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August 21, 2014

VIA EMAIL

Sina Pruder, P.E.
Chief
Wastewater Branch
Environmental Management Division
Department of Health
919 Ala Moana Blvd., Room 309
Honolulu, HI 96814

Re: Additional Comments re Hawaii Dairy Farms' Waste Management Plan, dated July 23, 2014

Dear Ms. Pruder:

This letter supplements our letter of August 11, 2014. In our prior letter, we presented preliminary comments on behalf of Kawailoa Development LLP ("Kawailoa") regarding Hawai'i Dairy Farms' Waste Management Plan ("Plan"), dated July 23, 2014, for its proposed dairy farm ("Dairy") in Māhā'ulepū, Kaua'i.

At the time that we submitted our first set of comments, some of our experts were simply not available due to previously scheduled travel commitments. The comments that are now submitted with this letter are in addition to those submitted earlier.

Comments of Mark Madison.

Preliminary comments of Mark Madison of CH2M HILL are attached as Exhibit B. CH2M HILL is a global engineering and consulting firm. Mr. Madison is an agricultural, environmental and civil engineer, and senior project manager with CH2M HILL. He holds a B.S. in Agricultural Engineering from Oregon State. Mr. Madison specializes in managing soil, water, plants, and nutrient relationships for wastewater reuse, wetlands treatment, and agricultural production. His CV is attached as Exhibit A.

We appreciate that the Department of Health ("Department") has allowed and will consider all comments by our experts. Mr. Madison's comments serve to underscore the

importance of comments from the public on this proposed project. As set forth in his comments, the current Plan does not address the significant non-point source discharges from dairy operations, including run-off and groundwater recharge. The current Plan does not use appropriate technology, let alone the best available technology. The current Plan does not address the effect of the Dairy's operations on Kaua'i County water wells, shown on page 9 of the Plan.

The wells are significant because according to a water quality report by the Kaua'i Department of Water, at least two sources of drinking water, Koloa Wells F and C, are close to the Dairy's boundaries. The water quality report is attached as Exhibit C. Although the Plan states on page 8 that the Koloa F well is "located over ½ mile away from the dairy facility site," using the scale of the map on page 9, Koloa F appears to be less than 750 feet from the adjacent grazing paddocks and Koloa C appears to be approximately 750 feet from the farm. Without mention of the proximity to the dairy farm itself, it is disingenuous to imply, as Hawai'i Dairy Farms ("HDF") has done, that the community drinking water wells will not be subject to contamination.

Scope of the Plan.

The planned size of the Dairy is 2,000 cows. The projected size of the Dairy when fully operational is not conditional or speculative; it is clearly and expressly stated by HDF in its Plan: "Hawaii Dairy Farms LLC (HDF) intends to ultimately develop a 2,000-cow dairy in the Mahaulepu Valley at Grove Farm on the island of Kauai." However, HDF now proposes to develop the project in two phases: "Phase 1 will have no more than 699 cows, and Phase 2 will have up to 2,000 cows." While the Plan purports to be for the first phase, it actually seeks approval of the same facilities that will be used in Phase 2. In other words, all of the buildings, ponds, wastewater systems, pastures, irrigation system, graves, etc. are exactly the same. As approval is sought for full build-out, the impacts of the dairy at full build-out must be studied now. Critically, in this Plan, HDF makes no commitment to return to DOH for additional approvals before there are 700 or more cows. The fact that HDF is treating this application as the first of a series of similar applications, without full disclosure of planned impacts, should be reason enough to deny the application.

Conclusion.

Hawai'i Dairy Farms has not made full disclosure of its operations or the consequences therefrom. The Plan contains incomplete, inconsistent and contradictory information, and fails to address significant issues that have a direct impact on the environment of the Māhā'ulepū area, including wells, ground water and nearby Class 1 waters. The HRS Chapter 343 process would allow the public to have an opportunity to identify these critical issues, would allow HDF to respond to them and would inform the Department's decision-making. Hawai'i Dairy Farms does not come close to meeting its burden of demonstrating that

no pollution or harmful environment degradation will occur. The Plan should therefore be rejected by the Department.

Thank you for your attention to this matter. Please do not hesitate to contact me with any questions regarding these comments.

Sincerely,

Lisa Woods Munger

LWM

cc: Edward Bohlen, Esq.
Becky Mitschele, EPA Region 9, NPDES Permits Office
Jun Fukada, Kawailoa Development LLP

Enclosures:
Exhibit A, Mark Madison's CV
Exhibit B, Mark Madison's Comments on Hawai'i Dairy Farms' Waste Management Plan
Exhibit C, Kaua'i Department of Water's Water Quality Report
Exhibit D, Custom Soil Resource Report for Island of Kauai, Hawaii, USDA and NRCS (with Mark Madison's comments)
Exhibit E, Custom Soil Resource Report for Island of Kauai, Hawaii, USDA and NRCS (original version)

Exhibit A

Mark F Madison
Agricultural Engineer

Education

B.S., Agricultural Engineering, Oregon State University, 1979
A.S., Production Agriculture (Irrigation Emphasis), Blue Mountain Community College, 1975

Professional Registrations

Professional Engineer (Agricultural, Environmental, Civil): Oregon, 1983 (No. 12178); Washington, 1985 (No. 022457)
CH2M HILL Certified Project Manager: 1995
Certified Water Rights Examiner, Oregon, 1992 (No. 325)

Distinguishing Qualifications

- Principal technologist with 34 years experience studying, designing, and building irrigation, land application, and natural treatment systems
- Specialized expertise in successful use of tree plantations for phytoremediation, biosolids, and wastewater management
- Specializes in drip, micro-spray, and sprinkler irrigation modeling, design optimization, field testing, and performance monitoring
- Managed design of the worlds' largest contiguous drip irrigation system (16,000 acres) and the world's largest saline water subsurface drip irrigation system (2,500 acres)
- Helped write new wastewater reuse regulations for the Oregon Department of Environmental Quality (DEQ)
- National expert in design of constructed wetlands for wastewater quality improvement that also have mitigation credits
- Managed five national award-winning projects; four in effluent reuse and one in irrigation technology

Relevant Experience

Mr. Madison is an agricultural, environmental, and civil engineer and senior project manager with CH2M HILL's Water Business Group in Rio de Janeiro, Brasil. He specializes in managing soil, water, plants, and nutrient relationships for wastewater reuse, wetlands treatment, and agricultural production. His experience includes site investigation, data collection, modeling, model calibration, design, construction, management, operations, and monitoring and maintenance of irrigation, reuse systems, wetlands and uplands phytoremediation systems. Mr. Madison served on the State of Oregon (USA)Department of Environmental Quality (DEQ) task force that wrote new municipal wastewater reuse regulations. He also served on a task force with the Oregon Department of Water Resources that developed a water marketing law and on a DEQ task force that wrote new industrial reuse regulations. Mr. Madison is an internationally known expert in irrigation, water reuse, and constructed treatment wetlands.

Representative Projects

International

Technology leader; Terracal Food and Biofuels Farm Development; Guadalupe, Brasil. Worked in the Terracal office for over a year assisting the client in the planning, permitting, and conceptual design of a major food and bioenergy

farm. The farm will occupy 35 thousand hectares of non-irrigated land in the State of Piaui near Guadalupe and plans to develop the farm with drip and pivot irrigation. The area will be irrigated for the cultivation of cocoa on 3,000 hectares, sugar cane on 27,300 hectares, and tomatoes on 4,700 hectares-the tomatoes will be in rotation with the cane. Terracal is investing R$ 1.5 billion in the integrated agricultural and industrial processing project to produce ethanol, electricity, sugar, tomato paste, and cocoa. The industrial complex will cover 350 hectares and have three processing plants and multiple warehouses. The sugar mill will grind 3.4 million tons of sugar cane per year and the cane fiber will be fuel for the 135 MW co-generation power plant. The tomato paste plant will render 525 thousand tons of tomatoes per year. The cocoa processing plant will produce 10.5 million tons of cocoa beans annually. The project included development of an agricultural plan, graphical schedule of phasing and construction sequencing, LiDAR survey procurement and oversight, preparing terms of reference for an intensive soil survey and conceptual design of all major facilities of the irrigation system.

Team leader and Resident Engineer; Mahawili System B Irrigation Project; Puntaranus, Sri Lanka. Team leader and resident engineer for this project funded by USAID and the Sri Lankan government. CH2M HILL designed, managed construction, and performed startup operations for the 40,000-hectare irrigation system that included a concrete-lined main canal up to 20 meters wide and 5 meters deep. The canal system has several 5-meter drop sections as it traverses the relatively uneven topography of the lower Mahawili River valley. The canal system construction included sections of blasted cuts in granite bedrock, as well as significant fills and inverted siphons. The sloped canal system has radial gates and re-regulation reservoirs to match supply to demands without operational spills. Distribution canals are unlined earthen canals and were constructed primarily by local farmers that are served by each canal. The irrigation system serves approximately 20,000 subsistence farmers, each with about one hectare of rice paddy and one hectare of upland crops. The startup operations team managed the irrigation system to deliver water through three crop growing seasons. CH2M HILL trained the local water management engineering and technical staff in system operations and monitoring and established maintenance procedures. Our water management training included establishment and training of local farmer user groups on each distribution canal who monitor their own water use and control the main canal turnout gates to their distribution canal and the on-farm water control structures. The on-farm irrigation systems are all gravity flow surface irrigation and shallow flooding with tail-water reused on adjacent fields or returned to re-regulation reservoirs or lower canals.

Project Manager; Kwajalein Atoll Irrigation Pipeline Rehabilitation; U.S. Army; Island of Kwajalein. Managed an island-wide pipeline rehabilitation project for the island of Kwajalein. The project included evaluating and rehabilitating all pipelines in the non-potable irrigation system, potable water system and sewer system for the city of 3,000 people and the military base facilities that support the "Star Wars Missile Defense System" research. The project included master planning and basic field investigations including flow and pressure tests and leak detection, design, construction management, and acceptance testing. Hydraulic models of the systems were developed with EPANET and calibrated with field testing. Pipe segments that were verified to have high friction losses or leaks were sampled and analyzed to determine the integrity of the pipe material so that an appropriate rehabilitation method could be selected for it. Pipeline rehabilitation included the following technologies and construction methods: HDPE slip lining inside cast iron pipe, concrete pipe, and steel pipe; cement mortar lining in-situ in cast iron pipe and steel pipe; pipe replacement with PVC, ductile iron, and lined and coated steel. The irrigation system pipeline rehabilitation work occurred while the system was not in use. The irrigation system was expanded to include a complete new irrigation system on a golf course. The drinking water system was rehabilitated in phases while the system was in service with the use of temporary surface piping to bypass the segments that were under construction. The sewer system rehabilitation also occurred while the system was in service by use of temporary bypass piping and pumping to sewers in adjacent streets. The irrigation system uses all of the treated effluent from the WWTP and delivers it for irrigation as well as toilet flushing to conserve fresh water. The project dramatically improved the island wide water security and sustainability.

Task Manager; Municipal Water System Master Plan and Pipeline Rehabilitation; City of Lviv; Lviv, Ukraine. Lviv is working to restore continuous drinking water service to over one million residents. The break-up of the former Soviet Union left a void in infrastructure maintenance while regions and cities organized agencies to manage critical facilities. The water supply system in Lviv consists of old cracked concrete pipe, cast iron pipe with leaking lead joints, unlined corroded steel pipe, and galvanized steel for the smallest diameter pipe. At the beginning of this project, water was only

available for 12 hours per day for most residents who had enjoyed continuous service only a few years before. The water system master plan recommended an aggressive program of pipe replacement supplemented with a massive rehabilitation program to extend the useful life of failing pipelines. Worked on the hydraulic modeling for the master plan and helped develop the city's first comprehensive computer model using EPANET. Performed site investigations and collected samples of pipeline material for integrity analysis. It was determined that most of the leaking concrete, cast iron, and unlined steel pipelines could be restored with cement mortar lining in-situ. A U.S. contractor and all necessary lining machinery and supplies were imported and worked under Mr. Madison's direction to rehabilitate over 100,000 feet of pipeline. The machinery was transferred to the Lviv Municipal Water Service Company, which continues to line additional failing pipelines throughout the city.

Task Leader; Rainwater Harvesting and Reuse Irrigation for Water Independence; U.S. Embassy; Freetown, Sierra Leone. Led site investigation and concept development for capturing rainwater from building roof tops and storing and treating to provide 100 percent of the domestic water needs of the 280-person U.S. Embassy. Evaluated landscape irrigation system and wastewater treatment plant upgrades to enable reuse irrigation to replace 100 percent of the irrigation water needs within the compound to result in no discharge of effluent. Water shortages in Sierra Leone prompted the Embassy to remove itself from the water supply grid and to stop discharging effluent which was potentially being used as drinking water by locals. Task leader for final design of the project which has become an example of water independence for U.S. Embassies and overseas buildings. Assisted the State Department Office of Overseas Building Operations to modify their specifications and standards to allow rainwater harvesting for drinking water and to encourage effluent reuse for landscape irrigation to reduce the impact of US facilities in foreign countries.

Technologist; Landfill Leachate Irrigation on Poplar Trees; Kumi Landfill; South Korea. Provided technical input into the design of a drip irrigation system to apply landfill leachate to a poplar tree reuse site in South Korea. The highly loaded site is lined to capture percolation water for recycle to treat the maximum amount of Leachate on the available space. Irrigation includes subsurface drip, filtration, and conveyance piping.

Technologist; Phytoremediation of Chemical Processing Plant Site; Dow Chemical; Sarnia, Canada. Designed and provided construction oversight for a phytoremediation site using five species of trees and several planting methods for a chemical processing brown field site. Trees were planted in bore holes up to 10 feet deep and drip irrigated to grow roots into the groundwater for plume control.

QA/QC Reviewer; Post Military Exercise Restoration and Remediation Program; U.S. Army; Al Khobar, Saudi Arabia. Developed concepts for irrigation of desert vegetation in seed beds to reestablish native plants in areas disturbed by military vehicles. Alternatives for water supply include deep wells, tank trucks delivering to reservoirs, and tank trucks directly connecting to the irrigation pipeline. The irrigation system is widely spaced surface and subsurface drip designed with very low application rates to provide water for establishing native plants in seed bank strips perpendicular to wind for natural seed dispersion.

Technologist; Constructed Wetland for Wildlife Habitat and Water Quality Improvement; ICI Canada Inc.; Sarnia, Canada. Converted the former 60-acre gypsum processing prefiltration pond into a pond/wetland system by leveling portions of the former pond bottom, excavating deep zones perpendicular to the flow, installing gravity flow level control structures and underground distribution piping, and adding features, such as wetland shelves and islands. The primary treatment function of the wetlands is to remove phosphorus and gypsum residuals from the industrial process water. The wetland outlet is to the St. Clair River.

Irrigation

Project Manager; Potlatch Corporation Hybrid Poplar Farm; Boardman, Oregon. Managed all engineering assistance to Potlatch Corporation when they purchased the Eastern Oregon Farming Company and Pacific Northwest Farming Company landholdings in Boardman, Oregon, to develop a 22,000-acre hybrid poplar tree plantation. Developed a dynamic hydraulic network model of the irrigation pumping and distribution system (total system demand of 186,000 gallons per minute) on EPANET and calibrated using operational data from the supervisory control and data acquisition (SCADA) system. This model was used to evaluate instantaneous demand from the points of diversion under different

distribution system configurations and operational scenarios, evaluate required facility upgrades, and evaluate energy savings due to facility modifications. The design and construction management of the irrigation system for the poplar plantation rehabilitated the 50 miles of existing pipelines 24 inches in diameter up to 72 inches in diameter with cement mortar lining. PVC pipe was used to expand the system to more than 200 miles of pipeline. The application system was converted from center pivot sprinkler irrigation to drip irrigation. Energy savings from pipeline upgrades and replacements and pump station modifications were verified with this model to authorize payments to Potlatch Corporation from the Bonneville Power Administration Waterwise Program. The project won Engineering Excellence award from the Consulting Engineers Council.

