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QUALITY

Ms. Clare Hachmuth, Executive Director
Natural Energy Laboratory of Hawaii Authority
Post Office Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

I am pleased to accept the Final Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority Development of the 83 Acre Land Exchange Parcel as satisfactory fulfillment of the requirement of Chapter 343, Hawaii Revised Statutes. This environmental impact statement will be a useful tool in the process of deciding if the action described therein should be allowed to proceed.

My acceptance of the statement is an affirmation of the adequacy of that statement under the applicable laws and does not constitute an endorsement of the proposed action. When the decision is made regarding the proposed action itself, I expect the appropriate legislative bodies and governmental agencies to consider if the societal benefits justify the economic, social, and environmental impacts which will likely occur. These impacts are adequately described in the statement and, together with the comments made by reviewers, provide useful analysis of the proposed action.

With kindest regards,

Sincerely,

/S/ John Waihee

JOHN WAIHEE

cc: ✓Honorable John C. Lewin

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FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

DEVELOPMENT OF LAND EXCHANGE PARCEL

STATE OF HAWAII
THE NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY
KEAHOLE, NORTH KONA, HAWAII

September, 1992

Office of Environmental Quality Control
235 S. Beretania #702
Honolulu HI 96813
586-4185

DATE DUE

Sept. 19, 2001

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

DEVELOPMENT OF LAND EXCHANGE PARCEL

Proposing Agency:
Natural Energy Laboratory of Hawaii Authority
State of Hawaii

Accepting Authority:
Governor, State of Hawaii
through
Office of Environmental Quality Control

Clare Hachmuth
Executive Director

Prepared By
GK & Associates
Kailua, Hawaii

September 1992

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II. SUMMARY

II. SUMMARY

A. BACKGROUND

The Natural Energy Laboratory of Hawaii (NELH) was established by the State in 1974 for ocean related, research and demonstration, energy and aquaculture projects. In 1986, ground was broken on adjacent lands for the State's Hawaii Ocean Science and Technology (HOST) Park, a development which is intended to provide sites for the commercialization of research activities initiated at NELH. The properties are located at Keahole Point, North Kona, Hawaii, west of Queen Kaahumanu Highway, and adjacent to the western and southern boundaries of the Keahole Airport.

The major natural asset of the Keahole site for ocean thermal energy conversion research and cold water aquaculture is the steep ocean bottom gradient directly offshore which makes possible the intake of deep, cold ocean water at depths in excess of 2,000 feet by means of relatively short lengths of pipe. There are presently seven cold water pipelines bringing ashore 6°C (43°F) water from about 600 m (2,000 ft.) deep. The total cold water pumping capacity is more than 20,000 gallons per minute. The maximum permitted seawater intake is 142,000 gpm (204.48 MGD).

Administration of the 322-acre NELH and the 547-acre HOST Park has been consolidated under the Natural Energy Laboratory of Hawaii Authority (NELHA). Existing activities include ten aquaculture enterprises, one agriculture project and four energy projects, including Ocean Thermal Energy Conversion (OTEC) research.

To the south of the NELHA property is the 'O'oma II resort development, proposed by Kahala Capital Corporation. Eighty three acres of HOST Park land located in the southeastern portion of the Park have been exchanged for 83 acres of ocean front property belonging to Kahala Capital.

Most of the NELHA lands are situated within the State Land Use Urban District. The 83-acre exchange parcel and about 33 acres of shoreline below the access road within HOST Park are in the State Conservation District. NELHA also uses submerged offshore lands, all State-owned and included in the Conservation District.

B. PRIOR NELHA ENVIRONMENTAL COMPLIANCE

The cumulative impacts of long-term operation and expansion of NELHA operations were evaluated in three previously-accepted environmental impact statements:

> *Environmental Impact Statement for the Natural Energy Laboratory of Hawaii at Keahole Point, Hawaii (Phase I)* (RCUH EIS), Research Corporation of the University of Hawaii, 1976.

Final Environmental Impact Statement, Development Plan for the Hawaii Ocean Science and Technology Park and Expansion of the Natural Energy Laboratory of Hawaii, Keahole, North Kona, Hawaii (HTDC FEIS), High Technology Development Corporation, 1985.

Final Environmental Impact Statement, Alternative Methods of Seawater Return Flow Disposal, Keahole, North Kona, Hawaii (NELH FSEIS), Natural Energy Laboratory of Hawaii, 1987.

The following accepted EIS addressed the impacts of land development and proposed aquaculture uses on the adjacent 83-acre parcel obtained by NELHA in the 1986 land exchange:

Final Environmental Impact Statement, 'O'oma II, North Kona, Hawaii ('O'oma II FEIS), prepared for Kahala Capital Corporation by Helber, Hastert, Van Horn & Kimura, Planners, 1986. Submitted to the Planning Department, County of Hawaii.

C. THE PROPOSED ACTION

NELHA's objectives for the exchange lands are to subdivide and lease parcels for aquaculture, energy and other uses in conformance with the HOST Park master plan. The State, through NELHA, would provide funding for essential infrastructure development, such as seawater systems, roads, potable water distribution, and power and telecommunications distribution systems.

The primary tenant for a portion of these lands is KAD Partners. The KAD Project is conceived as an integrated ocean science and technology center which includes marine education and research (Ocean Center), ocean engineering (OTEC Power Plant), and aquaculture (Lobster Farm) components. The KAD Project concept is based on multiple usage of the available ocean resources. The project also includes provision of a Visitor Center for NELHA, extension of Wawaloli Beach and an Archaeological Preserve.

The remainder of the 83-acre parcel would be available for aquaculture and supporting businesses as provided in the HOST Park Master Plan.

D. PURPOSE OF THIS SEIS

OEQC has determined that the proposed action requires a Supplemental Environmental Impact Statement (SEIS) under Chapter 343, Hawaii Revised Statutes, Section 343-5, and Chapter 200 of Title 11, Section 11-200-26, Hawaii Administrative Rules, because the actions proposed for the land exchange parcel differ in scope, location and timing from those previously assessed. Other uses of this document will include:

1. Support a petition to the State Land Use Commission for a District Boundary amendment from the Conservation District to the Urban District.

2. Support applications to the County of Hawaii for a Zoning Change, Shoreline Management Area Use Permit and Shoreline Setback Variance.

E. PERMITS AND OTHER APPROVALS REQUIRED

The following permits and approvals will be required before the project, or portions of it, may proceed.

- State Board of Land and Natural Resources (BLNR) - approval of subleases to tenants (conditions of General Land Leases Nos. S-4717 and S-5157)
- State Land Use Commission - District Boundary Amendment
- State Department of Land and Natural Resources, Historic Preservation Division - 6E clearance of archaeological mitigation measures
- County of Hawaii - Change of Zone
- County of Hawaii - Special Management Area Use Permit
- County of Hawaii - Shoreline Setback Variance
- County of Hawaii - Planned Unit Development (PUD)
- County of Hawaii - Ministerial permits associated with construction (eg., Building Permit; Grading Permit, etc.)
- State Department of Health - NPDES Permit for grading of more than five acres
- State Department of Health - Public Health Regulations Chapter 1-A, "Food Service and Food Establishment Sanitation Code" require that the plans for the restaurant be reviewed by the Director.
- State Department of Health - Chapter 11-62, HAR, "Wastewater Systems" requires approval of the Director to construct and operate a wastewater treatment system.

- State Board of Agriculture - Chapter 150A, HRS, Hawaii's "Plant and Non-Domestic Animal Quarantine" law requires a permit to import restricted commodities.

- U.S. Fish and Wildlife Service (FWS) - Importation of certain protected "wildlife" may require an application (SF 3177). An example is the giant clam.

F. THE KAD PROJECT

The proposed KAD Project would use 40 of the 83 acres obtained in the land swap and 26 acres of previously zoned HOST Park lands.

1. PROJECT COMPONENTS

a. OTEC Plant

KAD Partners would build and operate an OTEC plant (1 MW gross) on three acres of the exchange parcel. The proposed OTEC plant would be a closed-cycle ammonia turbine electrical generator driven by the heat difference between cold seawater pumped from deep offshore and warm seawater pumped from near the surface. The OTEC Plant would supply the Ocean Center, Lobster Farm Visitor Center and other HOST Park tenants with warm and cold seawater.

b. Ocean Center

The 12-acre Ocean Center would consist of low buildings and structures, most enclosing below-grade aquatic and botanical exhibits, and parking for automobiles and buses. The facility would be designed to accommodate an annual attendance of 500,000. The facility would be open to the public daily between the hours of 10am and 6pm. The exhibits would be focused on specific island habitats of the Pacific from high to low latitudes, making use of the range of water temperatures available. Each major tank or habitat exhibit would be supported by a gallery of smaller tanks. The transition between major exhibits would be through underground botanical gardens covered by greenhouse roofs. An educational area would contain facilities to assist in the transmission of marine and biological science to targeted school groups. Qualified teachers would relate the specially developed curriculum to small independent study groups. A research area would contain facilities to assist visiting researchers. The reproduction and conservation of marine tropical fish and the understanding of the near shore environment would be areas of concentrated research at the Ocean Center.

c. Lobster Farm

The Lobster Farm would occupy a total of 20 acres, mostly on previously zoned HOST Park lands. The total nominal facility area would be about 700,000 square feet or approximately 16 acres in either a square or rectangular shape. The entire facility would be covered with continuous greenhouse modules. The Farm is planned to produce 500,000 pounds of American Lobster per year. At full production capacity, the facility would contain about 1.5 million lobsters with an average inventory of about 350,000 pounds. The Farm would employ 13 people.

d. Visitor Center

The NELHA Visitor Center envisioned in prior EISs and the HOST Park Master Plan (HTDC, 1989) would be provided by KAD Partners. Admission to the facility would be free. The focus of the Center would be to inform visitors about the activities at NELHA. Exhibits would display the species cultured at NELH and HOST Park, demonstrate closed and open cycle OTEC, explain research activities in progress, and provide information on the cultural and historical significance of the area.

e. Archaeological Preserve

A number of archaeological sites and features have been identified along the coast in the exchange parcel. The sites of greatest significance are clustered in the southwestern corner of the parcel which would be established as an Archaeological Preserve of about five acres in size. Interpretive displays would be established where appropriate in the Preserve, and additional information provided in the Visitor Center.

f. Wawaloli Beach Extension

The Wawaloli Beach Extension would consist of approximately 10 acres along the shoreline. The area would be improved by the upgrading of the existing jeep road, providing parking spaces, and landscaping irregular-shaped picnic areas improved with pavilions, tables, and barbecues.

2. PHASING AND TIMING

The KAD Project would be developed over a 30-month period beginning in 1993 and concluding in 1995. Construction of the major operating components, the OTEC Plant, Lobster Farm and Ocean Center, would occur simultaneously with the OTEC Plant scheduled to be operational in 1994. The Ocean Center would open in mid-1995. The sequence of construction for the Lobster Farm would correspond to phases of the production system, with completion approximately 26 to 28 months after construction start-up and operationally deployed in about 30 months. Lobster harvesting would begin after about 36 months (1996).

The remainder of the 83-acre parcel would be available for development by other tenants in conjunction with scheduled improvements.

G. ALTERNATIVES

Other potential uses of the exchange parcel include high to low volume ocean water uses including aquaculture and OTEC, appropriate industrial uses, support commercial uses, education, infrastructure and open space.

Alternatives examined specific to the KAD Project included project location, site layout, components of the project. None of the alternatives examined had the combination of potential benefits as the proposed project.

H. POTENTIAL IMPACTS AND MITIGATION MEASURES

1. AIR QUALITY

Short-term direct and indirect impacts to air quality could potentially occur due to project construction. These would consist of dust and exhaust emissions. Strict compliance with State of Hawaii Air Pollution Control Regulations reduce total emissions.

Operation of the proposed facilities would result in increased motor vehicle traffic on nearby roadways, potentially causing long-term impacts on ambient air quality in the project vicinity. Both active and passive mitigation measures would reduce exposures to operations-related emissions. Active mitigation measures could include both design and operational components. Passive mitigation will result from implementation of more stringent federal regulations pertaining to increased efficiency in removing carbon monoxide and nitrogen oxides from the exhausts of new motor vehicles.

2. NOISE

NELHA is an industrial facility adjacent to a busy regional (eventually to be international) airport. The major source of man-made noise affecting the project site originates from air traffic operations at the Keahole Airport. To insure compatibility of land uses, all of the Ocean Center exhibits, including the botanical gardens, would be enclosed in greenhouse structures.

Construction activities would generate significant amounts of noise. Blasting would probably be employed in excavating the exhibit areas of the Ocean Center. Blasting was addressed in previous EISs for NELHA properties, particularly with regards to impacts to marine mammals from blasting in the marine environment. The proposed action would not require blasting in the marine environment. NELHA and its tenants have conducted blasting operations many times previously without adverse environmental effects or disturbance to neighbors. Prior to blasting, potentially affected neighbors, particularly the airport, would be notified.

In comparison to aircraft noise exposure levels, the added noise due to elevated traffic levels would be insignificant. Operational noises would not exceed established noise level guidelines.

3. WATER QUALITY AND BIOTA

a. Groundwater

The groundwater lens in the Keahole vicinity is brackish, probably less than 125 feet thick and discharges freely along the coast in a narrow band a few feet wide in the intertidal zone. The groundwater does not meet the U.S. Drinking Water Standards even at the top of the lens and at a distance about 3 miles from the shoreline. The project area is makai of the underground injection control (UIC) line. The NELHA Cooperative Environmental Monitoring Program (CEMP) includes monthly groundwater quality monitoring from 16 wells at six locations.

The various activities at NELHA utilize warm and cold seawater, and in some instances brackish groundwater. These waters are disposed of in several ways, but primarily through gravity seepage from shallow trenches. The KAD concept is to reutilize pumped water to the maximum possible extent. Water pumped for energy production in the OTEC plant would be reused in the KAD Project's air conditioning system, Ocean Center, and Lobster Farm, the Visitor Center and for other HOST Park tenants' uses. Present plans for the KAD Project indicate pumping of 13,600 gpm of cold water and 21,200 gpm warm water. Thus, approximately 35,000 gpm (50 MGD) would be disposed of into two trenches.

A hydrological modeling study was conducted (Mink and Yuen Inc., Appendix C). The impact of the trench disposal system would be to displace the lens beneath the trench and for some distance laterally as the plume sinks and spreads to a density equilibrium near the bottom of the brackish lens. Displacement of the lens would not affect other NELHA users of brackish water or the groundwater usage plans by the 'O'oma II resort.

Mitigation of potential impacts of seawater disposal would take two forms, one proactive, one reactive. The original plan for seawater disposal at HOST Park envisioned centralized trenches where the streams of return flows of various tenants would be commingled. This causes high pumping costs, maximum potential effects on the groundwaters under and downstream of the disposal trench, and reduced potential to trace the source of any introduced contaminant. NELHA therefore proposes to use a decentralized disposal method for future discharges. That is, smaller disposal trenches would be sited at appropriate locations to serve the needs of tenants as they arise. For the KAD project, two trenches would be utilized. Particulate matter would be removed from the water in settling ponds prior to disposal in trenches.

The reactive component of the mitigation plan is the expansion of the CEMP to include the land exchange parcel. A major focus of the CEMP has been to document effects and impacts of these discharges on groundwaters, anchialine ponds and coastal marine ecosystems. The CEMP annual report (Appendix B) indicates that at least through June, 1991, there were no negative impacts from the discharges.

b. Anchialine Ponds

Disposal of seawater return flows into trenches could impact water quality, and consequently the biota, in nearby anchialine ponds if the plume extends this distance without sinking below the brackish water lens. The CEMP includes a water quality monitoring station (A2) in this series of ponds, so such an impact would be quickly detected. It would be useful for future impacts assessment to intensively monitor these ponds immediately after initiation of major flows into the trenches. If plume waters fill the ponds, additional monitoring of impacts to biota should be immediately initiated. Presumably, cessation of disposal or reduction of flows to a level which does not impact the ponds would restore the anchialine ecosystem.

c. Marine Waters

Keahole Point is characterized by strong tidal and eddy currents and is exposed to the direct impact of southerly swells. The marine bottom community is held in an early to intermediate stage of succession by periodic storm waves which destroy the more fragile organisms and structures.

In their natural pristine state both deep ocean water and groundwaters violate state water quality standards for nitrogen and phosphorous, however, because the ambient concentrations of these nutrients are quite predictable, the best indication of potential alteration of water quality from any human-caused source or action is the CEMP (Appendix B). Evidence of discharge waters has been detected within the groundwater, and immediately at the shoreline, but no impacts to the biota have been documented. Recent surveys indicate no significant differences in number of fish counted or number of species present. The most recent benthic community monitoring data do not reveal any changes in the community attributable to disposal of NELHA waters. Substantial changes in the benthic community have occurred as a result of storm wave activity.

Discharges from the KAD Project would collectively represent approximately one fourth of the total permitted water flow for NELHA, and more than any volume previously discharged. The most potentially damaging aspect of the return flows would be low temperatures which could damage or kill corals. Mixing and reuse of the water, residence time in settling ponds, and warming throughout each system would raise the temperature of the discharge to above 18°C, the threshold for damage to Hawaiian corals.

4. SOCIAL AND ECONOMIC

The KAD Project would create temporary jobs in construction and long-term employment in facilities operations and management. A total construction employment requirement of 204 person-years is estimated to complete the infrastructure and facilities covering a 45-acre area. The peak of construction activity would be in 1995 when 100 person-years would be required. The total direct, indirect and induced construction employment would be 378 person-years between 1993 and 1995.

The operating components of the KAD Project would create a variety of jobs. Maximum staffing levels of 75 would be reached in 1996. Indirect and induced employment resulting from the OTEC Plant would be three jobs; from the Lobster Farm would be 18 jobs; and from the Ocean Center would be 101 jobs for a total of 122 indirect and induced jobs created. Adding the direct jobs created, the grand total would be 197 jobs created.

The KAD Project would provide a major West Hawaii attraction for residents and visitors alike. Visitors to the Kona side of the island totaled 1,030,900 in 1990. The annual attendance at the Ocean Center is projected at 500,000 people. Annual admission revenues are projected at $7.5 million. Revenues from food and beverage and retail sales are estimated at an additional $5.5 million, bringing total annual revenues from the Ocean Center to $13 million. Adding the indirect and induced expenditures yields a total annual visitor expenditure of $18 million. Total Lobster Farm direct revenues of $19.6 million would generate another $12.4 million in indirect and induced revenues, for a total of $32 million.

The KAD Project would increase 1995 personal income by $4.9 million, and provide a steady-state 1996 and beyond annual personal income of $1.4 million. Household income impact from the development of the KAD project would be $6.7 million annually beginning in 1996.

Development of 66 acres by KAD Partners would increase property taxes to the county by as much as $280,500. Annual property tax revenues minus the increased operating expenses would represent a net benefit of about a quarter of a million dollars a year.

The combined state tax revenue from all sources in $1,444,000 per year. An additional revenue stream for the state would be the collection of lease rents from KAD, estimated at $652,000 a year after full build-out. This would represent a net annual benefit of about $2 million. At this rate, the prorated capital costs associated with infrastructure improvements at NELHA would be recovered in well under five years.

Comparable socio-economic analysis applied toward the use of the remainder of the exchange parcel in other aquaculture ventures would produce similar impacts. These aquaculture ventures would increase the Big Island's producing acreage and aquaculture revenues.

5. BUILT ENVIRONMENT

a. Archaeology

NELHA properties, including the exchange parcel, have been thoroughly surveyed for archaeological resources. At the time of the HTDC FEIS (1985), there had been eight surveys of HOST Park and seven of NELH. Other surveys of the area had been completed prior to the creation of NELH. The coastal portion of the exchange parcel is rich with archaeological sites. During preparation of the NELH SEIS (1987), Dr. Ross Cordy of the State Historic Sites Section (now Historic Preservation Division) again surveyed the NELH sites, and prepared a preservation/mitigation plan. This plan was subsequently expanded to include the HOST Park sites and those on the exchange parcel.

Archaeological mitigation is an integral component of the KAD Project. An Archaeological Preserve is planned wherein a number of sites would be preserved and interpreted for public education and appreciation. Prior to construction data recovery work will be completed for those sites so designated. Those sites requiring preservation would be contained in the proposed Archaeological Preserve.

b. Traffic

If the NELHA entrance is unsignalized, the left turns from the access road would experience long delays and operate at LOS F. Left turns into the project would operate at LOS D. The intersection has separate left turn lanes into and out of the access road, therefore, Queen Kaahumanu Highway would remain at LOS B.

The state currently has plans to improve Queen Kaahumanu Highway to an access controlled facility. As yet, there is no indication that this would occur within the time frame used in the traffic study (1992-1997). It is understood that when Queen Kaahumanu Highway is improved, access to NELHA would be via a frontage roadway, probably from an interchange at the airport. This would alleviate the potential problem at the intersection of Queen Kaahumanu Highway and the NELHA access road.

c. Electricity

The OTEC Plant would supply power for the seawater pumps eliminating the need to purchase approximately 880 kilowatts from the utility. Cold water pumped for power generation would also be used for air conditioning, considerably reducing electrical demand. Diesel generators would be installed for emergency back-up power for critical equipment.

d. Potable Water

Fresh water for domestic use and fire protection is supplied by the Department of Water Supply, County of Hawaii. The County has allocated NELHA 500,000 gpd. The current fresh water usage at NELHA is approximately 110,000 gpd. The proposed KAD Project would require approximately 30,000 gpd.

e. Wastewater Treatment and Disposal

A self-contained sewage treatment plant is planned to handle the human sewage from the operation of the KAD facilities. Secondary treatment would be employed. Septic tanks would not be necessary because all effluent waters would be used to irrigate landscaping on the site.

Seawater return flows from the Lobster Farm and Ocean Center would be collected in a lined settling pond, evaporated and the residue trucked to a landfill or sewage treatment plant. Effluents would be disposed of in the two disposal trenches. Wastewaters from exhibits with non-indigenous tropical and sub-tropical species would be treated by filtration, ozonation, ultraviolet light, or other means prior to final disposition in a lava trench.

f. Solid Waste Disposal

The proposed project would generate several solid waste streams, including sludge from the sewage treatment plant, settled solids from the Ocean Center exhibits and Lobster Farm, food wastes from the food service facility, green waste from the landscaping and miscellaneous wood, paper, plastic and metallic wastes.

NELHA fully supports the integrated solid waste management efforts of the state and county. The primary sources of solid waste from the KAD Project would be the Lobster Farm and the Ocean Center. Each facility would institute waste management and waste reduction plans conforming to state and county policies.

g. Recreation

An integral component of the KAD Project is extension of the Wawaloli Beach area by about 10 acres. Physical improvements would include upgrading a portion of the existing jeep trail and provision of parking spaces, landscaping and picnic areas.

h. Education

The Ocean Center would provide a significant resource to area educational programs. The educational function is a very important part of the Ocean Center concept, and both facilities and staff would be provided to assist in curriculum development and instruction. The Ocean Center would also be a significant resource for education and research if plans for creation of a new West Hawaii campus of the University of Hawaii in the area are implemented.

I. RELATIONSHIP TO LAND USE PLANS

Granting of the necessary changes to state and county land use designations and development of the exchange parcel as proposed, would, at the state level, bring the project into conformity with the Hawaii State Plan and Functional Plans, the state Land Use Law, the West Hawaii Regional Plan, the Hawaii Coastal Zone Management Plan, state environmental quality statutes, and the HOST Park Master Plan; and at the county level, into conformity with the Hawaii County General Plan, the Keahole to Kailua Development Plan, Zoning and Subdivision Ordinances, and guidelines for protection of the Special Management Area and Shoreline Setback.

J. UNAVOIDABLE IMPACTS

Short-term impacts attributable to the project would be associated with construction. There would be a temporary interruption of recreational access to the shoreline during this period, and emissions of air pollutants and noise would temporarily increase. Traffic would also increase.

The development of the exchange parcel would involve the irretrievable commitment of certain natural, fiscal and human resources, some of which are non-renewable. Major resource commitments would include land, money, construction materials, labor and energy. The benefits of the project could not be realized without the commitment of these resources.

K. UNRESOLVED ISSUES

There are several unresolved issues surrounding development of the exchange parcel and implementation of the KAD Project. With respect to the entire parcel, the future tenants and uses other than KAD Partners are not known. A second unresolved issue is the overall build-out rate for NELHA, which would determine when certain impact mitigation measures would be required. The third unresolved issue is the efficacy of the trench disposal method. All indications from the ongoing CEMP are that the present discharge is having no negative impact on marine or anchialine ecosystems in the area. It is expected that increased return flow volumes would present similar impacts to those indicated in the CEMP. It is unknown if the discharge plume from the trenches would intersect the southern group of anchialine ponds, and if it did what the impact to that ecosystem would be. This would be observed through the monitoring program, and if impacts were unacceptable could be reversed through alteration of disposal volumes, locations or methods.

III. INTRODUCTION

III. INTRODUCTION

A. NELHA - HISTORICAL PERSPECTIVE

The Natural Energy Laboratory of Hawaii (NELH) was established by the State in 1974 for ocean related research and demonstration energy and aquaculture projects. In 1986, ground was broken on adjacent lands for the first increment of the State's Hawaii Ocean Science and Technology (HOST) Park, a development which was intended to provide sites for the commercialization of research activities initiated at NELH.

Until 1990, the properties, which are located at Keahole, North Kona, Hawaii (Figure 1), were separately administered, although their missions were complementary. The 1990 State Legislature (Chapter 227D, HRS) consolidated management of NELH and HOST Park lands and facilities under a single administrative organization, the Natural Energy Laboratory of Hawaii Authority (NELHA). Figure 2 shows the Keahole property presently managed by NELHA; NELHA also manages the Geothermal Research Park at Puna, Hawaii.

The major natural asset of the Keahole site for ocean thermal energy conversion research and cold water aquaculture is the steep ocean bottom gradient directly offshore which makes possible the intake of deep, cold ocean water at depths in excess of 2,000 feet by means of relatively short lengths of pipe, generally in the range of 6,000 to 8,000 feet.

There are presently seven cold water pipelines (including a 40-inch system installed as a joint project between NELHA and the U.S. Department of Energy) bringing ashore 6°C (43°F) water from about 600 m (2,000 ft.) deep. The total cold water pumping capacity is more than 20,000 gallons per minute.

Existing activities on the sites include ten aquaculture enterprises, one agriculture project and four energy projects, including Ocean Thermal Energy Conversion (OTEC).

B. THE EIS PROCESS

1. OVERVIEW OF THE PROCESS

Chapter 343, HRS, requires the preparation of an environmental assessment for projects involving various stated "triggering" actions. The assessment, prepared either by an applicant or agency according to the nature of the sponsoring entity, is reviewed by the sponsoring agency in the case of an agency action or by the approving agency, the lead permitting agency in the case of an applicant action. If the review concludes that the project would have no significant negative impacts, a negative declaration is drafted and published in the OEQC Bulletin. If the review concludes that significant negative impacts <u>may</u> occur, then a full environmental impact statement is required, and a notice of preparation is

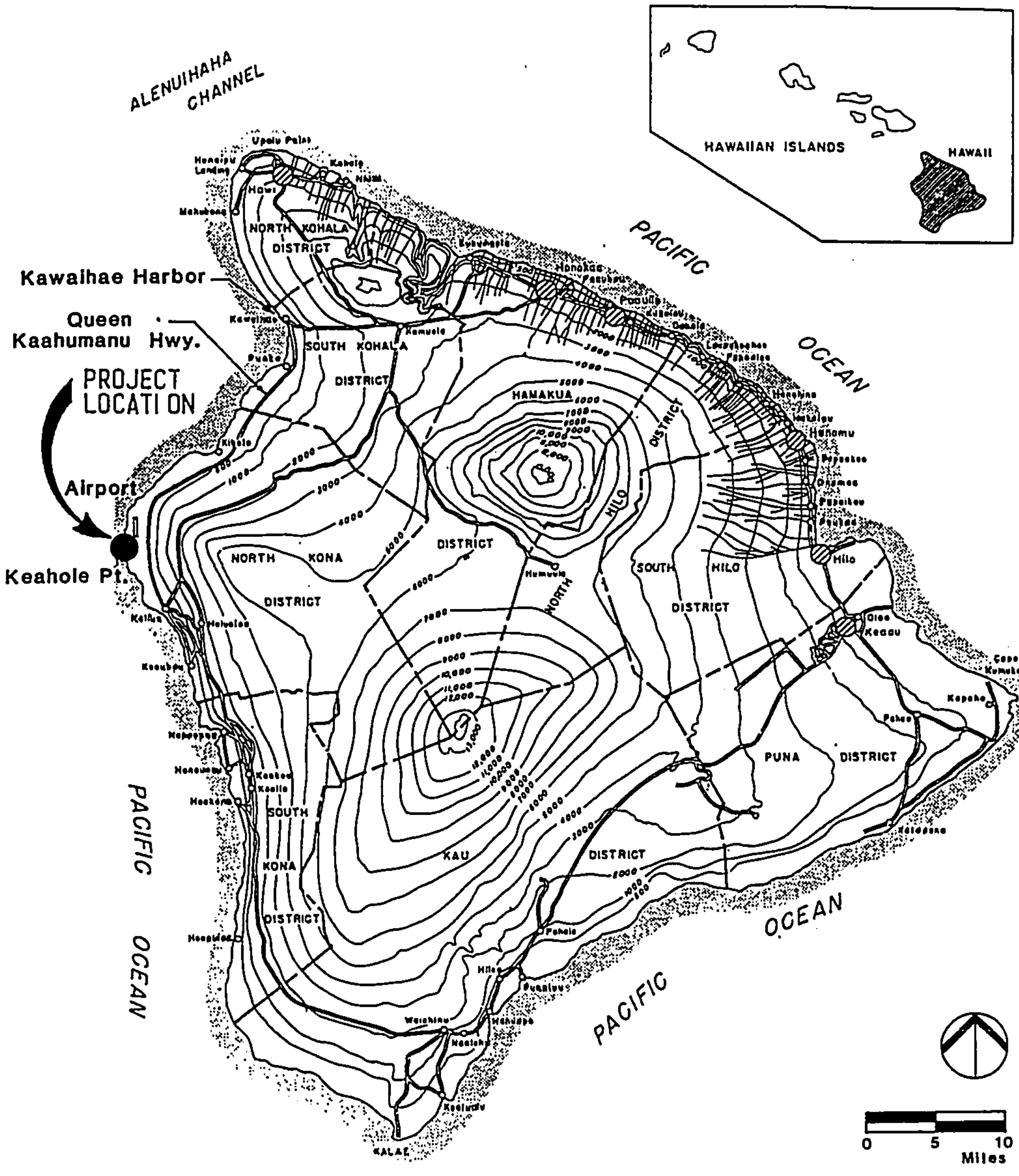


Figure 1
PROJECT LOCATION

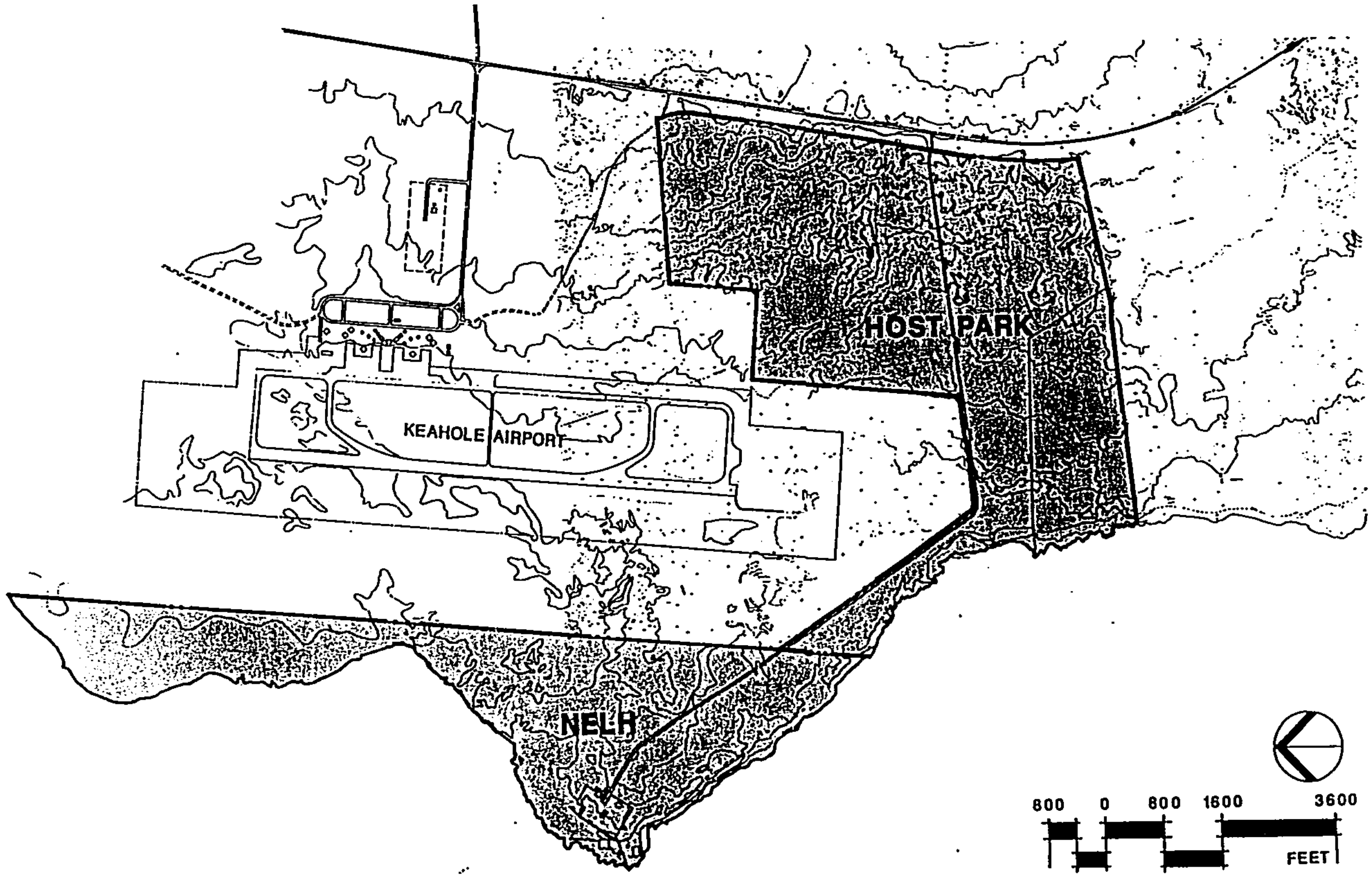


Figure 2
NELHA KEAHOLE PROPERTIES

drafted and published in the OEQC Bulletin. A 30-day consultation period ensues during which any interested party may register concerns about the project and request to be a consulted party. This period is commonly referred to as "scoping", and issues identified in this process must be addressed in the EIS.

Once a draft EIS is produced, a summary of the action, its impacts and proposed mitigation measures is published in the OEQC Bulletin, and there ensues a 45-day period in which agencies, organizations and individuals may submit written comments. The EIS is finalized by adequately responding to these comments, and modifying the draft EIS as appropriate. The proposing agency, in the case of an agency action, or the approving agency, in the case of an applicant action, determines the adequacy of the final document. The ultimate acceptance of the document, however, is the responsibility of the Governor (for a "state" action) or the respective mayor (for a "county" action) or their designated representative. The designated representative of the Governor is the Office of Environmental Quality Control.

If in planning or implementation, a project changes significantly, a new assessment of its impacts must be prepared and submitted to the prior designated accepting authority for a determination of whether or not a supplemental EIS will be required. In the absence of a significant change in the project and consequent significant change in its impacts, a supplemental EIS is not required.

In the present instance, some aspects of the proposed action differ in size and location from prior descriptions of the project for OEQC, in consultation with NELHA and the LUC, to conclude that the potential environmental impacts <u>may</u> differ from those previously disclosed, and therefore a supplemental EIS is required.

2. PRIOR NELHA ENVIRONMENTAL COMPLIANCE

The cumulative impacts of long-term operation and expansion of NELHA operations were evaluated in three previously-accepted environmental impact statements:

> *Environmental Impact Statement for the Natural Energy Laboratory of Hawaii at Keahole Point, Hawaii (Phase I)* (RCUH EIS), Research Corporation of the University of Hawaii, 1976.
>
> *Final Environmental Impact Statement, Development Plan for the Hawaii Ocean Science and Technology Park and Expansion of the Natural Energy Laboratory of Hawaii, Keahole, North Kona, Hawaii* (HTDC FEIS), High Technology Development Corporation, 1985.
>
> *Final Environmental Impact Statement, Alternative Methods of Seawater Return Flow Disposal, Keahole, North Kona, Hawaii* (NELH FSEIS), Natural Energy Laboratory of Hawaii, 1987.

The following accepted EIS addressed the impacts of land development and proposed aquaculture uses on the adjacent 83-acre parcel obtained by NELHA in the 1986 land exchange:

> *Final Environmental Impact Statement, 'O'oma II, North Kona, Hawaii* ('O'oma II FEIS), prepared for Kahala Capital Corporation by Helber, Hastert, Van Horn & Kimura, Planners, 1986. Submitted to the Planning Department, County of Hawaii.

The HTDC FEIS and the NELH FSEIS both evaluated environmental effects based on "worst case" conditions at full development. The full-development scenario previously assessed would not change as a result of any of the actions described in this supplemental EIS. The impacts anticipated in the 'O'oma II FEIS for the parcel which was received by NELHA in the exchange are similar to those that would occur under NELHA management. This is a consequence of the fact that the original 'O'oma II Master Plan included high-tech aquaculture as a buffer zone between HOST Park and their resort use area.

3. ACTIONS PREVIOUSLY ASSESSED

The HTDC FEIS and the NELH FSEIS described a very comprehensive range of actions, disclosed their potential impacts and proposed extensive mitigation measures, as appropriate and feasible. To the extent that these actions and impacts are not anticipated to be altered by the present project, the accepted EISs remain valid and their contents are by reference included herein. A comprehensive list of previously assessed actions is included as Appendix A to this SEIS.

C. PURPOSE OF THIS SUPPLEMENTAL EIS

OEQC has determined that the proposed action will require a Supplemental Environmental Impact Statement (SEIS) under Chapter 343, Hawaii Revised Statutes, Section 343-5, and Chapter 200 of Title 11, Section 11-200-26, Hawaii Administrative Rules, because the actions proposed for the land exchange parcel differ in scope, location and timing from those previously assessed. Other uses of this document will include:

1. Support a petition to the State Land Use Commission for a District Boundary amendment from the Conservation District to the Urban District.

2. Support applications to the County of Hawaii for a Zoning Change, Shoreline Management Area Use Permit and Shoreline Setback Variance.

D. SCOPING, CONSULTATION AND COORDINATION COMPLETED

The notice of preparation of the SEIS was published in the November 8, 1991 edition of the OEQC Bulletin. In addition, the environmental assessment was provided to a comprehensive list of federal, state and county agencies, private organizations, and individuals. The notice of availability of the draft SEIS was first published in the July 8, 1992 OEQC Bulletin, and the 45-day comment period extended through August 22. Chapter IX provides a list of consulted parties, copies of all letters received and responses sent.

Issues of concern identified in scoping and consultation include:

<u>Project Description</u>

- Facilities and operations
- Number/location of intake water pipes
- Wastewater treatment and disposal
- Solid waste management

<u>Infrastructure</u>

- Traffic
- Electricity demand and redundancy
- Potable water demand
- Civil Defense Warning System Location

<u>Land Use</u>

- Regional impacts
- Compatibility with neighboring uses
- Compatibility with airport noise
- Use of shoreline setback area
- Coastal access and recreational facilities

<u>Economics</u>

- Feasibility
- Employment
- Housing

<u>Natural Environment</u>

- Groundwater quality
- Soil erosion
- Endemic birds
- Strand vegetation
- Coastal marine and anchialine resources
- Release of exotic diseases, microbes or aquatic biota
- Results of the Comprehensive Environmental Monitoring Program (CEMP)

E. FURTHER PREREQUISITES FOR PROJECT IMPLEMENTATION

The following permits and approvals will be required before the project, or portions of it, may proceed.

- State Board of Land and Natural Resources (BLNR) - approval of subleases to tenants (conditions of General Land Leases Nos. S-4717 and S-5157)
- State Land Use Commission - District Boundary Amendment
- State Department of Land and Natural Resources, Historic Preservation Division - 6E clearance of archaeological mitigation measures
- County of Hawaii - Change of Zone
- County of Hawaii - Special Management Area Use Permit
- County of Hawaii - Shoreline Setback Variance
- County of Hawaii - Planned Unit Development (PUD)
- County of Hawaii - Ministerial permits associated with construction (eg., Building Permit; Grading Permit, etc.)
- State Department of Health - NPDES Permit for grading of more than five acres
- State Department of Health - Public Health Regulations Chapter 1-A, "Food Service and Food Establishment Sanitation Code" require that the plans for the restaurant be reviewed by the Director.
- State Department of Health - Chapter 11-62, HAR, "Wastewater Systems" requires approval of the Director to construct and operate a wastewater treatment system.
- State Board of Agriculture - Chapter 150A, HRS, Hawaii's "Plant and Non-Domestic Animal Quarantine" law requires a permit to import restricted commodities.
- U.S. Fish and Wildlife Service (FWS) - Importation of certain protected "wildlife" may require an application (SF 3177). An example is the giant clam.

IV. DESCRIPTION OF THE PROPOSED ACTION

IV. DESCRIPTION OF THE PROPOSED ACTION

A. PURPOSE OF AND NEED FOR THE ACTION

NELHA proposes the following modifications to existing approvals for the lands and facilities at Keahole:

- Subdivision, infrastructure development, and leasing of 83 acres of ocean front land at 'O'oma II, North Kona, Hawaii (TMK: 7-3-09: 23). This land, which was obtained from Kahala Capital Corporation in 1986 in exchange for 83 acres of the original HOST Park property (Figure 3), must be reclassified from Conservation to Urban by the State Land Use Commission and rezoned to General and/or Limited Industrial by the County of Hawaii before infrastructure can be developed and the parcels leased. A County Special Management Area (SMA) Use Permit must also be obtained;

- Alteration of location, size and timing for development of certain facilities and projects that were assessed in previous EISs;

- Disposal of seawater return flows into small trenches on individual properties rather than into a large common trench.

B. PROJECT LOCATION

The Island of Hawaii is the most recently formed of the Hawaiian Islands. Commonly referred to as the Big Island, it has nearly twice the combined land area of all of the other islands in the state combined. Formed by five volcanoes, its area is still being expanded by volcanic eruptions. Mauna Kea, the highest of the five, rises 13,796 feet from the northerly part of the island. The County of Hawaii encompasses the entire island.

The project area lies within the North Kona Judicial District, one of nine judicial districts in Hawaii County. The North Kona District lies on the western coast of the island of Hawaii within a larger region known as West Hawaii. Anaeho'omalu Bay marks the district's northern boundary and Kealakekua Bay marks the southern boundary. The inland boundaries are defined by the land masses of Mauna Loa and Hualalai. The North Kona Judicial District includes Census Tracts 215 (Kailua-Kona) and 216 (the remainder).

The primary commercial center of the District is located at Kailua-Kona, the second largest town on the Island of Hawaii. Secondary urban centers are found in the communities of Holualoa, Honalo, Kainaliu, Keahou and Kalaloa. The basic industries in North Kona are tourism, agriculture, and construction. The North Kona Coast is the County's major visitor destination area.

The 322-acre Natural Energy Laboratory of Hawaii (NELH) and the 547-acre Hawaii Ocean Science and Technology (HOST) Park (see Figure 2) have been consolidated under NELHA. The properties are located at Keahole Point, North Kona, Hawaii, west of Queen Kaahumanu Highway, and adjacent to the western and southern boundaries of the Keahole Airport. A lighthouse operated by the U.S. Coast Guard occupies the tip of Keahole Point, seaward of NELH. To the south of the NELHA property is the proposed 'O'oma II resort development.

There are no recent usages or contemporary cultural resources within most of the site. The shore areas which include small beaches are used for informal recreation. A jeep trail exists along the ocean frontage as part of a continuous casual access system. Significant Hawaiian archaeological sites have been located and will be managed as per guidelines established by the State Division of Historic Preservation and outlined in later sections.

C. LEGAL AND REGULATORY STATUS OF THE SITE

NELH lands are held under General Lease No. S-4717 from the State of Hawaii, Board of Land and Natural Resources (BLNR). This lease, commencing 1 November 1978, secures 321.8 acres of State-owned land at Keahole Airport for the term of 65 years. HOST Park lands are held under General Lease No. S-5157 from the BLNR. This lease, commencing 1 September 1985, secures 421 acres of State-owned land at Keahole Airport for the term of 65 years. An additional 127 acres were added to the northeastern corner of HOST Park adjacent to Queen Kaahumanu Highway by the Governor's Executive Order No. 3282. The land directly at Keahole Point is owned by the U.S. Coast Guard and used by NELHA under a revocable license.

By Exchange Deed and Agreement for Exchange dated December 30, 1986, 83 acres of HOST Park land located in the southeastern portion of the Park were exchanged for 83 acres of ocean front property belonging to Kahala Capitol Corporation (Figure 3). The Tax Map Keys for all NELHA properties are shown on Figure 4.

Most of the NELHA lands are situated within the State Land Use Urban District. The 83-acre exchange parcel and about 33 acres of shoreline below the access road within HOST Park are in the State Conservation District. NELHA also uses submerged offshore lands, all State-owned and included in the Conservation District. Conservation District Use Permit (CDUP) HA-1862 covers approved activities located on Conservation lands and 2,940 acres of ocean waters and submerged lands. This "master" permit approves of up to 15 water intake pipelines, maximum size not to exceed 48 inches in diameter. Previously, under CDUP HA-879, three 12-inch and two 15-inch diameter intake pipelines were approved. The maximum permitted seawater intake is 142,000 gpm (204.48 MGD).

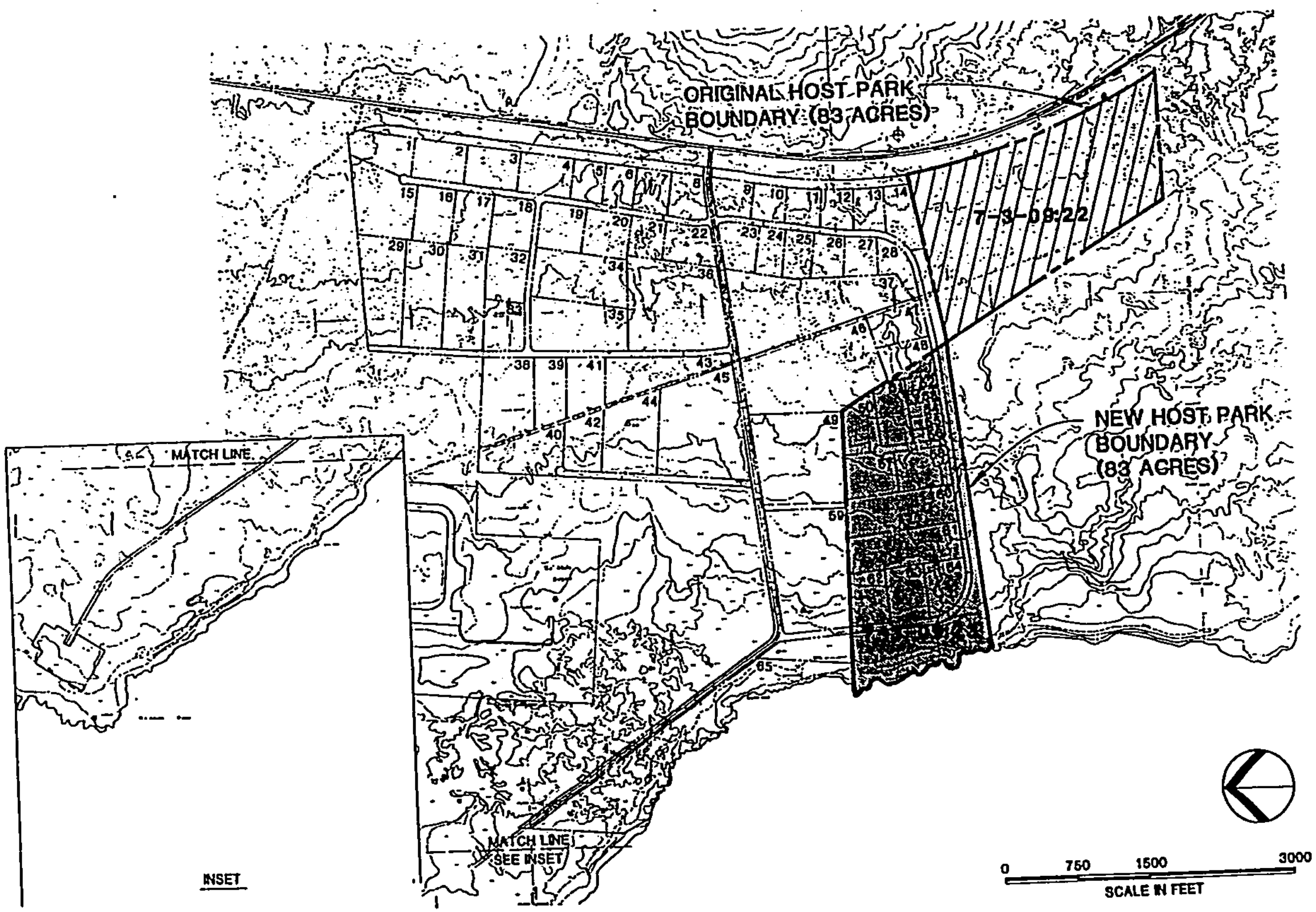


Figure 3
LAND EXCHANGE PARCELS

SOURCE: R. M. TOWILL CORPORATION

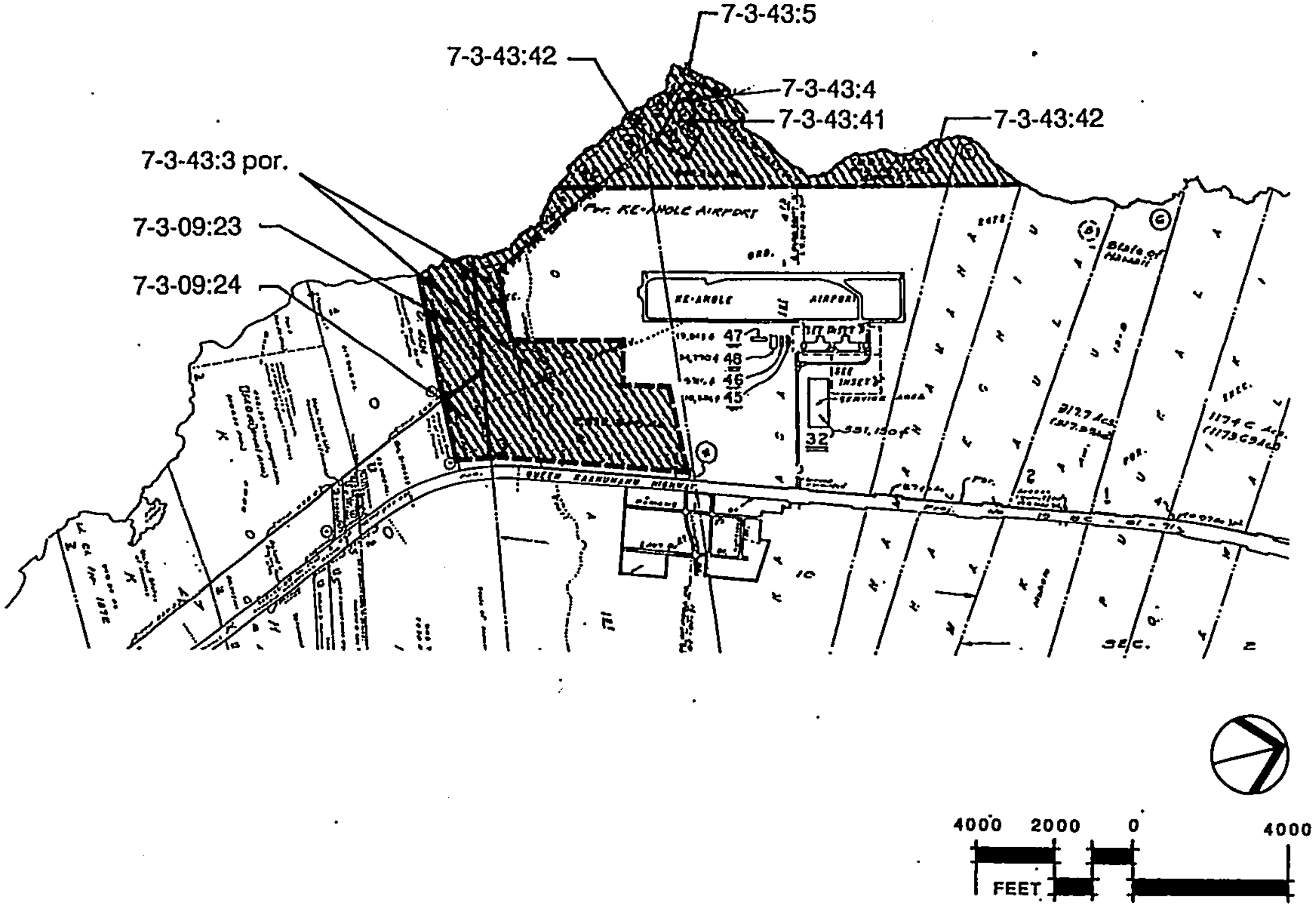


Figure 4
TAX MAP KEYS: NELHA KEAHOLE PROPERTIES

The County of Hawaii General Plan Land Use Pattern Allocation Guide (LUPAG) Map designates the properties as "Industrial." The NELHA properties are zoned MG-1a, MG-3a and Open (Figure 5). The properties are located within the County of Hawaii's Special Management Area (SMA).

The exchange parcel, which is undeveloped, has been incorporated into the HOST Park Master Plan (R.M. Towill, 1989) (Figure 6).

D. PROJECT OBJECTIVES

NELHA's objectives for the exchange lands are to subdivide and lease parcels for aquaculture, energy and other uses in conformance with the HOST Park master plan. At this time, the only identified tenant for a portion of these lands is KAD Partners. The KAD Project is conceived as an integrated ocean science and technology center which includes marine education and research (Ocean Center), ocean engineering (OTEC Power Plant), and aquaculture (Lobster Farm) components. The project concept is based on multiple usage of the available ocean resources. Cost effectiveness will be maximized by integration of project infrastructure and shared administration. The project also includes provision of a Visitor Center for NELHA, extension of Wawaloli Beach and an Archaeological Preserve.

The Ocean Center is intended to function with the essential social characteristics of a public facility such as an art museum, library, or park. However, it is critical to distinguish this facility from commercial marine parks, theme parks, and roadside zoos. This distinction will be evident in the planning and implementation of the facility design, facility public relations activities and the ongoing operations of the facility as they define its character. The intended character of the facility is exemplified in the following theme statement developed by the design team:

> The Ocean Center is to be a world class, profitable, state-of-the-art facility designed to educate, entertain, and inform visitors about the terrestrial and marine environments of the Pacific islands and about the activities of marine researchers in an exciting and compelling manner so that visitors will acquire a new appreciation of the value, diversity, and beauty of the ocean's resources and a greater awareness of the consequences of human interactions with the environment.

A significant aspect of the Ocean Center made possible by the availability of the clean, cold, deep-ocean water at NELHA is that it is intended to provided a complete overview of marine ecology, natural history, fisheries and research activities, and environmental concerns of the region - ranging from the Pacific Arctic to the Pacific Antarctic.

Aquaculture is a natural adjunct to the Ocean Center and ocean energy extraction components of the project in that it provides a means of further utilizing the available

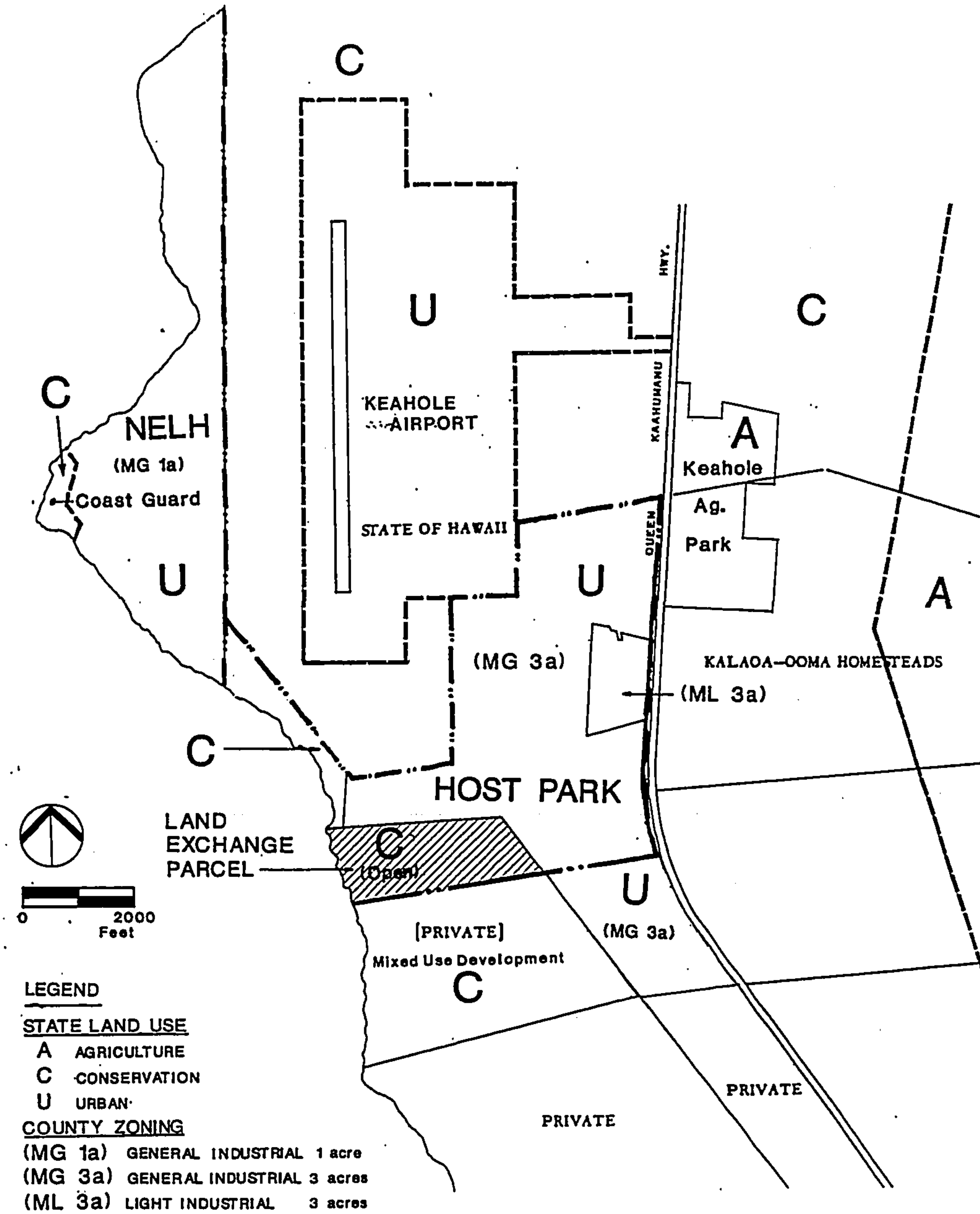


Figure 5

LAND USE AND ZONING

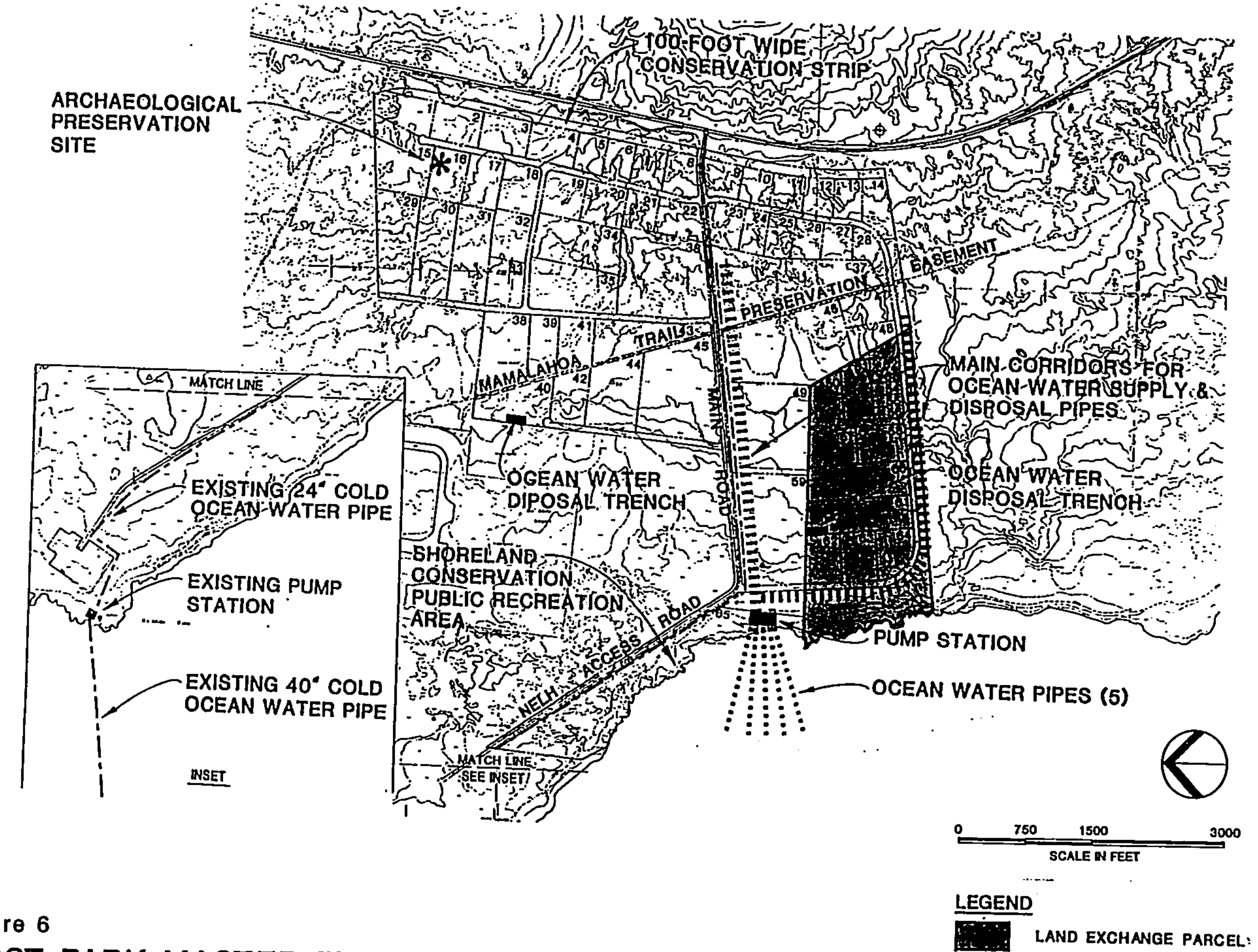


Figure 6
HOST PARK MASTER PLAN (JUNE 1989)

SOURCE: R. M. TOWILL CORPORATION

seawater resources in a beneficial way. The commercial aquaculture component of the KAD Project, the Lobster Farm, is intended to profitably apply innovative and technically sound techniques of aquaculture production developed by KAD Partners. The aquaculture project component is a means of creating a valuable product, additional employment, and diversification of the regional economic base while demonstrating environmentally compatible utilization of ocean resources.

The OTEC component would generate electrical energy from the ocean resource. OTEC supplied power would replace electricity which would otherwise be supplied by HELCO. All of the seawater pumps would be powered by the OTEC Plant. These pumps would provide large continuous supplies of cold and warm seawater for applications over a wide temperature range. The net effect of the OTEC energy would be to reduce the need for additional generating capacity.

E. GENERAL DESCRIPTION OF THE ACTION

The description below and much of the information provided in this SEIS pertains specifically to the KAD Project. Neither potential tenants nor intended uses of other portions of the exchange parcel have been determined. It is assumed that other future uses would be similar to existing uses of NELHA properties. Further environmental assessments will not be required unless a proposed future project, its impacts and mitigation of those impacts have not been considered in prior EISs.

NELHA would be responsible for providing certain infrastructure and services for tenants of the exchange parcel. These actions were described and their impacts assessed in previous EISs, the contents of which are incorporated herein by reference. Principal among these are supplies of warm and cold seawater. Seawater would be provided by two pipelines positioned within the approved ocean use corridor. Total seawater volumes are presently estimated to be 60,000 gpm (30,000 gpm per pipeline), although optimization could lower the volume or change the ratio of warm and cold water. Direct impacts to the nearshore environment would be minimized by using construction technology such as slant drilling to pass beneath beach and reef areas. An experimental slant drilling program was recently completed at NELHA. Such technology, when feasible, has been identified in prior EISs and permits as a desirable alternative to trenching across the shoreline and nearshore shelf off Keahole Point.

The proposed KAD Project would use 40 of the 83 acres obtained in the land swap and 26 acres of previously zoned HOST Park lands (Figure 7). KAD Partners would develop, own and manage all components of the project. The individual components of the KAD Project (Figure 8) are described in the following sections.

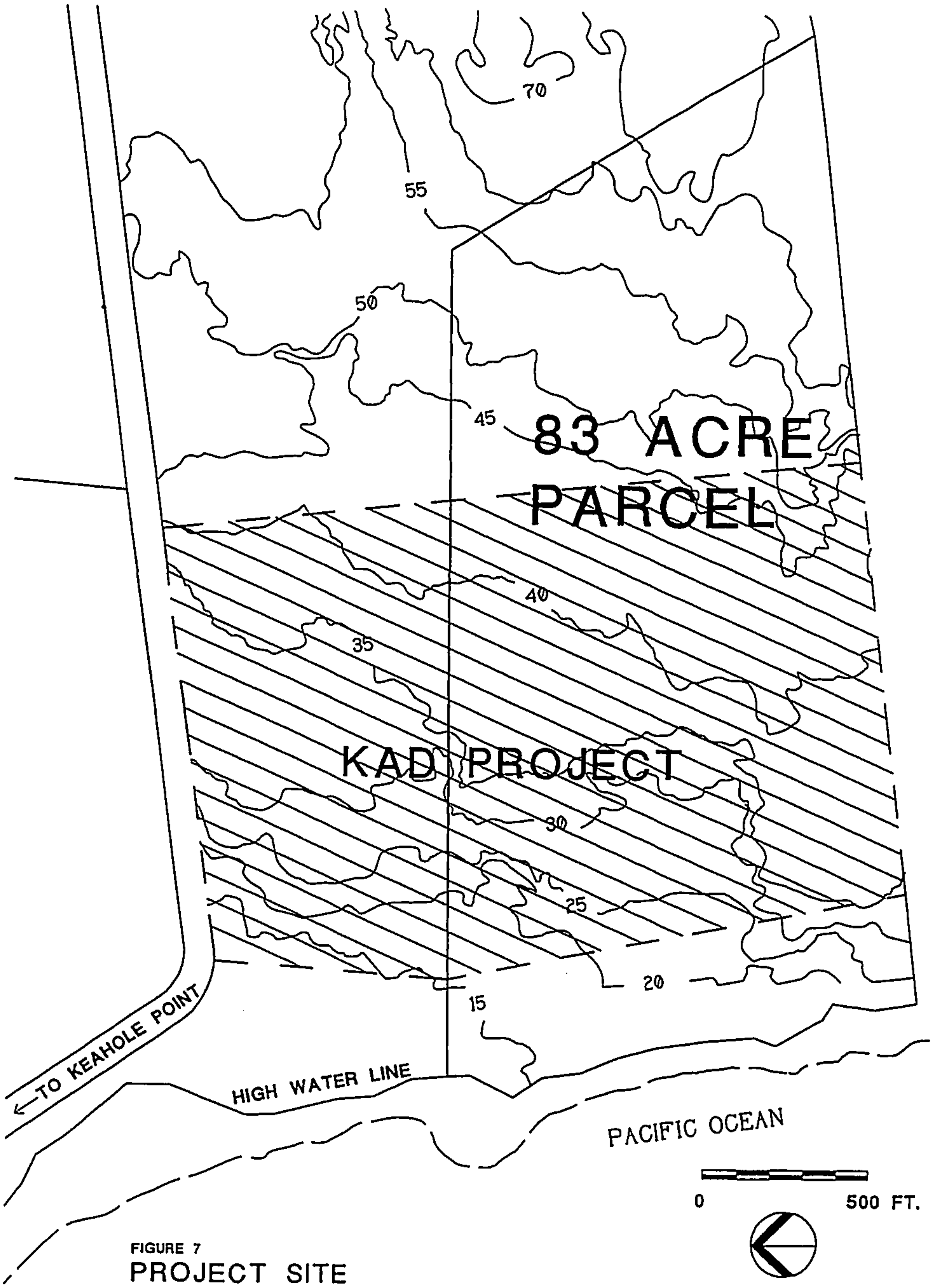


FIGURE 7
PROJECT SITE

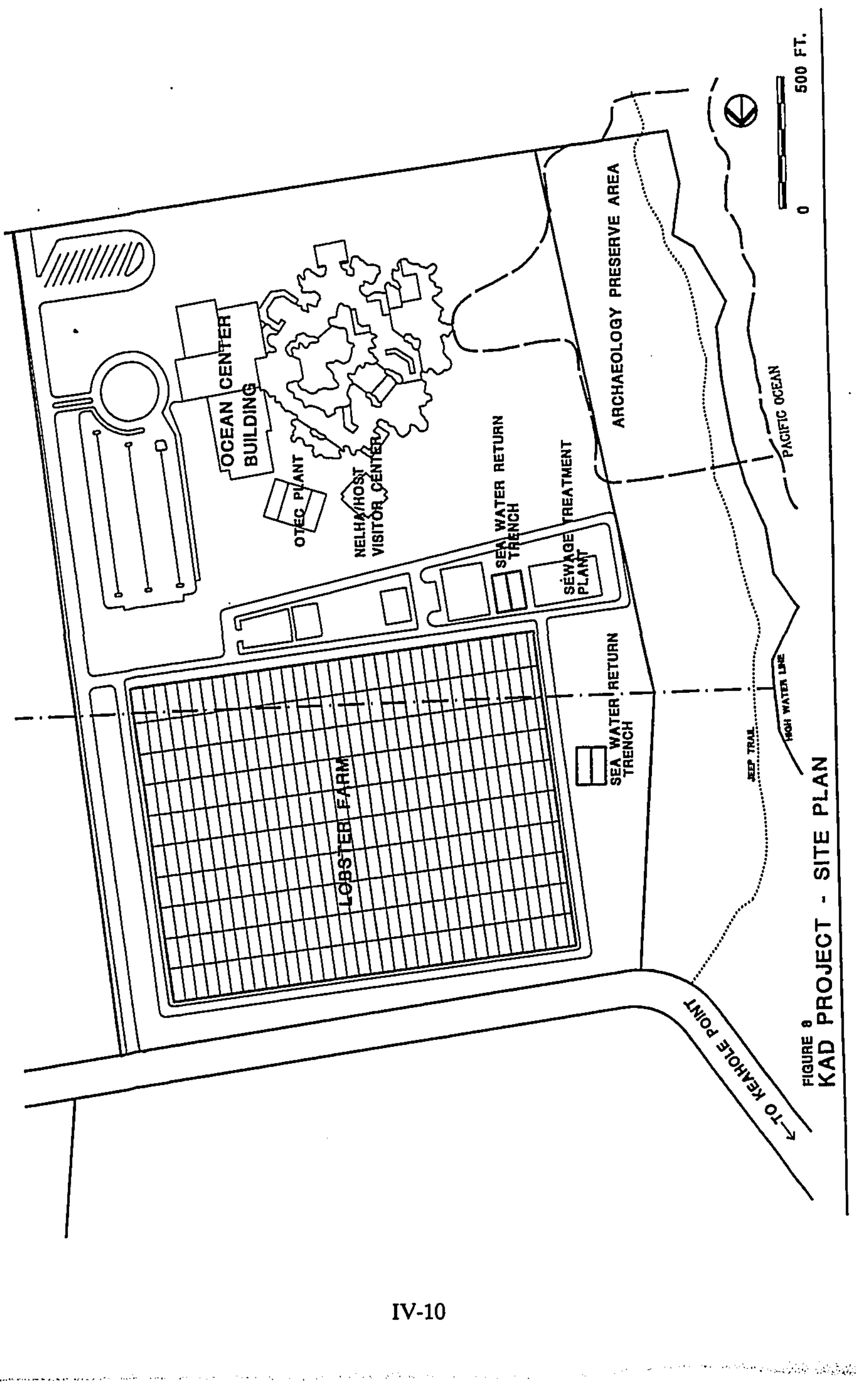


FIGURE 8
KAD PROJECT - SITE PLAN

1. OTEC POWER PLANT

KAD Partners would build and operate an OTEC plant (1 MW gross) on three acres of the exchange parcel. The proposed OTEC plant would be a closed-cycle ammonia turbine electrical generator driven by the heat difference between cold seawater pumped from deep offshore and warm seawater pumped from the surface water offshore. Development of this type of technology was one of the earliest reasons for establishment of the NELH and subsequently, HOST Park. The pioneering research done at Keahole Point has helped advance the technology to its present emerging commercial status. NELHA would provide the pipeline and pump station, which would service other tenants as well. Power for the pumps would come from the OTEC plant.

Current engineering analysis indicates that the OTEC plant can deliver adequate amounts of water to an elevation of approximately 35 feet above sea level. Within this limitation, both the Lobster Farm and the Ocean Center could be supplied water on a gravity flow-through basis.

The OTEC effluent would supply the Lobster Farm with two seawater supply streams, one cold (about 10° Celsius) and one warm (about 21° Celsius). The actual blending of seawater to the appropriate temperature specification would be accomplished in a mixing sump from which the blended water would be distributed to the local sub-system such as the hatchery, broodstock holding or growout enclosure.

The facilities associated with the OTEC plant include the plant itself, the pump station and pipelines, a network of distribution pipelines for effluent waters, an administrative office, a maintenance area, and a visitor area. The Plant would employ three people. Capital costs are expected to be about $3,000,000.

2. OCEAN CENTER

The Ocean Center would consist of a set of low buildings, most enclosing below grade aquatic and botanical exhibits. The facility would be designed to accommodate an annual attendance of 500,000, a daily attendance of 4,400, and a peak in-facility population of 1,760 persons. The facility would be open to the public daily between the hours of 10am and 6pm. At this size, 38 full-time employees would be required. The Ocean Center would occupy 12 acres, including parking.

Public areas would be aligned around a central lobby, as would visitor service elements such as food services and a gift shop. The administrative, operational, research and educational functions would also be located in this area. From a central parking area (capacity 628 to 942 automobiles) visitors could access the Visitor Center, the Ocean Center, administrative offices or the education/school group entry. Provisions are planned for bus drop-off and remote bus parking. Access for deliveries, service vehicles and employees would be via a separate driveway around the perimeter of the facilities.

Adjacent to the bus drop-off and visitor parking lot would be a landscaped entry area providing information about the Ocean Center and a covered reception area for queuing, ticket purchase and group entry. This lobby would also provide access to the administrative offices, restrooms, first aid services, telephones, gift shop, and general information and orientation services.

Because of the length of time required to adequately tour the Ocean Center, a restaurant facility would be provided. Evening operation of this facility is a possibility, as is evening use for catered events or meetings. Food storage and preparation, staff areas and service access would be required. Midway through the facility a second set of restrooms would be available, and as attendance grows, a smaller snack bar could be added there.

The exhibit area, most of which would be below grade, would be bracketed by: 1) an introductory exhibit, perhaps using a multimedia film or visual presentation with a spoken narrative to explain the purpose of the facility, outline the central exhibits and provide information about other events and programs, and 2) a final exhibit to recap the events and purpose of the facility, provide information about other related activities and programs, and redirect visitors to the lobby area.

The exhibit components of the Ocean Center would be designed to be visited in sequence from the entrance to the exit. The major natural history exhibits would be located in excavations forming the ground floor of the facility, while the operational facilities and visitor services would be located at-grade, forming the second level.

The exhibits would be focused on specific island habitats of the Pacific. Each island community has specific geological and evolutionary history, and each has stories that illustrate the rapid evolution and specialization of island and isolated species. Stories such as speciation, migration and genetic drift of populations would illuminate the diversity and breadth of natural history. Exhibits would be sequenced in order from the North Pacific Deep Water exhibits to an Australia-Pacific Rim exhibit. Each major tank or habitat exhibit would be supported by a gallery of smaller tanks to allow for close-up viewing, interpretation and the display of small or difficult-to-keep specimens. The transition between major exhibits would be through underground botanical gardens covered by greenhouse roofs. Each botanical garden would contain representative flora and fauna found in the terrestrial environments associated with the various marine habitat exhibits. An outline of the planned exhibits follows.

- *Introduction to the Pacific Islands*: a theater area featuring an audio-visual program outlining the whole Aquarium.

- *The North Pacific*: a cold environment with schooling, pelagic animals (salmon, mullet, herring and hake) and major pelagic sharks and rays disrupted by artificial wave action. In the background would be a kelp forest with its associated diverse group of coastal fishes and invertebrates. The bottom of the tank would be inhabited by an active and diverse community of rockfish, crabs, wolf eels, and cod.

The North Pacific Gallery areas would contain exhibits relating to the islands of Japan, the Aleutians, Alaska, Oregon and California. Approximately ten 670 gallon tanks are planned. A potential exhibit in this area is marine mammals such as California Sea Otters and/or California Sea Lions, but no performing animal exhibits are contemplated. A major theater would feature films of the larger cetaceans of the area including dolphins, humpback whales, right whales and other species, as appropriate.

- *The South Pacific*: Exhibits in this area would feature fauna from the Galapagos Islands, the coast of South America, New Zealand and other areas. A major exhibit is planned for the unique fauna that occurs under the Antarctic ice. Seabirds, including penguins, could be included. A South Pacific Gallery would contain ten 650 gallon tanks for the display of species too small or incompatible with species in the larger tanks.

- *The Tropical Pacific*: Major exhibits of Hawaiian Islands fauna are planned for both interior and exterior areas. Three exterior tanks enclosed in a greenhouse or otherwise partially shaded would exhibit: 1) the sandy shore with shore birds, crabs and amphipods on the shore and clams, sea pens, sponges, urchins and flatfishes in the water; 2) the tidal flat with schooling fishes, sea turtles and bottom fish; and 3) the intertidal zone/rocky shore with limpets, barnacles, snails and other encrusting invertebrates, blennies, shrimps, crabs and worms. The latter tank would have active wave action. The interior exhibits would display a typical reef area, seafloor vents, deep ocean animals and pelagic jellyfishes. A Hawaiian Gallery of ten tanks would display such interesting species as lobsters, seastars, urchins, clams, oysters and flatfishes.

A Tropical Pacific Exhibit Tank, one of the two largest tanks in the Aquarium, would display species characteristic of the offshore waters such as jacks, mullet, snapper, grouper, ocean sunfish, sharks and rays. This tank would enclose an eight-foot diameter acrylic viewing tunnel through which visitors would walk.

A Reef Exhibit, likely based on the creatures of the Australian Barrier Reef, would display the entire vertical organization of the reef, from the inshore reef flat through the surf zone to the outer reef face and down to the deep reef base. The Reef Exhibit would be separated into two parts: a deep pool section exhibiting larger reef fishes, near-reef schooling fishes, and reef visitors such as black-tip sharks and barracuda; and a lagoon/reef flat section exhibiting more delicate corals and small colorful reef fish. Because of the limitations of subdued light, lack of planktonic organisms and balanced water chemistry, the corals would have to be artificial, fabricated of concrete and polyester resins.

All of the above-grade exhibits would display examples of marine ecology; those below-grade, however, would educate the viewer about man's interaction with the sea and its creatures. Exhibits would describe aspects of fisheries research, aquaculture, environmental management and so forth. A final exhibit would emphasize the importance of oceanic issues to island ecosystems.

Throughout the Ocean Center, professional personnel would be involved in communicating information about the exhibits and their relevance to the visitors. Demonstrations of actual management practices and animal handling, care and husbandry would be provided on a scheduled basis.

To operate the Ocean Center, a number of specialized support services would be required. These include: veterinary care facilities including surgery, large and small animal holding facilities, office space, storage, and a small laboratory/necropsy area; animal food service facilities including storage and preparation areas; exhibit maintenance shops; general service access areas behind the tanks; operating areas for staff offices and rest, animal quarantine, holding and storage, equipment storage, fabrication and repair, SCUBA equipment storage and maintenance, employee lockers, showers and storage, and a water quality laboratory. Provisions for tank isolation and research would be available.

The engineering staff would manage areas and equipment included in a general shop, loading dock, service yard, life support equipment, building equipment, and the technical monitoring equipment such as water level, temperature and pump failure alarms.

An educational area would contain classroom space, water tables, laboratory equipment, educational materials, and video capability to assist in the transmission of marine and biological science to targeted school groups. Qualified teachers would relate the specially developed curriculum to small independent study groups.

A research area would contain both wet and dry laboratory space, a science library, computer and administrative capability to assist visiting researchers and institutions who have a scientific interest in the marine habitats and ecosystems which have been created by the Ocean Center. The reproduction and conservation of marine tropical fish and the understanding of the near shore environment would be areas of concentrated interest and specialization for the Ocean Center.

The Ocean Center would operate as an independent financial unit with from 38 to 57 employees. It would be sized to accommodate 500,000 visitors per year. Capital and operating cost estimates for the facility have been based on comparable operations elsewhere in the United States. Construction costs have been estimated using a 20%

premium over mainland U.S. costs. Income figures for the Ocean Center have been estimated based on 1989 State of Hawaii attendance at comparable attractions and is weighted to allow for the relatively higher per capita spending of Hawaii visitors. Start-up planning costs are estimated at $1.5 million dollars. Total development costs for the KAD Project, including the Ocean Center, are estimated at $33 million.

3. LOBSTER FARM

The total nominal facility area would be about 700,000 square feet or approximately 16 acres in either a square or rectangular shape. The entire facility would be covered with continuous greenhouse modules each provisionally 27 feet wide. If the outside dimensions of the facility were 700 by 1,000 feet, 26 twenty-seven foot wide greenhouses would be required. The Farm would occupy a total of 20 acres, mostly on previously zoned HOST Park lands. The Farm would employ 13 people.

Owing to the quantity and quality of the seawater supply offered by the integrated project concept, the project has the potential to grow lobsters in near optimal temperature conditions which are essential to the acceleration of growth and, consequently, to the economics of production. Lobsters are relatively large crustaceans with very slow growth rates in nature. Temperature control is the key environmental determinant which makes it possible to culture lobsters to one pound market size in less than three years compared to six to eight years in nature. By combining the appropriate flows of warm and cold seawater from the OTEC water discharge, the optimal range of water temperature for lobster growth, about 21° Celsius (70° Fahrenheit), can be maintained.

Lobsters present special challenges to a commercial aquaculture venture. They are benthic (bottom dwelling) creatures that require more surface area than is required by finfish which utilize the entire water column. They also tend to eat one another when grown under communal conditions and thus must be individually segregated in a culture system. These characteristics prescribe the appearance of the culture facility. The animals are grown in a habitat that is engineered to provide sufficient space for growth and protection from neighbors. The habitats are fabricated in arrays housing dozens of animals. The habitat arrays are inserted into shallow tanks that are housed in a greenhouse structure designed to shade the lobsters from sunlight. The proposed culture facility would cover about 16 acres with enclosed structures in which the lobsters would spend the 30 months required for each production cycle. The various stages of the production cycle and respective facility requirements are described below.

- *Breeding*: The breeding cycle would be completely controlled through manipulation of the critical environmental parameters of light, temperature and feeding conditions. A supply of broodstock substantially in excess of minimum requirements would be maintained in specialized tanks with precise environmental controls. Enclosures for broodstock would be larger than those for growout, about three to four square feet per animal. About 20,000 square feet would be allocated to broodstock holding, sufficient to maintain several thousand female lobsters in breeding compartments with an adequate proportion of male lobsters.

- *Hatching*: The hatchery space requirements would be allotted to three primary functions: final incubation and hatching, larval rearing, and larval food production. Prior to egg hatching, a female would be transferred to a specialized incubation tank. The tank would be temperature controlled and have a skimmer device to collect the larvae which are periodically removed to a rearing tank. About thirty incubation tanks would be required within the hatchery area. The area would have a timer-regulated lighting system with which to control photoperiod in the incubation and larval rearing areas.

- *Larval Rearing*: Larvae would be held in 40 liter circular tanks having spherical bottoms and a circulation diffuser to mix the larvae and their food. Several thousand first stage larvae would be held in the same tank. About 60 units would be sufficient to produce over 2,000,000 fourth stage lobsters per year. Larvae reach the second stage in about two days; the third in three to four days and the fourth in four to six days. During this period larval weight increases by a factor of five. Survival averages 50 to 60%. On about the eleventh day the larvae begin to molt into small lobster-like creatures which prefer to crawl about rather than swim. They are then siphoned out of the larval tanks into individual rearing cubicles and transferred to nursery tanks.

  The primary larval food would be brine shrimp, *Artemia salina*, that would be consumed in both live-cultured and frozen forms. The frozen brine shrimp would be acquired in bulk from natural production sites and stored frozen until needed. Space requirements for rearing live brine shrimp from brine shrimp cysts (dehydrated eggs) would include hatching tanks, algal culture space, and brine shrimp rearing tanks.

- *Growout*: The vast majority of the facility space requirements would be allocated to the rearing of lobsters from their fourth stage juvenile form to one pound market animals in individual enclosures. Growout production areas would be subdivided into five phases, with the fifth phase, because of the size of the animals, requiring about 45% of the entire surface area of the farm.

  Each month, a new batch ("cohort") of lobsters would enter the nursery, the first growout phase. There would therefore be 30 cohorts maturing simultaneously at any given time. Approximately three lobsters are programmed into each initial cohort for every two lobsters expected to complete the growth cycle. About 30,000 square feet are programmed for the nursery growout area.

The 30-month production cycle would be conducted in five 6-month phases, corresponding to lobster size and the appropriate enclosure size. Individual lobster enclosures of an elongated hexagonal shape would be fabricated of plastic mesh in multiple units designed to be inserted into uniform growing tanks. The five enclosure sizes vary in area from 9 to 148 square inches.

The tanks into which the pen arrays would be placed are shallow (about one foot in depth), long, rectangular tanks. The actual length of these tanks will be determined by site constraints; width would be about ten feet. They would be fabricated of concrete. Tanks would be enclosed in double-poly greenhouses to minimize sunlight.

Growout tanks would be serviced daily by a mechanized feeder that passes over the enclosure arrays and provides each individual lobster enclosure with an appropriate measured food ration. About every six months, each lobster would be transferred to a larger enclosure, with the market sized individuals harvested. To avoid the problems associated with accumulation of wastes at the downstream end of raceway-type tanks, a lateral water distribution system would be used that disperses the water over the length of the tank and drains it from a gutter on the opposite side.

Temperature control in the tanks is described above. In addition, the oxygen concentration in the feed waters would be augmented by injecting pure oxygen into the mixing and distribution tanks. The seawater, however, cannot be recycled indefinitely due to the accumulation of ammonia excreted by the lobsters. Existing biofiltration technology is inadequate to economically remove ammonia, and regulation of its concentration thus becomes the primary determinant of the net seawater consumption rate. The fully operational facility would require a flow rate of about 35,000 gpm without supplementary oxygenation, or about 8,000 gpm when limited by a safe ammonia concentration criterion and oxygen is supplied by a diffusion device. A fortunate corollary benefit is that effluent waters would have concentrations of ammonia non-toxic to even highly sensitive species such as lobsters.

Modest administrative offices of modular construction similar to those at the existing prototype facility would provide offices for the General Manager, an Administrative Assistant, and key department managers. An additional conference room would be provided for staff meetings and meetings with visitors. A production worker cafeteria area would provide a dining area, kitchen appliances, and food preparation space. Adjoining locker rooms would have restrooms with showers and individual lockers.

Lobster food would be formulated daily in a small processing plant. A shop would be equipped to deal with all routine maintenance of vehicles and implements. This would include work benches, basic metal and plastic fabrication equipment, and a complement of woodworking and mechanical hand tools. Storage space of spare parts and consumable supplies would be provided.

A laboratory divided into wet space with aquaria for holding animals and for conducting small experiments would adjoin a clean dry area for water chemistry apparatus, analytical scales and instruments. An isolated area would be dedicated to pathology and equipped with dissection instruments, microscopes, refrigerator and basic bacteriology equipment.

A cleaning device, similar to a pool vacuum cleaner, would vacuum accumulated solid waste from beneath the lobster enclosures, and would discharge this material into the drainage channels which, in the cleaning mode, would divert the waste discharge to a common waste drain for the farm that would discharge into a treatment system for solid waste separation and disposal.

The Lobster Farm is intended to be a profit center. Historically, the American Lobster has demonstrated a singular value as a seafood commodity. It is consistently among the highest priced seafoods and when consideration is given to trading whole live lobsters compared to the meat fraction of other fish and shellfish, it overshadows other seafood products in its value per pound of marketable product. Despite unprecedented increases of lobster supply landed by the fishery during the last decade, its price has outpaced other seafoods. Compared to a price index of 109 (1982 = 100) for all seafood, American Lobster recorded a very respectable 122 in 1989. This strong indication of consumer demand took place while supplies increased 80% from 1980 to 1989.

The Farm is planned to produce 500,000 pounds of American Lobster, *Homarus americanus*, per year. The product is destined for domestic consumption in the State of Hawaii and for export to other Pacific Rim markets. At full production capacity, the facility would contain about 1.5 million lobsters with an average inventory of about 350,000 pounds. Annual revenue from the lobster crop is projected at three to four million dollars after the three years required to develop the production capacity of the facility. The projected production costs at full capacity total about $3.53 per pound in comparison to a base projected market price of $6.50 in 1993 which is then escalated by a modest 1% per year to $6.70 in 1996 when the first output is anticipated.

In anticipation of Lobster Farm sales revenues, a marketing assessment program has been initiated which involves the pounding of fishery lobsters for resale. The pounded fishery lobsters would be marketed to Southeast Asian destinations which are unreachable via a non-stop flight from Maine or Massachusetts. Revenues would be generated based on a $6.50 per pound unit price FOB Keahole Point.

The Lobster Pound would hold lobsters in multi-level trays within a concrete tank system, more efficiently using the ground area than in the raceway single level configuration of the Lobster Farm. Individual lobsters would have their claws banded and be held communally. The Lobster Pound would be supplied with cold water from the OTEC Plant to slow the lobsters' metabolic rate and provide a rejuvenation period ranging from two days to two weeks. Total holding capacity is projected at 50,000 adult lobsters requiring less than 1 acre of greenhouse-covered land area.

4. VISITOR CENTER

The NELHA Visitor Center envisioned in prior EISs and the HOST Park Master Plan (HTDC, 1989) would be provided by KAD Partners. Admission to the facility would be free. The focus of the Center would be to inform visitors about the activities at NELHA. Exhibits would display the species cultured at NELH and HOST Park, demonstrate closed and open cycle OTEC, explain research activities in progress, and provide information on the cultural and historical significance of the area.

Tenants of NELHA would be responsible for constructing and maintaining their own exhibits, and would receive the benefit of potential revenue from sales of their cultured products. NELHA would be relieved of the capital cost to provide its own display facility for public viewing. The operation and staffing of the Visitor Center (two employees) would be provided by NELHA.

5. ARCHAEOLOGICAL PRESERVE

A number of archaeological sites and features have been identified along the coast in the exchange parcel. Plans for mitigation, including data recovery, passive preservation, and preservation with interpretation, were initiated by the previous owners and have been completed by NELHA. The sites of greatest significance are clustered in the southwestern corner of the parcel which would be established as an Archaeological Preserve of about five acres in size. Interpretive displays would be established where appropriate in the Preserve, and additional information provided in the Visitor Center. One full-time staff member would be available to answer questions and possibly conduct escorted tours through the Preserve.

6. WAWALOLI BEACH EXTENSION

The Wawaloli Beach Extension would consist of approximately 10 acres along the shoreline. The area is a mixture of sand and lava rocks interspersed with small trees and brush. It is presently utilized by area residents as a day use recreation area. The plan anticipates the development of this area by the upgrading of the existing jeep road, providing parking spaces, and landscaping irregular-shaped picnic areas improved with pavilions, tables, and barbecues. Archaeological sites within the area have been surveyed by the State Historic Preservation Division and data recovery would be completed prior to initiating any improvements.

Extension of Wawaloli Beach would be a public service benefit to the community provided by KAD Partners. The long-term maintenance and operation of the facility would be jointly administered by NELHA and KAD.

7. OTHER KAD PROJECT ELEMENTS

Certain support services and facilities would be shared among the various components of the KAD Project. Such facilities would include parking and roads, fencing, drainage, signage and outdoor lighting, security systems and services, solid and liquid waste management, electrical and communications utilities management, janitorial and custodial services and landscape maintenance.

F. USE OF PUBLIC FUNDS AND LANDS

The exchange parcel is owned by the State of Hawaii and managed by NELHA for the purposes of providing facilities and services to tenants engaged in aquaculture, alternate energy and related enterprises. To accomplish this mission the State, through NELHA, would provide funding for essential infrastructure development, such as seawater systems, roads, potable water distribution, and power and telecommunications distribution systems.

G. PHASING AND TIMING

The KAD Project would be developed over a 30-month period beginning in 1993 and concluding in 1995. Initial infrastructure work would include grading, perimeter fencing, landscaping, sewerage, electrical and seawater systems. Additional infrastructure work would be required in the ten acre Wawaloli Beach Extension and the five acre Archaeological Preserve. Construction of the major operating components, the OTEC Plant, Lobster Farm and Ocean Center, would occur simultaneously with the OTEC Plant scheduled to be operational in 1994. The Ocean Center would open in mid-1995. The sequence of construction for the Lobster Farm would correspond to phases of the production system, with completion approximately 26 to 28 months after construction start-up and operationally deployed in about 30 months. Lobster harvesting would begin after about 36 months (1996).

V. ALTERNATIVES CONSIDERED

V. ALTERNATIVES CONSIDERED

A. SITES

The NELHA facility is unique in the world in providing opportunities for commercial applications of ocean thermal gradients. The proposed KAD project integrates several components, the OTEC plant, the Lobster Farm, the Ocean Center, and the Visitor Center, efficiently entwining utilizations of the unique resources available. The site and the project are inseparable.

B. PROJECT COMPONENTS

1. OTEC PLANT

The Natural Energy Laboratory has been at the forefront of OTEC research since its earliest operations. The mission of HOST Park is to provide opportunities for commercialization of technologies incubated at NELH. The purpose of the OTEC Plant is to provide electricity to power the seawater pumps. The small amount of power estimated to be in excess of the pump needs would be used within the KAD Project. The OTEC Plant would also provide seawater at a broad potential range of water temperatures to the Ocean Center, Lobster Farm, Visitor Center and other HOST Park tenants. The OTEC Plant is essential to the project and a most appropriate use on the site. The alternatives would be to rely solely on the HELCO grid, a system presently experiencing a lack of capacity, or to install fossil-fuel burning diesel generators. Neither of the alternatives would provide the flows of warm and cold seawater essential to other project components.

2. OCEAN CENTER

The Ocean Center concept, with its focus on education and research, is appropriate for the site and it complements other project components both thematically and in terms of operational integration. The Ocean Center would provide a captive user for both the seawater and the electricity produced by the OTEC Plant. Revenues generated by the Ocean Center would be used to offset the costs of developing the Visitor Center, Archaeological Preserve and the Wawaloli Beach Extension. Thematically, the Ocean Center would make use of a broad range of water temperatures blended from the warm and cold waters flowing through the OTEC Plant to simulate marine ecosystems around Pacific Islands from low to high latitudes. Exclusion of the Ocean Center would unbalance the project economically and ecologically.

3. LOBSTER FARM

Aquaculture is one of the anticipated and intended uses of HOST Park. Selection of a cold water species, such as the American Lobster (*Homarus americanus*), utilizes a significant volume of the cold water required to operate the OTEC Plant. Secondary water usage in aquaculture is intrinsically productive, and economically necessary to the development of OTEC technology.

Technology for the Lobster Farm has been developed by the principals of KAD Partners over more than twenty years of research and development. The facilities design and operations plan implement over thirty years of academic, public and proprietary research into all aspects of lobster cultivation.

The opportunities of the site, the technical appropriateness of the species, the sophistication of the technology are intriguing, but it is the market potential of the product that completes the aquaculture component, rendering it potentially profitable. Selection of any other culture species would increase the technical risks to the venture while decreasing the potential returns.

4. VISITOR CENTER

Integration of the Visitor Center with components of the KAD Project would provide a focal point and much needed facility in which to present to the public information about the research and produce of NELHA and its tenants. The location is good because of proximity to the Ocean Center where visitors would be concentrated. It would also make use of available seawater supplies. The alternative would be development at another NELHA site with other financing.

5. OTHER PROJECT COMPONENTS

The Archaeological Preserve and Wawaloli Beach Extension are necessary and appropriate uses of the coastal portions of the site. Improvements to these resources would be required of NELHA, regardless of the specific projects proposed for the exchange parcel. The proposed project includes provision of these improvements at no cost to the State.

C. SITE PLANS

During the planning process the configuration of the major site components evolved in consultation with the State, County and nearby land owners. The plan (see Figure 8) features the Lobster Farm to the north, and the Ocean Center to the south. Supporting infrastructure, including the OTEC Plant and the sewage treatment plant would be efficiently located in a corridor bisecting the KAD site between the two primary components. The advantages of this site plan include placing the primary visitor attraction, the Ocean Center, adjacent to the proposed 'O'oma II Resort, thereby creating a smoother continuum of uses from industrial and aquacultural to educational and cultural to residential and resort. Placing the primary visitor attraction as far as possible to the south also minimizes the impacts of airport noise on Ocean Center visitors.

D. ALTERNATIVES TO THE KAD PROJECT

Other potential uses of the exchange parcel include high to low volume ocean water uses including aquaculture and OTEC, appropriate industrial uses, support commercial uses, education, infrastructure and open space, as described in the HTDC FEIS, the NELH FSEIS, and the HOST Park Master Plan (HTDC, 1989).

E. NO ACTION

The No Action Alternative and its implications were thoroughly discussed in the HTDC FEIS. Its adoption would constitute a major shift in State policy.

VI. THE AFFECTED ENVIRONMENT, POTENTIAL IMPACTS AND PROPOSED MITIGATION MEASURES

VI. DESCRIPTION OF THE AFFECTED ENVIRONMENT, POTENTIAL IMPACTS AND PROPOSED MITIGATION MEASURES

A. PHYSICAL ENVIRONMENT

1. METEOROLOGY, CLIMATOLOGY AND AIR QUALITY

a. Regional Overview

Coastal areas of North Kona have a semi-tropical, semi-arid climate. The average annual temperature is 75°F, with an average high of 83°F, and an average low of 67°F. Relative humidity is generally stable year-round, the daily average ranging from 71 to 77 percent. Average annual precipitation in Kailua-Kona is 25 inches, however NELHA has ten years of records from its own station at Keahole Point which indicate an annual precipitation of just over 13 inches. Solar radiation at the site is constant, with the days cloud-free an estimated 95% of the year (HTDC, 1985). Pan evaporation is typically high, in the general range of 0.18 inches per day for the winter and 0.36 inches per day for the summer as measured at Anaehoomalu (Kay, et al., 1977). Annual evaporation thus exceeds precipitation by a factor ranging from nearly four to well over seven.

The North Kona Coast is largely sheltered from the predominant trade wind system by the land masses of Mauna Loa, Mauna Kea and Hualalai. Trade winds pass over the east rift of Kilauea and cross South Point and the lower southern slope of Mauna Loa. As the air passes the southern tip of the island, frictional forces cause it to turn northward into a convergence behind the mountains. At the same time, heating of the protected lee slope of Mauna Loa and, to a lesser extent, Hualalai drives an upslope onshore wind. This is the "Kona Sea Breeze" (Schroeder, n.d.). This breeze meets whatever trade wind flow crosses the Saddle and a precipitating cloud band forms. This accounts for the mid-elevation band of higher rainfall which lies between the 1,200- and 3,000-foot elevations on the leeward slopes of Hualalai and Mauna Loa. Rainfall decreases at lower elevations near the coast. After sunset the land cools and a downslope breeze drains offshore. Typical wind velocities range between 3 and 14 knots. One implication of this circulation pattern is that sulfur dioxide, the predominant pollutant emitted from Kilauea volcano, oxidizes to sulfur trioxide, is injected into the Kona Sea Breeze where it can meet water vapor in the mid-level clouds and be incorporated as acid rain. A second implication is that air pollutants injected into this system will tend to persist in the area rather than be blown offshore by tradewinds as is the case in most other leeward areas of the state.

b. Local Conditions

Present air quality in the project area is influenced by air pollutants from natural, industrial, agricultural and vehicular sources. Natural sources of air pollutant emissions which may affect the project area include the ocean (sea spray), plants (aero-allergens), wind blown dust and volcanoes. Of the natural sources of pollution, volcanoes are the clearly the most significant. This is especially so since the latest eruption phase of the Kilauea volcano, which began in 1983. Emissions from this eruption can be seen in the form of volcanic haze (vog) which persistently hangs over West Hawaii. In a study of the volcanic aerosol Morrow, et al. (1991) found annual sulfate levels in Captain Cook comparable to those in mainland urban areas.

The major industrial sources in the project vicinity include the Keahole Power Plant (operated by Hawaii Electric Light Company) and the Kailua Landfill, operated by the County of Hawaii. Emissions from the landfill consist mainly of fugitive dust from heavy equipment operations and noxious fumes from underground fires, which have been the subject of numerous complaints from people residing and working nearby. The project is situated far enough away so as not to be adversely impacted by emissions from the landfill.

Keahole Airport is a major source of air pollutant emissions. Aircraft, motor vehicles and fuel handling and storage are a significant source of carbon monoxide, nitrogen oxides, hydrocarbons, and to a much lesser extent, particulate matter and sulfur dioxide. These emissions are expected to increase in coming years as a result of airport expansion. Despite the significant emissions, however, ambient concentrations of these pollutants are projected to remain in compliance with federal and state ambient air quality standards (Morrow, 1988).

Queen Kaahumanu Highway is the region's major arterial roadway, and motor vehicles traversing it contribute exhaust gases to the air. Vehicle exhausts contain carbon monoxide, nitrogen dioxide, ozone and lead. The latter three are generally broad-scale problems, if present, and rarely if ever exceed Ambient Air Quality Standards (AAQS) in Hawaii. It is likely that elevated concentrations of exhaust are confined to limited areas near intersections where and when traffic congestion occurs during poor dispersion conditions. Carbon monoxide would be the primary pollutant of concern.

The State Department of Health operates a network of air quality monitoring stations at various locations around the state. Unfortunately, very little data are available for the Island of Hawaii, and even less are available for the Kona area, specifically. Sulfur dioxide and particulate matter concentrations were monitored at Kealakekua during 1985 and 1986; no exceedences of state or federal AAQS were recorded.

c. Regulatory Standards

Ambient Air Quality Standards (AAQS) have been established by the federal government (Code of Federal Regulations, Section 40, Part 50) and the state (Chapter 11-59, Hawaii Administrative Rules). These are summarized in Table 1.

National primary standards are intended to adequately protect the public health. National secondary standards are intended to protect the public welfare including such things as visibility, comfort and the natural or built environment. Hawaii's standards are intended to protect public health and welfare as well as to prevent the significant deterioration of air quality. Averaging times reflect a balance between the persistence of a pollutant and the exposure required to violate the basis of the standard. Hence, the short averaging times for carbon monoxide standards. The state standards are often more stringent than the federal standards, most notably in the case of carbon monoxide.

TABLE 1
AMBIENT AIR QUALITY STANDARDS

POLLUTANT	AVERAGING TIME	MAXIMUM ALLOWABLE CONCENTRATION ($\mu g/m^3$)		
		NATIONAL PRIMARY	NATIONAL SECONDARY	STATE OF HAWAII
Suspended Particulate Matter	Annual	-	-	60[a]
	24 Hours	-	-	150[b]
Particulate Matter[c]	Annual	50	50	-
	24 Hours	150[b]	150[b]	-
Sulfur Dioxide	Annual	80	-	80
	24 Hours	365[b]	-	365[b]
	3 Hours	-	1,300[b]	1,300[b]
Nitrogen Dioxide	Annual	100	100	70
Carbon Monoxide	8 Hours	10,000[b]	-	5,000[b]
	1 Hour	40,000[b]	-	10,000[b]
Ozone	1 Hour	235[b]	235[b]	100[b]
Lead	Calendar Quarter	1.5	1.5	1.5

[a]Geometric mean
[b]Not to be exceeded more than once per year
[c]Particles less than or equal to 10 microns aerodynamic diameter

d. Potential Impacts

No significant change in the site's macro (or regional) climate is anticipated as a result of the proposed action. Modification of the micro (or site-specific) climate will result from the planting of shade trees and the construction of buildings that channel air flows.

An assessment of the existing air quality in the project area and the potential short-term and long-term direct and indirect air quality impacts that could result from the construction of the adjacent proposed 'O'oma II project was conducted by B.D. Neal & Associates in November 1990. This study is directly relevant to the actions proposed by NELHA. Impacts to air quality as the result of the proposed project can be differentiated between short-term and long-term impacts.

Short-term direct and indirect impacts to air quality could potentially occur due to project construction. There are two potential types of air pollutant emissions which could directly result in short-term air quality impacts during the construction phase: (1) fugitive dust (particulate matter) from vehicle movement and site excavation; and (2) exhaust emissions (primarily nitrogen oxides, but also carbon monoxide, sulfur oxides and hydrocarbons) from on-site diesel construction equipment. Indirectly, there could also be short-term impacts from slow-moving construction equipment traveling to and from the project site and from a temporary increase in local automotive traffic caused by commuting construction workers. Carbon monoxide comprises the largest fraction of emissions from gasoline-powered vehicles.

After construction is completed, use of the proposed facilities would result in increased motor vehicle traffic on nearby roadways, potentially causing long-term impacts on ambient air quality in the project vicinity. Motor vehicles with gasoline-powered engines are significant sources of carbon monoxide. They also emit nitrogen oxides, and those burning leaded gasoline contribute lead to the atmosphere. As older vehicles continue to be taken out of service, lead emissions from this source are approaching zero. Lead in the atmosphere is not considered to be a problem anywhere in the state.

Potentially the most problematic area in terms of air pollutants would be the parking lot near the Ocean Center. This would be a result of both the concentration of vehicles and the presence of a large number of pedestrians. The intersection at Queen Kaahumanu Highway would be less a problem because most vehicles are enclosed and air conditioned, and pedestrian traffic is almost non-existent.

e. Proposed Mitigation Measures

Strict compliance with State of Hawaii Air Pollution Control Regulations (Section 11-60-5, HAR) regarding establishment of a regular dust-watering program and covering of dirt-hauling trucks would be required to effectively mitigate fugitive dust emissions from construction activities. Twice-daily watering is estimated to reduce dust emissions by up to

50 percent. Soil transported onto paved roads by construction vehicles and activities should be promptly removed. Use of wind screens and/or limiting the area that is disturbed at any given time may be required in sensitive or dust-prone areas. Paving of designated areas and landscaping as early as possible in the construction sequencing would reduce total fugitive dust emissions. Construction equipment should be properly maintained and tuned to minimize exhaust emissions (Section 11-60-4, HAR). Equipment should be shut down rather than left idling when not in use.

Both active and passive mitigation measures would reduce exposures to operations-related emissions. Active mitigation measures could include both design and operational components. Human exposure to exhaust emissions could be minimized by routing pedestrians out of the parking area as quickly as possible. Operationally, buses and other vehicles should be shut down when parked, rather than left idling. To the extent possible, arrivals and departures should be scheduled throughout the day, avoiding peak traffic hours.

Passive mitigation will result from implementation of more stringent federal regulations pertaining to increased efficiency in removing carbon monoxide and nitrogen oxides from the exhausts of new motor vehicles. By 1995 emissions of carbon monoxide are expected to be reduced about 30 percent due to the replacement of older vehicles

2. NOISE AND VIBRATION

a. Existing and Projected Acoustical Environmental

NELHA is an industrial facility adjacent to a busy regional (eventually to be international) airport. Ambient noise and noise impacts to properties on both sides of NELHA have recently been examined. Noise impacts associated with the 'O'oma II project were analyzed by Darby & Associates in November 1990. Noise impacts associated with expansion of Keahole Airport were addressed in the Noise Compatibility Program for the Keahole Airport Master Plan (KPMG Peat Marwick, 1987). A summary of relevant analyses is presented below.

The major source of man-made noise affecting the project site originates from air traffic operations at the Keahole Airport. Otherwise, most of the site is exposed to relatively low ambient noise levels, with wind, surf and occasional traffic being the only noticeable sounds.

The most dominant aircraft noise is that from inter-island jets flying over the coastal portion of the project site, after taking off from Runway 17 at Keahole Airport. The normal flight pattern is a right turn out to sea, shortly after takeoff. This flight pattern is followed by commercial flights to Honolulu and Kahului, the two predominant destinations for aircraft leaving Keahole Airport. Less commonly, aircraft also fly over the project site on their final approach to Runway 35.

In measuring the impacts of noise, it is important to note that although people respond to the noise of single events, the long-range effects of prolonged exposure to noise appear to correlate best with cumulative metrics. "Ldn" is the Federal Aviation Administration's (FAA) standard metric for determining such exposure to noise. It measures average sound level in decibels for the period from midnight to midnight, obtained after the addition of ten decibels to sound levels for the period 10 P.M. to 7 A.M. the next day, local time. Aircraft noise exposure maps with continuous noise contour levels of Ldn 55, 60, 65, 70 and 75 have been prepared showing anticipated 1990 and 2005 noise contour lines (KPMG Peat Marwick, 1987). These maps are reproduced as Figures 9 and 10.

b. Regulatory Standards and Guidelines

Development of the NELHA exchange parcel would not involve any residential uses so standards and guidelines developed for that purpose by the U.S. Environmental Protection Agency (EPA), the federal Department of Housing and Urban Development (HUD), and the State of Hawaii do not apply. Table 2 summarizes the Federal Aviation Administration's suggested land use compatibility standards for various land uses in aircraft noise exposure areas.

c. Potential Impacts

The 1990 noise exposure contour map (Figure 9) shows that the project site would be exposed to Ldn values between 65 and 75. The 2005 exposures are about five points lower over the project area. Most of the types of land uses being proposed are compatible with the projected noise levels; however, for auditoriums and offices some noise level reduction (NLR) would be required. All of the Ocean Center exhibits, including the botanical gardens, would be enclosed in greenhouse structures.

In comparison to aircraft noise exposure levels, the added noise due to elevated traffic levels would be insignificant. For example, the increase in traffic noise along Queen Kaahumanu Highway due to the completion of the proposed 'O'oma project is expected to be about 1-1/2 dB to the south of that project site and less than 1 dB to the north. This degree of increase is not considered significant.

Operational noises such as those from the sewage treatment plant, air conditioning system, pumps, fans, trash compactors and any other stationary equipment would not exceed noise levels established as guidelines by the State Department of Health (at this time only the City and County of Honolulu has adopted these noise regulations, and they are thus not applicable in the County of Hawaii). Because the infrastructure for the KAD Project is clustered between the Ocean Center and the Lobster Farm, these noises would not impact adjoining residences at 'O'oma II. The 'O'oma site plan also calls for a 15-foot high berm and a 100-foot wide landscaped buffer along sensitive areas of the resort.

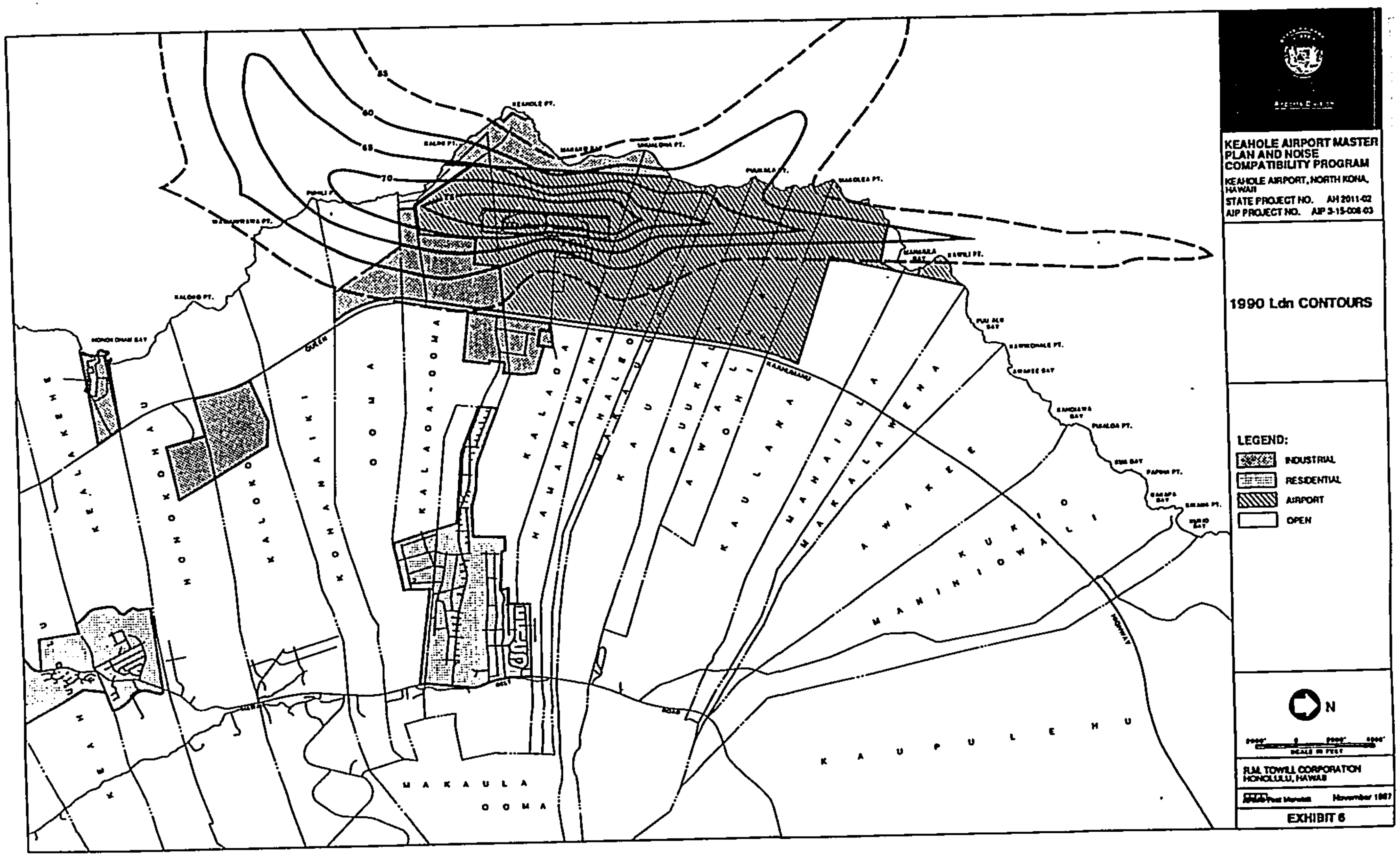


Figure 9
1990 Ldn CONTOURS

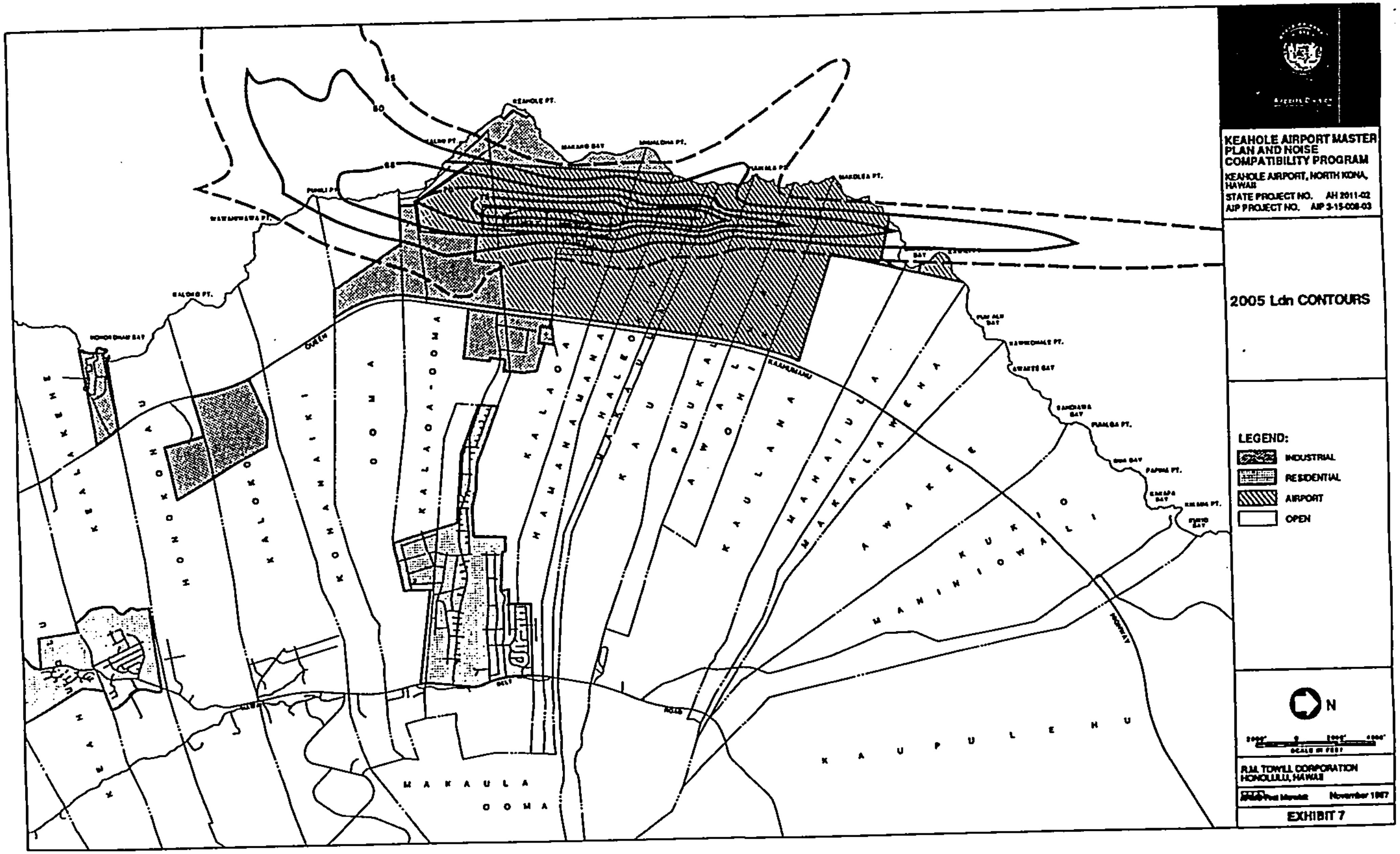


Figure 10
2005 LDN CONTOURS

TABLE 2
SUGGESTED LAND USE COMPATIBILITY STANDARDS IN AIRCRAFT NOISE EXPOSURE AREAS

The designations contained in this table do not constitute a federal determination that any use of land covered by the program is acceptable or unacceptable under federal, State, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Land use	Ldn 55 to 65	Ldn 65 to 70	Ldn 70 to 75	Over Ldn 75
Residential:				
Residential, other than mobile homes and transient lodgings	Compatible[a]	NLR required[b]	NLR required[b]	Incompatible
Mobile homes	Compatible[a]	Incompatible	Incompatible	Incompatible
Transient lodgings	Compatible[a]	NLR required[b]	NLR required[b]	Incompatible
Public uses:				
Schools, hospitals, and nursing homes	Compatible[a]	NLR required[b]	Incompatible	Incompatible
Churches, auditoriums, and concert halls	Compatible	NLR required[b]	NLR required	Incompatible
Governmental services	Compatible	Compatible	NLR required	NLR required
Transportation	Compatible	Compatible	Compatible[c]	Compatible[c]
Parking	Compatible	Compatible	Compatible[c]	Compatible[c]
Commercial use:				
Offices, business, and professional	Compatible	NLR required	NLR required	NLR required
Wholesale and retail--building materials, hardware, and farm equipment	Compatible	Compatible	Compatible[c]	Compatible[c]
Retail trade--general	Compatible	NLR required	NLR required	NLR required
Utilities	Compatible	Compatible	Compatible[c]	Compatible[c]
Communication	Compatible	NLR required	NLR required	NLR required
Manufacturing and production:				
Manufacturing, general	Compatible	Compatible	Compatible[c]	Compatible[c]
Photographic and optical	Compatible	Compatible	NLR required	NLR required
Agriculture (except livestock) and forestry	Compatible	Compatible	Compatible	Compatible
Livestock farming and breeding	Compatible	Compatible	Compatible	Incompatible
Mining and fishing resources production and extraction	Compatible	Compatible	Compatible	Compatible
Recreational:				
Outdoor sports arenas and spectator sports	Compatible	Compatible	Compatible	Incompatible
Outdoor music shells, amphitheaters	Compatible	Incompatible	Incompatible	Incompatible
Nature exhibits and zoos	Compatible	Compatible	Incompatible	Incompatible
Amusements, parks, resorts, and camps	Compatible	Compatible	Compatible	Incompatible
Golf courses, riding stables, and water recreation	Compatible	Compatible	Compatible	Incompatible

Ldn = Yearly day-night sound level in decibels.

Compatible = Generally, no special noise attenuating materials are required to achieve an interior noise level of Ldn 45 in habitable spaces, or the activity (whether indoors or outdoors) would not be subject to a significant adverse effect by the outdoor noise level.

NLR = Noise Level Reduction. NLR is used to denote the total amount of noise transmission loss in decibels required to reduce an exterior noise level in habitable interior spaces to Ldn 45. In most places, typical building construction automatically provides an NLR of 20 decibels. Therefore, if a structure is located in an area exposed to aircraft noise of Ldn 65, the interior level of noise would be about Ldn 45. If the structure is located in an area exposed to aircraft noise of Ldn 70, the interior level of noise would be about Ldn 50, so an additional NLR of 5 decibels would be required if not afforded by the normal construction. This NLR can be achieved through the use of noise attenuating materials in the construction of the structure.

Incompatible = Generally, the land use, whether in a structure or an outdoor activity, is considered to be incompatible with the outdoor noise exposure, even if special attenuating materials were to be used in the construction of the building.

a. In climates where existing structures have thin, single-wall construction with minimal insulation, the Ldn 55 to 65 area may not be compatible without additional noise level reduction incorporated into the design and construction. However, it should be noted that in many urban areas, the ambient noise level may be above Ldn 65, so structures in the Ldn 55 to 65 area must be evaluated on a case-by-case basis.

b. The land use is generally incompatible and should only be permitted in areas of infill in existing neighborhoods or where the community determines that the use must be allowed.

c. NLR required in offices or other areas with noise-sensitive activities.

Source: Peat Marwick, as derived from the U.S. Department of Transportation, Federal Aviation Administration, Federal Aviation Regulations (FAR) Part 150, "Airport Noise Compatibility Planning," Code of Federal Regulations, Title 14, Chapter 1, Subchapter I, Part 150, Table 1, January 18, 1985.

Development of the project site would involve grubbing, grading and the construction of infrastructure and buildings. The various construction phases of a development project generate significant amounts of noise. Actual noise levels would depend on the methods of construction employed during each stage of the process. Earthmoving equipment such as bulldozers and diesel powered trucks would probably be the loudest equipment used during the construction. However, because there are no residences within several miles of the project site, impacts to residents would be negligible.

It is probable that blasting would be employed in excavating the exhibit areas of the Ocean Center. Blasting was addressed in previous EISs for NELHA properties, particularly with regards to impacts to marine mammals from blasting in the marine environment. The proposed action would not require blasting in the marine environment.

d. Proposed Mitigation Measures

The key factors relative to aircraft noise exposures at the project site are 1) that there are no residential uses proposed, and 2) there would be no (or very limited) nighttime exposures. If the night cargo flights which typically use older, noisier aircraft are removed along with the 10 dB penalty for nighttime intrusiveness, the Ldn contours for 1990 would likely show compatibility with all proposed uses. As discussed above, projections of Ldn contour lines for 2005 show reductions in noise from the 1990 levels. This is due to two factors. First, the aircraft mix itself will change due to greater use of Stage 3 (quieter) aircraft. Second, the planned lengthening of the runway to the north would reduce noise impacts to NELHA and other properties to the south of the airport. A longer runway would allow higher aircraft elevations over the project area and lower thrust from reduced flap angle with increased land speeds possible.

Much of the proposed development would be within substantial structures, portions of which would extend below grade. This would effectively eliminate any noise exposure problem. Additional design measures could provide a higher than normal degree of sound insulation for above grade structures. Clearly the success of the proposed project would depend on the quality of the experience of the visitor to the Ocean Center and NELHA Visitor Center. Mitigation of aircraft noise impacts is a primary criterion for architectural design development.

All equipment powered by internal combustion engines would have exhaust mufflers. The noise from ground maintenance operations would not cause "unreasonable" or "excessive" noise as defined by "Chapter 43 - Community Noise Control for Oahu," (Department of Health, State of Hawaii, Administrative Rules, Title 11, 1981). It should be noted that no similar rules have been adopted by Hawaii County.

All construction equipment and on-site vehicles or devices requiring an exhaust of gas or air must be equipped with mufflers. Also, construction vehicles using trafficways will satisfy the noise level requirements adopted for Oahu for similar noise generation ("Chapter

42 - Vehicular Noise Control for Oahu," Department of Health, State of Hawaii, Administrative Rules, Title 11, 1981.)

If blasting is used in the excavation of the Ocean Center, there would always be undisturbed land between the blasting site and the open sea such that there would be no overpressure pulses to injure endangered species (namely humpback whales and green sea turtles) or other marine mammals. NELHA and its tenants have conducted blasting operations many times previously without adverse environmental effects or disturbance to neighbors. Prior to blasting, potentially affected neighbors, particularly the airport, would be notified.

3. TOPOGRAPHY, GEOLOGY AND SOILS

a. Topography - Impacts and Mitigation

The topography of the NELHA site at Keahole Point is generally level and varies from sea level to approximately 20 feet above MSL. The coastline is rocky and contains intermittent coral and basaltic (black) sand beaches, as well as basalt boulder beaches. The shoreline varies from level areas to elevations up to 15 feet which drop steeply into the ocean to depths of -10 to -20 feet. The nearly vertical areas of the shoreline have numerous caves and lava tubes extending horizontally under them (HTDC, 1985).

Average slopes in the HOST Park area are less than five percent, sloping downward from Queen Kaahumanu Highway (elevation approximately 120 feet) toward the ocean. The predominant land type is pahoehoe lava with smaller areas of a'a lava and beaches.

The KAD Project site is on a westerly facing slope from sea level to elevation 50 feet. The ground is relatively flat, but with areas of abrupt relief (to 12 feet) in the lava flows. No significant soil cover is present. Because of the relative flatness of the site, large-scale reshaping of the ground would be minimized. Construction of proposed improvements would alter the existing site conditions through clearing, excavating, filling, landscaping, new and expanded roadways, and lighting improvements. The landscape areas would require importation of soils. The exhibit tanks of the Ocean Center would be excavated, but the general contours of the land would be retained.

b. Geological Setting and Hazards

(1) Geology

The Keahole Point region consists of primitive basalts of the Hualalai volcanic series, the principal effusive rock of Hualalai volcano (Stearns and MacDonald, 1946). The series is composed of heterogeneous, poorly-layered, laterally and vertically restricted units of aa, clinker, and pahoehoe lavas consisting predominantly of basalts and olivine basalts.

Individual units extend laterally no more than several hundred feet and vertically less than 100 feet. The average lava flow thickness is about 10 feet.

(2) Soils and Erosion

The U.S. Department of Agriculture Soil Conservation Service Soil Survey report for the area designates soil types as aa (rLV) and pahoehoe (rLW) lava flows. These lava flows have practically no soil covering and are bare of vegetation except for mosses, lichens, ferns and a few small ohia trees. According to the Land Study Bureau's Detailed Land Classification report for the Island of Hawaii, the area is designated as class "E" lands. Class "E" lands are very poor or the least suited for agricultural uses.

(3) Volcanic Eruptions

The Keahole area is located on the western edge of Hualalai mountain and consists almost entirely of barren pahoehoe lava flows. The coastline is intermittent coral and basaltic (black) sand beaches, as well as basalt boulder beaches. The Hualalai volcano, although one of the oldest on the island of Hawaii, erupted as recently as 1800 to 1801 when the Kaupulehu lava flow reached to within 2,000 feet of Keahole Point. The 1800 to 1801 and previous visible flows have broken, rough surfaces transected by irregular vertical fractures. Lava tubes and other large openings, many of them collapsed, are common. *(Dames & Moore, 1985)*

The area, which could be affected by eruptions of Hualalai, is classified as risk zone DE (Mullineaux and Peterson, 1974); risk increasing from A through F. Lava flows have buried land in this area more recently than areas in zone D, but the frequency of Hualalai eruptions has been much less than Kilauea or Mauna Loa. Risk on Hualalai is rather poorly defined because of the sparse historic record. The area has also been identified as at risk from particle-and-gas clouds emanating from a Hualalai eruption.

(4) Faulting

The nearest rift zone is at least five miles to the north. There is no evidence of faulting or other regional deformation (Dames & Moore,1985).

(5) Seismicity

All of the island of Hawaii is located in Earthquake Zone 3 (on a scale of 0-4 of increasing seismic occurrence and danger). All construction work is subject to provisions of the "Uniform Building Code" which requires that all structures be designed and constructed to resist anticipated stresses. Earthquakes are frequent in the Kona area; a quake of magnitude 5 was recorded west of Kona in 1972.

c. Proposed Mitigation of Impacts and Minimization of Hazards

The relative flatness of the site minimizes earthwork requirements. The lava surface, however, would be crushed, excavated and shaped by bulldozers, periodically exposing loose lava particles to wind and water erosion. Mitigation measures described in the Air Quality section above would be employed to minimize fugitive dust and wind erosion. All of the proposed structures would be located, designed and constructed to conform to county standards and regulations with respect to seismic risks.

Soil erosion by water is not expected to be a significant impact given the extreme arid nature of the site and the lack of soil cover. An attempt was made to estimate potential soil loss using the Universal Soil Loss Equation (USLE), however the erodibility factors for the aa and pahoehoe lavas on the site are 0.0 (Soil Conservation Service, 1981), and there is no overland flow of water across the site from which to generate a slope-length factor.

4. WATER RESOURCES

a. Groundwater

(1) Aquifers, Hydrology and Water Quality

Groundwater recharge in the area comes primarily from the small residual of rainfall after abstraction by evapotranspiration in the upland area and to a lesser extent from the infrequent cyclonic-storm rain affecting the entire area.

An unconfined Ghyben-Herzberg lens underlies the coastal region of western Hawaii from Keahole northward to beyond Kawaihae and southward to beyond Keauhou. In the Keahole vicinity, the lens is brackish, probably less than 125 feet thick and discharges freely along the coast in a narrow band a few feet wide in the intertidal zone (WRRC, 1980). The basal lens water does not meet the U.S. Drinking Water Standards even at the top of the lens and at a distance about 3 miles from the shoreline. Chloride, for example, was measured to be about 5,000 milligrams per liter (mg/1) to 520 mg/l, and total dissolved solids (TDS) to be about 10,000 to 1,200 mg/l over this distance (Ibid.).

The brackish water of the lens flows toward the coast along a regional gradient of about 1 foot per mile. The head in well 4360-1 (Kalaoa), 3 miles inland of Wawaloli Beach, was 3.2 feet when drilled, implying an average gradient of 1.1 feet per mile. Kanehiro and Peterson (1977) gave an average gradient of 1-to 2-feet per mile north of Keahole for the reach between Kiholo and Puako. The brackish water discharges preferentially at indentations in the coast. Groundwater flow lines converge toward these indentations while diverging at head-lands (Ibid.). At Keahole Point, these discharges are primarily diffused and not usually visible along the shoreline (Dames & Moore, 1985). Aerial infrared photography failed to detect major infusions of groundwater near the point (G. Wilkins, Pers. comm.), but there is a spring closer to the project site at Wawaloli Beach.

The coastal part of the lens experiences appreciable ocean tidal influence. At distances of up to 336 feet inland, tidal efficiencies range from 69% to 100%. Further inland, at 600 feet, the efficiencies decrease from 43 to 68% (WRRC, 1980).

The NELHA Cooperative Environmental Monitoring Program (CEMP) includes monthly water quality monitoring from 16 wells at six locations (Figure 11). Well Set 2, consisting of three wells drilled to different depths (53.5, 24.5 and 14.5 feet), is located at the makai edge of the project site. At this distance from the shore, the brackish water lens is thinning as can be seen from the relative salinities at the three sampling depths. The deepest well has a salinity approximately 80 percent that of seawater. This decreases to about 50 percent and 20 percent, respectively, at the shallower depths. As is typical of groundwater in Hawaii, plant nutrient concentrations, especially nitrogen forms, are abundant. All of the CEMP monitoring data are collected in the most recent annual report included herein as Appendix B.

(2) Developed Sources

There is no groundwater development of any kind on the project site. Fresh water for the Kona area is supplied from deep groundwater sources by the County of Hawaii Department of Water Supply. The major municipal water sources are wells at Kahaluu and Keei, located more than ten miles south of the proposed project.

(3) Regulatory Standards

The project area is makai of the underground injection control (UIC) line. This line is intended to delimit the boundary between mauka areas having developable potable groundwater aquifers and makai areas having non-potable brackish groundwaters. Prohibitions against waste injection protect the former, but do not apply to the latter.

(4) Potential Impacts

The various activities at NELHA utilize warm and cold seawater, and in some instances brackish groundwater as well. These waters are disposed of in several ways, but primarily through gravity seepage from shallow trenches. A major focus of the CEMP has been to document effects and impacts of these discharges on groundwaters, anchialine ponds and coastal marine ecosystems. The CEMP annual report (Appendix B) indicates that at least through June, 1991, there were no negative impacts from the discharges. The monitoring program has detected elevated nutrient concentrations related to isolated tenant discharges. In this instance, the source of the enrichment was determined and operating procedures were modified, reducing the nutrient concentrations in the groundwater.

Seawater return flows discharged into trenches and shallow wells have increased over the past five years from 755 gpm to as high as 10,330 gpm. Discharge locations are shown

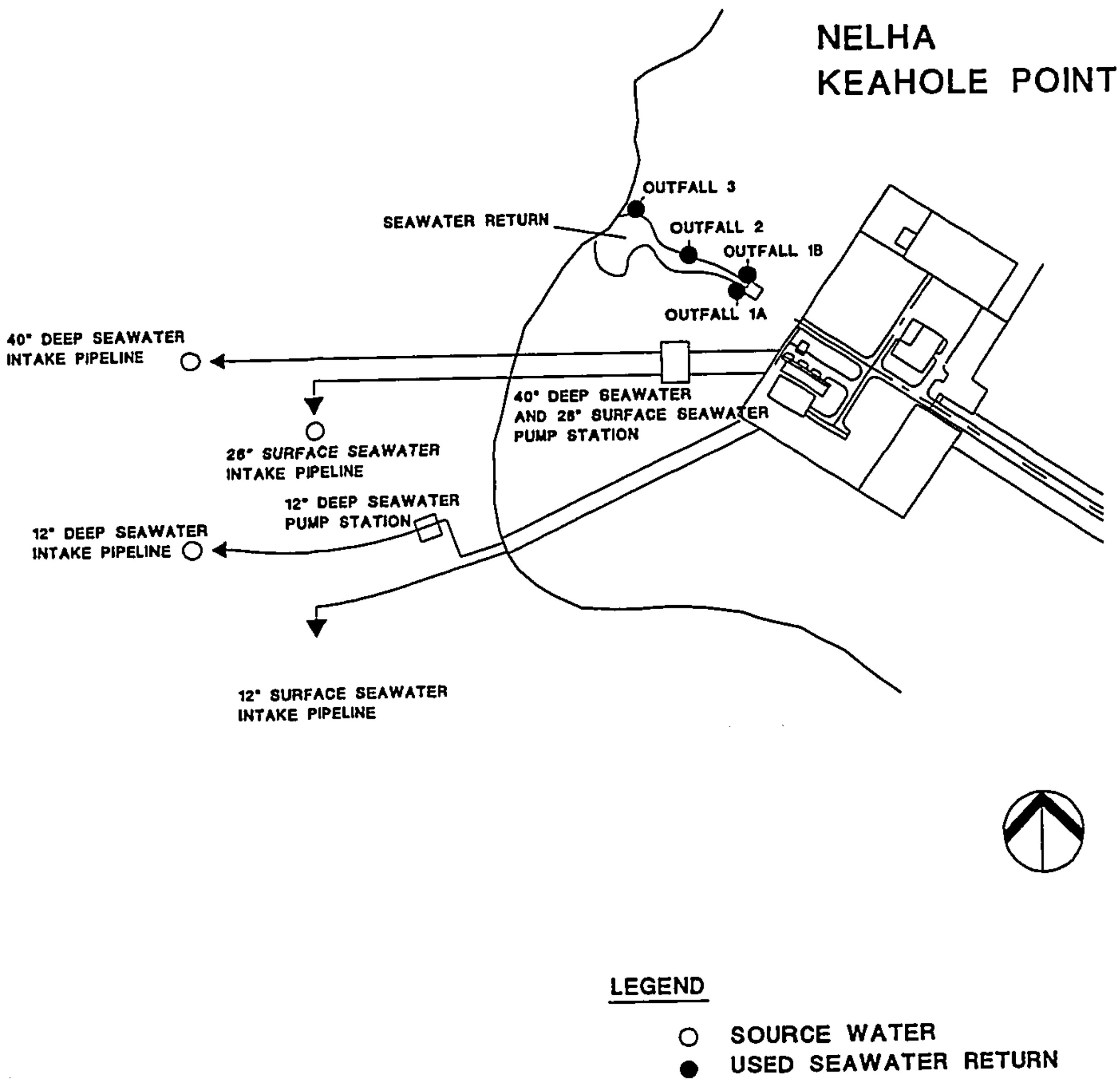


FIGURE 11A
WEEKLY WATER QUALITY MONITORING STATIONS

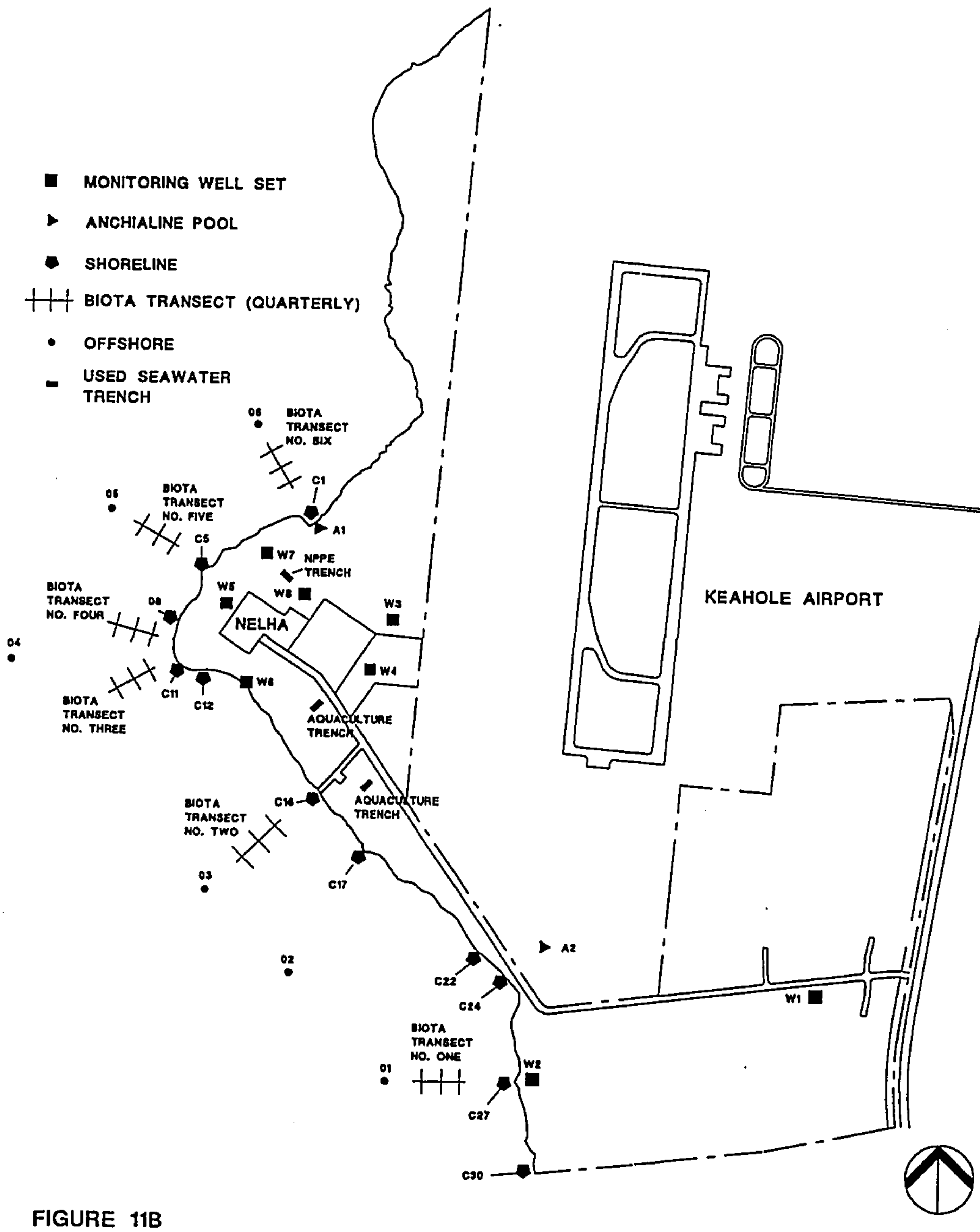


FIGURE 11B

MONTHLY AND QUARTERLY WATER QUALITY MONITORING STATIONS

0 2000 FT.

on Figure 11 with the monitoring station locations. The KAD concept is to reutilize pumped water to the maximum possible extent. Water pumped for energy production in the OTEC plant would be reused in the air conditioning system, Ocean Center and Lobster Farm. Present plans indicate pumping of 13,600 gpm of cold water and 21,200 gpm warm water. Thus, approximately 35,000 gpm (50 MGD) would be disposed of into two trenches (see locations shown on the Site Plan, Figure 8).

To investigate the fate of these flows and their impact on groundwaters a hydrological modeling study was conducted (Mink and Yuen Inc., Appendix C). Results of this study indicate that water exiting the trenches would move vertically downward, as well as laterally. The brackish groundwater lens would be displaced in the vicinity of the trenches. The stagnation point of the plume, i.e., where inland movement of the plume against the ambient basal lens would terminate, would occur somewhat over 1,000 feet away. The radius of the plume at the coast line would be of a similar dimension. Seepage through the ocean floor would begin within about two days after disposal.

In terms of the groundwater resources, the impact of the trench disposal system would be to displace the lens beneath the trench and for some distance laterally as the plume sinks and spreads to a density equilibrium near the bottom of the brackish lens. Groundwater flux would presumably be increased near the plume boundaries. The brackish groundwater is unsuitable for drinking purposes, and in the immediate area is used only for certain aquaculture purposes at NELHA. Displacement of the lens would not affect other NELHA users of brackish water. At this time groundwater usage plans by the 'O'oma II resort are not finalized, but wells to provide water for various planned water features would be drilled to depths well below the influence of the NELHA plume. The discharge plume could extend into the vicinity of ponds located in the northwestern portion of the 'O'oma property. If the ponds were lined, no impacts would be expected. If the ponds were unlined, the head created by inflowing water would create its own plume beneath the pond, prohibiting any influx of water from below.

Potential impacts of the trench disposal system to biological resources are discussed later in this Chapter.

(5) Proposed Mitigation Measures

Mitigation of potential impacts of seawater disposal would take two forms, one proactive, one reactive. The original plan for seawater disposal at HOST Park envisioned centralized trenches where the streams of return flows of various tenants would be commingled. This scheme has several drawbacks including high pumping costs, maximum potential effects on the groundwaters under and downstream of the disposal trench, and reduced potential to trace the source of any introduced contaminant. For these reasons, NELHA proposes to use a decentralized disposal method for future discharges. That is, smaller disposal trenches would be dispersed at appropriate locations to serve the needs of tenants as they arise. For the KAD project, two trenches would be utilized, one receiving the discharges from the Ocean Center and air conditioning system, and one receiving discharges from the Lobster Farm. Particulate matter would be removed from the water in settling ponds prior to disposal in trenches.

The reactive component of the mitigation plan is the expansion of the CEMP to include the land exchange parcel. New station locations are shown on Figure 11. To date the CEMP has been effective in detecting unacceptable discharges, tracing them to their source and providing management options for mitigation.

b. Surface Water

(1) Drainage and Flooding

No significant drainage patterns have been established in the region due to the relatively young age of the lava, its permeability and the characteristic light rainfall. There are no surface streams in the area. Overland flows are negligible, except during severe storms when gulches may have heavy discharges.

Queen Kaahumanu Highway serves as a barrier between the higher Hualalai Mountain drainage areas and the lower coastal region of the project site. Drainage culverts convey excess storm runoff from the higher drainage basins across the highway. A set of two 96-inch diameter corrugated metal pipe culverts cross under the highway and discharge near the northeastern corner of HOST Park. The culverts were designed to accommodate 1251 cubic feet per second (cfs) stormflow.

(2) Potential Impacts and Mitigation Measures

Due to the very porous nature of the substratum, surface water flows rarely develop. It is anticipated that runoff water from the buildings and other major structures would be allowed to percolate into the ground. Where necessary, swales, culverts, drains, catch basins and other drainage improvements would be provided to accommodate storm runoff.

To minimize the impact of runoff from buildings and major structures, only non-toxic building materials would be utilized. No pesticide or anti-fungal treated materials would be used in the roofing of any of the site buildings or structures. Copper or zinc containing downspouts or roofing metals (including galvanized steel) would be avoided. The preferred materials for gutters and downspouts is PVC.

c. Anchialine Ponds

(1) Physical Description and Water Quality

Anchialine ponds are coastal land-locked bodies of water lacking surface connection to the sea, but with measurable salinities and damped tidal fluctuations. They are found in porous substrata such as recent lava or limestone adjacent to the sea.

The West Hawaii coast harbors most of the anchialine ponds in the state. Two clusters of ponds have been identified on the NELHA property. A northern complex of approximately five pools is situated north of the NELH complex, and another group of seven small ponds lies north of the most southerly bend in the NELH access road mauka of Wawaloli Beach. These ponds were first described by Maciolek and Brock (1974). Sampling of the water quality and biota in the NELHA ponds was suggested in the CEMP (GK & Associates, 1989), and a baseline established by Brock (1989). Water quality and biota have been monitored regularly (NELHA, 1992; Brock, 1991). No significant changes have been observed in biotic parameters or water quality since monitoring began. Transient high fecal coliform counts have been recorded in the northern pond complex, but the source has yet to be positively identified.

(2) Regulatory Standards

Anchialine ponds are classified as Class 1 inland (brackish) waters for purposes of Hawaii's Water Quality Standards (Title 11, Chapter 54, HAR). Specific water quality criteria have not been developed for these waters, but the basic criteria applicable to all state waters (section 11-54-04, HAR) apply. It is the objective of Class 1 waters that these water remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character of these areas shall be protected. Waste discharge into these waters is prohibited (section 11-54-03(b)(1), HAR).

(3) Potential Impacts and Mitigation Measures

The present project site is well away from the northern pond complex, but relatively close to the southern complex. Disposal of seawater return flows into trenches could impact water quality, and consequently the biota, in the southern ponds if the plume extends this distance without sinking below the brackish water lens. The CEMP includes a water quality monitoring station (A2) in this series of ponds, so such an impact would be quickly detected. It would be useful for future impacts assessment to intensively monitor these ponds immediately after initiation of major flows into the trenches. If plume waters fill the ponds, additional monitoring of impacts to biota should be immediately initiated. Presumably, cessation of disposal or reduction of flows to a level which does not impact the ponds would restore the anchialine ecosystem. Alternatively, if operationally feasible the start-up of the OTEC Plant could be incrementally staged while the ponds are monitored for the intrusion of plume waters. If plume waters were detected, flows into the trench nearest the ponds could be reduced until impacts were no longer apparent.

d. Coastal Marine Waters

(1) Coastal Processes

(a) *Tides, Waves and Currents*

Currents off Keahole Point are dominated by two processes. Tidal oscillations drive reversing currents with diurnal and semi-diurnal periods. Typical maximal tidal current speeds are 3/4 to 1 knot. Tidal currents may be obscured for extended time periods by even stronger currents, large-scale eddies propagated from the Alenuihaha Channel. These eddy currents commonly reach 2 knots. Offshore surface currents range in speed from 10 to 37 cm/sec or, on average, less than half a knot (Bathen, 1975). Deep currents have been measured in the range 1-10 cm/sec (Bretschneider, 1978).

The wave climate of the Kona coast is typically characterized by two to four foot waves with periods of 9 to 15 seconds. Wave heights rarely exceed seven feet, except during the winter months. Larger waves are generated by local "kona" storms and distant North Pacific storms.

Sea surface temperatures vary relatively little, generally remaining within the 24-28°C range. The wind-mixed surface layer extends 50 to 100 meters deep. The bottom of the thermocline may extend to 150 meters.

(b) *Tsunami Hazards*

Keahole Point is sheltered from the major tsunami generation centers for the Pacific (the Aleutians and Chile); however, the effects of local quakes such as the one occurring in Ka'u in 1868, reported to have been 7.5 on the Richter scale and to have generated a wave as high as 45 feet, are more severe.

Examination of the Federal Emergency Managements Agency's Flood Insurance Rate Map (FIRM), Panel 155166-0683-C, dated September 16, 1988, indicates that coastal areas of the project site are located within the following zones: Zone VE (areas inundated by the 100-year flood with velocity hazards and a base flood elevation of 9 feet above mean sea level and Zone AE (areas inundated by the 100-year flood with a base flood elevation of 9 feet above mean sea level). The Archaeological Preserve and extension of Wawaloli Beach could be impacted by a tsunami. Inland areas where the remainder of the KAD Project and exchange parcel are located are within Zone X (areas determined to be outside of the 500-year flood plain).

(2) Water Quality

In general, the water quality off Keahole Point is very good due to the excellent circulation patterns and lack of major sources of pollutants. The quality of the offshore waters was a major factor in selection of the site for the Natural Energy Laboratory. In terms of the state standards referenced below, however, both the deep ocean intake waters, and the groundwaters entering the ocean at the shoreline and through the seafloor violate standards for nitrogen and phosphorus.

The essential plant nutrients, especially forms of nitrogen and phosphorous, are commonly used as indicators of water quality because they are often major components of waste discharge and, where adequate light is available, can cause undesirable growths of algae. Three distinct nutrient layers have been identified in offshore depth profiles (Noda, et al., 1980). In the surface, wind-mixed layer, concentrations are low and uniform, the result of rapid nutrient uptake by phytoplankton, single-celled algae passively suspended in the water column. Below about 150 meters where light can no longer penetrate, nutrient concentrations rapidly increase due to lack of algal uptake, decomposition of particulate organic matter raining down from above and vertical diffusion from deeper waters. Maximal nutrient concentrations are found below 600 meters.

Often nutrient concentrations right at the shoreline are elevated somewhat due to the seepage of nutrient-rich, brackish groundwater. This is evidenced by the values at the CEMP Coastal stations (Appendix B).

(3) *Regulatory Standards*

Coastal waters off Keahole Point are classified AA by the Department of Health. "Wet" criteria apply due to the volume of groundwater seepage. Waters classified AA are intended to remain as nearly as possible in their natural pristine state with a minimum alteration of water quality from any human-caused source or action.

(4) Potential Impacts

In their natural pristine state both deep ocean water and groundwaters violate nitrogen and phosphorous standards, however, because their concentrations of these nutrients are quite predictable, the best indication of potential alteration of water quality from any human-caused source or action is the CEMP (Appendix B). Evidence of discharge waters within the groundwater is seen in the temperature profiles for Well Sets 5 and 6. Some indications of nutrient enrichment have also been seen in those wells and in Well Set 4. Some nutrient enrichment has also been seen in the Coastal stations taken at the shoreline seaward of Well Sets 5 and 6. Once this trend became evident, an additional series of biological and water quality transects were conducted to investigate whether the observed effect was in fact negatively impacting any living marine resources. Five experimental transects and a control were extended from shore about 100 yards to where the shelf drops off steeply to greater depths. Water chemistry and temperature were checked at the top and bottom of the water column at 25 feet offshore and at the drop-off. Additional temperature measurements were made every 50 feet along the transects. Neither temperature nor nutrient concentration anomalies were detected. No evidence of change in the benthic community was detected. These results indicate that it is possible to detect the presence of discharge waters in the monitoring wells and in samples collected at the shoreline. As the discharge waters seep into the ocean, however, they are rapidly mixed with the receiving waters and advected away by the prevailing currents. No evidence of discharges has been seen more than a few feet from shore.

Discharges from the KAD Project, however, would collectively represent approximately one fourth of the total permitted water flow for NELHA, and more than any volume previously discharged. Mixing and reuse of the water, residence time in settling ponds, and warming throughout each system would raise the temperature of the discharge.

(5) Proposed Mitigation Measures

Mitigation of potential impacts of trench discharges from the KAD Project and other future aquaculture farms would rely on the CEMP. Monitoring wells, coastal and offshore stations have been established to monitor all NELHA properties including the exchange parcel. While not truly a mitigation measure in the sense of direct intervention, the CEMP provides an early warning system to detect changes in environmental parameters which may eventually cause negative impacts. In this way it serves to alert management as to when mitigation is necessary and what needs to be mitigated. To date the CEMP has effectively detected changes and prompted special studies to further investigate circumstances.

Discharge temperatures should be at least 18°C to avoid impacts to corals during very calm periods. If temperature or another parameter begins to negatively impact the marine environment, implementation of other disposal options, including deep injection wells and a deep ocean outfall, would have to be considered. These options were assessed in the NELH FSEIS. The outfall would be the more expensive option, but would be more reliable than injection wells which tend to clog over time. A management mitigation strategy for well clogging and fouling of trenches is to separate effluent streams where economically feasible into high particulate and low particulate flows, as is being proposed by KAD Partners, and treat the separate streams appropriately to mitigate the nutrient loading on groundwater, anchialine ponds and ocean waters.

5. VISUAL RESOURCES

a. Existing Resources

The topography of the site and much of the region is gently sloping toward the sea. Vegetation is sparse. Relatively featureless lava flows contrast with the distant ocean. Scenic vistas are common from Queen Kaahumanu Highway. Keahole Point itself is a scenic site according to the Hawaii County General Plan. Nevertheless, the NELHA facility is an industrial site adjacent to a soon to be international airport.

b. Potential Impacts and Mitigation Measures

KAD Partners has not completed the architectural development of the Ocean Center, but philosophically an "inside-out" concept (i.e., architecture is subordinate to the exhibit design integrity) is being employed. The appearance and texture of the structures at the Keahole Airport and the Polynesian Cultural Center on Oahu approximate the natural feel that KAD is espousing, subject to the requirement to mitigate airport noise levels. The indoor areas would be on one level (i.e., a single story building). The outdoor exhibit area would follow the existing contours of the land, excavated to as deep as 20 feet. Both marine and terrestrial features would be accessed by the public through passageways covered by greenhouse roofs to permit sufficient light for viewing and interpretation as well as allowing passage of the preferred wavelengths for proper growth of botanical specimens.

The Lobster Farm would be characterized by unobtrusive functionality, and would not interfere with the scenic view from any of the numerous perspectives around the facility. The unbroken quadrangle of the facility enclosure would provide a low level silhouette against either the sky or ocean vista. The homogeneity of the space would avoid the appearance of clutter. The regular curvature of the greenhouse roofs would pleasantly complement the rolling contours of the adjacent land.

The OTEC Plant which would be located adjacent to the Visitor Center would be a modular structure less than one story in height. The operational components of the Plant would use less than one-half acre of land.

