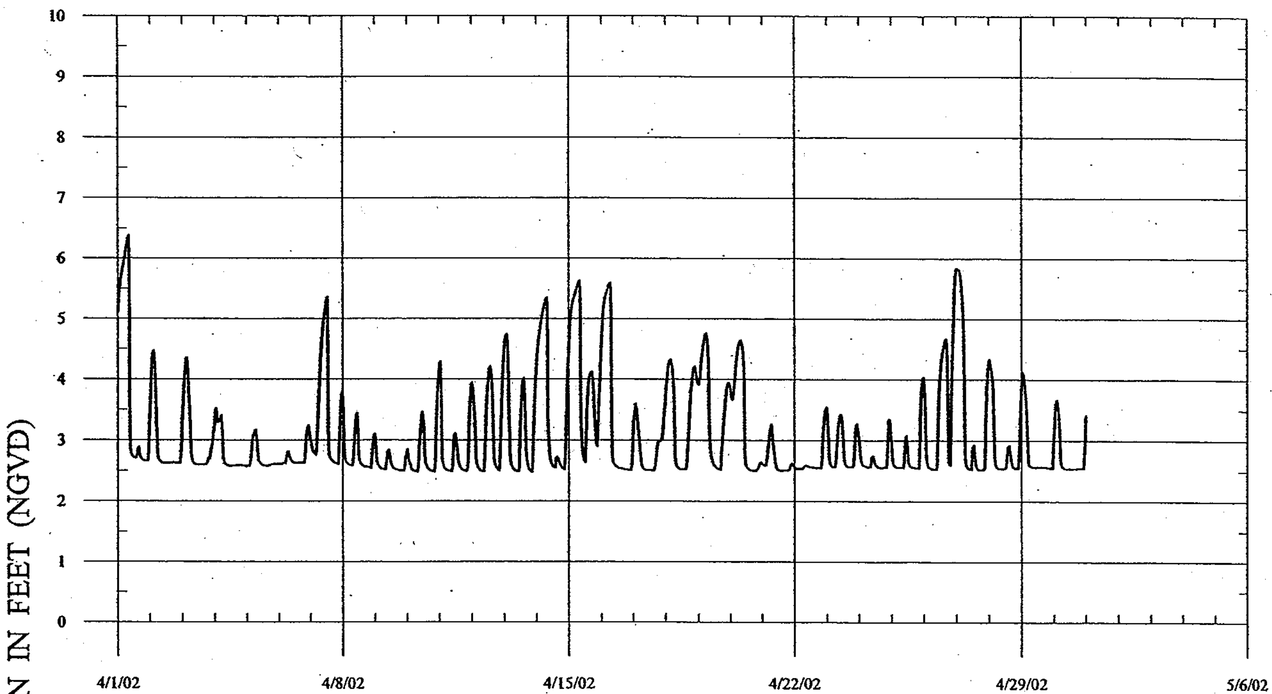


FIGURE A-56

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 2002



MAY 2002

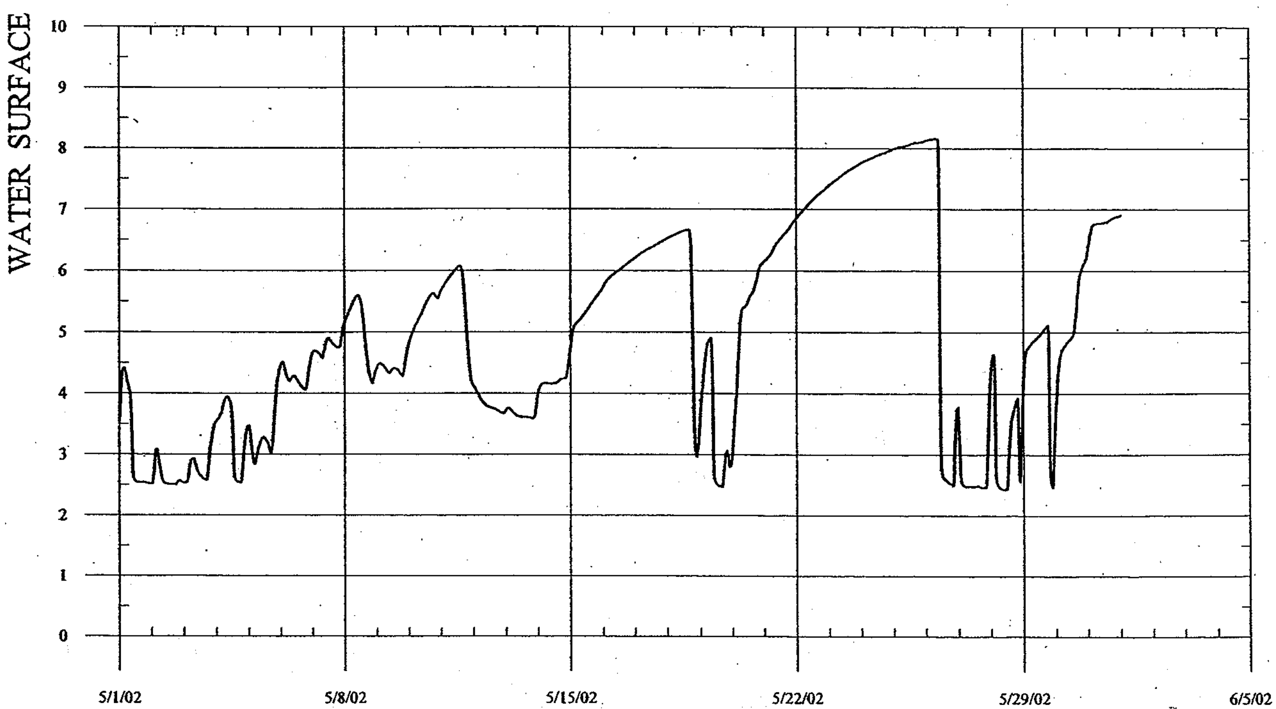
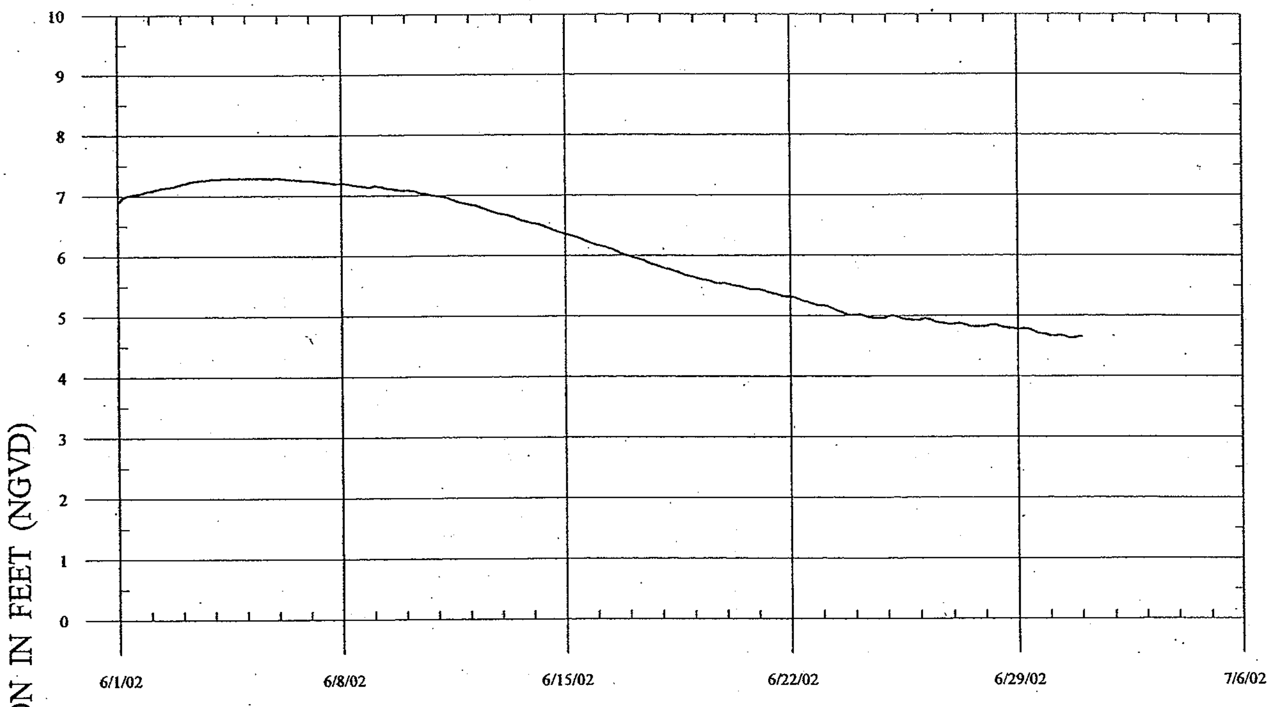


FIGURE A-57

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

JUNE 2002



JULY 2002

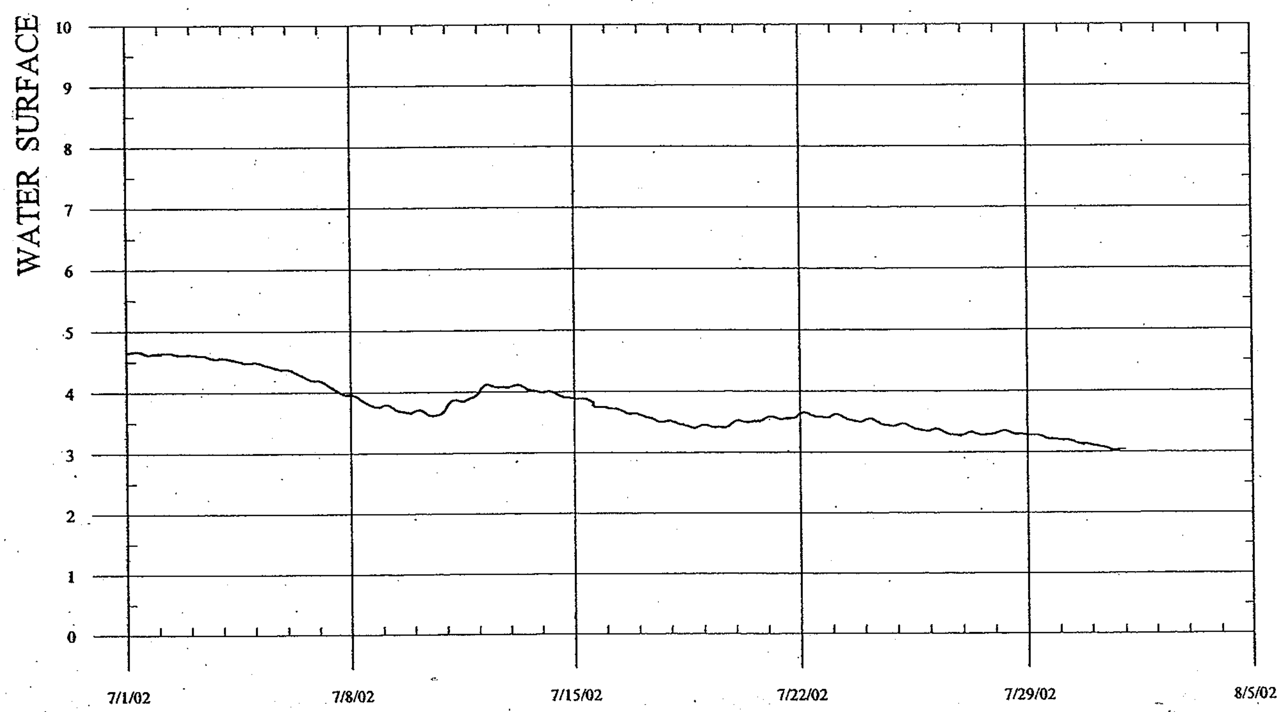
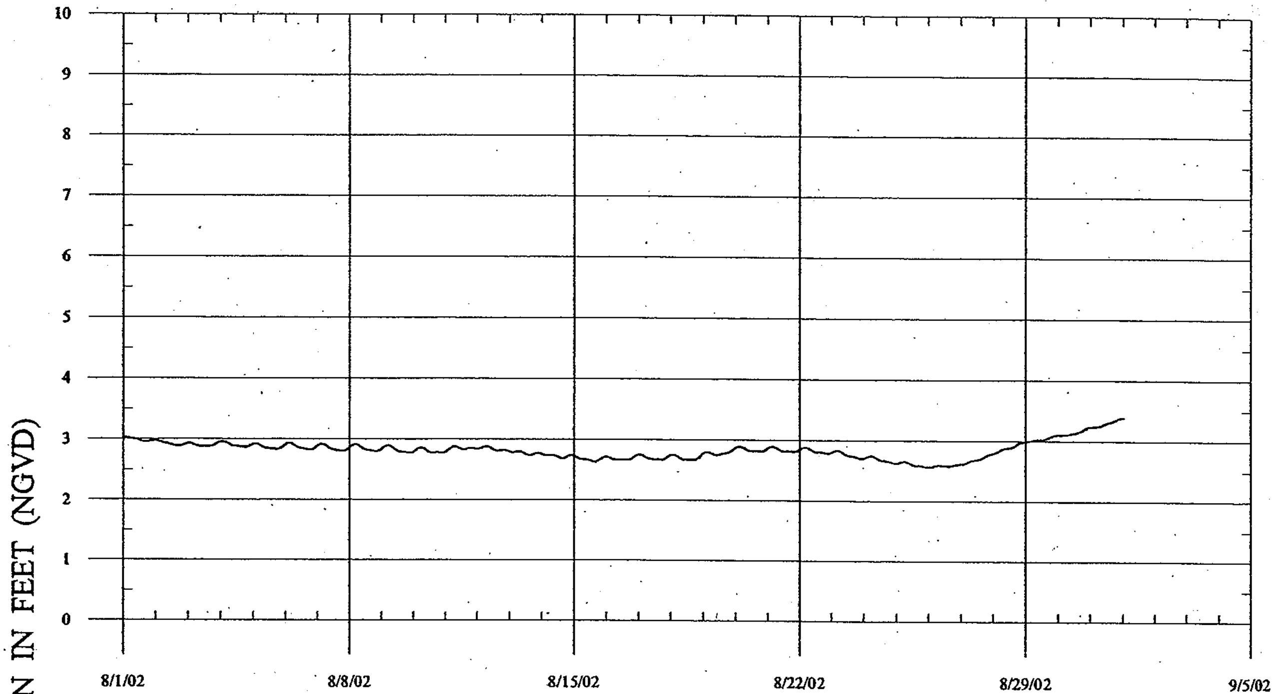


FIGURE A-58

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

AUGUST 2002



SEPTEMBER 2002

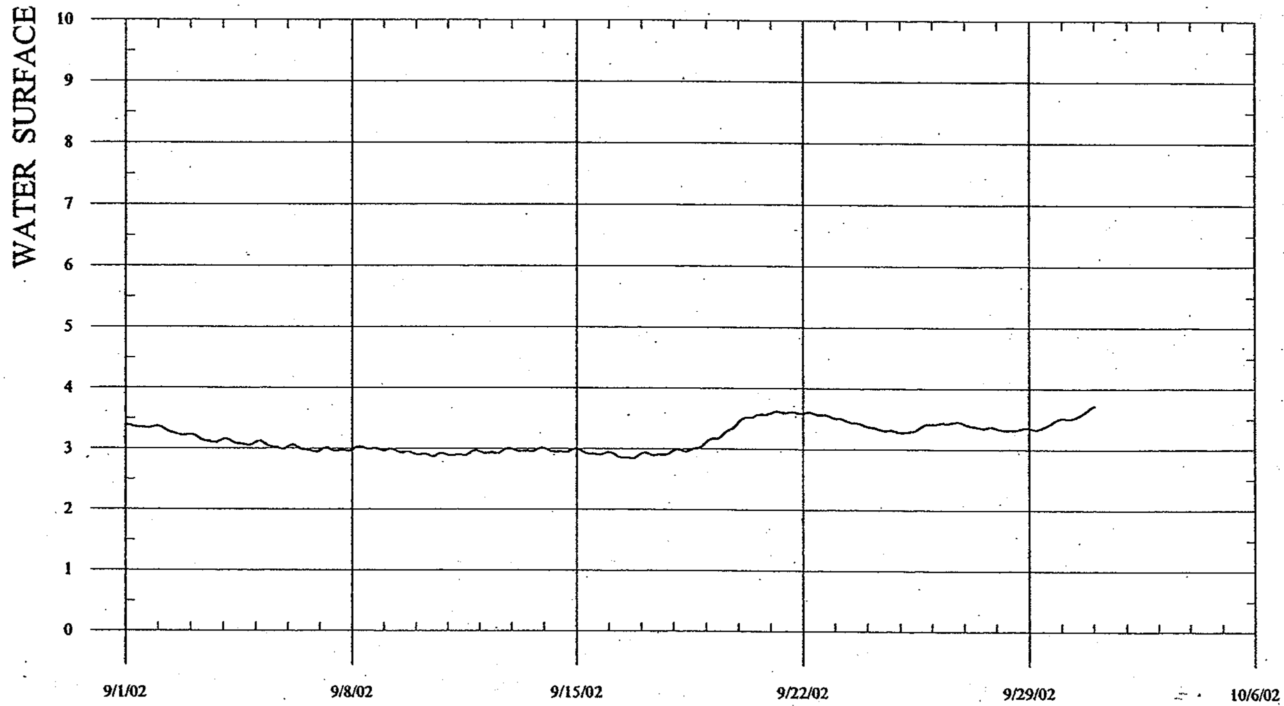
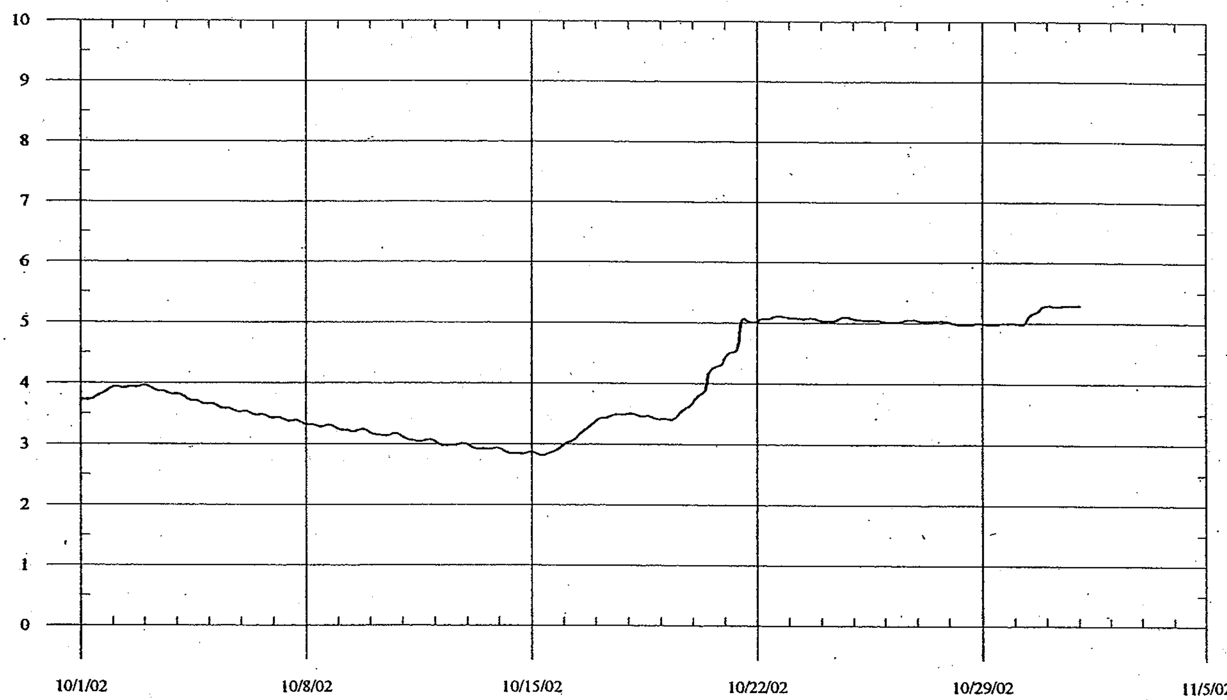


FIGURE A-59

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

OCTOBER 2002



WATER SURFACE ELEVATION IN FEET (NGVD)

