The Natural Energy Laboratory of Hawai'i Authority

Ke-ahole Point

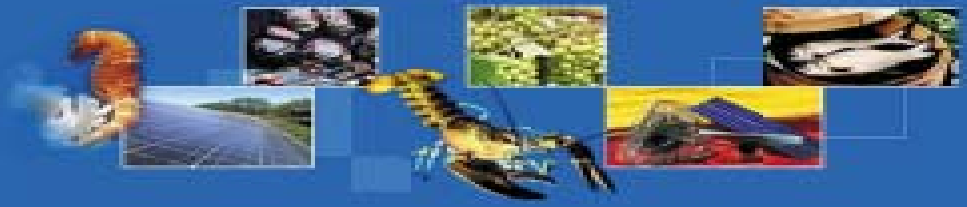
NELHA

Natural Energy Laboratory of Hawaii Authority

"Hawaii's most innovative ocean science and technology park"

Welcome to the Natural Energy Laboratory of Hawaii Authority

Learn how NELHA and its business and research partners are using sunshine, seawater and ingenuity to bring economic development and diversity to the State of Hawaii.



- Highest Solar Insolation (Coastal USA)
- Abundant Cold Sea Water Source (~5°C)
- Abundant Warm Class AA Sea Water Source (~26°C)
- Deepest-Widest-Longest Pipeline Infrastructure
- World Leader in Algae Technology
- Acres of Undeveloped Land
- Borders International Airport
- Free Trade & Enterprise Zones
- Culture of Experimentation, Incubation & Entrepreneurship

nelha.org

NELHA MISSION STATEMENT:

<u>To develop and diversify the Hawai'i economy,</u>

by providing resources and facilities for energy and ocean-related research, education, and commercial activities in an environmentally sound and culturally sensitive manner.

What is NELHA?

- ECONOMIC DEVELOPMENT AGENCY
- RESEARCH SUPPORT FACILITY
- TECHNOLOGY INCUBATOR
- BUSINESS INCUBATOR

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NELHA Contribution

- Over 300+ JOBS (90% privately funded)
- Over $35 M annual economic impact

Local Employees New Skills

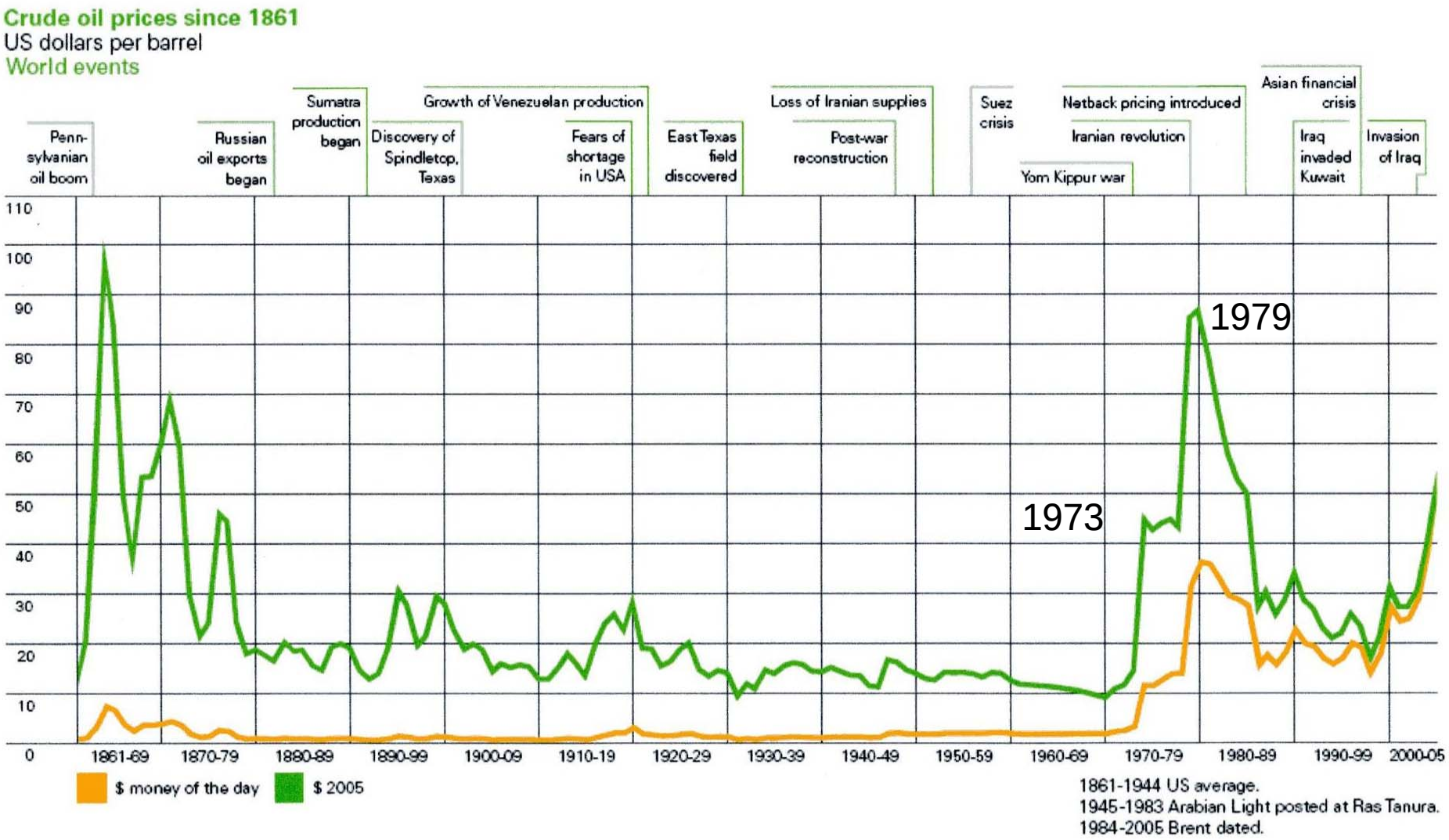
Value to the Community

NELHA AND OTEC

THE NATURAL ENERGY LABORATORY HAWAI'I AUTHORITY [NELHA] AND OCEAN THERMAL ENERGY CONVERSION [OTEC] HAVE BEEN INTEGRALLY CONNECTED SINCE THEIR ORIGINAL CONCEPTION IN 1974.

THE INTERESTS IN NELHA & OTEC HAVE DRAWN A DIRECT PARALLEL TO ENERGY [OIL] COSTS.

Crude oil prices since 1861



AN ANCIENT MARINER

"The status quo is too entrenched – the next generation will benefit from these technologies"

John Craven

NELHA HISTORY

- 1974, NATURAL ENERGY LABORATORY HAWAI'I [NELH] MANDATED BY HAWAI'I FOR OTEC RESEARCH AND RELATED TECHNOLOGIES; ~324 ACRES.
- 1976 EARLY MARINE BIOFOULING AND CORROSING EXPERIMENTS AT KEAHOLE POINT FUNDED BY DOE
- 1979, MINI-OTEC BARGE AT KEAHOLE POINT DEMONSTRATES WORLDS FIRST NET ELECTRICAL POWER VIA CLOSED CYCLE.
- 1979, WARM SURFACE SEA WATER [SSW]
- 1981, 2000' COLD DEEP SEA WATER [DSW]