B. BIOLOGICAL ENVIRONMENT

1. TERRESTRIAL BIOTA

a. Flora

A botanical survey of the project site was conducted for the 'O'oma II EIS (Char and Associates, 1986). Two types of vegetation are recognized within the project area. Descriptions of these follow.

Strand Vegetation: A band of vegetation composed primarily of beach naupaka (*Scaevola taccada*), one to two meters tall, is found along the coastal portion of the project area. The substratum varies from unconsolidated coralline sand to coral rubble, and occasionally, pahoehoe flows. The band varies in width from about 50 feet to as much as 300 feet. In places where the strand is very narrow, the pahoehoe flows come down very close to the beach; the beach naupaka occurs as scattered individuals in these areas and fountaingrass (*Pennisetum setaceum*) is common, occupying even the sandy areas.

Where the strand vegetation is widest, beach naupaka forms almost solid stands. Clusters of tree heliotrope (*Messerschmidia argentea*), three to five meters tall, are scattered among the naupaka shrubs. Among the herbaceous species found in the strand are nohu (*Tribulus cistoides*), pohuehue or beach morning glory (*Ipommoea brasiliensis*), Bermuda grass (*Cynodon dactylon*), alena (*Boerhavia diffusa*), and the native poppy (*Argemone glauca*).

Scrub Vegetation: The scrub vegetation is composed of a mixture of various grass and shrub species on pahoehoe flows. Fountaingrass is usually the most abundant species, especially in areas closer to the shore. Further inland, however, large areas may be dominated by the native piligrass (*Heteropogon contortus*) or by a Natal redtop (*Rhynchelytrum repens*) and 'uhaloa (*Waltheria indica* var. *americana*) association. Shrubs of 'ilima (*Sida fallax*) and indigo (*Indigofera suffruticosa*) may be locally common, especially in depressions in the pahoehoe flows.

Widely scattered throughout the site are taller plants of kiawe (*Prosopis pallida*), Christmas berry (*Schinus terebinthifolius*), 'a'ali'i (*Dodonaea viscosa*), maiapilo (*Capparis sandwichiana* var. *zohari*), and noni (*Morinda citrifolia*).

In some of the collapsed lava tubes which are frequently encountered on the site, ferns such as kilau-o-pueo (*Pteris vittata*), 'iwa'iwa (*Doryopteris decora*), and swordfern or kupukupu (*Nephrolepis multiflora*) may be found, although rarely.

The rough 'a'a flows support only a few plants, usually fountaingrass, coat buttons (*Tridax procumbens*), or 'uhaloa.

b. <u>Fauna</u>

Char and Associates (1986) also surveyed fauna on the 'O'oma property. Two major faunal habitats were present, corresponding approximately to the vegetation types in the area.

The predominant habitat in the study area consists of an arid plain of scattered fountaingrass on pahoehoe lava with occasional native and alien shrub species. Bird densities in this habitat were very low, and most birds seen in these areas were passing through on their way to more preferred habitats that provided more food, water, and cover. One species (the Grey Francolin) was found in this habitat on a more regular basis and presumably is able to utilize the available food sources more effectively than most of the birds found there. This habitat usually extends to within 30 meters or so (sometimes closer) of the shoreline, where it is replaced by the coastal strand community.

The coastal strand habitat occurs immediately inland of the high water line and varies in width. The primary component of this habitat is *Messerschmidia* shrubs to about three meters in height. Also present are a number of native coastal strand plants and some alien weedy species. Birds were much more abundant in this habitat, although much of the activity is of a transitory nature. Many species feed in this area during daytime hours, but roost elsewhere at night.

Beaches and sections of rocky coastline on the seaward edge of the strand vegetation comprise an important habitat for migratory shorebirds, although only one species was seen in the survey.

No endemic Hawaiian birds are known to nest in the proposed project area, although two endemic species are known to range through the Keahole region. The endangered Hawaiian stilt, known to be present in pond areas several miles to the north and south of the site, may fly over the area, and the Hawaiian owl (Pueo) may feed on rodents in the area. The Hawaiian stilt prefers the pond areas and the Hawaiian owl has a large home range over which it forages for rats and mice.

Other common, indigenous birds which have been observed in the area are the golden plover, wandering tattler and ruddy turnstone, which are all found elsewhere in the world. Introduced species known to be present in the area include the Indian grey francolin, barred dove, common mynah, Japanese white-eye, house finch, house sparrow, cardinal and Brazilian cardinal, among other species.

The Indian mongoose, the common house mouse, roof rat, the Polynesian rat, and feral cats are known to inhabit the undeveloped portions of the NELHA site.

c. Rare, Threatened or Endangered Species

No rare, threatened or endangered plant species have been recorded in the project area. The native species that are found on the project site also occur in similar habitats throughout the West Hawaii area.

The Hawaiian Hoary Bat, Hawaii's only endangered land mammal, is found from sea level to the 13,200-foot elevation and is known to occur in Kona. The bat probably feeds on insects along the coastal area of the project site during the evenings and night.

d. Potential Impacts and Mitigation Measures

The proposed project would result in the loss of some scrub vegetation and some associated faunal habitat. This is expected to have only a minimal impact on the total island populations of the species involved. The strand community would not be impacted except where improvements associated with the beach park are required. Some of the native plant species found in the strand, such as the naupaka, pohuehue, and hinahina (*Heliotropium anomalum* var. *argentum*) are used in landscaping, and could be incorporated into landscaping plans.

2. ANCHIALINE PONDS

a. Biological Description

In their pristine state, anchialine ponds harbor a distinctive assemblage of organisms. Certain of these organisms (hypogeal organisms), primarily decapod crustaceans, move between the open waters of the ponds and the interconnected water table below. Many of the existing ponds have been degraded by the introduction of exotic fish which prey on the natural fauna.

A cluster of seven small ponds lie adjacent to the NELHA access road across from the project site. These ponds are more than 70 meters inland, and lie in a pahoehoe lava flow. They are scattered around the perimeter of a large mixed stand of Christmas berry and kiawe. None of these ponds contain introduced exotic fish. All have a mixed assemblage of opae'ula (*Halocaridina rubra*) and small unidentified red amphipods. One of the ponds also has opae'o'haa (*Macrobrachium grandimanus*) (Brock, 1991).

b. Potential Impacts and Mitigation Measures

Disposal of seawater return flows into trenches could displace the ambient groundwater in the southern ponds if the plume extends this distance without sinking below the brackish water lens. Monitoring of this potential impact was discussed above with water quality of the anchialine ponds. If plume waters fill the ponds, additional monitoring of impacts to biota should be immediately initiated. Of the seven hypogeal shrimp species found in Hawaiian anchialine ponds, only the most abundant one - the opae'ula or *Halocaridina rubra* is found in the Keahole ponds. This shrimp feeds on detritus, benthic diatoms, phytoplankton, filamentous algae, vascular plant tissue, and when available, animal tissue. They are extremely hardy animals which have been kept for years in small sealed containers where they live off bacterial films. It is uncertain how plume waters would impact anchialine ecosystems, but cessation of disposal or reduction of flows to a level which would not impact the ponds would very likely restore the anchialine ecosystem to its previous state.

One of the greatest threats to the integrity of the anchialine systems is introduction of exotic fishes intended to be used as bait by fishermen. Increased access to the ponds would encourage this practice as well as present a greater opportunity for beachgoers to dispose of rubbish and human waste into the ponds. This has been observed at all of the NELHA ponds, but has apparently decreased subsequent to imposition of limitations on overnight camping in the area. As the beach access and facilities are improved, greater usage of the area can be expected. This may increase the threat to the anchialine ponds. As the southern ponds are on airport property, active management by NELHA is not appropriate. Perhaps a cooperative effort of DOT and NELHA to educate the public (perhaps using unobtrusive signage) regarding the nature and value of these ponds would reduce incidences of abuse. A continuation of the policy against overnight camping in the area may be beneficial to these habitats.

3. MARINE BIOTA

a. Intertidal and Nearshore

The CEMP contains a marine biota monitoring component. The most recent reports of monitoring results for fish communities (Brock, 1992) and benthic biota (Marine Research Consultants, 1992) are summarized here, and included in their entirety in Appendices D and E, respectively.

The nearshore marine communities in the vicinity of Keahole Point have, for years been recognized as some of the most biologically diverse in Hawaiian waters. Fish communities are exceptionally diverse and standing crops among the greatest in the islands.

The CEMP fish community monitoring is done along four permanent transect lines (Figure 11). The Hoona Bay and Wawaloli Beach transects are intended to sample offshore of areas of known groundwater influx. The 40-inch pipe site is offshore of existing NELHA trench disposal sites, and the 18-inch site is offshore of several aquaculture operations which are or have been discharging aquaculture effluents into the ground.

Along each transect, stations have been established in each major biotope: from shore, the boulder/*Pocillopora meandrina* zone; the *Porites lobata* zone; and the *Porites compressa* zone.

Comparing the results for the most recent sampling (March, 1992) with the October 1991, baseline indicates no significant differences in number of fish counted or number of species present. There has, however, been a decrease in estimated standing crop. Additional sampling will be required to determine if this is in fact a result of onshore disposal practices, fishing pressure, a sampling artifact or a measure of natural variability.

The benthic community monitoring component has been designed to assess abundance, diversity and distribution of stony and soft corals, motile benthos such as echinoderms, and macroalgae. The most recent monitoring data do not reveal any changes in the community attributable to disposal of NELHA waters. Substantial changes in the benthic community have occurred as a result of storm wave activity.

b. Offshore

(1) Plankton

The surface waters off Keahole Point are typically low in concentrations of dissolved plant nutrients, and consequently support a low standing crop of phytoplankton. The nutrient and chlorophyll data accumulated in the CEMP confirm this. In general, calanoid copepods would be expected to be the most abundant zooplankton group feeding on phytoplankton.

(2) Nekton

Myctophidae, midwater lantern fish, were the most abundant fish larvae found in 1980 samples (Noda, et al., 1980). They are of no direct economic importance, but may be, because of their large numbers, important components of midwater food chains.

c. Fisheries Resources

West Hawaii fisheries resources were evaluated in an assessment of the potential impacts of a new marina in South Kohala (Swerdloff, 1991). Of interest here are the inshore fisheries resources near Keahole Point. In 1989, about 82,000 pounds of fish were reported landed in waters within two nautical miles of shore from Keahole Point to Lapakahi. Round scad (opelu) and big-eye scad (akule) dominated the landings in the inshore waters, the former being of more importance off Keahole. Of secondary importance were the high-value snappers and wahoo (ono). While the schooling scad species may be found in relatively shallow water, the snappers are found deeper, in water ranging from 80 to 300 meters deep. Thirty-nine other species of demersal fishes (including wrasses, goatfishes, surgeonfishes, squirrelfish) were reported landed, most caught by commercial divers using spears and nets. Most of these species occur in shallow water (less than 40 meters) and many are difficult to catch on hook and line. There is some evidence of overfishing of the more popular species.

The Keahole region is one of the most important areas in the state for aquarium fish collecting (Nolan, 1978). In fiscal year 1983-84, the areas from Keahole Point north produced about 16% of the statewide catch of aquarium fish; areas from Keahole Point south produced about 3% of the statewide catch.

Monitoring of the fish communities off NELHA as part of the CEMP has indicated a localized reduction in standing stocks, believed to be a result of increased fishing pressure made possible by improved access (R. Brock, 5/11/92, pers. comm.).

d. Rare, Threatened, Endangered and Protected Species

Offshore of Keahole, the endangered humpback whale (*Megaptera novaeangliae*) is seasonally present. A number of dolphin species (protected marine mammals) are common. Marine turtles may occasionally be seen inshore. The threatened green sea turtle (*Chelonia mydas*) is the only turtle species which lives and breeds in Hawaii. The endangered hawksbill and leatherback turtles are also present. More than ninety percent of all breeding by Hawaiian green turtles occurs at French Frigate Shoals, and most other nesting sites are also in the Northwestern Hawaiian Islands. The nearest important resident area of green turtles to the Keahole region is at the northwestern tip of Hawaii. Another important area is found along the southeast coast in the Ka'u district.

e. Potential Impacts and Mitigation Measures

Any potential impacts of the proposed project to the marine environment would be experienced in shallow, nearshore waters. Two types of impacts are possible: 1) impacts of disposal of seawater return flows, and 2) impacts of increased human accessibility.

As explained above, the impacts of water disposal are being intensively investigated through the CEMP which has groundwater and marine water quality and marine biota monitoring components. To date, with less than maximal flow rates, no negative impacts have been documented. The CEMP has been expanded to include the new land areas, and will continue to function as an "early warning system" for degradation of the marine environment.

The other potential impact, increased fishing pressure due to enhanced accessibility to the shoreline is more difficult to mitigate. It is the policy of both state and county governments to increase accessibility of the shoreline to recreational users. The proposed project thus includes plans to expand the area and facilities of the existing beach park. A concomitant increase in fishing pressure in water immediately offshore can be expected. Mitigation of this impact is possible through institution of size limits, bag limits, rotating area closures, seasonal closures, or prohibitions regarding use of gillnets in nearshore waters. Any of these measures would require action on the part of the state legislature.

C. SOCIAL, CULTURAL AND ECONOMIC ENVIRONMENT

1. POPULATION AND DEMOGRAPHICS

a. Existing Population and Growth Trends

The 1990 census estimates the Big Island's resident population at 120,317 and defacto population at 135,080, increases of 30.7 and 36.9 percent, respectively, over the prior decade. On a county-wide basis, the rate of population growth slowed from 45.0 percent in the 1970's to 30.7 percent in the 1980's. Approximately 63 percent of the increase in the resident population was due to net in-migration.

By ethnicity, the population of the Big Island is approximately 26 percent part-Hawaiian, 25 percent Caucasian, 22 percent Japanese, 12 percent mixed (non-Hawaiian) and 10 percent Filipino.

The fastest-growing districts of the island from 1980 to 1990 were South Kohala (98 percent increase), Puna (77 percent increase) and North Kona (62 percent increase) (DBED, 1991). The rate of population growth in North Kona slowed considerably from the

184.5 percent experienced in the 1970's, but the actual number of residents increased at a very constant rate of about 8,500 to 9,000 per decade. According to the 1990 Census, North Kona had a resident population of 22,284 people (DBED,1991).

b. Impacts and Mitigation Measures

Impacts to the North Kona population by the proposed project could result from additional employment opportunities on-site or off-site in supporting businesses. The KAD Project would create between 57 and 76 jobs, most associated with the Ocean Center. The HTDC FEIS evaluated the impacts of a projected total direct employment of 1,590 to 3,580 at full build-out of NELH and HOST Park. An additional indirect employment in West Hawaii was estimated at 1,780 to 4,200. Presently, there are 105 employees on NELHA properties. The KAD Project will not expand the envelope of potential impacts previously assessed.

2. HOUSING

a. Existing Stock and Trends

As of April 1, 1991 there were 50,579 housing units on the Big Island (DBED, 1991), including 2,401 non-resident units. In 1990, residential construction totaled 2,023 new single-family houses, 50 duplexes and 580 apartments.

b. Impacts and Mitigation Measures

Housing requirements would be of two distinct types: purchase and rental units. It is assumed that temporary construction workers would almost exclusively require rental units. The peak construction activity in 1995 is estimated at 100 person years. Utilizing the various factors for off-island sourcing of employees, dependents, sharing and rental unit multipliers, it is estimated that approximately 25 rental units would be required in 1995 to accommodate direct construction employment.

Operational employees are expected to occupy full-time positions, and would create a demand for purchased and rental housing totalling 30 units. Applying the same generic factor classifications for off-island sourcing of employees, dependents, sharing, and rental unit multipliers, but different quantitative assessments than for construction workers, it is expected that a total of 18 houses would be purchased over the two-year 1996-1997 period and 12 would be rented. The type of house required is determined by an affordability index based on household income and standard monthly mortgage payment tables. Approximately 45% of the purchases units could be in the affordable range which equates to eight affordable houses and ten market price houses. Of the 12 rental houses, approximately 70% could qualify for affordable housing assistance which equates to eight affordable units and four market rate rental units.

Correspondence with the County of Hawaii Planning Department (Kanuha, 1989) states:

> Affordable units completed or under construction within the Kealakehe Planned Community project will be eligible for credits towards the affordable housing requirement of the proposed HOST Park projects. In the event that sufficient credits are not available for a particular proposal, other contributions may be required prior to the issuance of building permits for that project.

At this early stage of development of both Kealakehe and HOST Park adequate credits are available.

3. ECONOMIC RESOURCES

a. Industries and Employment

The Hawaii County civilian labor force in 1990 totaled 61,550, a 7.6 percent increase over 1989. Civilian employment was up a proportionate amount to 59,200. The 2,350 unemployed represented 3.8 percent of the labor force, equaling the lowest rate for the decade established the previous year. The unemployed were predominantly male (65.5 percent), 25 to 34 years of age (31.8 percent), seeking work in the construction (29.7 percent), services (24.2 percent), and wholesale/retail trade (13.5 percent) industries. By industry, Hawaii County jobcounts in 1990 included 14,250 in services, 12,600 in wholesale/retain trade, and 8,450 in government. Agriculture, including self-employed, had 5,700 jobs; construction 3,250. Personal income in 1989 totaled $1.8 billion, or $14,969 on a per capita basis. That was an 11.6 percent increase over 1988 per capita income in the county.

The KAD Project would create temporary jobs in construction and long-term employment in facilities operations and management. These direct jobs would in turn create other indirect and induced jobs. Construction employment is discussed below. The operating components of the KAD Project would create a variety of jobs including professional, clerical, educational, technical, scientific, engineering, aquacultural, landscaping, security, utility, maintenance, curatorial and others. Maximum staffing levels of 75 would be reached in 1996. Using the appropriate DBED multipliers, indirect and induced employment resulting from the OTEC Plant would be three jobs; from the Lobster Farm would be 18 jobs; and from the Ocean Center would be 101 jobs for a total of 122 indirect and induced jobs created. Adding the direct jobs created, the grand total would be 197 jobs created.

b. Potential Impacts on Specific Industries

(1) Construction

The statistics presented above illustrate a need for construction jobs on the Big Island. West Hawaii in particular, has lost construction jobs with the current slowdown in resort development. The HTDC FEIS estimated that average annual construction employment at NELH and HOST Park would range from 73 to 150 jobs, indirectly generating another 88 to 180 jobs in West Hawaii, and 95 to 195 elsewhere (primarily Honolulu). In recent years, construction jobs at NELHA have ranged from none to about 50 at any given time, with an average of about 15.

The major operating components of the KAD Project, the OTEC Plant, Lobster Farm and Ocean Center would require the major direct construction employment over a 2.5 year period culminating in mid-1995. The Wawaloli Beach Extension and Archaeology Preserve would require one year of construction time and also be completed in mid-1995. By applying a selected basis to each component, a total requirement of 204 person-years is estimated to complete the infrastructure and facilities covering a 45-acre area. The peak of construction activity would be in 1995 when 100 person-years would be required. The DBED Input/Output Econometric Model provides factors for estimating indirect and induced employment. Applying these factors yields an additional 174 person-years of indirect and induced employment. The total direct, indirect and induced construction employment would thus be 378 person-years between 1993 and 1995.

(2) Visitor Industry

In 1990, attendance at 11 Big Island museums and other cultural attractions totaled over 4.4 million people. While not all of this attendance is visitor related, most visitors could be expected to partake of one or more of these attractions. By far the two most popular attractions on the Big Island are the Kilauea Visitor Center and the Jagger Museum with two million visitors each in 1990.

The KAD Project would provide a major West Hawaii attraction for residents and visitors alike. Visitors to the Kona side of the island totaled 1,030,900 in 1990. The annual attendance at the Ocean Center is projected at 500,000 people after the July 1995 opening. With a $16 maximum adult admission fee and reduced children's rates, annual admission revenues are projected at $7.5 million. Revenues from food and beverage and retail sales are estimated at an additional $5.5 million, bringing total annual revenues from the Ocean Center to $13 million. Using the DBED multiplier of 1.39 to account for indirect and induced expenditures yields a total annual visitor expenditure of $18 million.

(3) Aquaculture

Hawaii was the first state to develop an aquaculture policy and development plan. Since 1980, revenues from Hawaii's aquaculture industry have increased 27 percent a year. The estimated 1991 wholesale value of Hawaii's aquaculture products was $10 million (Kamhis, 1992). Technology transfer brought another $16 million into the state. At the end of 1990, there were 53 aquaculture operations with 489 acres producing 1.45 million pounds. On the Big Island, there were 21 operations with 84 acres producing 580,000 pounds worth over $5.0 million (DBED, 1991). About three quarters of the Big Islands aquaculture production (and revenue) was algae, most being produced by Cyanotech at HOST Park.

The KAD Lobster Farm would occupy about 16 acres, increasing the Big Island's producing aquaculture acreage by almost 20 percent. At full production, the KAD Lobster Farm is designed to produce 500,000 pounds per year, doubling the Big Island's aquaculture production. At a unit price of $6.50 per pound annual revenues would total $3.3 million. The Lobster Pound would cycle through another 2.5 million lobsters annually, also at $6.50 per pound, yielding additional revenues of $16.3 million. For diversified agriculture at the wholesale level without manufacturing or value added packaging the DBED multiplier is 1.64. Total Lobster Farm direct revenues of $19.6 million would generate another $12.4 million in indirect and induced revenues, for a total of $32 million.

Utilization of the remainder of the exchange parcel in other aquaculture ventures would increase the Big Island's producing acreage and aquaculture revenues.

(4) Other Ocean Industries

The KAD Project would positively impact several other ocean-related industries, including marine research and education, ocean recreation and seafood marketing. The Ocean Center is intended to provide facilities for both research and education. The Ocean Center would passively stimulate the ocean recreation industry by encouraging attendees to observe natural ecosystems through snorkeling, SCUBA diving and riding glass-bottomed boats. The extension of Wawaloli Beach would indirectly stimulate sales of ocean recreation equipment and supplies. The seafood marketing industry would benefit from the addition of a premium, local-grown product.

(5) Commercial Fishing

In 1989, the inshore waters of the Kona coast produced 340,369 pounds of fish, almost nine percent of the Big Island's total landings. The total landed value was $546,938. Almost 70 percent of the Kona inshore catch was opelu (round scad) (Swerdloff, 1991). Inshore waters of the Kona coast are the most important opelu grounds in the state. Aquarium fish collecting is also important in this area.

The opelu is found in tropical waters worldwide, and in Hawaii in coastal waters around all of the islands. Adults school near the surface in shallow waters and feed predominantly on planktonic crustaceans. Larvae and juvenile opelu disperse far offshore, returning to coastal waters at a length of about five inches (DLNR, 1979). Because the opelu eggs are buoyant, the larvae planktonic and the juveniles dispersed offshore, entrainment in intake waters would not be a significant problem to the resource. Schooling fish are highly susceptible to impingement (NOAA, 1985), but because opelu favor surface waters, only the warm water intake is of concern. Experience to date has been that neither impingement nor entrainment of opelu or any other fish species have been a problem for NELHA operations. Seepage of nutrient-rich return seawater into coastal waters could have a biostimulatory effect on planktonic communities, which has been shown to benefit fisheries.

Indirect impacts to the commercial fishing industry would result from potential substitution of an aquacultured product for a captured product. American lobsters, however, are a specialty food item, not readily interchanged with other seafoods, particularly the finfish products which dominate Hawaii's fresh market.

4. FISCAL IMPACTS

a. Growth Assumptions

The HTDC FEIS assessed the impacts of full development of NELH and HOST Park. Three scenarios for HOST Park were examined: 1) 78 acres of ocean-related industrial and 385 acres of ocean water commercial employing 1,200 people on-site; 2) 178 acres of ocean-related industrial and 285 acres of ocean water commercial employing 2,100 on-site; and 3) 299 acres of ocean-related industrial and 165 acres of commercial employing 3,190 people on-site.

At the present time, there are no projects of any kind at HOST Park. Addition of the KAD Project to HOST Park would increase the ocean water commercial acreage and employment levels somewhat, but development of the Park remains at an early stage, and these incremental increases would not exceed the limits of impacts previously assessed.

b. Personal and Household Income

Personal income is derived from the wages and salaries paid to direct construction and operations employees. Using industry standards for the various construction and operations classifications as published in the State of Hawaii Data Book and applying those standards to the direct employment person-years yields an estimate of the 1995 personal income impact of $4.9 million, and a steady-state 1996 and beyond annual impact of $1.4 million.

Because personal income does not address the indirect or induced impact, and development of a meaningful statistical relationship is difficult, DBED uses Household income for this purpose. It estimates that for every dollar of direct visitor-related expenditure there is $0.52 in economic activity to households in the state. Therefore, the household income impact from the development of the KAD project would be $6.7 million annually beginning in 1996.

c. State and County Revenue Growth

Construction and operation of the KOC would increase property taxes to the county. It would also increase personal income taxes and excise taxes to the state. Although State lands are exempt from County property taxes, tenants are taxed on improvements. At the present time, property tax rates at NELHA are $8.50 per $1,000 of assessed valuation. The valuation may be reduced to reflect agricultural (aquaculture) use. Development of 66 acres by KAD Partners would increase property taxes by as much as $280,500.

Visitors to the Ocean Center would generate excise tax revenues to the state at a 4% rate on gross sales. The Lobster Farm would generate excise tax revenues on the sale of lobsters at the wholesale rate of 0.5% on gross sales. Direct excise tax revenues to the state are estimated at $638,000 per year. Indirect and induced expenditures also generate excise tax revenues to the state, and this amount is estimated at $731,000 per year. In-migrant operations employees would also generate revenues to the state from income taxes, excise taxes and other state taxes. This is estimated at $2,460 per person annually. The estimated 30 in-migrant direct operations employees would therefore generate about $74,000 annually in state tax revenues. The combined state tax revenue from all sources in $1,444,000 per year.

An additional revenue stream for the state would be the collection of lease rents from KAD. Current rates at NELHA are $100 per acre per month or 2% of gross revenues, whichever is greater. During construction then, lease rents would be $79,200 per year. At full production, annual revenues would be $13 million from the Ocean Center and $19.6 million from the Lobster Farm. Annual lease rents at 2% would total $652,000.

d. Costs of Capital Improvements and Services

The HOST Park Master Plan (HTDC, 1989) estimated the total costs for infrastructure development at full build-out to be $83,009,884. For the 547-acre, this would amount to $151,755 per acre. The 66-acre KAD parcel would therefore represent a capital investment in infrastructure of about $10 million for the state. The KAD Project would, however, absorb those costs associated with the Visitor Center, Wawaloli Beach extension, the Archaeological Preserve and a portion of the electrical, telecommunications, freshwater and seawater systems (because the size of the project cuts NELHA's costs to supply smaller individual lots with these utilities). Of these, the Visitor Center was budgeted at $2,072,000, but the other costs are not quantified. Assuming the beach extension, Archaeological

Preserve and infrastructure savings total $1.5 million, the state's investment is about $6.5 million.

In addition, new visitors and in-migrant employees would require additional services from the public sector at state and county levels. New visitors require public services in the areas of public safety, highways, recreation, health, transportation, and special capital improvements. In-migrant employees require public services in excess of the new visitor requirements principally in government operations, education, transit, health, sanitation, natural resources, and other public sector functions.

Using the published county operating budgets segregated by department, budget amounts can be determined to benefit visitors, residents or both. This analysis suggests a 1990 division of $630 per resident and $430 per visitor. In-migrant employment and dependents would be additional residents of the Big Island, and these 60 persons at $630 each would require the expenditure of $37,800 annually. The 500,000 annual visitors to the Ocean Center would be drawn from the existing visitor inventory, i.e., the Ocean Center would not be dependent upon increasing the visitor count.

Using the published state operating budgets segregated by department, budget amounts can be determined to benefit visitors, residents or both. An analysis for 1990 suggests various state services totaled $2,860 per resident and $810 per visitor. In-migrant employment and dependents total 60 persons, and at $2860 per person would require the expenditure of $184,200 annually. New visitors to the state are not required for the economic feasibility of the Ocean Center which simply needs to capture a significant portion of the existing visitor inventory.

e. Net Impacts

At the county level, annual property tax revenues minus the increased operating expenses would represent a net benefit of about a quarter of a million dollars a year.

At the state level, annual tax revenues and lease rents minus the costs of increased services would represent a net annual benefit of about $2 million. At this rate, the prorated capital costs associated with infrastructure improvements at NELHA would be recovered in well under five years.

5. CULTURE AND LIFESTYLE

a. Social/Cultural Setting and Historical Development

The prehistoric and early historic background of the area, existing lifestyles, values and social cohesion were summarized in the HTDC FEIS and are herein included by reference.

b. Potential Impacts and Mitigation Measures

Potential impacts of the proposed project to archaeological sites and recreational resources are discussed in later sections. In terms of the present social and cultural setting, the project would have minor impacts due to the factors enumerated in the HTDC FEIS:

- potential increases in the West Hawaii population;
- potential increased in-migration from outside Hawaii; and
- possible industry-related hiring practices (based on required skills).

Population increases due to the proposed project would be quite small, and well within the ranges assessed in the previous EISs. The development of HOST Park has been slower than anticipated, and projected potential population-based impacts less as a consequence of their being spread over a longer time period.

Development of the proposed project may well require relocation of selected senior personnel from the mainland to Hawaii. This would tend to intensify the existing trend toward a more "mainland lifestyle" and value orientation. The number of people involved, however, is so small as to be insignificant in comparison to that of resort and residential estate developments throughout West Hawaii.

The specialized technical nature of the OTEC, Lobster Farm and Ocean Center components of the project may require recruitment of senior staff from outside Hawaii. In the longer term, however, these facilities would provide opportunities for local people to receive training and advancement in scientific and technical disciplines (for example, aquaculture) very much in harmony with local traditions and cultural preferences. The less skilled positions which would be created would be much less susceptible to the vagaries of the "boom and bust" cycles of the visitor industry.

The success of the proposed project would also positively impact community pride. If the KAD project aids Hawaii in its quest for world leadership in ocean-based science (as the observatories on Mauna Kea have done in astronomy), there will be a community-wide, and in fact state-wide, sense of satisfaction that West Hawaii has proven its potential for economic development in fields other than tourism. Successful economic diversification would also earn the community greater respect, recognition and security by reducing the dependence of the region on the visitor industry.

D. BUILT ENVIRONMENT

1. HISTORIC AND ARCHAEOLOGICAL SITES

a. Prior Surveys and Coordination

NELHA properties, including the exchange parcel, have been thoroughly surveyed for archaeological resources. At the time of the HTDC FEIS (1985), there had been eight surveys of HOST Park and seven of NELH. Other surveys of the area had been completed prior to the creation of NELH. During preparation of the NELH SEIS (1987), Dr. Ross Cordy of the State Historic Sites Section (now Historic Preservation Division) again surveyed the NELH sites, and prepared a preservation/mitigation plan. This plan was subsequently expanded to include the HOST Park sites and those on the exchange parcel. Since that time, additional data recovery work has been completed on some on the sites. Until recently there remained three sites in the northwestern corner of the exchange parcel that were possible human burials. These were excavated and found not to be burials. The complete report of the data recovery for these sites is contained here as Appendix F. That report also summarizes what has been learned about use of the area dating back to the sixteenth century.

b. Existing Sites

The coastal portion of the exchange parcel is rich with archaeological sites. Figure 12 shows the locations of all significant archaeological sites on the exchange parcel, and the recommended level of impact mitigation for each site.

c. Proposed Mitigation Measures

Archaeological mitigation is an integral component of the KAD Project. An Archaeological Preserve is planned wherein a number of sites would be preserved and interpreted for public education and appreciation. Prior to construction data recovery work will be completed for those sites so designated. Those sites requiring preservation would be contained in the proposed Archaeological Preserve. The plan for and layout of this component of the KAD Project is detailed in Chapter III. A long-range preservation plan for those sites to be preserved and interpreted would be prepared for approval by the State Historic Preservation Division and the County Planning Department. The Preserve would be large enough to provide a buffer zone around the sites to be preserved, and interim protection measures would be effected during construction. These would include fencing of vulnerable sites, and provision of detailed instructions to construction crews on protection of all sites.

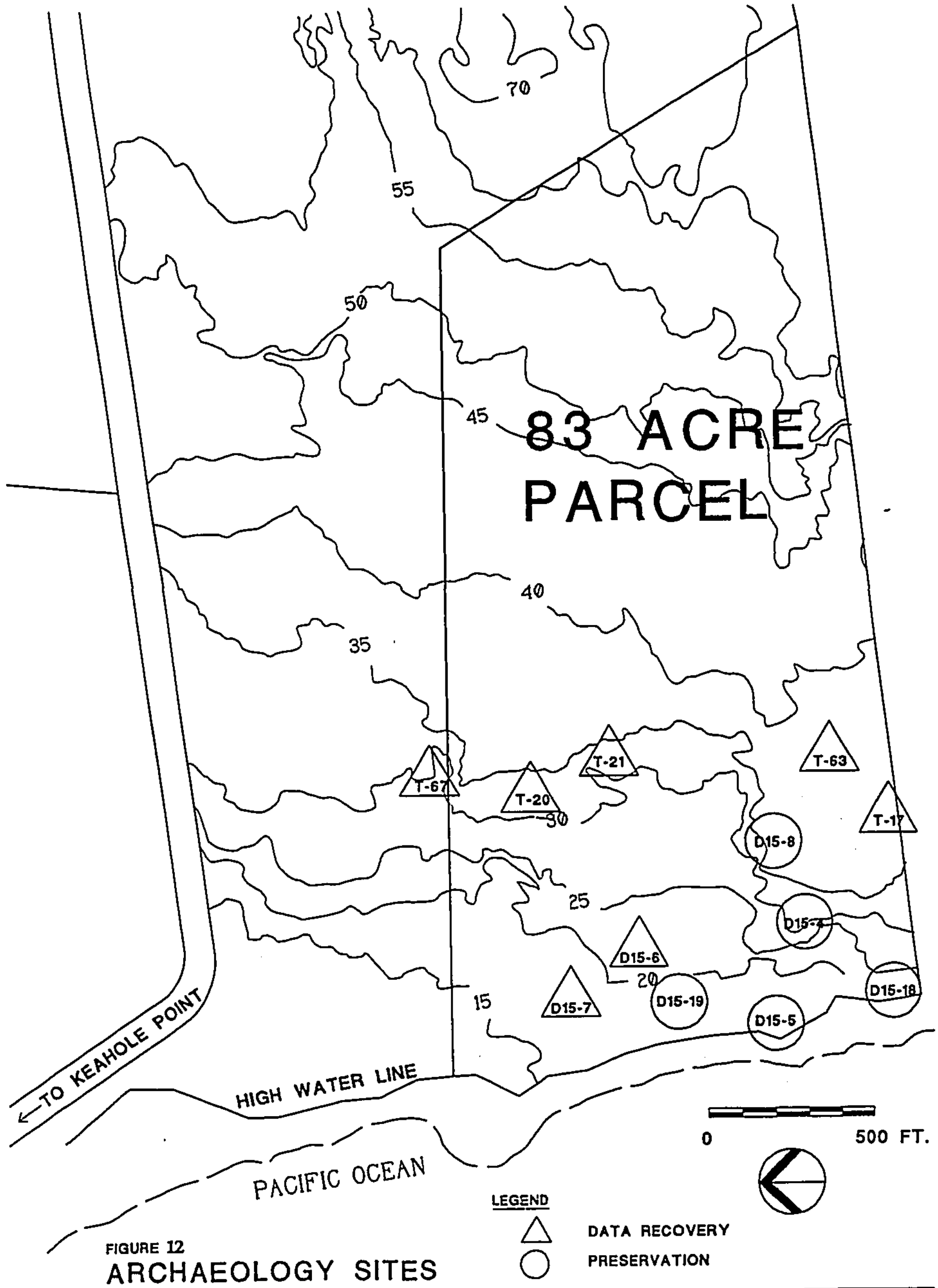


FIGURE 12
ARCHAEOLOGY SITES

2. INFRASTRUCTURE AND PUBLIC SERVICES

a. Transportation

(1) Keahole Airport

(a) *Potential Impacts*

The proposed project would not directly negatively impact Keahole Airport. All structures would conform to height limitations within runway approach zones. The property is industrial and the proposed uses are compatible with anticipated noise levels. Some additional passenger and cargo demand would be generated by the project and its personnel, but these are not significant, particularly in view of the airport expansion plans.

(b) *Proposed Mitigation Measures*

No mitigation of impacts to the airport is necessary. Mitigation of noise impacts on the project would be carried out through proper design of the respective facilities as described in Chapter III and Section A.2 above.

(2) Roadway Network

(a) *Access*

Access to NELHA is via a two-lane 24 foot-wide asphaltic concrete paved road with an 80-foot easement width. The road is approximately two miles long from its intersection with Queen Kaahumanu Highway to the NELHA administration building. There is no road to the northern portions of the NELHA property and a jeep trail is the only other access to the coastal areas. The Queen Kaahumanu Highway intersection is improved with acceleration and deceleration lanes for left and right turns. There is a gate at the highway which is open during the day and closed at night.

(b) *Traffic*

The HTDC FEIS contained a traffic impact report based on the range of development scenarios then projected. That study considered full build-out of HOST Park with energy and aquaculture projects, a restaurant, a visitor center and an oceanarium. For all of the scenarios studied the level-of-service (LOS) at the Queen Kaahumanu intersection would have been reduced to the point that major improvements, including signalization, would have been required at full build-out. Clearly those development scenarios were overly optimistic, as development at HOST Park has proceeded much more slowly than any of the projections.

For this SEIS an update of the traffic impact study was done (Appendix G). Two factors prompted this: first, the growth of the West Hawaii region has been very rapid since the earlier traffic study, and background traffic on Queen Kaahumanu Highway has increased significantly during that time; and second, the early oceanarium plans were not fully developed and so the traffic impacts could not be fully assessed.

The approach taken in the present traffic study was as follows: 1) determine existing traffic and levels-of-service; 2) project future traffic growth from both undefined regional expansion and from specific planned nearby projects during the period of KAD Project build-out; 3) characterize traffic generation by the KAD Project; 4) superimpose the KAD-generated traffic and all of the concomitant increases in background traffic onto the existing situation to predict future levels-of-service; and 5) identify possible measures which could mitigate impacts where decreased levels-of-service so warrant.

Since 1978 the Average Daily Traffic (ADT) along Queen Kaahumanu Highway has increased from 4,537 vehicles per day to about 12,000 vehicles per day. This represents an annual compounded growth rate of 8.4 percent. Nevertheless, Queen Kaahumanu Highway in the vicinity of the NELHA access road currently operates at level-of-service B during peak hours. (Levels-of-service are ranked from A (best) to F (worst). See Appendix G for a more complete description.)

The traffic study assumed that background traffic would continue to grow at recent rates (8.4 percent per year compounded) through KAD Project build-out, a conservative assumption in view of the present economic contraction. Traffic to be generated by five proposed neighboring projects and additional NELHA growth was then added to background levels to project future conditions without the KAD Project. In this case, the projected level-of-service for Queen Kaahumanu Highway remained at B, but left turns into and out of NELHA would experience long delays. In this scenario, adequate traffic flow is maintained on Queen Kaahumanu Highway because there are no delays due to signalized intersections, despite the fact that the theoretical capacity of the highway is exceeded.

(c) *Traffic Impacts and Mitigation Measures*

If the NELHA entrance is unsignalized, the left turns from the access road would experience long delays and operate at LOS F. Left turns into the project would operate at LOS D. Assuming that the intersection would have separate left turn lanes into and out of the access road, Queen Kaahumanu Highway would remain at LOS B.

The state currently has plans to improve Queen Kaahumanu Highway to an access controlled facility. As yet, there is no indication that this would occur within the time frame used in the traffic study (1992-1997). It is understood that when Queen Kaahumanu Highway is improved, access to NELHA would be via a frontage roadway, probably from an interchange at the airport. This would alleviate the potential problem at the intersection of Queen Kaahumanu Highway and the NELHA access road.

An analysis was conducted for signalized intersection conditions. It concluded that a traffic signal would decrease the LOS unless Queen Kaahumanu Highway were widened to provide two through lanes in each direction. Without widening the highway, the LOS would be F because of additional delays. With widening, the LOS would be C.

b. Utilities and Energy Resources

(1) Electricity

(a) *Existing Service*

Electrical power to the area is supplied by the Hawaii Electric Light Company, Inc. (HELCO) via an existing HOST Park distribution substation that was sized to serve the Park, including the original 83 acres which was exchanged.

(b) *Potential Impacts and Mitigation Measures*

The OTEC Plant would supply power for the seawater pumps eliminating the need to purchase approximately 880 kilowatts from the utility. Cold water pumped for power generation would also be used for air conditioning, considerably reducing electrical demand. Diesel generators would be installed for emergency back-up power for critical equipment.

According to HELCO, to serve the proposed new loads, an extension to the underground cables would be required along with associated switches and padmount transformers. This would be arranged in consultation with HELCO once specific plans are available.

(2) Communications

Hawaiian Telephone Company has an existing 3-inch conduit serving the NELHA facilities. The existing capacity is adequate for the proposed project.

Staff communications would be by portable FM radio systems. A public address system would service all major structures.

(3) Water Supply

Fresh water for domestic use and fire protection is supplied by the Department of Water Supply, County of Hawaii, via a 4-inch water line connected to the 12-inch diameter transmission main located along Queen Kaahumanu Highway which conveys water from the Kahaluu water storage tanks to a 0.5 million gallon (MG) reservoir near the entrance to Keahole Airport. The capacity of the 4-inch diameter pipeline is approximately 200 to 400 gpm (300,000 to 600,000 gpd). The County has allocated NELHA 500,000 gpd. The current fresh water usage at NELHA is approximately 110,000 gpd. The proposed KAD Project would require approximately 30,000 gpd.

(4) Wastewater Treatment and Disposal

The Keahole to Kailua Development Plan indicates that sewage from NELHA will be treated at the proposed Sewage Treatment Plant No. 2 to be constructed 2.5 miles north of Keahole Airport. According to correspondence from Dr. John Lewin, Director of Health to Mr. Norman Hayashi, Hawaii County Planning Director, relative to the State Land Use Boundary Amendment Application:

> Until Sewage Treatment Plant No. 2 is completed, septic tanks will be an acceptable treatment method, provided that the system meets all of the applicable requirements of the Department of Health (DOH) Administrative Rules, Chapter 11-62, "Wastewater Systems." In addition, detailed plans for both domestic and non-domestic wastewater treatment/disposal must be submitted to and approved by DOH.

A self-contained sewage treatment plant is planned to handle the human sewage from the operation of the KAD facilities. Secondary treatment would be employed. Septic tanks would not be necessary because all effluent waters would be used to irrigate landscaping on the site.

Seawater return flows from the Lobster Farm would be of two types: continuous flows and periodic cleaning wastes. Continuous flows of wastewater would result from the single pass overflow of the lobster culture raceways and would gravity flow into an unlined collection trench. Periodic cleaning waste would result from vacuuming of the raceway bottom to collect uneaten lobster food particles, lobster feces and other detritus. These wastes would be collected in a lined settling pond, evaporated and the residue trucked to a landfill or sewage treatment plant.

Seawater return flows from the Ocean Center would be of two types: continuous flows and periodic cleaning wastes. Continuous flows of wastewater would result from the single pass overflow of the marine habitat exhibits and would gravity flow into an unlined collection trench. Periodic cleaning waste would result from the vacuuming of habitat bottoms to collect uneaten food particles, feces and other detritus. These wastes would be collected in a lined settling pond, evaporated and the residue trucked to a landfill or sewage treatment plant. Exhibits with non-indigenous tropical and sub-tropical species would have their wastewaters treated by filtration, ozonation, ultraviolet light, or other means prior to final disposition in a lava trench.

Further safeguards would result from expansion of the Comprehensive Environmental Monitoring Program which has successfully detected unacceptable discharges and provided management options with which to eliminate the source before harm to the environment could occur.

The NELHA Facilities Use Manual (Appendix H) provides guidelines for mitigation of potential impacts from industrial wastes generated by tenants. Discharges from tenant facilities to NELHA disposal trenches must meet the basic water quality criteria applicable to all state waters. It is the responsibility of each tenant to collect data on discharge water quality and quantity. NELHA reserves the right to independently monitor wastestreams and shut down any operation in violation of discharge standards.

(5) Solid Waste Disposal

The Hawaii Integrated Solid Waste Management Act (Chapter 342G, HRS) establishes guidelines for the counties for development of management plans by January 1, 1993. In order of priority, the recommended practices and processing methods are 1) source reduction, 2) recycling and bioconversion (including composting), and 3) landfilling and incineration. The Hawaii County plan is under development, and will be available for public comment shortly.

The proposed project would generate several significant solid waste streams, including sludge from the sewage treatment plant, settled solids from the Ocean Center exhibits and Lobster Farm, food wastes from the food service facility, green waste from the landscaping and miscellaneous wood, paper, plastic and metallic wastes.

NELHA fully supports the integrated solid waste management efforts of the state and county. The primary sources of solid waste from the KAD Project would be the Lobster Farm and the Ocean Center. Each facility would institute waste management and waste reduction plans conforming to state and county policies. In particular, composting would be employed if appropriate sites and facilities become available. Newspaper, paper, glass and metal would be segregated into separate waste streams and transported to recycling centers where and when available. It would be the operating policy of the KAD Project to utilize recycled products when available.

c. <u>Public Services</u>

(1) Health Care Facilities

Existing health care facilities would be adequate to service the small population increase resulting from the project. Because of the anticipated daily presence of a considerable number of visitors to the Ocean Center and Visitor Center, an on-site first-aid station would be incorporated into the lobby area of the Ocean Center.

(2) Fire Protection

Fire protection planning for the proposed project would utilize appropriate provisions of the Uniform Fire Code as required by the County of Hawaii Fire Department. Prior to construction the Fire Department would review and approve plans for fire access roads, building access, water supply, fire protection systems and life-safety systems. Minimum fire-flow water requirements will depend on building construction and floor area in accordance with the information provided by the Fire Department in its response to the EIS Notice of Preparation (see Chapter IX).

(3) Police and Security

Facility design criteria include deterrents to the common problems of souvenir collecting and vandalism. These include selection of secure methods of construction and assembly, locks, access locations, fixture size and maintenance.

Overall site security would be enhanced through perimeter fences and conventional lock and key controlled access. Certain areas may also require additional security systems such as alarms or remote video. A full-time on-site security service would be contracted for, and a guard station would be located at the Ocean Center entrance.

(4) Emergency Services

Because of the concentration of visitors and staff at the Ocean Center, a first-aid station is incorporated into the design of the main lobby area. Response to remote on-site emergencies would be facilitated by a system of portable FM radios for communications between emergency and security staff.

d. Recreation

An integral component of the KAD Project is extension of the Wawaloli Beach area by about 10 acres. Physical improvements would include upgrading a portion of the existing jeep trail and provision of parking spaces, landscaping and picnic areas.

e. Community Institutions

(1) Educational Facilities

Impacts to area schools were addressed in the HTDC FEIS. The population growth attributable to development of the exchange parcel would be well within limits previously assessed. The Ocean Center would provide a significant resource to area educational programs. The educational function is a very important part of the Ocean Center concept, and both facilities and staff would be provided to assist in curriculum development and instruction.

The Ocean Center would also be a significant resource for education and research if plans for creation of a new West Hawaii campus of the University of Hawaii in the area are implemented.

(2) Social Services

The small increment of population growth attributable to the proposed project would not significantly impact the availability of social services to the community.

(3) Cultural Facilities

The Archaeological Preserve and portions of the Ocean Center exhibit area would constitute new cultural facilities for area residents and visitors. Enjoyment of these facilities would tend to increase general awareness of and appreciation for other aspects of the natural and cultural environment of West Hawaii.

(4) Commercial Centers

The proposed project would not compete with existing commercial centers, nor would it constitute a commercial center in itself. By providing a unique attraction on the West Hawaii coast it would stimulate patronage of existing commercial centers by staff and visitors alike.

3. NEIGHBORING PROPERTIES

a. Keahole Airport

The Keahole Airport Master Plan (R.M. Towill, 1987) and subsequent analyses projected that passenger traffic at Keahole Airport will increase from 1.49 million passengers in 1985 to 4.68 million passengers in 2005. Considerable facilities expansion and upgrading is thus required. Existing facilities are located in the southern portion of the airport property, and expansion will occur to the north. The runway will be extended from 6,500 ft. to 11,000 ft. to accommodate larger aircraft. The terminal will be expanded from 95,000 sq. ft. to 314,525 sq. ft. All supporting facilities, including taxiways, aprons, parking, ground transportation, airport operations, roadways, and fuel facilities will have to be expanded. Other related facilities, including cargo facilities, commuter airlines, air taxi, heliport, and general aviation, will also require expansion. The improvements are scheduled into three phases extending to the year 2005.

The proposed project would not directly negatively impact Keahole Airport. All structures would conform to height limitations within runway approach zones. The property is industrial and the proposed uses are compatible with anticipated noise levels. Some additional passenger and cargo demand would be generated by the project and its personnel, but these are not significant in view of the airport expansion plans.

The Department of Transportation, Airports Division, is currently preparing an Air Quality and Water Quality Monitoring Program for Keahole Airport expansion. It is likely that the air quality monitoring station would be situated on NELHA property and staffed by NELHA personnel. The water quality portion of this program would be integrated with the CEMP and carried out by NELHA personnel to broaden monitoring coverage along this segment of coastline.

b. 'O'oma II

To the south of the NELHA facility is planned the 'O'oma II development. According to the EIS for that project, it is anticipated to include a 550-room hotel on 22 acres, a 50-room Japanese-style inn, a golf course with clubhouse and driving range (176 acres), 70 golf course house lots (10,000 square feet each), 130-230 condominiums, 35,000 square feet of retail space, six acres of maintenance facilities including a sewage treatment plant, a 19-acre water recreation park including a seven-acre unlined salt water lagoon with a wave-generating machine, a conference center with 100 parking stalls and a 12-acre ocean science center with a restaurant, meeting facilities and 300 parking stalls. The latter component has significant similarities to the proposed KAD Ocean Center, and in consultation with the state and county, the 'O'oma developers have agreed to remove this component from their plans.

Mitigation plans for the resort include a large berm along sensitive areas of the property and a landscaped buffer between the property line and residential areas to aid the transition from industrial to residential and resort uses.

VII. RELATIONSHIP TO LAND USE PLANS, POLICIES AND CONTROLS

VII. RELATIONSHIP TO LAND USE PLANS, POLICIES AND CONTROLS

A. FEDERAL

1. NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA requires preparation of an EIS for major federal actions affecting the environment. The proposed KAD Project has no direct federal involvement, nor does it require any major federal permit. NEPA requirements, therefore, are not triggered. The relevance of NEPA is limited to its service as a model for state EIS legislation, including Hawaii's EIS Law (Chapter 343, HRS).

2. CLEAN WATER ACT

The Clean Water Act established national goals and policies for protection and propagation of fish, shellfish, and wildlife, and the protection of recreational uses. The Act provides for water quality standards and enforcement, permits and licenses. The Act establishes effluent limitations, water quality standards, and pretreatment effluent standards, among others. The State of Hawaii has employed the goals, policies and criteria of the federal Act in establishing its approved Water Quality Standards (Chapter 11-54, HAR), to which the KAD Project and all NELHA operations must conform.

Section 402 of the Federal Water Pollution Control Act Amendments of 1972 established the National Pollutant Discharge Elimination System (NPDES). Recent changes expand the scope of the NPDES program from point source discharges only to non-point source discharges, in particular, those associated with stormwater runoff associated with industrial activities. An NPDES application is now required for "Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not a part of a larger common plan of development or sale." Construction of the KAD Project, or any other project clearing more than five acres, would thus require an NPDES permit.

3. SAFE DRINKING WATER ACT

The Act requires the states to develop primary standards for the protection of public health and secondary standards for the protection of public welfare. The Act also provides for the protection of underground sources of drinking water through the issuance of regulations for state underground injection control programs. NELHA uses drinking water provided by the county which meets all primary and secondary standards. The state Underground Injection Control Program (Chapter 11-23, HAR) establishes protected aquifers into which injection of wastes is prohibited. An Underground Injection Control (UIC) line separates protected aquifers from non-potable aquifers along the coast. The NELHA facilities lie makai of the UIC line, meaning that the Director of Health has determined that the subsurface aquifer is exempted from being used as an USDW (underground source of drinking water). Injection of sewage or certain industrial wastes may be permitted into exempt aquifers.

4. CLEAN AIR ACT

The purpose of the federal Clean Air Act is to protect and enhance the quality of the nation's air resources so as to promote the public health (through primary standards) and welfare (through secondary standards), and the productive capacity of its population. The Act regulates both stationary and mobile sources of air pollution. Primary responsibility for assuring air quality is delegated to the states. Hawaii's Ambient Air Quality Standards are comprise Chapter 11-59, HAR, and its Air Pollution Control Regulations are Chapter 11-60, HAR.

5. ENDANGERED SPECIES ACT

The Act provides for the protection of species of animals and plants that are in danger of extinction and conservation of ecosystems upon which they depend (critical habitat). The NELHA facility neither contains nor would impact any endangered species or critical habitat.

6. NATIONAL HISTORIC PRESERVATION ACT

The Act provides for a National Register of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, and culture. There are no National Register listings on NELHA property.

B. STATE

1. HAWAII STATE LAND USE LAW

State lands are classified into one of four land use districts (Urban, Rural, Agricultural, and Conservation) by the State Land Use Commission (LUC) pursuant to Chapter 205, HRS. NELHA properties are in the Urban district with the exception of the exchange parcel and the coastal lands set aside for public recreation. As part of this action, NELHA has petitioned the LUC to reclassify the exchange parcel, except those portions within a 340-foot wide setback from the certified shoreline, into the Urban District.

Criteria used by the LUC for evaluation of petitions for reclassification include:

(1) The extent to which the proposed reclassification conforms to the applicable goals, objectives, and policies of the Hawaii state plan and the adopted functional plans;

(2) The extent to which the proposed reclassification conforms to the applicable district standards; and

(3) The impact of the proposed reclassification on the following areas of state concern:
    (A) Preservation or maintenance of important natural systems or habitats;
    (B) Maintenance of valued cultural, historical, or natural resources;
    (C) Maintenance of other natural resources relevant to Hawaii's economy, including, but not limited to, agricultural resources;
    (D) Commitment of state funds and resources;
    (E) Provision for employment opportunities and economic development; and
    (F) Provision for housing opportunities for all income groups, particularly the low, low-moderate, and gap groups.

Criterion (1) is specifically discussed below; the elements of criterion (3) are discussed in the appropriate sections of Chapter VI. The standards for determining the Urban District boundaries are found in the Land Use Commission Rules (Section 15-15-18, HAR), and are as follows:

(1) It shall include lands characterized by "city-like" concentrations of people, structures, streets, urban level of services and other related land uses;

(2) It shall take into consideration the following specific factors:
    (A) Proximity to centers of trading and employment except where the development would generate new centers of trading and employment;
    (B) Substantiation of economic feasibility by the petitioner;
    (C) Proximity to basic services such as sewers, transportation systems, water, sanitation, schools, parks, and police and fire protection; and
    (D) Sufficient reserve areas for urban growth in appropriate locations based on a ten year projection;

(3) It shall include lands with satisfactory topography and drainage and reasonably free from the danger of floods, tsunami, unstable soil conditions, and other adverse environmental effects;

(4) In determining urban growth for the next ten years, or in amending the boundary, land contiguous with existing urban areas shall be given more consideration than non-contiguous land, and particularly when indicated for future urban use on state or county general plans;

(5) It shall include lands in appropriate locations for new urban concentrations and shall give consideration to areas of urban growth as shown on the state and county general plans;

(6) It may include lands which do not conform to the standards in paragraphs (1) to (5):
   (A) When surrounded by or adjacent to existing urban development; and
   (B) Only when those lands represent a minor portion of this district;

(7) It shall not include lands, the urbanization of which will contribute toward scattered spot urban development, necessitating unreasonable investment in public infrastructure or support services;

(8) It may include lands with a general slope of twenty percent or more which do not provide open space amenities or scenic values if the commission finds that those lands are desirable and suitable for urban purposes and that official design and construction controls are adequate to protect the public health, welfare and safety, and the public's interests in the aesthetic quality of the landscape.

The NELHA exchange parcel lies adjacent to existing urban, industrial lands comprising the remainder of the HOST Park, Keahole Airport, and to the south, the lands of 'O'oma II, presently also the subject of a petition to be reclassified to urban. Adequate infrastructure and support services are available, or would be made available as part of the proposed project. The site is relatively level and is not subject to unreasonable risks from natural hazards. Preliminary recommendations from the on-going five-year district boundary review are that the coastal areas in the Keahole to Kailua area should be classified urban.

The project would have a positive economic impact on the region and the state. It would create a modest number of jobs and enhance the use and enjoyment of the natural resources of the area.

2. HAWAII STATE PLAN

The overall theme of the Hawaii State Plan (Chapter 226, HRS) is comprised of three principles or values:

(1) Individual and family self-sufficiency;

(2) Social and economic mobility; and

(3) Community or social well-being.

To effect the above principles, the Plan articulates three goals:

(1) A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaii's present and future generations.

(2) A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well-being of the people.

(3) Physical, social and economic well-being, for individuals and families in Hawaii, that nourishes a sense of community responsibility, of caring, and of participation in community life.

The proposed project would diversify the economy by providing a broad range of jobs in construction, education, marine research, and numerous services. It would complement the existing visitor industry in the region. The extension of Wawaloli Beach and the Archaeological Preserve would preserve and enhance the uniqueness of the coastal setting and the nearby cultural resources. The educational and research functions of the Ocean Center would enhance understanding of the marine environment, its role in traditional Hawaiian and modern societies, and community participation in the stewardship of these resources.

The goals expressed in the Plan are intended to be achieved through the adoption of a series of objectives and policies in specific areas. Not all of the objectives and policies have relevance to the proposed project, but those that do are discussed below.

The proposed project would be in accordance with state policies for population by providing "...increased opportunities for Hawaii's people to pursue their physical, social and economic aspirations while recognizing the unique needs of each county." The project would represent "...an increase in economic activities and employment opportunities on the neighbor islands consistent with community needs and desires." It would "[p]romote increased opportunities for Hawaii's people to pursue their socio-economic aspirations throughout the islands." It would "[e]ncourage research activities and public awareness programs to foster an understanding of Hawaii's limited capacity to accommodate population needs...."

With respect to the economy in general, the proposed project would help achieve both state objectives including "[i]ncreased and diversified employment opportunities...," and a "...steadily growing and diversified economic base that is not overly dependent on a few industries." The project would also further at least 13 of the 16 policies in this area.

In Hawaii, aquaculture is considered a component of diversified agriculture and so the economic objective for agriculture of "...growth and development of diversified agriculture...." would be furthered by the Lobster Farm and other future aquaculture farms. The project also would provide support for most of the policies for agriculture including specifically "[e]xpand Hawaii's agricultural base by promoting growth and development of...aquaculture...."

The Ocean Center would contribute toward attainment of the visitor industry objective of an "...industry that constitutes a major component of steady growth for Hawaii's economy." It also would provide support for each of the eight policies for the visitor industry.

Components of the proposed project support the state objectives and policies for encouraging growth industries, specifically the Lobster Farm and other aquaculture farms would "[f]acilitate investment and employment in economic activities that have the potential for growth such as...aquaculture...." The OTEC Plant would "[a]ccelerate research and development of new energy-related industries based on...ocean...resources...." The Lobster Farm, the Ocean Center and the OTEC Plant would "[p]romote Hawaii's geographic, environmental, social, and technological advantages to attract new economic activities..." and "[i]ncrease research and the development of ocean-related economic activities such as...food production and scientific research."

The proposed project would help achieve state objectives and policies for land-based, shoreline, and marine resources. Notably, the project would "[p]romote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes." It would likewise support the objectives and policies for scenic, natural beauty, and historic resources. For example, it would "[p]romote the preservation and restoration of significant natural and historic resources..." and it would "[p]rotect those special areas, structures, and elements that are an integral and functional part of Hawaii's ethnic and cultural heritage. With respect to land, air and water quality, it would promote "[g]reater public awareness and appreciation of Hawaii's environmental resources..." and "[f]oster educational activities that promote a better understanding of Hawaii's limited environmental resources."

The KAD Project would further many of the objectives and policies listed under the facility systems categories, most notably including the policy to "[p]romote research to develop more efficient and economical treatment and disposal of solid and liquid waste..." and the objective of "[i]ncreased energy self-sufficiency."

Most of the objectives and policies in the socio-cultural advancement categories are limited in their relevance to the proposed project, however, the project would contribute to attainment of those in the categories of education, leisure, and culture. Objectives and policies concerning federal expenditures, the information industry, are of little relevance to the proposed project.

3. HAWAII STATE FUNCTIONAL PLANS

The Hawaii State Plan directs the appropriate state agencies to prepare functional plans for their respective program areas. There are fourteen Functional Plans that serve as the primary implementing vehicle for the goals, objectives and policies of the State Plan. The relationships of the proposed project to the various Functional Plans are discussed below.

In its present form, the Agricultural Functional Plan (DOA, 1991) has little relevance to the proposed project. To the extent that aquaculture is considered diversified agriculture, the Lobster Farm and other aquaculture farms would contribute to agriculture development. It is state policy to "[p]rovide suitable public lands at reasonable cost and with long-term tenure for commercial agriculture purposes."

The proposed project is very much in concert with the Conservation Lands Functional Plan (DLNR, 1991). The project, through expansion of the Cooperative Environmental Monitoring Program, would assist in establishment of data bases and inventories of existing lands and resources. The Conservation Lands Plan contains a number of policies and implementing actions supporting aquaculture research and commercial development including provision of business assistance and investment incentives. State policy is to "[l]ocate, preserve and encourage the availability of sites suitable for commercial aquaculture by both private and public sector landowners." HOST Park is being developed specifically for this purpose. It is also state policy to "[e]xpand and enhance outdoor recreation opportunities...." Extension of Wawaloli Beach would further this policy, and its implementing action to "[p]rovide and improve public access to the shoreline...." Both the extension of Wawaloli Beach and the Archaeological Preserve would further state policy to "[d]evelop recreational and archaeological resources on the shoreline and mauka areas...", and the latter would also effect the implementing action to "[a]cquire and/or develop areas for historic preservation." The Ocean Center would further the state objective of "[e]xpansion and promotion of a public conservation ethic through education...", and the policy to [d]evelop and implement educational programs for schools."

The basic goal of the Education functional Plan (DOE, 1989) is to foster academic excellence. The Ocean Center would further this aim in that it would "...develop environmental literacy through direct interaction with dynamic ecosystems...", "...help train the education workforce...", "...use community resources to strengthen implementation of environmental education programs...", and "...develop and expand Business-Education Partnerships." The Archaeological Preserve would "...strengthen multicultural awareness..." and may help the Hawaiian Studies Program. The Ocean Center and Archaeological Preserve would also help implement the objectives and policies of the Higher Education Functional Plan (DOE, 1984) through provision of research facilities and opportunities. This function could be considerable strengthened after construction of the planned West Hawaii Campus of the University of Hawaii.

Employees throughout the KOC would benefit from occupational skill training, a primary objective of the Employment Functional Plan (DLIR, 1989).

The KAD Project, and most specifically the OTEC plant component, would further the objectives of the Energy Functional Plan (DBED, 1991) to "[m]oderate the growth in energy demand through conservation and energy efficiency...", and "[d]isplace oil and fossil fuels through alternate and renewable energy resources." This plan specifically mandates the state to "[c]ontinue support of Ocean Thermal Energy Conversion (OTEC) technology...", and to "[c]ontinue to support the operation of energy research facilities such as the NELH..."

With respect to the Health Functional Plan (DOH, 1989), research to be conducted at the Ocean Center and continuation of the CEMP would further goals in the area of environmental health and protection, and monitoring of environmental quality.

Research already completed on the site, as well as the opportunities afforded by the creation of the Archaeological Preserve, would further the objectives and policies of the Historic Preservation Functional Plan (DLNR, 1991). These include expansion of the statewide historic sites inventory system, protection of known historic sites, development of innovative means to manage historic sites, increased documentation of Hawaii's history, heritage and traditional arts and skills, implementation of programs to disseminate information to the public, and development of site-specific interpretative programs for publicly-owned historic sites.

The Housing Functional Plan (HFDC, 1989) contains a policy to "[e]nsure that projects which impact housing provide affordable rental opportunities for employees." The housing requirement for the development of NELHA is accommodated by the state's Kealakehe project.

The Human Services Functional Plan (DHS, 1989) has little relevance to the proposed project except to the extent that some employees or their family members might require state provided services in this area. The KAD Project would lessen the need for such services through the provision of employment opportunities which would assist families in achieving economic and social self-sufficiency.

One of the primary issue areas of the Recreation Functional Plan (DLNR, 1991) is ocean and shoreline recreation, and the top priority in this area is saturation of beach park capacity. Clearly, extension of Wawaloli Beach as a component of the KAD Project would help alleviate this problem. The project would help prevent loss of public access to recreational resources, would assist in monitoring the quality of the marine environment at key ocean recreation sites, and assist in maintaining existing parks and recreation areas.

The goal of the Tourism Functional Plan (DBEDT, 1991) is steady and balanced growth of the industry. The proposed project would aid this goal as well as help to diversify the industry by providing a quality, environmentally oriented attraction and possibly increase the average length of stay for visitors to the West Hawaii region thereby assisting the State's goal of fully utiling the existing visitor plant inventory. The extension of Wawaloli Beach would lessen competition for limited outdoor recreational resources, and the Archaeological Preserve would help to preserve, protect and interpret historic and cultural resources.

The Transportation Functional Plan (DOT, 1991) includes expansion of Keahole Airport and widening of Queen Kaahumanu Highway as priorities. To the extent that the proposed project impacts these infrastructure resources, the Plan provides mitigating measures:

The Water Resources Development Functional Plan (DLNR, 1984) primarily concerns governmental operations. The Plan presents guidelines for the regulation of the development and use of water to assure adequate supplies in the future; development of water resources to meet municipal, agricultural and industrial requirements and the reduction of flood damage; and preservation of water-related ecological, recreational and aesthetic values and the quality of water resources. All of the state agencies in having facilities in North Kona are being asked to contribute their fair share to enlarge the potable water system to meet potential future needs of those agencies. The agreement is close to execution and some funds will likely be appropriated in the next legislative session (C. Hachmuth, pers. comm.).

4. WEST HAWAII REGIONAL PLAN

The West Hawaii Regional Plan (Office of State Planning, 1989) was prepared because of the state's interest in formulating and implementing a plan for West Hawaii that would (1) coordinate state activities in the region in order to respond more effectively to emerging needs and critical problems, (2) address areas of state concern, (3) coordinate the capital improvements program within a regional planning framework, and (4) provide guidance in the state land use decision-making process. The plan addresses critical topical issues which require state attention in order to most effectively meet the region's present and emerging needs. The West Hawaii Regional Plan is meant to complement the County General Plan and Community Development Plans.

The proposed project would further the following goals of the plan:

- Optimize the use of State owned lands.
- Promote a diversified economic base which maximizes job choice and opportunities.
- Minimize adverse impact of new development on local lifestyles, historic and cultural resources and community values.
- Provide a wide range of outdoor recreational opportunities.

- Support urban developments that maintain the unique character of the West Hawaii region.

- Protect State investment at the Natural Energy Laboratory of Hawaii, the Hawaii Ocean Science and Technology Park....

- Ensure that new development does not adversely impact:
  - agricultural resource activities
  - aquacultural resource activities
  - the quality of the aquifer
  - the quality of nearshore waters (including anchialine ponds)
  - the quality of offshore and deep ocean waters
  - the quality of the air
  - the watersheds

- Develop only within infrastructure capacities and constraints.

- Maintain the diversity of the regions natural and cultural assets.

- Maintain the diversity and character of existing communities.

- Ensure that development does not lead to deterioration in the quality of life.

5. ENVIRONMENTAL QUALITY

State policy on environmental quality is established in Chapter 344, HRS, the purpose of which is to "...encourage productive and enjoyable harmony between man and his environment, promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man, and enrich the understanding of the ecological systems and natural resources important to the people of Hawaii." The proposed project is supportive of policies regarding conservation of natural resources and enhancement of the quality of life. It is also in consonance with guidelines established for management of natural resources, protection of flora and fauna, establishment of historic, cultural and recreational areas for public recreational, educational and scientific uses, appropriate economic development, and encouragement of both formal and informal environmental education for all age groups.

6. HAWAII WATER QUALITY

Coastal water quality is protected by the federal Clean Water Act (33 USC 1251 et. seq.) and the State Environmental Quality Act (Chapter 342, HRS), administered by the Hawaii Department of Health. The two applicable regulations are Water Quality Standards and Water Pollution Control, Chapters 54 and 55 of Title 11, Administrative Rules.

The waters off Keahole are classified AA in the Water Quality Standards. The objective of this class is to keep these waters in their natural pristine state as nearly as possible with an absolute minimum of pollution. Uses to be protected in this classification include oceanographic research.

The Water Pollution Control rules define the requirements for National Pollution Discharge Elimination System (NPDES) permits. The NELH Seacoast Test Facility has a NPDES permit for a small discharge stream.

Groundwater quality is protected under the Hawaii Safe Drinking Water Act (Chapter 340E HRS). Under this Act, rules have been adopted to regulate injection wells (Chapter 23, Administrative Rules, Underground Injection Control). Even though the NELH site is in an exempted aquifer area, that is, designated as unsuitable as an underground source of drinking water, a permit is required from the Department of Health if injection wells are used.

Discharge into a trench, assessed in the NELH FSEIS, is not covered by any specific environmental regulation. NPDES permits apply only to direct discharges to surface waters; a UIC permit is required only for a well, defined as "a bored, drilled or driven shaft, or a dug hole, whose depth is greater than its widest surface dimension." However, Section 33 of Chapter 342 contains a general prohibition against the discharge of any pollutant into state waters, which by definition include ground water.

7. HAWAII COASTAL ZONE MANAGEMENT

The relationship of HOST Park development to the objectives and policies of the Hawaii State Coastal Zone Management Program (HRS 205A-2) was discussed in the HTDC FEIS. The proposed action would not result in reduction of public access to the shoreline, destruction of historic sites or degradation of scenic and open space resources. The Cooperative Environmental Monitoring Program that has been implemented would continue to "improve the technical basis for natural resource management."

The CZM objective relating to coastal ecosystems is to "protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems." Groundwaters, nearshore marine waters and ecosystems and anchaline ponds are being monitored in the CEMP. The proposed project is also in conformance with CZM policies and objectives regarding economic uses, coastal hazards and managing development.

8. HOST PARK MASTER PLAN

The HOST Park Master Plan (R.M. Towill Corp., 1989) was revised to reflect the 83-acre land exchange which resulted in more shoreline acreage and less highway frontage. The Master Plan provides that "Development Plans and Management Programs for HOST Park must be closely coordinated with plans and programs for NELH. The 66-acre KAD

Project which would use approximately 35,000 gpm of seawater is consistent with the goal as stated: "HOST Park will be developed to provide the large lots and large volumes of ocean water -- and other basic infrastructure elements -- that full scale ocean-related commercial activities will require...."; and "The special ocean water resources available at HOST Park should be used as the primary development theme and marketing tool for the Park."

Another area of importance is "...the Master Plan for HOST Park is largely based on an environmental protection, and open space preservation framework...." The project site includes a 340-foot setback from the certified shoreline to be developed as the expansion of Wawaloli Beach and the Archaeological Preserve, both of which provide environmental protection and open space.

A listing of potential uses of HOST Park includes Maine lobster cultivation, and is followed by: "A number of other potential user types...include a visitors' center, a small office building for use by tenants, a university training center focused on ocean-related industrial skills, a restaurant featuring ocean products grown at HOST Park, and an oceanographic research institute." The visitor center, restaurant, research and education programs which would be part of the KAD Project fit well within these categories.

C. COUNTY

1. HAWAII COUNTY GENERAL PLAN

The Hawaii County General Plan (1989) "...is the policy document for the long-range comprehensive development of the island of Hawaii. The General Plan provides the direction for the future growth of the County. It brings into focus the relationship between residents and their pursuits and institutions, offering policy statements which embody the expressed goals for present and future generations."

The General Plan represents the first level in a three-tiered hierarchy. As such, it provided the legal basis for all of the other elements of the County's planning structure. the second level consists of short and middle-range plans which further define the long-range goals of the general Plan. These plans are related to specific regions or districts (eg., Kona), functions or specific areas within regions (eg., Keahole to Kailua). The third level consists of specific mechanisms to implement the two higher levels of the hierarchy. These include the Zoning and Subdivision Codes, and both the operating and capital improvement program budget.

The General Plan assessed resources and needs in thirteen study elements, and articulated goals, policies and standards for their preservation, maintenance and enhancement. The General Plan also contains Land Use Pattern Allocation Guide (LUPAG) Maps which outline thirteen categories of land uses in the County. The proposed project is consistent with the LUPAG map. All of the NELHA properties are classified industrial. The project is also consistent with the goals, policies and standards put forth in the plan. The following discussion highlights where the correspondence is particularly significant.

The proposed project would further the goals and policies of the County with respect to economic development. In particular, its components would further policies to "...encourage the expansion of the research and development industry...", "...encourage the development of a visitor industry which is consistent with the social, physical, and economic goals of the residents of the County....","...encourage the expansion of...various forms of aquaculture, and other...ocean water-based activities....", "...encourage the research, development and implementation of advanced technologies and processes in existing and potential economic endeavors....", and "...encourage development and utilization of by-products from alternate energy conversion projects."

The OTEC Plant component of the KAD Project would further both County goals regarding energy: "[s]trive towards energy self-sufficiency for Hawaii County...." and "[e]stablish the Big Island as a demonstration community for the development and use of natural energy resources. It also would further policies to "...encourage the development of alternate energy resources...." and "...encourage the expansion of energy research industry."

With regard to environmental quality, the existing Cooperative Environmental Monitoring Program (CEMP) will be expanded to include sampling along the shoreline of the exchange parcel. The CEMP furthers the County policy to "...encourage the State to establish...water quality monitoring stations in areas of existing and potential urban growth."

Compliance with goals and policies regarding flood control and drainage would be achieved through application of the appropriate standards. As cited in the Plan, these include the County "Storm Drainage Standards" (1970); "Flood Control" (Chapter 27, Hawaii County Code); "Erosion and Sedimentation Control" (Chapter 10, Hawaii County Code); and applicable standards and regulations of the federal Emergency Management Agency (FEMA).

The proposed Archaeological Preserve would further both County goals for historic sites: "[p]rotect and enhance the sites, buildings and objects of significant historical and cultural importance to Hawaii...." and "[a]ccess to significant historic sites, buildings and objects of public interest should be made available." The Preserve would likewise further a number of relevant policies.

Although the proposed project is largely industrial in character, both the Ocean Center and the extension of Wawaloli Beach would further County goals and policies regarding natural beauty, including "[p]rotect, preserve and enhance the quality of areas endowed with natural beauty, including the quality of coastal scenic resources." Several policies would also be furthered, including "[i]ncrease public pedestrian access opportunities to scenic places and vistas....", and "[a]ccess easement to public or private lands which have natural or scenic value shall be provided or acquired for the public."

The Plan lists six goals in the area of natural resources and shoreline. The KAD project would contribute to each of these, particularly "[p]rovide opportunities for the public to fulfill recreational, economic, and educational needs without despoiling or endangering natural resources." It would also conform to established policies in this area, particularly "[t]he shoreline...shall be maintained for recreational, educational, and/or scientific uses in a manner that is protective of resources and is of the maximum benefit to the general public."

The anticipated level of employment resulting from the proposed project is only a small fraction of that originally expected for the NELHA facilities. Thus impacts on housing would be minimal. Nevertheless, the project, through the State's provision of housing at Kealakehe, conforms to the County policy that "...industries which create a demand for housing shall provide employee housing based on a ratio to be determined by an analysis of the locality's needs."

The County's goals, policies and standards for public facilities focus primarily on actions to be effected by the County itself. Nevertheless, the proposed project would further the policy encouraging underground electrical distribution lines, and that encouraging private sewerage systems for developments along shorelines.

Goals and policies of the County for recreation would be furthered by the Beach Park. Specifically, "[p]ublic access to the shoreline shall be provided in accordance with an adopted program of the County of Hawaii."

Conformity with county aims for transportation would be accomplished through compliance with appropriate standards for streets.

County goals and policies with regard to land use would be complied with through conformity with the uses delineated on the LUPAG Map. This map provides a long-range, graphic expression of the General Plan policies relating to land use. Other factors to be considered in this element are State Land Use District classification, existing zoning, and the zone guide map and interpretation.

In addition to the above goals, policies and standards, the General Plan contains preferred "courses of action" for each district. Relevant actions for North Kona include:

- The County, in order to achieve greater diversity and stability of the economy, shall assist in the further development of agriculture, including aquacultural activities, in North Kona. Necessary capital improvements which will aid agriculture, such as water, should be given priority for funding.

- The County shall continue to encourage development and utilization of by-products from the University of Hawaii's Ocean Thermal Energy Conversion (OTEC) project.

- Reserve, acquire and develop additional public shoreline recreation areas in North Kona.

- Future land uses in the vicinity of the Ke-ahole Airport should be of a compatible nature and/or be compatible with the anticipated aircraft noise exposure levels for that vicinity.

2. KONA REGIONAL PLAN

The Kona Regional Plan, drafted in 1982 and adopted by the County Planning Commission in 1984, has never been acted upon by the County Council. Its guidance is somewhat dated due to the rapid growth which has occurred in the area since its drafting. For all practical purposes, it has been superseded by the K to K Plan discussed below.

3. KEAHOLE TO KAILUA DEVELOPMENT PLAN

The objectives of the Keahole to Kailua Development Plan (K to K Plan) (R.M. Towill Corporation, 1989b) encompassed land use, design, roads, drainage, water, sewer, solid waste, parks and finance. The Plan was adopted by the County Council on April 3, 1991 (Resolution No. 296).

The proposed project is consistent with the K to K Plan in that the Plan recognizes HOST Park as an area to be used for ocean research - commercial and industrial. The land use portion of the Plan states that "HOST/NELH would...together with the Keahole Airport, constitute a significant employment and business "node" at one end of the Keahole to Kailua subregion."

The K to K Plan also shows a waterfront park along the entire coast bordering HOST Park, a feature entirely consistent with the KAD Project. According to the Plan the park would be "passive", and "...would feature paths, trails, scenic viewing areas, interpretive signs, and historical markers. Picnic areas, restroom facilities and parking areas would also be provided." Considering the improvements planned for the Archaeological Preserve as well as the extension of Wawaloli Beach, all of these features would be present.

4. SPECIAL MANAGEMENT AREA (SMA) AND SHORELINE SETBACK

An SMA Use Permit is required for any development as defined by Section 205A-2, HRS), which involves lands within the designated SMA. HOST Park lands, including the exchange parcel lie within the SMA. Granting of an SMA permit by the County Planning Commission is contingent upon finding that:

- The development will not have any significant adverse environmental of ecological effect except as such adverse effect is minimized to the extent practicable and is clearly outweighed by public health, safety, of compelling public interest;

- The development is consistent with the objectives and policies as provided by Chapter 205A, HRS, and the Special Management Area Guidelines (Hawaii County Planning Commission, Rule 9); and

- The development is consistent with the General Plan, Zoning and Subdivision Codes and other applicable ordinances.

Consistency of the HOST Park Development Plan with Chapter 205A, HRS, and Hawaii Planning Commission Rule 9 were discussed in the HTDC FEIS. Both HOST Park and NELH have existing SMA Permits. Consideration was given to consolidation of these permits and inclusion of the exchange parcel, but on the advice of Planning Department staff the present intention is to apply for a third SMA Use Permit for the exchange parcel.

The shoreline setback area is generally forty feet inland from the upper reaches of the waves other than storm or tidal. A Shoreline Setback Variance is required for all proposed construction, improvement, grading, and such related activities within the shoreline setback area. At the time of initial NELH and HOST Park development, projects proposed by government agencies within the shoreline setback area were exempt from the provisions of Planning Commission Rule 8, subject to certain public hearing provisions. This is no longer the case, and a setback variance would be required for work on the extension of Wawaloli Beach and the Archaeological Preserve. This could represent somewhat of a dilemma because Rule 8 has been under revision for some time now, and variances are not being considered pending finalization of the rule. The proposed project would involve no permanent structures within the setback.

5. ZONING AND SUBDIVISION ORDINANCES

The exchange parcel is presently zoned "open". A change of zone to "general industrial" (MG) would be required for the project to proceed. Once the zoning is changed, the proposed uses would be consistent with the code (Hawaii County Code, Chapter 25). HOST Park also has been granted a Planned Unit Development (PUD) permit. The purpose of a PUD is to encourage comprehensive site planning productive of optimum adaptation of development to the land by allowing diversification in the relationships of various uses, buildings, structures, open spaces and yards, building heights, and lot sizes in planned building groups while insuring that the intent of the zoning will be observed. It is anticipated that the PUD would be expanded to include the new parcel and proposed uses.

D. STATUS OF PERMITS AND APPROVALS

The status of the necessary permits and approvals is summarized in Table 3.

TABLE 3
STATUS OF PERMITS AND APPROVALS

PERMIT OR APPROVAL	AGENCY	STATUS
Sublease Approval	BLNR	Approval received for KAD Partners sublease.
District Boundary Amend.	LUC	Application pending.
Chapter 6E Clearance	SHPO	Archaeological mitigation measures have been approved.
Change of Zone	Hawaii Planning Commission	Application being prepared.
SMA Use Permit	Hawaii Planning Commission	Application being prepared.
Shoreline Setback Variance	Hawaii Planning Commission	Application being prepared.
PUD	Hawaii Planning Commission	Application being prepared.
Building, Grading, Etc. Permits	Hawaii Public Works Department	Ministerial permits would be obtained by the general contractor.
Restaurant Plan Review	DOH	To be done after completion of final design.
Species Import Permits	BOA and/or FWS	To be submitted as necessary after final species selections.
Wastewater System Approval	DOH	To be submitted after completion of final design.
NPDES Permit (Grading)	DOH	Application being prepared.

VIII. ENVIRONMENTAL MANAGEMENT CONSIDERATIONS

VIII. ENVIRONMENTAL MANAGEMENT CONSIDERATIONS

A. RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

1. TRADE-OFFS BETWEEN SHORT-TERM LOSSES AND LONG-TERM LOSSES OR VICE VERSA

The undeveloped project area consists of barren lava fields harboring scattered cultural remains along the shoreline near Keahole Point. The area which would be developed for industrial uses is presently non-productive. Without development, its usefulness would be as a visual example of an undisturbed lava field, of which there are many in the region. The location, land ownership and land use designations of the parcel imply future development of facilities such as those described here.

The proposed uses of the land would enhance the productivity of the parcel through food production, energy production, education, scientific research, provision of employment opportunities, provision of economic diversification and revenues for the private and public sectors. Additionally, the long-term productivity of the parcel would be enhanced by the creation of the Archaeological Preserve and extension of Wawaloli Beach.

Short-term losses attributable to the project would be associated with construction. There would be a temporary interruption of recreational access to the shoreline during this period, and emissions of air pollutants and noise would temporarily increase.

Disposal of seawater return flows into shallow trenches behind the shoreline has the potential to impact nearshore biota. This potential has been recognized since the practice was begun on an experimental basis. To date the Cooperative Environmental Monitoring Program has been effective in detecting discharges with the potential for adverse impacts and no long-term adverse impacts have been documented. Seawater return flows from the KAD Project and other aquaculture farms would increase the total disposal volumes. In terms of the monitoring program, this would represent the next increment in the experiment. If adverse impacts are detected, alternative methods of seawater disposal (injection wells or a deep ocean outfall) would have to be implemented. The most serious consequences of disposal would be destruction of coral communities as a result of thermal stress; however, it is anticipated that commingled flows would be warmer than the stress threshold. If thermal stress occurred it would represent a short-term loss of productivity, as once the stress was removed by implementation of an alternative disposal methodology, the habitat would again be suitable for coral colonization and growth.

2. EXTENT TO WHICH ACTION FORECLOSES FUTURE OPTIONS, NARROWS THE RANGE OF BENEFICIAL USES, OR POSES LONG-TERM RISKS TO HEALTH OR SAFETY

The proposed action would foreclose the options to leave the parcel in open space or develop it for other uses. Land ownership, land use designations, and the proximity to Keahole Airport, however, foreclose most other developmental options. The range of beneficial uses of the site would be greatly increased by implementation of the project. No unique or unreasonable long-term risks to health and safety would result from implementation of the project. The typical risks associated with urbanization, including construction, traffic and industrial accidents, could increase. Particular attention would be given to spill prevention, containment and clean-up of the OTEC Plant working fluid in the event a toxic compound such as ammonia is used. Noise from aircraft operations at Keahole Airport would be a chronic nuisance for employees working outdoors, but can be mitigated individually on an as-needed basis.

B. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The development of the exchange parcel would involve the irretrievable commitment of certain natural, fiscal and human resources, some of which are non-renewable. Major resource commitments would include land, money, construction materials, labor and energy. The benefits of the project could not be realized without the commitment of these resources.

1. HUMAN RESOURCES

Human labor would be expended in construction, operation and maintenance of the facilities, but monetary compensation and other benefits would result. Benefits would accrue directly to the construction industry, and indirectly to other sectors of the economy and government. The operation of the project would create new jobs for West Hawaii residents, and diversify the economic base.

2. LAND

The land which would be committed to the project is presently unutilized lava fields. Its use would represent a long-term commitment to an altered land form. The specific uses to which it is put could be altered at some future time, but the natural appearance would be lost. The site is adjacent to airport industrial activities and thus the proposed uses would represent a continuation of an existing land use pattern. The Keahole to Kailua Development Plan foresees urbanization of most of the lands makai of Queen Kaahumanu Highway in this region.

3. WATER

Implementation of the project would increase the demand for and consumption of potable water. This was anticipated in previous EISs, and the County has allotted adequate supplies for the project. Wastewaters would be treated on-site, and the effluents used for irrigation of the landscaping.

4. MATERIAL RESOURCES

The commitment of material resources required to accomplish development of the parcel would include all types of construction materials and supplies. To the extent that it's feasible to do so, the use of recycled products such as "glassphalt" for road paving would be incorporated into the construction materials specifications.

5. ENERGY RESOURCES

Electricity and transportation fuels derived from non-renewable petroleum products would be required for construction and operation of the facility. The demand for electrical power from the HELCO grid would be minimized by the 1 MW OTEC Plant which would power the seawater pumps and possibly provide electricity for other uses as well. Cold seawater would be used as the air conditioning working fluid, minimizing electrical demand from this source. Transportation fuels would be required for shipping purposes, employee commuting and visitor travel.

6. FISCAL RESOURCES

The capital committed to the construction of facilities would be irrevocably committed, but would circulate throughout the economy. Ultimately, the investments by both public and private sector entities would generate income to replace that initially committed.

7. VEGETATION AND WILDLIFE

There are no endangered, threatened or candidate species on the parcel. With the exception of the strand plant community at the coastline, the biotic resources are undistinguished. The strand would be preserved as part of the Archaeological Preserve and Wawaloli Beach. Offshore marine biological resources would be monitored for negative impacts of seawater return flows as part of the CEMP.

8. VISUAL RESOURCES

The visual character of the site is undisturbed lava fields adjacent to industrial and airport uses. The project would change the appearance of the area to a more industrial setting, but the landscaping, particularly surrounding the Ocean Center, would soften the view.

C. UNAVOIDABLE ADVERSE EFFECTS

1. TRAFFIC

There would be an unavoidable increase in traffic during the construction period in order to bring construction equipment, materials and labor to the site. Once operational, the facility would generate traffic by employees, visitors and service vehicles. Even with the projected increases, however, the level-of-service along Queen Kaahumanu Highway would not be lower than "B", in an unsignalized condition.

2. AIR QUALITY

Increased traffic and the use of heavy construction equipment would lead to the temporary generation of emissions from internal combustion engines. Construction activities would lead to increased dust and particulate matter in the air. These impacts would be mitigated by existing governmental regulations concerning air quality. Additional mobile emissions sources (automobiles, buses, trucks, etc.) would frequent the area once its operational.

3. NOISE

Construction and operation of the KAD Project and other aquaculture development would cause additional noise from vehicles and machinery. The site, however, is intended for industrial use, and is in a high ambient noise area due to its proximity to Keahole Airport.

4. VEGETATION

Vegetation in the area is generally sparse and scattered, but construction of the proposed facilities would destroy some of the existing vegetation. Species that are found in the project area also occur in similar habitats throughout the West Hawaii area so there would be minimal impact on the total island populations of the native components. Where possible and appropriate, native species would be used in landscaping.

5. TERRESTRIAL FAUNA

Resident fauna in the areas directly disturbed by construction would be affected. Other fauna inhabiting the site may be temporarily frightened away. The area has a low concentration of wildlife because of its sparse vegetation. There are no known officially designated endangered or threatened terrestrial species that inhabit the project site. Landscaping of the new facilities would create habitat for a variety of animal species, although the typical exotic species associated with urban development would be expected to benefit most.

6. ARCHAEOLOGICAL SITES

Significant sites worthy of preservation and interpretation would be included in the Archaeological Preserve where they would be protected, but available for public use and education. Archaeological sites directly affected by construction activities would be destroyed. Data recovery plans have been prepared for these sites and approved by the DLNR Historic Preservation Division.

7. RECREATIONAL ACTIVITIES

Some disruption of beach recreation can be expected during the construction period due to concerns for public safety, but in the long-term recreational opportunities would be increased as a result of the Ocean Center, Archaeological Preserve and extension of Wawaloli Beach.

D. POSSIBILITY OF ENVIRONMENTAL ACCIDENTS

An environmental accident could result from a catastrophic natural disaster, an aircraft crash into the project, or failure of a critical operational control or system. The latter is unlikely because of the redundancies and alarm systems which would be included in the design of the facilities. The facilities, however, cannot be designed or constructed to be absolutely secure in the event of either of the former. One type of accident which could occur would be release of a toxic substance. An example would be a release of ammonia gas from the OTEC Plant. This type of accident would require evacuation of the immediate area until the gas dispersed. Some loss of wildlife or vegetation could occur. A second type of accident would involve release or escape of an exotic species. A great number of factors would come into play to determine the outcome of such a release. Although one could hypothesize scenarios in which an exotic species could become established in the wild, the plausibility of such a scenario is limited by the following factors. The type of catastrophic accident which would be required to destroy the containment facility would also destroy many of the organisms. If an organism did survive the accident it would have to traverse a considerable distance to the ocean. A significant proportion of the display organisms would require a cold water habitat. Hawaii's warm surface waters would not support breeding populations of these organisms. Likewise, appropriate stocks of food organisms would be unavailable. The organism would have to elude predators, out-compete well-established species for appropriate habitat and food, and in most cases find a mate to reproduce. In some cases the available habitat, even if suitable for the adult of the species, might not support larvae or juveniles of that species. Thus, a scenario envisioning a catastrophic accident leading to establishment in the wild of an exotic species is implausible. Nevertheless, this type of discussion is useful in establishing design standards for the facilities and in selection of species for culture and display.

E. UNRESOLVED ISSUES

There are several unresolved issues surrounding development of the exchange parcel and implementation of the KAD Project. With respect to the entire parcel, the future tenants and uses other than KAD Partners are not known. This is a relatively minor issue, as the purpose of NELHA would determine the appropriateness of a project, and the BLNR must approve all tenants. Expected uses include various types of aquaculture and supporting industries.

A second unresolved issue is the overall build-out rate for NELHA, which would determine when certain impact mitigation measures, for example installation of traffic signals at Queen Kaahumanu Highway, would be required. This is merely an issue of scheduling however, and not whether or not mitigation ultimately would be necessary.

The third unresolved issue is the efficacy of the trench disposal method. All indications from the ongoing CEMP are that the present discharge is having no significant negative impact on marine or anchialine ecosystems in the area. It is expected that increased return flow volumes would present similar impacts to those indicated in the CEMP. It is unknown if the discharge plume from the trenches would intersect the southern group of anchialine ponds, and if it did what the impact to that ecosystem would be. This would be observed through the monitoring program, and if impacts were unacceptable could be reversed through alteration of disposal volumes, locations or methods.

IX. PREPARERS AND CONSULTED PARTIES

IX. PREPARERS AND AGENCIES, ORGANIZATIONS AND INDIVIDUALS CONSULTED IN PREPARATION OF THE EIS

A. PREPARERS

This EIS was prepared by GK & Associates under contract to the Natural Energy Laboratory of Hawaii Authority. The principal author was Mr. George Krasnick. Descriptions of existing facilities and the proposed action were provided by NELHA and KAD Partners. The Annual Report of the Cooperative Environmental Monitoring Program (Appendix B) was written and provided by NELHA. The hydrological analysis (Appendix C) was written by Dr. John Mink under contract to NELHA. The marine biological portions of the CEMP (Appendices D and E) were written by Dr. Richard Brock of Environmental Assessment Company and Dr. Steven Dollar of Marine Research Consultants, respectively. The archaeological excavations report (Appendix F) was written by Mr. William Barrera, Jr. of Chiniago, Inc. The traffic impact assessment (Appendix G) was written by Mr. Phil Rowell of Barton-Aschman Associates.

B. CONSULTED PARTIES

The following agencies, organizations and individuals were provided copies of the Environmental Assessment/Notice of Preparation of EIS for review and comment. Those responding substantively are marked with a double asterisk (**), and their letters and the responses to them are reproduced below in section C. Those responding, but without substantive comment, are marked with a single asterisk (*). Their letters are not reproduced herein.

1. FEDERAL

Advisory Council on Historic Preservation
Department of Agriculture, Soil Conservation Service
** Department of the Army, Army Engineer District
Department of Commerce, National Oceanic and Atmospheric Administration
Department of Energy
* Department of Housing and Urban Development
Department of the Interior, Environmental Services
Department of the Interior, Fish and Wildlife Service
Department of the Interior, Geological Survey
** Department of Transportation, Federal Aviation Administration
* Department of Transportation, Federal Highways Administration
Department of Transportation, United States Coast Guard
Environmental Protection Agency, Region IX
Western Pacific Regional Fishery Management Council

2. STATE ADMINISTRATION

Governor
Board of Directors, High Technology Development Corporation
Board of Directors, Natural Energy Laboratory of Hawaii
Department of Accounting and General Services
** Department of Agriculture
* Department of Budget and Finance
* Department of Defense
Department of Education
** Department of Health
** Department of Land and Natural Resources
** Department of Business, Economic Development and Tourism
Department of Social Services and Housing
** Department of Transportation
** Land Use Commission
** Office of Environmental Quality Control
Office of Hawaiian Affairs
Office of State Planning
University of Hawaii, Department of Oceanography
University of Hawaii, College of Engineering
University of Hawaii, College of Tropical Agriculture
University of Hawaii, Energy Research Coordinator
University of Hawaii, Environmental Center
University of Hawaii, Hawaii Institute of Geophysics
University of Hawaii, Hawaii Institute of Marine Biology
University of Hawaii, Hawaii Natural Energy Institute
University of Hawaii, Pacific International Center for High Tech. Research
University of Hawaii, Sea Grant Marine Advisory Program
University of Hawaii, Water Resources Research Center

3. STATE LEGISLATURE

Senate President
Senators, Island of Hawaii
Senate Committees on Agriculture; Economic Development; Energy; Finance; Tourism and Recreation
House of Representatives, Speaker
Representatives, Island of Hawaii
* (Representative Wayne Metcalf)
House Committees on Agriculture; Finance; Ocean and Marine Resources; Planning, Energy, Ecology and Environmental Protection; Water, Land Use Development and Hawaiian Affairs

4. COUNTY OF HAWAII

Mayor
County Council, Chairman and Members
County Council, Committee on Economic Development
** Fire Department
Housing and Community Development Office
Parks and Recreation Department
** Planning Department
Planning Commission
** Police Department
Public Works Department
Research and Development
** Water Supply Department

5. ORGANIZATIONS AND INDIVIDUALS

Conservation Council, Hawaii Island
Construction Industry Legislative Organization (CILO)
Friends of Kohanaiki
Friends of the Future (Sophie Aoki Robertson)
Hawaii Audubon Society
** Hawaii Electric Light Company (HELCO)
Hawaii Island Board of Realtors
Hawaii Island Chamber of Commerce
Hawaii Leeward Planning Conference
Hawaii Society of Professional Engineers, Big Island Chapter
Hawaiian Electric Industries, Inc.
Hawaiian Telephone Company
Hawaii's Thousand Friends
KAD Partners
Kahala Capital Corporation
Keahole Point Association (Gerry Cysewski)
Kona Board of Realtors
Kona Charter Skippers Association
Kona Coast Chamber of Commerce
Kona Jaycees
Life of the Land
Marine Advisory Program, Hawaii Agent (Howard Takata)
Pacific Ocean Research foundation
Public Access for Shoreline Hawaii (PASH)
Sierra Club, Hawaii Chapter

C. COMMENTS AND RESPONSES TO THE NOTICE OF PREPARATION

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
BUILDING 230
FT. SHAFTER, HAWAII 96858-5440

November 22, 1991

REPLY TO ATTENTION OF:

Planning Division

Ms. Clare Hachmuth
Executive Director
Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

We have reviewed the Supplemental Environmental Impact Statement Preparation Notice (SEISPN) for reclassification of 83 acres of land from conservation to urban at Keahole, North Kona, Hawaii (TMK 7-3-09: 23). The following comments are provided pursuant to Corps of Engineers authorities to disseminate flood hazard information under the Flood Control Act of 1960 and to issue Department of the Army (DA) permits under the Clean Water Act; the Rivers and Harbors Act of 1899; and the Marine Protection, Research and Sanctuaries Act.

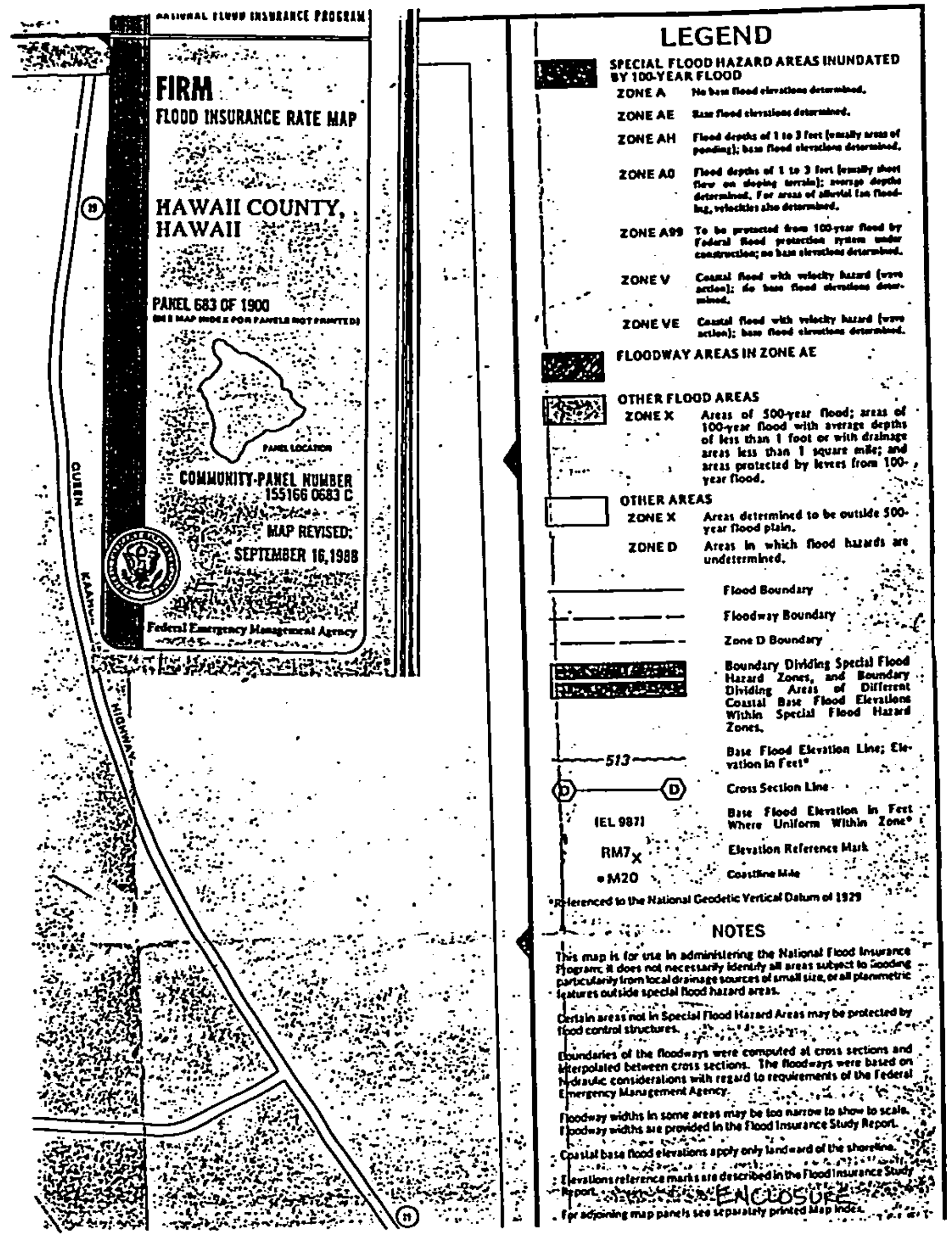
a. The parcel reclassification will not require a DA permit. A DA permit would be required for any work in waters of the United States. For more information on permit requirements, please contact the Operations Division at 438-9258.

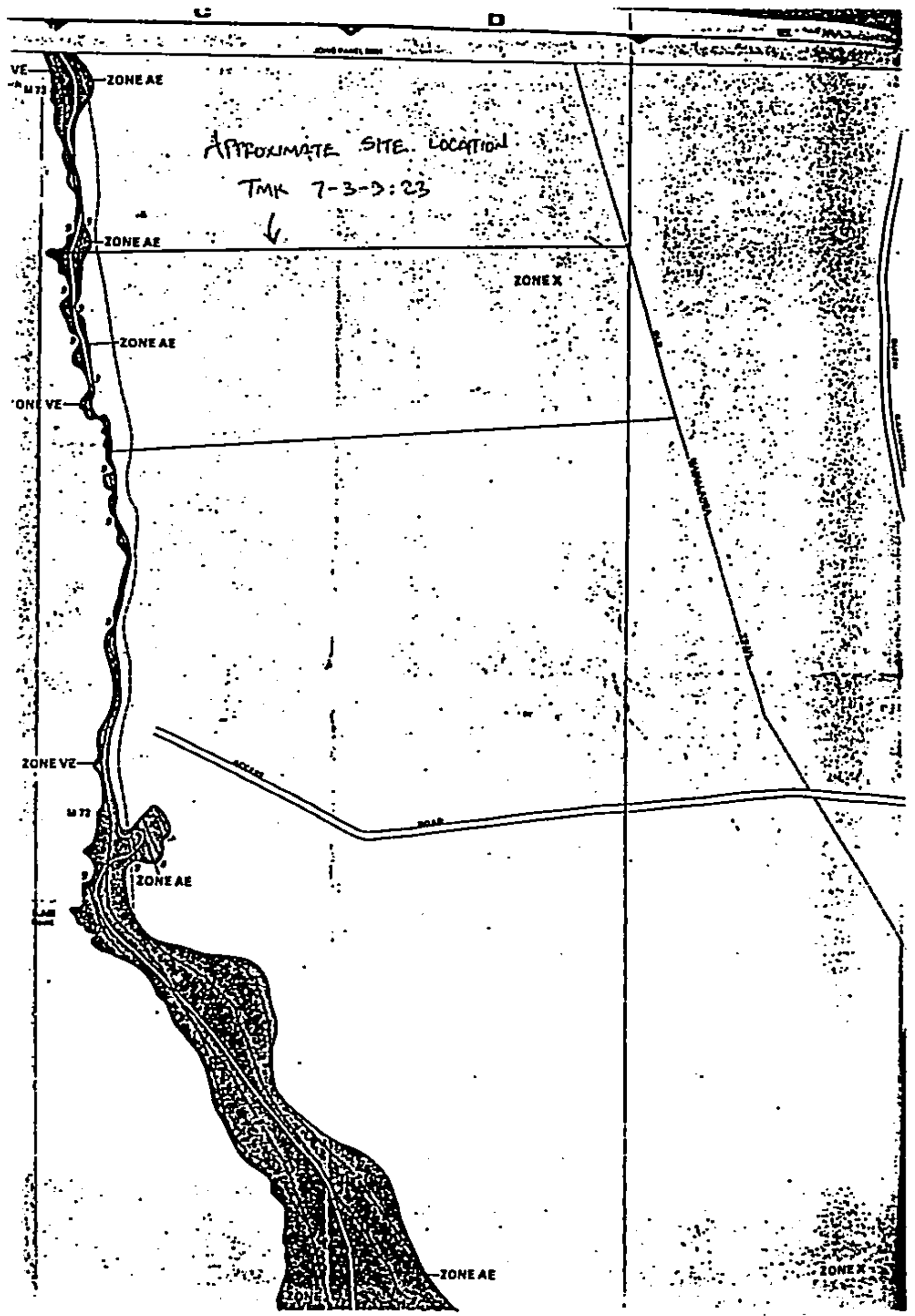
b. According to the Federal Emergency Management Agency's Flood Insurance Rate Map (FIRM), Panel 155166-0683-C, dated September 16, 1988 (copy enclosed), the project site is located in the following zones: Zone AE (areas inundated by the 100-year flood with a base flood elevation of 9 feet above mean sea level); Zone X - unshaded (areas determined to be outside of the 500-year flood plain); and Zone VE (areas inundated by the 100-year flood with velocity hazards and a base flood elevation of 9 feet above mean sea level).

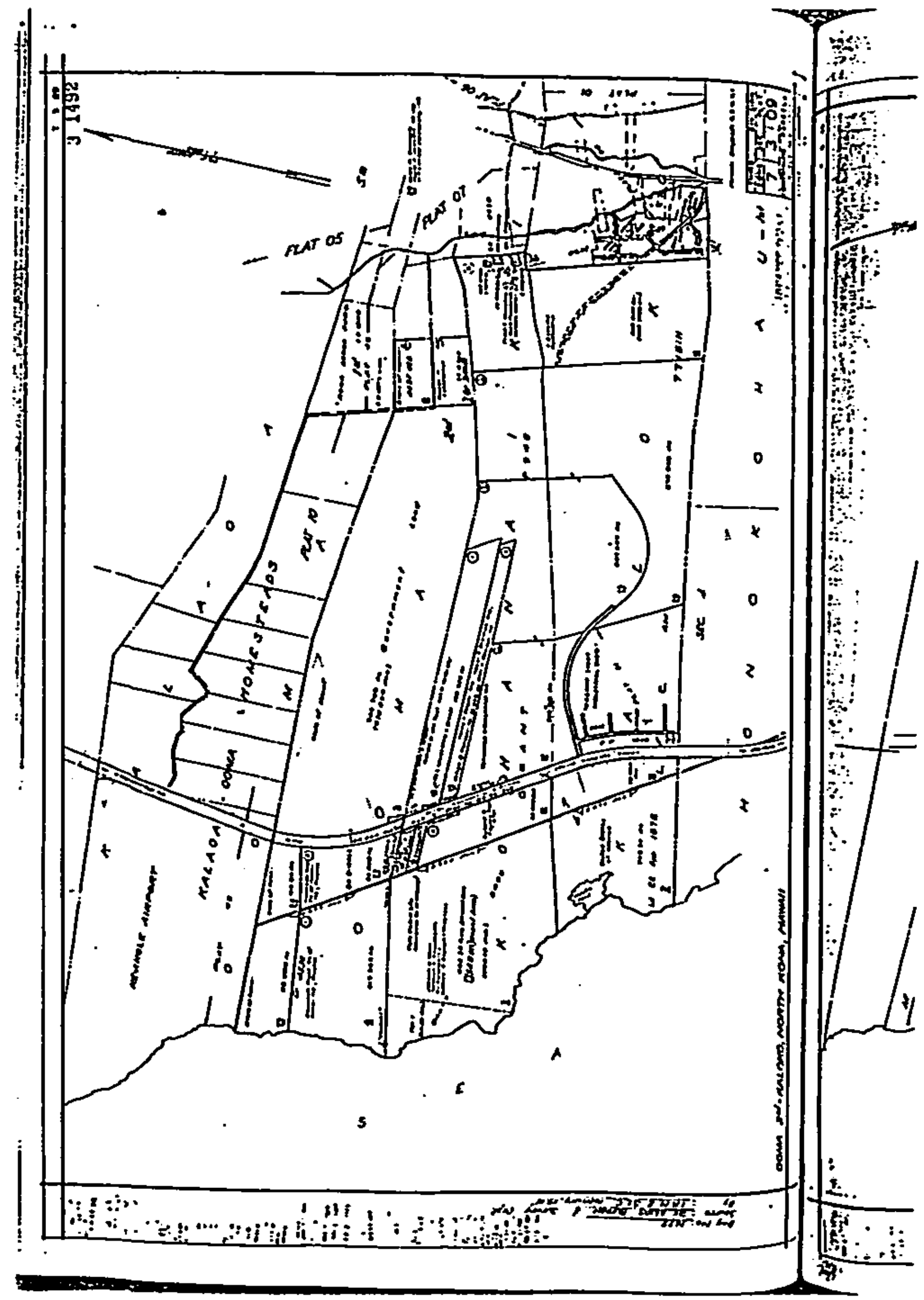
Sincerely,

Kisuk Cheung, P.E.
Director of Engineering

Enclosure




ZONE AE
Approximate site location
TMK 7-3-9:23
ZONE AE
ZONE X
ZONE AE
ZONE VE
ZONE VE
M72
ZONE AE
ZONE AE
ZONE X


3 1492
FLAT 05
FLAT 07
HOMESTEADS
KALAOA
KEAHOLE AIRPORT

NELH — Natural Energy Laboratory of Hawaii

HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Kisuk Cheung, Director of Engineering
U.S. Army Engineer District, Honolulu
Building 230
Ft. Shafter, Hawaii 96858-5440

Dear Mr. Cheung:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for the information contained in your letter of November 22, 1991. We appreciate the constraints of construction in flood zone areas and will apply those constraints during the development of the project.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

Clare Hachmuth

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

U.S. Department of Transportation
Federal Aviation Administration

AIRPORTS DISTRICT OFFICE
BOX 50244
HONOLULU, HI 96850-0001
Telephone: (808) 541-1243
Fax: (808) 541-3462

November 19, 1991

Ms. Clare Hachmuth
Executive Director
Natural Energy Laboratory
of Hawaii Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

We have reviewed the Notice of Preparation of Supplemental Environmental Impact Statement (NPSEIS) prepared for the NELH to reclassify 83 acres from conservation to urban adjacent Keahole Airport.

We note that this parcel is impacted by aircraft noise as detailed in the Keahole Airport Noise Compatibility Program (NCP) with a portion lying within the 70 Ldn noise contour. To preserve the land use compatibility for this parcel, we have enclosed Table 6 of the NCP which denotes suggested standards for use in aircraft noise exposure areas. These standards, incorporated in the SEIS and subsequent development, will help to preserve the land use compatibility of this parcel.

If you have any questions regarding our review, please call us.

Sincerely,

David J. Welhouse

David J. Welhouse
Airport Engineer/Planner

Enclosure

cc: (w/o encl.)
MCH Consulting (Marilyn Metz)
Land Use Commission (Ester Ueda)

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SUGGESTED LAND USE COMPATIBILITY STANDARDS IN AIRCRAFT NOISE EXPOSURE AREAS

The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Land use	Ldn 55 to 65	Ldn 65 to 70	Ldn 70 to 75	Over Ldn 75
Residential:				
Residential, other than mobile homes and transient lodgings	Compatible[a]	NLR required[b]	NLR required[b]	Incompatible
Mobile homes	Compatible[a]	Incompatible	Incompatible	Incompatible
Transient lodgings	Compatible[a]	NLR required[b]	NLR required[b]	Incompatible
Public use:				
Schools, hospitals, and nursing homes	Compatible[a]	NLR required[b]	Incompatible	Incompatible
Churches, auditoriums, and concert halls	Compatible	NLR required[b]	NLR required	Incompatible
Governmental services	Compatible	Compatible	NLR required	NLR required
Transportation	Compatible	Compatible	Compatible[c]	Compatible[c]
Parking	Compatible	Compatible	Compatible[c]	Compatible[c]
Commercial use:				
Offices, business, and professional	Compatible	NLR required	NLR required	NLR required
Wholesale and retail—building materials, hardware, and farm equipment	Compatible	Compatible	Compatible[c]	Compatible[c]
Retail trade—general	Compatible	NLR required	NLR required	NLR required
Utilities	Compatible	Compatible	Compatible[c]	Compatible[c]
Communication	Compatible	NLR required	NLR required	NLR required
Manufacturing and production:				
Manufacturing, general	Compatible	Compatible	Compatible[c]	Compatible[c]
Photographic and optical	Compatible	Compatible	NLR required	NLR required
Agriculture (except livestock) and forestry	Compatible	Compatible	Compatible	Compatible
Livestock farming and breeding	Compatible	Compatible	Compatible	Incompatible
Mining and fishing resources production and extraction	Compatible	Compatible	Compatible	Compatible
Recreational:				
Outdoor sports arenas and spectator sports	Compatible	Compatible	Compatible	Incompatible
Outdoor music shells, amphitheaters	Compatible	Incompatible	Incompatible	Incompatible
Nature exhibits and zoos	Compatible	Compatible	Incompatible	Incompatible
Amusements, parks, resorts, and camps	Compatible	Compatible	Compatible	Incompatible
Golf courses, riding stables, and water recreation	Compatible	Compatible	Compatible	Incompatible

Ldn = Yearly Day-night Sound level in decibels.

Compatible = Generally, no special noise attenuation materials are required to achieve an interior noise level of Ldn 45 in habitable spaces, or the activity (whether indoors or outdoors) would not be subject to a significant adverse effect by the outdoor noise level.

NLR = Noise Level Reduction. NLR is used to denote the total amount of noise transmission loss in decibels required to reduce an exterior noise level in habitable interior spaces to Ldn 45. In most places, typical building construction automatically provides an NLR of 20 decibels. Therefore, if a structure is located in an area exposed to aircraft noise of Ldn 65, the interior level of noise would be about Ldn 45. If the structure is located in an area exposed to aircraft noise of Ldn 70, the interior level of noise would be about Ldn 50, so an additional NLR of 5 decibels would be required if not afforded by the normal construction. This NLR can be achieved through the use of noise attenuating materials in the construction of the structure.

Incompatible = Generally, the land use, whether in a structure or an outdoor activity, is considered to be incompatible with the outdoor noise exposure, even if special attenuating materials were to be used in the construction of the building.

a. In climates where existing structures have thin, single-wall construction with minimal insulation, the Ldn 55 to 65 area may not be compatible without additional noise level reduction incorporated into the design and construction. However, it should be noted that in many urban areas, the ambient noise level may be above Ldn 45, so structures in the Ldn 55 to 65 area must be evaluated on a case-by-case basis.

b. The land use is generally incompatible and should only be permitted in areas of infill in existing neighborhoods or where the community determines that the use must be allowed.

c. NLR required in offices or other areas with noise-sensitive activities.

Source: Peat, Marwick, Mitchell & Co., as derived from the U.S. Department of Transportation, Federal Aviation Administration, Federal Aviation Regulations (FAR) Part 150, "Airport Noise Compatibility Planning," Code of Federal Regulations, [illegible] Part 150, Table 1, January 19, 1985.

NELH — Natural Energy Laboratory of Hawaii

HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. David J. Welhouse, Airport Engineer/Planner
Federal Aviation Administration
Airports District Office
PO BOX 50244
Honolulu, Hawaii 96850-0001

Dear Mr. Welhouse

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of November 19, 1991, and the attached information. We have reviewed the Noise Compatibility Program, and it appears that the proposed aquaculture and OTEC power plant uses are compatible with the projected noise levels. In the case of the aquarium, noise reduction techniques may be required to mitigate potential impacts to the occupational environment and the quality of the visitor experience.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

Clare Hachmuth

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

JOHN WAIHEE
GOVERNOR

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 So. King Street
Honolulu, Hawaii 96814-2512

YUKIO KITAGAWA
CHAIRPERSON, BOARD OF AGRICULTURE

ILIMA A. PIIANAIA
DEPUTY TO THE CHAIRPERSON

FAX: 548-6100

Mailing Address:
P. O. Box 22159
Honolulu, Hawaii 96823-2159

December 6, 1991

Ms. Clare Hachmuth
Executive Director
Natural Energy Laboratory of Hawaii Authority
P. O. Box 1749
Kailua Kona, Hawaii 96745

Dear Ms. Hachmuth:

Subject: Supplemental Environmental Impact Statement Preparation Notice for State Land Use District Boundary Reclassification of an 83-acre Parcel of Land in Kailua-Kona
TMK: 7-3-09: 23

The Department of Agriculture has reviewed the subject document and offers the following comments.

According to the document, the purpose of the proposed reclassification of the property from the Conservation to the Urban District is to subdivide and improve the property and make most of it available for the same types of projects that are presently allowed on the existing NELH and HOST Park property.

We recommend that the Environmental Impact Statement address our concern that there be no release of exotic diseases, micro-organisms, and other aquatic biota into the ocean via the disposal of the deep seawater effluent from the proposed facilities. According to our information, recent discoveries of freshwater aquifers along the Kona coast may indicate that the injection disposal of effluent may result in a more direct entry into the ocean than previously believed. Similarly, we recommend that should the use of trenches to dispose of effluent be considered, the trench area should be secured by perimeter fencing or an equivalent means to reduce the likelihood that exotic species be inadvertently removed and released into the open ocean.

Should you have further questions, please call me at 973-7102, or my staff at the Plant Quarantine Branch at 548-7175.

Thank you for the opportunity to comment.

Sincerely,

Yukio Kitagawa
YUKIO KITAGAWA
Chairperson, Board of Agriculture

c: MCM Consulting
703 Honua Street
Honolulu, Hawaii 96819

State Land Use Commission
355 Merchant Street
Room 105
Honolulu, Hawaii 96813

Mr. Larry Nakahara, Manager
Plant Quarantine Branch
Plant Industry Division

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
MANABU TAGOMORI
Dan T. Kochi

REF:OCEA:SKK

DEC 18 1991

File No.: 92-344
Gov. Ref. No.: 91:610-18
Doc. No.: 2258R

Ms. Clare Hachmuth
Executive Director
Natural Energy Laboratory of Hawaii
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

Governor Waihee asked me to respond to your letter relative to your upcoming Supplemental Environmental Impact Statement for the NELH State Boundary Amendment from the Conservation district to the Urban district.

You plan to expand the existing NELH facilities at Keahole Point, Hawaii by reclassifying 83 acres of an adjacent property for Conservation to Urban. According to the submitted EIS preparation notice, ten acres of the parcel fronting the shoreline will be reserved for public recreational activities and 73 acres will be subleased for various commercial activities, similar to the current ongoing programs at NELH.

Our department's Aquatic Resources Division suggests that the Supplemental EIS discuss in detail any new potential short-term impacts related to the expansion of the NELH facility (i.e. slant drilling, blasting, etc.) and longterm effects that may adversely affect aquatic resources values.

The Supplemental EIS should also cover the specific access provisions (details of pedestrian and parking easements; provision for transit and fishing along the shore.

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Ms. C. Hachmuth -2- File No.: 92-344
Gov. Ref. No.: 91:610:18

Further, all planned shoreline improvements and modifications should be adequately described in the Supplemental EIS for review by the Department.

Our Department's State Parks Division recommends that the 10 acres within the 30-foot setback from the shoreline be retained in the Conservation District. This would be consistent with Conservation District objectives. Specifically, the protection of coastal recreation resources and native coastal plant communities found at the site.

The likely effect that the proposed boundary amendment will have on the coastal wildland environment also needs to be addressed. In addition, a more detailed description of the flora is required to adequately assess the likely effect this proposal will have, particularly on the native coastal plant communities that occur along the shoreline.

We appreciate this early opportunity to offer our suggestions and hope that our comments and recommendations have been helpful. We look forward to reviewing the draft document when it is completed. Also, our Historic Preservation Division will submit comments in a separate letter.

Please feel free to call me or Sam Lemmo at our Office of Conservation and Environmental Affairs, at 587-0377, should you have any questions or are in need of assistance.

Very truly yours,

WILLIAM W. PATY

cc: Governor's Office

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. William W. Paty, Chairman
State of Hawaii
Department of Land and Natural Resources
P.O.Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 18, 1991. The proposed action has several diverse, but integrated, components which will be described in the Supplemental EIS. In accordance with Chapter 343, HRS (Hawaii's EIS Law), to the extent that the proposed action, its potential impacts or recommended mitigation measures differ significantly from those contained in previous EISs for the Natural Energy Laboratory of Hawaii and the Hawaii Ocean Science and Technology (HOST) Park they will be thoroughly assessed. In response to the comment from your Aquatic Resources Division, however, please be aware that many aspects of this action (OTEC, cold-water aquaculture, slant drilling, etc.) have been the subject of prior assessments and impact statements which have been reviewed by your department. Much of the development proposed for the new land areas consists only of relocation of actions earlier proposed and environmentally assessed for NELH and HOST Park lands. The relevant Environmental Assessments and Environmental Impact Statements will be incorporated by reference in the supplemental document.

Proposed shoreline improvements and plans for their ongoing operation and maintenance will be described in the SEIS. It is anticipated that these areas would remain in the Conservation District.

The land area received in the exchange with the neighboring 'O'oma II development was included in a botanical field reconnaissance in 1986 as part of the EIS for that project. The report[1] detailed the composition of the shoreline strand vegetation.

---

[1] Char and Associates. 1986. *Biological Survey: Proposed 'O'oma II Project, North Kona, Island of Hawaii.* Appendix D in 'O'oma II Final EIS (Helber, Hastert, Van Horn & Kimura).

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

Clare Hachmuth

CLARE HACHMUTH
Executive Director

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Yukio Kitagawa, Chairperson
State of Hawaii
Board of Agriculture
1428 South King Street
Honolulu, Hawaii 96814-25112

Dear Mr. Kitagawa:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 6, 1991. The below paragraphs respond to your specific comments.

Comprehensive measures are being developed to insure that there is no release of exotic diseases, micro-organisms or other aquatic biota into ocean waters. These measures may include filtration, ozonation or other methodologies, singly or in combination. These measures will require your approval prior to granting of any species import permits. As you suggest, disposal areas will be secured by perimeter fencing.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

Clare Hachmuth

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

JOHN C. LEWIN, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:
91-323/epo

January 7, 1992

Ms. Clare Hachmuth
Executive Director
Natural Laboratory of Hawaii
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

Subject: Supplemental Environmental Impact Statement Preparation Notice
83 Acre Parcel Rezoning from Conservation to Urban
Keahole, North Kona, Hawaii

Thank you for allowing us to review and comment on the subject request. We have the following comments to offer:

Water Pollution

1. A storm water National Pollutant Discharge Elimination System (NPDES) permit application is required for construction activities which involve the clearing, grading, and excavation of more than five (5) acres of total land area. This application should be submitted to the Director of Health at least 90 days before the date on which construction is to commence.

2. A copy of the Comprehensive Environmental Monitoring Program cited on page 13 of the subject document should be transmitted to the Clean Water Branch for review and comment.

If you have any questions on this matter, please contact Mr. Mark Tomomitsu, Engineering Section of the Clean Water Branch, at 586-4309.

Solid Waste

As this project will be funded and coordinated by a state agency, all tenant leases should include a requirement to provide adequate space for waste diversion activities and develop an internal operational plan aimed at achieving the state goals as established by Act 324-91 (Integrated Solid Waste Management Act).

Ms. Clare Hachmuth
January 7, 1992
Page 2

91-323

If you should have any questions on this matter, please contact Mr. John Harder of the Office of Solid Waste at 586-4227.

We will be commenting in more detail when we review the draft Environmental Impact Statement (EIS). I am also attaching our comments addressed to Mr. Norman Hayashi, Hawaii County Planning Department, regarding the request for a State Land Use Boundary Amendment.

Very truly yours,

JOHN C. LEWIN, M.D.
Director of Health

Enc.

c: Solid Waste Office
Clean Water Branch
HCM Consulting
Land Use Commission

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Dr. John C. Lewin, Director
State of Hawaii
Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801

Dear Dr. Lewin:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of January 7, 1992. The following paragraphs respond to your comments.

As you suggest, we have been in contact with your Clean Water Branch to ascertain the current requirements for an NPDES permit for construction activities, and these will be complied with.

The Comprehensive Environmental Monitoring Program was developed in response to various conditions attached to several state and county permits. The Program was finalized in 1989, and implemented that year. Your agency participated in the review of the various drafts of the CEMP and is on the distribution list for quarterly and annual reports. The most recent annual report was distributed in March.

We have been in contact with your Office of Solid Waste and have received a list of various potential components of a solid waste management strategy. These recommendations and appropriate provisions of the Act will be integrated to the extent possible in the master plan for the development.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE HISTORIC PRESERVATION DIVISION
33 SOUTH KING STREET, 6TH FLOOR
HONOLULU, HAWAII 96813

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
KEITH W. AHUE
MANABU TAGOMORI
DAN T. KOCHI

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER RESOURCE MANAGEMENT

January 7, 1992

LOG NO: 4116
DOC NO: 3313C

Clare Hachmuth, Executive Director
NELH Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

SUBJECT: Supplemental EIS Prep Notice -- Ooma 2 Lands
Ooma, North Kona, Hawaii (OCEA File No: 92-284)

This letter is long overdue, so our Office of Conservation and Environmental Affairs (OCEA) asked us to respond separately.

At this point, you have worked closely with our staff on this project area, so we have minimal concerns. Mr. Barrera's revisions on his work will be needed, to address several of the points on the function of the mounds (no longer burials) and thus enable significance and mitigation to be fixed. Otherwise, the general mitigation plans are quite clear.

Sincerely,

DON HIBBARD, Administrator
State Historic Preservation Division

RC:jle

cc: Marilyn Metz, HCM Consulting
Ester Ueda, State LUC
OCEA File 92-284

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Don Hibbard, Administrator
State of Hawaii
Department of Land and Natural Resources
Historic Preservation Division
33 South King Street, 6th Floor
Honolulu, Hawaii 96813

Dear Mr. Hibbard:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of January 7, 1992. Since that date, Mr. Barrera has completed his work, and his assessments of significance and proposed mitigation which were transmitted to you have been reviewed and approved.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

Central Pacific Plaza, 220 South King Street, 11th Floor, Honolulu, Hawaii
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804 Telephone: (808) 586-2406 Fax: (808) 586-2377

JOHN WAIHEE
Governor
MURRAY E. TOWILL
Director
BARBARA KIM STANTON
Deputy Director
RICK EGGED
Deputy Director
TAKESHI YOSHIHARA
Deputy Director

December 6, 1991

Natural Energy Laboratory of Hawaii
P. O. Box 1749
Kailua-Kona, Hawaii 96745

ATTENTION: Clare Hachmuth
Executive Director

SUBJECTt: Supplemental Environmental Impact Statement Preparation Notice

Dear Ms. Hachmuth: Clare

Thank you for the opportunity to review and comment on your Supplemental Environmental Impact Statement Preparation Notice on behalf of the Department of Business, Economic Development and Tourism (DBED). My comments are as follows:

DESCRIPTION OF PROPOSED ACTION. DBED is primarily concerned that the entire project proposed by KAD Partners, sublessors of NELHA, is set out in its entirety in the Supplemental Environmental Impact Statement.

INFRASTRUCTURE - Water Service. Please discuss in detail in your SEIS your plans and solutions to obtaining additional sources of fresh water to support proposed plans. Although you state that the County of Hawaii's Department of Water Supply has allocated 400,000 gallons per day to NELHA and this is a sufficient allocation. Please indicate what documentation is used to substantiate this statement.

WASTEWATER TREATEMENT AND DISPOSAL. Please set out in detail in your SEIS what determination is used by you to indicate that septic tanks would be the acceptable treatment of waste, since the county of Hawaii does not have a municipal waste system. Please explain this in anticipation of KAD Partners proposals for commercial usage adding domestic sewage and disposal of non-domestic waste water and other industrial wastes as well.

You state in your preparation notice that until the municipal system is ready, septic tanks are acceptable, and any industrial wastes are the responsibility of the individual tenant. Please explain in your SEIS how you plan to implement and enforce this requirement of your tenants.

COASTLINE ACCESS AND BEACH RIGHT-OF-WAY. In your SEIS, please explain and outline how you plan to address the cumulative impacts of full development and other developments in the area on the accessability of the beaches and ocean to the public. Also, address how you plan to answer concerns of the public's perception that the coastline is off limit to the public and the area is subject to overdevelopment.

HOUSING. Please outline in your SEIS how you plan to minimize the impact to the housing inventory, which is extremely limited in this area. Also indicate what provisions will be made to house project workers.

Thank you for the opportunity to review and respond.

Sincerely,

Murray

Murray E. Towill

cc: Marilyn Metz, MCM Consulting
Esther Ueda, LUC

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Murray E. Towill, Director
State of Hawaii
Department of Business, Economic Development & Tourism
P.O. Box 2359
Honolulu, Hawaii 96804

Dear Mr. Towill:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 6, 1991. The following paragraphs respond to your specific comments.

A complete description of KAD Partners "Kona Ocean Center," including its OTEC, aquaculture and aquarium components, will be provided in the EIS.

Water demand projections will be provided in the EIS.

Management and disposal of wastewaters from the various sources will be discussed in the EIS. The Keahole to Kona Development Plan indicates that sewage from NELHA will be treated at the proposed Sewage Treatment Plant No. 2 to be constructed 2.5 miles north of Keahole Airport. According to correspondence from Dr. John Lewin, Director of Health to Mr. Norman Hayashi, Hawaii County Planning Director, relative to the State Land Use Boundary Amendment Application...

> Until Sewage Treatment Plant No. 2 is completed, septic tanks will be an acceptable treatment method, provided that the system meets all of the applicable requirements of the Department of Health (DOH) Administrative Rules, Chapter 11-62, "Wastewater Systems." In addition, detailed plans for both domestic and non-domestic wastewater treatment/disposal must be submitted to and approved by DOH.

The existing NELHA Facility Use Manual provides for mitigation of potential impacts from industrial wastes. These rules and the management options will be explained in the EIS. Further safeguards will result from expansion of the Comprehensive Environmental Monitoring Program which is designed to detect impacts and provide management options with which to mitigate these impacts.

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

The existing HOST Park Special Management Area Permit will be amended to include the new areas. This permit addresses shoreline accesses and impacts. We do not have any indication that the public now perceives the shoreline area as off-limits, and in fact it receives substantial and varied use. Additional facilities will be constructed to facilitate public use of the shoreline areas.

With the proposed project, employment at NELHA will remain below the projections given in prior EISs. Impacts, therefore, will be within the range previously assessed. The housing needs associated with development of HOST Park and NELH were factored into the sizing of the State's Kealakehe Housing Project.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

Clare Hachmuth

CLARE HACHMUTH
Executive Director

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

EDWARD Y. HIRATA
DIRECTOR

DEPUTY DIRECTORS
AL PANG
JOYCE T. OMINE
JEANNE K. SCHULTZ
CALVIN M. TSUDA

IN REPLY REFER TO:
HWY-PS
2.9892

November 26, 1991

Ms. Clare Hachmuth
Executive Director
Natural Energy Laboratory
of Hawaii Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

Supplemental Environmental Impact Statement
Preparation Notice, Natural Energy Laboratory
of Hawaii Authority 83 Acre Parcel Rezoning,
Keahole, North Kona, Hawaii, TMK: 7-3-09: 23

Thank you for your letter of November 8, 1991, requesting our comments on the subject supplemental environmental impact statement.

The proposal to reclassify 83 acres of land that was gained in a land swap with Kahala Capital Corporation will not impact our State highway facilities.

Please note that we intend to improve Queen Kaahumanu Highway into a high-speed four-lane divided highway with access via frontage roads at interchanges. At that time, the Hawaii Ocean Science & Technology Park access road will have to connect to a frontage road and access Queen Kaahumanu Highway at the Keahole Airport interchange.

You are also expected to participate in the funding of regional roadway improvements, such as the widening of Queen Kaahumanu Highway, on a prorata basis as determined by the State Department of Transportation.

Very truly yours,

Edward Y. Hirata
Director of Transportation

✓bc: Ms. Marilyn Metz
MCM Consulting
703 Honua Street
Honolulu, Hawaii 96816

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Edward Y. Hirata, Director
State of Hawaii
Department of Transportation
869 Punchbowl Street
Honolulu, Hawaii 96813-5097

Dear Mr. Hirata:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, THK No.: 7-3-09:23.

Thank you for your letter of November 26, 1991 noting planned improvements to Queen Kaahumanu Highway fronting the project site. A traffic impact assessment is being prepared as part of the EIS process. This will identify any interim improvements to the intersection necessary to maintain an adequate level-of-service prior to upgrading of Queen Kaahumanu Highway.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813
Telephone: 548-4611

November 7, 1991

Mr. Brian Choy, Director
Office of Environmental
Quality Control
Central Pacific Plaza
220 S. King Street, 4th Fl.
Honolulu, Hawaii 96813

Dear Mr. Choy:

Subject: Notice of Preparation of Supplemental Environmental Impact Statement (NPSEIS) for The Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, THK No.: 7-3-09:23

We have reviewed the subject NPSEIS for the Natural Energy Laboratory of Hawaii Authority and have the following comments:

1. We suggest that the draft Supplemental Environmental Impact Statement (DSEIS) contain a detailed discussion on the role of the KAD project within the overall NELHA and HOST complex, as well as on the project itself, including the operations of the OTEC plant and lobster farm, visitor projections of the proposed oceanarium and visitor center, traffic generation studies, market studies, impacts to the proposed O'oma project and the Keahole airport, and background information on the sublessors, KAD Partners.

2. The DSEIS should also include detailed information on the cumulative regional impact of the proposed uses on the existing infrastructure, population, and coastal/aquatic resources.

3. On page 8 of the NPSEIS, it is mentioned that two species of endemic Hawaiian birds are known to exist in the coastal area of the subject property, and that development of the property is not expected to impact the habitat of either species. The DSEIS should explain the basis for this finding.

If you have any questions, please call me or Bert Saruwatari of our office at 587-3822.

Sincerely,

ESTHER UEDA
Executive Officer

EU:to

Enclosures

cc: Clare Hachmuth
Marilynn Metz
DBED

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

April 24, 1992

Ms. Ester Ueda, Executive Officer
State of Hawaii
Land Use Commission
335 Merchant Street, Room 104
Honolulu, Hawaii 96813

Dear Ms. Ueda:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of November 7, 1991. The following paragraphs reference your numbered comments.

1. A description of the proposed physical facilities and operations of the KAD project (Kona Ocean Center) will be contained in the EIS. To the extent that there are differences in the operations of the OTEC power plant and the aquaculture component from those envisioned in prior EISs, they will be disclosed. It should be recognized, however, that much of the proposed project falls within the envelope of impacts previously assessed. In particular, the OTEC and aquaculture components have been addressed in prior EISs. Visitor projections will be provided, and traffic impact studies based on these projections will be included. Impacts of the project on surrounding land uses will be addressed. Background information on KAD Partners will be presented to the extent appropriate to establish the capabilities of the organization to construct and operate the facilities in an environmentally compatible manner.

2. To the extent that they exceed those previously addressed in accepted EISs, the cumulative impacts of the project will be disclosed.

3. Impacts to endemic fauna will be assessed in the EIS.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
220 SOUTH KING STREET
FOURTH FLOOR
HONOLULU, HAWAII 96813

December 5, 1991

Ms. Clare Hachmuth
Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

Subject: Notice of Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole, North Kona, Hawaii

Thank you for the opportunity to review the subject document. We have the following comment:

- On page 12 of the subject document, you describe that under the worst case scenario the computed soil erosion rate is considerably lower than the allowable rate. Please disclose the computed soil erosion rate that is mentioned above.

Sincerely,

for BRIAN J. J. CHOY
Director

BC:jt

c: MCM Planning
State Land Use Commission

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Brian J. J. Choy, Director
State of Hawaii
Office of Environmental Quality Control
220 South King Street, Fourth Floor
Honolulu, Hawaii 96813

Dear Mr. Choy:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 5, 1991. We will include a further discussion of the computed soil erosion rate in the EIS.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

Fire Department

466 Kinoole Street • Hilo, Hawaii 96720-2983 • (808) 961-8297 • Fax (808) 961-6920

Lorraine R. Inouye
Mayor
Daniel Ayala
Fire Chief
Harding Fragas, Jr.
Deputy Fire Chief

December 4, 1991

Ms. Clara Hachmuth
Executive Director
Natural Energy Laboratory of Hawaii
P. O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

Subject: Supplemental Environmental Impact Statement
Preparation Notice

We have reviewed your Supplemental Environmental Impact Statement and would like to comment that the building size and type will be permitted only if fire flow is provided in accordance with Appendix III-A, Table No. A-111-A.1. Please note exception: Minimum fire flow shall not be less than 1,000 gallons per minute.

Thank you for giving us the opportunity to submit our comments.

Very truly yours,

DANIEL AYALA
Fire Chief

DA/mo

Enclosure

cc: ✓Marilyn Metz, MCM Consulting
Land Use Commission, Attn: Ester Ueda

Division II

FIRE APPARATUS ACCESS ROADS

General

Sec. 10.201. Fire apparatus access roads shall be provided and maintained in accordance with this division.

Plans

Sec. 10.202. Plans for fire apparatus access roads shall be submitted to the fire department for review and approval prior to construction.

Required Access

Sec. 10.203. Fire apparatus access roads shall be provided for every facility, building or portion of a building hereafter constructed or moved into or within the jurisdiction when any portion of the facility or any portion of an exterior wall of the first story of the building is located more than 150 feet from fire apparatus access as measured by an approved route around the exterior of the building or facility.

EXCEPTIONS: 1. When buildings are completely protected with an approved automatic fire sprinkler system, the provisions of this section may be modified by the chief.

2. When access roads cannot be installed due to topography, waterways, nonnegotiable grades or other similar conditions, the chief is authorized to require additional fire protection as specified in Section 10.501 (b).

3. When there are not more than two Group R, Division 3, or Group M Occupancies, the requirements of this section may be modified, provided, in the opinion of the chief, firefighting or rescue operations would not be impaired.

More than one fire apparatus road shall be provided when it is determined by the chief that access by a single road may be impaired by vehicle congestion, condition of terrain, climatic conditions or other factors that could limit access.

For high-piled combustible storage, see Section 81.109 (a).

For open yard storage, see Section 30.102.

For hazardous materials, see Article 80.

For fire safety during construction, alteration or demolition of a building, see Section 87.103 (b).

Specifications

Sec. 10.204. (a) Dimensions. Fire apparatus access roads shall have an unobstructed width of not less than 20 feet and an unobstructed vertical clearance of not less than 13 feet 6 inches.

EXCEPTION: Upon approval by the chief, vertical clearance may be reduced, provided such reduction does not impair access by fire apparatus and approved signs are installed and maintained indicating the established vertical clearance.

Vertical clearances or widths shall be increased when, in the opinion of the chief, vertical clearances or widths are not adequate to provide fire apparatus access.

(b) Surface. Fire apparatus access roads shall be designed and maintained to support the imposed loads of fire apparatus and shall be provided with a surface so as to provide all-weather driving capabilities.

(c) Turning Radius. The turning radius of a fire apparatus access road shall be as approved by the chief.

(d) Dead Ends. Dead-end fire apparatus access roads in excess of 150 feet in length shall be provided with approved provisions for the turning around of fire apparatus.

(e) Bridges. When a bridge is required to be used as access under this section, it shall be constructed and maintained in accordance with the applicable sections of the Building Code and shall use designed live loading sufficient to carry the imposed loads of fire apparatus.

(f) Grade. The gradient for a fire apparatus access road shall not exceed the maximum approved by the chief.

Obstruction

Sec. 10.205. The required width of a fire apparatus access road shall not be obstructed in any manner, including parking of vehicles. Minimum required widths and clearances established under this section shall be maintained at all times.

Marking

Sec. 10.206. When required, approved signs or other approved notices shall be provided and maintained for fire apparatus access roads to identify such roads and prohibit the obstruction thereof or both.

Division III

FIRE DEPARTMENT ACCESS TO BUILDINGS

Premises Identification

Sec. 10.301. (a) General. Approved numbers or addresses shall be placed on all new and existing buildings in such a position as to be plainly visible and legible from the street or road fronting the property. Said numbers shall contrast with their background.

(b) Street or Road Signs. When required by the chief, streets and roads shall be identified with approved signs.

Key Boxes

Sec. 10.302. When access to or within a structure or an area is unduly difficult because of secured openings or where immediate access is necessary for life-saving or firefighting purposes, the chief is authorized to require a key box to be installed in an accessible location. The key box shall be a type approved by the chief and shall contain keys to gain necessary access as required by the chief.

Shaftway Marking

Sec. 10.303. Exterior windows in buildings used for manufacturing or for storage purposes which open directly on shaftways or other vertical means of communication between two or more floors shall be plainly marked with the word SHAFTWAY in red letters at least 6 inches high on a white background. Warning signs shall be easily discernible from the outside of the building. Door and window openings on such shaftways from the interior of the building shall be similarly marked with the word SHAFTWAY in a manner which is easily visible to anyone approaching the shaftway from the interior of the building, unless the construction of the partition surrounding the shaftway is of such distinctive nature as to make its purpose evident at a glance.

Exterior Doors

Sec. 10.304. (a) **Obstruction and Elimination.** Exterior doors or their function shall not be eliminated without prior approval by the chief. Exterior doors which have been rendered nonfunctional and which retain a functional door exterior appearance shall have a sign affixed to the exterior side of such door stating THIS DOOR BLOCKED. The sign shall consist of letters having principal stroke of not less than $^3/_4$ inch wide and at least 6 inches high on a contrasting background. Required fire department access doors shall not be obstructed or eliminated. See Article 12 for exit doors.

(b) **Access Doors and Openings.** For firefighting purposes, access doors, openings and exit doors shall be provided and readily accessible in occupancies as required by the Building Code.

For access doors for high-piled combustible storage, see Section 81.109 (b).

Floor Openings

Sec. 10.305. Floor openings shall be surrounded by guardrails as set forth in the Building Code or shall have covers which are automatic closing or maintained in a closed position at all times.

Division IV

WATER SUPPLIES FOR FIRE PROTECTION

General

Sec. 10.401. An approved water supply capable of supplying the required fire flow for fire protection shall be provided to all premises upon which facilities, buildings or portions of buildings are hereafter constructed or moved into or within the jurisdiction. When any portion of the facility or building protected is in excess

of 150 feet from a water supply on a public street, as measured by an approved route around the exterior of the facility or building, on-site fire hydrants and mains capable of supplying the required fire flow shall be provided when required by the chief.

Type of Water Supply

Sec. 10.402. Water supply may consist of reservoirs, pressure tanks, elevated tanks, water mains or other fixed systems capable of providing the required fire flow. In setting the requirements for fire flow, the chief may be guided by the provision in Appendix III-A.

Fire Hydrants

Sec. 10.403. The location, number and type of fire hydrants connected to a water supply capable of delivering the required fire flow shall be provided on the public street or on the site of the premises or both to be protected as required and approved by the chief. Fire hydrants shall be accessible to the fire department apparatus by roads meeting the requirements of Division II.

For fire safety during construction, alteration or demolition of a building, see Section 87.103 (c).

Division V

INSTALLATION AND MAINTENANCE OF FIRE-PROTECTION AND LIFE-SAFETY SYSTEMS

General

Sec. 10.501. (a) **Type Required.** The chief is authorized to designate the type and number of fire appliances to be installed and maintained in and upon all buildings and premises in the jurisdiction other than private dwellings. This designation shall be based upon the relative severity of probable fire, including the rapidity with which it may spread. Such appliances shall be of a type suitable for the probable class of fire associated with such building or premises and shall have approval of the chief.

(b) **Special Hazards.** For occupancies of an especially hazardous nature or where special hazards exist in addition to the normal hazard of the occupancy, or where access for fire apparatus is unduly difficult, the chief is authorized to require additional safeguards consisting of additional fire appliance units, more than one type of appliance, or special systems suitable for the protection of the hazard involved. Such devices or appliances may consist of automatic fire alarm systems, automatic sprinkler or water spray systems, standpipe and hose, fixed or portable fire extinguishers, suitable fire blankets, breathing apparatus, manual or automatic covers, carbon dioxide, foam, halogenated or dry chemical or other special fire-extinguishing systems. Where such systems are provided, they shall be designed and installed in accordance with the applicable Uniform Fire Code Standards.

Division III

FIRE PROTECTION

APPENDIX III-A

FIRE-FLOW REQUIREMENTS FOR BUILDINGS

1. SCOPE

The procedure determining fire-flow requirements for buildings or portions of buildings hereafter constructed shall be in accordance with this appendix. This appendix does not apply to structures other than buildings.

2. DEFINITIONS

For the purpose of this appendix, certain terms are defined as follows:

FIRE AREA is the floor area, in square feet, used to determine the required fire flow.

FIRE FLOW is the flow rate of a water supply, measured at 20 psi residual pressure, that is available for firefighting.

3. MODIFICATIONS

(a) **Decreases.** Fire-flow requirements may be modified downward by the chief for isolated buildings or a group of buildings in rural areas or small communities where the development of full fire-flow requirements is impractical.

(b) **Increases.** Fire flow may be modified upward by the chief where conditions indicate an unusual susceptibility to group fires or conflagrations. An upward modification shall not be more than twice that required for the building under consideration.

4. FIRE AREA

(a) **General.** The fire area shall be the total floor area of all floor levels within the exterior walls, and under the horizontal projections of the roof of a building, except as modified in this section.

(b) **Area Separation.** Portions of buildings which are separated by one or more four-hour area separation walls constructed in accordance with the Building Code, without openings and provided with a 30-inch parapet, are allowed to be considered as separate fire areas.

(c) **Type I and Type II-F.R. Construction.** The fire area of buildings constructed of Type I and Type II-F.R. construction shall be the area of the three largest successive floors.

5. FIRE-FLOW REQUIREMENTS FOR BUILDINGS

(a) **One- and Two-Family Dwellings.** The minimum fire flow and flow duration requirements for one- and two-family dwellings having a fire area which does not exceed 3,600 square feet shall be 1,000 gallons per minute. Fire flow and flow duration for dwellings having a fire area in excess of 3,600 square feet shall not be less than that specified in Table No. A-III-A-1.

EXCEPTION: A reduction in required fire flow of 50 percent, as approved by the chief, is allowed when the building is provided with an approved automatic sprinkler system.

(b) **Buildings other than One- and Two-Family Dwellings.** The minimum fire flow and flow duration for buildings other than one- and two-family dwellings shall be as specified in Table No. A-III-A-1.

EXCEPTION: A reduction in required fire flow of up to 75 percent, as approved by the chief, is allowed when the building is provided with an approved automatic sprinkler system. The resulting fire flow shall not be less than 1,500 gallons per minute.

TABLE NO. A-III-A-1
MINIMUM REQUIRED FIRE FLOW AND FLOW DURATION FOR BUILDINGS

FIRE AREA (square feet)					FIRE FLOW (gallons per minute)	FLOW DURATION (hours)
Type I-F.R. II-F.R.[1]	Type II One-HR. III One-HR.[1]	Type IV-H.T. V-One-HR.[1]	Type II-N III-N[1]	Type V-N[1]		
22,700	12,700	8,200	5,900	3,600	1,500	2
30,200	17,000	10,900	7,900	4,800	1,750	
38,700	21,800	12,900	9,800	6,200	2,000	
48,300	24,200	17,400	12,600	7,700	2,250	
59,000	33,200	21,300	15,400	9,400	2,500	
70,900	39,700	25,500	18,400	11,300	2,750	
83,700	47,100	30,100	21,800	13,400	3,000	3
97,700	54,900	35,200	25,900	15,600	3,250	
112,700	63,400	40,600	29,300	18,000	3,500	
128,700	72,400	46,400	33,500	20,600	3,750	
145,900	82,100	52,500	37,900	23,300	4,000	4
164,200	92,400	59,100	42,700	26,300	4,250	
183,400	103,100	66,000	47,700	29,300	4,500	
203,700	114,600	73,300	53,000	32,600	4,750	
225,200	126,700	81,100	58,600	36,000	5,000	
247,700	139,400	89,200	65,400	39,600	5,250	
271,200	152,600	97,700	70,600	43,400	5,500	
295,900	166,500	106,500	77,000	47,400	5,750	
Greater	Greater	115,800	83,700	51,500	6,000	
"	"	125,500	90,600	55,700	6,250	
"	"	135,500	97,900	60,200	6,500	
"	"	145,800	106,800	64,800	6,750	
"	"	156,700	113,200	69,600	7,000	
"	"	167,900	121,300	74,600	7,250	
"	"	179,400	129,600	79,800	7,500	
"	"	191,400	138,300	85,100	7,750	
"	"	Greater	Greater	Greater	8,000	

[1]Types of construction are based upon the Building Code.

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Daniel Ayala, Fire Chief
County of Hawaii
Fire Department
466 Kinoole Street
Hilo, Hawaii 96720-2983

Dear Mr. Sewake:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 4, 1991 and enclosed information which will be used by our engineers in design of the fire protection systems for the various components of the project.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

Planning Department
25 Aupuni Street, Room 109 • Hilo, Hawaii 96720 • (808) 961-8288

Lorraine R. Inouye
Mayor
Norman K. Hayashi
Director
Tad Nagasako
Deputy Director

December 4, 1991

Ms. Clare Hachmuth
Executive Director
NELHA
P. O. Box 1749
Kailua-Kona, HI 96745

Dear Ms. Hachmuth:

Notice of Preparation
Supplemental Environmental Impact Statement (SEIS)
State Land Use Boundary Amendment
Applicant: NELHA
TMK: 7-3-9:23

Thank you for the opportunity to provide comments on NELHA's SEIS Preparation Notice. Our comments are as follows:

1. Page vi, Item No. 7. As it relates to County land use reviews, it would be more accurate to say that the SEIS will be used as a supplemental document to accompany the County's Change of Zone and Special (not Shoreline) Management Area Use Permit applications.

2. The SEIS should discuss the proposed "resort community" known as O'oma II, presently undergoing Draft SEIS review. Are any of the proposed O'oma II uses duplicated in the NELHA development? If so, does NELHA feel that this situation needs to be resolved? How?

3. The section on Wastewater Treatment and Disposal should be discussed with clarity. The timetable for completion of the municipal sewage treatment plant and NELHA's target date for hook-up should be given. Will existing NELHA tenants be required to connect?

4. Exhibit 5. The proposed pump station appears within the 40-foot shoreline setback area. As such, a shoreline setback variance may be required. (SMA No. 239 depicted a

pump station further mauka with two ocean water pipes. The increased numer of water pipes from two to five should be explained in greater detail.

5. Page 12, Section 3.3 Access. The SEISPN states that the Level of Service will remain at "A." Traffic studies which lead to this conclusion should be referenced and included in the appendix.

6. Page 12, Section 3.4, Hydrology. This section combines discussion on brackish/fresh groundwater and near-shore/ocean-water quality. It also mentions a water quality monitoring program that has been in operation since 1989. The results of this monitoring program should be included in the SEIS.

7. Since the underlying brackish water may be used for aquaculture, what assurances are provided for its continued quality?

8. Page 15, Section 3.11 Recreational Resources. The SEIS should include the conceptual recreational plan including mauka-makai and lateral accesses. Who will be responsible for developing and maintaining the recreational facilities?

9. Generally, because this document serves as a supplement to previous EIS's, applicable sections of the SEIS should reference the specific EIS's when the analysis and conclusions are set forth in more detail in prior documents.

Should you have any questions regarding the above, please feel free to contact Connie Kiriu or Rodney Nakano of this office at 961-8288.

Sincerely,

NORMAN K. HAYASHI
Planning Director

CRK:smo
3891D
cc: Marilyn Metz
State Land Use Commission (Esther Ueda)
Mayor Lorraine R. Inouye
Research and Development
Office of Environmental Quality Control

NELH — HOST PARK

Natural Energy Laboratory of Hawaii — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Norman K. Hayashi, Director
County of Hawaii
Planning Department
25 Aupuni Street, Room 109
Hilo, Hawaii 96720

Dear Mr. Hayashi:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 4, 1991. The following paragraphs reference your numbered comments.

1. The correct wording will be used in reference to the SMA Use Permit.

2. Potential impacts to the O'oma II development will be addressed in the EIS. As you know, their EIS included an Ocean Science Center and a Kona Ocean Center has been proposed by KAD Partners for the NELHA site. This issue has been resolved jointly, and the KAD Kona Ocean Center will be the only such facility. Other issues of mutual concern such as access to the facility, parking, and adjacent land use compatibility are being resolved to mutual satisfaction in the same manner.

3. At the present time, it is planned to construct a small wastewater treatment plant on the site to serve both the Kona Ocean Center and the beach park facilities. Wastewater disposal will be into septic tanks. Eventual integration into County facilities will be addressed in the EIS, to the extent that information is available.

4. The exact location of the pump station is not yet established, but the intention is to construct it mauka of the shoreline setback. SMA No. 239 includes a summary table of 10-16 projected pipelines with a total flow volume of 142,000 gpm to be phased in as tenant needs develop.

5. A traffic impact assessment is being conducted as part of the EIS process, and will appear as an appendix to the document.

6. Additional hydrological analyses are being conducted for the EIS and a summary of the results of the Comprehensive

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

Environmental Monitoring Program (CEMP) will be included in the document. The latest CEMP annual report was completed in March and a copy provided to your office at that time.

7. Discharges into brackish aquifers will be sited down-gradient from intake points. The CEMP is providing baseline data on the brackish aquifers and information on dispersion of existing discharge streams. This information, in conjunction with the latest hydrological analyses will be used to develop management strategies to protect both groundwaters and coastal marine waters. The CEMP will be expanded to monitor the 83 acre parcel.

8. The SEIS will include a conceptual recreational plan including mauka-makai and lateral accesses. KAD Partners and NELHA will jointly develop and maintain the shoreline area.

9. Prior EISs will be referenced extensively in the supplemental document. Where neither the proposed action nor the potential impacts are significantly different from those previously disclosed, no further analyses will be performed.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Lorraine R. Inouye
Mayor
Victor V. Vierra
Chief of Police
Francis C. DeMorales
Deputy Chief of Police

Police Department

349 Kapiolani Street • Hilo, Hawaii 96720-3998 • (808) 961-2244 • Fax (808) 961-2702

November 22, 1991

Ms. Clare Hachmuth
Executive Director
Natural Energy Laboratory of Hawaii
P. O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

RE: SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE

We do not have any comments on your supplemental environmental impact statement preparation notice.

Thank you for the opportunity to comment.

Sincerely,

VICTOR V. VIERRA
CHIEF OF POLICE

JD:sk

cc: √Ms. Marilyn Metz, MCM Consulting
Land Use Commission, Attn: Ester Ueda
Kona Police

SEP-23-91 MON 11:04 NELHA, KONA HAWAII P.04

TO : VICTOR V. VIERRA, CHIEF OF POLICE

VIA : CHANNELS

FROM : WENDELL PAIVA, CAPTAIN, PATROL, KONA DISTRICT

SUBJECT : STATE LAND USE BOUNDARY AMENDMENT 91-3
APPLICANT: NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY-STATE OF HAWAII
REQUEST: CONSERVATION TO URBAN
TAX MAP KEY: 7-3-9:23

We are concerned that any future development in the area will affect the traffic volume on Queen Kaahumanu Highway. The area is already considered a high density traffic area with related problems concerning traffic safety.

It is our recommendation that before any zoning change or any major development for that area is approved, consideration be given that appropriate traffic control devices be included to facilitate traffic in the area and on Queen Kaahumanu Highway.

WENDELL PAIVA
CAPTAIN
AUGUST 30, 1991

WP:akk

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Victor V. Vierra, Chief of Police
County of Hawaii
349 Kapiolani Street
Hilo, Hawaii 96720-3998

Dear Mr. Vierra:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of November 22, 1991 and your memo of September 9 transmitting Captain Paiva's concerns about traffic on Queen Kaahumanu Highway fronting the project site. A traffic impact assessment is being prepared as part of the EIS process. This will identify any improvements to the intersection necessary to maintain an adequate level-of-service. As you may know, the long-term plan for Queen Kaahumanu Highway is to transform it into a limited access expressway. When this happens, the Keahole Point facilities will likely be accessed with a frontage road from the airport exit. These planned improvements are being factored into the traffic impact assessment.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

DEPARTMENT OF WATER SUPPLY • COUNTY OF HAWAII
25 AUPUNI STREET • HILO, HAWAII 96720
TELEPHONE (808) 969-1421 • FAX (808) 969-6996

December 2, 1991

Natural Energy Laboratory of Hawaii
Host Park
P. O. Box 1749
Kailua-Kona, HI 96745

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT PREPARATION NOTICE

We have reviewed the subject document. Please be informed that the development was previously allocated an amount of 400,000 gallons per day of water.