NOVEMBER 2002

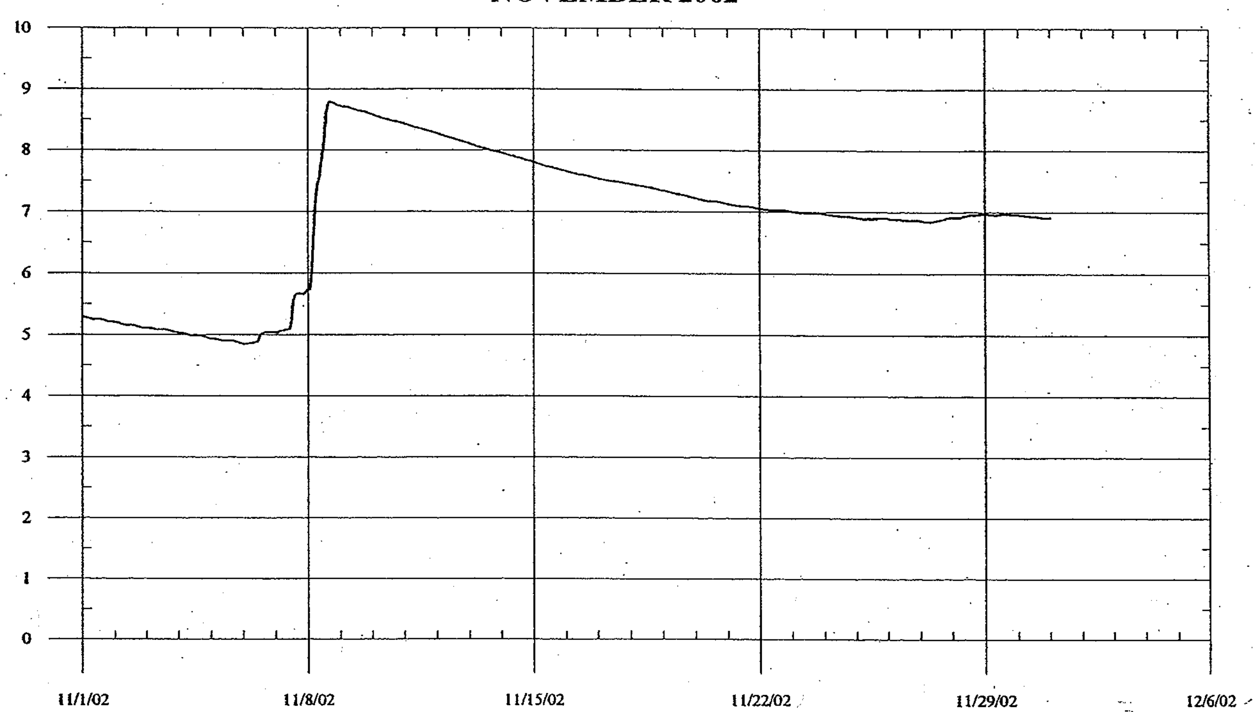


FIGURE A-60

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

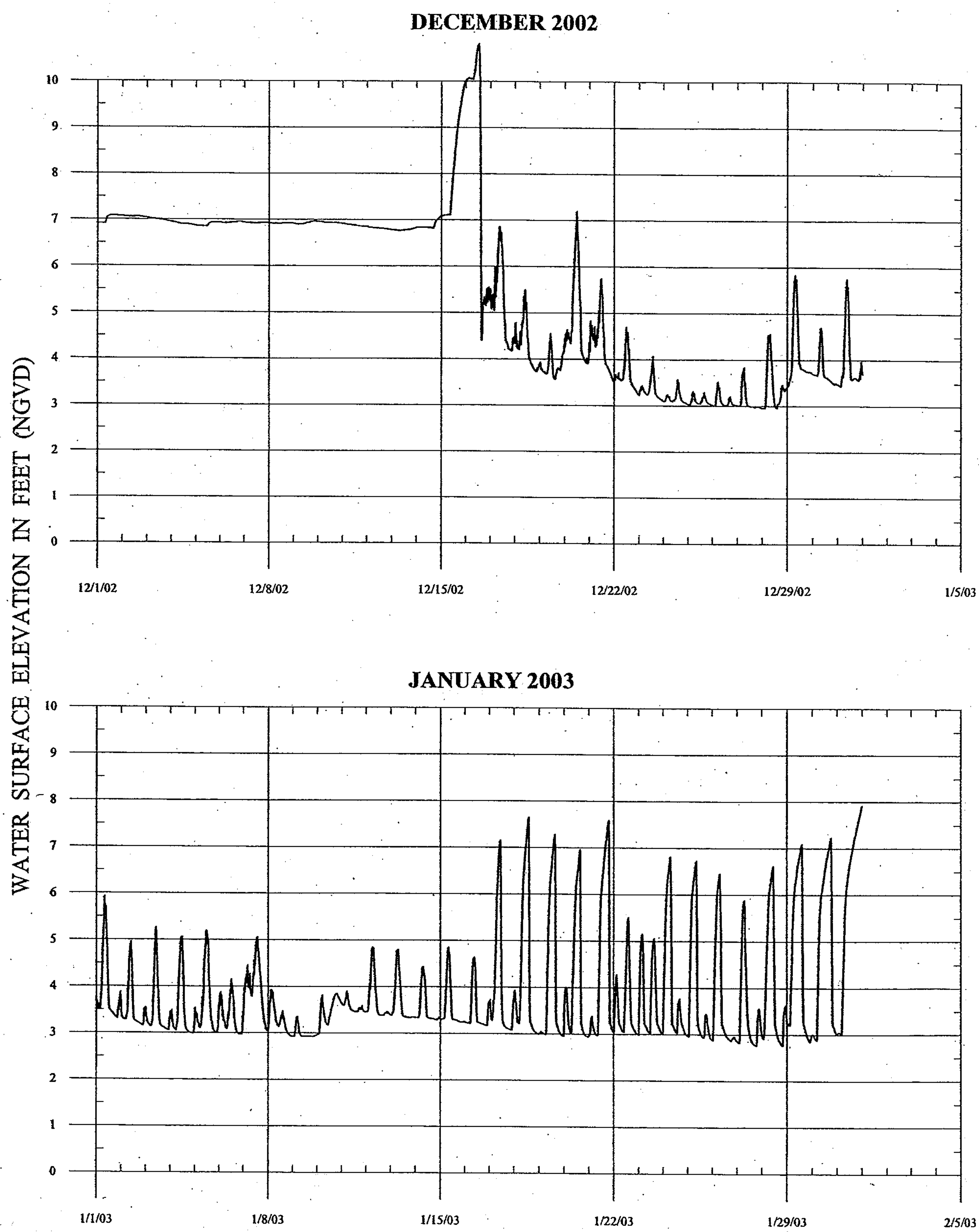


FIGURE A-61

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

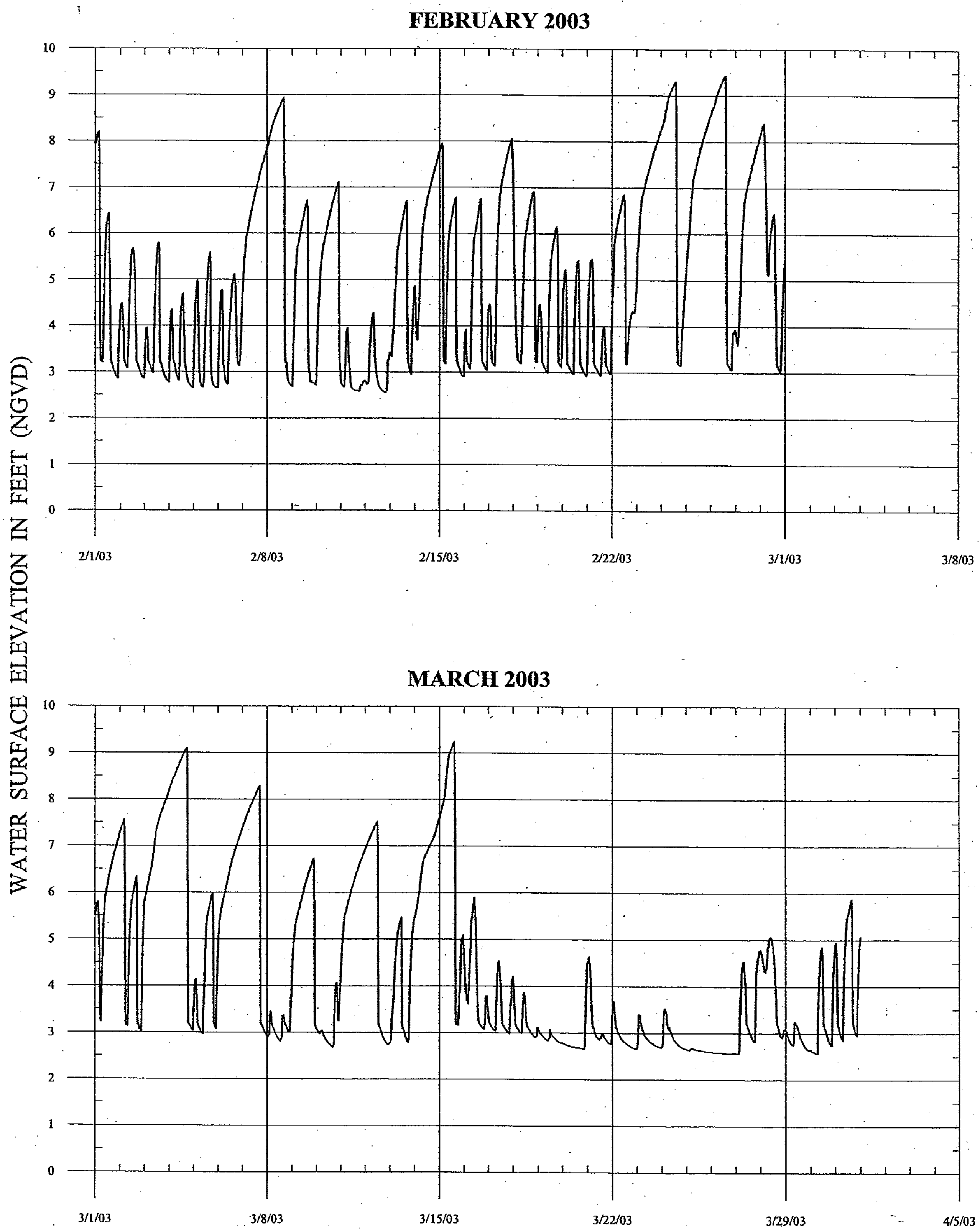
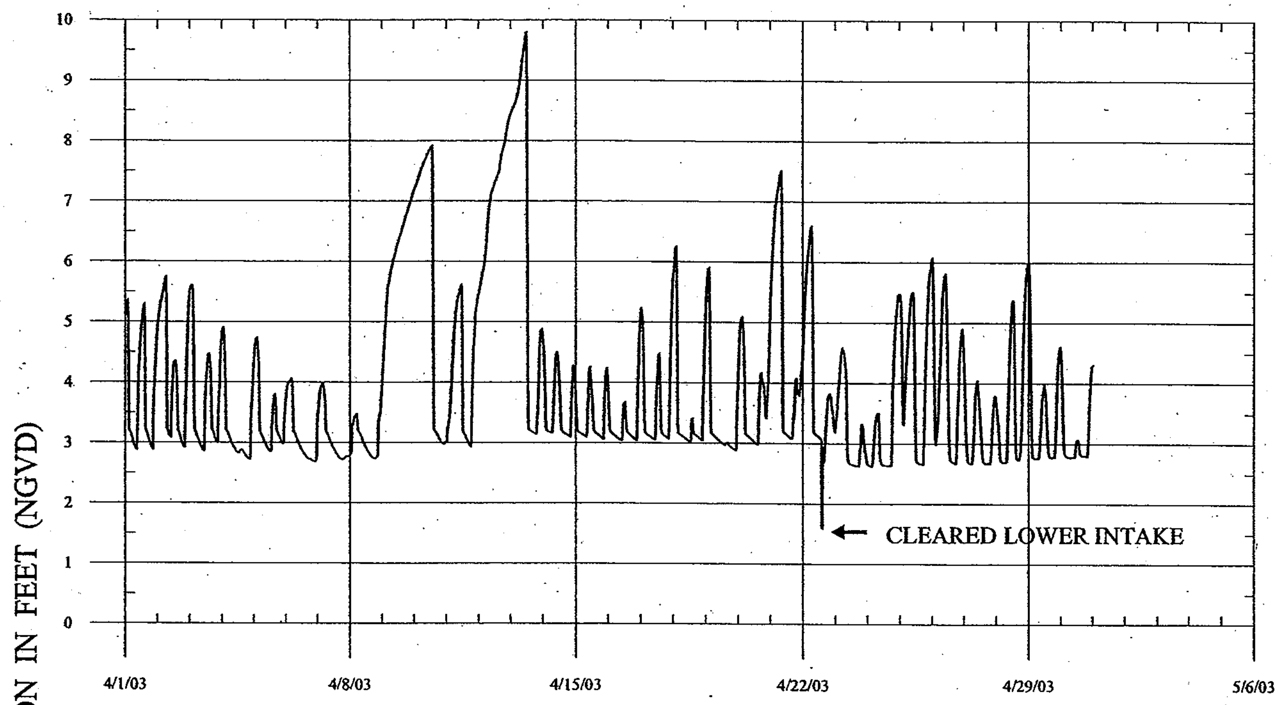


FIGURE A-62

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

APRIL 2003



MAY 2003

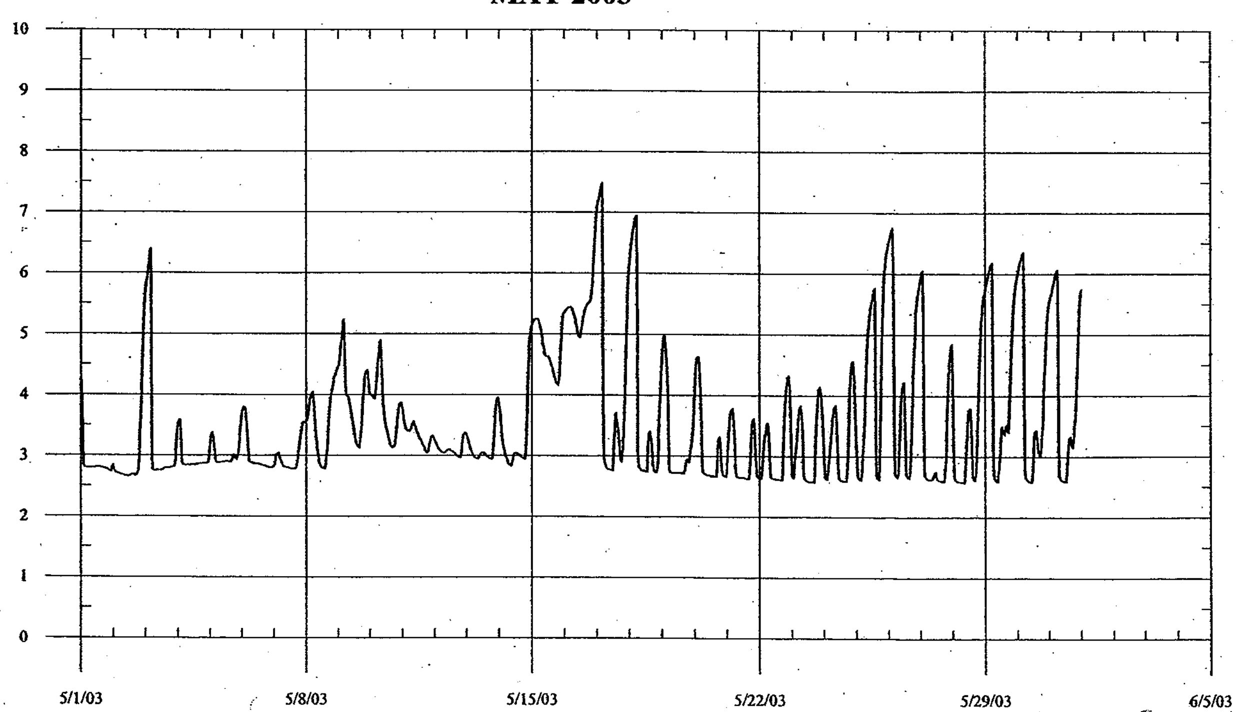


FIGURE A-63

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

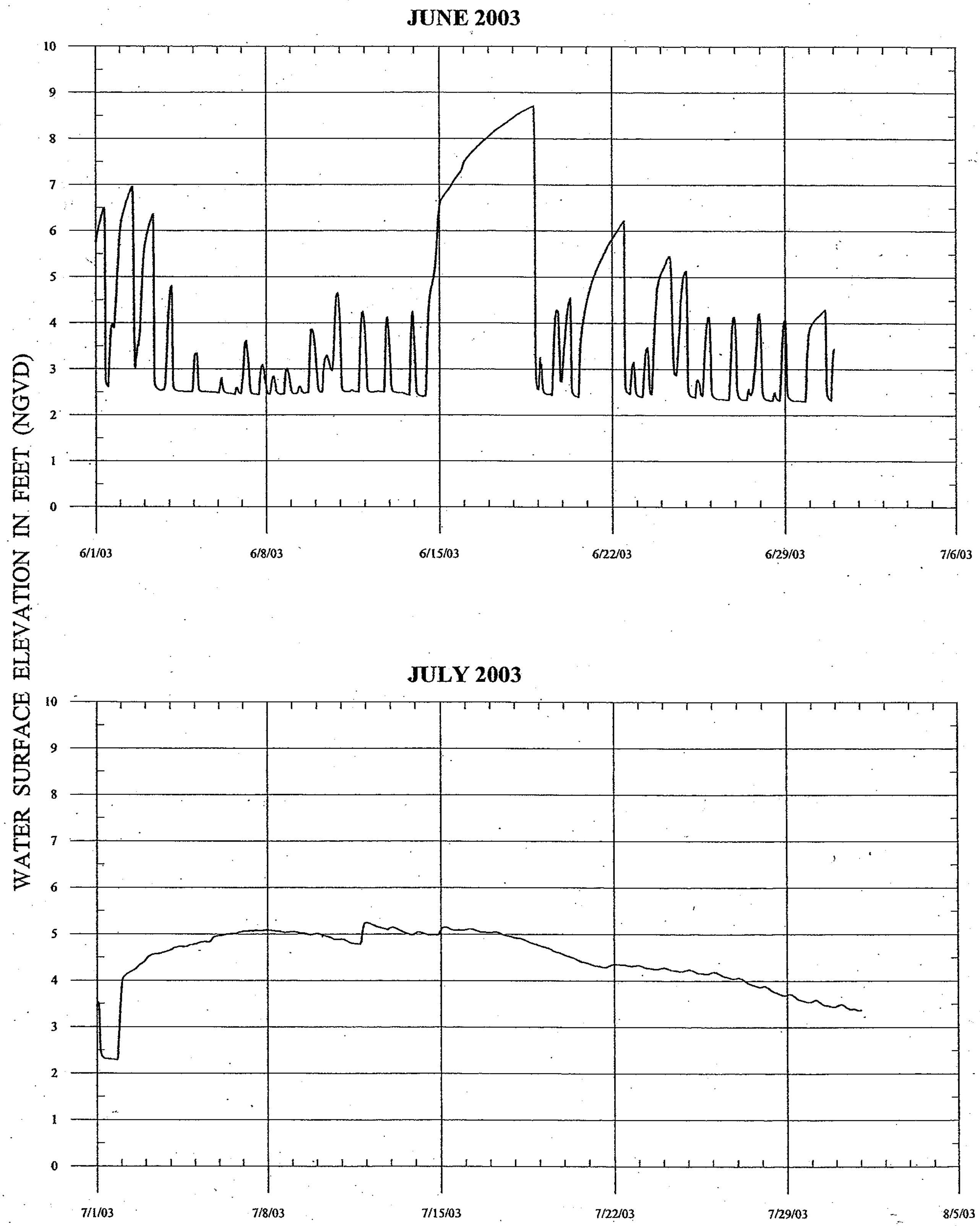
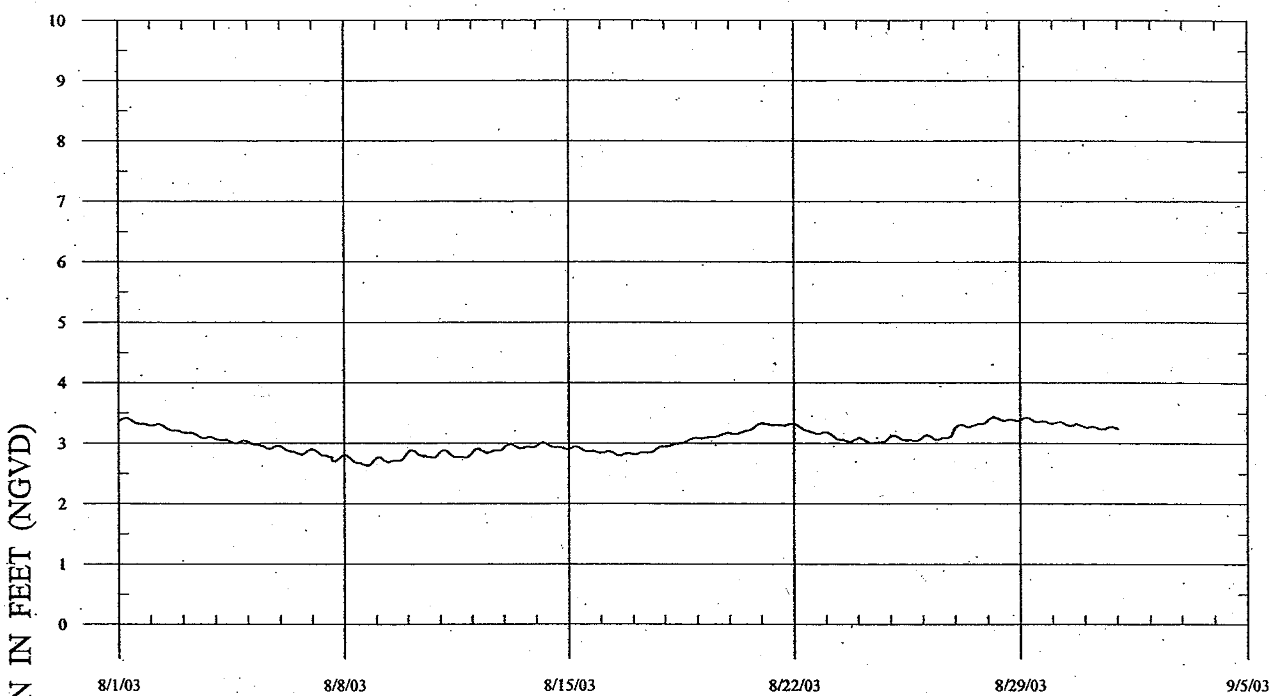


FIGURE A-64

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

AUGUST 2003



SEPTEMBER 2003

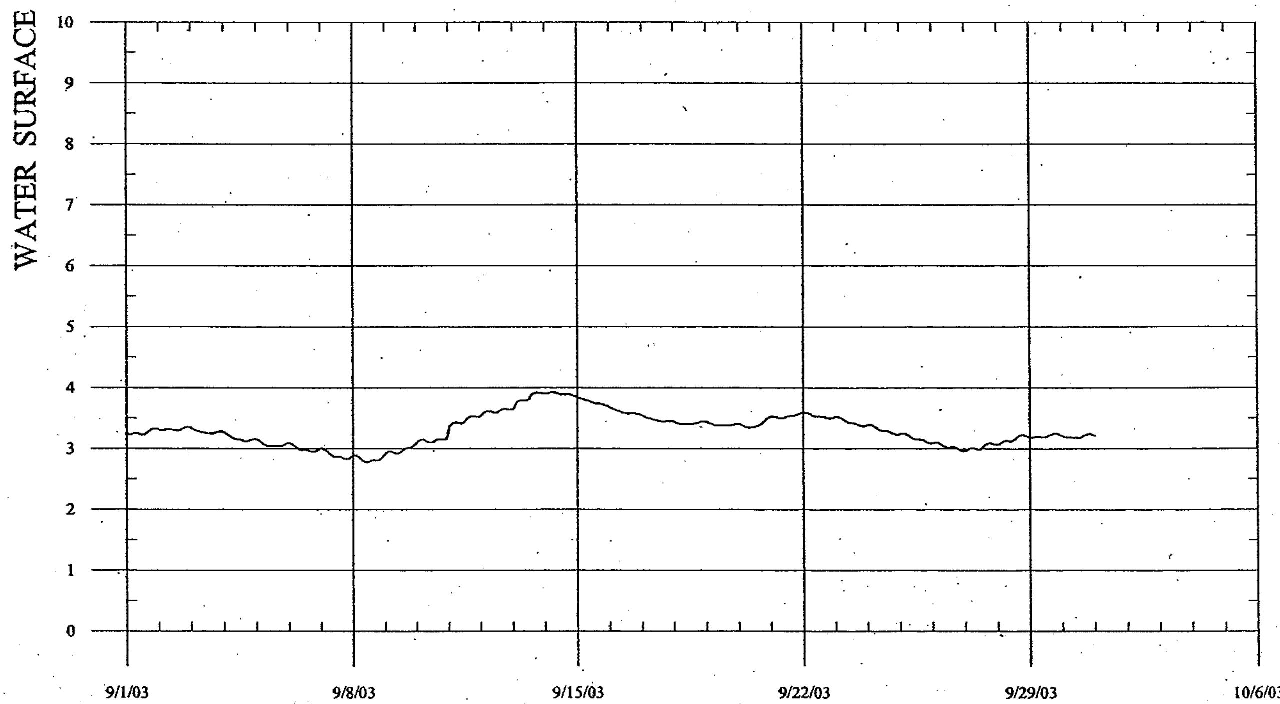
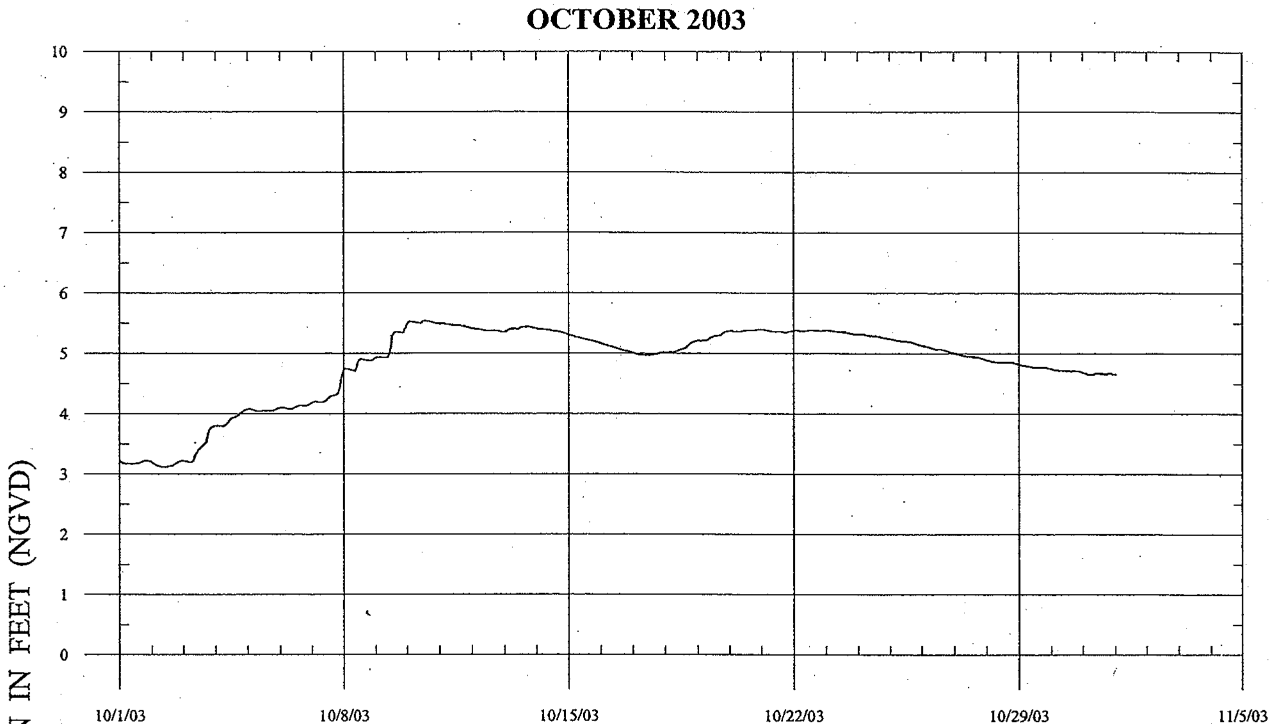


FIGURE A-65

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



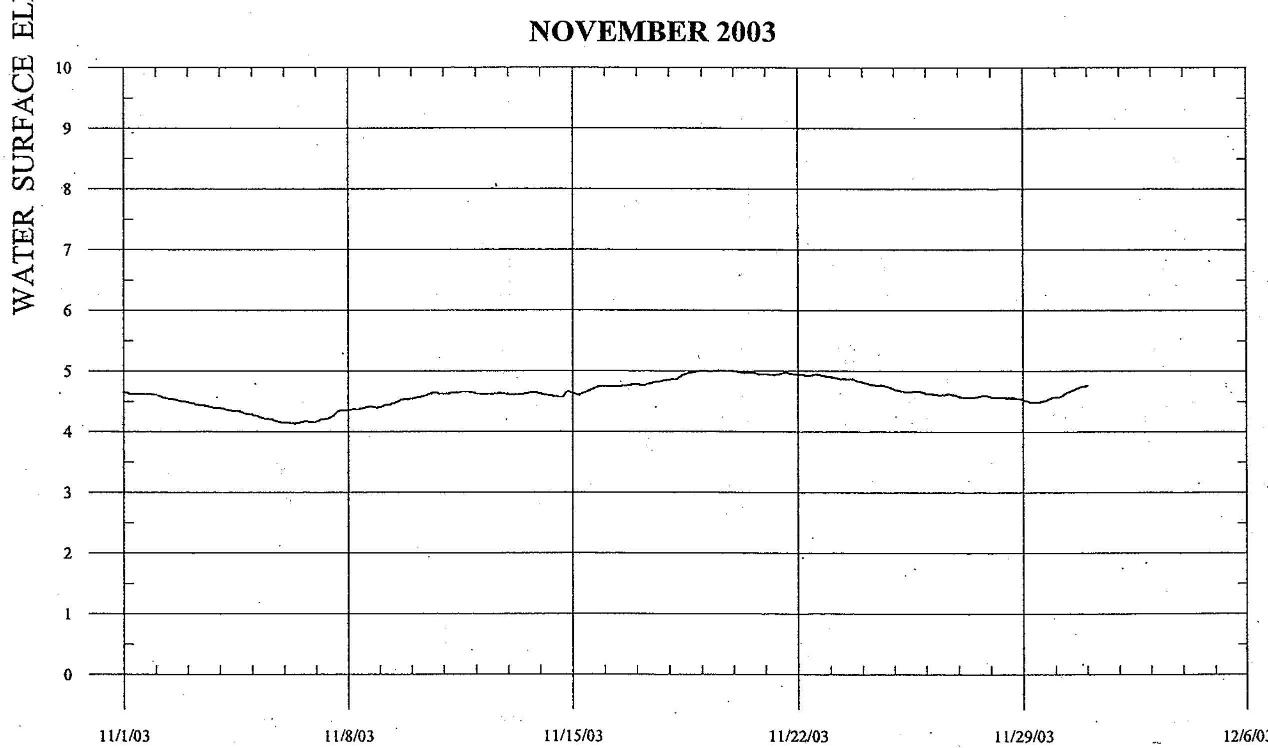
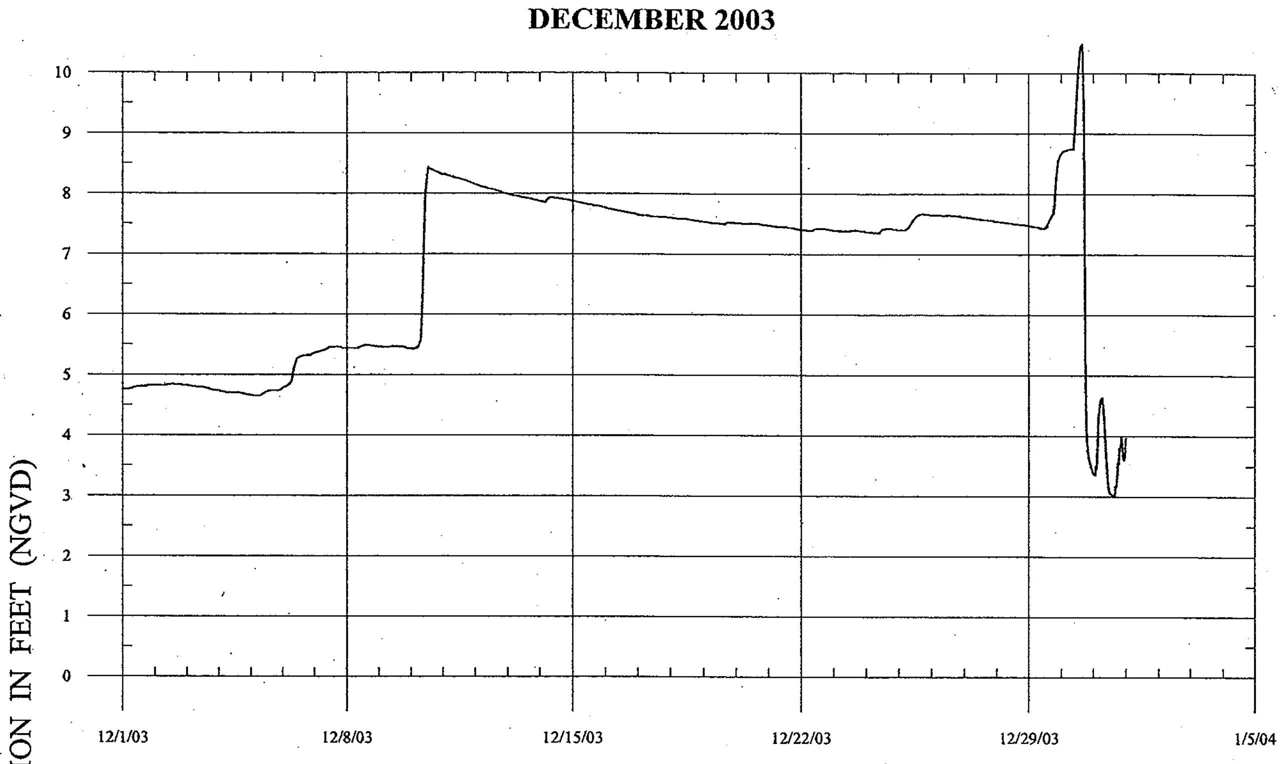


