



Water Resources Research Center

University of Hawaii at Manoa

May 2004 Bulletin

New Environmental Microbiology Lab Launched at WRRC

By Audrey Asahina, WRRC Researcher

WRRC'S new environmental microbiology laboratory is finally here! The unveiling of the new lab, located in Holmes Hall 183, took place on March 9, 2004. Those who stopped by were even treated to a coffee hour complete with coffee (of course), juice and assorted pastries. The remodeled lab was the result of about 11 months of planning, design, storage, bidding, construction, dust, dust, meetings, meetings, more meetings and inspections....Whew!

The old laboratory was a safety nightmare and a far cry from what you see today (see below). Equipment had to be placed on a "lab bench," which consisted of a variety of desks put together like a jigsaw puzzle. Now, in place of this makeshift bench is a spankin' new 14 foot laboratory bench with attached chemical reagent shelf and a 6 foot long ADA (Americans with Disabilities Act compliant) bench. Also installed was a large ADA sink. Both benches are equipped with gas, air, vacuum and several electrical outlets. Hopefully, an autoclave will be installed in the next few months. Then the lab will be fully functional.

This new laboratory is capable of performing microbiological as well as some molecular biological methods such as polymerase chain reaction (PCR). So, as far as equipment goes, you will find a PCR thermal cycler, a biological safety hood, aerobic and anaerobic incubators, water baths, microscopes, membrane filtration apparatus, tabletop centrifuges, electrophoresis equipment and storage refrigerators... to name a few items.

For rapid water quality testing to detect coliforms and *E. coli*, the Colilert system is used in this lab. Likewise, the Microtox bioassay testing system is used for the toxicity screening of water samples (marine or fresh). Additionally, this lab houses a low-pressure, low-intensity UV and a medium-pressure, high-intensity UV collimated beam unit, both of which are used to test the disinfection capabilities of ultraviolet light against various microorganisms. As you can see the new WRRC Environmental Microbiology Laboratory has a lot to offer and is capable of accomplishing research that will benefit the community, the State of Hawaii and the University.



The new lab and happy staff



Before...



After...

In this issue:

New Environmental Micro Lab	pg. 1	Conferences and Meetings	pg. 5
Source Water Assessment Project	pg. 2	Visit from Shanghai Delegates	pg. 6
Neighbor Island Water Quality Study	pg. 3	State Science Fair Participation	pg. 7
Land-based Ocean Radars	pg. 5	Watershed Assessment Project	pg. 7

Source Water Assessment Project Wrapping Up

A WRRC team headed by Dr. Aly El-Kadi has recently completed the task of conducting an assessment of Hawaii's 450-odd drinking water sources for the Department of Health. The work implemented Hawaii's source water assessment program (SWAP) plan that the EPA approved in November 1999.

Groundwater

For each public drinking water well in the state, the WRRC team performed modeling of the source's capture area based on elements of hydrogeology at each site and the rate and pattern of withdrawal for each source. Much of this work drew upon data obtained from studies conducted by the U.S. Geological Survey (USGS). The software employed in this modeling was MODFLOW, a USGS three-dimensional groundwater flow model that is widely used in conjunction with MODPATH, a USGS groundwater particle tracking model. The models are integrated in the commercially available Groundwater Modeling System (GMS), which was used as a vehicle for data preparation and results presentation. GMS facilitates the modeling process by utilizing geographic information