H. William Sewake
Manager

WA

cc - Ms. Marilyn Metz
Ms. Ester Ueda

...Water brings progress...

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. H. William Sewake, Manager
County of Hawaii
Department of Water Supply
25 Aupuni Street
Hilo, Hawaii 96720

Dear Mr. Sewake:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of December 2, 1991 confirming our water allocation of 400,000 gallons per day.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

Hawaii Electric Light Company, Inc. • PO Box 1027 • Hilo HI 96721-1027

CUST
H-H/G

November 19, 1991

Natural Energy Laboratory of Hawaii Authority (NELHA)
P. O. Box 1749
Kailua-Kona, Hawaii 96745

Attention: Clare Hachmuth

Gentlemen:

Subject: NELH Supplemental EIS Notice

In response to your November 8, 1991 letter, we have no objections to the proposed land swap of 83 acres from conservation to urban. Our existing HOST Park distribution substation have been sized to serve the original 83 acres along the Queen Kaahumanu Highway.

To serve the proposed new loads, an extension to the existing underground cables are required along with associated switches and padmount transformers. Due to the long lead time required to purchase the equipment, the developer's electrical consultant should contact HELCO's Engineering Department as soon as praticable to discuss the project schedule and requirements.

On page 5, paragraph 8, HELCO's generating station is a 32.4 megawatt generating station instead of a 1 megawatt station.

We strongly recommend that energy efficient and conservation features suitable to reduce the peak electrical demand be a part of the development's plans and requirements. We recommend that this development take full advantage of waste heat recovery equipment to recycle and reuse the waste heat rejected by air conditioning and refrigeration equipment. If this equipment is incorporated in the development's original design, the amount of energy required will be substantially reduced. Other energy saving devices such as fluorescent lighting (with high efficiency ballasts) and sodium lighting for parking lot and roadway lighting are also recommended.

Our Director of Customer and Consumer Services, Mr. Tom Goya, is available to assist you on the demand side planning concerns. He can be reached on the Big Island at (808) 969-0131.

Sincerely,

Clyde H. Nagata, Manager
Engineering Department

CHN:HKK:ts
cc: ✓Marilyn Metz (MCM Consulting)
Ester Ueda (Land Use Commission)
Tom Goya

An HEI Company

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

April 24, 1992

Mr. Clyde H. Nagata, Manager
Engineering Department
Hawaii Electric Light Company, Inc.
PO BOX 1027
Hilo, Hawaii 96721-1027

Dear Mr. Nagata:

SUBJECT: Consultation Regarding Preparation of Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for the information contained in your letter of November 19, 1991. We are currently in the Master Planning and permitting phase of development. When more definitive engineering is complete, we will contact your Engineering Department to coordinate specifics of equipment acquisition and installation if appropriate. Please note that at this time we envision the inclusion of a 1 MW OTEC Power plant to power the primary seawater pumps.

We will change the description of the generating station as per your comment.

Our engineers are exploring a number of energy minimizing and conservation technologies for incorporation into the facilities design. Again note that we do not envision increasing demand on HELCO facilities.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

D. DISTRIBUTION OF THE DRAFT SEIS

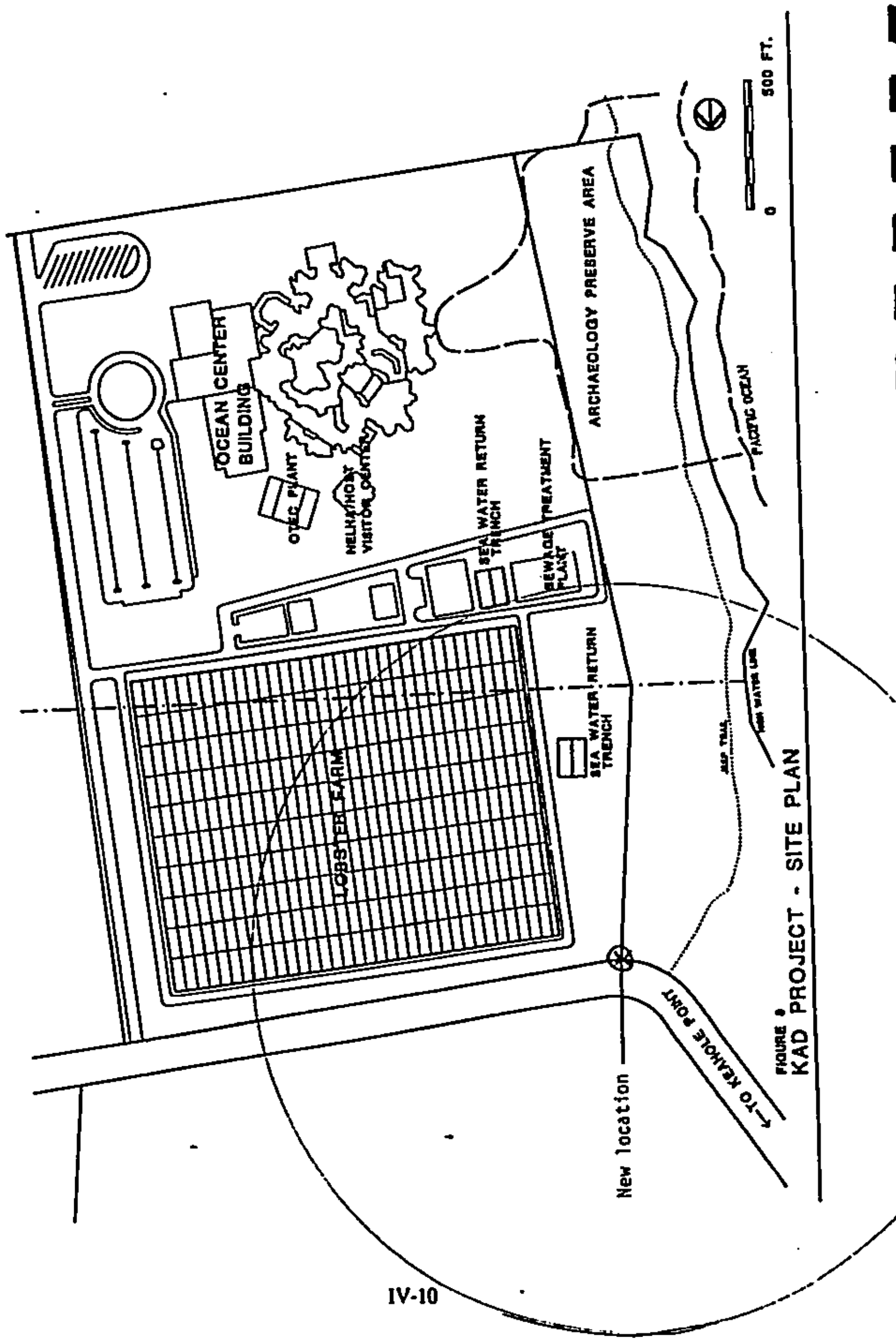
The following agencies, organizations and individuals were provided copies of the Draft Supplemental EIS for review and comment. Those responding substantively are marked with a double asterisk (**), and their letters and the responses to them are reproduced below in section E. Those responding, but without substantive comment, are marked with a single asterisk (*). Their letters are not reproduced herein.

1. FEDERAL

Department of Agriculture, Soil Conservation Service
* Department of the Army, Army Engineer District
Department of the Interior, Fish and Wildlife Service
Department of the Interior, Geological Survey
* Department of Transportation, Federal Aviation Administration
Department of Transportation, United States Coast Guard
Environmental Protection Agency, Region IX
* Commander, Naval Base Pearl Harbor

2. STATE ADMINISTRATION

Board of Directors, Natural Energy Laboratory of Hawaii
* Department of Accounting and General Services
Department of Agriculture
** Department of Defense
Department of Health
** Department of Land and Natural Resources
** Department of Business, Economic Development and Tourism
** Department of Transportation
Housing Finance and Development Corporation
** Land Use Commission
Legislative Reference Bureau
* Office of Environmental Quality Control
Office of Hawaiian Affairs
** Office of State Planning
State Archives
** University of Hawaii, Environmental Center
University of Hawaii, Water Resources Research Center
University of Hawaii, Hamilton Library
University of Hawaii, Hilo Campus Library
State Main Library
Kaimuki Regional Library
Kaneohe Regional Library
Pearl City Regional Library



NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

August 31, 1992

Mr. Roy C. Price, Sr.
Vice Director of Civil Defense
State of Hawaii
Department of Defense
3949 Diamond Head Road
Honolulu, Hawaii 96816-4495

Dear Mr. Price:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 20, 1992. Your proposal to site a new warning siren at NELHA has merit, and we will be in contact with you to further discuss equipment, siting and logistics.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

JOHN WAIHEE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P.O. BOX 621
HONOLULU, HAWAII 96809

WILLIAM W. PATY, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
JOHN P. KEPPELER II
DONA L. HANAIKE

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND ENVIRONMENTAL AFFAIRS
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION PROGRAM
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

REF:OCEA:SKK

AUG 17 1992

FILE NO.: 93-027
DOC. ID.: 1242

The Honorable Brian J. J. Choy, Director
Office of Environmental Quality Control
220 South King Street, Fourth Floor
Honolulu, Hawaii 96813

Dear Mr. Choy:

SUBJECT: Draft Supplemental Environmental Impact Statement for the Development of Host Park Project, North Kona, Hawaii, TMK: 7-3-09: 23

Thank you for giving our Department the opportunity to comment on this matter. We have reviewed the Draft Supplemental Environmental Impact Statement for the Development of a Land Exchange Parcel at Keahole, North Kona and have the following comments.

Brief Description:

The applicant proposes to develop, on 40 of 83 acres obtained in a land swap and 26 acres of previously zoned HOST Park land, an extensive project consisting of an OTEC plant, an ocean center, a lobster farm, a visitor center, an archaeological preserve, and an extension of Wawaloli Beach.

Division of Aquatic Resources Comments:

Additional significant adverse impacts to aquatic resource values at Keahole Point are not expected from activities proposed. Most of the projects are similar to the activities of the adjacent HOST & NELH Park which have been reviewed previously by the Department. However, mitigation measures proposed in the Supplemental EIS should be mandatory to prevent potential impacts to aquatic resources.

We understand from the response to our earlier comments that the shoreline is expected to remain in the Conservation District. Therefore, all improvements or modifications within the Conservation District would be subject to evaluation during the process of obtaining the permit for the construction activities.

Precautions should be taken during development activities to prevent construction material, petroleum products, debris, and other potential contaminants from entering the anchialine ponds or nearshore waters.

Finally, future deviations from the activities proposed and described in the Draft Final Supplemental EIS should be submitted in advance to the Department for review. Information on deviations provided after-the-fact, that could adversely affect aquatic resources is unacceptable.

Division of Land Management Comments:

Our Department's Land Management Division has no objections to the proposed State Land Use District Boundary Amendment from the Conservation District to the Urban District, provided that a coastal strip of land between the proposed KAD project and the ocean is preserved within a perpetual conservation easement.

In addition, Land Management questions the proposed KAD Partners Lease which would encumber approximately 40 acres of the subject parcel and 26 acres of an abutting property managed by NELHA.

NELHA should be required to justify the research benefits that will be derived in relationship to the profit to be generated from tourism.

The Land Management Division has no objections to the consolidation and resubdivision of the subject parcel provided that a State Land Use Boundary Amendment from Conservation to Urban is approved first.

Historic Preservation Division Comments:

In complying with Chapter 6E, NELH is working closely with our Division to finalize the historic preservation mitigation plan for this parcel. An historic preserve will set aside in an interpretive setting two heiau's, a small shrine, and several house sites. The final details on the preserve's boundary are being worked out. A few other sites, significant solely for their information content, will undergo archaeological data recovery. These actions, in complying with Chapter 6E, will result in a "no adverse effect" determination.

Hilo Regional Library
Wailuku Regional Library
Kauai Regional Library
Kailua-Kona Library
Holualoa Library
Kealakekua Library

3. COUNTY OF HAWAII

* Fire Department
Parks and Recreation Department
** Planning Department
* Police Department
Public Works Department
Research and Development
Water Supply Department

4. ORGANIZATIONS AND INDIVIDUALS

American Lung Association
Hawaii Electric Light Company (HELCO)
Hawaii Tribune Herald
Honolulu Advertiser
Honolulu Star Bulletin
KAD Partners
Kahala Capital Corporation
West Hawaii Today

E. COMMENTS AND RESPONSES TO THE DRAFT SEIS

JOHN WAIHEE
GOVERNOR

MAJOR GENERAL EDWARD V RICHARDSON
DIRECTOR OF CIVIL DEFENSE

ROY C. PRICE, SR.
VICE DIRECTOR OF CIVIL DEFENSE

STATE OF HAWAII
DEPARTMENT OF DEFENSE
OFFICE OF THE DIRECTOR OF CIVIL DEFENSE
3949 DIAMOND HEAD ROAD
HONOLULU, HAWAII 96816-4495

PHONE (808) 734-2161

August 20, 1992

TO: Governor, State of Hawaii
c/o Office of Environmental Quality Control

ATTENTION: Mr. Brian Choy

FROM: Roy C. Price, Sr.
Vice Director of Civil Defense

SUBJECT: DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT FOR DEVELOPMENT OF LAND EXCHANGE PARCEL

We appreciate this opportunity to comment on the Draft Supplemental Environmental Impact Statement, Development of Land Exchange Parcel, between Kahala Capital Corporation and Natural Energy Laboratory of Hawaii Authority (NELHA) at 'O'oma II, North Kona, Hawaii, TMK: 7-3-09:23.

We do not have negative comments specifically directed at the Draft EIS. We do, however, have a proposal that entails the addition of one new siren with a minimum output of 115 db and a siren simulator that is compatible with the existing civil defense warning system.

The recommended location of the siren is annotated in red on the enclosed map from page IV-10 of the Draft Supplemental Environmental Impact Statement. This site affords coverage to the Draft EIS parcel as well as the adjoining parcels. This device would help alert and inform the users of the development and adjacent beaches of an impending or actual event that threatens their well-being. The siren simulator should normally be placed in an office manned 24 hours a day (such as a security office) and one with the capability of disseminating a warning to people at risk within the project.

Just as parks, schools, fire hydrants, underground/overhead utilities and sidewalks are planned as integral infrastructures of any projects, so must emergency warning systems be planned for the safety of the users of this project.

The purchase and installation of a siren, a siren simulator and the infrastructure for the support of these warning devices as part of the project negate the need for excavation or modification of newly built roads and sidewalks or structures for the later installation of these devices. A well built installation for warning devices has the following characteristics. Siren installation requires access by vehicle and a buffer zone of 100-foot radius where no residential buildings are located. Siren simulator installation includes the coaxial cable and duct from the antenna on the rooftop to the simulator. The siren simulator should be located in a office that is manned 24 hours a day and supplied with emergency AC electrical power.

Our State Civil Defense planners and technicians are available to discuss this further if there is a requirement. Please have your staff call Mel Nishihara of my staff at 734-2161.

Enc.

c: Ms. Clare Hachmuth
Natural Energy Laboratory
of Hawaii Authority

✓Mr. George Krasnick
GK & Associates

Thank you for your cooperation in this matter. Please feel free to call Sam Lemmo at our Office of Conservation and Environmental Affairs, at 587-0377, should you have any questions.

Very truly yours,

WILLIAM W. PATY

cc: NELHA, [redacted]

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

August 31, 1992

Mr. William W. Paty, Chairman
State of Hawaii
Department of Land and Natural Resources
P.O.Box 621
Honolulu, Hawaii 96809

Dear Mr. Paty:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 17, 1992. The following paragraphs respond to the concerns of the respective Divisions.

Division of Aquatic Resources:

It is the intention of NELHA management to ensure that all proposed impact mitigation measures are implemented by tenants and contractors. Construction along the shoreline will be restricted to extending the existing beach park and providing interpretative materials within an archaeological preserve. Appropriate mitigation measures will be implemented during construction to prevent construction materials, petroleum products, debris and other contaminants from entering nearshore waters. The anchialine ponds are on the other side of the access road from all proposed construction, and will not be directly affected by construction activities. If in the future the project is significantly changed in any manner, another supplemental EIS, and consequently DLNR review, will be required.

Division of Land Management:

It is intended that the coastal strip of land remain in the Conservation District and used for public purposes. The sublease of the property to KAD Partners has been approved by the Board of Land and Natural Resources. Both portions of the property, that is, the 40 acres of the exchange parcel and the 26 acres of previously zoned lands are within the HOST Park. The mission of the HOST Park is to commercialize technologies such as OTEC and cold water aquaculture researched at NELH. While the proposed project has significant research components, it is intended to generate a profit for the tenants. The State will share directly in the project's success through receipt of lease rents and increased excise tax revenues.

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

Historic Preservation Division:

We have worked closely with the Division to identify, interpret, preserve and protect the cultural resources on the property. We look forward to continuing to work with the Division to establish the proposed Archaeological Preserve and its interpretative materials.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

DEPARTMENT OF BUSINESS,
ECONOMIC DEVELOPMENT & TOURISM

ENERGY DIVISION, 335 MERCHANT ST., RM. 110, HONOLULU, HAWAII 96813 PHONE: (808) 587-3800 FAX: (808) 587-3820

JOHN WAIHEE, Governor
MUFI HANNEMANN, Director
BARBARA KIM STANTON, Deputy Director
RICK EGGED, Deputy Director
TAKESHI YOSHIHARA, Deputy Director

92:03821-167

August 19, 1992

RECEIVED
AUG 20 1992
NELH

Ms. Clare Hachmuth
Executive Director
National Energy Laboratory
of Hawaii Authority (NELHA)
P. O. Box 1749
Kailua-Kona, Hawaii 96745

Dear Ms. Hachmuth:

SUBJECT: Department of Business, Economic Development & Tourism, Energy Division Comments on the Draft Environmental Impact Statement (DEIS) for the Development of Land Exchange Parcel

The Department of Business, Economic Development & Tourism (DBED) strongly supports the development of a 1-MW, closed-cycle, Ocean Thermal Energy Conversion (OTEC) facility at NELHA, providing that it can be done in an environmentally acceptable manner.

We have reviewed the subject document and have the following comments and questions.

Effluent Seawater Disposal

1. Please discuss in detail the advantages, disadvantages, and relative costs of various effluent seawater disposal methods (trench, injection well, disposal pipe). Why was trench disposal selected?

2. What types of measures are being taken to mitigate the effects of effluent seawater disposal on anchialine pond and coral reef communities?

3. What will be the temperature of the effluent seawater as a function of the surface warm water temperature?

Thank you for the opportunity to review and comment on this DEIS.

Sincerely,

for Mufi Hannemann

DAR/MH:yl
Enclosure

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

August 31, 1992

Mr. Mufi Hannemann, Director
State of Hawaii
Department of Business, Economic Development & Tourism
P.O. Box 2359
Honolulu, Hawaii 96804

Dear Mr. Hannemann:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 19, 1992. The following paragraphs respond to your specific comments.

1. In 1987 NELH produced a supplemental EIS entitled "Alternative Methods of Seawater Return Flow Disposal" which examined the costs and consequences of various seawater disposal options including canals, trenches and injection wells. The ocean outfall option was assessed in the 1985 EIS for the HOST Park Development Plan. Both of these documents are incorporated by reference into the present draft supplemental EIS. Selection of trench disposal was based on both environmental and economic considerations. Experience gathered to date indicates that trench disposal of large volumes of seawater is feasible and cost-effective. The Cooperative Environmental Monitoring Program (CEMP) described in the EIS was designed to rapidly detect negative impacts on marine and anchialine resources. To date, no significant impacts on these resources as a consequence of trench disposal have been detected. The most recent annual report of the monitoring program is included in the EIS as Appendix B.

2. As noted above, the CEMP has to date confirmed the lack of impacts of trench disposal to marine and anchialine resources. Because of the increased disposal volumes associated with the proposed project two additional measures are proposed in the EIS. First, to further dilute seawater return flows, a decentralized trench system is proposed. That is, instead of collecting all return flows into several large trenches, individual trenches at appropriate locations are proposed. This will act to dilute the concentrations of return flows at the shoreline, minimize pumping costs and

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allow identification of the source of any return flow not meeting applicable standards. Second, during start-up, it is recommended that the CEMP be expanded to include more frequent monitoring in the nearby anchialine ponds and at the coast down-gradient from the disposal sites. The experimental nature of the trench disposal method has been recognized since the initial NELH EIS in 1985. Since that time return flow volumes have increased without causing negative impacts. This increment of increasing flow volumes will be carefully monitored to ensure that this remains the case. Should negative impacts result from the proposed trench disposal, other, more expensive, disposal options such as injection wells or a deep ocean outfall would be required.

3. In order to protect coastal marine resources, in particular corals, the return flow temperatures will not be lower than 18°C. NELHA management has the enforcement authority to shut down tenant operations which do not comply with the Facilities Use Manual (included in the EIS as Appendix H).

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

JOHN WAIHEE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097
AUG 6 1992

REX D. JOHNSON
DIRECTOR

DEPUTY DIRECTORS
JOYCE T. OMINE
AL PANG
JEANNE K. SCHULTZ
CALVIN M. TSUDA

IN REPLY REFER TO

HWY-PS
2.3160

TO: Brian Choy, Director
Office of Environmental Quality Control

FROM: Rex D. Johnson, Director
Department of Transportation

SUBJECT: DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT, DEVELOPMENT OF LAND EXCHANGE PARCEL (HAWAII OCEAN SCIENCE AND TECHNOLOGY PARK), KEAHOLE, NORTH KONA, HAWAII, TMK: 7-3-09: 23

Thank you for your transmittal of the subject draft supplemental environmental impact statement for our review.

The traffic study is inadequate in that it does not propose interim measures to mitigate the traffic impact of this development.

The traffic report should be expanded to include interim mitigation measures and resubmitted for our review. There is no definitive date for implementing the widening of Queen Kaahumanu Highway.

Plans for construction work within the State highway right-of-way must be submitted for our review and approval.

c: Ms. Clare Hachmuth, Executive Director
Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96745

✓Mr. George Krasnick
GK & Associates
294 Awakea Road
Kailua, Hawaii 96734

NELH
Natural Energy Laboratory of Hawaii

HOSTPARK
Hawaii Ocean Science and Technology Park

August 31, 1992

Mr. Rex D. Johnson, Director
State of Hawaii
Department of Transportation
869 Punchbowl Street
Honolulu, Hawaii 96813-5097

Dear Mr. Johnson:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 6, 1992. To clarify the issues raised in your letter, on August 20 we met with Mr. Ron Tsuzuki of your Planning Branch. In reviewing the traffic study prepared for the proposed project with Mr. Tsuzuki, we emphasized the conservative nature of our projections. From DOT traffic counts collected over the past decade, we calculated a compounded annual background rate of traffic increase of 8%, a very high rate of increase, and one unlikely to be sustained in a down economy. Further, we assumed that all other known projects which would be contributing traffic to Queen Kaahumanu Highway in this vicinity would be built-out and fully occupied by the time the proposed project comes on line. With the financing and marketing difficulties now facing most developers, this assumption is perhaps unrealistically conservative. Therefore, we have gone back to the original EISs (and even more recent information in some cases) describing other projects in the vicinity, and adjusted build-out and absorption rates to more realistically reflect the current economic downturn. This results in a significant lessening of the total increase in traffic on Queen Kaahumanu Highway during and after build-out of the proposed project.

It should be noted that the EIS for the Development Plan for HOST Park and expansion of NELH in 1985 anticipated a much greater increase in traffic than has or is now anticipated to occur. The traffic study for that EIS indicated that in the short-term, left-turn pockets and acceleration and deceleration lanes would be required and that eventually signalization of the NELH access road intersection would be required. The interim mitigation measures have already been implemented.

Natural Energy Laboratory of Hawaii Authority
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Mr. Rex D. Johnson
August 31, 1992
Page 2

It has been understood and accepted that without signalization of the intersection left turns into and out of the project will not operate efficiently, especially during the afternoon peak hour. Signalization however, would greatly impede the flow of traffic along Queen Kaahumanu Highway. It is our opinion that the low level of service for the left turn movements is acceptable in the interim before the Queen Kaahumanu Highway widening project is implemented. Given the relatively low contribution of this project to peak traffic flows it doesn't seem reasonable to signalize this intersection when so many others in the vicinity, including the airport access road and major resort entrances, are not signalized.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

JOHN WAIHEE
GOVERNOR

ESTHER UEDA
EXECUTIVE OFFICER

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
Room 104, Old Federal Building
335 Merchant Street
Honolulu, Hawaii 96813
Telephone: 587-3822

July 27, 1992

Mr. Brian Choy, Director
Office of Environmental
Quality Control
Central Pacific Plaza
220 S. King Street, 4th Fl.
Honolulu, Hawaii 96813

Dear Mr. Choy:

Subject: Draft Supplemental Environmental Impact Statement (DSEIS) for Development of Land Exchange Parcel, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23

We have reviewed the subject DSEIS for the Natural Energy Laboratory of Hawaii Authority's (NELHA) development of its exchanged parcel.

We would like to reiterate our comments expressed in our letter of November 7, 1991 for the Notice of Preparation of a Supplemental EIS, that the DSEIS include a detailed discussion on the background of KAD Partners, the sublessors and primary tenant of the subject parcel. This information should include financial as well as the development, construction and operational experience of KAD Partners with respect to such facilities as those proposed for the subject parcel.

We appreciate the opportunity to provide comments on this matter.

If you have any questions, please call me or Bert Saruwatari of our office at 587-3822.

Sincerely,

Esther Ueda

ESTHER UEDA
Executive Officer

EU:th

cc: NELHA
Attn: Clare Hachmuth
✓GK & Associates
Attn: George Krasnick

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

August 31, 1992

Ms. Ester Ueda, Executive Officer
State of Hawaii
Land Use Commission
335 Merchant Street, Room 104
Honolulu, Hawaii 96813

Dear Ms. Ueda:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, THK No.: 7-3-09:23.

Thank you for your letter of July 27, 1992. As noted in the EIS, the principals of Kad Partners have been involved in aquaculture research and commercial development for over twenty years. The Board of Land and Natural Resources has approved a sublease to them based on their proposed plans, their experience and their financial capacity to perform successfully. Much of the information provided to the Board, and in which you are interested as well, is proprietary, confidential, and not relevant to a description of the project and its potential environmental impacts. Nevertheless, this information has been collated as per your request and is being provided under separate cover. We will be happy to meet with you to review this material and answer any other questions you may have about the project or KAD Partners.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

OFFICE OF STATE PLANNING
Office of the Governor
MAILING ADDRESS: P.O. BOX 3540, HONOLULU, HAWAII 96811-3540
STREET ADDRESS: 250 SOUTH HOTEL STREET, 4TH FLOOR
TELEPHONE: (808) 587-2846, 587-2800

August 5, 1992

MEMORANDUM

TO: Mr. Brian Choy, Executive Director
Office of Environmental Quality Control

SUBJECT: Comments on Draft Supplemental Environmetal Impact Statement (DSEIS)
State of Hawaii, Natural Energy Laboratory of Hawaii Authority
Development of Land Exchange Parcel
83 acres
TMK: 7-3-9: 23
North Kona, Hawaii

The Office of State Planning (OSP) has reviewed the subject Draft Supplemental Environmental Impact Statement (DSEIS) for the development of the land exchange parcel.

As you may know, the "land exchange parcel" consists of 83 acres which were the subject of a 1986 land exchange between the proposing agency, Natural Energy Laboratory of Hawaii Authority (NELHA), and the landowner of adjacent property, Kahala Capital Corporation. In July 1991, NELHA petitioned the State Land Use Commission (LUC) in Docket No. A91-669 to reclassify the subject 83 acres from the Conservation to the Urban Land Use District for the development of research and commercialization of ocean-related technologies. NELHA filed an Environmental Assessment (EA) as a part of the petition, as well as three previously prepared and accepted Environmental Impact Statements (EIS) related to the development and operation of NELHA and the Hawaii Ocean Science and Technology (HOST) Park, and an EIS previously submitted by Kahala Capital Corporation and accepted by the LUC for a boundary amendment proposal which included the subject 83 acres in 1986. In August 1991, the LUC determined that the proposed reclassification from the Conservation to the Urban Land Use District may have a significant effect on the environment, and required NELHA to prepare a Supplemental EIS. The subject DSEIS reflects NELHA's efforts toward fulfilling this requirement. OSP assumes the inclusion of this document in NELHA's LUC petition once it has been finalized and approved by the LUC.

Mr. Brian Choy
July 24, 1992
Page 2

The KAD Project site plan shown on p. IV-10 of the DSEIS should also be shown in relation to the HOST Park Master Plan and plans for NELH. These plans should include major vehicular and pedestrian linkages as well as seawater transmission/disposal and other utility systems.

OSP has no further comments to make at this time. However, we will continue to review and evaluate NELHA's petition when the Final EIS is accepted by the LUC. Thank you for the opportunity to comment. If you have any questions, please call the Land Use Division at 587-2886.

for Harold S. Masumoto
Director

cc: Ms. Esther Ueda, LUC
Ms. Claire Hachmuth

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

August 31, 1992

Mr. Harold S. Masumoto, Director
State of Hawaii
Office of State Planning
P.O. Box 3540
Honolulu, Hawaii 96811-3540

Dear Mr. Masumoto:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 5, 1992. The following paragraphs respond to your comments.

The LUC, in its role of granting land use boundary amendments, may request inclusion in a petition information relative to a broad range of topics, including the environmental impacts of a proposed use. NELHA provided the LUC with an EA, and will provide the LUC with this EIS as information supplemental to its land use boundary amendment petition. This EIS is being prepared by a state agency, therefore the Governor is the accepting authority, while the LUC is the approving agency.

The Land Exchange Parcel, use of which is the subject of this SEIS, is shown in relation to the HOST Park Master Plan on page IV-7 of the EIS. Major vehicular and pedestrian linkages, seawater transmission/disposal and basic infrastructure were described in the 1985 EIS concerning the HOST Park Development Plan and NELH expansion and the 1987 SEIS on alternative methods of seawater return flow disposal which are incorporated by reference into the present document.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

University of Hawaii at Manoa

Environmental Center
A Unit of Water Resources Research Center
Crawford 317 • 2550 Campus Road • Honolulu, Hawaii 96822
Telephone: (808) 956-7361

August 20, 1992
RE:0599

Governor, State of Hawai'i
c/o Office of Environmental Quality Control
220 South King Street, 4th Floor
Honolulu, Hawai'i 96813

Dear Governor Waihe'e:

Supplemental Draft Environmental Impact Statement (SDEIS)
NEIHA Development of Land Exchange Parcel
North Kona, Hawai'i

The Natural Energy Research Laboratory of Hawai'i (NEIHA) has exchanged 83 acres of land for 83 acres of ocean front property belonging to Kahala Capital located in the State Conservation District. The primary tenant of the proposed NEIHA oceanfront development will use 40 of the 83 acres obtained in the land swap and 26 acres of previously zoned HOST Park lands. The proposed project contains six components: 1) a 1 MW OTEC plant (closed-cycle ammonia turbine) which would power the seawater pumps and supply the Ocean Center, Lobster Farm Visitor Center and other HOST Park tenants with warm and cold seawater; 2) a 12-acre Ocean Center consisting of low buildings and structures, most enclosing below-grade aquatic and botanical exhibits, and parking for automobiles and buses. The facility would be designed to accommodate an annual attendance of 500,000. The exhibits would be focused on specific island habitats of the Pacific from high to low latitudes, making use of the range of water temperatures available. The Ocean Center would contain both educational and research areas; 3) a Lobster Farm would occupy a total of 20 acres, mostly on previously zoned HOST Park lands. The entire facility would be covered with continous greenhouse modules. The Farm is planned to produce 500,000 pounds of American Lobster per year; 4) the NEIHA Visitor Center; 5) an Archaeological Preserve of about five acres would be established along the coast in the exchange parcel, including interpretive displays would be developed; and 6) an extension of Wawaloli Beach would be provided, consisting of approximately 10 acres along the shoreline.

The Environmental Center has reviewed this document with the assistance of Yu-Si Fok and Paul Ekern (Emeritus), Water Resources Research Center; Hans-Jurgen Krock, Ocean Engineering; and Alex Buttaro, Environmental Center.

An Equal Opportunity/Affirmative Action Institution

Project Location

Some of our reviewers commented that the maps provided did not include enough information concerning the project site's relationship to the larger area, and to adjacent locations and activities.

Pan Evaporation

OTEC's Keahole solar data shows the arrival of seabreeze and cloud cover which may significantly reduce sunshine and therefore evaporation, and should be factored into pan-evaporation estimates.

Additionally, a report by Dennis Nullet stresses that where there is onshore flow of seabreezes, the cool air coming onshore from the ocean will reduce evaporation (Physical Geography, 1987, volume 8, pages 36-45).

An accurate idea of evaporation should be derived for the lobster ponds and to enable an adequate estimation of the storage capacity of the settling trenches. Our reviewers suggest that the data on evaporation provided may be over-extrapolated. Ekern and Chang found 60-70 inches of evaporation (Pan Evaporation in the State of Hawai'i, DLNR Report R-74), as opposed to 90-95 inches cited in Kay's report.

Noise

Our reviewers expressed concern that lobsters may be negatively affected by high noise levels from airplanes taking off and landing, which may significantly impact growth.

OTEC Plant

We note the absence of any engineering diagrams and other specifics for the proposed OTEC plant, and suggest such information should be provided to better assess the potential environmental impacts.

How will the OTEC pipeline traverse the sensitive coastal region and what storm wave protection will be provided?

Water Disposal

The document notes that the disposal water will be 18 degrees Celsius, which should be sufficiently warm to allow survival of Hawaiian corals. Most of the data that support this statement are from short-term experiments. A question arises when corals are exposed to these temperatures over a long time period. Does long-term exposure to these minimal temperatures have an impact on the growth, fecundity and ability to resist disease? The EIS should address these issues in greater depth and detail.

Aquaculture

Dr. John Craven successfully oversaw the cultivation of strawberries using condensation from cold brine pipes. Do the results of his experiment lend insight into the possibility of using cold brine to grow strawberries at this site?

There appear to be at least as many failures as successes in Hawai'i's recent aquaculture ventures. Our reviewers expressed concern that the revenue/production figures given in the document are very optimistic. We suggest that revenue and production figures be approached with cautious skepticism, and the subject should be addressed in greater detail in an effort to address any potential shortcomings of previous aquaculture revenue analyses.

Ocean Outfall

We once again note that the rock that underlies the trenches is highly fractured and permeable, and a trench disposal is suboptimal for protecting the nearshore biota. Have the developers investigated the possibility of using an ocean outfall to pipe water back into the ocean instead of using trenches? Could the discharge pipeline be "piggy-backed" on the intake pipeline and released prior to the intake point? The rock that constitutes the trenches is highly fractured and permeable and may be inadequate in its ability to protect the near-shore biota. The trenches may also negatively affect warm-water intakes.

Water Quality Monitoring

The southern complex of anchialine ponds are in much better condition than the pools located at the northern part of the property. Water quality in southern pools could be affected by the proposed action. The EIS states that monitoring of these pools will continue, but the protocol for this monitoring is not clearly stated. Our reviewers suggest that the present quarterly sampling effort would not be sufficient, because impacts could occur much more rapidly than the present system can respond. The EIS should provide some idea of a scope of anchialine pool monitoring to insure continued quality of these resources.

Summary

We note that the specifics of much of the proposed development within the project area have not been disclosed in this document, and that such information is very important to facilitate adequate assessment of potential environmental impacts. Therefore, due to the apparent preliminary nature of this project and the lack of specific design disclosures in the EIS, we suggest that once detailed plans have been developed, another SEIS be prepared.

Thank you for your time and consideration and we hope our comments are helpful.

Sincerely,

John T. Harrison ck

John T. Harrison, Ph.D.
Environmental Coordinator

cc: Clare Hachmuth (NELHA)
George Krasnick, GK & Associates
Roger Fujioka
Paul Ekern
Yu-Si Fok
Hans-Jurgen Krock
Alex Buttaro

NELH
Natural Energy Laboratory of Hawaii

HOST PARK
Hawaii Ocean Science and Technology Park

August 31, 1992

Dr. John T. Harrison, Environmental Coordinator
University of Hawaii at Manoa
Environmental Center
Crawford 317
2550 Campus Road
Honolulu, Hawaii 96822

Dear Dr. Harrison:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 20, 1992. The following paragraphs respond to the concerns identified by your reviewers.

Project Location

The project location and component properties are shown in Chapter III (Figures 1 and 2). The project, the site and surrounding properties are further described in six additional figures (Figures 3-8) in Chapter IV. The only nearby uses not shown on any of these figures are those mauka of Queen Kaahumanu Highway, and include the Keahole Agricultural Park and the HELCO Substation.

Pan Evaporation

The pan evaporation data are included in the EIS to characterize the project site, not for predictive engineering purposes. All facilities, including the disposal trenches will be covered.

Noise

KAD Partners is presently growing lobsters in a prototype facility at NELHA. This facility and the proposed commercial facility are enclosed. No negative effects of aircraft noise on growth rates have been observed or are expected.

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

OTEC Plant

OTEC technology has matured to the extent that a turn-key installation will be sought. This means that the internal details of the plant and its operations will be described by prospective bidders. Potential environmental impacts are associated with pipeline installation, seawater return flow disposal, and releases of working fluids. These topics are addressed in the EIS.

Water Disposal

The condition to be imposed on KAD Partners is that the temperature of the seawater return flows not be less than 18°C. It is likely that the temperature will be somewhat higher than this minimum. As you are aware, the Cooperative Environmental Monitoring Program contains a coastal marine biota component. To date, no significant negative impacts of trench disposal have been detected. The experimental nature of the trench disposal method has been recognized since the initial NELH EIS in 1985. Since that time return flow volumes have increased without causing negative impacts. This increment of increasing flow volumes will be carefully monitored to ensure that this remains the case. Should negative impacts result from the proposed trench disposal, other, more expensive, disposal options such as injection wells or a deep ocean outfall would be required. Academically, the question of chronic effects of low temperature on corals has not been adequately researched. Dr. Paul Jokiel at the Hawaii Institute of Marine Biology has done considerable research into the chronic effects of coral exposure to warm waters such as power plant effluents. So far, however, efforts to attain funding for research into cold water effects have not been successful. This is precisely the type of research which would be appropriate to carry out at the proposed Ocean Center.

Aquaculture

While Dr. Craven's results are encouraging, there are no plans to integrate agriculture such as cultivation of strawberries into the proposed project.

The financial projections for the Lobster Farm are derived from the prototype facility now operational at NELHA. Previous aquaculture venture financial projections have often overstated either production capacity or market price. The over twenty years of experience of Aquaculture Enterprises in research, rearing, and marketing lobsters affords a much more realistic estimate than is typical in this young industry. The financial stability of this proposed project is further enhanced by the integrated nature of its various components. The OTEC Plant will avoid purchased power costs while providing the seawater streams essential for the other project elements. Further, the HOST Park concept is to provide basic infrastructure to entrepreneurs in a manner similar to an agricultural park. This means that the infrastructure costs can be minimized through economies of scale, and recovery of these costs by the State can be spread over a longer period than would otherwise be possible.

Ocean Outfall

In 1987 NELH produced a supplemental EIS entitled "Alternative Methods of Seawater Return Flow Disposal" which examined the costs and consequences of various seawater disposal options including canals, trenches and injection wells. The ocean outfall option was assessed in the 1985 EIS for the HOST Park Development Plan. Both of these documents are incorporated by reference into the present draft supplemental EIS. Selection of trench disposal was based on both environmental and economic considerations. Experience gathered to date indicates that trench disposal of large volumes of seawater is feasible and cost-effective. The Cooperative Environmental Monitoring Program (CEMP) described in the EIS was designed to rapidly detect negative impacts on marine and anchialine resources. To date, no significant negative impacts on these resources (or on the warm water intake) as a consequence of trench disposal have been detected. The most recent annual report of the monitoring program is included in the EIS as Appendix B.

Water Quality Monitoring

We agree that during start-up impacts to the southern anchialine pools could occur more rapidly than might be detected by the standard monitoring protocol. This is the reason a more intensive monitoring program is proposed during start-up. An excerpt from section VI.A.4.c.(3) follows.

> Disposal of seawater return flows into trenches could impact water quality, and consequently the biota, in the southern ponds if the plume extends this distance without sinking below the brackish water lens. The CEMP includes a water quality monitoring station (A2) in this series of ponds, so such an impact would be quickly detected. It would be useful for future impacts assessment to intensively monitor these ponds immediately after initiation of major flows into the trenches. If plume waters fill the ponds, additional monitoring of impacts to biota should be immediately initiated. Presumably, cessation of disposal or reduction of flows to a level which does not impact the

> ponds would restore the anchialine ecosystem. Alternatively, if operationally feasible the start-up of the OTEC Plant could be incrementally staged while the ponds are monitored for the intrusion of plume waters. If plume waters were detected, flows into the trench nearest the ponds could be reduced until impacts were no longer apparent.

Summary

The intent of the EIS process is to assess an action at the earliest practicable time. In the present instance, the project components are adequately defined to assess the potential impacts. It is true that certain design elements are still under development. This is invariably the case if the EIS is prepared at the earliest practicable time. The undefined elements are architectural and cosmetic in nature affecting principally the visual appearance of the facility. NELHA has established design guidelines which must be complied with by all tenants, and these are more than adequate to protect to visual appearance of this industrial property. The intent of KAD Partners, however, is to go considerably beyond minimum requirements and develop an attractive world-class facility.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

Clare Hachmuth

CLARE HACHMUTH
Executive Director

Lorraine R. Inouye
Mayor

Norman K. Hayashi
Director

Tad Nagasako
Deputy Director

Planning Department

County of Hawaii • 25 Aupuni Street, Room 109 • Hilo, Hawaii 96720 • (808) 961-8288

August 20, 1992

The Honorable John Waihee
Governor, State of Hawaii
c/o Office of Environmental Quality Control
220 South King Street, 4th Floor
Honolulu, HI 96813

Dear Governor Waihee:

Draft Supplemental Environmental Impact Statement
NELHA Development of Land Exchange Parcel
State Land Use Boundary Amendment
TMK: 7-3-09:23

Thank you for the opportunity to provide comments on NELHA's Draft Supplemental Environmental Impact Statement (SEIS). We provide you with the following comments:

1. The SEIS should include the conceptual recreational plan map including mauka-makai and lateral accesses.

2. A 1 MW (gross) OTEC Power Plant is proposed for this project. OTEC Plants have not been run on a sustained basis as such the reliability of this planned power plant needs to be discussed further. When the OTEC unit is not operating, how will water required for the other aspects of the project be provided? Can HELCO provide backup?

3. Slant drilling is discussed on page IV-8 as construction technology to drill beneath beach and reef areas and used to site pipelines. The experimental slant drilling program at Keahole was tremendously expensive. The SEIS should discuss further the effectiveness and/or reliability of such technology.

4. The project seems to rely upon two techniques which expanded discussion in these two areas need to be included in the SEIS.

Should you have any questions, please feel free to contact Alice Kawaha or Rodney Nakano of this office.

Sincerely,

NORMAN K. HAYASHI
Planning Director

AK:smo
6268D

cc: Clare Hachmuth, NELHA
LGK & Associates
West Hawaii Office

NELH — Natural Energy Laboratory of Hawaii
HOST PARK — Hawaii Ocean Science and Technology Park

August 31, 1992

Mr. Norman K. Hayashi, Director
County of Hawaii
Planning Department
25 Aupuni Street, Room 109
Hilo, Hawaii 96720

Dear Mr. Hayashi:

SUBJECT: Supplemental Environmental Impact Statement for the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Hawaii, TMK No.: 7-3-09:23.

Thank you for your letter of August 20, 1992. The following paragraphs reference your numbered comments.

1. As described in the EIS, KAD Partners intends to extend the Wawaloli Beach improvements across more than half of the ocean frontage of their parcel. The plan is to improve the existing jeep trail as far south as the Archaeological Preserve, add parking spaces, pavilions, tables, barbecues and landscaping. The jeep trail would be terminated at the Archaeological Preserve, but pedestrian access would be maintained through the Preserve, with appropriate interpretative materials provided to educate users about the historical and cultural significance of the area.

   This work will require an SMA Use Permit. As part of the SMA Use Permit process, NELHA intends to work with your staff and others to complete a detailed plan of the beach area which will serve the needs of the public, NELHA and its tenants.

2. Included in the KAD Project is complete electrical redundancy in the form of a 1MW diesel generator which will automatically switch on should the primary power source fail. Maintenance of power to seawater pumps, aerators, etc. is critical to the Lobster Farm, Ocean Center and NELHA Visitor Center. Service connections from HELCO will not be required.

3. The present project does not propose any pipelines in addition to those which have already been approved. Slant drilling was the subject of a separate

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

environmental review completed prior to the experimental program. In the original approval process for the pipeline installations, slant drilling was identified as a potential mitigation measure to avoid impacts to the shoreline and reef areas, providing it became technically and economically feasible. The test program did prove the technique technically feasible in the basalt substratum, however, as you point out, it was very expensive compared to crossing the shore above grade. At this time, therefore, it is uncertain if slant drilling will in fact be economically feasible. NELHA is continuing to examine slant drilling along with other techniques such as trenching and tunneling to determine if they can be employed in such a manner as to minimize environmental impacts. Preliminary indications are that tunneling will be more expensive than slant drilling. Trenching is both technically and economically feasible, but previous trenching operations at Keahole have resulted in significant, if transitory, negative impacts. If trenching operations can be conducted without major environmental disruptions, then this may be the method of choice to protect the long-term environmental quality, public enjoyment of the coastal resource and the pipeline installations themselves.

4. The methodology and potential impacts of slant drilling are described in the document entitled "Slant Drilling Demonstration Project: Project Description and Environmental Review" prepared by MCM Planning and dated April 1991. Your department was previously provided a copy of this document.

If you have any further questions or comments, please contact me at 329-7341.

Sincerely,

CLARE HACHMUTH
Executive Director

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X. REFERENCES

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XI. APPENDICES

APPENDIX A
ACTIONS ASSESSED IN PRIOR EISs

ACTIONS ASSESSED IN "FEIS: DEVELOPMENT PLAN FOR HOST PARK AND EXPANSION OF NELH," HTDC, 1985

OCEAN WATER RELATED USES

A. MARICULTURE

See pages II-1; Table 2-1 (following page II-15); II-16; II-19; II-20; IV-19; IV-33; IV-35; IV-36; IV-39; IV-40; Appendix A and Appendix F.

- Algae

  Phytoplankton
  Macro-algae

- Crustaceans

  Brine shrimp
  Marine Shrimp

- Mollusks

  Clams
  Oysters

- Non-Bivalve Mollusks

  Abalone

- Finfish

B. ENERGY

See pages II-1 through II-4; Table 2-1 (following page II-15); II-16; II-19 through II-21; IV-33; IV-34; Appendix C and Appendix F.

- Ocean Thermal Energy Conversion (OTEC)

  Open cycle
  Closed cycle

- Solar ponds (SPOTEC)

  30 KWe

- Marine biomass energy

C. OTHER

See Table 2-1 (following page II-15); pages II-16; II-19 through II-21.

- Marine biotechnology
- Materials testing
- Hydrogen from seawater
- Refrigeration and cooling
- Agriculture

CAMPUS INDUSTRIAL USES

See pages II-4; Table 2-1 (following page II-15); II-20; II-21; IV-42.

- Scientific laboratories
- Educational facilities
- Desalination plant
- Renewable energy projects not using ocean water

SERVICE AND SUPPORT USES

See pages II-8; II-9; II-21; IV-42; IV-73; IV-74; Appendix E and Appendix G.

- Visitor center/restaurant
- Light industrial (shops, etc.)
- Offices

- Minimal warehousing/storage (related to primary activities)
- Public shoreline facilities

OCEAN USE CORRIDOR AND SEAWATER SUPPLY SYSTEMS

See pages II-23 through II-30; Table 2.2, page II-27; IV-21 through IV-32; Appendix B and Appendix F.

- Expansion of corridor
- Construction and operation of 9 to 15 seawater intake pipes (Table 2.2)
- Construction/deployment methodologies
- Mixed water discharge pipe
- Pump stations and on-land seawater distribution systems

SEAWATER RETURN FLOW DISPOSAL

See pages IV-33 through IV-42; Appendix C and Appendix F.

- Direct disposal via canal
- Shallow injection wells
- Surface spreading
- Ocean outfall
- Large-diameter, deep, gravity injection wells
- Shallow surface trench disposal
- Domestic sewage disposal systems - septic tanks and leaching fields.

BASIC INFRASTRUCTURE

See pages II-9; II-12; II-21; IV-4 through IV-20; IV-41; IV-65 through IV-73; Appendix C and Appendix E.

- Improvements to intersection at Queen Kaahumanu Highway
- Construction of entry feature
- Road construction and improvements
- Construction of underground utilities (water and electricity) and upgrades to existing systems
- Overland piping and header tanks
- Construction of maintenance road to northern portions of NELH
- Construction of individual domestic wastewater disposal systems (septic tanks with leaching fields)
- New electrical substation
- Drainage improvements

ACTIONS ASSESSED IN "FSEIS FOR ALTERNATIVE METHODS OF SEAWATER RETURN FLOW DISPOSAL," NELH, 1987.

MARICULTURE

See pages II-6; II-8; IV-26 through IV-28; Appendix B and Appendix E.

A. SPECIES

- Microalgae

  Chaetoceros
  Dunaliella
  Tetraselmis
  Spirulina
  Phaeodactylum

- Macroalgae

  Gelidium
  Gracilaria
  Laminaria
  Nori seaweed (*Porphyra tenera*)

- Marine Mollusks

  abalone (*Haliotis* sp.)
  oysters (*Crassostrea*, *Ostrea*)
  clams (*Tapes*, *Mercinaria*, *Tridacna*)
  opihi (*Celana* sp.)

- Crustaceans

  brine shrimp (*Artemia*)
  shrimp (*Penaeus*)
  lobster (*Homarus*, *Panulirus*)

- Finfish

  coho salmon
  rainbow trout
  steelhead trout
  mullet

tilapia
carp
mahimahi

B. CONSTITUENTS OF MARICULTURE SEAWATER RETURN FLOWS

- Organic wastes from crop metabolism and unused feeds
- Inorganic fertilizers
- Antibiotics and other disease treatments
- Larvae or other propagules
- Chemicals used for maintenance of water quality or facility disinfection:

  Aquatic Herbicides/Selective Toxicants: Aquathol-K (oxabicycloheptane-dicarboxylic acid); Copper Control/Cutrine-Plus (Copper-triethanolamine-complex); Copper sulfate; Diquat (1,1-ethylene-2,2-bipyridylium dibromide cation); and Rotenone.

  Disinfectants: Argentyne (Polyvinylpyrrolidone-iodine, 10%); Benzalkonium Chloride (N-alkyl quaternary amines); and Chlorine (Sodium or calcium hypochlorite).

  Antibiotics/Antiparasitics: Erythromycin, Neomycin, Penicillin, Sulfamerazine; Chloramine-T (Sodium para-toluene-sulfonchloramide); Formaldehyde; Malachite Green; Potassium Permanganate; Prefuran/Furance/P 7138 (Nifurpirinol); and Trichlorfon/Masoten/Dylox/Dipterex/Chlorofos/Metrifonate/Neguvon (Dimethyl-trichloro-hydroxyethyl) phosphonate.

  Enrichment media for: diatoms; naked flagellates; eukaryotes such as *Chaetoceros*, *Dunaliella*, *Tetraselmis* and *Pheodactylum*; *Spirulina* and other blue-green algae.

- Salinity
- Temperature

ENERGY

See pages II-I through II-6; IV-3 through IV-7; Appendix A and Appendix E.

A. PROGRAMS AND PROJECTS

- Testing open cycle (OC) OTEC components
- Tests of direct contact and conventional heat exchangers
- Heat exchanger corrosion
- Studies of non-condensible gases
- Tests on turbine materials
- Evaluation of the mist lift cycle
- 165 kw OC OTEC demonstration plant

B. CONSTITUENTS OF OTEC SEAWATER RETURN FLOWS

- Mixed (cold/warm) seawater discharge

  Dissolved oxygen
  Nitrate + nitrite
  Orthophosphate
  Total nitrogen
  Total phosphorus
  Silicon

- Lysing constituents
- Dissolved gases
- Trace metals
- Chlorine
- Nutrients from mixing warm and cold water
- Salinity
- Temperature

NELH DEVELOPMENT PLAN

See pages II-9 through II-13; IV-50 through IV-53; Appendix D.

- Experimental test facility at NELH
- New driveway and improved road makai of laboratory
- Four holding tanks
- Control building for electrical power controls and a pumping station
- Ocean water distribution lines
- Seawater return flow disposal facility for OTEC water
- Expansion north of existing compound for future energy projects
- Subdivision of about 60 acres into one to seven-acre lots for use or lease by R & D firms
- Subdivision of about 60 acres into 5 to 10 acre lots for lease to commercial entrepreneurs
- Construction and operation of seawater disposal facilities
- Use of about 21 acres for future shoreside marine projects such as solar ponds, wave energy conversion and marine biomass energy
- Additional public parking
- Expansion of fresh water distribution
- Construction of road to northern portions of the site

ALTERNATIVE METHODS OF SEAWATER RETURN FLOW DISPOSAL

See pages II-2 through II-6; II-8 through II-9; IV-7 through IV-49; Appendices A, B, C, E and F.

- Disposal via canal

- Disposal via deep injection wells
- Disposal via shallow trench
- Research trench
- Simultaneous and/or combined disposal of OC OTEC and mariculture seawater return flows
- Mixed-water deep ocean discharge pipe

MITIGATING MEASURES FOR SEAWATER RETURN FLOW DISPOSAL ALTERNATIVES

See pages IV-45 through IV-47; Appendices A, B, C, D, E and F.

- Comprehensive Environmental Monitoring Program (CEMP)
- Reoxygenation through aeration
- Other project specific mitigations

APPENDIX B
COMPREHENSIVE ENVIRONMENTAL MONITORING PROGRAM
ANNUAL REPORT, 1991

NELHA Water Quality Lab Staff

Annual Report

for the

COMPREHENSIVE ENVIRONMENTAL MONITORING PROGRAM

Covering the period:

July 1990 through June 1991

Prepared by:

NELHA Water Quality Lab Staff

January 1992

Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749 • Kailua-Kona • Hawaii 96745 Phone (808) 329-7341 FAX (808) 326-3262

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INTRODUCTION

The Comprehensive Environmental Monitoring Program was designed in 1987 and 1988 as a cooperative effort between the Natural Energy Laboratory of Hawaii (NELH) and Hawaii Ocean Science and Technology (HOST) Park, both operated at Keahole Point on the Big Island of Hawaii by the State of Hawaii. Legislation enacted in 1990 has combined these two organizations into the new Natural Energy Laboratory of Hawaii Authority (NELHA), which now assumes responsibility for the CEMP.

This report presents the data collected in the second year of the CEMP. Graphical summaries include the first year's data for completeness. The first quarterly report issued under the provisions of the CEMP in February 1990 also included a tabular summary of all water quality data collected since 1987. Those data, collected under the auspices of the U.S. Department of Energy and other sponsors, include analyses of the seawater intakes and the ocean "outfall channel". The data provide a valuable background and baseline against which to interpret the CEMP data presented herein.

The CEMP significantly expands the scope of the water quality monitoring program. In addition to continuation of the intake and outfall monitoring, the new program also mandates collection and analysis of samples from near surface offshore waters, from selected sites along the shoreline, from anchialine ponds just inland of the shoreline and from a series of groundwater monitoring wells located around Keahole Point.

In this second year of monitoring, NELHA has implemented all but the anchialine pond and nearshore benthic biota monitoring aspects of the CEMP. These final components of the monitoring are now beginning, with the initiation of two consultant contracts in July of 1991.

During 1990-91, CEMP has collected more than 9,000 data points. This report presents these data in both tabular and graphic forms.

In addition to the data presentations contained in the report for 1990-91, this second annual report includes interpretive graphical analyses of the groundwater and coastal enrichment for the various parameters which are affected by groundwater intrusion. The analyses utilize the "Mixing Line" hypothesis (Dollar and Atkinson, in press), whereby all values are normalized against salinity to compensate for the influence of freshwater input.

GENERAL INFORMATION ON THE DATA

Variables Measured and Techniques Used

This section briefly summarizes the sampling techniques, instrumentation and experimental techniques used in collecting CEMP data. Detailed protocols are on file in the NELHA Water Quality Laboratory.

Temperature - Temperatures are measured in situ for all samples except the pumped surface and deep seawater, which are both measured at the sampling ports on shore. The deep water temperatures are thus higher than the in situ temperature by an unknown amount. For the 12" seawater system, spot comparisons with measurements by submersible at the pipe intake indicate a warm up of about 4°C with one pump running (approx. 500 gal/min) and about 1°C with all three pumps running (about 1,000 gpm). Calculations indicate that any pipe with a flow greater than 1000 gpm will exhibit less than 1°C warmup from intake at 600 m to discharge under the conditions at Keahole Point.

All temperatures are measured with laboratory thermometers, accurate to +/- 0.2°C. All thermometers are recalibrated annually.

Salinity - Salinity samples are collected in full 125 ml amber neoprene bottles and stored at room temperature until analysis using the A.G.E. Mod. 2100 precision salinometer. "Copenhagen" reference water is used as a standard, and results are reproducible to better than 0.002 per mil (2 ppm).

Total Suspended Solids - Samples are collected in 2-4 liter bottles and filtered by standard methods, collecting all solids on the pre-weighed filters. Filtration volumes depend upon how much is required to produce a measurable filtrate. Following moisture removal by incubation overnight at 45°C, the filters are stored in a desiccator until TSS values are determined by reweighing. Since the values for deep seawater have generally been near the limit of detectability at about 0.1 mg/l, TSS has not been measured in the 40" deep seawater system. The measurements have continued in the 12" deep seawater system for continuity.

pH - Samples are collected in tightly-capped 500 ml amber polypropylene bottles and allowed to sit for 2-3 hours to equilibrate to room temperature. The Ross electrode attached to the Corning Model 135 pH meter is allowed to equilibrate for 30 minutes before calibration with pH 7.00 and 4.00 seawater buffers and then soaks in the actual sample for 5 more minutes before readings are taken. After measurements are completed the pH 7.00 buffer is again measured to establish the extent of drift. Repeatability is within about .001 pH unit. The enclosed tables also present the measured electrode millivolts and the temperature at measurement to allow for corrections to in situ pH when desired.

A magnetic stirrer has been used to mix the pH samples since February 1990. This has impproved the consistency of the pH measurements, particularly for the groundwater well samples.

Alkalinity - The Corning pH meter is again used to measure the pH of subsamples of the pH samples which have been acidified by a precise addition of HCl. Careful pipetting provides repeatability of better than +/- .003 pH units, which allows calculation of alkalinity to within about +/- .01 mEq/liter.

Dissolved Oxygen - Dissolved oxygen samples are collected in tightly stoppered glass bottles and inoculated immediately at the time of collection with $MnSO_4$ and KI to fix all of the dissolved oxygen in an alkaline solution as $Mn(OH)_x$. They are then stored at room temperature until analysis at the NELHA water quality laboratory by the Winkler titration method. This well-established method provides accuracy to about 0.02 ppm, and repeated tests have demonstrated that extended storage does not degrade this accuracy as long as the samples are properly buffered at the time of sampling. Note that these values are reported as ppm, but they are calculated (according to standard practice, e.g. Strickland and Parsons, 1986) assuming that seawater has a specific gravity of 1.0. They should precisely be reported as "mg/l" or "$mg \cdot dm^3$". They can be converted to the more common oceanographic units of "ml/liter" at NTP by multiplying by the factor 0.7641.

Nutrients - Nutrient samples are collected in acid-rinsed 125 ml polypropylene bottles with a small air gap included. The samples are frozen until analysis on the Technicon AutoAnalyzer II. This instrument produces high accuracy (+/- 0.1 micromolar) values for concentration of nitrate (actually, nitrate + nitrite), orthophosphate, silicate and ammonium. These are presently recorded as peaks on the Technicon chart recorder and read into the log book by the operator, thus providing an operator check not always present in automated peak recording systems.

Jumps in the nutrient data for nitrates, phosphates and silicates have apparently been caused by problems with the freezing of the samples. Though previous publications (e.g. MacDonald, et al., 1986) have indicated that frozen samples will not degrade over long time periods, we have found significant offsets in the nutrient data for samples frozen for more than a few hours. NELHA has, therefore, recently adopted a prtotocol requiring immediate analysis of all seawater samples, and it appears that this is improving the consistency of the analysis.

Total Dissolved Nitrogen and Phosphorus - Subsamples of the nutrient samples are oxidized in an Ace Glass ultraviolet irradiator, converting all other nitrogen to nitrate and phosphorous to orthophosphate. These subsamples are then run through the Technicon Autoanalyzer which gives new nitrate and phosphate values representing TDN and TDP.

Total Organic Carbon - Samples collected in 2/3 full 60 ml polypropylene bottles are frozen for later analysis on NELH's Shimadzu TOC5000 analyzer. This analyzer uses a modification of Suzuki's (Sugimura and Suzuki, 1988) oxidation method, combusting the sample at 680°C in the presence of a platinum catalyst. This method, as demonstrated in many inter-comparison experiments (e.g. Williams and Druffell, 1989), produces TOC values about 400% greater than those previously measured using perchlorate and UV oxidation techniques. Though there is still some debate about the validity of these new values, their correlation with apparent oxygen utilization and recent demonstrations that the values are somewhat independent of the catalyst used appear to have convinced most investigators that the new values are valid.

Prior to January 1990, NELH nutrient and TOC analyses were performed by Analytical Services (A.S.) at UHM. Subsamples of the nutrients were used for the TOC analyses, which were performed utilizing persulfate and UV oxidation techniques. The same sample collection procedures were continued from January through April 1990, and a backlog of samples developed before it was realized that all the TOC analyses would be performed at NELHA instead of A.S. Beginning in May 1990, separate samples were collected, allowing nutrient analyses to be completed independent of TOC; however, the nutrient analyses for January through April could not be done until the NELHA TOC analyzer became operational in September 1990. The NELHA water quality lab staff this year completed processing the backlog of those samples which required simultaneous nutrient and TOC analyses, while also keeping up with current sampling and analyses. These backlogged data are reported as new values in this annual report.

As expected, there is a significant jump in the TOC time series at the time of initiation of this new analysis technique.

Missing Data

Only two anchialine ponds have thus far been sampled for water quality, and it is clear that population and benthic data should also be collected in this regime. Beginning in July 1991, NELHA is contracting out further anchialine pond sampling and the benthic monitoring also required by the CEMP to professional organizations with appropriate expertise.

Some other data values are missing due to unavoidable errors in sampling and analysis, but these represent only a very small portion of the data collected under the CEMP.

INTAKE WATER QUALITY DATA

Discussion

There are three separate data sets presented in Tables I-III for the two deep seawater intake systems and the surface intake system. A portion of the mixed seawater return from these systems is discharged through the NELHA Outfall channel, which is sampled at four different locations as presented in Tables IV-VII. All of these data are summarized in a series of graphs presented in Figures 2-14. The following subsections briefly discuss the seawater systems and sampling sites.

The Surface Seawater System - The original 12" surface seawater system installed in 1980 consisted of two 12" diameter PVC pipelines extending to the laboratory from intakes about 3 m offshore at a depth of 3 m. In 1983, one of the intakes was extended 100 m offshore, where a riser extends about 12 m off the bottom in 20 m of water. Four fiberglass-lined pumps which work for both of these pipelines are located in the laboratory compound at the base of the header tank tower, about 200 m from the shoreline. A vacuum system removes air from high points of the pipelines by maintaining a constant pressure between 4 and 7 psia (28 and 48 KPa), with a consequent effect on dissolved gases in the delivered water. Total flow varies between 500 gal/min (.03 m^3/s) and 1,000 gpm (.06 m^3/s), depending on the number of pumps operating and which intakes are open. Through 1987, the surface seawater was sampled in the laboratory building at a calibration tank which was part of the ongoing DOE biofouling and corrosion experiments. Following termination of the DOE experiments, new sampling ports were established, first at a point on the supply lines and later, when the flow was reduced at that point, in the outdoor wet lab. Since January 1989, most of the surface water has come through the 28" diameter intake installed in conjunction with the HOST/DOE/PICHTR 40" seawater system. This intake is located approximately 200 m offshore about 15 m above the bottom at 30 m water depth. The pipeline runs through a backfilled trench into the surface water pump sump 15 m onshore, where submersible pumps push the water into the DOE/PICHTR surface water supply line. A crossover from this line feeds the water into the NELHA surface water header tanks, from which it is distributed to sampling ports and laboratory users. Since the whole intake line and the pumps are under water, dissolved gas concentrations in this supply are only changed by pump action and the surface interactions in the sump and the header tank. The three primary pumps in this system each provide about 3,600 gpm (.23 m^3/s) of water for a nominal maximum flow capability of 9,600 gpm (.61 m^3/s). Since demand has only occasionally approached the flow capability of even one of these pumps, NELHA has installed a 500 gpm (.03 m^3/s) submersible pump in the sump, and this pump has provided the surface water from the 28" system. Surface seawater samples since January 1989 have been taken from a mixture of water from the 12" system and the 28" system. The mixing ratio is unknown, although the new system generally pumps the majority of the water. Sampling is done from ports in the outdoor wet lab, just downstream from the header tanks.

The 12" Deep Seawater System - The 12" deep seawater pipeline has provided seawater continuously since August 1982 from an intake approximately 30 m off the bottom at 583 m. depth. The water is pumped up by three in-line submersible pumps located in a manifold approximately 30 m offshore at 10 m depth. Approximate flow rates are 500 gpm (.03 m^3/s) with one pump, 800 gpm (.050 m^3/s) with two pumps and 1100 gpm (.069 m^3/s) with all three pumps operating. Since January 20, 1989 all 12" DSW samples have been taken from a sample port located prior to all valves or diversions in the system.

To ensure simultaneous sampling of possibly correlated variables, subsamples for all parameters between September 1984 and February 1991 were taken from carboys which were filled at the indicated sampling ports. After January 1986, samples for alkalinity, pH and D.O. were taken separately from the carboy to eliminate possible contamination of these samples by the acid rinse required to ensure pristine nutrient values. From February through June 1986, a 1-liter bottle replaced the carboy. Carboy sampling was discontinued from mid-1986 until September 1988 and from June 13, 1989 until it was restarted September 11, 1989. In the interim, samples were taken directly from the sample ports. From September 1989 through February 1991, two 2-liter carboys were used, one for pH, alkalinity and D.O. and one for all other samples. Though there has been much discussion on the subject, it does not appear that correlations between the variables were any greater when the carboy was used, so all sampling has been done directly from the sampling ports since February 1991.

The 12" DSW system has continued in operation through the present reporting period, in spite of its marginal usefulness to NELHA operations. Though earlier plans had called for its discontinuance, it now appears that it will be kept operating as a backup system. This will ensure continuation of the continuous time series collected since 1982.

The 40" Deep Seawater System - This system was installed in the summer of 1987 under the joint sponsorship of the State of Hawaii's HOST Park, the U.S.D.O.E. and PICHTR (see Daniel, 1989). The 40" diameter polyethylene pipeline runs from an intake some 30 m off the bottom in 670 m water depth in a buoyant catenary configuration over a pipe length of about 1.8 km to its landing through a sub-bottom trench extending from 200 m offshore into a large pump sump located approximately 20 m onshore.

Though designed to provide both high-head flow to 30 m elevation at HOST Park and low-head flow to D.O.E. experiments near sea level, the high head pumps have not been required and all pumping has been via low-head 3,600 gpm (.23 m^3/s) pumps. Flows since 1988 have been typically between 6,000 gpm and 7,200 gpm, with most water being sold to Ocean Farms of Hawaii, an aquaculture tenant of NELHA. Since temperature increase in the pipe is minimal for flows more than 1,000 gpm and other parameters are probably not affected by the flow rate, flow values at the time of sampling are not recorded. The data are available at NELHA if required for future analysis.

All-316 stainless steel pumps were specified for the system to minimize corrosion problems and the resultant dissolution of iron ions into the water. Severe corrosion problems at the beginning of operation of the pumps led to the installation of an impressed current corrosion control system, which became operational in January 1989. This, together with major design modifications by the pump manufacturer, has effectively eliminated the corrosion problems. The impressed current system, which uses Pt electrodes, was chosen because of concern that conventional sacrificial zinc anodes might introduce possibly harmful levels of Zn ion (though evidence of detrimental effects is purely anecdotal).

Initial sampling of the 40" DSW in mid-1988 indicated significant differences between this water and that from the 12" system, even though the new intake is only about 500 m north and 85 m deeper than the 12" intake. These differences led to the decision to continue independent sampling of the two deep seawater systems. This simultaneous sampling has continued through the present reporting period.

Seawater samples from the 40" DSW system are taken weekly in the outdoor wet lab through a 1/2" sample line running about 10 m from the main 24" HOST Park delivery pipeline.

Outfall Sampling - A portion of surface and deep seawater pumped ashore at NELHA is returned to the sea via a channel through the tidepools just North of Keahole Point. NPDES Permit No. HI0020893 allows NELHA to discharge water from the original 12" seawater systems through this "outfall", and a mixture of surface and deep water has been discharged in the area continuously since operations began in 1981. The high nutrient content of the deep water has led to the development of a luxuriant and unique biota in the outfall area (Kay, 1989), and there has been much interest in the uptake of the excess nutrients by the algae. Weekly sampling and analysis of water from several sites in the outfall area has been conducted since 1985. Four sets of samples are taken at the sites indicated in Figure 1. Samples 1A and 1B are taken from the two streams of water which discharge at site 1. The Site 1A stream comes from the header tank discharge drain, representing mostly overflow, and the site 1B stream comes from the laboratory drain after the water has passed through various research projects. Major users of the 1B water have included the

U.S.D.O.E. biofouling and corrosion experiments from 1981 through 1987, the PICHTR/D.O.E. open cycle heat and mass transfer experiments intermittently since August 1987 and the ALCAN aluminum heat exchanger tests continuously since April 1985.

Major changes are observed in the outfall area following large waves. The area has been stripped of all vegetation several times over the eleven years that the system has been in operation. This has forced a change in the sampling schedule a few times, and the sampling sites OF-2 and OF-3 have had to be relocated when some of the landmark rocks used for marking the sites have moved. We estimate that they have been relocated to within about one meter after each wave event. Total inundation of the site has not occurred since February 1986.

The data from each outfall site are presented separately in Tables IV-VII. Data are plotted on the same figures 2-14 as the incoming seawater data. This provides some visual indication of how the outfall samples fall between the values for the surface water and the deep water.

Data Discussion

As noted above (p. 4), significant offsets show up in the nitrate, phosphate and silicate values, especially in the deep seawater. These offsets coincide with sampling batches, so it appears that they may be caused by sample degradation after freezing between collection and analysis. NELHA has now begun analyzing samples immediately after collection, and we expect that this will eliminate the analytical variability.

The TOC values show an increase of about 400% above values reported previously under the CEMP and earlier programs. As noted above, this increase was expected because of the higher TOC values measured by the new Shimadzu 5000 Suzuki-type TOC analyzer. We have, however, been unable to find an analytical explanation for the anomalously large TOC excursions found from April through November 1990.

Figure 1. Location Map for Seawater Pipelines and Outfall Sampling Sites.

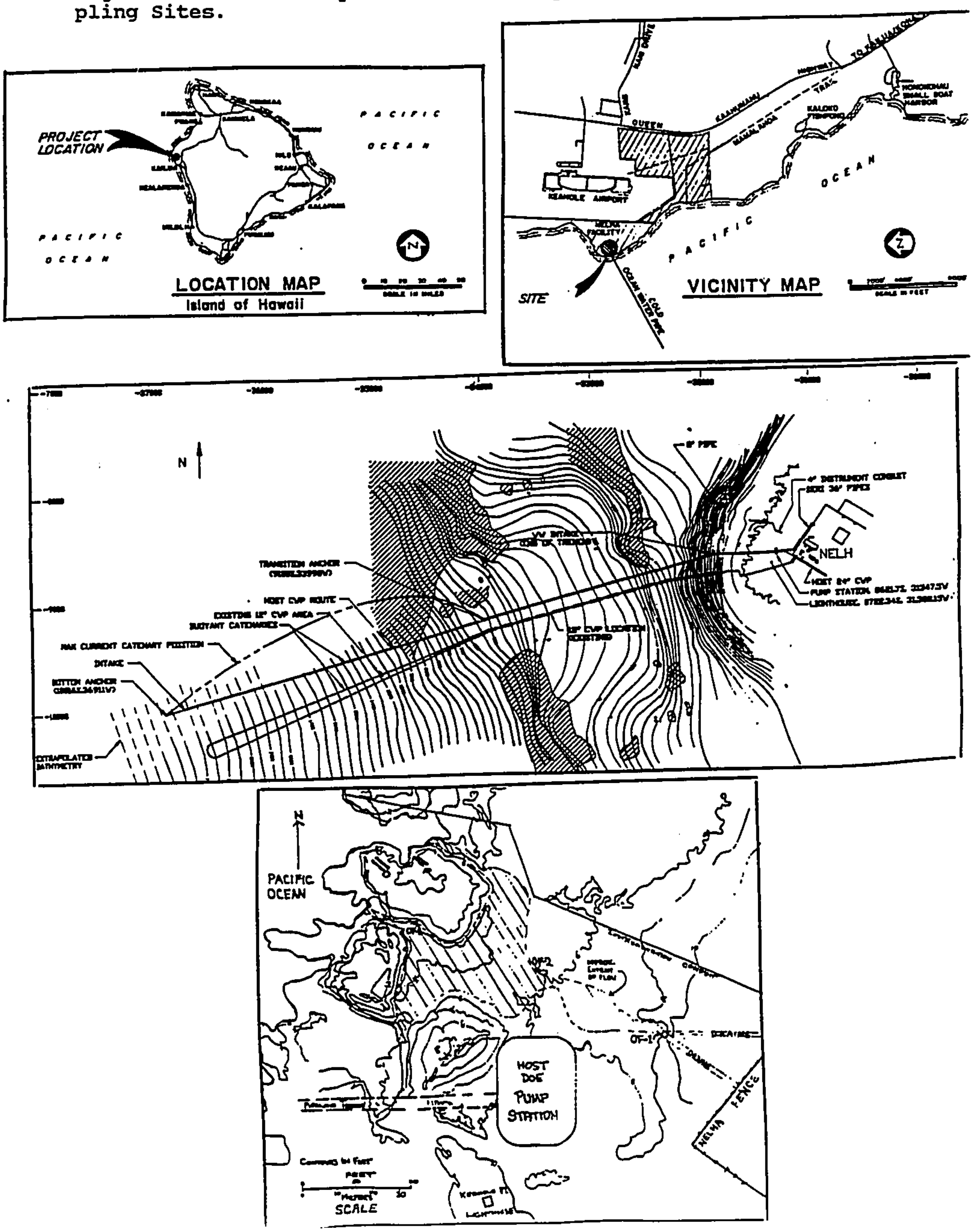


Table I. Surface Seawater Water Quality Data

SURFACE SEAWATER

NELH WATER QUALITY DATA
1990-1991

D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	UM TDP	UM TDN	MG/L TOC	MG/L TSS	MEQ/L ALK	O/OO SALINITY	DEG-C TEMP	pH	mV	DEG. C TEMP H	DO (ppm)
02-Jul-90	1990.50	0.08	0.17	0.37	1.90	0.11	3.30	2.66	0.37	2.292	34.734	26.3	8.290	-136.4	23.7	6.60
06-Jul-90	1990.51	0.08	0.20	0.40	2.61	0.13	3.30	1.06	0.53	2.298	34.744	26.0	8.296	-136.8	23.6	6.60
13-Jul-90	1990.53	0.10	0.14	0.44	2.02	0.11	2.94	1.18	0.51	2.303	34.714	26.4	8.290	-137.5	24.5	6.76
23-Jul-90	1990.56	0.08	0.11	0.37	2.25	0.11	3.73	3.27	0.53	2.306	34.727	26.8	8.296	-138.1	23.5	6.44
30-Jul-90	1990.58	0.05	0.14	0.37	1.84	0.13	5.69	1.95	0.32	2.300	34.700	27.5	8.270	-137.6	26.7	6.39
06-Aug-90	1990.60	0.10	0.20	0.59	1.79	0.44	3.35	3.62	0.32	2.306	34.686	27.7	8.292	-138.8	24.3	6.33
13-Aug-90	1990.62	0.14	0.20	0.43	1.96	0.42	3.10	1.04	0.49	2.310	34.751	27.4	8.281	-138.7	24.9	6.43
20-Aug-90	1990.63	0.09	0.15	0.51	1.79	0.42	3.40	1.42	0.58	2.302	34.735	27.6	8.293	-139.2	23.3	6.55
27-Aug-90	1990.65	0.09	0.20	0.43	2.13	0.38	2.72	2.57	0.61	2.307	34.735	27.9	8.282	-138.9	24.4	6.40
04-Sep-90	1990.68	0.13	0.33	0.51	3.08	0.42	2.79	2.13	0.72	2.315	34.764	28.1	8.271	-139.1	25.4	6.71
10-Sep-90	1990.69	0.14	0.20	0.59	4.03	0.42	2.74	0.85	0.69	2.307	34.789	27.9	8.293	-140.5	23.3	7.39
17-Sep-90	1990.71	0.14	0.25	0.51	2.24	0.44	4.02	1.20	0.62	2.315	34.756	28.4	8.263	-142.0	25.1	6.64
24-Sep-90	1990.73	0.13	0.23	0.51	2.35	0.39	3.66	1.36	0.74	2.315	34.770	28.3	8.282	-139.7	24.0	6.46
01-Oct-90	1990.75	0.13	0.23	0.51	1.79	0.45	3.92	1.07	0.81	2.257	34.790	27.9	8.280	-139.1	23.9	6.57
10-Oct-90	1990.77	0.14	0.25	0.75	2.46	0.38	3.66	0.94	0.58	2.255	34.786	27.9	8.290	-139.9	23.7	6.40
15-Oct-90	1990.79	0.18	0.67	1.23	2.46	0.45	3.97	1.04	0.69	2.255	34.779	28.0	8.244	-138.2	24.9	6.16
22-Oct-90	1990.81	0.09	0.20	0.43	2.74	0.42	3.33	3.03	0.65	2.252	34.846	27.4	8.266	-139.3	24.4	6.54
29-Oct-90	1990.83	0.10	0.42	0.15	3.55	0.16	5.03	2.60	0.77	2.249	34.899	27.2	8.265	-138.7	23.8	6.23
05-Nov-90	1990.85	0.08	0.17	0.08	2.08	0.11	3.83	1.02	0.75	2.260	34.882	27.4	8.273	-139.4	23.7	6.36
13-Nov-90	1990.87	0.05	0.12	0.26	2.49	0.30	3.35	1.18	0.67	2.260	34.990	26.4	8.252	-138.4	23.7	6.23
20-Nov-90	1990.89	0.05	0.12	0.26	2.77	0.33	3.35	1.21	1.11	2.257	34.968	25.9	8.281	-138.9	21.9	6.36
28-Nov-90	1990.91	0.05	0.26	0.26	3.60	0.33	3.32	0.94	2.90	2.268	34.861	26.2	8.303	-139.8	23.0	6.28
03-Dec-90	1990.92	0.07	0.12	0.20	4.43	0.36	2.89	0.98	0.91	2.283	34.657	26.5	8.288	-140.0	22.8	6.34
11-Dec-90	1990.94	0.09	0.12	0.26	5.88	0.36	3.01	1.02	0.44	[illegible]	34.631	26.4	8.262	-139.7	24.2	6.41
17-Dec-90	1990.96	0.09	0.16	0.26	3.60	0.36	2.97	0.82	1.05	[illegible]	34.782	26.4	8.280	-140.0	22.5	6.56
28-Dec-90	1990.99	0.11	0.14	0.13	2.71	0.40	4.79	0.91	1.08	[illegible]	34.666	25.4	8.287	-140.0	20.8	6.41
02-Jan-91	1991.00	0.08	0.09	0.16	2.22	0.40	3.22	1.05	0.76	2.282	34.740	25.6	8.308	-140.5	20.8	6.57
07-Jan-91	1991.02	0.14	0.20	0.18	2.27	0.36	3.05	0.95	0.90	2.279	34.707	25.5	8.307	-140.1	21.7	6.59
14-Jan-91	1991.04	0.11	0.09	0.16	2.07	0.46	3.28	0.97	0.97	2.279	34.710	25.1	8.289	-140.8	21.9	6.62
24-Jan-91	1991.06	0.06	0.23	0.35	2.43	0.27	2.90	1.45	1.12	2.282	34.741	25.1	8.306	-139.9	23.2	6.60
28-Jan-91	1991.08	0.08	0.23	0.38	1.98	0.23	2.93	0.90	0.83	2.248	34.794	24.9	8.300	-140.2	23.7	6.86
04-Feb-91	1991.09	0.06	0.10	0.38	2.29	0.32	3.12	0.96	0.89	2.248	34.744	25.1	8.304	-139.7	22.1	6.77
11-Feb-91	1991.11	0.10	0.26	0.38	2.95	0.32	3.71	1.56	0.15	2.244	34.748	25.2	8.297	-138.2	21.4	6.83
19-Feb-91	1991.14	0.10	0.21	0.38	2.64	0.24	3.53	1.11	0.56	2.250	34.801	25.2	8.305	-138.1	21.8	6.76
25-Feb-91	1991.15	0.14	0.33	0.45	3.43	0.24	3.10	0.97	0.29	2.249	34.774	25.0	8.288	-136.5	21.3	6.73
04-Mar-91	1991.17	0.14	0.33	0.38	3.25	0.24	3.31	0.96	1.51	2.257	34.820	24.9	8.290	-135.6	23.6	6.86
11-Mar-91	1991.19	0.12	0.36	0.40	2.90	0.28	3.37	0.98	0.43	2.255	34.837	24.8	8.280	-134.0	22.8	6.69
18-Mar-91	1991.21	0.12	0.39	0.38	2.64	1.39	3.46	0.87	0.25	2.250	34.801	23.6	8.270	-131.1	21.4	9.68
27-Mar-91	1991.23	0.14	0.39	0.35	2.55	0.23	2.92	0.89	0.04	2.244	34.738	24.7	8.282	-128.6	22.0	11.10
01-Apr-91	1991.25	0.12	0.33	0.35	2.29	0.28	4.00	1.21	0.04	2.244	34.769	24.5	8.270	-127.0	22.6	10.91
08-Apr-91	1991.27	0.09	0.19	0.45	3.13	0.22	2.82	1.18	0.19	2.383	34.729	24.8	8.281	-126.1	21.6	6.62
15-Apr-91	1991.29	0.09	0.19	0.45	3.43	0.27	3.10	0.99	0.37	2.376	34.645	25.3	8.270	-124.8	22.4	21.72
23-Apr-91	1991.31	0.09	0.14	0.48	2.70	0.30	3.04	0.93	0.19	2.371	34.589	24.9	8.270	-121.1	21.8	12.43
29-Apr-91	1991.32	0.09	0.19	0.43	2.11	0.27	2.59	0.93	0.13	2.376	34.642	25.1	8.287	-118.7	22.2	14.23
06-May-91	1991.34	0.09	0.19	0.40	2.99	0.28	3.04	1.02	0.32	2.373	34.630	25.4	8.298	-110.6	22.3	6.61
08-May-91	1991.35															6.45
13-May-91	1991.36	0.09	0.19	0.39	2.40	0.28	2.70	1.20	0.32	2.376	34.661	25.3	8.299	-109.9	22.7	6.77
20-May-91	1991.38	0.09	0.06	0.50	1.70	0.36	3.30	1.18	0.49	2.368	34.508	26.0	8.297	-106.3	22.6	6.75
28-May-91	1991.40	0.07	0.17	0.21	2.31	0.34	4.25	1.04	0.30	2.376	34.590	25.5	8.300	-106.0	22.7	6.64
04-Jun-91	1991.42	0.07	0.17	0.24	3.11	0.34	4.25	1.15	0.31	2.373	34.578	26.1	8.301	-100.6	23.1	6.64
10-Jun-91	1991.44	0.06	0.19	0.18	10.80	0.34	3.60	0.98	0.47	2.385	34.619	25.9	8.284	-101.2	22.6	6.69
17-Jun-91	1991.46	0.06	0.21	0.26	2.91	0.31	3.60	0.94	0.76	2.309	34.633	26.1	8.274	-102.9	23.5	6.58
24-Jun-91	1991.4[illegible]	[illegible]	[illegible]	0.2[illegible]	3.7[illegible]	0.3[illegible]	[illegible].63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
01-[illegible]-91	[illegible]	[illegible]	[illegible]	0.40	18.30	0.44	2.96	1.05	0.23	2.312	34.666	26.1	8.270	[illegible]	[illegible]	[illegible]

Table II. Deep 12" Seawater Water Quality Data

DEEP 12"
SEAWATER

NELHA WATER QUALITY DATA
1990-1991

D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	UM TDP	UM TDN	MG/L TOC	MG/L TSS	MEQ/L ALK	O/OO SALINITY	DEG-C TEMP/F	pH	mv	TEMP/M	DO ppm
02-Jul-90	1990.50	3.05	40.80	0.07	74.78	3.48	41.98	0.97	0.39	2.320	34.303	10.8	7.605	-96.3	21.8	1.32
06-Jul-90	1990.51	2.98	40.38	0.00	73.45	3.29	41.27	0.76	0.02	2.332	34.293	10.9	7.599	-96.0	20.4	1.40
13-Jul-90	1990.53	3.01	40.14	0.04	72.12	3.29	41.04	0.93	0.17	2.332	34.283	10.8	7.596	-96.4	20.1	1.38
23-Jul-90	1990.56	3.15	41.55	0.10	77.00	3.47	42.45	1.92	0.16	2.336	34.324	10.4	7.580	-96.2	20.8	1.23
30-Jul-90	1990.58	3.15	41.31	0.00	77.43	3.29	42.26		0.21	2.330	34.328	11.0	7.597	-96.9	17.9	1.12
06-Aug-90	1990.60	3.13	41.08	0.00	76.11	3.36	42.03	3.05	0.24	2.335	34.325	11.0	7.573	-96.8	22.6	1.19
13-Aug-90	1990.62	2.84	40.27	0.00	NA	3.31	41.50	1.69	0.21	2.338	34.335	10.8	7.577	-97.4	22.2	1.19
20-Aug-90	1990.63	2.98	40.27	0.00	NA	3.44	42.12	1.97	0.28	2.332	34.328	11.2	7.571	-97.0	22.2	1.19
27-Aug-90	1990.65	2.90	39.45	0.00	NA	3.42	41.09	2.83	0.27	2.327	34.305	10.6	7.566	-97.0	22.2	1.23
04-Sep-90	1990.68	2.94	40.27	0.00	NA	3.40	41.71	3.39	0.24	2.340	34.371	8.9	7.552	-96.2	23.3	1.30
10-Sep-90	1990.69	2.90	39.86	0.00	NA	3.35	41.50	1.11	0.35	2.327	34.311	10.7	7.554	-97.0	22.8	1.11
17-Sep-90	1990.71	2.27	38.45	0.00	81.49	2.78	41.47	0.96	0.47	2.290	34.292	12.4	7.574	-98.5	22.8	1.29
24-Sep-90	1990.73	2.88	40.60	0.00	84.10	2.70	43.10	1.27	0.29	2.295	34.331	10.2	7.563	-97.6	21.8	1.31
01-Oct-90	1990.75	3.05	43.40	0.00	99.10	2.34	37.27	0.96	0.23	2.292	34.312	10.2	7.577	-97.9	19.8	1.22
10-Oct-90	1990.77	3.03	42.90	0.00	91.90	2.47	38.40	0.64	0.29	2.295	34.329	10.0	7.573	-98.1	22.1	1.20
22-Oct-90	1990.81	2.80	39.50	0.00	75.90	2.83	42.50	0.64	0.31	2.289	34.284	10.2	7.557	-97.8	22.5	1.31
29-Oct-90	1990.83	3.10	43.60	0.00	90.90	2.27	35.39	0.68	0.22	2.292	34.312	10.1	7.556	-97.2	22.4	1.23
05-Nov-90	1990.85	3.13	44.40	0.00	86.60	2.53	38.77	0.65	0.29	2.292	34.323	10.0	7.556	-97.5	21.6	1.15
13-Nov-90	1990.87	3.12	44.80	0.00	78.20	3.25	46.57	0.82	0.19	2.296	34.326	10.0	7.550	-97.3	20.7	1.14
20-Nov-90	1990.89	3.08	41.51	0.00	80.09	3.19	42.92	0.64	0.58	2.296	34.337	9.1	7.564	-97.6	20.1	1.05
28-Nov-90	1990.91	2.98	41.29	0.00	80.50	3.10	42.70	0.75	1.83	2.296	34.341	9.2	7.600	-98.9	20.8	1.09
03-Dec-90	1990.92	3.06	41.02	0.00	80.62	3.02	43.16	0.91	0.40	2.328	34.345	9.5	7.563	-97.9	21.8	1.13
11-Dec-90	1990.94	2.81	45.51	0.00	79.05	2.96	46.60	0.63	0.34	2.331	34.327	9.9	7.565	-99.0	21.8	1.10
17-Dec-90	1990.96	2.98	43.80	0.00	78.60	3.05	45.10	0.55	0.43	2.331	34.358	10.0	7.548	-97.4	21.0	1.04
28-Dec-90	1990.99	2.97	37.05	0.00	78.50	3.36	38.11	0.60	0.75	2.337	34.359	9.3	7.561	-98.0	18.8	1.04
02-Jan-91	1991.00	2.96	40.24	0.13	75.06	2.99	42.60	0.62	1.01	2.341	34.333	9.4	7.563	-97.4	20.5	1.02
07-Jan-91	1991.02								0.95			9.8	7.609	-99.4	19.1	0.96
11-Jan-91	1991.03	2.88	41.90	0.13	74.90	3.09	42.20	0.63		2.341	34.294					
14-Jan-91	1991.04	2.97	42.95	0.11	78.80	3.12	45.81	0.67	0.94	2.341	34.344	9.7	7.563	-98.6	19.3	0.88
24-Jan-91	1991.06	2.76	40.39	0.03	73.60	2.79	42.75	0.67	0.32	2.344	34.295	9.6	7.609	-99.2	19.4	1.08
28-Jan-91	1991.08	3.05	40.90	0.19	76.30	3.09	42.39	0.68	0.93	2.288	34.343	9.8	7.571	-97.5	20.1	0.89
04-Feb-91	1991.09	2.99	41.70	0.16	74.04	3.16	44.20	1.11	0.43	2.285	34.350	9.8	7.543	-95.6	20.7	0.87
11-Feb-91	1991.11	3.09	41.70	0.11	74.60	3.23	44.36	0.92	0.15	2.288	34.352	9.5	7.588	-97.0	19.2	0.81
19-Feb-91	1991.14	2.78	40.23	0.16	75.31	2.88	41.71	0.77	0.09	2.275	34.312	10.2	7.567	-95.3	20.1	1.03
25-Feb-91	1991.15	2.77	39.80	0.21	80.30	2.94	42.80	0.68	0.06	2.295	34.378	9.8	7.571	-95.1	20.3	0.81
04-Mar-91	1991.17	2.61	36.90	0.34	87.80	3.23	47.10	0.80	0.09	2.275	34.280	10.5	7.570	-93.7	21.1	1.14
11-Mar-91	1991.19	2.63	36.70	0.11	86.40	3.16	45.80	0.69	0.07	2.278	34.289	10.2	7.554	-91.6	19.7	1.06
18-Mar-91	1991.21	3.20	44.10	0.08	97.90	3.70	51.20	0.64	0.10	2.291	34.332	9.1	7.496	-86.4	19.8	0.98
27-Mar-91	1991.23	2.28	38.70	0.20	104.00	3.60	49.40	0.59	0.09	2.296	34.371	9.2	7.538	-85.3	18.7	0.92
01-Apr-91	1991.25	3.10	41.40	0.00	81.10	3.12	44.20	0.87	0.04	2.288	34.386	9.3	7.546	-84.6	17.9	0.96
08-Apr-91	1991.27	3.12	41.70	0.00	84.50	3.26	44.20	0.63	0.05	2.366	34.352	9.2	7.549	-83.5	18.5	0.89
15-Apr-91	1991.29	2.92	40.00	0.13	74.70	3.06	41.40	0.76	0.07	2.360	34.346	9.6	7.524	-81.5	21.6	0.99
23-Apr-91	1991.31	2.97	31.50	0.00	73.60	3.12	33.50	0.77	0.13	2.353	34.292	9.6	7.554	-75.9	21.7	1.11
29-Apr-91	1991.32	3.08	42.30	0.03	78.90	3.19	43.20	0.73	0.15	2.360	34.357	9.7	7.560	-67.3	19.4	0.99
06-May-91	1991.34	2.87	39.70	0.09	76.40	2.99	42.05	0.74	0.13	2.355	34.305	9.7	7.560	-67.3	19.4	1.08
13-May-91	1991.36	2.91	39.50	0.16	75.90	2.97	41.80	0.70	0.31	2.350	34.303	9.7	7.511	-63.9	20.8	1.14
20-May-91	1991.38	2.97	41.70	0.09	75.60	3.03	44.96	0.81	0.08	2.349	34.291	10.0	7.525	-61.1	19.3	1.15
28-May-91	1991.40	2.93	42.60	0.22		3.16	44.10	0.88	0.13	2.349	34.303	9.9	7.507	-59.8	21.0	1.12
04-Jun-91	1991.42	2.90	40.60	0.00	78.90	3.02	42.90	0.77	0.06	2.359	34.320	10.0	7.585	-58.7	22.0	1.05
10-Jun-91	1991.44	2.98	34.30	0.26	74.97	3.26	37.30	0.65	0.10	2.352	34.312	9.8	7.561	-59.4	22.2	1.07
17-Jun-91	1991.46	2.95	38.70	0.12	70.90	3.01	40.80	0.64	0.19	2.347	34.264	10.4	7.601	-63.3	20.5	1.38
24-Jun-91	1991.48	3.05	40.30	0.26	73.80	3.40	42.90	0.69	0.01	2.360	34.314	10.1	7.551	-62.2	22.0	1.13
01-Jul-91	1991.50	3.05	37.30	0.24	78.10	3.27	39.80	0.59	0.11	2.351	34.302	10.3	7.578	-64.8	22.0	1.20

Table III. Deep 40" Seawater Water Quality Data

DEEP 40" SEAWATER

NELH WATER QUALITY DATA
1990-1991

D-M-Y DATE	JULIAN DATE	UH PO4	UH NO3	UH NH4	UH SI	UH TDP	UH TDN	MG/L TOC	MEQ/L ALK	O/OO SALINITY	DEG-C TEMP/F	pH	mv	TEMP/H	DO (ppm)
02-Jul-90	1990.50	3.20	42.86	0.02	86.73	3.33	43.63	2.25	2.379	34.410	7.8	7.598	-96.6	22.0	1.13
06-Jul-90	1990.51	3.15	43.10	0.22	87.26	3.36	43.63		2.359	34.415	7.5	7.580	-94.9	21.3	1.15
13-Jul-90	1990.53	3.20	42.72	0.16	84.96	3.43	43.54	0.90	2.354	34.396	7.9	7.583	-95.7	20.7	1.20
23-Jul-90	1990.56	3.20	42.63	0.00	84.67	3.36	43.16	2.17	2.354	34.390	7.8	7.575	-96.1	21.5	1.13
30-Jul-90	1990.58	3.20	42.48	0.00	82.32	3.33	43.44	1.30	2.356	34.378	8.1	7.564	-95.6	20.7	1.09
06-Aug-90	1990.60	3.22	42.72	0.10	84.96	3.22	43.40	1.47	2.351	34.403	8.1	7.560	-96.1	23.3	1.11
13-Aug-90	1990.62	2.98	41.71	0.00	NA	3.42	42.73	2.69	2.356	34.395	8.0	7.568	-97.0	22.7	1.16
20-Aug-90	1990.63	3.02	42.11	0.00	NA	3.32	43.35	0.69	2.351	34.409	8.0	7.566	-96.8	22.2	1.11
27-Aug-90	1990.65	3.02	42.11	0.00	NA	3.32	43.14	4.88	2.356	34.412	8.9	7.552	-96.2	23.3	1.20
04-Sep-90	1990.68	3.02	42.11	0.00	NA	3.36	43.55	3.53	2.354	34.411	7.9	7.544	-96.6	23.7	1.10
10-Sep-90	1990.69	3.02	41.91	0.00	NA	3.34	43.55	0.74	2.354	34.394	7.1	7.558	-91.5	21.7	1.07
17-Sep-90	1990.71	2.54	41.31	0.00	96.70	3.69	45.60	0.78	2.325	34.292	8.4	7.546	-99.8	22.7	1.20
24-Sep-90	1990.73	3.17	41.67	0.00	85.80	3.46	43.08	0.81	2.341	34.382	7.9	7.557	-97.4	22.2	1.11
01-Oct-90	1990.75	3.30	44.65	0.00	86.44	3.51	45.43	0.76	2.331	34.389	8.0	7.565	-97.3	21.0	1.17
10-Oct-90	1990.77	2.78	37.22	0.00	98.50	3.63	47.92	0.88	2.333	34.388	7.9	7.570	-98.0	22.3	1.12
15-Oct-90	1990.79	2.78	37.60	0.00	100.30	3.93	50.46	0.63	2.331	34.383	7.6	8.400	-97.9	20.7	1.13
22-Oct-90	1990.81	3.39	42.65	0.00	88.30	3.43	45.04	0.97	2.331	34.369	8.0	7.544	-97.2	22.8	1.10
29-Oct-90	1990.83	3.39	42.84	0.00	87.05	3.50	45.42	0.67	2.336	34.397	8.0	7.545	-96.6	22.6	1.12
05-Nov-90	1990.85	3.27	43.04	0.00	85.10	3.56	45.04	0.65	2.331	34.378	8.0	7.545	-96.9	22.0	1.11
13-Nov-90	1990.87	3.07	46.30	0.00	86.30	3.26	48.69	0.62	2.336	34.398	8.8	7.536	-96.5	21.9	1.09
20-Nov-90	1990.89	3.21	44.68	0.00	87.96	3.53	46.74	0.66	2.333	34.389	7.5	7.554	-97.0	20.3	1.04
28-Nov-90	1990.91	3.14	42.60	0.00	88.50	3.23	44.16	0.67	2.340	34.397	7.2	7.594	-98.7	20.7	1.10
03-Dec-90	1990.92	3.17	42.24	0.00	86.42	3.28	43.93	0.62	3.334	34.392	7.2	7.552	-97.2	21.9	1.06
11-Dec-90	1990.94	3.13	47.35	0.00	86.19	3.28	49.91	0.59	2.334	34.397	7.3	7.555	-98.3	22.2	1.05
17-Dec-90	1990.96	3.16	45.20	0.00	87.30	3.24	46.80	0.53	2.337	34.417	7.4	7.551	-97.6	20.9	1.08
28-Dec-90	1990.99	3.10	38.50	0.00	91.60	3.43	38.90	1.14	2.345	34.423	6.6	7.557	-97.8	18.9	1.08
02-Jan-91	1991.00	3.11	42.20	0.04	88.50	3.16	44.10		2.334	34.424	7.0	7.557	-97.3	20.6	0.97
07-Jan-91	1991.02								2.326		7.7	7.603	-99.0	18.4	0.94
11-Jan-91	1991.03	3.10	45.02	0.13	86.86	3.29	45.90	0.68		34.402					
14-Jan-91	1991.04							0.63	2.329	34.414	7.5	7.564	-98.6	18.4	0.88
24-Jan-91	1991.06	2.91	42.45	0.03	78.60	3.01	44.66	0.61	2.318	34.384	7.6	7.583	-97.9	18.8	0.83
28-Jan-91	1991.08	3.26	43.00	0.13	84.70	3.30	44.40	0.62	2.267	34.427	7.4	7.570	-97.5	19.8	0.96
04-Feb-91	1991.09	3.12	42.49	0.14	78.80	3.23	44.87	1.33	2.257	34.389	7.8	7.548	-95.8	20.7	0.87
11-Feb-91	1991.11	3.19	43.80	0.14	86.50	3.30	46.50	1.39	2.269	34.448	7.8	7.586	-97.0	19.7	1.01
19-Feb-91	1991.14	3.03	42.71	0.16	87.80	3.14	44.50	1.27	2.260	34.407	8.1	7.559	-94.7	19.8	0.88
25-Feb-91	1991.15	2.28	32.40	0.02	104.80	3.50	49.20	1.01	2.257	34.403	7.9	7.594	-96.5	21.1	0.86
04-Mar-91	1991.17	2.60	35.50	0.05	93.10	3.16	45.10	1.08	2.254	34.385	8.4	7.556	-93.0	21.0	0.89
11-Mar-91	1991.19	2.50	34.40	0.02	98.90	3.43	48.60	1.16	2.257	34.371	8.0	7.543	-91.0	19.8	0.89
18-Mar-91	1991.21	2.33	33.50	0.00	103.70	3.45	49.00	1.02	2.244	34.408	7.6	7.506	-87.0	20.1	0.96
27-Mar-91	1991.23	2.27	31.80	0.05	113.80	3.23	46.30	1.00	2.253	34.432	7.8	8.542	-85.5	18.8	1.03
01-Apr-91	1991.25	3.21	41.90	0.00	89.90	3.25	44.20	0.76	2.238	34.350	8.0				0.96
08-Apr-91	1991.27	3.26	42.70	0.00	89.20	3.33	45.80	0.63	2.374	34.416	8.0	7.548	-83.4	18.5	0.99
15-Apr-91	1991.29	2.96	41.40	0.13	78.10	3.13	42.70	0.65	2.369	34.412	8.5	7.531	-81.9	21.5	1.02
23-Apr-91	1991.31	3.21	33.90	0.00	87.20	3.30	35.70	0.71	2.374	34.412	7.9	7.507	-76.9	18.9	1.07
29-Apr-91	1991.32	3.16	43.20	0.05	84.70	3.24	44.70	0.71	2.370	34.396	8.3	7.549	-75.6	21.7	1.02
06-May-91	1991.34	3.00	41.90	0.11	85.90	3.10	43.70	0.67	2.370	34.400	8.4	7.538	-66.1	19.8	1.07
13-May-91	1991.36	3.04	42.00	0.16	87.40	3.14	44.30	0.69	2.374	34.416	8.3	7.519	-64.3	20.6	1.07
20-May-91	1991.38	3.17	46.00	0.11	90.30	3.23	49.30	0.74	2.377	34.411	7.5	7.508	-60.0	19.0	0.98
28-May-91	1991.40	3.17	44.60	0.31		3.20	46.10	0.71	2.372	34.403	7.7	7.500	-59.5	21.0	1.03
04-Jun-91	1991.42	3.02	42.30	0.00	86.50	3.13	44.40	0.70	2.371	34.389	8.7	7.580	-58.3	21.5	1.07
10-Jun-91	1991.44	3.18	37.30	0.24	86.50	3.37	38.10	0.70	2.368	34.401	8.4	7.551	-58.8	22.3	1.02
17-Jun-91	1991.46	3.19	42.00	0.12	84.80	3.41	43.50	0.80	2.373	34.369	8.9	7.595	-6[illegible]	20.8	1.03
24-Jun-91	1991.48	3.30	42.90	0.22	84.80	3.50	46.50	0.66	2.384	34.412	8.2	7.565		[illegible].7	0.67
0[illegible]-91	[illegible]91.[illegible]	3.[illegible]	[illegible]0.4[illegible]	[illegible].21	[illegible]00	[illegible]51	[illegible]0	[illegible]	[illegible]	[illegible]92	[illegible]8.7	[illegible].56	[illegible]	[illegible]	[illegible]0.6

Table IV. Outfall I-A Water Quality Data

OUTFALL 1-A Comprehensive Environmental Monitoring Program

D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	UM TDP	UM TDN	MG/L TOC	MG/L TSS	O/OO SALINITY	DEG-C TEMP/F	pH	mv	TEMP/H	DO (ppm)
06-Jul-90	1990.51	1.45	11.22	0.08	23.25	2.02	8.55	1.25	0.11	34.669	21.2	8.148	-128.8	26.1	7.33
13-Jul-90	1990.53	2.58	2.57	0.20	8.77	1.55	6.00	1.15	0.37	34.684	25.4	8.211	-134.6	29.6	6.72
23-Jul-90	1990.56	1.98	20.93	0.20	48.25	2.45	22.75	1.62	1.26	34.195	17.4	8.038	-123.2	24.6	7.81
30-Jul-90	1990.58	1.93	21.50	0.10	48.68	2.39	23.50	1.65	0.96	34.300	17.1	8.025	-122.7	24.7	7.57
06-Aug-90	1990.60	1.03	8.93	0.20	22.89	1.84	12.15	1.22	1.21	34.486	23.1	8.163	-131.9	27.9	7.07
13-Aug-90	1990.62	0.84	10.03	0.00	19.82	1.21	13.63	1.06	1.00	34.603	22.4	8.147	-131.4	27.4	6.83
20-Aug-90	1990.63	0.53	6.88	0.00	17.55	1.10	9.58	1.14	0.95	34.518	24.3	8.184	-133.7	27.5	7.43
27-Aug-90	1990.65	0.17	1.26	0.09	6.52	0.61	5.31	2.37	0.39	34.655	27.2	8.241	-137.5	28.8	7.13
04-Sep-90	1990.68	0.42	5.98	0.00	15.85	1.05	9.13	2.47	1.08	34.573	24.9	8.179	-134.5	28.7	6.94
10-Sep-90	1990.69	0.29	3.73	0.09	15.57	0.40	6.66	1.50	1.24	34.740	26.3	8.208	-136.6	28.5	6.77
17-Sep-90	1990.71	0.60	6.32	0.23	21.08	0.99	8.51	1.02	1.31	34.683	24.4	8.158	-136.7	28.7	6.69
24-Sep-90	1990.73	0.46	4.58	0.00	9.89	1.05	7.11	1.13	1.13	34.729	25.5	8.201	-135.9	28.4	6.77
01-Oct-90	1990.75	0.46	4.58	0.00	10.81	1.07	7.85	1.20	1.04	34.671	25.3	8.206	-135.4	26.5	6.67
10-Oct-90	1990.77	0.52	4.58	0.00	10.51	1.05	6.86	0.87	1.04	34.762	25.3	8.208	-135.7	26.6	6.83
15-Oct-90	1990.79	0.75	8.01	0.00	16.65	1.34	11.81	1.41	3.38	34.713	23.0	8.154	-132.9	24.8	7.10
22-Oct-90	1990.81	0.54	8.34	0.24	17.73	1.11	12.13	1.67	1.20	34.759	23.5	8.156	-133.2	26.3	6.89
29-Oct-90	1990.83	0.35	4.68	0.24	12.67	1.00	8.36	1.34	1.80	34.867	24.6	8.189	-135.0	27.3	6.49
05-Nov-90	1990.85	0.43	3.48	0.00	9.10	0.45	6.82	1.70	2.10	34.860	25.7	8.212	-136.7	27.3	6.44
13-Nov-90	1990.87	0.30	4.52	0.00	11.40	0.53	7.69	1.16	2.01	34.893	24.4	8.193	-135.2	25.1	6.51
20-Nov-90	1990.89	0.09	0.81	0.06	3.64	0.33	4.81	1.08	1.79	34.882	25.5	8.265	-138.3	22.0	6.53
28-Nov-90	1990.91	0.45	6.45	0.68	15.90	0.65	10.42	0.97	6.42	34.800	23.4	8.228	-135.6	23.2	6.84
03-Dec-90	1990.92	0.15	1.62	0.06	5.90	0.40	4.17	0.92	1.40	34.606	25.4	8.230	-137.6	26.6	6.63
11-Dec-90	1990.94	0.15	0.97	0.00	5.90	0.40	3.04	1.01	1.40	34.650	25.8	8.228	-138.5	27.9	6.58
17-Dec-90	1990.96	0.10	0.81	0.00	4.28	0.35	3.20	8.67	1.60	34.777	25.7	8.243	-138.6	26.3	6.67
28-Dec-90	1990.99	0.43	3.16	0.00	10.40	0.62	6.82	0.91	2.11	34.606	24.2	8.250	-138.1	22.2	6.78
02-Jan-91	1991.00	0.36	2.41	0.05	9.00	0.57	6.06	1.27	2.14	34.698	24.5	8.276	-138.7	20.9	6.79
07-Jan-91	1991.02	0.37	2.41	0.38	10.40	0.57	7.28	1.06	1.95	34.624	24.4	8.285	-139.1	23.3	6.81
14-Jan-91	1991.04	0.29	1.50	0.00	7.63	0.50	6.21	1.02	2.06	34.609	24.7	8.270	-139.9	22.8	6.78
24-Jan-91	1991.06	0.36	1.95	0.00	6.95	0.43	5.61	1.15	5.85	34.739	24.3	8.297	-139.5	23.2	6.78
28-Jan-91	1991.08	0.12	1.17	0.29	3.92	0.35	4.08	0.97	1.53	34.802	24.5	8.277	-139.1	25.1	7.08
04-Feb-91	1991.09	0.14	0.78	0.29	3.92	0.37	3.82	1.04	6.22	34.738	24.6	8.282	-138.8	24.0	6.93
11-Feb-91	1991.11	0.27	3.40	0.31	9.54	0.57	6.64	1.02	0.56	34.718	23.3	8.236	-135.3	24.5	6.98
19-Feb-91	1991.14	0.41	3.71	0.25	18.38	0.64	7.43	1.12	1.19	34.826	23.5	8.236	-134.7	24.1	7.00
25-Feb-91	1991.15	0.41	4.45	0.23	11.60	0.67	8.47	0.92	0.59	34.737	23.1	8.224	-133.0	21.9	7.03
04-Mar-91	1991.17	0.26	2.21	0.22	8.05	0.50	6.08	0.88	0.62	34.806	23.6	8.242	-133.2	25.3	6.97
11-Mar-91	1991.19	0.24	2.09	0.23	7.77	0.47	6.08	0.85	1.01	34.780	23.6	8.235	-131.7	23.6	7.02
18-Mar-91	1991.21	0.51	6.81	0.25	17.20	0.77	10.27	0.95	1.11	34.637	21.6	8.178	-125.9	21.8	7.11
27-Mar-91	1991.23	0.44	6.35	0.39	17.90	0.68	9.00	0.77	0.28	34.571	21.9	8.204	-124.1	22.1	7.13
01-Apr-91	1991.25	0.31	4.02	0.23	11.60	0.50	7.43	1.10	0.18	34.691	22.8	8.217	-124.2	23.6	7.02
08-Apr-91	1991.27	0.55	6.91	0.23	17.60	0.74	10.20	0.90	0.30	34.638	21.5	8.170	-120.2	23.7	7.11
15-Apr-91	1991.29	0.23	1.49	0.29	6.34	0.37	5.26	1.03		34.599	24.2	8.247	-123.9	24.1	6.91
23-Apr-91	1991.31	0.65	8.46	0.29	22.10	0.85	10.50	0.97	0.61	34.506	21.1	8.157	-114.8	22.7	7.32
29-Apr-91	1991.32	0.23	2.55	0.27	21.80	0.35	5.33	0.96	0.62	34.559	23.5	8.251	-116.5	21.9	6.97
06-May-91	1991.34	0.20	2.26	0.23	7.77	0.45	5.40	0.97	0.87	34.636	24.1	8.265	-109.0	23.6	6.90
13-May-91	1991.36	0.45	6.49	0.29	16.30	0.68	10.50	1.03	0.82	34.579	22.0	8.201	-104.4	23.6	7.12
20-May-91	1991.38	0.25	2.55	0.33	7.48	0.35	5.19	0.98	1.08	34.496	24.4	8.255	-104.3	24.4	6.85
28-May-91	1991.40	0.13	1.00	0.33	4.62	0.29	3.51	1.00	0.73	34.577	24.9	8.268	-104.2	23.0	6.84
04-Jun-91	1991.42	0.95	13.96	0.23	31.50	1.23	17.50	0.90	0.58	34.495	18.8	8.127	-90.3	22.8	7.66
10-Jun-91	1991.44	1.09	14.90	0.22	34.80	1.16	16.50	0.89	0.61	34.495	18.8	8.086	-89.7	22.5	7.61
17-Jun-91	1991.46	1.05	13.70	0.22	32.20	1.20	15.70	0.87	1.03	34.520	19.6	8.114	-93.5	23.1	7.45
24-Jun-91	1991.48	1.22	16.00	0.22	40.40	1.41	17.90	0.81	1.17	34.534	18.5	8.081	-93.1	23.1	7.79
01-Jul-91	1991.50	1.17	15.70	0.22	39.80	1.46	18.60	0.79	0.50	34.385	18.3	8.089	-94.6	22.5	7.81

Table V. Outfall I-B Water Quality Data

OUTF1B Comprehensive Environmental Monitoring Program

D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	UM TDP	UM TDN	MG/L TOC	O/OO SALINITY	DEG-C TEMP/F	pH	mv.	DEG-C TEMP/M
02-Jul-90	1990.50	2.72	24.40	0.00	45.61	2.95	25.50	4.51	34.576	15.4	7.980	-117.9	22.2
06-Jul-90	1990.51	2.31	24.21	0.00	45.18	2.59	25.50	0.79	34.558	15.6	7.970	-117.5	21.4
13-Jul-90	1990.53	2.58	24.21	0.14	46.49	2.80	26.00	0.95	34.556	16.3	7.967	-118.0	21.5
23-Jul-90	1990.56	2.22	24.30	0.16	48.25	2.50	26.00	0.95	34.561	15.8	7.971	-118.8	21.4
30-Jul-90	1990.58	2.15	23.83	0.43	46.05	2.35	25.75	0.82	34.532	16.3	7.984	-119.7	21.0
06-Aug-90	1990.60	2.12	23.64	0.10	46.49	2.50	25.90	1.81	34.538	16.4	7.965	-119.5	22.8
13-Aug-90	1990.62	1.68	23.98	0.21	43.02	2.21	26.68	1.36	34.513	16.1	7.954	-119.1	22.3
20-Aug-90	1990.63	1.68	24.43	0.00	46.42	2.17	26.68	1.34	34.540	16.1	7.959	-119.4	21.5
27-Aug-90	1990.65	1.81	24.43	0.00	45.57	2.17	26.68	1.57	34.533	16.3	7.941	-118.7	22.7
04-Sep-90	1990.68	1.89	24.43	0.09	45.29	2.17	28.26	0.86	34.556	16.4	7.928	-118.8	23.3
10-Sep-90	1990.69	1.76	24.43	0.17	46.70	2.37	28.26	0.50	34.542	16.2	7.944	-119.9	22.1
17-Sep-90	1990.71	1.83	20.76	0.19	32.09	2.31	24.18	1.00	34.509	16.7	7.929	-122.2	22.8
24-Sep-90	1990.73	1.87	21.26	0.53	36.10	2.33	25.01	1.00	34.552	16.0	7.948	-119.6	20.8
01-Oct-90	1990.75	1.91	21.43	1.28	33.23	2.39	25.01	0.96	34.546	15.9	7.949	-119.3	20.7
10-Oct-90	1990.77	1.91	21.43	0.71	33.80	2.19	25.01	0.85	34.572	15.9	7.961	-120.3	21.4
15-Oct-90	1990.79	1.93	21.26	0.98	35.24	2.35	24.68	1.56	34.563	16.0	7.926	-119.1	21.8
22-Oct-90	1990.81	1.71	24.90	0.16	44.97	2.26	27.80	1.72	34.556	16.0	7.924	-119.9	22.5
29-Oct-90	1990.83	1.78	21.60	0.20	51.30	2.32	28.60	1.16	34.603	15.6	7.940	-119.3	20.7
05-Nov-90	1990.85	1.57	24.11	0.00	53.60	1.80	27.87	2.34	34.607	15.7	7.939	-119.4	20.4
13-Nov-90	1990.87	1.69	25.50	0.00	51.10	1.87	26.92	0.84	34.625	15.2	7.920	-118.4	19.7
20-Nov-90	1990.89	1.67	24.80	0.00	53.70	1.90	27.87	0.81	34.591	14.9	7.928	-118.6	19.8
28-Nov-90	1990.91	1.57	25.50	0.18	53.40	1.89	28.53	0.78	34.590	14.9	7.957	-119.3	21.3
03-Dec-90	1990.92	1.77	25.70	0.86	53.70	1.98	28.85	0.74	34.490	14.9	7.931	-118.7	19.5
11-Dec-90	1990.94	1.82	26.10	0.74	55.60	1.95	28.50	0.83	34.500	15.0	7.944	-120.5	20.3
17-Dec-90	1990.96	1.82	25.80	0.43	53.70	2.08	28.50	0.96	34.552	15.0	7.929	-119.1	20.1
28-Dec-90	1990.99	1.95	25.40	0.00	54.70	2.03	28.10	0.93	34.518	14.4	7.937	-119.6	19.2
02-Jan-91	1991.00	1.95	25.40	0.00	54.70	2.10	27.60	0.72	34.555	14.3	7.926	-118.6	20.6
07-Jan-91	1991.02	1.98	25.40	0.00	53.70	2.08	28.40	0.83	34.530	14.7	7.961	-119.7	19.2
14-Jan-91	1991.04	2.14	27.71	0.00	58.80	1.86	26.10	0.79	34.521	14.5	7.922	-119.4	19.7
24-Jan-91	1991.06	1.93	25.40	0.00	52.00	1.55	21.30	0.92	34.537	14.5	7.954	-119.2	20.4
28-Jan-91	1991.08	1.70	25.70	0.37	51.60	1.87	27.40	0.95	34.570	14.4	7.928	-117.7	19.0
04-Feb-91	1991.09	1.80	25.04	0.42	48.60	2.02	27.61	0.91	34.543	14.6	7.919	-117.1	20.5
11-Feb-91	1991.11	1.88	25.70	0.31	52.10	2.02	28.60	0.96	34.549	14.4	7.938	-117.1	19.6
19-Feb-91	1991.14	1.81	25.07	0.38	64.96	2.00	28.80	0.95	34.570	14.4	7.930	-116.1	20.5
25-Feb-91	1991.15	1.77	24.99	0.50	51.20	1.88	24.40	0.90	34.556	14.5	7.922	-115.1	20.2
04-Mar-91	1991.17	1.80	24.99	0.50	48.30	1.97	26.32	1.06	34.563	14.4	7.938	-114.7	20.7
11-Mar-91	1991.19	1.83	25.10	0.55	49.80	2.00	27.30	0.83	34.561	14.2	7.921	-112.8	20.5
18-Mar-91	1991.21	1.85	25.22	0.50	50.10	2.07	27.30	0.74	34.559	13.9	7.869	-107.8	19.8
27-Mar-91	1991.23	1.77	25.10	0.49	51.60	1.87	26.40	0.74	34.532	14.1	7.913	-106.8	19.5
01-Apr-91	1991.25	1.78	24.40	0.35	52.00	1.98	26.60	1.06	34.542	13.9	7.921	-106.2	18.8
08-Apr-91	1991.27	1.73	23.60	0.38	49.10	1.89	27.30	0.95	34.542	14.0	7.930	-105.4	19.1
15-Apr-91	1991.29	1.96	25.50	0.42	58.40	2.06	26.40	0.78	34.180	14.4	7.892	-102.8	21.7
23-Apr-91	1991.31	1.94	24.70	0.35	50.90	2.11	27.60	0.83	34.467	14.1	7.913	-100.2	19.7
29-Apr-91	1991.32	1.60	21.60	0.24	46.30	2.04	28.10	0.80	34.485	14.0	7.939	-98.2	21.4
06-May-91	1991.34	1.64	21.20	0.31	45.60	1.97	28.80	0.78	34.479	14.4	7.924	-88.5	20.3
13-May-91	1991.36	1.98	25.50	0.42	53.10	2.08	28.20	0.88	34.499	14.4	7.907	-86.8	20.9
20-May-91	1991.38	1.87	24.70	0.38	50.70	1.97	27.90	0.90	34.434	14.5	7.908	-83.2	20.2
28-May-91	1991.40	1.31	19.09	0.35	41.60	1.93	28.80	0.73	34.473	14.4	7.893	-82.3	21.8
04-Jun-91	1991.42	1.49	19.70	0.28	45.20	1.89	29.80	0.73	34.486	14.6	7.941	-79.3	21.2
10-Jun-91	1991.44	1.94	25.70	0.22	54.60	2.11	23.50	0.78	34.475	14.5	7.895	-78.6	21.4
17-Jun-91	1991.46	1.94	25.60	0.25	53.00	2.09	28.30	1.12	34.451	14.7	7.928	-82.3	21.0
2[illegible]-Jun-91	199[illegible]	1[illegible]	26.[illegible]	0.[illegible]	50.[illegible]	2.16	[illegible]60	[illegible]13	[illegible].50[illegible]	14[illegible]	7[illegible]	[illegible]9	22.4
0[illegible]	1991.50	2.04	27.20	0.22	67.50	2.24	30.30	0.92	34.074	14.6	7.[illegible]	[illegible]	21.[illegible]

Table VI. Outfall 2 Water Quality Data

OUTFALL2 Comprehensive Environmental Monitoring Program

D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	DEG-C TEMP/F	pH	mv	DEG.C TEMP/M	DO (ppm)
02-Jul-90	1990.50	1.47	14.62	0.10	33.77	18.2	8.196	-131.5	26.8	8.58
06-Jul-90	1990.51	2.38	16.46	0.10	39.47	19.6	8.176	-130.6	27.1	8.33
13-Jul-90	1990.53	1.61	12.64	0.22	29.65	20.4	8.202	-133.3	28.8	8.51
23-Jul-90	1990.56	1.81	20.28	0.22	46.49	17.4	8.058	-124.8	27.6	7.23
30-Jul-90	1990.58	1.52	15.80	0.04	37.98	19.4	8.162	-131.4	27.8	8.06
06-Aug-90	1990.60	1.30	12.69	0.04	32.28	20.9	8.185	-133.6	29.3	8.02
13-Aug-90	1990.62	1.13	14.20	0.32	32.22	19.6	8.182	-133.6	28.0	8.13
20-Aug-90	1990.63	1.10	10.50	0.20	26.42	21.6	8.188	-134.2	27.9	7.63
27-Aug-90	1990.65	1.09	9.82	0.32	25.53	24.6	8.565	-156.6	28.6	8.06
05-Sep-90	1990.68	1.07	7.08	0.20	19.73	24.1	8.211	-136.7	30.0	7.77
10-Sep-90	1990.69	0.80	9.13	0.00	19.82	23.1	8.171	-134.5	28.4	7.04
17-Sep-90	1990.71	0.99	9.83	0.22	20.77	21.9	8.185	-138.3	29.2	7.82
24-Sep-90	1990.73	0.88	8.59	0.00	19.55	22.3	8.208	-136.5	29.0	7.92
01-Oct-90	1990.75	0.84	7.85	0.28	18.94	22.4	8.236	-137.2	26.4	8.18
10-Oct-90	1990.77	0.72	6.86	0.11	17.72	23.2	8.218	-136.4	26.5	7.48
15-Oct-90	1990.79	1.01	9.58	0.22	21.99	21.3	8.208	-136.2	25.6	8.31
22-Oct-90	1990.81	0.82	11.23	0.16	27.55	21.4	8.226	-137.5	26.7	8.83
29-Oct-90	1990.83	0.65	8.53	0.16	29.13	22.5	8.217	-136.7	27.1	7.69
05-Nov-90	1990.85	0.48	6.88	0.00	24.00	23.2	8.234	-137.9	27.1	7.73
13-Nov-90	1990.87	0.73	9.96	0.12	24.00	21.5	8.164	-133.4	24.6	7.01
20-Nov-90	1990.89	0.64	8.15	0.12	20.10	22.1	8.199	-134.4	21.1	6.74
28-Nov-90	1990.91	0.82	10.80	0.09	27.40	28.8	8.224	-135.5	23.1	7.33
03-Dec-90	1990.92	0.75	8.85	0.18	23.70	21.7	8.228	-137.2	26.1	8.00
11-Dec-90	1990.94	0.64	6.90	0.06	18.70	22.5	8.212	-137.6	27.4	7.66
17-Dec-90	1990.96	0.61	7.18	0.12	19.40	22.5	8.211	-136.9	26.1	7.39
28-Dec-90	1990.99					20.5	8.227	-136.6	21.1	7.65
02-Jan-91	1991.00					21.1	8.238	-136.5	20.8	7.46
07-Jan-91	1991.02					20.3	8.253	-137.1	22.8	7.29
14-Jan-91	1991.04					21.3	8.240	-138.1	22.4	7.49
24-Jan-91	1991.06	0.59	6.20	0.11	19.20	21.7	8.274	-138.1	23.3	7.25
28-Jan-91	1991.08	0.48	5.29	0.06	15.10	22.5	8.263	-138.2	24.3	7.32
04-Feb-91	1991.09	0.65	8.65	0.37	19.60	21.6	8.210	-134.5	23.1	7.05
11-Feb-91	1991.11	0.75	9.96	0.28	22.85	21.2	8.146	-130.5	26.1	6.92
19-Feb-91	1991.14	0.72	9.67	0.34	21.80	20.2	8.178	-131.2	23.5	7.32
25-Feb-91	1991.15	0.68	7.87	0.26	23.60	20.6	8.254	-134.8	22.6	8.74
04-Mar-91	1991.17	0.75	8.70	0.30	22.60	20.6	8.246	-133.2	24.3	8.27
11-Mar-91	1991.19	0.61	6.93	0.27	20.30	21.2	8.253	-132.7	23.5	8.25
18-Mar-91	1991.21	0.99	11.41	0.32	30.30	18.3	8.264	-130.7	21.5	9.73
27-Mar-91	1991.23	0.84	18.10	0.52	34.10	18.2	8.342	-132.0	21.8	10.91
01-Apr-91	1991.25	0.72	8.30	0.40	26.10	19.7	8.323	-130.5	24.4	10.10
08-Apr-91	1991.27	1.02	13.40	0.33	48.70	18.6	8.196	-121.8	24.1	8.62
15-Apr-91	1991.29	0.62	8.60	0.45	26.10	21.9	8.225	-122.6	24.1	7.80
23-Apr-91	1991.31	0.99	12.60	0.43	34.90	18.5	8.198	-117.2	22.7	8.68
29-Apr-91	1991.32	1.34	17.20	0.49	42.30	16.7	8.093	-107.4	22.1	7.80
06-May-91	1991.34	0.69	7.32	0.60	22.00	21.8	8.242	-107.7	24.0	7.71
13-May-91	1991.36	0.99	10.30	0.67	37.40	19.0	8.264	-108.2	24.0	9.21
20-May-91	1991.38	0.69	7.19	0.54	21.60	21.6	8.256	-104.4	24.5	8.12
28-May-91	1991.40	0.72	7.19	0.51	20.30	21.5	8.234	-102.3	23.1	7.71
04-Jun-91	1991.42	1.15	11.80	0.51	35.70	18.3	8.250	-98.0	24.6	9.46
10-Jun-91	1991.44	1.17	12.10	0.66	36.50	18.2	8.220	-97.7	23.6	9.40
17-Jun-91	1991.46	1.29	11.80	0.42	37.60	18.4	8.226	-100.3	24.2	9.58
24-Jun-91	1991.48	1.20	12.30	0.53	44.70	18.2	8.226	-101.6	23.3	9.76
01-Jul-91	1991.50	1.25	12.50	0.45	42.10	18.6	8.229	-103.0	23.9	9.63

Table VII. Outfall 3 Water Quality Data

OUTFALL3 Comprehensive Environmental Monitoring Program

D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	DEG-C TEMP	pH	mv.	DEG. C TEMP.M	DO (ppm)
02-Jul-90	1990.50	1.46	6.51	0.78	28.07	22.4	8.557	-153.6	27.7	14.09
06-Jul-90	1990.51	1.21	7.55	0.71	29.39	22.9	8.510	-151.1	30.4	13.91
13-Jul-90	1990.53	1.19	6.13	0.76	24.47	23.1	8.506	-151.7	30.7	13.85
23-Jul-90	1990.56	1.57	13.44	0.80	42.37	19.7	8.235	-135.8	29.4	10.73
30-Jul-90	1990.58	1.03	6.13	0.67	29.30	19.4	8.162	-131.4	27.8	15.13
06-Aug-90	1990.60	0.80	4.01	0.44	24.30	24.8	8.587	-157.8	30.3	13.30
13-Aug-90	1990.62	0.93	4.61	0.56	23.97	24.6	8.632	-160.9	30.4	14.33
20-Aug-90	1990.63	0.78	4.34	0.64	21.74	24.6	8.565	-156.6	28.6	12.73
27-Aug-90	1990.65	0.66	4.34	0.60	20.18	25.4	8.547	-156.1	30.6	12.43
04-Sep-90	1990.68	0.60	3.93	0.60	19.73	25.4	8.458	-151.7	31.3	11.39
10-Sep-90	1990.69	0.69	4.86	0.34	20.67	23.8	8.396	-147.9	29.1	10.62
17-Sep-90	1990.71	0.74	3.64	0.88	16.81	25.3	8.595	-162.9	30.5	14.80
24-Sep-90	1990.73	0.68	4.14	0.77	17.72	25.3	8.442	-150.8	30.5	12.59
01-Oct-90	1990.75	0.61	3.15	0.72	15.89	24.7	8.566	-157.0	28.1	13.60
10-Oct-90	1990.77	0.53	3.39	0.61	22.60	24.3	8.411	-147.9	27.7	10.30
15-Oct-90	1990.79	0.47	1.91	0.66	14.98	25.0	8.398	-147.8	27.0	10.21
22-Oct-90	1990.81	0.62	5.26	0.40	21.53	23.3	8.350	-156.8	27.8	14.11
29-Oct-90	1990.83	0.47	3.91	0.40	38.63	24.2	8.450	-150.6	28.2	11.08
05-Nov-90	1990.85	0.39	2.90	0.22	22.70	25.1	8.509	-154.5	28.5	12.09
13-Nov-90	1990.87	0.59	6.35	0.12	22.70	22.5	8.282	-140.5	25.5	8.99
20-Nov-90	1990.89	0.37	3.99	0.42	18.70	23.4	8.380	-144.9	21.8	9.45
28-Nov-90	1990.91	0.51	6.49	0.70	19.40	23.7	8.335	-141.8	23.8	8.44
03-Dec-90	1990.92	0.43	4.68	0.61	16.70	24.4	8.365	-145.8	27.6	9.71
11-Dec-90	1990.94	0.41	3.43	0.39	14.40	24.4	8.331	-144.7	28.1	9.00
17-Dec-90	1990.96	0.30	2.74	0.48	10.70	25.4	8.340	-144.6	27.3	8.77
28-Dec-90	1990.99					25.3	8.309	-141.5	22.3	6.94
02-Jan-91	1991.00					24.6	8.337	-142.3	20.9	7.24
07-Jan-91	1991.02					22.2	8.396	-145.5	23.3	9.62
14-Jan-91	1991.04					23.7	8.392	-147.1	23.1	9.49
24-Jan-91	1991.06	0.39	2.71	0.30	11.70	23.9	8.378	-144.4	24.3	8.53
28-Jan-91	1991.08									
04-Feb-91	1991.09	0.44	3.93	0.52	13.10	23.8	8.319	-141.0	24.1	8.42
11-Feb-91	1991.11	0.17	1.17	0.29	5.69	25.1	8.276	-138.2	26.7	7.02
19-Feb-91	1991.14	0.16	0.97	0.34	4.84	24.5	8.299	-138.5	24.9	7.17
25-Feb-91	1991.15	0.14	0.44	0.30	6.19	25.0	8.287	-137.4	25.6	7.34
04-Mar-91	1991.17	0.14	0.44	0.27	5.48	24.5	8.308	-137.4	26.7	7.29
11-Mar-91	1991.19	0.34	2.21	0.47	12.34	23.7	8.420	-142.6	24.7	10.60
18-Mar-91	1991.21	0.68	5.39	0.52	27.60	20.3	8.415	-139.7	22.4	12.00
27-Mar-91	1991.23	0.47	2.66	0.44	22.10	21.0	8.474	-140.2	24.0	12.05
01-Apr-91	1991.25	0.98	4.30	0.55	17.10	21.4	8.399	-135.3	25.7	11.32
08-Apr-91	1991.27	0.49	4.30	0.55	19.20	21.9	8.434	-136.4	26.7	11.83
15-Apr-91	1991.29	0.47	5.40	0.75	41.70	23.6	8.396	-132.9	25.2	10.53
23-Apr-91	1991.31	0.62	4.17	0.65	28.10	20.3	8.355	-126.6	23.7	11.52
29-Apr-91	1991.32	0.96	9.84	0.67	34.10	20.1	8.271	-117.8	22.1	9.46
06-May-91	1991.34	0.46	3.94	0.83	17.60	23.2	8.388	-116.4	24.6	9.54
13-May-91	1991.36	0.86	6.74	0.98	30.80	21.5	8.395	-116.2	25.3	11.70
20-May-91	1991.38	0.29	0.92	0.57	6.84	25.6	8.341	-110.1	27.5	7.95
28-May-91	1991.40	0.34	1.85	0.60	9.29	24.7	8.312	-106.9	23.3	7.59
04-Jun-91	1991.42	1.04	9.31	0.84	32.40	20.4	8.329	-103.1	26.4	10.87
10-Jun-91	1991.44	0.41	2.44	0.60	12.70	24.4	8.337	-104.9	25.1	8.45
17-Jun-91	1991.46	1.00	7.82	0.67	39.70	21.4	8.377	-109.6	26.0	12.06
24-Jun-91	1991.48	0.96	7.71	0.67	35.00	20.8	8.400	[illegible]	[illegible]	[illegible]
01-[illegible]-91	[illegible]	1.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.63