FIGURE A-66

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



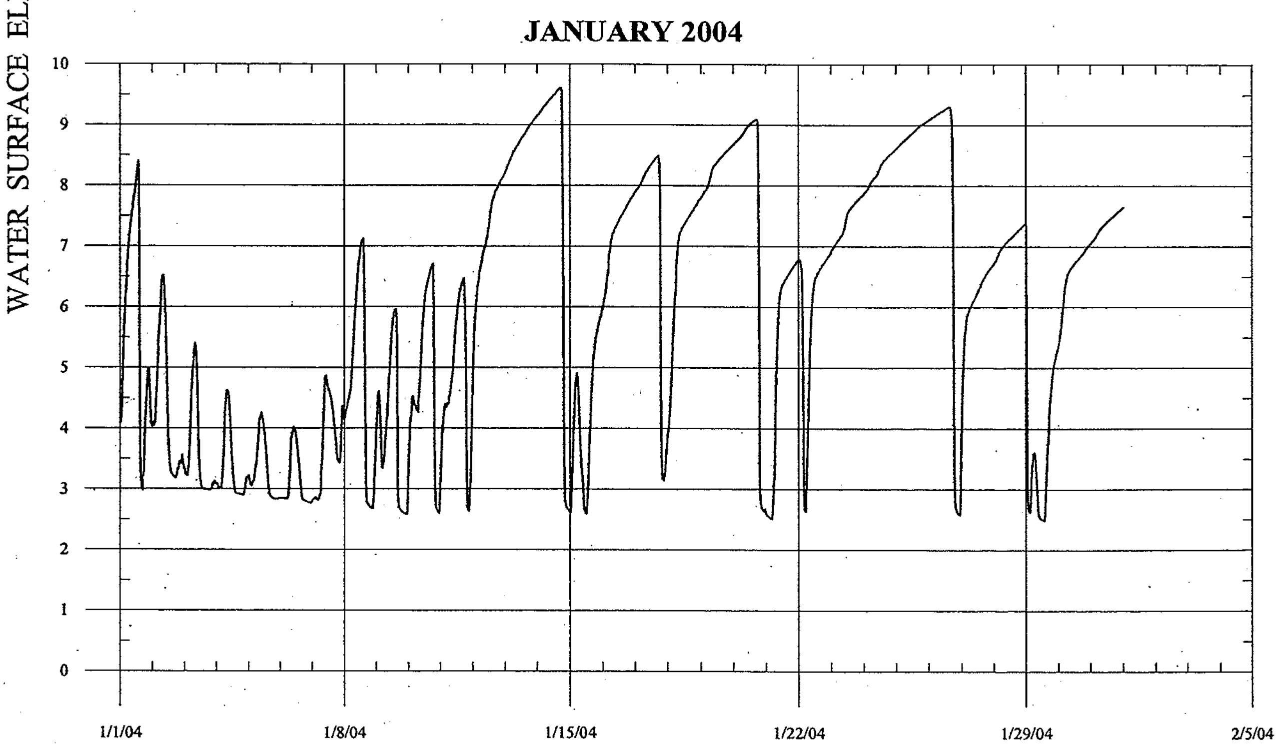
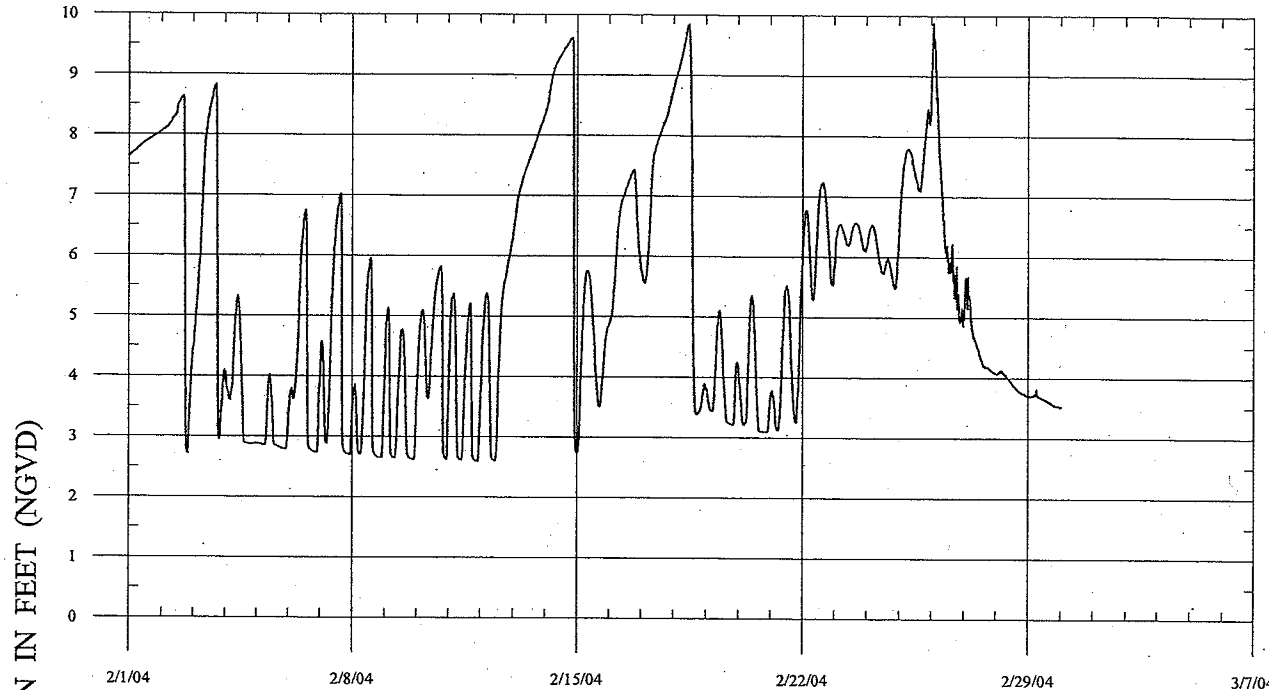


FIGURE A-67

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 2004



MARCH 2004

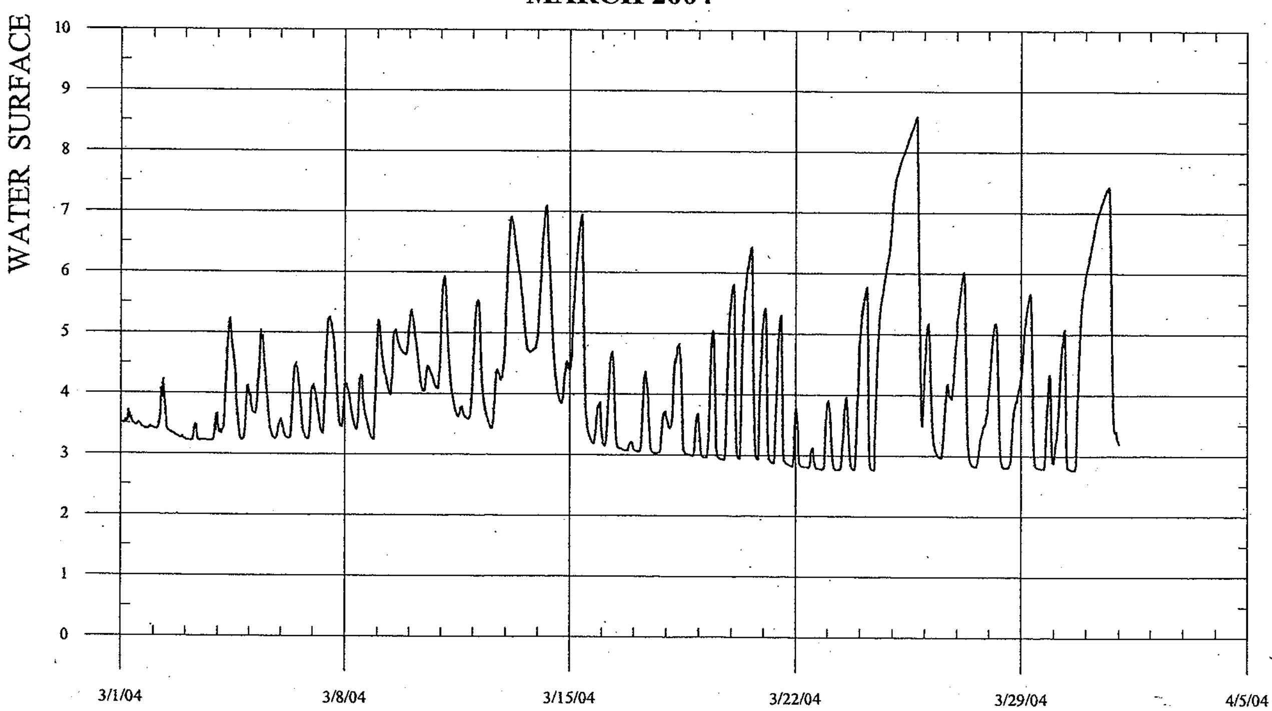
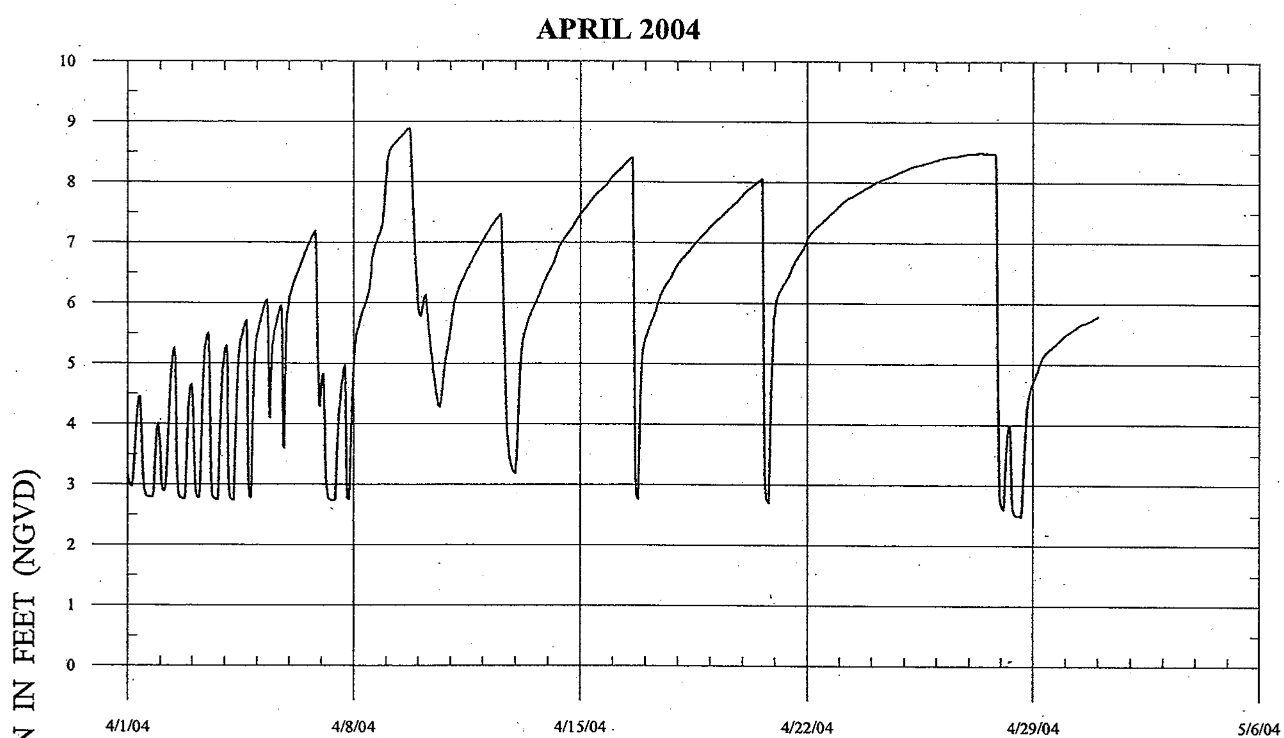


FIGURE A-68

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



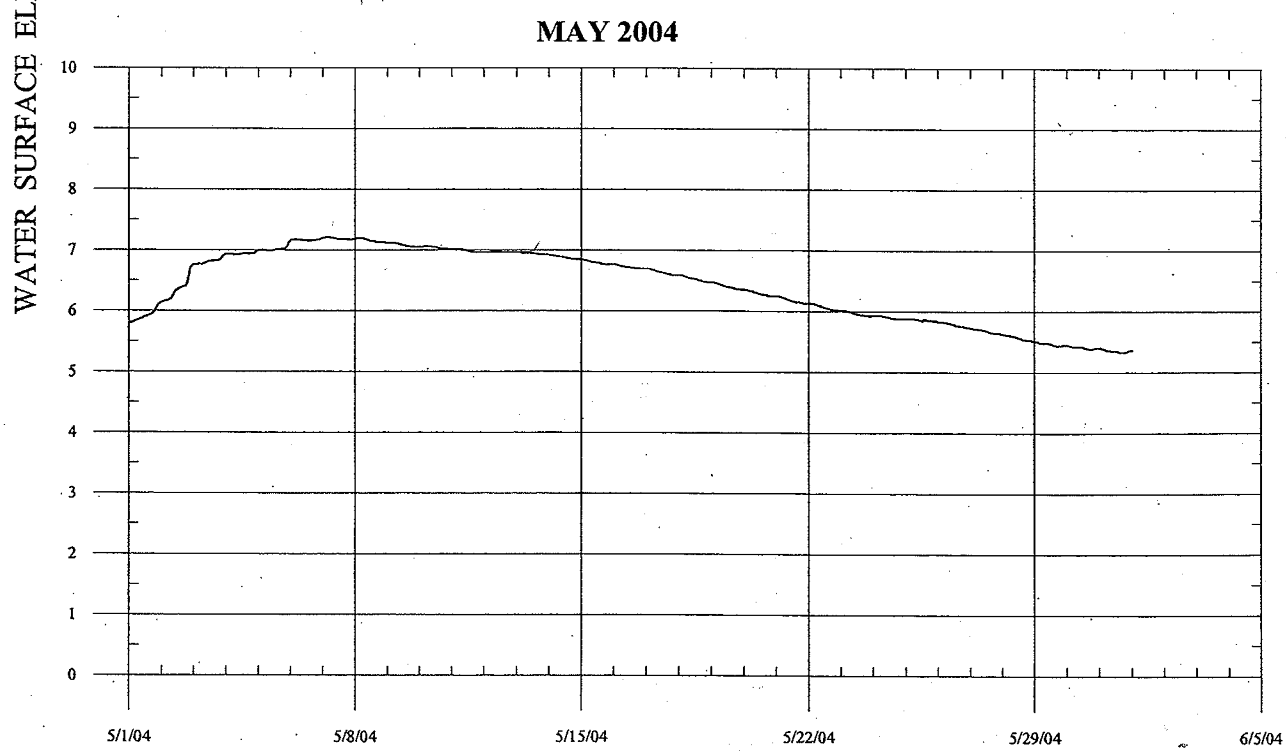
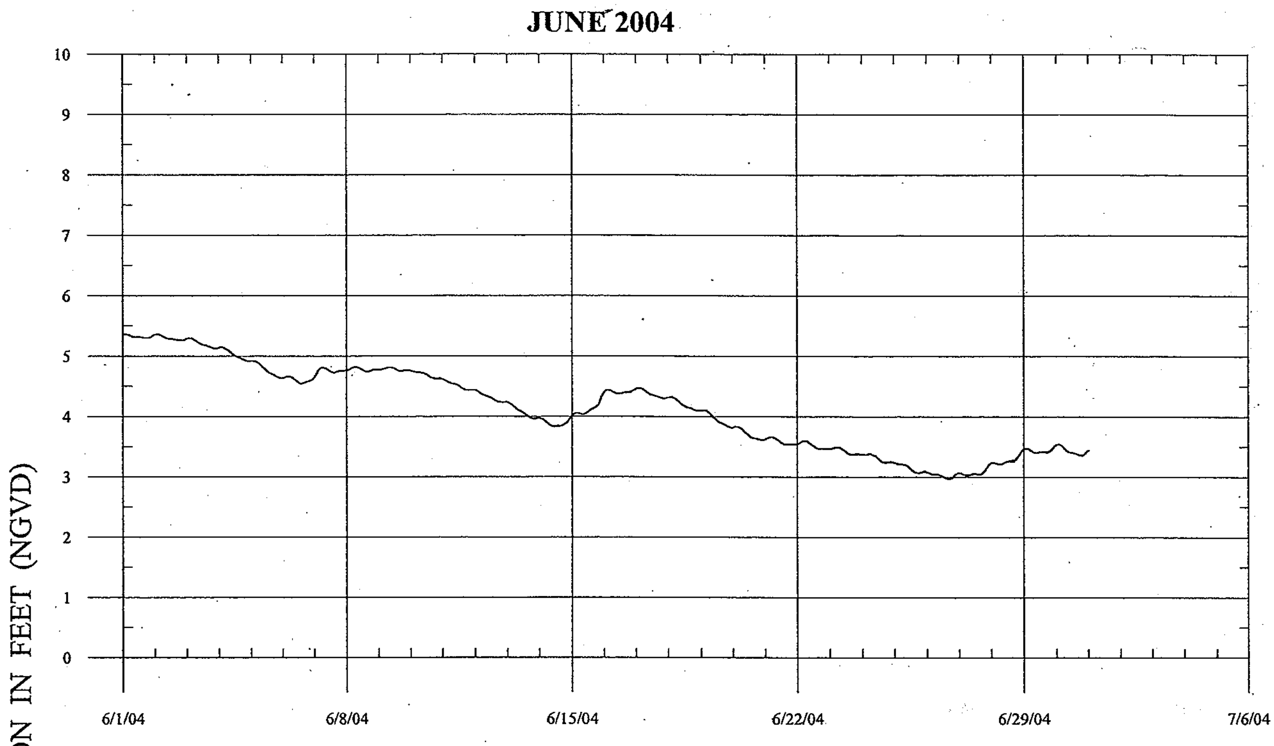


FIGURE A-69

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



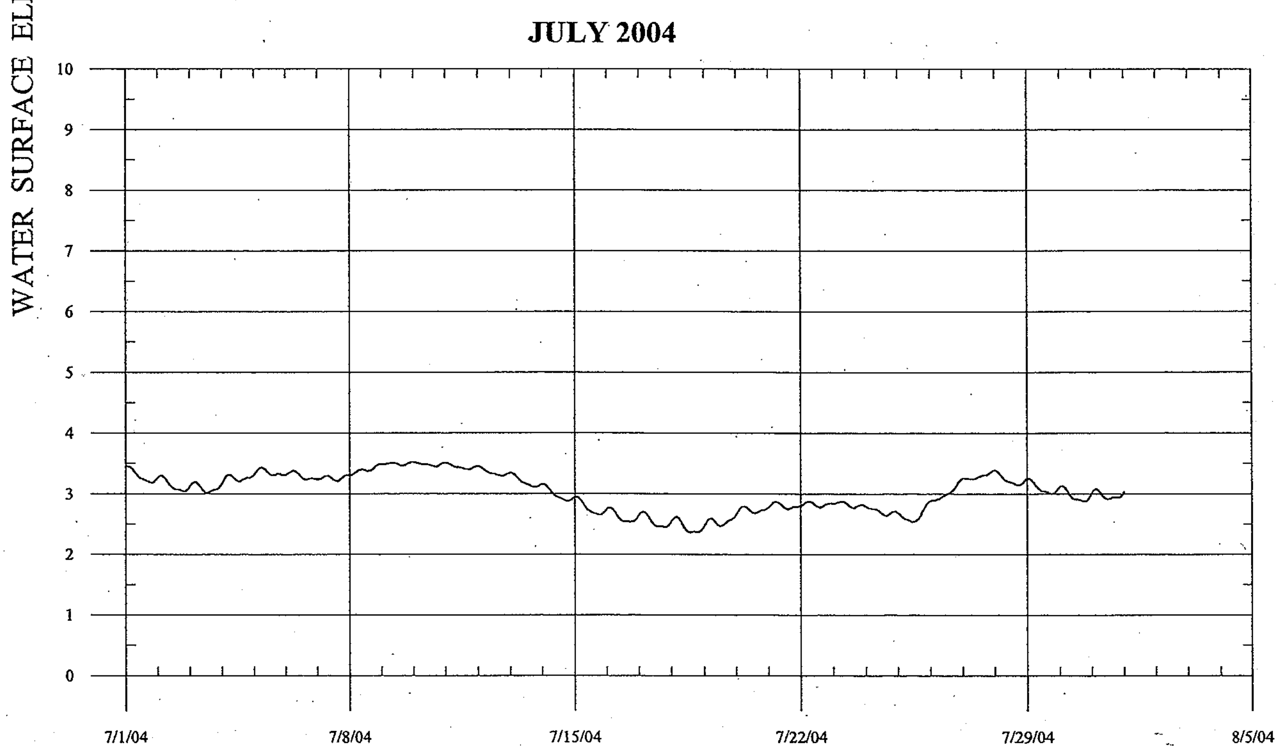
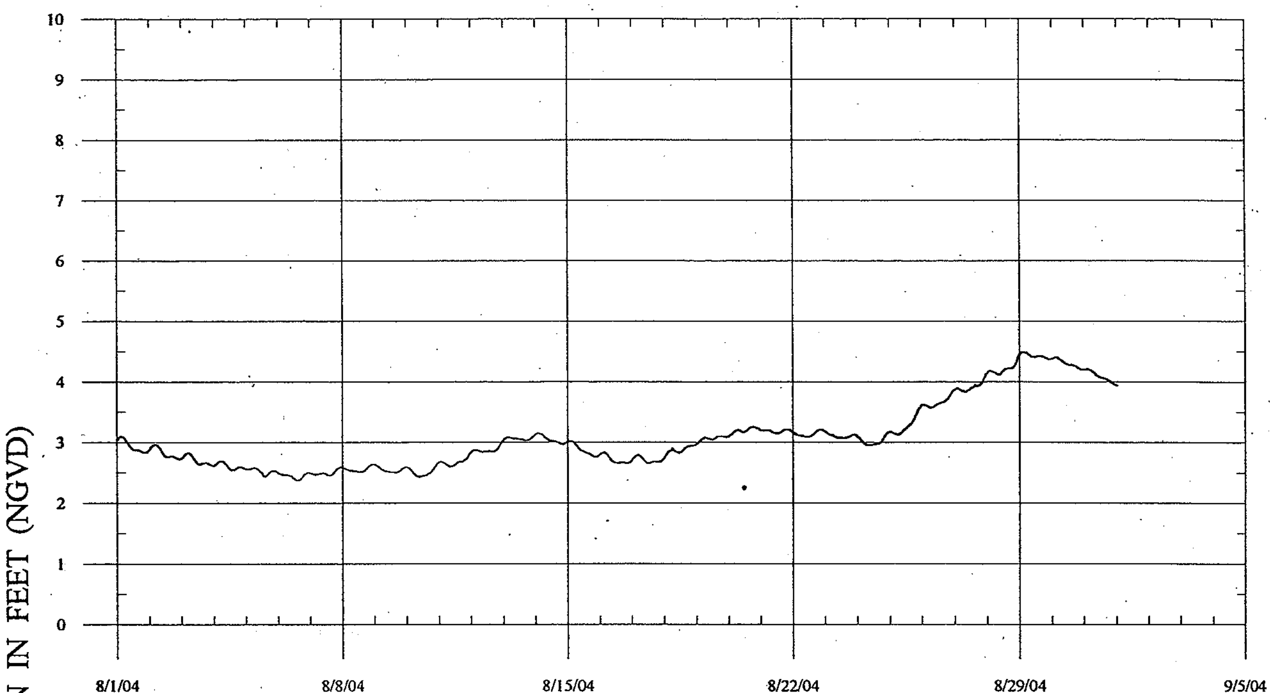