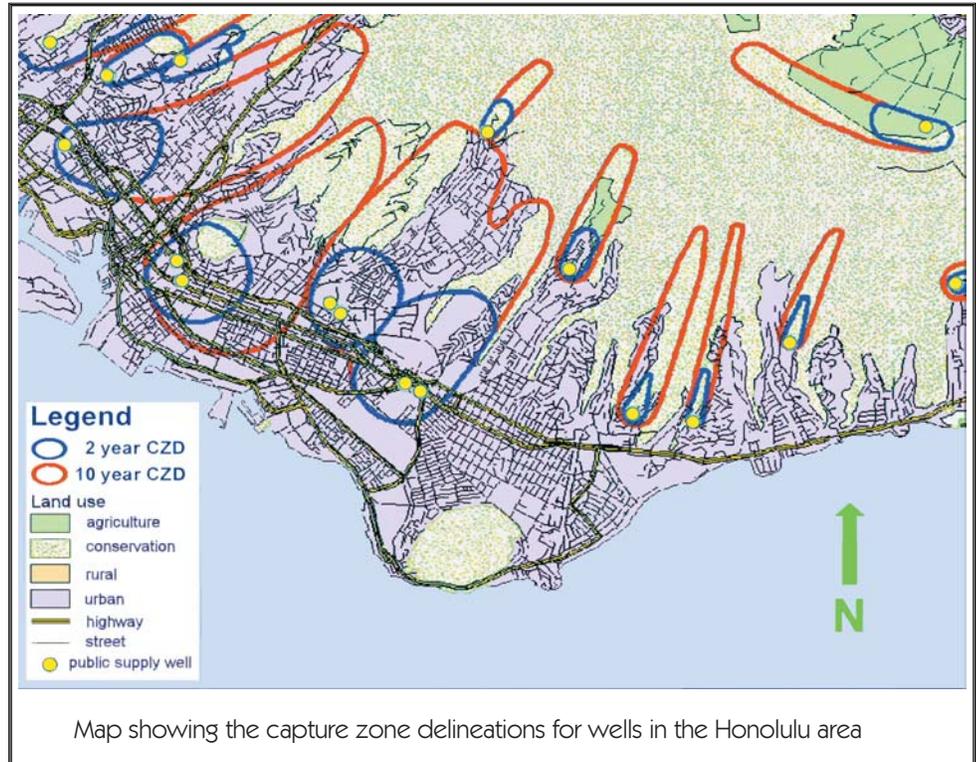
system maps. Two capture areas were defined using this software: a 10-year travel time zone, and a 2-year travel time zone. In addition to these two zones, a third area, the "well site control zone" with a diameter of 50 meters around each source, was established. The logic of these travel time zones is that chemical contaminants can be expected to last 10 years in the environment, microbiological contaminants can be expected to last 2 years, and all types of activities within the 50-meter well site control zones naturally warrant close examination. The 2-year zone ties into the provisions of the soon-to-be-implemented groundwater disinfection rule which mandates disinfection for all groundwater sources. Together, the three zones are referred to as Capture Zone Delineations (CZDs). In addition a 25-year time-of-travel zone was delineated for the groundwater sources on Molokai in accordance with Hawaii's Well-Head Protection Demonstration Project performed in 1992.

Surface Water

Similar to the groundwater CZDs surface water CZDs were delineated using the following three-part formula; Zone A – 200 foot radius around the water intake point; Zone B – 400 feet from the perimeter of reservoirs and lakes and 200 feet from the banks of rivers, canals and ditches; and Zone C – the watershed area upstream of and contributory to the intake point and a 400-foot corridor along any open channel portions of the transmission system. For Zone C, Watershed Management Software (WMS) was used to delineate watershed boundaries based on available digital elevation maps. Watersheds thus generated were compared to those developed by the Hawaii Coastal Zone Management Program of DBEDT in 1994.

Under this scheme, Zone A (direct chemical contamination zone) corresponds to the well site control zones for wells, intended to assess the source's vulnerability to tampering, vandalism and direct introduction of contaminants. Zone B (microbial contamination zone) designates the area that may introduce pathogenic microorganisms directly into the water source. Zone C represents the area from which indirect chemical contamination of a source could originate.

Source areas for water development tunnels were treated as groundwater under the direct influence of surface water (GWUDI) and modeled using the watershed approach because of the complexity of the geology where these types of sources occur.



continued on page 8...

Neighbor Island Drinking Water Quality Assessment

Under a grant from the Hawaii Department of Health's Drinking Water Branch, WRRC researcher Dr. Roger Fujioka has been working on a statewide, island-by-island assessment of microbial quality of potable water sources.