Figure 2. Seawater Temperature (At Sampling Sites) vs. Time

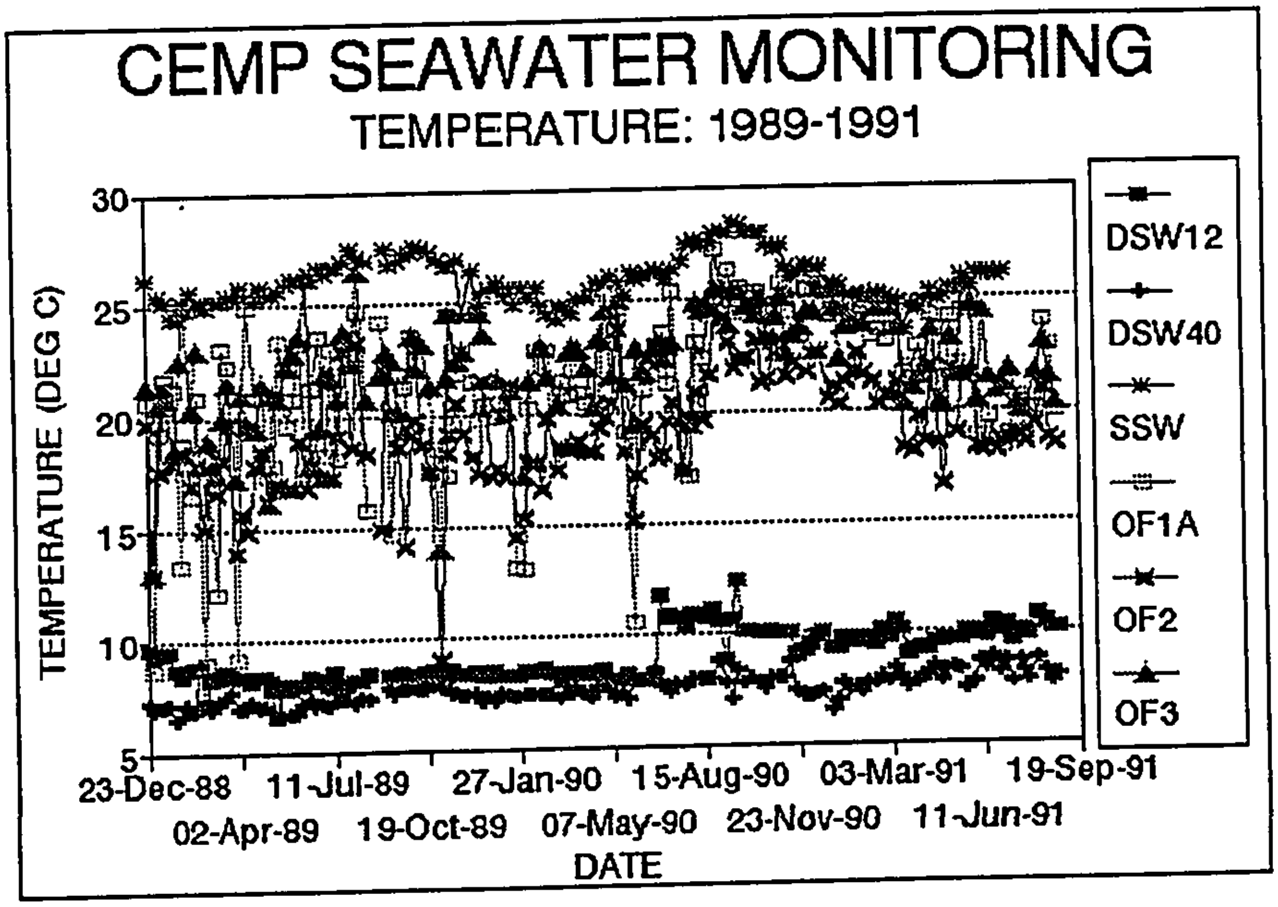


Figure 3. Seawater Salinities vs. Time

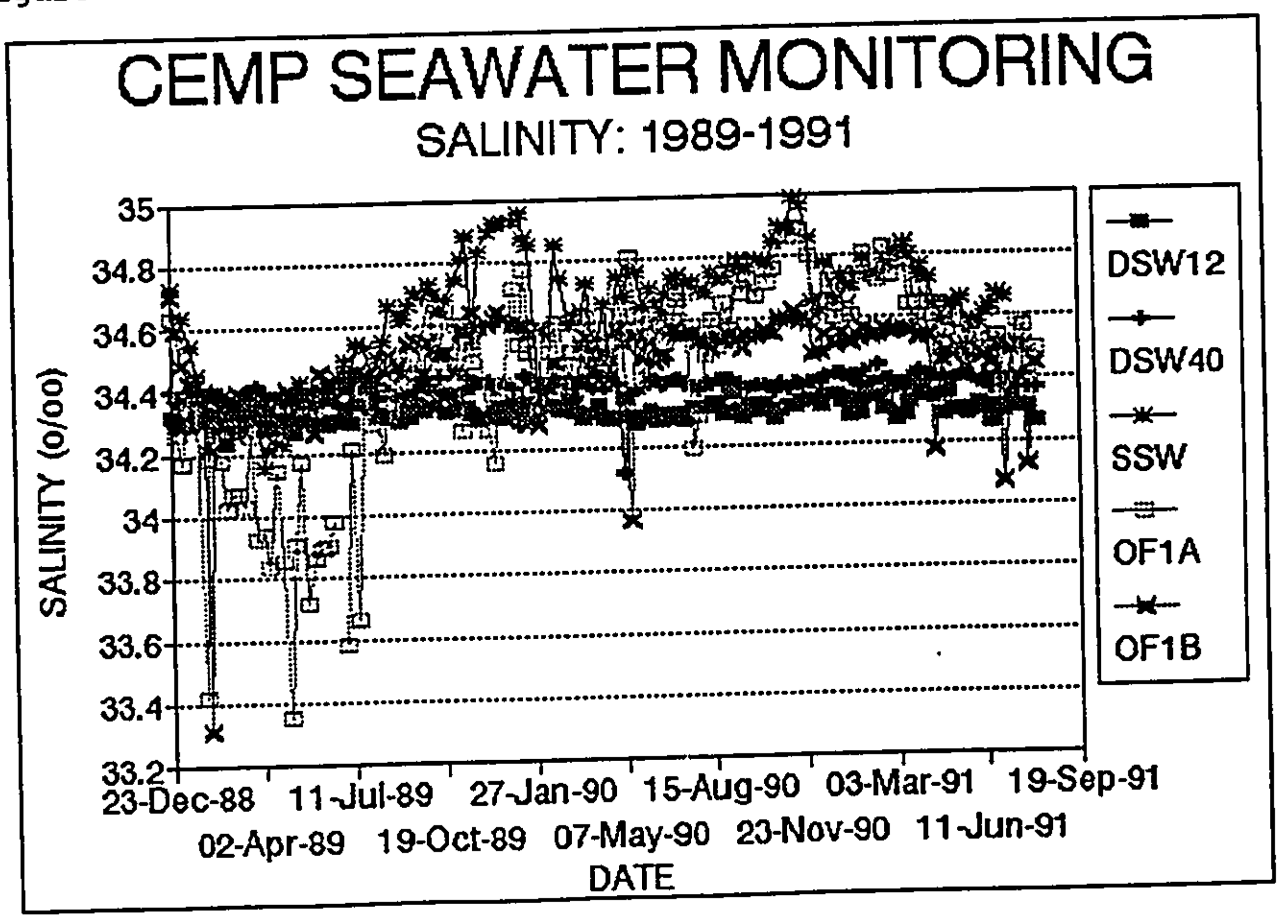


Figure 4. Seawater pH vs. Time

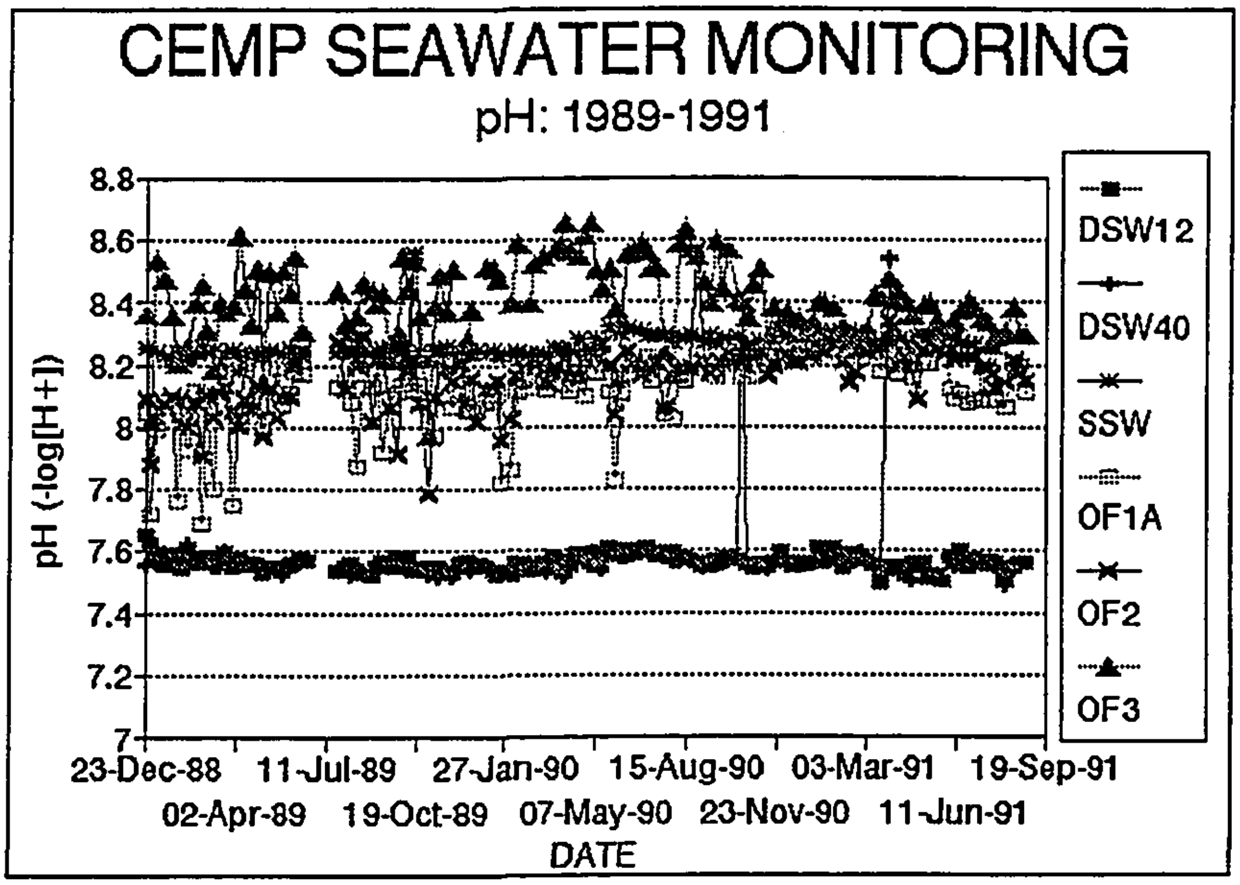


Figure 5. Seawater Alkalinity vs. Time

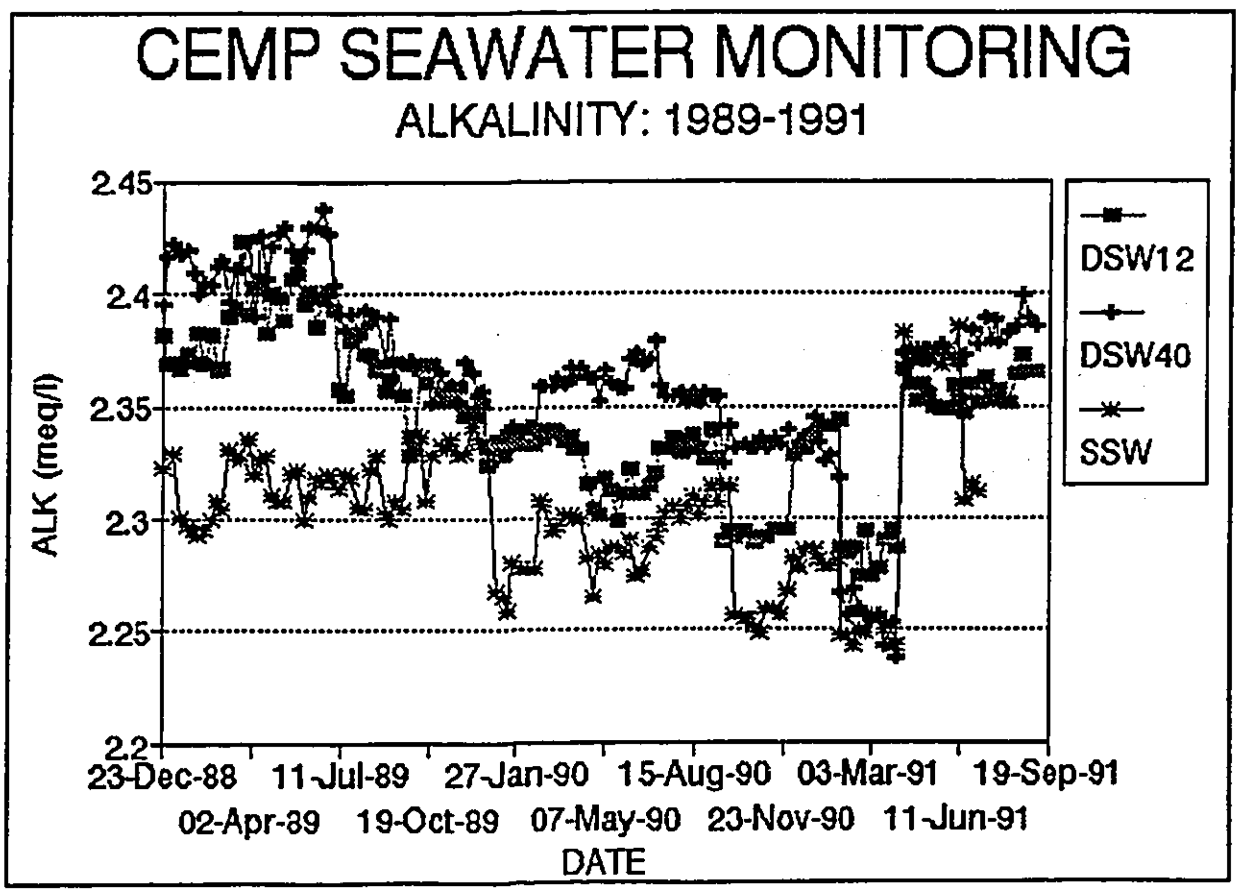


Figure 6. Seawater Dissolved Oxygen vs. Time

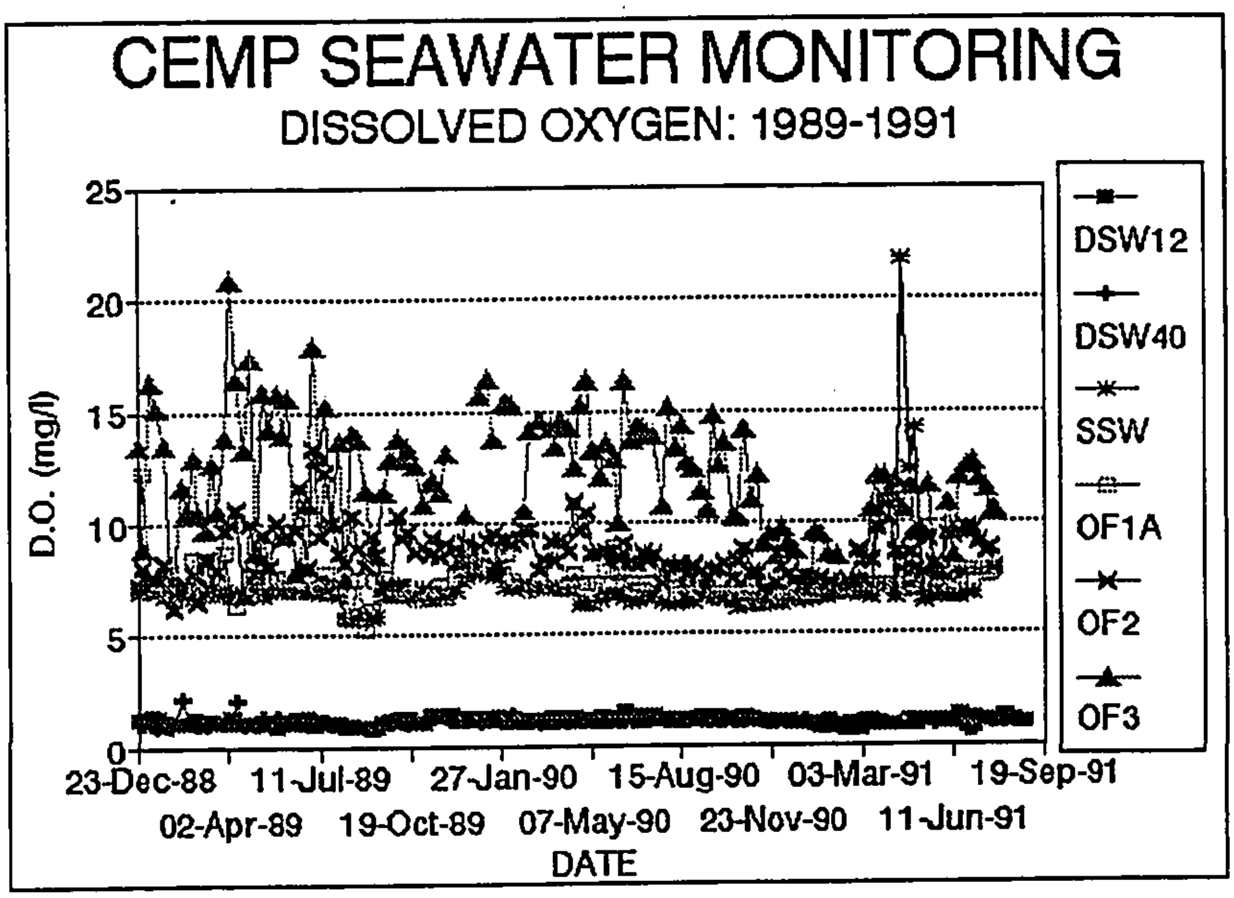


Figure 7. Seawater Nitrate vs. Time

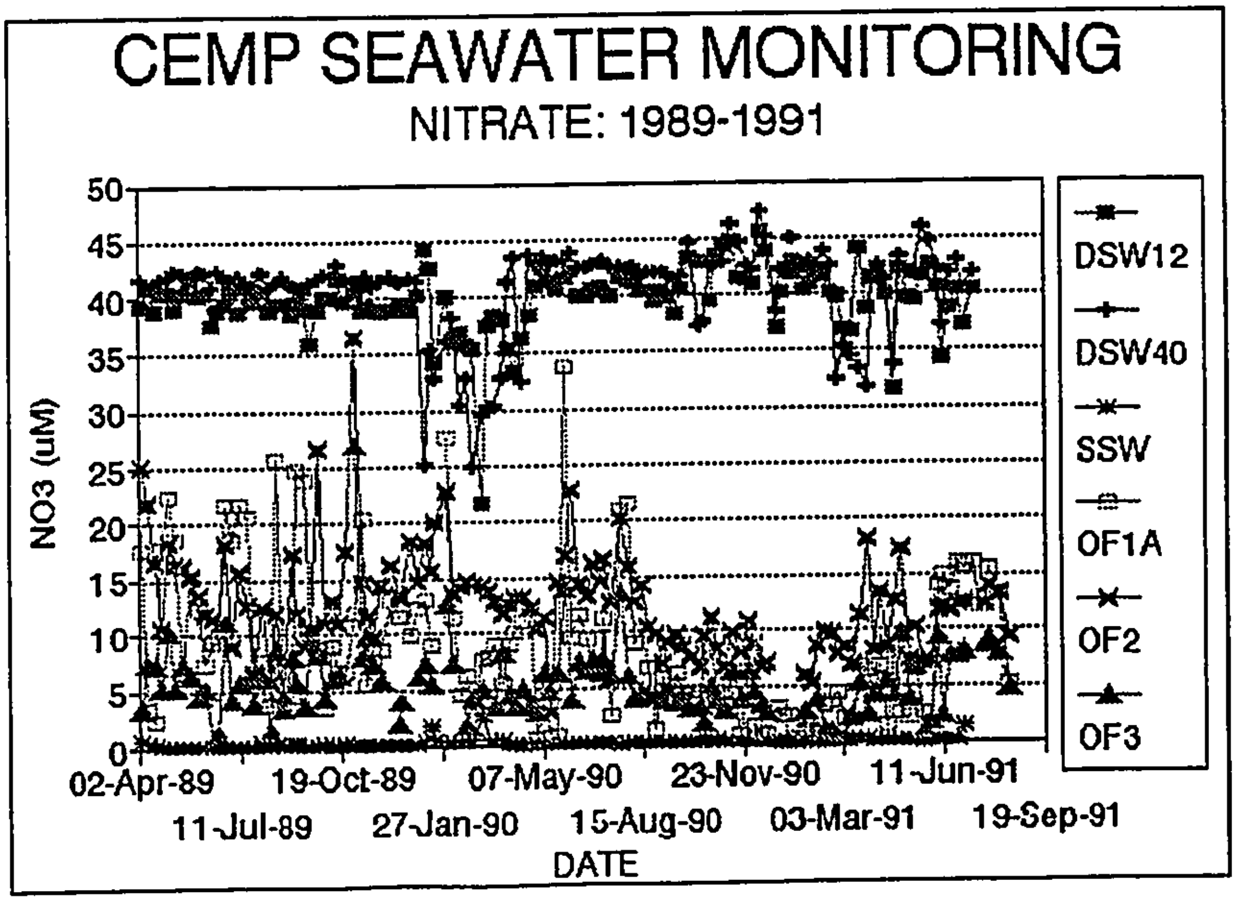


Figure 8. Seawater Phosphate vs. Time

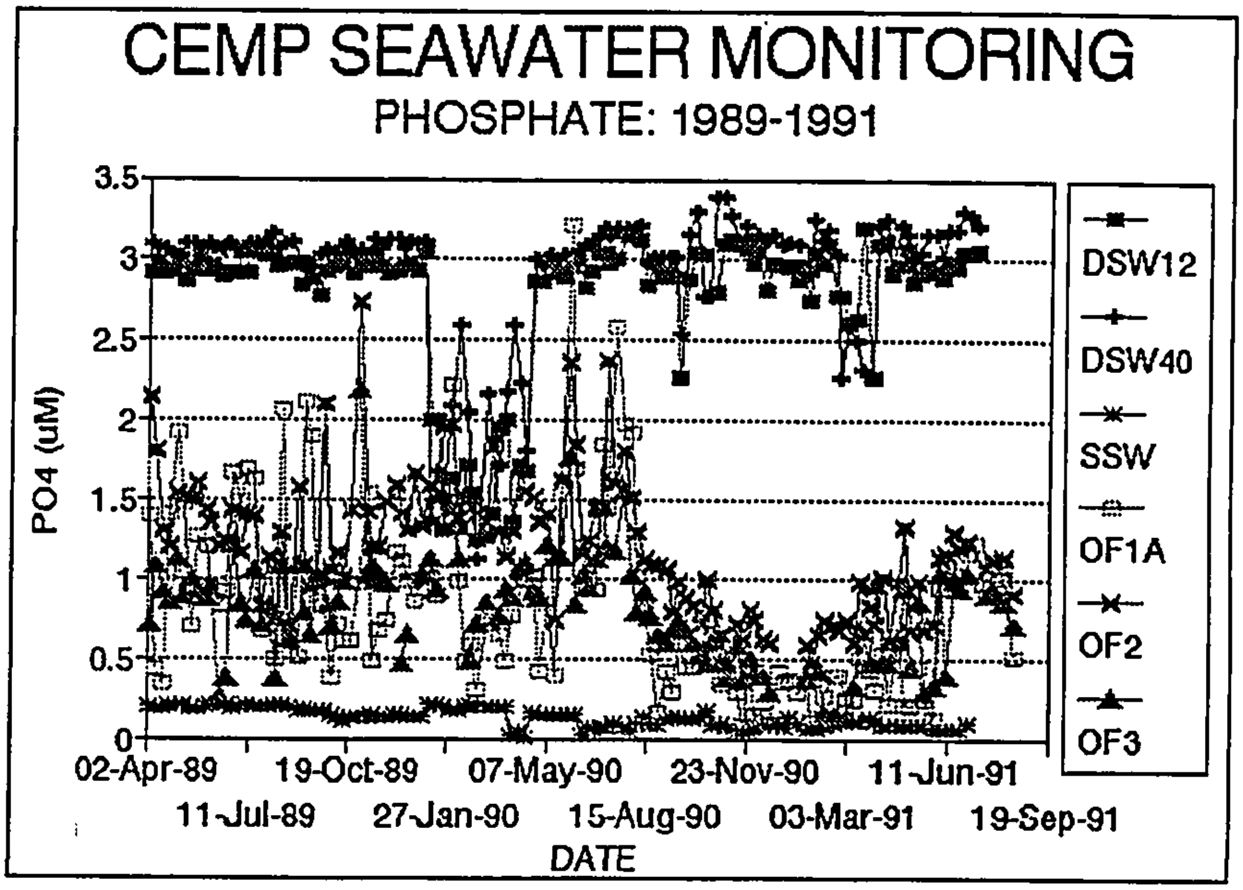


Figure 9. Seawater Silicate vs. Time

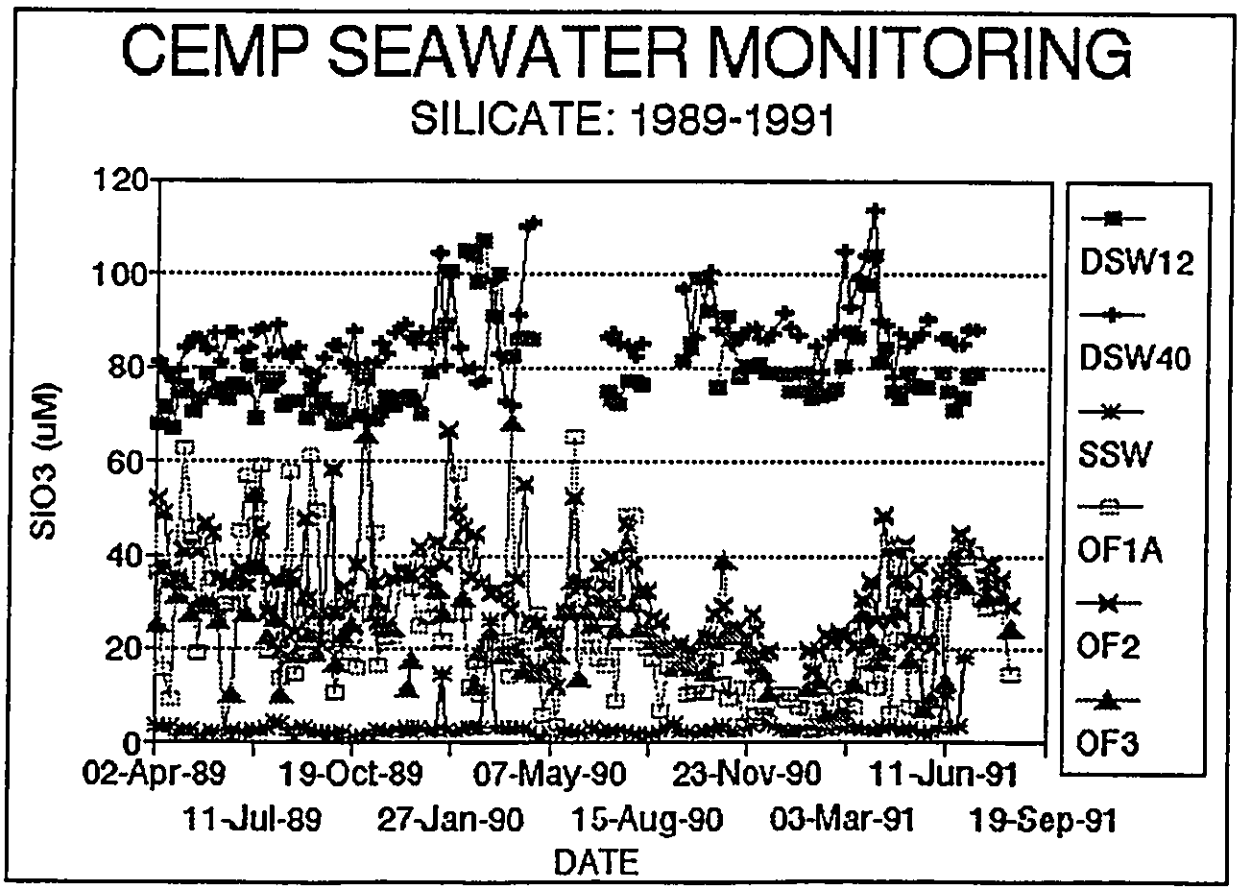


Figure 10. Seawater Ammonium vs. Time

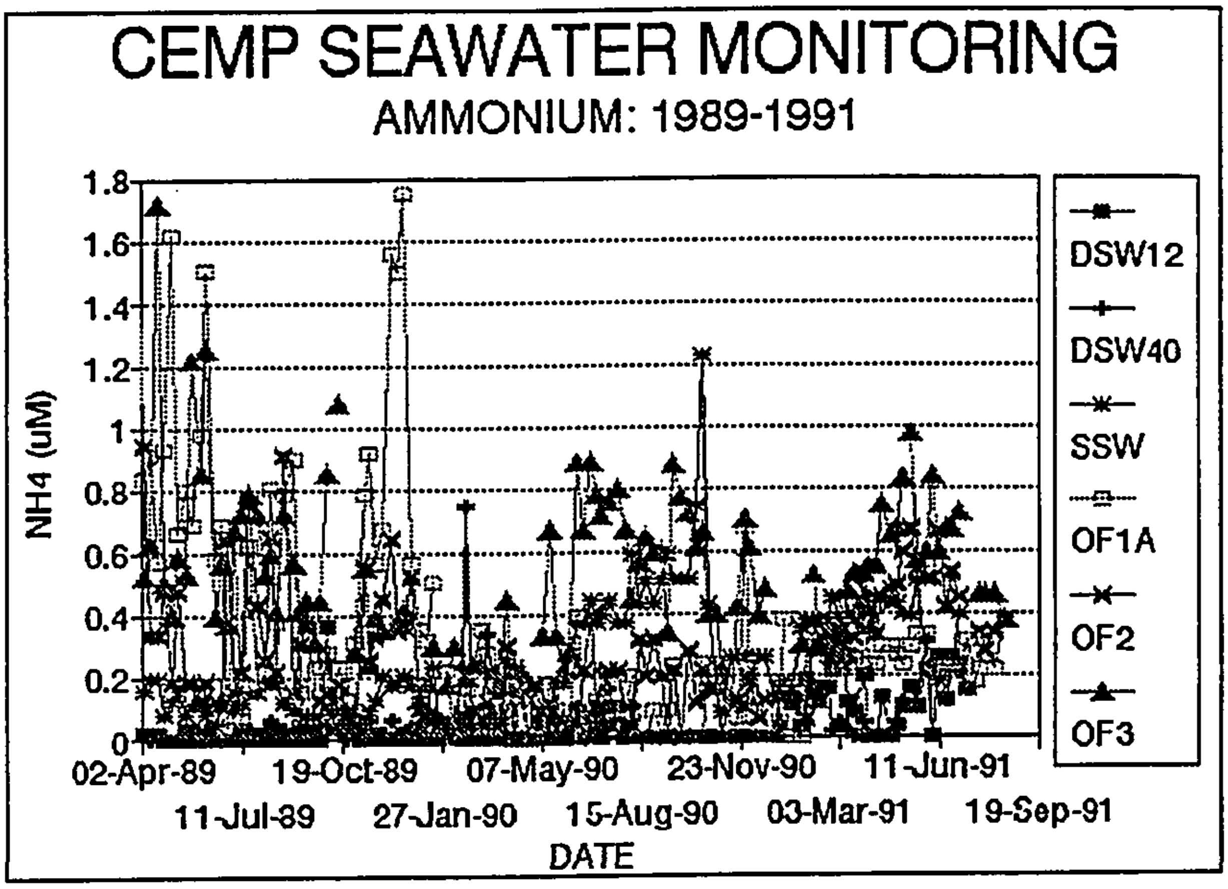


Figure 11. Seawater Total Dissolved Nitrogen vs. Time

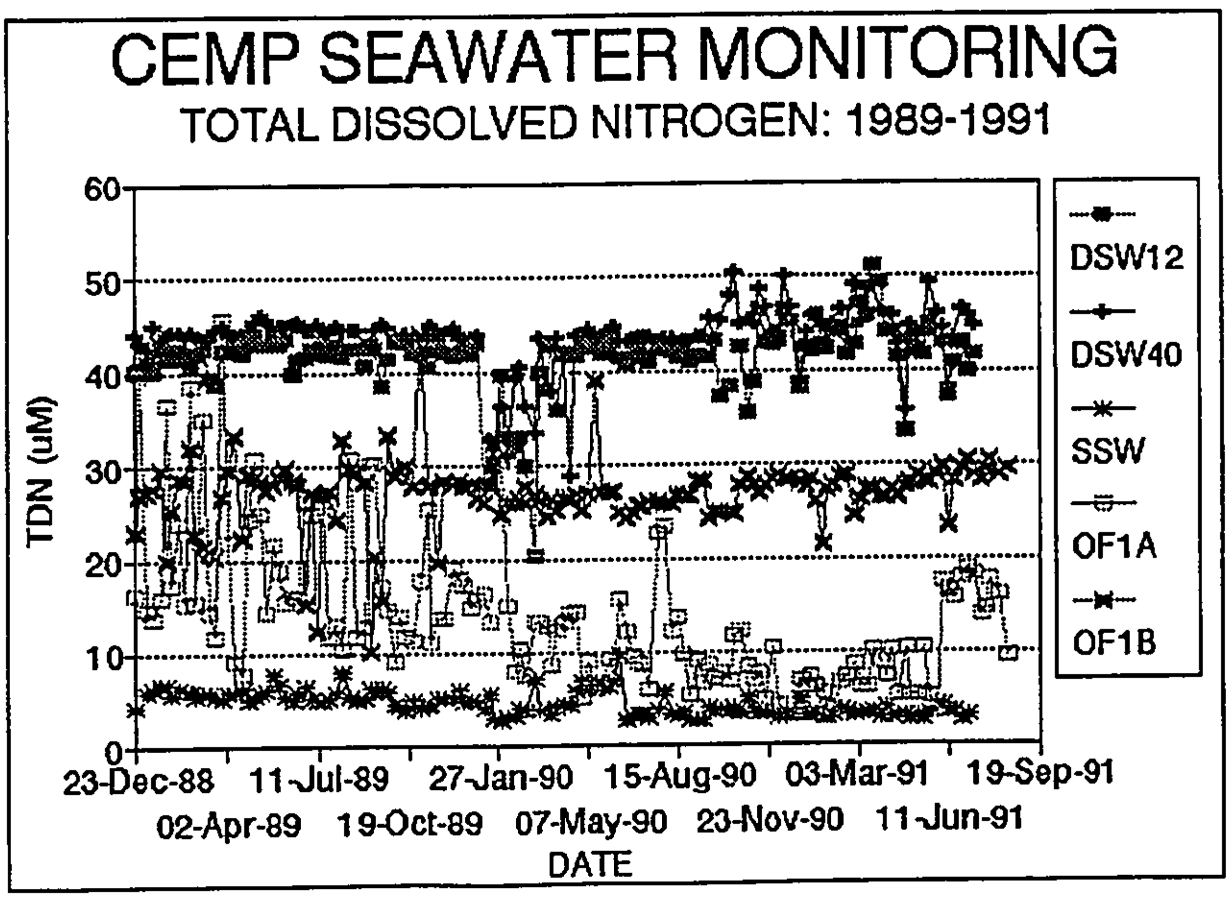


Figure 12. Seawater Total Dissolved Phosphorus vs. Time

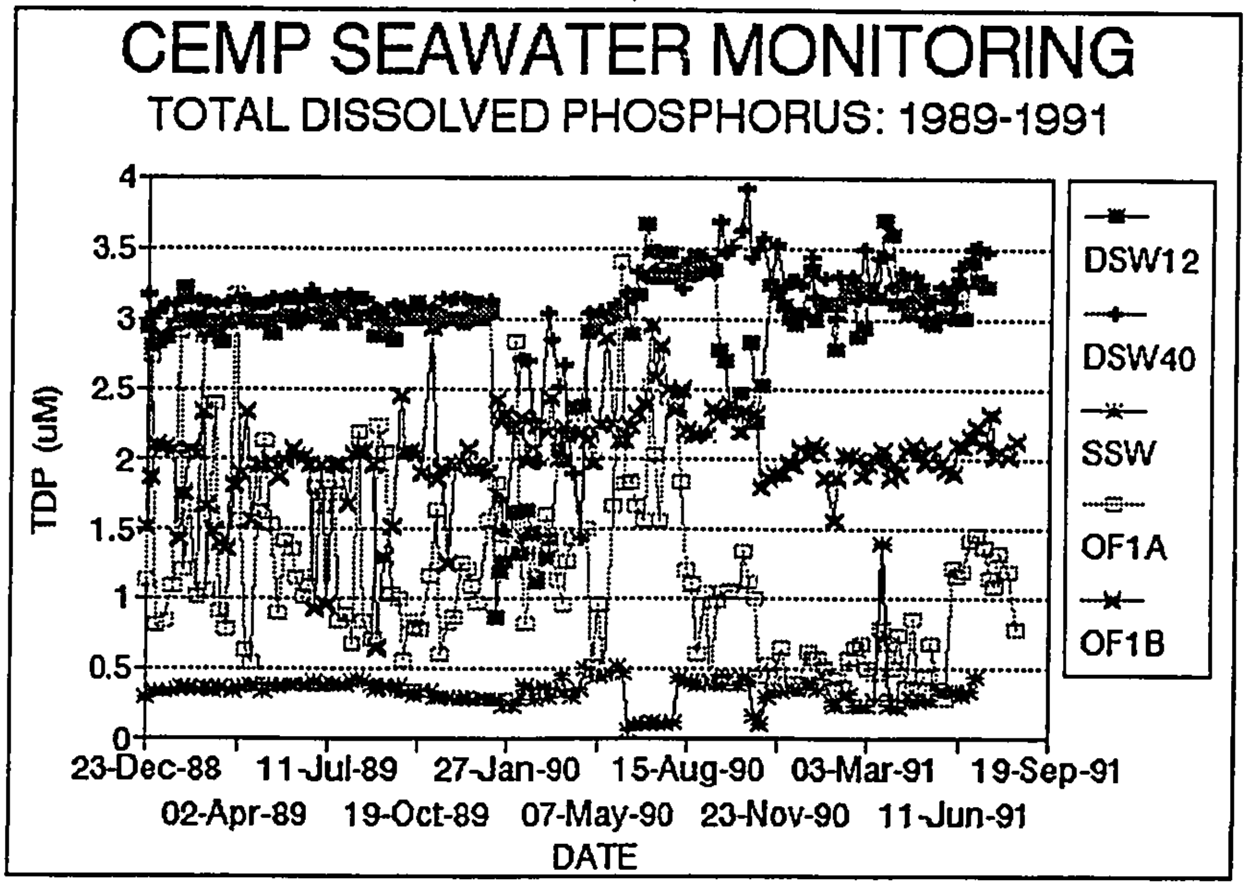


Figure 13. Seawater Total Organic Carbon vs. Time

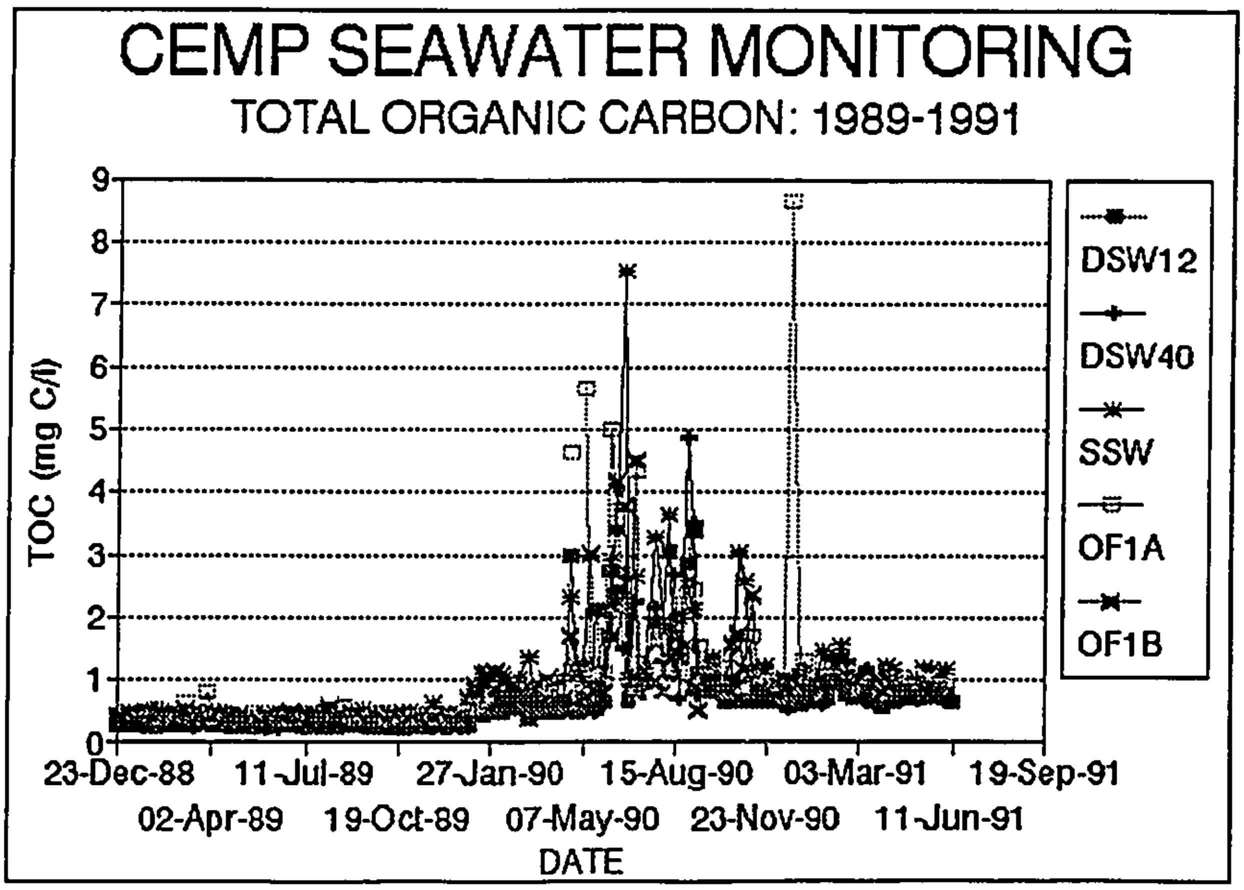
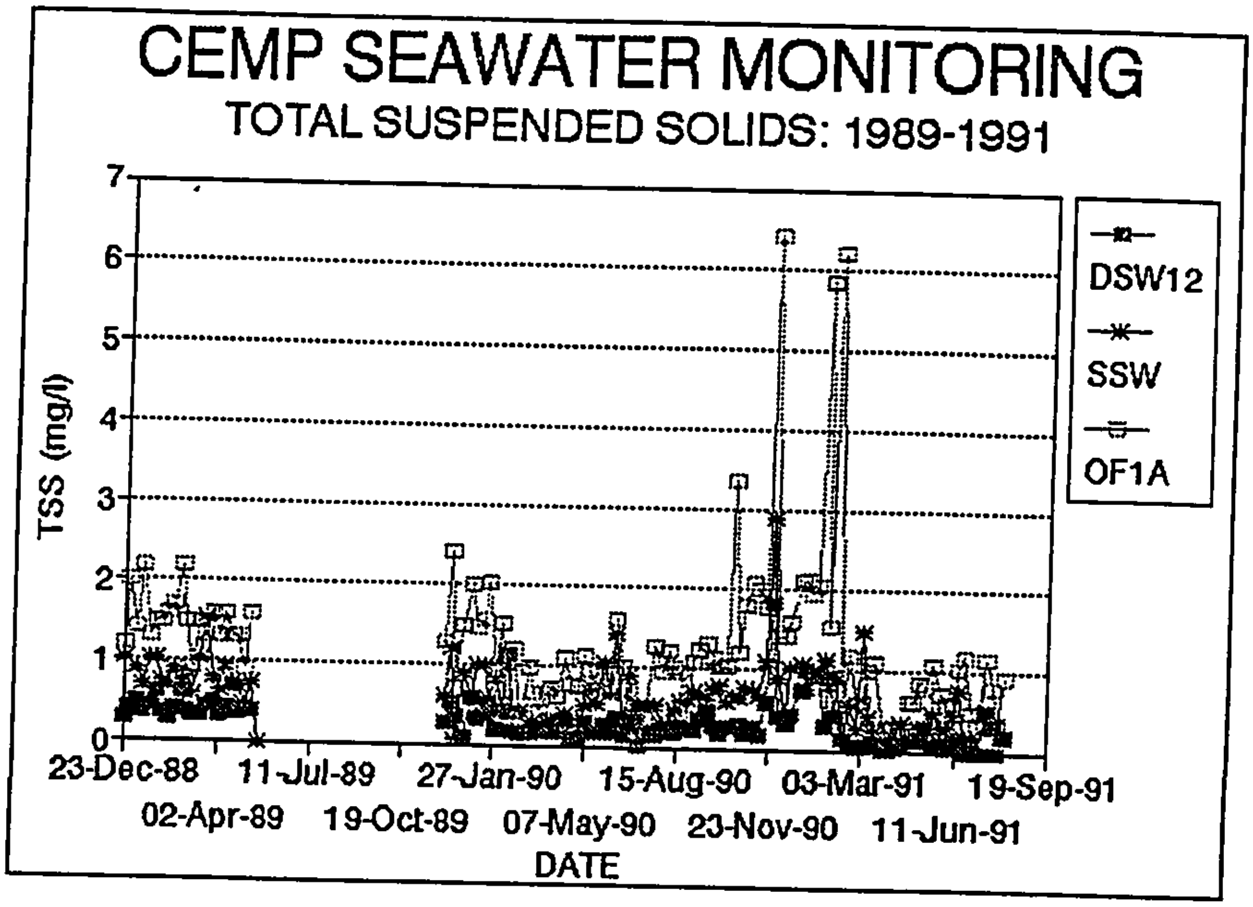


Figure 14. Seawater Total Suspended Solids vs. Time



OFFSHORE WATER QUALITY DATA

Discussion

The CEMP mandates collection of samples from the offshore region around Keahole Point. Sampling began in April 1990. Samples are taken monthly at four sites, designated O-1 through O-4, which are located at approximately the 30 m contour as shown in the CEMP Sampling Site Map, Figure 15. Using the NELHA 24-ft outboard, personnel take samples from depths of approximately 1 m and 20 m at each site. In the following tables and graphs, these samples are labeled as OX-3 and OX-60 for site number X = 1 to X = 4. Samples were initially taken by diving to the requisite depth, but a 5-liter Niskin Sampler now allows samples to be collected in a more traditional fashion.

Figure 15. Sampling Site Location Map

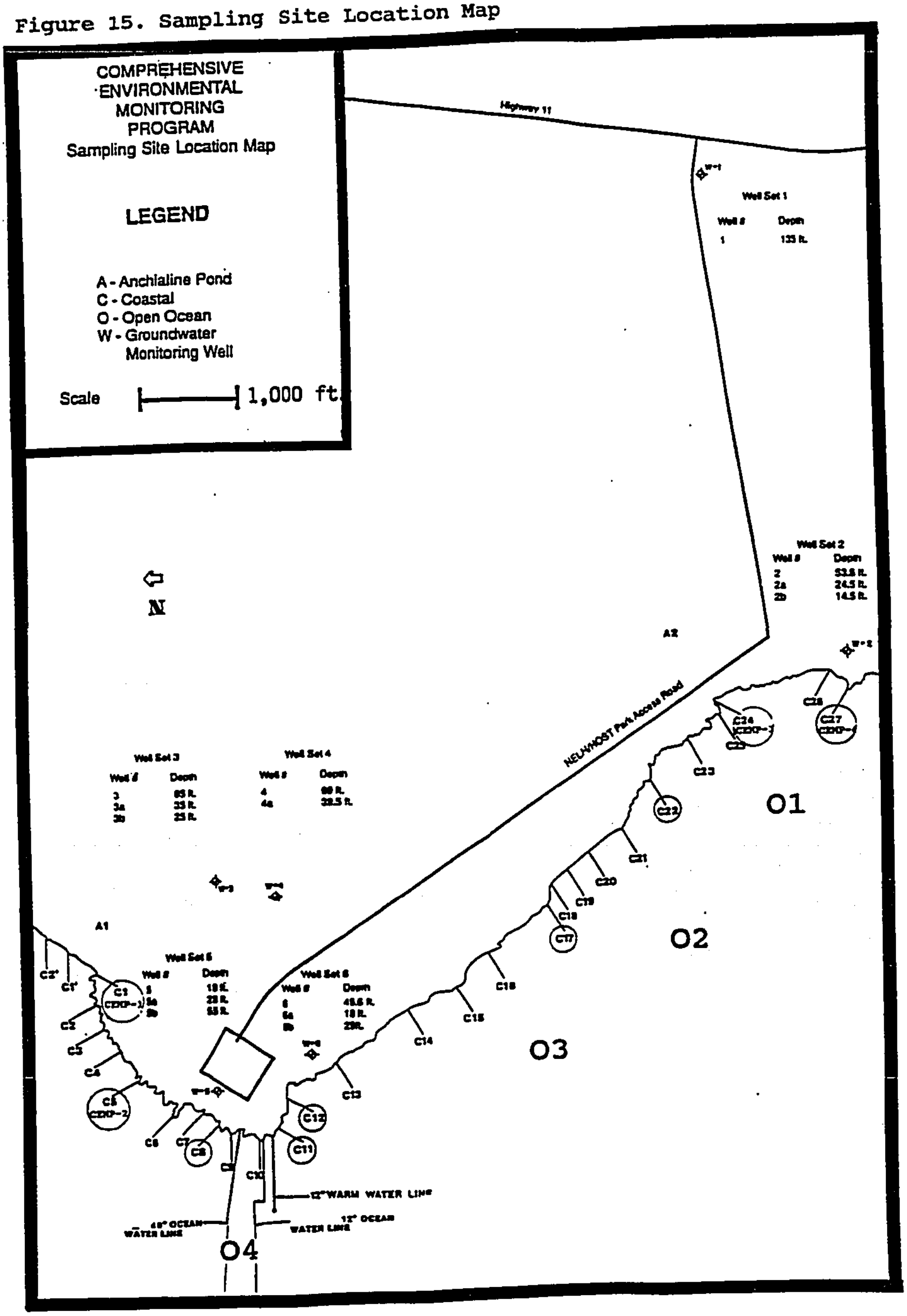


Table VIII. Open Ocean Water Quality Data: Sites O1 & O2

OPEN OCEAN SEAWATER

NELH WATER QUALITY DATA 1990-91

Site ID	D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	UM TDP	UM TDN	MG/L TOC	mg/L TSS	O/OO SALINITY	DEG-C TEMP(F)	pH	mv	TEMP/H	DO (ppm)
O1-3	19-Jul-90	1990.55	0.26	1.49	0.00	21.34	0.76	4.77	3.39	0.26	34.150	26.5	8.267	-137.1	24.0	6.52
	16-Aug-90	1990.62	0.16	0.83	0.00	8.71	0.56	4.55	1.22	0.62	34.494	27.6	8.226	-138.4	24.1	6.32
	25-Sep-90	1990.73	0.16	0.09	0.00	2.42	0.53	2.83	1.20	1.00	34.777	28.0	8.265	-139.6	25.5	6.33
	17-Oct-90	1990.79	0.13	0.85	0.00	9.22	0.77	4.32	1.16	0.66	34.496	27.5	8.239	-138.5	25.2	5.88
	14-Nov-90	1990.87	0.07	0.81	0.00	7.77	0.27	4.77	1.28	0.81	34.675	26.4	8.260	-138.7	23.0	6.36
	18-Dec-90	1990.96	0.06	0.03	0.00	2.48	0.34	2.91	0.96	0.96	34.749	25.3	8.267	-139.5	22.7	6.62
	16-Jan-91	1991.04	0.12	0.14	0.16	3.63	0.38	3.84	1.12	1.40	34.647	25.3	8.282	-140.4	23.1	6.80
	15-Feb-91	1991.12	0.06	0.04	0.29	2.47	0.23	3.18	1.03	0.24	34.745	25.0	8.271	-137.7	22.0	6.81
	13-Mar-91	1991.20	0.09	0.66	0.28	10.71	0.28	4.64	0.99	0.30	34.566	24.6	8.265	-132.3	22.6	6.85
	18-Apr-91	1991.29	0.07	0.85	0.17	11.00	0.30	4.58	1.05	0.03	34.320	24.4	8.245	-121.5	22.5	6.65
	15-May-91	1991.37	0.08	0.06	0.40	2.29	0.19	2.64	1.28	0.30	34.640	25.2	8.250	-106.9	24.3	6.81
	19-Jun-91	1991.46	0.06	0.26	0.18	5.94	0.31	2.96		0.13	34.512	25.9	8.254	-102.9	23.4	6.74
O1-60	19-Jul-90	1990.55	0.15	0.39	0.00	2.69	0.62	3.69	1.20	0.06	34.661	26.6	8.268	-137.2	24.1	6.45
	16-Aug-90	1990.62	0.14	0.23	0.00	2.74	0.53	3.85	2.24	0.61	34.706	27.5	8.277	-139.0	24.2	6.34
	25-Sep-90	1990.73	0.16	0.12	0.49	2.24	0.53	3.80	1.34	3.30	34.777	28.0	8.269	-139.9	25.5	6.09
	17-Oct-90	1990.79	0.13	0.04	0.00	2.70	0.67	4.71	2.11	0.94	34.785	27.5	8.254	-139.4	25.3	5.90
	14-Nov-90	1990.87	0.04	0.17	0.00	2.82	0.26	3.72	1.32	1.09	34.844	26.4	8.262	-138.9	23.1	6.39
	18-Dec-90	1990.96	0.06	0.06	0.00	2.62	0.36	3.34	1.00	0.98	34.751	25.3	8.268	-139.6	23.2	6.54
	16-Jan-91	1991.04	0.11	0.09	0.16	3.15	0.40	3.39	1.10	0.99	34.640	25.3	8.281	-140.4	23.1	6.60
	15-Feb-91	1991.12	0.06	0.10	0.32	2.88	0.32	3.71	0.94	0.42	34.727	24.9	8.266	-137.4	22.4	6.81
	13-Mar-91	1991.20	0.07	0.21	0.23	2.64	0.26	3.05	0.96	0.11	34.746	24.8	8.272	-132.7	22.8	6.88
	18-Apr-91	1991.29	0.04	0.01	0.08	2.04	0.29	4.09	0.98	0.43	34.639	24.7	8.261	-122.3	22.1	6.91
	15-May-91	1991.37	0.08	0.06	0.29	2.23	0.25	2.38	1.14	1.04	34.653	25.4	8.171	-102.3	24.4	6.77
	19-Jun-91	1991.46	0.07	0.17	0.18	3.82	0.35	3.49		0.65	34.582	26.0	8.263	-103.5	23.5	6.72
O2-3	19-Jul-90	1990.55	0.16	0.64	0.00	5.75	0.63	3.72	1.40	0.19	34.538	26.8	8.274	-137.5	24.0	6.44
	16-Aug-90	1990.62	0.13	0.14	0.09	2.24	0.49	3.25	21.01	1.05	34.731	27.7	8.277	-139.0	24.3	6.33
	25-Sep-90	1990.73	0.16	0.09	0.72	1.60	0.36	3.45	1.25	2.90	34.794	28.0	8.274	-140.1	25.3	6.23
	17-Oct-90	1990.79	0.13	1.00	0.00	8.95	0.69	4.20	1.16	0.56	34.502	27.6	8.223	-137.5	25.2	6.16
	14-Nov-90	1990.87	0.04	0.04	0.00	1.60	0.27	2.97	1.31	0.98	34.934	26.5	8.258	-138.7	23.2	6.07
	18-Dec-90	1990.96	0.10	0.01	0.00	7.11	0.33	3.32	1.01	0.88	34.766	25.3	8.269	-139.8	23.2	6.78
	16-Jan-91	1991.04	0.11	0.09	0.18	3.34	0.40	3.44	1.05	1.15	34.668	25.4	8.279	-140.5	23.5	6.62
	15-Feb-91	1991.12	0.06	0.04	0.29	2.29	0.33	3.95	0.95	0.51	34.740	25.0	8.272	-137.8	22.2	6.79
	13-Mar-91	1991.20	0.09	0.33	0.23	5.97	0.18	3.20	0.92	0.19	34.681	24.7	8.268	-132.4	22.5	6.78
	18-Apr-91	1991.29	0.08	0.29	0.12	9.08	0.30	3.85	0.95	0.21	34.404	24.5	8.245	-121.5	22.5	
	15-May-91	1991.37	0.08	0.10	0.25	2.09	0.22	2.51	1.12	0.30	34.340	25.4	8.181	-102.9	24.6	6.77
	19-Jun-91	1991.46	0.05	0.12	0.18	3.11	0.34	2.96	1.18	0.33	34.607	26.0	8.254	-103.0	23.7	6.67
O2-60	19-Jul-90	1990.55	0.12	0.35	0.00	3.00	0.53	3.23	2.54	0.20	34.646	26.8	8.282	-137.9	23.9	6.65
	16-Aug-90	1990.62	0.14	0.14	0.06	1.85	0.46	3.43	4.06	1.92	34.737	27.5	8.281	-139.3	24.3	6.41
	25-Sep-90	1990.73	0.13	0.09	0.00	1.50	0.57	3.18	1.22	3.53	34.785	28.0	8.274	-140.0	25.3	6.32
	17-Oct-90	1990.79	0.09	0.04	0.04	2.16	0.75	3.66	1.74	1.05	34.808	27.6	8.260	-139.6	25.1	6.16
	14-Nov-90	1990.87	0.04	1.20	0.00	12.20	0.31	5.07	21.56	0.93	34.941	26.4	8.265	-139.2	23.2	6.61
	18-Dec-90	1990.96	0.08	0.01	0.00	3.22	0.40	3.17	1.00	0.98	34.761	25.3	8.270	-139.8	23.3	6.62
	16-Jan-91	1991.04	0.11	0.03	0.13	2.81	0.40	3.72	1.16	0.88	34.678	25.3	8.274	-140.0	23.4	6.66
	15-Feb-91	1991.12	0.06	0.07	0.29	2.40	0.33	4.45	0.92	0.72	34.738	25.2	8.269	-137.6	22.4	6.76
	13-Mar-91	1991.20	0.05	0.21	0.26	3.16	0.23	3.78	0.94	0.01	34.724	24.8	8.272	-132.7	22.6	6.82
	18-Apr-91	1991.29	0.04	0.00	0.00	2.20	0.29	3.37	1.03	0.55	34.631	24.9	8.262	-122.4	21.9	6.94
	15-May-91	1991.37	0.08	0.12	0.25	3.40	0.26	3.17	1.22	0.29	34.536	25.9	8.176	-102.5	24.2	6.77
	19-Jun-91	1991.46	0.05	0.07	0.18	2.31	0.34	2.96	1.16	0.38	34.636	25.8	8.268	-103.8	23.6	6.69

Table IX. Open Ocean Water Quality Data: Sites O3 & O4

OPEN OCEAN SEAWATER

NELH WATER QUALITY DATA 1990-91

Site ID	D-M-Y DATE	JULIAN DATE	UM PO4	UM NO3	UM NH4	UM SI	UM TDP	UM TDN	MG/L TOC	mg/L TSS	O/OO SALINITY	DEG-C TEMP(F)	pH	mv	TEMP/M	DO (ppm)
O3-3	19-Jul-90	1990.55	0.16	0.53	0.00	2.82	0.64	3.69	2.68	0.41	34.565	26.9	8.274	-137.5	23.9	6.65
	16-Aug-90	1990.62	0.14	0.14	0.00	2.54	0.46	3.43	1.12	0.64	34.738	27.8	8.281	-139.3	24.3	6.35
	25-Sep-90	1990.73	0.13	0.09	0.00	1.73	0.44	2.66	1.32	0.91	34.788	28.0	8.274	-140.1	25.5	6.32
	17-Oct-90	1990.79	0.09	0.13	0.07	2.16	0.75	3.96	1.21	0.47	34.753	27.7	8.254	-139.4	25.1	6.24
	14-Nov-90	1990.87	0.02	0.04	0.00	1.11	0.22	2.37	1.18	0.82	34.948	26.6	8.280	-139.9	23.1	6.12
	18-Dec-90	1990.96	0.08	0.01	0.00	3.22	0.40	3.17	1.06	1.18	34.757	25.2	8.265	-139.5	23.4	6.60
	16-Jan-91	1991.04	0.11	0.11	0.16	3.15	0.37	2.71	1.08	1.04	34.669	25.5	8.271	-140.0	23.9	6.62
	15-Feb-91	1991.12	0.06	0.07	0.35	2.12	0.33	5.63	0.95	0.54	34.758	25.2	8.274	-137.9	22.0	6.79
	13-Mar-91	1991.20	0.05	0.12	0.23	1.67	0.26	2.91	1.01	0.20	34.749	24.7	8.278	-133.1	22.7	6.85
	18-Apr-91	1991.29	0.07	0.63	0.05	11.00	0.31	3.91	0.92	0.32	34.319	24.5	8.238	-121.2	22.7	6.63
	15-May-91	1991.37	0.08	0.02	0.23	1.57	0.28	2.64	1.13	0.16	34.461	25.6	8.179	-102.8	24.6	6.77
	19-Jun-91	1991.46	0.05	0.19	0.18	4.53	0.33	3.60	1.17	0.34	34.575	25.9	8.248	-102.8	24.0	6.66
O3-60	19-Jul-90	1990.55	0.13	0.39	0.00	2.82	0.53	3.38	2.96	0.42	34.660	26.9	8.280	-137.7	23.8	6.60
	16-Aug-90	1990.62	0.13	0.09	0.06	1.43	0.56	4.09	4.79	0.51	34.758	27.5	8.282	-139.3	24.4	6.46
	25-Sep-90	1990.73	0.13	0.15	1.98	1.83	0.56	3.88	1.19	1.29	34.774	28.1	8.269	-139.7	25.5	6.27
	17-Oct-90	1990.79	0.13	0.04	0.00	1.61	0.77	3.35	1.24	0.89	34.810	27.7	8.260	-139.7	25.2	6.60
	14-Nov-90	1990.87	0.04	0.04	0.00	1.74	0.26	2.52	1.23	0.87	34.943	26.5	8.275	-139.6	22.9	6.39
	18-Dec-90	1990.96	0.08	0.03	0.00	2.28	0.40	2.56	1.05	0.94	34.750	25.2	8.267	-139.7	23.4	6.62
	16-Jan-91	1991.04	0.11	0.06	0.16	3.24	0.40	2.71	1.08	1.01	34.688	25.4	8.274	-140.2	23.8	6.62
	15-Feb-91	1991.12	0.06	0.10	0.26	2.74	0.37	4.85	0.95	0.45	34.730	25.1	8.269	-137.6	22.3	6.76
	13-Mar-91	1991.20	0.05	0.15	0.26	1.76	0.26	2.91	1.05	0.24	34.755	24.8	8.280	-133.0	22.3	6.81
	18-Apr-91	1991.29	0.04	0.00	0.03	2.04	0.29	2.52	0.94	0.62	34.633	24.9	8.260	-122.4	22.3	6.90
	15-May-91	1991.37	0.06	0.06	0.33	2.88	0.28	2.97	1.12	0.41	34.570	25.6	8.166	-102.0	24.3	6.77
	19-Jun-91	1991.46	0.05	0.07	0.21	4.13	0.33	2.96	1.09	0.41	34.626	26.0	8.272	-104.0	23.6	6.80
O4-3	19-Jul-90	1990.55	0.16	0.53	0.00	4.63	0.56	3.69	2.55	0.38	34.593	26.8	8.275	-137.5	24.0	6.74
	16-Aug-90	1990.62	0.16	0.16	0.00	2.86	0.56	4.13	1.11	0.67	34.704	27.8	8.276	-139.0	24.5	6.25
	25-Sep-90	1990.73	0.10	0.12	0.00	8.98	0.51	3.45	1.13	3.44	34.779	28.0	8.269	-139.8	25.6	6.47
	17-Oct-90	1990.79	0.09	0.07	0.00	2.70	0.69	4.32	1.11	0.51	34.758	27.8	8.246	-138.9	25.2	5.96
	14-Nov-90	1990.87	0.04	0.04	0.00	0.86	0.26	3.57	1.06	0.64	34.941	26.7	8.277	-139.7	23.0	6.34
	18-Dec-90	1990.96	0.06	0.01	0.00	2.48	0.36	2.76	1.14	1.05	34.752	25.2	8.271	-139.9	23.4	6.62
	16-Jan-91	1991.04	0.11	0.03	0.16	3.39	0.40	2.94	1.24	1.04	34.671	25.4	8.279	-140.5	23.9	6.86
	15-Feb-91	1991.12	0.08	0.10	0.35	2.26	0.23	4.51	1.06	0.56	34.745		8.275	-137.9	22.2	6.74
	13-Mar-91	1991.20	0.04	0.21	0.30	2.55	0.31	5.22	1.22	0.30	34.755	24.7	8.274	-132.9	22.8	6.81
	18-Apr-91	1991.29	0.06	0.18	0.08	6.52	0.30	3.85	0.95	0.27	34.488	24.6	8.263	-122.5	22.3	6.68
	15-May-91	1991.37	0.08	0.02	0.29	1.96	0.25	3.57	1.11	0.27	34.313	25.6	8.185	-103.1	24.5	6.77
	19-Jun-91	1991.46	0.06	0.09	0.21	2.31	0.34	3.28	1.07	0.13	34.626	25.6	8.265	-103.6	23.5	6.73
O4-60	19-Jul-90	1990.55	0.13	0.39	0.00	2.44	0.53	3.49	3.15	0.19	34.669	26.9	8.283	-138.1	24.0	6.58
	16-Aug-90	1990.62	0.11	0.07	0.20	1.14	0.51	4.41	2.44	1.84	34.790	27.4	8.286	-139.6	24.5	6.60
	25-Sep-90	1990.73	0.13	0.06	0.00	1.87	0.66	4.23	1.18	3.67	34.779	28.1	8.272	-140.0	25.3	6.33
	17-Oct-90	1990.79	0.13	0.28	0.07	2.70	0.33	4.26	1.56	0.43	34.768	27.8	8.256	-139.4	25.2	6.14
	14-Nov-90	1990.87	0.04	0.04	0.00	0.91	0.26	3.57	1.16	1.33	34.942	26.4	8.267	-139.1	23.1	6.27
	18-Dec-90	1990.96	0.06	0.01	0.00	2.62	0.36	4.46	1.07	0.79	34.747	25.2	8.268	-139.6	23.2	6.54
	16-Jan-91	1991.04	0.11	0.09	0.10	4.22	0.41	3.84	1.01	0.99	34.661	25.4	8.249	-138.7	23.7	6.63
	15-Feb-91	1991.12	0.06	0.07	0.26	2.19	0.37	4.82	1.05	0.31	34.745		8.272	-137.7	22.2	6.78
	13-Mar-91	1991.20	0.07	0.18	0.21	2.46	0.26	4.50	0.99	0.20	34.740	24.8	8.280	-133.0	22.4	6.90
	18-Apr-91	1991.29	0.04	0.00	0.03	2.68	0.28	3.91	0.94	0.41	34.584	24.6	8.260	-122.3	21.9	6.91
	15-May-91	1991.37	0.08	0.06	0.50	1.70	0.29	4.49	1.17	0.25	34.540	25.7	8.168	-102.1	24.3	6.78
	[illegible]-Jun[illegible]	[illegible]46	[illegible]05	[illegible]	[illegible]	2[illegible]	0.[illegible]	3.8[illegible]	[illegible]20	[illegible]07	[illegible].69[illegible]	25[illegible]	8.2[illegible]	[illegible]	23[illegible]	6.7[illegible]

Figure 16. Offshore Seawater Temperature: Sites 1-2

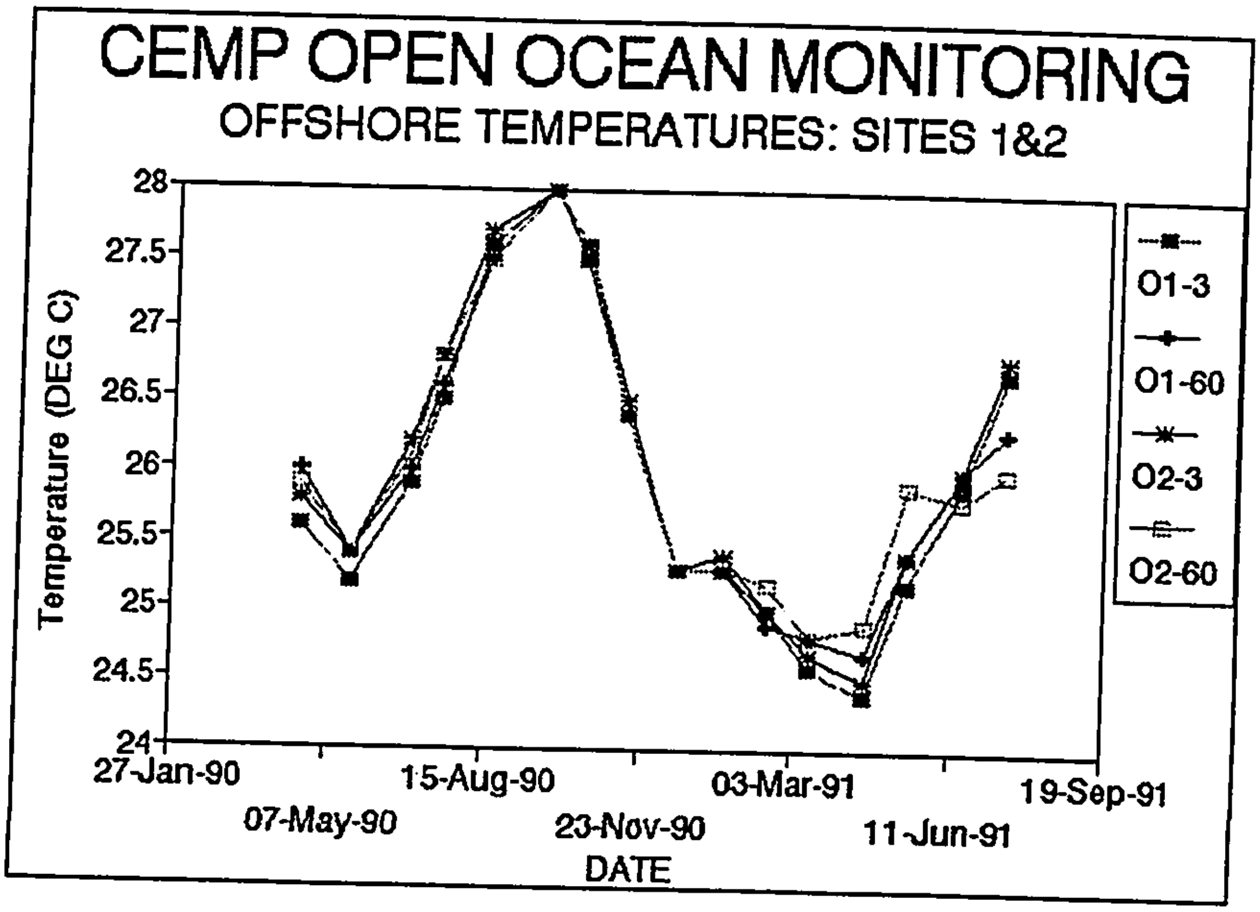


Figure 17. Offshore Seawater Temperature: Sites 3-4

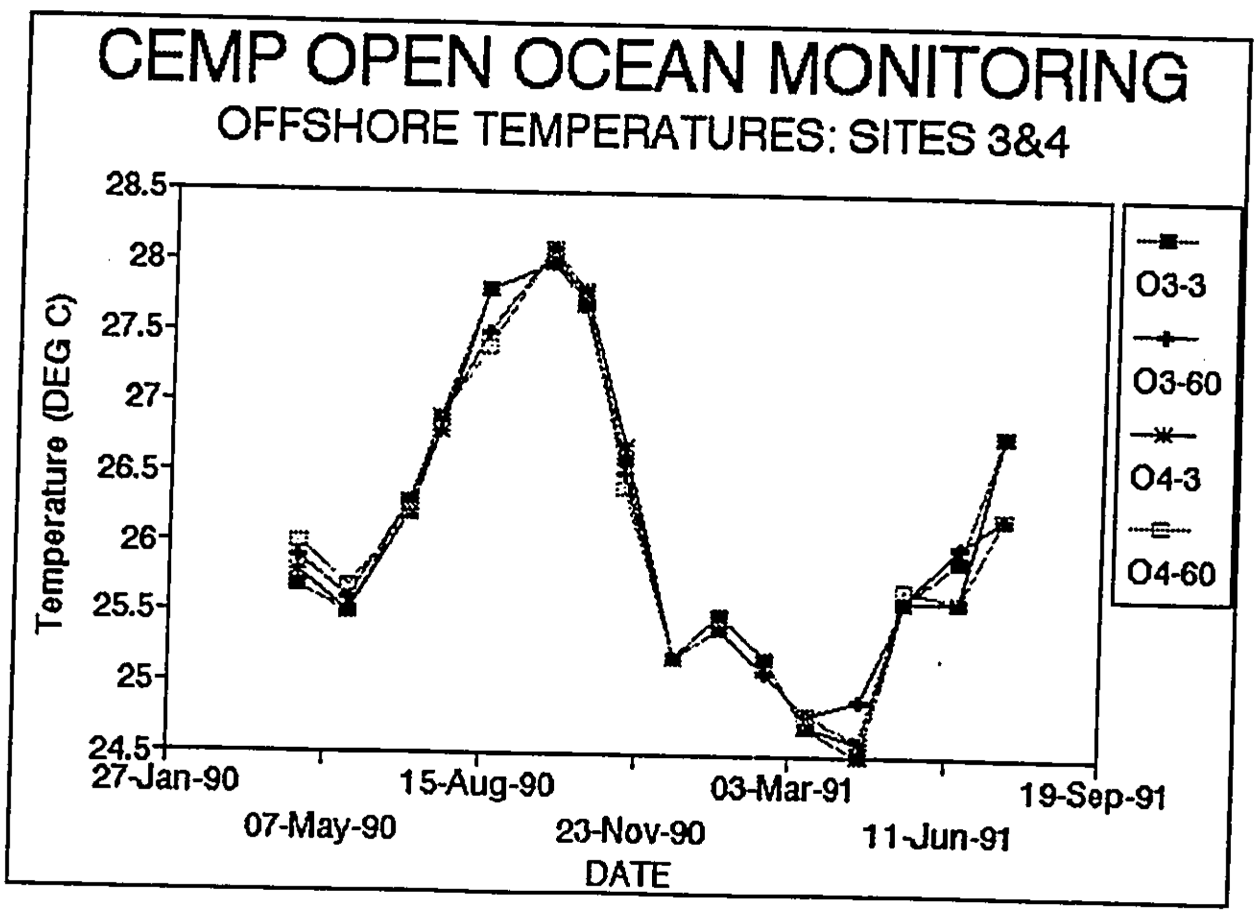


Figure 18. Offshore Seawater Salinity: Sites 1-2

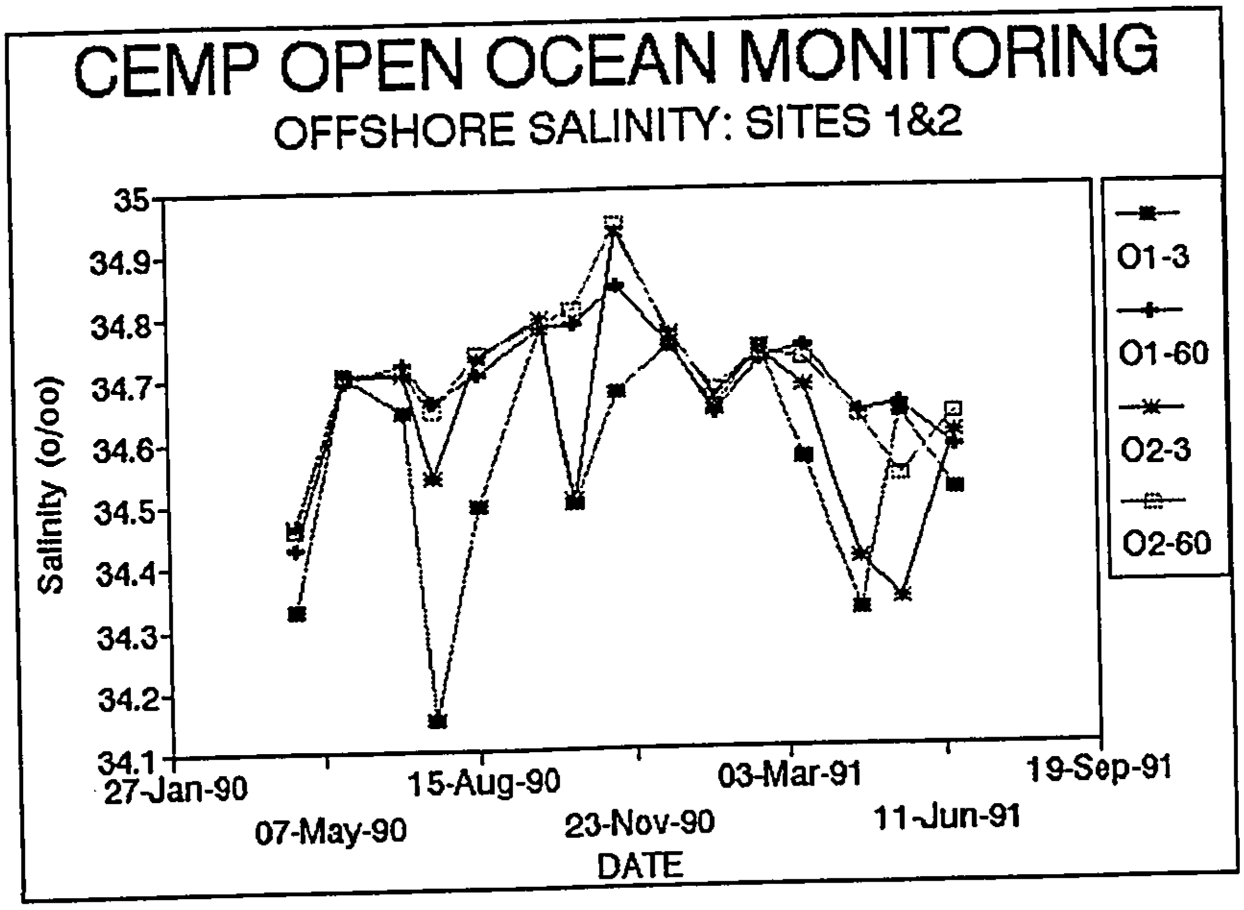


Figure 19. Offshore Seawater Salinities: Sites 3-4

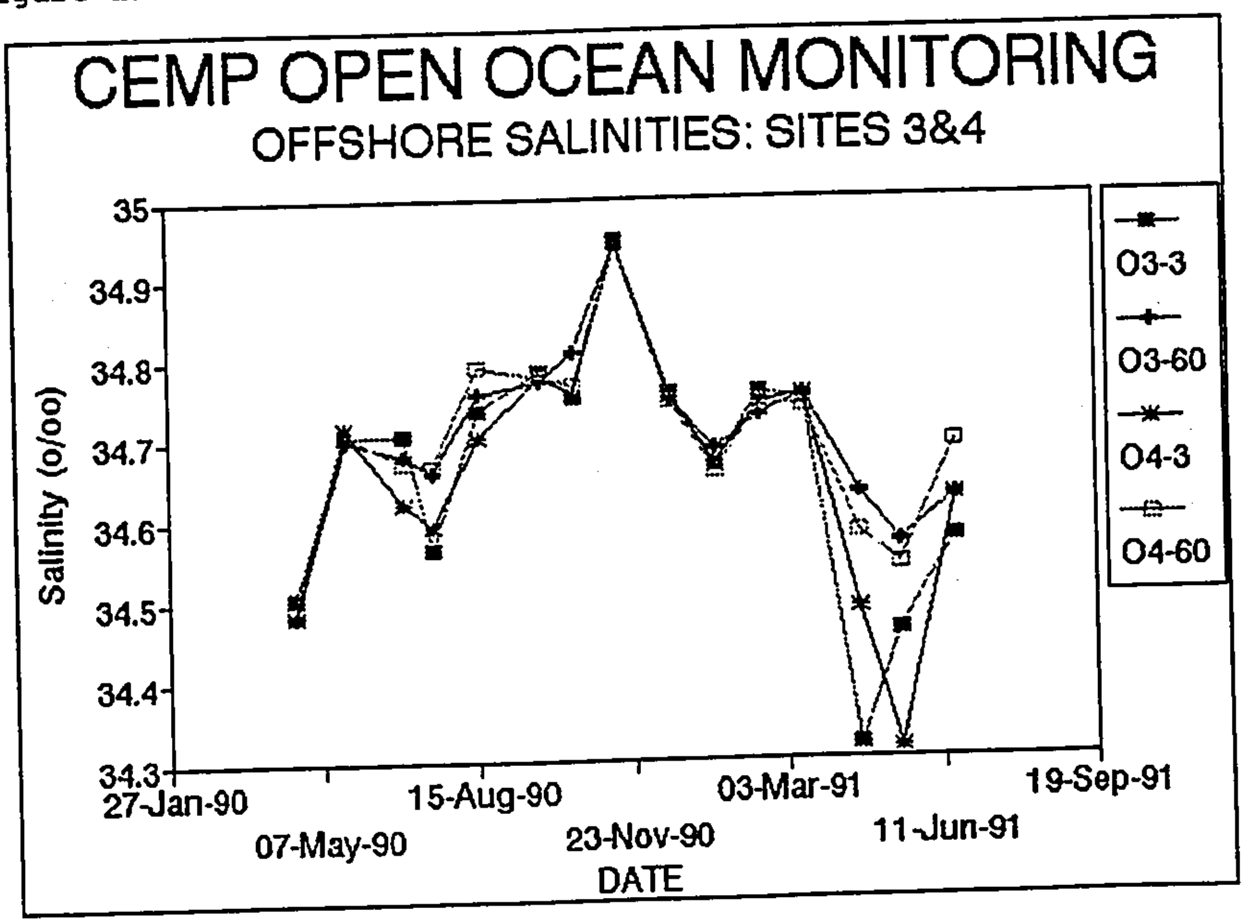


Figure 20. Offshore Seawater pH: Sites 1-2

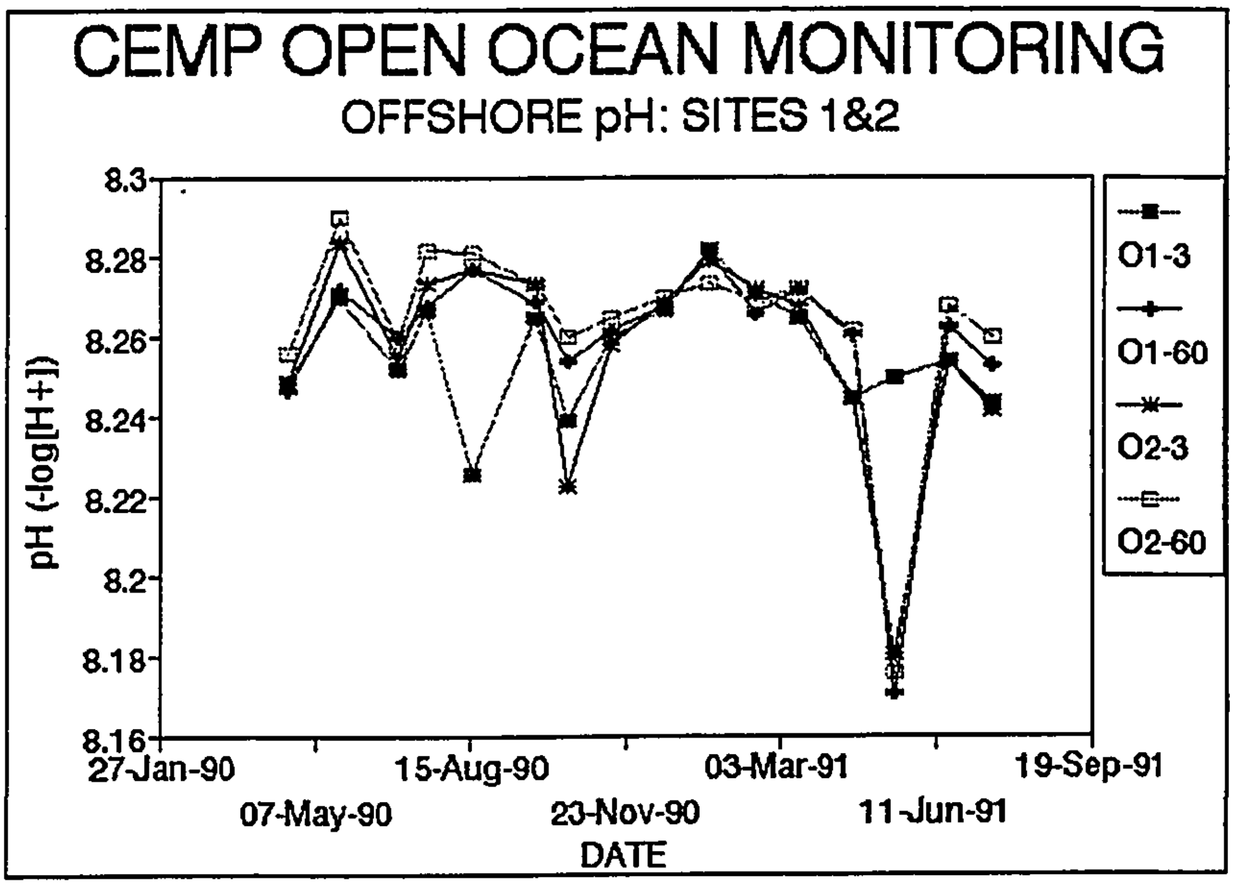


Figure 21. Offshore pH: Sites 3-4

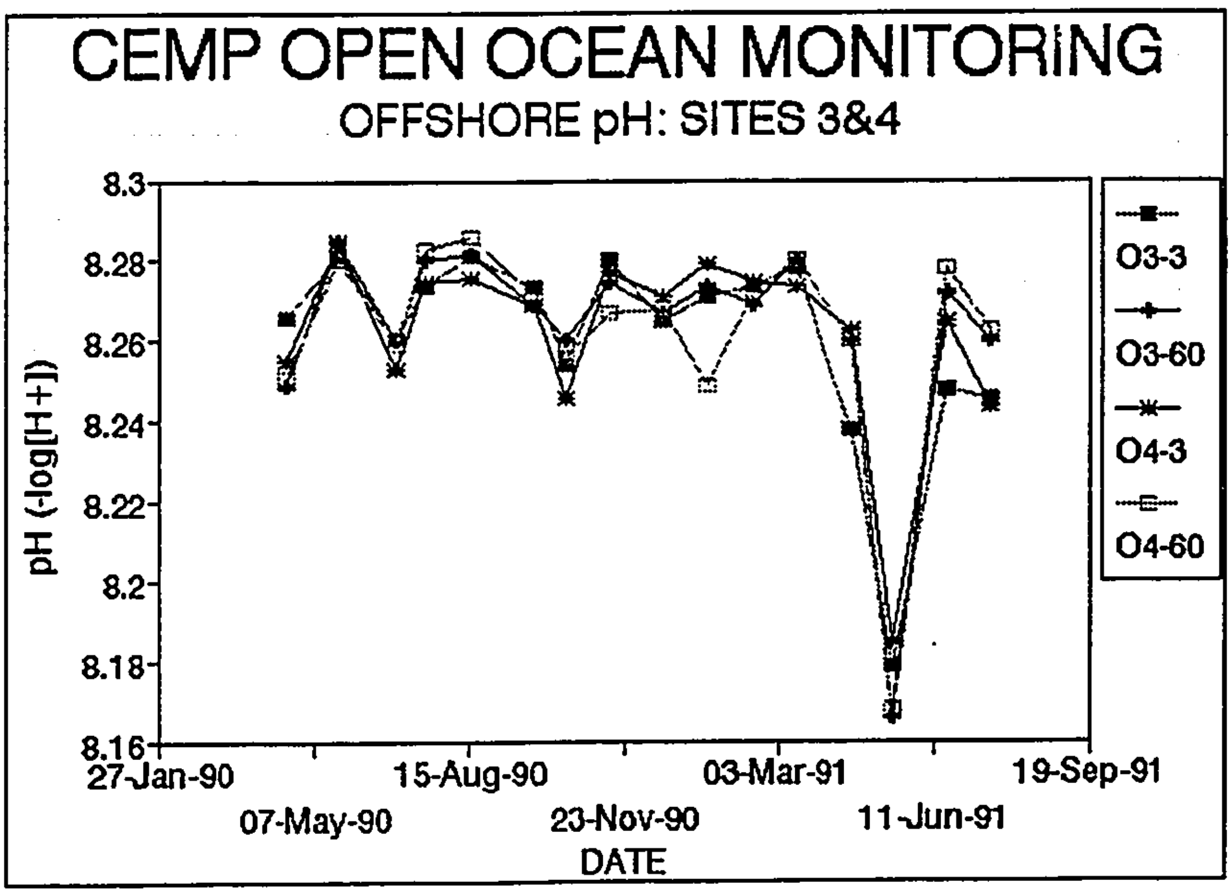


Figure 22. Offshore Seawater Dissolved Oxygen: Sites 1-2

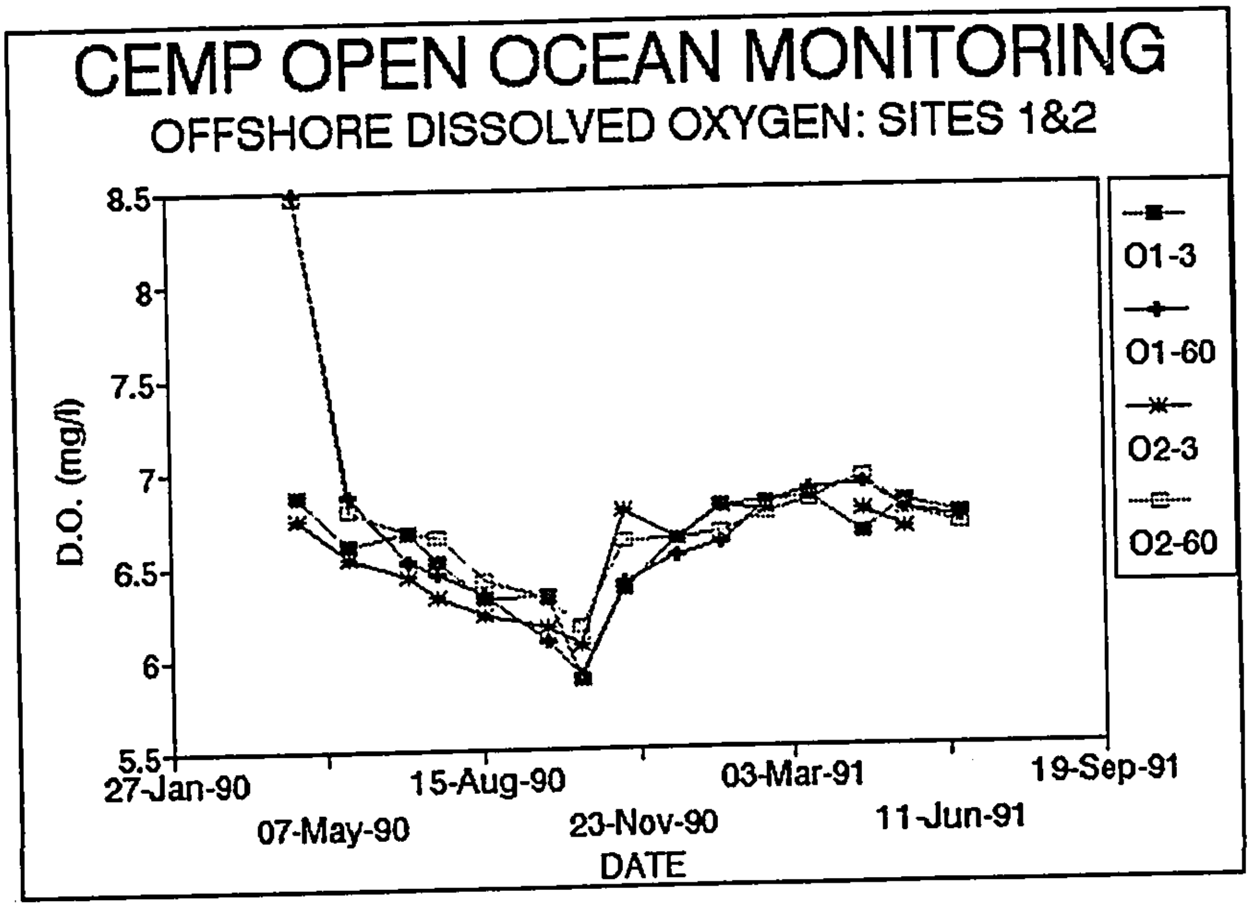


Figure 23. Offshore Seawater Dissolved Oxygen: Sites 2-3

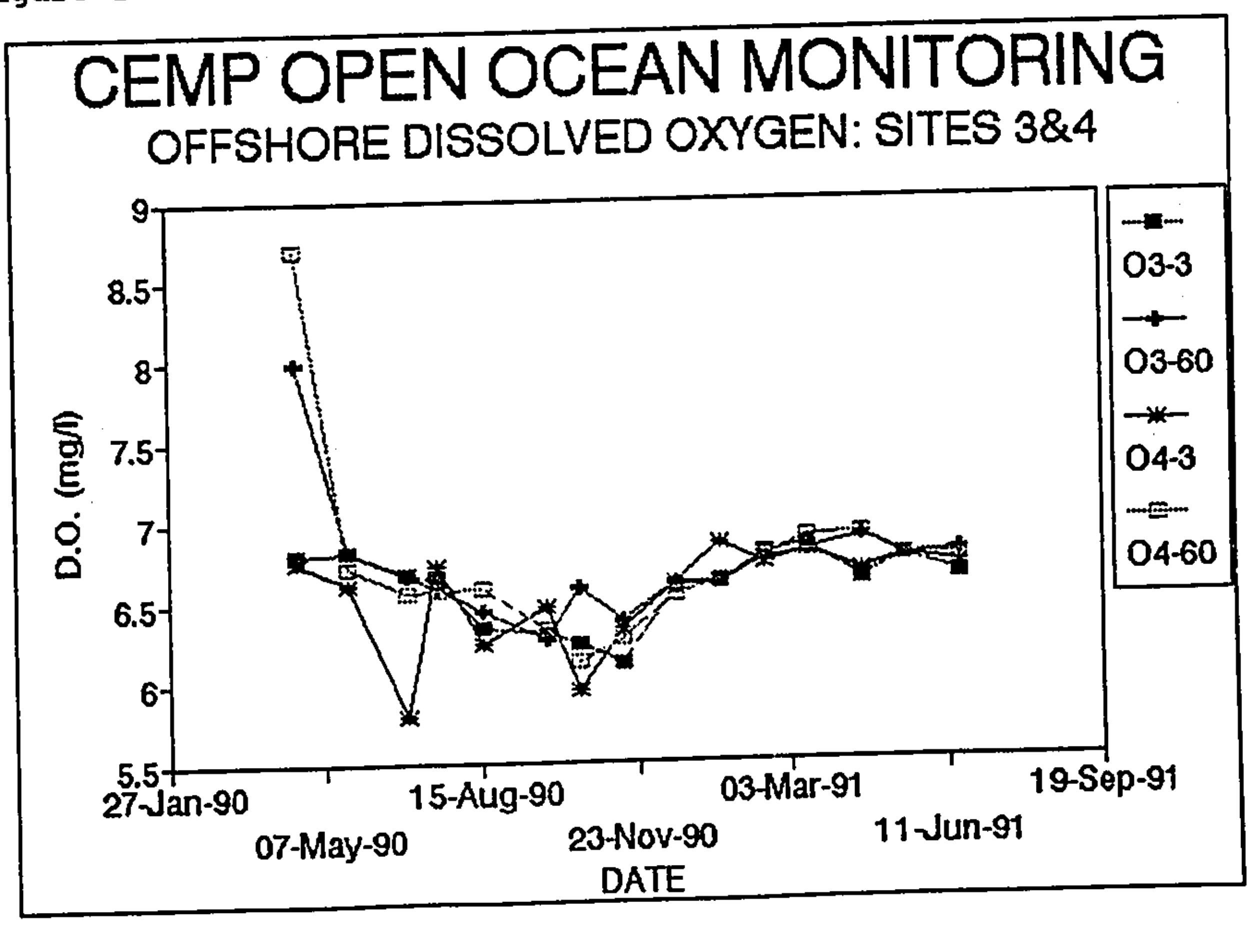


Figure 24. Offshore Seawater Nitrate: Sites 1-2

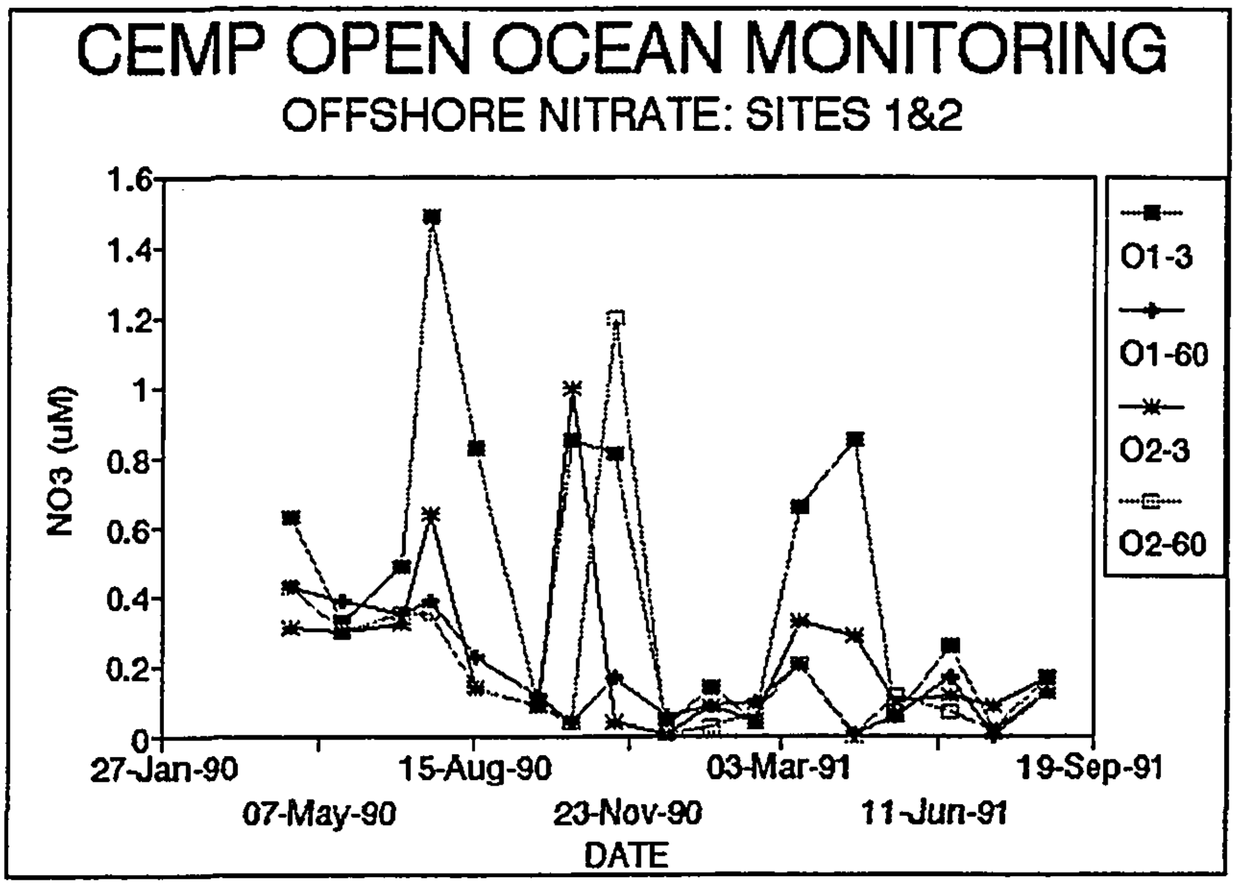


Figure 25. Offshore Seawater Nitrate: Sites 3-4

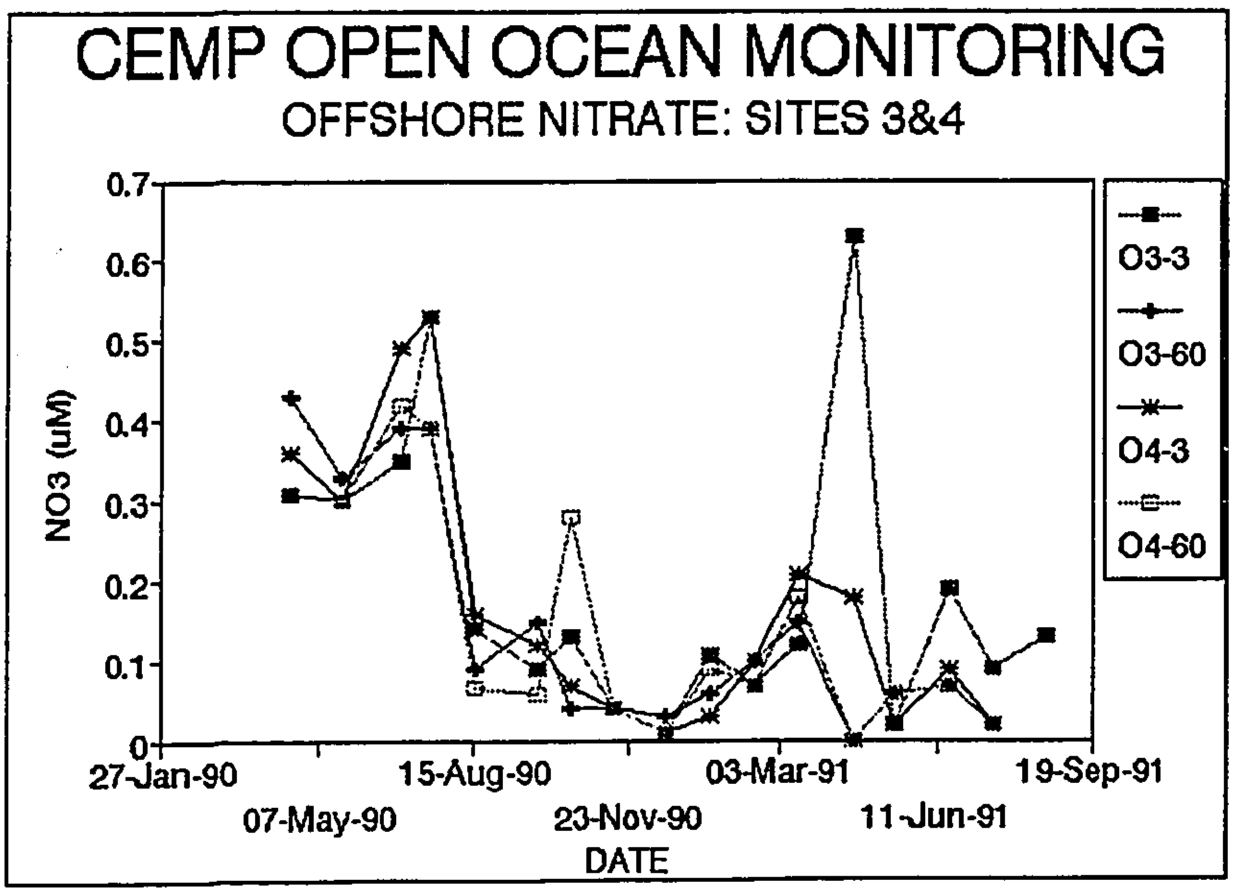


Figure 26. Offshore Seawater Phosphate: Sites 1-2

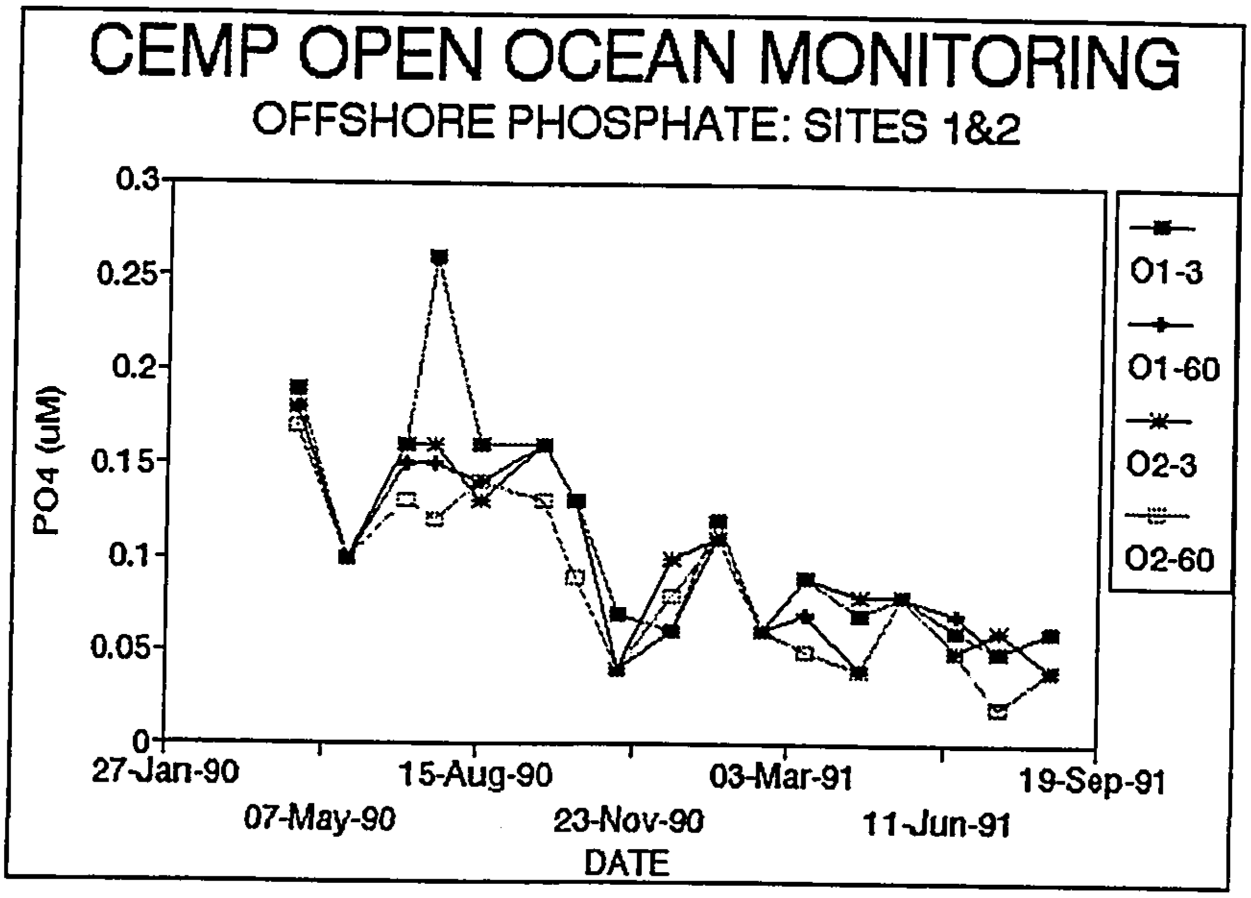


Figure 27. Offshore Seawater Phosphate: Sites 3-4

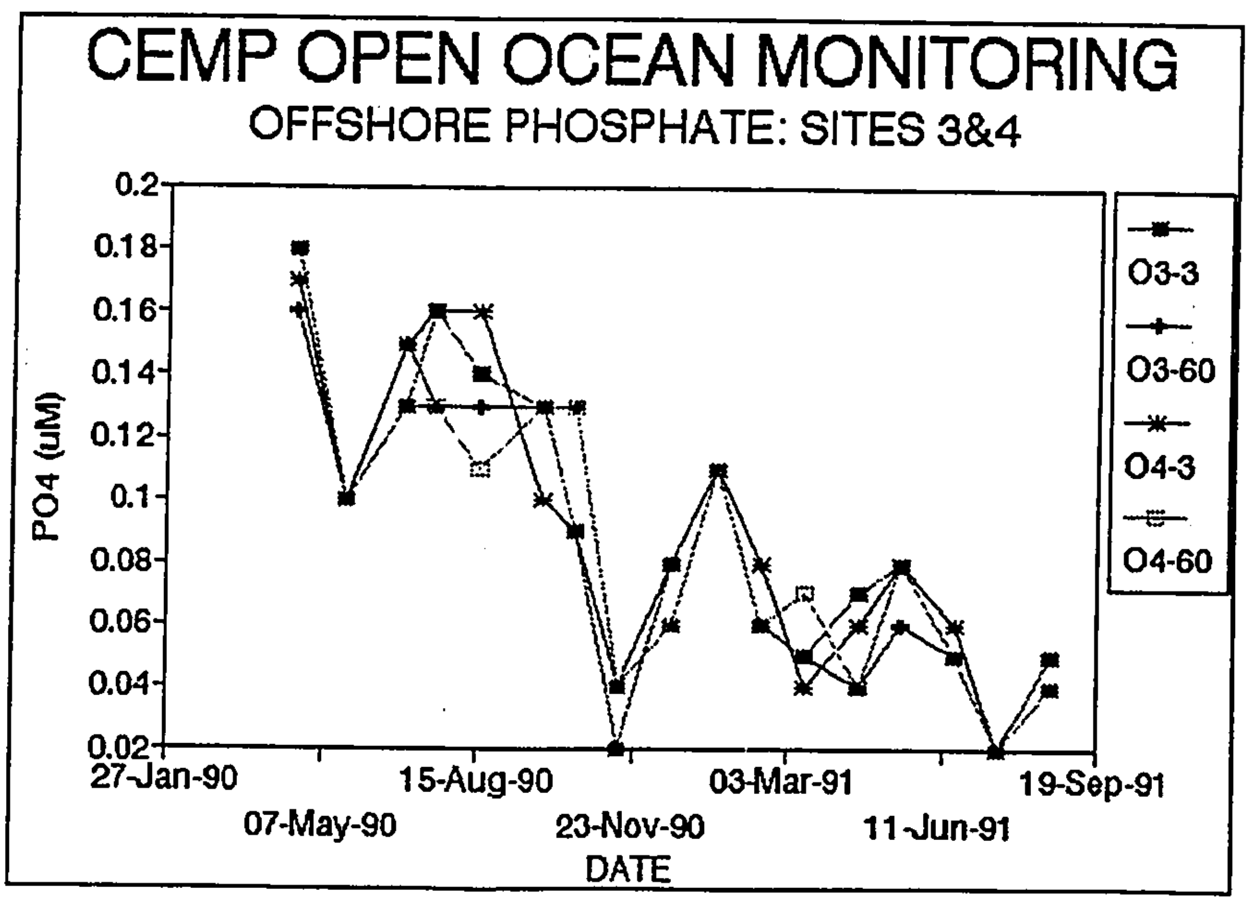


Figure 28. Offshore Seawater Silicate: Sites 1-2

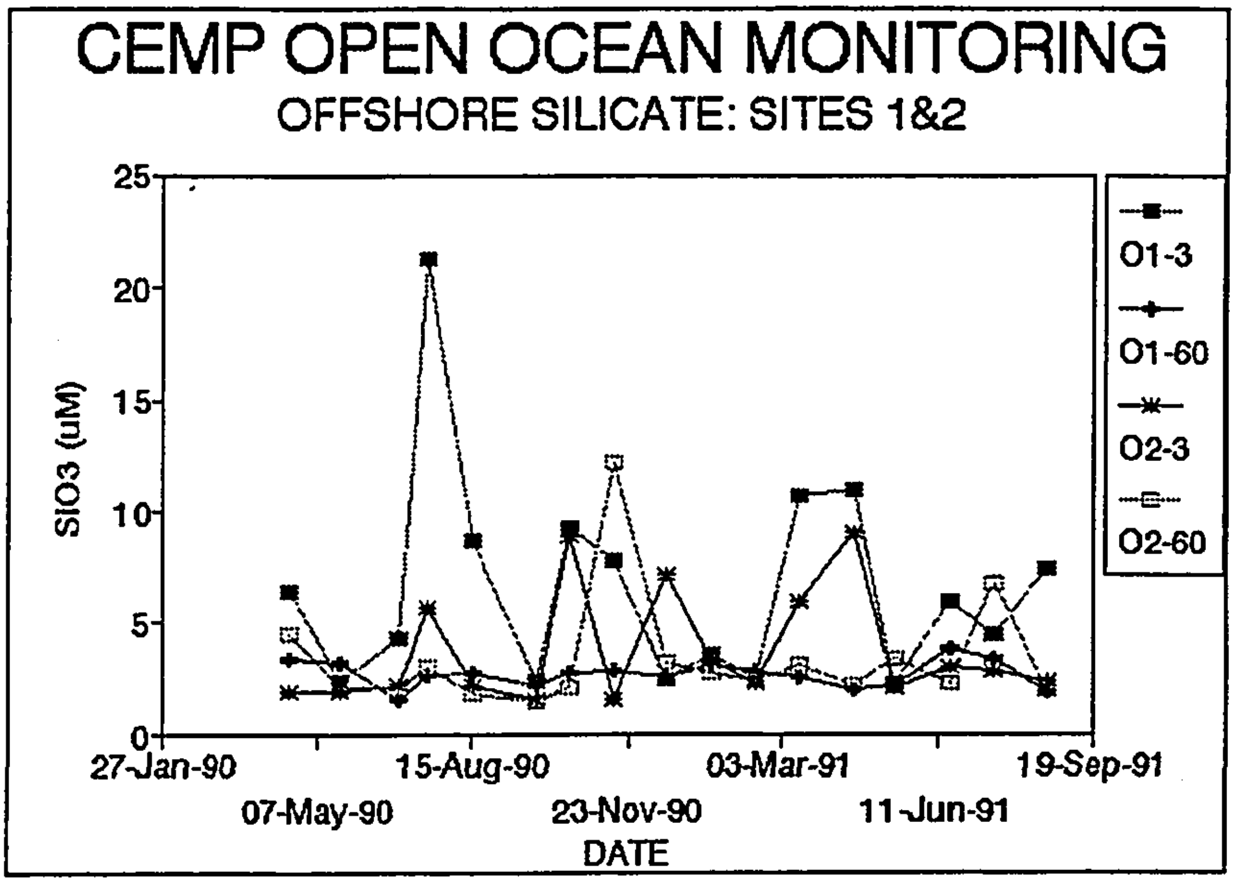


Figure 29. Offshore Seawater Silicate: Sites 3-4

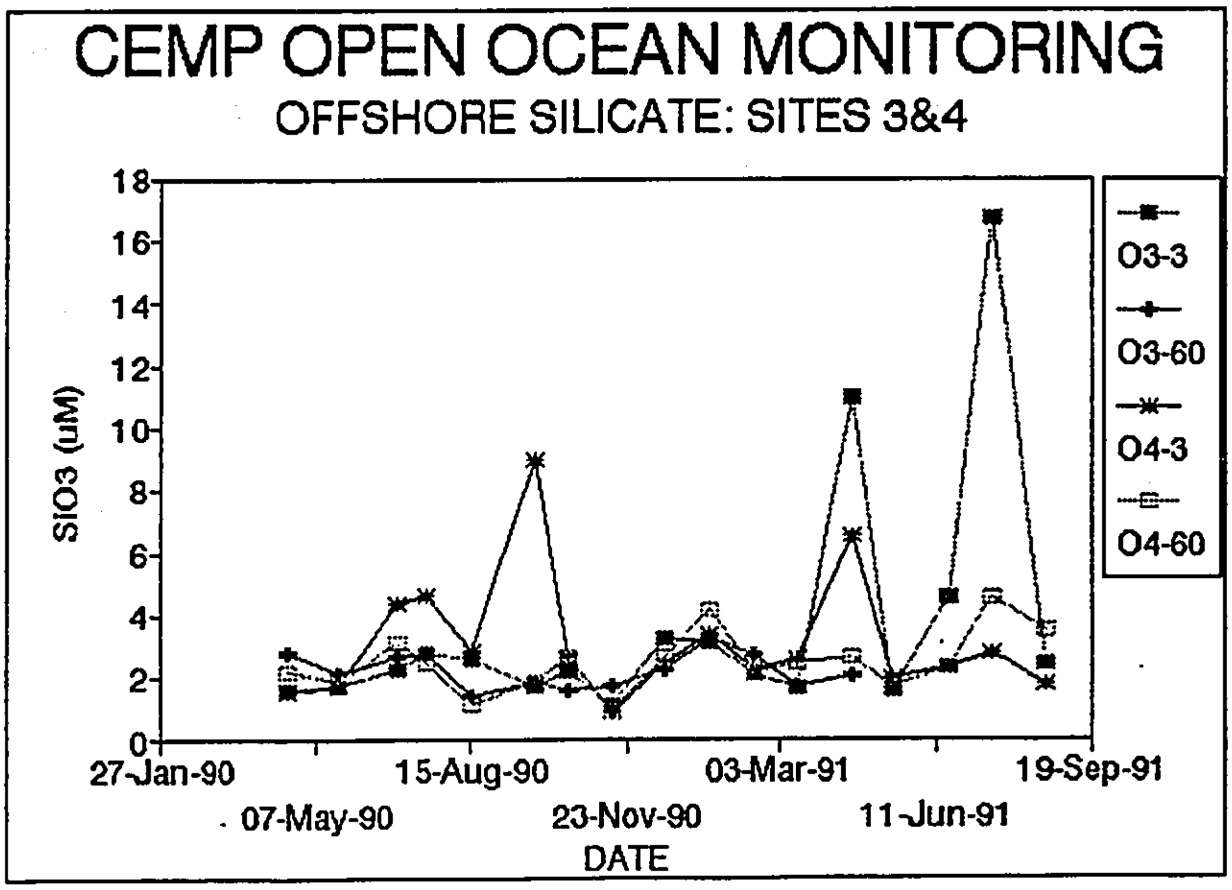


Figure 30. Offshore Seawater Ammonium: Sites 1-2

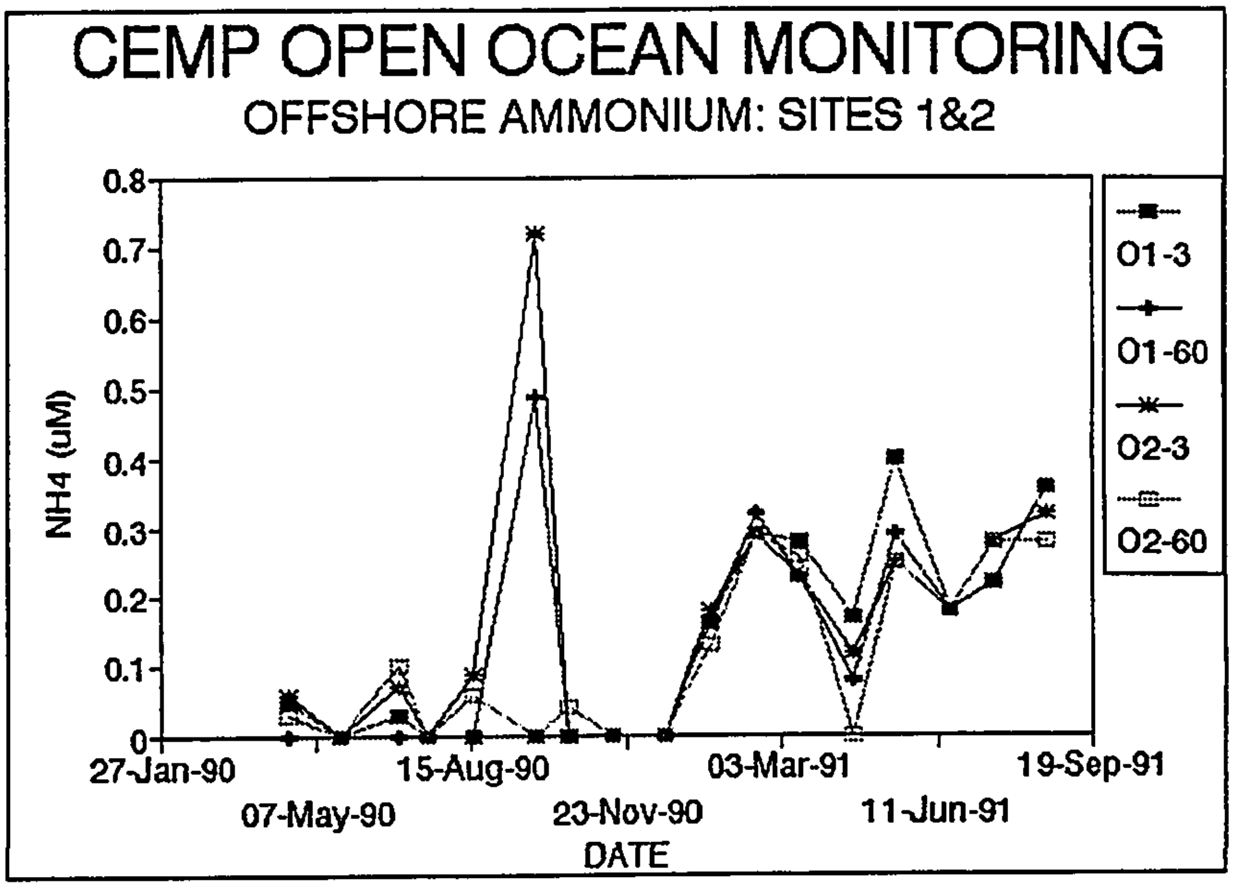


Figure 31. Offshore Seawater Ammonium: Sites 3-4

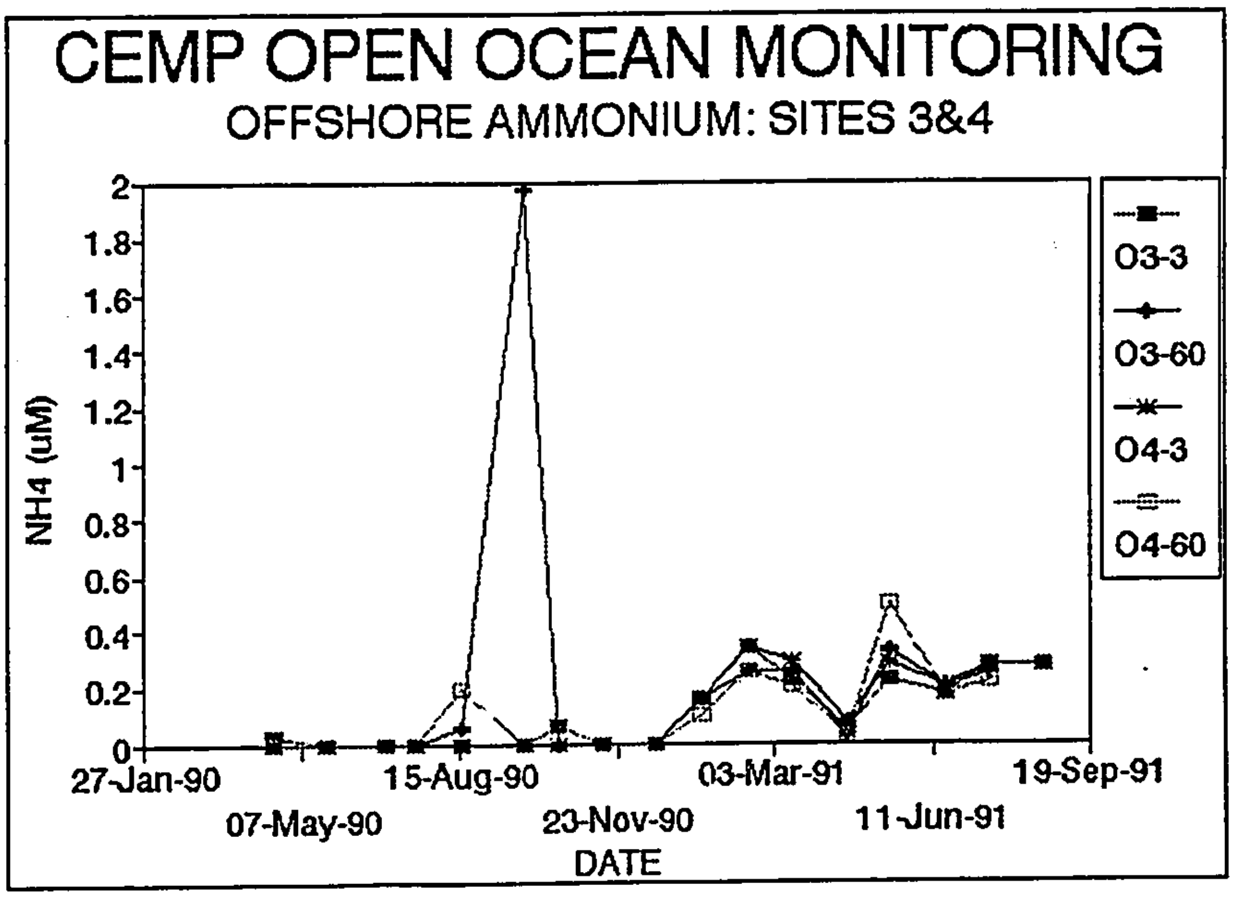


Figure 32. Offshore Seawater Total Dissolved Nitrogen: Sites 1-2

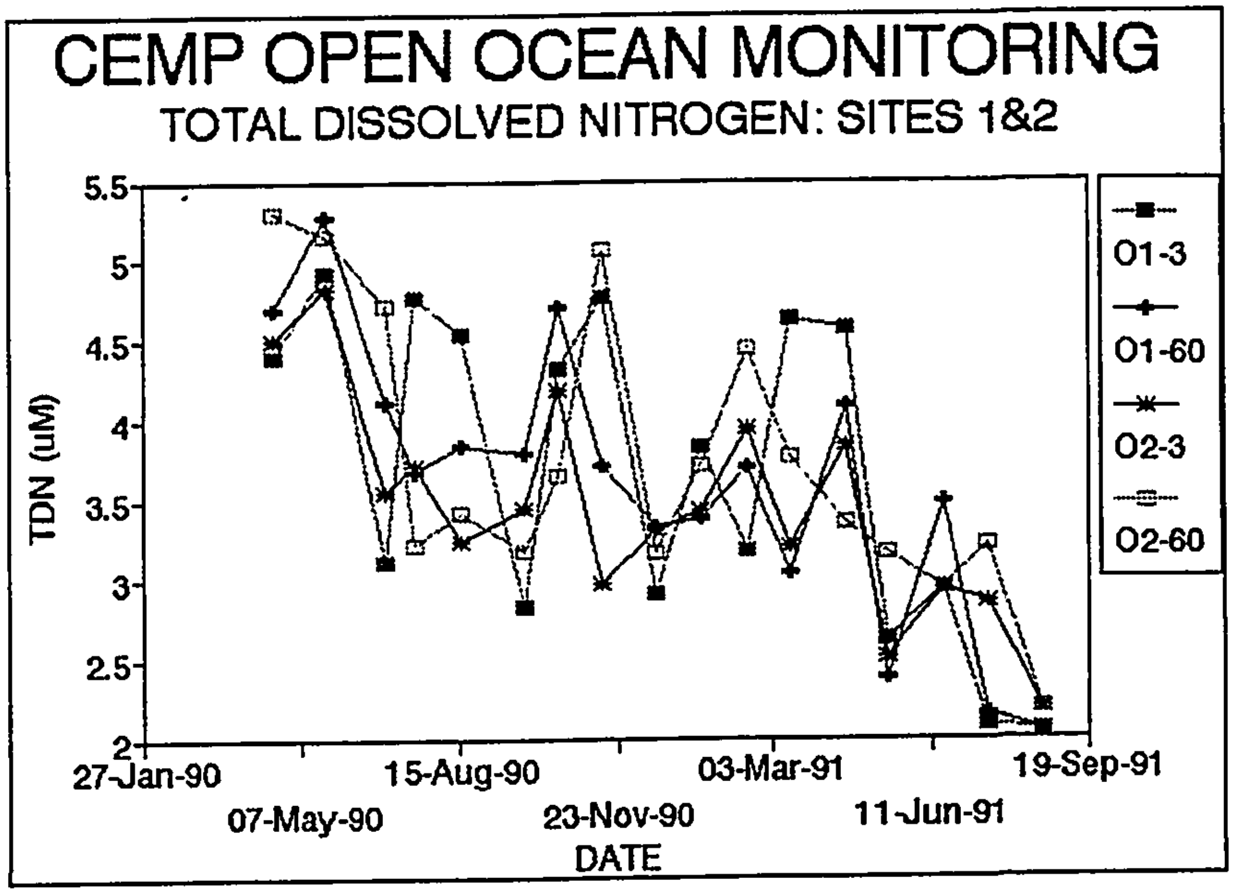


Figure 33. Offshore Seawater Total Dissolved Nitrogen: Sites 3-4

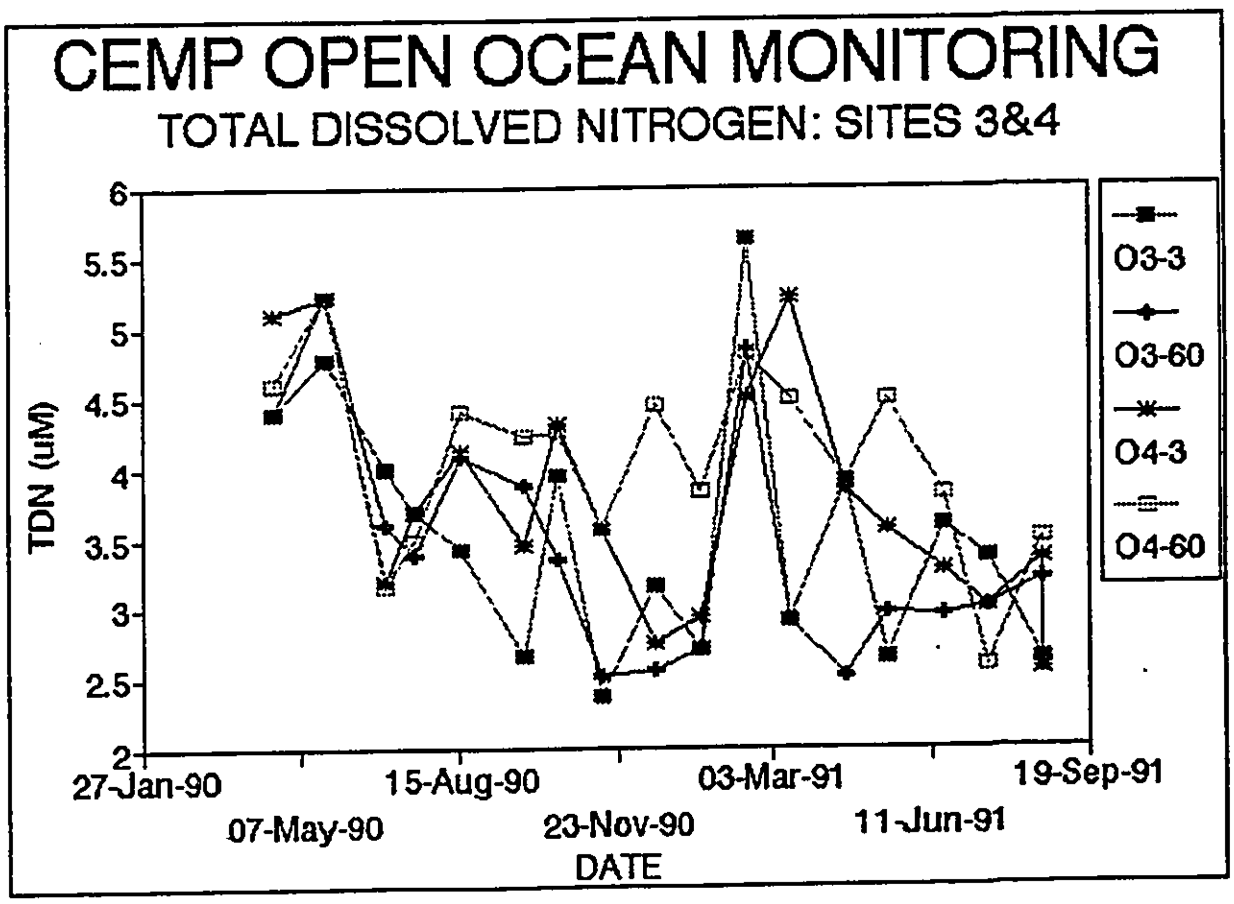


Figure 34. Offshore Seawater Total Dissolved Phosphorus: Site 1-2

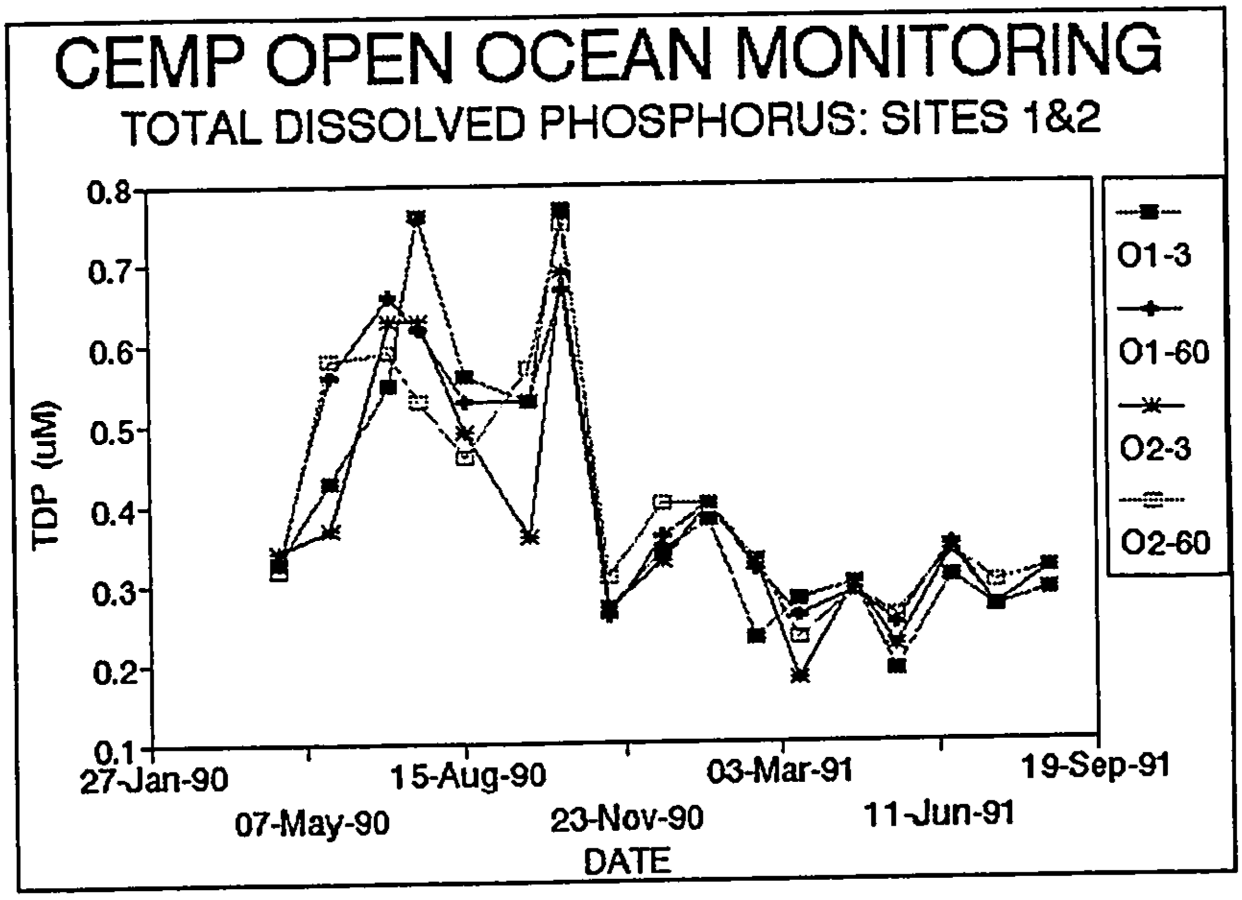


Figure 35. Offshore Seawater Total Dissolved Phosphorus: Site 3-4

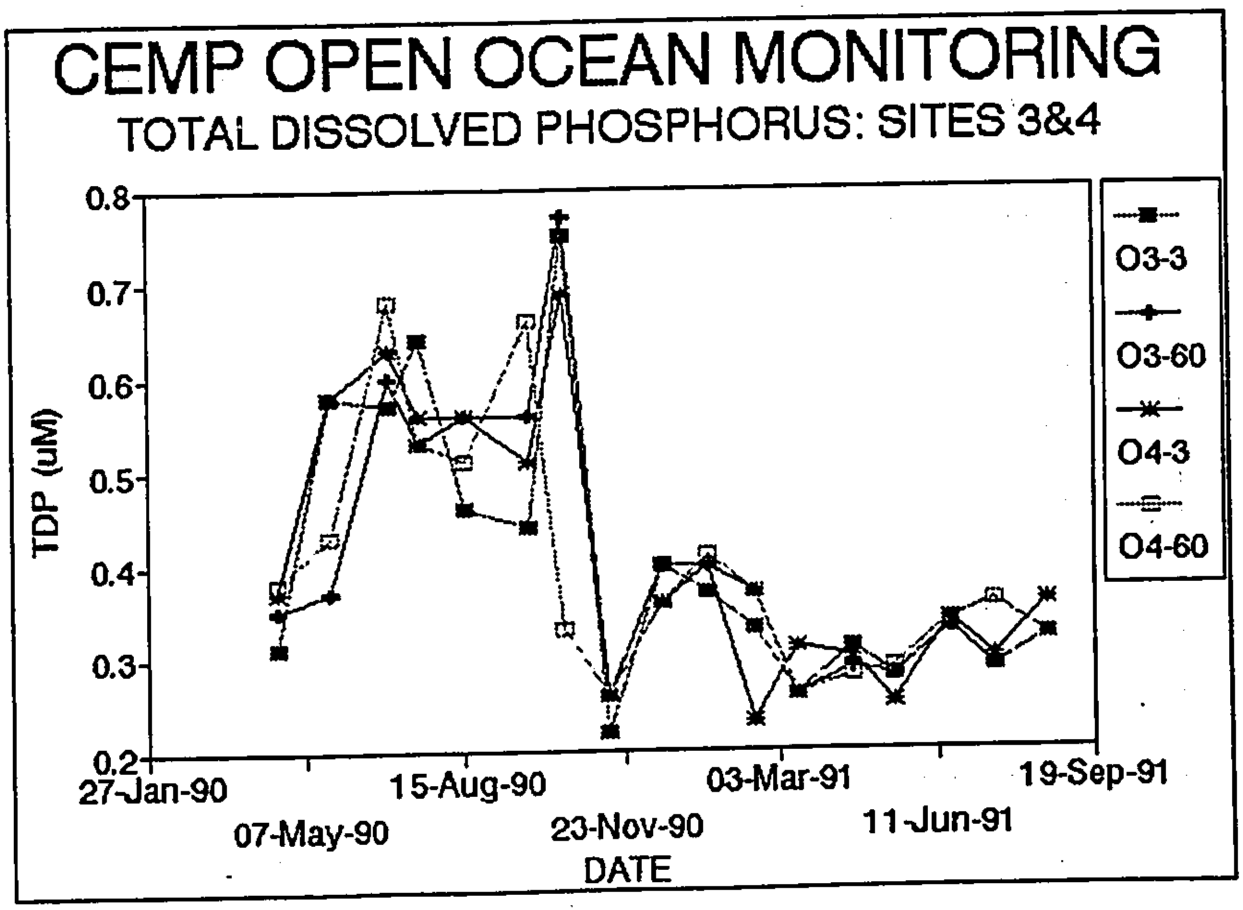


Figure 36. Offshore Seawater Total Organic Carbon: Site 1-2

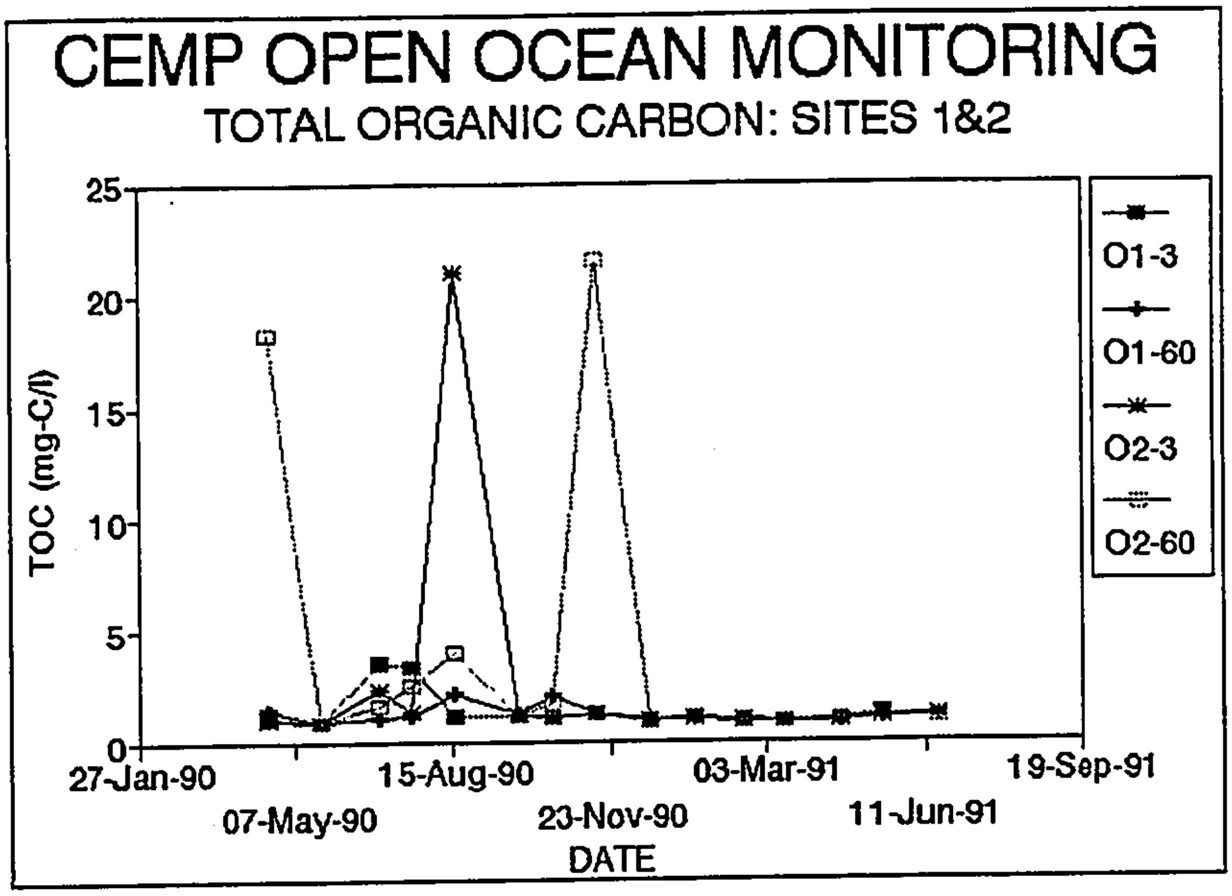


Figure 37. Offshore Seawater Total Organic Carbon: Site 3-4

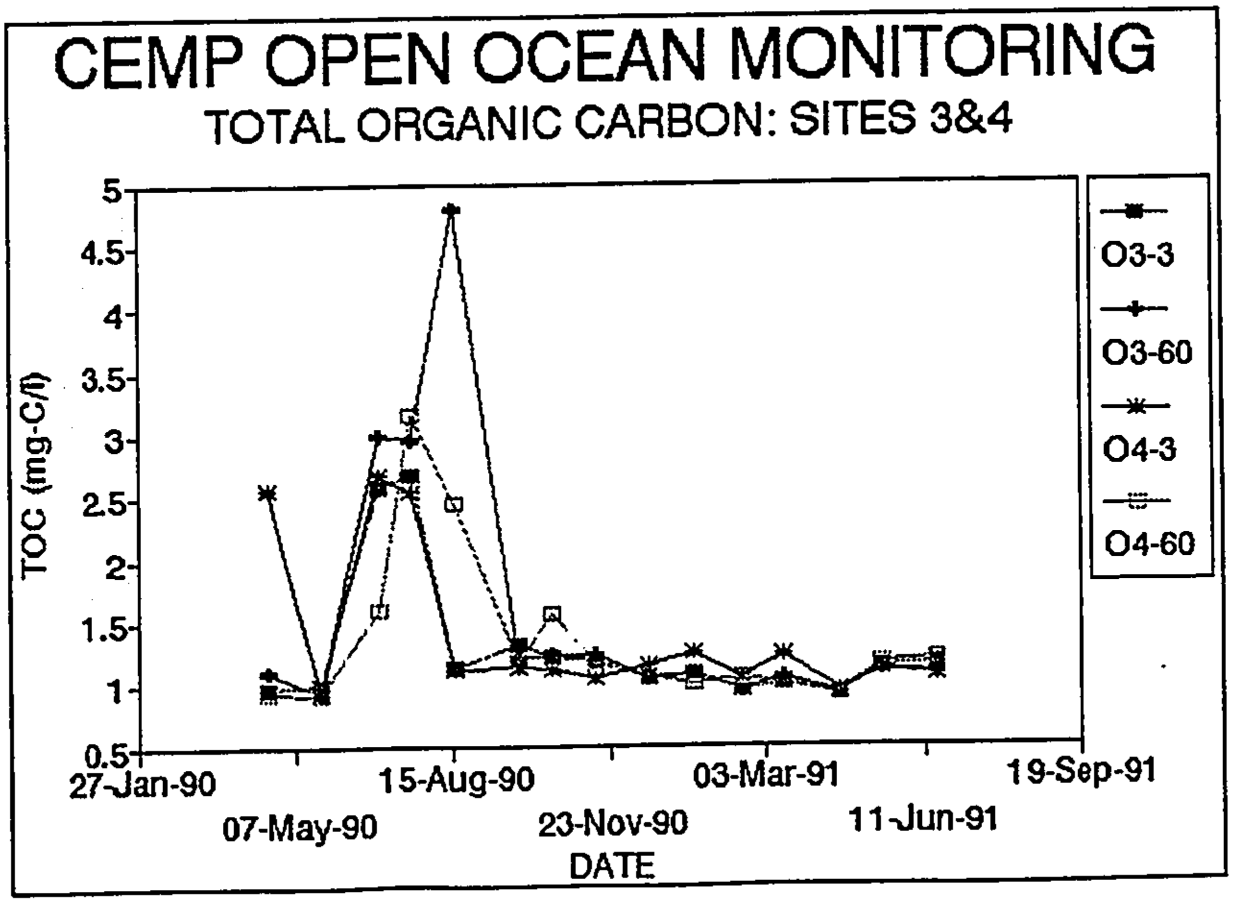


Figure 38. Offshore Seawater Total Suspended Solids: Site 1-2

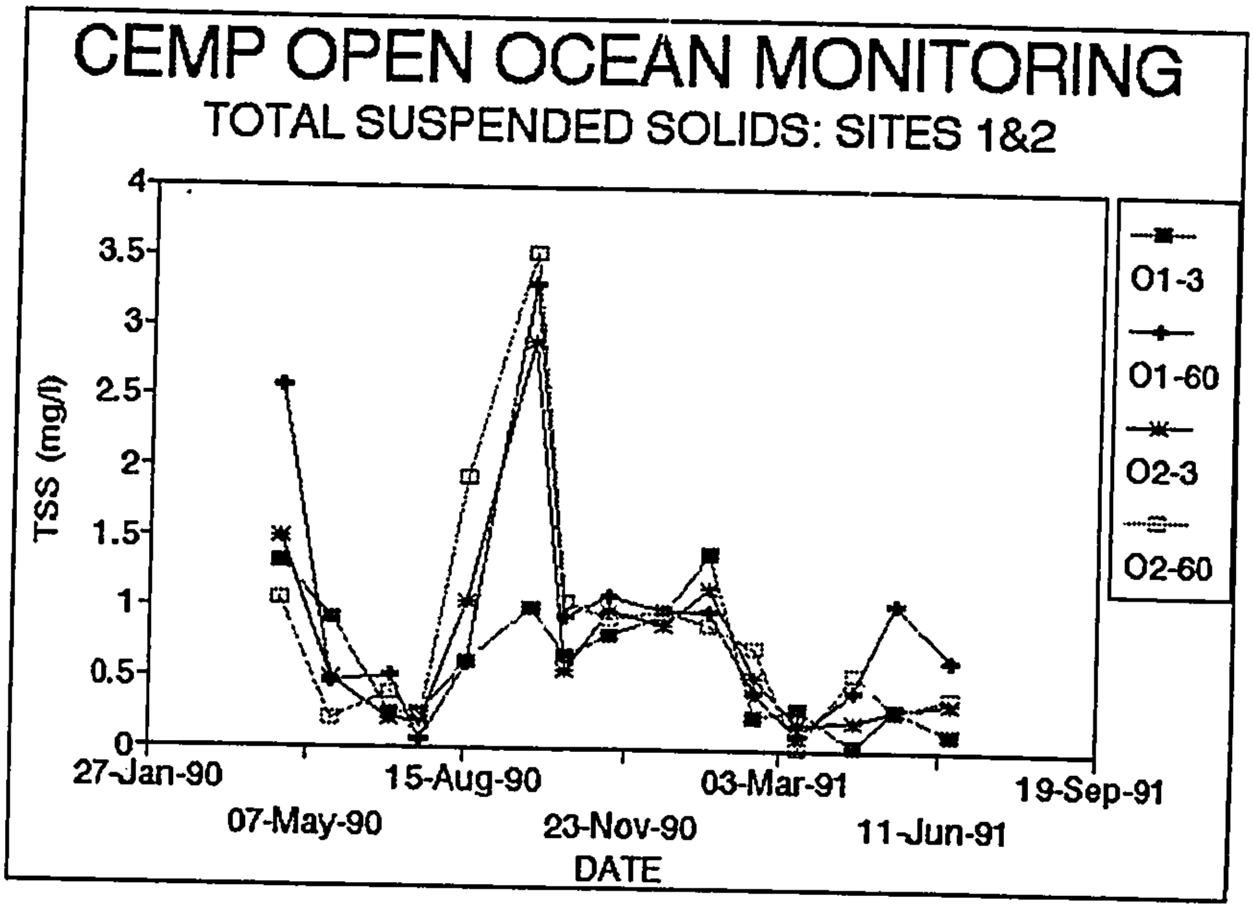
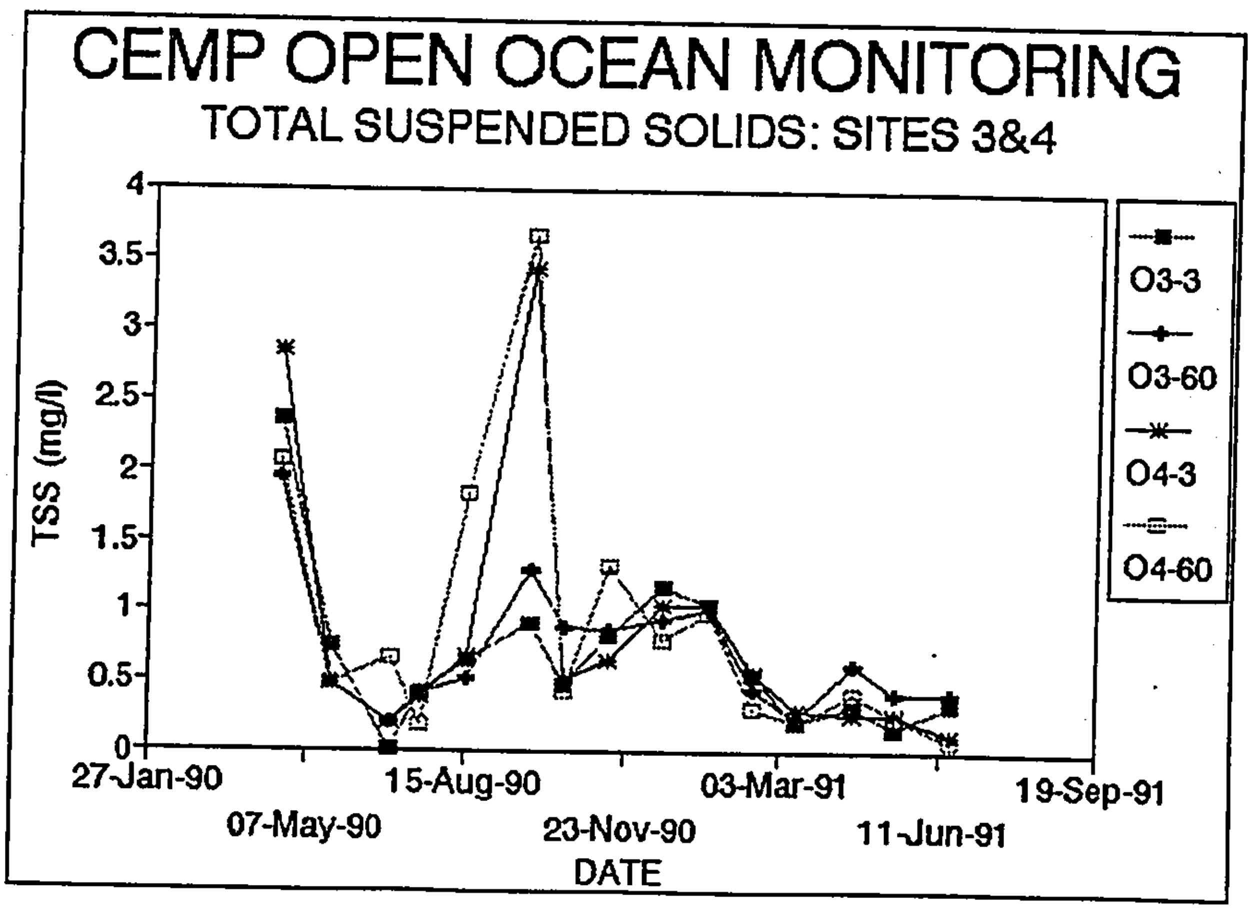


Figure 39. Offshore Seawater Total Suspended Solids: Site 3-4



COASTAL SEAWATER QUALITY DATA

Discussion

The CEMP requires collection of samples at four coastal sites, but NELHA had already begun sampling at a total of 29 sites (C1′, C2′ and C1 to C27) as shown on the Sampling Site Location Map, Figure 15. For the period of the present report, samples were only collected at the nine sites circled on Figure 15. All of these data are presented in Tables IX - XI. The data plots, Figures 27 - 37, present the measurements only at the four CEMP sites, designated CEMP 1 through CEMP 4. These correspond to Sites C1, C5, C24 and C27, respectively, in Figure 15.

The nutrient data are plotted as "enrichment", or deviations from the "mixing line" determined by a regression of salinity on all of the coastal values of the variable (Dollar and Atkinson, in press). This technique is intended to compensate for the intrusion of groundwater (which has naturally high nutrient content) into the coastal samples, so that the plotted enrichment values indicate other possible effects. Mixing line regression parameters are presented in Table XII, and plots of all of the data used are included with the data plots.

Samples are taken from shore in standard sampling containers using standard rinsing techniques to avoid sample contamination. When high surf conditions preclude sample collection, sampling is done at the first opportunity after the surf subsides.