FIGURE A-70

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

AUGUST 2004



SEPTEMBER 2004

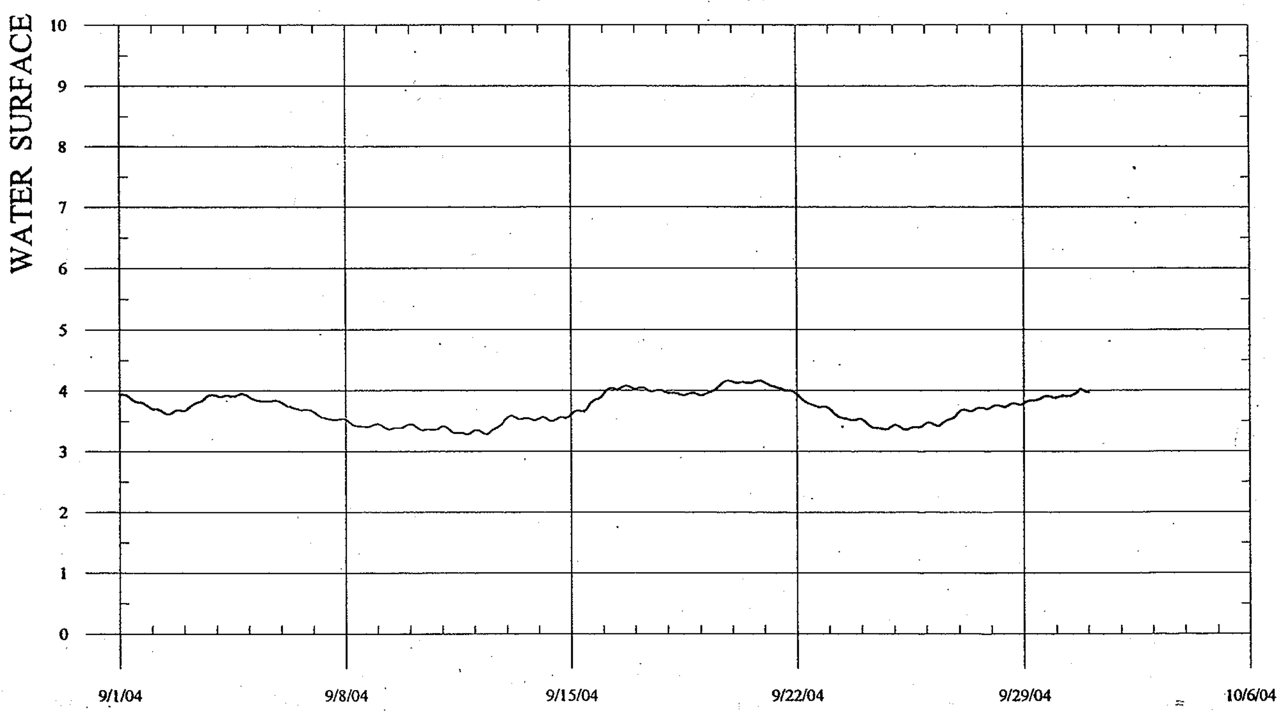
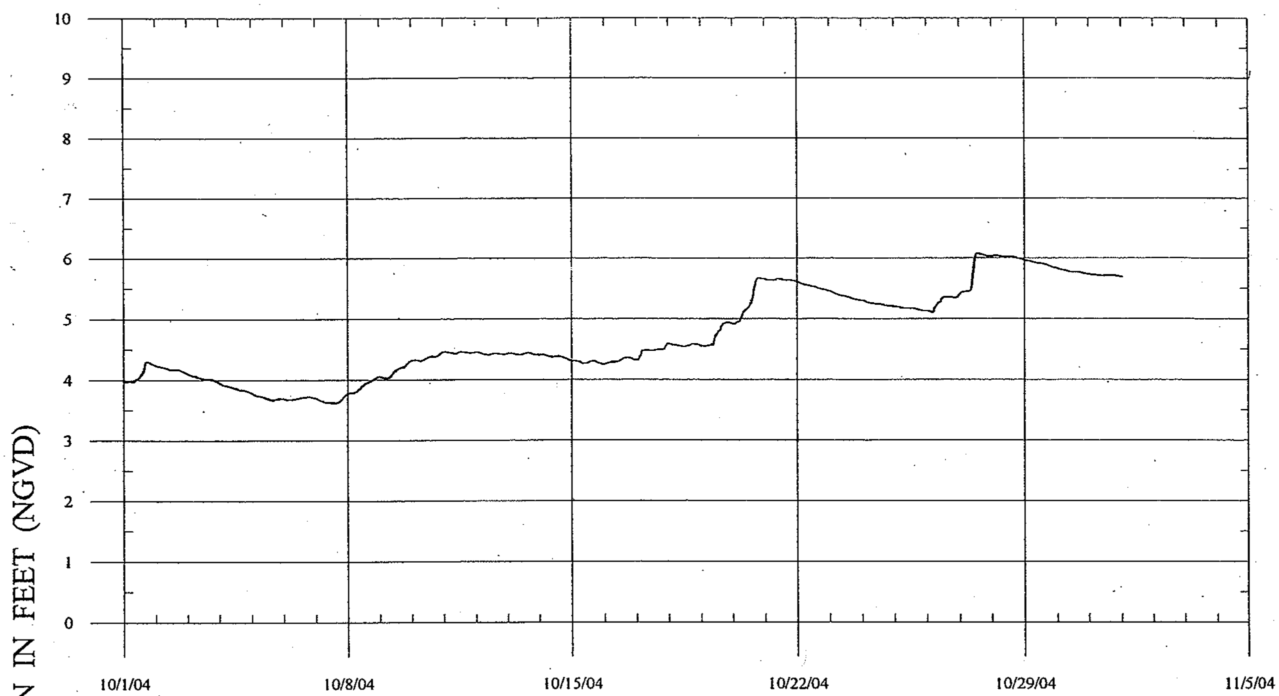


FIGURE A-71

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

OCTOBER 2004



NOVEMBER 2004

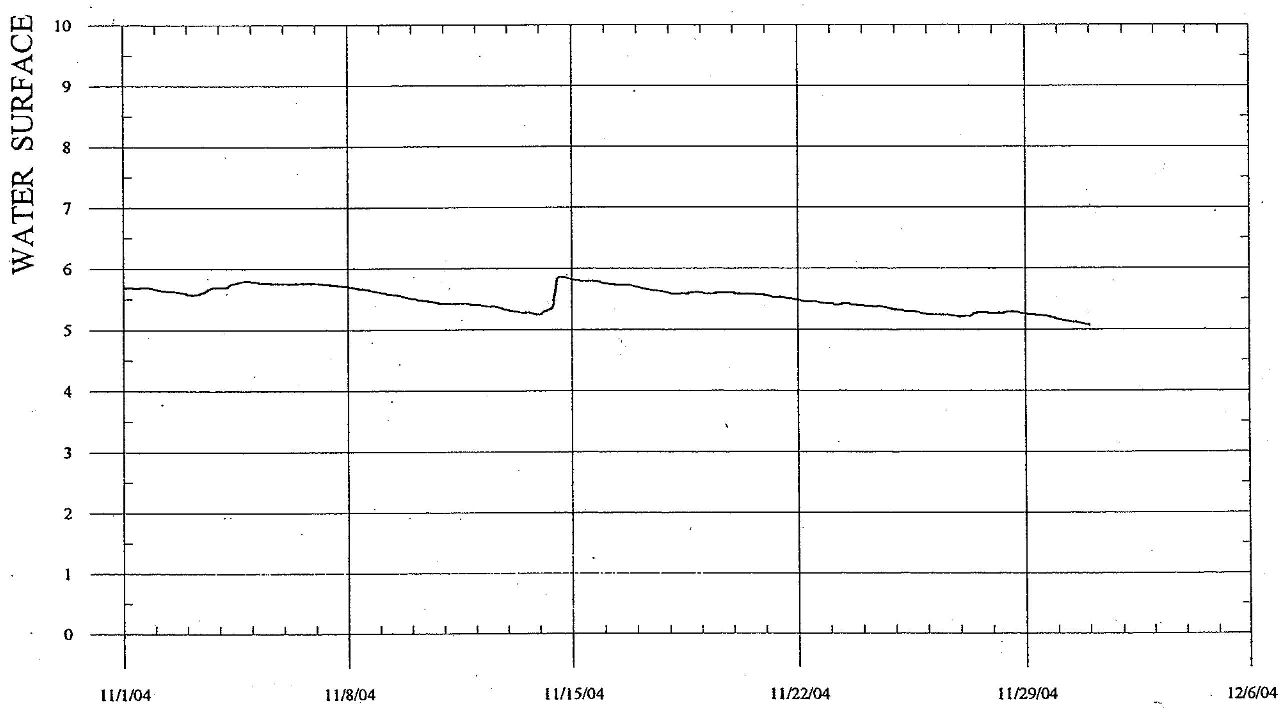
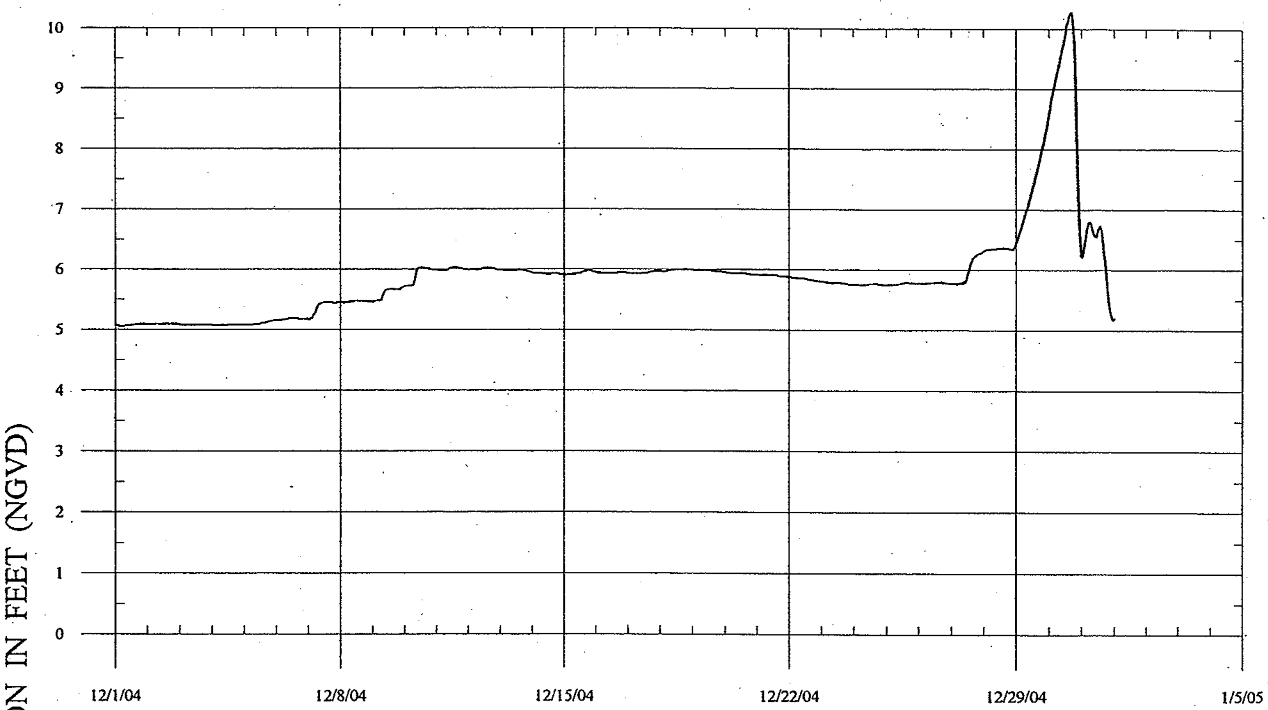


FIGURE A-72

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

DECEMBER 2004



JANUARY 2005

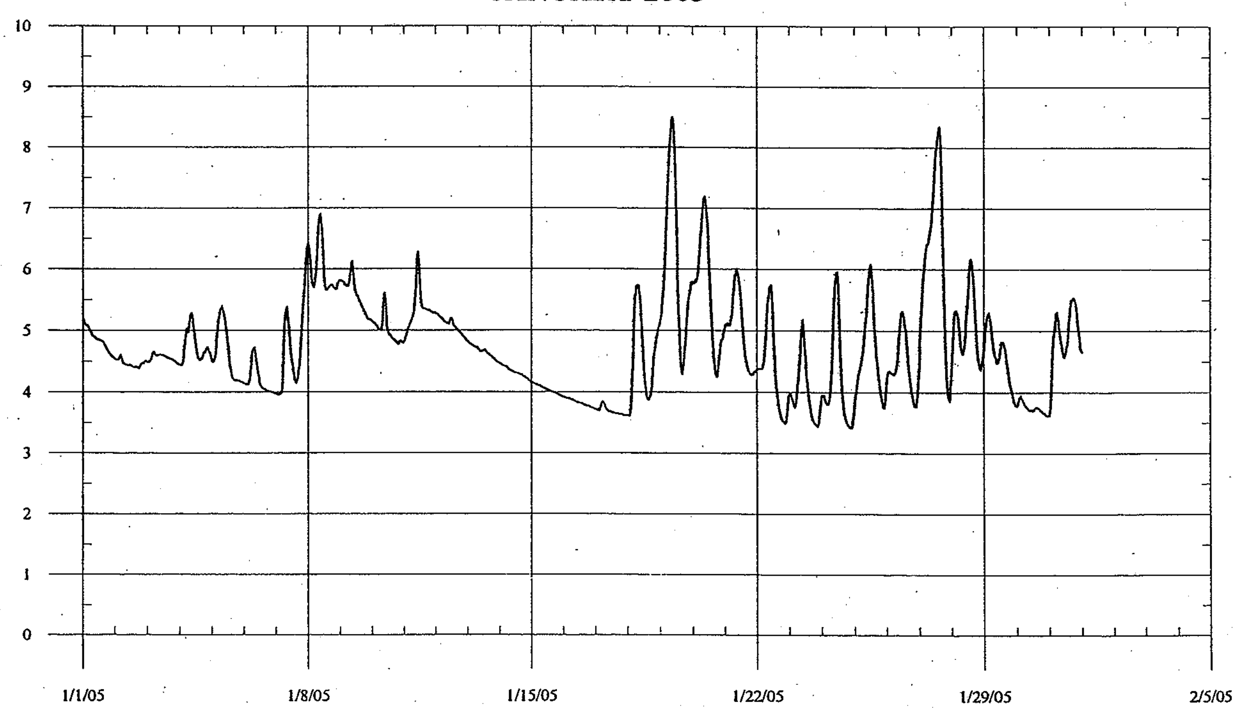
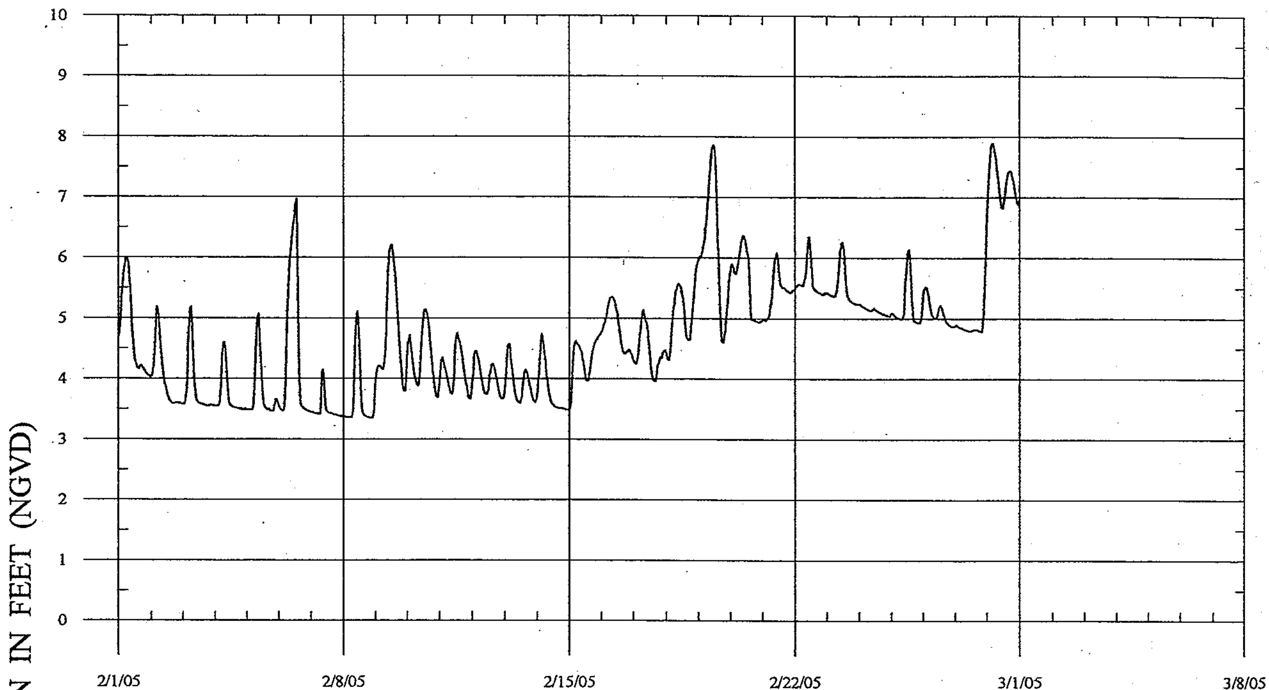


FIGURE A-73

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

FEBRUARY 2005



MARCH 2005

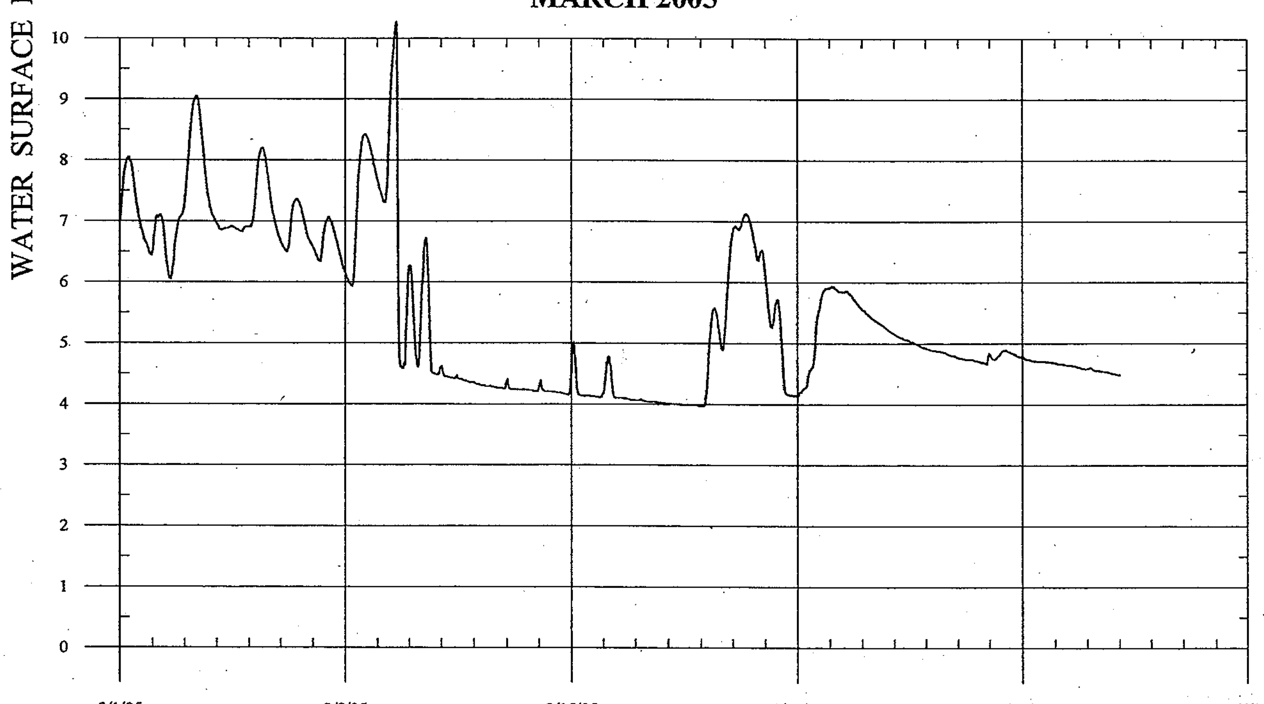
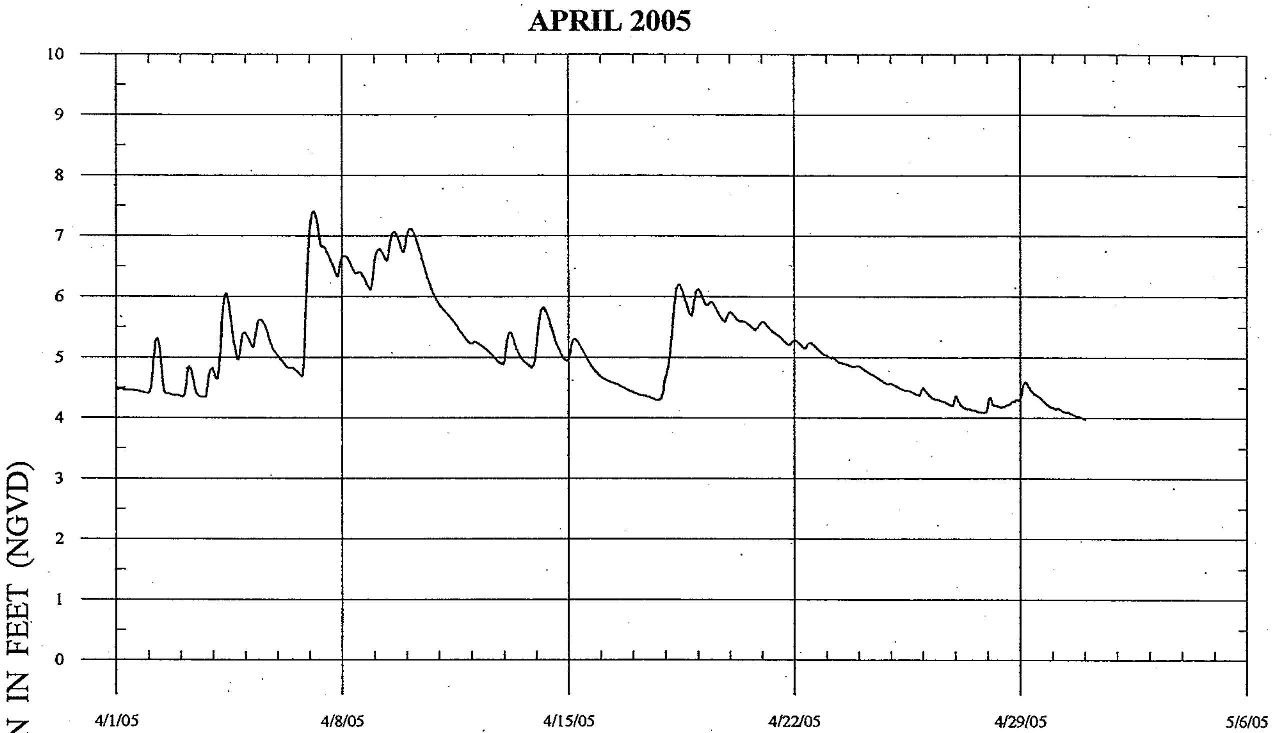


FIGURE A-74

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON



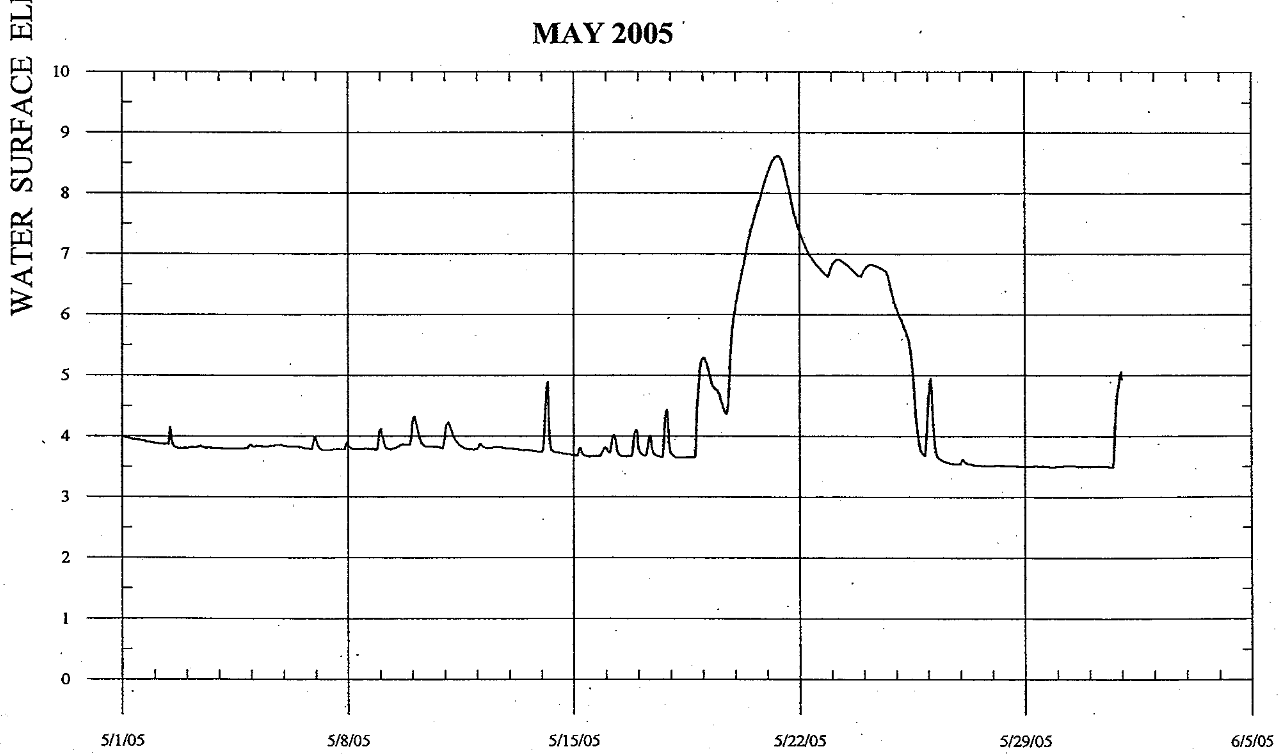
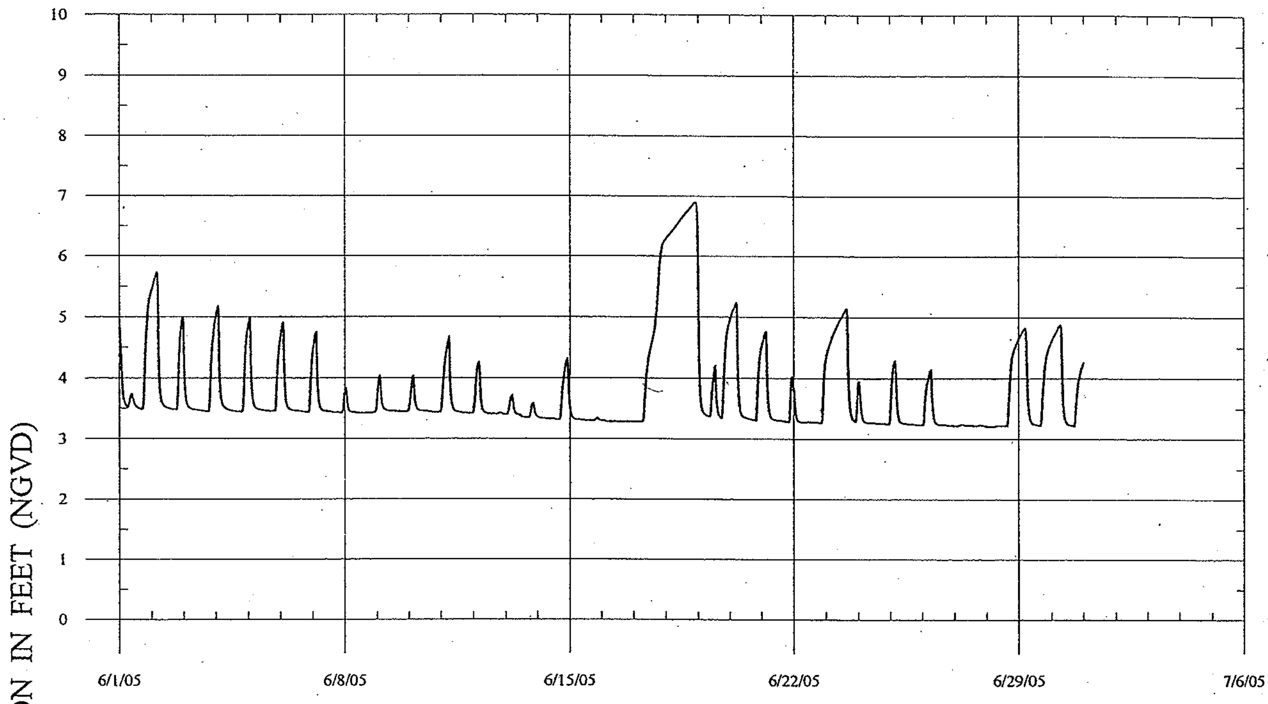