Inherent differences in geology and topography characterize the Hawaiian islands, owing primarily to their different ages. These differences may have implications for the quality of both ground and surface waters. For example, it is intuitive that the relatively unweathered, overburden-free, surface of the Big Island, the youngest island in the chain, provides less of a barrier to the infiltration of contaminants to groundwater than does the heavily weathered surface of Kauai, the eldest island. Fujioka's work is aimed at evaluating the microbial contamination found in water supplies around the state to see if the islands' differences do indeed affect water quality.

Fujioka has previously tested Oahu's drinking water in a series of experiments conducted in the late 1980s. His results indicated that the quality of Oahu's groundwater was excellent. Oahu is blessed with favorable geology and with abundant rainfall on the undeveloped mountainous part of the island. This rain infiltrates through hundreds of feet of soil and rock to the sub-basal aquifer that underlies the island. The water which is available for extraction through the many wells drilled at lower elevations around the island, represents almost 100% of Oahu's drinking water supply.

The 1986 amendments to the federal Safe Drinking Water Act (SDWA) greatly increased the numbers of regulations designed to ensure that the nation's potable water is safe and free of contaminants. One of the new rules to come out of these amendments is the "total coliform rule" which stipulates that total coliform, a group of ubiquitous, mostly harmless bacteria, should be monitored in distribution systems as a surrogate for harmful microorganisms. Under the new rule, the presence of these surrogate organisms in a drinking water system

would be taken as an indication of sewage contamination, and therefore the water would require disinfection.

Another change that EPA proposed long ago that is on the threshold of being implemented, is the so-called groundwater rule under which disinfection of all groundwater supplies will be required. Currently, only those systems using surface water, and ground water under the direct influence of surface water, are required to disinfect their water supplies.

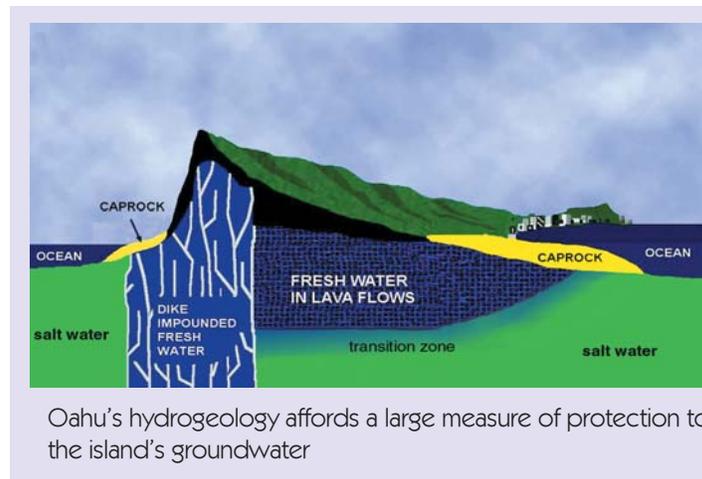
The implication of these new rules is that all water providers will have to add a disinfectant (usually chlorine) in order to meet EPA regulations. But of course chlorination is not without its costs: financial, aesthetic, and health. The Honolulu Board of Water Supply (HBWS) has registered its opposition to mandatory chlorination, citing the excellent protection accorded our groundwater by the above-mentioned geology of the island.

Fujioka conducted a monitoring study in 1998, showing that well water and water in the HBWS distribution system were essentially free of fecal bacteria and fecal viruses. In a subsequent study using

culture and gene probe methods, he found that ambient groundwater and water in the distribution system were not contaminated with human enteric viruses. This was an important finding inasmuch as regulations such as the total coliform rule are based on the assumption that the detection of any bacteria is indicative of the presence of pathogenic microorganisms.

In summary, Oahu's groundwater and water in the distribution system have been extensively monitored for fecal contamination using traditional fecal indicator bacteria (total coliform, *E. coli*, enterococci), as well as *C. perfringens*, *Legionella*, total heterotrophic bacteria, bacterial viruses and human enteric viruses. The overall verdict is that Oahu's water is of excellent quality, meeting drinking water standards without treatment.