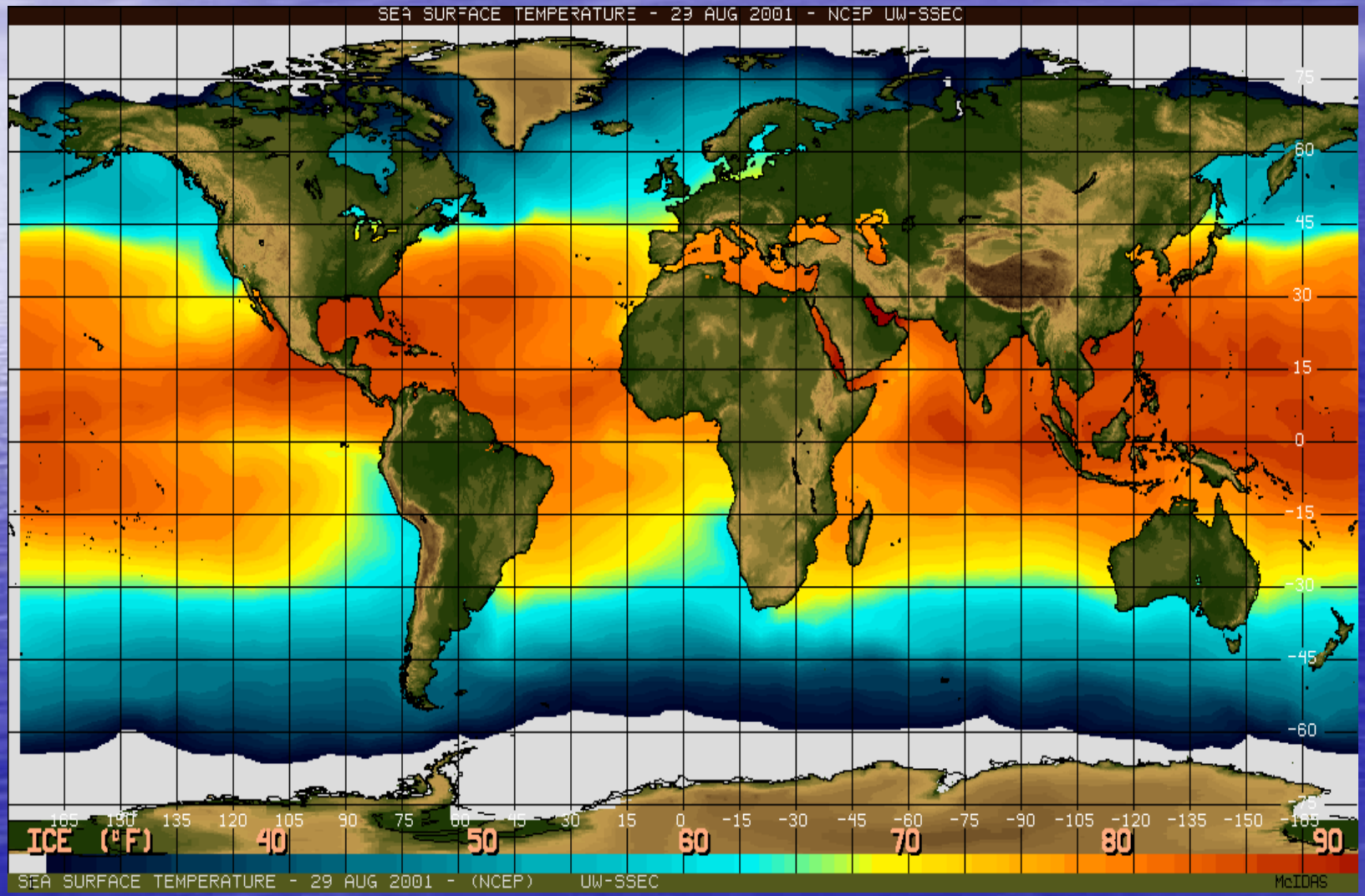
WHAT IS OTEC

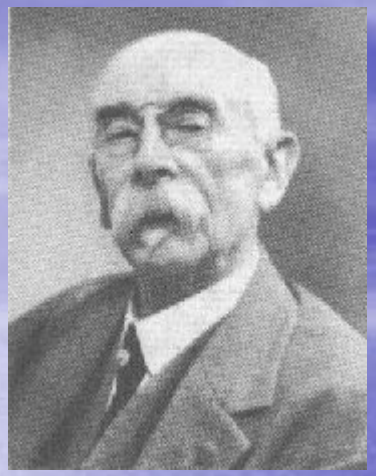
- MASSIVE THERMAL ENERGY RESOURCE
- FIRM BASE LOAD POWER – 24/7
- ENERGY RESOURCE THAT DOES NOT COMPETE WITH LAND, FOOD, WATER
- ENERGY SOURCE FOR NH3 / H2

WHY OTEC?

- WARM AND COLD OCEAN TEMPERATURES AVAILABLE ACROSS A WIDE AREA OF THE WORLDS EQUITORIAL OCEANS (20-DEGREE N/S)
- NO FOSSIL FUELS REQUIRED OPERATIONS
- NO POLLUTION EMITTED TO THE ATMOSPHERE
- OPEN CYCLE BYPRODUCT: CLEAN WATER
- DSW RETURN FROM OTEC HAS MANY USES, AS SHOWN AT NELHA

SURFACE SEAWATER TEMPERATURES





OTEC
OCEAN THERMAL
ENERGY CONVERSION

JACQUES D'ARSONVAL

- 1881 CLOSED CYCLE OTEC CONCEPT PROPOSED BY JACQUES D'ARSONVAL
- 1930 - 1ST OTEC PLANT MATANZAS BAY, CUBA BY GEORGES CLAUDE (OPEN CYCLE - NEGATIVE NET POWER)
- 1979 - MINI-OTEC - WORLD'S FIRST NET POWER PRODUCING OTEC PLANT (NELH - KEAHOLE POINT HAWAI'I)

OTEC: OCEAN THERMAL ENERGY CONVERSION

- MINI-OTEC: 1979

  50 kW $_{gross}$

First net power Up to 15 kW !

- OPEN-CYCLE OTEC: 1993

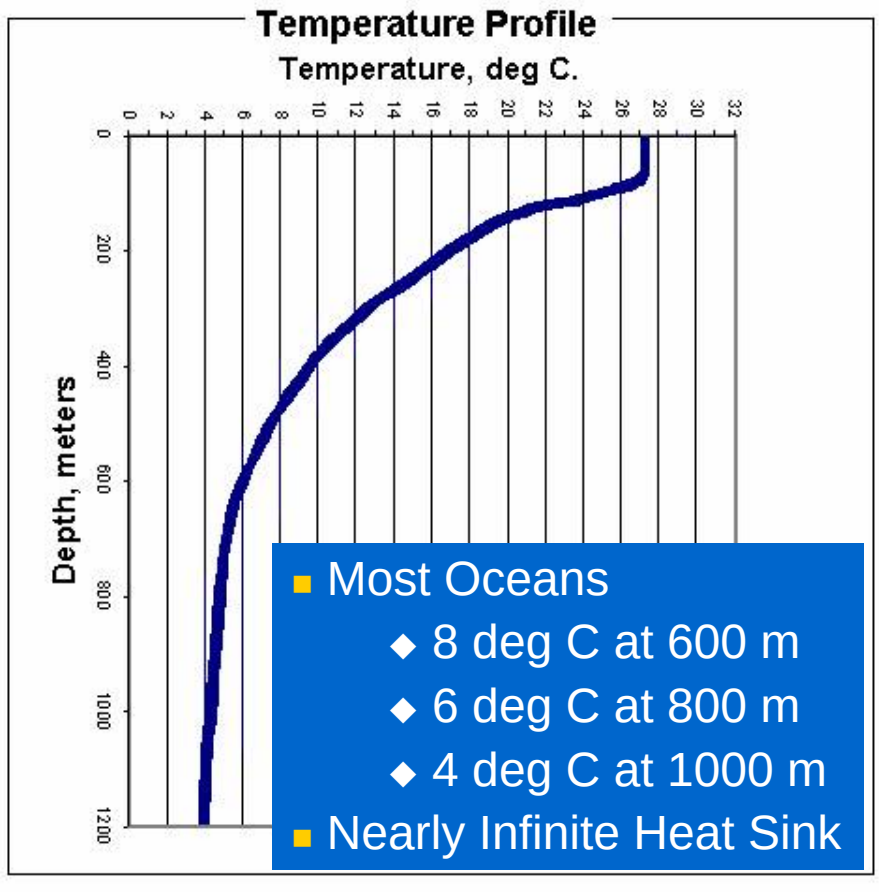
  210 kW

OTEC AT KEAHOLE PT.?

NEAR IDEAL CONDITIONS EXIST AT KEAHOLE POINT (DELTA TEMP ~ 40 DEG F)

- SURFACE SEA WATER [SSW], ~80 ^{O}F, CAN BE TURNED DIRECTLY INTO STEAM BY LOWERING THE PRESSURE TO NEARLY A FULL VACUUM (32”/Hg).
- DEEP SEA WATER [DSW] [~40 ^{O}F] IS USED TO CONDENSE THE STEAM OR VAPOR TO A LIQUID.
  - THE CONDENSED STEAM IS A SOURCE OF PURE WATER [OPEN CYCLE]
  - THE CONDENSED VAPOR IS RECYCLED [CLOSED CYCLE]

Cold Water: Valuable Resource



- Most Oceans
  - 8 deg C at 600 m
  - 6 deg C at 800 m
  - 4 deg C at 1000 m
- Nearly Infinite Heat Sink