FIGURE A-75

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

JUNE 2005



JULY 2005

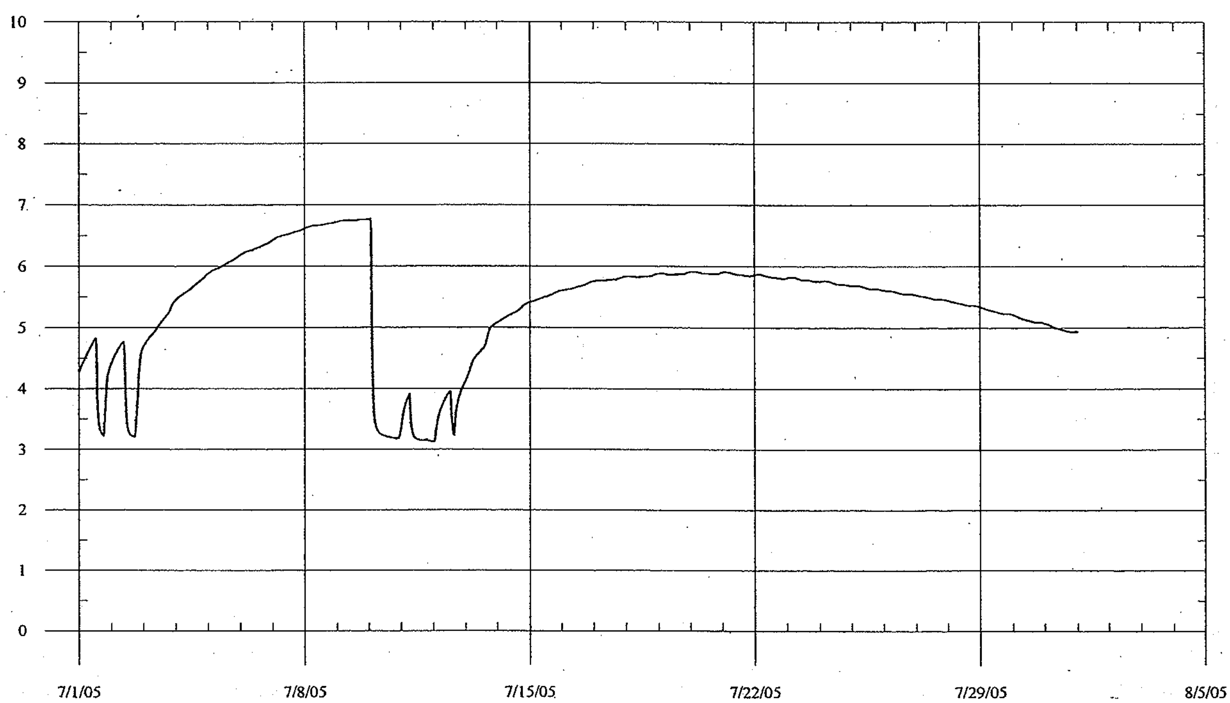
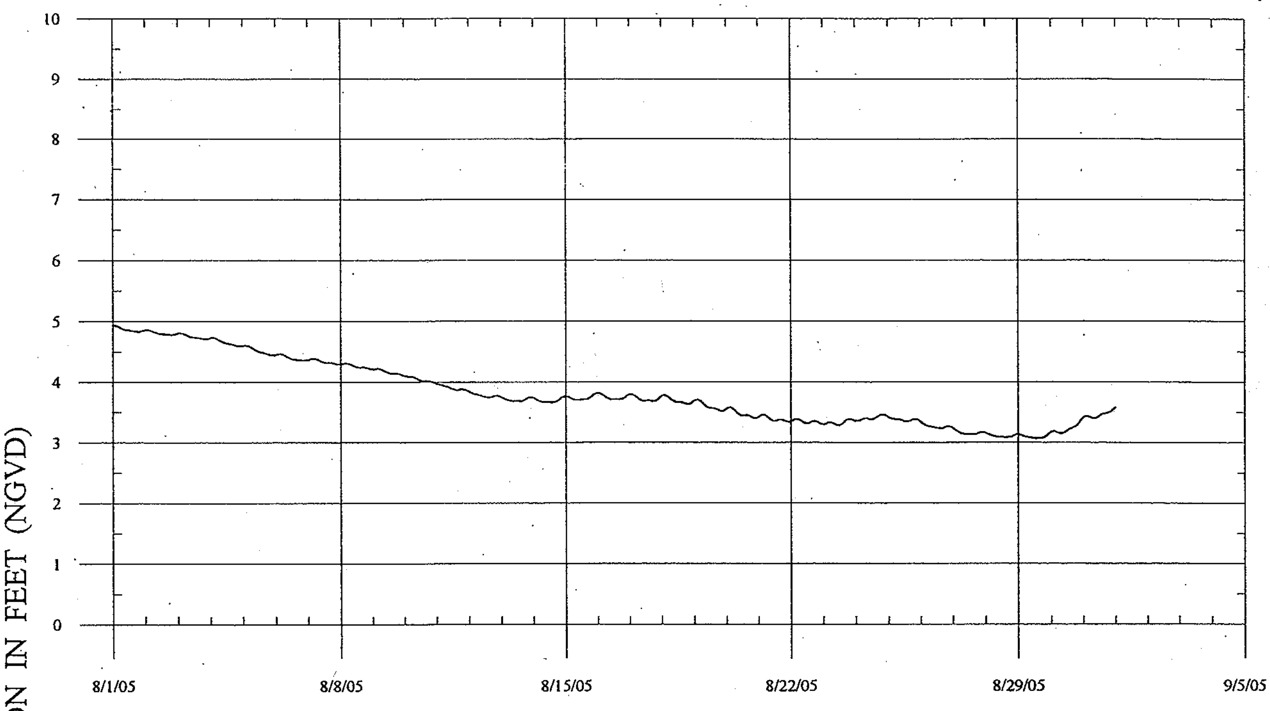


FIGURE A-76

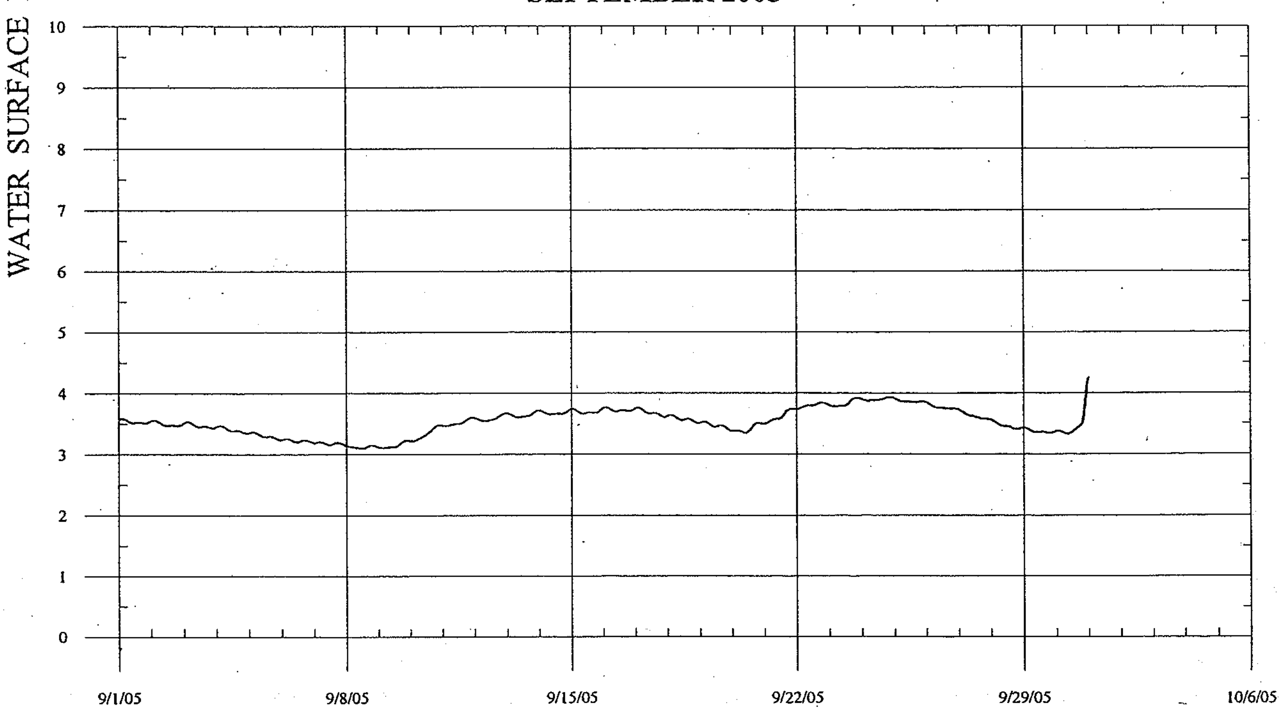
MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

CARMEL RIVER LAGOON

AUGUST 2005



SEPTEMBER 2005



MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

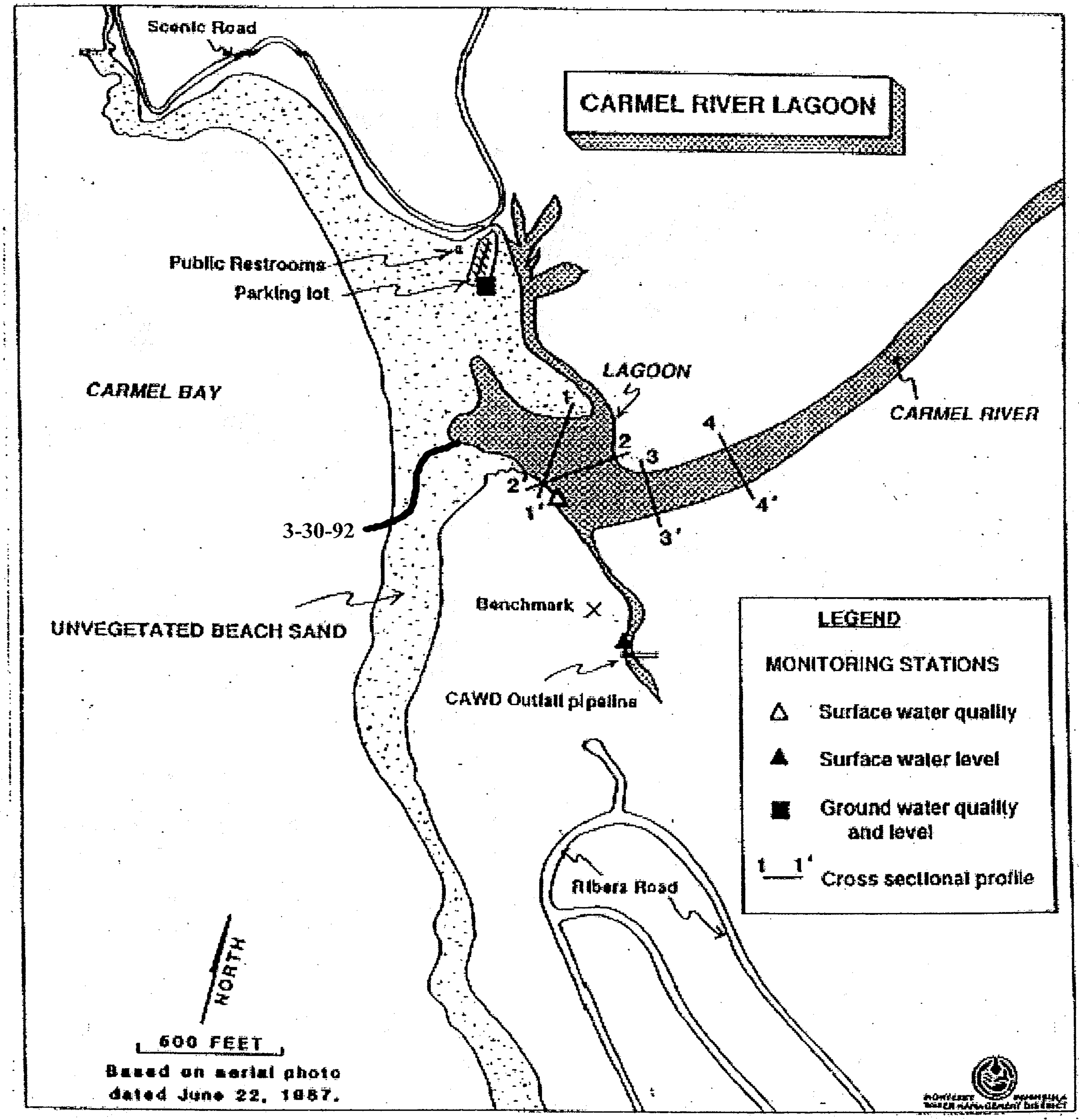
TECHNICAL MEMORANDUM 05-01

SURFACE WATER DYNAMICS AT THE CARMEL RIVER LAGOON
WATER YEARS 1991 - 2005

APPENDIX B

LAGOON OUTFLOW CHANNEL LOCATIONS

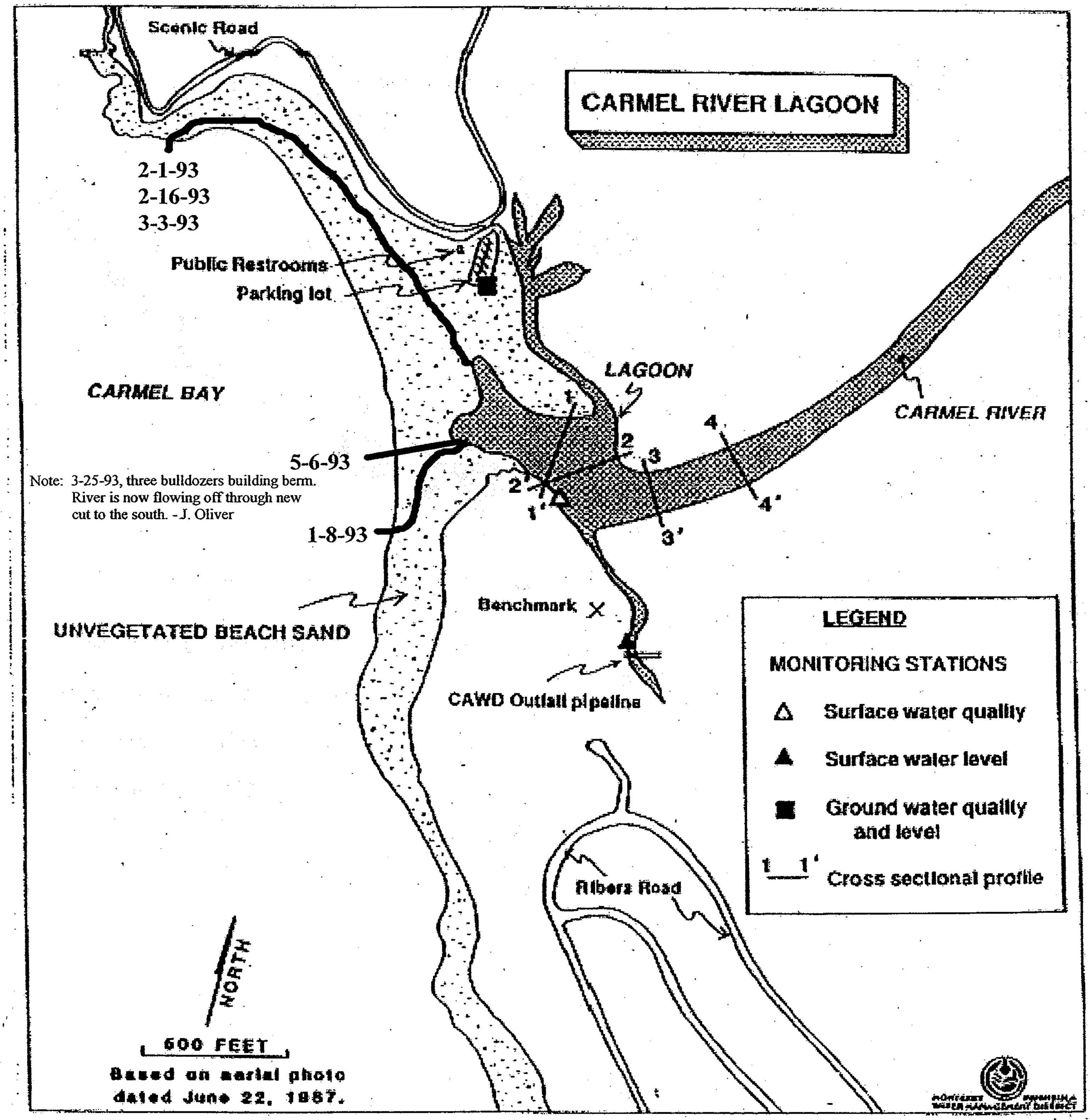
FIGURE B-1
WATER YEAR 1992
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-2

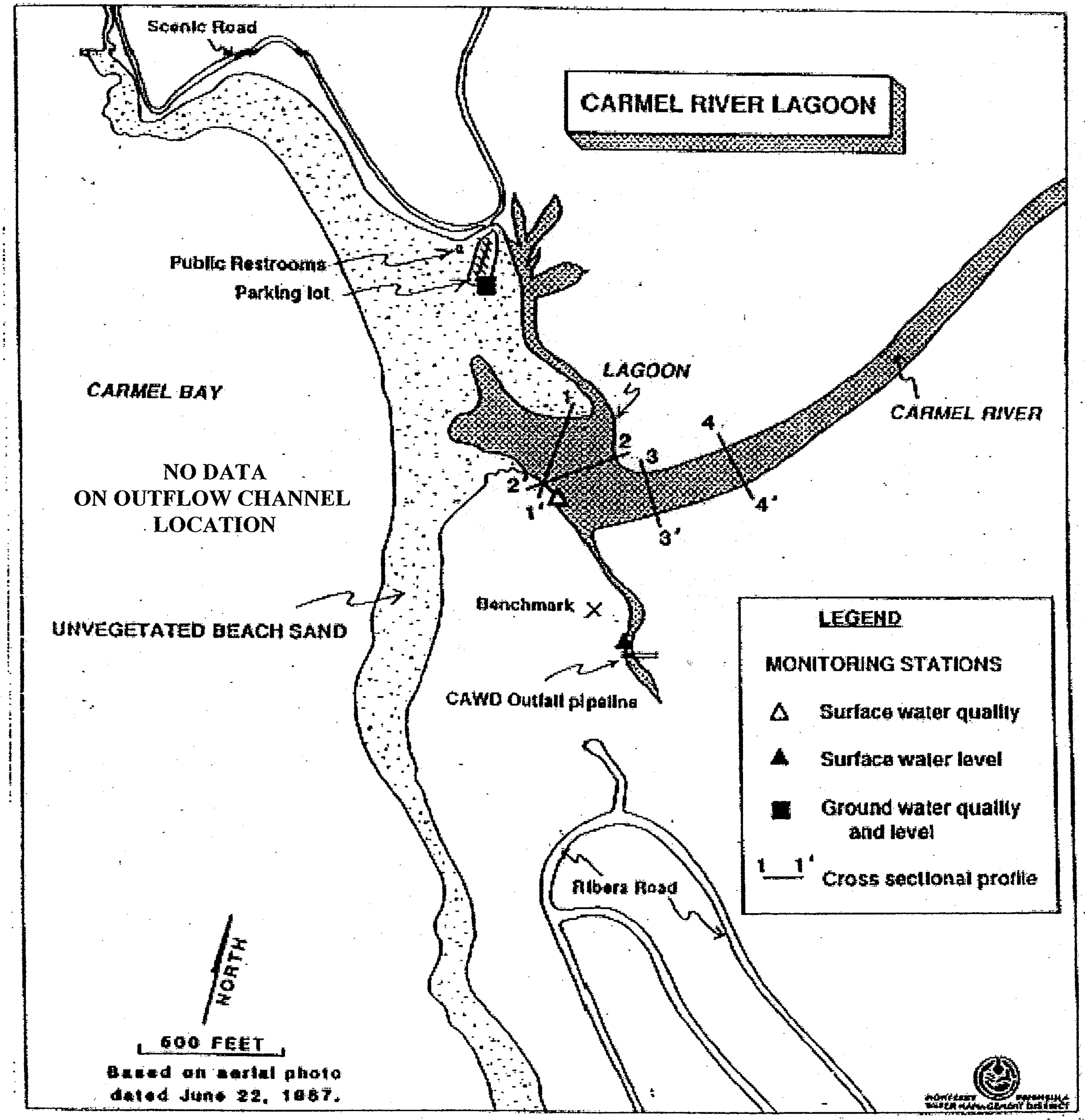
WATER YEAR 1993
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-3

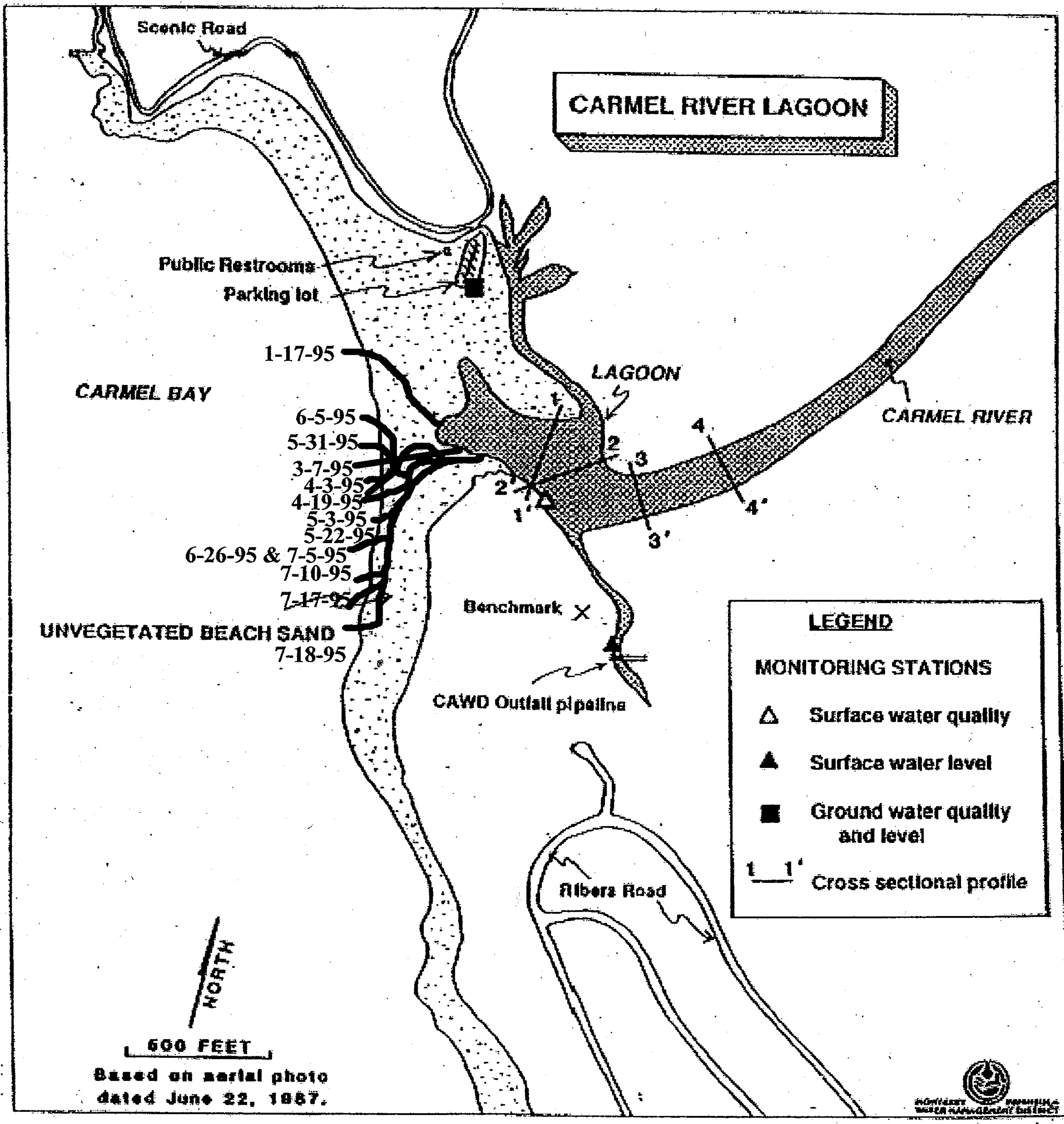
WATER YEAR 1994
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-4