Project Manager; Irrigation System Modification; Boeing Company; Boardman Farms, Oregon. Managed study and upgrade design of the 28,000 acre Boeing Farm irrigation system. Used farm records, design data, field data, and farm and irrigation managers' working knowledge of the system to develop an EPANET computer model of the irrigation system. The model was used to evaluate potential energy-saving modifications of the irrigation system and its operation. The goal of the engineering investigation was to identify cost-effective system modifications that would substantially reduce the energy requirements for irrigation at the Boeing Farm. Modifications were identified to reduce the annual power bill by about 30 percent. The study recommended scheduling irrigation to reduce over-irrigation and to take greater advantage of off-peak power costs. It also recommended adjusting cropping patterns so that a variety of crops grown in the normal rotation would be located on each lateral to reduce the effects of peak water demand by any one crop. The work included design of rehabilitation and betterment upgrades to the irrigation system.

Project Manager; Fresh Water and Wastewater Irrigation System Development; Madison Ranches; Echo, Oregon. As CH2M HILL project manager, provided engineering design services for development of a combined freshwater and wastewater irrigation system at his family's farm—Madison Ranches. Madison Ranches received a water right from the Columbia River to irrigate 10,000 acres. The project, to develop the first 6,000 acres for irrigation, began in 1990 and irrigation was phased in over 10 years. Madison Ranches uses an existing river supply from the Columbia Improvement District. A major relift pump station was built on the district's irrigation canal to pump into the farm's penstock. A looped pipeline design was developed to provide greater flexibility of operation. The 10 miles of new pipeline system includes steel, HDPE, and PVC materials and a canal under crossing and a bore and jack casing under crossing of the I-84 freeway. The farm irrigation system also includes four wells and three creek diversions. The irrigation system incorporates the use of wastewater from the Lamb Weston potato processing plant and cooling water from the 440 MW Hermiston Generating gas fired power plant. Isolation valves allow the center pivot circles to use fresh water from the irrigation canals or groundwater aquifers, wastewater from the Lamb Weston plant and power plant, or a combination of fresh water and wastewater. CH2M HILL provided engineering design services for all pipeline and pump station design. Provided specification of all irrigation sprinklers and equipment, coordinated the design with crop rotations and wastewater reuse scheduling, and assisted Lamb Weston and Hermiston Generating in obtaining DEQ permits to apply their wastewater on 6,000 acres of the Madison Ranches.

Project Manager; Irrigation System Improvements; Sandpiper Farms Inc.; Paterson, Washington. Sandpiper Farms irrigates 5,000 acres with five 1,500-horsepower (hp) pumps lifting water from the Columbia River. Managed the team that evaluated the irrigation system and pump plant design as part of a master plan to reduce energy consumption as a participant of the Bonneville Power Administration's Water Wise conservation program. A hydraulic model of the system was developed to simulate various modifications and identify bottlenecks in the piping system. The selected option for pump station renovation involved modifying two of the 1,500-hp pumps to draw 1,200 hp and installing a variable speed drive on a third 1,500-hp unit. Other options provided similar energy savings, but the variable-speed drive option was chosen because it could automatically adjust to changes in flow and pressure requirements—greatly simplifying system management. Operations of a peaking reservoir were also evaluated. Pipeline modifications, including expansion of the service area, were modeled, and CH2M HILL prepared preliminary designs. Improvements to the pumping and water distribution systems reduced the power required to deliver the same volume of water by approximately 25 percent. The total project engineering and equipment cost was paid back in two years through substantial energy savings.

Project Manager; Irrigation System Efficiency Assessment and Improvement Study; Hawman Farms; Hermiston, Oregon. Managed an irrigation system efficiency assessment and improvement study of the 2,500-acre Hawman Farms located near Hermiston. The work included developing a master plan recommending alternatives that would reduce

energy requirements of the pumping and water distribution system. The irrigation system consists of two pump stations used to lift the water from the McNary pool of the Columbia River over 650 feet vertically. The network of pipes includes pipe diameters ranging from 30- to 4-inches. Most of the large-diameter main line was cement-mortar-lined, and some laterals were replaced with PVC pipe to rehabilitate failing sections of the system and to improve flow as part of the plan's recommendations. A computer model created to simulate the operation of the irrigation system used farm records, as well as design and test data. This model was then used to investigate alternatives for reducing energy costs and sizing new pipelines. The recommended improvements reduced the pumping energy requirements by 19 percent. The primary recommendations were to install new PVC laterals, cement mortar line large unlined steel pipe, install a small booster pump station, repair the booster pumps so that they produce original design pressure at the existing flow rates with better efficiency, modify the river pumps to produce less pressure to match the modified system requirements after all system improvements have been implemented, and manage the system with irrigation scheduling so that minimum peaking of water demand occurs.

Project Manager; Eastern Oregon Farming Company; Boardman, Oregon. Managed the CH2M HILL team that redesigned an existing 10,500-acre pivot irrigation system to improve operating efficiencies. The system was originally designed to use 23,350 horsepower (hp) located in five pump stations. The redesigned system required only 17,000 hp to deliver an adequate volume of water, resulting in a peak hp reduction of 30 percent over the original design. Operator training in irrigation scheduling, water management, and efficient system operations further reduced the energy consumption. After the system modifications, the farm irrigated the same acreage with approximately 50 percent less energy than was required before system modifications and operation improvements. The total cost of the project, including engineering and equipment modification, was equal to the amount of the energy savings in the first year.

The redesign recommended irrigation scheduling, lower sprinkler operating pressure, improved pipe, valve, and manifold designs, and major pump station modifications. CH2M HILL also provided specifications for pump modifications, and testing and inspection for installation and startup. A model was developed and used to command the farm microcomputer to access data from a local weather station and recommend an irrigation schedule for each field. CH2M HILL and Eastern Oregon Farming Company were jointly awarded The Irrigation Association's National Award for Water and Energy Conservation.

Irrigation Technology Lead; Owens Lake Dust Mitigation Program; Los Angeles Department of Water and Power; Inyo County; California. Managed design of a system for drip-irrigated saltgrass production. Project required site investigation, irrigation projections for salt management, monitoring, and designing a buried drip irrigation system over 4.75 square miles of dry lakebed. Developed water demands for shallow flooding and drip-irrigated saltgrass dust control measures for water resource planning, using local climate and soils data and plant growth and salt response criteria to generate project water requirements. Final water demand estimates were used to size a water conveyance system serving a 16.5-square-mile area and a separate conveyance system serving a 22-square-mile area. Also developed conceptual design and design-build-operate bid documents for the irrigation and drainage components of a 13.5-square-mile shallow flooding dust control project. Provided design review throughout final design and construction phases. Worked as part of a multiagency research team developing objectives and refining plot designs for efficient reclamation of saline sodic soils and establishment of saltgrass on the lakebed.

Project Manager; Pacific Islands Phytoremediation Project; U.S. Army Corps of Engineers; Hickam Air Force Base, Honolulu, Hawaii. Managed developing water balance and designing and installing an irrigation system, primarily a drip irrigation system, with one spray-irrigated plot of native trees and shrubs. The project was delivered as design/build. The project included a research component with the University of Hawaii to determine which native plants were most effective in phytoremediation of petroleum products that resulted in the University being awarded a patent. The plants were installed with 5 innovative planting methods to place the roots in petroleum contaminated soil above and below the sea water aquifer. The project continues to remediate the site of a tank farm leak.

Technology Lead; Drip Irrigation System Design;Black Rock Ranch; Moxee, Washington. Designed a drip irrigation system complete with filters and pump stations for 500 acres of apple orchards at Black Rock Ranch near Moxee, Washington.

Project Manager; Rehabilitation and Betterment of Irrigation Facilities; Crown Zellerbach; Boardman, Oregon. Evaluated an 8,000-acre sprinkler irrigation system for rehabilitation and conversion to drip irrigation. The evaluation included disassembly, inspection, and reassembly of a 6,000-hp pump station, and corrosion evaluation of penstocks and main lines. Corrective action was recommended for removal and prevention of a sand bar that had formed around the pump station. A computer model was used to evaluate the performance of the existing distribution system when converted to supply drip irrigation.

Tree Reuse Systems

Project Manager; Poplar Tree Water Reuse Demonstration System; City of Woodburn; Woodburn, Oregon. Designed, built, and operated a four-acre demonstration site at the city's wastewater treatment plant to establish design criteria for a 320-acre full-scale poplar tree water reuse system installation. This demonstration site was the first poplar tree effluent irrigation site in Oregon and was used to establish the agronomic irrigation rate for poplar in a joint research project with Oregon State University. The prototype installation features land application of effluent from the secondary treatment system using an irrigation system with low-pressure, mini-sprinklers to irrigate the tree/grass ecosystem. Design variables tested at the site include various drip, sprinkler, and spray irrigation, poplar tree varieties, tree planting densities, and irrigation loading rates. The monitoring effort includes climatic data, soil moisture measurements throughout the tree rooting zone, quantity and quality of wastewater, quality of soil water, plant tissue analyses, and soil analyses for nutrients and waste stream constituents. This innovative project won an Honors Award for Engineering Excellence from the American Consulting Engineers Council.

Project Manager; Full-Scale Poplar Tree Water Reuse System; City of Woodburn; Woodburn, Oregon. The full-scale system was completed at a cost nearly 50 percent less than tertiary treatment or conventional reuse. Evaluated use of food processor wastewater for irrigation to reduce the peak loadings discharged to the city's wastewater treatment plant (WWTP). The evaluation included meetings with food processors, cooperative farmers, and WWTP staff to coordinate reuse objectives. Potential application sites were evaluated to determine acceptable loading rates and management practices. Also prepared a feasibility analysis and design, construction management, and permitting for the project. The new total maximum daily load (TMDL) for the Pudding River limits dry season effluent discharge. The reuse system includes 84 acres of trees, a pump station, and other improvements.

Technology Lead; Poplar Tree Water Reuse Demonstration System; Oremet Titanium; Albany, Oregon. Worked with Oremet, city of Albany, and the Oregon DEQ to design, install, manage, and monitor a five-acre poplar tree water reuse demonstration system. Identified criteria for developing an approximately 70-acre tree reuse site to consume the water and nutrients in the industrial waste during the growing season. Salts are stored in the soil during summer and collected in a drainage network in the winter months when the soil is saturated. This drainage water is discharged through the existing wetlands system during high flow periods of Oak Creek, allowing Oremet to be in compliance with the modified National Pollutant Discharge Elimination System (NPDES) permit. The five-acre demonstration site has automated micro-spray irrigation, drip irrigation, and a 10 foot deep drainage network.

Project Manager; Wastewater Effluent Reuse on Poplar Trees; Weyerhaeuser; Klamath Falls, Oregon. Designed, installed, managed, monitored, and analyzed a prototype installation featuring land application of effluent from Weyerhaeuser's industrial wastewater treatment system to determine design variables for a larger-scale system for effluent reuse. Variables tested at the site include various poplar tree varieties, tree planting densities, and irrigation loading rates and management techniques. The monitoring effort included climatic data, soil moisture measurements throughout the tree rooting zone, wastewater quantity and quality, soil water quality, plant tissue analyses, and soil analyses for nutrients and waste stream constituents.

Project Manager; Poplar Tree Irrigation System—Riverbend Landfill; Waste Management, McMinnville, Oregon. Designed the irrigation system for 55 acres of poplar trees planted at the landfill. The trees, soil, and microorganisms effectively remove nutrients and other contaminants from up to 12.6 million gallons of leachate annually. The project uses under-the-tree precision sprinkler heads and drip irrigation to irrigate the ground evenly to prevent runoff and promote adequate infiltration. The sprinkler heads discharge large droplets of water, rather than a finely atomized spray, to minimize the volatilization of leachate and reduce odors. A fully automated monitoring system allows Waste

Management to effectively manage the leachate generated annually at the site with zero discharge. This project won the National Engineering Excellence Award from the Consulting Engineers Council of Oregon and the American Consulting Engineers Council.

QA/QC Reviewer; Hardwood Trees Effluent Reuse Evaluation; Georgia-Pacific Paper Mill; Palatka, Florida. Evaluated potential for using hardwood trees to treat wastewater effluent from the mill. Conducted pilot studies to determine effectiveness of growing engineered short-rotation, intensive-culture hardwood trees for uptake of nutrients and increased water use.

Wetland Treatment Systems

Project Manager; Talking Water Gardens Low-Energy Passive Effluent Cooling Project; Albany, Oregon. CH2M HILL evaluated the potential temperature reduction capabilities of a constructed wetland and developed an explicit energy balance model for evaluating constructed wetlands and successfully calibrated the model to flow and temperature data collected from another constructed wetland. The wetland system is the nation's first constructed wetlands designed to further treat a unique combination of treated municipal wastewater and industrial effluent, and resulted in the first design model developed specifically for designing constructed wetlands for water cooling. The wetlands polish the water to remove metals and nutrients to levels that allow river discharge as well as discharge through the bottom on the wetland into shallow groundwater that provides hyporheic discharge to the adjacent lakes through springs and seeps to provide cool water to the lakes. The wetland system functions to educate and inform the public (the "talking waters") and the regulatory community about the benefits of wetlands treatment to reduce thermal loads and other pollutants. The wetlands are designed for phosphorus, nitrogen, sediment, and temperature reduction of warm effluent from the Albany-Millersburg WWTF and a large rare metals processor. The project was awarded federal stimulus funding. The constructed wetlands will treat an unusual mix of 26 different effluent constituents that were proven to have a synergetic treatment benefit when tested in pilot scale wetlands. This project won the National Grand Conceptor Award from the American Academy of Environmental Engineers.

Principal Engineer; Owens Lake Dust Mitigation and Wetlands Project; Los Angeles Department of Water and Power; Keeler, California. Principal engineer for planning, design, services during construction, and operations support for restoration of approximately 50 acres of shoreline saturated alkaline meadow wetlands and fresh water spring mounds or moist alkaline meadow wetlands. The project included development of flood and drip irrigation systems over more than 12,000 acres to mitigate dust emissions from the dry lakebed surface while protecting and enhancing existing wetlands and sensitive Snowy Plover nesting habitat areas. Served as the principal engineer for design, services during construction, startup, and operations support. Approximately 300 acres of the drip irrigated salt grass meadow is being managed and monitored as mitigation dry alkaline meadow wetlands. All of the wetlands plants are being propagated from seed of native plants collected in the immediate vicinity and replicated on a seed farm developed by the project.

Technology Lead; Natural Treatment System for Phosphorus Removal; RUSA; Roseburg, Oregon. Provided technology input to develop the first large-scale natural treatment system to remove phosphorus from municipal effluent to below 0.05mg/L. The 340-acre farm owned by RUSA is now a treatment process unit of the wastewater treatment facility and uses constructed wetlands, agronomic rate and high rate irrigation, and 60 acres of restored natural wetlands for infiltration of effluent into clay soils that bind phosphorus. The treatment process discharges clean water into an ephemeral stream from the hyporheic zone along both sides of the stream with more than three miles of diffuse stream bed springs. The treatment process removes about 100 pounds per day of phosphorus from effluent that was previously discharged to the South Umpqua River. The treatment process includes natural wetlands and is a landmark project in that the restoration of the natural wetlands with effluent provides mitigation credits for the uplift in ecosystem function and treatment benefits.