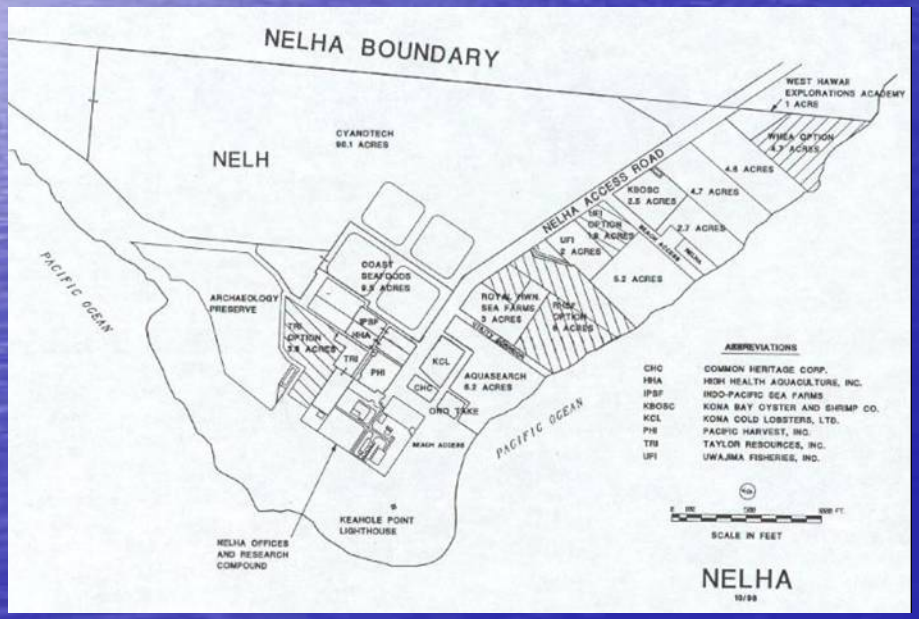
NELHA HISTORY

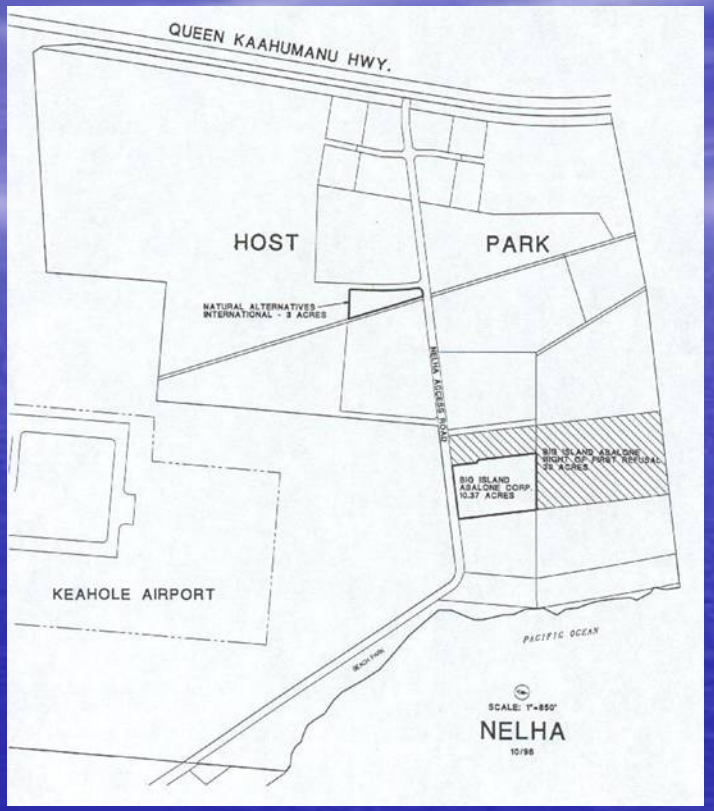
- 1980-1983, EXPANSION OF TESTING PROGRAM FOR BIOFOULING, CORROSION AND COUNTERMEASURES OF HEAT EXCHANGERS USING SSW & DSW
- 1984, HAWAI'I RECOGNIZES MANY PROFITABLE USES AS A BYPRODUCT OF OTEC DSW/SSW
  - EXPANSION INTO COMMERCIAL USE ON STATE LAND
- 1986, HAWAI'I CREATES HAWAI'I OCEAN SCIENCE AND TECHNOLOGY [HOST] PARK. ~547 ACRES AND VALUABLE INFRASTRUCTURE ADDED TO NELHA

NELHA

NELHA Site Map

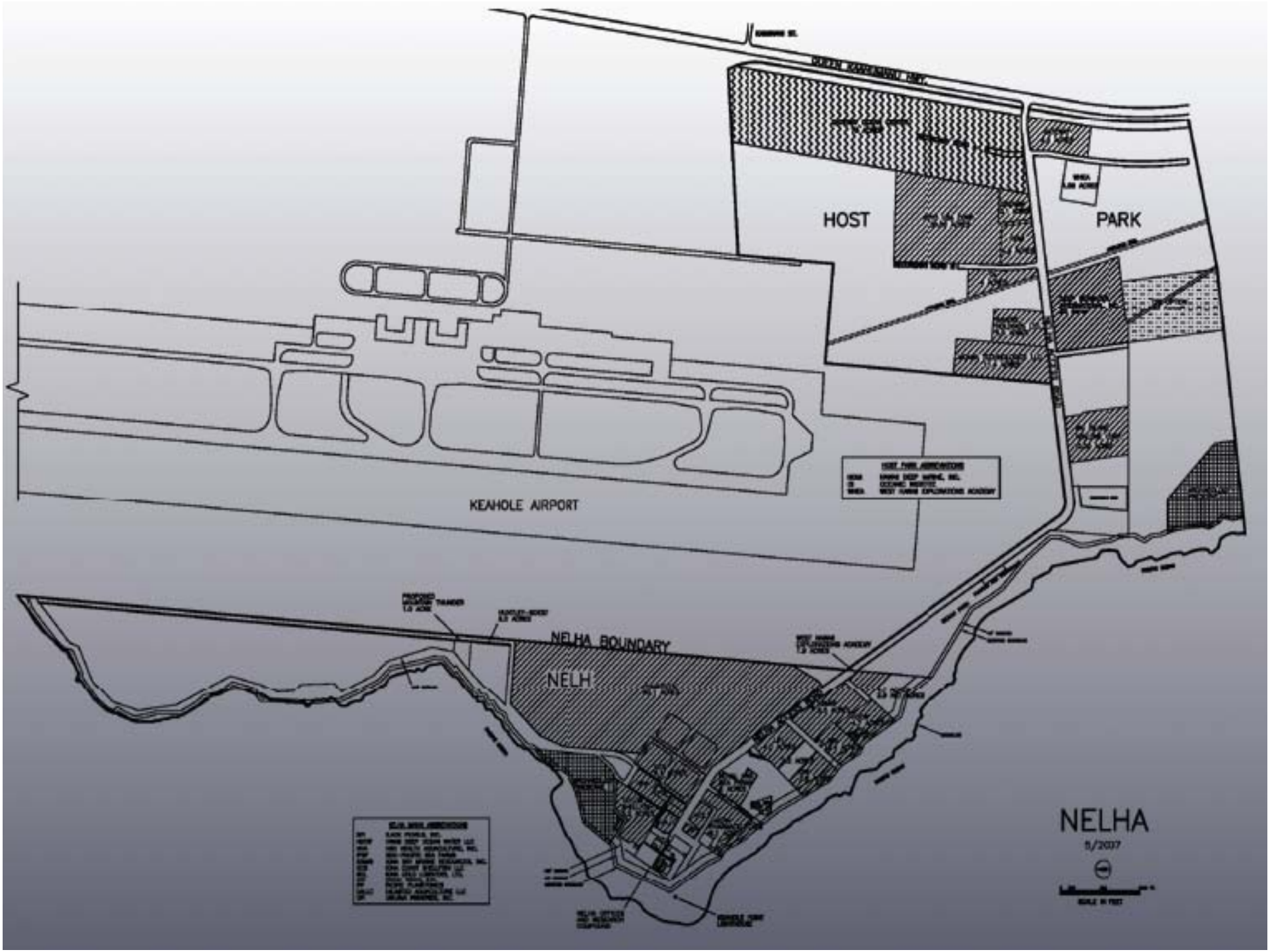
NELH – 1974 (324 ACRES)





HOST Park – 1990

(547 Acres)