Table X. Coastal Seawater Quality Data: Sites C1 - C11

COASTAL Keahole Point Comprehensive Environmental Water Quality Program
SEA WATER

Site	Date	Time (2400 hr)	Tide (ft)	Tide Direction	PO4 (um/L)	NO3 (um/L)	NH4 (um/L)	SI (um/L)	TDP (um/L)	TDN (um/L)	TOC (mg/L)	TSS (mg/L)	Salinity (‰)	Temp (F) (Deg. C)	pH	mV	Temp. (M) (Deg. C)	DO (ppm)	Chl a ug/L	Coliform FC/100ml	Enterococ Ent./100m
C1	05-Jul-90	1355	0.8	Flood	0.45	0.98	0.08	9.73	1.20	6.30	0.83	0.62	34.552	27.0	8.372	-142.6	27.8	7.84		NA	None
C C1	01-Aug-90	920	1.0	Flood	0.79	3.31	0.00	66.36	0.80	7.96	2.28	0.76	33.056	26.7	8.370	-143.8	24.2	7.54		NA	None
E C1	11-Sep-90	935	2.0	High	0.09	0.34	0.41	3.23	0.86	3.13	0.74	1.40	34.770	28.2	8.362	-144.1	28.1	7.02		NA	8
M C1	02-Oct-90	1445	1.8	High	0.06	5.52	0.00	3.74	0.76	3.15	1.20	1.13	34.789	28.5	8.348	-144.5	29.5	6.89		NA	1
P C1	07-Nov-90	1310	0.6	Ebb	0.72	19.20	0.16	199.40	0.57	19.70	0.68	1.53	28.363	25.9	8.267	-139.3	27.3	7.20		NA	1
C1	04-Dec-90	1025	1.0	Ebb	0.56	15.80	0.37	165.80	0.78	18.60	0.74	2.18	27.972	25.2	8.250	-138.7	27.6	7.36		NA	1
1 C1	08-Jan-91	930	0.9	Ebb	0.14	2.20	0.20	22.40	0.42	7.50	0.93	4.65	33.956	25.4	8.331	-142.9	22.4	7.18		NA	None
1 C1	12-Feb-91	841	0.4	Ebb	0.16	4.20	0.31	43.20	0.36	7.43	1.03	1.25	33.340	24.8	8.306	-139.7	22.2	7.21		NA	None
C1	12-Mar-91	940	0.2	Low	0.10	1.39	0.44	18.50	0.29	4.17	1.32	0.27	34.179	24.7	8.330	-137.2	23.2	7.65	0.03	NA	None
C1	09-Apr-91	1008	0.4	Flood	0.62	15.30	0.19	205.80	0.74	19.30	0.95	0.57	28.133	24.2	8.342	-130.4	23.7	8.39		NA	None
C1	14-May-91	903	-0.4	Low	0.61	16.70	0.54	124.00	0.94	22.40	1.13	0.33	27.431	24.0	8.285	-108.9	23.4	8.47		NA	None
C1	03-Jun-91	1147	0.5	Low	0.63	13.50	0.42	145.00	0.76	16.90	1.56	0.36	29.252	25.4	8.365	-106.6	23.8	8.17		None	None
C5	09-Jul-90	1300	0.6	Flood	0.48	1.88	0.10	6.49	1.24	7.65	1.97	0.84	34.580	26.4	8.318	-138.7	24.9	7.38		NA	None
C C5	01-Aug-90	955	0.8	Flood	0.17	0.38	0.20	3.44	0.89	6.36	3.06	0.91	34.671	27.1	8.249	-138.9	24.3	6.67		NA	None
E C5	11-Sep-90	1015	2.0	High	0.09	0.21	0.26	2.08	0.78	2.90	1.79	1.61	34.772	27.5	8.306	-140.9	24.0	6.59		NA	None
M C5	02-Oct-90	1415	1.7	High	0.08	4.35	0.00	2.51	0.80	3.64	1.13	1.71	34.777	27.9	8.285	-140.1	29.0	7.10		NA	None
P C5	07-Nov-90	1230	0.8	Ebb	0.41	5.31	0.00	18.40	0.63	8.38	1.40	1.06	34.435	26.7	8.236	137.5	27.9	6.89		NA	None
C5	04-Dec-90	1100	0.6	Ebb	0.28	4.11	0.19	15.89	0.53	7.55	17.78	1.70	34.281	25.5	8.250	-138.4	26.3	6.76		NA	None
1 C5	08-Jan-91	945	0.9	Ebb	0.15	2.20	0.20	7.90	0.49	8.42	0.93	5.82	34.569	24.8	8.244	-137.8	22.3	6.62		NA	None
2 C5	12-Feb-91	904	0.3	Ebb	0.16	1.47	0.31	13.32	0.39	4.95	1.07	0.72	34.705	24.9	8.275	-138.0	22.4	6.95		NA	None
C5	12-Mar-91	1012	0.2	Low	0.07	0.43	0.44	4.29	0.23	3.03	1.02	0.11	34.756	24.7	8.269	-133.3	23.3	7.11	0.07	NA	9
C5	09-Apr-91	1044	0.5	Flood	0.32	5.01	0.10	12.40	6.50	8.80	0.97	-0.01	34.315	24.2	8.231	-123.8	23.5	6.86		NA	12
C5	14-May-91	937	-0.4	Low	0.63	10.70	0.29	31.50	0.79	14.10	1.16	0.28	33.714	24.1	8.204	-101.2	23.7	6.81		NA	None
C5	03-Jun-91	1213	0.5	Low	0.26	2.41	0.33	10.30	0.42	5.57	1.42	0.43	34.350	25.5	8.284	-101.7	23.6	7.13		None	None
C8	11-Jul-90	1030	0.6	Flood	0.52	2.03	0.00	6.32					34.580	26.2	8.310	-138.7	24.9				
C8	01-Aug-90	1355	1.8	High	0.14	0.25	0.14	2.71					34.687	27.2	8.278	-138.9	29.3				
C8	12-Sep-90	940	2.0	High	0.21	0.45	0.00	2.50					34.740	27.5	8.276	-139.8	27.1				
C8	11-Oct-90	915	2.0	High	0.05	4.74	0.00	2.82					34.798	27.4	8.277	-139.1	25.6				
C8	08-Nov-90	1300	1.0	Ebb	0.29	0.97	0.00	5.55					34.841	26.9	8.278	-140.7	28.1				
C8	06-Dec-90	1025	1.4	Ebb	0.88	0.76	0.00	3.80					34.554	25.8	8.283	-140.3	24.1				
C8	08-Jan-91	1110	1.0	Ebb	0.14	0.94	0.31	4.58					34.661	25.8	8.300	-141.4	23.8				
C8	12-Feb-91	1308	0.6	Flood	0.10	0.35	0.28	4.24					34.705	25.3	8.263	-138.7	27.9				
C8	14-Mar-91	850	0.1	Low	0.12	1.51	0.49	10.90					34.616	25.6	8.318	-141.6	26.6				
C8	10-Apr-91	745	0.0	Low	0.19	2.53	0.17	9.72					34.503	23.9	8.196	-120.7	23.3				
C8	16-May-91	811	0.2	Ebb	0.15	3.31	0.33	7.60					34.535	24.8	8.247	-101.5	23.1				
C8	05-Jun-91	837	0.6	Flood	0.11	0.36	0.35	6.44					34.598	25.1	8.267	-99.8	23.6				
C11	11-Jul-90	1100	0.5	Ebb	0.43	1.13	0.00	5.11					34.627	26.5	8.267	-137.0	28.5				
C11	01-Aug-90	1320	2.0	High	0.17	0.41	0.23	5.32					34.574	27.3	8.270	-138.5	29.4				
C11	12-Sep-90	1000	2.0	High	0.18	0.41	0.00	2.50					34.767	27.6	8.273	-139.8	27.1				
C11	11-Oct-90	935	2.0	High	0.05	4.74	0.00	1.90					34.804	27.5	8.281	-139.4	25.8				
C11	07-Nov-90	1430	0.4	Low	0.22	0.94	0.12	6.12					34.784	27.2	8.270	-140.2	28.2				
C11	06-Dec-90	1050	1.2	Ebb	0.03	0.79	0.00	3.46					34.538	25.9	8.278	-140.0	24.1				
C11	08-Jan-91	1125	0.9	Ebb	0.14	1.57	0.29	5.78					34.630	25.1	8.288	140.6	23.4				
C11	12-Feb-91	1312	0.6	Flood	0.11	0.48	0.36	3.80					34.722	25.3	8.318	-141.3	25.4				
C11	14-Mar-91	906	0.1	Low	0.10	0.88	0.44	5.97					34.601	24.5	8.277	-131.9	22.9				
C11	10-Apr-91	805	0.0	Low	0.71	4.10	0.22	12.30					34.509	23.7	[illegible]	[illegible]	22.2				
[illegible]	16-May-91	[illegible]	0.1	[illegible]	[illegible]	0.94	[illegible]	[illegible]					34.576	25.2	[illegible]	[illegible]	23.4				
C11	05-Jun-91	[illegible]	0.6	Flood	0.14	0.41	0.35	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

Table XI. Coastal Seawater Quality Data: Sites C12 - C17

COASTAL Keahole Point Comprehensive Environmental Water Quality Program
SEA WATER

Site	Date	Time (2400 hr)	Tide (ft)	Tide Direction	PO4 (um/L)	NO3 (um/L)	NH4 (um/L)	SI (um/L)	TDP (um/L)	TDN (um/L)	TOC (mg/L)	TSS (mg/L)	Salinity (‰)	Temp (F) (Deg. C)	pH	mV	Temp. (M) (Deg. C)	DO (ppm)	Chl a ug/L	Coliform FC/100ml	Enterococ Ent./100m
C12	11-Jul-90	1120	0.6	Ebb	0.63	5.59	0.00	5.11					34.246	26.1	8.294	-138.6	28.4				
C12	01-Aug-90	1345	2.0	High	0.17	0.41	0.11	6.55					34.517	27.5	8.305	-140.5	29.3				
C12	12-Sep-90	1025	2.0	High	0.18	0.43	0.00	10.48					34.725	27.9	8.316	-142.2	27.1				
C12	11-Oct-90	1000	2.0	High	0.05	3.96	0.00	1.90					34.809	27.5	8.322	-141.8	25.7				
C12	07-Nov-90	1454	0.4	Low	0.35	4.37	0.27	18.10					34.445	26.9	8.282	-140.2	27.2				
C12	06-Dec-90	1110	1.0	Ebb	0.19	3.99	0.06	16.20					34.160	25.8	8.284	-140.4	24.3				
C12	08-Jan-91	1135	0.9	Ebb	0.27	6.76	0.31	29.65					34.193	24.9	8.309	-142.0	23.8				
C12	12-Feb-91	1327	0.7	Flood	0.18	1.10	0.34	6.47					34.703	25.6	8.318	-141.6	26.6				
C12	14-Mar-91	923	0.2	Low	0.17	3.62	0.33	21.60					34.370	24.5	8.285	-132.4	23.0				
C12	10-Apr-91	821	0.0	Low	0.30	6.34	0.17	20.30					34.058	23.5	8.214	-121.5	22.4				
C12	16-May-91	902	0.0	Ebb	0.12	0.72	0.31	5.03					34.264	25.3	8.285	-103.8	23.5				
C12	05-Jun-91	926	0.7	Flood	0.18	1.00	0.35	7.46					34.492	25.3	8.288	-101.0	23.7				
C17	11-Jul-90	1150	0.4	Low	0.58	4.28	0.00	58.00					33.027	26.5	8.330	-140.5	27.8				
C17	01-Aug-90	1410	2.0	High	0.17	0.44	0.34	7.22					34.467	27.9	8.415	-146.9	29.0				
C17	12-Sep-90	1050	2.0	High	0.18	0.45	0.00	2.43					34.727	28.2	8.365	-145.0	27.1				
C17	11-Oct-90	1025	2.0	High	0.08	4.74	0.00	2.51					34.814	27.6	8.360	-143.8	25.5				
C17	08-Nov-90	1325	0.8	Ebb	0.26	3.98	0.36	48.90					33.145	26.9	8.294	-141.4	27.3				
C17	06-Dec-90	1135	1.0	Ebb	0.23	4.92	0.15	62.90					32.585	25.7	8.299	-141.4	24.9				
C17	08-Jan-91	1150	0.8	Ebb	0.25	6.60	0.35	553.00					32.513	25.0	8.348	-144.3	24.1				
C17	12-Feb-91	1346	0.8	High	0.14	0.72	0.38	11.30					34.412	25.3	8.318	-141.3	25.4				
C17	14-Mar-91	954	0.1	Low	0.20	4.44	0.41	59.10					32.834	24.4	8.313	-133.8	22.2				
C17	10-Apr-91	851	0.0	Low	0.38	7.80	0.17	93.38					31.587	23.5	8.225	-122.3	22.8				
C17	16-May-91	937	-0.1	Ebb	0.13	1.93	0.31	11.60					32.700	25.1	8.293	-104.2	23.3				
C17	05-Jun-91	950	0.8	Flood	0.16	1.07	0.35	18.00					34.088	25.3	8.320	-103.0	23.9				
C22	11-Jul-90	1220	0.4	Low	0.58	4.80	0.00	48.60					33.199	26.4	8.299	-138.7	27.4				
C22	01-Aug-90	1430	2.0	High	0.19	1.01	0.14	13.72					34.240	27.7	8.294	-139.6	28.4				
C22	12-Sep-90	1115	2.0	High	0.21	0.79	0.00	5.03					34.606	27.9	8.317	-142.1	26.4				
C22	11-Oct-90	1045	2.0	High	0.06	6.68	0.00	11.12					34.695	27.5	8.306	-140.7	25.2				
C22	08-Nov-90	1345	0.8	Ebb	0.22	3.98	0.20	40.04					33.426	26.8	8.268	-139.8	26.7				
C22	06-Dec-90	1155	0.8	Ebb	0.14	4.17	0.06	58.60					32.751	25.5	8.286	-140.7	24.8				
C22	08-Jan-91	1200	0.8	Ebb	0.20	5.97	0.35	49.30					33.080	24.9	8.315	-142.4	23.9				
C22	12-Feb-91	1405	0.8	High	0.41	3.97	0.38	26.70					34.022	25.2	8.292	-139.6	24.8				
C22	14-Mar-91	1018	0.0	Low	0.17	3.55	0.44	43.70					33.381	24.3	8.292	-132.4	21.6				
C22	10-Apr-91	926	0.1	Low	0.24	4.55	0.24	48.10					33.153	23.7	8.260	-124.2	22.5				
C22	16-May-91	957	-0.2	Low	0.16	3.06	0.31	87.20					32.767	24.8	8.274	-103.1	23.3				
C22	05-Jun-91	1018	0.9	Flood	0.16	2.19	0.35	22.20					33.903	25.4	8.301	-101.8	23.7				

Table XII . Coastal Seawater Quality Data: Sites C24, C27

COASTAL Keahole Point Comprehensive Environmental Water Quality Program
SEA WATER

Site	Date	Time (2400 hr)	Tide (ft)	Tide Direction	PO4 (um/L)	NO3 (um/L)	NH4 (um/L)	SI (um/L)	TOP (um/L)	TON (um/L)	TOC (mg/L)	TSS (mg/L)	Salinity (%.)	Temp (F) (Deg. C)	pH	mV	Temp. (M) (Deg. C)	DO (ppm)	Chl a ug/L	Coliform FC/100ml	Enterococc Ent./100m
C24	09-Jul-90	930	0.6	Ebb	2.80	76.00	0.00	365.00	4.44	96.00	2.12	0.11	18.034	21.4	8.032	-121.9	23.6	7.27		NA	None
C C24	01-Aug-90	1045	1.4	Flood	2.49	59.46	0.07	512.00	2.49	63.34	1.98	0.62	16.872	24.2	8.286	-138.3	25.6	7.80		NA	None
E C24	11-Sep-90	1045	2.0	High	0.27	1.06	0.37	16.20	0.93	6.35	1.63	1.96	34.253	27.9	8.341	-142.9	23.9	6.89		NA	9
M C24	02-Oct-90	1120	0.8	Flood	2.30	58.50	0.00	620.08	2.76	66.02	0.95	0.82	16.551	24.1	8.276	-138.8	23.7	7.23		NA	7
P C24	07-Nov-90	935	1.8	Ebb	0.72	30.93	0.20	242.30	1.38	41.50	0.60	1.14	25.023	25.5	8.239	-137.2	24.8	6.61		NA	None
C24	04-Dec-90	1130	0.6	Ebb	2.47	70.47	0.22	924.00	2.85	72.71	0.49	0.61	34.106	21.3	8.015	-124.4	25.4	6.60		NA	None
# C24	08-Jan-91	1015	0.9	Ebb	2.91	95.19	0.05	631.00	3.16	99.20	0.65	1.26	8.806	21.0	8.041	-126.0	22.5	7.50		NA	6
3 C24	12-Feb-91	1045	0.2	Low	2.00	82.00	0.00	366.50	2.05	84.50	0.82	0.97	9.476	21.6	8.160	-131.4	22.9	7.46		NA	8
C24	12-Mar-91	1049	0.4	Flood	0.77	13.74	0.33	124.10	0.96	17.25	0.92	0.73	30.209	24.5	8.278	-134.4	25.8	7.69	0.08	NA	None
C24	09-Apr-91	1114	0.6	Flood	3.09	77.80	0.00	765.00	3.13	82.40	0.67	0.00	10.625	20.9	7.965	-108.6	24.4	7.02		NA	None
C24	14-May-91	1023	-0.4	Low	2.63	74.60	0.00	534.00	3.09	83.80	0.70	0.20	16.101	21.1	8.032	-94.1	23.8	7.45		NA	10
C24	03-Jun-91	1252	0.4	Low	2.79	81.60	0.00	641.20	3.18	90.10	0.97	0.27	9.128	21.5	8.069	-89.3	24.2	7.39		107	4
C27	09-Jul-90	1050	0.2	Low	0.47	2.18	0.05	17.90	1.78	8.40	1.18	0.78	34.153	25.9	8.305	-137.6	23.5	6.85		NA	None
C C27	01-Aug-90	1120	1.4	Flood	0.14	0.25	0.06	2.91	1.64	5.57	2.92	1.04	34.675	27.1	8.306	-139.4	25.0	6.26		NA	1
E C27	11-Sep-90	1115	2.0	High	0.09	1.27	0.07	4.14	0.93	3.59	0.99	1.53	34.667	27.6	8.306	-140.8	23.4	6.54		NA	None
M C27	02-Oct-90	1200	1.0	Flood	0.14	5.91	0.00	13.58	0.78	2.90	1.29	1.80	34.649	27.9	8.313	-140.9	23.7	6.72		NA	None
P C27	07-Nov-90	1045	1.4	Ebb	0.22	0.37	0.39	6.12	0.47	3.41	0.97	1.74	34.760	27.0	8.280	-139.5	24.5	6.45		NA	None
C27	04-Dec-90	1200	0.2	Low	0.21	1.76	0.09	20.55	0.50	5.67	1.08	1.95	34.013	25.7	8.266	-139.3	26.3	6.96		NA	None
# C27	08-Jan-91	1040	0.9	Ebb	0.15	1.57	0.20	12.13	0.52	5.81	1.84	5.31	34.308	25.0	8.295	-141.1	22.6	6.88		NA	None
4 C27	12-Feb-91	1015	0.2	Low	0.16	0.85	0.25	17.84	0.31	3.21	0.97	0.44	34.473	25.0	8.280	-138.3	22.7	6.97		NA	None
C27	12-Mar-91	1017	0.2	Low	0.10	1.00	0.44	14.10	0.31	3.79	0.98	0.31	34.306	24.6	8.275	-133.7	23.9	7.16	0.05	NA	None
C27	09-Apr-91	1137	0.7	Flood	0.23	0.82	0.01	17.20	0.30	3.31	0.97	0.09	34.365	24.4	8.245	-124.9	24.5	7.11		NA	None
C27	14-May-91	1050	-0.3	Low	0.23	1.35	0.23	20.90	0.35	5.12	1.05	0.25	34.089	24.9	8.265	-107.8	24.0	7.16		NA	None
C27	03-Jun-91	1313	0.4	Low	0.26	1.84	0.23	27.80	0.40	5.68	1.42	0.29	33.721	25.6	8.292	-102.3	24.1	7.21		None	None

Figure 40. Coastal Seawater Temperatures vs. Sample Date

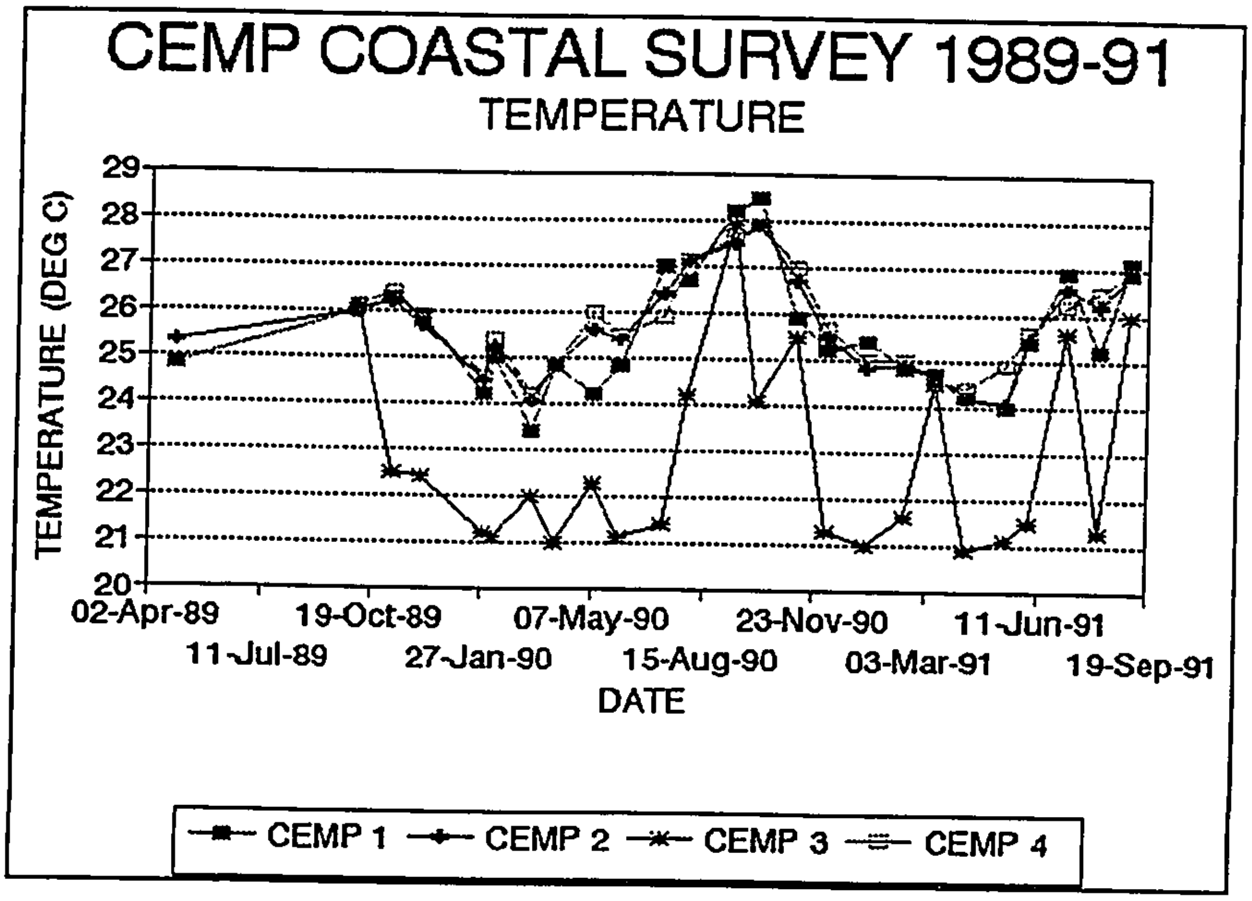


Figure 41. Coastal Seawater Salinity vs. Sample Date

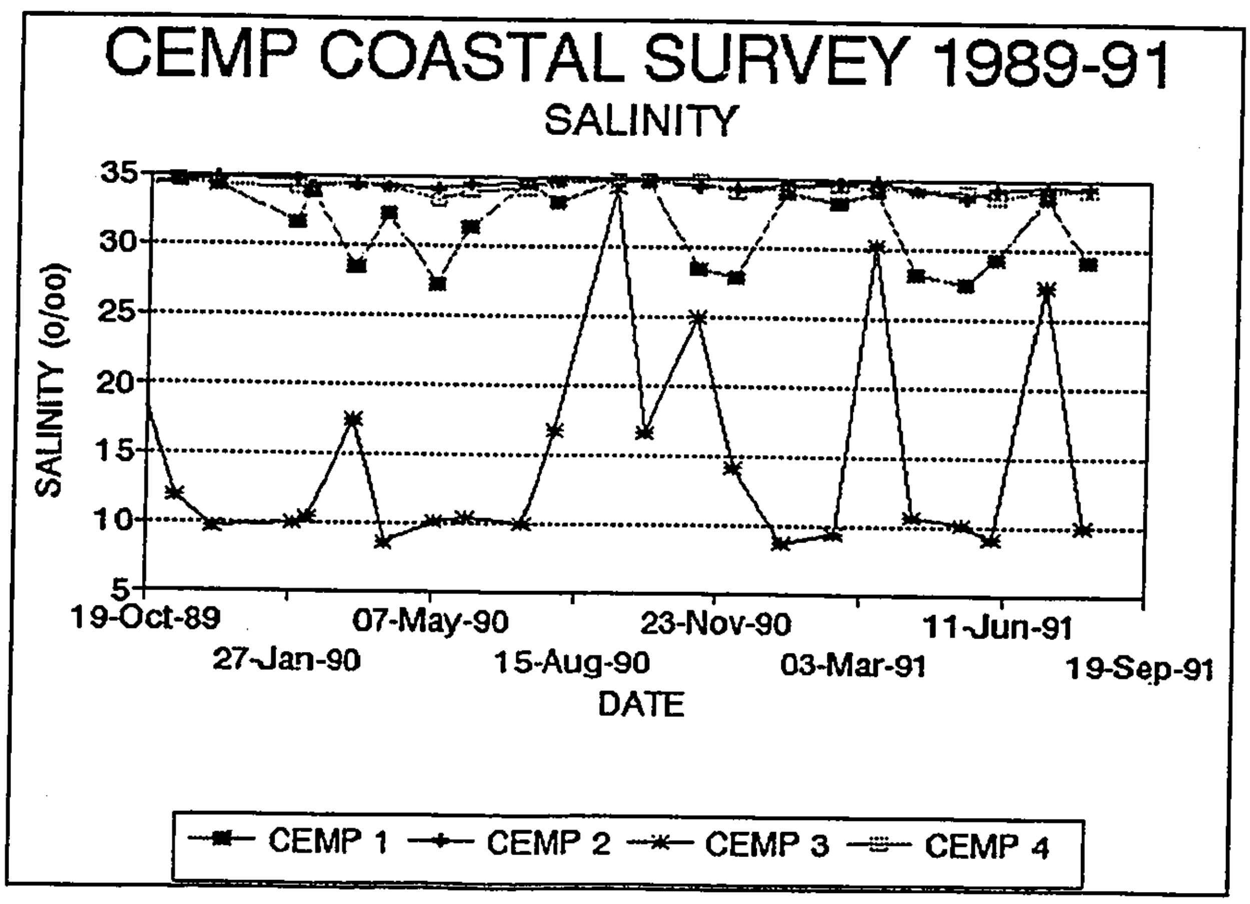


Figure 42. Coastal Seawater pH vs. Sample Date

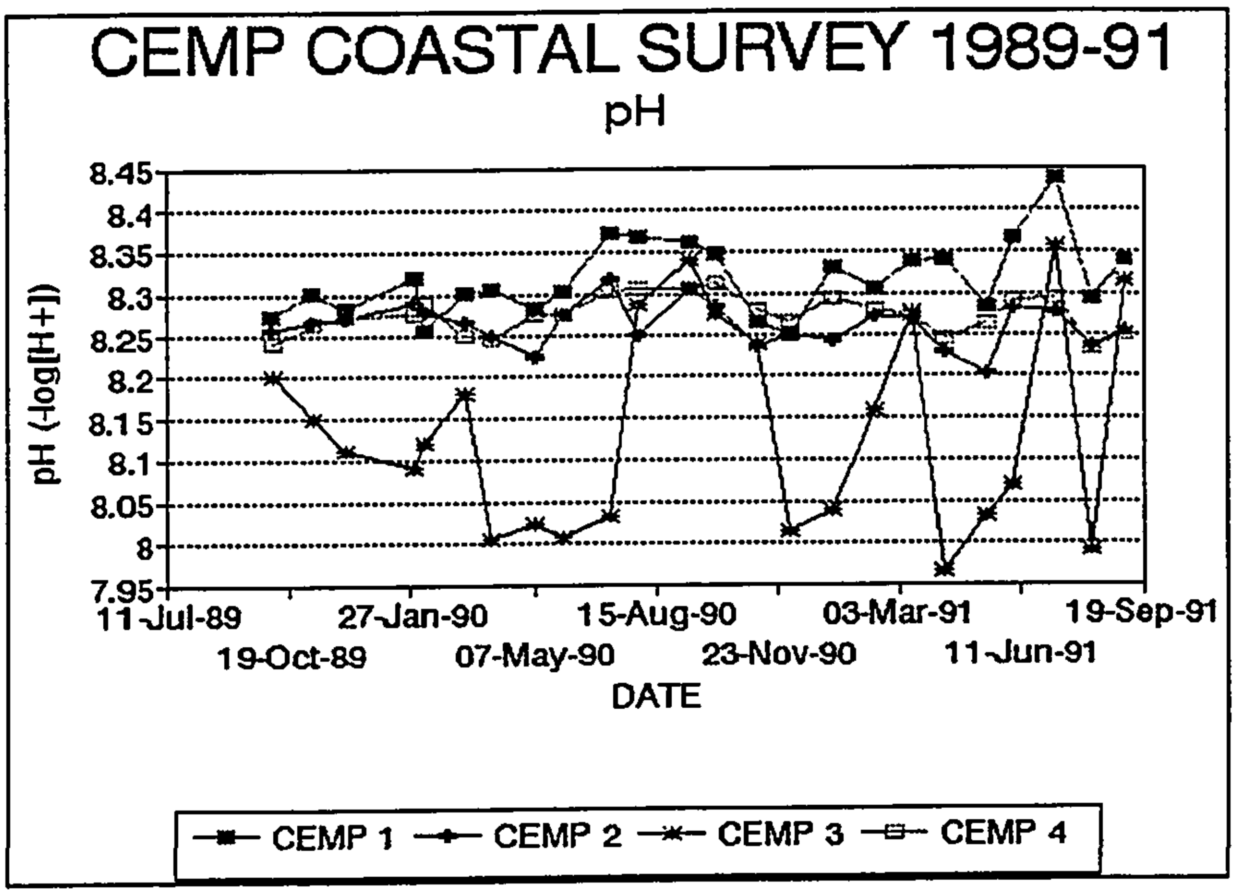


Figure 43. Coastal Seawater Dissolved Oxygen vs. Sample Date

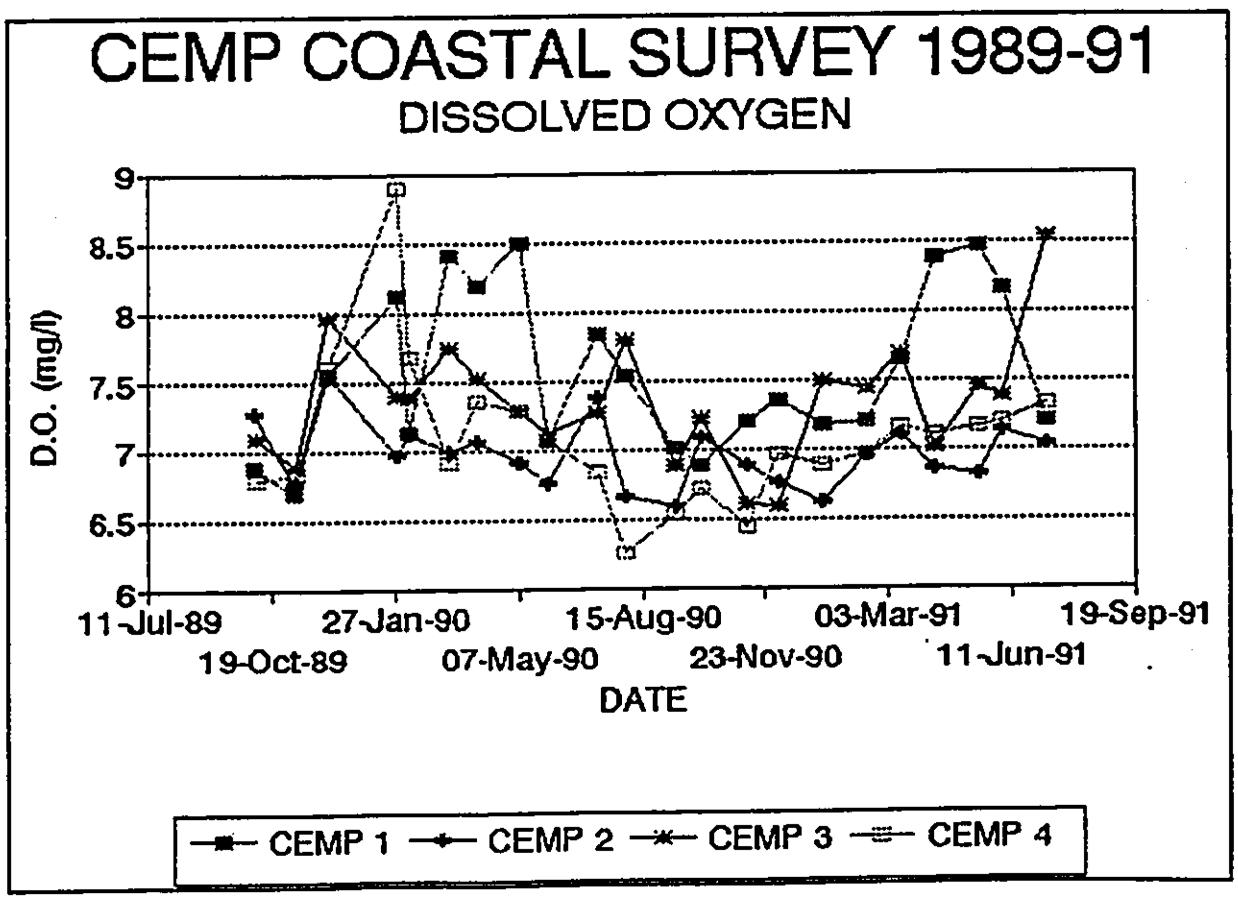


Table XIII. Coastal Seawater Nutrient Mixing Line Regression Parameters

Nitrate Regression Output:

Constant		110.72
Std Err of Y Est		4.35
R Squared		0.96
No. of Observations		242.00
Degrees of Freedom		240.00
X Coefficient(s)	-3.18	
Std Err of Coef.	0.04	

Phosphate Regression Output:

Constant		4.068
Std Err of Y Est		0.209
R Squared		0.920
No. of Observations		237.000
Degrees of Freedom		235.000
X Coefficient(s)	-0.11063	
Std Err of Coef.	0.00213	

Silicate Regression Output:

Constant		842.92
Std Err of Y Est		58.52
R Squared		0.87
No. of Observations		239.00
Degrees of Freedom		237.00
X Coefficient(s)	-24.10	
Std Err of Coef.	0.60	

Ammonium Regression Output:

Constant		0.090
Std Err of Y Est		0.345
R Squared		0.007
No. of Observations		231.000
Degrees of Freedom		229.000
X Coefficient(s)	0.0046	
Std Err of Coef.	0.00	

Total Dissolved N: Regression Output:

Constant		113.85
Std Err of Y Est		8.65
R Squared		0.92
No. of Observations		88.00
Degrees of Freedom		86.00
X Coefficient(s)	-3.157	
Std Err of Coef.	0.101	

Total Dissolved P: Regression Output:

Constant		4.23
Std Err of Y Est		0.38
R Squared		0.87
No. of Observations		88.00
Degrees of Freedom		86.00
X Coefficient(s)	-0.105	
Std Err of Coef.	0.004	

Tot. Org. Carbon: Regression Output:

Constant		-0.81
Std Err of Y Est		0.58
R Squared		0.11
No. of Observations		18.00
Degrees of Freedom		16.00
X Coefficient(s)	0.068	
Std Err of Coef.	0.05	

Figure 44. Coastal Seawater Nitrate Mixing Line

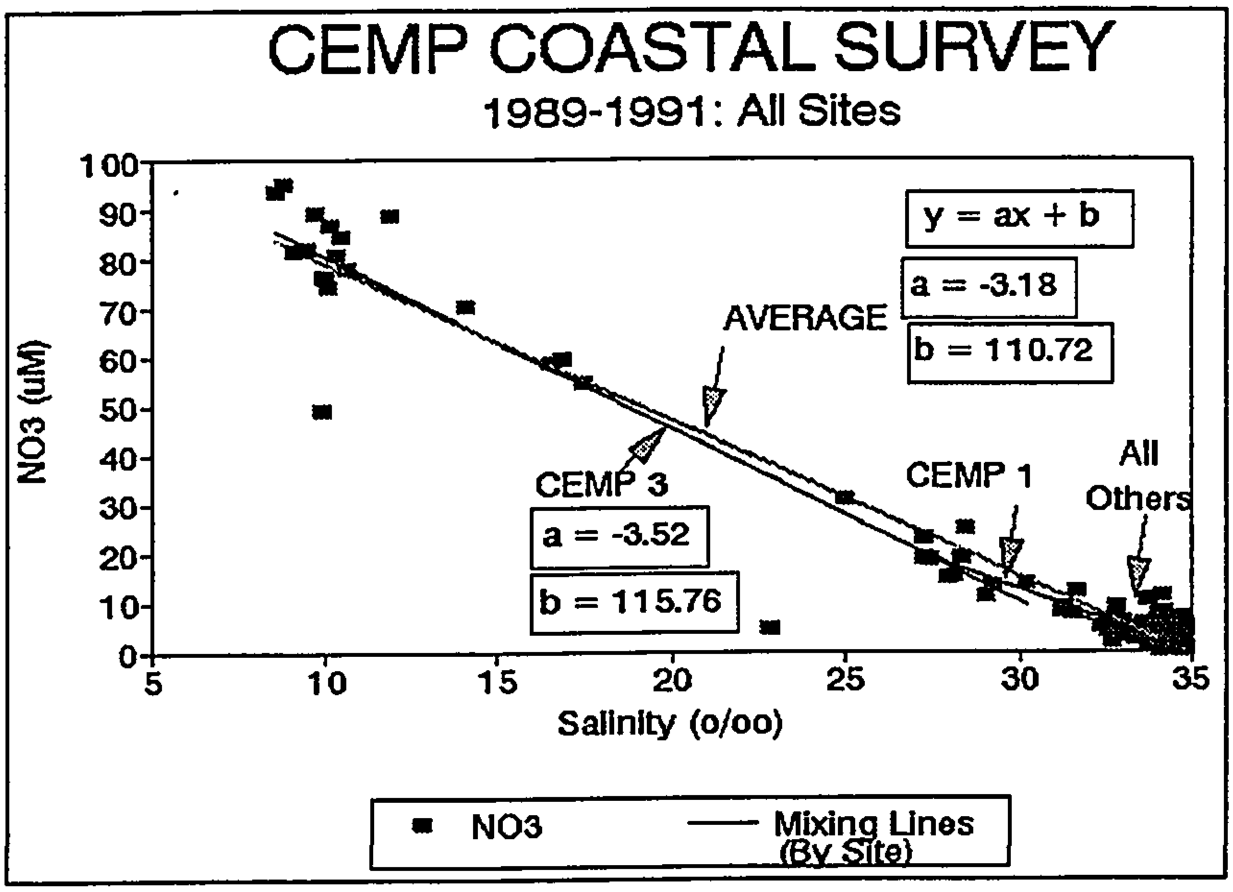


Figure 45. Coastal Seawater Nitrate Enrichment vs. Sample Date

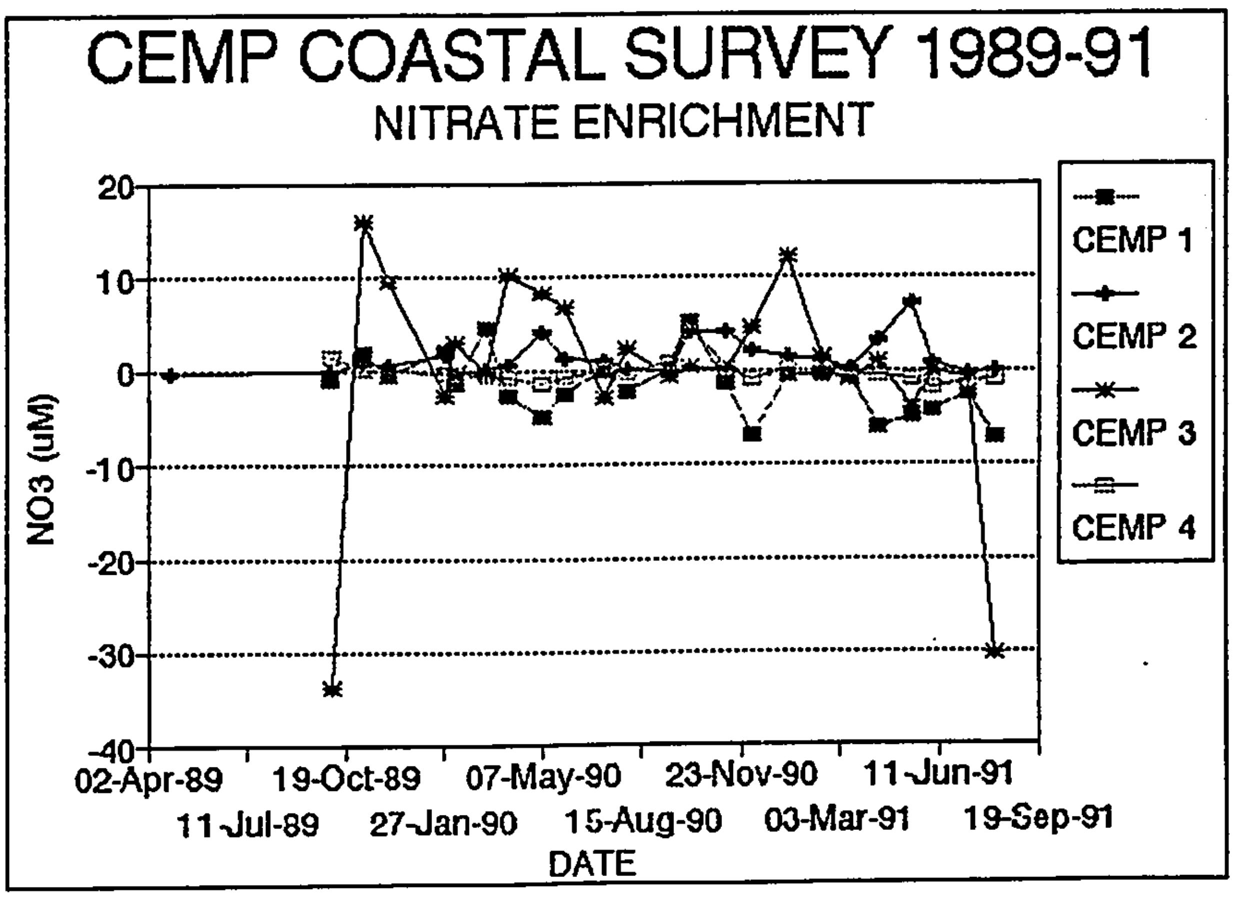


Figure 46. Coastal Seawater Phosphate Mixing Line

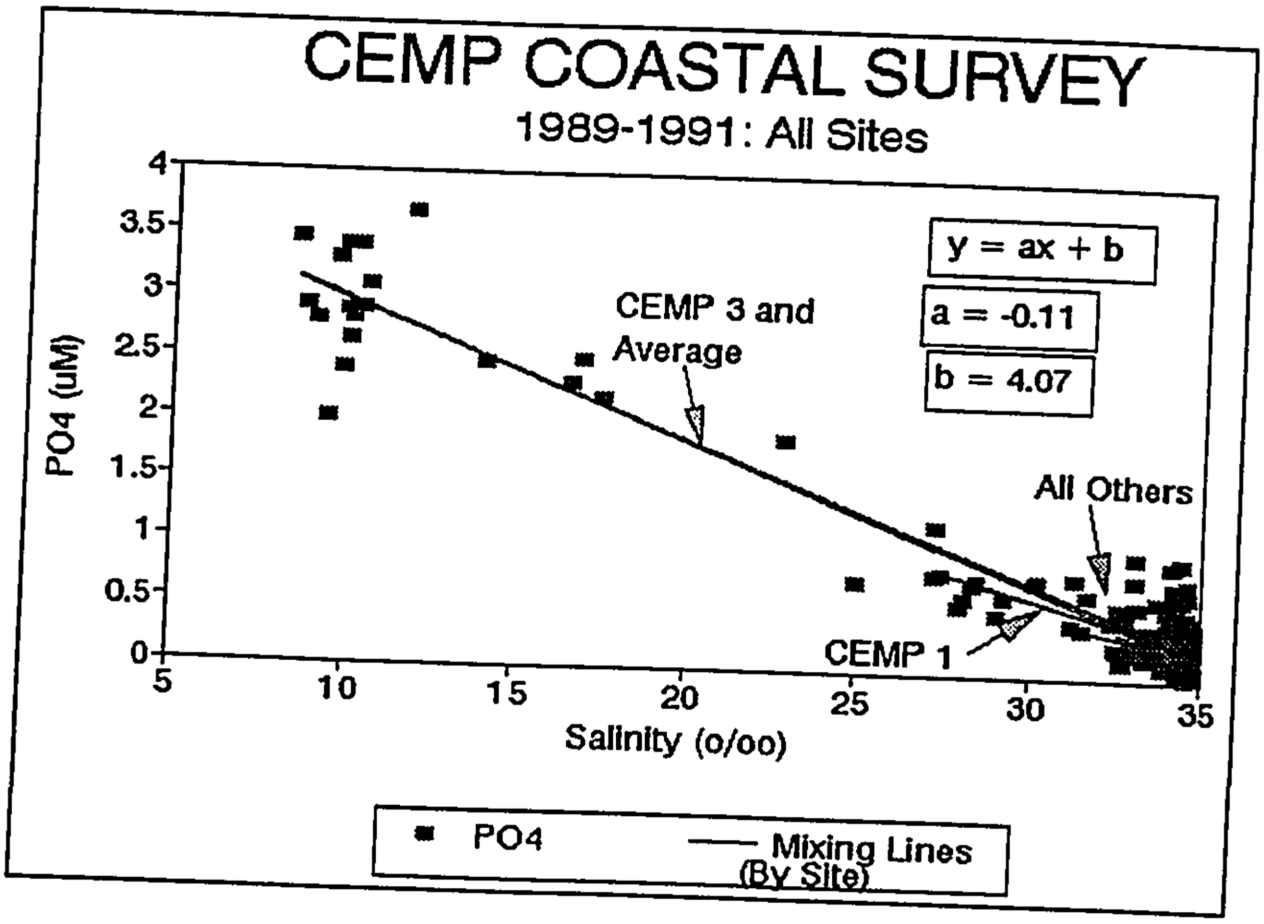


Figure 47. Coastal Seawater Phosphate Enrichment vs. Sample Date

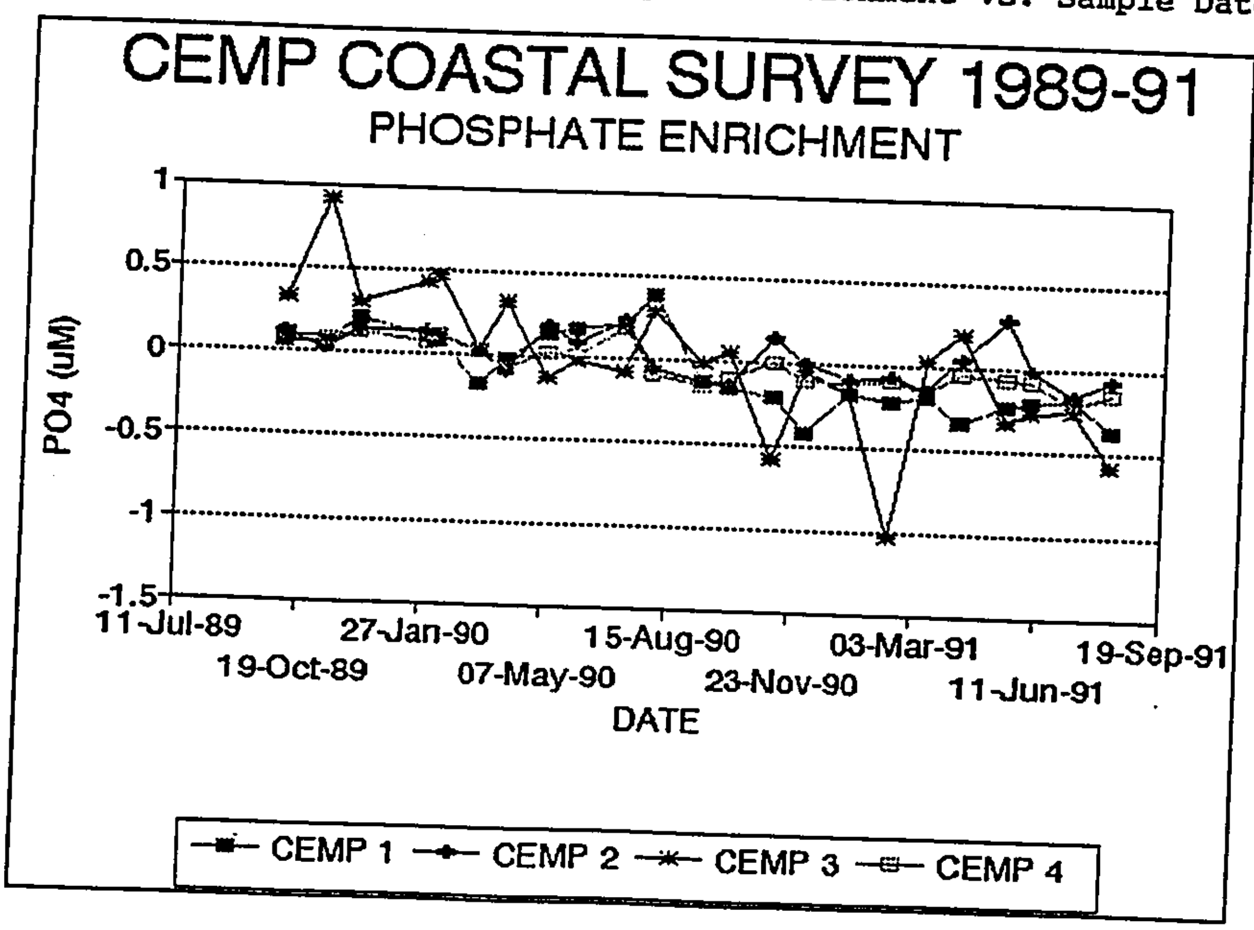


Figure 48. Coastal Seawater Silicate Mixing Line

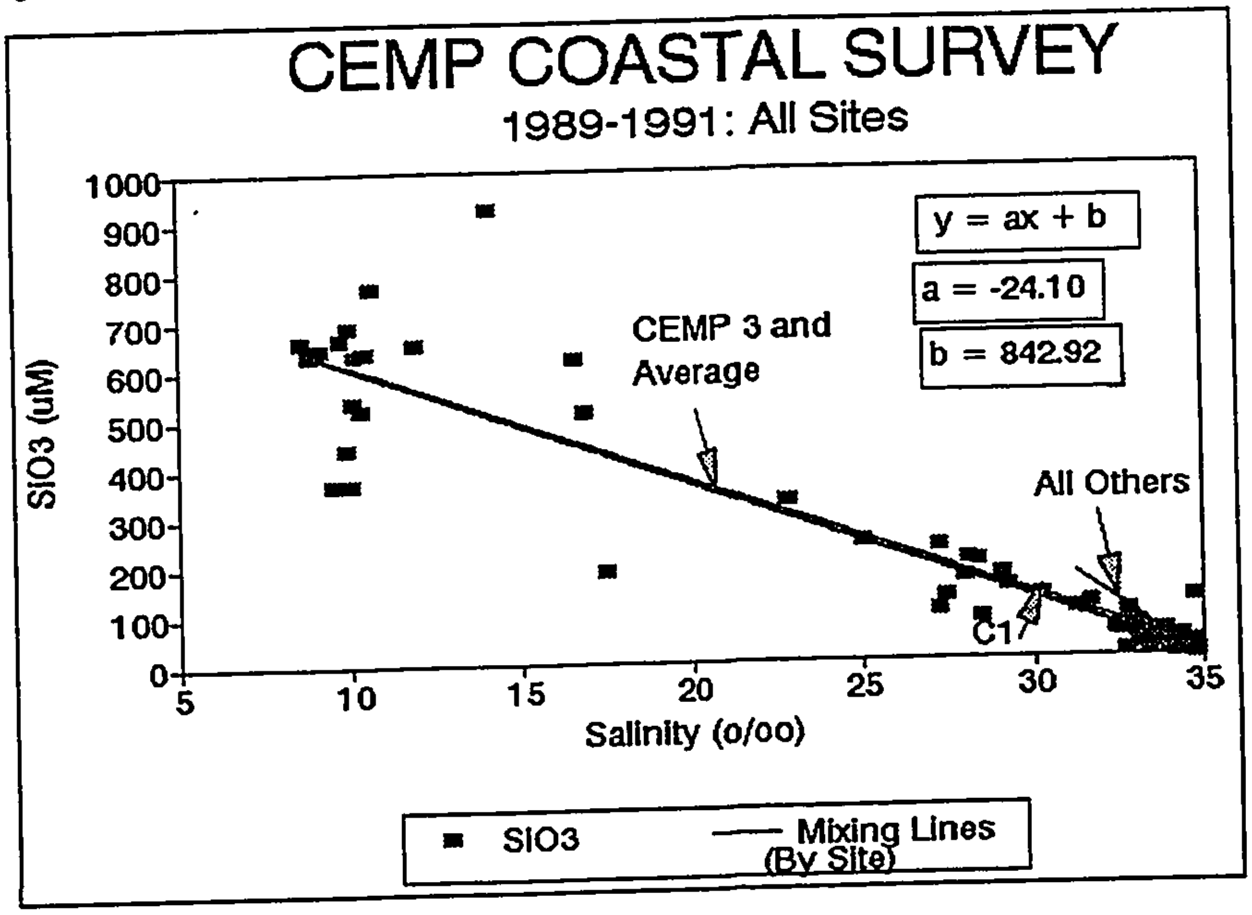


Figure 49. Coastal Seawater Silicate Enrichment vs. Sample Date

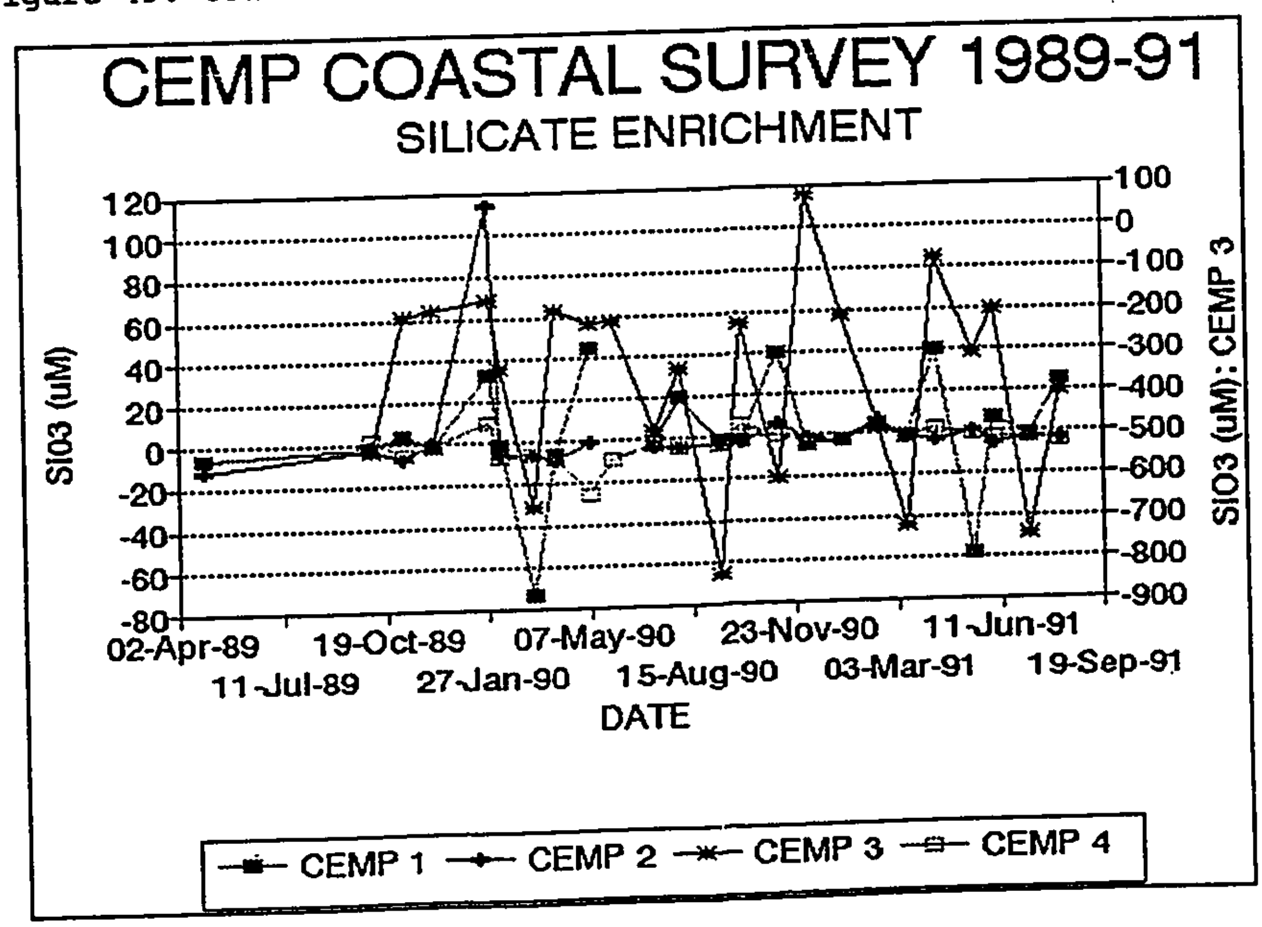


Figure 50. Coastal Seawater Ammonium Mixing Regression (not used)

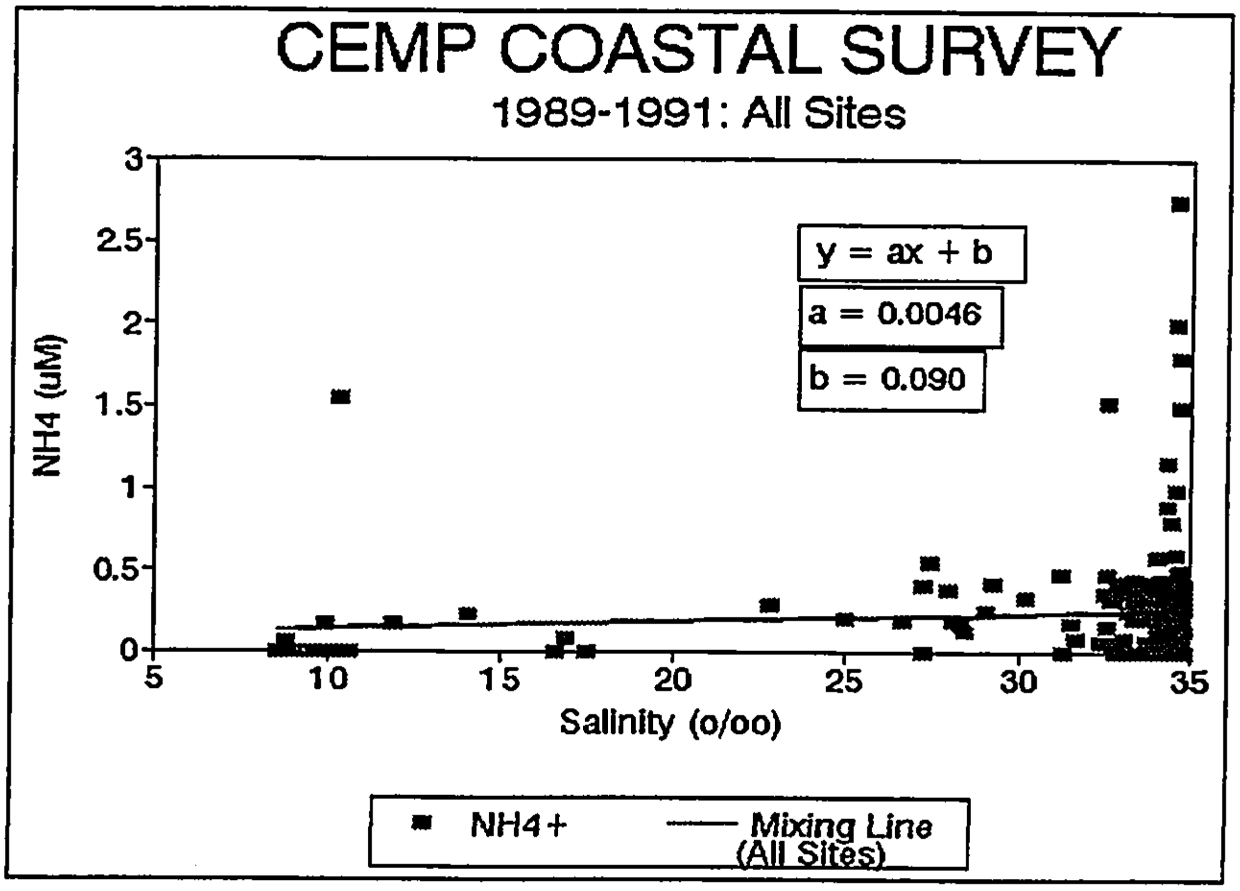


Figure 51. Coastal Seawater Ammonium vs. Sample Date

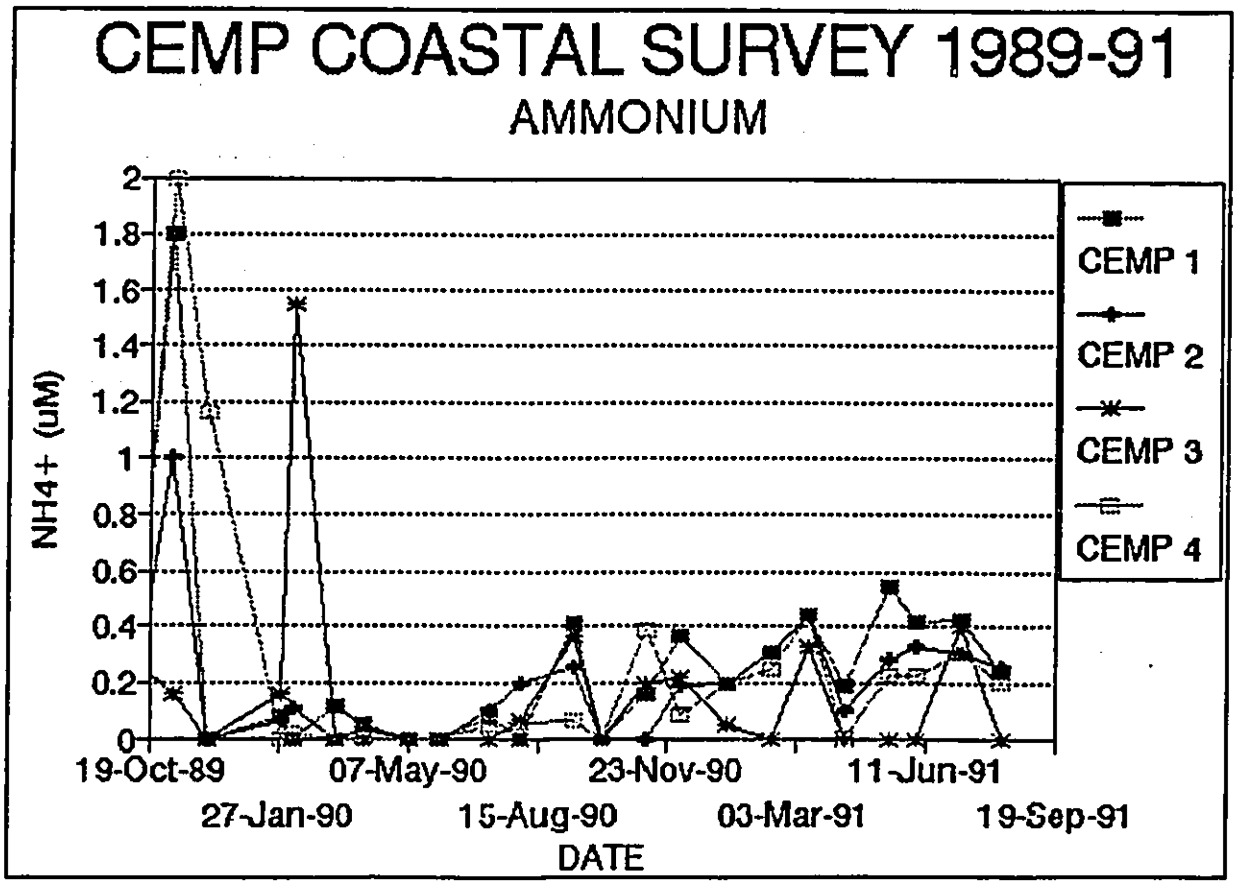


Figure 52. Coastal Seawater Total Dissolved Nitrogen Mixing Line

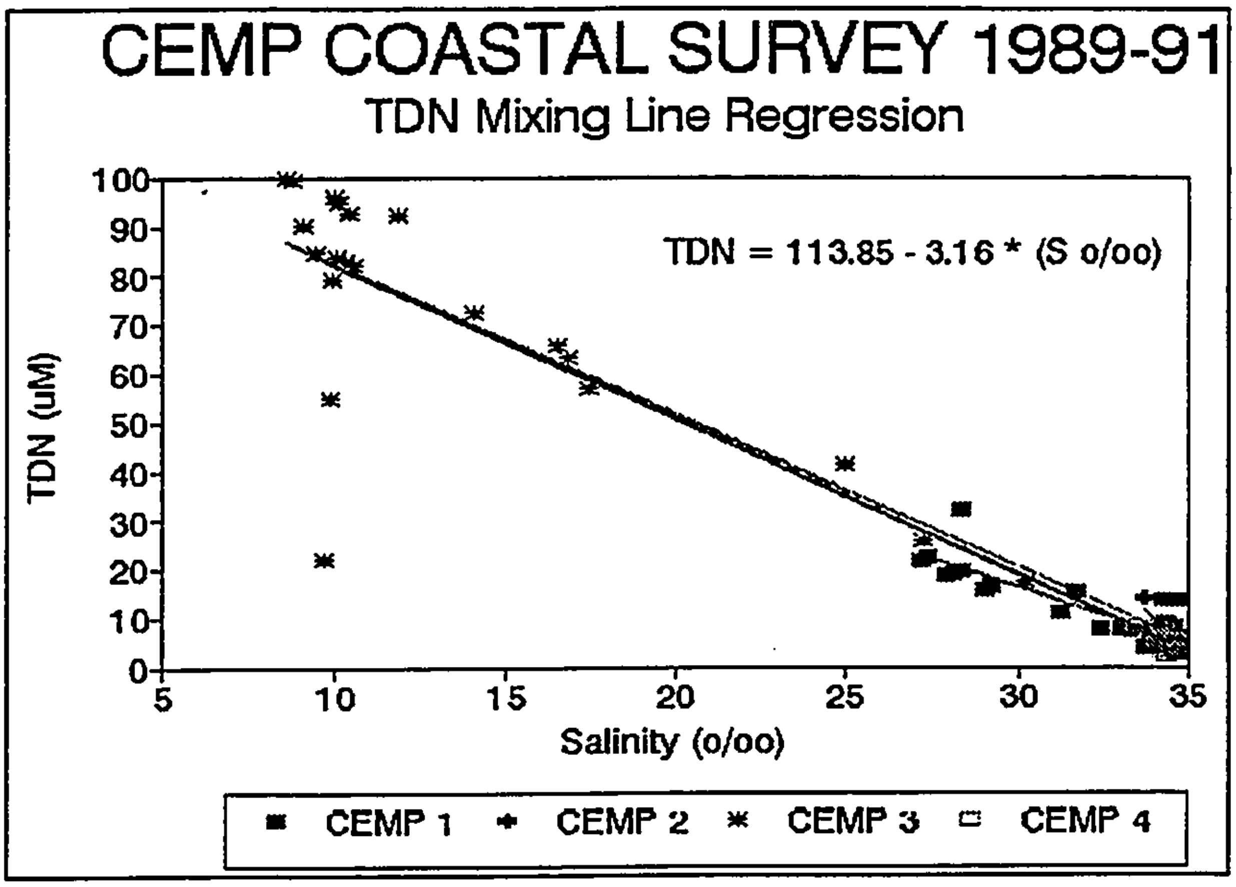


Figure 53. Coastal Seawater Total Dissolved Nitrogen Enrichment vs. Sample Date.

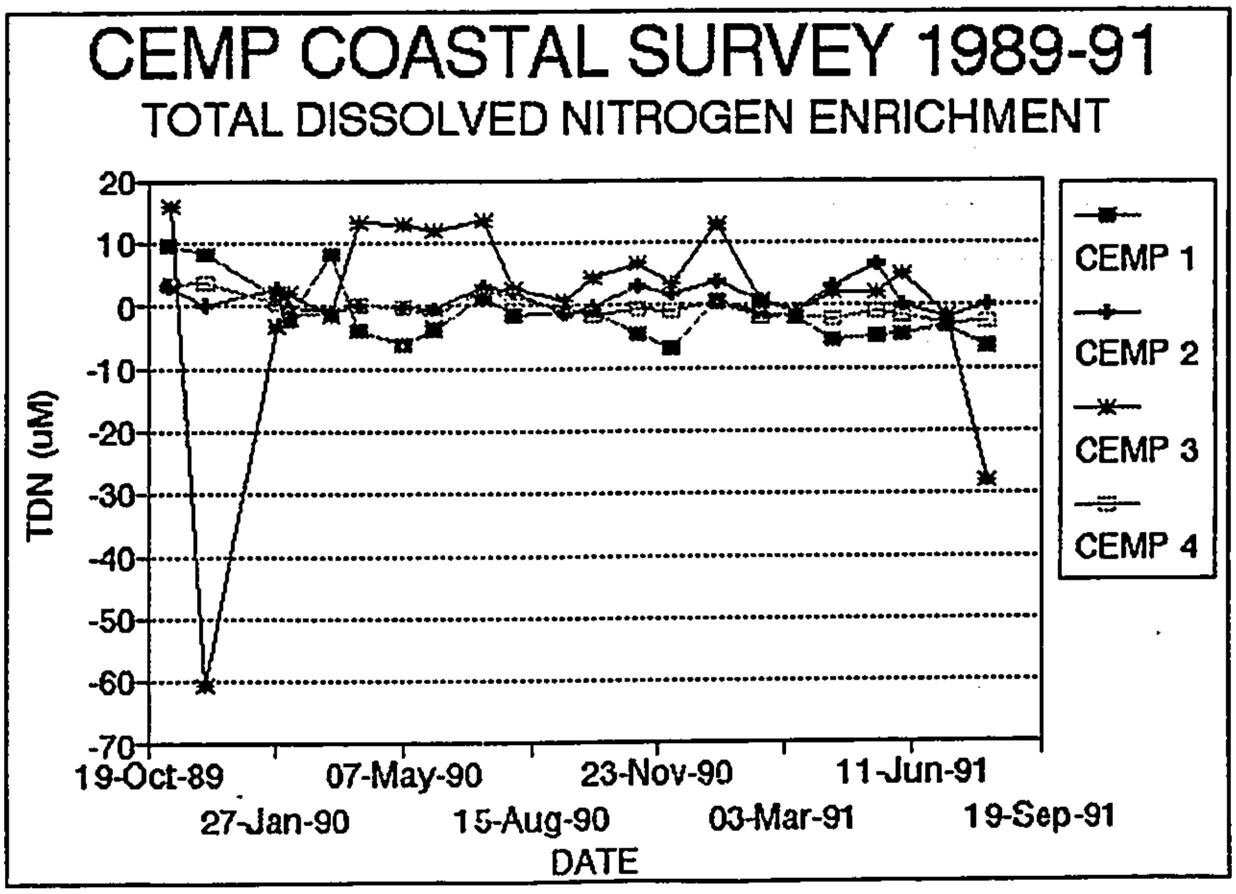


Figure 54. Coastal Seawater Total Dissolved Phosphate Mixing Line

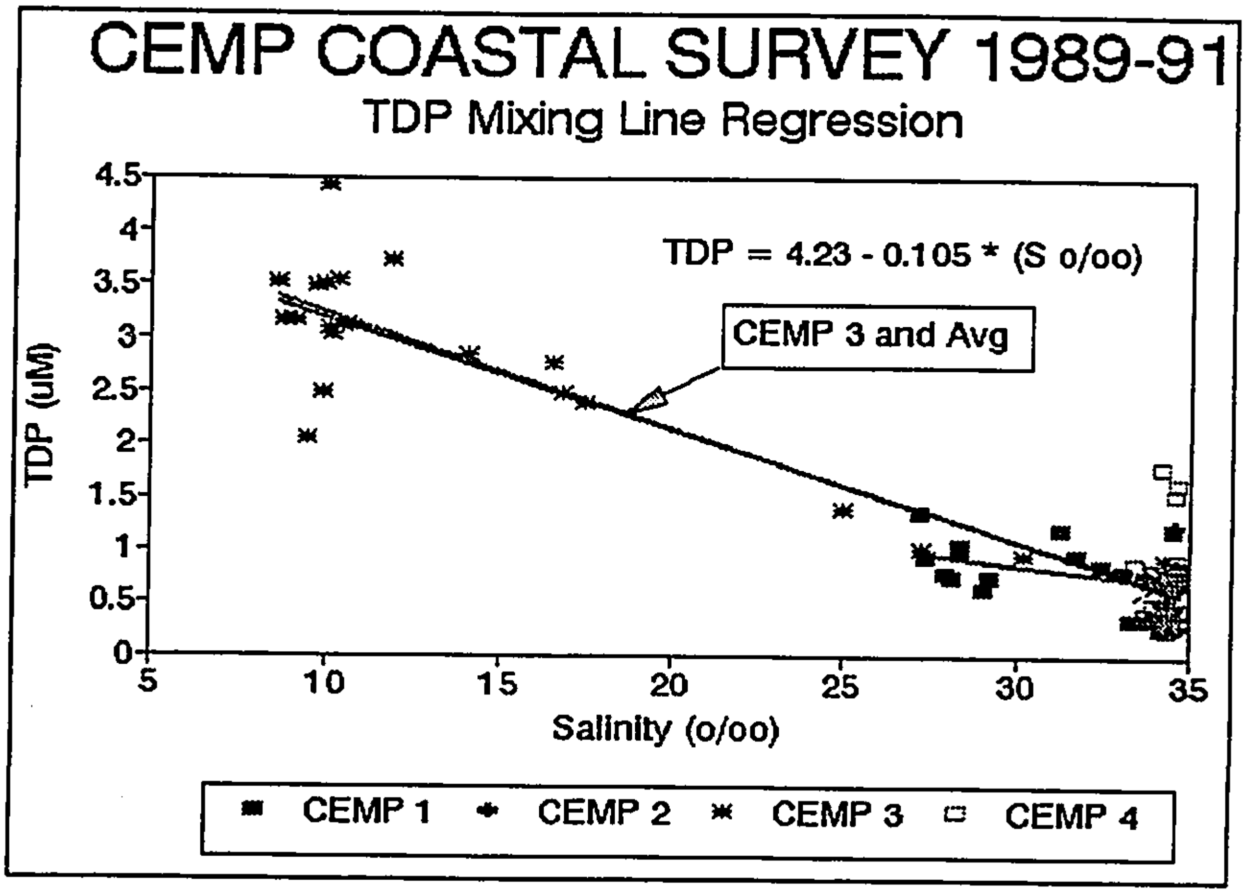


Figure 55. Coastal Seawater Total Dissolved Phosphate Enrichment vs. Sample Date

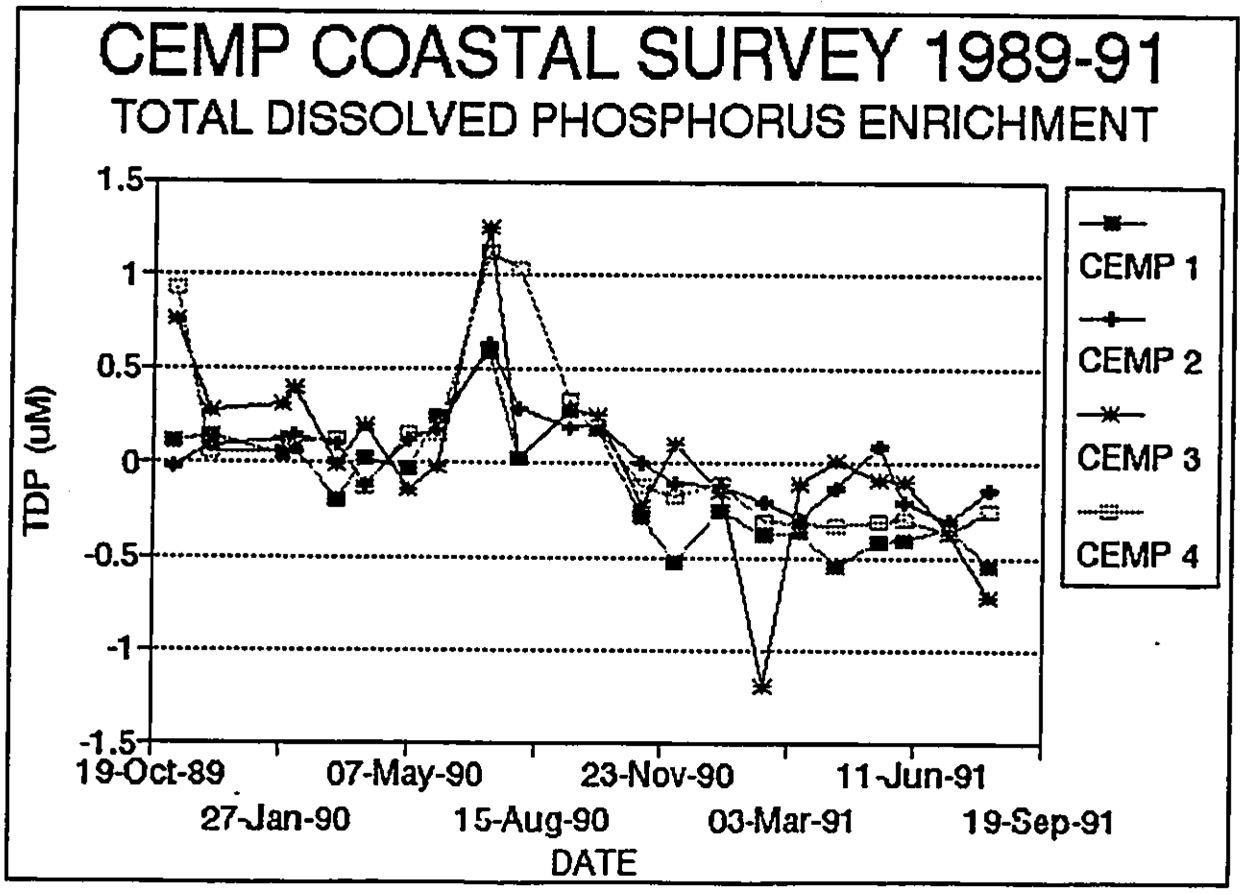


Figure 56. Coastal Seawater Total Organic Carbon Mixing Line (not used)

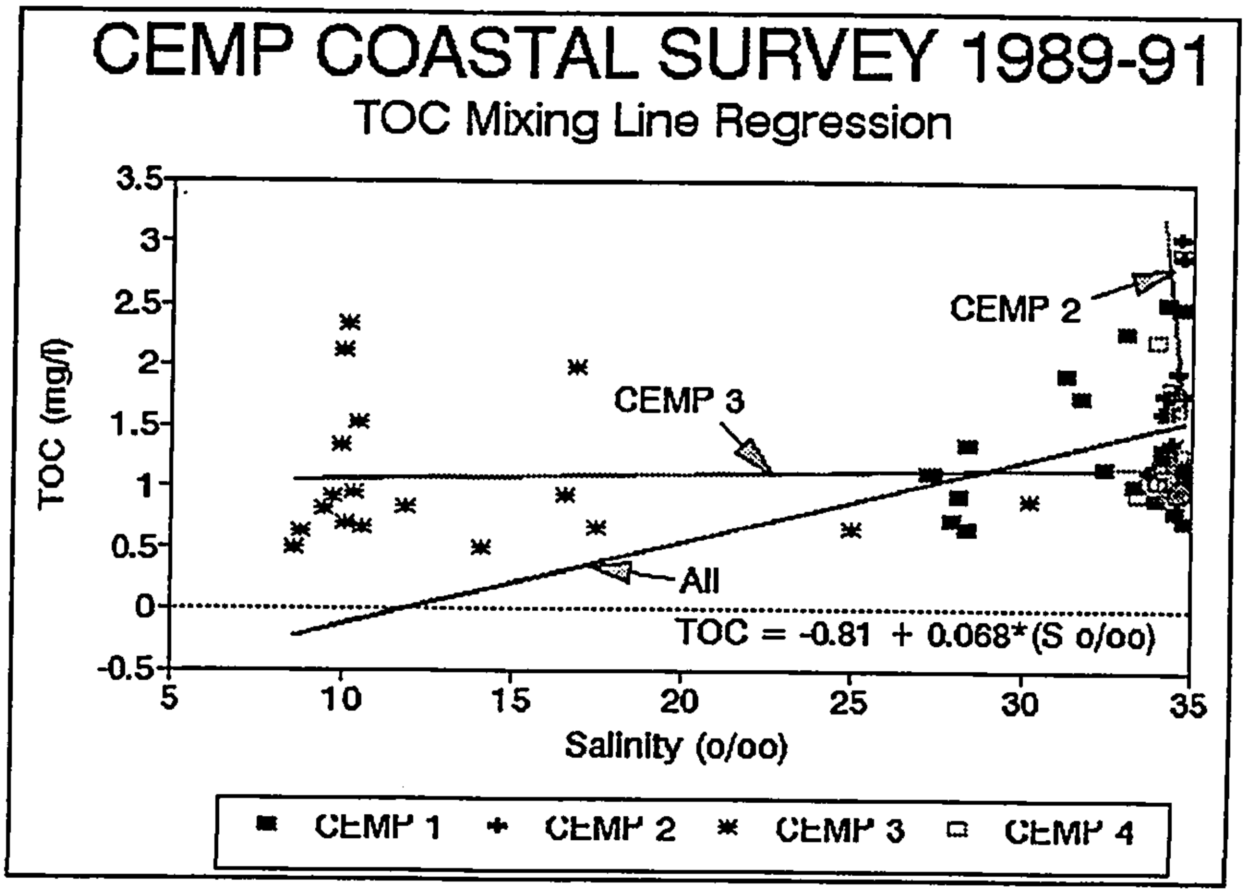


Figure 57. Coastal Seawater Total Organic Carbon vs. Sample Date

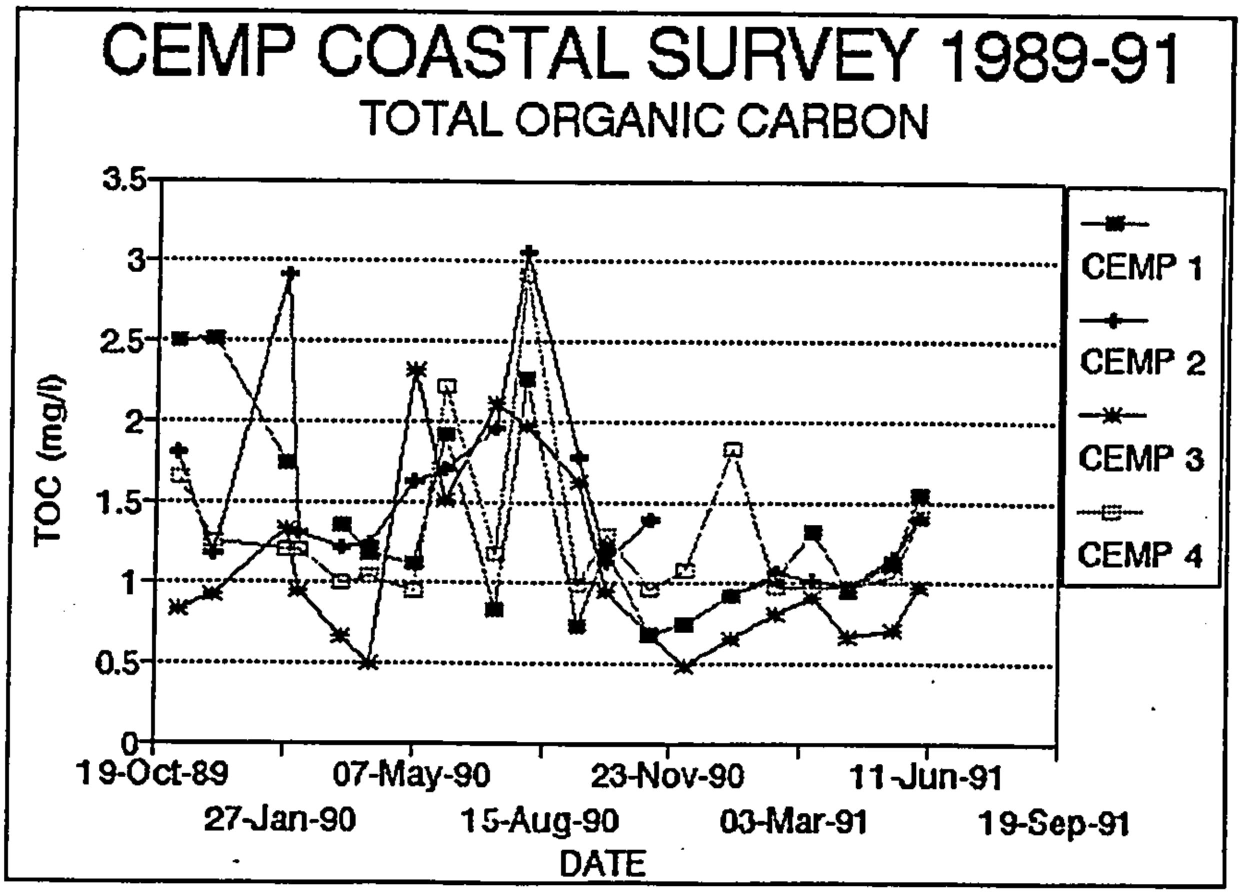
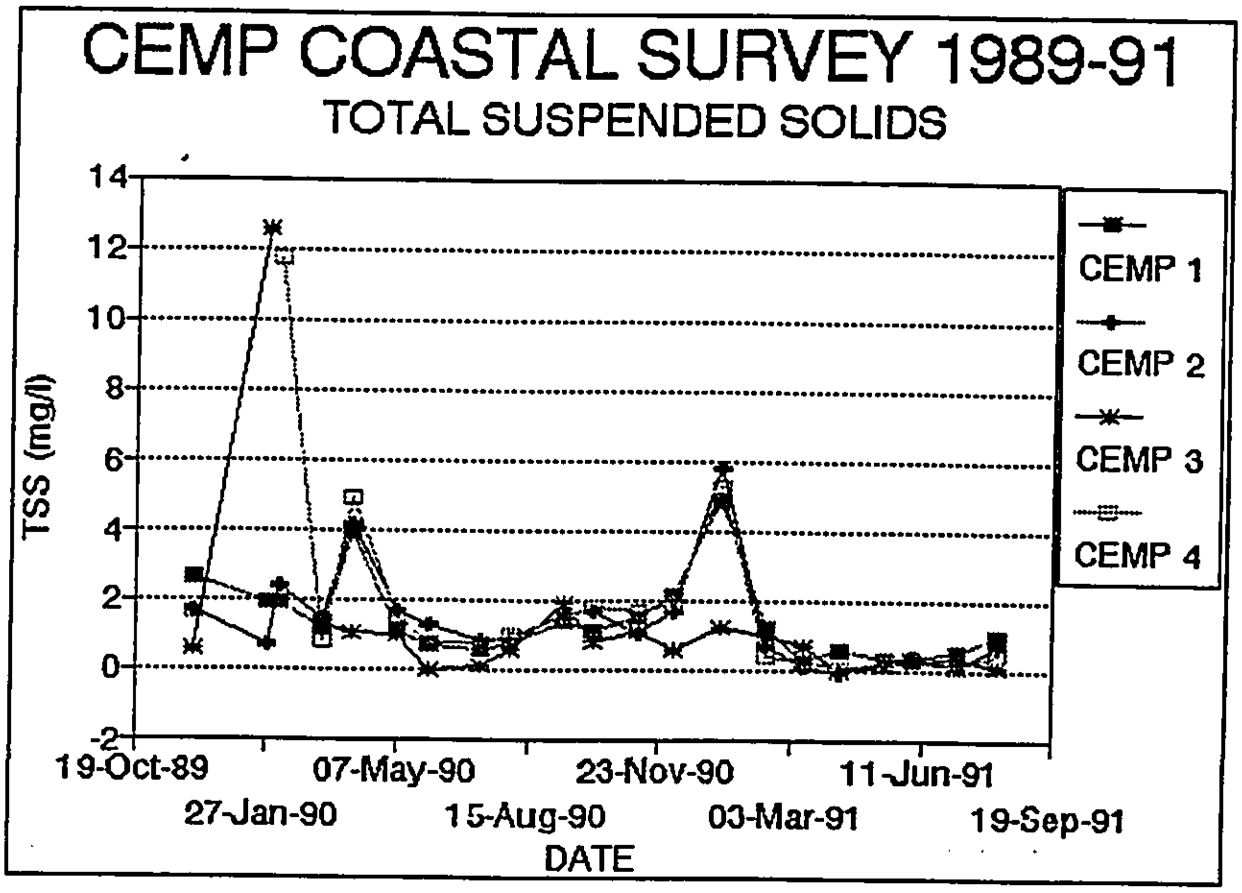


Figure 58. Coastal Seawater Total Suspended Solids vs. Sample Date



ANCHIALINE POND WATER QUALITY DATA

Discussion

Two of the many anchialine ponds on the NELH Site (see Maciolek and Brock, 1974) are being initially sampled for water quality. The sites are indicated as A1 and A2 on Figure 15, the Sampling Site Location Map. As noted in the introduction, regular data collection is just beginning at the end of this reporting period for the CEMP-mandated monitoring of the pond and benthic biota. Pond samples are taken in the ponds in a fashion similar to the coastal water samples.

Coliform analysis is an important parameter in the anchialine pond data, and it has indicated high levels at site A1. Actions have been taken to discourage swimming in the pond and to remove campers near the site, but high fecal coliform counts persist. NELHA continues to monitor this situation.

Table XIV. Anchialine Pond Water Quality Data

ANCHIALINE PONDS — Keahole Point Comprehensive Environmental Monitoring Program

SITE	DATE D-M-Y	JULIAN DATE	Time (2400 hrs)	Tide	PO4 UM	NO3 UM	NH4 UM	SI UM	TDP UM	TDN UM	TSS mg/L	TOC MG/L	SALINITY 0/00	TEMP(F) DEG-C	pH	MV	TEMP(M) DEG-C	DO MG/L	Coliform FC/100ml	Enterococ Ent./100m
A1	09-Jul-90	1990.52	1435	1.0 Flood	3.43	53.4	0.00	607	3.50	53.8	1.56	1.27	12.987	24.8	7.954	-117.5	23.2	7.32	23	NA
A1	09-Aug-90	1990.60	1000	0.8 Ebb	2.23	42.2	1.52	622	2.76	47.6	3.24	1.38	13.231	23.5	7.720	-105.9	25.9	6.58	>200	NA
A1	11-Sep-90	1990.69	1410	1.4 Ebb	2.37	42.9	0.87		4.00	44.1	0.14	1.21	12.504	24.9	8.173	-134.2	28.4	10.42	147	NA
A1	02-Oct-90	1990.75	1515	1.6 High	2.44	56.2	1.77	613	3.48	60.5	0.52	1.23	11.893	26.0	8.373	-145.2	26.9	12.29	58	NA
A1	07-Nov-90	1990.85	1340	0.6 Ebb	2.22	38.7	1.96	716	2.67	44.0	1.16	1.03	13.484	24.9	8.145	-131.8	25.8	11.36	None	NA
A1	05-Dec-90	1990.93	1052	0.8 Ebb	2.28	52.7	2.55	625	2.97	59.6	1.31	0.53	13.405	22.8	7.938	-119.6	23.3	8.30	>800	NA
A1	15-Jan-91	1991.04	800	1.2 Ebb	2.59	60.6	1.46	579	2.73	65.3	1.26	0.88	12.635	22.0	7.794	-112.8	21.7	6.05	2800	NA
A1	07-Feb-91	1991.10	843	0.6 Low	2.52	58.8	3.87	812	2.70	67.4	0.77	0.99	9.372	21.9	7.765	-108.0	21.4	5.59	>2000	NA
A1	12-Mar-91	1991.19	818	0.3 Low	2.82	25.5	18.95	952	3.20	49.6	0.56	8.42	10.488	21.0	7.485	-87.7	22.3	3.98	118	NA
A1	09-Apr-91	1991.27	803	0.1 Low	2.85	7.9	0.92	647	3.16	31.2	0.80	9.84	10.355	20.9	7.575	-85.7	23.2	3.75	51	NA
A1	14-May-91	1991.37	1225	0.2 Flood	2.93	53.3	5.10	575	2.94	63.4	3.54	1.01	11.545	24.4	8.005	-92.7	24.5	9.06	1848	NA
A1	03-Jun-91	1991.42	1108	0.6 High	1.70	37.9	2.78	722	1.72	45.1	1.16	1.60	11.888	24.7	8.267	-100.5	22.7	11.61	None	12
A2	09-Jul-90	1990.52	1010	0.0 Low	3.43	94.9	0.00	689	3.87	95.3		0.83	7.019	21.6	8.077	-124.4	23.5	8.36	6	NA
A2	09-Aug-90	1990.60	910	1.0 Ebb	3.22	99.6	0.14	693	2.76	100.6	0.17	1.11	7.072	21.4	8.062	-125.2	23.0	7.85	16	NA
A2	11-Sep-90	1990.69	1330	1.6 Ebb	3.44		0.20		4.28	93.3	0.16	0.95	6.992	22.0	8.033	-125.6	27.1	7.93	None	NA
A2	02-Oct-90	1990.75	1335	1.4 High	3.17		0.21	696	4.32	96.0	0.45	0.78	6.772	22.4	8.060	-127.0	27.9	8.62	None	NA
A2	07-Nov-90	1990.85	1018	1.8 Ebb	3.77	99.3	0.39	824	3.96	101.5	0.40	3.48	7.164	21.6	8.026	-124.8	24.7	7.77	None	NA
A2	05-Dec-90	1990.93	1013	1.4 Ebb	2.87	100.7	0.06	681	3.51	101.4	0.51	1.12	7.260	21.1	8.037	-125.4	23.3	7.85	None	NA
A2	15-Jan-91	1991.04	730	1.4 Ebb	3.43	96.0	0.12	666	3.46	101.0	0.20	0.79	6.689	20.6	8.021	-125.9	21.8	8.06	None	NA
A2	07-Feb-91	1991.10	910	0.6 Low	3.30	85.8	0.00	786	3.40	88.2	0.63	0.85	6.028	20.7	8.045	-124.1	21.1	8.14	3	NA
A2	12-Mar-91	1991.19	851	0.2 Low	3.12	96.0	0.05	725	3.17	97.0	-0.14	0.59	6.615	20.5	8.040	-119.8	22.6	8.23	None	NA
A2	09-Apr-91	1991.27	908	0.2 Flood	3.16	91.4	12.20	746	3.19	92.8	-0.02	1.66	6.853	20.7	8.013	-111.2	23.8	8.15	None	NA
A2	14-May-91	1991.37	1143	-0.1 Flood	3.19	89.6	0.18	838	3.45	90.9	1.51	0.69	6.996	21.5	8.074	-96.8	24.6	8.63	None	NA
A2	03-Jun-91	1991.42	1023	0.6 High	2.99	94.3	0.00	886	3.02	99.9	1.02	0.88	6.767	21.3	8.059	-88.5	23.2	8.17	2	None

Figure 59. Anchialine Pond Temperature and Salinity

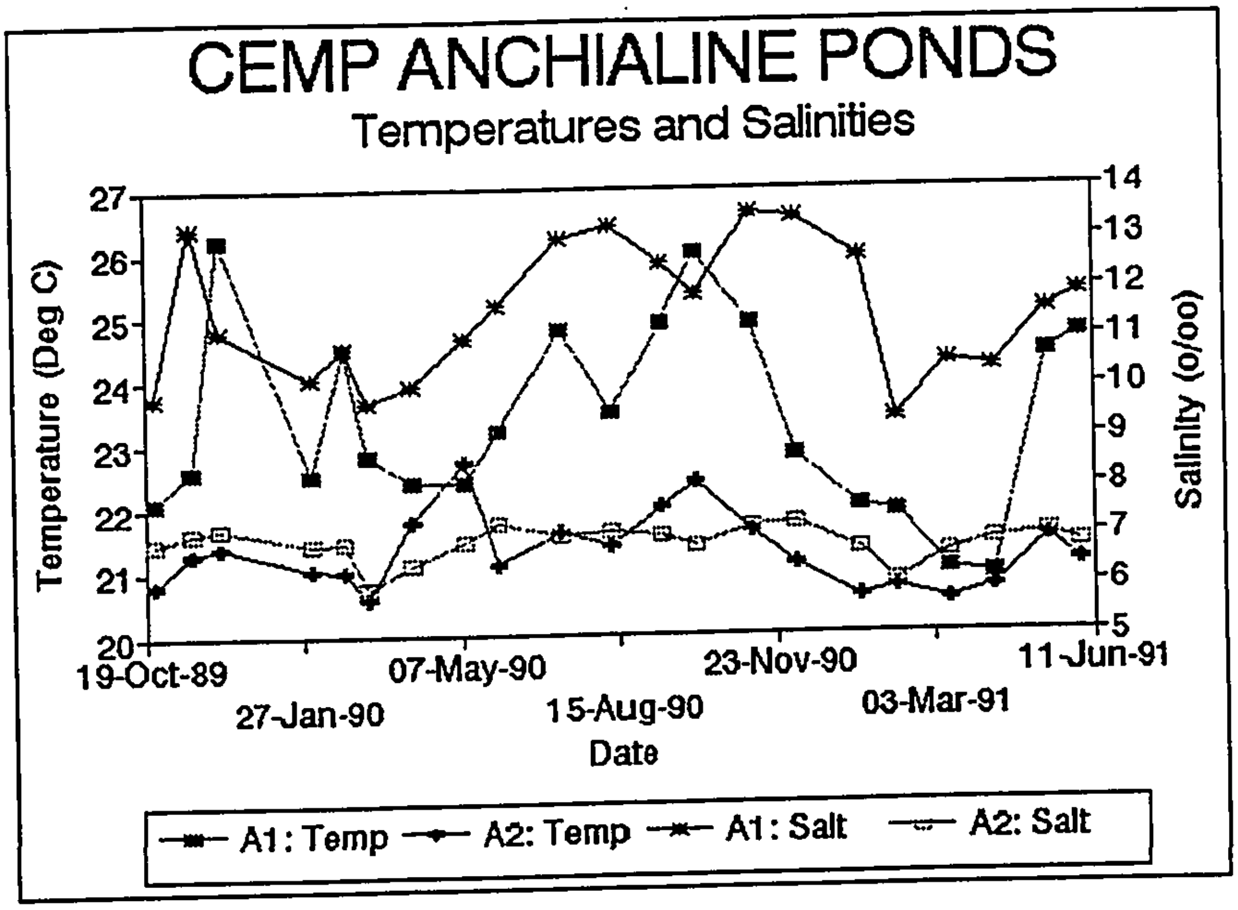


Figure 60. Anchialine Pond Dissolved Oxygen and pH

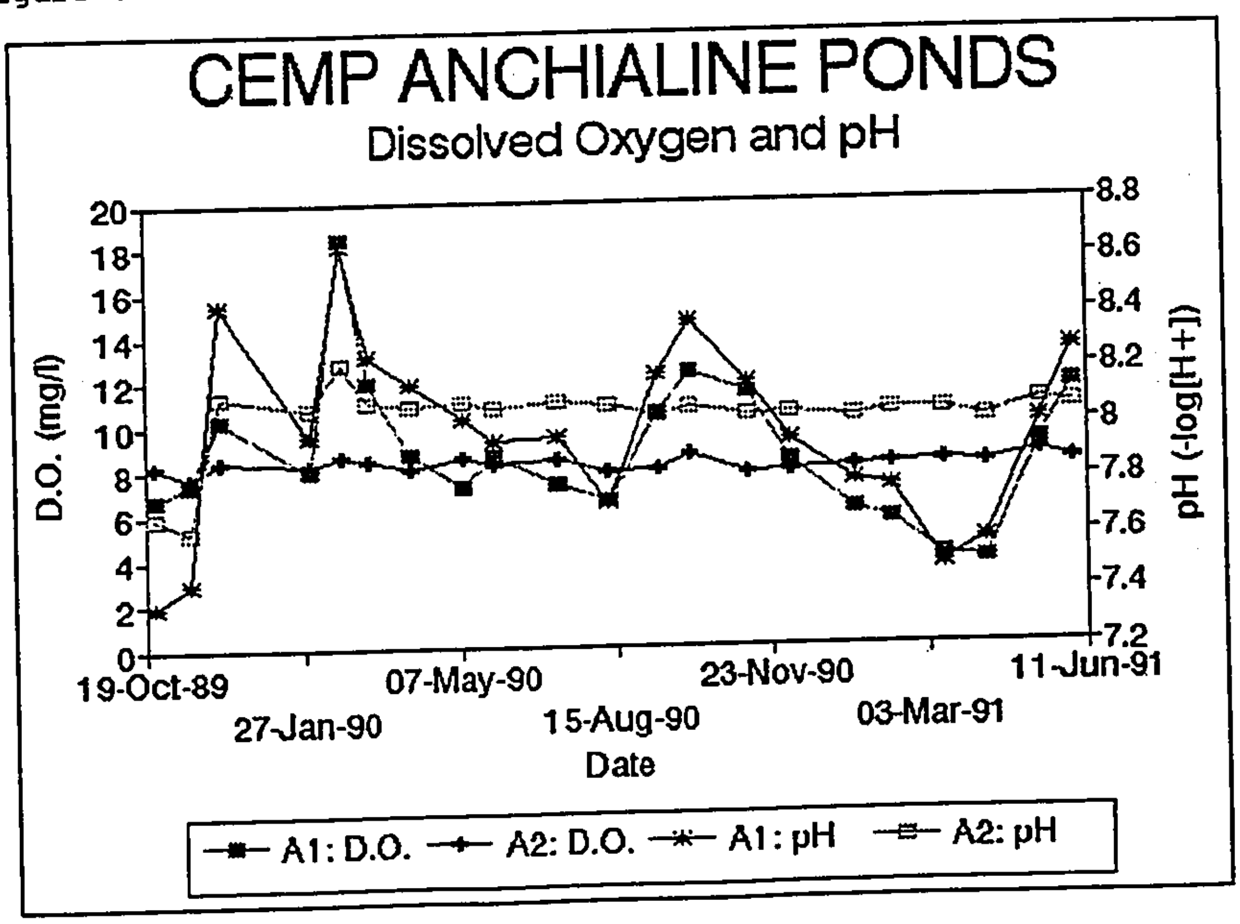


Figure 61. Anchialine Pond Nitrate and Total Dissolved Nitrogen

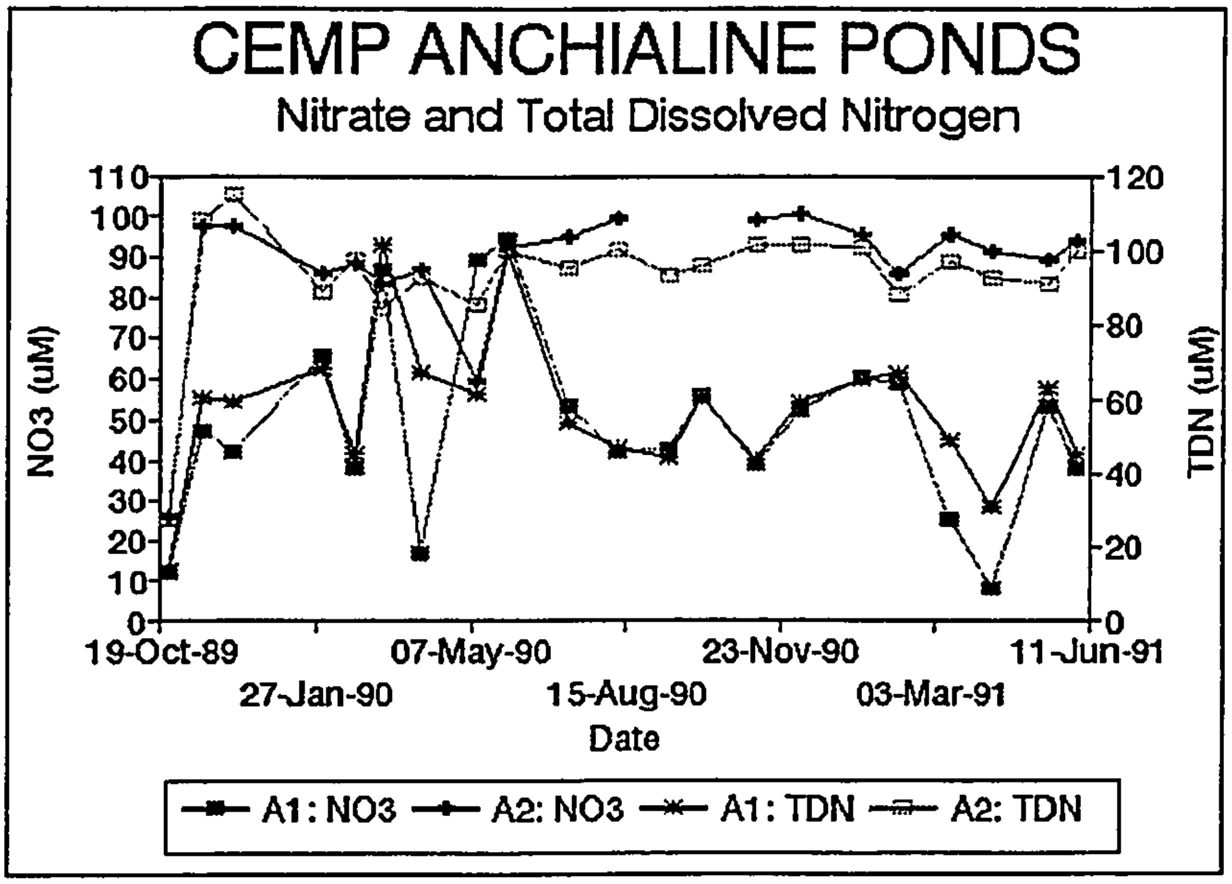


Figure 62. Anchialine Pond Phosphate and Total Dissolved Phosphorus

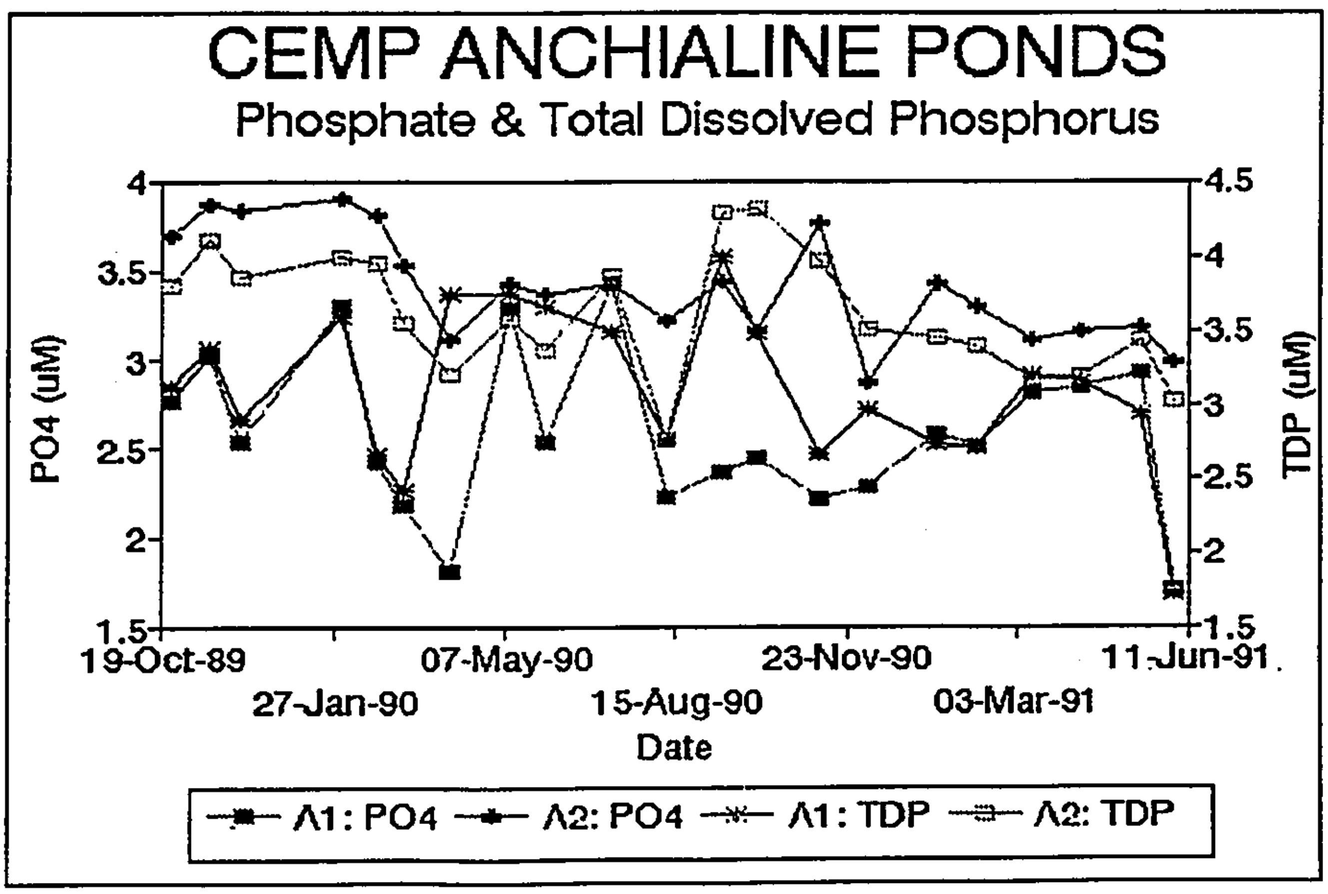


Figure 63. Anchialine Pond Ammonium and Silicate

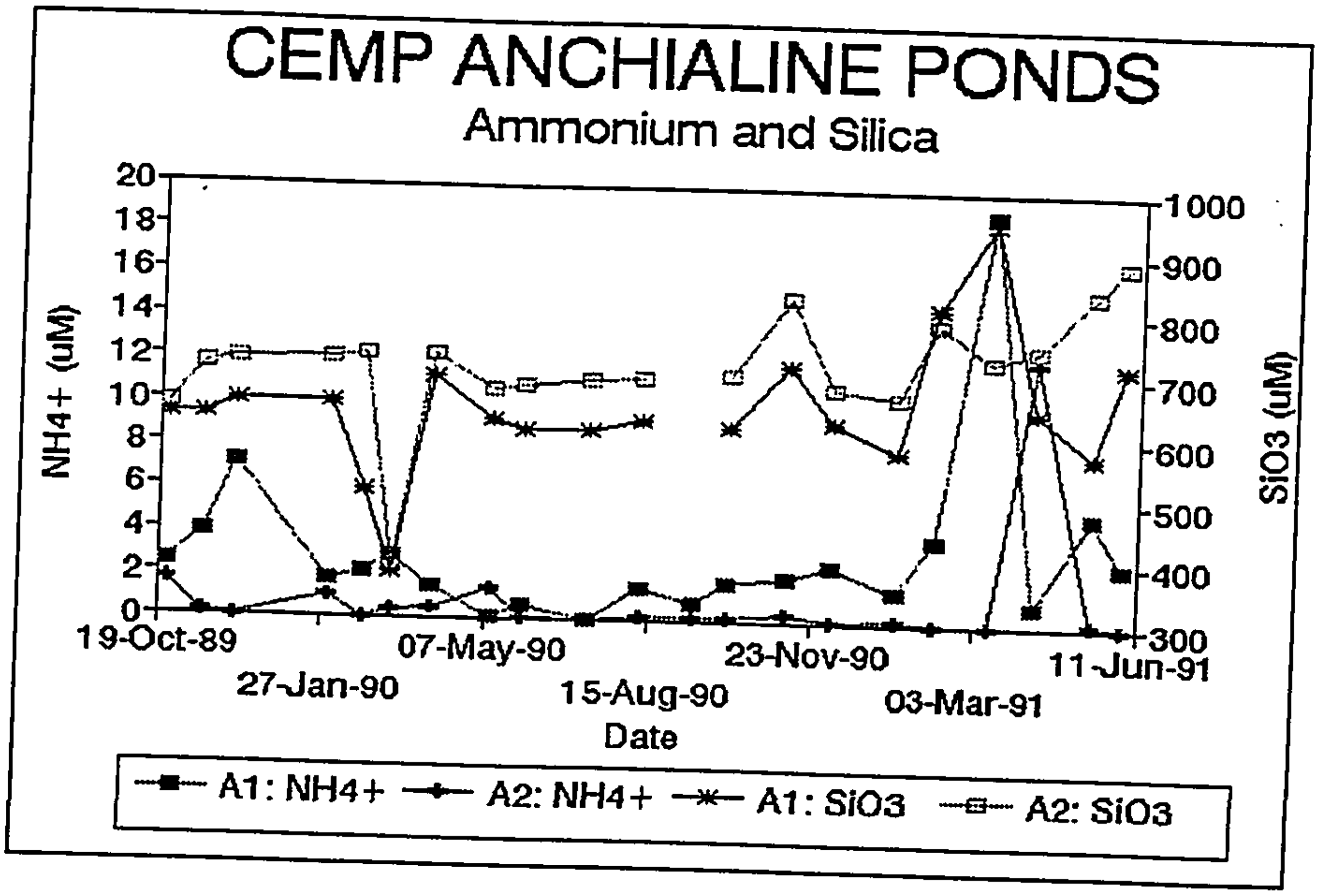


Figure 64. Anchialine Pond Total Suspended Solids and Total Organic Carbon

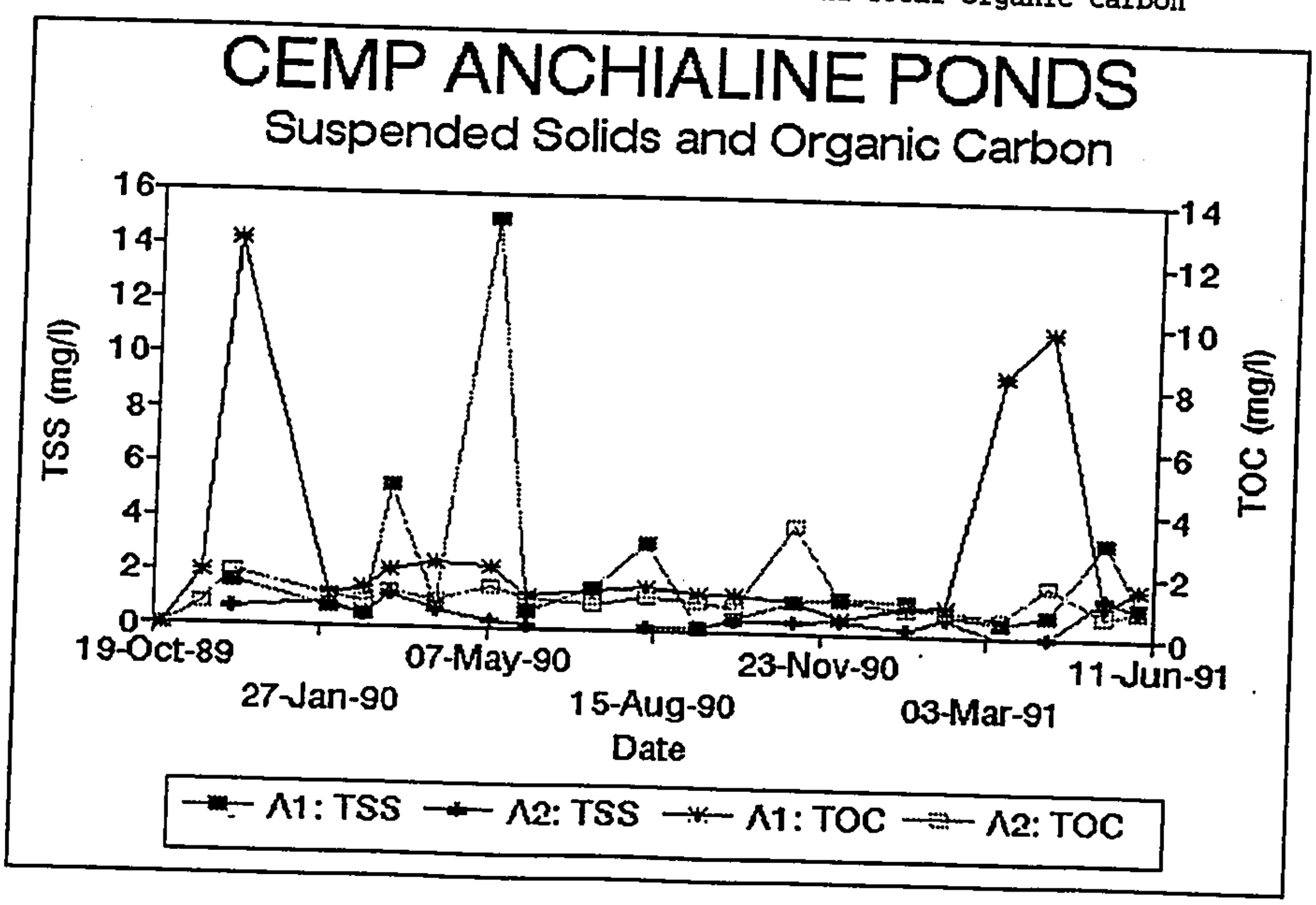
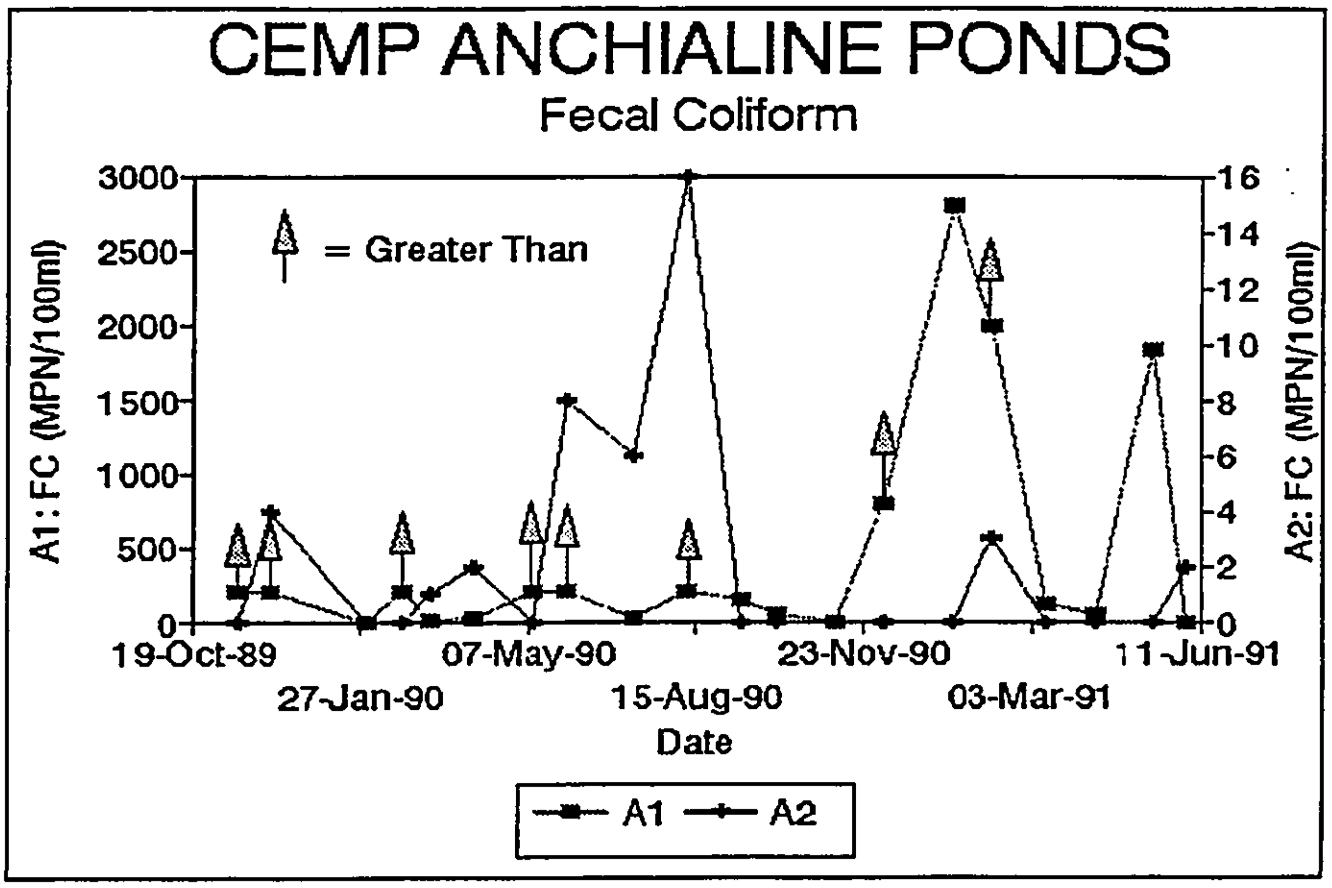


Figure 65. Anchialine Pond Fecal Coliform



GROUNDWATER WELL WATER QUALITY DATA

Discussion

Figure 15, the Sampling Site Location Map, indicates the locations of the sixteen groundwater sampling wells installed at six sites at NELHA. Table XV summarizes the physical information on the groundwater wells. Sites and specifications were established under contract with Geolabs Hawaii, and their report (C.W. Associates, Inc., 1988) also specified sample collection methods required to assure useful data. The casing on Well 4B was destroyed after installation, so it is unavailable for sampling.

The wells are sampled monthly, using a mobile, gasoline-powered teflon-lined bladder pump. Standard purging and rinsing techniques are employed to minimize contamination of the samples.

All well samples have been within normal ranges except those from Well 4/39.5 which is located immediately adjacent to algal raceways of Cyanotech Corporation. Follow-up to the data reporting has indicated that Cyanotech sometimes discharges nutrient-rich water near the well. Samples at this site have been closer to normal when such discharges are discontinued. The anomalously low silicate values in well 4/39.5 are probably caused by some other contamination interfering with the silicate analysis.

The anomalously low values of nearly all groundwater parameters measured on 21 May 1991 probably originate in the sampling and analysis, but we have been unable to ascertain the source of the problem.

Table XV. Groundwater Well Physical Data

Well No.	Coordinate Location (Akahipuu Origin)	Elevation of Top of Cap (Feet above MSL)	Bottom Depth (Feet below MSL)
W-1	-13,138.71S -22,356.54W	104.94 ft	135 ft
W-2	-14,277.97S -27,038.58W	7.84 ft	53.5 ft
W-2A	-14,279.37S -27,036.61W	8.54 ft	24.5 ft
W-2B	-14,281.27S -27,034.08W	8.68 ft	14.5 ft
W-3	- 8,427.13S -28,971.94W	20.52 ft	65 ft
W-3A	- 8,425.26S -28,969.87W	21.33 ft	35 ft
W-3B	- 8,426.24S -28,967.26W	21.38 ft	25 ft
W-4	- 9,028.75S -29,161.97W	24.49 ft	69 ft
W-4A	- 9,030.85S -29,165.56W	25.20 ft	39.5 ft
W-4B	- 9,033.79S -29,167.32W	25.31 ft	NA
W-5	- 8,391.76S -31,110.90W	12.21 ft	18 ft
W-5A	- 8,388.54S -31,109.11W	12.53 ft	28 ft
W-5B	- 8,394.83S -31,113.02W	12.77 ft	55 ft
W-6	- 9,161.37S -30,819.95W	9.91 ft	49.6 ft
W-6A	- 9,160.33S -30,821.69W	9.68 ft	18 ft
W-6B	- 9,158.50S -30,823.80W	9.87 ft	29 ft

Table XVI. Groundwater Well Data: Well Sets 1 and 2

GROUND WATER

Keahole Point Comprehensive Environmental Monitoring Program

SITE/Depth (feet)	DATE (D-M-Y)	JULIAN DATE	TIME (2400 hr)	PO4 (um)	NO3 (um)	NH4 (um)	SI (um)	TDP (um)	TDN (um)	TOC (mgC/l)	SALINITY (‰)	DEG-C TEMP	pH	DO	Coliform FC/100ml	Enteroc... Ent/100ml
W1/135	12-Jul-90	1990.53	1412	3.98	83.00	0.02	700	4.10	88.10	0.67	6.680	20.3	7.953	7.52	None	NA
	07-Aug-90	1990.61	1351	3.20	83.90	0.11	690	3.58	84.22	0.57	7.026	20.4	7.965	7.58	None	NA
	06-Sep-90	1990.69	1157	3.04	84.65	0.00		3.67	86.01	0.35	6.835	20.4	7.933	7.58	None	NA
	03-Oct-90	1990.76	1205	3.54	81.62	0.00	690	3.62	81.72	1.21	6.950	20.4	7.965	7.53	None	NA
	31-Oct-90	1990.84	1400	3.36	81.90	0.19	673	3.48	83.87	1.01	7.276	20.4	7.941	7.53	None	NA
	07-Dec-90	1990.94	1123	3.37	83.20	0.08	682	3.59	87.80	0.65	7.289	20.3	7.944	7.39	None	NA
	10-Jan-91	1991.03	1020	3.79	90.60	0.28	697	3.93	90.80	1.12	6.640	21.5	7.955	7.42	None	NA
	06-Feb-91	1991.11	712	3.48	76.20	0.13	645	3.53	76.50	0.71	6.242	19.9	7.956	7.54	None	NA
	06-Mar-91	1991.18	1050	3.47	94.10	0.04	756	3.51	94.80	0.91	6.222	20.4	7.958	8.02	None	NA
	02-Apr-91	1991.26	903	3.38	88.70	0.35	683	3.40	89.70	2.13	6.552	20.1	7.940	7.61	None	NA
	21-May-91	1991.39	1102	3.50	49.10	0.00	719	3.60	49.60	0.56	7.038	20.0	7.915	7.28	None	NA
	25-Jun-91	1991.49	1027	3.49	73.60	0.00	714	3.55	76.80	0.46	6.626	20.3	7.938	7.75	None	None
W2/53.5	17-Jul-90	1990.55	1340	1.33	23.70	0.02	296	1.87	26.50	0.34	27.740	18.9	7.902	3.93	None	NA
	08-Aug-90	1990.61	1327	0.97	24.70	0.20	283	1.51	25.14	0.81	28.087	18.9	7.881	3.83	None	NA
	05-Sep-90	1990.68	1340	1.49	23.59	0.12		1.49	24.31	0.38	28.121	18.9	7.899	3.83	None	NA
	04-Oct-90	1990.76	1340	1.22	23.04	0.03	293	1.61	23.49	1.15	27.826	18.9	7.886	3.85	None	NA
	01-Nov-90	1990.84	1355	1.09	25.24	0.09	288	1.56	26.15	0.39	27.665	18.9	7.889	3.80	None	NA
	10-Dec-90	1990.95	1357	1.03	25.09	0.00	270	1.34	25.20	0.23	28.547	19.0	7.887	3.69	None	NA
	09-Jan-91	1991.03	1000	1.01	26.98	0.00	285	1.08	27.60	0.29	27.607	17.2	7.942	3.83	10	NA
	06-Feb-91	1991.11	957	0.77	23.80	0.00	255	1.06	25.20	0.51	27.870	18.8	7.897	3.73	None	NA
	06-Mar-91	1991.18	1020	0.96	24.60	0.08	289	1.08	26.20	0.58	27.595	18.6	7.905	3.78	None	NA
	03-Apr-91	1991.26	1005	0.88	29.10	0.00	263	1.07	31.00	0.46	28.568	18.8	7.897	3.72	None	NA
	22-May-91	1991.39	1026	0.95	12.70	0.09	343	1.02	13.10	0.24	27.157	18.7	7.900	3.83	None	NA
	26-Jun-91	1991.49	1031	0.78	23.20	3.18	290	1.10	23.90	0.39	28.265	18.8	7.904	3.74	None	None
W2A/24.5	17-Jul-90	1990.55	1407	2.53	47.00	0.00	496	2.77	50.00	0.65	18.216	19.8	7.918	5.59	None	NA
	08-Aug-90	1990.61	1355	2.10	51.60	0.17	504	2.77	52.80	0.84	17.192	19.9	7.909	5.36	None	NA
	05-Sep-90	1990.68	1432	2.45	49.21	0.00		2.45	49.82	0.32	17.677	19.7	7.924	5.36	None	NA
	04-Oct-90	1990.76	1426	2.24	47.10	0.04	508	2.65	50.03	1.40	17.663	19.6	7.916	5.02	None	NA
	01-Nov-90	1990.84	1438	2.30	49.68	0.03	505	2.55	51.15	0.44	17.530	19.5	7.916	5.32	None	NA
	10-Dec-90	1990.95	1446	2.33	57.32	0.15	501	2.65	59.50	0.35	16.072	19.6	7.927	5.64	None	NA
	09-Jan-91	1991.03	1025	2.36	56.68	0.05	512	2.38	58.73	0.38	16.241	19.3	7.916	5.66	14	NA
	06-Feb-91	1991.11	1016	2.11	49.70	0.11	475	2.28	51.10	0.64	15.837	19.4	7.922	5.76	None	NA
	07-Mar-91	1991.19	1036	2.27	53.90	0.22	510	2.39	54.10	0.61	15.907	19.2	7.925	5.75	None	NA
	03-Apr-91	1991.26	1021	2.16	59.40	0.00	507	2.30	66.50	0.49	15.958	19.3	7.928	5.75	None	NA
	22-May-91	1991.39	1049	2.03	31.90	0.00	567	2.28	26.20	0.51	16.735	19.3	7.919	5.45	None	NA
	26-Jun-91	1991.49	1117	2.30	53.60	0.00	534	2.35	55.70	0.38	16.574	19.3	7.926	5.63	None	None
W2B/14.5	17-Jul-90	1990.55	1433	3.77	78.00	0.03	658	3.97	83.10	0.81	7.978	20.5	8.020	7.99	22	NA
	08-Aug-90	1990.61	1418	3.22	81.30	0.15	663	3.62	82.50	0.93	7.616	20.7	8.014	7.98	7	NA
	05-Sep-90	1990.68	1454	3.41	80.60	0.00		3.41	81.43	0.39	7.828	20.7	8.024	7.98	59	NA
	04-Oct-90	1990.76	1400	3.42	77.96	0.00	664	3.95	78.13	1.42	7.613	20.7	7.999	8.70	None	NA
	01-Nov-90	1990.84	1414	3.36	80.05	0.08	791	3.52	82.40	0.57	7.682	20.7	7.990	7.93	None	NA
	10-Dec-90	1990.95	1443	3.30	81.83	0.14	652	3.71	86.50	0.46	7.422	20.5	7.978	7.89	None	NA
	09-Jan-91	1991.03	1035	3.41	81.90	0.12	647	3.41	86.70	0.69	7.047	20.5	8.026	8.13	None	NA
	06-Feb-91	1991.11	1031	3.15	65.51	0.07	586	3.24	67.60	0.79	6.493	20.6	8.006	8.23	None	NA
	07-Mar-91	1991.19	1049	3.20	80.80	0.18	650	3.35	82.30	0.68	6.952	20.3	8.014	8.24	None	NA
	03-Apr-91	1991.26	1035	3.05	65.90	0.00	645	3.20	100.00	0.69	7.372	20.2	7.998	8.15	None	NA
	22-May-91	1991.39	1100	3.01	39.70	0.00	748	3.25	41.00	0.65	7.253	20.6	8.015	8.08	None	NA
	26-Jun-91	1991.49	1128	3.08	84.30	0.00	665	3.18	87.90	0.52	7.553	20.5	8.009	8.26	None	None

Table XVII. Groundwater Well Data: Well Sets 3 and 4

GROUND WATER

Keahole Point Comprehensive Environmental Monitoring Program

SITE/Depth (feet)	DATE (D-M-Y)	JULIAN DATE	TIME (2400 hr)	PO4 (um)	NO3 (um)	NH4 (um)	SI (um)	TDP (um)	TDN (um)	TOC (mgC/l)	SALINITY (‰)	DIG-C TEMP	pH	DO	Coliform FC/100ml	Enterococ Ent/100ml
W3/65	17-Jul-90	1990.55	930	1.60	25.60	0.16	369	1.90	27.10	0.38	25.882	20.8	7.899	3.73	None	NA
	08-Aug-90	1990.61	1020	1.29	26.70	0.21	363	1.77	27.23	0.37	26.026	21.9	7.878	3.96	None	NA
	05-Sep-90	1990.68	939	1.63	25.73	0.14		1.63	26.93	0.27	26.018	20.7	7.878	3.95	None	NA
	04-Oct-90	1990.76	940	1.38	24.44	0.07	363	1.99	24.54	0.82	26.048	20.8	7.877	3.56	None	NA
	01-Nov-90	1990.84	959	1.39	26.35	0.07	361	1.43	25.60	0.34	26.273	20.9	7.867	3.76	None	NA
	10-Dec-90	1990.95	943	1.36	29.25	0.03	352	1.75	30.34	0.26	25.721	20.8	7.880	3.74	None	NA
	10-Jan-90	1990.03	800	1.35	27.22	0.00	356	1.49	28.50	0.30	26.065	20.7	7.874	3.84	None	NA
	06-Feb-91	1991.11	815	1.12	26.60	0.00	307	1.45	26.80	0.54	25.446	20.8	7.870	3.65	None	NA
	07-Mar-91	1991.19	846	1.26	27.30	0.00	358	1.32	27.80	0.57	25.492	20.5	7.881	3.77	None	NA
	04-Apr-91	1991.26	814	1.02	22.70	0.00	364	1.38	27.20	0.57	25.600	20.5	7.883	3.79	None	NA
	22-May-91	1991.39	858	1.17	12.90	0.14	417	1.21	13.50	0.32	25.680	21.6	7.883	3.67	None	NA
	26-Jun-91	1991.49	903	1.52	27.90	0.17	380	1.63	28.60	0.33	25.421	20.6	7.880	3.78	None	None
W3A/35	17-Jul-90	1990.55	1002	2.75	44.90	0.01	551	3.17	52.10	0.24	16.675	21.8	7.940	5.49	3	NA
	08-Aug-90	1990.61	935	2.56	52.90	0.37	571	2.76	53.80	0.40	16.416	22.4	7.921	5.75	None	NA
	05-Sep-90	1990.68	1008	2.99	63.73	0.00		2.81	65.08	0.33	12.994	21.9	7.969	5.75	None	NA
	04-Oct-90	1990.76	1008	2.80	58.26	0.00	661	3.37	58.90	0.90	13.063	22.1	7.962	6.25	None	NA
	01-Nov-90	1990.84	1025	2.63	57.09	0.11	616	2.94	57.95	0.43	14.241	22.2	7.944	5.82	None	NA
	10-Dec-90	1990.95	1009	2.23	51.84	0.10	547	2.67	52.89	0.30	17.745	21.7	7.928	5.19	None	NA
	10-Jan-90	1990.03	820	2.64	60.91	0.01	582	2.92	62.40	0.41	13.964	21.7	7.948	6.30	None	NA
	06-Feb-91	1991.11	838	2.84	62.30	0.25	597	3.04	66.30	0.54	10.985	21.9	8.010	6.84	None	NA
	07-Mar-91	1991.19	902	2.76	68.70	0.03	612	2.87	70.02	0.62	9.461	21.9	8.017	7.36	None	NA
	04-Apr-91	1991.26	831	2.65	62.86	0.01	626	2.70	63.70	0.80	10.828	22.0	8.019	7.31	None	NA
	22-May-91	1991.39	912	2.57	31.40	0.00	632	2.68	32.40	0.47	11.872	22.1	7.987	6.96	None	NA
	26-Jun-91	1991.49	918	2.90	76.10	0.00	656	3.10	75.40	0.43	9.692	21.9	8.014	7.52	None	None
W3B/25	17-Jul-90	1990.55	1026	3.63	73.70	0.01	684	3.83	78.80	1.22	8.277	23.8	8.075	7.77	None	NA
	06-Aug-90	1990.61	902	3.24	74.70	0.19	681	3.48	75.63	0.98	8.556	22.9	8.050	7.49	None	NA
	05-Sep-90	1990.68	1031	3.35	75.47	0.04		3.35	77.07	0.34	8.570	23.2	8.053	7.49	None	NA
	04-Oct-90	1990.76	1027	3.40	73.60	0.03	705	3.89	73.65	0.89	8.345	23.2	8.043	7.56	None	NA
	01-Nov-90	1990.84	1044	3.23	76.16	0.08	765	3.69	78.00	0.34	8.306	23.1	8.047	7.61	None	NA
	10-Dec-90	1990.95	1030	3.13	76.33	0.13	635	3.54	77.08	0.34	8.275	23.1	8.065	7.61	None	NA
	10-Jan-90	1990.03	835	3.10	75.76	0.10	656	3.16	76.85	0.94	7.821	22.2	8.051	7.66	None	NA
	06-Feb-91	1991.11	855	2.92	62.00	0.57	574	3.11	71.40	0.61	6.661	22.8	8.157	7.61	None	NA
	07-Mar-91	1991.19	917	2.93	72.10	0.06	631	3.08	72.96	0.75	8.152	22.2	8.047	7.73	None	NA
	04-Apr-91	1991.26	848	2.88	68.60	0.13	647	2.92	69.90	0.72	8.390	22.1	8.061	7.58	None	NA
	22-May-91	1991.39	923	2.91	36.00	0.00	770	3.06	37.60	0.51	8.322	22.3	8.053	7.57	None	NA
	26-Jun-91	1991.49	932	3.06	79.60	0.00	683	3.20	82.10	0.50	8.679	22.4	8.036	7.68	None	None
W4/69	17-Jul-90	1990.55	1122	2.57	41.50	0.00	493	2.97	44.50	0.44	19.677	21.4	7.923	4.70	None	NA
	08-Aug-90	1990.61	1115	1.99	51.80	0.29	496	2.64	43.99	0.34	19.841	21.4	7.901	4.74	None	NA
	05-Sep-90	1990.68	1119	2.39	42.81	0.00		2.39	43.28	0.29	17.356	21.4	7.898	4.74	None	NA
	04-Oct-90	1990.76	1128	2.24	40.48	0.00	496	2.87	40.73	0.84	19.640	21.2	7.893	4.80	None	NA
	01-Nov-90	1990.84	1143	2.16	42.64	0.04	494	2.61	43.80	0.28	19.799	21.3	7.886	4.47	None	NA
	10-Dec-90	1990.95	1120	2.26	44.19	0.13	537	2.70	45.31	0.35	19.239	21.3	7.898	4.82	None	NA
	10-Jan-91	1991.03	900	2.23	45.69	0.03	484	2.30	46.80	0.39	19.390	21.4	7.896	4.67	None	NA
	05-Feb-91	1991.10	1117	2.27	40.60	0.33	442	2.27	41.96	0.68	19.163	21.3	7.897	4.79	None	NA
	07-Mar-91	1991.19	745	2.04	43.50	0.06	477	2.11	45.25	3.00	19.098	21.0	7.901	4.92	None	NA
	03-Apr-91	1991.26	828	1.90	52.20	0.00	473	2.00	53.30	0.54	19.304	21.0	7.912	4.77	None	NA
	22-May-91	1991.39	804	1.96	21.30	0.00	555	2.17	22.20	0.35	19.625	21.2	7.890	4.68	None	NA
	26-Jun-91	1991.49	810	2.28	45.70	0.03	511	2.43	47.10	0.43	19.209	21.2	7.906	4.74	None	None

Table XVIII. Groundwater Well Data: Wells 4A and Set 5

GROUND WATER — Keahole Point Comprehensive Environmental Monitoring Program

SITE/Depth (feet)	DATE (D-M-Y)	JULIAN DATE	TIME (2400 hr)	PO4 (um)	NO3 (um)	NH4 (um)	SI (um)	TDP (um)	TDN (um)	TOC (mgC/l)	SALINITY (‰)	DEG-C TEMP	pH	DO	Coliform FC/100ml	Enter Ent/1
W4A/39.5	17-Jul-90	1990.55	1146	7.09	26.10	4.93	342	7.33	35.60	7.70	17.853	21.8	8.294	2.58	None	NA
	08-Aug-90	1990.61	1137	6.99	19.20	4.76	334	6.41	30.80	1.81	18.042	21.8	8.278	1.93	None	NA
	05-Sep-90	1990.68	1143	7.47	19.96	2.40		7.47	28.67	0.43	17.356	21.8	8.272	1.93	None	NA
	04-Oct-90	1990.76	1151	9.40	22.34	3.87	374	10.92	29.25	0.86	17.570	21.8	8.226	1.91	None	NA
	01-Nov-90	1990.84	1205	5.85	25.61	2.84	405	6.49	30.93	8.62	17.960	21.7	8.180	2.02	None	NA
	10-Dec-90	1990.95	1142	8.32	22.91	6.99	435	8.91	26.90	0.66	16.632	21.8	8.230	2.07	None	NA
	10-Jan-91	1991.03	1000	7.46	8.01	4.52	324	2.30	16.35	0.70	15.925	22.1	8.211	0.41	None	NA
	05-Feb-91	1991.10	1137	8.62	54.20	2.44	274	9.49	59.90	3.11	12.097	21.8	8.555	1.07	None	NA
	07-Mar-91	1991.19	803	8.67	40.10	0.37	289	9.31	44.60	20.74	14.018	21.5	8.369	0.81	None	NA
	03-Apr-91	1991.26	844	8.20	14.80	2.46	273	8.67	63.60	62.13	15.974	21.4	8.798	0.69	None	NA
	22-May-91	1991.39	819	4.30	8.10	2.57	371	6.75	11.60	5.73	16.709	21.6	8.294	0.46	None	NA
	26-Jun-91	1991.49	824	4.83	24.60	1.50	357	4.95	30.40	0.51	13.749	21.6	8.290	0.72	None	None
W5/18	12-Jul-90	1990.53	953	6.80	120.80	0.00	324	6.83	127.10	0.83	25.438	18.9	7.568	5.23	None	NA
	07-Aug-90	1990.61	932	0.57	121.70	0.19	336	6.29	119.40	1.27	25.056	18.9	7.559	5.64	None	NA
	05-Sep-90	1990.68	952	8.99	134.20	2.45		8.99	137.02	0.68	24.904	19.2	7.546	5.64	None	NA
	04-Oct-90	1990.76	1010	9.49	91.35	0.03	345	10.90	97.68	0.93	24.702	19.0	7.568	5.90	None	NA
	31-Oct-90	1990.84	925	7.21	105.23	0.05	327	7.54	110.30	0.68	25.155	19.3	7.536	5.84	None	NA
	07-Dec-90	1990.94	920	7.08	104.75	0.16	356	7.16	106.60	0.68	24.815	19.0	7.538	6.06	None	NA
	09-Jan-91	1991.03	700	6.54	102.40	0.02	296	6.55	103.50	0.88	25.996	18.6	7.555	6.00	None	NA
	05-Feb-91	1991.10	751	6.32	80.30	0.55	282	6.33	80.40	1.04	24.686	18.5	7.583	6.39	None	NA
	06-Mar-91	1991.18	809	5.32	90.60	0.03	268	5.38	91.40	4.86	25.901	16.2	7.480	6.25	None	NA
	02-Apr-91	1991.26	813	5.25	90.10	0.35	278	5.30	92.00	0.96	24.745	17.7	7.598	6.49	1	NA
	21-May-91	1991.39	835	5.60	52.00	0.07	117	5.62	54.30	0.81	25.285	17.5	7.564	6.77	None	NA
	25-Jun-91	1991.49	821	4.39	76.80	0.16	334	4.55	80.00	0.66	24.744	17.8	7.520	7.30	None	None
W5A/28	12-Jul-90	1990.53	1059	6.33	88.60	0.00	222	6.50	91.10	0.67	29.403	16.4	7.507	4.19	None	NA
	07-Aug-90	1990.61	1034	4.95	92.60	0.04	219	5.56	91.76	2.35	29.247	16.4	7.471	4.58	None	NA
	05-Sep-90	1990.68	1022	5.79	89.78	0.00		5.79	91.46	0.52	29.299	16.5	7.419	4.58	None	NA
	31-Oct-90	1990.84	951	5.11	77.46	0.03	211	5.23	80.74	1.98	29.764	18.9	7.525	5.25	None	NA
	07-Dec-90	1990.94	947	3.62	63.50	0.00	251	4.91	75.30	0.57	29.106	17.0	7.450	5.06	None	NA
	05-Jan-91	1991.03	755	5.67	81.90	0.00	208	5.69	89.30	0.69	29.808	16.5	7.521	5.18	None	NA
	05-Feb-91	1991.10	730	5.66	63.60	0.50	186	5.67	66.30	0.86	29.349	15.1	7.540	5.28	None	NA
	06-Mar-91	1991.18	754	5.11	73.20	0.07	186	5.14	75.90	5.85	29.371	14.4	7.576	5.81	None	NA
	02-Apr-91	1991.26	759	5.11	71.20	0.40	190	5.21	75.40	0.73	28.852	15.4	7.518	6.01	None	NA
	21-May-91	1991.39	823	5.25	41.50	0.07	186	5.39	43.40	0.71	29.200	15.3	7.510	6.16	None	NA
	25-Jun-91	1991.49	802	4.19	57.60	0.40	222	5.00	60.80	0.57	29.090	15.6	7.528	6.32	None	None
W5B/55	12-Jul-90	1990.53	1031	3.97	79.20	0.00	193	4.13	82.20	0.73	30.178	15.9	7.809	4.16	None	NA
	07-Aug-90	1990.61	1010	3.70	86.70	0.00	195	4.02	86.31	1.21	30.112	15.9	7.683	3.70	None	NA
	05-Sep-90	1990.68	1055	4.15	82.09	0.00		4.15	83.83	0.57	30.136	16.0	7.612	3.70	None	NA
	04-Oct-90	1990.76	1112	4.44	72.20	0.08	203	5.48	73.13	0.97	30.572	16.7	7.585	4.68	None	NA
	31-Oct-90	1990.84	1024	3.50	63.01	0.00	197	4.23	75.89	1.00	30.528	17.1	7.585	4.33	None	NA
	07-Dec-90	1990.94	1020	3.56	71.20	0.00	205	4.31	75.90	0.56	30.282	15.9	7.501	4.01	None	NA
	09-Jan-91	1991.03	740	4.56	78.50	0.00	189	4.60	84.60	0.63	30.422	15.7	7.467	4.07	None	NA
	05-Feb-91	1991.10	825	4.79	61.20	0.39	160	4.85	62.10	0.82	30.402	15.4	7.507	4.88	None	NA
	06-Mar-91	1991.18	734	4.21	76.70	0.19	170	4.25	79.30	1.05	30.546	15.2	7.571	4.39	None	NA
	02-Apr-91	1991.26	740	4.11	72.70	0.00	63.3	4.13	76.10	0.83	30.171	15.3	7.568	4.87	None	NA
	21-May-91	1991.39	808	4.30	39.10	0.07	210	4.53	41.20	0.75	29.999	15.0	7.566	5.73	None	NA
	25-Jun-91	1991.49	745	3.32	51.20	0.34	217	3.78	57.60	0.68	30.239	15.1	7.563	5.43	None	None

Table XIX. Groundwater Well Data: Well Set 6

GROUND WATER

Keahole Point Comprehensive Environmental Monitoring Program

SITE/Depth (feet)	DATE (D-M-Y)	JULIAN DATE	TIME (2400 hr)	PO4 (um)	NO3 (um)	NH4 (um)	SI (um)	TDP (um)	TDN (um)	TOC (mgC/l)	SALINITY (t.)	DEG-C TEMP	pH	DO	Coliform FC/100ml	Enterococ Ent/100ml
W6/49.6	12-Jul-90	1990.53	1157	5.00	80.50	0.00	204	5.17	83.05	0.16	29.528	16.1	7.592	5.67	None	NA
	07-Aug-90	1990.61	1135	4.10	83.03	0.56	204	4.60	83.60	1.00	29.212	15.8	7.585	5.92	None	NA
	05-Sep-90	1990.68	1326	4.79	84.65	0.00		4.79	86.88	0.48	28.690	15.7	7.443	5.92	None	NA
	04-Oct-90	1990.76	1412	5.04	82.66	0.10	238	5.92	83.93	0.85	28.473	15.5	7.390	5.73	1	NA
	31-Oct-90	1990.84	1117	4.01	72.64	0.00	236	5.31	93.07	0.64	28.853	15.4	7.347	5.41	None	NA
	07-Dec-90	1990.94	1336	4.13	86.74	0.00	211	4.67	89.95	0.56	29.000	15.5	7.450	5.65	None	NA
	09-Jan-91	1991.03	830	4.10	87.00	0.00	199	4.17	97.96	0.67	29.261	14.8	7.515	5.45	None	NA
	05-Feb-91	1991.10	922	4.31	66.70	0.39	180	4.41	67.60	0.78	29.117	15.1	7.540	6.16	None	NA
	06-Mar-91	1991.18	917	3.94	85.40	0.13	211	3.95	86.20	0.80	29.135	14.4	7.576	6.14	None	NA
	02-Apr-91	1991.26	958	3.42	78.50	0.50	196	3.83	80.90	0.81	28.962	14.4	7.556	5.87	None	NA
	21-May-91	1991.39	915	4.23	44.70	0.07	357	4.43	46.50	0.70	29.130	14.3	7.546	5.41	None	NA
	25-Jun-91	1991.49	908	3.16	57.60	0.40	408	3.54	59.20	0.64	29.191	14.3	7.587	6.03	None	None
W6A/18	12-Jul-90	1990.53	1227	3.33	62.70	0.00	384	3.47	65.30	1.03	21.152	22.5	7.996	6.39	None	NA
	07-Aug-90	1990.61	1202	3.50	70.80	0.13	391	3.51	71.23	1.11	20.901	22.1	7.985	6.22	None	NA
	05-Sep-90	1990.68	1353	4.27	68.00	0.00		4.27	70.31	0.69	21.716	22.4	7.920	6.22	1	NA
	04-Oct-90	1990.76	1505	4.33	69.42	0.11	404	5.16	69.53	0.85	21.585	22.2	7.898	5.72	6	NA
	31-Oct-90	1990.84	1205	3.73	67.09	0.09	483	4.67	81.62	0.49	21.818	22.1	7.873	5.68	2	NA
	07-Dec-90	1990.94	1425	2.17	59.91	0.00	396	3.74	68.90	0.51	20.070	22.3	7.882	6.47	None	NA
	09-Jan-91	1991.03	855	3.79	73.40	0.05	361	3.79	81.79	0.64	21.958	21.4	7.860	6.18	None	NA
	05-Feb-91	1991.10	940	3.91	62.12	0.36	317	4.00	63.80	0.80	20.546	20.9	7.899	6.54	None	NA
	06-Mar-91	1991.18	937	4.19	83.60	0.11	381	4.22	87.90	0.72	20.770	20.6	7.936	6.59	None	NA
	02-Apr-91	1991.26	1036	3.92	72.70	0.25	354	3.93	74.50	0.81	20.404	20.6	7.910	6.61	None	NA
	21-May-91	1991.39	952	3.80	35.90	0.00	254	4.00	37.30	0.83	22.873	20.7	7.886	6.62	None	NA
	25-Jun-91	1991.49	936	2.65	62.40	0.22	279	3.22	66.60	0.54	21.009	20.9	7.923	6.62	None	None
W6B/29	12-Jul-90	1990.53	1302	4.10	63.60	0.17	267	4.40	66.50	0.84	26.947	17.8	7.764	6.39	None	NA
	07-Aug-90	1990.61	1230	3.66	68.20	0.00	261	4.21	69.13	1.04	26.815	17.6	7.740	6.19	None	NA
	05-Sep-90	1990.68	1422	4.70	78.89	0.00		4.67	80.78	0.69	27.286	17.1	7.562	6.09	None	NA
	04-Oct-90	1990.76	1440	5.07	75.34	0.00	282	6.08	77.63	1.01	26.965	16.9	7.454	5.80	None	NA
	31-Oct-90	1990.84	1144	3.83	58.94	0.07	280	5.07	75.45	1.06	26.683	17.2	7.525	6.13	None	NA
	07-Dec-90	1990.94	1403	3.46	52.71	0.00	325	4.11	68.90	0.57	25.727	18.3	7.674	6.64	None	NA
	09-Jan-91	1991.03	905	3.96	58.02	0.06	259	4.00	70.80	0.72	26.890	17.2	7.630	6.30	None	NA
	05-Feb-91	1991.10	1000	4.16	57.60	0.36	228	4.27	61.20	0.85	26.216	17.2	7.674	7.06	None	NA
	06-Mar-91	1991.18	957	4.80	83.60	0.14	324	4.87	86.20	0.74	26.609	16.1	7.671	6.86	None	NA
	02-Apr-91	1991.26	1023	4.28	64.00	0.25	247	4.29	69.20	0.71	26.057	16.4	7.714	6.90	None	NA
	21-May-91	1991.39	935	4.26	36.10	0.09	147	4.50	37.30	0.64	27.137	16.0	7.669	7.01	None	NA
	25-Jun-91	1991.49	923	2.90	53.10	0.28	279	2.94	56.60	0.61	26.242	16.4	7.756	7.06	None	None

Mixing line analyses similar to those described for the coastal samples have been used to determine nutrient enrichment in the wells. Only the wells in relatively undisturbed areas (Well Sets 1,2 & 3) have been used to determine the mixing line parameters (Table XX). Enrichment values are not plotted for Ammonium since it is poorly correlated with salinity.

Note that the enrichment values for silica are less than zero in Well 4/39.5 and in all of Wells 5 & 6. This is probably due to some contaminant in the well waters interfering with the analyses, but the exact cause of these low values, which are significantly below the mixing line determined from Well sets 1-3, is unknown.

Table XX. Groundwater Mixing Line Regression Parameters: Well Sets 1-3

Phosphate Regression Output:			**Total Diss. P Regression Output:**		
Constant		4.139697	Constant		4.225655
Std Err of Y Est		0.251054	Std Err of Y Est		0.302678
R Squared		0.92521	R Squared		0.882662
No. of Observations		181	No. of Observations		147
Degrees of Freedom		179	Degrees of Freedom		145
X Coefficient(s)	-0.10779		X Coefficient(s)	-0.10083	
Std Err of Coef.	0.002291		Std Err of Coef.	0.003053	
Nitrate Regression Output:			**Total Diss. N Regression Output:**		
Constant		94.58335	Constant		100.1414
Std Err of Y Est		8.449715	Std Err of Y Est		10.05885
R Squared		0.863866	R Squared		0.835189
No. of Observations		181	No. of Observations		147
Degrees of Freedom		179	Degrees of Freedom		145
X Coefficient(s)	-2.59825		X Coefficient(s)	-2.75022	
Std Err of Coef.	0.077093		Std Err of Coef.	0.101457	
Ammonium Regression Output:			**Total Organic C Regression Output:**		
Constant		0.108045	Constant		0.875484
Std Err of Y Est		0.175144	Std Err of Y Est		0.30383
R Squared		0.00887	R Squared		0.163682
No. of Observations		181	No. of Observations		140
Degrees of Freedom		179	Degrees of Freedom		138
X Coefficient(s)	0.002023		X Coefficient(s)	-0.01633	
Std Err of Coef.	0.001598		Std Err of Coef.	0.003142	
Silicate Regression Output:					
Constant		835.5252			
Std Err of Y Est		38.51403			
R Squared		0.941777			
No. of Observations		140			
Degrees of Freedom		138			
X Coefficient(s)	-18.8036				
Std Err of Coef.	0.397993				

Figure 66. Groundwater Nitrate Mixing Line Regression

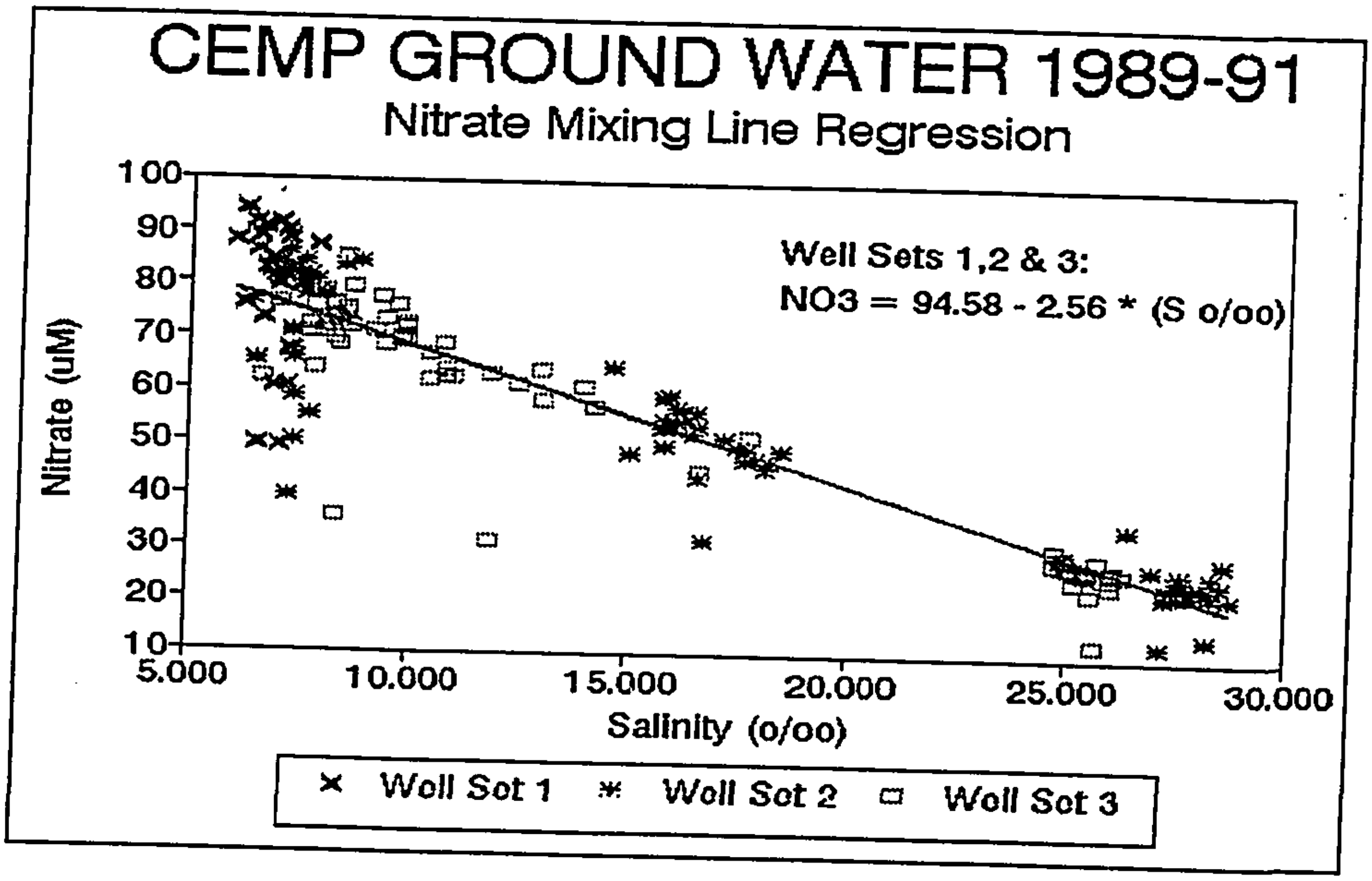


Figure 67. Groundwater Phosphate Mixing Line Regression

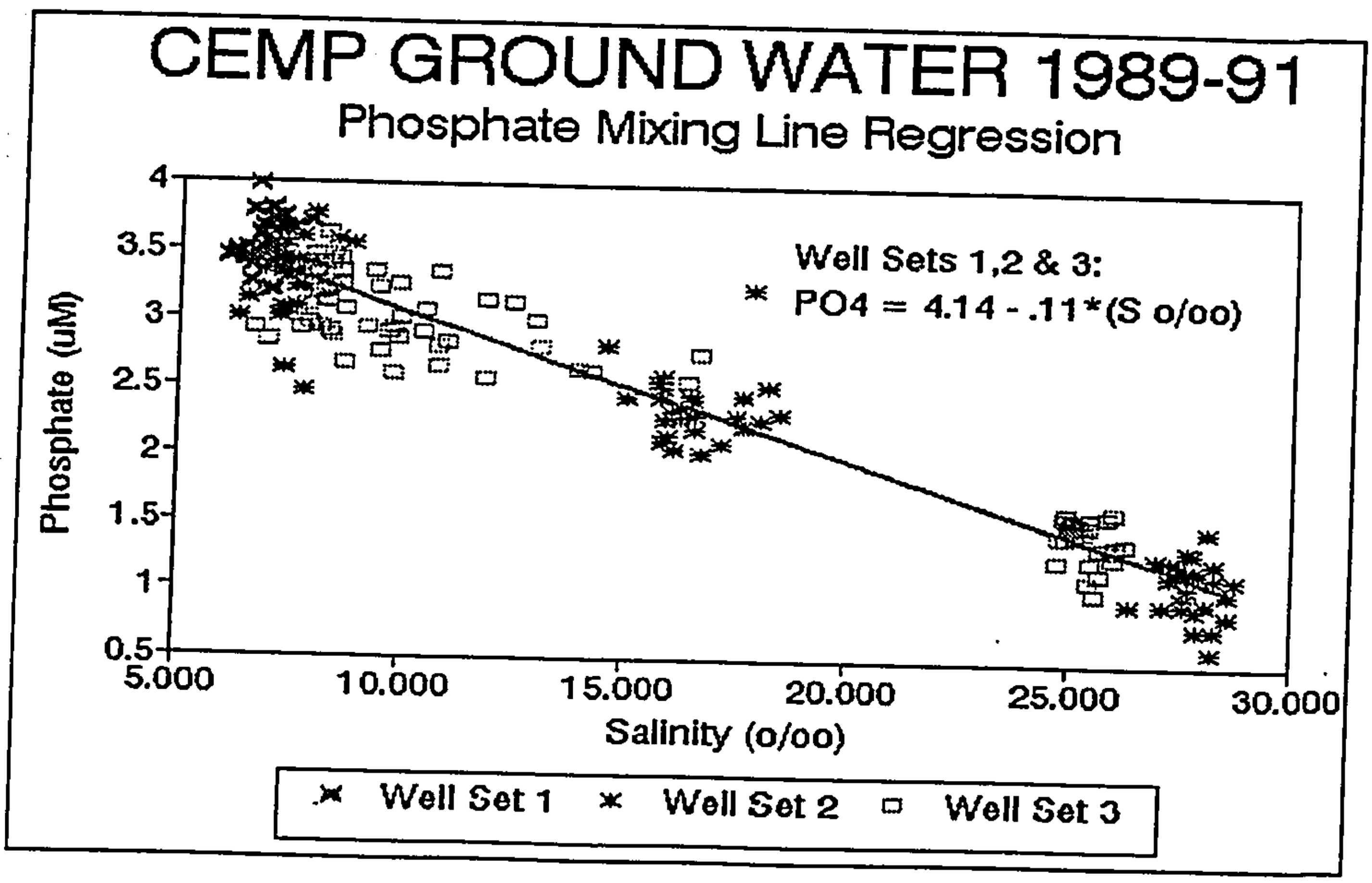


Figure 68. Groundwater Silicate Mixing Line Regression

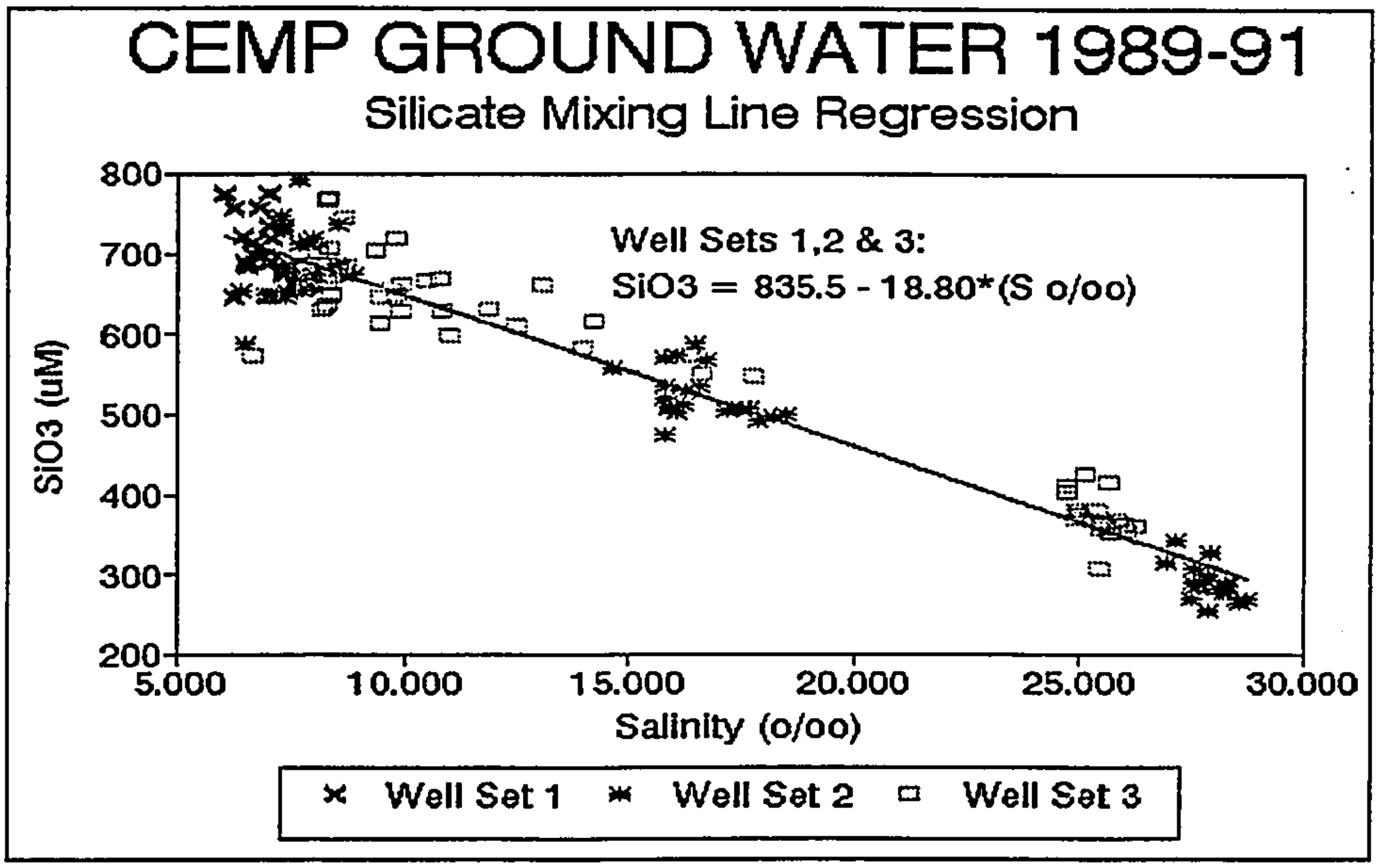


Figure 69. Groundwater Ammonium Mixing Line Regression (not used)