Project Manager; Wetland Treatment Demonstration Project; Pope & Talbot; Halsey, Oregon. Managed the design, construction, and startup services. Project was developed in partnership with Oregon State University as a field laboratory for the demonstration of wetland treatment technology and ongoing research. The system includes a pump station, water control structures, and ten separate wetlands with variable flow rates and plant management regimes.

One cell is a subsurface flow wetland with rock media. The system reuses paper mill effluent and polishes it before river discharge. This project is the oldest research wetlands in the state of Oregon.

Project Manager; Demonstration Natural Reclamation System (NRS); City of Salem; Salem, Oregon. Designed a wetland treatment demonstration project that compares three NRS technologies: overland flow wet meadow wetlands, vertical flow subsurface wetlands, and surface flow wetlands. Goals of the demonstration project include summer temperature, phosphorus, and ammonia reduction, creating new wetland habitat for wildlife, and improving water quality. The project also is providing a new source of class A agricultural and golf course reuse water, in conjunction with the Title 16 U.S. Bureau of Reclamation program which funded 25 percent of the construction cost. The class A reuse water is produced by adding alum, sedimentation, filtration, and disinfection in series after the wetlands treatment system. This system has been in operation for 10 years and has the most robust data set in Oregon on operations and water quality.

Technology Lead; Wetlands for Phosphorus Removal; City of Boise; Boise, Idaho. Developed a Wastewater Facilities Plan Amendment that evaluated constructed wetlands for cooling, effluent polishing, and phosphorus removal for the West Boise wastewater reclamation facility. Developed and evaluated innovative treatments of wastewater, including constructed treatment wetlands for secondary effluent with hyporheic discharge and soil treatment to allow no surface discharge.

Senior Technologist QA/QC Reviewer; Facilities Plan through Final Design; Treatment Wetlands and Poplar Tree Irrigation Expansion; City of Woodburn; Woodburn, Oregon. Feasibility evaluation and design of constructed treatment wetlands for phosphorus and ammonia removal and cooling as a final filter after the wastewater treatment plant. The 27 acres of constructed wetlands in the flood plain provide effluent polishing before river discharge from May through October and are designed to be flooded each winter without damage. Permitted and designed the 40-acre second phase of expansion for the poplar irrigation site.

Task Leader; Treatment Wetland System Feasibility Review; South Suburban Sanitary District; Klamath Falls, Oregon. Feasibility review/conceptual design for treatment wetland construction next to municipal wastewater treatment facilities to polish effluent before river discharge. Surface flow treatment wetlands were evaluated to further remove nutrients and naturalize the effluent before river discharge.

Technology Leader; Wetland PreDesign; Clean Water Services; Hillsboro, Oregon. Sited, designed, and provided field investigation oversight for a 350-acre wetland for water cooling and phosphorus and ammonia removal in a water-quality limited basin. The predesign included meeting with stakeholders and regulators to address permit and public acceptance issues. The site is located in a two-year floodplain and discharges into the Tualatin River. A peat filter cell is used to enhance metals removal and is followed by a series of treatment wetlands to further filter, polish, and cool the water.

Technology Leader; Tualatin River Wetlands Mitigation; Hillsboro Landfill; Waste Management, Inc; Hillsboro, Oregon. Delineation of river floodplain wetlands before their phased filling by a landfill expansion, with wet-lands restoration and creation as mitigation, design, construction oversight, and monitoring. Developed 25 acres of constructed wetlands for stormwater treatment and mitigation for expanding the landfill. The wetlands system included a 100-acre-foot stormwater detention pond and four wetlands cells for specific habitat and treatment. The project improved the water quality of the Tualatin River and augmented summer flows in the water quality and quantity limited watershed.

Project Manager; Sycan Marsh Restoration; The Nature Conservancy; Beattie, Oregon. Managed design and construction services to facilitate the restoration of the original hydrology and native plant communities of the 25,000-acre Sycan Marsh in the headwaters of the Klamath River Basin. Included construction of three large water control structures in the 800 cfs Sycan River. Tasks included landowner coordination, site survey, hydrology and soils evaluations, hydraulic modeling, hydraulic control structure design, services during construction, and post-construction and system performance evaluation.

Principal Engineer; Williamson River; River Delta Restoration Alternatives; Oregon. Principal engineer for evaluation of alternatives to restore the Williamson River Delta in Klamath Lake to historic wetland conditions for endangered species fish spawning and rearing. Evaluated impacts of flooding, sedimentation, and agriculture on water quality and habitat values.

Project Manager; River Diversion Structure Assessment; The Nature Conservancy; John Day River, Oregon. Managed impacts assessment of a river diversion structure and field assessment of structure and impacts on river channel. Developed alternatives for structure removal.

Biosolids Land Application

Technology Leader; Wastewater Irrigation System, Idaho State Penitentiary Farm; Boise, Idaho. Provided site evaluation and designed a system to develop barren land for agricultural production. Project used municipal wastewater for irrigation and biosolids application for soil amendment and fertilization.

Technology Leader; Lagoon Biosolids Utilization Plan; City of Portland; Portland, Oregon. Developed the plan that provided characterization and inventory of the 63,000 dry tons of biosolids to be used. Developed alternatives and cost estimates for removing biosolids from the lagoon, transportation, and land application. Recommended uses included land application on food-chain crops, non-food-chain crops, and reclamation sites for various qualities of biosolids. Prepared specifications and contract documents and assisted the City to solicit bidders.

Technology Leader; Boise Twenty Mile South Farm Biosolids Reuse Project; Boise City, Idaho. Principal technologist for farmland biosolids application from two wastewater treatment plants. Included developing a Biosolids Management Plan, determining the best type of irrigation system for the farm and establishing operating criteria, and designing the irrigation system. Initially, biosolids applications were thickened liquid from an interim post digestion thickening facility. Dewatered biosolids cake has been applied since 1996, when the permanent dewatering facility came on line. Currently 1,000 acres receive biosolids. This project won the Consulting Engineers of Idaho Engineering Excellence Award.

Task Leader; Biosolids Land Application Program; Blue Plains Wastewater Treatment Plant; Washington, D.C. Determined land requirements for a 20-year program of biosolids land application. The plant land-applies 130 dry tons per day now and will expand to 200 dry tons per day in 20 years. The project included working with regulatory agencies, land application contractors, and biosolids generators to evaluate existing programs and make recommendations for ongoing land application.

Task Leader; Biosolids Land Application and Lime Stabilization; City of Rochester; Rochester, Minnesota. Prepared specifications and contract documents for lime stabilization and land application of municipal biosolids. The purpose of the documents was to retain a contractor to augment the city's ongoing land application program. This required careful coordination at the treatment plant and the city's land application farm. The contractor was also required to develop additional application sites, as well as stabilize, transport, and land-apply biosolids.

Technologist; Biosolids Land Application; City of Manhattan; Manhattan, Kansas. Due to operational difficulties, including over-application of biosolids, the city evaluated the potential for implementing irrigation capabilities at its biosolids farm. If implemented, irrigation would help maintain steady crop growth, providing flexibility for farm use. With the planned improvements, which include procuring or leasing additional land for biosolids application, the city can continue to use the biosolids farm for land application throughout the identified planning horizon.

Technologist; Biosolids Land Application; Cities of Minneapolis and St. Paul, Minnesota. Developed a computer program to recommend and size various systems and equipment for land application of biosolids.

Technologist; Biosolids Land Application; Water Environment Services;Clackamas County, Oregon. Designed transportation and land application systems to use municipal biosolids for agricultural production. Evaluated expansion of the biosolids program to include dewatered biosolids and transportation to arid regions of the state for winter application.

Technologist; Biosolids Land Application; City of Seattle; Seattle, Washington. Evaluated sites and designed storage, transportation, and application systems used to apply municipal biosolids from the city to forest lands.

Technologist; Biosolids Application for Agricultural Use, Multiple Clients. Designed land application and livestock feeding systems to use food processing waste streams and biosolids for agricultural production for Ore-Ida in Ontario, Oregon; Wise Foods in Berwick, Pennsylvania; and Frito Lay in Frankfurt, Indiana. Also completed conceptual layout, design, and construction supervision for all-weather transportation and livestock feeding facilities to use cheese whey from the country's largest mozzarella cheese plant in Waverly, New York.

Wastewater Reuse Systems

Technology Lead; Wastewater Irrigation Site Improvements—Forest Grove Wastewater Treatment Plant; Clean Water Services; Washington County, Oregon. Developed a conceptual plan for recycled wastewater irrigation site improvements. The plan recommended tree plantings for a forested perimeter buffer strip, demonstration plots, site expansion, and irrigation system improvements. Also assisted with developing wastewater facilities plan and treated wastewater reuse master plan, primarily identifying user needs and concerns. Participated in user interviews, surveys, and public meetings.

Project Manager; Wastewater Reuse Irrigation System; City of Madras; Madras, Oregon. Developed wastewater reuse irrigation system for a golf course and 1,200 acres of irrigated area. Helped develop the reuse plan and get DEQ permits for the project. CH2M HILL improved the plant to produce Class A for reuse.

Project Manager; Wastewater Reuse Feasibility Study; City of Hermiston; Hermiston, Oregon. Led CH2M HILL's team in evaluating the option of improving treatment plant capacity for phosphorus and other nutrient removal to meet impending discharge standards for the river at low flow during the summer months. Alternatives evaluated included reuse of wastewater for land application and crop production to eliminate or significantly reduce river discharge during dry months, or constructing additional treatment facilities to meet TMDL discharge standards. The land application system allowed the existing facility to continue to operate in compliance for an additional 10 years.

Project Manager; Wastewater Reuse Irrigation System; Lamb-Weston, Inc.; Hermiston, Oregon. Prepared a feasibility study, hydraulic model, and design of a 5,500-acre wastewater reuse irrigation system. Also provided construction observation startup assistance and performance monitoring and obtained DEQ wastewater reuse permits for the project. The reuse system includes improvements at the 3-million-gallon-per-day (mgd) WWTP for greater solids and nutrient removal, four pump stations, more than 20 miles of pipeline, irrigation systems, a freeway crossing, and a canal crossing. The system is designed for year-round operation. The new reuse system coordinates with the existing 750-acre reuse farm for agronomic loading rates on all sites.

Technology Lead; Municipal Reuse Irrigation System; Acoma Pueblo; Acoma, New Mexico. Led master planning, site investigation, and design team for this two-year project to provide a low-cost, low-maintenance reuse system to handle sewage flows from the existing community and handle expected growth in the area. The Acoma Pueblo sewage treatment, storage, and evaporation lagoons were unable to adequately handle existing sewage flows. The wastewater master plan identified land application of the wastewater to a nearby field as an acceptable alternative for reusing the wastewater and reducing the volume of water that must be evaporated from the lagoons. CH2M HILL designed and provided construction services for the pump station, mainline, and irrigation piping. The pipeline design included directional drilling to install HDPE piping under a river and irrigation canal and a bore and jack crossing under the main highway. The irrigation system piping was HDPE and PVC.

Stormwater and Drainage

Technologist; Watershed Storm Sewer System; Arlington, Texas. Designed a complete storm sewer system for a 50-acre paved industrial site and surrounding watershed for a 6-inch-per-hour design storm. Design included overland flow routing, detention, and collection of surface water and downspouts into a network of graduated-size storm sewers up to 54 inches in diameter. Also designed an open channel and structures for final discharge from the site.

Technologist; Industrial Stormwater and Transmission System; Tualatin, Oregon. Designed a stormwater collection and transmission system for a 40-acre industrial development. The system included inlets, gravity pipe, pressure pipe, open channels, culverts, and a detention pond. The system is designed to accommodate expansion of the site up to 160 acres without replacing existing facilities.

Technologist; Surface Drainage Control Plans, Wyoming and Oregon Sites. Developed a surface drainage control plan including runoff detention and routing, erosion control, and disturbed area stabilization for a large surface coal mine in Antelope, Wyoming. Prepared a similar plan that included rerouting of a stream for a future landfill site in the Oregon Coast Range.

Water Management Plans

Project Manager; Sycan Marsh Water Management Plan; The Nature Conservancy; Beatty, Oregon. Performed extensive site investigations, including aerial inspection and ground survey, of the 25,000-acre Sycan marsh. Existing structures and channels were inspected to determine how they could be modified and used in the Water Management Plan. The objective of the plan was to improve nesting habitat for Sand Hill Cranes in the spring by maintaining a proper water depth and to allow dewatering after the nesting period to produce the maximum amount of grass for livestock feed during the summer and fall. Project required developing hydrology and flow data and detailed maps. Installed and monitored gauging stations in five streams that feed the marsh. Maps and applications were prepared for filing of water rights.

Maduru Ova System B Irrigation Project, Sri Lanka. Team leader and water management engineer for 15 months on a USAID-funded project to provide technical services for the irrigation system. The project involves 28,000 hectares of irrigable land. It is the only concrete-lined canal system in Sri Lanka and includes 120 kilometers (km) of lined canal with a capacity up to 65 cubic meters per second and 2,100 km of unlined distribution and field canals. The sloped canal system is manually operated and requires careful monitoring, operation, and maintenance to perform properly. The System B project established, equipped, organized, and trained the local staff to assume responsibility for water management, operation, and maintenance. It also established a unit to monitor operating efficiency.

Water Supply

Project Manager; Water System Optimization Analysis; Maui Electric Company (MECO) and County of Maui; Maui, Hawaii. Evaluated the county's upcountry water system to identify alternatives for operations optimization that could reduce peak demands. The study identified a potential savings in peak energy use of 1.1 megawatts. Trained MECO staff in computer modeling and analysis of large water systems. Together developed a detailed computer model of the complex water system to simulate existing and proposed system operations. The model was used to develop a plan for off-peak pumping and reservoir operation to reduce peak period electrical demand and increase the water system delivery capacity. The water supply system that was modeled includes approximately 75 reservoirs, 20 pumps, and many miles of pipeline serving multiple-pressure zones from near sea level to more than 4,000 feet elevation. A plan was recommended to integrate the management of the water and energy systems for the benefit of both MECO and the county's Department of Water Supply.

Resident Engineer; Upper Kula Water Treatment Plant Construction; Maui, Hawaii. Resident engineer during construction of the 1.7-mgd plant. Construction services provided included onsite design modifications, progress monitoring, as-built drawings, an operations and maintenance manual, and construction observation. Construction included new facilities and rehabilitation of an existing 3-million-gallon steel tank and 8.5-million-gallon rubber-lined reservoir.

Technologist; Water Well Construction Inspection; Rockwood Water District; Portland, Oregon. Provided construction inspection for the drilling of water supply wells for the district and for quality control during pipe manufacturing for several large projects.

Technologist; Water Supply and Fish Handling System; Rocky Reach Dam, Columbia River, Oregon. Supervised design and construction of a water supply and fish handling system for fish mortality studies at Rocky Reach Dam on the Columbia River.

Hazardous Waste Management

Lead Technologist; Hazardous Waste Treatment Facility Closure Permit and Cleanup; Waste Management; Arlington, Oregon. Prepared the closure plan, post-closure plan, and financial requirements for the Resource Conservation and Recovery Act (RCRA), Part B permit application for a hazardous waste treatment and disposal facility. Facilities covered by the permit include hazardous waste landfills, surface impoundments, land treatment areas, an incinerator, drum decant and storage facilities, tanks, and all associated equipment and support buildings. Also developed a conceptual plan and operating procedures for a large-scale land treatment system that included soil amendment, moisture control, application, and monitoring systems based on site investigations. The closure plan included detailed design of a closure cap and a revegetation program.