The testing of Oahu's water has been a priority due to the large population living on the island. While of course the drinking water of the other islands is routinely checked by the local water supply utilities, the neighbor islands have lacked the population base and therefore the



For more information on the upcoming groundwater rule visit the EPA web site at:
<http://www.epa.gov/OGWDW/gwr/>

wherewithal to conduct more in-depth characterization of their drinking water sources. Furthermore, because surface water sources are more commonly used on the neighbor islands, the utilities on those islands have adopted a practice of routine chlorination to ensure compliance with SDWA standards for water entering their distribution systems. A consequence has been that the quality of source waters has not been examined as closely as it has on Oahu. The bacteriological quality of the water on the neighbor islands needs to be better characterized to permit good, science-based operational/management decisions.

Parameters being monitored in the current study include:

- Total coliform – presence of any of the coliform group. A very crude measure of microbial quality.
- *E. coli* – a coliform more likely to be of fecal origin.
- FRNA coliphage (virus that infects *E. coli* bacteria) recommended by EPA, sewage specific.
- *Clostridium perfringens* – bacterium that doesn't reproduce in the environment as the coliform bacteria have been shown to do.

Monitoring of FRNA is recommended by EPA because of its similarity to human enteric viruses, one of the most important pathogens found in groundwater.

In addition to preparing for the imminent total coliform and groundwater rules, Fujioka's study will endeavor to characterize ambient source water quality as a preparatory measure against possible future intentional bacterial contamination of source waters. The approach taken to address this issue will be to utilize a suite of tests which, while not capable of identifying specific contaminants, will provide rapid warning of changes in water quality. Tests will include:

- Total aerobic spores
- Total anaerobic spores
- Turbidity
- Conductivity
- ID of bacteria using a RiboPrinter*
- Total ATP activity (enzymatic measurement for total bacteria)
- Indirect measurements (BOD, COD, total organic carbon, total suspended solids, nitrates, surfactants)



Water flume, upcountry Maui

*RiboPrinter is an automated system capable of speciation and subspeciation of a bacterial isolate in eight hours, based on the distribution pattern of genetic sequences.

Oahu Aquifers Generally OK, but Urban Streams Are Substantially Degraded, USGS Report Shows

A 3-year study by the U.S. Geological Survey (USGS) detected many chemicals in Oahu ground water, but concentrations of those chemicals were below drinking-water standards in all but a few cases. Streams were found to be more contaminated than ground water, particularly where streams pass through developed urban and agricultural lands.

Results of the USGS assessment suggest that fish may be more at risk than humans from chemical contaminants because Oahu streams are not used for drinking water, but they are home to fish and other aquatic animals, said Stephen Anthony, USGS Project Chief of the study. Besides the threat from chemicals, physical factors such as siltation, stream diversions, and high water temperatures also degrade stream habitat, particularly for native species.

Results of the assessment will be presented a WRRC sponsored seminar on Monday, June 28th at 2:00 PM in the Marine Science Building (Room 114) on the U.H. Manoa campus. Copies of the USGS report, "Water Quality on the island of Oahu, Hawaii, 1999-2001" published as USGS Circular 1239 will be available at the seminar.

Upcoming Conferences and Meetings...

May 30 - June 4, 2004: The Eleventh Pacific Congress on Marine Science and Technology PACON 2004 (20th Anniversary), New Technologies, New Opportunities, Waikiki Beach Marriott Resort, Honolulu, Hawaii.

<http://www.hawaii.edu/pacon/2004TableContents.html>

June 26-30, 2004: North American Membrane Society 2004 meeting, Sheraton Waikiki, Honolulu, Hawaii.

<http://www.membranes.org/>

August 16-20, 2004: American Geophysical Union Western Pacific Geophysics Meeting, Hawaii Convention Center, Honolulu, Hawaii.

<http://www.agu.org/meetings/wp04/>

October 14-24, 2004: 13th Annual Meeting of the North Pacific Marine Science Organization (PICES), Hawaii Convention Center, Honolulu, Hawaii.

www.pices.int/meetings/annual/Pices13/default.aspx

November 2004: Hawaii Water Environment Association Biennial Water Reuse Conference, Maui, Hawaii

<http://www.hwea.org/regmtgs.htm>

February 16-18, 2005: 27th Annual Hawaii Water Environment Association Conference, Hawaii Convention Center, Honolulu, Hawaii.