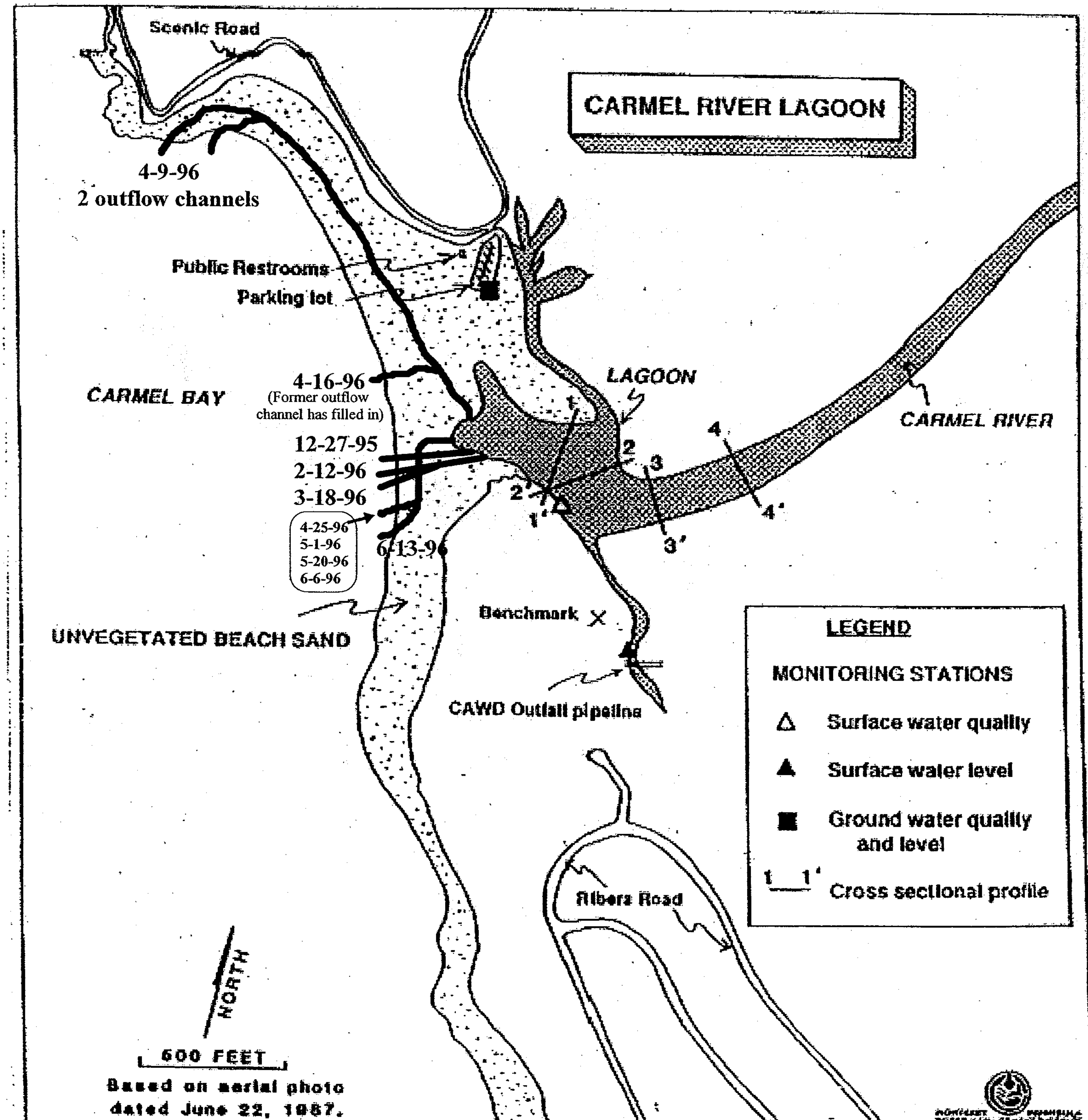
WATER YEAR 1995
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-5

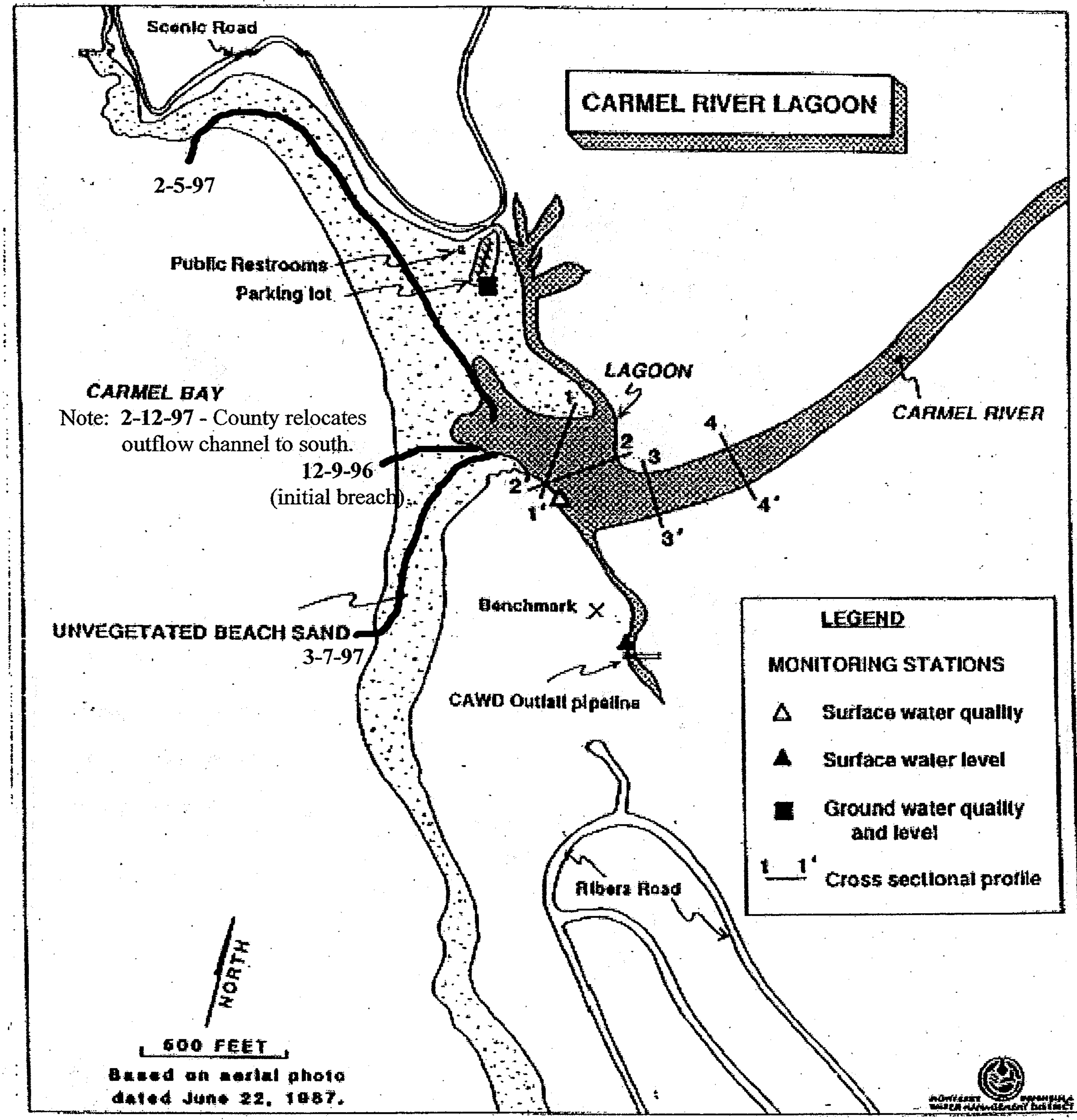
WATER YEAR 1996
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-6

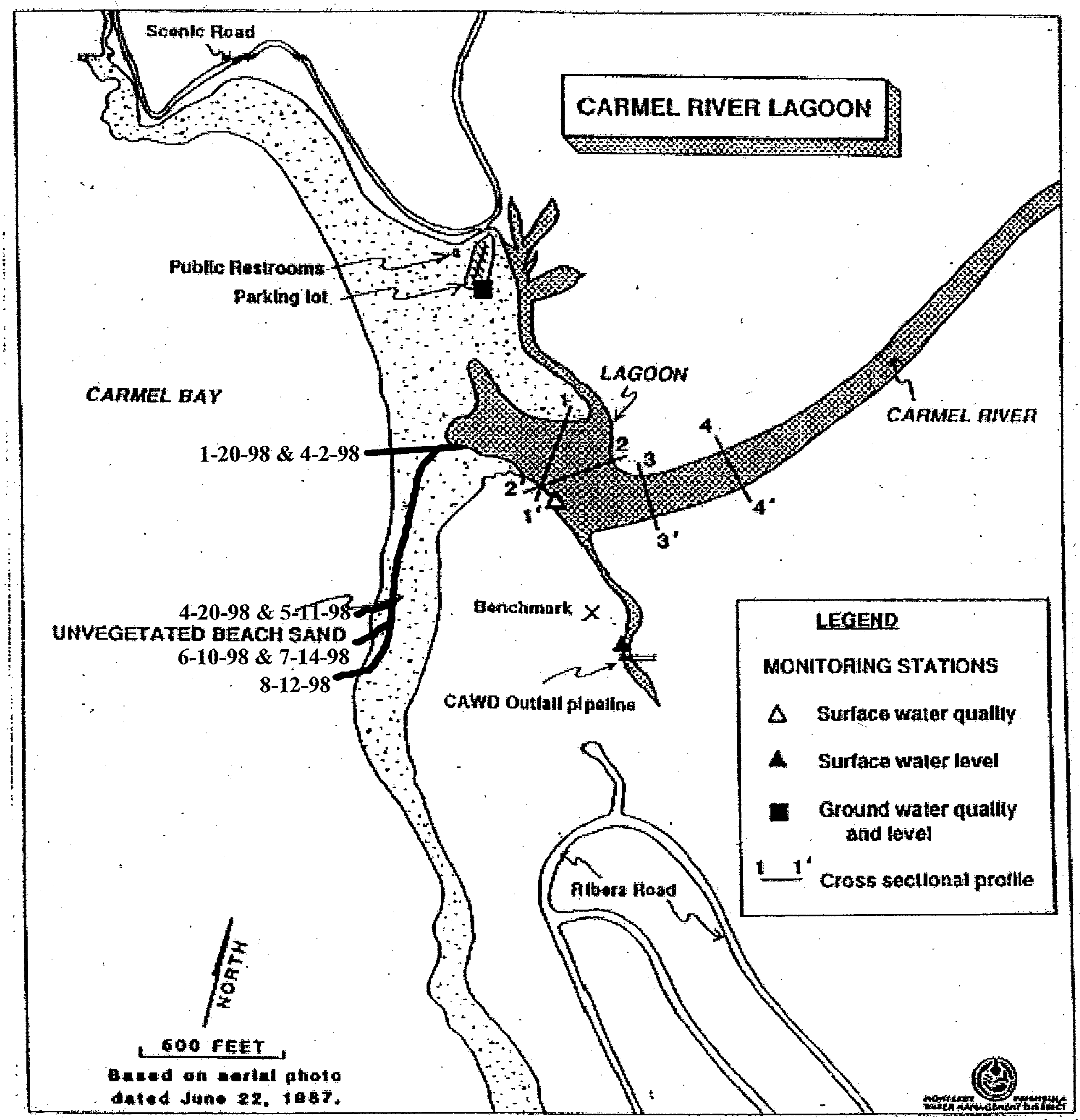
WATER YEAR 1997
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-7

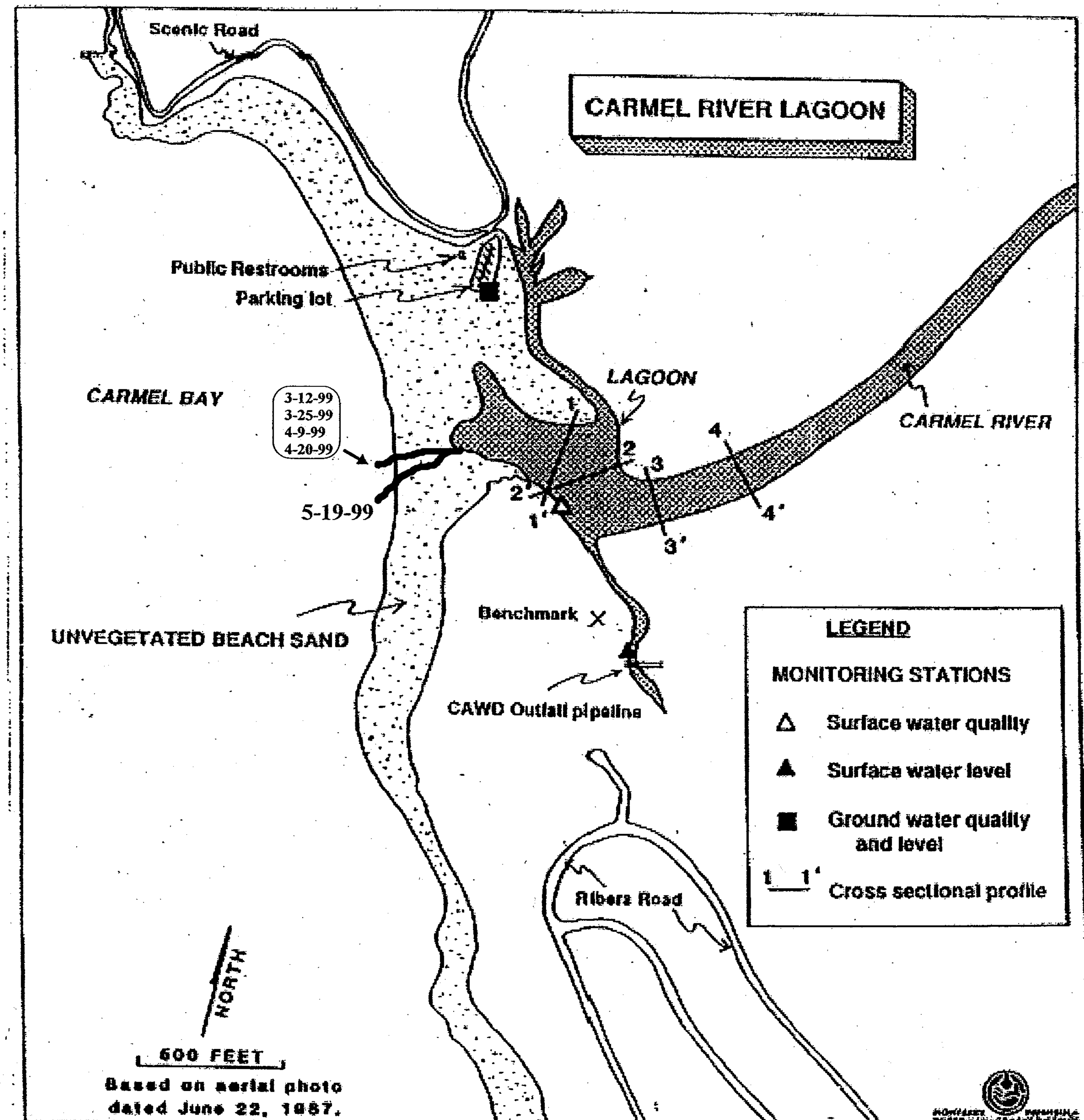
WATER YEAR 1998
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-8

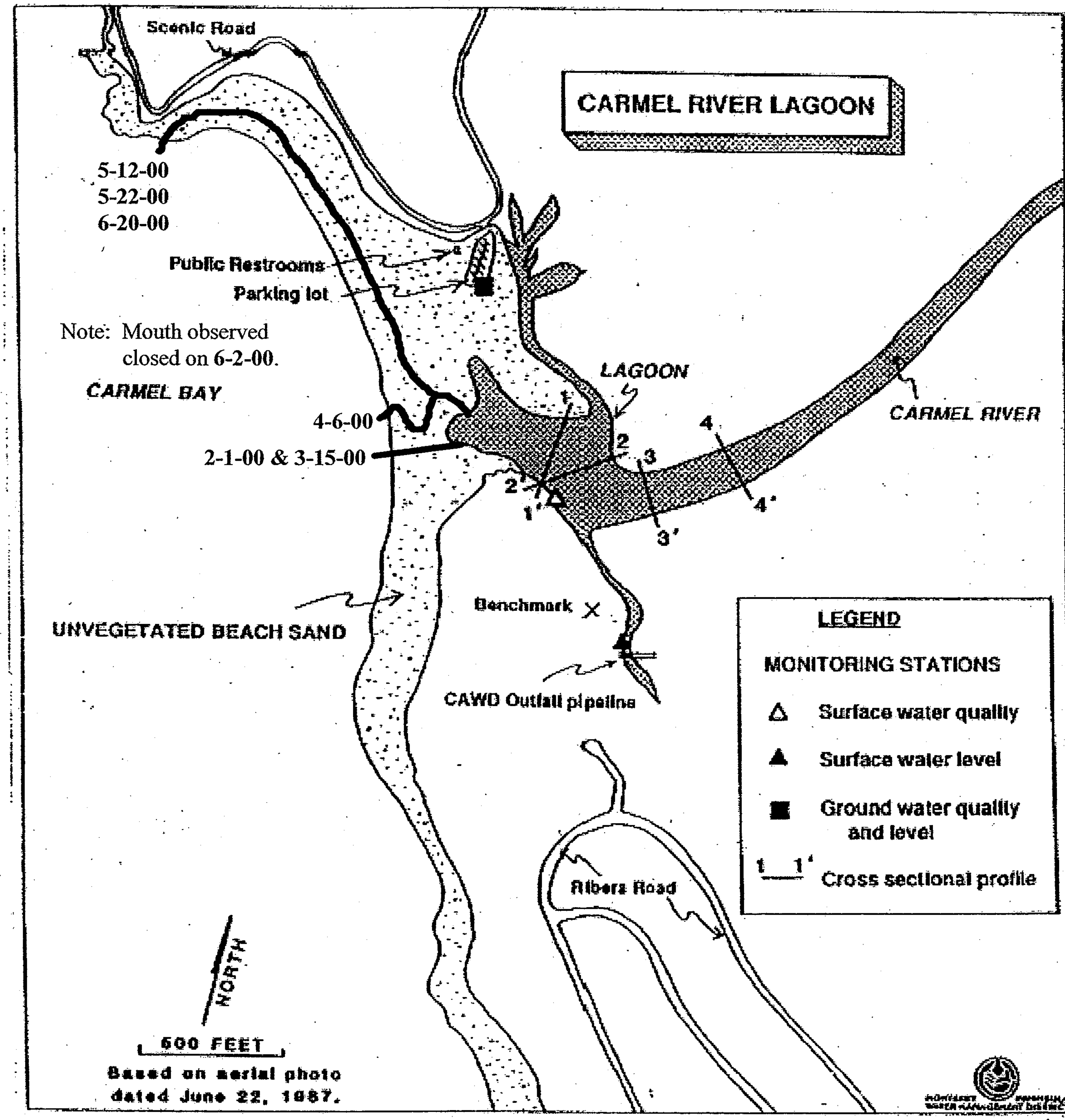
WATER YEAR 1999
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-9

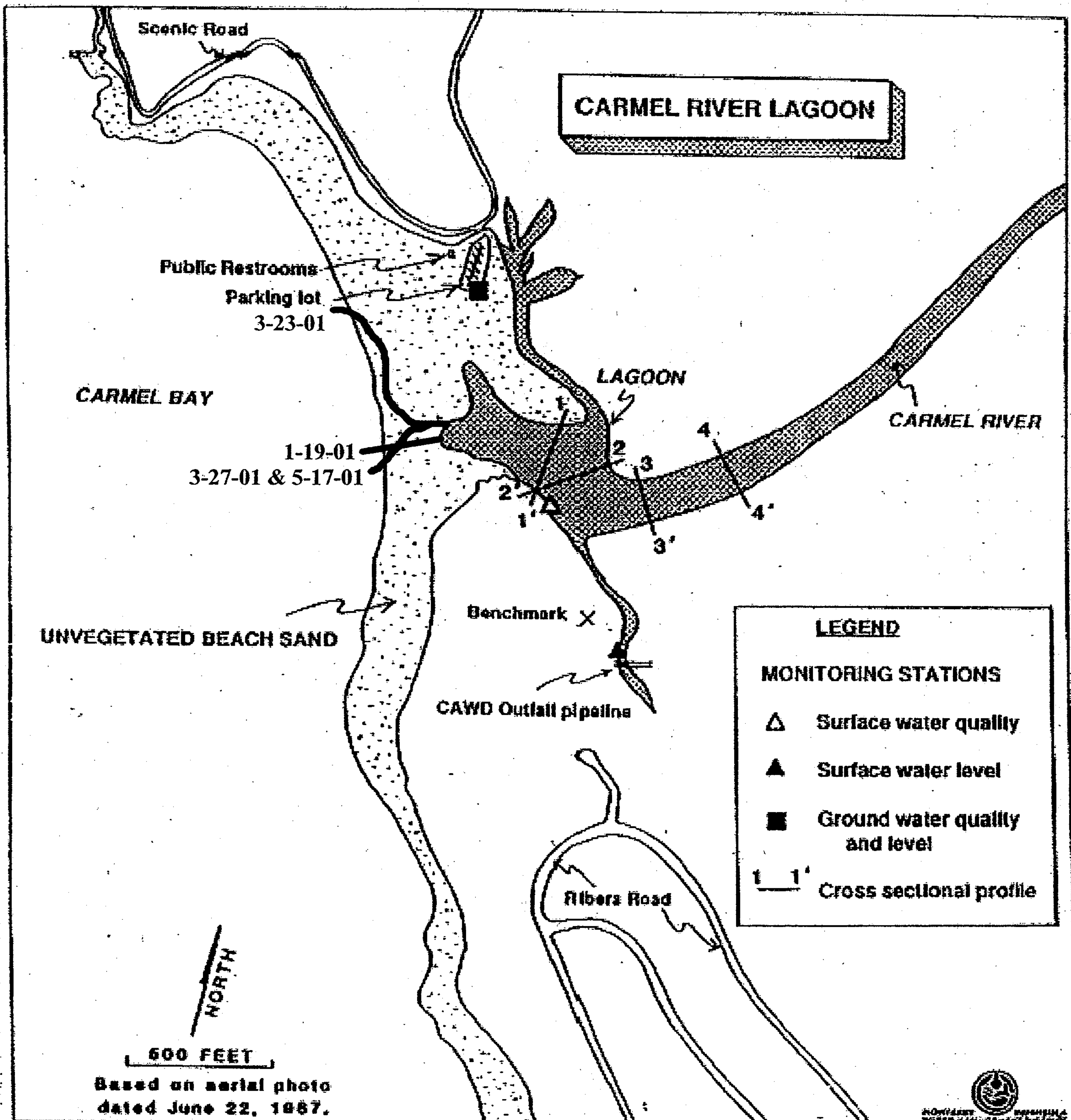
WATER YEAR 2000
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-10

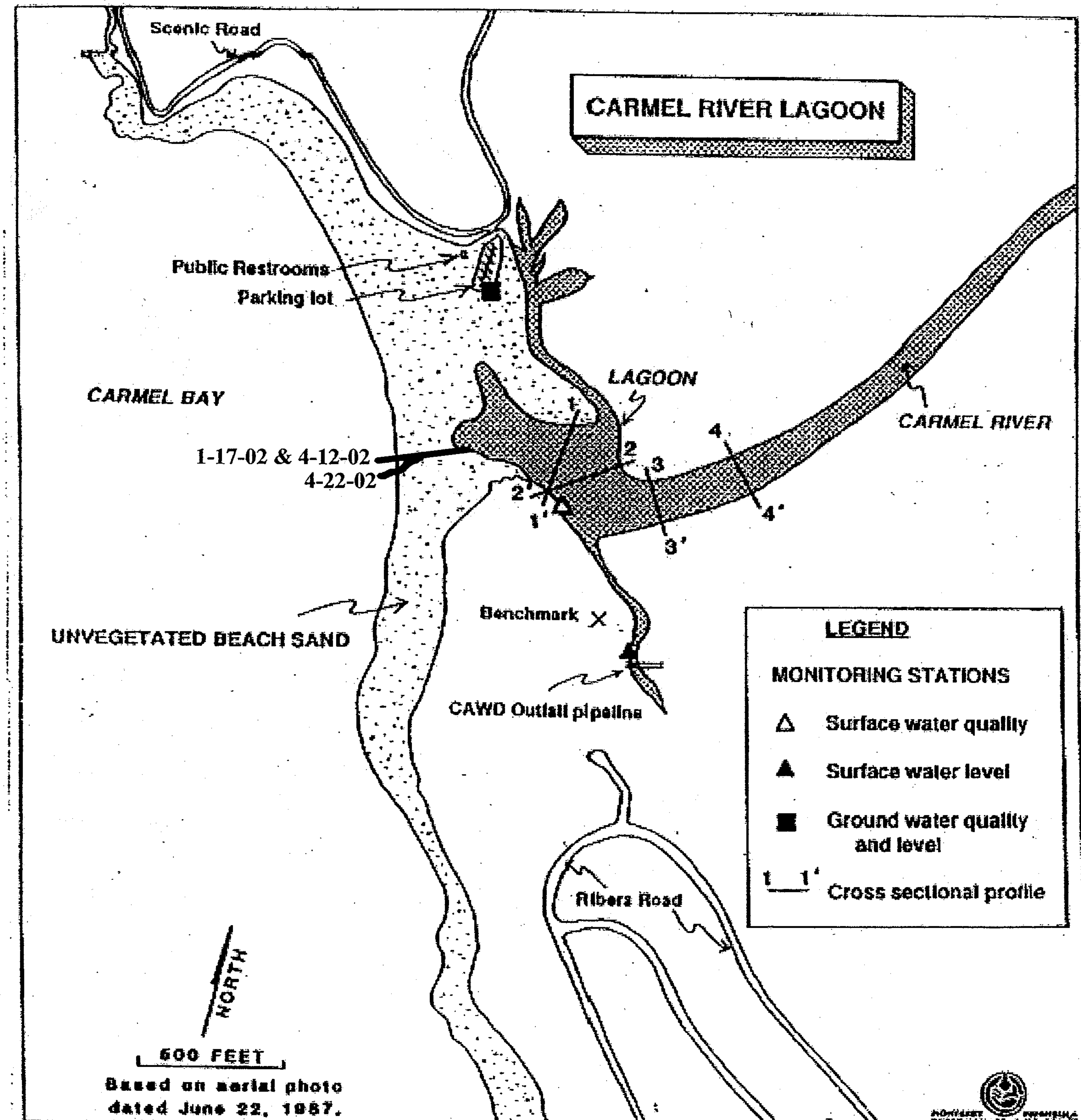
WATER YEAR 2001
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-11