Technologist; Agricultural Waste Drainage Land Application Feasibility Study; Westlands Irrigation District; San Joaquin Valley, California. Performed site investigations and compiled hydrological data to evaluate the feasibility of land application of agricultural drainage water in the valley, which contains high concentrations of boron and selenium. Developed water balance to size storage, blending, and land application systems and provided conceptual designs.

Technology Leader; Land Farm Hazardous Waste Treatment and Permit; Texaco; Anacortes, Washington. Provided site evaluation and prepared the land treatment demonstrations, land treatment program, and land farm design measures and operating practices for the RCRA, Part B permit application for a hazardous waste treatment land farm for an oil refinery. Also developed provisions for unsaturated zone monitoring and a detection monitoring program. Project included rehabilitating an existing land farm and adding another land farm to the treatment system.

Technologist; Contaminated Steel Tank Rehabilitation, Confidential Client. Resident engineer for rehabilitating a 3-million-gallon steel tank previously painted with lead-based paint. The sand blast grit contaminated by the lead paint was by definition a hazardous waste. Followed RCRA regulations in sampling and analyzing the waste. The sand blast grit was tested and approved as a raw product for manufacturing concrete and was collected and used for construction of a parking area. The site was cleanly closed at a relatively low cost.

Wastewater Facility Plans

Senior Consultant; Waipio Wastewater Pump Station Upgrade; City and County of Honolulu; Honolulu, Hawaii. Senior consultant for review of the Waipio Wastewater Pump Station Upgrade project that considered expansion of an existing pump station from 2.5 mgd to 4.3 mgd. Alternatives included replacement of pumps and motors with wet well modifications and construction of a new pump station.

Senior Consultant; Moiliili-Kapahulu Sewer Rehabilitation/Reconstruction; Honolulu, Hawaii. Evaluated methods to increase flow capacity in this critical segment of sewer in Honolulu. The design alternatives report recommendation is for open trench construction of the Date Street Relief Sewer, cured in place pipe lining for rehabilitation of the Moiliili-Kapahulu sewer, and 100 percent solids epoxy coating system for manhole rehabilitation. Senior reviewer for the study.

Technology Lead; Regional Wastewater Facilities Master Plan, Phases 1 and 2; Metropolitan Wastewater Management Commission; Eugene and Springfield, Oregon. For Phase 1, evaluated short-term improvements to increase facility efficiency. Identified several projects to improve process performance and reliability and to reduce operations and maintenance costs. Phase 2 required evaluation of growth and facility siting requirements, long-term water quality regulatory compliance, infiltration and inflow program assessment, determination of treatment plant cost-effective peak capacity expansion, alternative disinfection methods, air quality assessment, risk management, and expansion and diversification of the biosolids management program.

Senior Reviewer; Pearl City Wastewater Pump Station Capacity Study; Pearl City, Hawaii. Reviewed design alternatives and evaluated upgrades. Project needed to add flow for the Waiawa Ridge Development. The recommended alternative of a new 48-inch force main 12,500 feet long with an underwater crossing of West Loch of Pearl Harbor could cost $38 million. A 24-inch relief sewer between the discharge manhole of the new force main and Fort Weaver Road is recommended. This 7,000-foot-long 24-inch relief pipeline could cost $10 million and is needed in 2030. The Pearl City pump station upgrade was estimated to cost $34.5 million and is needed in 2019.

Senior Reviewer; Beachwalk Wastewater Pump Station to Ala Moana Park Sewer Phase 1 Force Main System; Honolulu, Hawaii. Reviewed contract documents for bidding construction to ensure consideration of existing facilities in sensitive soil conditions. The proposed 72-inch-diameter tunnel crosses under the existing 42-inch-diameter force main three times with less than 30 feet of separation. The Beachwalk force main is constructed within a formation that is identified to be liquefiable by strong ground shaking. Liquefaction can occur because of vibratory construction equipment in surrounding soils. Special monitoring and construction procedures will be used to protect existing facilities.

Senior Reviewer; Central Oahu Wastewater Facilities and Effluent Reuse Project, Wahiawa Wastewater Treatment Plant Improvements Plan; Hawaii. An objective of building the membrane bioreactor (MBR) plant is to produce reuse water and stop continuous discharge to Wahiawa Lake. The current capacity of the plant is 2.5 mgd (average daily flow). Initially the Central Oahu Park, along with golf courses and other points of application, will use up to 2 million gallons per day of Type R-1 effluent from the Wahiawa Wastewater Treatment Plant.

Project Manager; Large Sewer Structural Condition Assessment Program; City and County of Honolulu, Hawaii. The program identified critical sewers 15 inches to 84 inches in diameter to inspect with manned entry, closed circuit television, pole camera, sonar, and laser profiling to determine condition and need for repair or replacement. Some of the identified sewer segments will be inspected under the assessment contract and others will be inspected under a separate City contract for indefinite deliverables and indefinite quantities for inspection and repairs.

Senior Reviewer; Indefinite Delivery/Indefinite Quantity (IDIQ3) Contracts. Assisted in preparing and reviewing bid documents for IDIQ3 to hire two contractors for sewer inspections including about 10 miles of large-diameter sewer and about 100 miles of pipe in total in the first 18 months with three one-year extensions possible. The inspections will include closed circuit television, sonar, and laser profiling. Met regularly with the currently ongoing IDIQ2 contractors who are inspecting and lining pipe up to 24 inches in diameter and performing spot repairs. Inspected the contractors operations yards and project sites to understand construction processes and limitations that should be considered in future contracts.

Senior Reviewer; Waimalu WWPS Force Main Condition Assessment Report and Rehabilitation Plan. The 44-year-old force main was found to be in good condition and only minor rehabilitation work on the air bleeder manhole and the flow meter vault was recommended.

Senior Reviewer; Sewer Infiltration/Inflow Assessment and Rehabilitation Program Update; City of Honolulu; Honolulu, Hawaii. Initial work is to develop a work plan, perform flow monitoring, and analyze flow data. Subsequent work will be to update (recalibrate) the City's hydraulic model where appropriate, develop flows from population estimated to 2030 and beyond, determine hydraulic capacity limitations, and evaluate the existing hydraulic and structural condition assessments. The plan will determine changes needed in the Capital Improvements Program (CIP) resulting from the hydraulic limitations or the combination of hydraulic and structural condition limitations, including use of deep tunnels leading to the treatment plants.

Technology Leader; Influent Pump Station Assessment; Honouliuli Wastewater Treatment Facility (WWTF); Honouliuli, Hawaii. Performed a study to determine if adequate standby diesel engine power currently exists at the pump station to meet the required pumping demand to prevent spills at the current peak hour flow. It was determined that no new standby power is required at the IPS. However, automatic switch gear should be added to both standby generators. Automatic switch gear should also be added to the clarifier under drain pumps that should also be connected to the IPS standby generator switch gear. A cogeneration system was considered for standby power that

would cost about $7 million with design-build procurement. At a power purchase cost of $0.14 per kWh, a one megawatt cogeneration unit could produce power worth about $1 million per year. The cogeneration system should have two engines with generators to be considered as a standby power supply for the IPS. In 2007, the Honouliuli WWTP consumed a total of about 12,500,000 Kwh and the power cost was about $1.8 million. The annual power cost could be reduced by about half with a cogeneration system.

Senior Reviewer; Aliamanu No. 1 and No. 2 Wastewater Pump Stations Upgrade and Sewer Relief Design Alternatives; Hawaii. The report evaluates alternatives of flood control around existing pump stations to reduce inflow and installation of a relief sewer to convey addition flow from inflow. Flood control requires cooperation of the Navy for work on adjacent property and extensive regrading but is the low cost alternative.

Senior Reviewer; Waikiki Sewer Rehabilitation/Reconstruction Design Alternatives; Honolulu, Hawaii. The report evaluated old sewers in the Waikiki section of Honolulu that are 10 feet deep to 15 feet deep in sandy soils in a densely developed area. Some segments require replacing with larger-diameter pipe to accommodate planned flows. Some pipe with adequate hydraulic capacity can be rehabilitated with cured in place pipe lining to minimize disruption. Identified and planned spot repairs.

Senior Review; Aiea Kai Place Sewer Rehabilitation Design Alternatives; Hawaii. The sewer lines in this area are in relatively good condition but will not attain self cleaning because of insufficient slope and flows and the lines have heavy deposits of grease and debris accumulation. The cost of replacing these lines will be very high since they need pile support and the new lines will have similar problems. These lines will need regular cleaning maintenance. The alternative evaluated was a pumped low pressure sewer system.

Senior Reviewer; The Kauhale Street Sewer Rehabilitation Design Alternatives; Hawaii. The system is vitrified clay pipe 50 to 75 years old and was mostly rated as excellent to fair condition by the consultant with the PACP process. Recommended spot repairs and rehabilitation by cured in place pipe lining of one segment.

Senior Reviewer; Waiawa Offsite Sewer Trunk Line; Hawaii. This difficult sewer construction project has 22 of 32 manholes greater than 15 feet deep and six are more than 40 feet deep. The 48-inch-diameter microtunnel project includes an inverted siphon and a connection to an existing pump station. The tunnel in steep terrain has segments with high velocity requiring special drop manholes for energy dissipation.

Senior Reviewer; The Foster Village Sewer Rehabilitation/Reconstruction Draft Design Alternatives; Hawaii. Determined which alternative to recommend in the final report. The evaluation of the 8-inch-diameter sewer considered open cut replacement and rehabilitation with cured in place pipe lining with spot repairs in isolated areas with structural damage.

Senior Reviewer; Kaneohe/Kailua Force Main No. 2 Design Alternatives; Hawaii. The study was for installing new 36-inch-diameter sewer force main by Horizontal Directional Drilling or Microtunneling methods. Installation of 10,000 feet of 42-inch-diameter steel casing or HDPE pipeline by HDD under the bay is unprecedented and is considered highly risky. Further study of modifications to the installation methods was recommended to reduce risk. Construction cost is estimated at about $50 million.

Senior Reviewer; Draft Design Alternatives; Makaha Interceptor Sewer Rehabilitation / Replacement; Hawaii. The sewer needing repair was evaluated for structural integrity and hydraulic capacity to determine which segments could be rehabilitated with lining and which segments require replacement with a larger size pipe.

Senior Reviewer; Wastewater Final Facilities Plan; City of McMinnville; McMinnville, Oregon. Made recommendations for wastewater treatment and reuse alternatives. The wastewater facilities plan was the final step in a planning process that ensured the city's wastewater discharges met the new Yamhill River water quality standards established by DEQ. Studied wastewater management options and recommended a cost-effective and environmentally sound plan to satisfy the planning criteria. Also recommended application rates for effluent irrigation and developed a plan for biosolids

handling and reuse. Possible land application sites were reviewed for suitability. Production and application programs were estimated to the year 2015.

Honors and Awards

Academy of Distinguished Engineers; College of Engineering, Oregon Stater Award for distinguished contributions to the profession, OSU, and society at large; Oregon State University, 2009.

Engineering Excellence Award, Water Resources Category, in 1998 from Consulting Engineers of Idaho for Boise City's Twenty Mile South Farm biosolids application program

Honor Award for Engineering Excellence in 1995 from Consulting Engineers Council of Oregon for Potlatch Corporation's Poplar Tree Water Reuse System in Boardman, Oregon

Honor Award for Engineering Excellence in 1994 from American Consulting Engineers Council for City of Woodburn's Poplar Tree Reuse Demonstration System

National Engineering Excellence Award in 1993 from Consulting Engineers Council of Oregon and the American Consulting Engineers Council for Waste Management's Poplar Tree Irrigation System at Riverbend Landfill in McMinnville, Oregon

The Irrigation Association's National Award for Water and Energy Conservation in 1984, jointly awarded to CH2M HILL and the Eastern Oregon Farming Company

Professional Organizations / Affiliations

United States Committee for Irrigation and Drainage; Urban Uses Committee member
American Society of Agricultural Engineers
Water Environment Federation
The Irrigation Association
Oregon Water Resources Congress
Oregon Association of Clean Water Agencies; Reuse Committee member

Publications and Presentations

Contributing Author, "Design and Operation of Farm Irrigation Systems, 2nd Edition" (863 pages). ASABE Publication. 2007. ISBN: 1-892769-64-6

Contributing Author, "Phytoremdiation – Transformation and Control of Contaminants," (987 pages). Wiely Inter-Science. 2003. ISBN: 0-471-39435-1

Contributing Author, "Water Use and Reuse in Industries of the Future." Chapter for Industrial Water Management: A Systems Approach, 2nd Edition. Prepared under contract to Center for Waste Reduction Technologies for U.S. Department of Energy, American Institute of Chemical Engineers, 3 Park Avenue, New York, NY 10016. July 2003.

With Derrel L. Martin and Dale F. Heermann, USDA; 2007. Hydraulics of Sprinkler and Microirrigation Systems. Published by the American Society of Agricultural and Biological Engineers. Vol. 4: 620-645. August 2007. www.asabe.org.

ASABE Proceedings Contributing Author with J. K. Smesrud, J. L. Jordahl, R. Jackson. Proceedings of the Eighth International Drainage Symposium, Drainage VIII. March 21-24, 2004. Sacramento, California.

With Chung-Shih, Wenhao H. Sun, Marisa Toma, Francoise M. Robert, and Ryan K. Jones. 2004. Evaluation of Agriculture-Based Phytoremediation in Pacific Island Ecosystems Using Trisector Planters. International Journal of Phytoremediation, 6(1):77-33

With J.L. Jordahl, J.K. Smesrud, H.M. Emond, and M.Q. Cotten. Waste Management Using Trees: Wastewater, Leachate, and Groundwater Irrigation. Presented at the AEES 45th Conference on Phytoremediation. June 11, 2004.

With Henriette Emond and J. Jordahl. Reuse System Utilizing Saline, Sodic Wastewater: Pueblo of Acoma, New Mexico. Presented at the Water Environment Federation's 76th Annual Technical Exhibition and Conference. Los Angeles, California. October 10–15, 2003.

With Henriette Emond, J. Smesrud, M.Q. Motte, and F. Sinclair. City of Woodburn Land Applies Liquid and Dewatered Biosolids, Facultative Sludge Lagoon Supernatant, and Effluent on Hybrid Poplar Trees. Presented at the Water Environment Federation's 76th Annual Technical Exhibition and Conference. Los Angeles, California. October 10–15, 2003.

With Henriette Emond. Natural Treatment Systems TMDLs, Temperature Management Plans, and Reuse. Presented at the Pacific Northwest Clean Water Association: Water Environment School. Oregon City, Oregon. March 25–27, 2003.

With Henriette Emond. Biosolids Effects on Poplars. Presented at the Pacific Northwest Clean Water Association: Water Environment School. Oregon City, Oregon. March 25–27, 2003.

With Jim Jordahl, J.K. Smesrud, H.O. Emond, and M.Q. Motte. "Waste Management Using Trees: Wastewater, Leachate, and Groundwater Irrigation." Phytoremediation: Transformation and Control of Contaminants. To be published by John Wiley and Sons, Inc., 2003.

With Jason Smesrud, J. Jordahl, and G. Duvendack. Drip Irrigation of Landfill Leachate to Hybrid Poplars. Presented at the 2002 Pacific Northwest Clean Water Association Annual Meeting, Yakima, Washington. October 21, 2002.

