From a standpoint of research and development accomplished to date, electrodialysis is the most advanced of the membrane processes. An electrodialysis conversion assembly is essentially a cell containing two different types of ion-selective membranes. One of the membrane types allows passage of positive ions, or cations, and the other allows passage of the negative ions, or anions. The electric current imposed on the electrodialysis cell provides the driving force for the ions. A basic electrodialysis cell is shown in figure 13. The cation-permeable membrane allows passage of the positive sodium ions, and the anion-permeable membrane allows passage of the negative chloride ions, leaving fresh water between the membranes.

The dialysis process at elevated temperatures. High temperatures reduce the electrical resistance of the electrolyte and lower electric power requirements. High-temperature operation shows promise of reducing power requirements sufficiently to make electrodialysis attractive for sea-water conversion.

The application of electrodialysis to brackish water presents a problem not usually associated with sea-water conversion. The chemical composition of sea water is relatively constant, whereas that of brackish water varies greatly. Variations in the mineral content of the brackish water require that an electrodialysis unit be designed for the particular water to be demineralized, or pretreatments be used. For example, the amount and type of constituents present influence the pretreatment needed, scale-forming tendencies, limits in brine concentration, and number of stages required.

**membrane development**

The membranes used in an electrodialysis unit are produced by chemically treating a polymeric material such as polystyrene or polyethylene. A number of fabrication techniques are being investigated. Some of the techniques give low cost membranes, while others give membranes of longer life and higher cost. The development program is directed toward obtaining membranes that give the best compromise between life, ion selectivity, and hydraulic and electrical characteristics.

The amount of electric current required in a unit which contains many sets of membranes between the electrodes depends on the amount of dissolved salt to be removed. Therefore, the cost of the energy consumed in the process depends on the concentration of dissolved minerals in the feed water. The relationship between electric current requirements and dissolved salts is the main reason that electrodialysis is favored for brackish-water conversion. However, if the cost of membranes and processing equipment can be reduced sufficiently, electrodialysis may become economically feasible for sea-water conversion, particularly in areas where electric energy is available at low cost. Research is currently being conducted to investigate the feasibility of operating the electro-

---

**Fig. 13. An electrodialysis cell.**
1. Well water

Honolulu well 82-2A at HIC. Drilled 7/14/67. 65 ft deep. Coral and brown clay.

Use: Water for fish pond.

Quality: TDS 3000 ppm, EC 4000 micromhos
Chloride 1300 ppm
Hardness 600 ppm
pH 7.7
Nitrate 18 ppm
Silica 42 ppm
Temp. 77°F

Bacterial quality: Being analyzed

2. ED unit

Ionics Aquamite I  Rated capacity 500 gpd
Minimum pressure 40 psi
Avg. power consumption 10 KWH/1,000 gal. of product
Rated dissolved mineral removal 80-85%
Maximum TDS in feed water 5,000 ppm
Electrical requirement: 115 volts A.C., 10 amps

3. Test period

3/31/70 - 4/5/70  about 4-5 hours per day
4/6/70 - to date  continuous 24-hr day

4. Test performance

Operation & maintenance: No special problems. Silent.
DO require 115 volt.

Membrane condition: Not known but no sign of fouling

Quantity: About 400 gpd and consistently steady

Quality: Consistently steady
About 85% removal of ions
No removal of silica
Detailed data in charts

Power requirement: Data being analyzed
July 21, 1967

Board of Water Supply
Box 3410
Honolulu, Hawaii 96801

ATTENTION: Mr. Bunji Higaki

Gentlemen:

This is to inform you that we have begun work on a project to drill two shallow wells at Honolulu International Center for the purpose of providing water for landscaping purposes.

These wells will be drilled to a maximum depth of 100 feet or less, of which approximately 25 feet will be cased.

Very truly yours,

James H. Whiton
Assistant Manager

JHW:gh

65' deep
196 oz. per cu. ft. Shallowwell No. 3 WR fluid pack
CHEMICAL LABORATORY REPORT

Subject: Honolulu International Center
   Shallow Well No. 1 (Waikiki Well)

Sample received, collected on 7/14/67 by B. Higaki.
   Sample received collected at 611 gpm. Lab. No. 100,699.

Analytic data:

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness, ppm a</td>
<td>266</td>
</tr>
<tr>
<td>Chloride, ppm</td>
<td>360</td>
</tr>
<tr>
<td>pH value</td>
<td>7.90</td>
</tr>
<tr>
<td>Turbidity units</td>
<td>0.5</td>
</tr>
</tbody>
</table>

a as calcium carbonate.

Well data: Well completed July 1967; 15' cased, open hole 50', total depth 65'.

July 17, 1967

Y. F. Lee
Chemist

Copies to: GY, KHL, SB, BH
NAT WHITON DRILLING CO., INC.
1160 Auahi Street
Honolulu, Hawaii 96814

82-2A
7-14-67

1.0 Tap Soil

6.0

Coral - clay fill

7.8

Black Sand

14.7 End of running

Med a lid coral

25.0

Coral - brown clay

41.0

Med a lid coral.