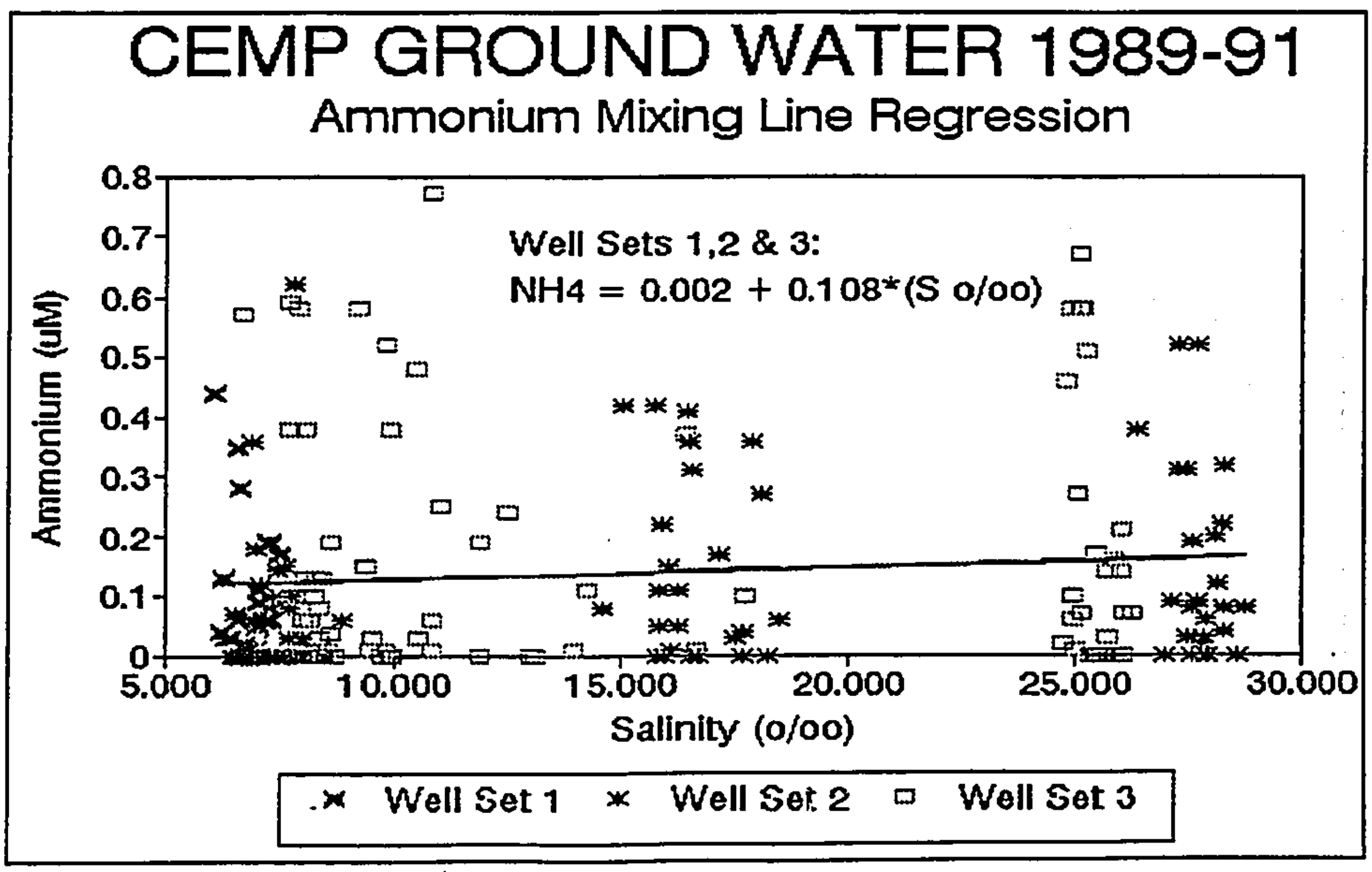


Figure 70. Groundwater Total Dissolved Nitrogen Mixing Line Regression

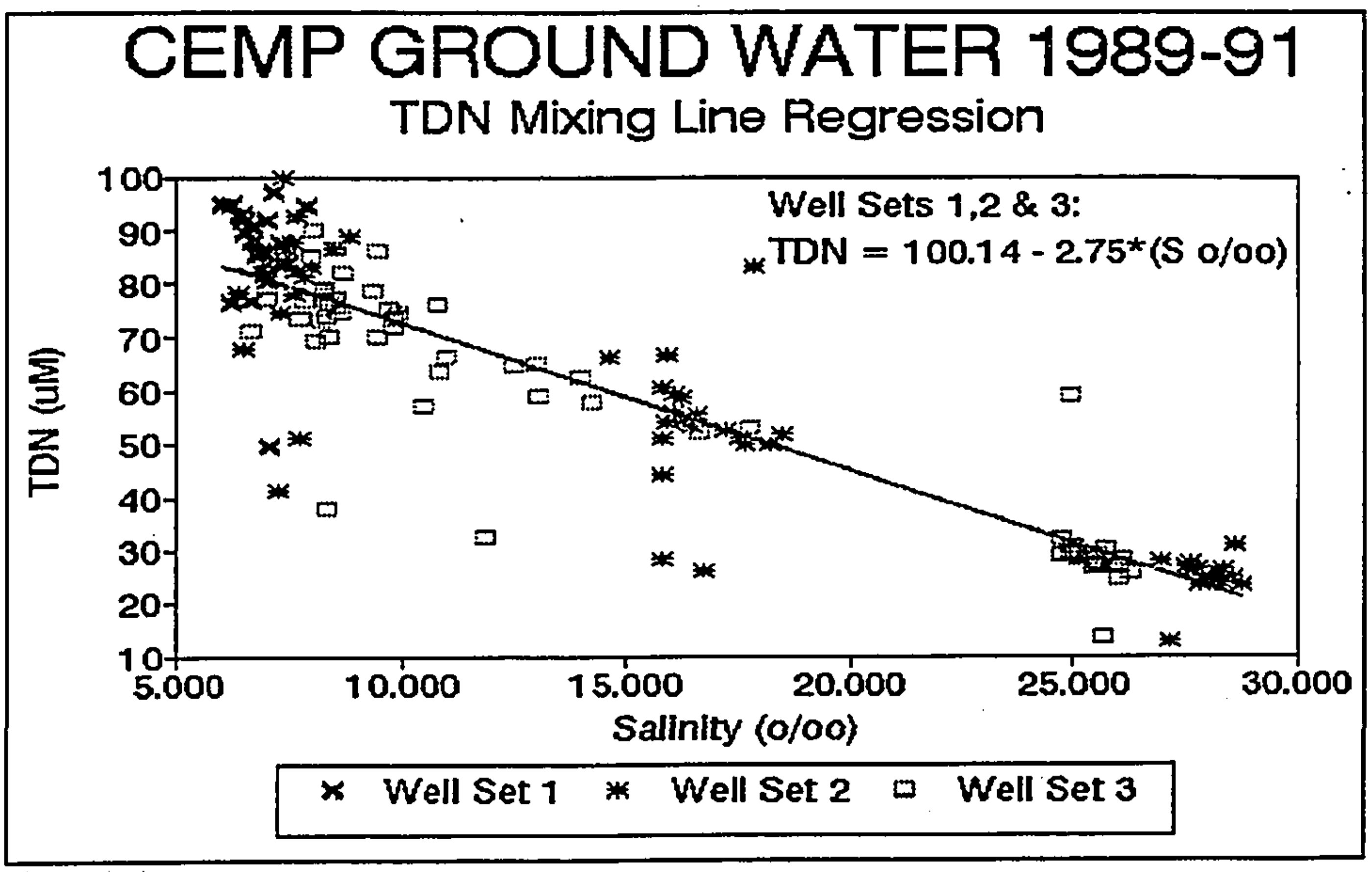


Figure 71. Groundwater Total Dissolved Phosphorus Mixing Line Regression

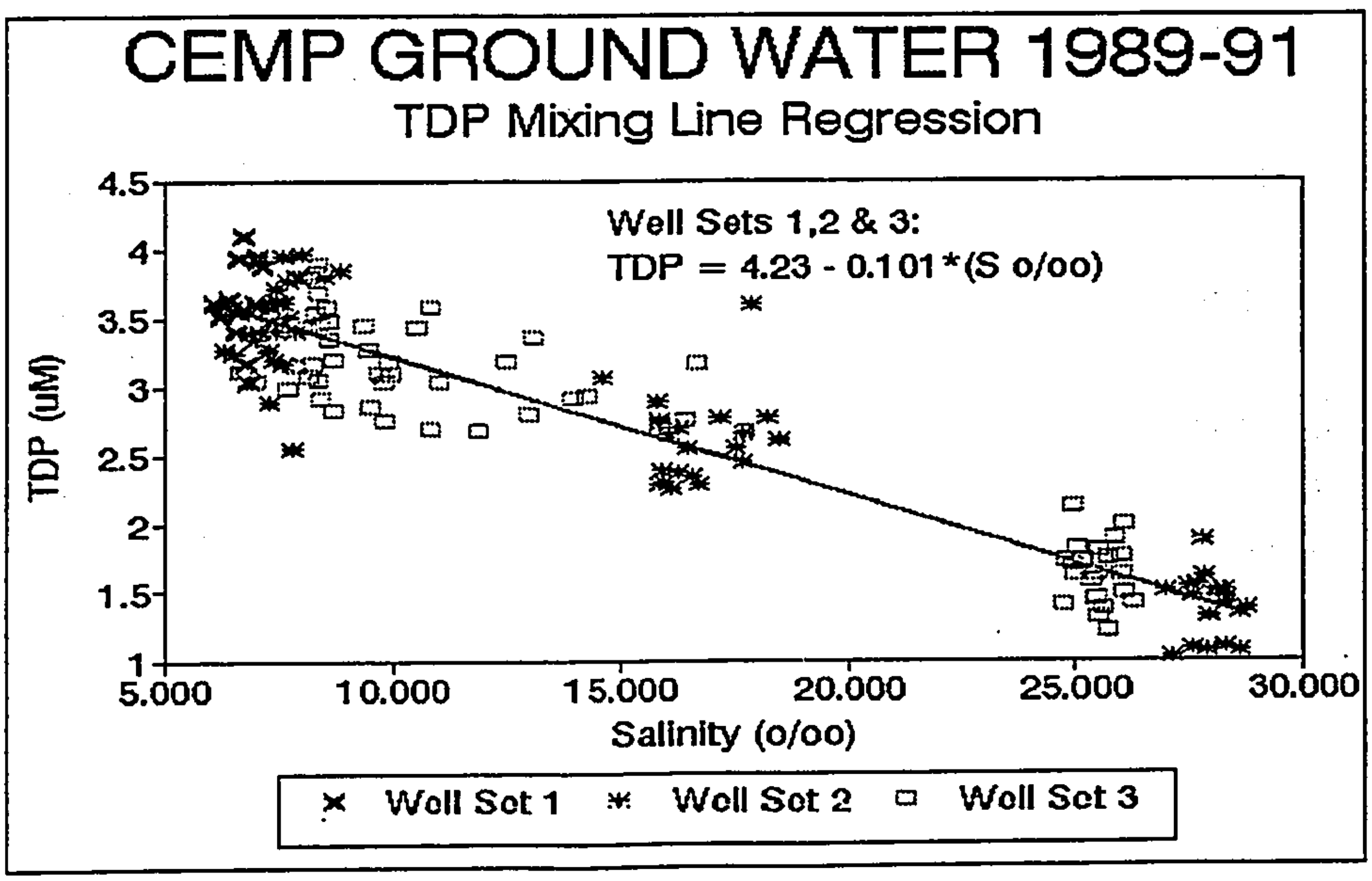


Figure 72. Groundwater Total Organic Carbon Mixing Line Regression

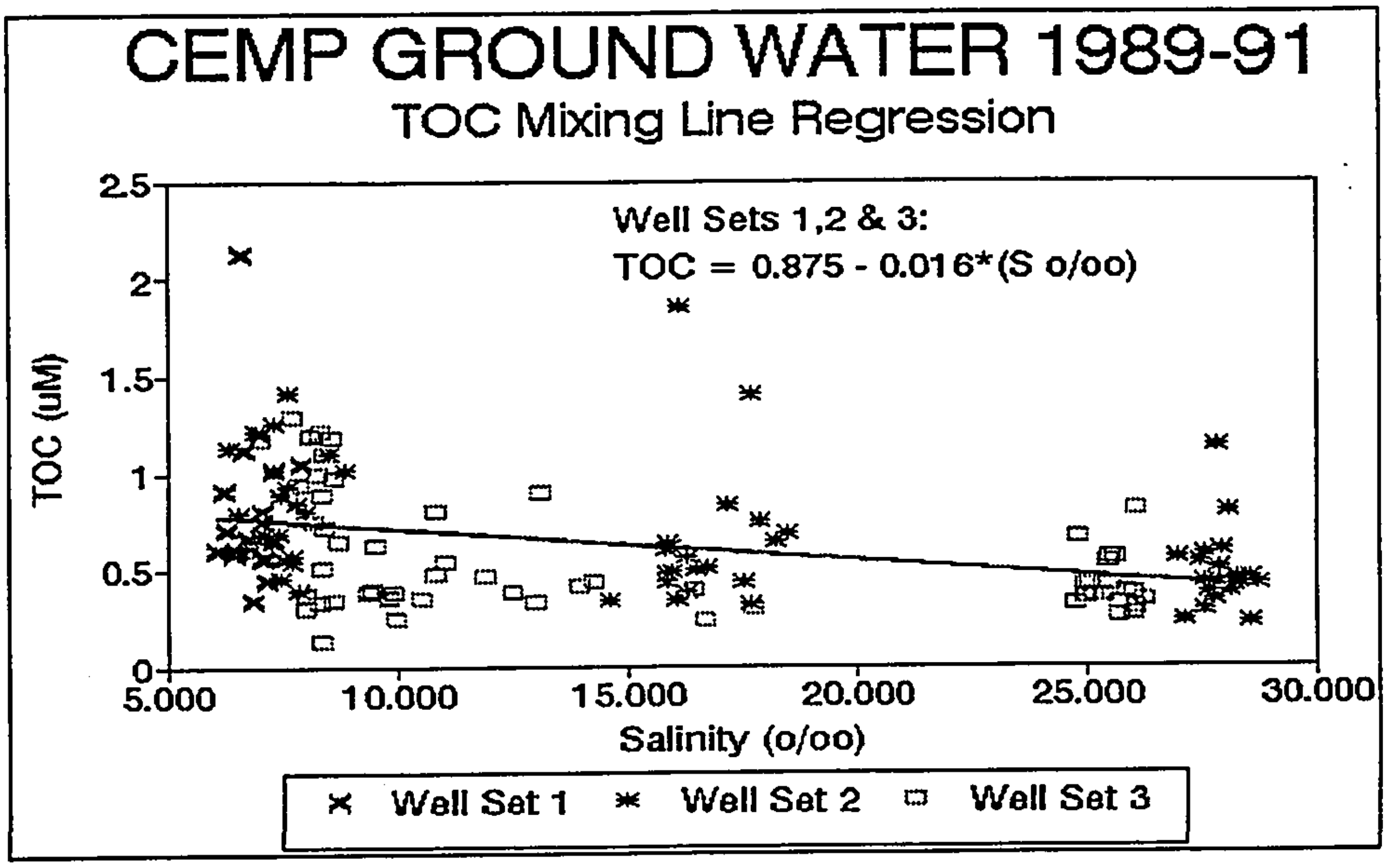


Figure 73. Groundwater Temperature: Wells 1 and 2

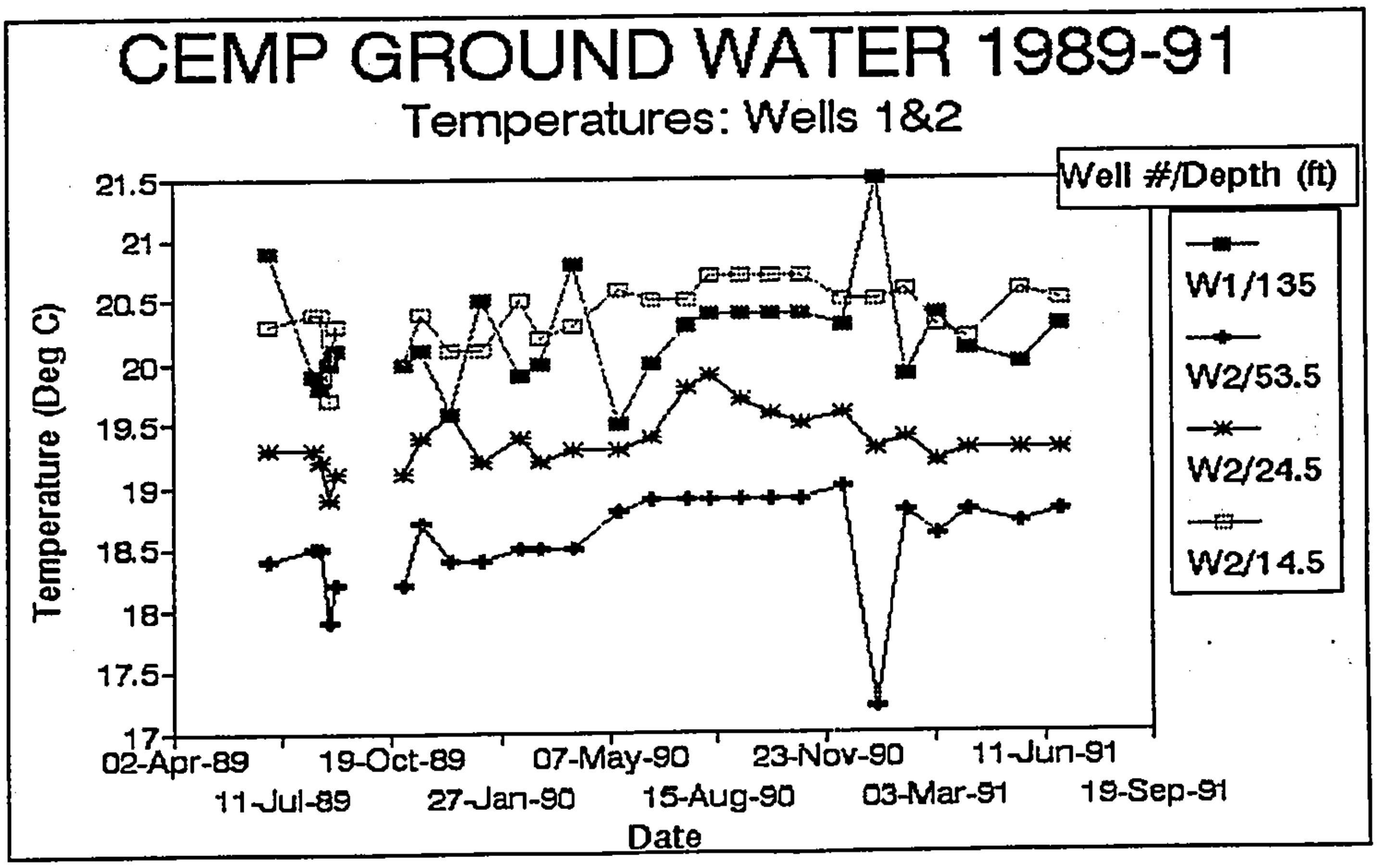


Figure 74. Groundwater Salinity: Wells 1 and 2

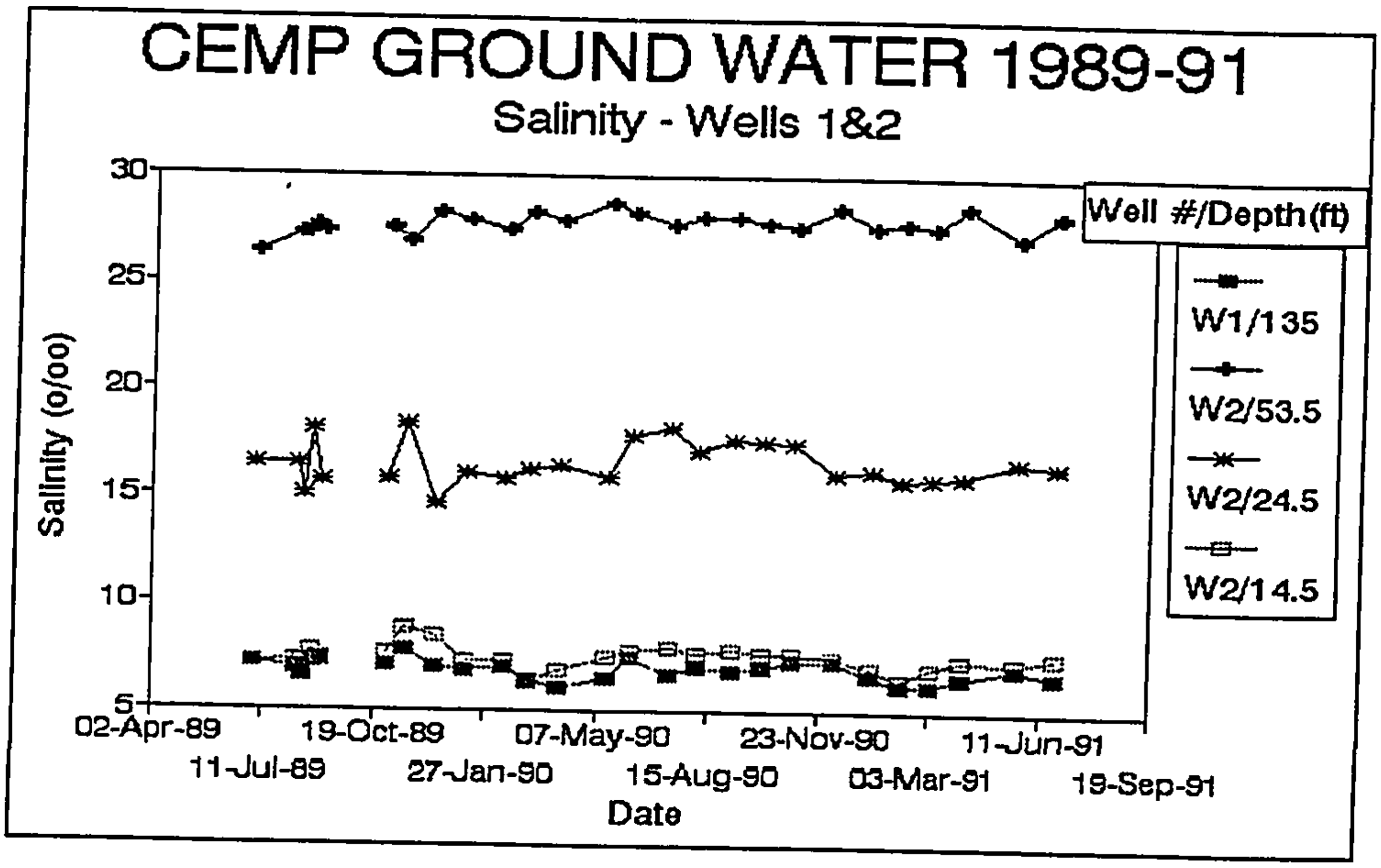


Figure 75. Groundwater pH: Wells 1 and 2

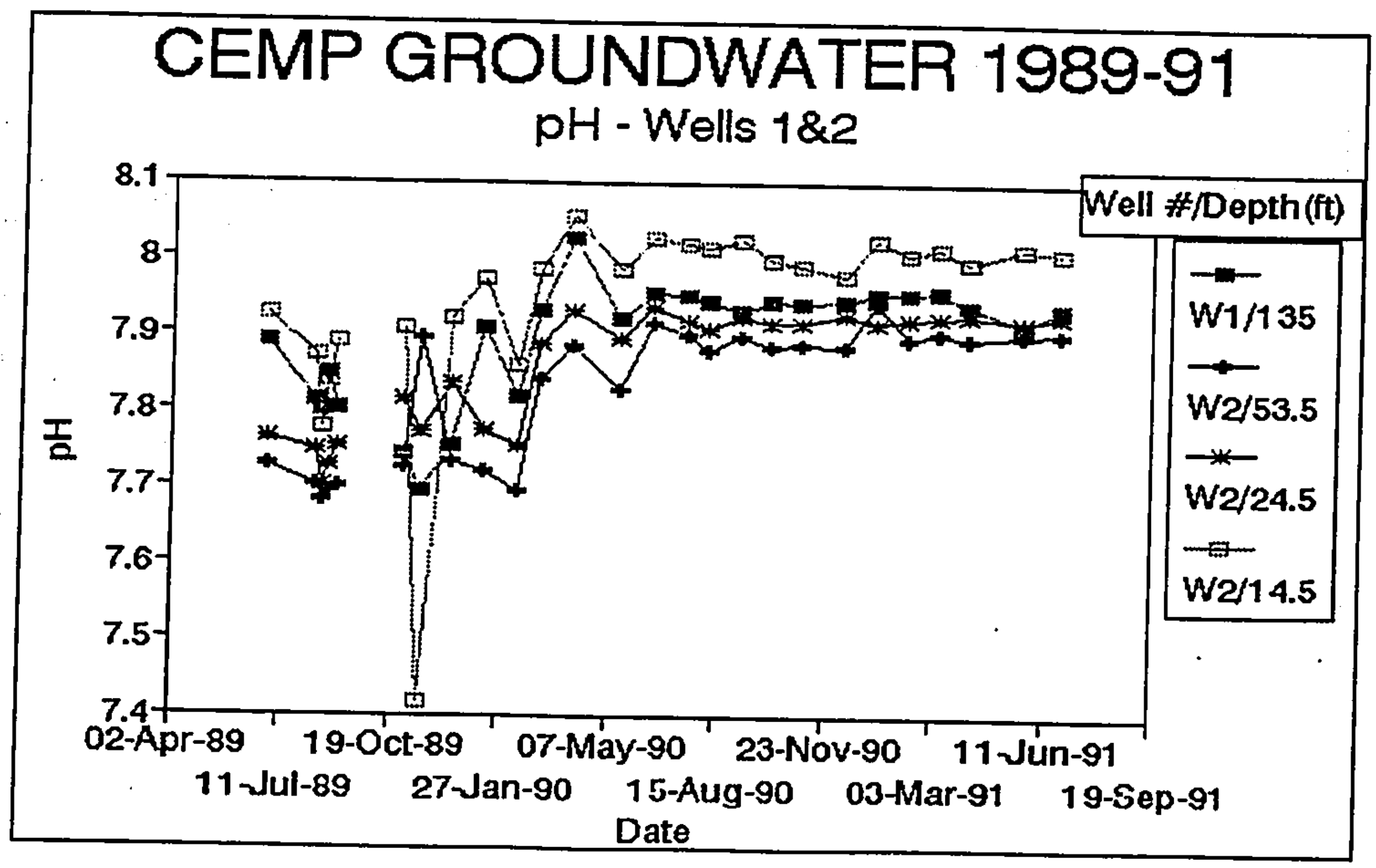


Figure 76. Groundwater Dissolved Oxygen: Wells 1 and 2

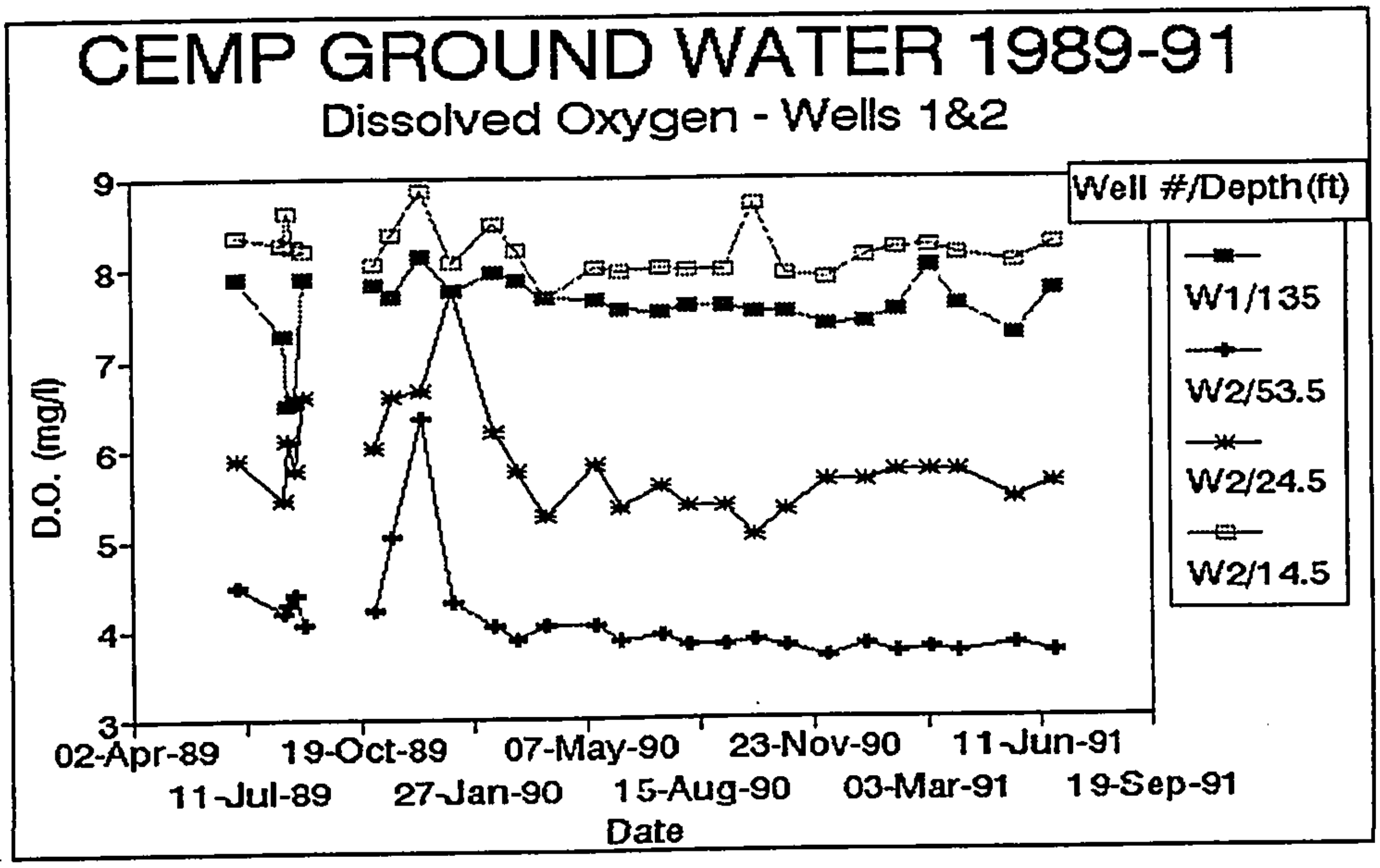


Figure 77. Groundwater Nitrate: Wells 1 and 2

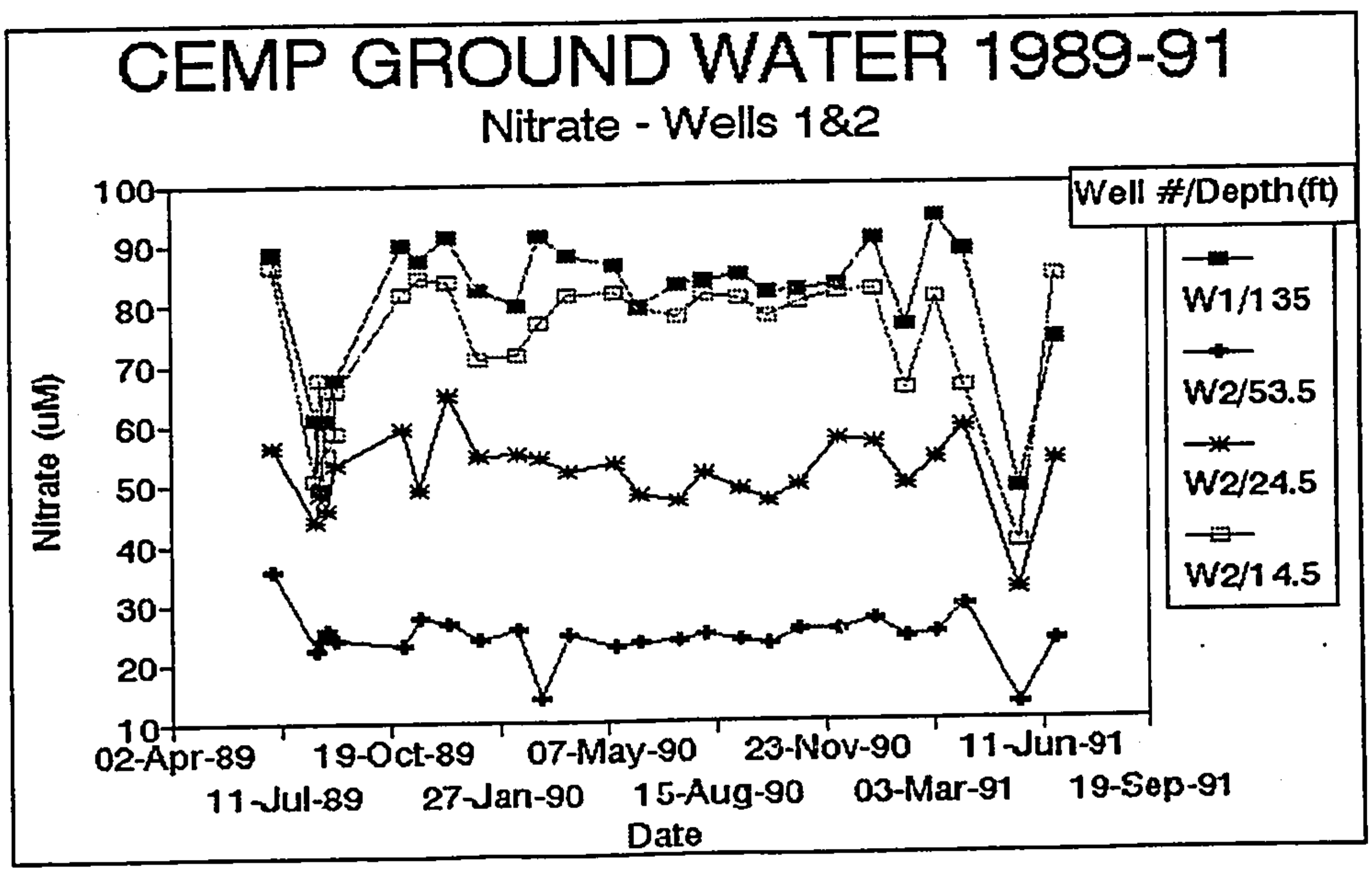


Figure 78. Groundwater Phosphate: Wells 1 and 2

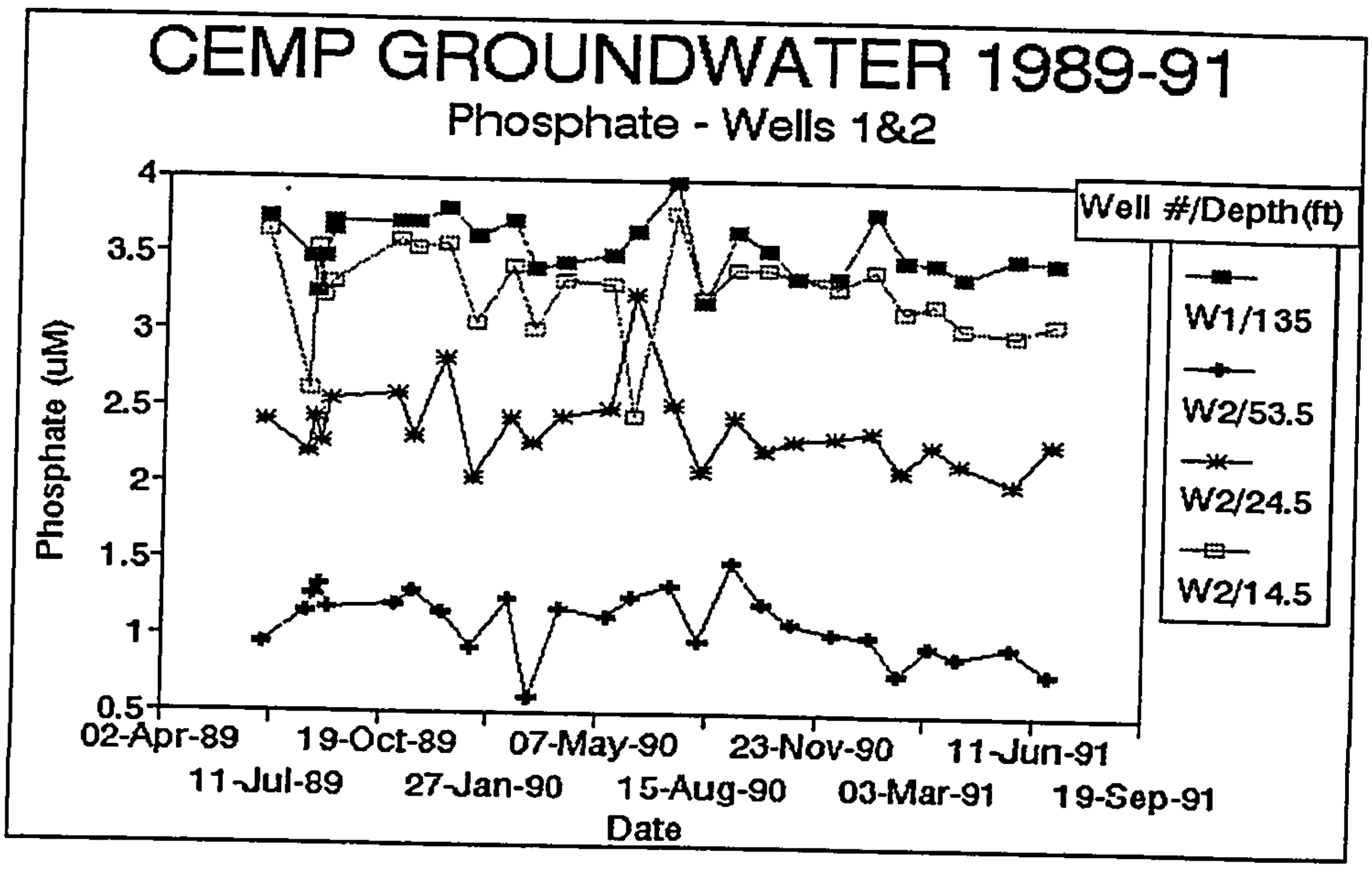


Figure 79. Groundwater Silicate: Wells 1 and 2

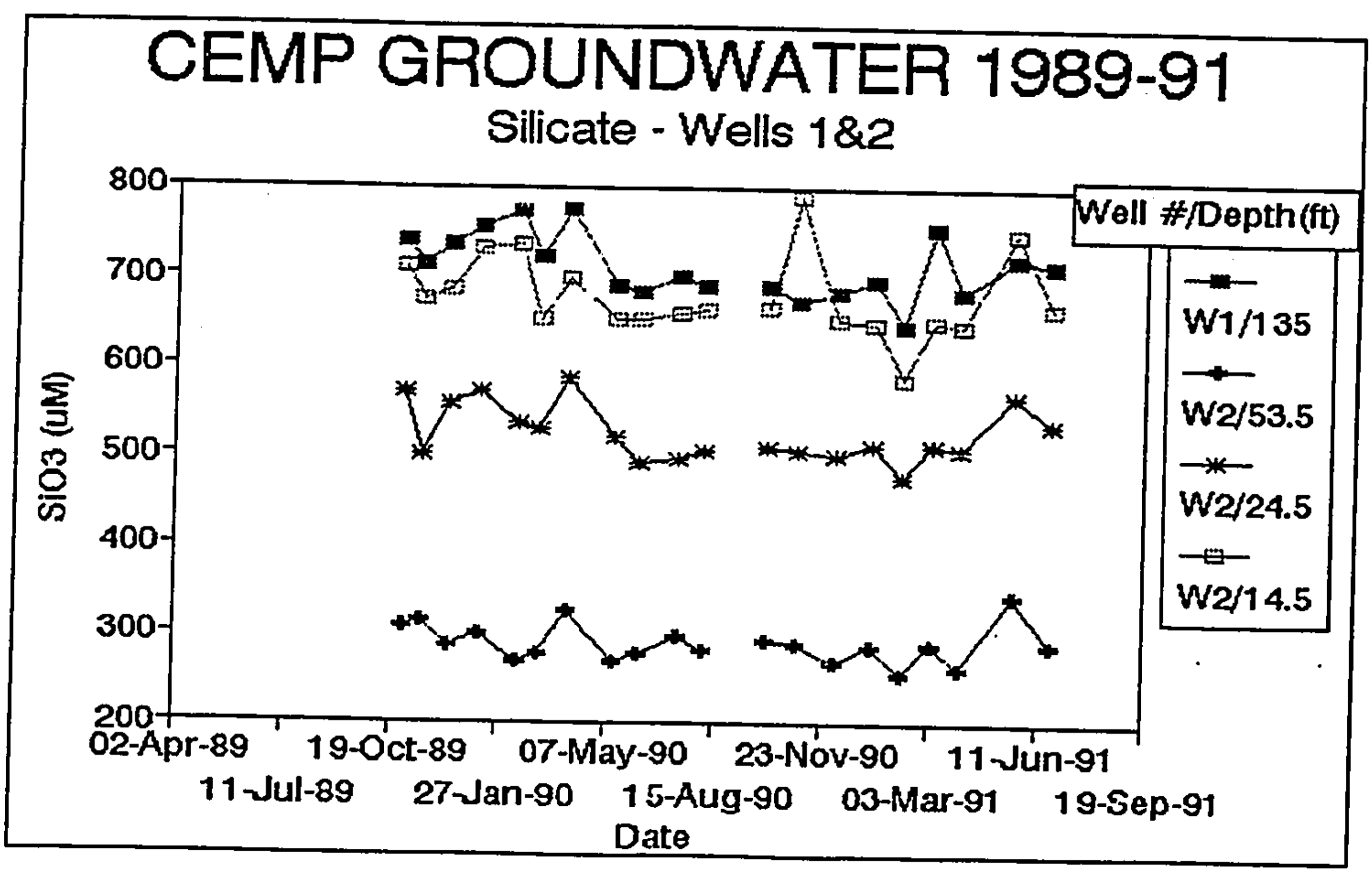


Figure 80. Groundwater Ammonium: Wells 1 and 2

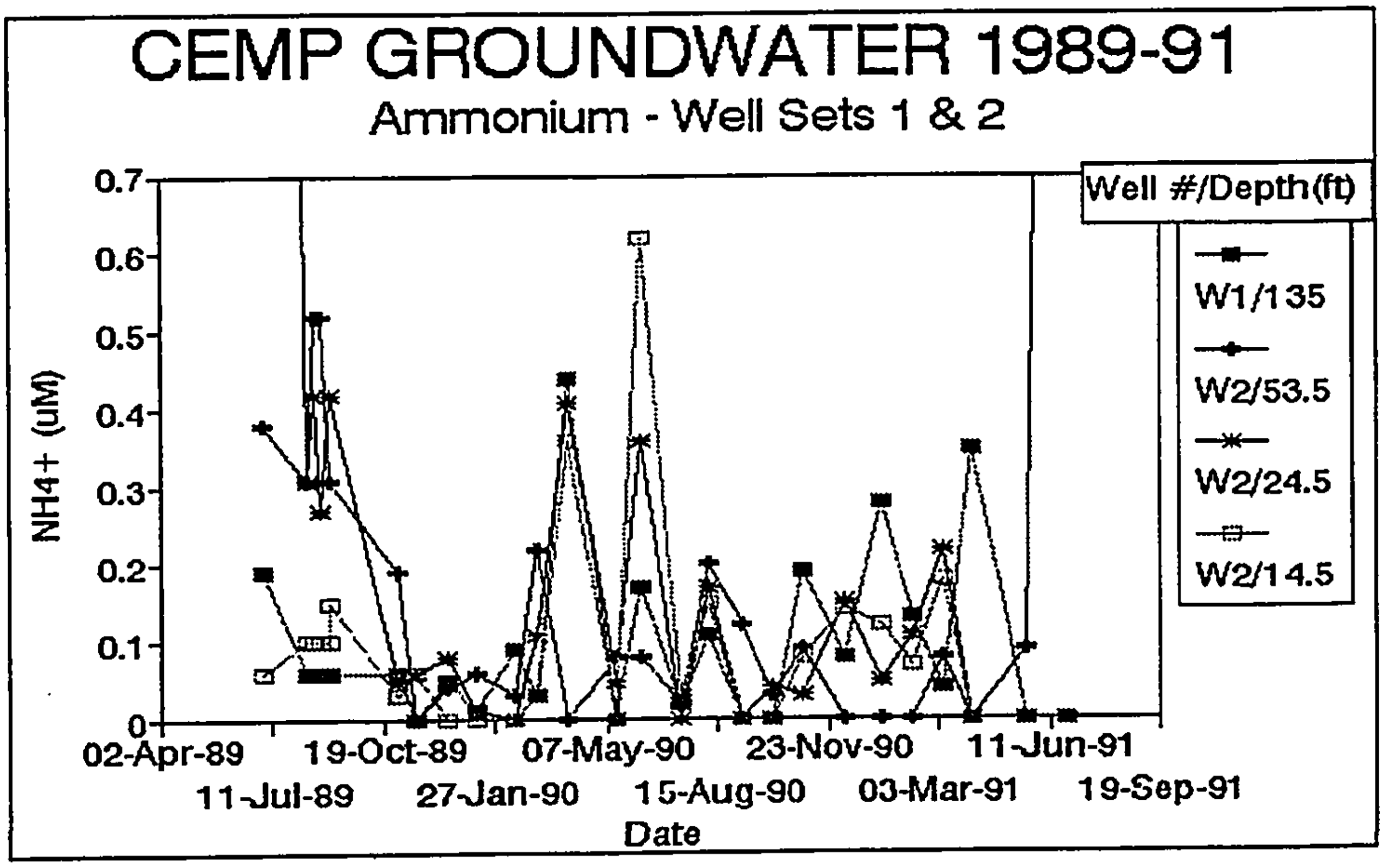


Figure 81. Groundwater Total Dissolved Nitrogen: Wells 1 and 2

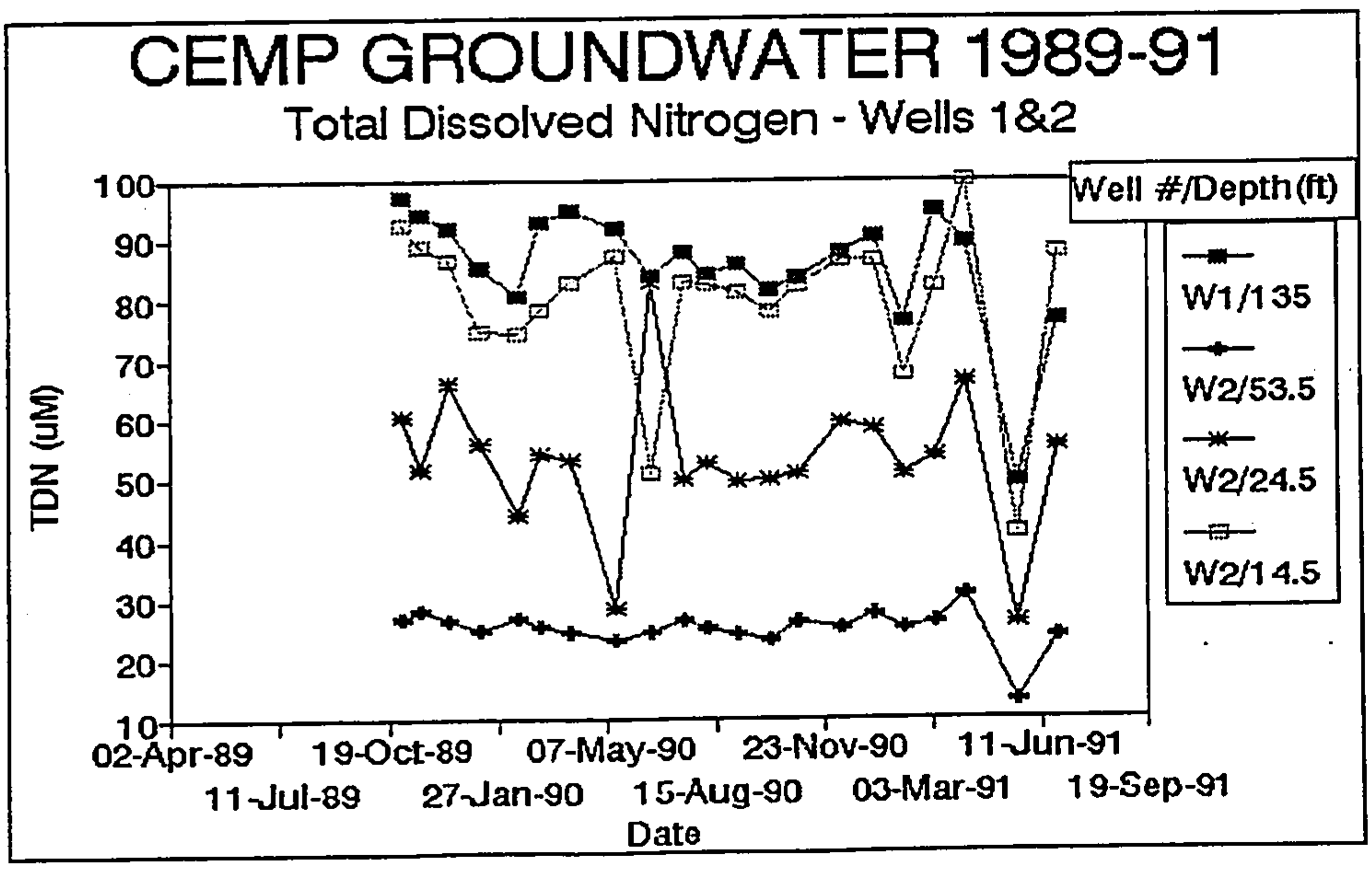


Figure 82. Groundwater Total Dissolved Phosphorous: Wells 1 and 2

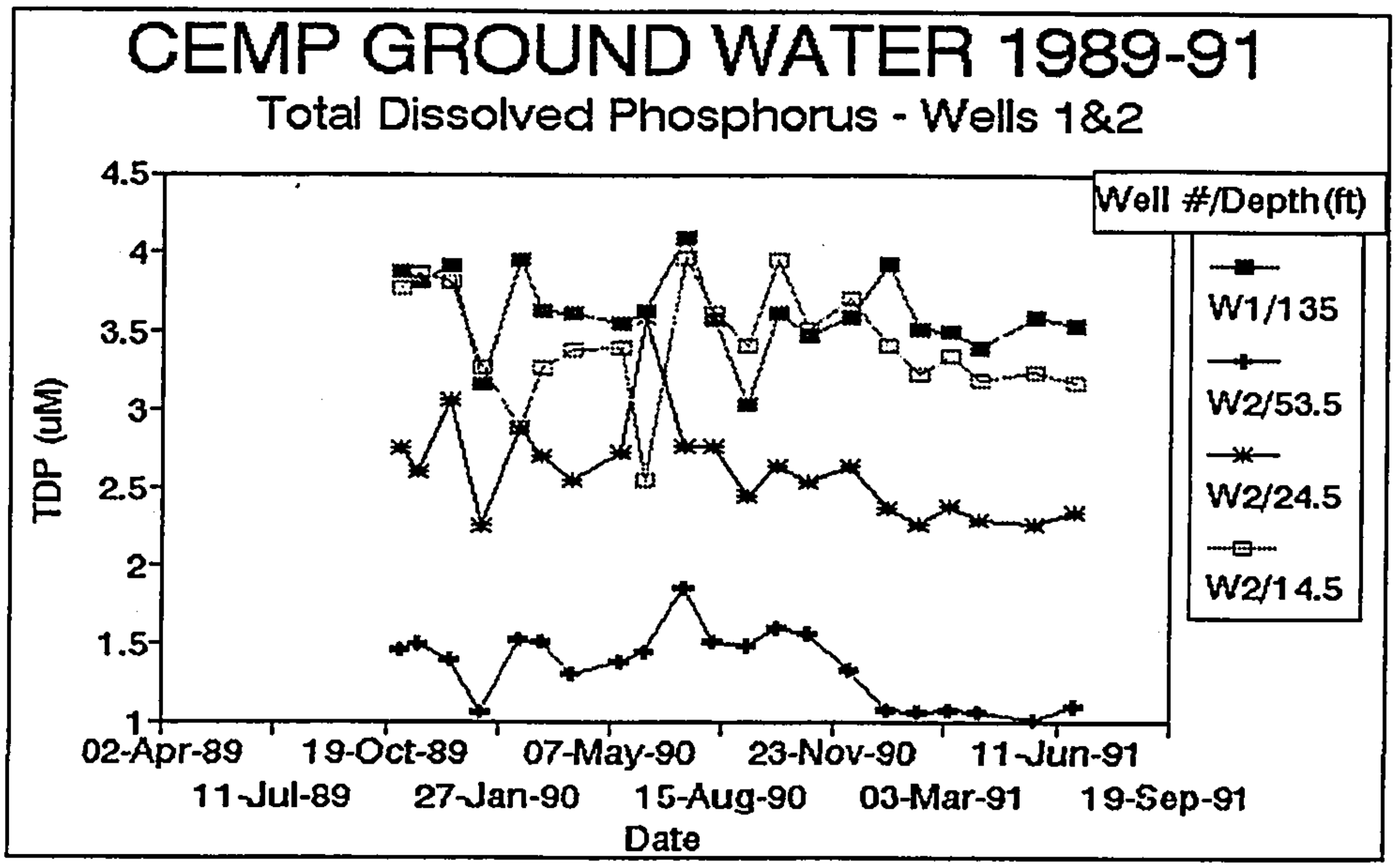


Figure 83. Groundwater Total Organic Carbon: Wells 1 and 2

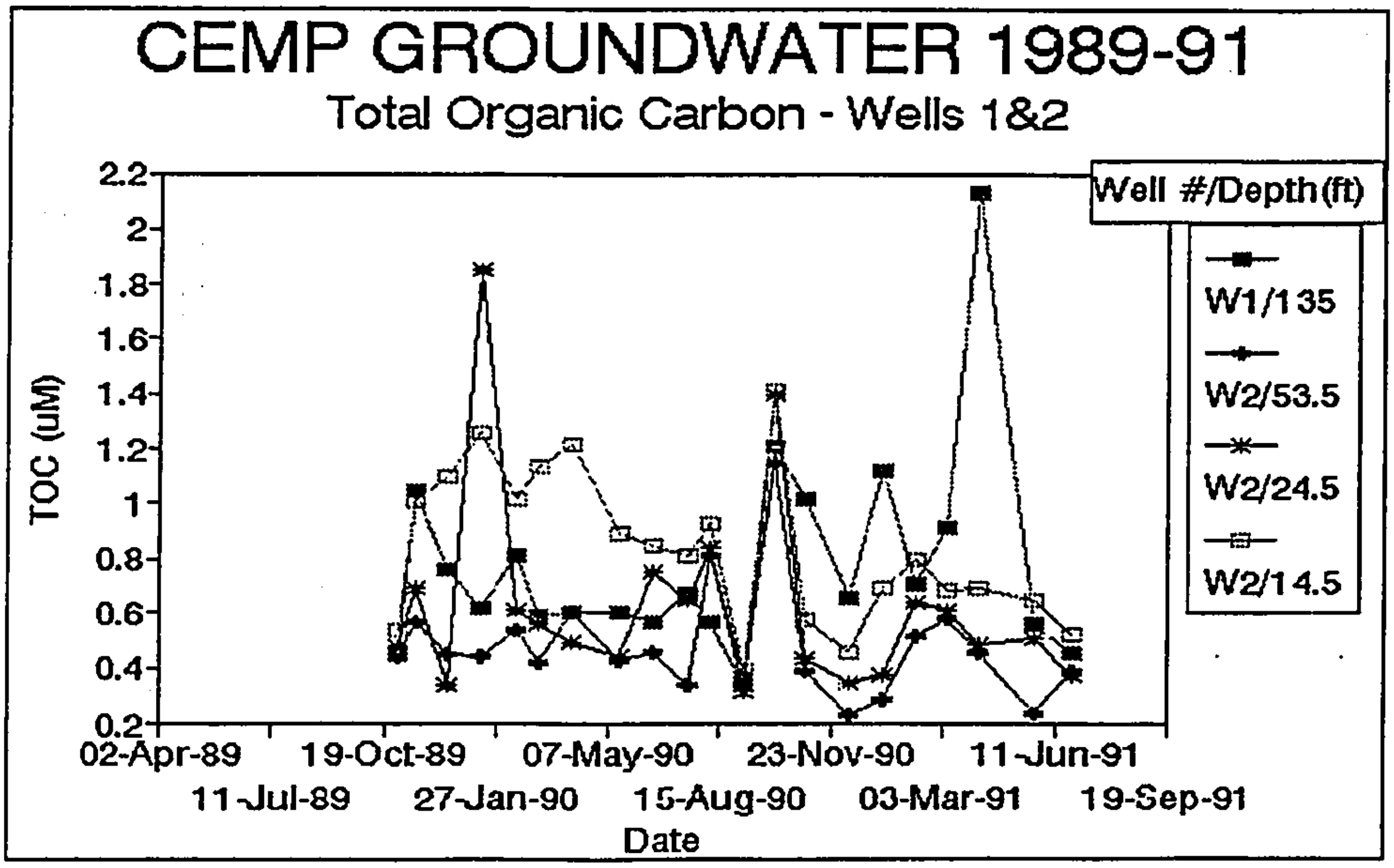


Figure 84. Groundwater Temperature: Wells 3 and 4

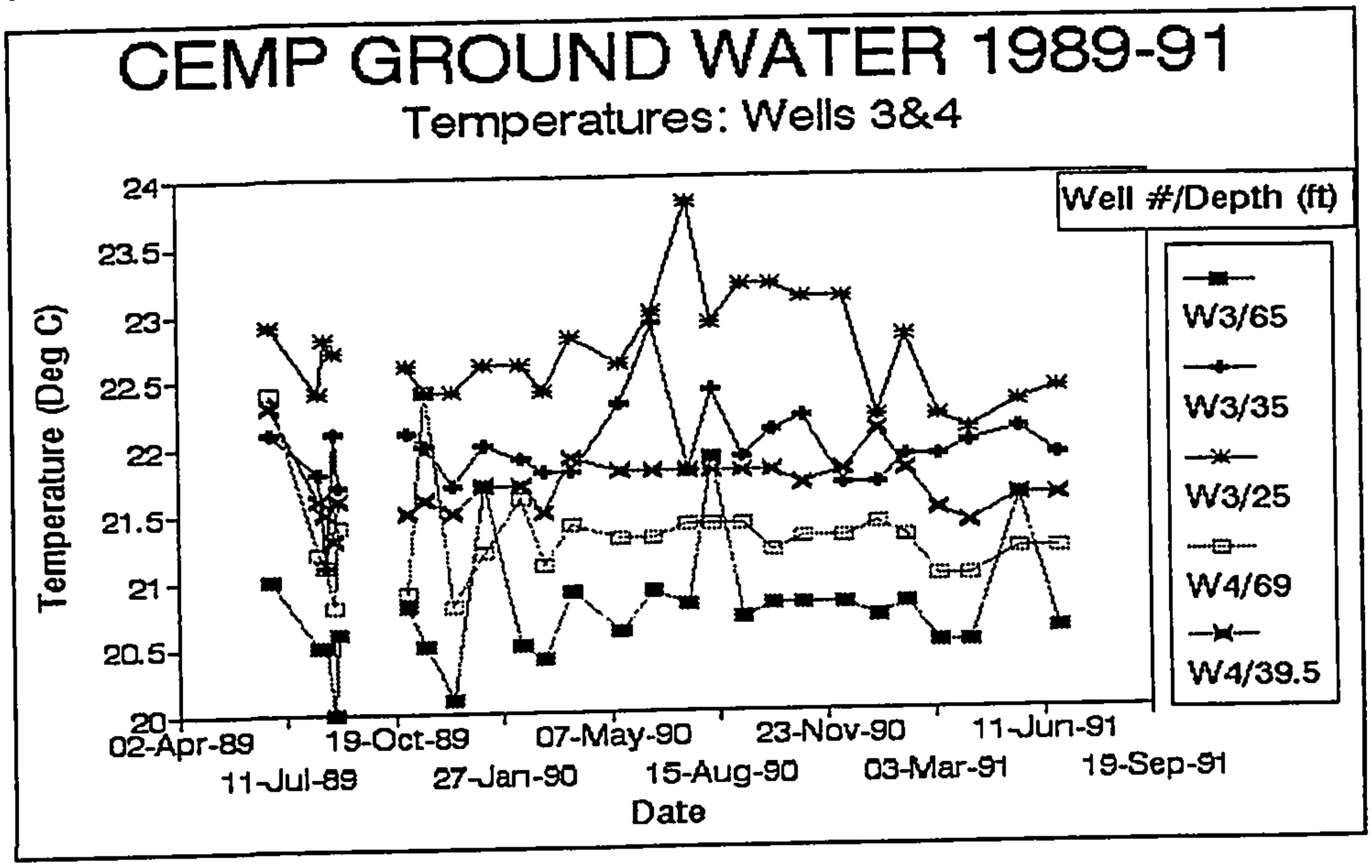


Figure 85. Groundwater Salinity: Wells 3 and 4

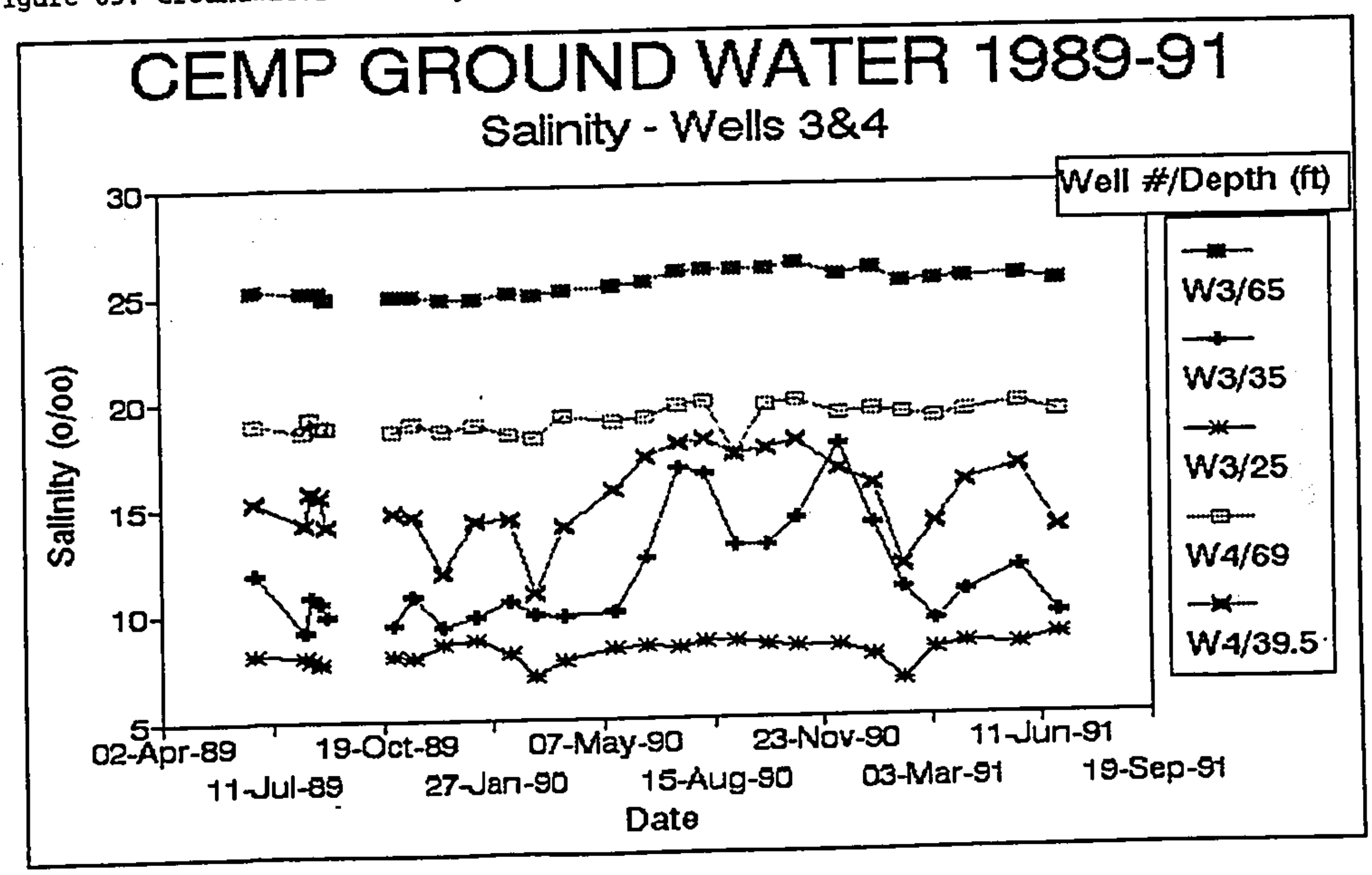


Figure 86. Groundwater pH: Wells 3 and 4

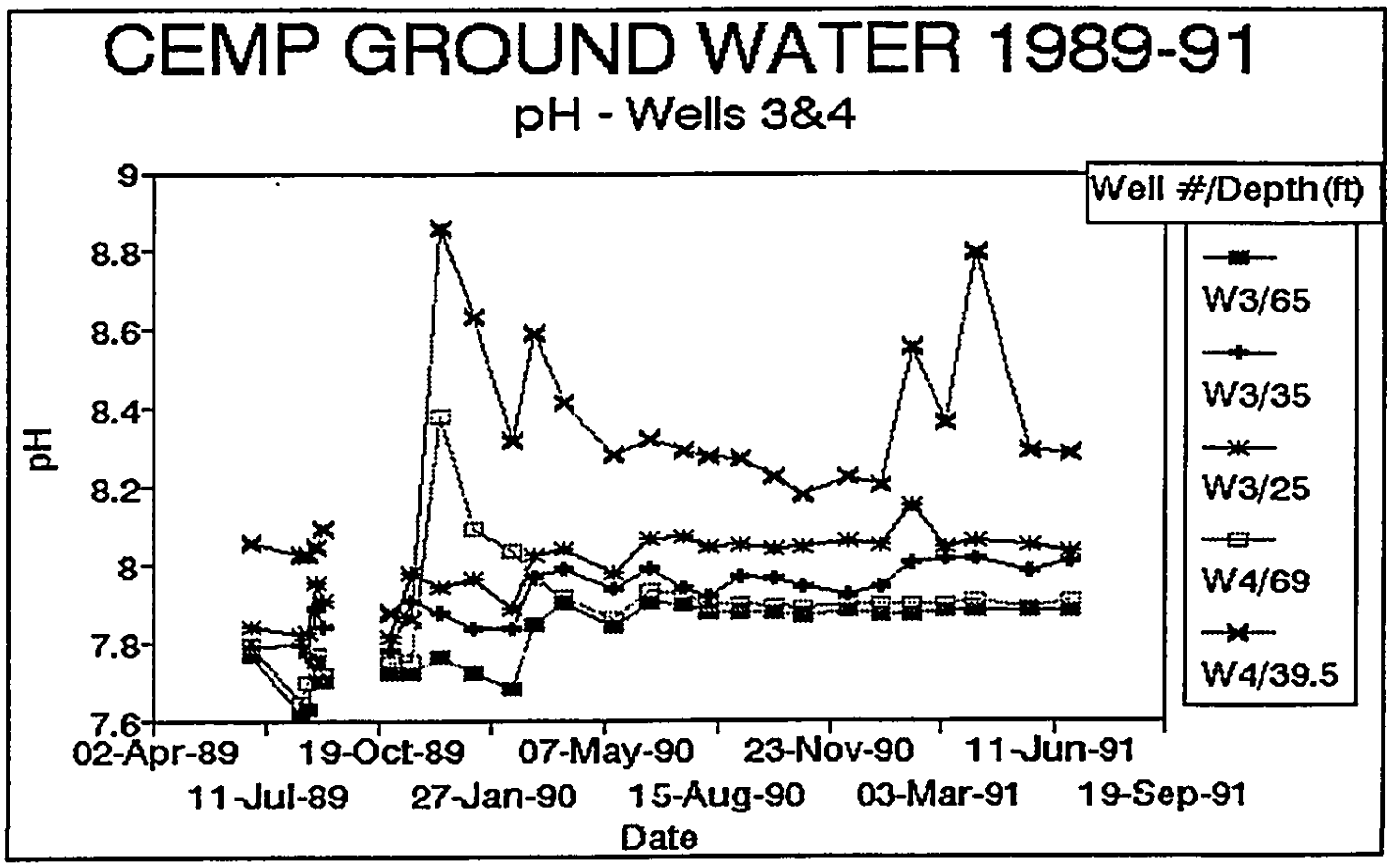


Figure 87. Groundwater Dissolved Oxygen: Wells 3 and 4

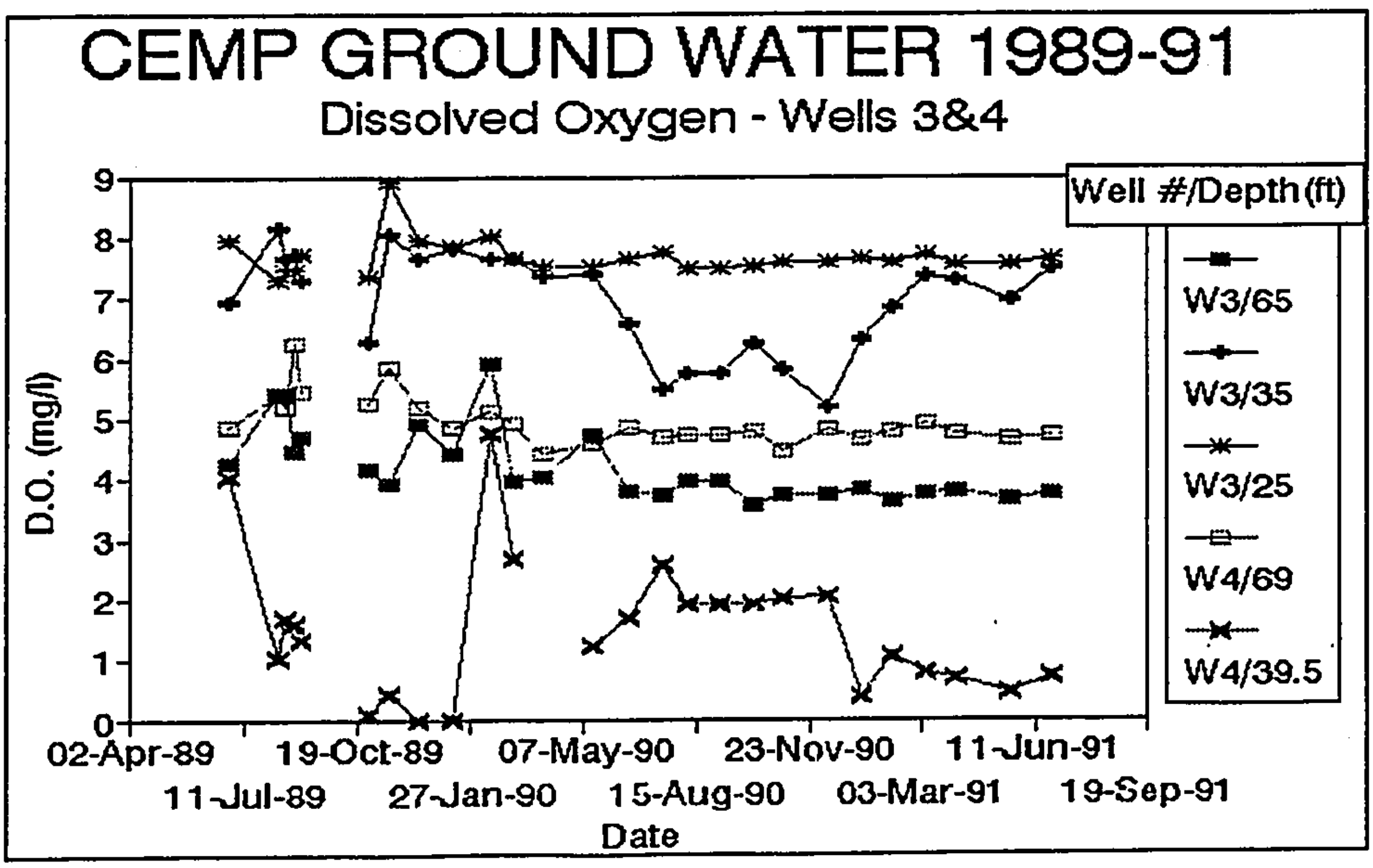


Figure 88. Groundwater Nitrate: Wells 3 and 4

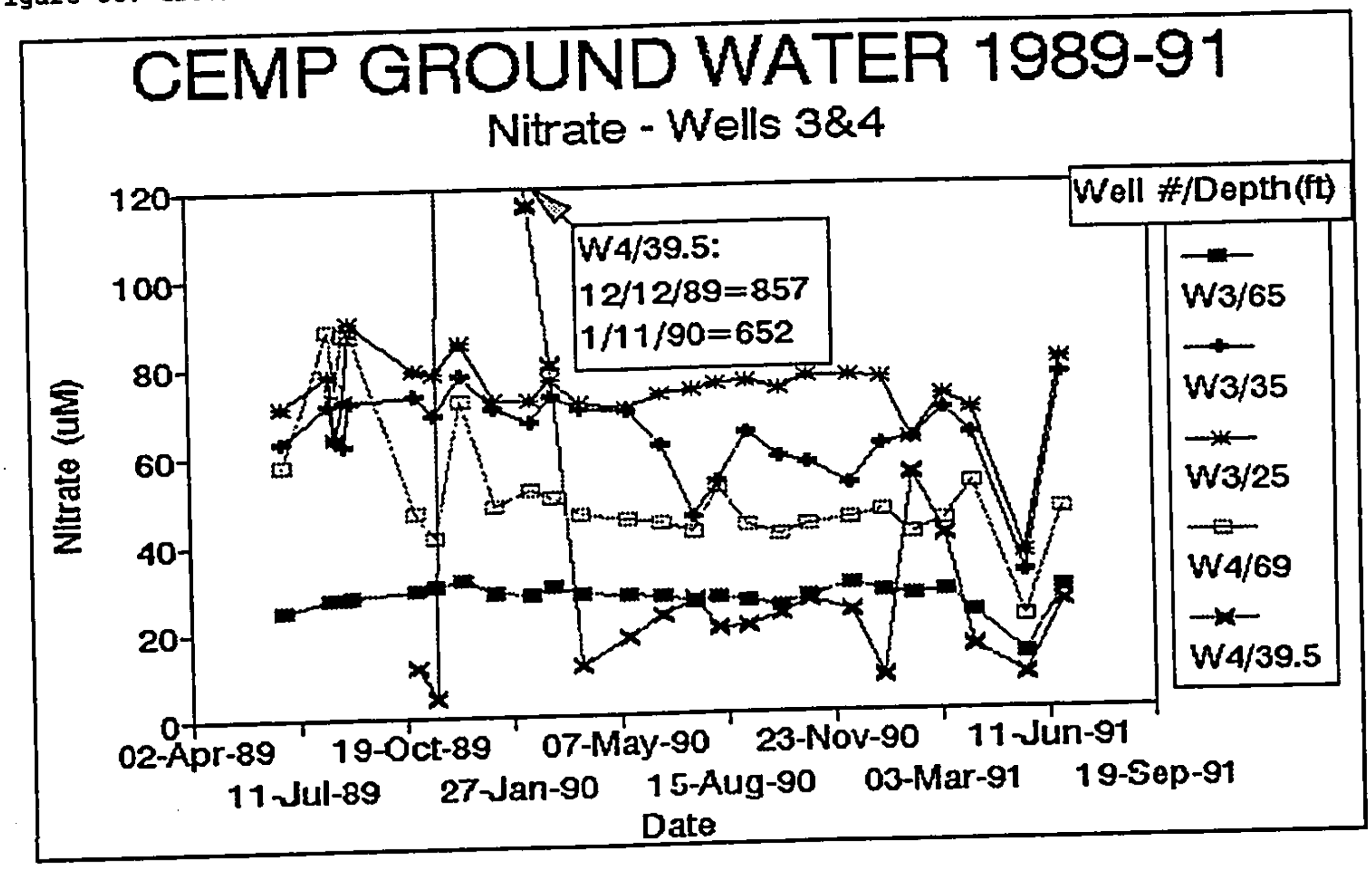


Figure 89. Groundwater Nitrate Enrichment: Wells 3 and 4

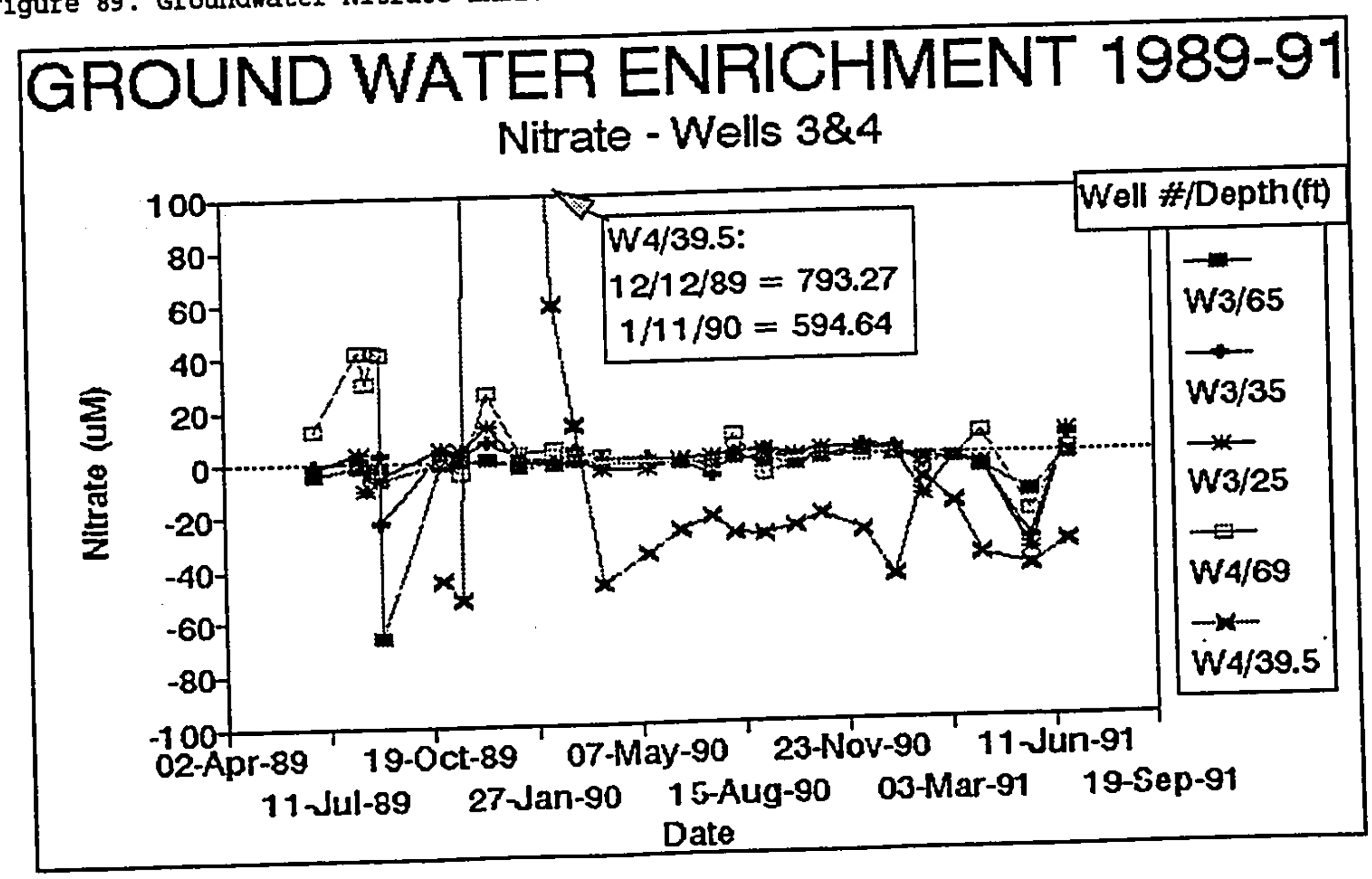


Figure 90. Groundwater Phosphate: Wells 3 and 4

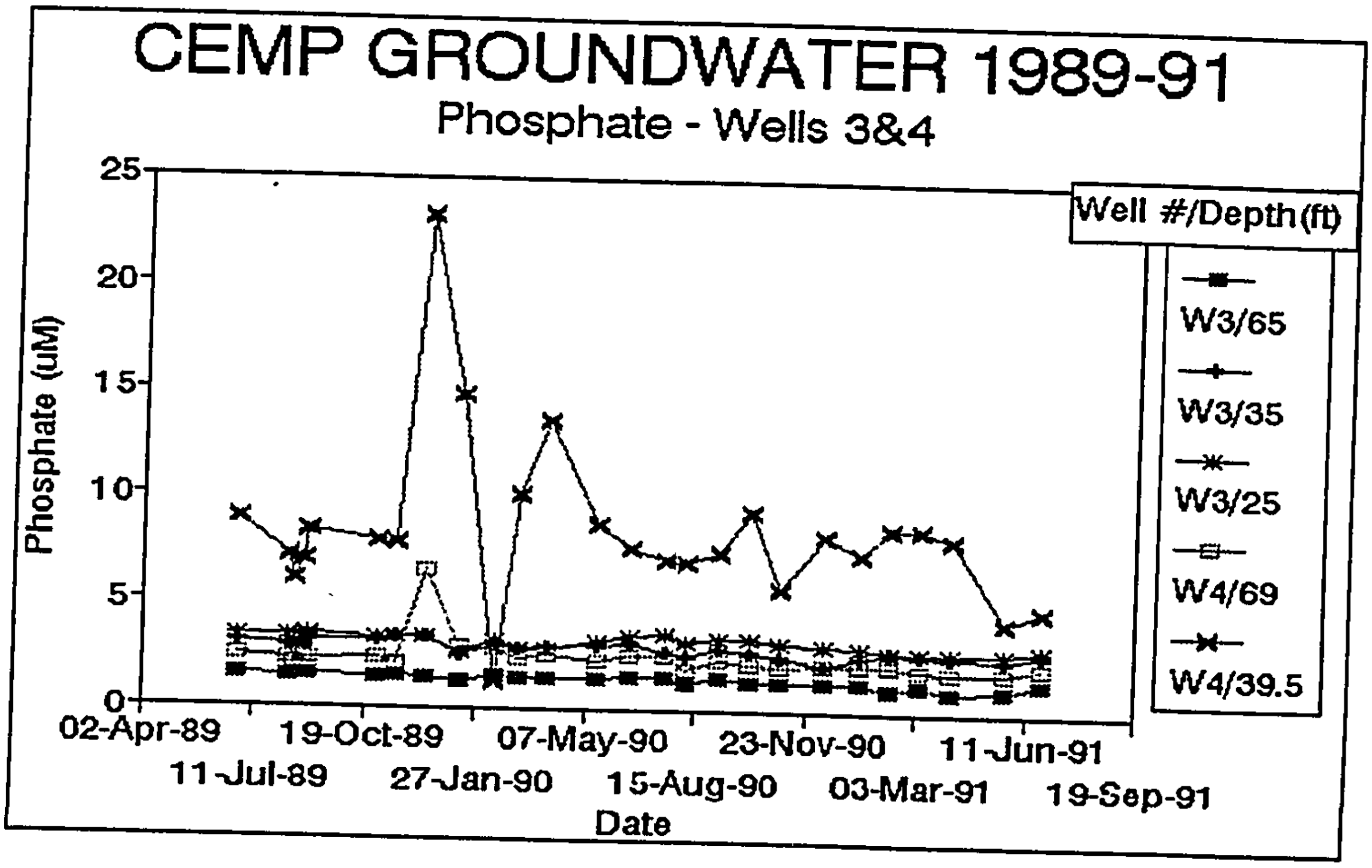


Figure 91. Groundwater Phosphate Enrichment: Wells 3 and 4

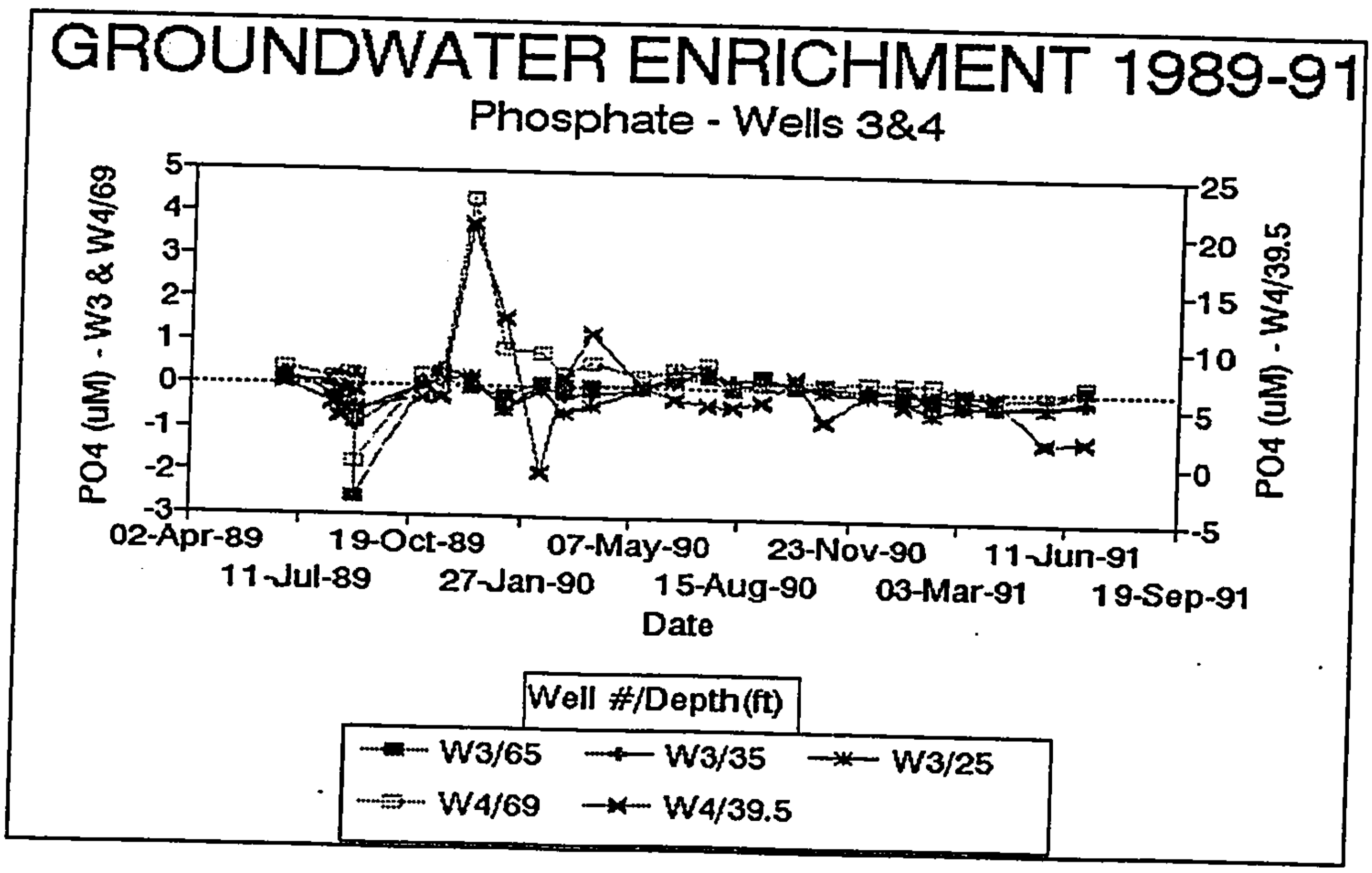


Figure 92. Groundwater Silicate: Wells 3 and 4

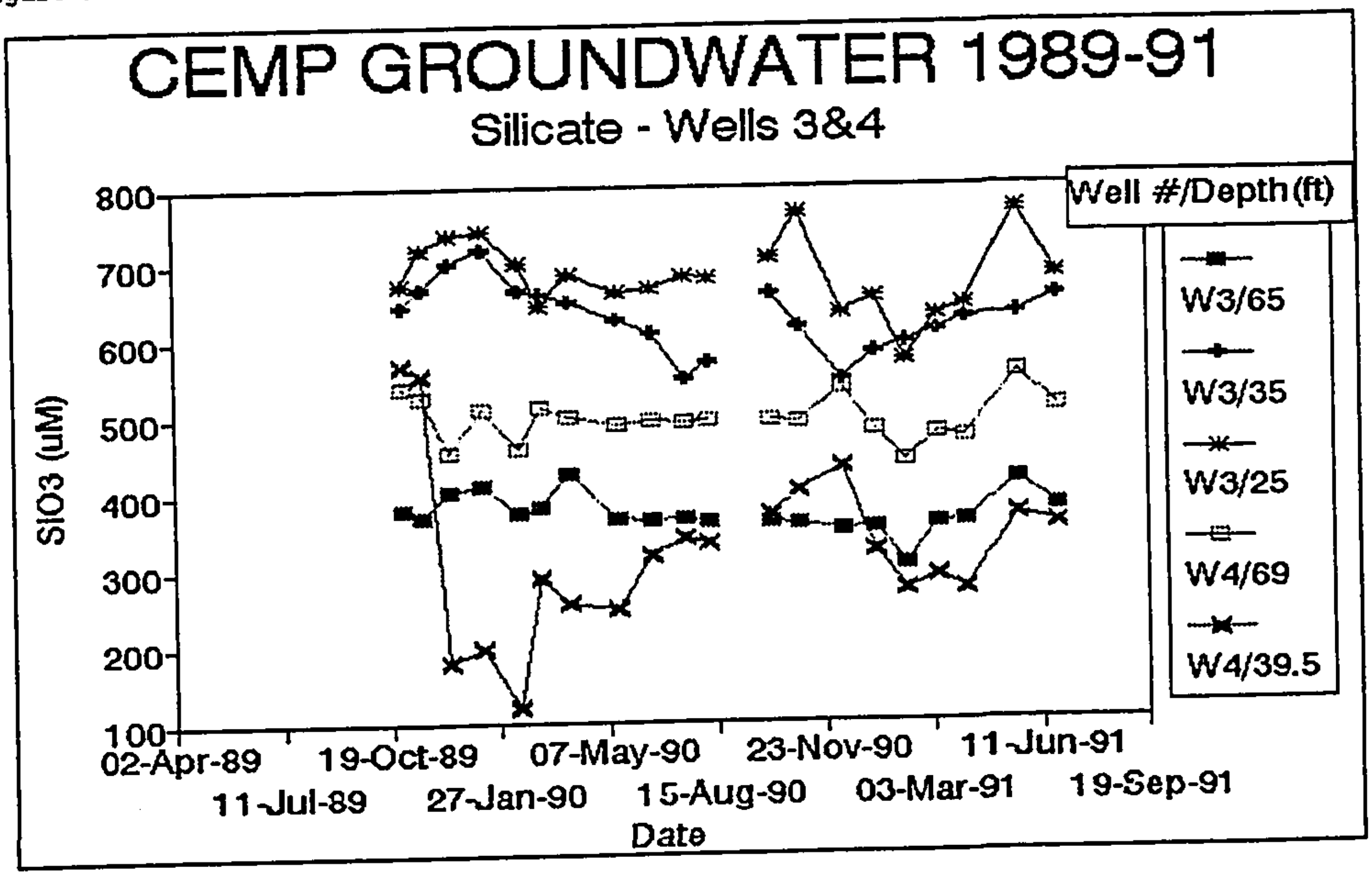


Figure 93. Groundwater Silicate Enrichment: Wells 3 and 4

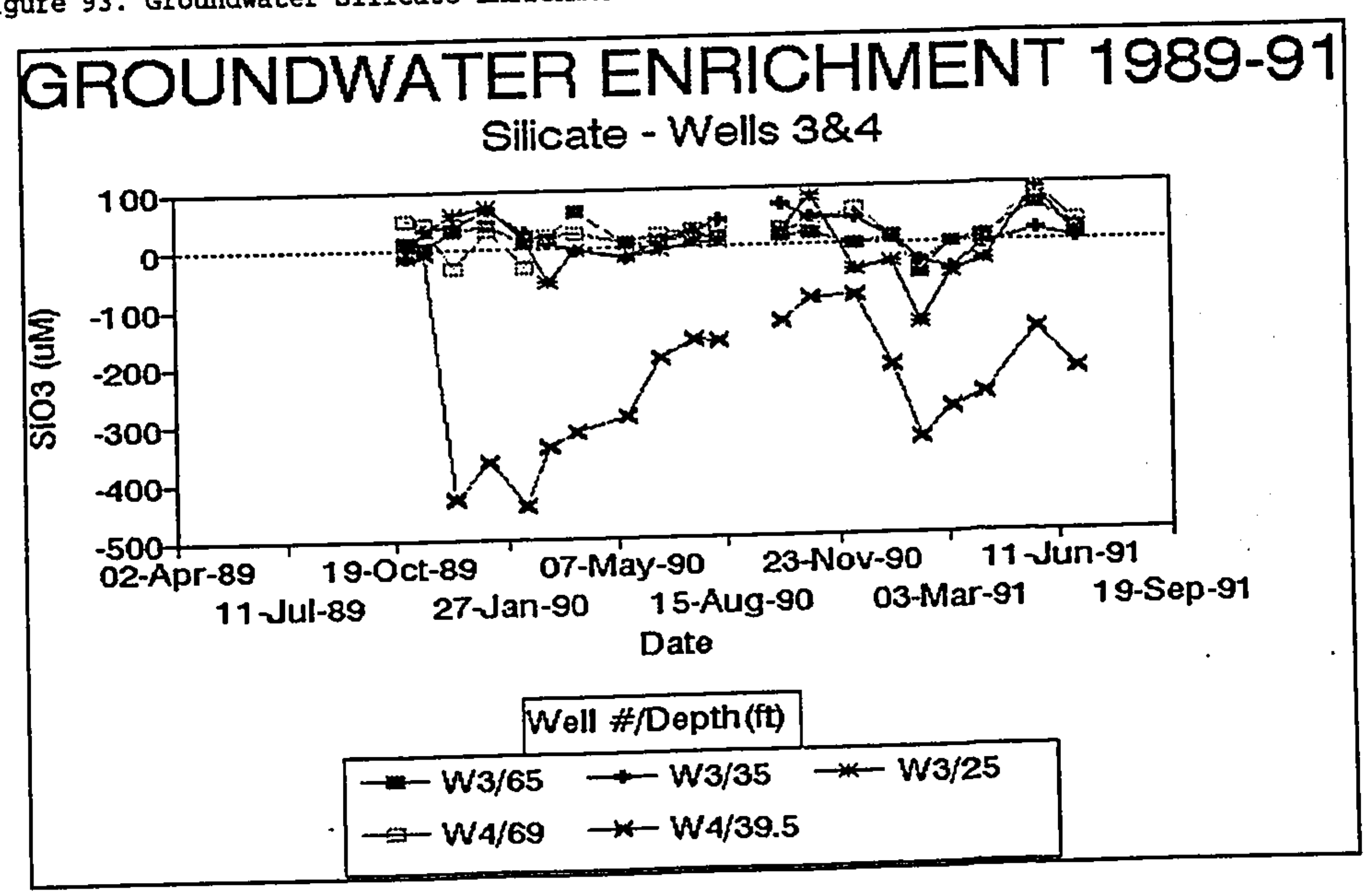


Figure 94. Groundwater Total Dissolved Nitrogen: Wells 3 and 4

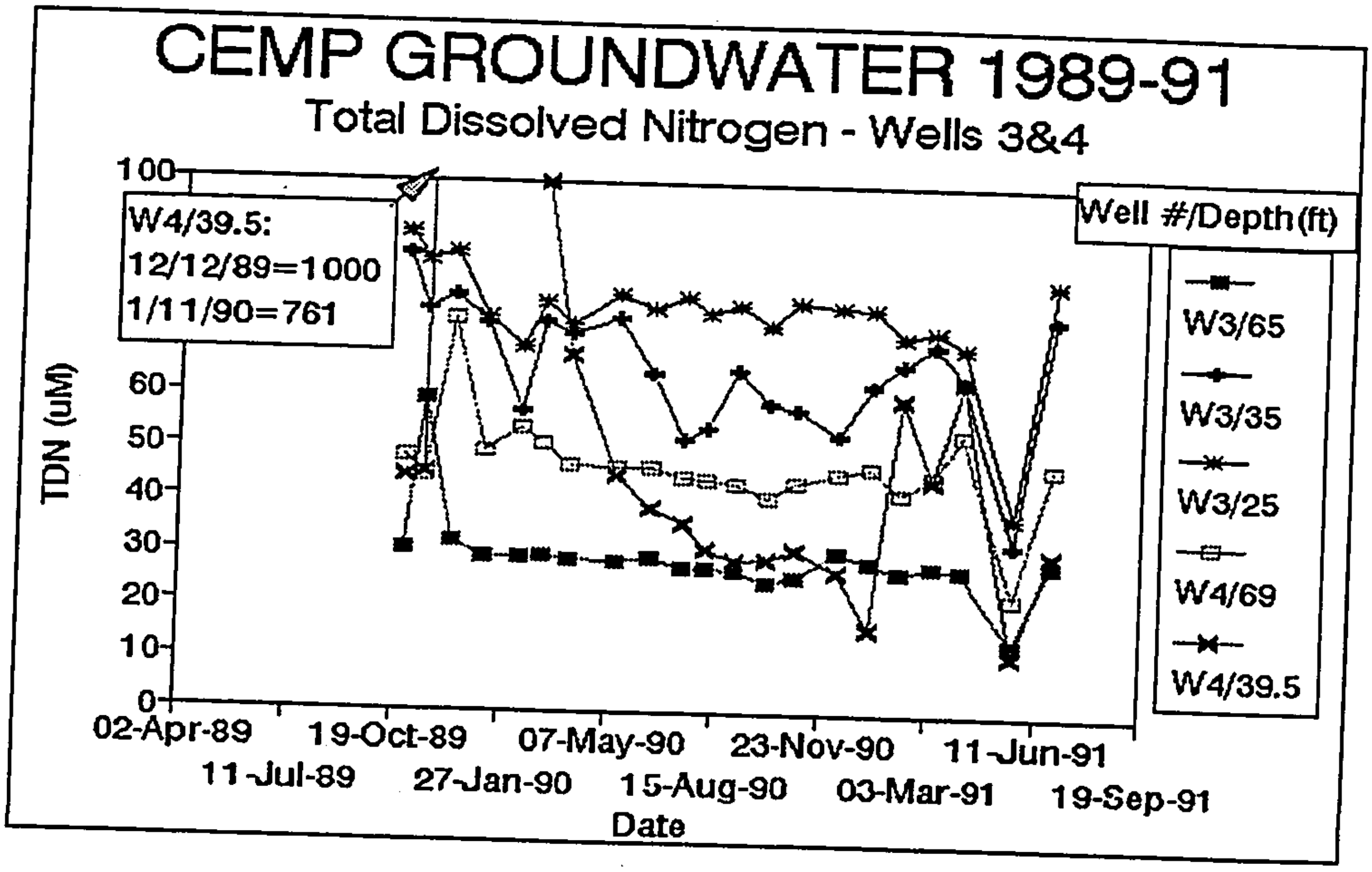


Figure 95. Groundwater Total Dissolved Nitrogen Enrichment: Wells 3&4

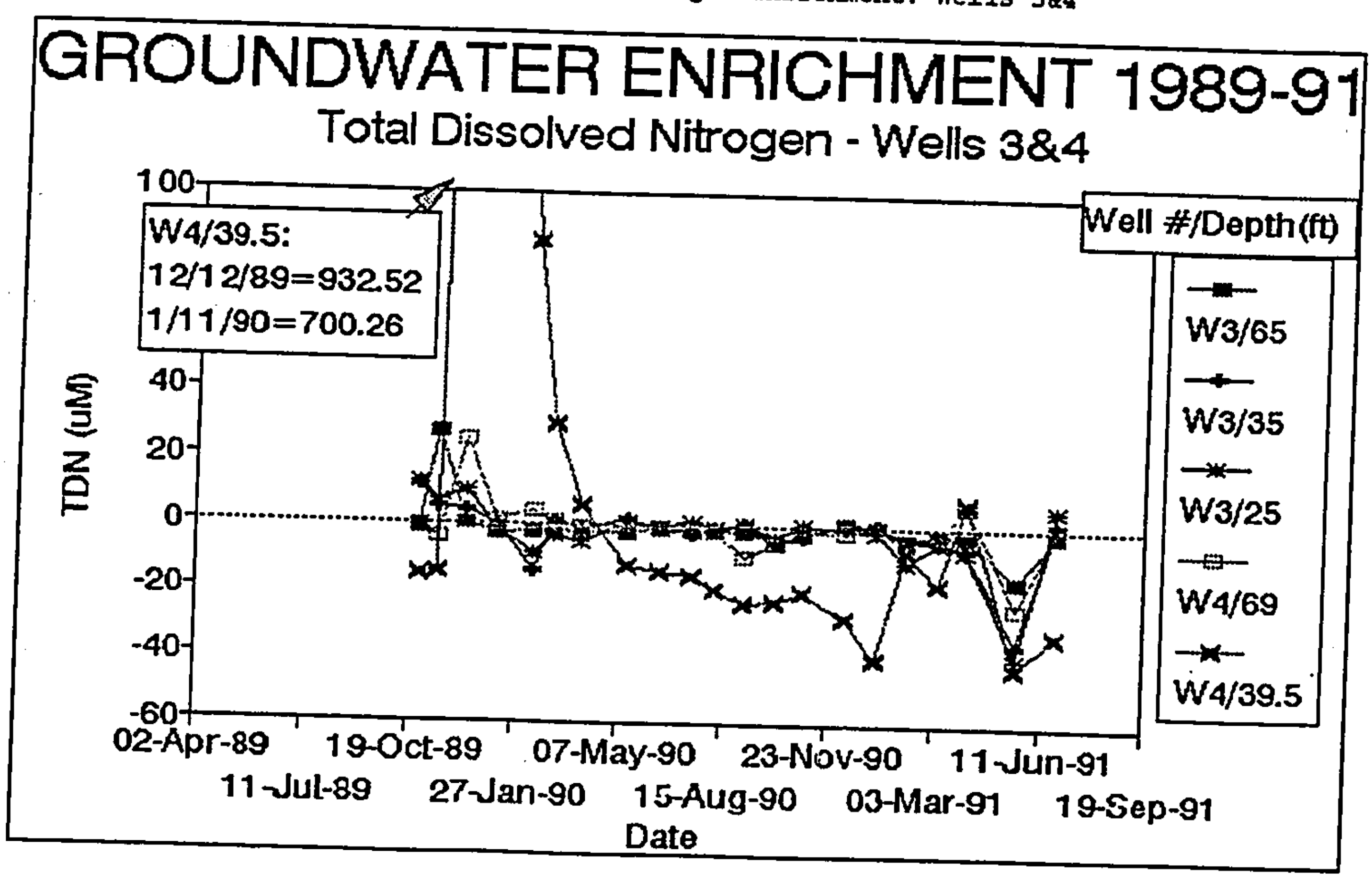


Figure 96. Groundwater Total Dissolved Phosphorous: Wells 3 and 4

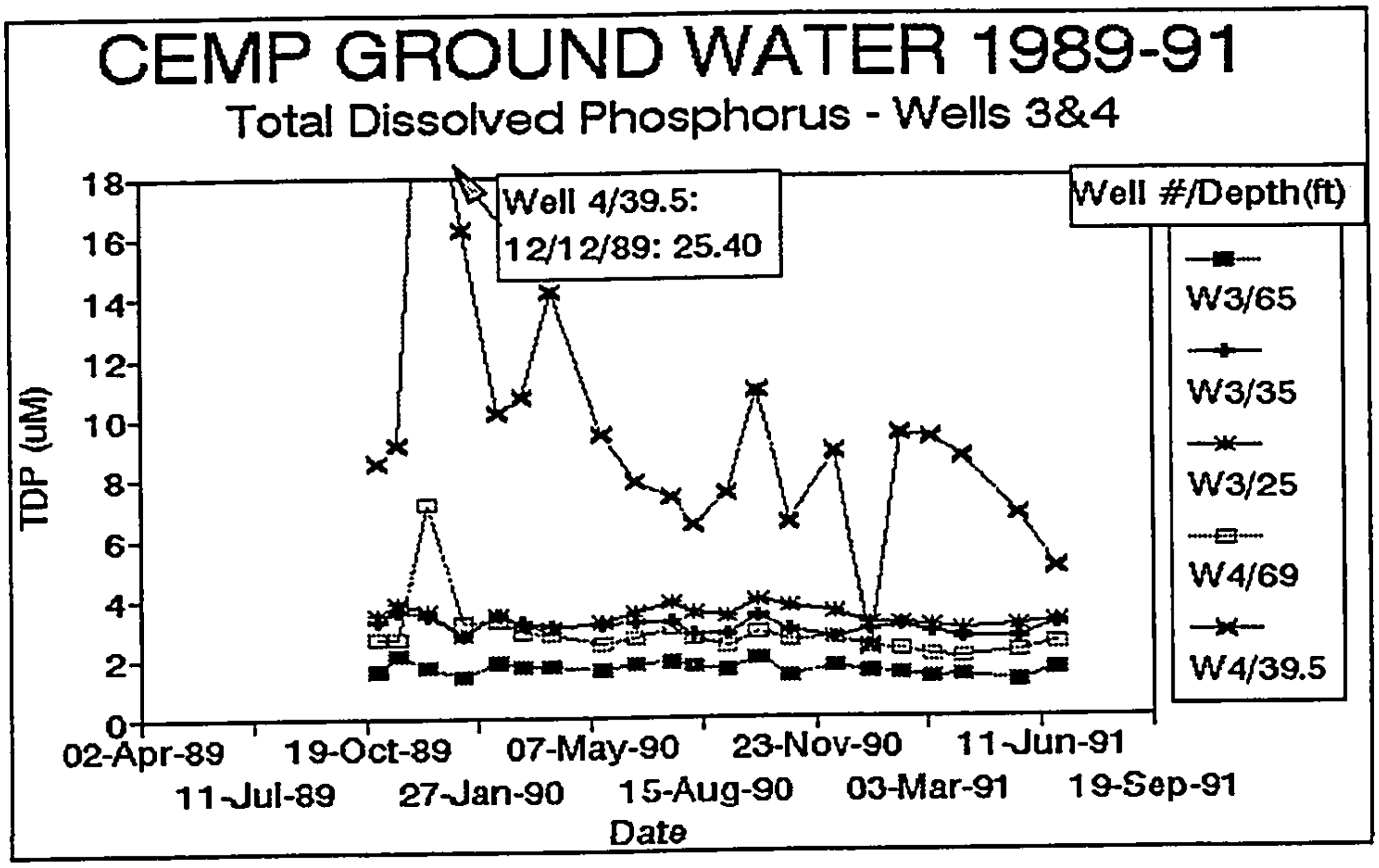


Figure 97. Groundwater Total Dissolved Phosphorous Enrichment: Wells 3&4

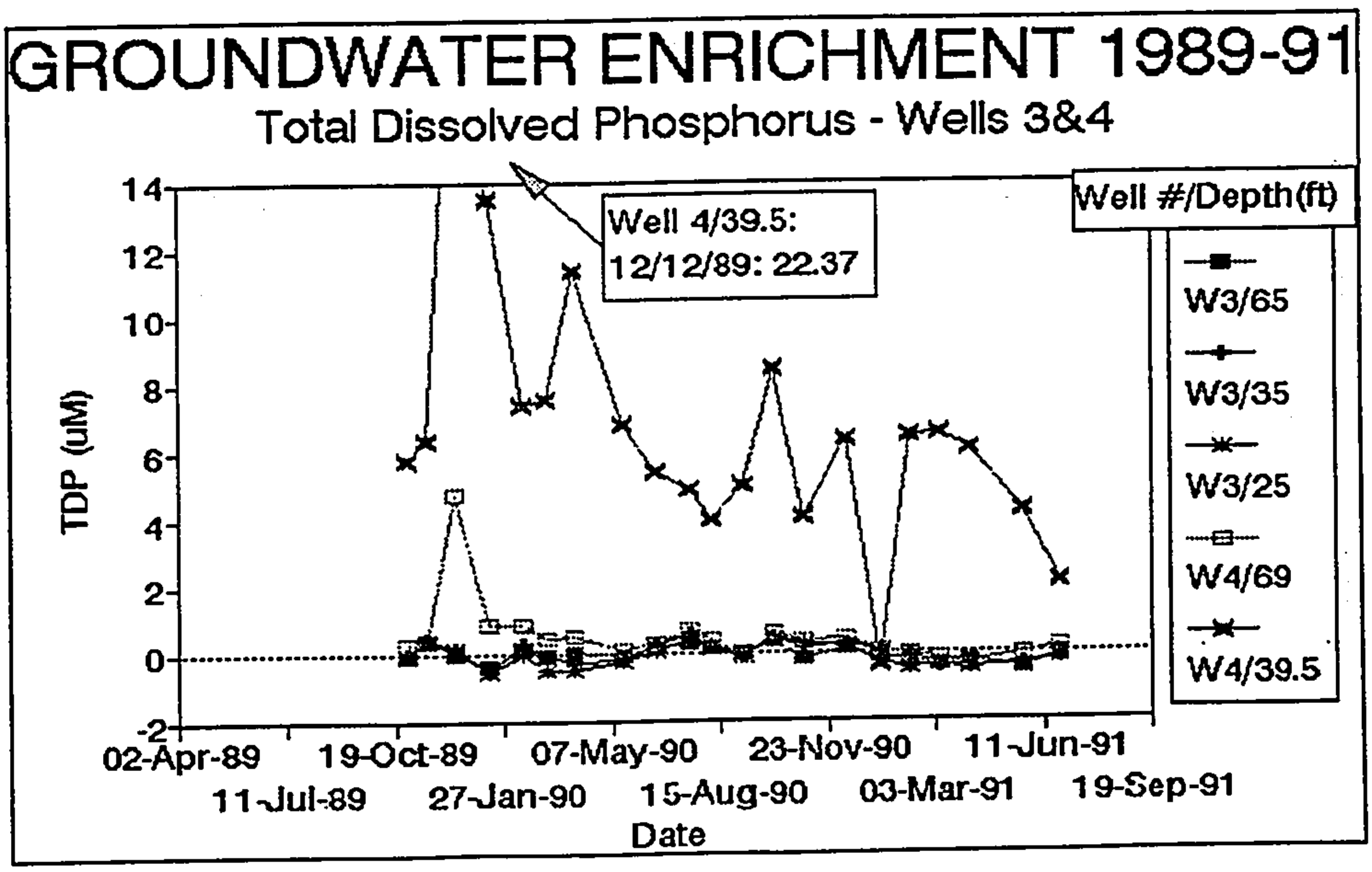


Figure 98. Groundwater Total Organic Carbon: Wells 3 and 4

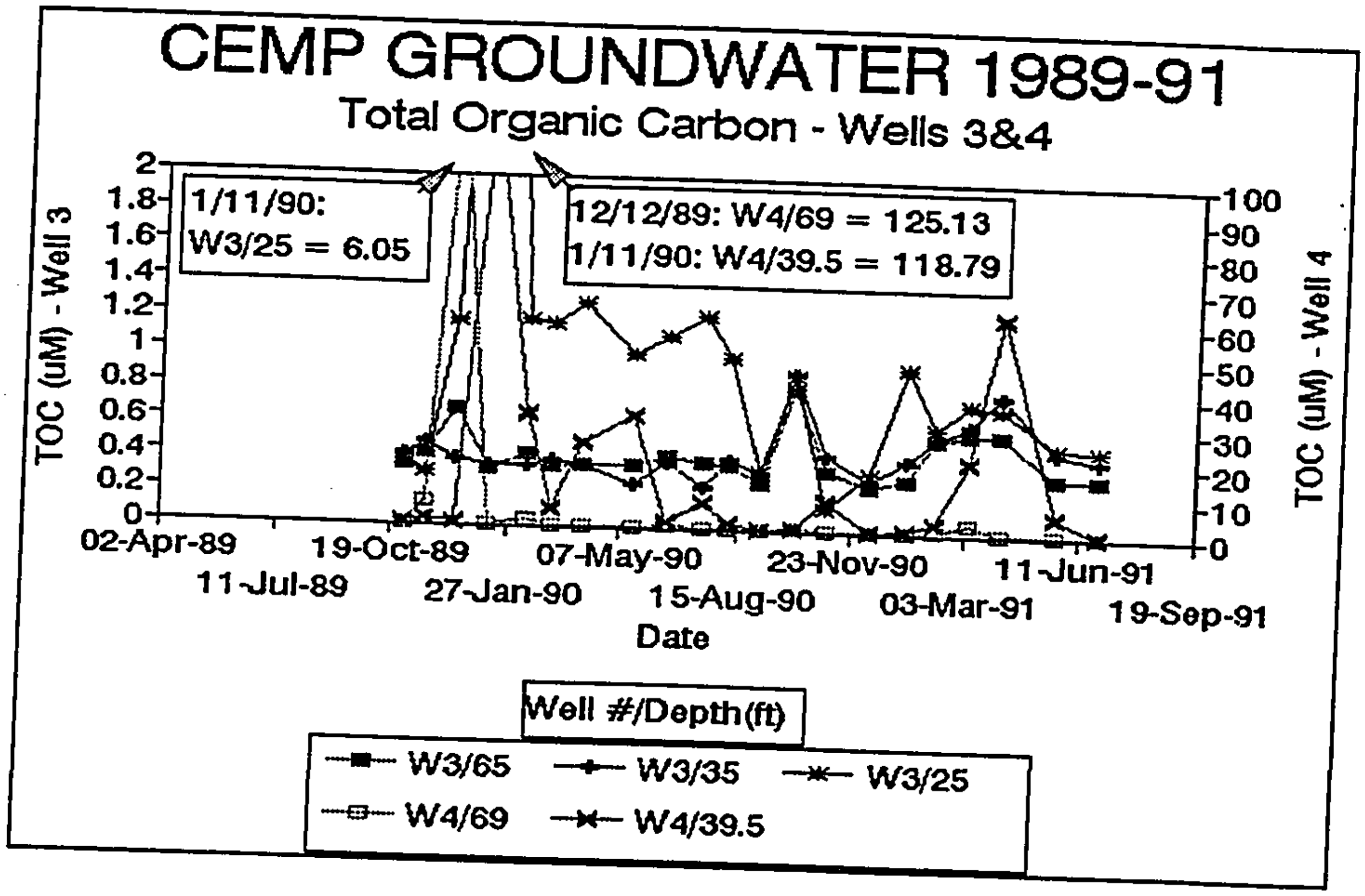


Figure 99. Groundwater Total Organic Carbon Enrichment: Wells 3&4

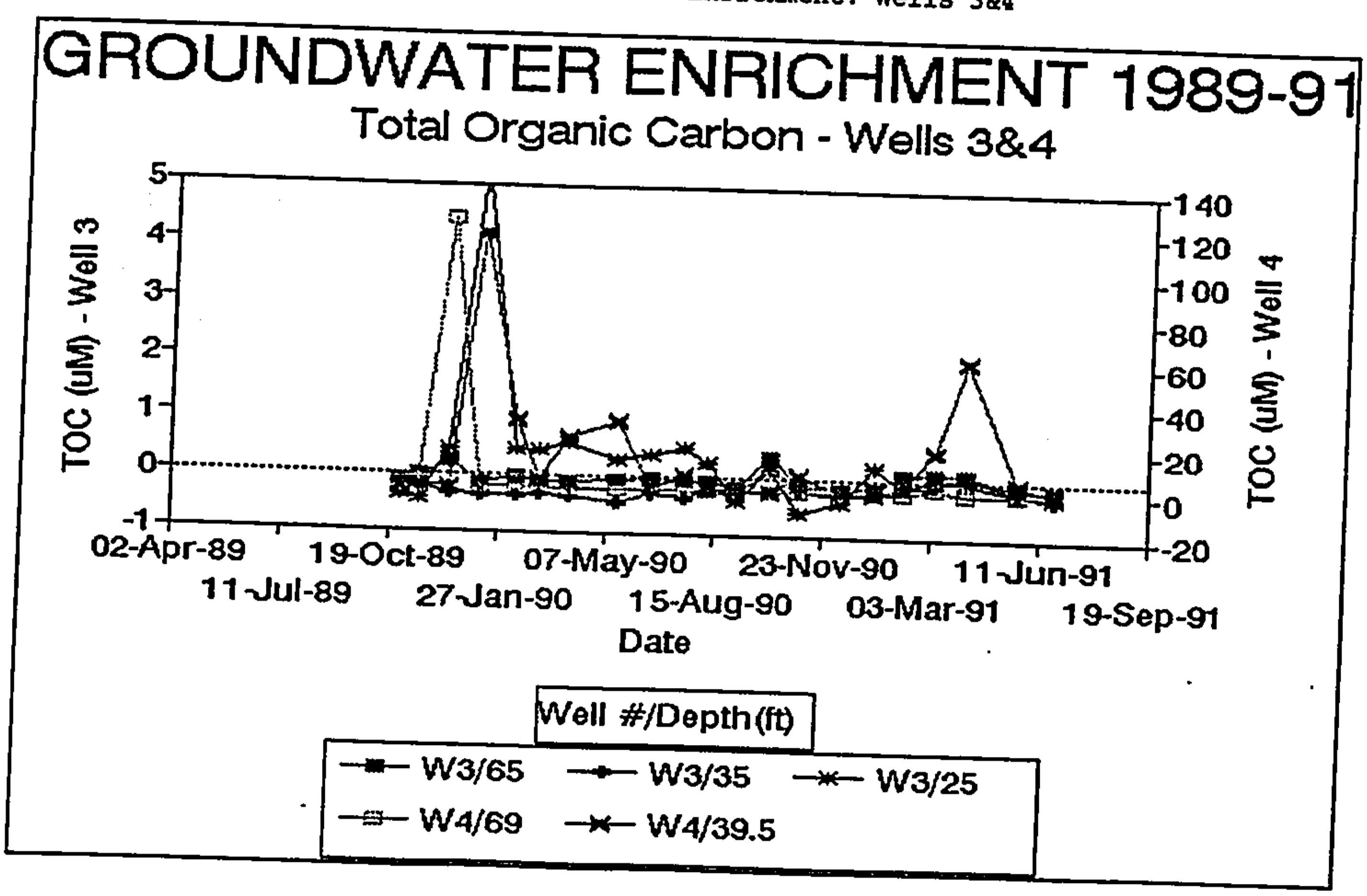


Figure 100. Groundwater Ammonium: Wells 3 and 4

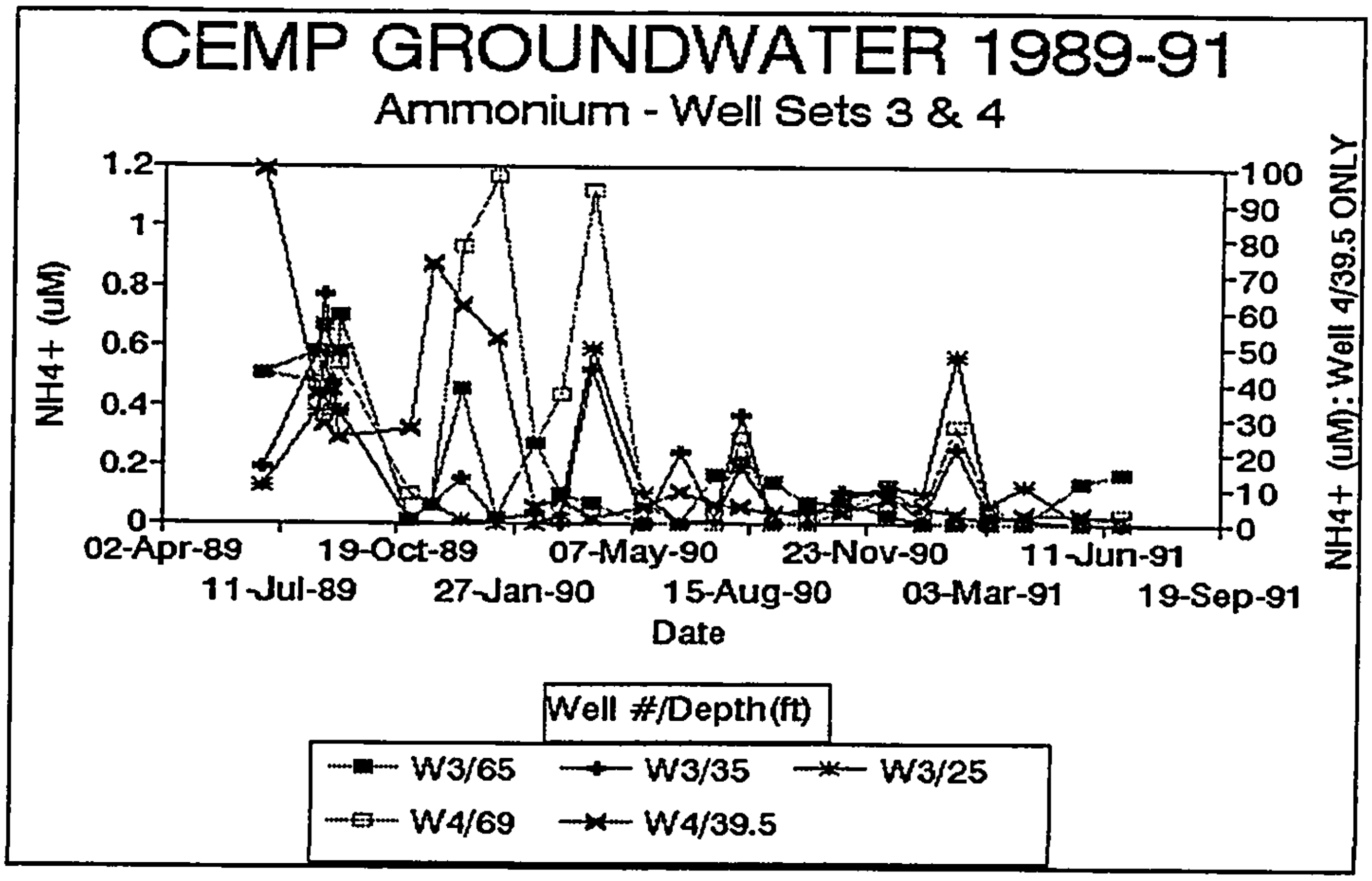


Figure 101. Groundwater Ammonium: Wells 5 and 6

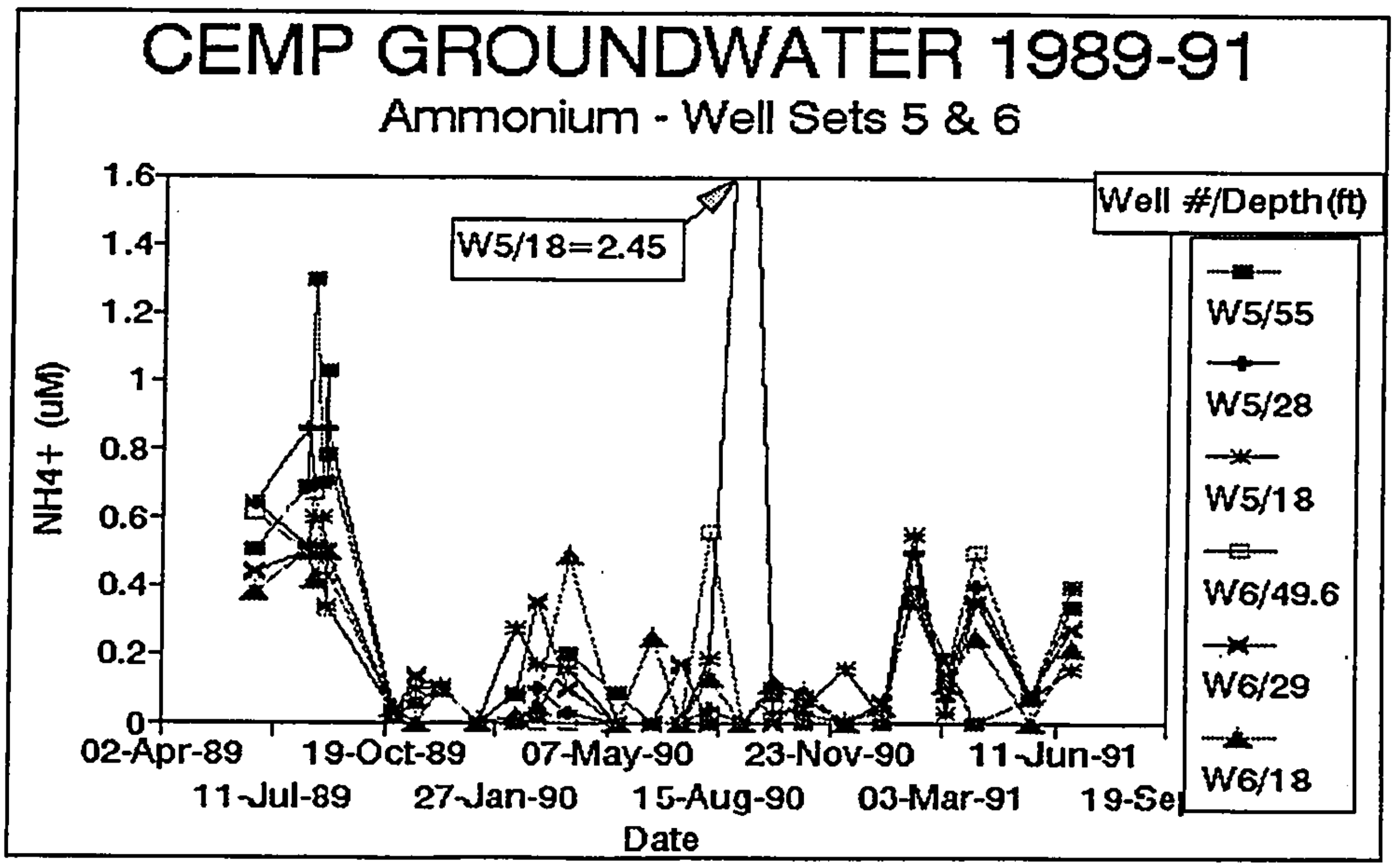


Figure 102. Groundwater Temperature: Wells 5 and 6

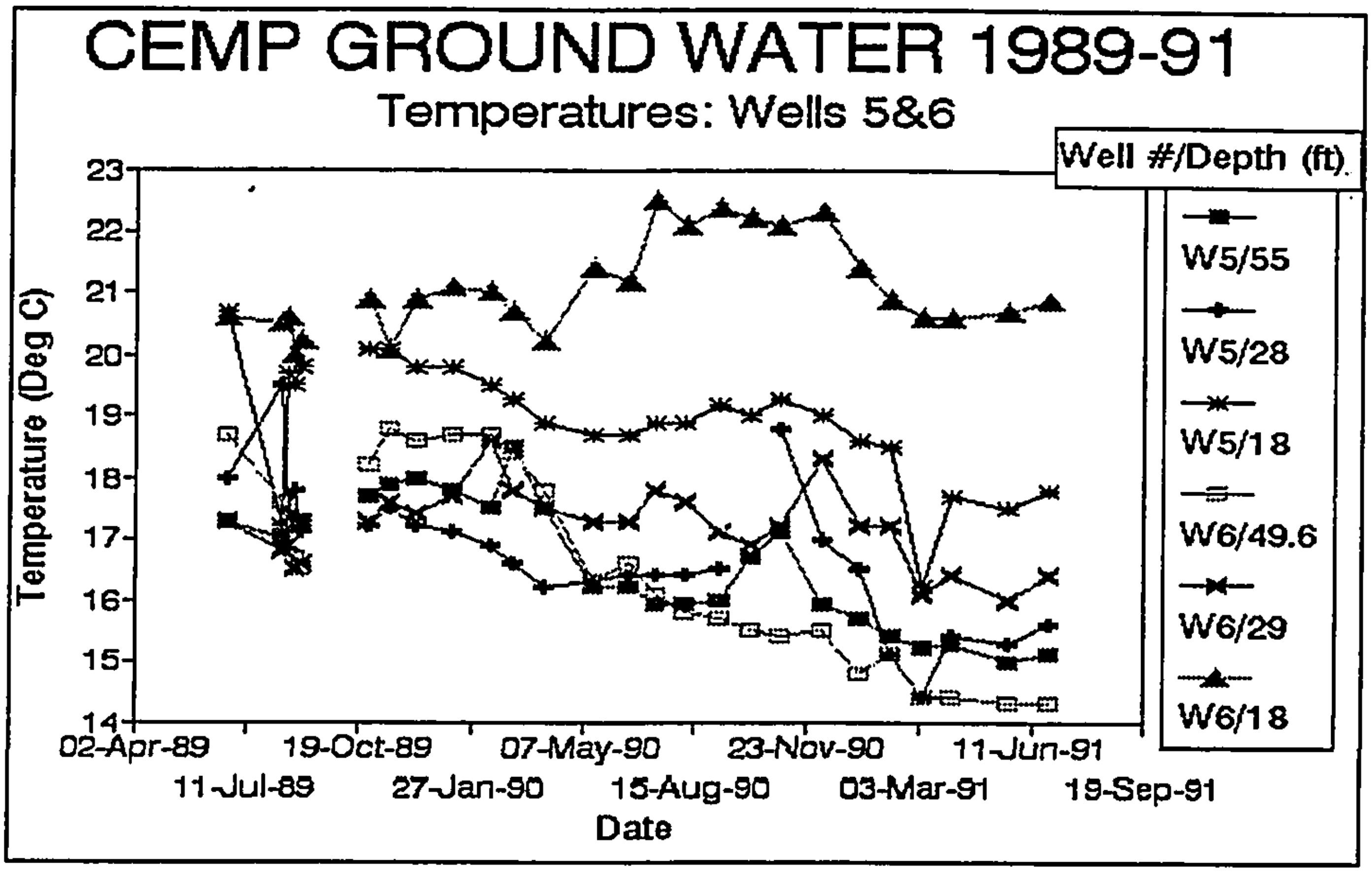


Figure 103. Groundwater Salinity: Wells 5 and 6

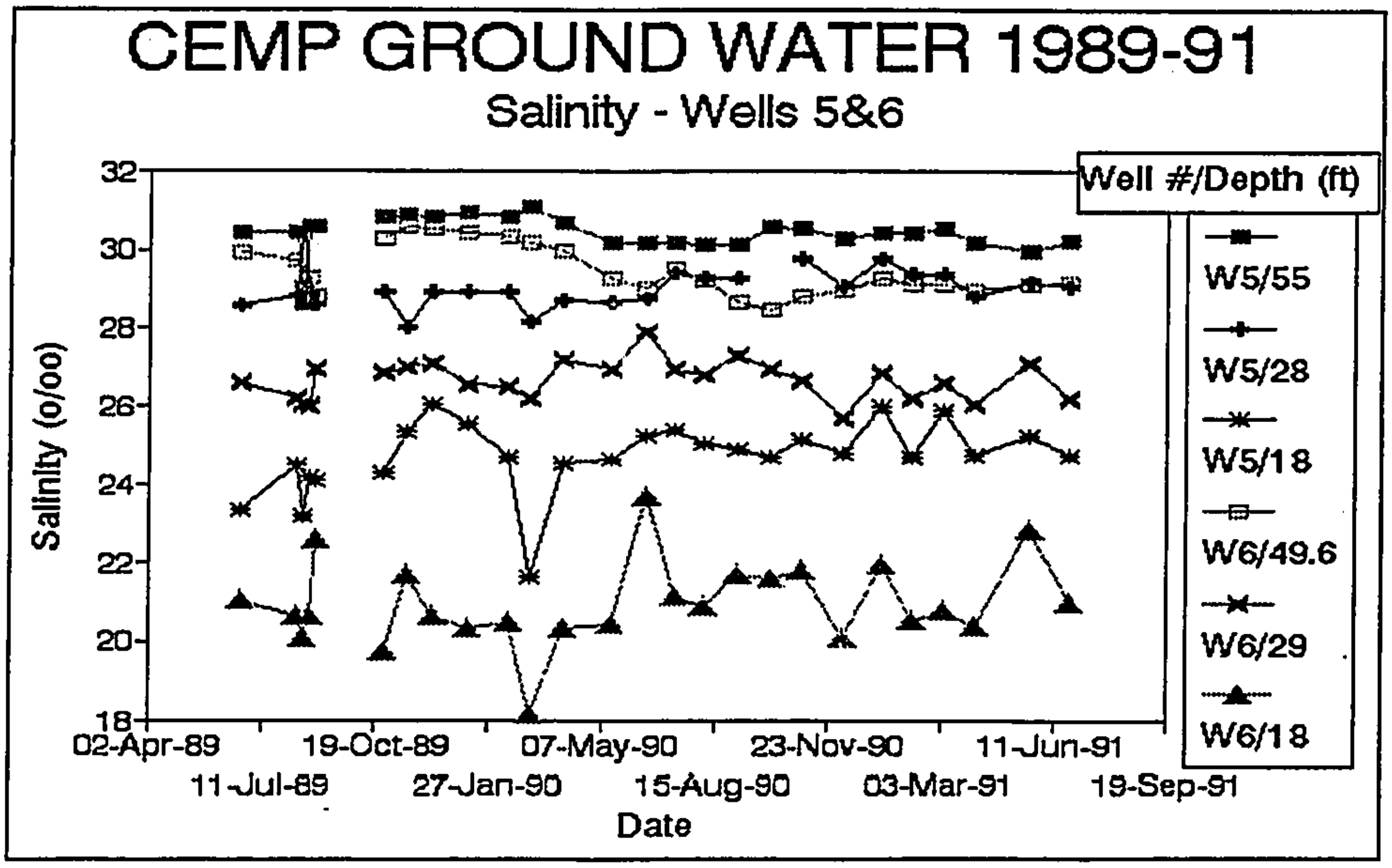


Figure 104. Groundwater pH: Wells 5 and 6

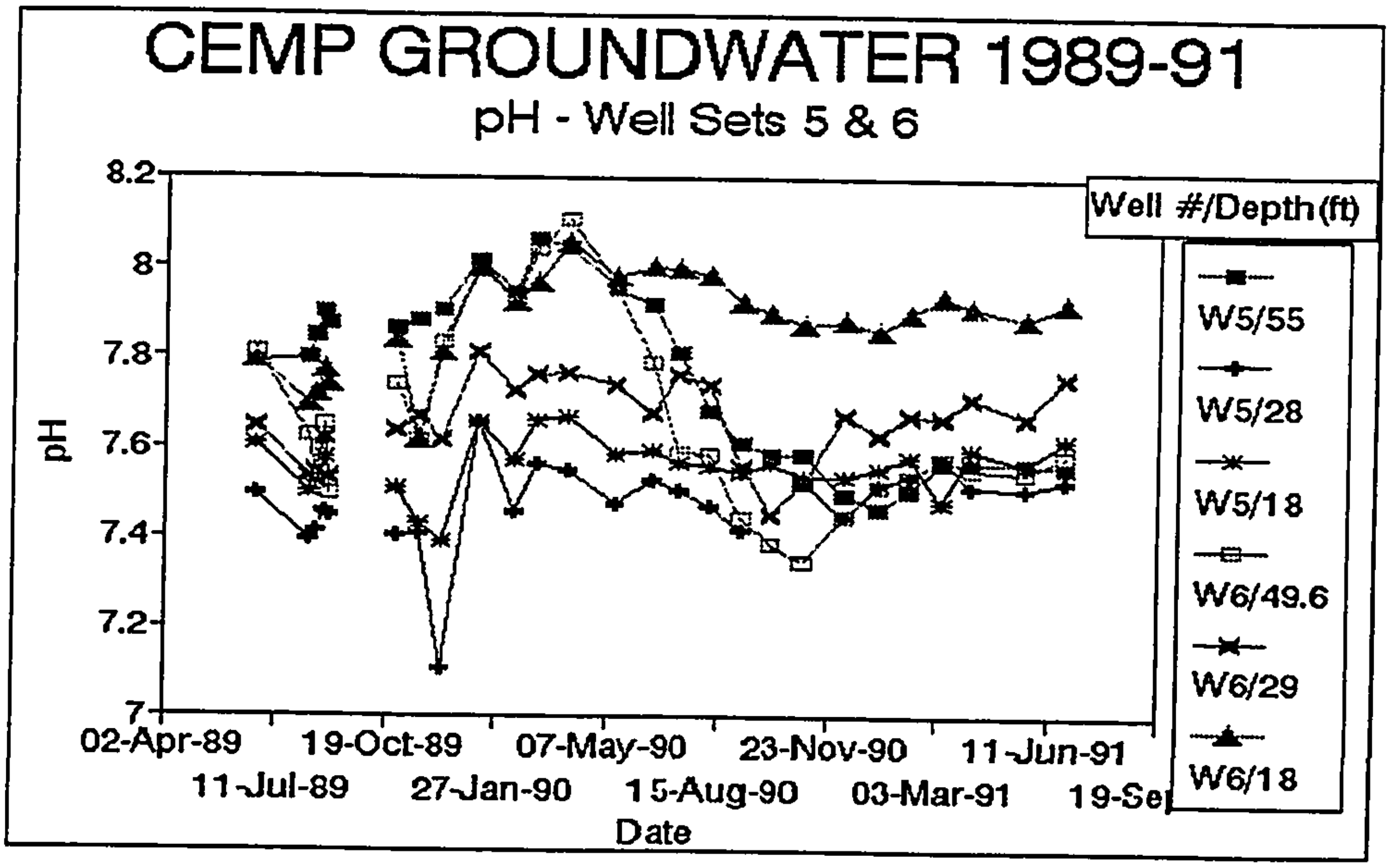


Figure 105. Groundwater Dissolved Oxygen: Wells 5 and 6

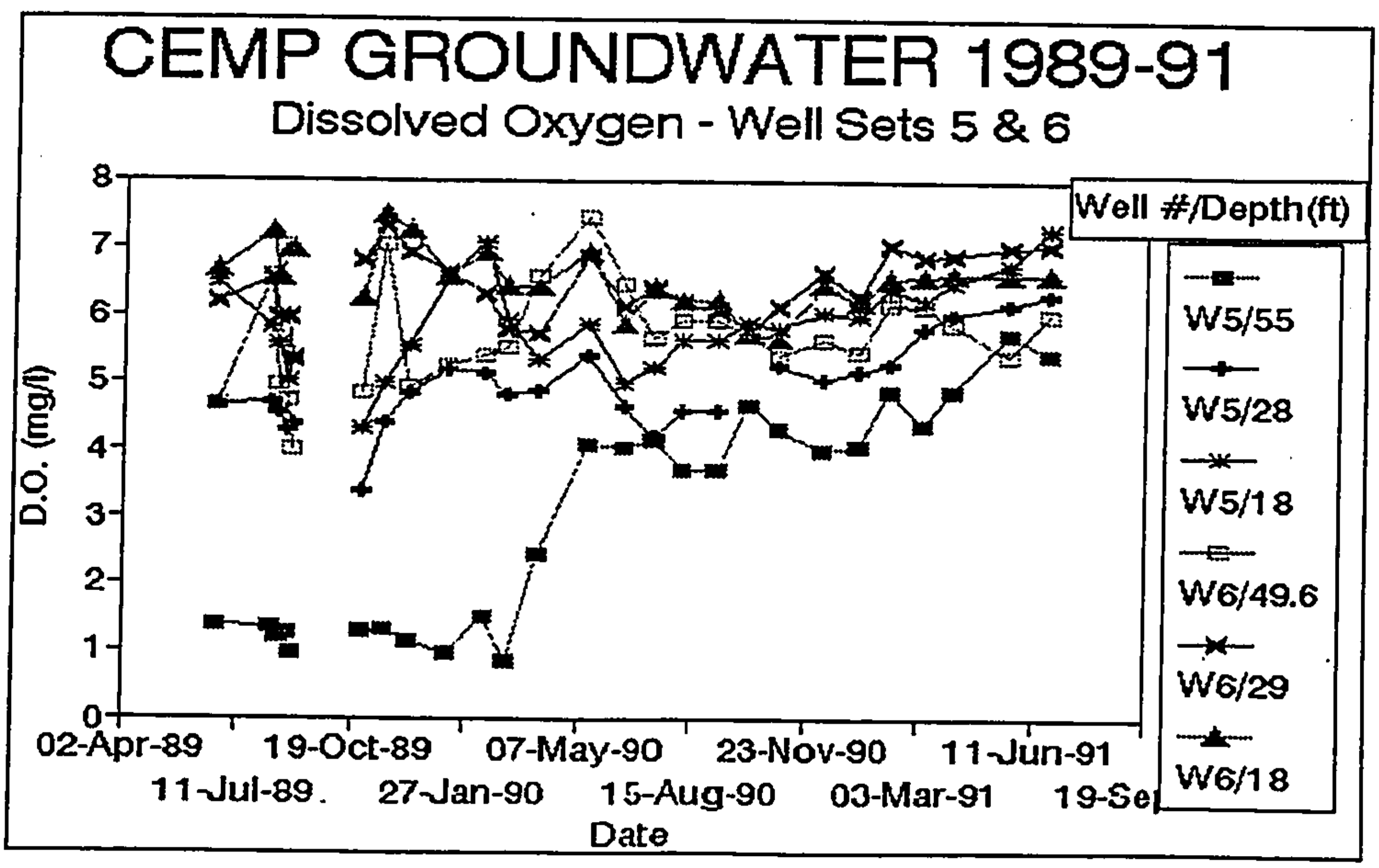


Figure 106. Groundwater Nitrate: Wells 5 and 6

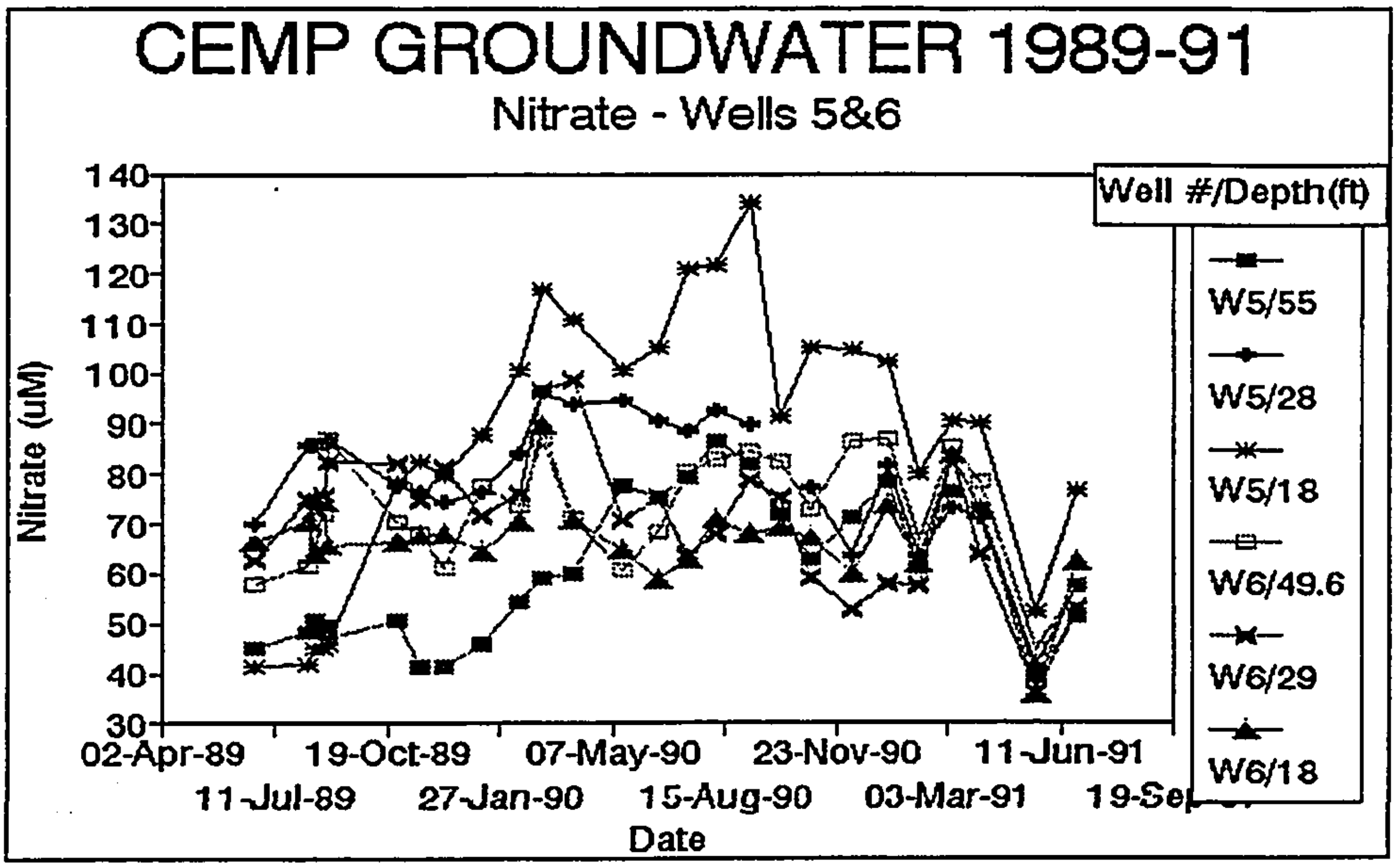


Figure 107. Groundwater Nitrate Enrichment: Wells 5 and 6

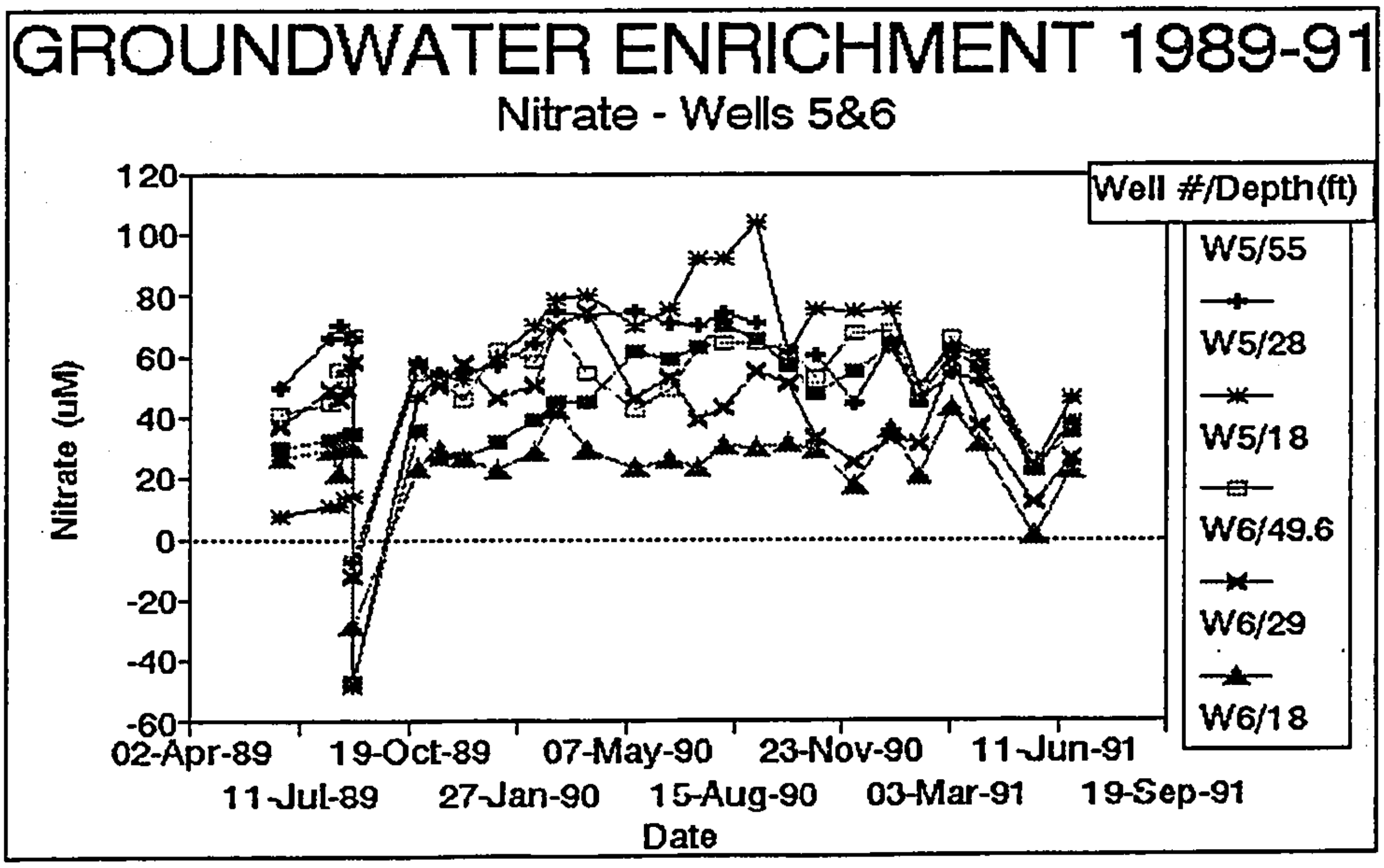


Figure 108. Groundwater Phosphate: Wells 5 and 6

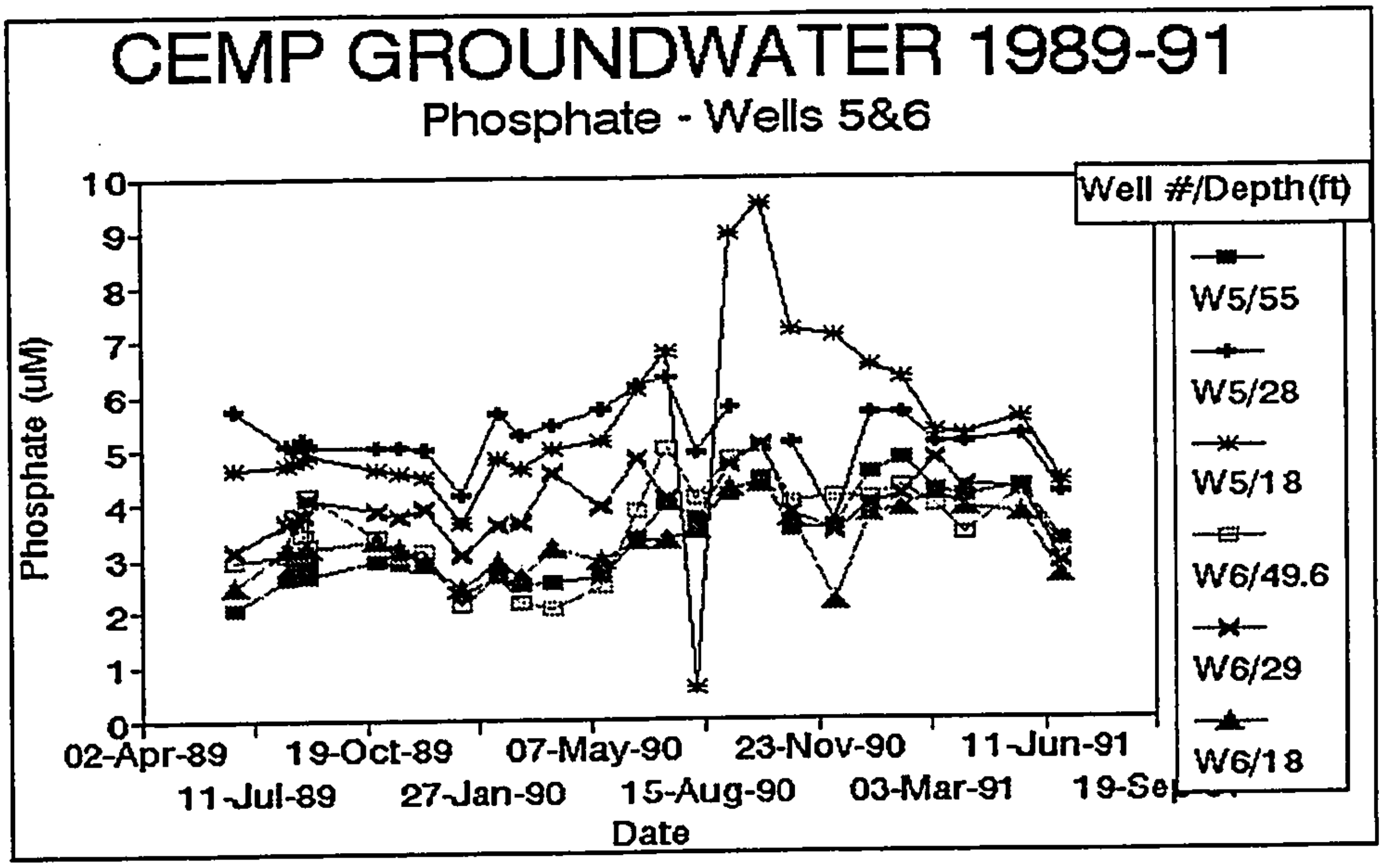


Figure 109. Groundwater Phosphate Enrichment: Wells 5 and 6

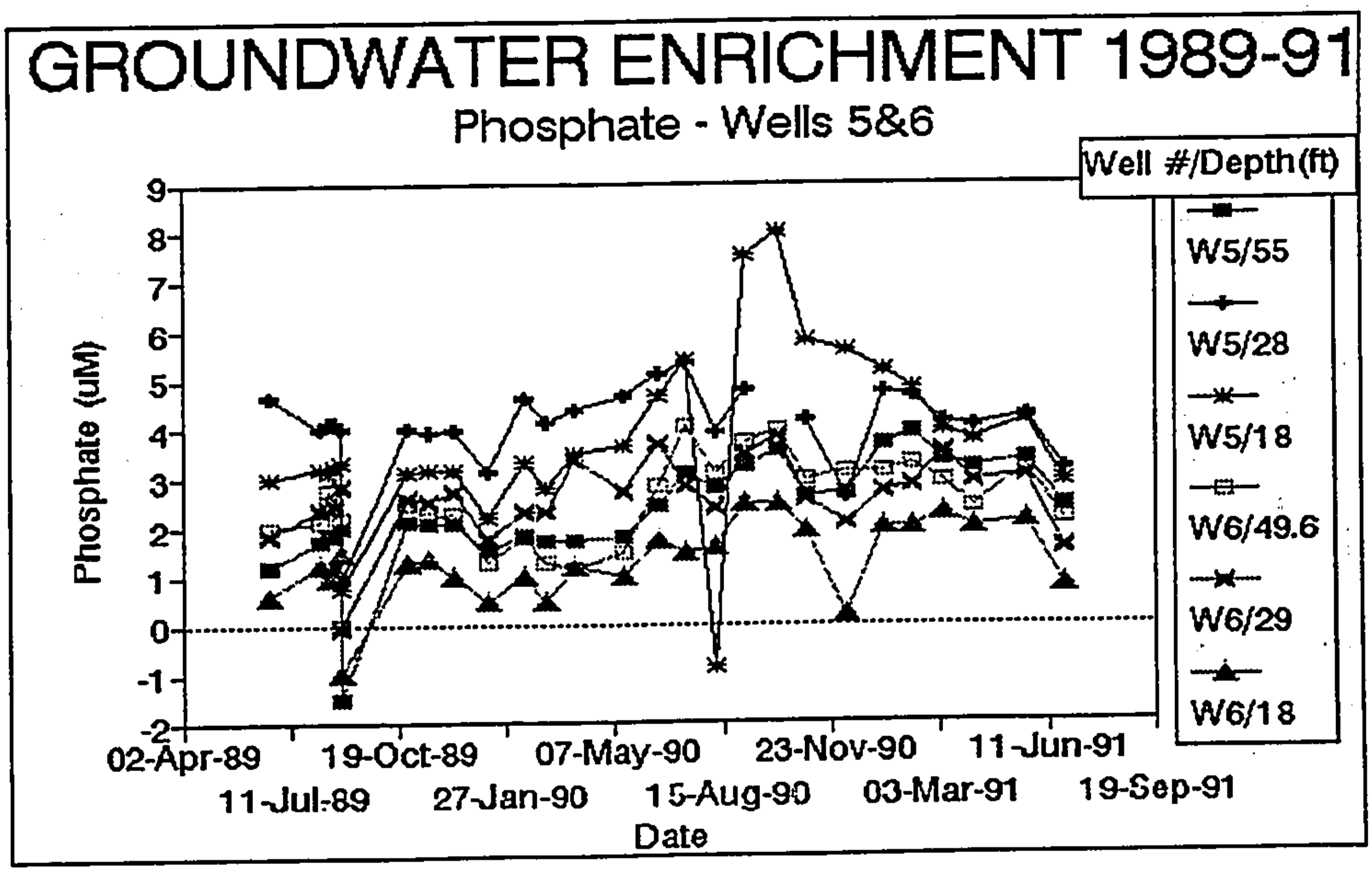


Figure 110. Groundwater Silicate: Wells 5 and 6

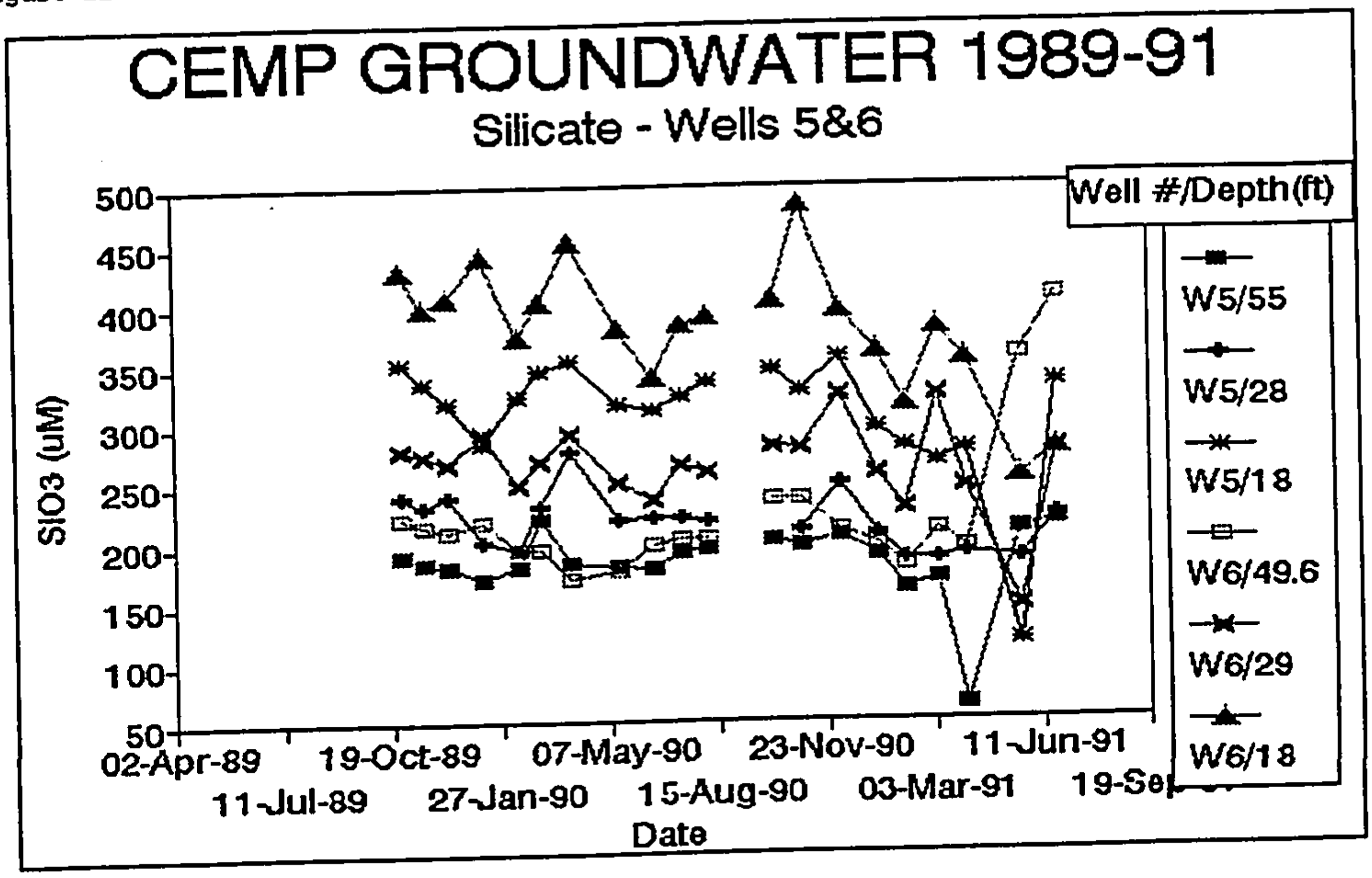


Figure 111. Groundwater Silicate Enrichment: Wells 5 and 6

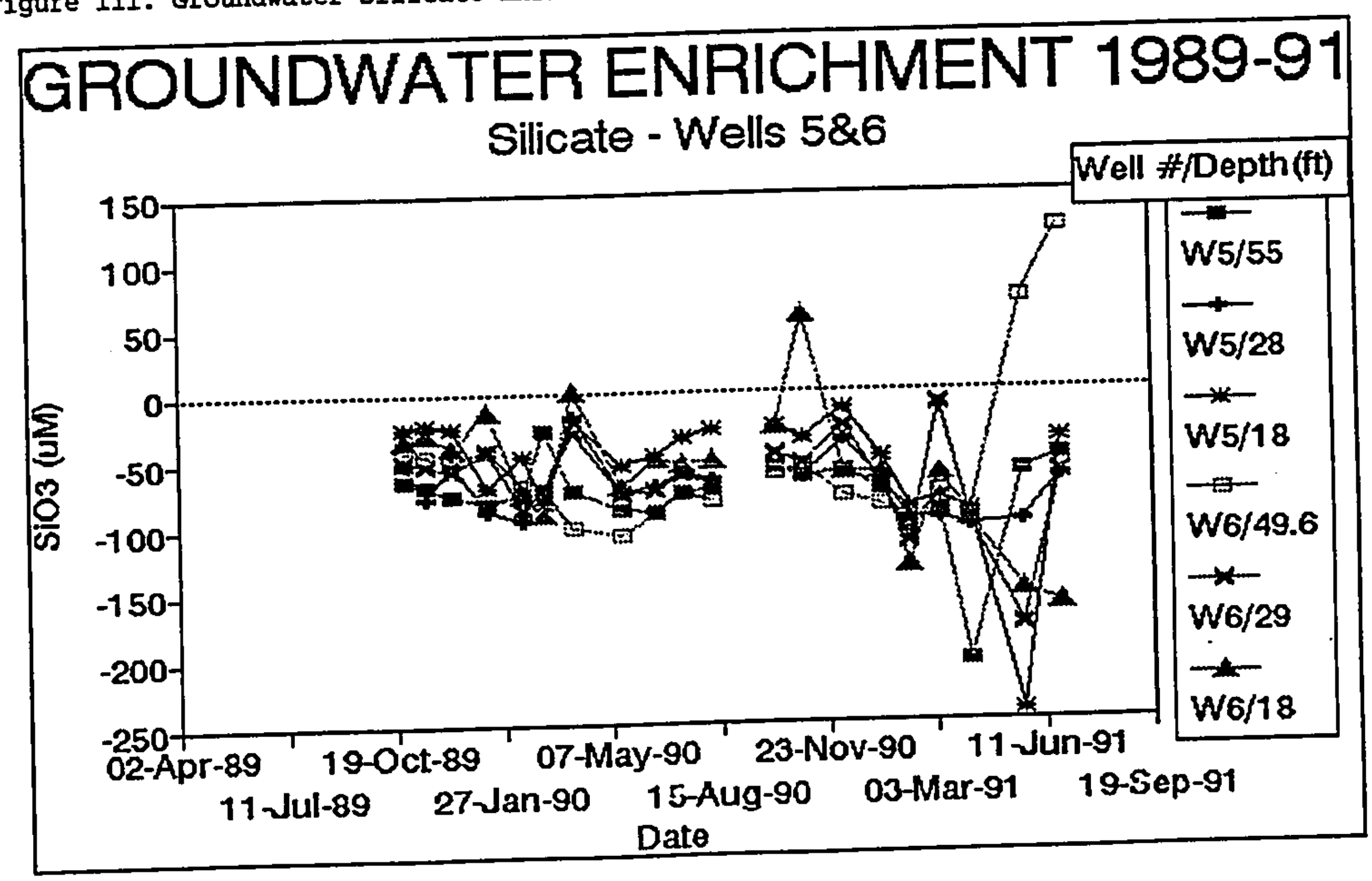


Figure 112. Groundwater Total Dissolved Nitrogen: Wells 5 and 6

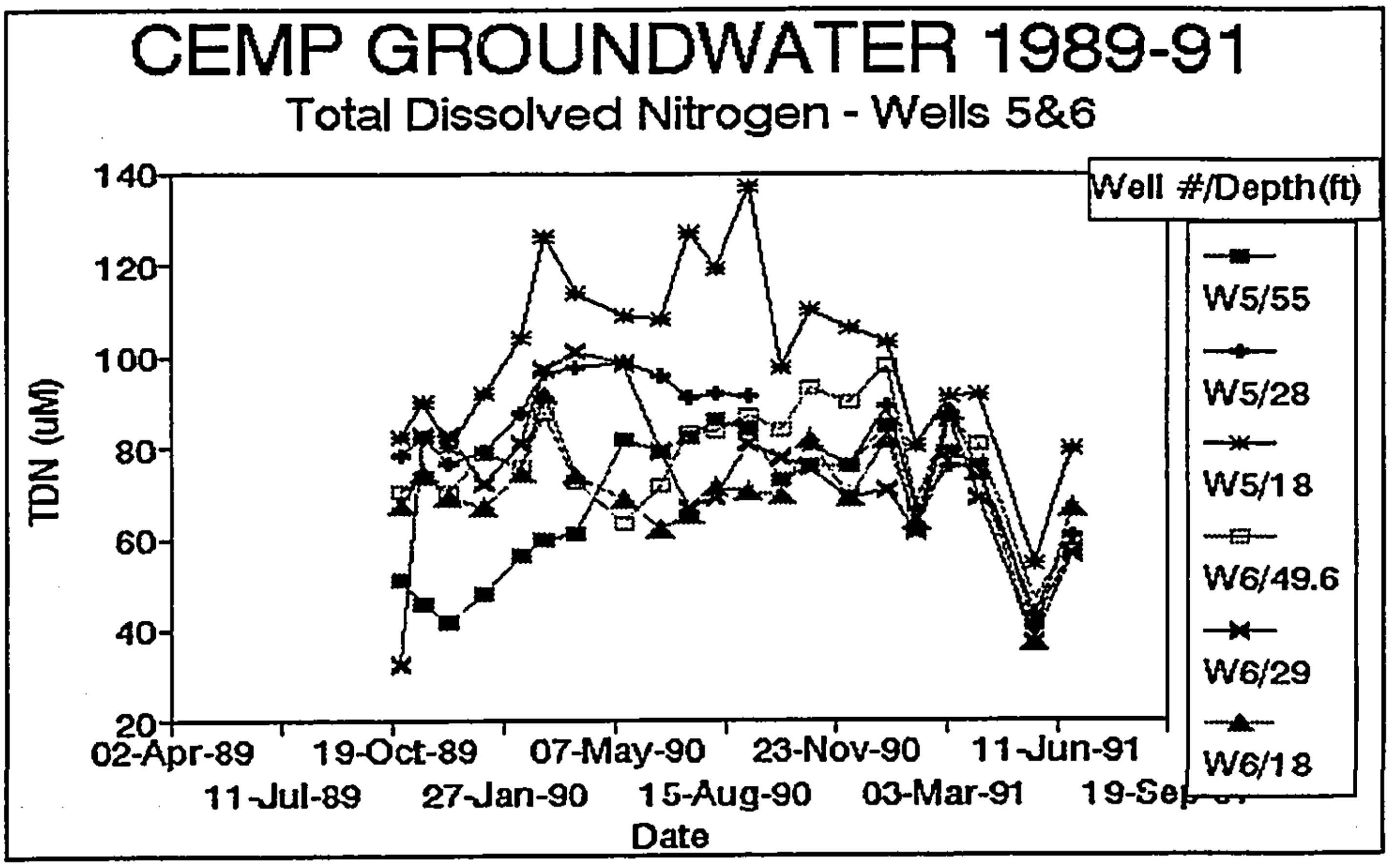


Figure 113. Groundwater Total Dissolved Nitrogen Enrichment: Wells 5&6

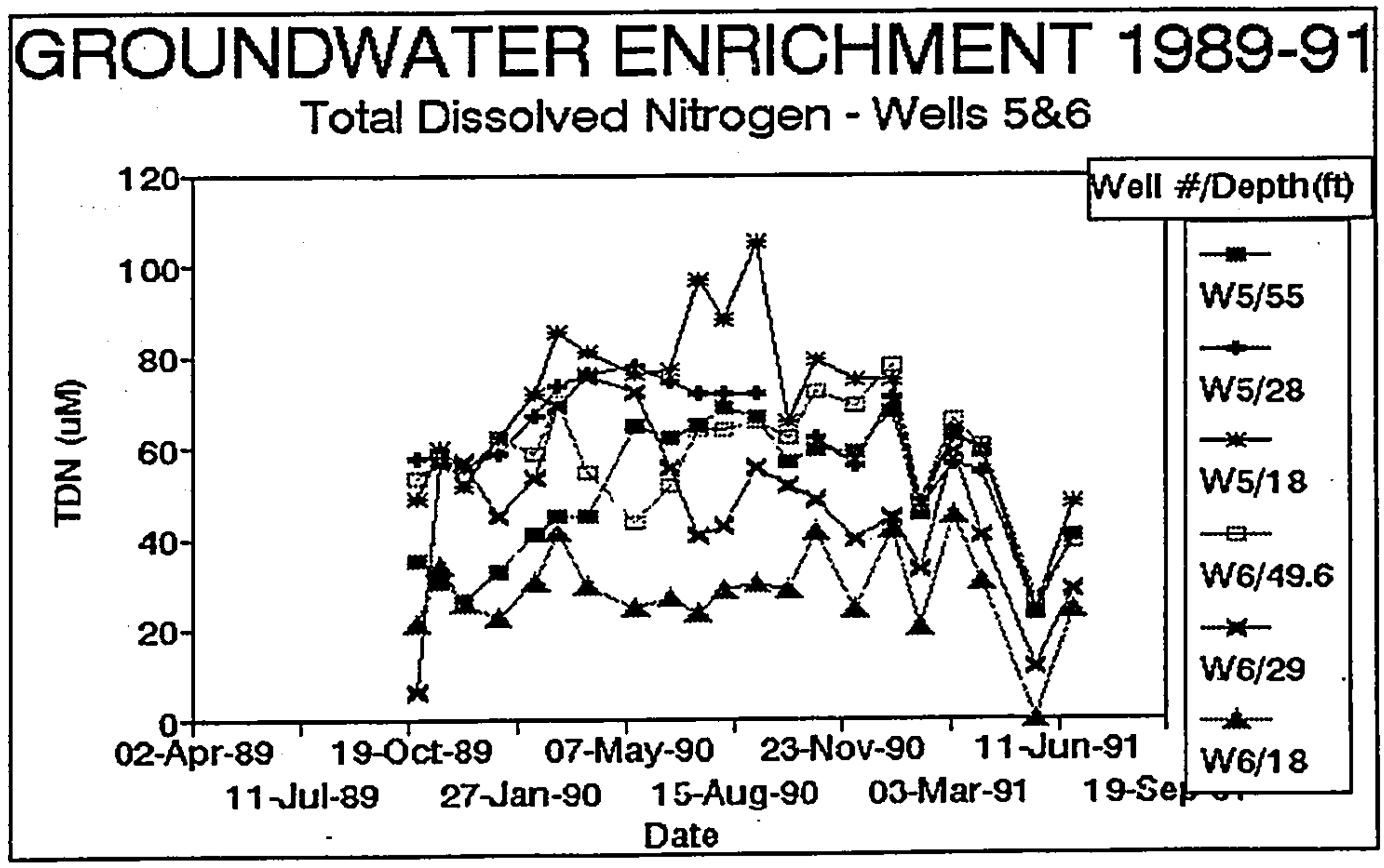


Figure 114. Groundwater Total Dissolved Phosphorous: Wells 5 and 6

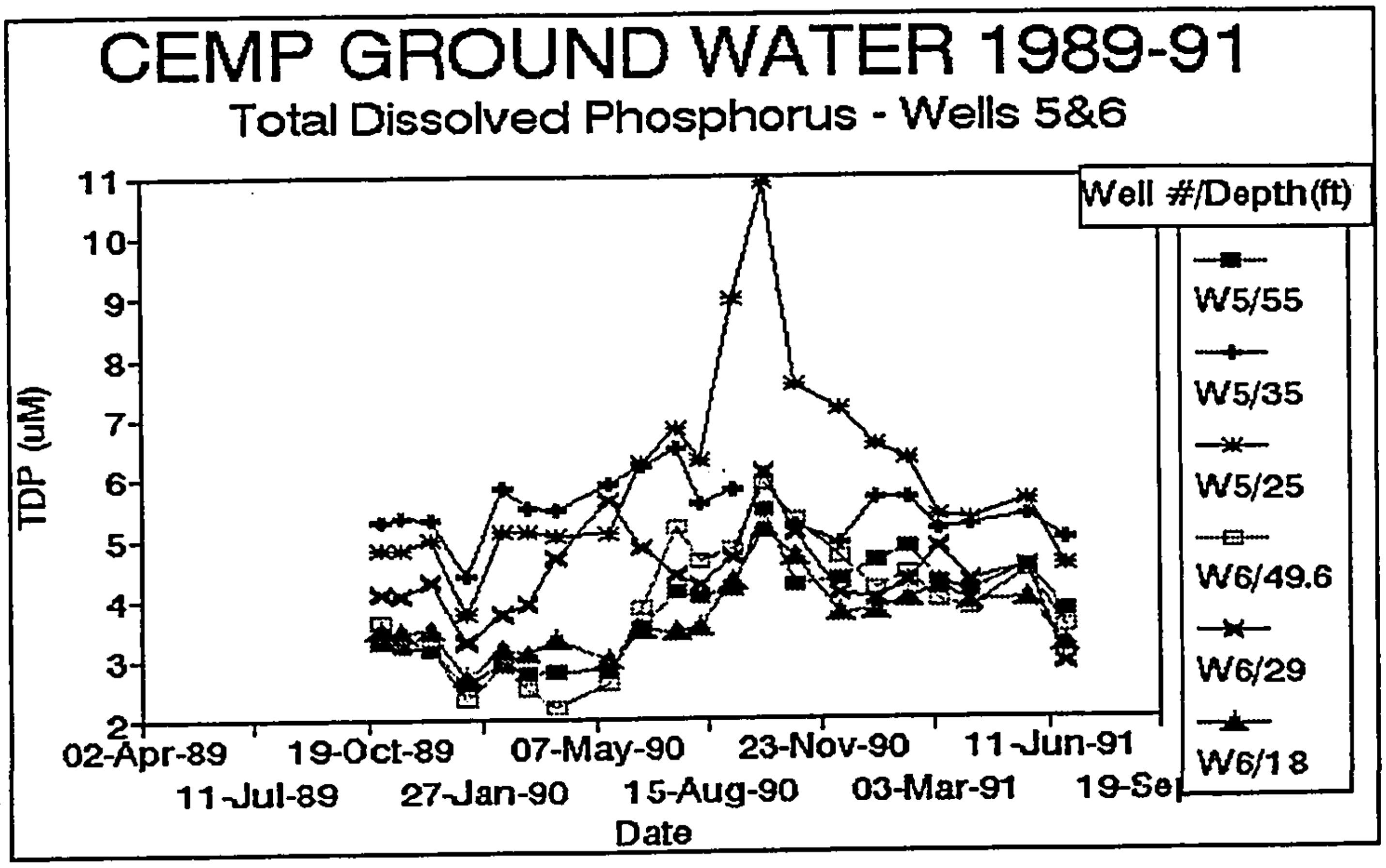


Figure 115. Groundwater Total Dissolved Phosphorous Enrichment: Wells 5&6

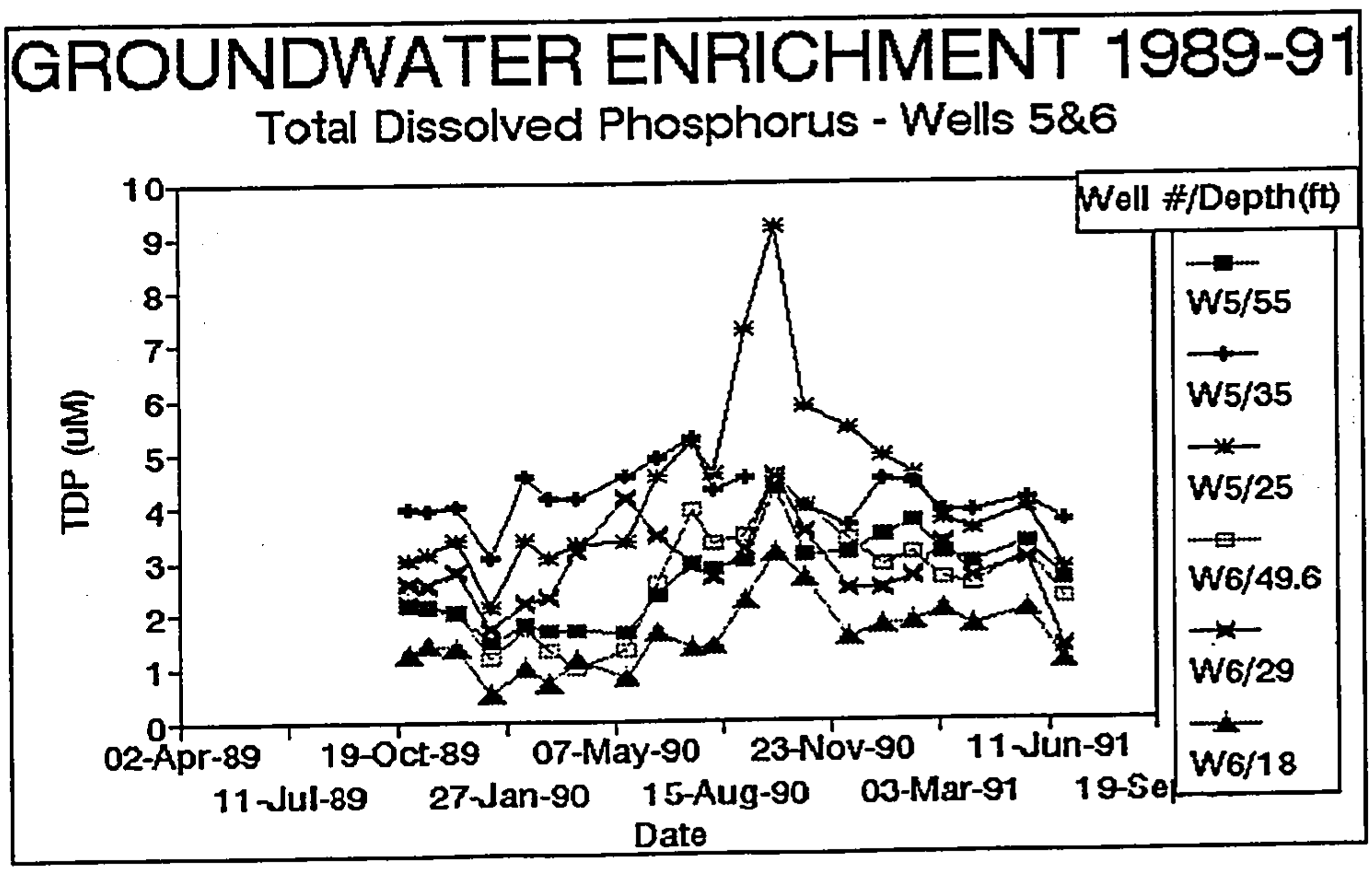


Figure 116. Groundwater Total Organic Carbon: Wells 5 and 6

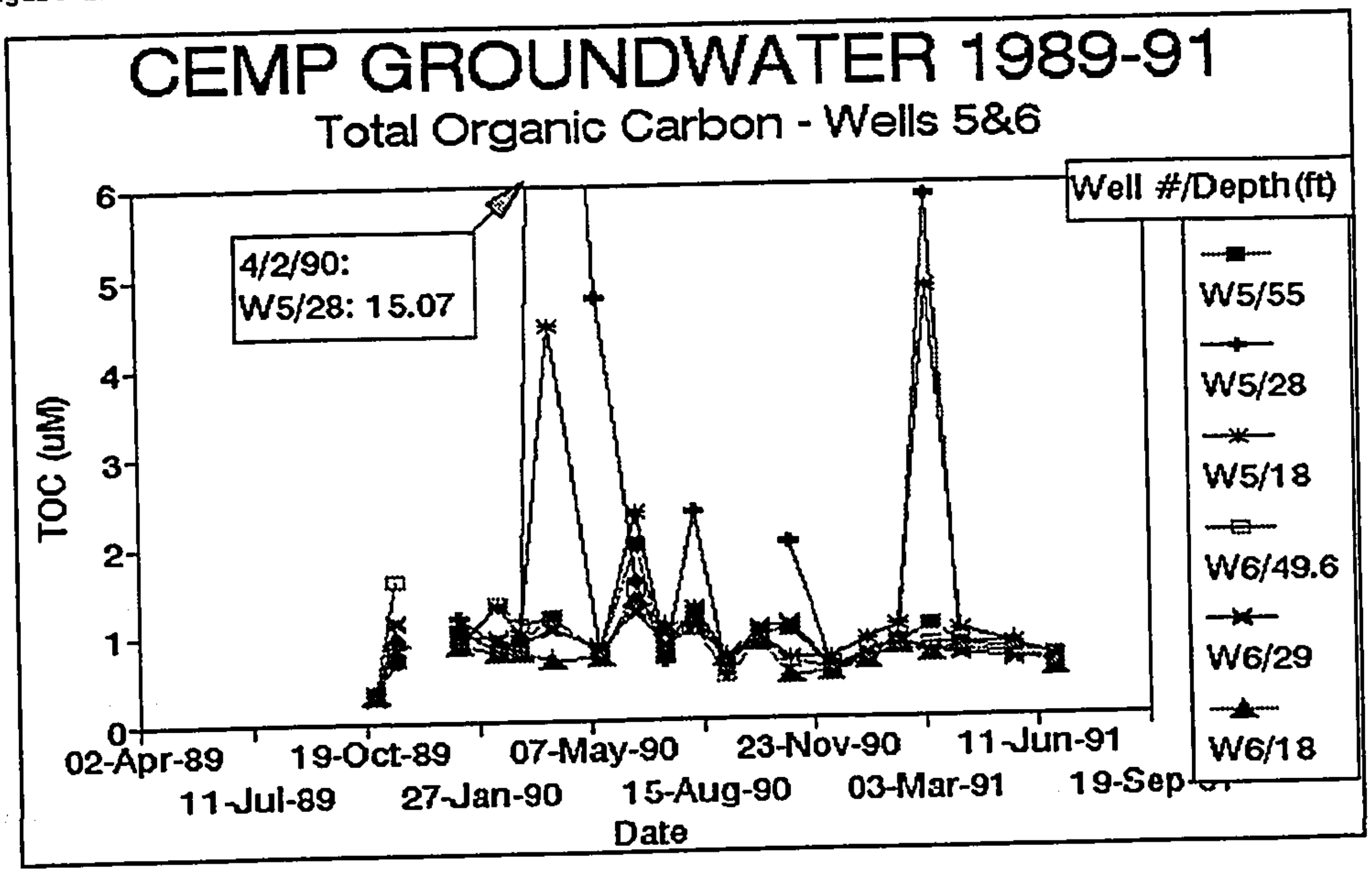
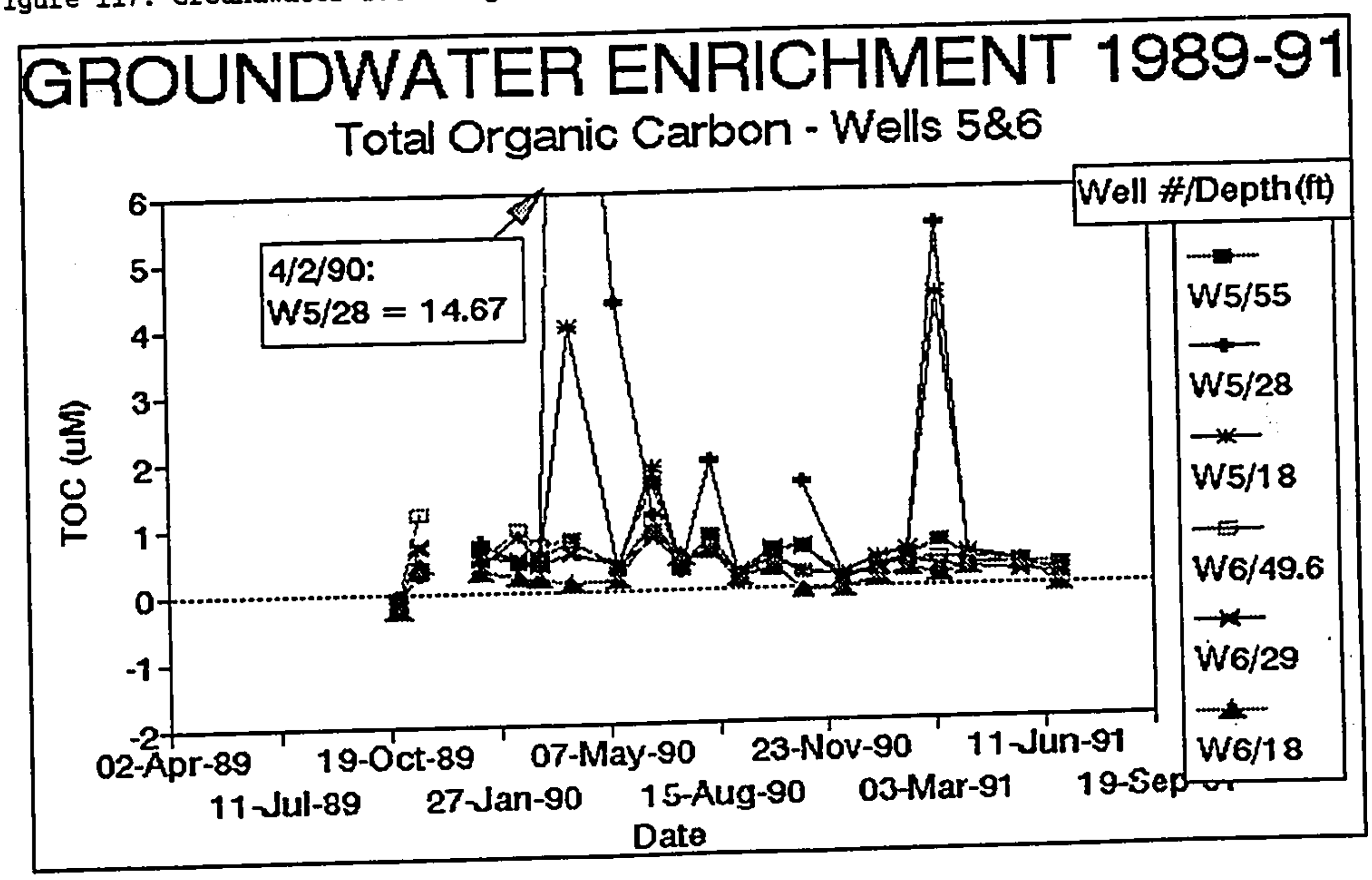


Figure 117. Groundwater Total Organic Carbon Enrichment: Wells 5&6



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APPENDIX C
ANALYSIS OF SUBSURFACE DISPOSAL OF SEAWATER

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Mink and Yuen, Inc.