With Henriette Emond and D. Whitaker of CH2M HILL and J. Russell and F. Kessler of City of Salem, Oregon. A Multifaceted Natural Reclamation System for Wastewater Treatment and Reuse—An Update. Presented at the Water Environment Federation WEFTEC Conference. September 28–October 2, 2002.

With Henriette Emond and D. Whitaker of CH2M HILL and J. Russell and F. Kessler of City of Salem, Oregon. A Multifaceted Natural Reclamation System for Wastewater Treatment and Reuse. Presented at Wetlands and Remediation, Batelle Second International Conference. Burlington, Vermont. September 5–6, 2001.

With Rich Coles, R. Harasick, T. Schade, J. Nelson, and G. Hille. Partnering Makes the Owens Lake Project Feasible. Presented at Water Environment Federation WEFTEC Conference. September 2002.

With Henriette Emond and J. Jordahl of CH2M HILL and C. Tang, F. Robert, and W. Sun of the University of Hawai'i. Phytoremediation of Petroleum Hydrocarbons in Pacific Island Ecosystems. Poster paper presented at the Battelle Conference on Chlorinated and Recalcitrant Compounds. Monterey, California. May 20–24, 2002.

Why Don't We Have Reuse? Presented to Oregon Department of Environmental Quality. May 2002.

With Jason Smesrud, R. Cuenca, J. H. Dickey, R. Coles, and R. Harasick. Irrigation and Drainage Management Criteria for Dust Control with Irrigated Saltgrass at Owens Lake. Presented at 2001 Annual Agronomy Society of America Conference, Charlotte, North Carolina. October 2001.

With Quitterie Motte, J.K. Smesrud, J.L. Jordahl, R. Coles, and R. Harasick. Subsurface Drip Irrigation System for Dust Control with Irrigated Saltgrass at Owens Lake. Presented at 2001 Annual Agronomy Society of America Conference, Charlotte, North Carolina. October 2001.

With Jim Jordahl, H.O. Emond, M.Q. Motte, J.K. Smesrud, W.H. Sun, F.M. Robert, and C.S. Tang. Phytoremediation of Petroleum Hydrocarbons in the Tropics. Presented at 2000 Annual Soil Science Society of America Conference, Minneapolis, Minnesota. November 2000.

With Jason Smesrud, J.H. Dickey, S. Asare, A.L. Lanier, and J.L. Jordahl. Beneficial Reuse of Landfill Leachate by Hybrid Poplar. Presented at Food and Agriculture Organization of the United Nations International Poplar Conference, Portland, Oregon. September 2000.

Marking Water Reuse Work: How-to Tips for Treated Wastewater Irrigation Projects. Presented at Annual Association of Clean Water Agencies Conference. July 2000.

With Henriette Emond, P.E., and J.L. Jordahl, CH2M HILL. Lessons Learned from Growing Poplar Trees with Wastewater. Presented at Second Conference of the Short Rotation Woody Crops Operations Group, Vancouver, Washington. August 1998.

With Henriette Emond, P.E. and J.L. Jordahl, CH2M HILL. The Use of Drainage in Expanding the Capabilities of Irrigated Land Application Systems. Presented at American Society of Civil Engineers Water Resources Conference, Nashville, Tennessee. August 1998.

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Exhibit B

Review Comments – July 23, 2014, Version of Waste Management Plan for Hawai'i Dairy Farms, Maha'ulepu

PREPARED FOR: Lisa Bail and Lisa Munger/Goodsill Anderson Quinn & Stifel

COPY TO: Jim Jordahl/CH2M HILL

PREPARED BY: Mark Madison/CH2M HILL

DATE: August 21, 2014

Overview: This document reflects my preliminary comments on Hawai'i Dairy Farms' Waste Management Plan dated July 23, 2014. Please be advised that additional comments are forthcoming, as due to the shortness of time, I was unable to complete my review of the Plan in its entirety. My comments below are organized by sections of the Waste Management Plan (referenced by section number).

- 1.0 Zero point source discharge only means that the waste does not discharge from a pipe into the environment. Non-point source discharge will distribute the waste over a large area and discharge to the environment may be equal in mass as a point source discharge. The impact to the environment from non-point source discharges should be evaluated by the Wastewater Branch in its review of the Management Plan ("Plan").
- 1.0 "1.3 animals per acre or 699 milking cows (grazing on ,...,517 acres)". This is only 0.77 acres per cow per year with 20 tons/acre is about 15 tons of pasture grass per cow per year, which is not consistent with feed needed for milk yield estimates. Of course, upon full build-out of the dairy's operation with 2,000 cows, the number of acres per cow and the corresponding amount of pasture grass per cow will be even less.
- 1.0 "Effluent Pond....will contain roughly 100 days of storage capacity." This storage capacity is only available when the pond is empty, which only occurs until the first milking. The Plan does not address how many days of capacity to hold additional manure is available on a normal operating scenario and how many days during wet weather when the effluent can't be land applied.
- 1.0 "The cows spend 22 hours in the paddock and only 2 hours in the milking area each day." The nutrient management calculations are for the manure from the cows for only 2 hours per day. The majority of the manure and nitrogen is directly discharged by the cattle onto the pasture. The plan underestimates the amount of manure and nitrogen on the pasture which can be moved by irrigation water and storm water to surface streams or groundwater aquifers.
- 1.0 "A small plot of land in the lower center of the valley is currently used for taro lo' i and will continue to be leased and farmed after the dairy and related pastures are in full operation." The center of the valley will have manure runoff during storm events. The Plan does not address this run-off or the impact of manure on the food value of Taro.
- 1.0 The cow cemetery is very near a stream in an area likely to have high seasonal perched groundwater. The Plan does not address the impact to groundwater of

decomposing animals being leached by storm water infiltration percolating to groundwater. The Plan should provide the total number of animals that will be buried on site in a typical year and in total over 20 years of operations.

- 2.2.1 Figure 5 indicates that many natural water courses are canals or ditches. Although the streams may have been straightened or cleaned in segments that cross the farm, they are still natural water courses and contain Waters of the State protected with water quality standards. The Plan does not address how non-point source discharges to these waters will affect aquatic habitat on the farm and downstream.
- 2.2.2 The Palustrine and Riverine wetlands within the site receive water from runoff and groundwater originating in the pastures. The Plan should address how the manure on the pastures that dissolves and moves with the water or is carried in storm water from large events like the 25 yr 24 hr storm will affect the wetlands flora and fauna and ecosystem functions.
- 2.2.3 The site makes up a significant portion of the watershed that feeds the groundwater aquifer under the site. The site has always had infiltration that enters the aquifer and will continue to be part of the aquifer recharge zone regardless of site management. All wells within the aquifer recharged by the farm must be shown on the map and well logs must be attached to the plan to allow risk assessment for every water user. Additional community drinking water wells exist within the aquifer recharged by the Dairy that are not discussed or shown of the map. The aquifer flow direction and recharge rate need to be calculated to define the amount of water from the site that contributes to flow from each well. In addition, the impact of nitrate, bacteria, and manure constituents that leach through the pastures on the public drinking water well Koloa F, which is less than ½ mile away from manure application fields, should be addressed. An appropriate discussion would include the travel time of nitrate in the aquifer, the cone of depression and zone of immediate recharge for the public water supply wells, and where the groundwater recharged by the Dairy discharges to wetlands, stream, and coastal shorelines. This Plan can't be properly reviewed without a detailed groundwater study.
- 2.3.1 "The average monthly precipitation depths will be used for sizing of the waste management systems and irrigation scheduling as required by the standards." Best management practices would consider daily precipitation for irrigation scheduling and waste management. Peak rainfall events and extended storms are the primary risk for waste management and they will be much greater than monthly average precipitation. The irrigation schedule should be adjusted for greater than average rainfall.
- 2.3.1 "The 25-year 24-hour precipitation data will be used for sizing of waste management systems as required by the standards." The Plan needs to identify which specific components of the waste management system are sized for the 25 yr. 24-hour storm as opposed to the statement in 2.3.1 that the waste management system is sized for the average monthly precipitation. The peak storm discharges over twice the monthly average of most months in only one day which will overwhelm a system designed for average monthly precipitation.
- 2.3.3 In September of 1996 there were 6 days of continuous rainfall followed by one week of non-continuous rainfall then immediately followed by 7 days of continuous rainfall. The

available storage in the manure and effluent storage basins during normal operations does not appear to be adequate to store during a prolonged period of rain followed by a short duration for saturated soils to dry enough for land application immediately followed by another extended period of continuous rainfall. This situation will force operators to apply during rainfall or before adequate drying which will result in runoff to surface water and deep percolation to the aquifer.

- 2.5 The soils data presented in the Plan appears to be a selected set of general conditions that does not inform the reader of the limitations of the site soils. I have attached both the entire site soils report as an exhibit (Exhibit E) and extracted pertinent sections (Exhibit D) that must be included as part of the Dairy's Plan to identify limitations so discussion of management within these limitations can be presented.
- The custom soil resources report (Exhibit E) was created for the specific area of Kauai that includes the proposed Dairy Operation and is much more detailed than the general information presented in the Plan. Yellow highlight was added to emphasize data that are in direct conflict with the Plan's claims that soils are suitable for an intensive confined animal feeding operation and animal waste disposal with land application and irrigation of effluent. The proposed Dairy Operation is situated on soils that are very limiting for land application of animal waste. An intensive animal waste management program for 699 cows on this site should not be allowed. A waste management program on this site will likely result in contamination of groundwater that is extracted by community wells within the aquifer recharged by the farm. Surface runoff from this site will contain manure contaminants that will be conveyed to streams, wetlands, and coastal waters.
- 4.1 The manure and urine that is deposited on the walkways and races is not accounted for in the nutrient balance. The Plan should state the amount of manure and urine that is deposited in these intensive use areas and describe its fate.
- 4.2.1 The Plan should state how many calves are on site at all times and describe the fate of their contaminated bedding and manure that is not presently defined or accounted for in the Plan.
- 4.2.4 The Plan should provide information concerning the nutrient content of feed that is wasted, how much waste feed is disposed of on the farm, the hormones, pharmaceuticals, and pesticides that are used on the Dairy and the ultimate annual usage at the Dairy of each. The ultimate fate of waste, and urine pass-through of pharmaceuticals, should be included.
- 5.0 The Plan should provide information concerning how much waste milk is produced annually and how is it disposed.
- 6.1 It is my professional opinion that a center pivot irrigation machine spraying effluent should never be permitted to cross a stream even with variable rate precision technology. I am very familiar with this technology and the frequency of failures of the wireless communication links, PC control, GPS control, very small valves at each nozzle that stick and fail open, and other normal mechanical failures that make it certain that at some times the pivot will discharge manure directly into the stream. No center pivot machines are 100% reliable and the complexity of the variable rate technology increases the failure rate of these special machines to several times that of standard pivots. If this equipment is used

nonetheless, the Plan should detail how the manure content of the stream will be measured and what operational shut downs will be triggered by manure in the stream.

- 6.2 It is my professional opinion that drip tape cannot be used in a cattle pasture. Drip tape is a one-use thin wall tape intended for crops such as vegetables with 6 month growing seasons and then tape disposal and replacement. Drip tape buried in pasture will fail with extensive leaks after cattle walk over it during the first large rain event. Heavy wall drip tube buried 12 inches deep will also have extensive cattle hoof damage and drip tube 12 inches deep is too deep to start new plants on the soil types on the site. Drip irrigation is not a feasible technology for cattle pastures that have cattle on them during heavy rainfall with the soils on this site. If drip tape is used nonetheless, the Plan should detail how the leaks will be detected at depth and how the aquifer will be monitored to know when the effluent has entered it.
- 6.2 Subsurface drip irrigation tubes under pastures with cattle grazing are often damaged by hooves sinking into saturated soils during extreme rainfall events. Cattle hooves will easily crush and cut any type of drip tubing. If such tubes are used nonetheless, the Plan should detail how drip tube leaks will be located and repaired, how long it will be before a cut drip tube can be located and repaired, how wastewater in groundwater will be monitored, and how much wastewater in groundwater will trigger a corrective action.
- 6.4 Irrigation setbacks must be defined as zones that no irrigation equipment can enter or cross. It is not acceptable to have a setback that an irrigation machine crosses while spraying effluent on part of the machine and if all systems are not perfect on the setback area. Perfect operation continuously over the life of the project will not occur with variable rate technology pivots. Partial circle pivots with physical stop barriers should be used on each side of the buffered streams so it is not physically possible for the irrigation equipment to enter the stream and fail. If equipment will enter the irrigation setbacks, the Plan must disclose how often the buffer and the streams will be penetrated by the variable rate pivot machine on an annual basis, the amount of manure that will drip off the machine even after the nozzles are turned off and the modifications to be made to the stream bed and riparian buffer wetlands to allow the wheels of the pivot machine to cross during all flow conditions without getting stuck.
- 6.4 Irrigation setbacks are intended to eliminate the potential for surface water runoff or wind drift spray to enter protected areas. The regional wind data and wind rose indicates that with center pivot irrigation and low pressure spray sprinklers significant water will blow much further than 50 feet into streams and 20 feet into the Taro field. Winds with velocity sufficient to blow sprinkler mist into and across the buffers occur on a regular basis for multiple months. Surface runoff will also exceed these flow distances during unexpected thunderstorms when the irrigation system is on or has recently irrigated near the buffers. The Plan should identify the wind speed beyond which irrigation will be terminated such that mist will not blow across buffers, and how wind speed will be monitored.
- 6.5 Irrigation demand is not calculated correctly in the Plan, and no supporting information or data is provided to allow review. This section is critical and can't be approved or even reviewed without much more data. Irrigation demand is never a constant, yet the Plan states: "**Irrigation water demand is based on a rate of 6 mm/0.24**

inches per day over the irrigated area." Irrigation demand is different on every soil type every day of the year based upon complex climatological data even for the same monoculture. Irrigation demand can be calculated for the 30 years of weather data to determine the statistically probable demand per day, week, and month. The irrigation demand from month to month likely changes by over 100%, and a "one number fits every day" design will fail. As but one example, the Plan fails to consider how much runoff will occur when the site is irrigated at an average annual demand when the actual demand is half that amount.