59.0

Soft Med coral (convert of brown clay)

65.0
STATE OF HAWAII
COMMISSION ON WATER RESOURCE MANAGEMENT
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF WATER RESOURCE MANAGEMENT

REGISTRATION OF WELL
AND
DECLARATION OF WATER USE

INSTRUCTIONS: Please type or print. If information is not available or not applicable, indicate as N/A. Fill out as completely as possible, sign, and file form with the Division of Water Resource Management, P.O. Box 373, Honolulu, Hawaii 96806. Phone 548-3948 or 548-7543 for assistance.

BATTERY OF WELLS: For a battery of wells, on the surface, in a tunnel, or in a shaft, submit a registration form for each well together with a single map or plot plan showing layout of wells.

STATE WELL NO.: 1851-62
ISLAND: Oahu

WELL NAME OR DESIGNATION: Neal Blaisdell Center

SOURCE OR STATION NAME (For a battery of wells):

A. WELL OPERATOR
Dept. of Parks & Recreation
City & County of Honolulu

Contact person: Daniel Takematsu

Address: 777 Ward Avenue
Honolulu, Hawaii

Zip: 96814 Phone: 527-5419

B. OWNER OF WELL SITE

Firm name: Nat Whiton Drilling Co.

Address:

Zip: _______ Phone: _______

C. WELL LOCATION

Tax Map Key: 2-3-08: 1 Town, Place, District: Honolulu (lower Makiki)

Attach USGS "Quad" map (scale 1:24,000), tax map, or other map showing the well location.

D. WELL DATA

For Drilled Wells, submit "as-built" drawing, driller's log, and pump test results, and complete items below.

For Tunnels and Shafts, submit construction drawings, plot plan, or sketch map.

Ground elevation (Mean sea level): 7± ft.

Reference point (Used to measure depth to water):

Elevation: ground surface est.

Description:

Depth to water (Below reference point): 6± ft.

Maximum recorded chloride: 360 ppm

Minimum recorded chloride: 1400 ppm

Maximum chloride in 1987: NA ppm

Year drilled or constructed: 1967

Well contractor: Nat Whiton Drilling Co.

Casing diameter: 16 in.

Solid casing depth (Below ground): 14 ft.

Perforated casing depth (Below ground): 65 ft.

Total depth of well: 65 ft.

Minimum chloride in 1987: NA ppm

E. INSTALLED PUMP DATA

Pump type: [ ] Vertical shaft [ ] Submersible [ ] Centrifugal [ ] Other (specify)

Power: [ ] Diesel, ___ HP [ ] Gas, ___ HP [ ] Electric, ___ HP [ ] Other (specify)

Pump capacity: _______ gallons per minute

Pump installation contractor:

(continued over)

For Official Use Only:

Date received: 1-18-89 Date accepted: _______

Field checked by: _______ Date: _______ Latitude: 21° 19' 13'' Hydrologic Unit:

Comments: _______ Longitude: 157° 51' 11'' State Well No.: 1851-62

References: Hawaii Revised Statutes, Chapter 174C.

Hawaii Administrative Rules, Chapters 13-167 to 13-171.
F. DECLARATION OF WATER USE

NOTE: The purpose of the Declaration of Water Use is to obtain information necessary for the management of the State's water resources. The Declaration does not confer a legal right to water or its use.

Water use data are recorded: ☐ Daily ☐ Weekly ☐ Monthly ☐ Other (Describe): ________________

Method of measurement: ☐ Flow Meter ☐ Orifice ☐ Other (Describe): ________________

Quantity of Use (Report metered or estimated monthly water use from the well described on the reverse side of this form, for the calendar years 1983 through 1987. For a battery of wells which are not individually metered, but which are connected to a single meter or other measuring device, report total use from the battery.):

WATER USE, IN GALLONS x 1000

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>January</td>
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<td>February</td>
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<td>December</td>
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<tr>
<td>TOTAL</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Minimum day's use: ________________ gallons Maximum day's use: ________________ gallons

Typical times of usage: ________________

Type of Use (Check all category boxes that apply and provide additional information as indicated.):

<table>
<thead>
<tr>
<th>Category</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Municipal (including resorts, hotels, businesses)</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Domestic (systems serving 25 people or less)</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Irrigation</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Acres Irrigated</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Crop(s): ☐ Sugar ☐ Pineapple ☐ Other (specify):</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Non-Crop: ☐ Landscape ☐ Golf Course ☐ Other (specify):</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Method: ☐ Drip ☐ Furrow ☐ Sprinkler</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Industrial</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ ☐ Cooling ☐ Manufacturing ☐ Mill ☐ Other (specify):</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Military</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ ☐ Other (specify):</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Other</td>
<td>______________________</td>
</tr>
<tr>
<td>☐ Specify (livestock, aquaculture, etc.):</td>
<td>______________________</td>
</tr>
</tbody>
</table>

I declare that the contents of the above Declaration of Water Use are, to the best of my knowledge and belief, true, correct, and complete.