WRRC Participates in Ocean Radar Project

Philip Moravcik, the Water Center's Technology Transfer Specialist, took a sabbatical last year to help on a project developing the use of high-frequency, land-based coastal radars for monitoring surficial currents and wave activity.

This project is being jointly conducted by the UH School of Ocean and Earth Science and Technology (SOEST) and the Italian National Institute of Oceanography and Experimental Geophysics (OGS). The work was supported by the U.S. Office of Naval Research and the Italian Ministry of Education, University and Research.

Coastal ocean radars are presently a focus of much research activity amongst oceanographers. Land-based radars can remotely monitor ocean-surface winds and currents over data-sparse ocean areas that would otherwise require thousands of widely dispersed in-situ instruments. Radar thus represents a relatively low-cost method of obtaining sea surface information over large expanses of ocean. Data obtained can be used by mariners, fishermen, biologists and meteorologists, for example.

At high frequencies, electromagnetic waves can propagate in a "trapped" ground wave along the conductive surface of the ocean. The useful range of the ground wave depends on attenuation and increases with decreasing frequency. Speaking approximately, range (km) times frequency (MHz) = 2000, thus a radar using a frequency of 32 MHz has a range of 60 km, 16 MHz = 125 km, and 8 MHz = 250 km. The actual range varies greatly depending on electromagnetic background noise and on the type of signal modulation. Propagation and range increase with salinity and decrease as sea state increases.



The 16 antenna receive array on the Po delta

Short pulses of radio energy are sent from transmit antennae, bounce off the ocean surface, and the returning pulses are received by another set of antennae. Since the ocean is generally covered by waves of many different wavelengths and directions (continuous spectrum), there are always trains of waves propagating toward and away from the radar. The return signal from either train will be Doppler-shifted by the wave velocity. Thus the spectrum of the return echoes consists of two peaks, symmetric with respect to the transmit frequency, in the absence of currents.

If the waves are riding on an underlying ocean current, the return signal is further Doppler-shifted

[Ocean Radar Study continued on page 6...](#)

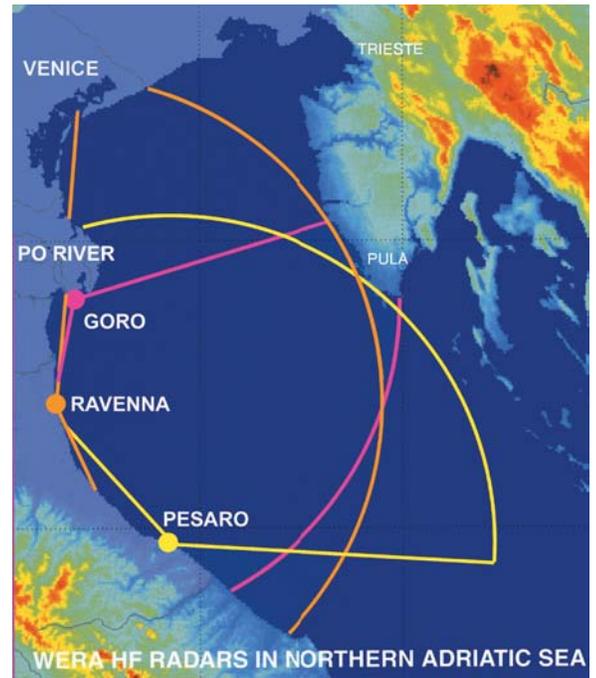
Ocean Radar Project continued from page 5...

by the radial component of the current, which can therefore be estimated from the signal. With two radars some distance apart along a coast, the direction of currents can be computed.

The venue for the project on which Moravcik worked was the northern Adriatic Sea (see map). Three radars were installed: one in the Po River delta (of interest because the enormous freshwater input of the Po has wide-ranging effects on circulation in the Adriatic), another near the city of Ravenna, and the third a short distance north of the city of Pesaro. The radars are of two designs. At Pesaro and Ravenna they consist of a transmit array of 4 antennae in a diamond configuration with a similar receive array for current mapping only. The Po delta radar's transmit array is the same; however the receive array is a line of 16 antennae, spaced 1/2 a wavelength apart – in this case approximately 8 meters as the radars broadcast at a frequency of 16 MHz. This configuration allows for the measurement of ocean wave fields.