Subsurface Disposal of Sea Water
Hawaii Ocean Science and Technology Park
Keahole, Hawaii

John F. Mink
Mink and Yuen, Inc.

June 10, 1992

Statement of Problem

Approximately 35,000 gallons per minute (gpm) of sea water following utilization for various purposes at HOST will have to be disposed of by infiltration through trenches approximately 400 feet inland of the coast. The trenches will total 600 feet in length and will be 25 feet wide by 15 feet deep. The initial plan suggests two separate trenches, each 300 feet long. The invert of the trenches evidently will penetrate to the water table. Groundwater in the region is brackish and floats as a thin basal lens on sea water.

At the time of disposal the effluent will have a temperature of 19° to 21^{0} Celsius, but it will have originated as 14,000 gpm of 4°Celsius sea water taken from a depth of 1000 meters and 21,000 gpm of near surface sea water having a temperature of 24^{0} to 27^{0} Celsius. The effluent will be stripped of particulates before disposal in the trenches.

A discharge rate of 35,000 gpm is enormous. probably the greatest in Hawaii. Other unusually high subsurface disposal rates are at the Hawaiian Electric generating station near Hilo where cooling water is discharged into wells, and at the

Kauai Electric plant near Port Allen where a similar practice takes place. Disposal at these sites is no more than about 20 percent of the anticipated rate at HOST.

The water directed to the HOST trenches is expected to infiltrate rapidly to become groundwater. What will eventually happen to this groundwater is a matter of some concern. It will move in three dimensions, vertically downward as well as laterally, under the injection potential, and a portion will begin to discharge at the coastline in a relatively short time. Eventually the injection plume will spread over a great distance so that the discharge per unit area of the plume will be quite small. The analyses that follow track movement of the plume by means of simple geometrical models. The results are indicative of rather than accurate representations of plume behavior.

Subsurface Environment

The trenches into which the used sea water will be spilled penetrates olivine basalt of the Hualalai volcanic series. The basalt are relatively fresh on the surface and will be unweathered throughout the depth of the trenches. Consequently the rock should be extremely permeable, although locally poorly permeable dense and massive layers frequently occur. Globally, however, the formation has an average hydraulic conductivity of about 5000 ft./day. Older basalt, for instance the comparable basalt belonging to the Koolau series in Oahu, have a hydraulic conductivity of 1500 ft./day, as determined by pump tests and calibration of numerical models. For the HOST region, a hydraulic conductivity of 5000 ft./day is assumed.

Lateral permeability is greater than vertical permeability, but for simplification the basaltic medium is treated as isotropic. Lateral movement of the plume will be more rapid than vertical flow, even though vertical transport will be very high. The asymmetric hydraulic conductivity vectors will somewhat distort the regular geometry of the expanding plume, but with increasing time the distortion effect relative to the size of the plume will become small. The high lateral permeability will allow water to seep from the trenches even though at the trench invert the rock may appear to be poorly permeable.

On a local scale volcanic rocks are heterogenous, but regionally they behave homogeneously. The regional hydraulic conductivity is taken as 5000 ft./day, as noted above, and effective porosity is assigned a value of 0.1. The gradient in the feeble basal lend of brackish water is 0.8 ft./5000 ft., as determined from monitor wells drilled in HOST and the Kalaoa well some distance inland. The depth of the aquifer as well as the lateral dimensions are infinite. With these parameters the aquifer system receiving the used sea water is defined.

<u>Groundwater Flow Models</u>

The quantity of injected water is so great relative to the ambient flux in the existing flux in the existing basal lens that the lens will be displaced in the vicinity of the trenches. The injected water will generate its own flow field driven by the potential (height of the water surface in the trench above sea level) in the trench. The flow field will be three dimensional and will not be restricted to depth of flow in the basal lens. This restriction has been employed in numerical models which have attempted to define the flow field of the injectant.

The ambient unit groundwater flux over the depth of flow in the existing basal lens where the head is approximately one foot is:

$$q = 40kh\ \delta h/\delta x = 32\,cu.ft./day/ft.$$

,or 239 gpd/ft.

On the other hand, over a total trench length of 600 feet the injection rate will be 84,000 gpd/ft. The ambient flux is less than 1 percent of the injection rate; the basal lens will be displaced in the vicinity of the trenches. In addition to the disparity in volume flux, the specific gravity of the injectant will be that of sea water, resulting in strong downward movement of the influent.

The models employed to track movement of the plume are based on hemispherical flow for representation of regional movement, and a half cylinder lying parallel to the coast as a trench surrogate for local behavior. Hemispherical flow is justified for regional behavior because the envelope of the plume after a long time will be measurable in miles while the length of the trenches will be just 600 feet. On a local scale, in particular at the coast just down gradient of the trenches, the half cylinder model is more appropriate. The overall advantage of the hemispherical model is that expansion of the plume takes place in all directions perpendicular to the axis of the trench.

Derivation of the models is given in an accompanying appendix. The hemispherical model is descended from analysis given in Muskat (1937) and first employed at HOST by the Water Resources Research Center, University of Hawaii (1980). The half cylinder models, analytical and simple numerical models of pathline movement were employed to estimate the envelope within which the flow of injectant will be restricted. These models, however, are based on cylindrical flow in which the axis of the cylinder is vertical and the cylinder is bounded below by a fixed basement.

The pathline calculations suggest that for a depth of flow of 100 meters (328 ft.) the outer flow line of the steady state envelope at the coast line would be about two miles from the trench, but if the depth of flow were twice as deep (656 ft.) the envelope would be just half as wide. These data are merely suggestive because of the limitations of the model but illustrate the tendency of the plume to spread. The model used is that of Kinzelbach and Rausch (1990). For the expanding geometrical models, the radius of the plume never ceases to grow, but the rate of growth becomes very small as the radius becomes large.

The useful equations derived from the geometrical models are as follows (in the equations, r is radius; t is time; n is porosity; and Q is rate of injection):

Parameter	Hemisphere	Half Cylinder
Velocity expansion	$\delta r/\delta t = Q/2n\pi r^2$	$\delta r/\delta t = Q/n\pi r$
Time, radius	$t = 2n\pi r^3/3Q$	$t = n\pi r^2/2Q$
Plume surface area	$A = 2\pi r^2$	$A = 2\pi r$

Results

The stagnation point of the trench and the width of the plume are determined by equating the velocity of expansion with ambient velocity in the basal lens. Particle velocity of the ambient groundwater is:

$$v = k/n\ \delta h/\delta x$$

When equated to the velocity of expansion of the hemisphere,

$$Q/2n\pi r^2 = k/n\ \delta h/\delta x$$

and,

$$r^2 = Q/2\pi q$$

in which q is the ambient Darcy flux, $q = k\ \delta h/\delta x$.
For an injection rate of 35,000 gpm the stagnation point lies 1158 feet inland of the trench.

The inland movement of the plume against the ambient basal lens will terminate somewhat aver 1000 feet away. In this reach the lens will be replaced by injectant. However, the plume will continue to move inland beneath the lens because the density of its water is the same as sea water on which the brackish lens floats.

Using the same approach for the half cylinder model,

$$Q/n\pi r = k/n\ \delta h/\delta x$$

and,

$$r = Q/\pi q$$

in which Q is the disposal rate per unit length of trench. The Stagnation point in this model lies 4448 feet up gradient of the trench. This value is excessively high because flow is restricted to a width equal to the width of the trench rather than following radial vectors to the arc of a circle. Nevertheless it places an upper limit on the possible distance to the stagnation point. The actual stagnation point will be closer to the value derived from the hemispherical model, between about 1000 and 2000 feet.

The ambient flow field also will affect the width of the plume as it moves to discharge at the coast. Hemispherical flow minimizes the width of the plume, achieved when the velocity of the plume equals ambient flow velocity, is similar to the distance to the stagnation point for hemispherical flow. Beyond this width the injected salt water continues to displace the resident salt water underlying the lens but does not intrude into the lens. For this model discharge of the plume at the open coast is contained within a distance of 1000 to 2000 feet on either side of the trench. However, the bulk of the plume discharging into the sea will occur as seepage through the sea floor. As the plume expands, the rate of seepage per unit area of sea floor will decrease.

In the half cylinder model, unit coastal flow is maximized because outflow is limited to the length of the trench. The ambient flow is displaced in this reach, as it is up gradient to the stagnation point. With increase n time, however, discharge per unit area decreases as the cylinder expands.

The time of travel of the plume from the disposal trench to the coast line, 400 feet away, is calculated as 1.99 days for the hemispherical model and 2.24 days for the half cylinder model. Discharge along the coast will begin within two days of the start of injection at a rate of 35,000 gpm.

The rate of seepage per unit area of the expanding hemisphere or half cylinder will depend on the radius reached by the plume. For example, in the case of hemispherical flow at the end of 1000 days of disposal the radius of the plume will be 3180 feet and the discharge per square foot of plume area will be 0.8 gpd. In the half cylinder model the radius achieved will be 8455 feet and discharge surface will extend several thousand feet off shore where seepage will take place in the ocean floor. Mixing with sea water will quickly dissipate the seepage.

At the shore line down gradient of the disposal trench the unit discharge, based on a radius of 400 feet for the plume, will be 33 gpd for the half cylinder and 50 gpd for the hemisphere. An open coast washed by constant wave activity should disperse the seepage quickly.

On either side of the injectant plume the brackish basal lens will continue to discharge at the coast. The expanding plume below the brackish lens will not displace lens seepage right at the coast but will reach the sea floor beyond where it will seep into the overlying column of sea water.

Conclusions

Disposal of 35,000 gpm of used sea water in the subsurface by means of infiltration trenches will displace the existing basal lens of brackish water near and at some distance from the injection site by creating a large plume about equivalent in density to sea water. The plume will generate a three dimensional flow pattern, moving vertically downward as well as laterally. The boundaries of the plume will expand until a barrier is struck, or seepage takes place at the interface of the aquifer and the open ocean on the sea floor.

Assigning simple geometrical dimensions to the plume (hemisphere and half cylinder) and then solving the equations of flow states that the ambient brackish lens will be displaced by the plume over a minimum width of about 2000 feet down gradient of the injection site. The stagnation point up gradient, where the velocity of the plume equals ambient groundwater velocity, will lie 1000 to 2000 feet inland of the disposal trench. In this reach, also, the lens will be displaced by the plume. However, the plume will continue to expand below the lens, displacing but behaving like the resident salt water because the density of each water is the same. The lens will continue to float on the plume up gradient of the stagnation point and beyond the flow envelope within which the surface manifestation of the plume appears.

The discharge per unit area of the plume will depend on the radius of expansion, and therefore on time after injection commenced. At the coast 400 feet down gradient of the disposal trench the unit discharge will be about 50 gpd/sq.ft. reaching the sea floor where it will discharge into the column of sea water above the seepage area. As time increases, so does the radius and area of the expanding plume, and thus discharge per unit area decreases.

These conclusions are based on simple geometrical models incorporating hydraulics of groundwater flow. They express the magnitude of the effects of injection, but local responses are controlled by heterogeneities in the aquifer.

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Appendix

Derivation of Flow Relationship

1. Hemisphere in porous media.

Volume of a hemisphere: $V=2/3\,(n\pi r^3)$, in which V is volume, n is porosity and r is radius. Because $V=Q\,\delta t$, where Q is constant flow, the volume can be expressed as

$$Q\,\delta t = 2/3\,(n\pi r^3) \quad .$$

Expanding this relationship gives,

$$Q\,\delta t = 2/3\,(n\pi)\,(r+\delta r)^3 - 2/3\,(n\pi r^3)$$

Ignoring differentials greater than order 1, the expansion is,

$$Q\,\delta t = 2n\pi r^2\,\delta r$$

which, expressed as a velocity, yields,

$$\delta r/\delta t = Q/2n\pi r^2$$

Integration of this equation leads to,

$$t = 2n\pi r^3/3Q.$$

2. Half cylinder in porous media oriented parallel to the coast, simulating a trench.

Volume of a half cylinder of unit length: $V = n\pi r^2/2$.

After expansion, $Q\,\delta t = n\pi r\,\delta r$, from which the velocity is,

$$\delta r/\delta t = Q/n\pi r$$

and after integration, $t = n\pi r^2/2Q$.

APPENDIX D
CEMP QUARTERLY SURVEY FOR ANCHIALINE AND MARINE FISH RESOURCES

Richard E. Brock
Environmental Assessment Co.

COOPERATIVE ENVIRONMENTAL MONITORING

PROGRAM FOR THE

NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY

II. SECOND QUARTERLY SURVEY FOR ANCHIALINE

AND MARINE FISH RESOURCES

Prepared For:

The Natural Energy Laboratory of Hawaii Authority
P.O. Box 1749
Kailua-Kona, Hawaii 96740

By:

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Environmental Assessment Co.
1820 Kihi Street
Honolulu, Hawaii 96821

29 March 1992

EAC Report No. 92-09

COOPERATIVE ENVIRONMENTAL MONITORING PROGRAM

FOR

HAWAII OCEAN SCIENCE AND TECHNOLOGY PARK

AND THE

NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY

II. SECOND QUARTERLY REPORT - MARCH 1992

INTRODUCTION

Both the Hawaii Ocean Science and Technology Park (HOST Park) and the Natural Energy Laboratory of Hawaii Authority (NELHA) are situated at Keahole Point, North Kona, Hawaii. These two State of Hawaii facilities are linked in a number of ways: they will share critical infrastructure for the delivery and disposal of seawater; the impact of their operations on the environment will be similar and affect the same ecosystems and they share certain environmental permits. These common elements have allowed the development of a combined program to monitor the environmental effects of operations at the two facilities.

The Cooperative Environmental Monitoring Program has two broad objectives: (1) to protect the unique environmental resources of the Keahole Point area and their diverse uses, and (2) to provide the information necessary to comply with the permit requirements of the various County, State and Federal agencies.

Both HOST Park and NELHA will in the future be using and disposing of large quantities of warm and cold seawater brought on-site and distributed through a network of pipes. At the present time, disposal of water from these facilities will be into trenches dug into the lava at some distance inland from the shore. The potential impacts of this and other disposal options (i.e., injection wells, deep ocean outfall, direct discharge) were described and compared in the Environmental Impact Statements for the respective facility (HTDC 1985; NELH 1987). The latter document suggested a monitoring program and GK and Associates (1989) presented the details for such a program. The first phase of the biological monitoring program establishing a preliminary baseline was carried out by Brock (1989).

In the Cooperative Environmental Monitoring Program are four steps to meeting the objective of protecting the environmental resources of Keahole Point. These steps are:

1. To collect field data in the monitoring program utilizing methods identical and complementary to those used in the baseline survey to allow comparative analysis;

2. To undertake comparative analysis of data from the monitoring program with hose of the baseline to detect change;

3. To work with NELHA personnel and the water quality monitoring program to trace the cause of any unacceptable change to its source;

4. To provide facilities management with suggested options for corrective measures.

Since the completion of the preliminary baseline in December 1989 (Brock 1989), several changes were instituted in the monitoring program. One change was to divide the sampling effort between two parties and to redefine some of the stations. Accordingly, this document is the second quarterly report covering the status of (1) the marine fish communities at a series of twelve permanently marked stations and (2) the aquatic fauna of the anchialine pools present on the NELHA project site. Marine benthic communities are covered by other parties. Data on the status of the anchialine resources is presented first followed by information on the nearshore fish communities resident to the waters fronting the NELHA project site.

ANCHIALINE POOL BIOTA

A. Introduction

Anchialine pools are land-locked bodies of water that may be characterized as not having any surface connections to the sea, yet have measurable salinities and display damped tidal fluctuations. Naturally occurring anchialine pools are restricted to highly porous substrates such as recent lavas or limestone adjacent to the sea. These unique habitats have been described from a number of widely dispersed tropical localities; anchialine pools are most numerous at sites in Fiji, the Ryukyus and Hawaii. Most of the known Hawaiian anchialine resources occur along the West Hawaii (Kona) shoreline and have in recent years been the focus of attention with respect to coastal development.

Anchialine pools harbor a distinctive assemblage of organisms, some of which are found nowhere else. Anchialine pond organisms fall into two classes, i.e., epigeal and hypogeal species. The epigeal fauna is comprised of species that require the well-illuminated (sunlit) part of the anchialine system. Most of these species are found in other Hawaiian habitats albeit individuals from anchialine systems frequently show ecotype (morphological) variations. The hypogeal organisms occur not in the illuminated part of the system but also in the interconnected watertable below. These species are primarily decapod crustaceans, some of which are known only from the anchialine biotope.

Species characteristic of Hawaiian anchialine pools include crustaceans (shrimps and amphipods), fishes, mollusks, a hydroid, sponges, polychaetes, tunicates, aquatic insects, algae and aquatic macrophytes. Most striking are a number of red-pigmented caridean shrimp species and the most abundant of these is the opae'ula or Halocaridina rubra.

In the NELHA/HOST Park area, two clusters of anchialine ponds have been identified: the northern complex of approximately five pools is situated north of the NELHA facility and the second more southerly group is comprised of seven small ponds adjacent to the most southerly bend in the NELHA access road. These latter ponds are located on Department of Transportation (Keahole Airport) lands. These pools are collectively known as the Keahole Point anchialine ponds.

The Keahole Point pools were first inventoried by Maciolek and Brock (1974); these authors noted nine anchialine ponds in the boundaries of the combined NELHA/HOST Park project area. Three of these ponds were situated north of the NELHA facility and six were located to the south, along Wawaloli Beach. In their study, Maciolek and Brock (1974) found one of the 3 northern pools to be less than 10 square meters in surface area while the two adjacent pools were between 10 to 100 square meters. Depths were shallow (0.5m), pond bottoms rocky with some sand and sediment, and salinities ranged between 7 and 8 ppt. Algae and plants present included the encrusting carbonate alga, Schizothrix calcicola; the alga, Rhizocionium sp. and the aquatic flowering plant, Ruppia maritima. In the vicinity of the ponds were kiawe (Prosopsis pallida), naupaka (Scaevola taccada), fountain grass (Pennisetum setaceum), pohuehue (Ipomoea pes-caprae) and pickleweed (Bacopa sp.). Fauna inventoried in these ponds included an unidentified oligochaete, the snails Assiminea sp. and Melania sp., the limpet Theodoxus cariosa in one pond, opae'ula (Halocaridina rubra) in one pond, and opae'o'haa (Macrobrachium grandimanus) present in two of the three ponds.

Ziemann (1985) examined ponds in the vicinity of NELHA and noted five bodies of water. It was hypothesized by Brock (1989) that coralline and basalt rubble washed ashore by storm surf and carried into these ponds subdividing them and temporarily creating additional pools. These rubble barriers subsequently broke down leaving the three pool complex at high tide as sampled by GK & Associates (1986). When he sampled these pools in 1985, Ziemann (1985) found higher salinities (10 to 11 ppt); shoreline vegetation included the sedge (Cladium sp.), fountain grass, pickleweed, pohuehue, pluchea, naupaka, akulikuli and kiawe. In the ponds Ziemann (1985) noted the alga, Enteromorpha sp., the snail, Melania sp., opae'ula in two ponds and only opae'o'haa in one pond. All aquatic species were noted as being abundant.

In September 1986 GK & Associates (1986) examined the northern or NELHA series of ponds. Three ponds were located, suggesting that rubble seen by Ziemann in 1985 had broken down. Further evidence for this was seen at high tide on 27 September 1986, when a very shallow surface interconnection between two of the ponds was observed. The more northerly situated pool of the pair had a surface area of about 20 square meters and was 38m inland of the ocean. The basin was rocky attaining a maximum depth of about 46cm. Salinity of this pool was 8 ppt. In the deeper parts of this pool was the alga, Cladophora sp. and numerous snails (Melania sp.) were present. Neither fish nor shrimp were observed in this pond. The more southerly adjoining pool was slightly deeper (about 75cm) and a single aholehole (Kuhlia sandvicensis) and rock crab (Metopograpsus thunkar) were observed. This pond had a surface area of about 11 square meters at high tide. Opae'ula (Halocaridinia rubra) were seen in this pool. The flora of this pond was dominated by the cyanophyte mat (Schizothrix and Lygnbya). The third pool sampled by GK & Associates (1986) located about 30m south of the above pools had a surface area of 11 square meters at high tide and a maximum depth of 1m. This pool was situated beneath a fringing canopy of kiawe and around it were naupaka and pickleweed. The salinity of this pond was 10 ppt. No fish or shrimp were observed in this pool.

In his baseline survey, Brock (1989) noted 12 anchialine pools in the project area; five of these were located in the northern complex north of the NELHA facility and the seven pools in the southern complex are on lands controlled by the Department of Transportation. These same pools were resurveyed under the present program in October 1991 (Brock 1991). The biological data from the 1989 baseline study as well as the October 1991 survey are presented in Appendix A and comparatively analyzed below.

B. Methods

GK and Associates (1989) suggested that the biota of all these anchialine pools be sampled on a quarterly basis; 3 to 15 permanent $0.1m^2$ quadrats should be placed in each pool and the biota in each assessed by counts or percent cover (as appropriate). If present, counts of larger motile forms (prawns, crabs and fish) were to be made for the entire pool.

Previous experience with leaving permanent quadrats in anchialine ponds in the Waikoloa Anchialine Pond Preservation Area and elsewhere has demonstrated that people remove them, thus negating the idea of using "permanent" quadrats in pools that are visited by the public. Accordingly Brock (1989, 1991) utilized temporarily placed 0.1m^2 quadrats in the sampled pools. Only native species were censused.

Sampling of the biota comprised using quadrats to assess benthic forms; a minimum of four quadrats were placed in each sampled pool where sufficient substratum was present as not to have quadrats overlap. Fishes were assessed using visual methods. No emphasis was placed on quantifying non-native species such as the poecilids. Approximate pool dimensions and relative locations were roughly mapped in the field; notes were taken on the species composition of surrounding vegetation, etc. Salinities were field measured using a refractometer. These methods duplicate those used previously (Brock 1989, 1991).

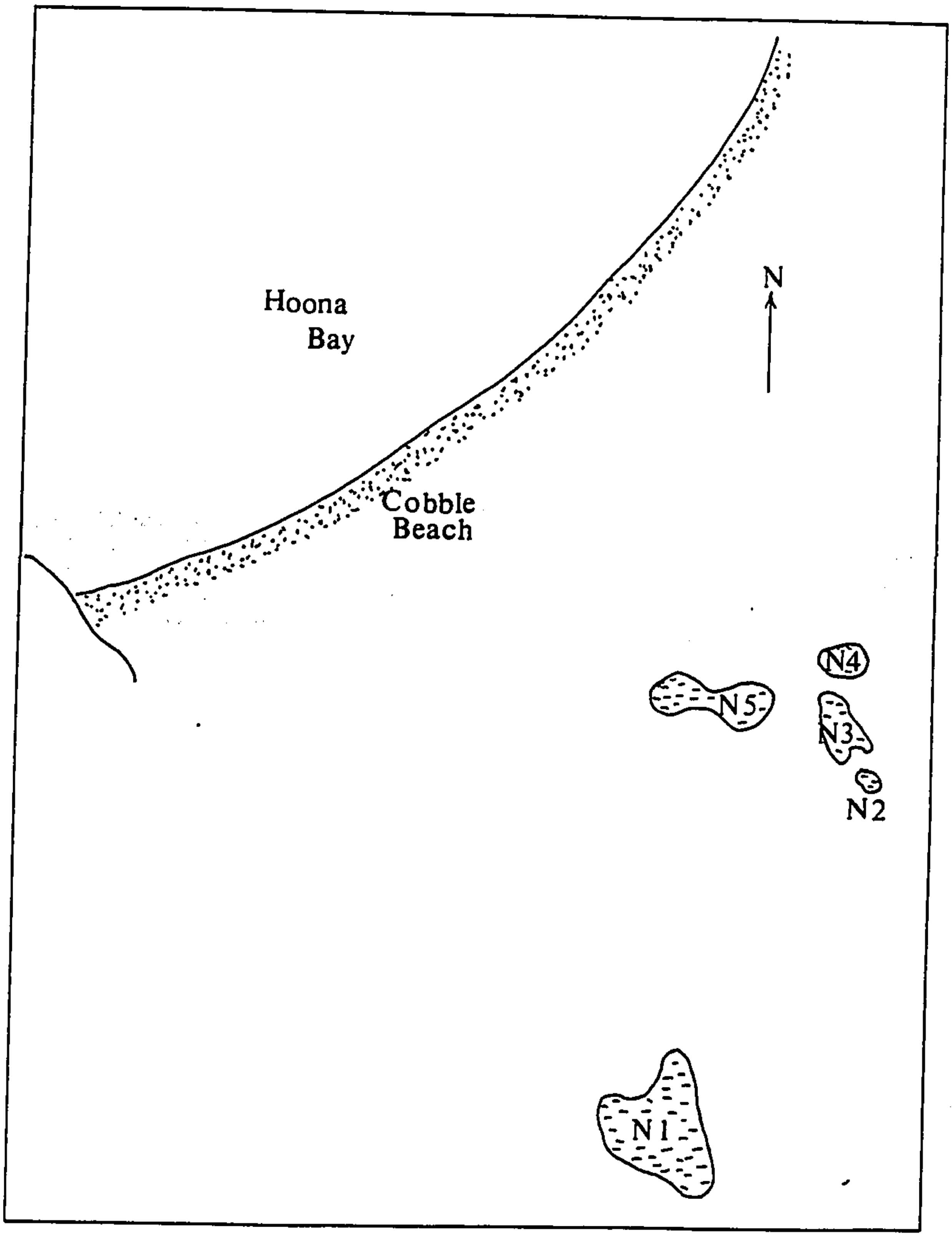
C. Results

In total fifteen anchialine pools were sampled in this study; eight of these are located in the northern complex north of the NELHA facility and the seven pools in the southern complex are on lands controlled by the Department of Transportation. The relative locations and sizes of the eight northern pools are shown in Figure 1; Figure 2 provides the same information for the seven southern pools. The tide was low (+6cm) at the time of sampling (morning of 7 March 1992) and this probably accounts for the appearance of 8 ponds in the northern complex when normally there are five pools present. Three of the ponds in the northern complex were small pools that under higher tide conditions are part of pool number N-5. In the October 1991 survey four of the pools in the northern site were coalesced into one because of the high tide. These pools were separated due to a lower tide at the time of the preliminary 1989 baseline survey. It was obvious that at middle and low tides the four northern pools are separated by intervening lava.

The northern complex of pools is situated primarily in a pahoehoe flow; on the seaward edge of the complex, the substratum is basalt and coral cobble which is part of a berm serving as part of the beach. The pools are from 30 to 40m mauka of the shoreline. As noted in the preliminary baseline, the number of pools in this complex obviously fluctuates with the movement of rubble caused by high surf as well as the state of the tide (see above discussion). Vegetation surrounding the northern pools is comprised of a mix of naupaka (Scaevola taccada), kiawe (Prosopis pallida), akulikuli (sesuvium portulacastrum), pluchea (Bluchea odorata) and fountain grass (Pennisetum setaceum). These plants occur along the landward (mauka) border of the system.

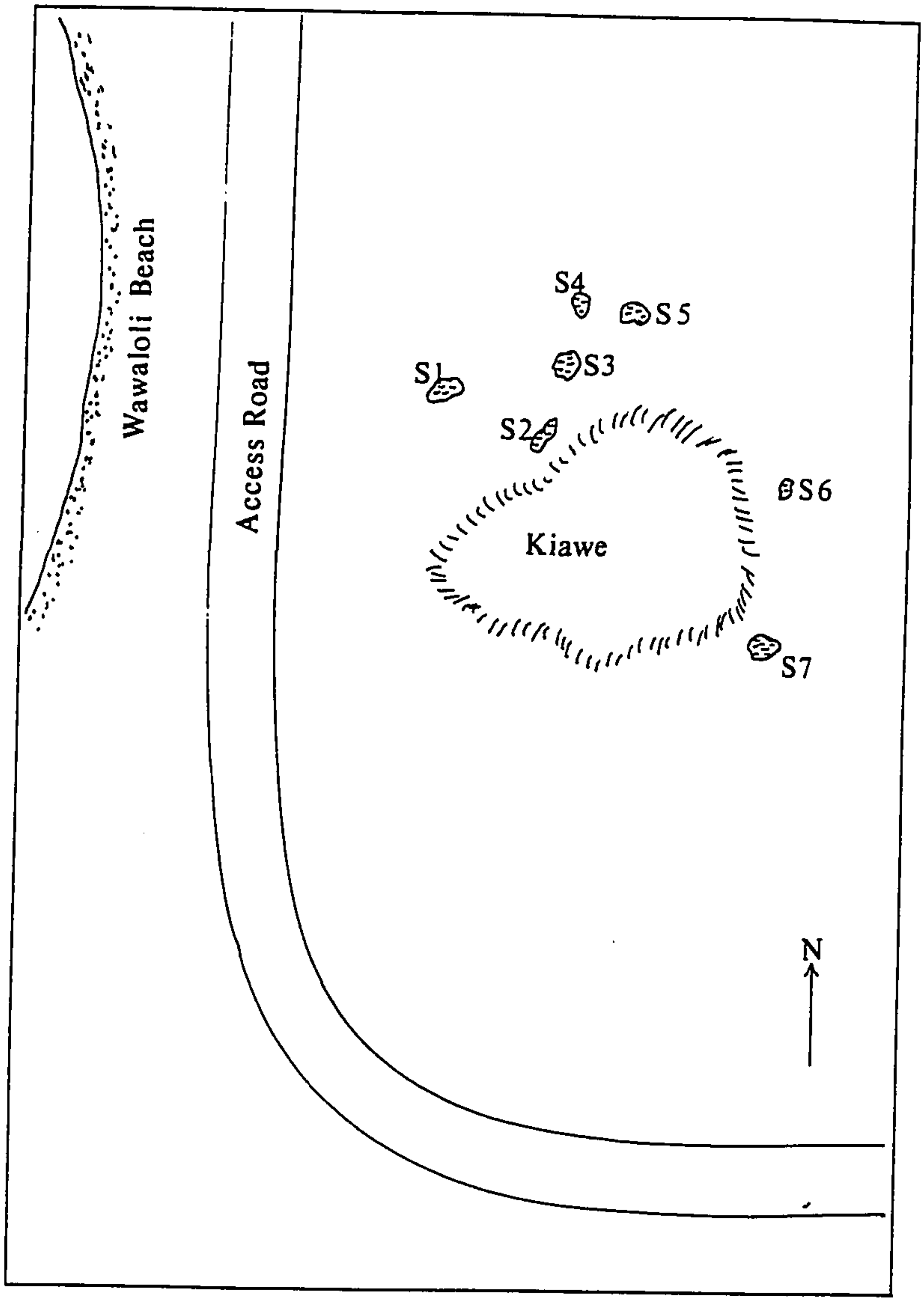
In the southern complex, ponds are situated in a pahoehoe

FIGURE 1. Map of the northern complex of two to five anchialine pools mauka of the beach berm of basalt cobble and coral rubble at *Hoona Bay, Keahole Point*. The apparent number of anchialine pools varies with the tide; solid lines show the boundaries of the pools as they were in the May 1989 and present survey. Map after Brock (1989). Not to scale.



Hoona
Bay
Cobble
Beach
N
N4
N5
N3
N2
N1

FIGURE 2. Map of the southern complex of seven anchialine pools mauka of Wawaloli Beach and the NELHA access road at Keahole Point. Map after Brock (1989). Not to scale.


Wawaloli Beach
Access Road
S4
S5
S3
S1
S2
S6
Kiawe
S7
N

flow; these pools are well inland of the beach, being mauka of the access road more than 70m from the shoreline. Some pools are surrounded by vegetation. Plant species present include kiawe (Prosopis pallida), fountain grass (Pennisetum setaceum), pluchea (Pluchea odorata), pohuehue or morning glory (Ipomoea pes-caprae), naupaka (Scaevola taccada), christmas berry (Schinus terebinthifolius) and noni (Morinda citrifolia).

All pools located in this study were sampled; organism abundance and basin morphology are given in Tables 1 - 4 for both complexes. Unlike many anchialine pools on the West Hawaii coast, the anchialine ponds in the southern complex have not been subjected to the introduction of exotic fishes; in the northern series of pools poecilids are present in Ponds N-1, N-3, N-4, and N-5. In the October 1991 survey guppies were only present in Pond N-1. Other pools in the northern complex were infested with poecilids (in 1988) but these had been removed sometime prior to October 1991 probably by chemical means. To prevent their spread, the exotic fishes should be entirely removed as soon as possible from the north complex of pools and signage placed around the ponds asking the public not to release fish into them.

Pool N-1 is the largest in the northern complex. This pond has a fine mud substratum and is the southernmost pool sampled by GK & Associates (1986) and Brock (1989, 1991). Besides the snail, Melania sp., exotic guppies are the dominant species. Other aquatic species found in this pool include the waterboatman (Trichocorixa reticulata) algae, (Cladophora sp. and an unidentified chlorophyte similar to Ulva reticulata) and on the surrounding bank the isopod (Ligia sp.). In the October 1991 sampling, the mud substratum of N-1 appeared to be covered with a layer of decaying algae which was producing a "grey layer" emitting hydrogen sulfide. It appears that the algae of the pool "crashed" in the recent past but is now recovering. The remaining aquatic biota appeared to be unaffected.

Ponds N-1, N-3, N-4 and N-5 all contained poeciliids and no native red shrimp or opae'ula (Halocaridina rubra) in the March 1992 survey. Only Pond N-2 continues to serve as habitat for Halorcaridina rubra. In this pool the March 1992 census noted only three H. rubra in a single quadrat (i.e., 3 shrimp/0.1m^2), but no poeciliids were present in this pool. The October 1991 reconnaissance noted opae'ula in ponds N-2, N-3 and N-4. The decline in H. rubra is probably due to the presence of the predaeous poecilids which, if removed, will probably allow the shrimp to return from the watertable below the pools.

The ubiquituous brackish water snail, Melania sp. was seen in all the pools of the northern complex. The abundances of these and other native species encountered in the northern pools are given in Table 2. The glass shrimp or 'opae (Palaemon debilis) was noted as being present in Pond N-5 in the present

TABLE 1. Summary of the physical characteristics of the anchialine pools of the northern complex (N-1 - N-5) sampled on 20 May 1989 (1330 hours approaching high tide), on 26 October 1991 at 0740 hours (high tide) and again on 7 March 1992 near zero tide at 0810 hours. Basins N-2 through N-5 were coalesced into one pond on 26 October 1991 and on 7 March 1992 the low tide created three small pools between N-3 and N-5.

Pond No.	Dimensions (m)	Basin Characteristics
N-1	15.5 x 6	deep mud bottom; in pahoehoe/basalt cobble
N-2	1 x 1	rubble basin; in pahoehoe
N-3	7.5 x 3	cobble basin; in pahoehoe
N-4	2 x 2	rubble & mud bottom; in pahoehoe
N-5	7.5 x 3	2 interconnected basins in cobble

TABLE 2. Summary of the census data and salinities of the anchialine pools of the northern complex (N-1 - N-5) sampled on 20 May 1989 (1330 hours approaching high tide), on 26 October at 0740 (high tide) and again on 7 March 1992 near zero tide (0810 hours).

Pond No.	Salinity ($^o/oo$) May89	Oct91	Mar92		Census Data ($no/0.1m^2$) May89	Oct91	Mar92
N-1	8	12	8	*Melania*	78	35	49
					71	52	31
N-2	10	12	8	*Melania*	36	42	72
				H. rubra	22	15	3
N-3	8	12	8	*Melania*	62	12	67
					21	9	23
						0	0
				H. rubra	1	0	0
					15	28	0
N-4	8	12	8	*Melania*	39	0	0
					115	4	9
				H. rubra	3	0	0
					21	23	0
N-5	8	13	8	*Melania*	2	2	42
					4	4	2

survey.

Mean densities of Halocaridina rubra in the northern complex of pools has changed over time. The grand mean for May 1989 was 12 shrimp/$0.1m^2$ and in October 1991 the mean density was 13 shrimp/$0.1m^2$ for those pools containing shrimp. The change between these two surveys is insignificant (Wilcoxon matched-pairs signed-ranks test, t=37, n=14, N.S.). However in March 1992 the grand mean fell to 0.6 shrimp/$0.1m^2$; this decrease is highly significant (Wilcoxon matched-pairs signed rank test, t=0 , n=9, P>0.01).

The populations of the snail Melania sp. have fluctuated through time; in May 1989 there were 48 snails/$0.1m^2$, in October 1991 the mean population estimate was 18 snails/$0.1m^2$. The mean abundance of snails in the March 1992 survey is 30 individuals/$0.1m^2$. One difficulty in censusing melanid snails is the fact that separating live from dead shells on the substratum is difficult without removing and disturbing the population. Also, the "apparent" abundance of Melania sp. in anchialine habitats appears to vary according to tide state and salinity. Often with higher tides (and salinities) the snails will frequently be under rocks rather than on dorsal aspects of the rocks where they may be censused. Mean salinity of the northern pools in May 1989 was $8.4^{o}/oo$; in October 1991 using the same refractometer, the mean measured salinity was $12.2^{o}/oo$ and again on 7 March 1992 the salinity was $8^{o}/oo$.

The pools in the southern complex are scattered around the perimeter of a large mixed stand of christmas berry and kiawe. These ponds all have a mixed assemblage of opae'ula (Halocaridina rubra) and small unidentified red amphipods (Tables 3 and 4). On inspection, there appears to be at least two species of amphipods. Many of the anchialine amphipods have received little scientific attention and undoubtably, there are species that have yet to be described. One pond, number S-7, has been physically modified to serve as a bathing pool. It should be noted that this pool appears to have changed little from the first time I surveyed it in 1972. Besides opae'ula, this pond also has opae'o'haa (Macrobrachium grandimanus). In the March 1992 survey Macrobrachium granidmanus was also seen in Pool S-1 for the first time.

In comparing the abundance of opae'ula in the southern complex of pools between the three surveys, we find that in May 1989 the density was estimated to be 49/$0.1m^2$, in October 1991 the estimated density was 57/$0.1m^2$ and in March 1992 the density was estimated to be 55 individuals/$0.1m^2$. No statistically significant changes have occurred in the abundance of H. rubra among the three surveys (Wilcoxon matched-pairs signed-ranks test; 1989-91: t=79, n=16, N.S.; 1991-92: t=70, n=16, N.S.).

TABLE 3. Summary of the physical characteristics of the seven anchialine pools of the southern complex (S-1 - S-7) sampled on 20 May 1989 (1630 hours high tide), 26 October 1991 (0835 high tide), and again on 7 March 1992 near zero tide (1000 hours).

Pond No.	Dimensions (m)	Basin Characteristics
S-1	1.4 x 1.2	Pahoehoe and rubble
S-2	1 x 1	Pahoehoe and rubble
S-3	1 x 1	Pahoehoe and rubble
S-4	0.75 x 0.75	Pahoehoe and rubble
S-5	2 x 2.5	Pahoehoe and rubble
S-6	0.2 x 0.5	Pahoehoe and rubble
S-7	2 x 2.4	Pahoehoe and rubble

TABLE 4. Summary of the census data and salinities of the anchialine pools of the southern complex (S-1 - S-7) sampled on 20 May 1989 (1330 hours approaching high tide), on 26 October at 0835 hours (high tide) and on 7 March 1992 near zero tide (1000 hours).

Pond No.	Salinity (°/oo) May89	Oct91	Mar92		Census Data ($no/0.1m^2$) May89	Oct91	Mar92
S-1	7	7.5	4	*H. rubra*	56	29	31
				M. grandimanus			1
S-2	6	7.5	4	*H. rubra*	71	31	40
				Amphipoda	185	32	6
S-3	6	7.5	3	*H. rubra*	38	21	43
				Amphipoda	54	14	9
S-4	6	7.5	3.5	*H. rubra*	9	42	6
S-5	6	7.5	4	*H. rubra*	43	121	131
				Amphipoda	94	65	48
S-6	6	7.5	3	*H. rubra*	3	3	1
				Amphipoda	0	9	2
				White "	0	2	0
S-7	5	7	4	*H. rubra*	97	95	87
				Amphipoda	11	17	12
				M. grandimanus	0.5	0.5	0.5

Abundance estimates of the unidentified red amphipods in the southern pools has been more variable between surveys; in May 1989 the estimated grand mean was $89/0.1m^2$, in October 1991 the estimated mean was $27/0.1m^2$ and in March 1992 the estimate was 15 individuals/$0.1m^2$. In 1989 red amphipods were seen in four of the southern pools and in both October 1991 as well as March 1992 they were seen in five pools. Because of their small size and cryptic habits, accurate counts of these organisms is very difficult and the results are of limited value. At this point, we assign little value to the amphipod data.

In the May 1989 survey, many of the anchialine ponds in both groups were being used by beach goers as receptacles for rubbish and human wastes. It appears that these practices have decreased probably because of more restricted access by keeping the public out of the area after hours. This management is important to the maintenance of the system.

D. Discussion

There appears to have been very little change in the apparent abundance of red shrimp (Halocaridina rubra) in the southern complex of pools but a decrease has occurred in the northern pools. The spread of exotic fish is probably responsible for the decrease in the abundance of shrimp. Unless the fish are removed, the density of opae'ula will remain low in the northern complex of pools. If this were to occur, the monitoring program will lose a species that is important to the maintenance of the anchialine benthic communities. The loss of Halocaridina rubra from this system will also hinder the monitoring program in that H. rubra is one of the dominant species in West Hawaii anchialine systems and without this species being present, the data from the monitoring of the anchialine system has less value.

Our estimates on the abundance of red amphipods show decreases from 1989 to the present. The small size and cryptic habits of these amphipods makes quantitative delineation very difficult and of dubius value. The decrease noted in the Melania sp. in the northern pools is probably related to sampling error rather than a real change in the snail population. The numerous melanid shells on the bottom of most anchialine pools makes it a near impossibility of separating live from dead shells (this is a problem in the northern complex of pools). Also, these snails often appear to move from under cover and out into the open (where they can be counted) with different tide states. These problems among others has lead the West Hawaii Monitoring Standards Task Force to recommend the use of Halocaridina rubra in quantitative monitoring programs because it can be counted; other species are not recommended.

There are seven hypogeal shrimp species found in Hawaiian anchialine pools. The surveys of the Keahole anchialine pools noted only one: the opae'ula or *Halocaridina rubra*. More life history information is available for *Halocaridina rubra* than for any of the other species. Opae'ula feed on detritus, benthic diatoms, phytoplankton, filamentous algae, vascular plant tissue (Wong 1975), and when available, animal tissue. *Halocaridina rubra* feed by plucking the substratum with bristled chelae; mid-water and surface film feeding is accomplished by using the chelae and bristles as plankton filters. Opae'ula have been maintained in small sealed containers for years. Presumably under these conditions, they are capable of utilizing bacterial films.

The embryogensis and larval development of *H. ruba* has been documented (Couret and Wong 1978). Opae'ula have a low fecundity with the female carrying 10 to 16 eggs for at least 38 days. Earlier studies suggested that darkness was necessary to induce oviposition and females remained in dark seclusion until after eclosion and the offspring emerged into the open water as juveniles (Maciolek 1983). This author noted that ovigerous females (those carrying eggs on the abdomen) have not been seen in nature among the thousands of individuals observed or hundreds collected. However, Maciolek (1983) notes that 12 to 42 percent of the females may have eggs visible within the carapace, which suggests that reproduction is not rare. Our recent observations on *H. rubra* maintained in aquaria is that reproduction is very common and does not require darkness but rather is dependent upon a steady source of food; apparently, females must be at least four years of age prior to reproduction. Laboratory observations indicate that opae'ula may have lifespans of at least 10 years.

Halocaridina rubra is the most abundant of the Hawaiian hypogeal shrimps. It frequently occurs in concentrations exceeding hundreds of individuals per square meter in a given pond on a rising tide; at other nearby pools it may be scarce. The apparent abundance of opae'ula in a given pond or pond system can be very misleading for nothing is known of the population size of these hypogeal shrimp in subterranean interstitial waters.

The remaining anchialine fauna found in the Keahole system has either marine or freshwater origins. This group includes the snail, *Melania* sp. This snail is known from both stream and brackish habitats. The native prawn, *Macrobrachium grandimanus* also is found as adults in streams. Individuals of this shrimp encountered in the anchialine habitat usually show morphological or ecotypic variation; the individuals seen in Ponds S-1 and S-7 in this survey are morphologically similar to those encountered in the Kukio anchialine system along the Kona coast.

Fishes are a part of the fauna of the Hawaiian anchialine habitat; usually, their presence in a pond signals the lack of hypogeal shrimp. Fishes in anchialine systems fall into two broad categories -- native or exotic species. Fishes are usually predators on the red shrimp species. Native fishes will have less of an impact than exotic species because the latter are able to complete their lifecycles in these systems whereas the native species require marine conditions to do so.

Guppies or topminnows (Family Poeciliidae probably _Gambusia affinis_ and/or _Poecilia mexicana_) appeared in the north Keahole pools sometime after the survey conducted in September 1986 by GK & Associates (1986). The most obvious impact resulting from the colonization of anchialine pond systems by fishes is their predation on resident crustaceans particularly the shrimps. The impact of native fish in anchialine systems continues only for the duration of the individual fish's lifespan. Exotic fishes, unlike their native counterparts are able to complete their life-cycle in the anchialine habitat, thus they present a continuing threat to the resident biota.

The introduction of exotic fishes to Kona coast anchialine systems has probably had the greatest negative impact to the biota of any perturbation to date. Brock (1985) documents the decline in native fauna following the introduction of exotic fishes to Kona coast anchialine pools. In the period from 1972 to 1985, exotic fish spread from 15 percent of the pools examined to 46 percent of the ponds. Recent estimates by Brock (unpublished) suggest that more than 90 percent of the Kona coast anchialine ponds are infested. With the spread of exotic fish has come a decline in the apparent distribution of _Halocaridina rubra_ from a presence in 67 percent of the sampled pools in 1972 to less than 39 percent in 1985; it is considerably lower today.

The removal of exotic fishes presents a problem. The only known successful method of fish eradication is to use ichthyocides such as rotenone. There are problems with the application of ichthyocides over a rough terrain and the use of these materials could possibly impact other aquatic species besides fish. Experiments with rotenone suggest that it may be used and impacts to native crustaceans are minimal. However without the removal of exotic fish from the northern complex of pools, many of the unique biological attributes of the system will be lost. Studies carried out by Brock (unpublished) in the Waikoloa Anchialine Pond Preserve demonstrate that once exotic fishes are removed, the hypogeal fauna reappears within hours to days.

As mentioned by Brock (1989) the anchialine pools at NELHA are important sampling points for the water quality monitoring program. It is also important to maintain and monitor the native anchialine pool biota for it serves to provide an "early warning system" should changes occur due to NELHA effluents placed into injection wells or open trenches on land. The first manifestation of problems in the aquatic fauna will probably occur in the anchialine pools which would be closer to these source(s).

MARINE BIOTA

A. Introduction

The nearshore marine communities in the vicinity of Keahole Point have, for years been recognized as some of the most biologically diverse in Hawaiian waters. In his pioneering survey work of Hawaiian fish communities, Brock (1954) noted that the fish communities of the Keahole Point area were amongst the most specious and had the greatest standing crops of any in the islands; more recent workers (Brock and Norris 1987a, 1987b, 1988; Brock and Kam 1989) have found similar results. Because of this diversity and the need to preserve the quality of nearshore waters, a comprehensive program of monitoring both water quality and the "health" of nearshore marine communities was identified as a central component to the cooperative environmental program at NELHA.

Important objectives of the marine study are to determine the baseline conditions of the nearshore communities and to quantitatively ascertain any impacts that might occur due to the discharge of cold/aquacultural water effluents into the water-table beneath adjacent on-land lava fields. Thus the ability to repeatedly sample the same communities through time is a prerequisite. Presumably impacts from this discharge to nearshore communities will come in the form of alterations in the quality of the groundwater entering the sea. If this is correct, one might expect to measure a gradient of impacts from greatest at the point of discharge dissipating with increasing distance from the source. Stations to monitor water quality, benthos and fish communities have been situated so as to capitalize on any existing gradients.

B. Methods

GK and Associates (1989) identified two areas fronting the NELHA project site that showed depressions in salinity, i.e., having groundwater input. These areas are directly fronting the northern complex of anchialine pools at Hoona Bay as well as to the south fronting Wawaloli Beach next to the southern boundary of the project site. These two locations served to pinpoint the locations of stations for baseline studies. An initial control site was selected in the vicinity of Honokohau Harbor and was sampled in 1989 and the first quarterly survey (Brock 1989, 1991) but has been subsequently dropped. A fourth site, the 18-inch pipe station was added to the program and first sampled in October 1991; it was resampled in the present survey. The 18-inch pipe is located about midway along the coast of the project area between Wawaloli Beach and Keahole Point.

Quantitative studies were carried out in the communities adjacent to the shore; the rationale was that it will be those communities in closest proximity to any nonpoint discharge of effluents that would be first impacted and thus the first in which change could be measured.

In the initial baseline, fish and benthic communities were sampled; four stations were established offshore of Hoona Bay, four stations fronting Wawaloli Beach and four stations offshore of Honokohau Harbor to serve as the control site. The October 1991 study established three transects at each location (Hoona Bay, 18-inch pipe, Wawaloli Beach and Honokohau) that sampled the boulder/<u>Pocillopora meandrina</u> zone, the <u>Porites lobata</u> zone and the <u>Porites compressa</u> zone that are common major biotopes on the West Hawaii coast. The present study sampled transects offshore of Wawaloli Beach, the 18-inch pipe and Hoona Bay and focused only on the fish communities at these locations. Additional studies were done along the 40-inch pipe path during the March 1992 survey and are summarized in a companion report.

Permanent stations have been established in each biotope or zone at each location. These stations are marked by small sub-surface floats that pinpoint the transect line. Fish communities were sampled using visual assessment techniques modified from Brock (1954). Immediately following station location, the visual fish census was undertaken to estimate the abundance and biomass of fishes. Data collected included species and numbers of individuals. The fish censuses were conducted over the entire lenght of the 25m transect line which was paid out as the census progressed as not to frighten wary fishes. All fishes within the 4 x 25m transect area to the water's surface were counted. A single diver equipped with SCUBA, transect line, slate and pencil would enter the water, count and note all fishes in the prescribed area. All quantitative studies were carried out using SCUBA.

Besides frightening wary fishes, other problems with the visual census technique include the underestimation of cryptic species such as moray eels (Family Muraenidae) and nocturnal species, e.g., squirrelfishes (Family Holocentridae), aweoweos (Family Priancanthidae), etc. This problem is compounded in areas of high relief and coral coverage affording numerous shelter sites. Species lists and abundance estimates are more accurate for areas of low relief, although some fishes with cryptic habits or protective coloration (e.g., the nohus, Family Scorpaenidae; the flatfishes, Family Bothidae) might still be missed. Obviously, the effectiveness of the visual census technique is reduced in turbid water and species of fishes which move quickly and/or are very numerous (e.g., opelu, Family Carangidae) may be difficult to count. Problems may arise with the bias related to the experience of the diver conducting counts when attempting to make comparisons between surveys. In spite of the above drawbacks, the visual census technique probably provides the most accurate non-destructive assessment of diurnally active fishes presently available (Brock 1982).

C. Results

Communities in closest proximity to any nonpoint source of pollution entering the sea via the groundwater would be the first to manifest problems thus we established quantitative stations to sample the fish and benthos in the boulder/Pocillopora meandrina zone, the Porites lobata zone and the Porites compressa zone. All of these biotopes or zones are in very close proximity of the shoreline in the Keahole Point area.

The depression in salinities taken adjacent to the shoreline fronting the northern complex of anchialine pools at Hoona Bay pointed to that site as an appropriate area in which to carry out quantitative marine baseline studies. Three stations were established; T-1 sampled the fish community in the boulder/Pocillopora meandrina zone, T-2 the community present in the Porites lobata zone and T-3 which sampled the fishes in the deeper Porites compressa zone. Figure 3 shows the approximate locations of these three stations relative to the shoreline, nearshore biotopes and to each other.

Station T-1 was established about 10m offshore of the pahoehoe bench in water from 2.5 to 3m in depth in the biotope of boulders and Pocillopora meandrina. The substratum at this station is comprised of pahoehoe overlain by basalt boulders ranging in size from 0.5 to 3m; much of the bottom is strewn with boulders providing considerable local cover. A complete listing of all fishes censused at this station in March 1992 are given in Appendix A. The same data for the October 1991 is presented in Appendix B; the May 1989 census data are presented in Brock (1989).

In total 32 species of fishes (263 individuals) were censused. The most abundant species on T-1 were the sergeant major or mamo (Abudefduf abdominalis), the damselfish (Chromis vanderbilti), convict tang or manini (Acanthurus triostegus), whitebar surgeonfish or maikoiko (Acanthurus leucoparieus), blue-lined surgeonfish or maiko (Acanthurus nigroris) and the goldring surgeonfish or kole (Ctenochaetus strigosus). The estiamted biomass of fishes at Station T-1 was 108 g/m^2; the species contributing most heavily to this biomass include the goldring surgeonfish or kole (Ctenochaetus strigosus), the orangespine unicornfish or umaumalei (Naso lituratus), the whitebar surgeonfish or maikoiko (Acanthurus leucoparieus) and the convict tang or manini (Acanthurus triostegus).

Station T-2 is situated about 45m from the shoreline at Hoona Bay in 7.9m of water. This station sampled the biotope of _Porites lobata_. The substratum at this station is comprised of boulders and _Porites lobata_ as the dominant coral. Boulders at this site range in size from 0.5 to about 2m. Again, the census results are presented in Appendix A; 28 species (144 individuals) were censused. The most abundant fish species at Station T-2 were the damselfish (_Chromis vanderbilti_), the brown surgeonfish or ma'i'i'i (_Acanthurus nigrofuscus_) and the goldring surgeonfish or kole (_Ctenochaetus strigosus_). The standing crop of fish at this station was estimated to be 36 g/m^2 and the orangespine unicornfish or umaumalei (_Naso lituratus_), goldring surgeonfish or kole (_Ctenochaetus strigosus_), brown surgeonfish or ma'i'i'i (_Acanthurus nigrofuscus_), parrotfish or uhu (_Scarus sordidus_) and the saddleback wrasse or hinalea lauwili (_Thalassoma duperrey_) were the largest contributors to this standing crop.

Station T-3 sampled the fish community of the _Porites compressa_ zone about 20m seaward of Station T-2. The substratum at this station is comprised of boulders, coral rubble and coral (_Porites compressa_) on a steep seaward facing slope. Thirty-two fish species (382 individuals) were encountered in the census at this station; biomass was estimated to be approximately 166g m^{-2}. The most abundant fishes at this station were the damselfishes (_Chromis agilis_, _C. hanui_ and _C. ovalis_, squirrelfishes or mempachis (_Myripristes kuntee_ and _M. amaenus_) and the yellow tang or lau'ipala (_Zebrasoma flavescens_). The biomass of fishes was estimated to be 166 g/m^2 and the squirrelfishes or mempachis (_Myripristes amaenus_ and _M. kuntee_), yellowfin goatfish or weke'ula (_Mulloides vanicolensis_) and parrotfish or uhu (_Scarus sordidus_) contributed most heavily to this standing crop.

Three stations were established offshore of the recently deployed 18-inch pipe south of the NELHA facility (Figure 3). These stations again sampled the boulder/_Pocillopora meandrina_ zone, the biotope of _Porites lobata_ and the biotope of _Porites compressa_ which lies in deeper water. All stations at the 18-inch pipe site commenced just to the south of the pipe, and paralleled the shore. Station T-4 was situated in the boulder/_Pocillopora meandrina_ zone in approximately 6m of water. The substratum at this station was boulders affording cover for fishes. These boulders ranged in size from 0.5 to well over 3m and covered much of the basalt substratum. The census at this station recorded 37 species and 274 individuals (Appendix A). The most abundant fishes at Station T-4 were the damselfish (_Chromis vanderbilti_), the sergeant major or mamo (_Abudefduf abdominalis_), whitebar surgeonfish or maikoiko (_Acanthurus leucoparieus_), and the yellow tang or lau'ipala (_Zebrasoma flavescens_). The standing crop at Station T-4 was estimated to be 230 g/m^2 and the blue goatfish or moano kea (_Parupeneus cyclostomus_, eye-stripe surgeonfish or palani (_Acanthurus dussumieri_), black surgeonfish

(Ctenochaetus hawaiiensis), orangespine unicornfish or umaumalei (Naso lituratus) and the unicornfish or kala holo (Naso hexacanthus) were the largest component to this biomass.

Station T-5 was established in 8-9m of water in the biotope of Porites lobata at the 18-inch pipe site. The substratum at this station was comprised of boulders and coral (dominant species Porites lobata). Thirty-one species and 467 individuals were recorded at this station. The most abundant fishes were the damselfish (Chromis vanderbilti), the brown surgeonfish or ma'i'i'i (Acanthurus nigrofuscus), the bluelined surgeonfish or maiko (Acanthurus nigroris) and the goldring surgeonfish or koie (Ctenochaetus strigosus). The standing crop of fishes at Station T-5 was estimated to be 158 g/m^2 and the parrotfish or uhu (Scarus sordidus), redlip parrotfish or palukaluka (Scarus rubroviolaceus), goldring surgeonfish or kole (Ctenochaetus strigosus) and orangespine unicornfish or umaumalei (Naso lituratus) contributed the greated biomass to this standing crop.

Station T-6 was established to sample the Porites compressa zone at the 18-inch pipe site. This station is situated in 13 to 14m of water at the shelf break. The substratum at this station is dominated by Porites compressa coral. The fish census noted 29 species and 499 individual fishes at this station. The most abundant species were the damselfishes (Chromis vanderbilti and C. agilis), the bluelined surgeonfish or maiko (Acanthurus nigroris) and the goldring surgeonfish or kole (Ctenochaetus strigosus). The biomass of fish at Station T-6 was estimated to be 248 g/m^2. The species of fishes that comprised the largest proportion of this standing crop include two large milkfish or awa (Chanos chanos) weighing about 13.6 kg, the squirrelfish or mempachi (Myripristes amaenus), the saddleback wrasse or hinalea lauwili (Thalassoma duperrey), the parrotfish or uhu (Scarus sordidus), the goldring surgeonfish or kole (Ctenochaetus strigosus) and the orangespine unicornfish or umaumalei (Naso lituratus).

A second area of major groundwater input was identified in the survey of coastal salinities at Wawaloli Beach. At this location a shallow subtidal bench extends seaward 60 to 80m before the depth increases from 1.2 to 6m where the biotope of boulders and Pocillopora meandrina is encountered. Three stations were established offshore of Wawaloli Beach; one of these (T-7) was situated in the biotope of boulders and Pocillopora meandrina, a second (Station T-8) was placed in the biotope of Porites lobata and the third station was setup in the biotope of Porites compressa. The approximate locations of these stations are given in Figure 3.

Station T-7 was established in 6m of water in the biotope of boulders and Pocillopora meandrina. The substratum at this station is dominated by large basalt boulders (mean size about 1.4m) with a small amount of coral present. The fish census (Appendix A) noted 25 species of fish having a total of 204 individuals present. The most abundant fishes were the mackeral scad or opelu (Decapterus macarellus), the damselfish (Chromis vanderbilti) and the brown surgeonfish or ma'i'i'i (Acanthurus nigrofuscus). The standing crop of fishes at Station T-7 was estimated to be 113 g/m^2. The mackeral scad or opelu comprised 55 percent of the total estimated biomass; the other major contributors to this standing crop include the parrotfish or uhu (Scarus sordidus) and the orangespine unicornfish or umaumalei (Naso lituratus).

Station T-8 sampled the biotope of Porites lobata in 6.7m of water. The substratum at this station is a mix of scattered basalt boulders (0.5 to 2m in diameter), and corals with Porites lobata being the dominant species. Twenty-six species of fishes were censused and 341 individual counted in the 100m^2 census area. The most abundant species present at Station T-8 were the damselfish (Chromis vanderbilti), the mackeral scad or opelu (Decapterus macarellus) and the bluelined surgeonfish or maiko (Acanthurus nigroris). The biomass of fishes was estimated to be 138 g/m^2 and mackeral scad or opelu (Decapterus macarellus) contributed 45 of this biomass; other major contributors include the blue goatfish or moano kea (Parupeneus cyclostomus) and the orangeband surgeonfish or na'ena'e (Acanthurus olivaceus).

Station T-9 was situated near the shelf break in 11m of water in the ecotone (zone of transition) between the biotope of Porites lobata and the Porites compressa zone. The substratum at this site is dominated by open basalt and some limestone; coral cover is limited at this site. The fish census yielded 24 species, 272 individuals and an estimated biomass of 57g m^{-2}. The most abundant fish species present at Station T-9 include the ubiquitous damselfish (Chromis vanderbilti), the bluelined surgeonfish or maiko (Acanthurus nigroris) and the goldring surgeonfish or kole (Ctenochaetus strigosus).

Table 5 presents a summary of the major parameters measured in the fish communities at each station for the May 1989, October 1991 and March 1992 surveys. For the most part, the data are not directly comparable between the May 1989 and October 1991 surveys because station locations were shifted in the October 1991 survey; however if the assumption that the sampling at the stations reflects the community development in each zone or biotope, some comparison may be made. A decline in the number of species is evident at all comparable stations between the 1989 and 1991 surveys except at Hoona Bay Porites lobata zone and in the boulder/Pocillopora meandrina zone at Wawaloli Beach. Similarly, there has been a decline in the number of individual fishes encountered at all stations except for the boulder/Pocillopora meandrina zone at Wawaloli Beach and the biotope of Porites lobata at offshore of Honokohau Harbor.

TABLE 5. Summary of the fish censuses from the May 1989, October 1991 and March 1992 surveys. Note that fish standing crop was not estimated in the May 1989 survey and that mean numbers of species and individuals are given where more than one station sampled a biotope at a given location. May 1989 and October 1991 data from Brock (1989, 1991).

	May 1989		October 1991			March 1992		
Location	No. Spp.	No. Ind.	No. Spp.	No. Ind.	Biomass (g/m^2)	No. Spp.	No. Ind.	Biomass (g/m^2)
Hoona Bay								
Boulder	26	389	24	339	105	32	263	108
P. lobata	33	430	34	399	187	28	144	36
P. compressa			35	481	170	32	382	166
18-Inch Pipe								
Boulder			39	510	379	37	274	230
P. lobata			32	604	327	31	467	158
P. compressa			36	824	271	29	499	248
Wawaloli Beach								
Boulder	25	187	30	209	210	25	204	113
P. lobata	37	346	33	237	51	26	341	138
P. compressa			28	188	57	24	272	54
Honokohau								
Boulder	30	265	28	180	72			
P. lobata	30	260	26	273	66			

The data in Table 5 allow direct comparisons to be made between the October 1991 and March 1992 surveys for the sample locations in Hoona Bay, the 18 inch pipe and offshore of Wawaloli Beach are now permanently marked. Combining individual stations and comparing data between sample dates using the non-parametric Wilcoxon matched-pairs signed-ranks test, there are no statistical differences in the number of fish species between the October 1991 and March 1992 surveys ($t=9$, $n=9$, N.S.) or in the number of individual fishes present ($t=8$, $n=9$, N.S.). However, there has been a statistically significant decline in the estimated standing crop of fishes from the October 1991 census to the March 1992 survey ($t=6$, $n=9$, $P>0.05$). Because the inclusion of a single large individual fish can heavily influence the biomass estimate for a given station, there is probably little reason for concern.

D. Discussion

As noted above, there are several biological zones or biotopes characterisitic of the Kona coast (Dollar 1975, Hobson 1974) whose presence in the Keahole area has been well documented (see Brock and Norris 1987a, 1987b, 1988; Brock and Kam 1989). The geologically young age of the Keahole Point region and its exposure to periodic high energy conditions dictates that the development of benthic communities (here primarily coral) are in an early stage of succession. Thus in mature coral reefs, the reef corals grow on a limestone or calcareous base developed over a considerable period of time; in the case of the reefs at Keahole Point and much of West Hawaii, they are young and the corals are growing on a basalt substratum. Typically, three zones are found in West Hawaii benthic communities that are defined by depth, physical conditions and dominant coral species. In the shallowest water (usually to about 30m offshore) is the boulder/Pocillopora meandrina zone; seaward is the Porites lobata reef bench zone that grades into the Porites compressa slope zone usually commencing at a depth of about 10m. The P. compressa slope zone continues deeper to depths of 30m or more.

The fish communities quantitatively assessed in this study at three geographically distinct areas are quite similar. At each location one station each sampled the biotope of boulders and Pocillopora meandrina, the biotope of Porites lobata and the Porites compressa zone further offshore. These biotopes are near continuous features along much of the West Hawaii coast and are the zones usually closest to shore hence would be most susceptible to impact from human generated effluents discharged with groundwater.

Qualitatively, declines are evident between the May 1989 and October 1991 fish censuses (Table 5); however direct comparison is difficult because the transect locations are not entirely duplicated. Direct comparison may be made between the censuses of October 1991 and March 1992 for the same permanently marked sites were sampled. The statistically significant decline seen in the standing crop estimates of fish communities between the October 1991 and March 1992 surveys (Table 5) may be related to (1) the chance inclusion of a few large fish, or (2) a real declines due to seasonal variation, environmental change or to fishing pressure.

Studies conducted on coral reefs in Hawaii and elsewhere have estimated fish standing crops to range from 20 to 200 g/m^2 (Brock 1954, Brock et al. 1979). Eliminating the direct impact of man due to fishing pressure and/or pollution, the variation in standing crop appears to be related to the variation in local topographical complexity of the substratum. Thus habitats with high structural complexity affording considerable shelter space usually harbor a greater estimated standing crop of coral reef fish; conversely, transects conducted in structurally simple habitats (e.g., sand flats) usually result in a lower estimated standing crop of fish (5 to 20 g/m^2). Goldman and Talbot (1975) noted that the upper limit to fish biomass on coral reefs is about 200 g/m^2. Ongoing studies (Brock and Norris 1989) suggest that with the manipulation (increasing) of habitat space or food resources (Brock 1987), local fish standing crops may approach 2000 g/m^2. Thus under certain circumstances, coral reefs may be able to support much larger standing crops of fishes than previously realized.

The high standing crops encountered in this study are probably related to the steep and rugged topographical relief found at most of the transect sites. The presence of adequate shelter coupled with strong tidal currents which transport particualte food materials may serve to sustain unusually high standing crops of fishes at specific sites.

Perhaps the most detailed data concerning nearshore fish and benthic communities are those for the construction of the 40-inch coldwater pipe (Brock and Norris 1987a, 1987b, 1988; Brock and Kam 1989); these data span the period from June 1987 (prior to pipe construction) to September 1989 (two years following completion of construction) and were collected at four points in time. These data provide information on community structure at a site situated between Hoona Bay on the north and the 18-inch pipe site on the south. These studies in conjunction with the present effort should provide the baseline against which changes could be assessed. If changes do occur, they will probably be mediated through changes in groundwater due to the generation of aquacultural and/or OTEC wastewater emanating with groundwater discharge into the ocean.

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APPENDIX A. Results of the quantitative visual censuses for fishes conducted at nine stations, three established each at Hoona Bay (T-1 - T-3), the 18-Inch Pipe (T-4 - T-6) and Wawaloli Beach (T-7 - T-9) at NELHA, Keahole Point, Hawaii on 6 March 1992. Each entry in the body of the table represents the total number of individuals of each species observed during each census. Census totals and biomass estimates are given at the foot of the table.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
HOLOCENTRIDAE									
Adioryx xantherythrus		3				1			
Myripristes amaenus		2	26			31			
M. kuntee			32						
Flammeo sammara			7						
AULOSTOMIDAE									
Aulostomus chinensis			2	1					
FISTULARIIDAE									
Fistularia commersoni						1	1	1	
SERRANIDAE									
Cephalopholis argus						1			
CHANIDAE									
Chanos chanos						2			
APOGONIDAE									
Apogon kailopterus			3						
CIRRHITIDAE									
Paracirrhitus arcatus	3		2	4	7	4	2	2	3
P. forsteri	1	1	1		2				
Cirrhitops fasciatus	3			1	1			1	2
CARANGIDAE									
Caranx melampygus					1			1	
Decapterus macarellus							75	75	
LUTJANIDAE									
Lutjanus kasmira			1						
Alphareus furcatus				1	1	1			
KYPHOSIDAE									
Kyphosus bigibbus	1								

APPENDIX A. Continued.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
MULLIDAE									
<u>Mulloides vanicolensis</u>			14						
<u>Parupeneus multifasciatus</u>	3	1			5	11	6	3	4
<u>P. bifasciatus</u>			1	1	1		1	2	
<u>P. cyclostomus</u>				3	2		1	3	
CHAETODONTIDAE									
<u>Forcipiger flavissimus</u>	1	4	5	4	3	11			2
<u>F. longirostris</u>		2			2				1
<u>Hemitaurichthys thompsoni</u>				1					
<u>Chaetodon auriga</u>				4					
<u>C. lunula</u>	2								
<u>C. kleini</u>			1			4			
<u>C. ornatissimus</u>		2	2	2	2				
<u>C. quadrimaculatus</u>							1		1
<u>C. multicinctus</u>	6	2	1	6	6		2	2	2
<u>C. miliaris</u>								1	
POMACANTHIDAE									
<u>Centropyge potteri</u>			4			3			3
POMACENTRIDAE									
<u>Dascyllus albisella</u>						5			
<u>Abudefduf abdominalis</u>	28			22					
<u>Plectroglyphidodon johnstonianus</u>	1	1	2	1					
<u>P. imparipennis</u>				1			2	1	
<u>Chromis vanderbilti</u>	32	39		96	259	70	53	160	141
<u>C. agilis</u>		9	133			128			13
<u>C. ovalis</u>			19	12					
<u>C. verator</u>			1			4			
<u>C. hanui</u>		4	18		4	22			9
<u>Stegastes fasciolatus</u>	4			3					3
LABRIDAE									
<u>Cheilinus rhodochrous</u>			2		1	1			
<u>Pseudocheilinus octotaenia</u>			1	1		1			
<u>P. tetrataenia</u>					1				
<u>Thalassoma duperrey</u>	17	3	9	13	16	16	6	19	9
<u>T. ballieui</u>		1					2	3	3
<u>Gomphosus varius</u>			3		2	1		1	
<u>Coris gaimard</u>		1			1		2		1
<u>Stethojulis balteata</u>				1		2			

APPENDIX A. Continued.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
SCARIDAE									
<u>Calotomus</u> <u>carolinus</u>	1								
<u>Scarus</u> <u>sordidus</u>	9	7	16	4	12	10	2		
<u>S</u>. <u>psittacus</u>	2								
<u>S</u>. <u>rubroviolaceus</u>					1			2	
ACANTHURIDAE									
<u>Acanthurus</u> <u>achilles</u>	4			4		2			
<u>A</u>. <u>leucoparieus</u>	20			21			8		
<u>A</u>. <u>nigrofuscus</u>	13	20			20		14	15	7
<u>A</u>. <u>nigroris</u>	19	9	5	3	34	61	2	11	21
<u>A</u>. <u>thompsoni</u>								9	
<u>A</u>. <u>olivaceus</u>	1	1	2	2	1	2	2	12	
<u>A</u>. <u>dussumieri</u>				10			1		3
<u>A</u>. <u>triostegus</u>	25	1							
<u>Ctenochaetus</u> <u>strigosus</u>	36	15	19		54	86			31
<u>C</u>. <u>hawaiiensis</u>				9					
<u>Zebrasoma</u> <u>flavescens</u>	13	5	38	20	12	9	10	6	
<u>Z</u>. <u>veliferum</u>	1						1		
<u>Naso</u> <u>literatus</u>	7	4	5	6	4	8	6	2	9
<u>N</u>. <u>hexacanthus</u>				4	2				1
<u>N</u>. <u>unicornis</u>	1			1			1		
ZANCLIDAE									
<u>Zanclus</u> <u>cornutus</u>	2	2	1	3	6			2	
BLENNIIDAE									
<u>Exallis</u> <u>brevis</u>		1							
BALISTIDAE									
<u>Melichthys</u> <u>niger</u>	2			1				2	1
<u>M</u>. <u>vidua</u>	1								
<u>Sufflamen</u> <u>bursa</u>	2	1	6	3	3	1		2	1
MONACANTHIDAE									
<u>Cantherhines</u> <u>sandwichiensis</u>		2		1					
<u>C</u>. <u>dumerili</u>					1		1		
CANTHIGASTERIDAE									
<u>Canthigaster</u> <u>jactator</u>	2	1		1			2	3	1
NUMBER OF SPECIES	32	28	32	37	31	29	25	26	24
NUMBER OF INDIVIDUALS	263	144	382	274	467	499	204	341	272
BIOMASS (g/m^2)	108	36	166	230	158	248	113	138	54

APPENDIX B. Results of the quantitative visual censuses for fishes conducted at nine stations established at Hoona Bay (T-1 - T-3), the 18-Inch Pipe (T-4 - T-6) and offshore of Wawaloli Beach (T-7 - T-9) at NELHA, Keahole Point, Hawaii on 25 October 1991. Each entry in the body of the table represents the total number of individuals of each species observed during each census. Census totals and biomass estimates are given at the foot of the table.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
MURAENIDAE									
<u>Gymnothorax</u> <u>meleagris</u>		1							
<u>G</u>. <u>flavomarginatus</u>			1						
<u>G</u>. <u>eurostus</u>							1		
SYNODONTIDAE									
<u>Saurida</u> <u>gracilis</u>		1		2				1	
HOLOCENTRIDAE									
<u>Adioryx</u> <u>lacteoguttatus</u>			3						
<u>A</u>. <u>xantherythrus</u>		3	8						
<u>Myripristes</u> <u>amaenus</u>	4	4	21	15		10			
AULOSTOMIDAE									
<u>Aulostomus</u> <u>chinensis</u>			1		1	1			1
FISTULARIIDAE									
<u>Fistularia</u> <u>commersoni</u>							7	1	
SERRANIDAE									
<u>Cephalopholis</u> <u>argus</u>		1	1			4			
CARANGIDAE									
<u>Caranx</u> <u>melampygus</u>			1	1					
LUTJANIDAE									
<u>Lutjanus</u> <u>kasmira</u>		1	2		1				
<u>L</u>. <u>fulvus</u>	1		1	1					
<u>Alphareus</u> <u>furcatus</u>				1	1	1	1		
SPARIDAE									
<u>Monotaxis</u> <u>grandoculis</u>		4	3						1
MULLIDAE									
<u>Mulloides</u> <u>vanicolensis</u>		2	8	17					
<u>Parupeneus</u> <u>multifasciatus</u>		3	23			8	11	9	8
<u>P</u>. <u>bifasciatus</u>		1	2	1	1		1		
<u>P</u>. <u>cyclostomus</u>				3			1	8	

APPENDIX B. Continued.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
CHAETODONTIDAE									
Forcipiger flavissimus	4	3			11	4			3
Heniochus diphreutes						3			
Hemitaurichthys thompsoni					8				
H. polylepis					4	36			
Chaetodon fremblii	1						1		
C. kleini			16			7			
C. ornatissimus				2		2		1	
C. quadrimaculatus					2		1		
C. multicinctus	7	12	8	8	5	7		6	
C. miliaris						7		5	
C. lunula							1		
C. lineolatus							2		
POMACANTHIDAE									
Centropyge potteri			1			7			1
POMACENTRIDAE									
Dascyllus albisella		4				7			
Abudefduf abdominalis				33	35				
Plectroglyphidodon johnstonianus				3	1	2		3	2
P. imparipennis				1			1	2	
Chromis vanderbilti	90	61	107	142	375		65	108	24
C. agilis	14	30	45			315			8
C. ovalis		34		27					
C. verator		9			9				
C. hanui		8	13			23			3
Stegastes fasciolatus	2			1			1	1	
CIRRHITIDAE									
Paracirrhitus arcatus		5	4	7	4	9		3	4
P. forsteri	1	2	1	1	1			1	1
Cirrhitops fasciatus			2						3
LABRIDAE									
Labroides phthirophagus	1								
Cheilinus rhodochrous					1				
Pseudocheilinus octotaenia		1	4		1	11		1	2
P. tetrataenia						4			
Thalassoma duperrey	8	29	24	24	11	25	25	17	9
T. ballieui	3			4		3		3	3
Gomphosus varius				2		1	1		1
Coris gaimard						1		1	2
Pseudojuloides cerasinus			7			4			5

APPENDIX B. Continued.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
LABRIDAE									
<u>Stethojulis balteata</u>					2				
<u>Macropharyngodon geoffroy</u>									4
SCARIDAE									
<u>Calotomus carolinus</u>		1		1	1				1
<u>Scarus perspicillatus</u>				1			7	3	
<u>S.sordidus</u>	11	28	12	23	8	12	1	1	
<u>S. psittacus</u>	8						1		
<u>S. rubroviolaceus</u>	1	1		2	2		1		
ACANTHURIDAE									
<u>Acanthurus achilles</u>	2			8		3			
<u>A. glacoparieus</u>				1					
<u>A. leucoparieus</u>	8			24	2		13		
<u>A. guttatus</u>				2					
<u>A. nigrofuscus</u>	71	50	35	27	45	16	27	10	19
<u>A. nigroris</u>		9	9		4	9			
<u>A. thompsoni</u>						110			
<u>A. olivaceus</u>				13	1		8	5	
<u>A. dussumieri</u>					1		2	1	
<u>Ctenochaetus strigosus</u>	77	30	56	57	37	107		23	54
<u>C. hawaiiensis</u>			7	8		4			
<u>Zebrasoma flavescens</u>	18	15	37	35	15	42	9	2	9
<u>Z. veliferum</u>				1			1		
<u>Naso literatus</u>	1	3	4	5	12	15	13	4	5
<u>N. hexacanthus</u>		31	8						9
<u>N. unicornis</u>							1		
ZANCLIDAE									
<u>Zanclus cornutus</u>	1	3		1		3	1	1	
BLENNIDAE									
<u>Cirripectus variolosus</u>								1	
BALISTIDAE									
<u>Melichthys niger</u>	4			4			4	1	
<u>Sufflamen bursa</u>	1	5	2		1	1		3	3
OSTRACIONIDAE									
<u>Ostracion meleagris</u>							1	1	

APPENDIX B. Continued.

FAMILY and Species	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9
CANTHIGASTERIDAE									
Canthigaster jactator		4	4	1	1		3	2	2
C. rivulata								1	
NUMBER OF SPECIES	24	34	35	39	32	36	30	33	28
NUMBER OF INDIVIDUALS	339	399	481	510	604	824	209	237	188
BIOMASS (g/m^2)	105	187	170	379	327	271	210	51	57

APPENDIX E
CEMP BENTHIC MARINE BIOTA MONITORING PROGRAM

Marine Research Consultants

BENTHIC MARINE BIOTA MONITORING PROGRAM

AT KEAHOLE POINT, HAWAII

Report II-91

Prepared for

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March 19, 1992

INTRODUCTION AND PURPOSE

Facilities at the Natural Energy Laboratory of Hawaii (NELH), and the Hawaii Ocean Science and Technology (HOST) Park employ nutrient rich waters from below the thermocline for various aquaculture activities at Keahole Point, on the west coast of the Island of Hawaii. A concern regarding discharge of these waters at the shoreline and into the aquifer is the potential for environmental alteration of community structure in the adjacent marine environment and anchialine ponds.

In the interest of addressing this concern and assuring maintenance of environmental quality, it has been deemed necessary to carry out a comprehensive marine environmental monitoring program off Keahole Point. One component of the monitoring deals with the benthic (bottom-dwelling) biological communities. The intent of the benthic component of the monitoring program is to quantitatively describe existing community structure, and to identify changes from natural and man-induced factors. This report described results of the second increment of benthic monitoring conducted in December 1991.

MONITORING RATIONALE

Benthic marine community structure can be defined as the abundance, diversity, and distribution of stony and soft corals, motile benthos such as echinoderms, and macroalgae. In the context of time-series surveys, benthic assemblages are often the most useful biological assemblages for direct evaluation of environmental impacts to the marine environment. Because benthos are generally long-lived, immobile, and intimately affected by input of potential pollutants, these organisms must either tolerate the surrounding conditions within the limits of adaptability or die.

As members of the benthos, stony corals are of particular importance in nearshore Hawaiian environments. Corals compose a large portion of the reef biomass and their skeletal structures are vital in providing a complex of habitat space, shelter, and food for other species. Because corals serve in such a keystone function, coral community structure is considered the most "relevant" group in the use of reef community structure as a means of evaluating past and potential impacts associated with activities on land. For this reason, and because alterations in coral communities are easy to identify, observable change in coral population parameters is a practical and direct method for obtaining the information that is required to meet existing environmental regulations.

The overall intent of the benthic monitoring program is to identify changes to biotic assemblages as a result of input of dissolved materials in aquaculture waters. These changes will potentially take the form of alteration in settlement and growth of the living components of the community. Such effects are likely to be difficult to decipher when superimposed over the combined effects of natural phenomenon (e.g. dislodgement, predation, sediment flow) that routinely cause alteration in the arrangement of the living, as well as nonliving components of the reef. Studies of windward reef areas have shown that while overall coral cover may remain fairly constant, there can be a high degree of spatial change as resources are continually covered and uncovered in a "temporally varying mosaic." As the study area at Keahole is known to be a high energy environment, natural factors of environmental change are likely to be substantial, and could mask changes related to the NELHA facilities.

Thus, it is essential that the sampling methodologies employed for benthic monitoring extend beyond repetitive surveys employing randomly placed quadrats on line transects. Instead, a series of permanent quadrats have been established, where intensive, rather than extensive, repetitive quantitative analyses are being routinely performed.

METHODS

All phases of the benthic monitoring program employs diver/scientists using SCUBA equipment, operating from a small boat. Four quantitative survey sites that were established in the preliminary NELHA surveys by R. Brock were utilized as monitoring sites in the initial monitoring survey in August 1991. Three of the survey sites are located off the NELHA area; the fourth was intended to serve as a control located in a region of similar physiographic structure, but removed from any potential inputs that could affect the marine environment. It was concluded, however, that the fourth site selected adjacent to the Honokohau Small Boat Harbor did not represent an adequate control. As a result, only the three survey stations off of the NELHA site were investigated during the present phase of monitoring (see Figure 1). Planning is currently underway to establish additional survey sites so that the monitoring program covers all necessary areas to determine environmental effects.

For ease of identification, each survey site is labeled with a name as well as a number. Site 1 is designated "Hoona Bay"; Site 2 is located at the "18" Pipe"; Site 3 is near the "O'oma

Boundary". Locations of the survey sites were fixed by triangulation with conspicuous landmarks as well as by global positioning system (GPS), and can be easily relocated for subsequent surveys.

In the initial survey in August, three permanent transect stations were established at each survey site. Wherever possible, each site was placed in one of the three major physiographic/biotic structural zones described for the Kona Coast in Dollar (1975, 1982). These zones are characterized as the nearshore boulder zone (depth ≈ 0-15 ft.), the reef-building platform zone (depth ≈ 15-30 ft.), and the reef slope zone (depth ≈ 30-60 ft.).

Permanent transects at each site were established by placing markers into solid substratum of the ocean floor (either basalt or limestone). Marker placement was carried out by Ocean Innovators, utilizing methods and equipment developed for the purpose of permanently attaching artificial reef structures to the sea floor. The attachment procedure involved drilling a hole for anchoring an expandable eye-bolt. Small marker buoys on wire rope that floated above the bottom were attached to the eye-bolts for ease in locating transect stations on subsequent surveys.

The permanent markers defined the ends of 25 meter (80 ft.) long transects, oriented parallel to depth contours. During the initial survey three permanent quadrats were defined on each transect. Each quadrat had the dimensions of 2 m x 1.3 m. Each permanent quadrat was photographed using a Nikonos camera with a super wide angle lens (15mm, 94° field of view) using color print film. The camera was mounted on a tripod frame to ensure the highest degree of comparative repeatability between surveys. The photographic technique provide excellent resolution of the detail of the benthic structure, to the degree that individual calices of certain corals are distinguishable.

During the first survey, each quadrat was composed of four photographs centered at the ends and center of the transect line, each of which shared a two common borders with the adjacent photo. However, because of the substantial vertical relief in many of the survey areas, matching the borders of the photographs was extremely difficult. As a result it was deemed necessary to alter the technique somewhat. In all surveys conducted after August 1991, photographs will be taken at ten fixed marks along the 25 m transect line. With this alteration in technique, a higher precision in quadrat location between surveys will be achieved. However, because of the alteration in technique, quantitative comparisons between results of the first two surveys will be limited.

In addition to the quadrat photographs, visual estimates of species abundance of attached and motile benthos was recorded on writing slates. Bared substratum (bare rock, sand, dead coral and coral rubble) were also evaluated in terms of areal coverage.

In the laboratory, accurate estimates of benthic cover of biota and substrata were performed using two methods. A grid of 100 evenly spaced points was overlaid on each quadrat photo, and the component under each point recorded. In addition, area coverage of each component in the quadrat photos was determined using a overlay grid divided into 100 equally sized segments. The number of segments of each coral species, and non-coral substratum type was summed to calculate area coverage. Verification of species identification was performed using the information collected in the field. The two methods for estimating cover are designated as the point intercept (PI) method, and the area coverage (AC) method.

The Shannon-Weiner index of diversity was also calculated for percent coral cover on each transect using estimates from both the area cover and point intercept methods. The formula for calculating diversity (H') is:

$$H' = -\sum_{i=1}^{s} pi \ln pi,$$

where pi is the proportion of the ith species in the population, and s is the number of species.

RESULTS

Physical Structure

The shoreline and intertidal area of the subject property consist predominantly of basaltic boulder outcrops interspersed between narrow, steeply sloping beaches. The beaches are composed of rounded cobbles and coarse calcium carbonate sands which extend into the intertidal area. The area directly off of Keahole Point consists of a basaltic extension of the island mass that meets the ocean in steep vertical cliff faces that extend approximately 15-20 feet below the ocean surface.

The structure of the offshore environment in the vicinity of Keahole Point generally conforms to the pattern that has been documented as characterizing much of the west coast of the Island of Hawaii (Dollar 1982). The zonation scheme consists of three predominant regions, each with a characteristic coral assemblage that is adapted to the prevalent physical regime (i.e. wave stress) of the region.

Beginning at the shoreline and moving seaward, the shallowest zone at the land-sea interface is comprised of a flat basaltic terrace that is the underwater continuation of the island landmass. In areas offshore of basaltic shorelines the intertidal zone is often covered with large boulders that have entered the ocean after breaking off from the shoreline. The seaward edge of the nearshore reef terrace terminates in a vertical cliff face approximately 10-15 feet in height. The face of the cliff is irregular in that it is scalloped and cut with caves and arches. In areas fronting shoreline beaches, boulder cover is not as prominent, and the intertidal area consists primarily of flat basaltic shelf. The nearshore zone receives most of the force of breaking waves and surge, and as a result is inhabited predominantly by organisms capable of withstanding these stresses on a regular basis. The predominant coral species occupying the nearshore area is *Pocillopora meandrina*, which is recognized as a "pioneering" species that is the first coral to settle on newly cleared substratum, or to occupy areas that are too harsh for other species. The shallow transects conducted at each of the survey stations traversed the "nearshore boulder" zone.

Seaward of the nearshore boulder zone, bottom structure is composed predominantly of a gently sloping reef bench. In some areas, the bench is characterized by high relief in the form of undercut ledges and basaltic pinnacles. Fine-grained calcareous sediments also comprise a component of bottom cover. Water depth in this mid-reef zone ranges from about 20 to 50 feet. As wave stress in this region is substantially less than in the shallower areas, and suitable hard substrata abounds, the area provides an ideal locale for colonization by attached benthos, particularly reef corals. The intermediate depth transects at each survey station were located on the "reef bench" zone.

The seaward edge of the reef platform (at a depth of about 45-50 feet) is marked by an sharp increase in slope to an angle of approximately 20-30 degrees. In the deep slope zone, substratum type changes from the solid continuation of the island mass to an aggregate of generally unconsolidated sand and rubble. Moving down the reef slope, coral settlement and growth ceases at a depth of approximately 80 feet; beyond this depth the bottom consists mostly of sand, with occasionally basaltic outcrops. The deep transects at each survey station were located on the upper portions of the "reef slope" zone.

While each of the survey stations had similarities to the typical scenario described above, each station also has distinctive characteristics, resulting in four relatively unique habitats.

At Hoona Bay the "typical" zonation scheme is best developed in that all three zones are clearly apparent. The entire zonation scheme is compressed into a relatively narrow band (about 300-500 feet wide) between the shoreline and the sand slope that extends to abyssal depths. At the 18" pipe station, the entire region from the shoreline to the reef slope is representative of the typical nearshore boulder zone, and biotic assemblages that occur in areas that are consistently subjected to intense wave scour. At the O'oma boundary station, the typical zonal structure appears to have been well-established. However, there is substantial evidence of relatively recent destruction of a major portion of living corals as a result of storm wave damage.

Biotic Community Structure

Reef Coral Communities

The overwhelming majority of benthic biota on the monitoring transects consisted of stony, reef-building (Scleractinian) corals. Benthic macroalgae where virtually nonexistent on survey transects, and motile invertebrates were limited to occasionally occurring echinoderms (sea urchins and sea cucumbers).

Table 1 shows the quantitative summary of coral community structure collected during the December 1991 survey, while Appendix A shows the composition of individual quadrats that comprises transect results. Table 2 shows comparative date from the two completed surveys in 1991. In August, seven species of corals were encountered on transects, while the number of coral species on a single transect ranged from one to six. In December ten species of corals were encountered, with the number on a single transect ranging from two to seven.

In August, five species of stony corals (*Pocillopora eydouxi, Pavona duerdeni, Cyphastrea ocellina, Porites brighami* and *Fungia scutaria*), and two "soft" corals (*Palythoa tuberculosa* and *Sarcothelia edmondsoni*) were observed in the study area but did not occur on any transects. In December, all of these species were also observed but *Fungia, Palythoa,* and *Sarcothelia* were encountered on transects.

The dominant species on all transects was *Porites lobata,* which accounted for 72.3% of total coral cover in August and 64.6% of cover in December (according to areal coverage estimates). The second and third most abundant species, *Porites compressa* and *Pocillopora meandrina*, accounted for 14.2%, and 13.1% of coral cover, respectively, in

August and 12.3% and 11.9%, respectively in December. Thus, the remaining "rare" species encountered on transects totaled about 0.4% of coral cover in August and 11.2% in December.

Figure 2 depicts coral community structure in December in terms of total coral cover estimated from both areal coverage and point intercept methods as a function of water depth. Two dominant points are evident in examining Figure 2. First, it can be seen in the plots that there is no consistent trend with respect to total coral cover and depth zone. At Sites 1, and 3 cover is highest on the deepest transects, while at Site 2 cover is nearly uniform across the depth gradient.

The second major result concerns the degree of similarity of coral cover estimates from the two methods. Estimates of coral cover from the area cover method and the point intercept method track each other well in terms of relative abundance on each transect. However, the estimates of cover based on area are consistently less than those based on point intercepts. While the area cover estimates are more time consuming to acquire, this methodology represents a more accurate representation of actual benthic cover. Therefore, it appears that an artifact of the point intercept method is an overestimation of cover. For this reason, considerations of coral cover discussed below are based on the area cover estimates. Comparison of results from the August survey exhibited the same pattern of consistently higher estimates with the point intercept method.

Figure 3 shows percent cover of total coral for both monitoring surveys. Change in coral cover between the August and December surveys is also shown in Table 2. Cover values between the two surveys was relatively consistent at Stations 1 and 2, with no consistent change during either survey. At Station 3, however, percent cover varied considerably during the two surveys. The greatest differences occurred at the mid-depth transect where cover of *Porites lobata* decreased by 23% in December, and at the deep transect where *P. lobata* increased by 12%. While part of the difference in comparative abundance may be a result of alteration in survey technique, observation of the area suggested that there had been changes that appeared to be the result of storm activity.

Figure 4 shows percent cover of the three dominant species (*Porites lobata, P. compressa,* and *Pocillopora meandrina*) on each transect in December. It can be seen that the relative distributions of these species differs at each monitoring station. At Station 1, community structure exhibits the typical pattern for west Hawaii described in Dollar (1982). In brief, *P. lobata* occurs at intermediate levels in the shallow boulder zone, peaks at the mid-depth reef building areas, and decreases on the reef slope. Owing to the fragile growth form with respect to wave energy, *P. compressa* is rare in the shallow zones, but is the most abundant coral on the deep reef slope. Conversely, *P. meandrina* is adapted to areas of high wave stress, and is most abundant in the nearshore boulder zones.

At Station 2, adjacent to the 18" pipe, the entire reef area from the shoreline to the slope appears to be subjected to substantial wave stress. As a result, the entire reef shelf exhibits characteristics of the nearshore boulder zone with *P. meandrina* the most prevalent coral. On the reef slope, abundance of both species of *Porites* increases, while *P. meandrina* abundance decreases (see Figure 4).

At Station 3, it appears that recent storm activity has reduced coral cover, and substantially altered the zonation scheme. The lack of substantial cover of *P. meandrina* as exhibited at Site 2 suggests that the area off the O'oma boundary is substantially different than the 18" pipe site in terms of physical forces and available substratum for settling. The only area of abundant coral cover at is the deep transect, which consisted of *P. lobata* and *P. compressa*. Cover on the mid-depth transect of all species was low, apparently as a result of breakage and scour by wave activity.

Figure 5 shows plots of diversity on each transect in December, while Figure 6 shows comparisons of diversity between the August and December surveys. Diversity is an index of the equitability of distribution of individual coral species within the total coral coverage. Thus, diversity can be low when there are a high number of species but an extremely uneven distribution of cover (e.g. most species occur in very lower percentages of cover). In general, the patterns of diversity were mirror images of the estimates of coral cover. When total coral cover is high, it tends to be the result of dominance by one species, resulting in relatively low diversity. Comparison of diversities from the two monitoring surveys does not show consistent trends (Figure 6).

Figure 7 shows plots of number of coral species on each transect in December, while Figure 8 shows the comparison of number of coral species between the two monitoring surveys. Number of species was either the same or higher using areal cover estimates compared to point intercept methods. The difference in species number using the two methods of estimates also increases with greater numbers of species. These results are an artifact of the relative inability of the point intercept method to detect rare or small species (Figure 7). Comparing numbers of species between the two surveys indicates similar numbers in the shallow and mid-depth zones at all stations. Species counts were higher in the deep reef zones of Stations 1 and 2 during the most recent survey (Figure 8).

Other Benthic Macroinvertebrates

The other dominant group of macroinvertebrates on survey transects are the sea urchins (Class Echinoidea) (see Table 3). The most common urchins are *Echinometra matheai, Heterocentrotus mammillatus*, and *Tripneustes gratilla*. *E. matheai* are small urchins that are generally found within interstitial spaces bored into basaltic and limestone substrata. *E. matheai* occurred on all transects, and were most abundant at Sites 1 and 3 where a total of 50 individuals were counted on transects. This species was generally least abundant on the reef slope transects where solid substrata was not common.

Heterocentrotus mammillatus, commonly called the "slate-pencil" sea urchin was the second most abundant species on the NELHA transects. *H. mammillatus* occurred on all transects at Sites 1. No individuals were observed at Site 2, possibly owing to the strong wave stress that might be capable of damaging these organisms. The third most abundant urchin, *Tripneustes gratilla* occurred only on that shallow transect at Site 3.

Three species of sea cucumbers (Holothurians) were observed sporadically on the reef, but did not occur on transects. These species, *Holothuria atra, H. nobilis*, and *Actinopyga obesa*. Individuals of these species were distributed sporadically across the mid-reef and deep reef zones. The most common large starfish (Asteroidea) observed on the reef surface was the crown-of-thorns starfish (*Acanthaster planci*). Several crown-of-thorns were observed feeding on colonies of *Pocillopora meandrina*. No starfish were observed in transect quadrats.

The design of the reef survey was such that no cryptic organisms or species living within interstitial spaces of the reef surface were enumerated. Since this is the habitat of the majority of mollusks and crustacea, detailed species counts were not included in the transecting scheme. No dominant communities of these classes of biota were observed during the reef surveys at any of the study stations.

SUMMARY

Quantifying differences in benthic community structure is difficult for the first two monitoring surveys owing to continued refinement of survey techniques. At sites 1 and 2, community structure is very similar between the two surveys, indicating that major disruptive events have not occurred between August and December 1991. At Site 3, however, substantial changes are evident in the survey data. These differences may be due in part to variation in methodology, and to alterations caused by extreme storm events. There is no reason to suspect that any of the observed changes area a result of activities associated with NELHA. With an increasing data base from continuing surveys, it will be possible to distinguish the causes and magnitudes of changes in community structure.

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TABLE 1. Percent coral cover and non-coral substratum cover on transects surveyed in the vicinity of NELHA at Keahole Point, Hawaii in December 1991. "AC" represents area cover estimates; "PI" represents point intercept estimates. For location of survey sites, see Figure 1.

HOONA BAY SITE 1	10'		20'		40'	
CORAL SPECIES	AC	PI	AC	PI	AC	PI
Porites lobata	12.3	17.9	37.4	49.7	12.5	26.3
Porites compressa			4.1	5.2	20.0	27.6
Pocillopora meandrina	2.4	2.9	0.6	0.7	0.5	0.9
Montipora patula					0.1	
Montipora verrucosa	0.4	0.9			0.4	0.2
Pavona varians					0.2	
Zoanthus sp.					1.0	
TOTAL CORAL COVER	15.1	21.7	42.1	55.6	34.7	55.0
NUMBER OF SPECIES	3.0	3.0	3.0	3.0	7.0	4.0
CORAL COVER DIVERSITY	0.55	0.56	0.39	0.38	0.93	0.79
NON-CORAL SUBSTRATA						
Basalt	83.6	77.1	22.2	18.8		
Limestone	1.3	1.2	26.3	16.9	58.4	40.9
Rubble			9.3	8.7	3.7	
Sand					2.2	1.9

18" PIPE SITE 2	15'		25'		45'	
CORAL SPECIES	AC	PI	AC	PI	AC	PI
Porites lobata	5.8	9.6	5.2	11.7	9.2	15.9
Porites compressa					2.5	5.9
Pocillopora meandrina	6.2	7.6	8.5	11.5	0.1	0.1
Montipora patula	0.5	0.2				
Montipora verrucosa			0.3	0.2		
Pavona varians	0.1		0.2			
Leptastrea purpurea			0.2			
Palythoa tuberculosa			0.1		0.1	
Sarcothelia edmondsoni					0.4	
Fungia scutaria					0.1	
TOTAL CORAL COVER	12.5	17.4	14.3	23.4	12.4	21.9
NUMBER OF SPECIES	4.0	3.0	6.0	3.0	6.0	3.0
CORAL COVER DIVERSITY	0.84	0.74	0.84	0.74	0.58	0.61
NON-CORAL SUBSTRATA						
Basalt	44.6	43.6	72.5	63.2	17.4	16.1
Limestone	5.4	7.5	12.3	12.4	69.8	62.5
Rubble			0.25	0.2	0.1	0.1
Sand			0.6	0.7	0.3	0.4

TABLE 1. continued.

O'OMA BOUNDARY SITE 3	15'		25'		45'	
CORAL SPECIES	AC	PI	AC	PI	AC	PI
Porites lobata	10.8	20.2	1.4	4.4	14.7	22.6
Porites compressa			0.2	0.5	9.2	14.7
Pocillopora meandrina	1.7	2.1	0.1	0.1	0.1	0.1
Montipora patula						
Montipora verrucosa			0.1			
Pavona varians						
Leptastrea purpurea						
TOTAL CORAL COVER	12.5	22.3	1.7	5.0	23.9	37.4
NUMBER OF SPECIES	2.0	2.0	4.0	3.0	3.0	3.0
CORAL COVER DIVERSITY	0.39	0.31	0.57	0.42	0.68	0.69
NON-CORAL SUBSTRATA						
Basalt	34.5	32.2	31.0	31.4		
Limestone	45.6	38.9	51.7	51.8	65.5	55.0
Rubble			10.9	7.1		
Sand			4.7	3.7		

TABLE 2. Comparison of coral and non-coral substratum cover on transects surveyed in August and December of 1991 in the vicinity of NELHA at Keahole Point, Hawaii. All percentages are in terms of areal cover. Positive change indicates increased cover in December. For location of survey sites, see Figure 1.

HOONA BAY SITE 1	10'			20'			40'		
CORAL SPECIES	12/91	8/91	CHANGE	12/91	8/91	CHANGE	12/91	8/91	CHANGE
Porites lobata	12.3	11.5	0.8	37.4	29.3	8.1	12.5	11.8	0.7
Porites compressa				4.1	2.9	1.2	20.0	20.0	0.0
Pocillopora meandrina	2.4	4.1	-1.7	0.6	0.7	-0.1	0.5		
Montipora patula							0.1		
Montipora verrucosa	0.4		0.4				0.4		
Pavona varians					0.2	-0.2	0.2		
Zoanthus sp.							1.0		
TOTAL CORAL COVER	15.1	15.6	-0.5	42.1	33.1	8.9	34.7	31.8	2.8
NUMBER OF SPECIES	3	2	1	3	4	-1	7	2	5
CORAL COVER DIVERSITY	0.55	0.58	-0.03	0.39	0.42	-0.03	0.93	0.37	0.56
NON-CORAL SUBSTRATA									
Basalt	83.6	71.0	12.6	22.2	5.8	16.4			
Limestone	1.3	8.6	-7.3	26.3	61.6	-35.3	58.4	68.2	-9.8
Rubble				9.3			3.7		3.7
Sand							2.2		2.2

18" PIPE SITE 2	15'			25'			45'		
CORAL SPECIES	12/91	8/91	CHANGE	12/91	8/91	CHANGE	12/91	8/91	CHANGE
Porites lobata	5.8	4.7	1.1	5.2	2.0	3.2	9.2	6.8	2.4
Porites compressa					0.4	-0.4	2.5	6.5	-4.0
Pocillopora meandrina	6.2	11.4	-5.2	8.5	7.3	1.1	0.1	0.9	-0.8
Montipora patula	0.5								
Montipora verrucosa		0.1	-0.1	0.3	0.3	-0.0			
Pavona varians	0.1		0.1	0.2	0.1	0.0			
Leptastrea purpurea				0.2	0.1	0.0			
Palythoa tuberculosa				0.1		0.1	0.1		0.1
Sarcothelia edmondsoni							0.4		0.4
Fungia scutaria							0.1		0.1
TOTAL CORAL COVER	12.5	16.2	-3.7	14.3	10.2	4.1	12.4	14.2	-1.8
NUMBER OF SPECIES	4	3	1	6	6		6.0	3.0	3
CORAL COVER DIVERSITY	0.84	0.62	0.22	0.84	0.82	0.02	0.58	0.89	-0.31
NON-CORAL SUBSTRATA									
Basalt	44.6	60.5	-15.9	72.5	40.8	31.7	17.4		17.4
Limestone	5.4	23.5	-18.1	12.3	49.5	-37.2	69.8	85.9	-16.1
Rubble				0.3		0.3	0.1		0.1
Sand				0.6		0.6	0.3		0.3

TABLE 2. continued.

O'OMA BOUNDARY SITE 3	15'			25'			45'		
CORAL SPECIES	12/91	8/91	CHANGE	12/91	8/91	CHANGE	12/91	8/91	CHANGE
Porites lobata	10.8	2.3	8.5	1.4	24.4	-23.0	14.7	3.1	11.6
Porites compressa					0.1	-0.1		1.0	-1.0
Pocillopora meandrina	1.7	2.4	-0.7	0.1	1.3	-1.3	0.1	0.5	-0.5
Montipora patula									
Montipora verrucosa				0.1		0.1			
Pavona varians		0.1	-0.1						
Leptastrea purpurea					0.1	-0.1			
TOTAL CORAL COVER	12.5	4.8	7.7	1.5	25.9	-24.4	14.8	4.6	10.2
NUMBER OF SPECIES	2	3	-1	3	4	-1	2	3	-1
CORAL COVER DIVERSITY	0.39	0.74	-0.35	0.57	0.23	0.34	0.68	0.85	-0.17
NON-CORAL SUBSTRATA									
Basalt	34.5	83.4	-48.9	31.0	8.5	22.5			
Limestone	45.6	12.2	33.4	51.7	65.7	-14.0	65.5	86.7	-21.2
Rubble				10.9		10.9		8.7	-8.7
Sand				4.7	3.7				

TABLE 3. Sea urchin abundance on transects surveyed in the vicinity of NELHA at Keahole Point, Hawaii in August and December 1991. For location of survey sites, see Figure 1.

HOONA BAY	12-91			8-91		
SITE 1	10'	20'	40'	10'	20'	40'
URCHIN SPECIES						
Echinometra matheai	4	39	7	19	16	12
Heterocentrotus mammillatus	2	7	4	8	15	8
Tripneustes gratilla						1
Echinothrix diadema				1		1
TOTAL URCHIN COUNT	6	46	11	28	31	22
18" PIPE	**12-91**			**8-91**		
SITE 2	**15'**	**25'**	**45'**	**15'**	**25'**	**45'**
Echinometra matheai	19	8	4	6	3	12
Heterocentrotus mammillatus						
Tripneustes gratilla						
Echinothrix diadema						
TOTAL URCHIN COUNT	19	8	4	6	3	12
O'OMA BOUNDARY	**12-91**			**8-91**		
SITE 3	**15'**	**25'**	**45'**	**15'**	**25'**	**45'**
Echinometra matheai	36	9	5	21	54	14
Heterocentrotus mammillatus			1	2	4	4
Tripneustes gratilla	2					
Echinothrix diadema						
TOTAL URCHIN COUNT	38	9	6	23	58	18

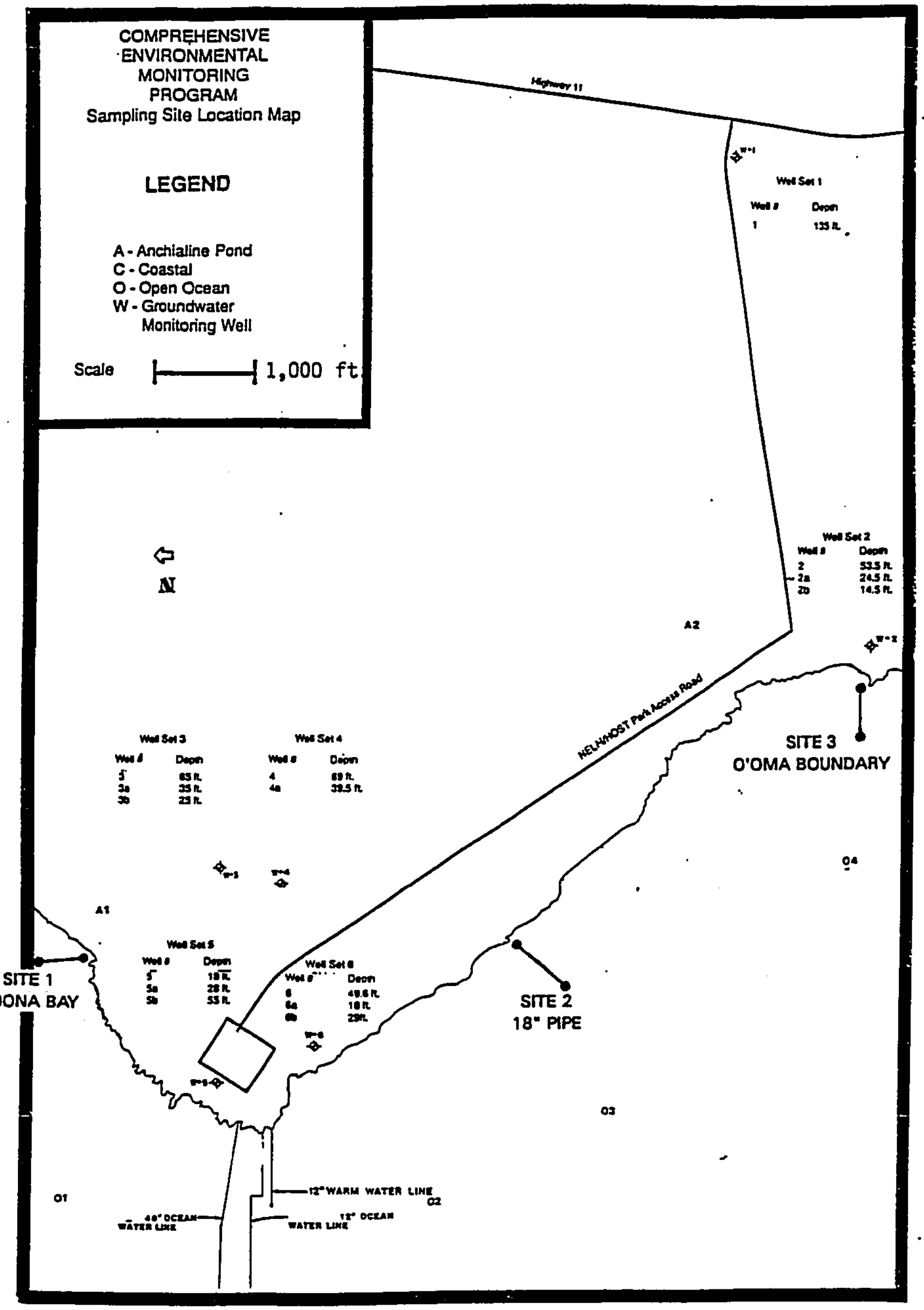

FIGURE 1. Map showing location of Natural Energy Laboratory of Hawaii Authority facilities at Keahole Point, and locations of three benthic monitoring sites at Hoona Bay (Site 1), the 18" Pipe (Site 2) and the O'oma Boundary (Site 3).

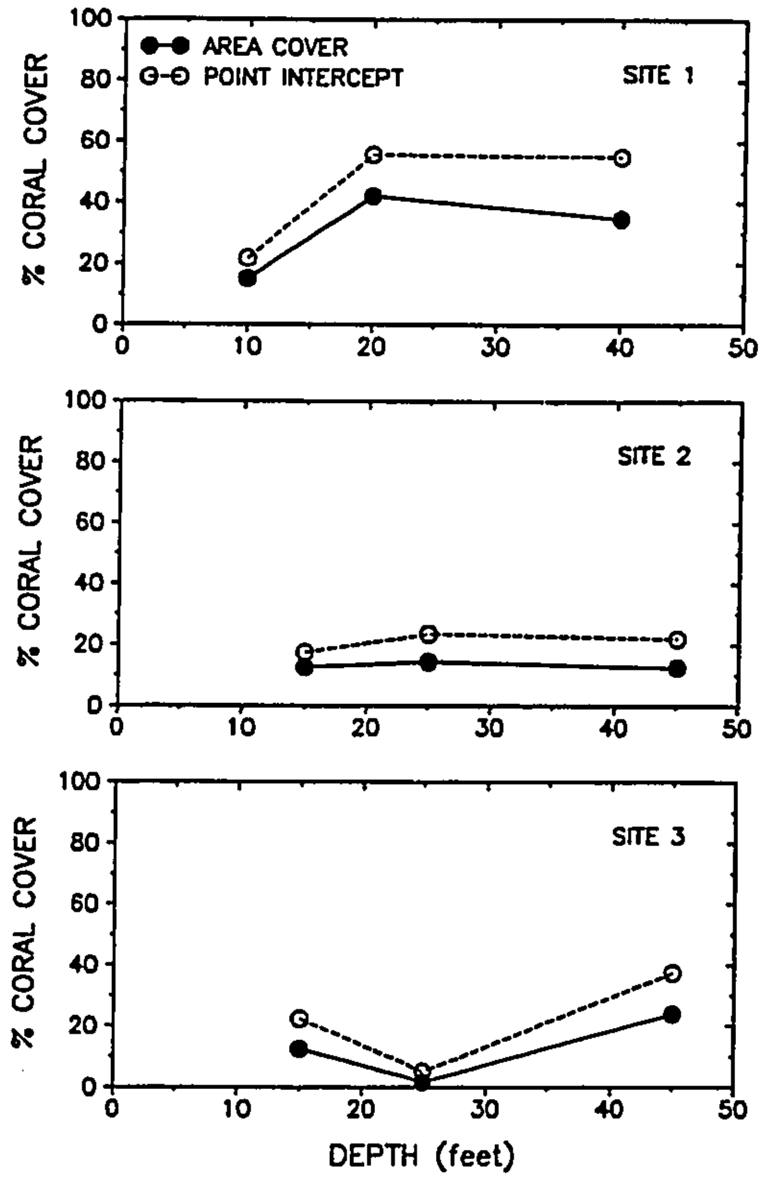

FIGURE 2. Plots of total percent coral cover on benthic transects at each monitoring site in December 1991. Analytical methods for area cover and point intercept estimates are explained in text. For locations of monitoring sites, see Figure 1.

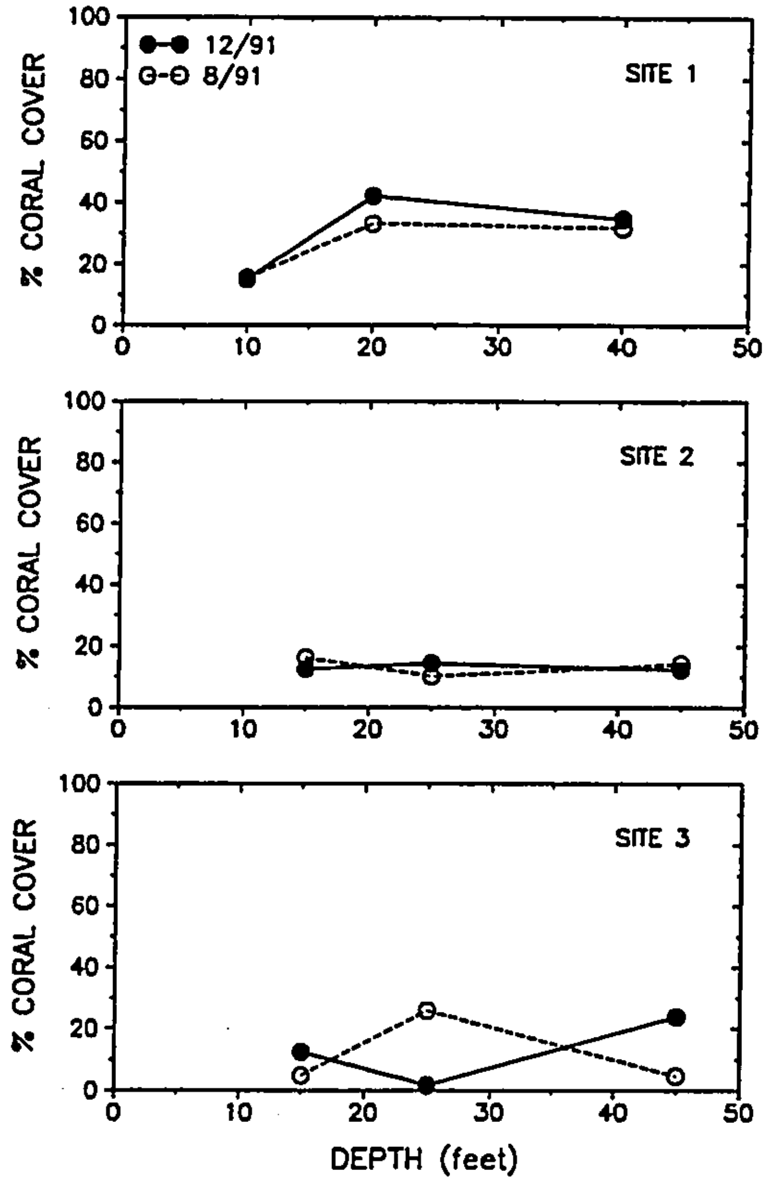

FIGURE 3. Plots of total percent coral cover on benthic transects at each monitoring site in August and December 1991. Data shown is from area cover estimates. For locations of monitoring sites, see Figure 1.

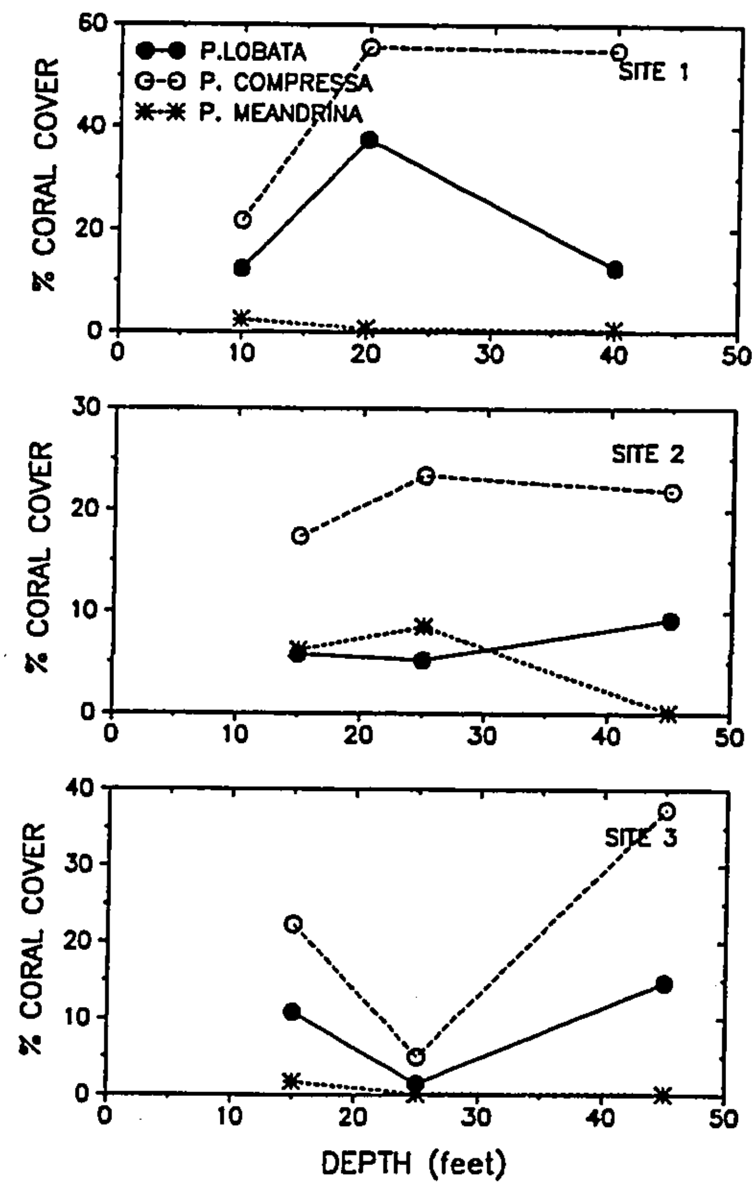

FIGURE 4. Plots of percent cover of three most abundant coral species on transects at each monitoring site in December 1991. Percent cover utilizes area cover estimates only. For locations of monitoring sites, see Figure 1.

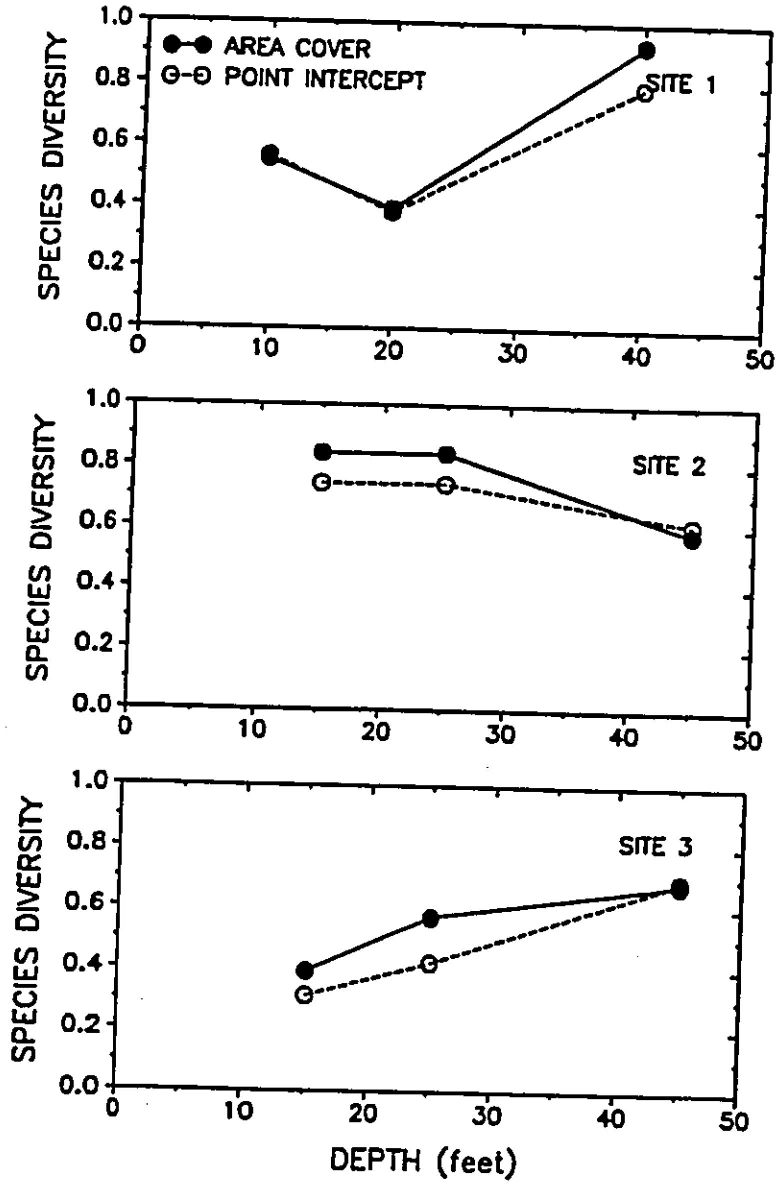

FIGURE 5. Plots of coral species cover diversity on benthic transects at each monitoring site in December 1991. Diversity calculation utilized percent cover estimates from area cover and point intercept methods. For locations of monitoring sites, see Figure 1.

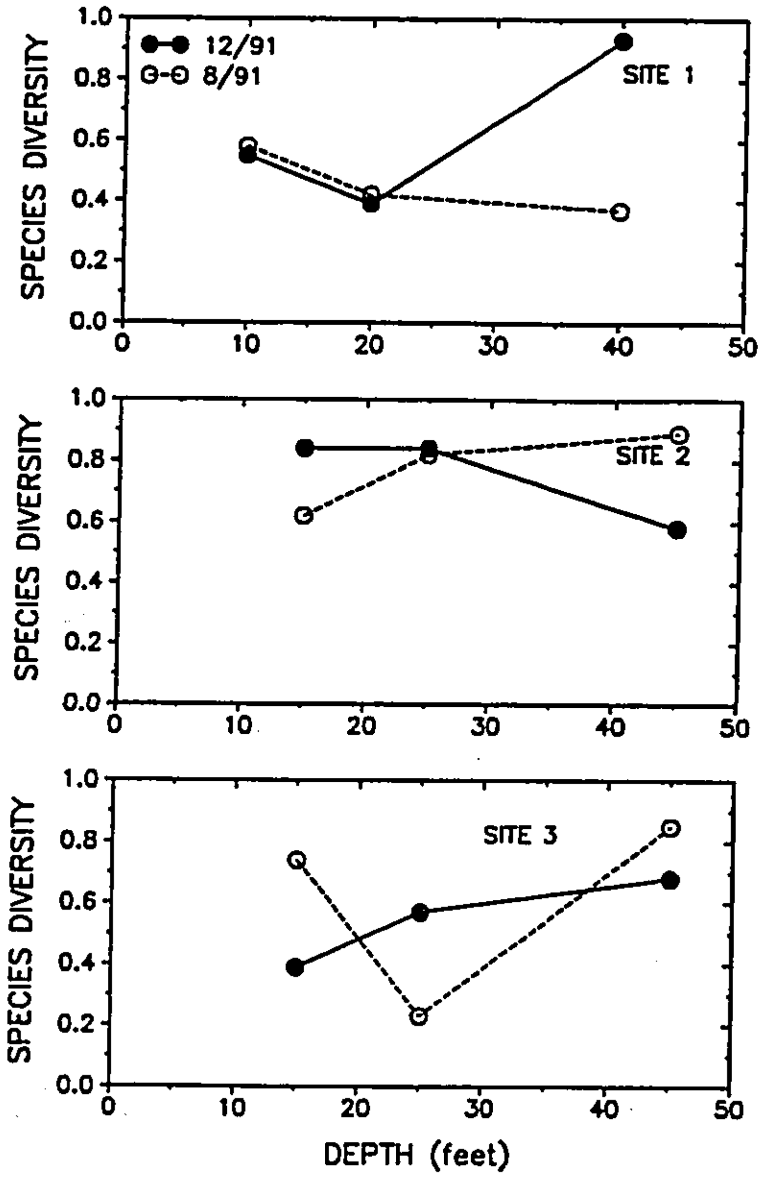

FIGURE 6. Plots of coral species cover diversity on benthic transects at each monitoring site in August and December 1991. Diversity calculation utilized percent cover estimates from area cover. For locations of monitoring sites, see Figure 1.

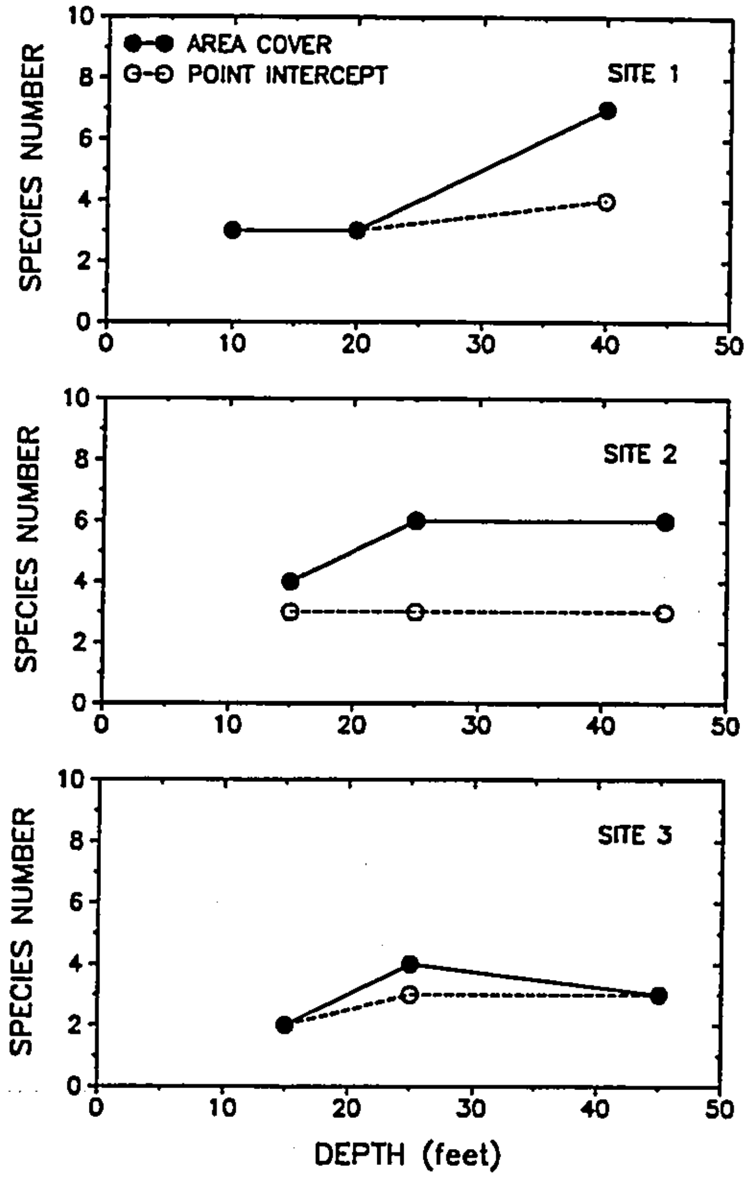

FIGURE 7. Plots of number of coral species on benthic transects at each monitoring site in December 1991. Species number taken from area cover methods. For locations of monitoring sites, see Figure 1.

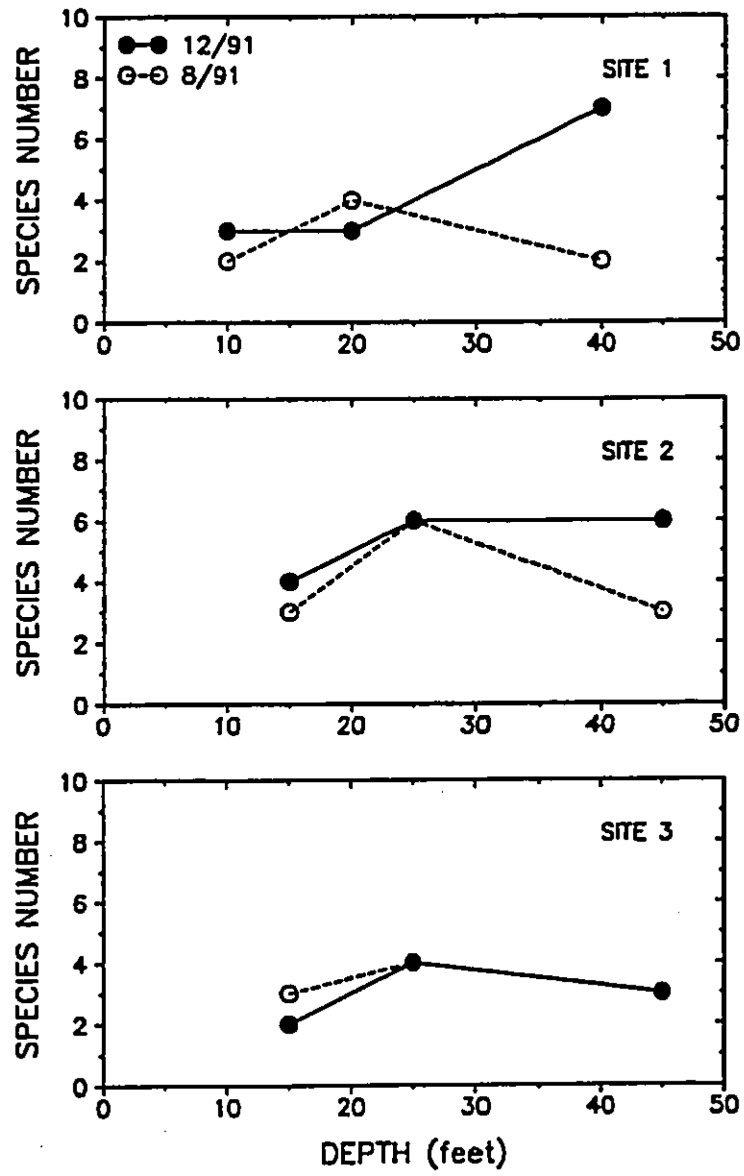

FIGURE 8. Plots of coral species number on benthic transects at each monitoring site in August and December 1991. Species number is from area cover estimates. For locations of monitoring sites, see Figure 1.