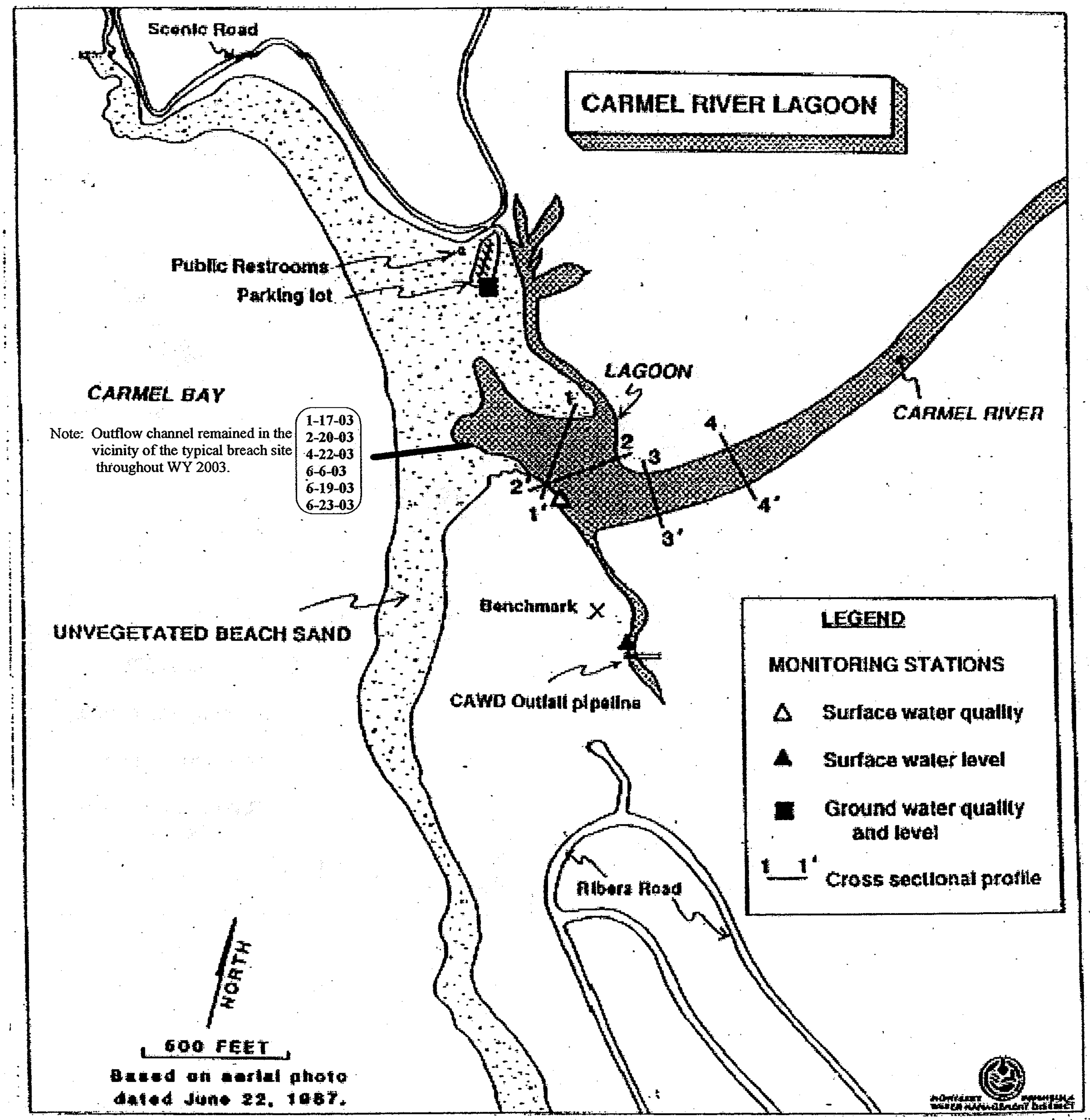
WATER YEAR 2002
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-12

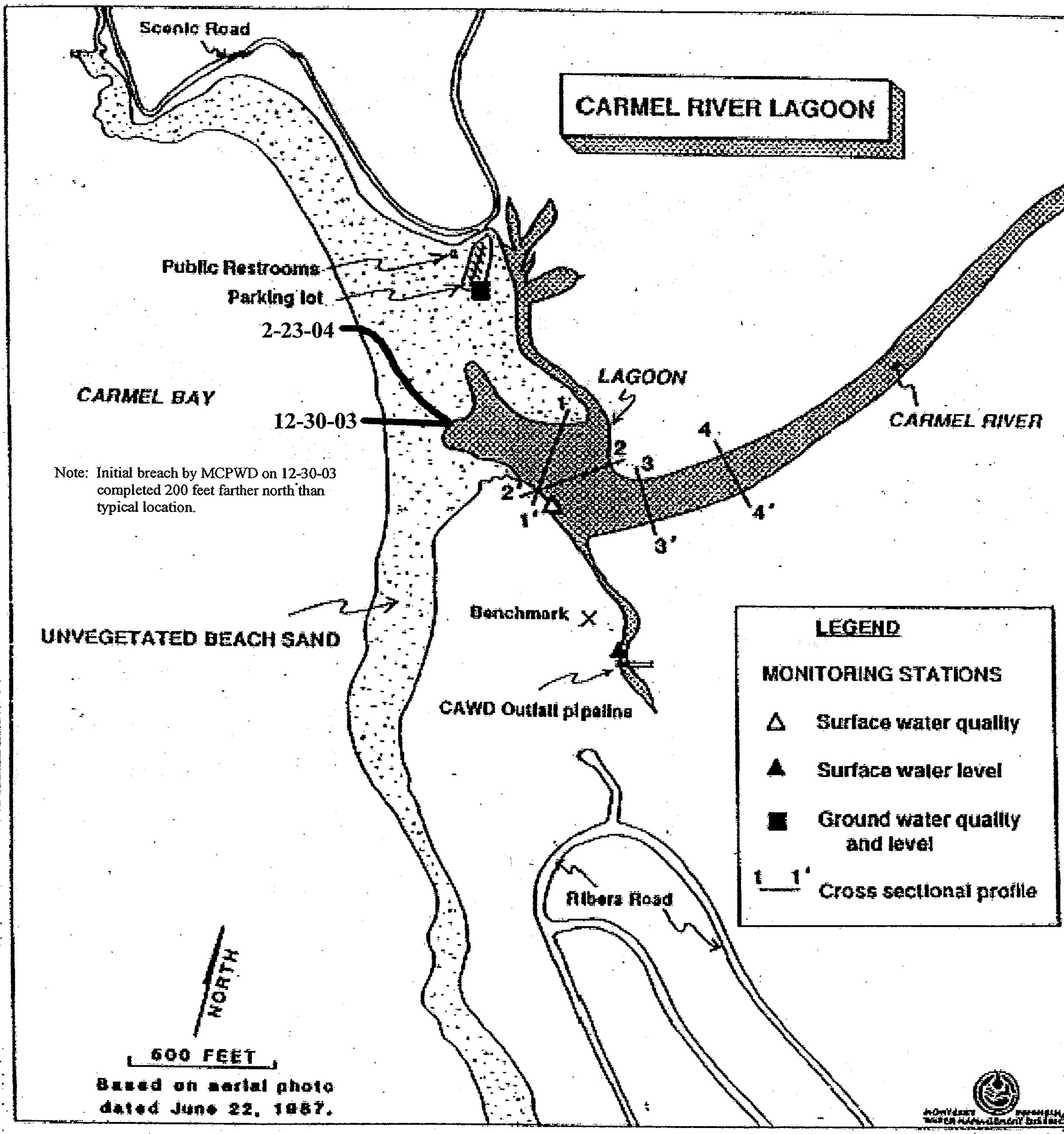
WATER YEAR 2003
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-13

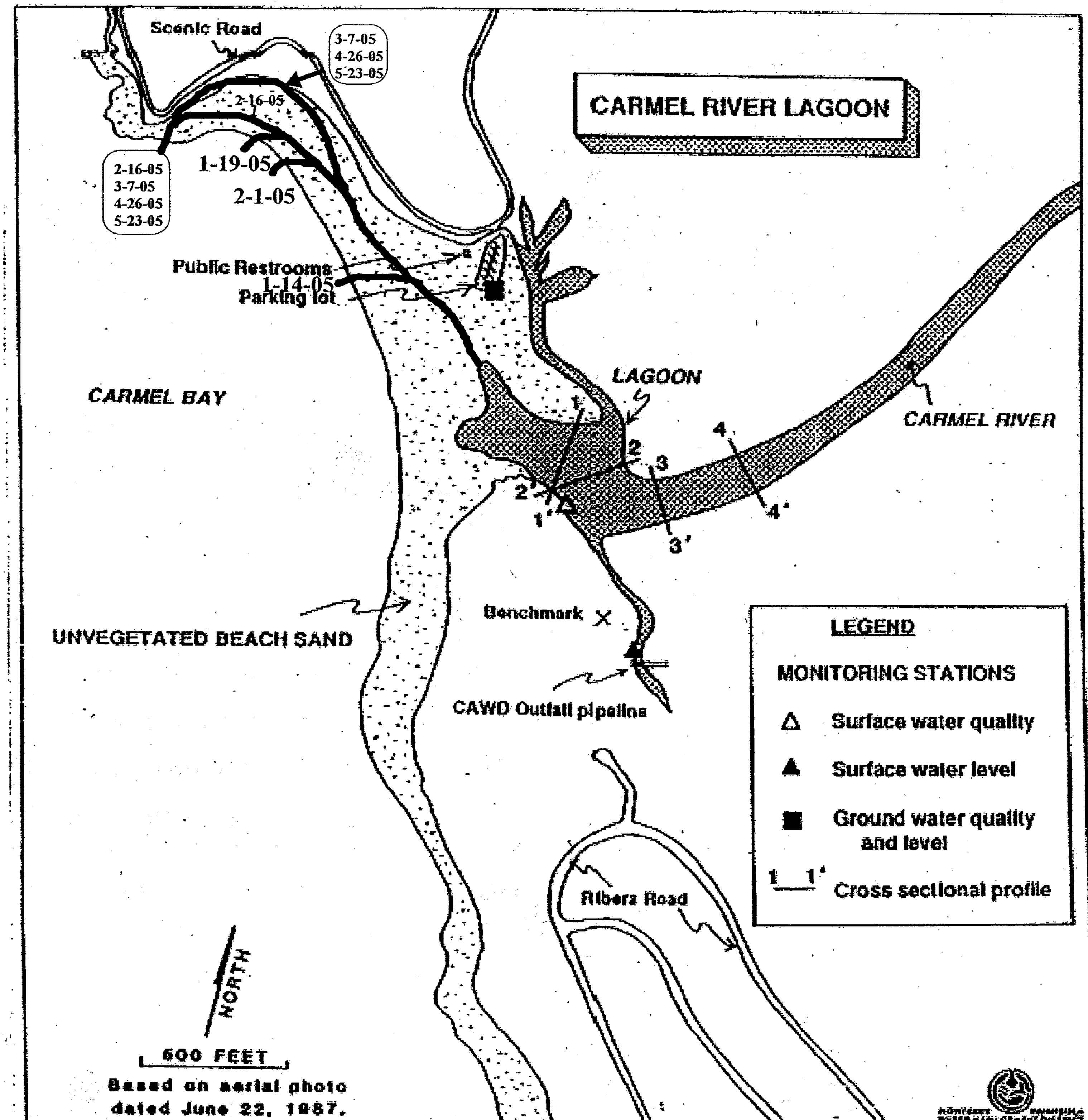
WATER YEAR 2004
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

FIGURE B-14

WATER YEAR 2005
APPROXIMATE LOCATION OF CARMEL RIVER LAGOON OUTFLOW CHANNEL
OBSERVED ON DATES INDICATED*



*Location of outflow channel based on documented field observations by G. James, MPWMD.

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TECHNICAL MEMORANDUM 05-01

SURFACE WATER DYNAMICS AT THE CARMEL RIVER LAGOON
WATER YEARS 1991 - 2005

APPENDIX C

MEAN DAILY STREAMFLOW AT THE CARMEL RIVER AT HIGHWAY 1 BRIDGE STREAMFLOW GAGING STATION

TABLE C-1

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR Oct 1992 TO Sep 1993

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0	0	0	6.0	285	868	251	78	31	3.6	0	0
2	0	0	0	40	261	775	231	76	48	4.4	.04	0
3	0	0	0	44	243	697	217	74	40	2.6	0	0
4	0	0	0	25	228	633	200	75	65	1.9	0	0
5	0	0	0	14	218	579	191	73	49	1.0	0	0
6	0	0	0	8.7	214	533	181	70	54	.39	0	0
7	0	0	0	519	202	492	176	68	52	.12	0	0
8	0	0	0	615	363	455	167	67	44	.05	0	0
9	0	0	0	422	433	423	159	66	41	0	0	0
10	0	0	0	483	403	391	152	63	34	.01	0	0
11	0	0	0	355	363	369	145	66	29	.02	0	0
12	0	0	0	310	328	345	139	60	27	.03	0	0
13	0	0	0	2,360	296	325	132	53	28	0	0	0
14	0	0	0	3,420	276	308	127	52	24	0	0	0
15	0	0	0	1,440	258	290	123	51	24	0	0	0
16	0	0	0	1,230	242	276	119	49	25	0	0	0
17	0	0	0	1,380	245	269	120	48	23	0	0	0
18	0	0	0	1,690	409	255	137	42	22	0	0	0
19	0	0	0	1,070	2,300	239	123	40	19	0	0	0
20	0	0	0	932	2,410	227	113	38	16	.10	0	0
21	0	0	0	1,100	1,650	213	108	36	16	.06	0	0
22	0	0	0	1,150	1,250	204	104	34	17	.02	0	0
23	0	0	0	948	1,220	202	102	33	18	0	0	0
24	0	0	0	779	1,280	221	100	35	15	0	0	0
25	0	0	0	657	1,110	227	97	36	11	0	0	0
26	0	0	0	568	1,530	441	93	33	11	.04	0	0
27	0	0	0	495	1,180	370	90	33	9.7	.06	0	0
28	0	0	0	437	994	346	88	31	8.2	.07	0	0
29	0	0	0	386	------	297	86	29	6.7	.05	0	0
30	0	0		350	------	269	82	29	5.4	.04	0	0
31	0	------	0	317	------	254	------	30	------	.03	0	------
TOTAL	0	0	0	23,550.7	20,191	11,793	4,153	1,568	813.0	14.59	0.04	0
MEAN	0	0	0	760	721	380	138	50.6	27.1	.47	.001	0
MAX	0	0	0	3,420	2,410	868	251	78	65	4.4	.04	0
MIN	0	0	0	6.0	202	202	82	29	5.4	0	0	0
AC-FT	0	0	0	46,710	40,050	23,390	8,240	3,110	1,610	29	.08	0

CAL YEAR 1992	TOTAL*	0.00	MEAN	0	MAX	0	MIN	0	AC-FT	0
WTR YEAR 1993	TOTAL*	62,083.33	MEAN	171	MAX	3,420	MIN	0	AC-FT	123,100

* Incomplete Record

TABLE C-2

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1993 TO SEP 1994

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	0	0	76	9.6	4.1	.28	0	0	0
2	0	0	0	0	0	70	8.2	3.3	.24	0	0	0
3	0	0	0	0	0	65	7.4	2.1	.13	0	0	0
4	0	0	0	0	0	60	8.3	1.5	.06	0	0	0
5	0	0	0	0	0	60	6.8	.77	.04	0	0	0
6	0	0	0	0	0	57	5.7	.39	.05	0	0	0
7	0	0	0	0	0	52	4.8	1.4	.03	0	0	0
8	0	0	0	0	0	48	5.8	.40	.03	0	0	0
9	0	0	0	0	16	44	7.0	2.5	.02	0	0	0
10	0	0	0	0	27	42	8.0	4.4	.01	0	0	0
11	0	0	0	0	21	40	8.1	5.1	0	0	0	0
12	0	0	0	0	15	37	5.5	5.2	0	0	0	0
13	0	0	0	0	13	34	6.0	5.0	0	0	0	0
14	0	0	0	0	11	34	6.2	4.0	0	0	0	0
15	0	0	0	0	8.2	30	3.8	3.2	0	0	0	0
16	0	0	0	0	7.7	26	3.2	3.1	0	0	0	0
17	0	0	0	0	80	24	4.1	3.1	0	0	0	0
18	0	0	0	0	217	23	2.2	4.9	0	0	0	0
19	0	0	0	0	193	24	1.1	5.4	0	0	0	0
20	0	0	0	0	511	22	2.3	7.6	0	0	0	0
21	0	0	0	0	333	20	1.0	8.0	0	0	0	0
22	0	0	0	0	224	19	.70	6.8	0	0	0	0
23	0	0	0	0	171	20	2.4	5.3	0	0	0	0
24	0	0	0	.10	139	22	3.9	2.8	0	0	0	0
25	0	0	0	.06	118	23	6.9	2.2	0	0	0	0
26	0	0	0	0	106	26	7.4	2.1	0	0	0	0
27	0	0	0	0	96	21	7.7	2.2	0	0	0	0
28	0	0	0	0	85	19	7.2	1.5	0	0	0	0
29	0	0	0	0	------	19	5.2	1.2	0	0	0	0
30	0	0	0	0	------	12	4.4	.75	0	0	0	0
31	0	------	0	0	------	11	------	.42	------	0	0	------
TOTAL	0	0	0	0.16	2,391.9	1,080	160.90	100.73	0.89	0	0	0
MEAN	0	0	0	.005	85.4	34.8	5.36	3.25	.030	0	0	0
MAX	0	0	0	.10	511	76	9.6	8.0	.28	0	0	0
MIN	0	0	0	0	0	11	.70	.39	0	0	0	0
AC-FT	0	0	0	.3	4,740	2,140	319	200	1.8	0	0	0

CAL YEAR 1993	TOTAL	62,017.94	MEAN	170	MAX	3,420	MIN	0	AC-FT	123,000
WTR YEAR 1994	TOTAL	3,734.58	MEAN	10.2	MAX	511	MIN	0	AC-FT	7,410

TABLE C-3

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1994 TO SEP 1995

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	0	465	107	600e	300	119	52	10	.23
2	0	0	0	0	410	106	550e	271	118	51	10	.14
3	0	0	0	0	366	127	510e	252	118	50	9.2	.10
4	0	0	0	0	330	142	465e	234	113	47	8.1	.08
5	0	0	0	0	303	157	430e	227	107	45	8.5	.07
6	0	0	0	.04	284	163	400e	232	103	41	8.1	.07
7	0	0	0	.01	266	152	375e	224	97	40	7.4	.05
8	0	0	0	12	255	145	365	210	96	38	5.7	.05
9	0	0	0	315	245	537	341	197	92	36	5.0	.04
10	0	0	0	6,350	228	7,960e	329	193	89	33	4.2	.03
11	0	0	0	2,490	215	5,280e	312	186	87	30	3.2	.03
12	0	0	0	1,050	205	2,440e	295	178	84	28	2.7	.02
13	0	0	0	676	198	1,760e	294	198	80	26	2.7	0
14	0	0	0	715	231	1,470e	286	214	77	24	2.1	.01
15	0	0	0	1,150	209	1,310e	274	220	81	24	1.3	0
16	0	0	0	1,090	190	1,160e	283	214	118	21	.98	0
17	0	0	0	810	178	1,060e	261	201	116	21	.70	0
18	0	0	0	630	167	981e	257	187	100	21	.53	0
19	0	0	0	517	159	919e	246	177	94	20	.53	0
20	0	0	0	485	150	936e	240	165	86	20	.52	0
21	0	0	0	622	142	1,100e	222	157	79	20	.53	0
22	0	0	0	534	135	1,610e	215	159	75	18	.49	0
23	0	0	0	863	130	2,630e	206	155	73	17	.36	0
24	0	0	0	1,780	124	1,370e	199	145	69	17	.30	0
25	0	0	0	1,560	121	1,080e	189	141	64	16	.30	0
26	0	0	0	1,110	117	975e	179	137	60	15	.23	0
27	0	0	0	921	113	885e	173	134	55	14	.21	0
28	0	0	0	883	110	828e	200	129	54	13	.27	0
29	0	0	0	737	------	748e	208	127	54	12	.25	0
30	0	0	0	627	------	672e	317	121	56	11	.21	0
31	0	------	0	539	------	611e	------	115	------	10	.22	------
TOTAL	0	0	0	26,466.05	6,046	39,421	9,221	5,800	2,614	831	94.83	0.92
MEAN	0	0	0	854	216	1,272	307	187	87.1	26.8	3.06	.031
MAX	0	0	0	6,350	465	7,960	600	300	119	52	10	.23
MIN	0	0	0	0	110	106	173	115	54	10	.21	0
AC-FT	0	0	0	52,500	11,990	78,190	18,290	11,500	5,180	1,650	188	1.8

CAL YEAR 1994	TOTAL	3,733.01	MEAN	10.2	MAX	511	MIN	0	AC-FT	7,400		
WTR YEAR 1995	TOTAL	90,494.80	MEAN	248	MAX	7,960	MIN	0	AC-FT	179,500		

TABLE C-4

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1995 TO SEP 1996

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	1.6	28	705	608	206	77	57	6.6	.08	0
2	0	0	1.9	26	433	557	318	73	54	5.5	.07	0
3	0	0	2.7	25	316	509	244	65	50	4.7	.06	0
4	0	0	3.7	25	348	524	213	62	44	4.7	.06	0
5	0	0	4.3	24	1,350	834	194	59	42	5.0	.06	0
6	0	0	4.2	23	734	673	181	56	41	4.9	.06	0
7	0	0	4.5	23	496	590	170	55	39	4.4	.05	0
8	0	0	5.5	24	378	525	162	51	36	4.6	.03	0
9	0	0	5.6	23	305	473	153	50	32	4.7	.02	0
10	0	0	5.5	23	258	429	146	49	27	4.1	.02	0
11	0	0	7.1	22	226	396	143	48	22	4.1	.01	0
12	0	0	8.4	23	200	591	137	45	19	3.6	.01	0
13	0	0	18	23	180	615	133	42	17	3.5	0	0
14	0	0	21	23	160	502	121	38	18	3.1	0	0
15	0	0	36	23	150	446	117	41	16	4.1	0	0
16	0	0	38	30	155	411	128	147	16	6.3	0	0
17	0	0	33	116	140	380	135	147	15	4.5	0	0
18	0	0	29	93	131	351	139	114	12	2.6	0	0
19	0	0	26	89	1,090	324	133	96	11	2.1	0	0
20	0	0	25	91	2,460	303	130	82	10	1.5	0	0
21	0	0	23	113	1,800	285	125	74	9.7	.89	0	0
22	0	0	25	140	1,490	268	119	79	11	.65	0	0
23	0	0 e	27	121	1,070	256	114	77	11	.49	0	0
24	0	0 e	29	106	899	240	111	72	9.9	.34	0	0
25	0	.20e	27	159	779	227	105	67	11	.16	0	0
26	0	.50e	26	200	647	219	102	63	11	.12	0	0
27	0	.80e	25	198	635	210	95	62	9.4	.19	0	0
28	0	1.0 e	24	267	581	212	90	63	8.7	.42	0	0
29	0	1.0 e	25	226	603	197	84	62	9.1	.43	0	0
30	0	1.1	25	195	------	185	81	59	7.8	.16	0	0
31	0	------	26	529	------	178	------	57	------	.11	0	------
TOTAL	0	4.60	563.0	3,031	18,719	12,518	4,329	2,132	676.6	88.56	0.53	0
MEAN	0	.15	18.2	97.8	645	404	144	68.8	22.6	2.86	.017	0
MAX	0	1.1	38	529	2,460	834	318	147	57	6.6	.08	0
MIN	0	0	1.6	22	131	178	81	38	7.8	.11	0	0
AC-FT	0	9.1	1,120	6,010	37,130	24,830	8,590	4,230	1,340	176	1.1	0

CAL YEAR 1995	TOTAL	91,062.40	MEAN	249	MAX	7,960	MIN	0	AC-FT	180,600
WTR YEAR 1996	TOTAL	42,062.29	MEAN	115	MAX	2,460	MIN	0	AC-FT	83,430

TABLE C-5

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1996 TO SEP 1997

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	13	2,150	737	156	63	36	2.3	.20	0	0
2	0	0	14	2,960	664	151	64	36	2.2	.08	0	0
3	0	0	14	2,060	605	149	62	29	1.7	.10	0	0
4	0	0	13	1,270	563	143	59	28	1.7	.07	0	0
5	0	0	18	978	525	137	59	28	2.7	.03	0	0
6	0	0	23	761	483	132	59	27	2.9	.04	0	0
7	0	0	26	625	445	128	57	24	2.9	.04	0	0
8	0	0	22	523	415	122	55	22	3.2	.04	0	0
9	0	0	24	447	389	118	55	23	2.4	.04	0	0
10	0	0	692	395	365	114	53	22	1.8	.03	0	0
11	0	0	1,420	360	341	110	51	22	1.6	.03	0	0
12	0	0	554	337	321	106	49	21	1.2	.01	0	0
13	0	0	385	324	304	105	49	17	.86	0	0	0
14	0	0	302	294	284	102	48	15	.65	0	0	0
15	0	0	246	512	271	100	46	13	.49	0	0	0
16	0	.04	205	479	258	98	44	12	.33	0	0	0
17	0	.10	178	397	256	98	45	9.7	.25	0	0	0
18	0	0	153	356	252	93	46	8.8	.23	0	0	0
19	0	0	134	325	230	89	47	7.9	.12	0	0	0
20	0	0	121	819	216	88	52	7.5	.11	0	0	0
21	0	.08	262	789	210	86	50	6.9	.05	0	0	0
22	0	0	965	853	202	84	47	6.1	.10	0	0	0
23	0	0	727	1,560	194	82	46	6.1	.11	0	0	0
24	0	0	497	1,140	186	79	43	6.9	.08	0	0	0
25	0	0	383	1,740	179	78	42	7.6	.05	0	0	0
26	0	0	323	2,810	175	74	37	7.3	.17	0	0	0
27	0	.21	304	1,920	172	69	36	6.6	.68	0	0	0
28	0	2.5	269	1,370	166	62	35	5.8	.65	0	0	0
29	.02	4.4	248	1,120	------	68	34	5.1	.29	0	0	0
30	0	10	833	949	------	64	35	4.2	.20	0	0	0
31	0	------	1,110	833	------	61	------	3.1	------	0	0	------
TOTAL	0.02	17.33	10,478	31,456	9,408	3,146	1,468	474.6	32.02	0.71	0	0
MEAN	.001	.58	338	1,015	336	101	48.9	15.3	1.07	.023	0	0
MAX	.02	10	1,420	2,960	737	156	64	36	3.2	.20	0	0
MIN	0	0	13	294	166	61	34	3.1	.05	0	0	0
AC-FT	.04	34	20,780	62,390	18,660	6,240	2,910	941	64	1.4	0	0