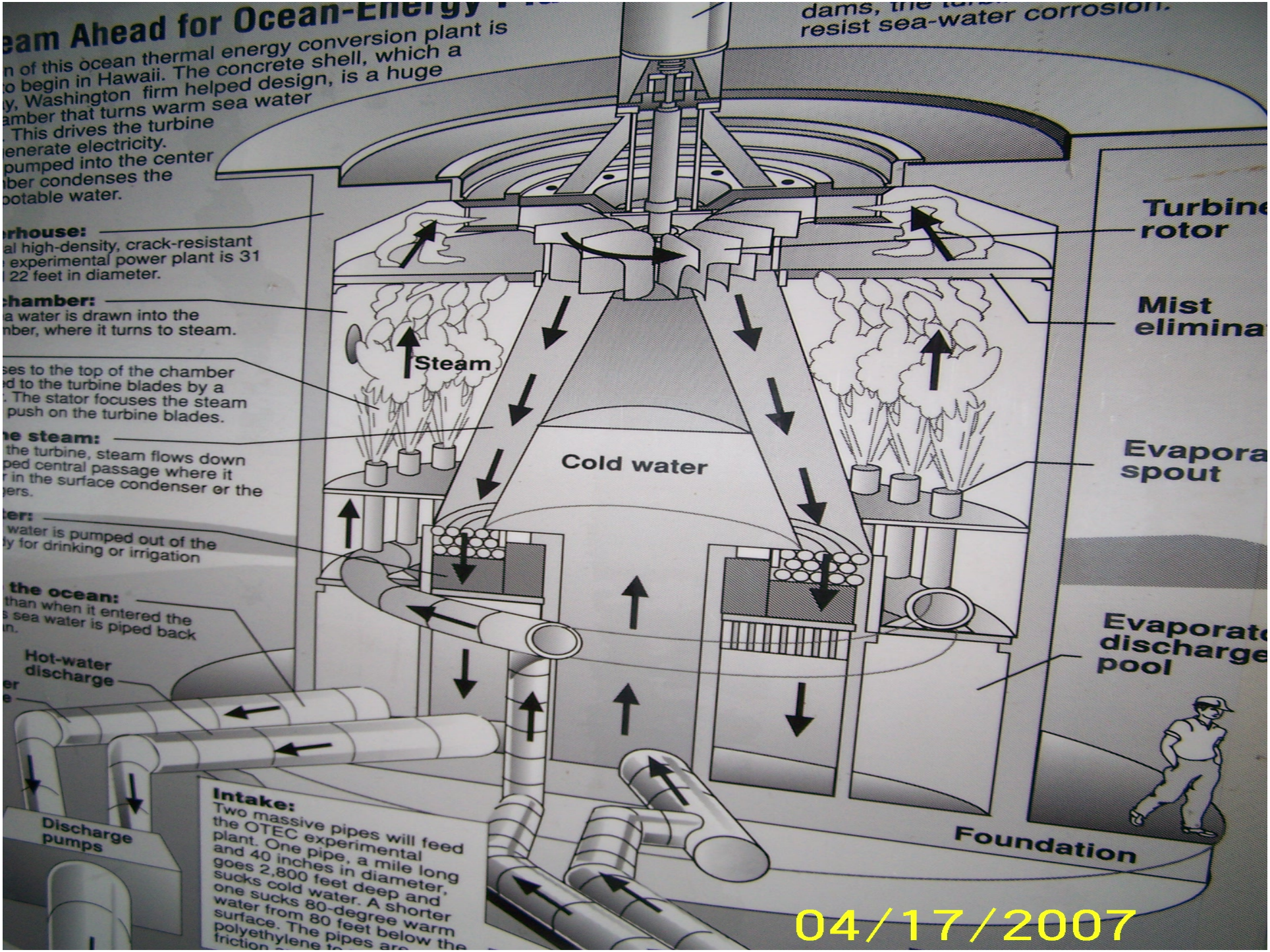

HOST
PARK
KEAHOLE AIRPORT
NELHA BOUNDARY
NELH
NELHA
5/2017

NELHA HISTORY

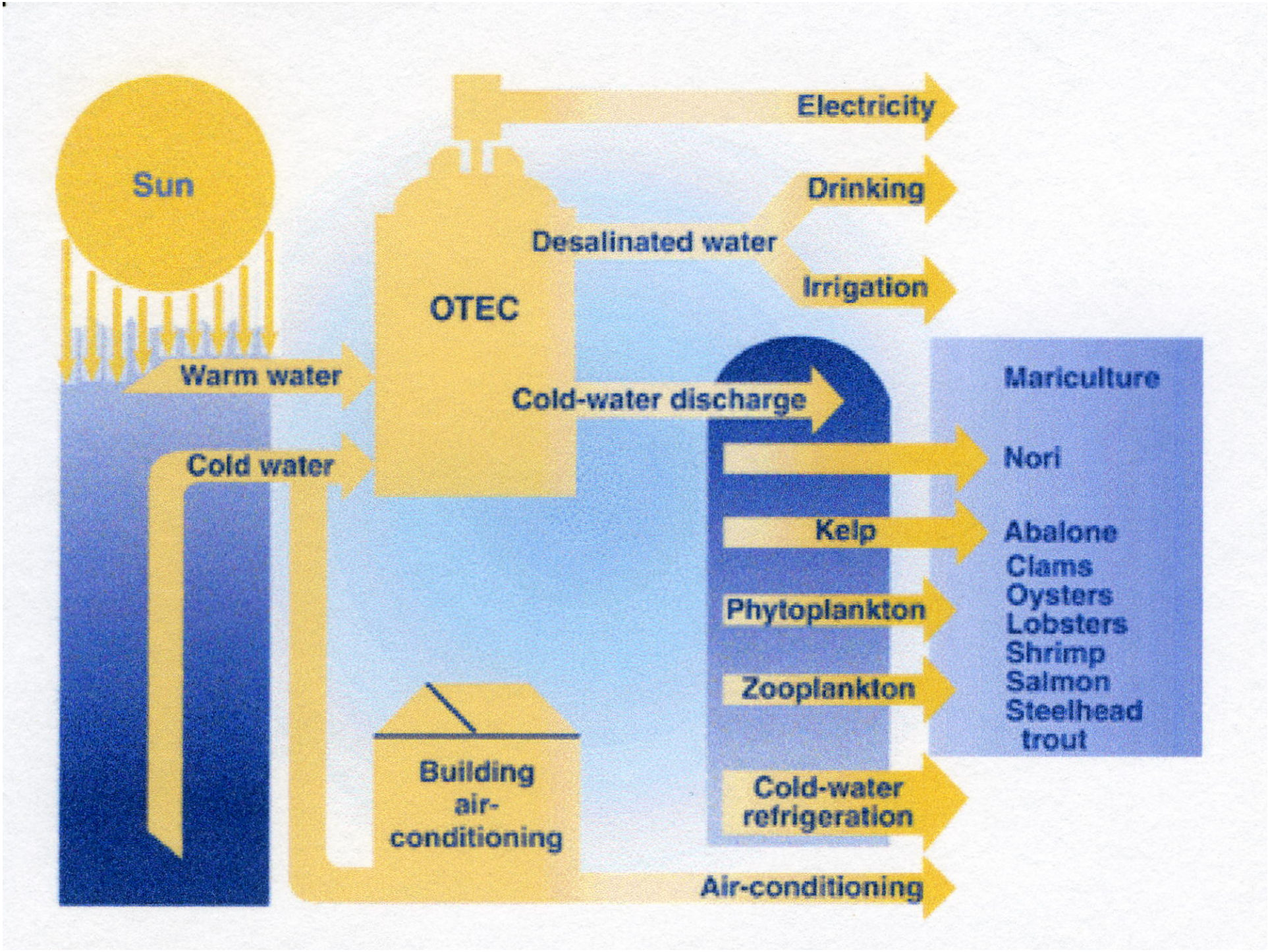
- 1990, NELH & HOST MELDED INTO NATURAL ENERGY LABORATORY HAWAI'I AUTHORITY [NELHA]
- 1993-1998, 210 kW CLOSED CYCLE OTEC OPERATES AT NELHA
- 1999, ADDITIONAL BUSINESS ACTIVITIES ALLOWED AT NELHA TO ENHANCE ECONOMIC DEVELOPMENT AND GENERATE REVENUES.

NELHA OTEC OPEN CYCLE RESEARCH

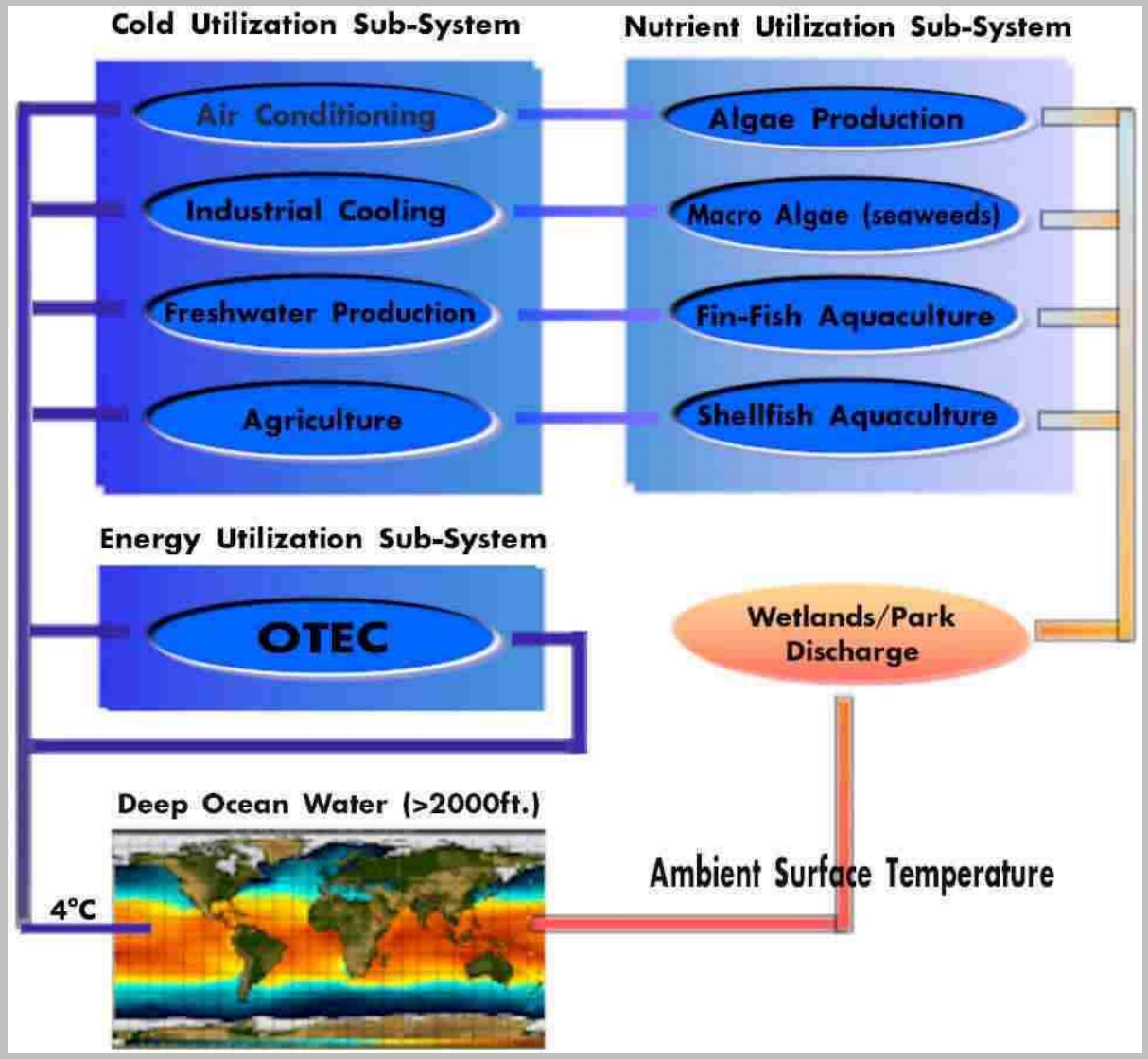
210 KW OC - OTEC EXPERIMENTAL POWER PLANT AND HEAT & MASS TRANSFER SCOPING TEST APPARATUS (1987 - 1998)