- 6.1 [sic] The section titled "Irrigation Schedule" is misleading since only general statements about irrigation are made and no schedule of irrigations is presented. A proper irrigation schedule for a wastewater management plan will include daily operations of each irrigation machine, soil moisture budget, monitoring targets, and rainfall contingencies. A wastewater management irrigation schedule is not based upon monthly average data. The plan defines a mostly dry day as less than 0.125" of rainfall but a full irrigation day is only 0.25 inches of effluent. Counting days with 50% of full irrigation as the definition of dry periods requires the duration of a dry period before irrigation is allowed to be double the amount presented. The rainfall data presented shows that there is more water applied by rain than used by the crop in December. The soil will be saturated with rainfall, in addition to the irrigation in November, and will not have capacity to hold additional water except during periods between rainstorms when it will dry only enough to hold the next rain storm. Soil water depletion to a level that requires irrigation for maximum crop yields will not occur in December. Excess water will runoff to surface water or percolate to groundwater. The soil moisture storage capacity will not be depleted to a level that allows any irrigation in December. The site will have surface water runoff and groundwater recharge in December without any irrigation and any amount of irrigation will add directly to the total amount of surface water runoff and groundwater recharge. A root zone soil moisture storage, depletion, and replenishment water balance is a critical part of a wastewater irrigation schedule and must be presented to allow evaluation of an irrigation plan. Data presented shows that January only requires 0.07" of irrigation properly timed with rainfall to meet crop demand without runoff or groundwater recharge. This is only about 1 hour of irrigation per month required. All additional water applied will directly result in additional surface water runoff to streams and groundwater recharge. The Plan must disclose how much runoff and recharge will be allowed per month, how much nitrate and bacteria will be allowed in the runoff and aquifer recharge before corrective action is triggered, what corrective action will be implemented when the off-site contamination exceeds the target level and how will steam water quality and groundwater aquifer quality impacts will be monitored.
- 6.1 "In the case of a continuously wet period that keeps soil at capacity, (the longest on 30-year record is 17 days) the irrigators can be programmed to drop effluent water only and at a rate as low as 0.04 inches, and the placement of the effluent water can be targeted to the freest draining soils on the farm. A target zone for an exceptionally wet season application is paddocks 111 - 115, where the Lualualei Clay soil is classified as "well drained" and a raceway (acting as a berm) separates the paddocks from any water ways." This statement is a direct admission of intentional groundwater recharge with effluent through saturated well drained soils when the site does not have irrigation needs in December and

January. It appears that the amount of groundwater recharge is equal to the amount of effluent that can't be held in the full storage lagoons over the two months that do not require irrigation when the soil water storage of rainfall is properly considered. Groundwater recharge with effluent is not acceptable in an aquifer with community drinking water wells.

- 7.1 This section accounts for manure for the two hours per day that the cows are in milking. The non-milking waking hours of 14 hours per day will also produce 87,654 pounds of manure that is directly deposited on the pasture. A 3 acre paddock with 115 cows on it will receive 4,807 pounds per acre per day of fresh manure application. The immediate concentration of manure nitrogen and other nutrients will greatly exceed the daily nutrient needs of the grass. The fresh manure will be applied every 18 days, and even though it may not exceed annual nutrient needs for the crop, it will greatly exceed nutrient needs the week that it is applied. The excess manure and nutrients will be readily available to runoff with irrigation and rainfall and percolate into groundwater. The excess irrigation planned for December and January when rainfall is enough to provide full crop water needs will certainly create discharge of manure at least one day per 18 day rotation when the cows apply 4,807 pounds/day/acre of fresh manure plus irrigation plus rainfall.
- 7.2 "Ponds will have minimal potential impacts from breach of embankment, accidental release, and liner failure." Any breach of embankment, accidental release, or liner failure will have a catastrophic impact on surface water streams, the aquifer, and coastal waters. The amount of storage in the settling pond and storage pond is not identified as minimum available storage which is the critical criteria. The size of the pond is less important than the amount of empty space that is available for buffer when the pond is full and ready to be emptied but unexpected rainfall requires additional storage. The pond suitability can't be evaluated with the information presented. At a minimum, the Plan needs to describe how much empty storage volume is available in each pond when the pond is full and ready to be cleaned out, whether the storage pond is emptied completely every 30 days regardless of weather, how much effluent must be discharged in December when there is no need for irrigation all month, and whether the settling pond performance changes when the "spare volume" in the storage pond is used during wet periods and the stored effluent backs up into the settling pond through the overflow pipes.
- 7.3 The Plan should state whether the emergency overflow containment area will have a liner.
- 7.4 "The best time to apply the effluent water is just after the cows have finished grazing, allowing 17days for the grass to utilize the nutrients before the cows next enter the paddock" This is actually the worst time to irrigate from an environmental protection perspective. The fresh manure will be most easily dissolved and mobilized with irrigation water that will runoff and create high nutrient percolation into the soil which is available for plant uptake but also deep percolation below the root zone. The Plan must disclose how the pivots that cover multiple soil types will be managed to not exceed the water holding capacity of every soil which is different and varies with plant uptake, rainfall, and soil depth and properties and the trigger point to stop irrigation if the soil moisture monitors indicate high moisture.

- 7.4 "Nonetheless, if a cataclysmic storm was forecast, the time to completely empty the storage pond, if it were full, is around 96 hours. If warranted due to potential impact from the approaching storm event, the settling pond could also be pumped empty within an additional 40 hours. If the forecasted storm is forecast six days prior, then virtually no effluent would remain in storage when the storm arrives." This statement is from a similar philosophy of management as the statement that, in December when irrigation needs are not enough, the excess effluent can be discharged to paddocks 111 to 115 because they are on well drained soils. Well drained soils with excess irrigation will recharge groundwater with effluent. Emptying the storage pond and settling pond because an extreme rain event is approaching will cause nearly all of the manure applied to soils (that are already wet) to be conveyed to streams and aquifers when the storm saturates the site and creates extreme runoff. If the ponds are emptied onto the fields before a major storm event, a point source discharge may be avoided but a major non-point source discharge will occur and in fact it appears that the site manager plans to create this worst case scenario as a standard procedure. This Plan can't be approved with intentional transfer of waste to the environment when extreme weather is approaching.
- 7.4 The gun application of manure is the single worst technology choice from the perspective of odor control. High pressure guns with high trajectory and a 65 feet spray radius spraying manure and dispensing a mist in the atmosphere that can drift for miles on a windy day are the poster child of neighbor odor complaints worldwide. If this method is used nonetheless, the Plan should identify the odor threshold at which operation of the big gun will be shut down when wind blows toward neighbors. An application rate of 9mm/hr exceeds the infiltration rate of some soils and will create runoff into streams. If this method is used nonetheless, the Plan should also describe how runoff will be monitored and controlled on low infiltration rate soils.
- 8.0 "Planned nutrient application rates were also compared to the Hawai'i NRCS 590 Nutrient Management Standard. This standard insures that the total amount of nutrients applied is not at a risk for nitrogen leaching or phosphorus indexing." The total annual nutrient loading rates are explained but the author appears to not understand that the primary risk is the immediate risk of high rate applications plus rainfall and irrigation even if the applications are infrequent. Application rates exceed soil infiltration rates. Applications are planned during December when the site soils are nearly always at field capacity and loadings proposed will generate deep percolation and runoff. A detailed soil water balance is required to prepare a waste management plan with any authority. A site soil investigation with test pits and samples to compare detailed soil survey data with actual field conditions is required to produce a plan that represents the actual site conditions and fully utilized the capacity of the specific soils while accommodating the limitations. This Plan cannot be approved because is too general in the most critical areas of data acquisition and utilization to support loading and management calculations.
- 8.2 "The effluent is highly diluted, to the extent that it will have next to no odor in the storage pond and certainly no odor at the farm boundary. The settling pond will also be aerated to help mitigate odor. To help further mitigate any odors arising from the facility a Windbreak / Shelterbelt (i.e. a multiple row planting of trees) will be established along the prevailing wind pattern of the pond." All dairies have odor at the farm boundary. Windbreaks can have a visual benefit and an immediate downwind benefit that exists

within the wind shadow that is usually only a few hundred feet. The odor further downwind is not improved by a windbreak. The Plan should explain how odor from pivots and big guns will be mitigated and monitored, and what odor threshold will create management change.

- 8.2 "Due to the high moisture and moderate temperatures, the microbial activity in the thatch is very high and the effluent will be largely broken down by microbial activity within 24 hours." This is not a true statement. Effluent nutrients are applied infrequently in large doses that will exceed microbial capacity to degrade nutrients. The effluent will flow through the microbial mat rapidly and infiltrate the soil or runoff. The breakdown of nutrients will occur over months and organic nitrogen will mineralize with some carry over occurring up to a year after application.
- 8.4.1 The nitrogen leaching potential must include rainfall plus irrigation which will totally change the results. Using only rainfall data is not correct for a fully irrigated site.
- 8.4.3 "However, less than two days after heavy rain, with rapid removal of the surface water during and after a significant rain event, they are observed as being dry enough to graze, even without a Kikuyu thatch." Rapid removal of water from the clay soil is equal to saying that there will be high rates of runoff. Such runoff should not be allowed.

Exhibit C

Water Quality Report

Covering the period of
January 1, 2013 to December 31, 2013

Department of Water
County of Kaua'i

Kaua'i Department of Water
Kalaheo-Koloa Water System
2014

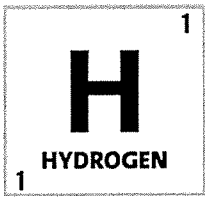
This report by the Kaua`i Department of Water describes the quality and source of your drinking water. The Safe Drinking Water Act, a federal law, requires water utilities to provide water quality information to its customers every year.

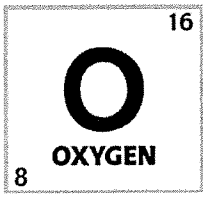
Providing safe drinking water is a complex business, but you and your neighbors have a right to know the results of our water quality monitoring. Safe drinking water is essential to our community. Your water is tested regularly through our certified laboratories and the State Department of Health.

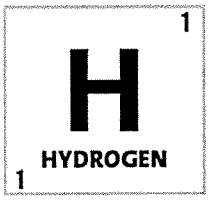
In summary, our drinking water meets, or is better than, state and federal standards. We spend in excess of $400,000 in chemical and microbial testing each year to assure the safety of your water.

A Source Water Assessment, intended to enable "well-founded, fair and reasonable decisions for the protection and preservation of Hawai'i's drinking water" has been completed by the State Department of Health and the University of Hawai'i. For Further information on this assessment, please contact the Department of Water at (808) 245-5455

We welcome your interest in the Department of Water's water system. Please refer to the directory in this publication for the Department's phone numbers. Also, the Water Board normally meets on the fourthThursday of each month, and their meetings are open to the public. Please call (808) 245-5408 for the time, date and location.



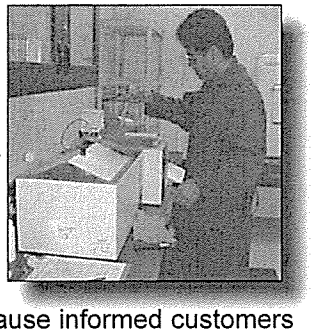




Clyde Nakaya
Chairperson, Board of Water Supply

Kirk Saiki, P.E.
Acting Manager and Chief Engineer

Why am I getting this brochure?



The Safe Drinking Water Act has been amended to require water systems to provide its customers with an annual report of the quality of their drinking water. This brochure is a snapshot of the quality of the water we provided last year. Included are details about where your water comes from, what it contains and how it compares to Environmental Protection Agency (EPA) and state standards.

We are committed to providing you with information because informed customers are our best allies.

Is my drinking water safe?

Yes. The Department of Water regularly conducts microbiological analysis and has contracted for extensive chemical testing in order to comply with Environmental Protection Agency (EPA) and Hawai'i State standards. The standards are very strict in order to ensure safe drinking water.

Where does my water come from?

Your water comes from ground water ***(underground)*** sources. Rain that falls in the mountain filters through the ground into formations called aquifers. Wells are drilled into these formations and the water is pumped out. These formations can also be found in the mountains ***(still considered ground water)***. Tunnels are constructed to tap these sources. The quality of groundwater is very good and requires no treatment except for disinfection ***(as opposed to surface water sources that require filtration and stronger disinfection).***

The water supply for the Kalaheo-Koloa Water System water system comes from the following sources:

Kalaheo Area

Kalaheo Deepwell A

Kalaheo Deepwell B

Lawa'i-Oma'o Area

Lawa'i Well No. 1

Lawa'i Well No. 2

Piwai Wells No. 2 & 3

Koloa-Po'ipu Area

Kolao Wells 16-A & 16-B

Koloa Wells C, D, E & F

All of the water is chlorinated and pumped into the distribution system or stored in the following tanks:

Kalaheo Area

Kalaheo Nursery
100,000 gallon tank

Kalaheo Clear Well Storage Tank
300,000 gallon tank

Kuku'iolono #1
250,000 gallon tank

Kuku'iolono #2
200,000 gallon tank

Kakela Makai
200,000 gallon tank

Kalaheo 908 Tank
500,000 gallon tank

Lawa'i-Oma'o Area

Andrade Tank
30,000 gallon tank

Lawa'i
250,000 gallon tank

Piwai
100,000 gallon tank

Koloa-Po'ipu Area

Koloa
1,000,000 gallon tank

Koloa (Pa'anao)
250,000 gallon tank

Po'ipu
1,500,000 gallon tanks @ 2 each

Paanau No. 2
500,000 gallon tank

Oma'o Tank
500,000 gallon tank

How do contaminants get into our drinking water?

The sources of drinking water ***(both tap water and bottled water)*** include rivers, lakes, streams, ponds, reservoirs, springs and wells.

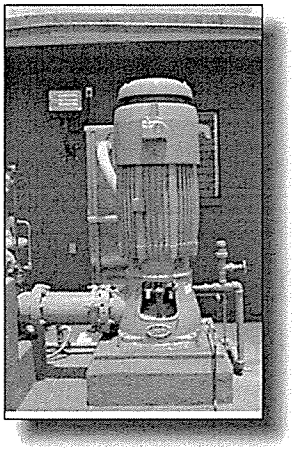
As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity.

Therefore, drinking water, including bottled water may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that the water poses a health risk.

Contaminants that may be present in source water before we treat it include:

> Microbial contaminants: Viruses and bacteria from sewage treatment plants, septic systems, agricultural livestock operations and wildlife.
>
> Inorganic contaminants: Salts and metals which can be naturally occurring or from other sources, such as urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining or farming.
>
> Pesticides and herbicides: Variety of sources such as agriculture, urban storm water runoff and residential uses.
>
> Radioactive contaminants: Naturally occurring.
>
> Organic chemical contaminants: Synthetic and volatile organic chemicals, by-products of industrial processes and petroleum production, also from gas stations, urban storm water runoff, and septic systems.

To ensure safe tap water, EPA sets limits on these substances in water provided by public water systems.



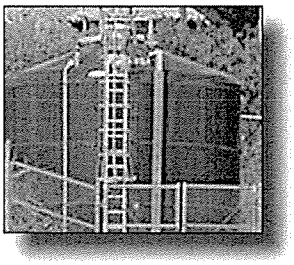
Should I take special precautions?

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders,some elderly and infants can be particularly at risk from infections. These people should seek advice about drinking water from their healthcare providers.

EPA/CDC (Centers for Disease Control) guidelines on appropriate means to lessen the risk of infection by ***Cryptosporidium*** and other microbial contaminants are available from EPA's Safe Drinking Water Hotline (1-800-426-4791).

More information about contaminants can also be obtained by calling the EPA's Hotline.

Other Frequently Asked Questions:



What is the pH of my water?
The pH of your water in the Kalaheo-Koloa area can range from 7.3 to 7.8.

What is the hardness of my water?
The hardness of your water can range from 60 to 70 ppm.

Why do I notice off-odors or taste in my water?
Sometimes if water in your house is not used, the microbes in the pipes can grow and cause odors and funny taste. Flushing the water can resolve this problem. Water should be flushed in the morning or when not used for an extended period of time.

What causes my water to look milky when it comes out of the faucet?
Air trapped in the water lines causes this problem. Let the water sit in a glass. The water becomes clear from the bottom up if air is the cause. The water is safe to drink.

Why is chlorine added to my water?
Chlorine is added to control microbe levels in the water distribution system to keep the water safe. The chlorine level ranges between 0.1 to 0.5 ppm. The small amounts of chlorine in the water do not pose a health hazard. If you want to remove chlorine, either let it sit for a while or filter it through an activated carbon filter.