CAL YEAR 1996	TOTAL	51,990.04	MEAN	142	MAX	2,640	MIN	0	AC-FT	103,100
WTR YEAR 1997	TOTAL	56,480.68	MEAN	155	MAX	2,960	MIN	0	AC-FT	112,000

TABLE C-6

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1997 TO SEP 1998

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	31	789	1,110	938	288	196	101	45	12
2	0	0	0	32	3,180	996	749	344	188	101	44	11
3	0	0	0	45	9,260	907	870	306	187	109	41	9.6
4	0	0	.08	172	4,850	819	874	314	188	106	38	7.5
5	0	0	42	215	2,430	767	770	361	184	101	35	7.4
6	0	0	61	146	5,060	767	735	348	185	96	33	7.2
7	0	0	92	118	7,010	669	820	345	181	91	31	6.9
8	0	0	165	99	6,710	623	713	323	185	86	29	6.1
9	.01	0	197	107	3,980	569	636	309	185	83	29	7.0
10	0	.09	136	516	2,160	532	583	280	176	85	29	8.6
11	0	0	99	420	1,490	500	655	278	170	86	26	7.9
12	0	0	77	443	1,170	471	589	312	170	83	24	5.8
13	0	0	65	660	978	490	656	308	164	77	23	5.0
14	0	0	80	460	1,200	447	625	287	161	71	22	5.0
15	0	.45	140	949	1,340	410	571	275	152	68	22	4.6
16	0	.07	116	1,260	1,340	391	533	267	143	63	21	6.0
17	0	0	97	754	1,540	376	504	259	142	59	20	6.0
18	0	0	87	778	1,410	360	474	249	137	59	19	5.6
19	0	.02	74	1,360	1,740	340	455	238	128	58	19	5.7
20	0	0	66	892	1,770	323	434	234	129	55	20	4.9
21	0	0	62	692	2,300	312	411	230	130	54	21	4.0
22	0	0	56	564	2,820	294	390	226	128	55	22	3.9
23	0	0	51	473	2,640	275	373	218	125	55	20	3.9
24	0	0	49	409	2,290	359	369	209	116	53	21	4.3
25	0	.60	48	360	1,830	410	353	207	115	53	17	4.1
26	0	6.6	45	318	1,570	385	334	204	117	51	18	7.7
27	0	.62	42	289	1,420	368	319	202	112	49	18	8.8
28	0	0	41	267	1,260	736	302	215	109	45	17	9.0
29	0	0	40	607	------	662	290	259	105	43	16	8.8
30	0	2.0	38	568	------	544	280	223	103	43	16	9.2
31	0	------	35	538	------	625	------	207	------	45	14	------
TOTAL	0.01	10.45	2,101.08	14,542	75,537	16,837	16,605	8,325	4,511	2,184	770	203.5
MEAN	0	.35	67.8	469	2,698	543	554	269	150	70.5	24.8	6.78
MAX	.01	6.6	197	1,360	9,260	1,110	938	361	196	109	45	12
MIN	0	0	0	31	789	275	280	202	103	43	14	3.9
AC-FT	.02	21	4,170	28,840	149,800	33,400	32,940	16,510	8,950	4,330	1,530	404

CAL YEAR 1997	TOTAL	48,096.87	MEAN	132	MAX	2,960	MIN	0	AC-FT	95,400
WTR YEAR 1998	TOTAL	141,626.04	MEAN	388	MAX	9,260	MIN	0	AC-FT	280,900

TABLE C-7

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1998 TO SEP 1999

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	10	16	64	36	199	116	197	111	42	9.1	.57	0
2	11	16	88	34	163	112	177	109	40	8.7	.56	0
3	10	16	77	32	144	114	170	110	46	8.0	.51	0
4	9.6	16	76	31	123	116	164	111	56	7.6	.31	0
5	9.0	17	66	30	112	110	160	110	53	7.8	.07	0
6	8.0	18	70	31	103	99	200	106	50	7.3	.17	0
7	7.4	19	72	29	116	93	202	101	45	6.5	.25	0
8	6.3	21	66	28	178	96	222	98	42	5.6	.30	.02
9	7.4	21	63	25	998	134	251	95	39	4.9	.24	.03
10	8.9	23	56	24	795	131	217	90	38	4.1	.05	0
11	9.5	27	55	24	444	124	383	91	35	4.3	.02	0
12	9.9	23	53	22	321	106	429	88	32	3.7	.01	0
13	9.7	23	50	21	261	104	355	83	32	2.2	.03	0
14	9.9	22	45	20	222	108	323	78	32	1.6	.05	0
15	11	21	46	19	193	152	293	73	30	1.3	.06	0
16	10	21	48	22	172	136	254	70	28	1.1	.05	0
17	9.6	20	46	21	168	121	237	72	27	.88	.04	0
18	9.6	19	43	19	160	115	225	70	26	1.0	.04	0
19	9.7	19	40	20	157	134	213	65	24	1.0	.05	0
20	9.5	19	39	65	150	153	201	66	22	.87	.03	0
21	8.7	19	46	153	189	141	189	65	22	.75	.04	0
22	8.5	19	46	122	170	138	178	64	22	.67	.05	0
23	9.8	18	41	102	160	160	165	60	21	.60	.02	0
24	14	17	37	135	150	158	159	55	21	.64	.02	0
25	15	19	38	118	154	362	155	53	20	.83	.02	0
26	15	18	42	122	145	365	147	52	18	.88	.01	0
27	14	21	40	143	136	305	140	52	17	.74	0	0
28	15	32	38	117	125	255	136	52	15	.71	0	0
29	16	29	36	99	------	235	130	49	12	.41	0	0
30	16	36	36	90	------	219	120	49	10	.41	0	0
31	16	------	37	164	------	219	------	44	------	.45	0	------
TOTAL	334.0	625	1,600	1,918	6,408	4,931	6,392	2,392	917	94.64	3.57	0.05
MEAN	10.8	20.8	51.6	61.9	229	159	213	77.2	30.6	3.05	.12	.002
MAX	16	36	88	164	998	365	429	111	56	9.1	.57	.03
MIN	6.3	16	36	19	103	93	120	44	10	.41	0	0
AC-FT	662	1,240	3,170	3,800	12,710	9,780	12,680	4,740	1,820	188	7.1	.1

CAL YEAR 1998	TOTAL	142,073.50	MEAN	389	MAX	9,260	MIN	3.9	AC-FT	281,800
WTR YEAR 1999	TOTAL	25,615.26	MEAN	70.2	MAX	998	MIN	0	AC-FT	50,810

TABLE C-8

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 1999 TO SEP 2000

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	0	158	554	134	75	38	5.2	.01	0
2	0	0	0	0	142	498	125	74	33	5.8	0	.31
3	0	0	0	0	135	452	123	71	33	5.2	0	0
4	0	0	0	0	146	406	118	67	34	5.2	0	0
5	0	0	0	0	123	788	114	65	31	5.9	0	0
6	0	0	0	0	119	829	110	66	30	6.2	0	0
7	0	2.5	0	0	112	611	100	67	33	5.1	0	0
8	0	0	0	0	105	632	98	67	34	4.6	0	0
9	0	0	0	0	101	660	95	67	40	4.6	0	0
10	0	0	0	0	108	592	93	62	37	5.2	0	0
11	0	0	0	0	246	538	94	62	34	4.9	0	0
12	0	0	0	0	710	503	90	57	32	4.5	0	0
13	0	0	0	0	834	459	88	58	30	3.6	0	0
14	0	0	0	0	2,370	419	87	56	22	2.9	0	0
15	0	0	0	0	1,260	387	91	60	19	2.9	0	0
16	0	.26	0	4.9	769	355	89	67	20	3.3	0	0
17	0	0	0	1.3	579	326	207	65	14	3.6	0	0
18	0	0	0	3.2	452	304	184	61	12	2.2	0	0
19	0	0	0	0	377	288	146	56	15	1.7	0	0
20	0	0	0	0	349	266	129	52	20	1.6	0	0
21	0	0	0	0	540	247	116	47	18	1.3	0	0
22	0	0	0	.20	469	231	109	44	15	.99	0	.01
23	0	0	0	172	930	213	109	43	12	.93	0	0
24	0	0	0	1,240	730	202	102	42	10	1.1	0	0
25	0	0	0	1,010	606	194	96	42	10	.91	0	0
26	0	0	0	464	511	183	91	42	9.7	.73	0	0
27	0	0	0	282	740	169	85	43	8.1	.22	0	0
28	0	0	0	199	747	168	84	40	7.2	.06	0	0
29	0	0	0	153	633	161	84	35	6.5	.03	0	0
30	0	1.0	0	134	------	151	78	34	6.8	.03	0	0
31	0	------	0	184	------	144	------	37	------	.02	0	------
TOTAL	0	3.76	0	3,847.60	15,101	11,930	3,269	1,724	664.3	90.52	0.01	0.32
MEAN	0	.13	0	124	521	385	109	55.6	22.1	2.92	0	.011
MAX	0	2.5	0	1,240	2,370	829	207	75	40	6.2	.01	.31
MIN	0	0	0	0	101	144	78	34	6.5	.02	0	0
AC-FT	0	7.5	0	7,630	29,950	23,660	6,480	3,420	1,320	180	.02	.6

CAL YEAR 1999	TOTAL	23,060.02	MEAN	63.2	MAX	998	MIN	0	AC-FT	45,740
WTR YEAR 2000	TOTAL	36,630.51	MEAN	100	MAX	2,370	MIN	0	AC-FT	72,660

TABLE C-9

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 2000 TO SEP 2001

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	5.8	89	232	90	71	20	0	0	0
2	0	0	.37	6.7	82	219	85	66	18	.06	0	0
3	0	0	1.5	8.2	75	203	80	63	18	0	0	0
4	0	0	1.6	5.0	71	568	79	60	17	0	0	0
5	0	0	2.0	3.3	68	1,730	75	59	14	0	0	0
6	0	0	2.2	2.1	64	991	78	56	13	0	0	0
7	0	0	2.9	2.2	59	713	103	53	11	0	0	0
8	0	0	3.6	7.9	56	559	109	43	10	0	0	0
9	0	0	4.0	7.5	64	466	97	39	7.6	0	0	0
10	.13	.06	4.4	25	103	408	94	40	6.7	0	0	0
11	0	0	5.2	110	231	356	87	40	6.9	0	0	0
12	0	0	6.0	366	311	315	87	40	7.1	0	0	0
13	0	0	6.1	220	241	285	83	43	6.6	0	0	0
14	0	0	6.1	137	192	260	80	43	4.8	0	0	0
15	0	0	6.3	106	162	240	79	43	4.0	0	0	0
16	0	0	7.4	90	138	229	77	42	3.5	0	0	0
17	0	0	7.3	77	121	212	73	34	3.0	0	0	0
18	0	0	7.3	72	117	194	70	32	2.3	0	0	0
19	0	0	6.9	69	205	180	75	32	1.5	0	0	0
20	0	0	6.8	63	290	161	81	33	.96	0	0	0
21	0	0	6.5	58	268	146	135	30	.46	0	0	0
22	0	0	6.8	53	259	141	118	24	.24	0	0	0
23	0	0	7.0	47	314	133	107	24	.16	0	0	0
24	0	0	7.0	69	319	124	103	24	.16	0	0	0
25	.20	0	8.4	95	350	120	98	23	.14	0	0	0
26	.11	0	8.8	188	326	114	91	24	.06	0	0	0
27	0	0	8.3	164	291	108	83	23	.03	0	0	0
28	.38	0	6.9	131	253	105	81	22	.01	0	0	0
29	.67	.03	5.8	114	------	98	81	21	.01	0	0	0
30	.01	0	6.7	103	------	94	78	20	.01	0	0	0
31	0	------	7.5	94	------	92	------	21	------	0	0	------
TOTAL	1.50	0.09	167.67	2,499.7	5,119	9,796	2,657	1,188	177.24	0.06	0	0
MEAN	.048	.003	5.41	80.6	183	316	88.6	38.3	5.91	.002	0	0
MAX	.67	.06	8.8	366	350	1,730	135	71	20	.06	0	0
MIN	0	0	0	2.1	56	92	70	20	.01	0	0	0
AC-FT	3.0	.2	333	4,960	10,150	19,430	5,270	2,360	352	.1	0	0

CAL YEAR 2000	TOTAL	36,796.01	MEAN	101	MAX	2,360	MIN	0	AC-FT	72,980		
WTR YEAR 2001	TOTAL	21,606.26	MEAN	59.2	MAX	1,730	MIN	0	AC-FT	42,860		

TABLE C-10

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 2001 TO SEP 2002

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	.03	224	50	54	79	33	8.0	0	0	0
2	0	0	18	209	50	42	67	32	8.4	0	0	0
3	0	0	289	358	51	40	64	29	9.0	0	0	0
4	0	0	134	291	50	43	65	28	7.6	0	0	0
5	0	0	79	242	48	41	65	26	6.6	0	0	0
6	0	0	53	213	41	42	62	27	5.0	0	0	0
7	0	0	43	185	39	60	55	24	4.1	0	0	0
8	0	0	35	158	56	75	52	22	3.4	0	0	0
9	0	0	33	146	73	73	46	20	3.0	0	0	0
10	0	0	36	138	66	64	47	19	2.0	0	0	0
11	0	.02	30	117	58	57	51	19	1.2	0	0	0
12	0	.32	28	103	49	54	51	18	.54	0	0	0
13	0	0	26	100	49	51	49	18	.35	0	0	0
14	0	0	31	96	49	54	41	18	.29	0	0	0
15	0	0	37	95	49	54	37	17	.29	0	0	0
16	0	0	31	90	49	56	39	16	.26	0	0	0
17	0	0	32	82	81	63	42	14	.20	0	0	0
18	0	0	27	73	109	88	47	14	.10	0	0	0
19	0	0	25	68	94	73	45	13	.12	0	0	0
20	0	0	32	65	89	62	44	16	.05	0	0	0
21	0	0	187	63	82	62	39	21	.01	0	0	0
22	0	0	197	63	80	58	37	24	0	0	0	0
23	0	0	156	58	77	85	35	21	0	0	0	0
24	0	.21	126	59	73	143	32	18	0	0	0	0
25	0	0	102	59	63	136	32	17	0	0	0	0
26	0	0	85	56	59	121	31	17	0	0	0	0
27	0	0	69	56	62	120	35	15	0	0	0	0
28	0	.06	61	57	58	113	37	13	0	0	0	0
29	0	.14	160	61	------	96	34	12	0	0	0	0
30	0	0	328	57	------	92	36	9.8	0	0	0	0
31	0	------	279	50	------	92	------	8.7	------	0	0	------
TOTAL	0	0.75	2,769.03	3,692	1,754	2,264	1,396	599.5	60.51	0	0	0
MEAN	0	.025	89.3	119	62.6	73.0	46.5	19.3	2.02	0	0	0
MAX	0	.32	328	358	109	143	79	33	9.0	0	0	0
MIN	0	0	.03	50	39	40	31	8.7	0	0	0	0
AC-FT	0	1.5	5,490	7,320	3,480	4,490	2,770	1,190	120	0	0	0

CAL YEAR 2001	TOTAL	24,206.78	MEAN	66.3	MAX	1,730	MIN	0	AC-FT	48,010
WTR YEAR 2002	TOTAL	12,535.79	MEAN	34.3	MAX	358	MIN	0	AC-FT	24,860

TABLE C-11

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 2002 TO SEP 2003

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	419	86	73	61	126	52	6.6	0	0
2	0	0	0	355	86	69	69	118	45	6.9	0	0
3	0	0	0	306	86	62	69	156	44	5.7	0	0
4	0	0	0	266	83	65	70	179	42	4.4	0	0
5	0	0	0	240	76	66	73	164	39	3.7	0	0
6	0	0	0	217	78	61	61	156	39	4.1	0	0
7	0	.01	0	193	75	57	58	157	39	4.0	0	0
8	0	.04	0	172	66	58	58	150	40	3.3	0	0
9	0	0	0	161	66	58	56	142	40	2.1	0	0
10	0	0	0	367	66	54	48	134	37	1.2	0	0
11	0	0	0	434	67	48	45	129	38	1.4	0	0
12	0	0	0	337	71	48	52	119	38	1.1	0	0
13	0	0	0	292	76	47	190	112	34	.96	0	0
14	0	0	.09	265	78	48	231	108	31	1.5	0	0
15	0	0	122	239	76	141	201	101	29	1.2	0	0
16	0	0	1,170	218	96	221	172	98	26	.96	0	0
17	0	0	830	198	99	167	163	94	24	.74	0	0
18	0	0	483	181	83	140	152	90	23	.23	0	0
19	0	0	424	173	82	124	142	84	22	.05	0	0
20	0	0	650	165	82	116	131	75	22	.03	0	0
21	0	0	502	161	82	107	124	70	22	.88	0	0
22	0	0	415	147	76	100	125	68	22	.27	0	0
23	0	0	331	134	70	94	120	71	21	.11	0	0
24	0	0	268	134	70	92	119	65	23	.06	0	0
25	0	0	222	121	77	83	131	64	21	.05	0	0
26	0	0	188	113	75	82	125	64	19	.03	0	0
27	0	0	166	112	74	82	117	56	15	0	0	0
28	0	0	202	109	72	72	133	53	12	0	0	0
29	0	0	540	105	------	67	147	53	8.9	0	0	0
30	0	0	445	94	------	66	136	56	7.6	0	0	0
31	0	------	462	87	------	63	------	57	------	0	0	------
TOTAL	0	0.05	7,420.09	6,515	2,174	2,631	3,379	3,169	875.5	51.57	0	0
MEAN	0	.002	239	210	77.6	84.9	113	102	29.2	1.66	0	0
MAX	0	.04	1,170	434	99	221	231	179	52	6.9	0	0
MIN	0	0	0	87	66	47	45	53	7.6	0	0	0
AC-FT	0	.1	14,720	12,920	4,310	5,220	6,700	6,290	1,740	102	0	0

CAL YEAR 2002	TOTAL	17,186.15	MEAN	47.1	MAX	1,170	MIN	0	AC-FT	34,090
WTR YEAR 2003	TOTAL	26,215.21	MEAN	71.8	MAX	1,170	MIN	0	AC-FT	52,000

TABLE C-12

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DRAFT

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 2003 TO SEP 2004

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	143	22	412	57	13	1.8			
2	0	0	0	331	28	370	54	11	1.2			
3	0	.01	0	214	84	319	52	10	.68			
4	0	0	0	147	133	284	47	9.5	.28			
5	0	0	0	111	128	256	47	10.	.29			
6	0	0	0	91	114	234	45	9.9	.19			
7	0	.50	0	77	100	214	41	9.5	.14			
8	0	.05	0	64	90	197	39	8.8	.10			
9	0	0	0	56	82	183	39	8.6	.19			
10	0	0	.10	51	73	169	37	8.7	0			
11	0	0	0	48	67	157	35	8.5	0			
12	0	0	0	43	65	147	34	9.6	0			
13	0	0	0	41	60	138	32	8.7	0			
14	0	.28	.99	38	56	130	32	7.8	0			
15	0	.13	0	37	52	120	32	7.2				
16	0	0	0	37	51	112	30	7.0				
17	0	0	0	35	58	104	26	6.5				
18	0	0	0	32	245	98	23	6.3				
19	0	0	.15	31	328	93	27	5.5				
20	0	0	0	29	241	85	28	5.4				
21	0	0	0	29	206	79	26	5.1				
22	0	0	0	28	186	80	24	4.9				
23	0	0	0	27	169	77	23	5.8				
24	0	0	0	29	150	73	21	6.4				
25	0	0	1.5	28	671	70	20	5.8				
26	0	0	.02	27	1,590	76	18	5.0				
27	0	0	0	26	945	71	16	4.1				
28	0	0	0	25	650	67	15	3.3				
29	0	0	11	24	494	66	14	3.1				
30	0	0	240	23	------	57	13	2.8				
31	.37	------	171	22	------	59	------	2.9	------			------
TOTAL	0.37	0.97	424.76	1,944	7,138	4,597	947	220.7	4.87			
MEAN	.012	.032	13.7	62.7	246	148	31.6	7.12	.35			
MAX	.37	.50	240	331	1,590	412	57	13	1.8			
MIN	0	0	0	22	22	57	13	2.8	0			
AC-FT	.7	1.9	843	3,860	14,160	9,120	1,880	438	9.7			
									*	*	*	*

CAL YEAR 2003	TOTAL	19,221.17	MEAN	52.7	MAX	434	MIN	0	AC-FT	38,130
WTR YEAR 2004	TOTAL*	15,277.67	MEAN	59.2	MAX	1,590	MIN	0	AC-FT	30,300

* Incomplete Record

TABLE C-13

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
CARMEL RIVER AT HIGHWAY 1 BRIDGE

DRAFT

DAILY DISCHARGE IN CUBIC FEET PER SECOND WATER YEAR OCT 2004 TO SEP 2005

Day	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	0	850	224	538	411	142	60	24	2.0	
2	0	0	0	537	209	496	381	131	58	22	1.2	
3	0	0	0	588	194	458	364	125	56	21		
4	0	0	0	455	183	548	381	120	55	20		
5	0	0	0	355	174	548	339	128	54	18		
6	0	0	0	292	169	462	314	129	53	18		
7	0	0	.50	520	164	421	308	123	52	18		
8	0	0	0	1,630	161	388	308	119	51	15		
9	0	0	0	1,630	150	355	350	132	57	14		
10	0	0	0	1,110	141	328	325	134	57	13		
11	0	0	0	1,420	133	308	299	125	54	13		
12	0	0	0	1,170	150	290	282	120	50	12		
13	0	0	0	875	137	274	272	116	47	11		
14	0	0	0	690	127	260	259	112	41	10		
15	0	0	0	568	165	248	246	108	39	9.0		
16	0	0	0	481	451	231	235	105	37	8.6		
17	.53	0	0	413	370	216	225	103	36	7.2		
18	0	0	0	362	511	207	217	97	37	6.6		
19	.65	0	0	320	563	223	209	95	37	5.8		
20	.14	0	0	287	1,080	260	201	92	37	5.8		
21	0	0	0	261	1,380	269	193	88	33	5.3		
22	0	0	0	239	1,340	851	183	85	31	6.5		
23	0	0	0	220	1,020	1,460	185	82	29	5.2		
24	0	0	0	199	815	1,000	183	77	28	3.9		
25	0	0	0	184	686	759	170	73	27	4.8		
26	.27	0	0	192	592	629	160	72	25	3.7		
27	0	0	1.6	212	529	547	150	69	25	2.1		
28	0	0	7.2	282	655	608	162	65	25	2.0		
29	0	0	97	311	------	537	158	65	25	1.3		
30	0	0	387	267	------	496	150	64	24	1.1		
31	0	------	1,650	242	------	449	------	62	------	1.3		------
TOTAL	1.59	0	2,143.30	17,162	12,473	14,664	7,620	3,158	1,240	309.2	3.2	
MEAN	.051	0	69.1	554	445	473	254	102	41.3	9.97	1.60	
MAX	.65	0	1,650	1,630	1,380	1,460	411	142	60	24	2.0	
MIN	0	0	0	184	127	207	150	62	24	1.1	1.2	
AC-FT	3.2	0	4,250	34,040	24,740	29,090	15,110	6,260	2,460	613	6.3	
											*	*

CAL YEAR 2004	TOTAL*	2,144.89	MEAN	23.3	MAX	1,650	MIN	0	AC-FT	4,250
WTR YEAR 2005	TOTAL*	58,774.29	MEAN	192	MAX	1,650	MIN	0	AC-FT	116,600

* Incomplete Record

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TECHNICAL MEMORANDUM 05-01

SURFACE WATER DYNAMICS AT THE CARMEL RIVER LAGOON
WATER YEARS 1991 - 2005

APPENDIX D

LAGOON WATER LEVEL GAGE
STATION DESCRIPTION

TABLE D-1

DESCRIPTION OF GAGING STATION ON CARMEL RIVER LAGOON

Location - South arm of Carmel River Lagoon, Carmel, at the Carmel Area Wastewater District (CAWD) effluent pipeline.

Establishment - Continuous recording station established November 1987 by MPWMD.

Drainage area - 255 sq. mi.

Gage - Campbell Scientific (CS) CR510 data recorder linked to Druck 5 psi pressure transducer. Gage housing consists of steel recorder shelter with two-inch galvanized pipe used as conduit and intake. Conduit runs approximately 50 ft. down west bank of south arm to lagoon. Nov. 28, 1995, the Monterey County Water Resources Agency (MCWRA) co-located its ALERT transmitter and pressure transducer at this installation to provide remote access to lagoon levels.

Enameled staff gage at orifice ranges from 2.00 to 10.0 ft. Additional staff gage at west bank ranges from 10.0 to 13.3 feet.

History - No other gages have been operated at the Carmel River Lagoon. Reliable continuous water level data begins April 1991. Initially, recorder was located on the CAWD effluent pipeline and utilized an Environmental Monitoring Systems (ENMOS) recorder and pressure transducer system. Nov. 5, 1993 the station was upgraded by relocating the recorder site to the west bank of the gage site, and a CS BDR-320 recorder was installed. The BDR-320 was replaced with the existing recorder Nov. 4, 1999. In 1997, the South Arm of the Lagoon was dredged, and connected to the western-most portion of the Odello West artichoke field to enhance lagoon volume/habitat. In a 2004 California State Parks Department restoration project, the South Arm of the Lagoon was excavated and extended across the former Odello West artichoke field toward Highway 1.

Reference and benchmarks - Brass disc at top of knoll above gage is elevation 59.34 ft. National Geodetic Vertical Datum (NGVD) of 1929. Gage datum is NGVD.

Channel -

Control -.

Discharge measurements -

Floods -

Point of zero flow -

Winter flow - No ice.

Regulation -

Diversion -

Accuracy - Stage records are good.

Cooperation - MCWRA maintains ALERT hardware.