eam Ahead for Ocean-Energy
n of this ocean thermal energy conversion plant is
o begin in Hawaii. The concrete shell, which a
y, Washington firm helped design, is a huge
amber that turns warm sea water
This drives the turbine
enerate electricity.
pumped into the center
ber condenses the
otable water.
rhouse:
al high-density, crack-resistant
experimental power plant is 31
22 feet in diameter.
chamber:
a water is drawn into the
nber, where it turns to steam.
es to the top of the chamber
d to the turbine blades by a
. The stator focuses the steam
push on the turbine blades.
e steam:
the turbine, steam flows down
ped central passage where it
in the surface condenser or the
ers.
er:
water is pumped out of the
y for drinking or irrigation
the ocean:
than when it entered the
s sea water is piped back
n.
Hot-water discharge
Discharge pumps
Intake:
Two massive pipes will feed the OTEC experimental plant. One pipe, a mile long and 40 inches in diameter, goes 2,800 feet deep and sucks cold water. A shorter one sucks 80-degree warm water from 80 feet below the surface. The pipes are polyethylene
friction
dams, the
resist sea-water corrosion.
Turbine rotor
Mist elimina
Steam
Cold water
Evapora spout
Evaporat discharge pool
Foundation
04/17/2007


OTEC
&
BEYOND


Sun
Electricity
Drinking
Desalinated water
Irrigation
OTEC
Warm water
Cold-water discharge
Mariculture
Cold water
Nori
Kelp
Abalone
Clams
Oysters
Lobsters
Shrimp
Salmon
Steelhead trout
Phytoplankton
Zooplankton
Building air-conditioning
Cold-water refrigeration
Air-conditioning

MODEL:
Deep Ocean Water Energy Recovery System

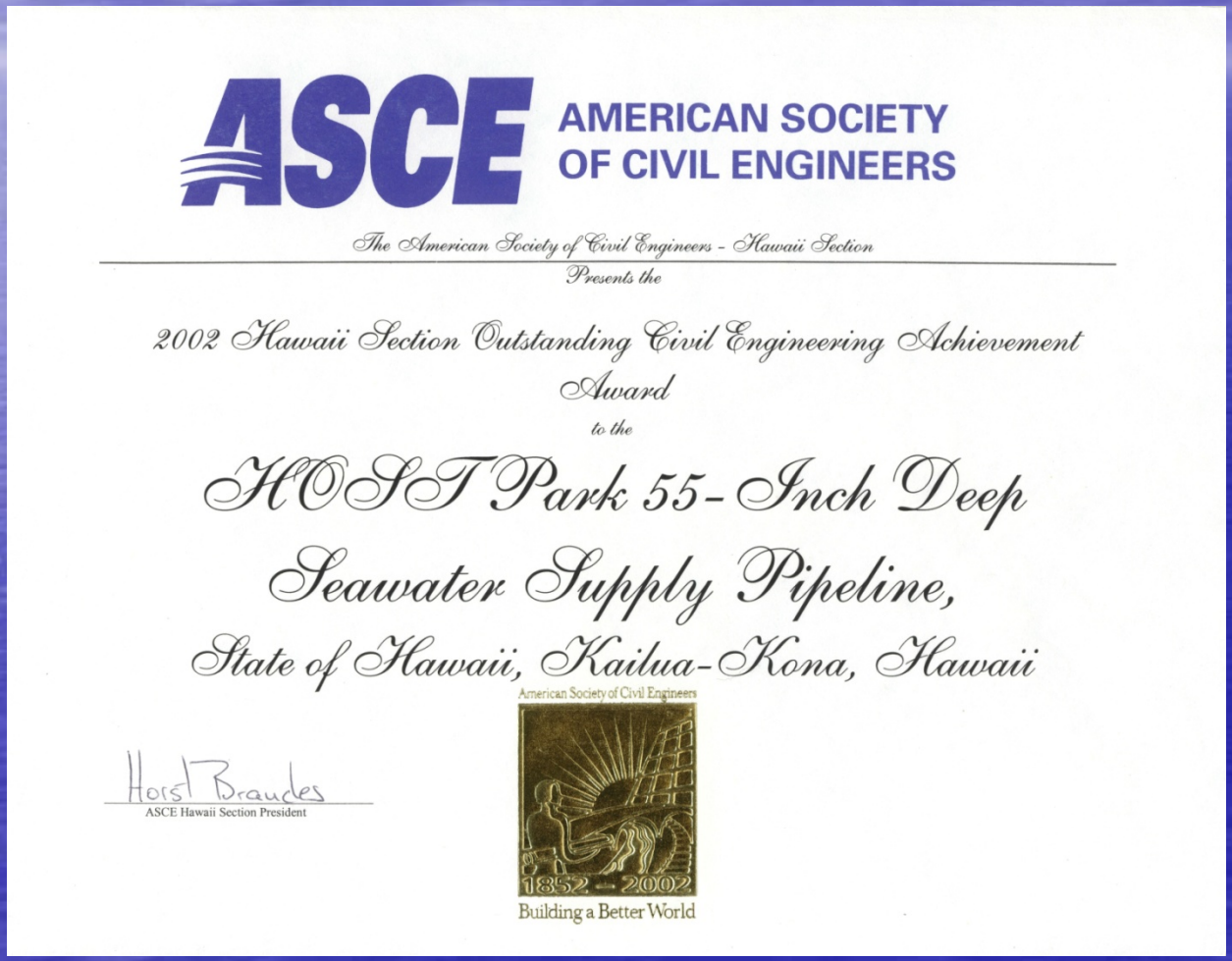


NELHA'S DUAL SEA WATER SYSTEMS

- THREE SETS OF WARM AND COLD SYSTEMS
  - DISTRIBUTION PIPELINE ON SHORE RUN IN PARALLEL TO THE VARIOUS TENANTS
  - TENANTS REGULATE TEMPERATURES
  - EACH DUAL SYSTEM SUPPLIES SPECIFIC TENANTS
  - SYSTEMS ARE NOT NORMALLY CROSS CONNECTED


55" 500' 80'
24" 300' 80'
28" 300' 80'
55" 9600' 3000'
40" 6000' 2000'
18" 6000' 2000'

Awarded 2002 ASCE Outstanding Civil Engineering Achievement Award



ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

The American Society of Civil Engineers - Hawaii Section

Presents the

2002 Hawaii Section Outstanding Civil Engineering Achievement Award

to the

HOST Park 55-Inch Deep Seawater Supply Pipeline, State of Hawaii, Kailua-Kona, Hawaii