Water Quality Data

We are required to test your tap water for:

- Different types of chemical contaminants: Regulated contaminants, each with a maximum contaminant level (MCL) and a maximum contaminant level goal (MCLG); and unregulated contaminants, which don't have maximum contaminant levels.

- Coliform bacteria.

- Heavy metals (lead and copper).

Remember that just because these contaminants may be present in your water, it doesn't mean your water has a health risk.

This past year, we tested your water for a wide array of contaminants. Most of them were not found in your water, and only those that we found are reported in the test results section that follows.

Regulated Contaminants

Microbiological Contaminants
Total Coliform Bacteria
Fecal Coliform Bacteria

Radioactive Contaminants
Alpha emitters
Beta/photon emitters
Radium

Inorganic Contaminants
Antimony
Arsenic
Asbestos
Barium
Beryllium
Cadmium
Chromium
Copper
Cyanide
Fluoride
Lead
Mercury
Nitrate
Nitrite
Selenium
Thallium

Organic Contaminants
2,4-D
2,4,5-TP [Silvex]
Acrylamide
Alachlor
Atrazine
Benzo(a)pyrene
Carbofuran
Chlordane
Dalapon
Di(2-ethylhexyl) adipate
Di(2-ethylhexyl) phthalate
Dibromochloropropane
Dinoseb
Diquat
Dioxin
Endothall
Endrin
Epichlorohydrin
Ethylene dibromide
Glyphosate
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Hexachlorocyclopentadiene
Lindane
Methoxychlor
Oxamyl [Vydate]
PCBs [Polychlorinated biphenyls]
Pentachlorophenol
Picloram
Simazine
Toxaphene

Volatile Organic Contaminants
Benzene
Carbon tetrachloride
Chlorobenzene
o-Dichlorobenzene
p-Dichlorobenzene
1,2-Dichloroethane
1,1-Dichloroethylene
cis-1,2-Dichloroethylene
trans-1,2-Dichloroethylene
Dichloromethane
1,2-Dichloropropane
Ethylbenzene
HAA (Haloacetic Acid)
Styrene
Tetrachloroethylene
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
1,2,3-Trichloropropane
TTHMs [Total trihalomethanes]
Toluene
Vinyl Chloride
Xylenes

Unregulated Contaminants

2,4,5-T
2,4-DB
Aldicarb
Aldicarb sulfone
Aldicarb sulfoxide
Aldrin
Butachlor
Carbaryl
Dicamba
Dieldrin
3-Hydroxycarbofurom
Methiocarb
Methomyl
Metolachlor
Metribuzin
Molinate
Nickel
Paraquat
Propachlor
Propoxur
Thiobencarb

Unregulated Contaminant Monitoring Rule 3 (CCCMR3)

1,3 - Butadiene
Chloromethane
1,1 - Dichloraethane
Bromomethane
Chlorodifluoromethane
Bromochloromethane
1,4 - Dioxane
Vanadium
Molybdenum
Cobalt
Strontium
Chromium - 6
Chlorate
Perfluorooctanesulfonic Acid
Perfluorononanoic Acid
Perfluorooctanoic Acid
Perfluorohexanesulfonic Acid
Perfluoroheptanoic Acid
Pefflurobutanesulfonic Acid

Results:

The following tables list all the drinking water contaminants that were found in 2013. Unless otherwise noted, the data presented in the following tables are from testing done January 1 - December 31, 2013.

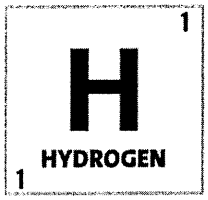
The State requires us to monitor for certain contaminants less than once per year because the concentrations of these contaminants are not expected to vary from year to year. Thus, some of the data, though representative of the water quality, is more than one year old.

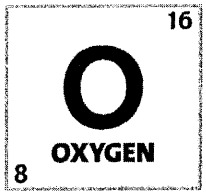
Terms and abbreviations used below:

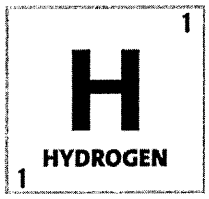
Maximum Contaminant Level Goal (MCLG): is the level of contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

Maximum Contaminant Level (MCL): the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

Action Level (AL): the concentration of a contaminant which, when exceeded, triggers treatment or other requirements which a water system must follow.







n/a: not applicable.

nd: not detectable at testing limit.

ppm: parts per million or milligrams per litter (corresponds to one penny in $10,000).

ppb: parts per billion or micrograms per liter (corresponds to one penny in $10,000,000).

pCi/L: picocuries per litter (a measure or radiation).

mrem/year: millirems per year (a measure of radiation exposure).

Microbiological Contaminants:

Substance	Highest Level Allowed (MCL)	EPA MCLG	Highest Monthly # of Positive Samples	Date	Violation	Source of Contaminant
Total Coliform Bacteria	No More than one sample per month is positive	0	1	2013	No	Naturally present in the environment

Inorganic Contaminants:

Substance	Highest Level Allowed (MCL)	EPA MCLG	Highest Level Detected	Detection Range	Date	Violoation	Source of Contaminant
Chromium (ppb)	100	100	2.6	ND - 2.6	2013	No	Erosion of natural deposits
Nitrate (ppm)	10	10	0.7	0.3 - 0.9	2013	No	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits

Organic Contaminants:

Substance	Highest Level Allowed (MCL)	EPA MCLG	Highest Level Detected	Detection Range	Date	Violoation	Source of Contaminant
TTHMs (Total triha-lomethanes) (ppb)	80	NA	8	ND - 8	2013	No	By-product of drinking water chlorination
Trichloro-propane (ppb)	0.6	NA	0.24	ND - 0.24	2013	No	Contaminate in pesticides used in soil fumigation

Lead and Copper Rule Compliance:

Substance	Action Level	MCLG	Highest Level Detected	# of Sites Sampled	# of Sites Found Above the AL	Date	Souce of Contaminant
Lead (ppb)	15	0	ND	33	0	2012	Corrosion of household plumbing systems
Copper (ppm)	1.3	1.3	0.08	33	0	2012	Corrosion of household plumbing systems

The Kalaheo-Koloa system is in compliance with the Lead and Copper Rule Requirements and is on a reduced monitoring schedule. Samples for lead and copper will be taken and analyzed every three years from residential customers.

Unregulated Contaminants:

Substance	Highest Level Allowed (MCL)	EPA MCLG	Highest Level Detected	Detection Range	Date	Violation	Source of Contaminant
Chlorate (ppb)	-	-	65	33-65	2013	No	Disinfection by product
Chromium 6 (ppb)	-	-	2.8	1.9 - 2.8	2013	No	Erosion of natural deposits
Strontium (ppb)	-	-	56	36 - 56	2013	No	Erosion of natural deposits
Vanadium (ppb)	-	-	33	16 - 33	2013	No	Erosion of natural deposits

Radioactive Contaminants:

Substance	Highest Level Allowed (MCL)	EPA MCLG	Highest Level Detected	Detection Range	Date	Violation	Source of Contaminant
None Detected							

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. The Department of Water is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in you water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline or at http://www.epa.gov/safewater/lead.

Where to call

Who	About	Number
Kaua'i Dept. of Water	General inquiries Water Quality Report	245-5400
State Dept. of Health	Contaminants, health effects State toll-free access line	808-586-4258 274-3141, ext. 64258
EPA Safe Drinking Water Hotline	Contaminants, health effects	1-800-426-4791

Exhibit D

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

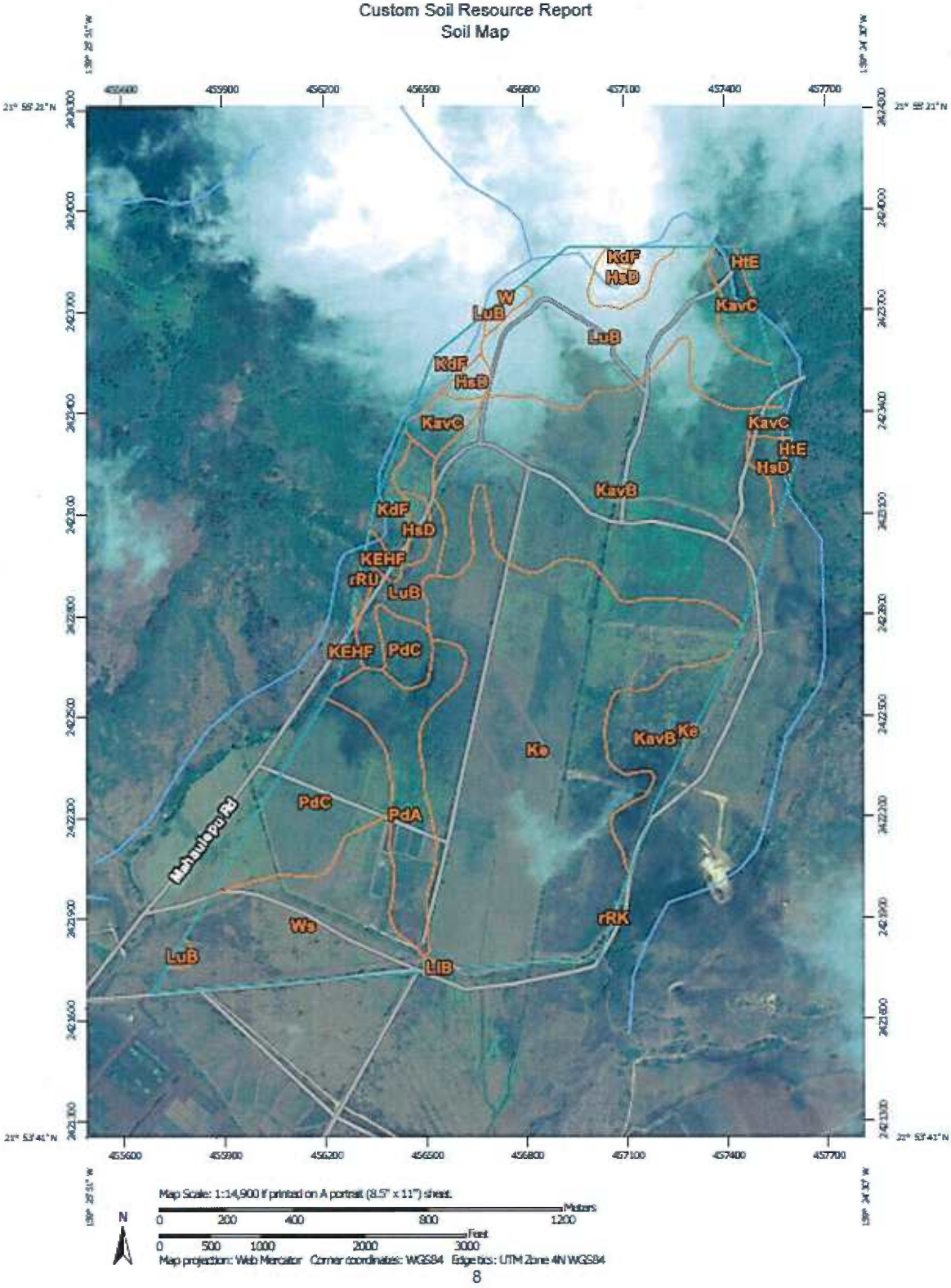
A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Island of Kauai, Hawaii

Contents

- Critical information in the site soils report includes the soil type location map and legend below and the following excerpts:

Custom Soil Resource Report
Soil Map



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Map Unit Legend

Island of Kauai, Hawaii (HI960)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
HsD	Hanamaulu silty clay, 15 to 25 percent slopes	17.3	2.9%
HtE	Hanamaulu stony silty clay, 10 to 35 percent slopes	1.1	0.2%
KavB	Kaena clay, brown variant, 1 to 6 percent slopes	152.0	25.4%
KavC	Kaena clay, brown variant, 6 to 12 percent slopes	17.0	2.8%
KdF	Kalapa silty clay, 40 to 70 percent slopes	12.5	2.1%
Ke	Kalihi clay	182.6	30.5%
KEHF	Kalapa very rocky silty clay, 40 to 70 percent slopes	4.0	0.7%
LIB	Lihue gravelly silty clay, 0 to 8 percent slopes	0.5	0.1%
LuB	Lualualei clay, 2 to 6 percent slopes	78.2	13.1%
PdA	Pakala clay loam, 0 to 2 percent slopes	31.1	5.2%
PdC	Pakala clay loam, 2 to 10 percent slopes	45.0	7.5%
rRK	Rock land	0.0	0.0%
rRU	Rubble land	1.7	0.3%
W	Water > 40 acres	1.9	0.3%
Ws	Waikomo stony silty clay	54.0	9.0%
Totals for Area of Interest		**598.9**	**100.0%**

- The text below is pages 33 through 49 from:

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Island of Kauai, Hawaii

Waste Management

This folder contains a collection of tabular reports that present soil interpretations related to waste management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Waste management interpretations are tools designed to guide the user in evaluating soils for use of organic wastes and wastewater as productive resources. Example interpretations include land application of manure, food processing waste, and municipal sewage sludge, and disposal of wastewater by irrigation or overland flow process.

Agricultural Disposal of Wastewater by Irrigation and Overland Flow

Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage.

This table shows the degree and kind of soil limitations affecting the treatment of wastewater, including municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food- processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. In the context of this table, the effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste.

Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter.

When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

The ratings in the table are for waste management systems that not only dispose of and treat wastewater but also are beneficial to crops. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the tables indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Disposal of wastewater by irrigation not only disposes of municipal wastewater and wastewater from food-processing plants, lagoons, and storage ponds but also can improve crop production by increasing the amount of water available to crops. The ratings in the table are based on the soil properties that affect the design, construction, management, and performance of the irrigation system. The properties that affect design and management include the sodium adsorption ratio, depth to a water table, ponding, available water capacity, Ksat, slope, and flooding. The properties that affect construction include stones, cobbles, depth to bedrock or a cemented pan, depth to a water table, and ponding. The properties that affect performance include depth to bedrock or a cemented pan, bulk density, the sodium adsorption ratio, salinity, reaction, and the cation-exchange capacity, which is used to estimate the capacity of a soil to adsorb heavy metals. Permanently frozen soils are not suitable for disposal of wastewater by irrigation.

Overland flow of wastewater is a process in which wastewater is applied to the upper reaches of sloped land and allowed to flow across vegetated surfaces, sometimes called terraces, to runoff-collection ditches. The length of the run generally is 150 to 300 feet. The application rate ranges from 2.5 to 16.0 inches per week. It commonly exceeds the rate needed for irrigation of cropland. The wastewater leaves solids and nutrients on the vegetated surfaces as it flows downslope in a thin film. Most of the water reaches the collection ditch, some is lost through evapotranspiration, and a small amount may percolate to the ground water.

The ratings in the table are based on the soil properties that affect absorption, plant growth, microbial activity, and the design and construction of the system. Reaction and the cation-exchange capacity affect absorption. Reaction, salinity, and the sodium adsorption ratio affect plant growth and microbial activity. Slope, saturated hydraulic conductivity (Ksat), depth to a water table, ponding, flooding, depth to bedrock or a cemented pan, stones, and cobbles affect design and construction. Permanently frozen soils are unsuitable for waste treatment.