Water User's Signature: ______________________ Date: ______________________

Printed Name: ______________________

Firm or Title (Well Operator, etc.): Dept. of Auditoriums
Superintendent, Maintenance Division
REGISTRATION OF WELL AND DECLARATION OF WATER USE

STATE WELL NO.: 1851-63
WELL NAME OR DESIGNATION: Neal Blaisdell Center
SOURCE OR STATION NAME (For a battery of wells):

**A. WELL OPERATOR**
Firm name: Dept. of Parks & Recreation
Contact person: Daniel Takamatsu
Address: 777 Ward Avenue
Honolulu, Hawaii
Zip: 96814 Phone: 527-5419

**B. OWNER OF WELL SITE**
Firm name: ______________________________________
Contact person: ______________________________________
Address: ___________________________________________
Zip: ________ Phone: __________________

**C. WELL LOCATION**
Tax Map Key: 2-3-08: 1 Town, Place, District: Honolulu (lower Makiki)
Attach USGS "Quad" map (scale 1:24,000), tax map, or other map showing the well location.

**D. WELL DATA**
For Drilled Wells, submit "as-built" drawing, driller's log, and pump test results, and complete items below.
For Tunnels and Shafts, submit construction drawings, plot plan, or sketch map.

<table>
<thead>
<tr>
<th>Ground elevation (Mean sea level): 7± ft.</th>
<th>Year drilled or constructed: 1967</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference point (used to measure depth to water):</td>
<td>Well contractor: Nat Whiton Drilling Co.</td>
</tr>
<tr>
<td>Elevation: _____________________________</td>
<td>Casing diameter: 16 in.</td>
</tr>
<tr>
<td>Description: ground ______________________</td>
<td>Solid casing depth (Below ground): 28 ft.</td>
</tr>
<tr>
<td>Depth to water (Below reference point): 6± ft.</td>
<td>Perforated casing depth (Below ground): 80 ft.</td>
</tr>
<tr>
<td>Maximum recorded chloride: 2750 ppm</td>
<td>Total depth of well: 80 ft.</td>
</tr>
<tr>
<td>Minimum recorded chloride: 2350 ppm</td>
<td>Minimum chloride in 1987: NA ppm</td>
</tr>
<tr>
<td>Maximum chloride in 1987: __________ ppm</td>
<td></td>
</tr>
</tbody>
</table>

**E. INSTALLED PUMP DATA**
Pump type: □ Vertical shaft □ Submersible □ Centrifugal □ Other (specify): __________
Power: □ Diesel, ___ HP □ Gas, ___ HP □ Electric, ___ HP □ Other (specify): __________
Pump capacity: _______ gallons per minute
Pump installation contractor: ________________________________________________

... (continued over)

For Official Use Only:
Date received: 1-19-69 Date accepted: __________________
Field checked by: __________ Date: ________
Comments: __________

Latitude: 21° 14' 12" Hydrologic Unit: [ ]
Longitude: 157° 51' 16" State Well No.: 1851-63

References: Hawaii Revised Statutes, Chapter 174C.
Hawaii Administrative Rules, Chapters 13-167 to 13-171.
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Method of measurement: ☐ Flow Meter ☐ Orifice ☐ Other (Describe):

Quantity of Use (Report metered or estimated monthly water use from the well described on the reverse side of this form, for the calendar years 1983 through 1987. For a battery of wells which are not individually metered, but which are connected to a single meter or other measuring device, report total use from the battery.):

<table>
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<th>WATER USE, IN GALLONS x 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
</tr>
</tbody>
</table>

Minimum day’s use: ____________ gallons Maximum day’s use: ____________ gallons

Typical times of usage:

Type of Use (Check all category boxes that apply and provide additional information as indicated.):

<table>
<thead>
<tr>
<th>Category</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Municipal (including resorts, hotels, businesses)</td>
<td>Number of service connections: ____________</td>
</tr>
<tr>
<td>☐ Domestic (systems serving 25 people or less)</td>
<td>Acres Irrigated: ____________</td>
</tr>
<tr>
<td>☐ Irrigation</td>
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</tr>
<tr>
<td>☐ Other (specify): Non-Crop: ☐ Landscape ☐ Golf Course</td>
<td></td>
</tr>
<tr>
<td>☐ Other (specify): Method: ☐ Drip ☐ Furrow ☐ Sprinkler</td>
<td></td>
</tr>
<tr>
<td>☐ Industrial</td>
<td>☐ Cooling ☐ Manufacturing ☐ Mill</td>
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<tr>
<td>☐ Other</td>
<td>☐ Other (specify): Specify (livestock, aquaculture, etc.): ____________</td>
</tr>
</tbody>
</table>

I declare that the contents of the above Declaration of Water Use are, to the best of my knowledge and belief, true, correct, and complete.

Water User’s Signature: ___________________________________________ Date: ____________

Printed Name: Daniel Takamatsu

Firm or Title (Well Operator, etc.): Department of Auditoriums

Superintendent, Maintenance Division