Horst Braudes

ASCE Hawaii Section President

American Society of Civil Engineers 1852 2002 Building a Better World

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5

33

The Fusion Machine

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5

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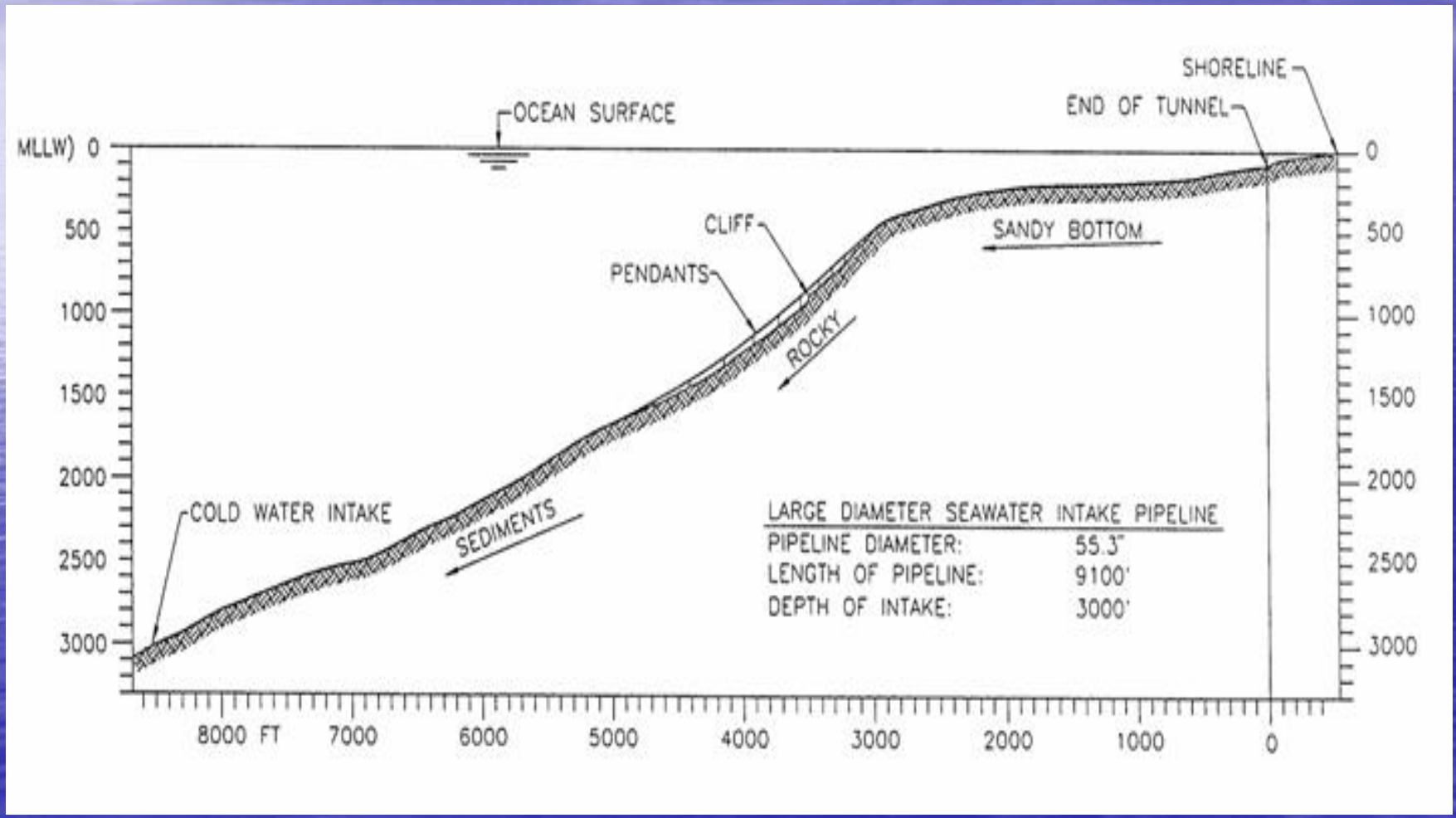
Side View / Offshore Profile



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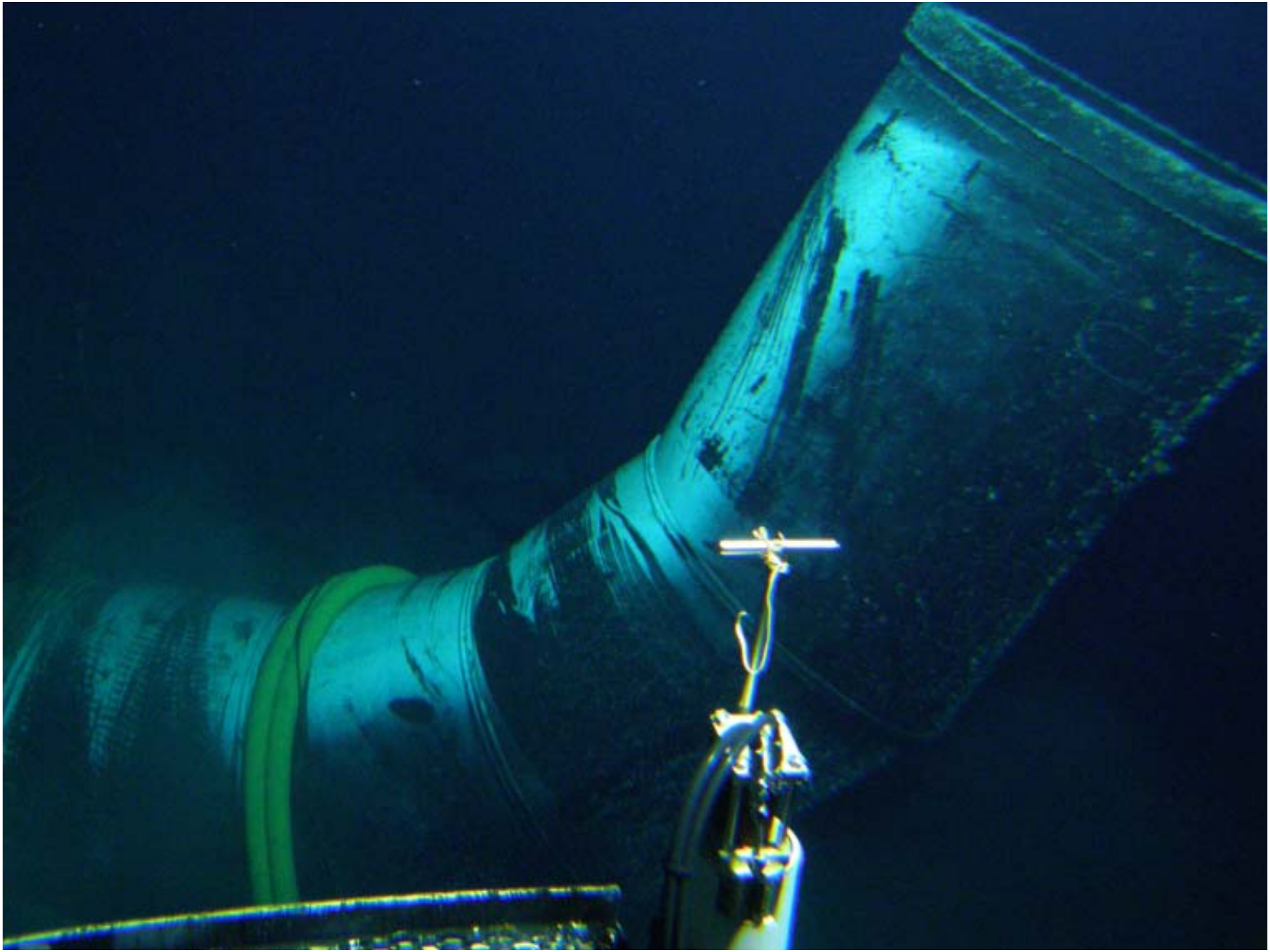
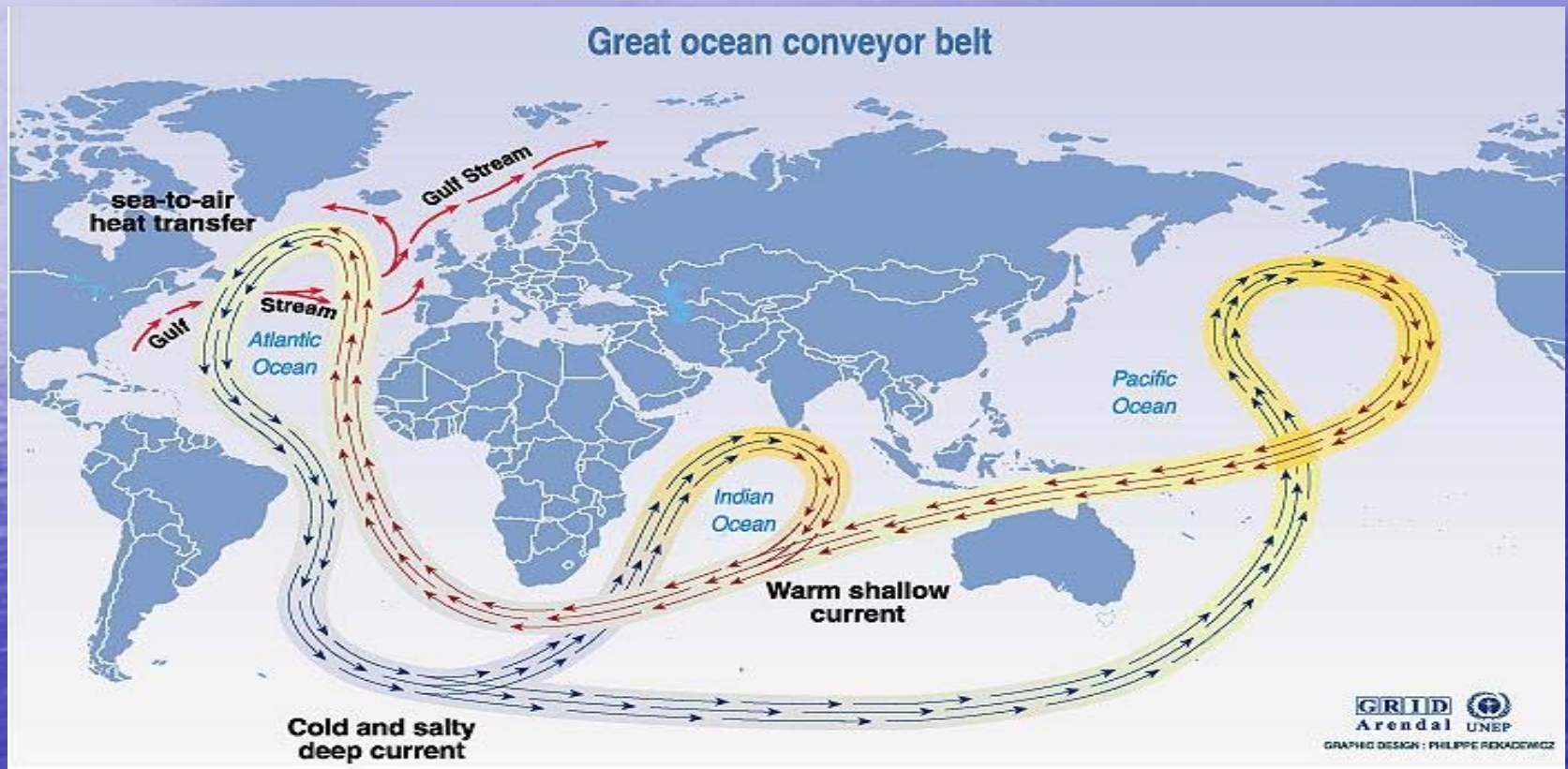