Overcoming numerous administrative and environmental difficulties, a team comprised of employees of the OGS. and UH managed to make all three radars operational. Maps of radial currents are being produced at intervals ranging between 20 minutes and one hour. These radial maps are combined to produce maps of surface currents on a uniform grid with 2 to 3 km spacing. The radar data include information about surface currents at a variety of scales, from tides to the seasonal signal. Surface wave parameters (peak direction and significant wave height) can also be extracted from the Po delta radar data.

For a more detailed explanation of how ocean radars work please visit: <http://radlab.soest.hawaii.edu/hfradar/introdocs/principles.html>



The Adriatic radars and their approximate coverage

Shanghai Environmental Delegation Visits Honolulu

WRRC faculty members Dr. Clark Liu and Mr. Philip Moravcik were part of a group recently invited to meet with a delegation from the Shanghai Environmental Protection Bureau (SEPB) who were in Honolulu to sign a memorandum of understanding (MOU) on cooperation in the fields of environmental protection and technologies between Shanghai and Hawaii.

This event, held in the Lieutenant Governor's office, was organized by the state Department of Business, Economic Development and Tourism. In recent years Shanghai, China's leading economic and commercial center, has been working hard at and making substantial investments in pollution control.



L to R; Phil Moravcik-UH, Charlie Kinoshita-UH, Xu Zuxin-SEPB, Steve Brettschneider-DBEDT, Clark Liu-UH



View of Shanghai in 2002

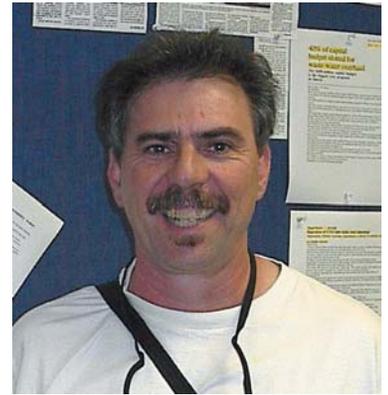


The MOU is an initiative meant to establish ties with this rapidly developing city, with an eye to establishing business agreements for Hawaii-based environmental concerns. Lieutenant Governor Duke Aiona greeted the delegation of seven visitors. He and Dr. Xu Zuxin, Director of the SEPB, signed the memorandum and then the assembled representatives of local environmental consulting businesses and UH had an opportunity to discuss with the delegates the environmental problems facing Shanghai and possible future collaborative efforts in environmental management.

Statewide Watershed Project: Background Data for Watershed Restoration Plans

By Peter Rappa, Environmental Center Researcher

The Environmental Center, an administrative sub-unit of WRRC, began a project late last year to assist the Hawaii Department of Health (DOH) gather information on seven Category I (“in need of restoration”) watersheds for the eventual purpose of developing management plans to address polluted runoff. This project is part of a larger DOH effort to implement Hawaii’s plan for polluted runoff control. The DOH requires background data on the causes of water pollution and resources degradation in seven key watersheds located throughout the state: (1) Hilo Bay, Hawaii; (2) Kahului Harbor, Maui; (3) Kihei, Maui; (4) Kaiaka-Waiialua Bay, Oahu; (5) Kahana Bay, Oahu; (6) Waimea Bay, Kauai; and (7) Hanapepe Bay, Kauai.



Peter Rappa

The Environmental Center’s team is led by Peter Rappa, Principal Investigator and Project Manager; Mr. Eric Yamashita, GIS Coordinator; and Dr. Jacquelin Miller, Project Co-Investigator. To gather information on each of the seven watersheds, the Environmental Center is going right to the source, the people who live in the watersheds, to involve them in identifying problem areas and possible solutions. The Environmental Center has recruited coordinators for each of the four islands to identify and work with local stakeholders. Island coordinators include Trish Macomber on the Big Islands, Brian Pellin on Maui, and Adam Asquith on Kauai.