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE:	NELHA	MEAN CORA COVER	15.05 %
TRANSECT ID #:	HOONA BAY, 10'	STD. DEV.	7.2
DATE:	12/19/91	SPECIES COUNT	3
		SPECIES DIVERSITY	0.551

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	6.0	9.0	20.5	9.0	5.5	3.5	7.5	14.5	27.5	20.0	123.0
Pocillopora meandrina	12.5			9.0	2.0						23.5
Montipora verrucosa							0.5	3.5			4.0
QUADRAT TOTAL	18.5	9.0	20.5	18.0	7.5	3.5	8.0	18.0	27.5	20.0	150.5
NON-CORAL COVER											
Limestone				13.0							13.0
Basalt	81.5	91.0	79.5	69.0	92.5	96.5	92.0	82.0	72.5	80.0	836.5
Rubble											

POINT INTERCEPT

TRANSECT SITE:	NELHA	MEAN CORA COVER	21.7 %
TRANSECT ID #:	HOONA BAY, 10'	STD. DEV.	10.9
DATE:	12/19/91	SPECIES COUNT	3
		SPECIES DIVERSITY	0.559

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	12	15	33	17	7	4	14	17	41	19	179.0
Pocillopora meandrina	16			11	2						29.0
Montipora verrucosa								9			9.0
Zoanthus sp.											
QUADRAT TOTAL	28	15	33	28	9	4	14	26	41	19	217.0
NON-CORAL COVER											
Limestone				12							12.0
Basalt	72	85	67	60	91	96	86	74	59	81	771.0

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE:	NELHA	MEAN CORA COVER	42.15 %
TRANSECT ID #:	HOONA BAY, 20'	STD. DEV.	22.7
DATE:	12/19/91	SPECIES COUNT	3
		SPECIES DIVERSITY	0.389

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	25.0	59.5	51.5	31.0	3.5	13.0	29.0	47.0	80.5	34.5	374.5
Porites compressa	10.0	3.0	9.0		3.0		1.0	2.0	4.5	9.0	41.5
Pocillopora meandrina	1.5							4.0			5.5
QUADRAT TOTAL	36.5	62.5	60.5	31.0	6.5	13.0	30.0	53.0	85.0	43.5	421.5
NON-CORAL COVER											
Limestone	59.5	23.5	39.5	69.0					15.0	56.5	263.0
Basalt	4.0	14.0				87.0	70.0	47.0			222.0
Rubble					93.5						

POINT INTERCEPT

TRANSECT SITE:	NELHA	MEAN CORA COVER	55.6 %
TRANSECT ID #:	HOONA BAY, 20'	STD. DEV.	23.9
DATE:	12/19/91	SPECIES COUNT	3
		SPECIES DIVERSITY	0.376

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	61	62	66	47	10	22	36	56	87	50	497.0
Porites compressa	8	3	15		3		2	5	4	12	52.0
Pocillopora meandrina	3							4			7.0
Zoanthus sp.											
QUADRAT TOTAL	72	65	81	47	13	22	38	65	91	62	556.0
NON-CORAL COVER											
Limestone	27	23	19	53					9	38	169.0
Basalt	1	12				78	62	35			188.0
Rubble					87						

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE:	NELHA	MEAN CORA COVER	34.7 %
TRANSECT ID #:	HOONA BAY, 40'	STD. DEV.	10.2
DATE:	12/19/91	SPECIES COUNT	7
		SPECIES DIVERSITY	0.929

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	8.5	1.5	21.5	24.0	3.5	12.0	17.5	14.5	12.0	10.0	125.0
Porites compressa	24.0	58.0	12.0	8.0	18.0	17.0	11.5	15.0	12.0	25.0	200.5
Pocillopora meandrina	3.5					1.0	0.5				5.0
Montipora verrucosa	0.5	0.5		1.0		1.0			1.0		4.0
Montipora patula	0.5										0.5
Pavona varians	1.0	1.0									2.0
Zoanthus sp.							10.0				10.0
QUADRAT TOTAL	38.0	61.0	33.5	33.0	21.5	31.0	39.5	29.5	25.0	35.0	347.0

NON-CORAL COVER

	1	2	3	4	5	6	7	8	9	10	TOTAL
Limestone	60.0	39.0	66.5	59.0	66.0	70.0	60.5	61.0	37.5	65.0	584.5
Sand	2.0			8.0	12.5						22.5
Rubble									37.5		

POINT INTERCEPT

TRANSECT SITE:	NELHA	MEAN CORA COVER	55.5 %
TRANSECT ID #:	HOONA BAY, 40'	STD. DEV.	8.6
DATE:	12/19/91	SPECIES COUNT	4
		SPECIES DIVERSITY	0.786

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	18	3	39	50	12	26	39	30	25	21	263.0
Porites compressa	36	66	13	9	25	30	14	31	21	31	276.0
Pocillopora meandrina	6					1	2				9.0
Montipora verrucosa	1					1					2.0
Zoanthus sp.							5				
QUADRAT TOTAL	61	69	52	59	37	58	60	61	46	52	550.0

NON-CORAL COVER

	1	2	3	4	5	6	7	8	9	10	TOTAL
Limestone	37	31	48	46	51	42	40	39	27	48	409.0
Sand	2			5	12						19.0

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE: NELHA
TRANSECT ID #: 18" PIPE, 15'
DATE: 12/19/91

MEAN CORA COVER 12.5 %
STD. DEV. 10.1
SPECIES COUNT 4
SPECIES DIVERSITY 0.845

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	15.5	7.5	9.5		20.0	5.0	0.5				58.0
Pocillopora meandrina	8.5	11.5	12.0		4.0	8.0	18.0				62.0
Montipora patula				2.5			2.0				4.5
Pavona varians				0.5							0.5
QUADRAT TOTAL	24.0	19.0	21.5	3.0	24.0	13.0	20.5	0.0	0.0	0.0	125.0
NON-CORAL COVER											
Limestone	14.0	13.5	6.5			18.0	2.0				54.0
Basalt	38.0	32.5	72.0	81.0	76.0	69.0	77.5				446.0
Rubble				16							

POINT INTERCEPT

TRANSECT SITE: NELHA
TRANSECT ID #: 18" PIPE, 15'
DATE: 12/19/91

MEAN CORA COVER 17.4 %
STD. DEV. 14.4
SPECIES COUNT 3
SPECIES DIVERSITY 0.741

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	20	15	17		30	13	1				96.0
Pocillopora meandrina	13	12	11		6	12	22				76.0
Montipora patula				1			1				2.0
QUADRAT TOTAL	33	27	28	1	36	25	24	0	0	0	174.0
NON-CORAL COVER											
Limestone	17	22	6			22	8				75.0
Basalt	50	51	66	84	64	53	68				436.0
Rubble				15							

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE:	NELHA	MEAN CORA COVER	14.25 %
TRANSECT ID #:	18" PIPE, 25'	STD. DEV.	8.4
DATE:	12/19/91	SPECIES COUNT	6
		SPECIES DIVERSITY	0.844

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	3.5	4.0	5.5	1.0	15.5	4.5	3.5	6.0	4.5	3.5	51.5
Pocillopora meandrina	26.0	20.0	2.5	9.5	4.0		0.5	6.0	12.0	4.0	84.5
Montipora verrucosa	0.5	0.5		0.5		0.5	0.5				2.5
Pavona varians		0.5	0.5	0.5							1.5
Palythoa tuberculosa		0.5							0.5		1.0
Leptastrea purpurea	1.0			0.5							1.5
QUADRAT TOTAL	31.0	25.5	8.5	12.0	19.5	5.0	4.5	12.0	17.0	7.5	142.5
NON-CORAL COVER											
Limestone	2.5	3.0	1.5	4.0		69.0	29.5	12.0	2.0		123.5
Basalt	66.5	71.5	90.0	84.0	78.0	20.0	66.0	76.0	81.0	92.5	725.5
Rubble					2.5						
Sand						6					

POINT INTERCEPT

TRANSECT SITE:	NELHA	MEAN CORA COVER	23.4 %
TRANSECT ID #:	18" PIPE, 25'	STD. DEV.	11.7
DATE:	12/19/91	SPECIES COUNT	3
		SPECIES DIVERSITY	0.736

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	7	6	14	1	41	10	8	10	12	8	117.0
Pocillopora meandrina	31	28	5	13	4		2	8	16	8	115.0
Montipora verrucosa		1		1							2.0
QUADRAT TOTAL	38	35	19	15	45	10	10	18	28	16	234.0
NON-CORAL COVER											
Limestone	2	4	1	6		65	18	26	2		124.0
Basalt	60	61	80	79	52	18	72	56	70	84	632.0
Rubble					2						
Sand						7					

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE: NELHA
TRANSECT ID #: 18" PIPE, 45'
DATE: 12/19/91

MEAN CORA COVER 12.35 %
STD. DEV. 9.2
SPECIES COUNT 6
SPECIES DIVERSITY 0.581

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	18.0	14.0	15.5	26.0	4.5	5.5	3.0	2.5	2.5	0.5	92.0
Porites compressa	2.5	6.0	1.0	4.0	0.5	1.5	1.0	4.5	4.0		25.0
Pocillopora meandrina			1.0								1.0
Sarcothelia edmondsoni	1.0	1.0		0.5	0.5			0.5	0.5		4.0
Palythoa tuberculosa			0.5			0.5					1.0
Fungia scutaria									0.5		0.5
QUADRAT TOTAL	21.5	21.0	18.0	30.5	5.5	7.5	4.0	7.5	7.5	0.5	123.5
NON-CORAL COVER											
Limestone		79.0	82.0	69.5	94.5	90.5		92.5	91.0	99.5	698.5
Basalt	78.5						96.0				174.5
Sand						1.5			1.5		
Rubble						1					

POINT INTERCEPT

TRANSECT SITE: NELHA
TRANSECT ID #: 18" PIPE, 45'
DATE: 12/19/91

MEAN CORA COVER 21.9 %
STD. DEV. 14.4
SPECIES COUNT 3
SPECIES DIVERSITY 0.610

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	29	21	30	39	13	11	8	3	3	2	159.0
Porites compressa	1	14		14	1	2	11	10	6		59.0
Pocillopora meandrina			1								1.0
QUADRAT TOTAL	30	35	31	53	14	13	19	13	9	2	219.0
NON-CORAL COVER											
Limestone		65	69	47	86	84		87	89	98	625.0
Basalt	70						91				161.0
Sand						2			2		
Rubble						1					

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE:	NELHA	MEAN CORA COVER	12.5 %
TRANSECT ID #:	O'OMA BOUNDARY, 15'	STD. DEV.	9.4
DATE:	12/19/91	SPECIES COUNT	2
		SPECIES DIVERSITY	0.390

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	7.5	4.0	28.0	8.0	22.0	13.5	4.0	11.5	5.5	4.5	108.5
Pocillopora meandrina	5.0				9.5	2.0					16.5
QUADRAT TOTAL	12.5	4.0	28.0	8.0	31.5	15.5	4.0	11.5	5.5	4.5	125.0
NON-CORAL COVER											
Limestone		4.0	63.0	56.0	68.5	48.5	15.5	88.5	59.5	52.5	456.0
Basalt	41.0	87.0	9.0	26.0		36.0	80.5		35.0	31.0	345.5
Sand	4	5		10						12	
Rubble	42.5										

POINT INTERCEPT

TRANSECT SITE:	NELHA	MEAN CORA COVER	22.3 %
TRANSECT ID #:	O'OMA BOUNDARY, 15'	STD. DEV.	12.1
DATE:	12/19/91	SPECIES COUNT	2
		SPECIES DIVERSITY	0.312

SPECIES	QUADRAT										SPECIES TOTAL
	1	2	3	4	5	6	7	8	9	10	
Porites lobata	12	12	39	25	34	21	13	27	8	11	202.0
Pocillopora meandrina	6				13	2					21.0
QUADRAT TOTAL	18	12	39	25	47	23	13	27	8	11	223.0
NON-CORAL COVER											
Limestone		2	54	51	53	47	11	73	52	46	389.0
Basalt	38	82	7	17		30	76		40	32	322.0
Sand	3	4		7						10	
Rubble	41										

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE:	NELHA	MEAN CORA COVER	1.65 %
TRANSECT ID #:	O'OMA BOUNDARY, 25'	STD. DEV.	1.1
DATE:	12/19/91	SPECIES COUNT	4
		SPECIES DIVERSITY	0.569

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	3.5	3.0	0.5	0.5	1.5	1.5	0.5	2.0	0.5	0.5	14.0
Porites compressa					0.5		1.0				1.5
Pocillopora meandrina								0.5			0.5
Montipora verrucosa								0.5			0.5
QUADRAT TOTAL	3.5	3.0	0.5	0.5	2.0	1.5	1.5	3.0	0.5	0.5	16.5
NON-CORAL COVER											
Limestone	60.5	78.0	71.5				11.0	97.0	99.5	99.5	517.0
Sand		19.0	28.0								47.0
Rubble	36				67	6.5					
Basalt				99.5	31.0	92	87.5				

POINT INTERCEPT

TRANSECT SITE:	NELHA	MEAN CORA COVER	5 %
TRANSECT ID #:	O'OMA BOUNDARY, 25'	STD. DEV.	3.5
DATE:	12/19/91	SPECIES COUNT	3
		SPECIES DIVERSITY	0.420

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	9	6	3	1	7	4	3	9	1	1	44.0
Porites compressa					3		2				5.0
Pocillopora meandrina								1			1.0
QUADRAT TOTAL	9	6	3	1	10	4	5	10	1	1	50.0
NON-CORAL COVER											
Limestone	73	68	76				13	90	99	99	518.0
Sand		16	21								37.0
Rubble	18				48	5					
Basalt				99	42	91	82				

REEF CORAL TRANSECT DATA SHEET

PERCENT COVER

TRANSECT SITE: NELHA
TRANSECT ID #: O'OMA BOUNDARY, 45'
DATE: 12/19/91

MEAN CORA COVER 23.9 %
STD. DEV. 13.8
SPECIES COUNT 3
SPECIES DIVERSITY 0.679

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	23.5	8.5	13.0	24.0	33.0	40.5	1.5	2.0	1.0		147.0
Porites compressa	11.5	7.5	1.0	17.0	4.5	2.5	16.0	21.0	10.5		91.5
Pocillopora meandrina				0.5							0.5
QUADRAT TOTAL	35.0	16.0	14.0	41.5	37.5	43.0	17.5	23.0	11.5	0.0	239.0
NON-CORAL COVER											
Limestone	65.0	84.0	86.0	58.5	62.5	57.0	82.5	77.0	82.5		655.0
Sand											0.0

POINT INTERCEPT

TRANSECT SITE: NELHA
TRANSECT ID #: O'OMA BOUNDARY, 45'
DATE: 12/19/91

MEAN CORA COVER 37.4 %
STD. DEV. 19.4
SPECIES COUNT 3
SPECIES DIVERSITY 0.687

SPECIES	QUADRAT 1	2	3	4	5	6	7	8	9	10	SPECIES TOTAL
Porites lobata	39	17	22	32	52	55	3	4	2		226.0
Porites compressa	18	18	4	23	10	4	25	26	19		147.0
Pocillopora meandrina				1							1.0
QUADRAT TOTAL	57	35	26	56	62	59	28	30	21	0	374.0
NON-CORAL COVER											
Limestone	43	65	74	44	62	41	72	70	79		550.0
Sand											0.0

APPENDIX F
ARCHAEOLOGICAL EXCAVATIONS REPORT

William Barrera, Jr.
Chiniago, Inc.

O'OMA, NORTH KONA, HAWAII ISLAND: ARCHAEOLOGICAL EXCAVATIONS

Prepared for:

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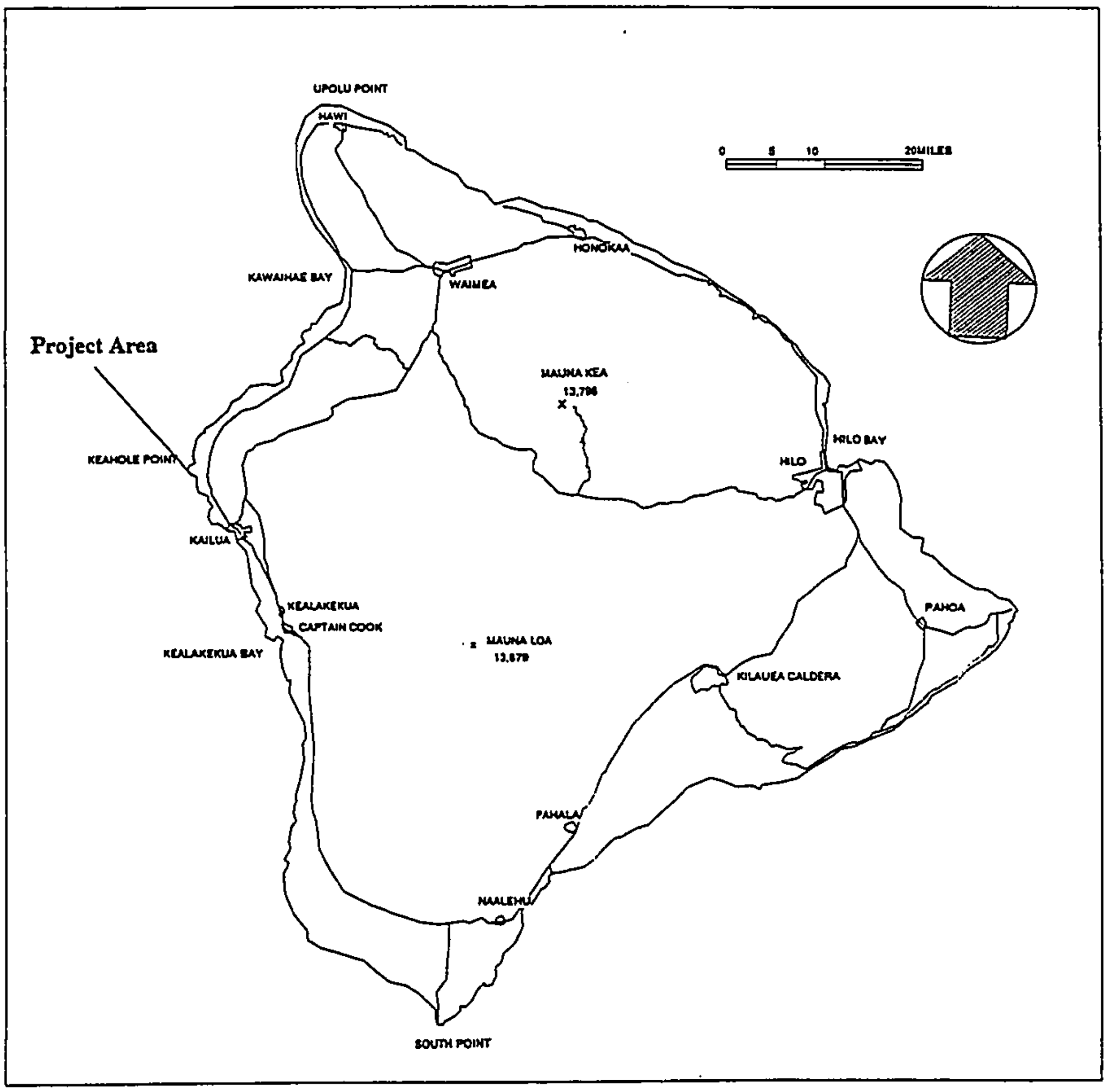
I. INTRODUCTION

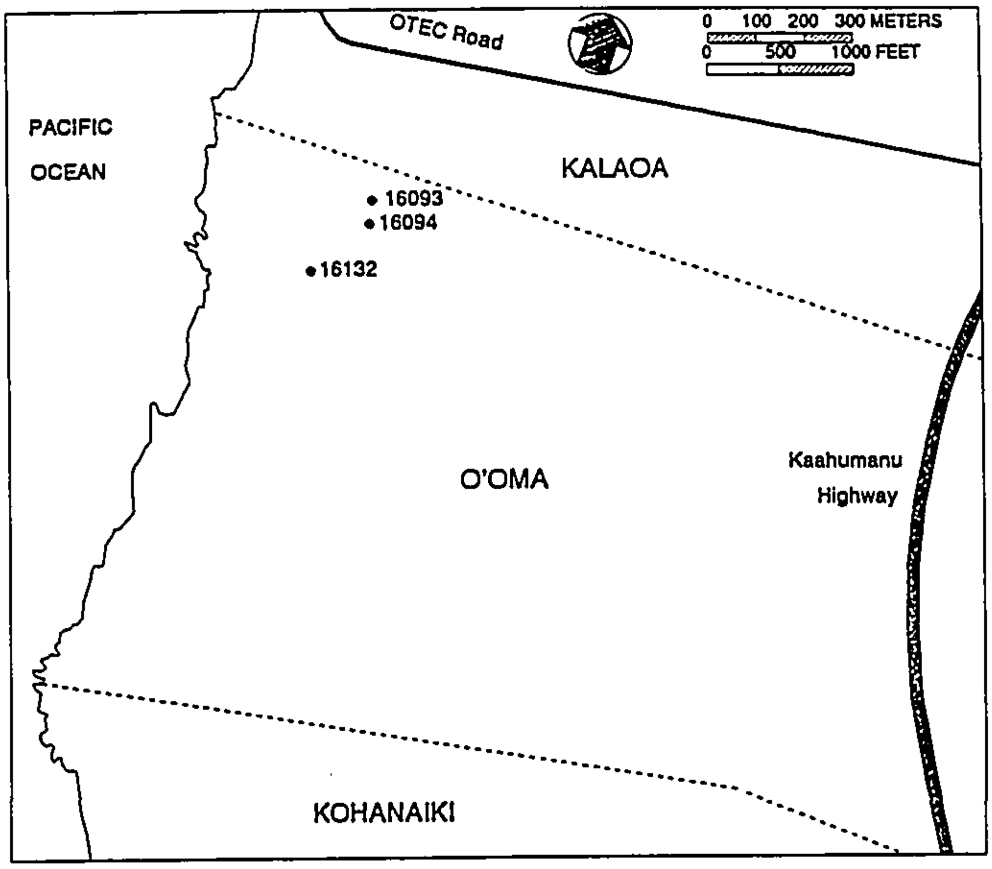
Archaeological excavations were conducted at three sites in O'oma, North Kona, Hawaii Island. The project area is located on the west side of Kaahumanu Highway, approximately 350 meters from the ocean at an elevation of about 30 feet. The terrain is generally flat to undulating pahoehoe, and the rare vegetation consists primarily of grass and scattered *Morinda citrifolia*. The area had previously been reconnoitered by Barrera [1985b], who briefly described and assigned temporary numbers to forty sites. The three sites presently reported, which were listed in the original reconnaissance report as Sites T-18, T-20 and T-21, were respectively assigned the HRHP numbers 16132, 16093 and 16094 for the purposes of this report. The purpose of the work was to determine whether these particular features contained human graves so the Natural Energy Laboratory of Hawaii could take this fact into account in their plans for the parcel.

II. PREVIOUS RESEARCH

The first archaeological work in the region was Reinecke's 1930 reconnaissance for Bernice P. Bishop Museum. The results of this investiga-



1. Hawaii Island, Showing Location of Project Area



2. Location of Sites Investigated

tion were a series of brief site descriptions and a location map.

The next work was a 1968 survey by the State of Hawaii Department of Land and Natural Resources and the University of Hawaii Department of Anthropology that was intended to document sites at the proposed Keahole Airport [Ching, Cluff and Riley 1968-69]. Additional survey work as part of this same project was done during the Summer of 1969, and involved at least ten people for a period of five or six weeks. The project included the excavation of at least one site, a cave. This work has apparently never been written up, and the Historic Sites Section at the Department of Land and Natural Resources has no record of the field notes, photographs, or artifact records.

Investigations along the right-of-way of the Queen Kaahumanu Highway conducted by the Department of Land and Natural Resources State Parks Division in 1971 and 1973 [Ching 1971] involved an initial reconnaissance of a 300 foot wide highway corridor. Descriptive data concerning the sites is very brief. This was followed by intensive survey and salvage excavations along the right-of-way by Bishop Museum [Rosendahl 1973].

In 1975 Rosendahl and Kirch [1975] did a reconnaissance of the proposed NELH facility and access road. Fourteen site localities were identified and briefly described.

In the winter of 1975 Cordy conducted survey and excavations along the coast in several sites characterized as permanent dwellings [Cordy 1978, 1981, 1985; Cordy and Kaschko 1980].

In May 1976 Rosendahl conducted a reconnaissance of a second road corridor and the periphery of the airport as a follow-up to the work of the previous year with Kirch.

In 1977 a reconnaissance of the proposed Keahole Agricultural Park was performed by Archaeological Research Center Hawaii [Davis 1977]. Test excavations were conducted but not reported, and the materials apparently have not been analyzed [Cordy 1985:13].

Another reconnaissance for the NELH facility and its road corridor was conducted by Bishop Museum in 1978 [Rogers-Jourdane 1978]. Eleven 'site areas' were photographed and briefly described.

In December of 1978 Rosendahl [1980] followed up the work of Rogers-Jourdane with an intensive survey and excavations.

Bonk [1979] conducted surveys in proposed borrow pits at Keahole Airport in May and June of 1979.

Two emergency service roads at Keahole Airport were surveyed by Barrera in 1979. Two sites were recorded and a test excavation was done in a walled shelter [Barrera 1979].

Barrera [1980] found and dismantled two C-shaped enclosures south of the Keahole Airport terminal.

In 1980, Archaeological Research Center Hawaii conducted excavations in nineteen sites in the Keahole Agricultural Park area inland of the highway [Hammatt and Folk 1980], and a reconnaissance of a small section in Kalaoa 1 near the highway was conducted. Personnel at the State Historic Preservation Office have been unable to locate the map for the sites that were found.

In 1984 Bishop Museum conducted further work at the NELH facility, including a field reconnaissance and the establishment of a single set of site numbers for the sites of the various previous surveys [Clark 1984].

In 1984 a brief reconnaissance-level walk-through of the HOST parcel was conducted, resulting in the identification of 45 sites [Barrera 1985a]. This was followed in 1985 by an identical effort in the present project area, consisting of 350 acres situated between the coastal jeep road and the HOST parcel boundary [Barrera 1985b].

In 1986 and 1987 Barrera excavated a number of sites in the HOST parcel [Barrera 1988] immediately adjacent to the present project area. His work suggested the following sequence:

Earliest occupation of the area was around the middle of the sixteenth century. Structural remains were not present at this period, and if shelters were present at all they were undoubtedly of a relatively temporary nature. Evidence for the exploitation of a wide variety of marine resources was present, including mollusks, crustacea, echinoderms and fish. Birds were clearly a part of the diet. *Aleurites moluccana* was present at this early period, indicating that exploitation of the forested uplands played a part in the economy as well.

During the seventeenth century an increase in the number of sites being utilized paralleled a corresponding increase in exploitation of the marine environment, and there was clearly a continuing emphasis on birds. The presence of *Porzana* sp. [a flightless rail] from one site is of particular interest. Domestic dogs were probably being raised at or near two sites, suggesting an agricultural component alongside a continuing strong reliance on marine products. The first use of structural remains is found in the early part of the this century, suggesting a tendency toward nucleation of habitation features.

Utilization continues at eight sites and possibly at one more during the eighteenth century, and new utilization is evident at five sites. Marine exploitation continued as before, but unmodified bones of *Canis familiaris* appear in quantity for the first time, suggesting that these animals were being raised locally. All but one of the sites at which these remains were found were characterized by structural remains, providing further indication of the development of a sedentary lifestyle.

One structure appears to have been built with more than just casual use in mind, and is probably evidence of a relatively late tendency toward permanent occupation of coastal locales. By the end of the eighteenth century most sites have been abandoned, and only two appear to continue into the 1800s.

The archaeological evidence demonstrates that the main reason people had for being at the coast at Keahole Point was to exploit the marine resource environment. Mollusks were regularly taken, and in quantity, but this activity was probably an adjunct to the main business of fishing and squidding.

The contribution of the non-marine environment was not inconsiderable. Birds certainly had a place in the subsistence pattern, perhaps more in the early periods than in the later, and *Canis familiaris* was no doubt a valuable source of meat towards the middle of the sequence, as well as of raw material for the manufacture of fishhooks throughout the sequence.

It is difficult to ascertain the degree of interaction with the uplands, either directly or through trade or gift exchange with residents of that area, but clear evidence that this took place is present in the form of shells of *Aleurites moluccana* in many of the sites.

The entire range of habitation types from temporary to permanent are represented in the area. At the one end of the scale are those sites which were utilized on an extremely temporary basis, perhaps for as few as just one or two nights. These are characterized by very crude, very low walls and a virtual absence of any midden or artifactual materials. Those that are situated near the coast in the midst of the other more permanently utilized sites may have served as storage areas. The functions of those that are more isolated and located further inland are more problematical, and it is worth considering that they may have been blinds for bird hunters. Next up the scale, but still probably only temporarily utilized, are sites that were more substantially built than the former sites and for the most part the presence of midden and artifacts argues for more than just casual use. The inland location of two suggest that they may have served as temporary overnight shelters for regular travelers between the uplands and the coast. Permanently occupied sites are larger, well-built structures with moderate to dense deposits of midden and artifacts and were the only sites [with only two exceptions] which produced specimens of basaltic glass.

Barrera concluded his excavation report with the following:

"In conclusion, recent work in North Kona suggests the following regional settlement pattern. Certain especially favorable locales [small protected bays such as Kaloko, North Kona and Anaehoomalu, South Kohala, for example] were being exploited by the tenth and eleventh centuries. A permanent inland agriculturally-oriented population developed by the fifteenth century, preceding most of the permanent coastal habitation. This is supported by recent excavation data in sites four miles from the ocean in the *ahupua'a* of Kohanaiki. Here, several permanent habitation structures and a large, well-built Men's House situated in the midst of agricultural fields were being utilized by the late fifteenth century. There was indirect access to ocean products through trade, and possibly temporary or intermittent direct access [Barrera 1987]. Lateral expansion from the early exploitation centers along the relatively less productive coastlines did not occur until the sixteenth century. This is followed in the late seventeenth and early eighteenth centuries by a period during which temporary coastal habitation evolves into more permanent occupation with full-time exploitation of marine and agricultural resources. The end of the sequence is marked by an abandonment of the agricultural fields in the early eighteenth century, with a concentration on marine resources and a tendency toward nucleation of coastal settlements that was interrupted by historic contact" [Barrera 1988: 231]

Views differ slightly concerning the regional prehistoric sequence. Barrera feels that the data from Kohanaiki indicate a permanent presence in the inland agricultural fields as early as the fifteenth century, with contemporary permanent coastal settlements only at particular favored locations such as Kaloko and Anaehoomalu. His interpretation suggests that the denser coastal habitation of later centuries developed via a process of daughter communities spreading laterally along the coast from these early centers [Barrera 1991]. An alternate view also suggests that population growth at coastal settlements was the impetus for outward expansion along the shore from these centers, but differs in proposing that the settlement of the inland agricultural fields was also a result of this expansion process [Rosendahl 1972; Cordy 1978, 1985; Donham 1986].

As for O'oma itself, the pattern is in general similar to that of Kalaoa. Crude and almost certainly temporary habitation areas are found throughout the coastal areas, although in O'oma they extend further inland and are found at a distance of about 400 meters from the ocean [Barrera 1985b; Donham 1986]. Habitation caves with associated habitation or burial platforms are present, and midden scatters are not uncommon. In contrast with the absence of large, obvious religious structures in coastal Kalaoa, two sites have been identified as such in O'oma [Cordy 1985], and it has been suggested that several habitation sites incorporate possible shrines [Cordy 1978; Donham 1986].

Trails consisting primarily of worn footpaths across the lava have been found in Kalaoa, but not in O'oma. They extend to the east, connecting the coastal sites with inland agricultural and permanent habitation areas at about the 800 to 1000 foot elevation [Cordy 1985, Barrera 1991]. They pass through a wide area where sites are scarce, and consist primarily of temporary resting places along the trails and various scattered low walled features that may have served as bird-hunting blinds [Barrera 1988, 1991].

III. RESULTS

SITE 16093

This was a roughly square platform measuring 4.30 by 4.70 meters [17.40 square meters] and standing to a height of 1.50 meters, the southwest corner of which had collapsed. It was constructed of stacked pahoehoe cobbles and boulders and a few waterworn coral cobbles and boulders. The perimeter was delineated by a 60 centimeter wide wall that extended 60 centimeters above the surface of the structure. There were three features on the surface:

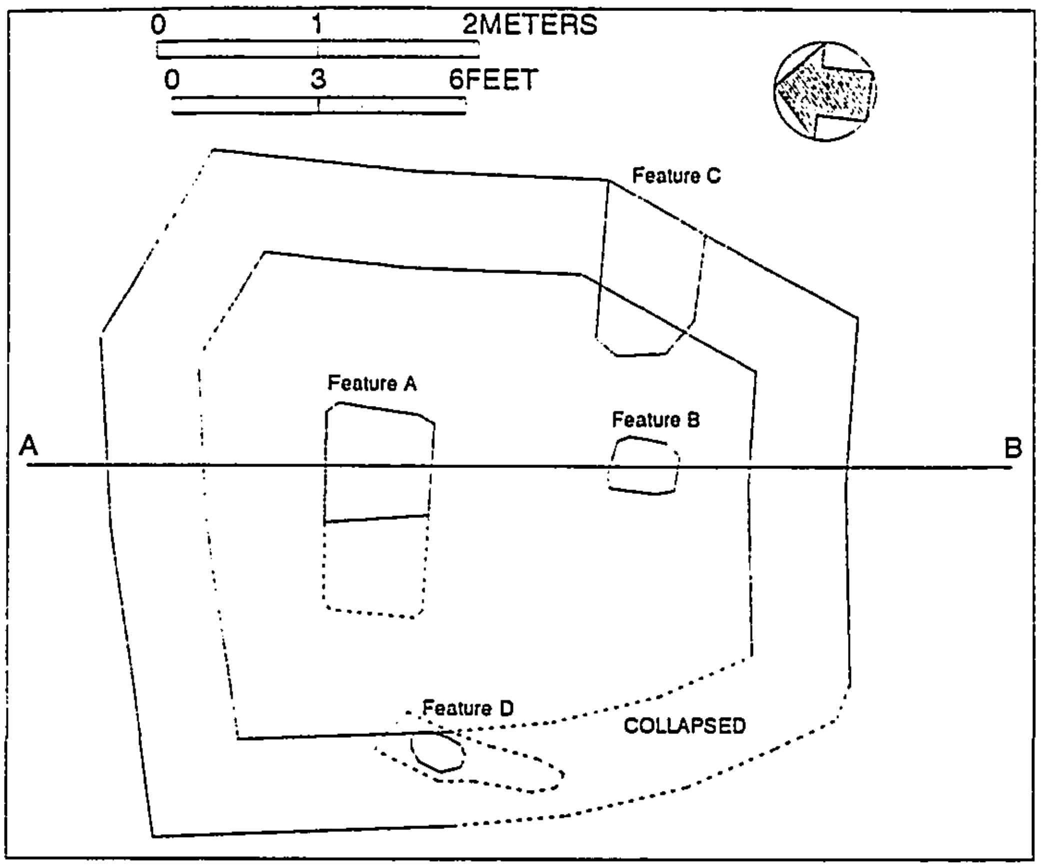
Feature A - This was a pit measuring 0.65 by 1.30 meters [0.8 square meter] and 60 centimeters in depth. The east half was open to the sky; the west half was roofed over with angular basalt cobbles.

Feature B - This was a pit measuring 0.35 by 0.45 meter [0.15 square meter] and 45 centimeters deep. It was open to the sky.

Feature C - This was a pit measuring 0.60 by 1.10 meter [0.60 square meter] and 45 centimeters deep. It was open to the sky. The east end was open as well, although this may have been the result of an attempt at looting the site, as a section of the side of the structure had apparently been intentionally removed at that point.

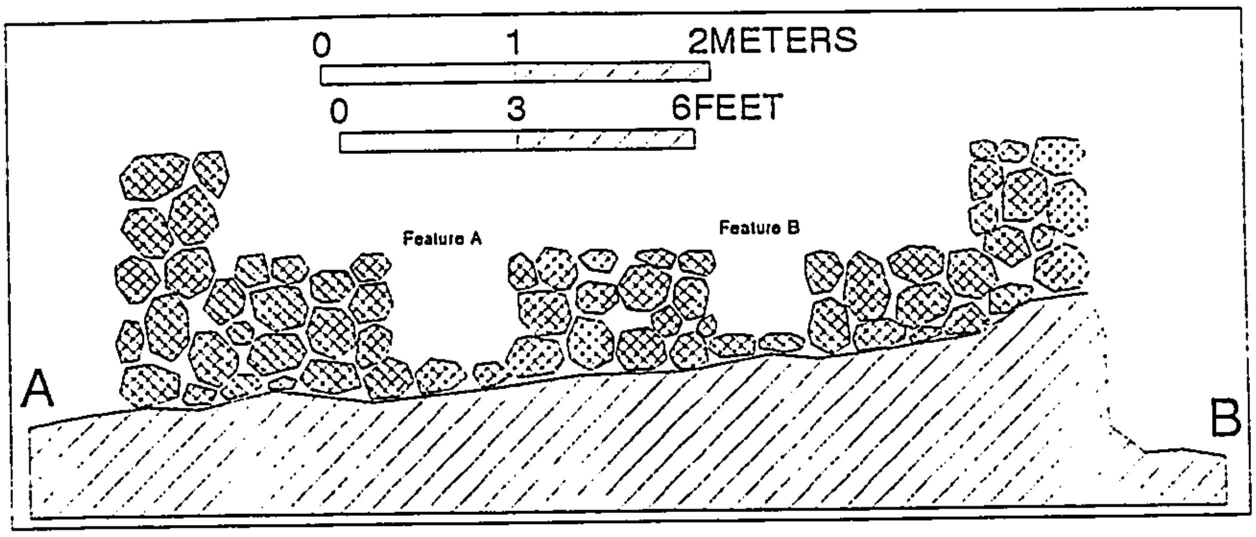
NUMBER	LAYER	MATERIAL	TYPE	LENGTH	WIDTH	THICK.
1		WATERWORN BASALT	MANUPORT	9.93	6.64	4.12
2	Cavity Beneath Structure	WATERWORN BASALT	MANUPORT	25.00	16.00	14.00
3	Cavity Beneath Structure	WOOD	STICK	128.00	1.88	0.00
4	Fill	PORITES CORAL	MANUPORT	3.90	2.73	1.96
5	Fill	PORITES CORAL	MANUPORT	2.56	1.71	1.28
6	Fill	PORITES CORAL	MANUPORT	3.46	2.05	1.62
7	Fill	PORITES CORAL	MANUPORT	2.10	1.40	1.07
8	Fill	BRANCH CORAL	MANUPORT	1.55	1.23	0.89
9	Fill	PORITES CORAL	MANUPORT	2.62	2.28	1.25
10	Fill	PORITES CORAL	MANUPORT	2.84	2.41	0.90

Table 1. SITE 16093 ARTIFACTS



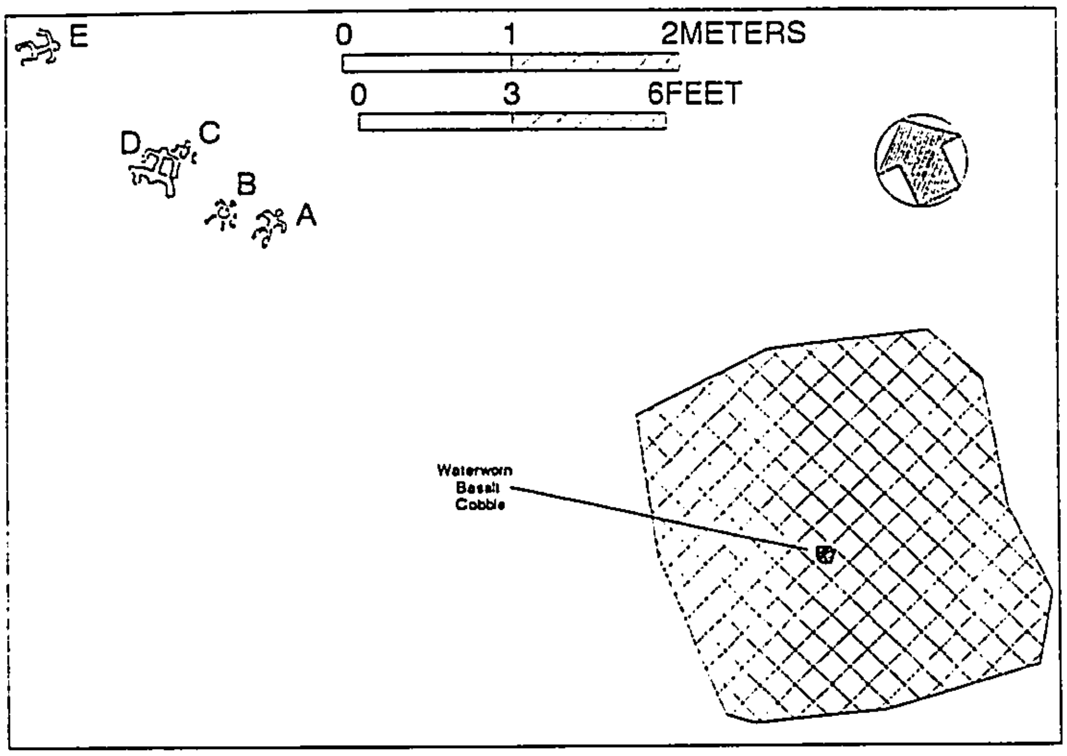
3. Plan of SITE 16093

4. SITE 16093, Looking Southwest



5. SITE 16093, Section A-B

6. SITE 16093 Feature D, Looking Northeast



7. Plan of SITE 10694

8. SITE 16094, Looking Northeast

9. SITE 16094, Petroglyphs

10. SITE 16094 During Excavation

11. SITE 16094 After Excavation

The complete dismantling of the south two-thirds of the structure revealed a fourth feature:

Feature D - This was a natural cavity in the pahoehoe bedrock beneath the west side of the structure. It measured 0.35 by 1.10 meter [0.30 square meter] and was 25 centimeters deep. In the bottom of the cavity was a waterworn basalt boulder on which was resting a 1.28 meter long specimen of a woody plant of some sort that had been uprooted along with portions of its roots.

Additional artifacts recovered from the structure include a waterworn basalt manuport [broken into two pieces] from the surface, seven coral pebble manuorts [one of which was waterworn branch coral], plus 26 larger coral cobbles and boulders that were counted and left in the field.

Marine midden remains found in the fill of the structure include 10.0 grams of *Cypraea caputserpentis*, 1.0 gram of *Morula tuberculata*, 3.8 grams of Thaididae, 0.3 gram of crab claw and 1.2 grams of unidentified shell. Vegetal remains consisted of 0.7 gram of unidentified wood and a trace of charcoal. In addition, there were 1.5 grams of unidentified bone.

SITE 16094

This was a square platform measuring 2.10 by 2.30 meters [4.40 square meters] and standing to a height of 80 centimeters. It was constructed of pahoehoe cobbles and boulders. A series of five anthropomorphic petroglyphs were pecked into the flat pahoehoe on the north side of the structure at a distance of between 2.40 and 4.30 meters.

Petroglyph A is a human figure with a triangular-shaped torso. It measures 25 centimeters in height and is 19 centimeters wide.

Petroglyph B is a human figure measuring 20 by 20 centimeters. The solid, not quite triangular, torso is very lightly pecked. The figure's left leg is quite vague, and may be a feature of the natural pahoehoe bedrock.

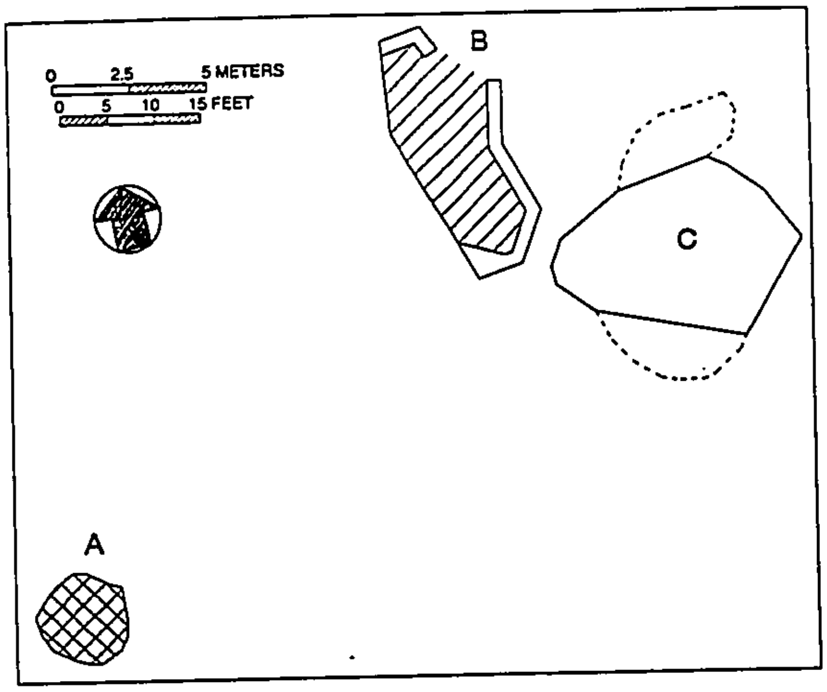
Petroglyph C is a partial human figure consisting of a straight stick-figure torso with associated head and arms. It measures 11 centimeters in height and 17 centimeters in width.

Petroglyph D is a complete human stick-figure measuring 27 centimeters high and 31 centimeters wide.

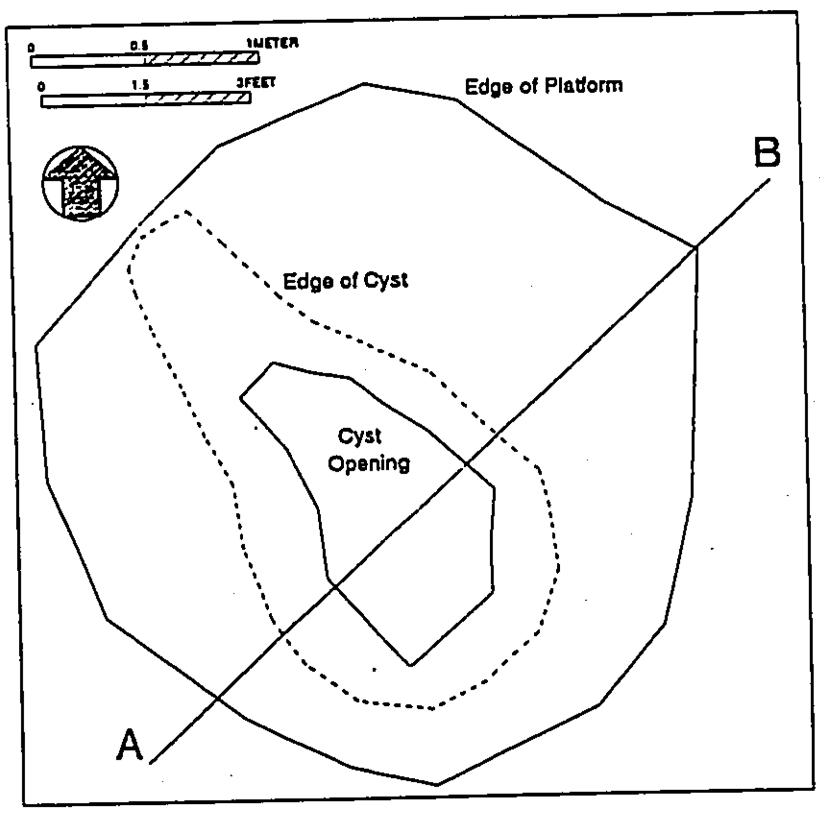
Petroglyph E is a complete human stick-figure measuring 25 centimeters high and 21 centimeters wide.

The entire interior of the structure was dismantled, leaving only the enclosing perimeter wall. This revealed a waterworn basalt cobble [14.7 by 16.0 centimeters, 6.6 centimeters thick] resting on the underlying pahoehoe bedrock at about the center of the structure.

Marine midden found in the fill of the structure includes 1.9 grams of *Cypraea caputserpentis* and 0.4 gram of *Cellana* sp. Vegetal materials consisted of 4.5 grams of unidentified

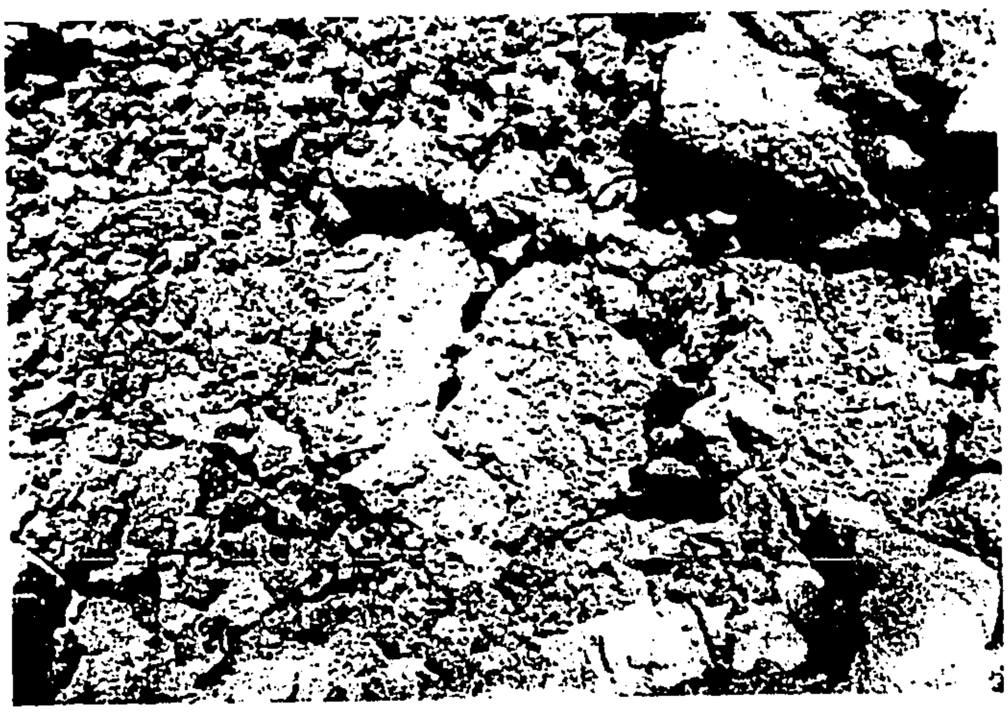


12. Plan of Portion of SITE 16132, Showing Location of Feature A

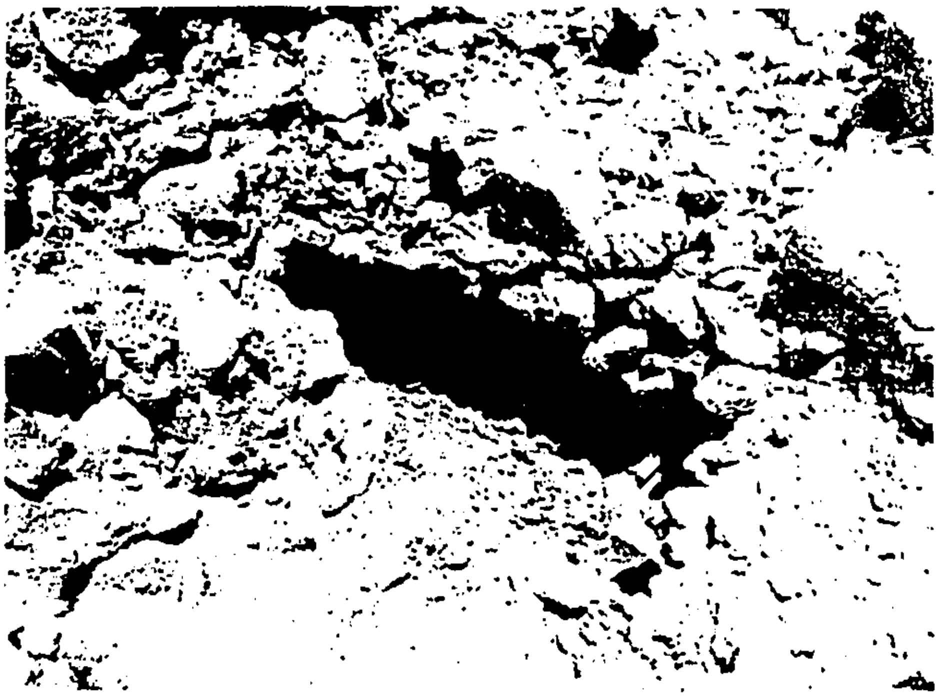


13. Plan of SITE 16132, Feature A

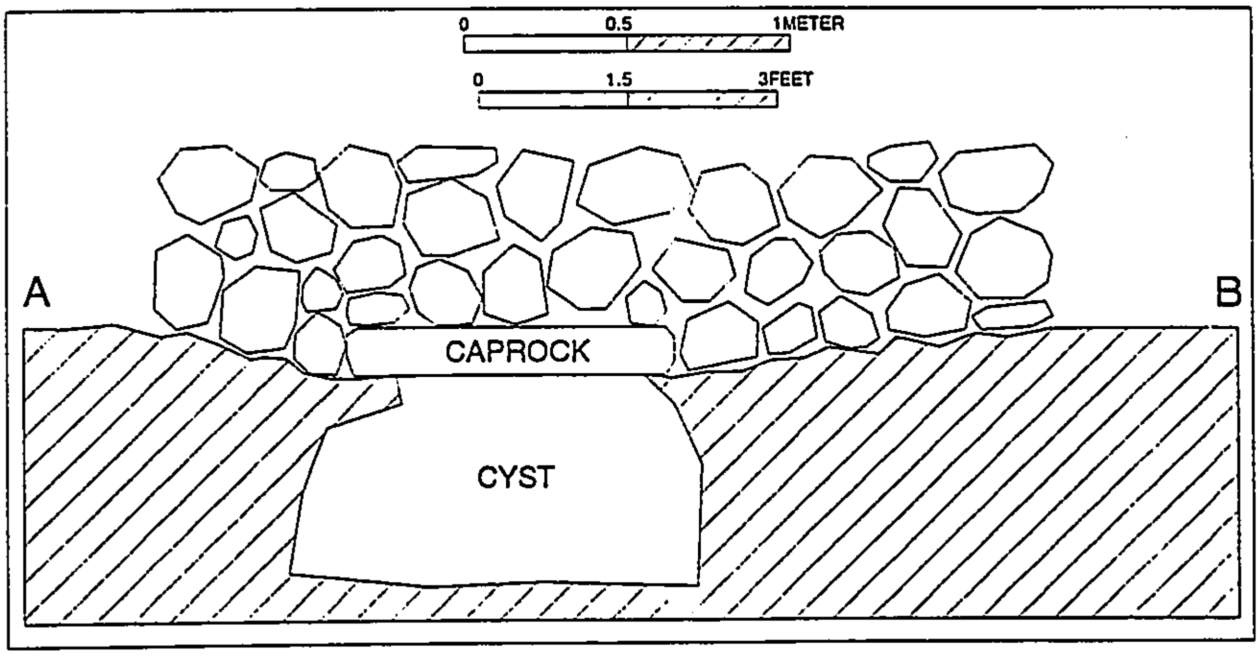
14. SITE 16132 Feature A, Looking Northwest



15. SITE 16132 Feature A, Showing Caprocks Over Cyst



16. SITE 16132 Feature A After Excavation, Showing Cyst



17. SITE 16132 Feature A, Section A-B

NUMBER	LAYER	MATERIAL	TYPE	LENGTH	WIDTH	THICK.
1	On Bedrock	WATERWORN BASALT	MANUPORT	16.00	14.73	6.60
2	Fill	BRANCH CORAL	MANUPORT	12.35	2.84	2.08
3	Fill	PORITES CORAL	MANUPORT	2.86	2.70	0.48
4	Fill	PORITES CORAL	MANUPORT	5.97	5.73	2.95
5	Fill	PORITES CORAL	MANUPORT	8.50	4.28	1.91

Table 2. SITE 16094 ARTIFACTS

wood, 39.6 grams of *Aleurites moluccana* shell and 0.3 gram of charcoal.

The fill of the structure produced four coral manuports, one of which was of branch coral.

SITE 16132, Feature A

This was an oval to square regular mound or small platform situated on a lava blufftop adjacent to a habitation terrace [Feature B] and a vandalized habitation cave [Feature C]. It measured 2.80 by 2.90 meters [6.60 square meters] and stood to a height of 60 centimeters. It was constructed of stacked pahoehoe cobbles and boulders.

The structure was completely dismantled, revealing a fill of angular basalt cobbles and boulders. This was resting on a series of flat pahoehoe slabs placed over a natural cavity in the bedrock so as to form a cyst. This cyst measured 1.30 by 2.40 meters [2.10 square meters] and was 60 centimeters deep.

Marine midden found in the structure fill consisted of 1.8 grams of *Isognomon californicum*, 22.9 grams of *Cypraea caputserpentis*, 60.5 grams of *C. mauritiana*, 0.9 gram of *Nerita picea*, 1.9 gram of Echinodermata, 2.0 grams of Thaididae, 0.7 gram of crab and 9.1 grams of unidentified shell. Bone remains consisted only of 0.6 gram of unidentified birdbone. Vegetal remains included 0.3 gram of charcoal, 23.2 grams of *Aleurites moluccana* shell and 2.3 grams of unidentified wood.

Artifacts recovered from the fill consisted of one waterworn basalt manuport, thirty branch coral manuports and sixteen porites coral manuports.

Marine midden found in the cyst beneath the structure consisted of 1.1 grams of *Nerita picea*, 1.4 grams of *Cypraea caputserpentis*, 16.4 grams of *C. maculifera*, 7.3 grams of *C. mauritiana*, 0.2 gram of *Isognomon californicum*, 1.6 grams of Echinodermata, 0.1 gram of crab and 3.6 grams of unidentified shell. Fish remains consisted of two mouth parts of Carangidae and 3.8 grams of unidentified fishbone. Vegetal remains consisted only of 2.4 grams of *Aleurites moluccana* shell and 2.1 grams of unidentified wood. Bone remains include 0.6 gram of birdbone and 1.5 grams of unidentified bone. Miscellaneous materials include one bird feather and a small bunch of unidentified hair.

Artifacts found in the cyst consisted of one echinoid spine abrader, three branch coral manuports and eight porites coral manuports.

IV. DISCUSSION

Only two features similar to those excavated during the present project have been investigated in the vicinity. Both were studied during the data recovery project for the HOST parcel [Barrera 1988]. One was Site 10169, a stone mound or small platform measuring 2.00 by 2.50 meters and standing to a height of 80 centimeters. The only midden remains found were adjacent to the structure, and consisted of the shells of two cowries [*Cypraea caputserpentis* and *C. mauritiana*] and a drupe [*Drupa ricina*]. The mound was dismantled by removing all of the rocks from the south half, but no midden or artifacts were found either in or beneath it. No function could be ascribed to the feature based upon either its form or its contents.

The other site was Site 10214, a cairn or small platform measuring 1.60 by 1.90 meters and standing to a height of 70 centimeters. Upon excavation it was determined that the fill rocks of the feature extended downward into a bedrock crevice. Beneath this was a deposit of coral gravel containing fragmentary human bones. Once the fact that this was a human grave had been established, excavation ceased and the rock fill was replaced.

The three features that were investigated during the present project shared certain characteristics. Each was a well constructed platform or straight-sided cairn, each contained more than usual amounts of coral fragments, and each was built over some sort of modified natural feature [a waterworn basalt manuport in the case of Sites 16093 and 16094, and a slab-covered cyst in the case of Site 16132 Feature A]. These characteristics, along with the scarcity of midden remains and artifacts typical of domestic sites and the absence of human skeletal remains, suggest a shared ritual or ceremonial function. The presence of a piece of a woody plant in the cavity beneath Site 16093 and the mouthparts of a carangid in the cyst beneath Site 16132 Feature A suggest that the ceremonies were associated with attempts at natural resource management.

Only Site 16093 shows evidence of recurring utilization, this in the form of the pits on the surface which were probably used for storage of frequently used objects or for the deposition of ritual offerings. There is the possibility that Sites 16094 and 16132 Feature A may have been periodically opened during their period of utilization, although evidence of

NUMBER	LAYER	MATERIAL	TYPE	LENGTH	WIDTH	THICK.
1	Cyst Fill	ECHINOID SPINE	ABRADER	8.41	0.99	0.93
2	Fill	WATERWORN BASALT	MANUPORT	5.56	3.97	1.15
3	Cyst Fill	BRANCH CORAL	MANUPORT	2.81	1.46	1.26
4	Cyst Fill	BRANCH CORAL	MANUPORT	3.04	1.42	1.21
5	Cyst Fill	PORITES CORAL	MANUPORT	3.19	2.25	2.17
6	Cyst Fill	PORITES CORAL	MANUPORT	2.59	1.44	1.34
7	Cyst Fill	PORITES CORAL	MANUPORT	8.91	6.29	3.99
8	Cyst Fill	PORITES CORAL	MANUPORT	3.49	2.83	2.06
9	Cyst Fill	PORITES CORAL	MANUPORT	3.89	3.42	1.68
10	Cyst Fill	PORITES CORAL	MANUPORT	3.54	3.35	1.79
11	Cyst Fill	PORITES CORAL	MANUPORT	2.88	2.53	1.30
12	Cyst Fill	PORITES CORAL	MANUPORT	16.00	12.98	7.28
13	Cyst Fill	BRANCH CORAL	MANUPORT	5.15	4.15	2.96
14	Fill	BRANCH CORAL	MANUPORT	3.92	2.80	1.23
15	Fill	PORITES CORAL	MANUPORT	3.59	2.49	0.99
16	Fill	PORITES CORAL	MANUPORT	4.07	2.65	1.25
17	Fill	PORITES CORAL	MANUPORT	3.34	3.26	2.60
18	Fill	BRANCH CORAL	MANUPORT	3.34	2.52	1.44
19	Fill	PORITES CORAL	MANUPORT	2.40	2.25	1.21
20	Fill	PORITES CORAL	MANUPORT	5.40	3.47	2.36
21	Fill	PORITES CORAL	MANUPORT	3.39	2.39	1.39
22	Fill	PORITES CORAL	MANUPORT	4.88	3.67	2.50
23	Fill	PORITES CORAL	MANUPORT	3.00	2.19	1.83
24	Fill	PORITES CORAL	MANUPORT	5.78	4.60	2.09
25	Fill	PORITES CORAL	MANUPORT	5.91	4.44	2.76
26	Fill	PORITES CORAL	MANUPORT	6.76	5.50	1.96
27	Fill	PORITES CORAL	MANUPORT	7.24	4.23	3.81
28	Fill	PORITES CORAL	MANUPORT	6.50	5.42	3.61
29	Fill	PORITES CORAL	MANUPORT	7.40	6.90	2.10
30	Fill	PORITES CORAL	MANUPORT	5.08	3.90	1.67
31	Fill	PORITES CORAL	MANUPORT	9.35	6.64	2.87
32	Fill	BRANCH CORAL	MANUPORT	5.54	3.72	1.37
33	Fill	BRANCH CORAL	MANUPORT	4.25	3.91	2.84
34	Fill	BRANCH CORAL	MANUPORT	4.42	3.50	1.51
35	Fill	BRANCH CORAL	MANUPORT	6.40	3.64	2.11
36	Fill	BRANCH CORAL	MANUPORT	5.50	2.37	1.55
37	Fill	BRANCH CORAL	MANUPORT	6.12	1.61	1.46
38	Fill	BRANCH CORAL	MANUPORT	4.19	3.60	1.11
39	Fill	BRANCH CORAL	MANUPORT	3.02	2.70	1.08
40	Fill	BRANCH CORAL	MANUPORT	5.80	4.97	1.91
41	Fill	BRANCH CORAL	MANUPORT	6.38	4.23	1.18
42	Fill	BRANCH CORAL	MANUPORT	6.73	4.65	1.77
43	Fill	BRANCH CORAL	MANUPORT	6.77	5.10	4.96
44	Fill	BRANCH CORAL	MANUPORT	8.14	4.64	1.36
45	Fill	BRANCH CORAL	MANUPORT	4.30	3.59	2.95
46	Fill	BRANCH CORAL	MANUPORT	7.71	6.50	4.19
47	Fill	BRANCH CORAL	MANUPORT	7.54	3.82	3.25
48	Fill	BRANCH CORAL	MANUPORT	5.46	5.37	4.02
49	Fill	BRANCH CORAL	MANUPORT	7.30	5.00	2.76
50	Fill	BRANCH CORAL	MANUPORT	8.34	4.33	2.90
51	Fill	BRANCH CORAL	MANUPORT	6.50	5.15	2.44
52	Fill	BRANCH CORAL	MANUPORT	8.33	5.80	2.75
53	Fill	BRANCH CORAL	MANUPORT	6.69	5.25	1.03
54	Fill	BRANCH CORAL	MANUPORT	5.33	3.80	2.32
55	Fill	BRANCH CORAL	MANUPORT	6.57	5.42	1.30
56	Fill	BRANCH CORAL	MANUPORT	9.96	5.29	1.24
57	Fill	BRANCH CORAL	MANUPORT	6.65	6.29	1.94
58	Fill	BRANCH CORAL	MANUPORT	6.23	3.90	1.63
59	Fill	BRANCH CORAL	MANUPORT	6.30	4.08	2.14

Table 3. SITE 16132 Feature A ARTIFACTS

this would be impossible to recognize. The carangid remains at Site 16132 were probably not disturbed after the mound was constructed, while the possibity remains that the waterworn basalt cobble at the base of Site 16094 may have been removed periodically for purposes of ritual or veneration. It appears most likely, however, that while some sort of initial ritual may have been associated with the construction of each of these structures, they did not subsequently function as religious sites.

V. SIGNIFICANCE

All three of the features investigated during the present project were significant for their information content, for they contained valuable information of importance to the study of Hawaiian prehistory. As this information has now been retrieved through archaeological excavation, they are no longer significant on this account.

The evidence that these features functioned as religious structures is not compelling, and Site 16093 is the only one which should be considered as possibly having cultural significance.

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APPENDIX G
TRAFFIC IMPACT STUDY

Barton-Aschman Associates, Inc.

TRAFFIC IMPACT STUDY FOR A NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY PROJECT IN KAILUA-KONA, HAWAII

Prepared For

GK & ASSOCIATES

Prepared By

BARTON-ASCHMAN ASSOCIATES, INC.

HONOLULU, HAWAII

June 1992

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1.

INTRODUCTION

Barton-Aschman Associates Inc. has been retained by GK & Associates to conduct a traffic impact study for the Natural Energy Laboratory of Hawaii Authority (NELHA) project adjacent to Keahole Airport on the Island of Hawaii. NELHA manages the Hawaii Ocean Science and Technology Park (HOST Park), a 548 acre research and commercial park. There is an existing traffic study (Parsons Brinckerhoff, June 1985) which was prepared for an Environmental Impact Statement for the "Development Plan for the HOST Park and Expansion of the Natural Energy Laboratory of Hawaii (NELH)". The Parsons Brinckerhoff study considered the intended development of small research projects and large aquaculture farms along with support services including restaurants, a visitor center and an oceanarium in assessing the traffic impact of the 548-acre HOST Park and the adjacent 322-acre NELH.

A prospective occupant of HOST Park is the Kona Ocean Center (KOC) which will include an aquaculture farm (lobster), oceanarium, visitor center, archeological preserve and an extension of the beach park. Although these types of activities were included in the previous EIS, it is believed that the visitor and employee count for an oceanarium was not included in the traffic study. Therefore, the major objective of the traffic impact study is to access the impact of this visitor traffic.

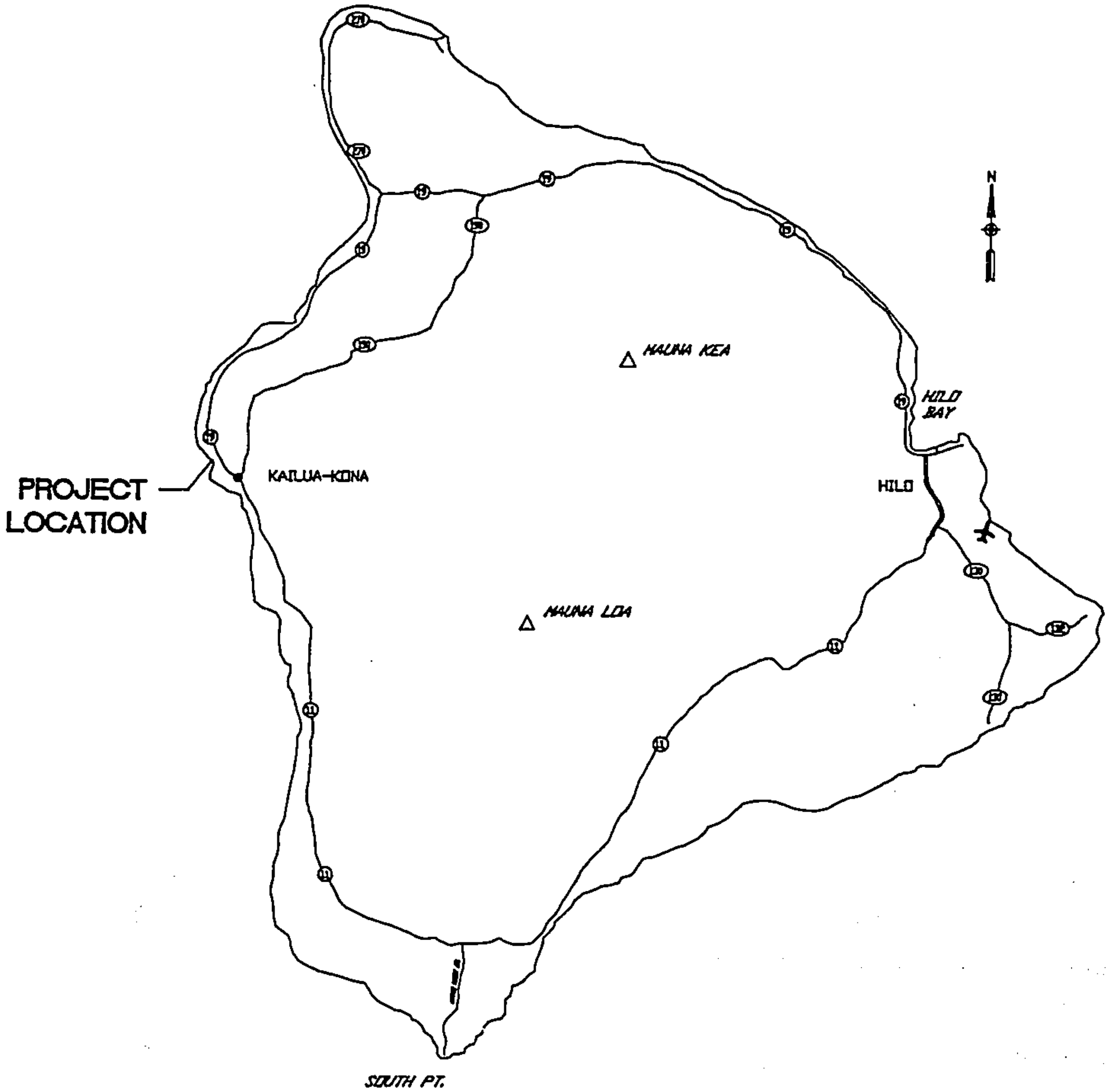
The following report has been prepared to describe the traffic characteristics of the project and the traffic-related impacts of the project on the adjacent roadway network. In this report, the proposed KAD project to be located at NELHA is referred to as the "project".

This introductory chapter discusses the location of the project, the proposed development scenario, and the study methodology.

PROJECT LOCATION AND DESCRIPTION

The location of the project is shown on Figure 1. Access to the project will be via an access road intersection along Queen Kaahumanu Highway. This intersection is approximately 1.2 miles south of the entrance to Keahole Airport.

The project is to consist of a lobster farm, OTEC plant, visitors center, oceanarium, archeological preserve and a beach park. The project is to be open from 10:00 a.m. to 6:00 p.m. and will have 74 to 93 additional employees for the minimum and maximum scenarios, respectively. The number of visitors to the visitor center has been determined to be between 4,400 and 6,600 persons on the design day based on data provided by the planner.



SITE LOCATION

NELHA PROJECT TIAR
KAILUA-KONA, HAWAII

Barton-Aschman Associates, Inc.

Figure 1

STUDY METHODOLOGY

In order to conduct this traffic study, several tasks were performed. These are discussed in the following paragraphs.

1. Data Collection

Traffic-related information was collected in order to analyze the existing traffic conditions and to estimate the future traffic volumes on the roadway adjacent to the study site. The data collected included the following:

- development plan data;
- roadway network;
- existing morning and afternoon (AM and PM) peak hour traffic volumes;
- traffic information for other planned projects; and
- previous traffic studies conducted for projects in the adjacent area.

2. Selection of Analysis Techniques

The method described in the 1985 Highway Capacity Manual (HCM) was used to determine the level-of-service (LoS) for Queen Kaahumanu Highway adjacent to the project. Level-of-Service is a qualitative measure of the operating conditions at an intersection or along a roadway. The LoS concept is presented and discussed in Chapter 2 of this report. Level-of-Service calculations are presented as Appendix A.

3. Analysis of Existing Traffic Conditions

Utilizing the existing data, the traffic conditions along Queen Kaahumanu Highway in the vicinity of the project were determined under present conditions. The method described in the HCM was used to determine the level-of-service.

4. Determination of Cumulative Traffic Projections

Based on comments from the County regarding previous studies, 1997 was used as the design year.

Future cumulative traffic volumes have two components. The first is background growth. The second is traffic generated by other planned projects in the vicinity and these volumes are referred to as "related project trips." The total future cumulative traffic is the sum of existing plus background growth plus related project trips. The assumptions used to estimate the 1997 cumulative trips and the resulting traffic projections are presented in Chapter 3 of this report. Operating conditions at the project entrance were analyzed using level-of-service calculations.

5. Analysis of Project-Related Traffic Impacts

The next step in the traffic analysis of the project was to estimate the AM and PM peak-hour traffic that would be generated by the proposed project. This was done using trip generation rates from Trip Generation (Fourth Edition, 1987), an informational report prepared by the Institute of Transportation Engineers (ITE).

These trips were distributed and assigned to the various traffic turning movements at the adjacent intersections. The site-generated traffic was then superimposed on 1997 cumulative traffic volumes at the subject intersections. The HCM methodology was then used again to conduct a level-of-service analysis.

A comparison of 1997 cumulative peak hour conditions to 1997 conditions with the project was made in order to determine the impact of this additional traffic on the roadway network. The resulting traffic projections for 1997 with the project are presented in Chapter 4.

The analysis of the project-related impacts and the conclusions of the analyses are discussed in Chapter 5.

2.
ANALYSIS OF EXISTING CONDITIONS

This chapter presents and discusses the existing traffic conditions and volumes on the roadways in the vicinity of the proposed project. The level-of-service concept and the results of the level-of-service analysis for existing conditions are also presented. The purpose of this analysis is to establish the base conditions for the determination of the impacts of the project which are described in a subsequent chapter.

Existing Roadway Conditions

Queen Kaahumanu Highway adjacent to the project is a two-lane, two-way highway. The grades are relatively flat. The posted speed limit along this section of Queen Kaahumanu

Highway is 45 miles per hour (mph). However, in the subsequent calculations 55 mph is assumed to be the average running speed.

At major intersections, separate left turn lanes are provided and acceleration and deceleration lanes are provided for right turns.

EXISTING PEAK HOUR TRAFFIC VOLUMES

The most recent traffic volumes available from HDOT are for 1990. Therefore, existing (1992) AM and PM peak hour traffic volumes were estimated using historical growth rates.

The historical traffic counts provided by HDOT are tabulated in Table 1. The calculation of the average annual growth rate (compounded) is also shown. Since 1978 the Average Daily Traffic (ADT) along Queen Kaahumanu Highway has increased from 4,537 vehicles per day (vpd) to 12,000 vpd, or 2.65 times. This represents a growth rate of approximately 8.4 per cent per year. The estimated 1992 traffic volumes are shown in Figure 2.

The level-of-service at an unsignalized intersection is based on delay and the potential or reserve capacity of each turning movement. Table 2 summarizes the definitions for level-of-service and the corresponding reserve capacity. These criteria and guidelines are used to determine the level-of-service of individual movements at the intersection. The weighted delay of the movements is then calculated to determine the average delay of all traffic using the intersection. Currently, Queen Kaahumanu Highway operates at Level-of-Service "B" in the vicinity of the NELHA entrance during the afternoon peak hour. See Appendix A.

TABLE 1
HISTORICAL TRAFFIC VOLUMES ALONG
QUEEN KAAHUMANU HIGHWAY
NELHA TRAFFIC STUDY
June 1992

Year	ADT(1)
1978	4537
1980	4220
1982	5256
1984	7091
1988	10,040
1990	12,000

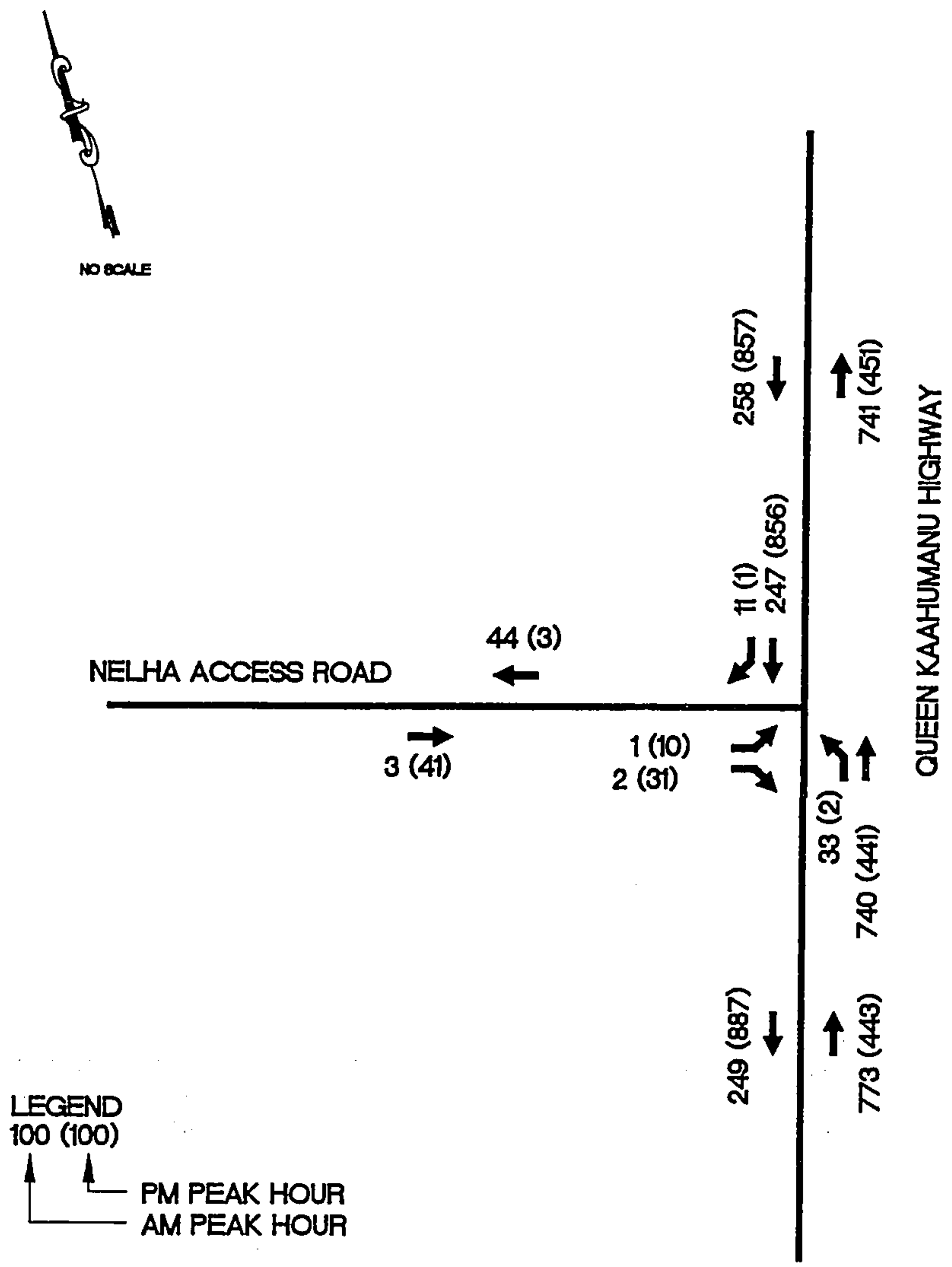
12,000 / 4,537 = 2.65

1/12 = 0.084

annual growth = i

$$i = (2.65)^{0.084} - 1 = 0.084$$
$$= 8.4\%$$

(1) Source: HDOT



1992 PEAK HOUR TRAFFIC VOLUMES

NELHA PROJECT TIAR

KAILUA-KONA, HAWAII

TABLE 2
LEVEL-OF-SERVICE DEFINITIONS FOR SIGNALIZED INTERSECTIONS
NELHA TRAFFIC STUDY
April 1992

Level-of-Service	Expected Delay to Minor Street Traffic	Reserve Capacity
A	Little or no delay	> 400
B	Short traffic delays	300 - 399
C	Average traffic delays	200 - 299
D	Long traffic delays	100 - 199
E	Very long traffic delays	0 - 99
F	See Note (2) below	--------

Notes: (1) Source: Highway Capacity Manual, 1985.
(2) When demand volume exceeds the capacity of the lane, extreme delays will be encountered with queuing which may cause severe congestion affecting other traffic movements in the intersection. This condition usually warrants improvements to the intersection.

3. PROJECTED CUMULATIVE TRAFFIC CONDITIONS

The purpose of this chapter is to discuss the assumptions and data used to estimate 1997 cumulative traffic conditions. Cumulative traffic conditions are defined as future traffic conditions resulting from background growth and related projects.

BACKGROUND TRAFFIC GROWTH RATE

The first component of cumulative trips is ambient background growth which is not associated with any particular project. This background growth rate was determined from historical traffic counts conducted by HDOT for Queen Kaahumanu adjacent to the project. Historical traffic count, data were discussed in Chapter 2. Since 1978, traffic has grown an average of 8.4 percent per year (compounded). Therefore, a growth rate of 8.4 percent per year for the next five years (1992 through 1997) was used in this study. This results in a growth factor of 1.497.

RELATED PROJECTS

The second component in estimating future traffic conditions without the project is the traffic generated by related projects in the vicinity. Related projects are defined as those projects that are approved or planned for construction during the time frame of this study which would significantly impact traffic at the intersections being analyzed. The following projects have been identified as ones which would have a significant impact on the adjacent traffic.

(1) O'oma II is a mixed use project to be located south of the NELHA project. The traffic assignments used to estimate background traffic were taken from the traffic study prepared for the O'oma project. The study was prepared by the Traffic Management Consultant and is dated July 29, 1991.

(2) Kohanaiki Mauka is also located south of the NELHA project. This project is to consist of 70 acres of light industrial development. This description is based on information contained in the June 8, 1991 OEQC Bulletin. Traffic assignments for the project were estimated by conducting a trip generation and assignment analysis used ITE trip generation from HDOT counts.

(3) Kohanaiki is a 470-acre development across Queen Kaahumanu Highway from Kohanaiki Mauka. Traffic projections are taken from the EIS provided by the developer.

(4) Manini'owali is located north of the airport. No traffic study was available so a trip generation and assignment analysis was conducted based on ITE trip generation rate. the directional distribution shown in the HDOT counts, and the project description

in the June 8, 1991 QEQC Bulletin, which indicated between 900 and 1100 single-family and multi-family residential units and golf course.

(5) Queen Liliuokalani Trust (QLT) is an 1100 plus acre mixed use project mauka of Hawaii Belt Road. The project is also referred to as Keahuloa Lands Development. However, on discussions with Hawaii Department of Public Works, no project has been approved nor is one currently under review. Therefore, even though a project is planned for this area no project description is available for input as a related project. This is consistent with other traffic studies conducted in the Kailua-Kona area. It would therefore be the task of the traffic study for QLT is address the traffic related impacts of the study.

(6) NELHA anticipated that employment will increase from 100 to 300 employees by 1997. Trips generated by these employees were estimated using ITE trip generation rates. Since these employees are not part of the KAD Project. The trips are considered as background.

1997 CUMULATIVE TRAFFIC VOLUMES

Cumulative traffic volumes for 1997 were calculated by superimposing background growth and related project trip onto existing traffic volumes. A factor of 1.497 was applied to existing traffic to obtain the 1997 background traffic volumes. The worksheet that calculates 1997 cumulative traffic volume is shown as Table 3. Volumes were assigned to the existing roadway network for both peak hours as shown on Figure 3.

1997 CUMULATIVE LEVEL-OF-SERVICE ANALYSIS

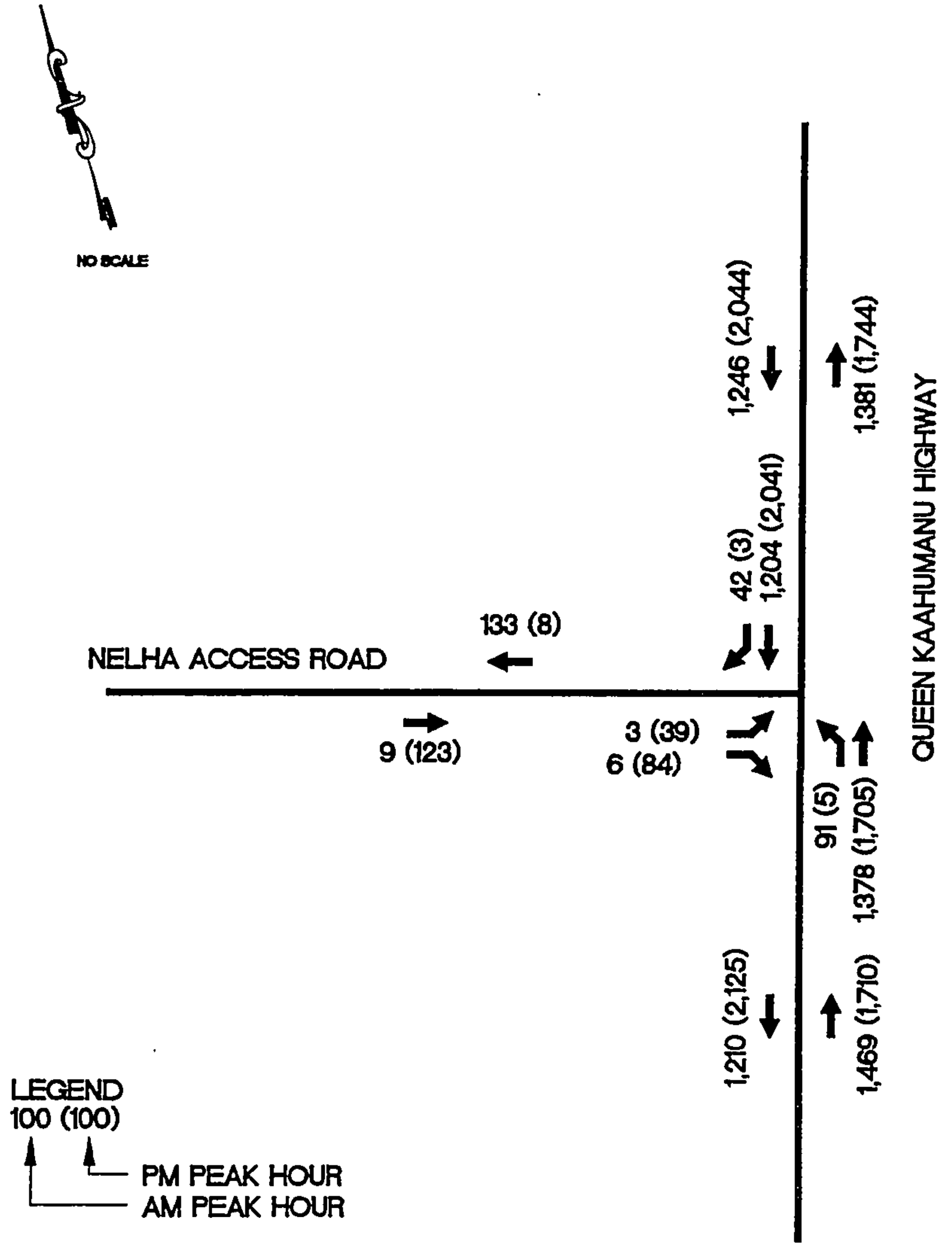
A level-of-service analysis for 1997 cumulative conditions was conducted to provide a basis for determining the project's impacts. The results of this level-of-service analysis are that the intersection of Queen Kaahumanu Highway or the NELHA entrance operates at Level-

TABLE 3
1997 TRAFFIC PROJECTION WORKSHEET
NELHA TRAFFIC STUDY
June 1992

Condition/Source	PM Peak Hour North-bound	South-bound	Total
1992 Existing	441	856	1,297
Background Growth (40%)	219	426	645
O'oma	130	110	240
Kohanaiki Mauka	140	40	180
Kohanaiki	365	324	689
Manini'owali	410	285	695
NELHA Expansion	5	84	89
Total	1,710	2,125	3,835

of-Service "B" at cumulative traffic conditions. However, left turns into and out of the project will operate at Level-of-Service "E" and "F", respectively.

The cumulative volume along Queen Kaahumanu Highway, which does not include any NELHA or KAD traffic exceeds the capacity of the existing two-lane highway. Therefore, to accommodate the future related project, Queen Kaahumanu Highway must be widened to a minimum of four lanes.



1997 CUMULATIVE PEAK HOUR TRAFFIC VOLUMES

NELHA PROJECT TIAR
KAILUA-KONA, HAWAII

4.
CUMULATIVE PLUS PROJECT TRAFFIC CONDITIONS

This chapter discusses the methodology used to identify the traffic-related impacts of the proposed project. This methodology involves the three step process of trip generation, distribution and assignment. First, the number of weekday AM and PM peak-hour trips that would be generated by the proposed project was determined. These trips were then distributed on the major approach and departure routes. Next, each trip was assigned a specific path to and from the site based on ingress/egress locations and travel patterns. Finally, the level-of-service was calculated for the roadway.

TRIP GENERATION

Traffic volumes for the proposed project are typically determined using trip generation equations contained in Trip Generation (Fourth Edition, 1987), an informational report prepared by the ITE and data for similar developments. However, this report does not contain any data relative to this particular type of development. Therefore, the trip generation analysis was conducted using market analysis data provided by the developer. Assumptions used for the trip generation analysis are as follows:

(1) 30% of the visitors will arrive via vans or tour buses, with an occupancy of 12 passengers per vehicles.

(2) Average vehicle occupancy for automobiles will be 2.8.

(3) No service vehicles during peak hours.

(4) Beachpark visitors are included in the visitor center traffic.

(5) Facility is closed during AM peak hours.

This trip generation analysis is summarized as Table 4.

TRIP DISTRIBUTION

The project-related trips were distributed based on existing peak, off-peak directional data. In this case, 65% of the traffic is destined for the south (or Kailua-Kona direction).

TABLE 4
TRIP GENERATION ANALYSIS
NELHA TRAFFIC STUDY
June 1992

Use	PM Peak Hour Trips Weekday	In	Out	Total
Visitors				
(Min)[1]	1210	12	109	121
(Max)[2]	1815	18	164	182
Employees				
(Min)	115	2	30	32
(Max)	152	2	39	41
Service Vehicle				
(Min)	13	0	0	0
(Max)	20			
Beach Park		0	0	0
Total				
(Min)	1338	14	139	153
(Max)	1987	20	203	223

Notes: (1) Minimum traffic volumes are based on a design day volume at 4,400 visitors.

(2) Maximum traffic volumes are based on a design day volume of 6,600 visitors.

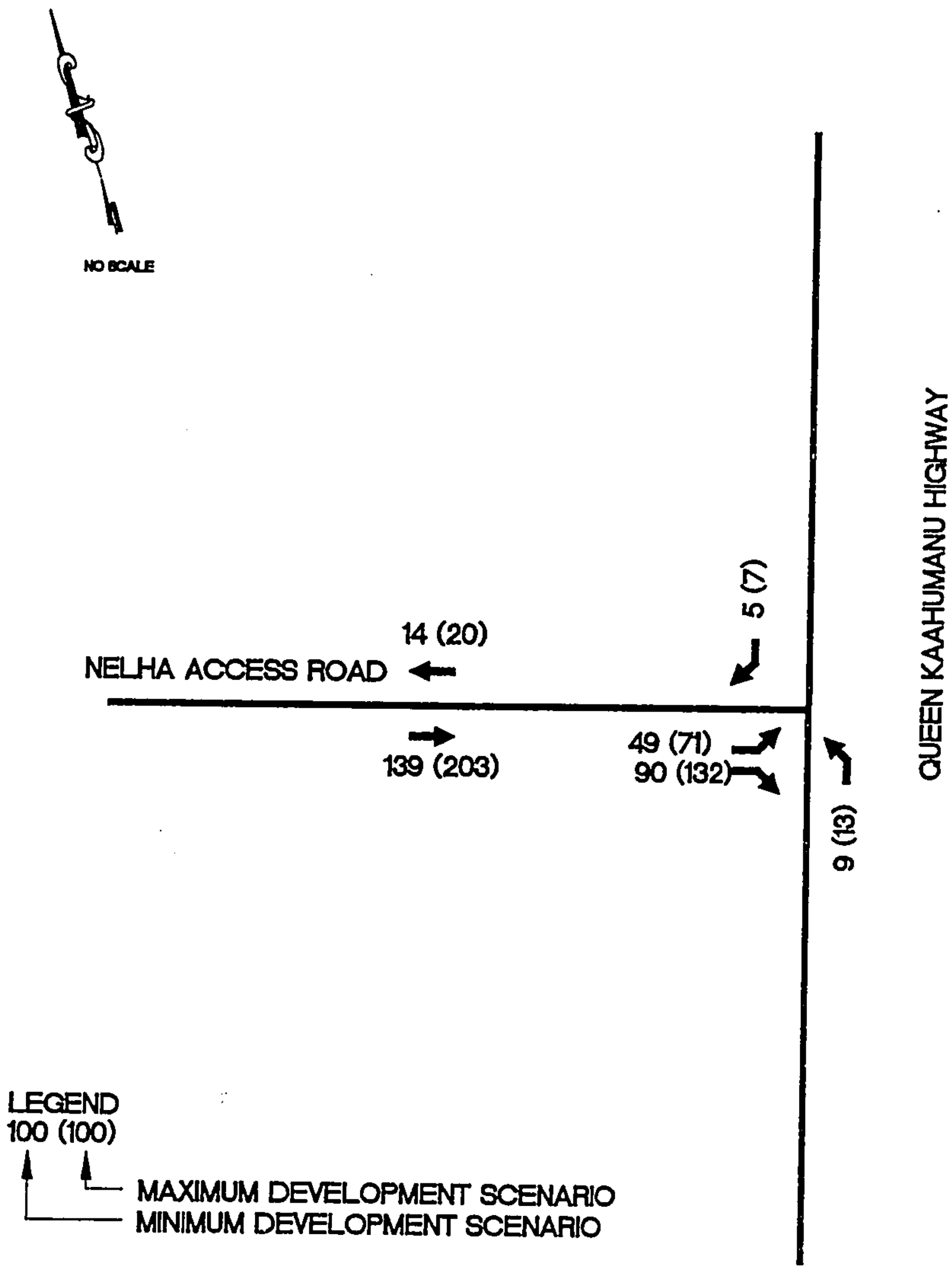
TRIP ASSIGNMENT

Using the trip generation and trip distribution previously discussed, site-generated traffic was assigned to the various turning movements at the intersections studied. The trip assignments for the AM and PM peak hours, are shown on Figure 4.

TOTAL PEAK HOUR TRAFFIC VOLUMES

Future traffic volumes with the project were determined by superimposing the site-generated traffic on the cumulative traffic volumes presented in the previous chapter. Thus, operating conditions under this scenario include existing traffic, background growth, related projects and proposed project trips on the roadway network.

The resulting 1997 cumulative plus project traffic volumes are shown for the AM and PM peak hours on Figure 5.

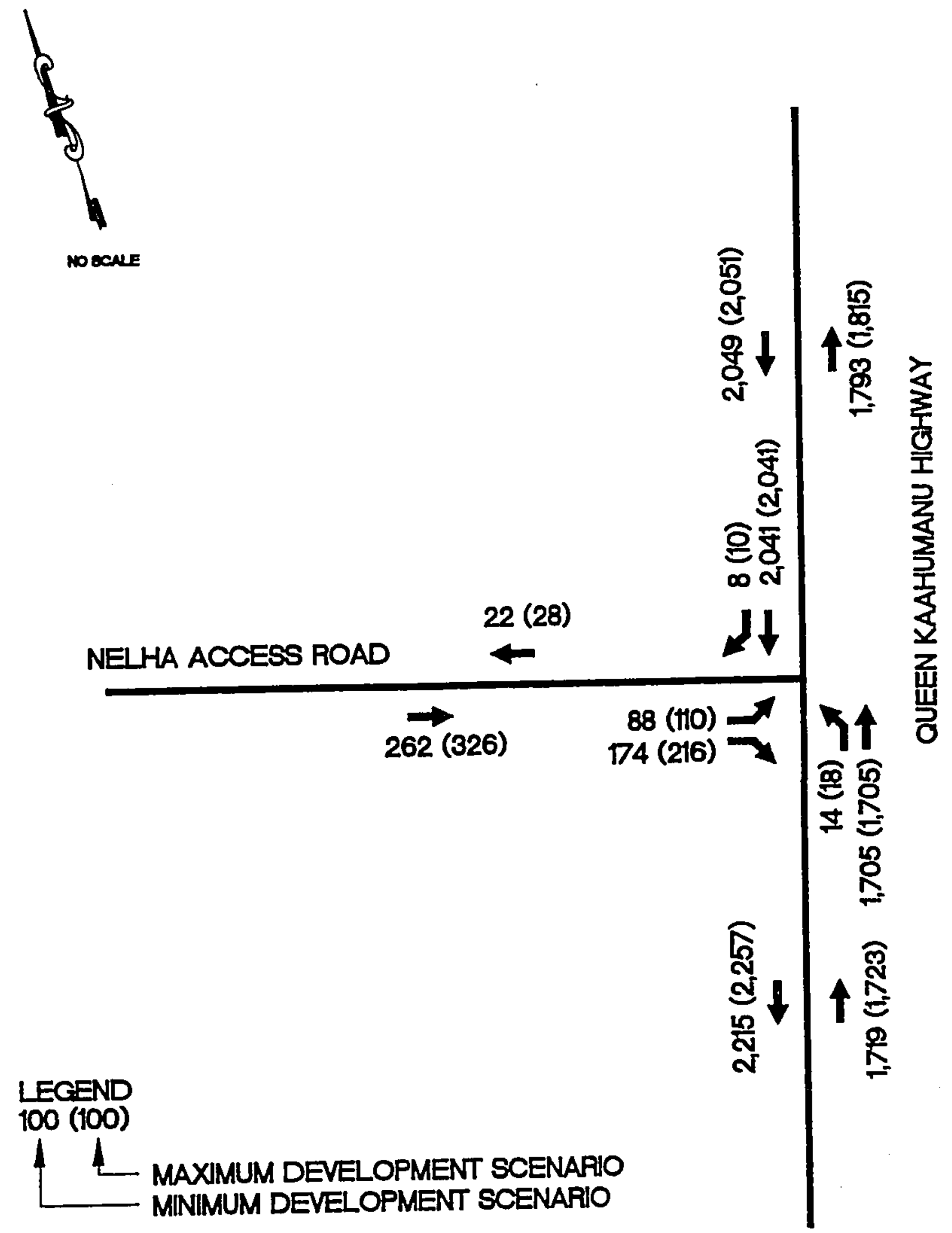


PROJECT TRIP ASSIGNMENT

1997 PM PEAK HOUR

NELHA PROJECT TIAR

KAILUA-KONA, HAWAII



CUMULATIVE PLUS PROJECT PEAK HOUR TRAFFIC VOLUMES

1997 PM PEAK HOUR

NELHA PROJECT TIAR

KAILUA-KONA, HAWAII

5.
SUMMARY OF IMPACTS AND MITIGATION MEASURES

The purpose of this chapter is to summarize results of the level-of-service analyses which identify the project-related impacts on the surrounding roadway network. In addition, any mitigation measures necessary and feasible are identified.

PROJECT RELATED IMPACTS

A level-of-service analysis for the minimum and maximum development scenario were conducted. The results for both were essentially the same.

If the entrance is unsignalized, the left turns from the project will experience long delays and operate at a level-of-service "F". Left-turns into the project will operate at level-of-service "D". However, the intersection as a whole will operate at Level-of-Service "B". These conclusions assume that the intersection will have separate left turn lanes into and out of the project and acceleration/deceleration lanes for right turns. It should also be noted that the background volumes exceed the capacity of a single lane.

FUTURE ROADWAY IMPROVEMENTS

The state currently has plans to improve Queen Kaahumanu Highway to an access controlled facility. As yet, there is no indication that this will occur within the time frame used in this study (1992-1997). It is understood that when Queen Kaahumanu Highway is improved, access to the NELHA project would be via a frontage roadway. This scenario has not been studied as part of this study as plans for Queen Kaahumanu Highway have not progressed to the point where access routes can be identified. Therefore, traffic from NELHA must be considered in the assessment and design of Queen Kaahumanu in the future.

SIGNALIZATION

An analysis was conducted for signalized intersection conditions. The analysis conducted that a traffic signal would decrease the level-of-service unless Queen Kaahumanu Highway is widened to accommodate two through lanes in each direction. Without widening the level-of-service would be "F" because of the additional delays. With widening, the level-of-service would be "C" with a volume-capacity ratio of 0.78.

APPENDIX A
LEVEL-OF-SERVICE CALCULATIONS

****

IDENTIFYING INFORMATION

AVERAGE RUNNING SPEED, MAJOR STREET.. 55

PEAK HOUR FACTOR.................... 1

AREA POPULATION..................... 30000

NAME OF THE EAST/WEST STREET......... NELHA ENTRANCE

NAME OF THE NORTH/SOUTH STREET....... QUEEN KAAHUMANU HWY

NAME OF THE ANALYST.................. RJR

DATE OF THE ANALYSIS (mm/dd/yy)...... 04-09-1992

TIME PERIOD ANALYZED................. PM PEAK HOUR

OTHER INFORMATION.... EXISTING CONDITIONS

INTERSECTION TYPE AND CONTROL

INTERSECTION TYPE: T-INTERSECTION

MAJOR STREET DIRECTION: NORTH/SOUTH

CONTROL TYPE EASTBOUND: STOP SIGN

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	10	—	2	0
THRU	0	—	441	856
RIGHT	31	—	0	1

850
1
10
E
31 A
2
E
441

NUMBER OF LANES

	EB	WB	NB	SB
LANES	1	—	2	2

ADJUSTMENT FACTORS

	PERCENT GRADE	RIGHT TURN ANGLE	CURB RADIUS (ft) FOR RIGHT TURNS	ACCELERATION LANE FOR RIGHT TURNS
EASTBOUND	0.00	90	75	Y
WESTBOUND	----	----	----	-
NORTHBOUND	0.00	90	20	N
SOUTHBOUND	0.00	90	20	N

VEHICLE COMPOSITION

	% SU TRUCKS AND RV'S	% COMBINATION VEHICLES	% MOTORCYCLES
EASTBOUND	0	0	0
WESTBOUND	----	----	----
NORTHBOUND	0	0	0
SOUTHBOUND	0	0	0

CRITICAL GAPS

	TABULAR VALUES (Table 10-2)	ADJUSTED VALUE	SIGHT DIST. ADJUSTMENT	FINAL CRITICAL GAP
MINOR RIGHTS EB	6.50	5.50	0.00	5.50
MAJOR LEFTS NB	6.00	6.00	0.00	6.00
MINOR LEFTS EB	8.50	8.50	0.00	8.50

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... EXISTING CONDITIONS

MOVEMENT	FLOW-RATE v(pcph)	POTEN-TIAL CAPACITY c_p (pcph)	ACTUAL MOVEMENT CAPACITY c_M (pcph)		SHARED CAPACITY c_{SH} (pcph)		RESERVE CAPACITY $c_R = c_{SH} - v$	LOS
MINOR STREET								
EB LEFT	11	60	60	>	60	>	49 >	E
				> 193		> 148	>D	
RIGHT	34	679	679	>	679	>	645 >	A
MAJOR STREET								
NB LEFT	2	338	338		338		336	B

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... EXISTING CONDITIONS

WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: NELHA TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: QUEEN KAAHUMANU HIGHWAY
EAST-WEST STREET: NELHA ENTRANCE
CONDITION: EXISTING PM PEAK HOUR
DATE: APRIL 24, 1992
NOTE 1:
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	1	A	5	5
2	Th	855	A	5	4280
3	Lt				0
4	E-Rt				0
5	Th				0
6	Lt				0
7	S-Rt				0
8	Th	441	A	5	2205
9	Lt	2	B	10	20
10	W-Rt	31	A	5	155
11	Th				0
12	Lt	10	E	50	500

Delay Inputs

LoS	Avg. Delay	Delay Range
A	5.0	<5.0
B	10.0	5.1 - 15.0
C	20.0	15.1 -25.0
D	32.5	25.1 - 40.0
E	50.0	40.1 - 50.0
F	60.0	>60

Level-of-Service Results

5.3 = Weighted Delay
B = Level-of-Service

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WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: NELHA TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: QUEEN KAAHUMANU HIGHWAY
EAST-WEST STREET: NELHA ENTRANCE
CONDITION: EXISTING PM PEAK HOUR
DATE: APRIL 24, 1992
NOTE 1:
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	1	A	5	5
2	Th	856	A	5	4280
3	Lt				0
4	E-Rt				0
5	Th				0
6	Lt				0
7	S-Rt				0
8	Th	441	A	5	2205
9	Lt	2	B	10	20
10	W-Rt	31	A	5	155
11	Th				0
12	Lt	10	E	50	500

Delay Inputs

LoS	Avg. Delay	Delay Range
A	5.0	<5.0
B	10.0	5.1 - 15.0
C	20.0	15.1 -25.0
D	32.5	25.1 - 40.0
E	50.0	40.1 - 50.0
F	60.0	>60

Level-of-Service Results

5.3 = Weighted Delay
B = Level-of-Service

****

IDENTIFYING INFORMATION

AVERAGE RUNNING SPEED, MAJOR STREET.. 55

PEAK HOUR FACTOR..................... 1

AREA POPULATION...................... 30000

NAME OF THE EAST/WEST STREET......... NELHA ENTRANCE

NAME OF THE NORTH/SOUTH STREET....... QUEEN KAAHUMANU HWY

NAME OF THE ANALYST.................. RJR

DATE OF THE ANALYSIS (mm/dd/yy)...... 04-09-1992

TIME PERIOD ANALYZED................. PM PEAK HOUR

OTHER INFORMATION.... 1997 CUMULATIVE W/O PROJ

INTERSECTION TYPE AND CONTROL

INTERSECTION TYPE: T-INTERSECTION

MAJOR STREET DIRECTION: NORTH/SOUTH

CONTROL TYPE EASTBOUND: STOP SIGN

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	39	--	15	0
THRU	0	--	1705	2041
RIGHT	84	--	0	3

NUMBER OF LANES

	EB	WB	NB	SB
LANES	1	--	2	2

	PERCENT GRADE	RIGHT TURN ANGLE	CURB RADIUS (ft) FOR RIGHT TURNS	ACCELERATION LANE FOR RIGHT TURNS
EASTBOUND	0.00	90	75	Y
WESTBOUND	----	----	----	-
NORTHBOUND	0.00	90	20	N
SOUTHBOUND	0.00	90	20	N

VEHICLE COMPOSITION

	% SU TRUCKS AND RV'S	% COMBINATION VEHICLES	% MOTORCYCLES
EASTBOUND	0	0	0
WESTBOUND	----	----	----
NORTHBOUND	0	0	0
SOUTHBOUND	0	0	0

CRITICAL GAPS

	TABULAR VALUES (Table 10-2)	ADJUSTED VALUE	SIGHT DIST. ADJUSTMENT	FINAL CRITICAL GAP
MINOR RIGHTS				
EB	6.50	5.50	0.00	5.50
MAJOR LEFTS				
NB	6.00	6.00	0.00	6.00
MINOR LEFTS				
EB	8.50	8.50	0.00	8.50

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... 1997 CUMULATIVE W/O PROJ

MOVEMENT	FLOW-RATE v(pcph)	POTEN-TIAL CAPACITY c_P (pcph)	ACTUAL MOVEMENT CAPACITY c_M (pcph)	SHARED CAPACITY c_{SH} (pcph)	RESERVE CAPACITY $c_R = c_{SH} - v$	LOS
MINOR STREET						
EB LEFT	43	35	32 >	32 >	-11 >	F
			>	82 >	-53	>F
RIGHT	92	322	322 >	322 >	229 >	C
MAJOR STREET						
NB LEFT	17	115	115	115	99	E

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... 1997 CUMULATIVE W/0 PROJ

WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: THEODAVIES EUROMOTORS TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: NELHA ENTRANCE
EAST-WEST STREET: QUEEN KAAUMANU HIGHWAY
CONDITION: CUMULATIVE PM PEAK HOUR
DATE: MAY 21, 1992
NOTE 1:
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	3	A	5	15
2	Th	2041	A	5	10205
3	Lt				0
4	E-Rt				0
5	Th				0
6	Lt				0
7	S-Rt				0
8	Th	1705	A	5	8525
9	Lt	15	E	50	750
10	W-Rt	84	C	20	1680
11	Th				0
12	Lt	39	F	60	2340

Delay Inputs

LoS	Avg. Delay	Delay Range
A	5.0	<5.0
B	10.0	5.1 - 15.0
C	20.0	15.1 -25.0
D	32.5	25.1 - 40.0
E	50.0	40.1 - 50.0
F	60.0	>60

Level-of-Service Results

6.0 = Weighted Delay
B = Level-of-Service

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IDENTIFYING INFORMATION

AVERAGE RUNNING SPEED, MAJOR STREET.. 55

PEAK HOUR FACTOR...................... 1

AREA POPULATION...................... 30000

NAME OF THE EAST/WEST STREET......... NELHA ENTRANCE

NAME OF THE NORTH/SOUTH STREET....... QUEEN KAAHUMANU HWY

NAME OF THE ANALYST.................. RJR

DATE OF THE ANALYSIS (mm/dd/yy)...... 04-09-1992

TIME PERIOD ANALYZED................. PM PEAK HOUR

OTHER INFORMATION.... 1997 MIN DEVLOPMENT

INTERSECTION TYPE AND CONTROL

INTERSECTION TYPE: T-INTERSECTION

MAJOR STREET DIRECTION: NORTH/SOUTH

CONTROL TYPE EASTBOUND: STOP SIGN

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	88	—	14	0
THRU	0	—	1705	2041
RIGHT	174	—	0	8

NUMBER OF LANES

	EB	WB	NB	SB
LANES	1	—	2	2

ADJUSTMENT FACTORS

	PERCENT GRADE	RIGHT TURN ANGLE	CURB RADIUS (ft) FOR RIGHT TURNS	ACCELERATION LANE FOR RIGHT TURNS
EASTBOUND	0.00	90	75	Y
WESTBOUND	----	----	----	-
NORTHBOUND	0.00	90	20	N
SOUTHBOUND	0.00	90	20	N

VEHICLE COMPOSITION

	% SU TRUCKS AND RV'S	% COMBINATION VEHICLES	% MOTORCYCLES
EASTBOUND	0	0	0
WESTBOUND	----	----	----
NORTHBOUND	0	0	0
SOUTHBOUND	0	0	0

CRITICAL GAPS

	TABULAR VALUES (Table 10-2)	ADJUSTED VALUE	SIGHT DIST. ADJUSTMENT	FINAL CRITICAL GAP
MINOR RIGHTS EB	6.50	5.50	0.00	5.50
MAJOR LEFTS NB	6.00	6.00	0.00	6.00
MINOR LEFTS EB	8.50	8.50	0.00	8.50

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... 1997 MIN DEVLOPMENT

MOVEMENT	FLOW-RATE v(pcph)	POTEN-TIAL CAPACITY c_p (pcph)	ACTUAL MOVEMENT CAPACITY c_M (pcph)	SHARED CAPACITY c_{SH} (pcph)	RESERVE CAPACITY $c_R = c_{SH} - v$	LOS
MINOR STREET						
EB LEFT	97	35	32 >	32 >	-65 >	F
			>	79 >	-209	>F
RIGHT	191	321	321 >	321 >	129 >	D
MAJOR STREET						
NB LEFT	15	115	115	115	100	E

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... 1997 MIN DEVLOPMENT

WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: NELHA TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: QUEEN KAAUMANU HIGHWAY
EAST-WEST STREET: NELHA ENTRANCE
CONDITION: CUMULATIVE PM PEAK HOUR
DATE: MAY 20, 1992
NOTE 1: MINIMUM DEVELOPMENT
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	8	A	5	40
2	Th	2041	A	5	10205
3	Lt				0
4	E-Rt				0
5	Th				0
6	Lt				0
7	S-Rt				0
8	Th	1705	A	5	8525
9	Lt	14	E	50	700
10	W-Rt	174	D	32.5	5655
11	Th				0
12	Lt	88	F	60	5280

Delay Inputs

LoS	Avg. Delay	Delay Range
A	5.0	<5.0
B	10.0	5.1 - 15.0
C	20.0	15.1 -25.0
D	32.5	25.1 - 40.0
E	50.0	40.1 - 50.0
F	60.0	>60

Level-of-Service Results

7.5 = Weighted Delay
B = Level-of-Service

WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: NELHA TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: QUEEN KAAUMANU HIGHWAY
EAST-WEST STREET: NELHA ENTRANCE
CONDITION: CUMULATIVE PM PEAK HOUR
DATE: MAY 20, 1992
NOTE 1: MINIMUM DEVELOPMENT
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	8	A	5	40
2	Th	2041	A	5	10205
3	Lt				0
4	E-Rt				0
5	Th				0
6	Lt				0
7	S-Rt				0
8	Th	1705	A	5	8525
9	Lt	14	E	50	700
10	W-Rt	174	D	32.5	5655
11	Th				0
12	Lt	88	F	60	5280

Delay Inputs

LoS	Avg. Delay	Delay Range
A	5.0	<5.0
B	10.0	5.1 - 15.0
C	20.0	15.1 -25.0
D	32.5	25.1 - 40.0
E	50.0	40.1 - 50.0
F	60.0	>60

Level-of-Service Results

7.5 = Weighted Delay
B = Level-of-Service

XEROX COPY

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IDENTIFYING INFORMATION

AVERAGE RUNNING SPEED, MAJOR STREET.. 55

PEAK HOUR FACTOR..................... 1

AREA POPULATION...................... 30000

NAME OF THE EAST/WEST STREET......... NELHA ENTRANCE

NAME OF THE NORTH/SOUTH STREET....... QUEEN KAAHUMANU HWY

NAME OF THE ANALYST.................. RJR

DATE OF THE ANALYSIS (mm/dd/yy)...... 04-09-1992

TIME PERIOD ANALYZED................. PM PEAK HOUR

OTHER INFORMATION.... 1997 MAX DEVELOPMENT

INTERSECTION TYPE AND CONTROL

INTERSECTION TYPE: T-INTERSECTION

MAJOR STREET DIRECTION: NORTH/SOUTH

CONTROL TYPE EASTBOUND: STOP SIGN

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	110	—	18	0
THRU	0	—	1705	2041
RIGHT	216	—	0	10

NUMBER OF LANES

	EB	WB	NB	SB
LANES	1	—	2	2

	PERCENT GRADE	RIGHT TURN ANGLE	CURB RADIUS (ft) FOR RIGHT TURNS	ACCELERATION LANE FOR RIGHT TURNS
EASTBOUND	0.00	90	75	Y
WESTBOUND	----	---	---	-
NORTHBOUND	0.00	90	20	N
SOUTHBOUND	0.00	90	20	N

VEHICLE COMPOSITION

	% SU TRUCKS AND RV'S	% COMBINATION VEHICLES	% MOTORCYCLES
EASTBOUND	0	0	0
WESTBOUND	---	---	---
NORTHBOUND	0	0	0
SOUTHBOUND	0	0	0

CRITICAL GAPS

		TABULAR VALUES (Table 10-2)	ADJUSTED VALUE	SIGHT DIST. ADJUSTMENT	FINAL CRITICAL GAP
MINOR RIGHTS	EB	6.50	5.50	0.00	5.50
MAJOR LEFTS	NB	6.00	6.00	0.00	6.00
MINOR LEFTS	EB	8.50	8.50	0.00	8.50

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... 1997 MAX DEVELOPMENT

MOVEMENT	FLOW-RATE v(pcph)	POTEN-TIAL CAPACITY c_p (pcph)	ACTUAL MOVEMENT CAPACITY c_M (pcph)	SHARED CAPACITY c_{SH} (pcph)	RESERVE CAPACITY $c_R = c_{SH} - v$	LOS
MINOR STREET						
EB LEFT	121	35	31	> 31 >	-90 >	F
				> 77 >	-282	>F
RIGHT	238	320	320	> 320 >	83 >	E
MAJOR STREET						
NB LEFT	20	115	115	115	95	E

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET...... NELHA ENTRANCE
NAME OF THE NORTH/SOUTH STREET.... QUEEN KAAHUMANU HWY
DATE AND TIME OF THE ANALYSIS..... 04-09-1992 ; PM PEAK HOUR
OTHER INFORMATION.... 1997 MAX DEVELOPMENT

WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: NELHA TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: QUEEN KAAUMANU HIGHWAY
EAST-WEST STREET: NELHA ENTRANCE
CONDITION: CUMULATIVE PM PEAK HOUR
DATE: MAY 1992
NOTE 1: MAXIMUM DEVELOPMENT
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	10	A	5	50
2	Th	2041	A	5	10205
3	Lt				0
4	E-Rt				0
5	Th				0
6	Lt				0
7	S-Rt				0
8	Th	1705	A	5	8525
9	Lt	18	E	50	900
10	W-Rt	216	E	50	10800
11	Th				0
12	Lt	110	F	60	6600

Delay Inputs

LoS	Avg. Delay	Delay Range
A	5.0	<5.0
B	10.0	5.1 - 15.0
C	20.0	15.1 -25.0
D	32.5	25.1 - 40.0
E	50.0	40.1 - 50.0
F	60.0	>60

Level-of-Service Results

9.0 = Weighted Delay
B = Level-of-Service

XEROX COPY

WORKSHEET TO CALCULATE
WEIGHTED VEHICLE DELAY AND LEVEL-OF-SERVICE
FROM HCS UNSIGNALIZED OUTPUT

PROJECT: NELHA TRAFFIC STUDY
LOCATION: KAILUA-KONA, HAWAII
NORTH-SOUTH STREET: QUEEN KAAUMANU HIGHWAY
EAST-WEST STREET: NELHA ENTRANCE
CONDITION: CUMULATIVE PM PEAK HOUR
DATE: MAY 1992
NOTE 1: MAXIMUM DEVELOPMENT
NOTE 2:

Volume & Delay Input

No	App & Mvt	Volume	LoS	Avg. Delay	Wt'd Delay
1	N-Rt	10	A	5	50
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5	Th				0
6	Lt				0
7	S-Rt				0
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10	W-Rt	216	E	50	10800
11	Th				0
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Delay Inputs

LoS	Avg. Delay	Delay Range
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Level-of-Service Results

9.0 = Weighted Delay
B = Level-of-Service

APPENDIX H
NELHA FACILITIES USE MANUAL

FACILITIES USE MANUAL

NATURAL ENERGY LABORATORY
OF HAWAII AUTHORITY
KEAHOLE POINT, HAWAII

NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY

FACILITIES USE MANUAL

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Intent and Purpose.

A. The Natural Energy Laboratory of Hawaii Authority (NELHA) was created to promote and provide for the research, development, demonstration and commercial application of activities that utilize the natural resources of two distant sites on the island of Hawaii: ocean water and solar resources at the Keahole Site in Kona and geothermal resources at the Pohoiki site in Puna.

B. The purpose of this manual is to establish for the Authority's Keahole site, standards, restrictions and guidelines that will ensure a high quality of coordinated development and a minimum of adverse environmental impacts, while providing sufficient design and operating flexibility to encourage sound economic development.

Definitions.

As used in this manual, unless the context otherwise specifies or indicated a different meaning:

"Accessory building" means a permanent building detached from and subordinate to a principal building on the same lot and used for purposes customarily incidental to those of the main building such as storage of equipment, research, processing, product development and testing.

"Approval" means written approval prior to implementation of the proposed action.

"Authority" means the Natural Energy Laboratory of Hawaii Authority (NELHA).

"Average lot width" means the total lot area divided by the maximum depth of the lot. In the case of a flag lot, the maximum depth of the lot excludes the length of the driveway portion of the lot.

"Board of Directors" means the appointed Board of the Authority.

"Capital Investment" means any permanent improvement to the leased land.

"County" means County of Hawaii, Island of Hawaii.

"Commercial" means occupied with or engaged in commerce or work intended for commerce.

"Development" means activity engaged in determining the commercial possibilities of a particular project.

"Director" means the executive director of the Authority.

"FRA" means Facilities Rental Agreement, an agreement between NELHA and a small scale (less than one acre) commercial tenant located within the NELH area for the use of land, lab and/or office space.

"FUA" means Facilities Use Agreement, an agreement between NELHA and a tenant for the use of land, lab or office space during the research and development stages of a project.

"Gross floor area" means the total area of all floors of a building including the basement measured along the exterior walls of such building.

"GSA" means general services agreement, an agreement between NELHA and a commercial tenant to cover the use of services such as equipment, facsimile, telephones, seawater, etc.

"Hazardous material" means material defined as hazardous waste by the State of Hawaii, Department of Health and the U.S. Environmental Protection Agency; and material classified by the National Fire Protection Association (NFPA) as either a flammable liquid, a Class II combustible liquid, or Class IIIA combustible liquid.

"HOST Park" is synonymous with the term "Hawaii Ocean Science and Technology Park" and means the site and facilities associated with commercial projects located at Keahole, North Kona, Island of Hawaii.

"Improvement" means any building, road, driveway, parking area, loading area, pond, raceway, tank, water containment structure, ocean water line, potable water line, sewer, electrical and gas distribution facilities, telephone line, retaining wall, fence, screen, berm, pond cover or screen, greenhouse, stairway, deck, pole, hedge, planting, sign, exterior illumination, and all other structures, installation and landscaping of every type and kind, whether above or below the land surface.

"Industrial/Support Area" means the real property so designated in the Master Plan.

"Lot" means a parcel identified by a lot number shown in the Master Plan, NELH subdivision map, or rented space as designated by the Authority.

"Lot area" means the total area of a lot, including any area to be used for a driveway.

"Master Plan" means the 1989 HOST Park Master Plan.

"NELH" is synonymous with the term "Natural Energy Laboratory of Hawaii" and means the site and facilities associated with research and development projects located at the Natural Energy Laboratory of Hawaii Authority, Keahole Point, North Kona, Island of Hawaii.

"NELHA" means the Natural Energy Laboratory of Hawaii Authority which collectively manages the NELH and HOST Park facilities.

"Ocean water area" means the real property so designated in the 1989 HOST Park Master Plan, and/or designated as an ocean water use area.

"Principal building" means a permanent building which provides facilities for the main use of a lot.

"Research" means the experimentation and/or collecting of information about a particular subject.

"Sign" means any structure, device or contrivance, electric or non-electric, temporary or permanently affixed, upon which any poster, bill, bulletin, printing, lettering, painting, device or other advertising of any kind whatsoever, is used, fastened or affixed.

"Street" means any street, road, or thoroughfare within NELHA and shown on any recorded subdivision or parcel map, or record of survey, whether designated as a street, boulevard, place, drive, road, court, terrace, way, land, circle or otherwise.

"Tenant" means a lessee, project or licensee who is lawfully occupying a lot with the authorization of the Board of Directors.

"Utilities" means potable water, ocean water, electricity, and telephone systems as supplied by the Authority, private utility, or by the County.

"Visible from adjacent lots" means, with respect to any given object on a lot, that such object is or would be visible to a person six feet tall, standing on any part of an adjacent lot, street or other part of an adjacent lot, street or other property at an elevation no greater than the ground elevation at the location of the object or activity being viewed.

Administration.

The Authority, or its designated representative, shall administer the provisions of these policies and procedures, except where indicated.

Rules for Construction of Language.

The following rules of construction apply to there rules:

(1) The particular shall control the general;

(2) In case of any difference of meaning or implication between the text of these rules and any caption, illustration, map, summary table or illustrative table, the text shall control;

(3) The word "shall" is always mandatory and not discretionary. The word "may" is permissive;

(4) Words used in the present tense shall include the future; and words used in the singular number shall include the plural, and the plural the singular, unless the context clearly indicated the contrary;

(5) A "building" or "structure" includes any part thereof;

(6) The word "person" includes an individual, a corporation, a partnership, an incorporated association, or any other similar entity;

(7) Unless the context clearly indicates the contrary, where a provision involves two or more items, conditions, provisions, or events connected by the conjunction "and" or "or", the conjunction shall be interpreted as follows:

  (a) "And" indicates that all the connected items, conditions, provisions, or events shall apply;
  (b) "Or" indicates that the connected items, conditions, provisions or events may apply singly or in any combination.

(8) The word "includes" shall not limit a term to the specified examples, but is intended to extend its meaning to all other instances or circumstances of similar king or character.

Compliance with General Leases.

A. A portion of Keahole Point is leased to the Authority by the Department of Land and Natural Resources. Tenants that occupy this portion of Keahole Point shall also be responsible for complying with the provisions of the appropriate general lease.

B. In the event of a conflict between these policies and procedures and general lease, the provisions of the latter shall prevail.

Severability.

If a court of competent jurisdiction finds any provision or provisions of these policies and procedures to be invalid or ineffective in whole or in part, the effect of that decision shall be limited to those provisions which are expressly stated i the decision to be invalid and ineffective and all other provisions of these policies and procedures shall be separately and fully effective.

Permitted Uses.

A. Keahole Point shall be divided into three types of use areas, designated ocean water area, industrial support area, and education/information area. The following uses are guidelines to be used in the placement of new projects.

B. The ocean water area is designated for research and development and/or commercialization of projects that utilize the ocean water resources available at Keahole Point. Priority is given to those projects utilizing the cold seawater resource. Permitted uses within the ocean water use area shall include but not be limited to:

(1) Aquacultural applications such as production of abalone, clam, oyster and other mollusks; lobster, shrimp, prawn and other crustaceans; micro- and macro-algae; and finfish;

(2) Agricultural applications which use the ocean water or brackish water resources;

(3) Research, development and commercialization of ocean related technologies;

(4) Oceanography;

(5) Alternate energy applications;

(6) Desalination of ocean water or brackish water.

(7) Research, development and commercial technologies which use the ocean water as an integral part of the process.

C. The industrial support area is designated for ocean related science and technology uses and tenant support services that require smaller acreage of land. This area is intended to be developed as low density industrial area with low lying buildings and planned landscaping to convey a park like atmosphere. Permitted uses within the industrial/support area shall include but not be limited to:

(1) Biotechnological, microbiological and pharmaceutical businesses;

(2) Design, manufacture and assembly of ocean related equipment of an electrical, electronic, electromechanical or optic nature, only if such equipment requires the special facilities of the HOST Park for its manufacture and/or testing;

(3) Support businesses, including but not limited to processing and packing services, and production and sale of ice for the packing and shipment of products, and refrigerated warehouses;

(4) Restaurant operations specializing in the preparation of species produced in the ocean water use area; and

(5) Office buildings.

D. The education/information area is intended to be developed as a low-density area primarily for educational, training and public information disseminating uses. Permitted uses within the education/information area shall include but not be limited to:

(1) Research and training facilities;

(2) Visitor information center;

(3) Libraries; and

(4) Administrative offices and laboratory facilities of tenants who maintain operations within other NELHA areas.

E. The following operations that are accessory to the principal permitted activities are permitted within the three designated areas:

(1) Administrative offices;

(2) Warehousing and distribution;

(3) Research and development operations;

(4) Product testing;

(5) Marketing of products;

(6) Incidental and necessary services for the convenience of persons working at the site that are conducted within an integral part of a principal building with entrances from the interior of the building and having no display or advertising visible from the street;

(7) Manufacture, assembly, testing and repair of testing ~~and repair of testing~~ equipment;

(8) Equipment and instrument storage; and

(9) Other buildings and uses normally considered accessory to the permitted uses.

Prohibited Uses.

The following uses and operations, including uses not listed that are similar in character or effect, shall not be permitted on any lot:

(1) Airport and heliports;

(2) Residential and commercial hotel uses of any type;

(3) Auctions;

(4) Junk yards or recycling facilities provided, however, that the foregoing does not prohibit recycling that is carried out in conjunction with

a primary permitted use when necessary to comply with emissions control standards, or required as an element of waste control facilities;

(5) Commercial excavation of building or construction materials or quarrying of any material except in the course of approved site preparation and construction;

(6) Dumping, disposal, incineration or reduction of garbage or other forms of refuse;

(7) The raising, fattening, fat rendering, stockyard or slaughter of non-aquatic animals such as cattle, swine, fowl and the like;

(8) Refining of petroleum or its products;

(9) Smelting of iron, tin, zinc, or other metallic ores;

(10) Saw or wood planing mills;

(11) manufacturing or production of cement, lime, asphalt, gypsum, firewood, wood pulp; etc.;

(12) Cemeteries;

(13) Truck or bus maintenance or storage facilities not related to approved operation of the tenant;

(14) Automobile, go cart, motorcycle, or other motorized vehicle race tracks;

(15) Oil or propane storage facilities except in an enclosed yard of a tenant's lot only when such tanks are limited for use in the approved operation of the tenant;

(16) Processing of sugar or pineapple;

(17) Automobile or truck dealerships, auto wrecking, auto repair or auto painting establishments, or car wash facilities;

(18) Jail or honor farms;

(19) Labor of migrant worker farms;

(20) Storage and handling of radioactive and other hazardous substances unless incidental to a permitted use, and then only in accordance with applicable governmental regulations and the hazardous materials standards established by the corporation;

(21) Contractor's construction yards;

(22) Establishments that rent, sell, or service heavy equipment; and

(23) Veterinary establishments and commercial kennels.

<u>Uses and Operations Not Listed</u>.

A use or operation that is neither specifically prohibited nor specifically authorized by these rules may be permitted in a specific case if it is consistent with the intent and purpose of the Authority and the county zoning code. An application for such use or operation shall be submitted in writing to the Authority in accordance with the procedures set forth in these rules. Approval or disapproval of the application shall be based upon the effect of the applicant's operations or uses on other properties and operations at the site or on the tenants, and shall be at the sole discretion of NELHA.

<u>Non-conforming Uses</u>.

Non-conforming uses shall be permitted and regulated in accordance with the county zoning code.

<u>Lots</u>.

A. Resubdivision of any lot by any tenant is prohibited except if approved by the Authority.

B. Whenever two or more adjacent lots are developed by one tenant, they shall be treated and considered as one development lot for the purpose of these rules.

<u>Height Limitation</u>.

A. The maximum height of all buildings and structures, excluding ponds and other water containment structures, shall be forty feet as measured from the finished ground level to the roof of the building including mechanical penthouse.

B. No fence, wall, hedge, shrub, bush, tree or other obstruction shall be permitted at street corners or at driveway entrances that will obstruct the sightlines for drivers so as to constitute a safety hazard.

Setback.

A. The minimum distance between improvements and property boundaries on leased or subleased land shall be as follows:

(1) From lot boundaries that abut the main access road and other streets, the minimum setback for principal buildings shall be thirty-five feet.

(2) For all other lot boundaries the setbacks for all improvements shall be twenty feet.

B. The following improvements may extend into the setback area as follows:

(1) Roof overhangs, balconies and decks, subject to the approval of the Authority provided that the overhangs, balconies or decks do not extend more than six feet into the setback area;

(2) Exterior stairs, ramps, driveways, parking areas, and walkways;

(3) Fences that are constructed of strand material which allow "see-through" visibility, such as chain-link;

(4) Landscaping and irrigation systems;

(5) Planters, not to exceed three feet in height and except with the approval of the Authority;

(6) Signs identifying the tenant of a lot and directional, parking and security signs, subject to the approval of the Authority;

(7) Lighting facilities, subject to the approval of the Authority; and

(8) Above and below ground utility facilities and sewers.

Buildings Coverage.

The maximum lot area covered by buildings and other structures on leased or subleased property shall not exceed fifty per cent of the total area. This limitation shall not apply to production facilities such as raceways, shade cloth structures, tanks or greenhouses.

Special Structure.

Special structures related to permitted uses, such as shade cloth structures and portable structures, may be permitted subject to the approval of the Authority.

Temporary Structures.

A. No structure of a temporary character shall be erected on any lot except those required during construction of permanent structures.

B. No trailer shall be placed or used on any lot within the HOST Park area except when in use as a construction office during the course of approved construction. Mobile structures and portable containers may be used in the NELH area on a temporary basis as determined by the Authority on a case by case basis.

Permanent Structures.

All structures must conform to all applicable County, State, and Federal permits, regulations and laws and require the approval of the Authority.

Driveways.

A. Access to any lot shall be permitted only from designated streets. The Authority may specify the location of each driveway.

B. Unless limited to one driveway by the Authority, each lot shall be permitted to have two driveways on a street upon which the lot abuts. A tenant may be permitted more than two driveways subject to the approval of the Authority.

C. The Authority shall determine which lots will be required to have paved driveways.

Ocean Water Supply.

A. Authority supplied ocean water:

(1) A supply of ocean water may be made available by the Authority for tenant use;

(2) Tenants shall be responsible for constructing and maintaining a transmission system from the distribution point of the ocean water supply to the tenant's facility;

(3) Tenants who use more than fifty (50) gpm of seawater are required to install a flow meter that is easily accessible to Authority staff The Authority will provide a flow meter or the tenant may install a flow meter approved by the Authority. The tenant is responsible for the cost of the meter and for any installation costs.

Tenants that use less than fifty (50) gpm of seawater are not required to install a flow meter.

(4) It is preferred that transmission of the ocean water supply be by a completely buried pipe. The Authority may allow above ground pipes provided that measures for addressing aesthetic and safety considerations are included;

B. Tenant supplied ocean water:

(1) Under some circumstances, a tenant may have the option of constructing and maintaining its own ocean water supply system. Approval of the Authority shall be required prior to the construction of such a system; the Authority is not responsible for the quality or consistency of water from private pipes;

(2) The offshore segment of the supply system, including pipe and pump station, shall be subject to the conditions of all applicable permits. Therefore, the design and construction of the offshore segment of the supply system, including sizes, locations, and methods of deployment and installation of any pipes and pump stations, shall be subject to the review and approval of the Authority. Design plans and specifications shall be prepared under the supervision of a qualified person with expertise in the field;

(3) The design and construction of the on shore segment of the supply system, including the sizes, locations, and method of installation of any pipes, tanks and pump stations, shall be subject to the approval of the Authority.

C. Reused Ocean Water Supply.

(1) Tenants are encouraged to maximize the use of the ocean water resources by reusing or recycling the ocean water as often as practicable before its disposal. Ocean water reuse may be by one tenant or among several tenants;

(2) The method of transmission of used ocean water from one tenant to another tenant for reuse shall require notification of the Authority. This notification must include the terms of the agreement between the tenants. NELHA does not assume any liability resulting from the transfer of seawater between tenants;

(3) It is preferred that transmission of reused ocean water from the supplying tenant to the receiving tenant be by means of a completely buried pipe. Unburied pipes of a temporary nature may be used in the HOST Park area for a period not to exceed three months, unless otherwise approved by the Authority. Above the ground pipes may be permitted subject to the approval of the Authority in the NELH area;

(4) The responsibility of the quality of the return water lies with the last user.

D. Tenants may be permitted to install transmission pipes within the Authority's utility corridor or other approved area. The locations for such installation shall be approved by the Authority.

<u>Ponds and Other Water-Containment Structures</u>.

A. Ponds, raceways, tanks, holding basins, ditches and other water containment structures shall be designed adequately for structural stability and for the prevention of unplanned overflows, leakage and infiltration into the subsurface. Ponds shall be designed as an integrated part of the total tenant facilities.

B. All ponds shall be lined with suitable impervious material unless otherwise approved by the Authority.

C. The Authority may require a cover or screen over ponds to prevent water surface reflection or the attraction of birds, both of which are hazardous to nearby airport operations.

Return Ocean Water: Disposal.

A. Disposal of used seawater will be by an approved method.

B. If disposal is by Authority supplied method, the tenant shall be responsible for constructing and maintaining a transmission system from the tenant's facility to the designated receiving point of the return ocean water disposal system supplied by the Authority. NELHA intends to have a common collection system which will abut a property line of each lot which is scheduled to receive ocean water.

C. A tenant may install his own ocean water disposal system, but only with the notification of the Authority and only if such disposal system is in accordance with the approved disposal methods, applicable County, State and Federal permits, regulations and laws.

Return Ocean Water: Water Quality.

A. It is the intent of the Authority to minimize adverse environmental effects in the return of the ocean water to the ocean. Therefore, used ocean water discharged into the Authority's disposal system or tenants own disposal system shall meet the basic water quality criteria applicable to all waters as described in the State Department of Health rules relating to water quality standards as set forth in section 11-54-04 a, Hawaii Administrative Rules. The Authority shall review, approve, and have the right to monitor the discharge water quality requirements for each tenant on a case by case basis.

B. Tenants shall be responsible for pretreating their return ocean water discharge, as necessary, to meet these standards.

C. If deemed necessary, and/or evidence exists of non-compliance with water quality standards, the Authority may enter the tenant's premises with the tenant's approval for the purpose of taking samples of the tenant's return ocean water discharge for independent water quality analysis.

D. In the event that monitoring indicates the discharge of substances at levels which exceed the predetermined water quality standards, the Authority shall have the right to order the tenant to cease operations until the discharge problem has been corrected to the satisfaction of the Authority. In the event that a cessation of operations would result in substantial damage to the particular mariculture species or crop, the Authority and the tenant shall work together to correct the water quality problem as expeditiously as possible, and cessation of operations will only be required if irreversible damage to area ocean resources would result from the problem discharges.

E. Tenant may be restricted to a maximum allowable discharge rate for the purpose of preventing overflows at the return ocean water disposal site. The maximum allowable discharge rate for each tenant will be individually established by the Authority at the time of final design approval. Such maximum allowable discharge rates notwithstanding, it is recognized that aquaculture operations may sometimes require the "dumping" of large quantities of water in the event of unforeseen problems. This "dumping" of ocean water will be allowed. However, the tenant shall be liable for any property damage or environmental damage that may result from such action.

Use of Brackish Water.

A. A tenant may be permitted to construct, maintain and use its own brackish water supply system. This activity must be in accordance with any applicable County and State regulations. Notification of the Authority is required prior to construction of such a system.

B. The Authority will not guarantee any aspect of the quality, accessible depth or abundance of the groundwater at any time.

C. The Authority will not be responsible for any changes in the groundwater, including quality, nor take action to correct or alter changes except in cases where there is potential harm to the environment.

D. Sale of the used brackish water to another tenant for reuse is permitted under the same conditions of the sale of used seawater.

Grading and Drainage.

A. All surface drainage shall be designed to conform to the overall drainage systems for the site.

B. Site grading shall conform with county grading requirements and tenants are responsible for obtaining applicable permits.

C. Grading and drainage improvements shall be designed and constructed to minimize adverse dust and runoff impacts on adjacent and downslope lots.

Potable Water Supply.

A. Due to the limited supply of potable water in the West Hawaii area, tenants shall use water saving devices on potable water supply lines wherever practicable.

B. The Authority may issue guidelines to tenants concerning use levels of potable water.

C. Tenants will notify the Authority if increases in potable water use are anticipated.

D. Tenant will supply the Authority with fresh water use data and projections as requested.

E. It is the tenant's responsibility to install a backflow preventer in the potable water line as required by the County.

Wastewater Treatment and Disposal.

A. Sanitary wastewater generated by the tenant shall be treated and disposed of at a private treatment and disposal system located within the boundaries of the tenant's lot unless a central sewage treatment plant is provided by the Authority. Collection lines to a central sewage treatment plant are the responsibility of the Tenant.

B. The design, construction, operation, maintenance and disposal system shall be the responsibility of the tenant and shall comply with State Department of Health and County requirements.

C. The treatment and disposal of industrial wastewater generated by the tenant in the course of product processing or other industrial activities shall be the responsibility of the tenant. Treatment and disposal methods shall comply with State Department of Health and County requirements. Industrial waste shall not be mixed with return ocean water for disposal.

Refuse.

A. The disposal of refuse generate by each tenant shall be the responsibility of the tenant and shall comply with State Department of Health and County requirements.

B. On-site disposal of refuse shall be prohibited.

Hazardous Materials Use, Handling and Storage.

The use, handling, and storage of hazardous materials must comply with Federal, State and County regulations. NELHA must be provided a list of all hazardous materials used by a tenant.

Air Pollutants.

A. Requirements for visible emissions, motor vehicle emissions, burning, fugitive dust, process industry emissions, waste gases, and other emissions shall be in accordance with State Department of Health rules entitled "Air Pollution Control".

B. No fumes, odors, vapors, volatile acids or other invisible emission shall be permitted to escape or be discharged into the atmosphere that may be hazardous or detrimental to the health, safety or welfare of persons, or that may interfere with the comfort of persons within the area, or that may be harmful to property or vegetation.

Glare and Heat.

Any operation producing intense glare or heat or such other radiation shall be performed only within an enclosed or screened area and then only in such manner that the glare, heat or radiation emitted will not be discernible from any point exterior to the lot upon which the operation is conducted. Glare conditions must meet FAA requirements.

Noise.

At no point outside of the tenant's property line shall the sound pressure level of any machine, device, or any combination of same, from any individual plant or operation exceed the decibel levels permitted under existing laws, ordinances and rules of any public agency or body having jurisdiction.

Vibration.

Buildings and other structures shall be constructed and machinery and equipment installed and insulated on each lot so that the ground vibration inherently and recurrently generated is not perceptible without instruments at any point along any of the property lines.

Non-production Animals.

Non-production animals, including pets, shall be kept under positive control at all times. Security dogs shall be allowed unrestrained movement, but only within securely fenced premises or within a building not accessible to the public.

Archaeological Mitigation.

A. Tenants are advised that several sites of archaeological value have been found at Keahole Point and have been recorded and preserved accordingly through an archaeological mitigation program implemented by the Authority. In the course of excavation activities, whenever the tenant encounters findings that have or that appear to have possible archaeological value, the tenant shall temporarily suspend all operations that would disturb those findings. The tenant shall contact the Authority so that the County Planning Department and the State Historic Preservation Office can be notified to evaluate such findings and determine the course of action. Any item of archaeological value found within the site shall be the property of the State. Tenants shall be responsible for the cost of performing archaeological mitigation activities and for the cost due to delays in construction.

B. When deemed necessary by the State, the State may have an archaeologist present to monitor grading work to ensure that no damage occurs to archaeological sites within the boundaries of the site.

C. A portion of the historic Mamalahoa trail is located within the HOST Park area and is delineated in the Master Plan. It is the intent of the Authority to protect and to preserve this historic trail. Therefore, tenants of properties that are adjacent to Mamalahoa Trail shall be prohibited from constructing any improvements that cross the trail, except where needed to provide access and ocean water and utilities connections, and in such cases only with the approval of the Authority nd the approval of the County Planning Department.

D. Tenants will be advised of known archaeological sites on property they wish to lease.

Protection of Conservation Corridor.

No tenant shall construct any improvements or in any way develop within the area designated as the conservation corridor as shown in the Master Plan. This corridor is a one-hundred foot wide strip of land that runs along the entire eastern boundary.

Maintenance.

The tenant shall have the duty and responsibility, at its sole expense, to keep all buildings, grounds, improvements, landscaping and appurtenances, in a secure, well-maintained, safe, and clean condition at all times. Such maintenance shall include but not be limited to the following:

(1) Removing all litter, trash, refuse and waste promptly;

(2) Lawn mowing on a regular basis;

(3) Tree and shrub pruning;

(4) Keeping exterior lighting and mechanical facilities in working order;

(5) Keeping lawn and garden areas alive, and any adjoining drainage ditches free to weeds and debris;

(6) Removing and replacing any dead plant material;

(7) Keeping vacant sections of the lot well maintained, and free of trash and tall weeds;

(8) Maintaining all ocean water transmission systems;

(9) Keeping parking area, driveways, walkways and roads in good repair;

(10) Complying with all governmental, health, fire and police requirements and directives;

(11) Striping of parking areas;

(12) Maintaining signs; and

(13) Maintaining the lot boundary pins established for the lot.

Repair of Improvements.

A. No building, structure or improvement upon any lot shall be permitted to fall into disrepair, and each such building and structure shall at all times be kept in good condition and repair and adequately painted or otherwise finished.

B. Nothing within these rules shall prevent a tenant from performing repair work on the tenant's pipes within the utility corridor. Tenant shall notify the Authority in writing at least thirty days before the start of construction or repair work within the utility corridor, except in case of emergency involving public health or public safety or involving viability of the commercial operation that requires immediate attention, in which case notice to the Authority shall be submitted within one day after the commencement of the emergency repair work.

Approval of Improvements.

A. No improvements shall be erected, placed, altered, maintained or permitted to remain on any lot by any person until final plans and specifications shall have been submitted to and approved by the Authority, except that minor improvements with a valuation not in excess of twenty-five thousand dollars, shall be permitted with the approval of the Authority. All improvements must be in compliance with applicable County codes and requirements and must have a building permit as required by the County. Applications for County building permits must be submitted through the office of the Authority director.

B. Any interested person that desires to occupy a parcel of land for the purpose of new development, or any tenant that desires to make a change in use of the tenant's existing development, shall follow a two step process for review and approval of the proposed project as described in these rules. The director of the Authority will determine whether action requires Board approval and inform the tenant.

C. Any tenant that desires to construct an expansion of, addition to, or modification of his existing development, without changing the use of the development as permitted by prior approval, shall be required to submit only a final design application for review and approval by the Authority. A modification to the existing use includes adding new species, changing the original configuration (such as using more or less seawater) and change in management which affects the sublease (such as buy out or name change).

Basis for Approval.

Approval of plans and specifications shall be based, among other things, upon general adequacy of site dimensions, conformity and harmony of the exterior design and location with neighboring structures, relation of finished grades and elevations to neighboring sites, compliance with applicable governmental requirements, and conformity to both the specific requirements and general intent of the provisions set forth herein. The Authority shall have the right to disapprove any plans or specifications submitted on any reasonable grounds including any matter which, in the judgement of the Authority, would render the proposed improvements or use inharmonious with the Master Plan for improvement of the NELH/HOST Park or with improvements located upon other lots or other property in the vicinity, or with the purposes or intent of these rules.

Procedures for Review and Approval.

A. For all proposed new developments of more than a twenty-five thousand dollar value a conceptual design application shall be submitted to the Authority to obtain approval of the concept for the proposed project. Upon receipt of the conceptual design approval, the applicant shall prepare a final design application.

B. The conceptual design application shall include the following information:

(1) A list of proposed uses, major resources to be used, hazardous materials use, products and by-products to be produced, special wastes generated, and other information pertinent to the development of the property;

(2) Site plan showing buildings, ponds, tanks, raceways and other major structures, circulation and utility service points, with relationships to

existing structures and conditions;

(3) Preliminary subdivision plat map if the development requires a new subdivision;

(4) Grading maps;

(5) Conceptual grading and drainage plan;

(6) Conceptual landscape plan, if required; and

(7) Schematic of ocean water and return ocean water transmission systems.

C. The Director and the Research Advisory Committee (RAC) are responsible for reviewing and recommending approval of the conceptual design to the Board of Directors. The Board of Directors shall be responsible for approving the conceptual design application. The Board of Directors shall reach a final decision on the conceptual design application and shall notify the applicant of such decision within forty-five days after receipt of the complete conceptual design application by the Authority.

D. Upon approval of the conceptual design application, a final design application shall be developed and submitted to the Authority. The final design application shall include plans and specifications with the following information:

(1) Proposed use of lot;

(2) Topographical plat showing contour lines (with two-foot contour intervals) and showing the location of all improvements. Existing and finished grades shall be shown at lot corners of proposed improvements. Lot drainage provisions shall be included as well as cut and fill details if any appreciable change in the lot contours is contemplated;

(3) Proposed ground elevations;

(4) Exterior materials, colors, textures and shapes, including the submittal of samples where practicable;

(5) Structural design concept with building elevation plans;

(6) Landscaping plan, including walkways, fences and walls, elevation changes, landscape irrigation systems, vegetation and ground cover;

(7) Parking area and driveway plan;

(8) Screening, including size, location, method and materials;

(9) Utility connections, including routing of electrical and telephone cables and connections to potable water supply;

(10) Flow requirements and transmission systems design for the ocean water systems including ocean water supply, reused ocean water and return ocean water;

(11) Brackish water system, if applicable;

(12) Exterior illumination;

(13) Details on proposed uses and qualities of potable water;

(14) Wastewater treatment and disposal systems;

(15) Solid waste treatment and disposal systems;

(16) Facilities and procedures for the containment, storage and disposal of hazardous materials;

(17) Signs, including size, location, orientation, shape, color, character and materials;

(18) Outside storage and refuse collection area and related screening;

(19) Location and installation of heavy equipment;

(20) Security program; and,

(21) Other information as may be required by other applicable governmental regulations.

E. The Director shall be responsible for reviewing and recommending approval of final design applications to the Board of Directors. Approval of the final design application shall be made by the Board of Directors in accordance with the Authority's rules and design guide. If the final design application is not sufficiently complete or is otherwise inadequate, the Board of

Directors may reject it as being inadequate or may approve or disapprove part, conditionally, and reject the balance. The Authority shall reach a final decision on the final design application and shall notify the applicant of such decision within thirty days after receipt of the complete final design application by the Board of Directors, unless an extension for time has been agreed to by the applicant.

Construction Without Approval.

If any improvement with a construction cost in excess of twenty-five thousand dollars is erected, placed or maintained upon any lot, or any new use commenced upon any lot, other than in accordance with approval by the Authority pursuant to these rules, such improvement or use shall be deemed to have been undertaken in violation of these rules, and upon written notice from the Authority, any such improvement in violation of these rules shall be removed or altered so as to conform to these rules, and such use shall cease or be amended so as to conform to these rules. Should such removal, alteration, cessation or amendment of use not be accomplished within thirty days after receipt of such notice, then the person in breach of these rules shall be subject to the enforcement procedures.

Construction Activities.

A. Construction activities shall be conducted in a manner as to minimize adverse or nuisance effects of noise, dust, soil erosion, traffic and other safety considerations. The Authority shall have the jurisdiction to place specific conditions on the tenant's construction schedule and methods, if, in the judgment of the Authority, the particular construction work could cause significant adverse impacts on other properties and operations of Keahole Point.

B. Construction zones, especially those which impact the public areas, will be clearly marked with caution signs. Construction is to be carried out observing all standard safety procedures such as the wearing of hard hats.

Construction Schedule.

A. All improvement work approved by the Authority shall be diligently completed and constructed in accordance with approved plans and specifications.

B. Upon receipt of approval from the Authority the tenant and any person to whom the same is given shall, as soon as practicable, satisfy all conditions thereof and diligently proceed with the commencement and completion of all approved work.

C. In all cases, work shall commence within one year from the date of such approval. If there is a failure to comply with this paragraph, then the approval given for construction shall be deemed revoked unless the Authority, upon request made prior to the expiration of said one year period, extends the time for ommencing work.

D. All improvement work shall be completed within two years after the commencement thereof except for so long as such completion is rendered impossible or would result in great hardship due to strikes, fires, national emergencies, natural calamities or other supervening forces, including unfavorable weather and unfavorable ocean conditions, beyond the control of the tenant. Failure to comply with this paragraph shall constitute a breach of these rules and shall subject the defaulting person to all enforcement procedures set forth in these rules and any other remedies provided by law or in equity.

E. If any tenant fails to commence construction, or once having commenced construction, fails to diligently proceed to complete construction within one year from the execution date of the lease agreement, and provided that such tenant did not obtain, in the contract documents for lease of the lot, approval for phased building plan, then the corporation may revoke the approval for construction.

F. After a revocation of approval, such person that desires to commence or continue construction shall be required to resubmit to the Authority applications for final design approvals.

G. "Commencement of construction" as defined in this paragraph means that the tenant of the lot:

(1) Obtained approval of the Authority as set forth in these rules;

(2) Obtained building permits from the appropriate governmental authorities authorizing construction of a building and improvements as approved by the Authority;

(3) Expended at least the sum of ten-thousand dollars pursuant to such construction contract for on-site construction work.

Bonds.

The Authority may require from the tenant the posting of a bond in a sufficient amount as decided upon by the Authority , to ensure that the improvements as proposed and approved in the final design application will be constructed in their entirety.

Construction Completion.

A. Upon the substantial completion of any work for which approved plans are required pursuant to these rules, the tenant shall give written notice to the Authority which shall within thirty days inspect the work to determine whether it was completed in compliance with these rules and the overall approved design.

B. If the Authority finds that the work was done in substantial compliance with such approved plans, it shall, if requested in writing by the tenant, provide to the tenant a notice of this concurrence that the work has been satisfactorily completed.

C. If the Authority finds that the work was not done in substantial compliance with approved plans, it shall notify the tenant of the noncompliance and require the tenant to remedy the noncompliance within thirty days from the day of notification, or such longer time as may reasonable be required and as approved by the Authority.

D. If the tenant shall not have commenced remedial action within the thirty-day period, and thereafter diligently and continuously prosecute the same to completion, the Authority shall have the rights of enforcement.

Variances.

A. A variance to these rules may be granted by the Authority if it is determined that the variance will be consistent with the general purpose and intent of these rules. The following circumstances will be considered by the Authority as reasons for granting a variance:

(1) The variance will not cause significant adverse impact to the area of to adjacent properties;

(2) The variance is required as a response to new technological developments;

(3) The variance is required because of special economic or financial circumstances; or

(4) There are special or unusual circumstances applying to the lot which require a variance to ensure the best use or manner of development of the lot.

B. Application for a variance shall be in the form of a written request submitted to the Authority for approval. The circumstances which cause the need for a variance must be included.

C. In the event that the Authority rejects a variance request, the applicant may appeal the decision by submitting a letter of appeal and supporting documents to the Authority. The Board of Directors of the Authority shall then consider and act upon the appeal within thirty days of receiving the letter of appeal.

<u>General Enforcement</u>.

A. Except as otherwise expressly provided in these rules, the Authority shall have the right to enforce upon the tenant or upon any property within the NELH/HOST Park any and all of the provisions of these rules.

B. No entry upon the lot of any tenant or other action to enforce these rules shall be made or taken without first giving at least ten days prior written notice to the tenant concerned to cure or rectify the violation involved, except when the corporation's sole discretion determines that an emergency situation or potential emergency situation exists where the health, safety or welfare of the environment or the tenants of the NELH/HOST Park is threatened.

C. Any act or omission that results in the violation of these rules, or any situation or condition created by a tenant that poses a risk to the health or safety of the NELH/HOST Park or its tenants, may be abated by the Authority or by a tenant as provided for in these rules provided that only the Authority may enforce these rules without the authority of a court.

D. The failure in any case to enforce any provision of this chapter shall not constitute a waiver of any right to enforce the same provision or any other provisions in another case against the same tenant or any other tenant.

Inspection.

During reasonable hours, and subject to reasonable security requirements and reasonable advance notice, the Authority shall have the right to enter upon and inspect any lot and the improvements thereon for the purpose of ascertaining whether the provisions of these rules have been or are being complied with, and shall not be deemed guilty of trespass or other wrongful act by reason of the entry or inspection.

Notice of Violation.

Notice of any violation of the provisions of these rules shall be given by the Authority by sending the notice by certified mail to the address of the tenant as shown on the lease and by leaving a copy of the notice in a conspicuous place on the tenant's property. If the tenant fails to correct the violation as determined by the Authority within thirty days after receipt of the said notice, then subject to the provisions the Authority shall be free to pursue any available remedies in law or equity.

Enforcement by Authority.

A. Violation of any provision of these rules shall give to the Authority the right to enter upon the property upon which the violation exists and to summarily:

(1) Abate or remove at the expense of the tenant any structure or condition to remedy the violation; or

(2) Prosecute a proceeding at law or in equity against the tenant who has violated any of these provisions in order to cause the violation to be remedied or to recover damages for the violation.

B. The right-of-entry shall be without liability for damages for wrongful entry, or trespass, to any person.

Reimbursement to Authority.

A. The tenant of any lot in the NELH/HOST Park on which remedial work is performed by the Authority shall be liable for the cost of enforcement, and shall promptly reimburse the Authority for such cost.

B. The cost of enforcement shall be the cost of the remedial work performed by the Authority together with interest at the rate of ten per cent per year from the date of the Authority's advancement of funds for the work to the date of reimbursement of the Authority by the tenant.

C. If the tenant fails to make reimbursement to the Authority within thirty days after receipt of a statement for the remedial work from the Authority, then the Authority may order the immediate cessation of operations.

<u>Enforcement by Tenants</u>.

A. Each tenant, by maintaining operations on a lot and therefore having an interest in the overall success of Keahole Point, shall be assured that these rules are enforceable upon all tenants equally. If any NELH/HOST Park tenant (hereinafter referred to as the "enforcing tenant") finds that another tenant is in violation of any part of these rules, and that the violation is detrimental to his own operations, and that the Authority has not taken action upon the violating tenant to enforce these rules, then the enforcing tenant shall have the right to address the Authority in writing to request that the Authority initiate enforcement action.

B. The Authority shall take prompt action to investigate the violation.

C. If the Authority is of the opinion that no violation has been committed, then the Authority shall inform the enforcing tenant of such finding in writing.

D. In the event that the Authority does not respond to the request of the enforcing tenant in a timely fashion, the enforcing tenant is not precluded from independently taking action by proper legal proceedings brought in a court of competent jurisdiction.

<u>Finders Fee to Agents</u>.

The Authority will, under no circumstances, pay a finders fee or commission to any agent or representative for locating and/or negotiating a lease at NELHA.

Spoils in Unleased Land.

With a written request to the Authority, a tenant may receive permission to use unleased lands as a depository for excavated materials (spoils), either for permanent or temporary use. If permission is not granted, the tenant must remove all spoils from their site.

Option Agreements.

The Authority will consider option agreements on unleased land. Terms of these agreements will be negotiated on a case by case basis but will generally be charged a reduced rate. Agreements will usually include a "first right of refusal clause" stating that if an existing or potential tenant desires the option land, it will be developed immediately, and will be leased at a non-reduced rate. The option holder can retain the land by leasing at full rate.

Tenant Request to have New Service or Infrastructure Provided.

In the event a tenant requests a new service or infrastructure which is not currently offered by the Authority, the tenant shall make a formal request in writing to the Authority to provide such infrastructure or service.

A. The Authority will assess the need for such a service or infrastructure through contact with other tenants either individually or through the Keahole Point Association.

B. If deemed necessary and determined feasible, the Authority will use its best efforts to comply with the request.

C. Any request for service or infrastructure should be of a general application nature, and not for the benefit of one tenant.

Default on Lease or Rental Agreements.

Tenant responsibilities in the event of voluntary or involuntary default or termination of a lease, sublease, facility rental agreement, or facilities use agreements include:

A. A date for vacating premises will be mutually determined by the Authority and Tenant.

B. As per provisions of the agreement, all improvements of whatsoever kind or nature located on the land prior to or on the commencement date of the lease or sublease shall belong to lessor. However, if tenant does not want improvements, the tenant shall notify the Authority in writing of its intent to abandon the improvements. The Authority is under no obligation to accept such improvements, and may require their removal at the cost of the tenant.

C. If improvements are not removed by the specified date, they shall be property of the Authority or they will be removed and the tenant will be charged for the removal.

Tenant Presentation to Board of Directors.

In the event a tenant desires to approach the Board of Directors for any reason which requires Board action, the tenant must notify the Authority in writing at least 10 working days prior to the next scheduled Board meeting for inclusion on the agenda.

A. The Authority reserves the right to deny such a request if it deems inappropriate or unnecessary.

B. A tenant or prospective tenant may request an executive session for Board discussion of proprietary information.

Changes to Facilities Use Manual

The Authority and its Board of Directors reserve the right to amend or to make exceptions to the Manual.

Periodic review and updating of this Manual is necessary in order to respond to constantly changing conditions, new information, State departmental priorities, and necessary regional priorities.

Any changes and or revisions will incorporate new information and new developments so that the Manual and its implementation can be a flexible and therefore, responsive working document.