THERMOHALINE OCEAN CONVEYOR BELT



Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.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PRODUCT: BOTTLED WATER

- NEW MANUFACTURING INDUSTRY FOR ASIAN & INTERNATIONAL MARKET
- NOVEL PRODUCT DEVELOPMENT FROM NELHA DEEP SEAWATER
- INCREASE EXPORTS FROM HAWAI'I TO ASIA

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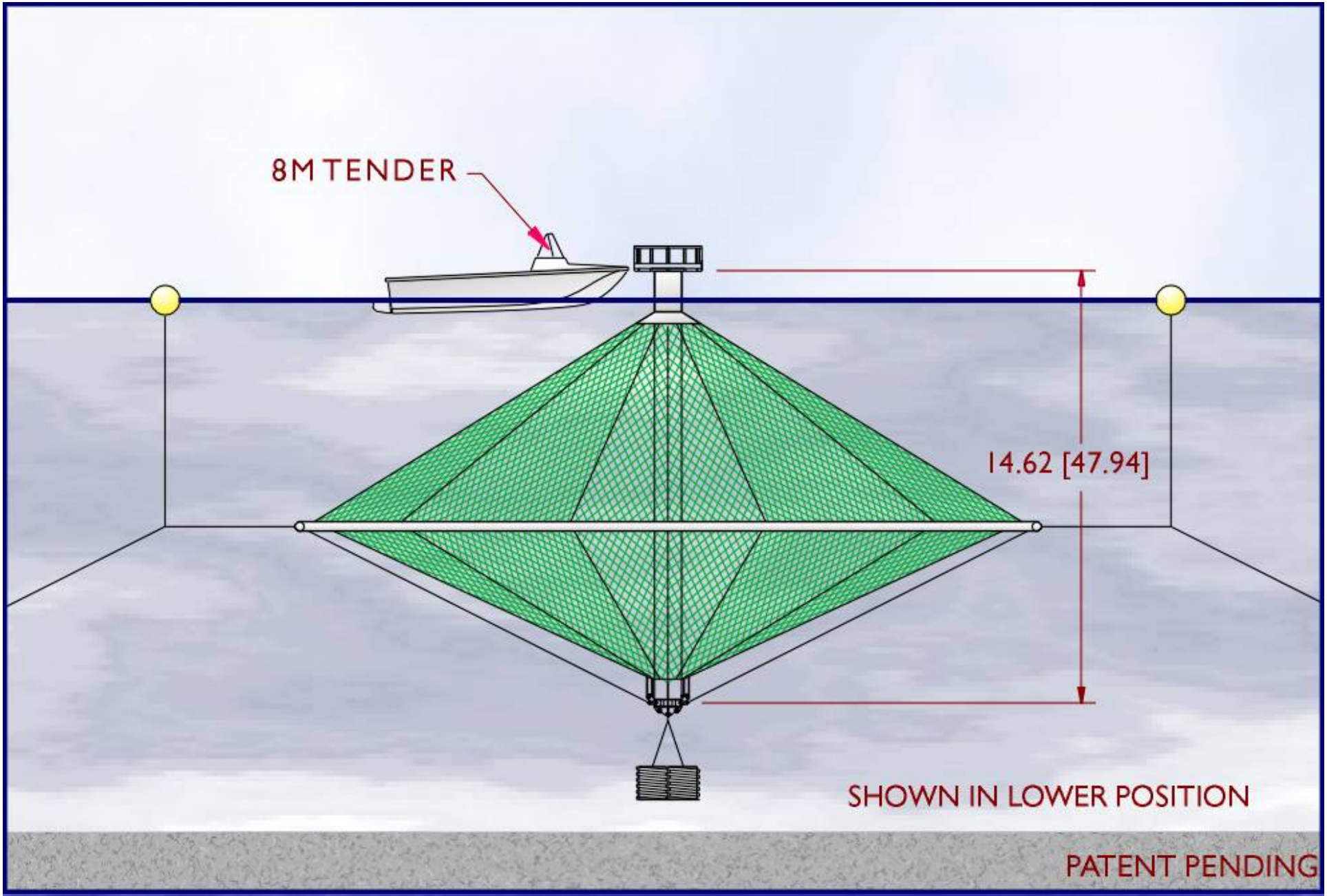

Sketch of OceanSpar SeaStation 3000 at the surface

PRODUCT: AQUACULTURE



IN AN INTEGRATED DSW SYSTEM, DEEP SEAWATER CAN BE USED TO GROW VALUABLE SEAFOOD PRODUCTS.

PRODUCT: SPF SHRIMP BROODSTOCK

- SPF CERTIFIED SHRIMP BROODSTOCK
- STRONGER, MORE RESILIENT GENETIC LINES DEVELOPED THROUGH TRADITIONAL BREEDING TECHNIQUES

PRODUCT: CLAMS/OYSTER SPAT

- READY FOR SALE AFTER 3.5 MONTHS
- NURSERY PRODUCTION NOT LIMITED BY NATURE'S SEASONS
- COST EFFECTIVE PRODUCTION AT 'WINTERLESS' NELHA

PRODUCT: COLDWATER ABALONE

- ABALONE IN SHORT SUPPLY WORLDWIDE
- OPTIMIZED GROWING CONDITIONS WITH NELHA RESOURCES

PRODUCT: MARINE ORNAMENTALS

- AQUARIUM INDUSTRY SPECIALTIES WITH INTERNATIONAL MARKET
- R&D AT NELHA PROVIDES BREAKTHROUGHS ON CAPTIVE-BREEDING OF HIGH VALUE, POPULAR SPECIES
- REDUCE PRESSURE ON WILD STOCK

PRODUCT: NATURAL ASTAXANTHIN

HUMAN NUTRACEUTICAL FROM MICROALGAE:

- POWERFUL ANTIOXIDANT
- SUNBURN PROTECTION
- HEALTH BENEFITS FOR:
  - CARPAL TUNNEL SYNDROME
  - RHEUMATOID ARTHRITIS
  - MACULAR DEGENERATION

PRODUCT: SPIRULINA

HUMAN NUTRACEUTICAL FROM MICROALGAE:

- CERTIFIED ORGANIC MICROALGAE
- HIGHEST GRADE OF SPIRULINA
- NUTRIENT-RICH DIETARY SUPPLEMENT
- RESEARCH EVIDENCE SHOWS SUPPORT OF HUMAN IMMUNOLOGICAL RESPONSE

PRODUCT: DSW COLDAG

A BOOST TO AGRICULTURE: GRAPES GROW TO HARVEST WITHIN ONLY 120 DAYS, ALLOWING THREE CROPS PER YEAR.

CEROS

The National Defense Center of Excellence for Research in Ocean Sciences

New Ocean Technology for Hawai'i

www.ceros.org

Secure Homing System

Neptune Technologies Inc.