For each watershed an advisory group was assembled from residents and non-residents with an interest in cleaning up the watershed. The advisory groups help identify problems areas in the watersheds. They also act as sounding boards and partners for assessing potential corrective measures which might become part of a restoration plan in the next phase of the project.

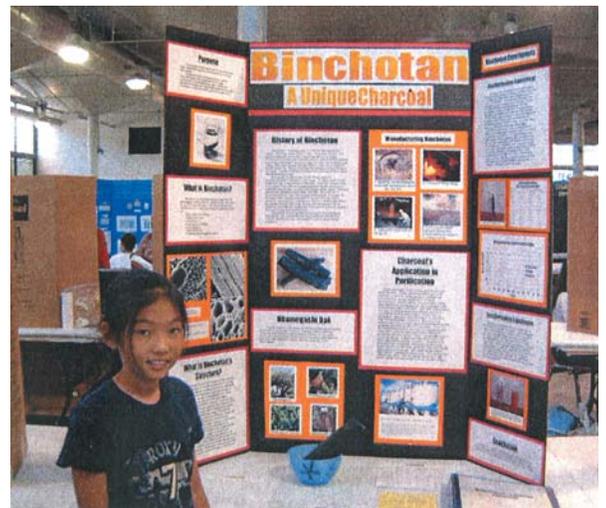
In the next phase the Environmental Center will identify the causes of water pollution and resource degradation, identify actions that can be taken in order to correct the problems, and list milestones that could be used to measure the progress the restoration actions for each of the watersheds. Development of the Watershed Restoration Plan is planned as a follow-up activity under a different contract.

The Environmental Center is developing a webpage to display all the types of data being gathered in each of the areas. The webpage will also include information on watershed meetings in each of the seven watersheds. The website is located at: <http://www.hawaii.edu/envctr/watershed/>. The project will be completed by July 2004.

WRRC Faculty Helps State Science Fair Participant

WRRC’s Technology Transfer Specialist Philip Moravcik recently had the opportunity to assist Iolani School sixth-grade student Mirabel Koike with her State Science Fair poster entitled “Binchotan – A Unique Charcoal”.

Mirabel researched and presented information about “Binchotan,” a type of high quality charcoal that is widely used in Japan for a variety of purposes. Mirabel’s work focused on this charcoal’s ability to purify water. She conducted a pair of experiments, one to demonstrate the coal’s capacity to remove chlorine from water and the other to determine if it could remove color from water. Mirabel worked extremely hard on her research and poster, and she won third place in the “Junior Demonstration” category. In addition to this honor Mirabel won a \$100 savings bond from the Hawaii Department of Health Drinking Water Branch for having the “Outstanding Individual Junior Research Project in any subject category related to groundwater and drinking water.” The State Science Fair is “an enrichment program which stimulates interest in science and engineering and encourages entry into a science related career.” It is organized by the Hawaii Academy of Science. More than 6,000 grade 6-12 students statewide participate in this annual event.



Mirabel Koike and her winning poster

For more about the State Science Fair go to: <http://www.hawaii.edu/acadsci/>

SWAP Project Wrapping Up; continued from page 2...

Once the CZDs were established, team members identified potentially contaminating activities (PCAs) within these zones. This involved acquiring and analyzing existing data layers showing land use; searching of business directories, maps and telephone records; and undertaking a limited number of site visits to the CZDs to clarify questions which arose from analysis of the collected datasets.

Each PCA was assigned a score (low, medium, high or very high), depending on the relative seriousness of its potential to contaminate the source water.

Finally, each source was assigned a score based on the cumulative scores of the PCAs identified within that source's CZD.

Reports that include maps of each CZD, lists of PCAs located therein and scores for each CZD have been delivered to the Hawaii Department of Health and are being distributed to all the water utilities in the state to aid them in their drinking water source protection efforts.

As a follow up project, the research team has been awarded a grant to update and maintain the SWAP. The project started in late April and will continue for a year. The main tasks include updating the information based on new data, correcting errors, and addressing model and data uncertainty.



The SWAP team and the reports produced for the project

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