NELHA HISTORY

- 2004, HAWAI'I GATEWAY ENERGY CENTER COMPLETED.
- 2005, LANDMARK EVENT, OPERATION OF 55" DSW PIPELINE COMMENCES SERVICE FROM ~3000'.
- 2007/8, RFP FOR 3 MW RENEWABLE PROJECT
- 2008, RFP FOR 1 MW OTEC
  - INCLUDES PHASE II VERTICAL 55" PUMPS

HAWAI'I GATEWAY ENERGY CENTER AT NELHA

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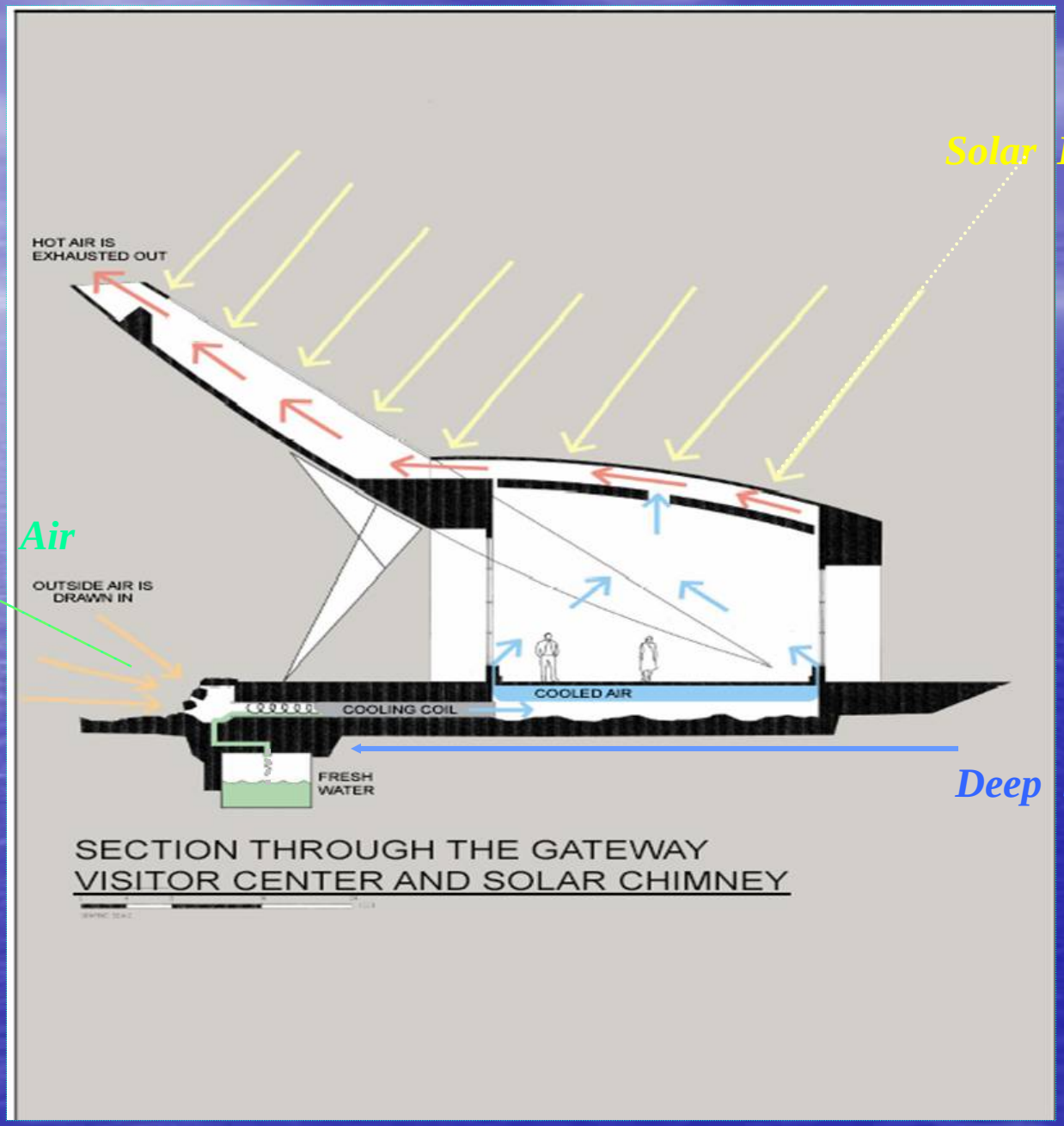
Solar Energy
HOT AIR IS EXHAUSTED OUT
Tropical Air
OUTSIDE AIR IS DRAWN IN
COOLED AIR
COOLING COIL
FRESH WATER
Deep Sea Water
SECTION THROUGH THE GATEWAY
VISITOR CENTER AND SOLAR CHIMNEY

NELHA PAST & FUTURE

- RESEARCH SUPPORT FACILITY
- BUSINESS and TECHNOLOGY INCUBATOR
- ECONOMIC DEVELOPMENT AGENCY

ENERGY

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Why Energy at NELHA?

- Charter for Natural Energy development
- Seawater Delivery is 60-80% Energy Cost
- Abundant Natural Resources
  - Highest Solar Insolation in Coastal US
  - Abundant cold = deep water
  - Abundant heat = surface water, solar intensity
  - Undeveloped land
  - West Hawai'i need
  - Majority of Power transmitted from East Side

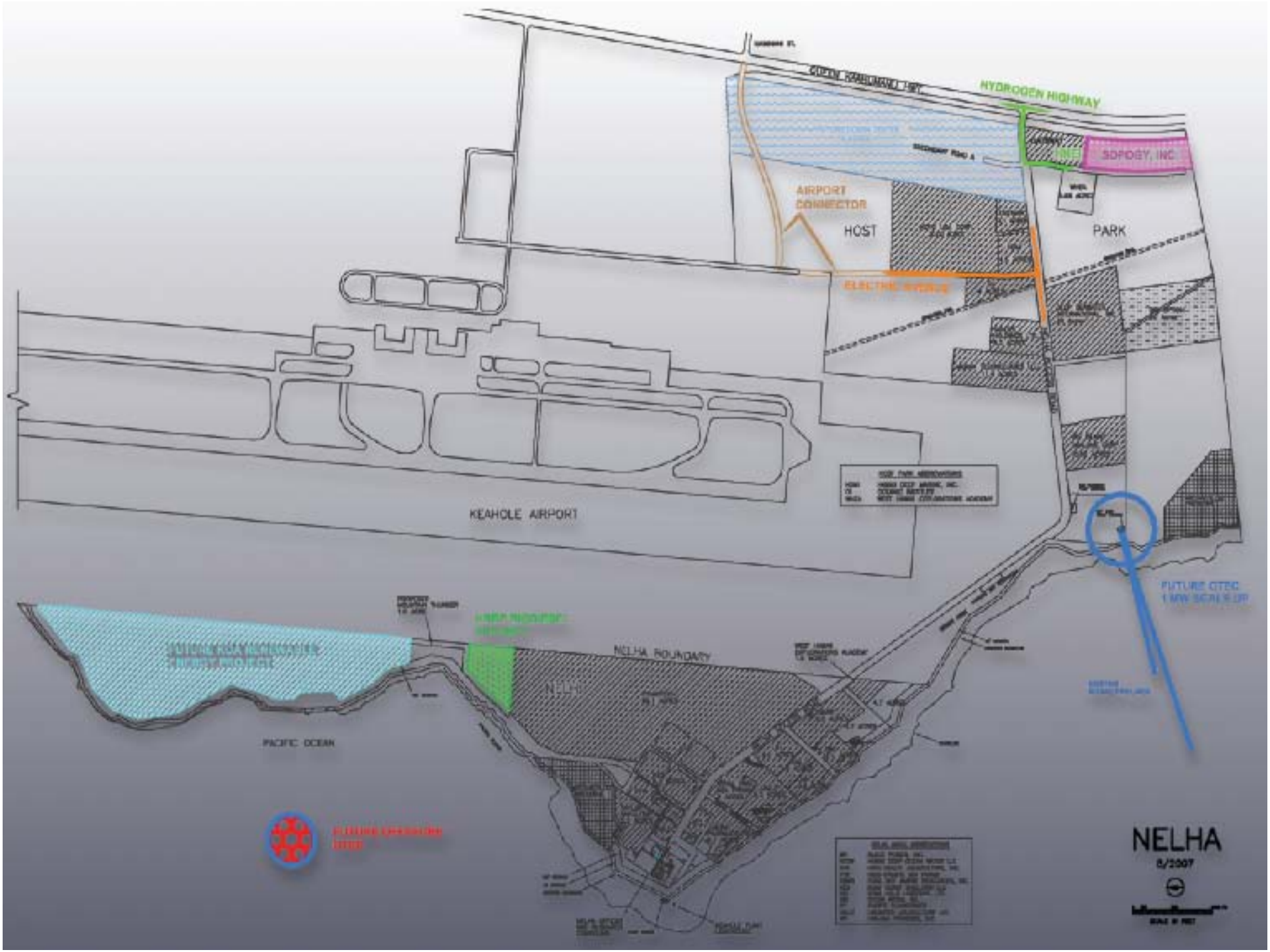
NELHA = GREEN ENERGY ZONE

Green Energy

Fast Track Permitting

Tax Cuts Economic Incentives

Green Energy Zone


HYDROGEN HIGHWAY
SOPOGY, INC.
AIRPORT CONNECTOR
HOST
PARK
KEAHOLE AIRPORT
FUTURE OTEC
NELHA ROUNDARY
NELHA
PACIFIC OCEAN
NELHA
8/2007

Energy Sustainability

High Technology Jobs

Economic Diversification

NELHA

Natural Energy Laboratory of Hawaii Authority

www.NELHA.org

VISION STATEMENT:
Growing sustainable industries for the 21st century

MAHALO