Report—Agricultural Disposal of Wastewater by Irrigation and Overland Flow

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Agricultural Disposal of Wastewater by Irrigation and Overland Flow–Island of Kauai, Hawaii					
Map symbol and soil name	Pct. of map unit	Disposal of wastewater by irrigation		Overland flow of wastewater	
		Rating class and limiting features	Value	Rating class and limiting features	Value
HsD—Hanamaulu silty clay, 15 to 25 percent slopes					
Hanamaulu	100	Very limited		Very limited	
		Too acid	1.00	Seepage	1.00
		Too steep for surface application	1.00	Too acid	1.00
		Too steep for sprinkler application	1.00	Too steep for surface application	1.00
		Low adsorption	0.78	Low adsorption	0.78
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes					
Hanamaulu, stony	100	Very limited		Very limited	
		Too acid	1.00	Seepage	1.00
		Too steep for surface application	1.00	Too acid	1.00
		Too steep for sprinkler application	1.00	Too steep for surface application	1.00
		Low adsorption	0.78	Low adsorption	0.78
		Large stones on the surface	0.37		
KavB—Kaena clay, brown variant, 1 to 6 percent slopes					
Kaena variant	100	Very limited		Somewhat limited	
		Slow water movement	1.00	Stone content	0.99
		Depth to saturated zone	0.09	Seepage	0.37
		Too steep for surface application	0.08	Depth to saturated zone	0.09
		Large stones on the surface	0.01		
KavC—Kaena clay, brown variant, 6 to 12 percent slopes					
Kaena variant	100	Very limited		Somewhat limited	
		Slow water movement	1.00	Stone content	0.99
		Too steep for surface application	1.00	Too steep for surface application	0.50
		Too steep for sprinkler application	0.22	Seepage	0.37
		Depth to saturated zone	0.09	Depth to saturated zone	0.09
		Large stones on the surface	0.01		

Agricultural Disposal of Wastewater by Irrigation and Overland Flow–Island of Kauai, Hawaii					
Map symbol and soil name	Pct. of map unit	Disposal of wastewater by irrigation		Overland flow of wastewater	
		Rating class and limiting features	Value	Rating class and limiting features	Value
KdF—Kalapa silty clay, 40 to 70 percent slopes					
Kalapa	100	Very limited		Very limited	
		Too acid	1.00	Too acid	1.00
		Too steep for surface application	1.00	Too steep for surface application	1.00
		Too steep for sprinkler application	1.00	Seepage	0.49
		Slow water movement	1.00		
Ke—Kalihi clay					
Kalihi	100	Very limited		Very limited	
		Ponding	1.00	Ponding	1.00
		Slow water movement	0.62	Flooding	1.00
		Flooding	0.60	Seepage	1.00
		Depth to saturated zone	0.09	Depth to saturated zone	0.09
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes					
Kalapa, very rocky	75	Very limited		Very limited	
		Too acid	1.00	Too acid	1.00
		Too steep for surface application	1.00	Too steep for surface application	1.00
		Too steep for sprinkler application	1.00	Seepage	0.49
		Slow water movement	1.00		
Rock outcrop	25	Not rated		Not rated	
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes					
Lihue, gravelly	100	Somewhat limited		Very limited	
		Slow water movement	0.50	Seepage	1.00
		Too steep for surface application	0.08		
LuB—Lualualei clay, 2 to 6 percent slopes					
Lualualei	100	Very limited		Very limited	
		Ponding	1.00	Ponding	1.00
		Slow water movement	1.00	Flooding	0.40
		Too steep for surface application	0.08	Seepage	0.37

Agricultural Disposal of Wastewater by Irrigation and Overland Flow–Island of Kauai, Hawaii					
Map symbol and soil name	Pct. of map unit	Disposal of wastewater by irrigation		Overland flow of wastewater	
		Rating class and limiting features	Value	Rating class and limiting features	Value
PdA—Pakala clay loam, 0 to 2 percent slopes					
Pakala	100	Very limited		Very limited	
		Ponding	1.00	Seepage	1.00
		Too acid	1.00	Ponding	1.00
		Flooding	0.60	Too acid	1.00
				Flooding	1.00
PdC—Pakala clay loam, 2 to 10 percent slopes					
Pakala	100	Very limited		Very limited	
		Too acid	1.00	Seepage	1.00
		Too steep for surface application	0.68	Too acid	1.00
		Flooding	0.60	Flooding	1.00
rRK—Rock land					
Rock land	55	Very limited		Very limited	
		Slow water movement	1.00	Seepage	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Droughty	1.00	Too steep for surface application	1.00
		Too steep for surface application	1.00		
		Too steep for sprinkler application	1.00		
Rock outcrop	45	Not rated		Not rated	
rRU—Rubble land					
Rubble land	100	Not rated		Not rated	
W—Water > 40 acres					
Water > 40 acres	100	Not rated		Not rated	
Ws—Waikomo stony silty clay					
Waikomo	100	Very limited		Very limited	
		Large stones on the surface	1.00	Depth to bedrock	1.00
		Droughty	1.00	Stone content	1.00
		Depth to bedrock	0.99	Seepage	1.00
		Slow water movement	0.50		
		Too steep for surface application	0.08		

Water Features

This folder contains tabular reports that present soil hydrology information. The reports (tables) include all selected map units and components for each map unit. Water Features include ponding frequency, flooding frequency, and depth to water table.

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long- duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely

grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding.

Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
HsD—Hanamaulu silty clay, 15 to 25 percent slopes										
Hanamaulu	B	High	Jan-Dec	—	—	—	—	None	—	None
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes										
Hanamaulu, stony	B	Medium	Jan-Dec	—	—	—	—	None	—	None
KavB—Kaena clay, brown variant, 1 to 6 percent slopes										
Kaena variant	D	Medium	January	2.0-5.0	>6.0	—	—	None	—	None
			February	2.0-5.0	>6.0	—	—	None	—	None
			March	2.0-5.0	>6.0	—	—	None	—	None
			April	2.0-5.0	>6.0	—	—	None	—	None
			November	2.0-5.0	>6.0	—	—	None	—	None
			December	2.0-5.0	>6.0	—	—	None	—	None
KavC—Kaena clay, brown variant, 6 to 12 percent slopes										
Kaena variant	D	High	January	2.0-5.0	>6.0	—	—	None	—	None
			February	2.0-5.0	>6.0	—	—	None	—	None
			March	2.0-5.0	>6.0	—	—	None	—	None
			April	2.0-5.0	>6.0	—	—	None	—	None
			November	2.0-5.0	>6.0	—	—	None	—	None
			December	2.0-5.0	>6.0	—	—	None	—	None

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
KdF—Kalapa silty clay, 40 to 70 percent slopes										
Kalapa	B	Very high	Jan-Dec	—	—	—	—	None	—	None
Ke—Kalihi clay										
Kalihi	D	Negligible	January	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			February	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			March	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			April	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			May	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			June	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			July	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			August	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			September	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			October	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			November	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			December	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes										
Kalapa, very rocky	B	Very high	Jan-Dec	—	—	—	—	None	—	None
Rock outcrop	D	—	Jan-Dec	—	—	—	—	None	—	None
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes										
Lihue, gravelly	B	Low	Jan-Dec	—	—	—	—	None	—	None

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
LuB—Lualualei clay, 2 to 6 percent slopes										
Lualualei	D	Very low	January	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			February	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			March	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			April	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			May	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			June	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			July	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			August	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			September	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			October	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			November	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			December	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
PdA—Pakala clay loam, 0 to 2 percent slopes										
Pakala	B	Very low	January	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			February	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			March	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			April	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			May	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			June	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			July	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			August	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			September	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			October	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			November	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			December	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
PdC—Pakala clay loam, 2 to 10 percent slopes										
Pakala	B	Medium	January	—	—	—	—	None	Very brief	Occasional
			February	—	—	—	—	None	Very brief	Occasional
			March	—	—	—	—	None	Very brief	Occasional
			April	—	—	—	—	None	Very brief	None
			May	—	—	—	—	None	Very brief	Rare
			June	—	—	—	—	None	Very brief	Rare
			July	—	—	—	—	None	Very brief	Rare
			August	—	—	—	—	None	Very brief	Rare
			September	—	—	—	—	None	Very brief	Rare
			October	—	—	—	—	None	Very brief	Rare
			November	—	—	—	—	None	Very brief	Occasional
			December	—	—	—	—	None	Very brief	Occasional
rRK—Rock land										
Rock land	D	Very high	Jan-Dec	—	—	—	—	None	—	None
Rock outcrop	D	—	Jan-Dec	—	—	—	—	None	—	None
rRU—Rubble land										
Rubble land	A	Low	Jan-Dec	—	—	—	—	None	—	None
W—Water > 40 acres										
Water > 40 acres	—	—	Jan-Dec	—	—	—	—	None	—	None
Ws—Waikomo stony silty clay										
Waikomo	D	Low	Jan-Dec	—	—	—	—	None	—	None

Water Management

This folder contains a collection of tabular reports that present soil interpretations related to water management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Water management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Irrigation - General and Sprinkler

This table shows the degree and kind of soil limitations that affect irrigation systems on mineral soils. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected.

Somewhat limited indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Irrigation systems are used to provide supplemental water to crops, orchards, vineyards, and vegetables in area where natural precipitation will not support desired production of crops being grown.

Irrigation – general evaluates a soil's limitation(s) for installation and use of non- specific irrigation methods and is intended to provide initial planning information. Additional interpretations provide more specific information. This interpretation does not apply if the crop planned for irrigation is rice or other crops with unique plant physiological characteristics (such as cranberries). The ratings are for soils in their natural condition and do not consider present land use.

The soil properties and qualities important in design and management of irrigation systems are sodium adsorption ratio, depth to high water table, available water holding capacity, permeability, slope, calcium carbonate content, ponding, and flooding. Soil properties and qualities that influence installation are stones, depth to bedrock or cemented pan, and depth to a high water table. The properties and qualities that affect performance of the irrigation system are depth to bedrock or to a cemented pan, the sodium adsorption ratio, salinity, and soil reaction.

Irrigation, sprinkler (close spaced outlets drops) evaluates a soil for installation and use of sprinkler irrigation systems equipped with close spaced outlets on drops. The ratings are for soils in their natural condition and do not consider present land use.

Sprinkler irrigation systems equipped with low pressure spray nozzles mounted on close spaced drops apply water close to the ground surface. These systems are generally found on linear move or center pivot systems and they have separate slope criteria from other sprinkler systems due to their higher application rate which increase risk of runoff and irrigation-induced erosion on steeper slopes. Examples of these types of systems include Low Pressure in Canopy (LPIC), Low Energy Precision Application (LEPA), Low Elevation Spray Application (LESA), and Mid-Elevation Spray Application (MESA) systems. These types of irrigation systems are generally suitable for small grains, row crops, and vegetables.

The soil properties and qualities important in the design and management of sprinkler irrigation systems utilizing close spaced spray nozzles on drops are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, permeability, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface texture, surface rocks, salinity, sodium adsorption ratio, wetness, erosion potential, and available water holding capacity.

Irrigation, sprinkler (general) evaluates a soil for installation and use of sprinkler irrigation systems excluding those equipped with close spaced outlets on drops. The ratings are for soils in their natural condition and do not consider present land use.

Sprinkler irrigation systems apply irrigation water to a field through a series of pipes and nozzles and can be either solid set or mobile. Generally, this type of irrigation system is suitable for small grains, row crops, vegetables, and orchards.

The soil properties and qualities important in the design and management of sprinkler irrigation systems are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, permeability, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface rocks, salinity, sodium adsorption ratio, wetness, and available water holding capacity.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet.

Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design. The irrigation interpretations are not designed or intended to be used in a regulatory manner.

Report—Irrigation - General and Sprinkler

[The information in this table provides irrigation interpretations for mineral soils. Onsite investigation may be needed to validate the interpretations and to confirm the identity of

the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Irrigation - General and Sprinkler–Island of Kauai, Hawaii							
Map symbol and soil name	Pct. of map unit	Irrigation (general)		Irrigation, Sprinkler (close spaced outlet drops)		Irrigation, Sprinkler (general)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
HsD—Hanamaulu silty clay, 15 to 25 percent slopes							
Hanamaulu	100	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.44	Surface clay	0.88	Surface clay	0.88
		Rapid water movement	0.40	Water Erosion	0.50	Too acid	0.44
		Seepage	0.18	Too acid	0.44		
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes							
Hanamaulu, stony	100	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.44	Surface clay	0.88	Surface clay	0.88
		Rapid water movement	0.40	Too acid	0.44	Too acid	0.44
		Seepage	0.18	Water Erosion	0.32		
KavB—Kaena clay, brown variant, 1 to 6 percent slopes							
Kaena variant	100	Not rated		Not Rated		Not Rated	
KavC—Kaena clay, brown variant, 6 to 12 percent slopes							
Kaena variant	100	Not rated		Not Rated		Not Rated	
KdF—Kalapa silty clay, 40 to 70 percent slopes							
Kalapa	100	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.04	Water Erosion	1.00	Surface clay	0.98
				Surface clay	0.98	Slow water movement	0.61
				Slow water movement	0.61	Too acid	0.04
				Too acid	0.04		
Ke—Kalihi clay							
Kalihi	100	Not rated		Not Rated		Not Rated	

Irrigation - General and Sprinkler–Island of Kauai, Hawaii							
Map symbol and soil name	Pct. of map unit	Irrigation (general)		Irrigation, Sprinkler (close spaced outlet drops)		Irrigation, Sprinkler (general)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes							
Kalapa, very rocky	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.04	Water Erosion	1.00	Surface clay	0.98
				Surface clay	0.98	Slow water movement	0.90
				Slow water movement	0.90	Too acid	0.04
				Too acid	0.04		
Rock outcrop	25	Not rated		Not Rated		Not Rated	
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes							
Lihue, gravelly	100	Somewhat limited		Somewhat limited		Somewhat limited	
		Seepage	0.18	Surface clay	0.98	Surface clay	0.98
		Slope	0.09	Slope	0.86		
		Rapid water movement	0.02				
LuB—Lualualei clay, 2 to 6 percent slopes							
Lualualei	100	Very limited		Very limited		Very limited	
		Ponding	1.00	Ponding	1.00	Ponding	1.00
		Slope	0.09	Surface clay	1.00	Surface clay	1.00
		Low water holding capacity	0.01	Slope	0.86	Slow water movement	0.61
				Slow water movement	0.61	Low water holding capacity	0.01
				Water Erosion	0.01		
PdA—Pakala clay loam, 0 to 2 percent slopes							
Pakala	100	Not rated		Not Rated		Not Rated	
PdC—Pakala clay loam, 2 to 10 percent slopes							
Pakala	100	Not rated		Not Rated		Not Rated	
rRK—Rock land							
Rock land	55	Not rated		Not Rated		Not Rated	
Rock outcrop	45	Not rated		Not Rated		Not Rated	
rRU—Rubble land							
Rubble land	100	Not rated		Not Rated		Not Rated	

Irrigation - General and Sprinkler–Island of Kauai, Hawaii							
Map symbol and soil name	Pct. of map unit	Irrigation (general)		Irrigation, Sprinkler (close spaced outlet drops)		Irrigation, Sprinkler (general)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
W—Water > 40 acres							
Water > 40 acres	100	Not rated		Not Rated		Not Rated	
Ws—Waikomo stony silty clay							
Waikomo	100	Very limited		Very limited		Very limited	
		Low water holding capacity	1.00	Low water holding capacity	1.00	Low water holding capacity	1.00
		Depth to hard bedrock	1.00	Content of large stones	1.00	Content of large stones	1.00
		Content of large stones	1.00	Depth to hard bedrock	0.99	Depth to hard bedrock	0.99
		Slope	0.09	Slope	0.86	Surface clay	0.50
		Rapid water movement	0.02	Surface clay	0.50		

Exhibit E

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Island of Kauai, Hawaii

June 5, 2014

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

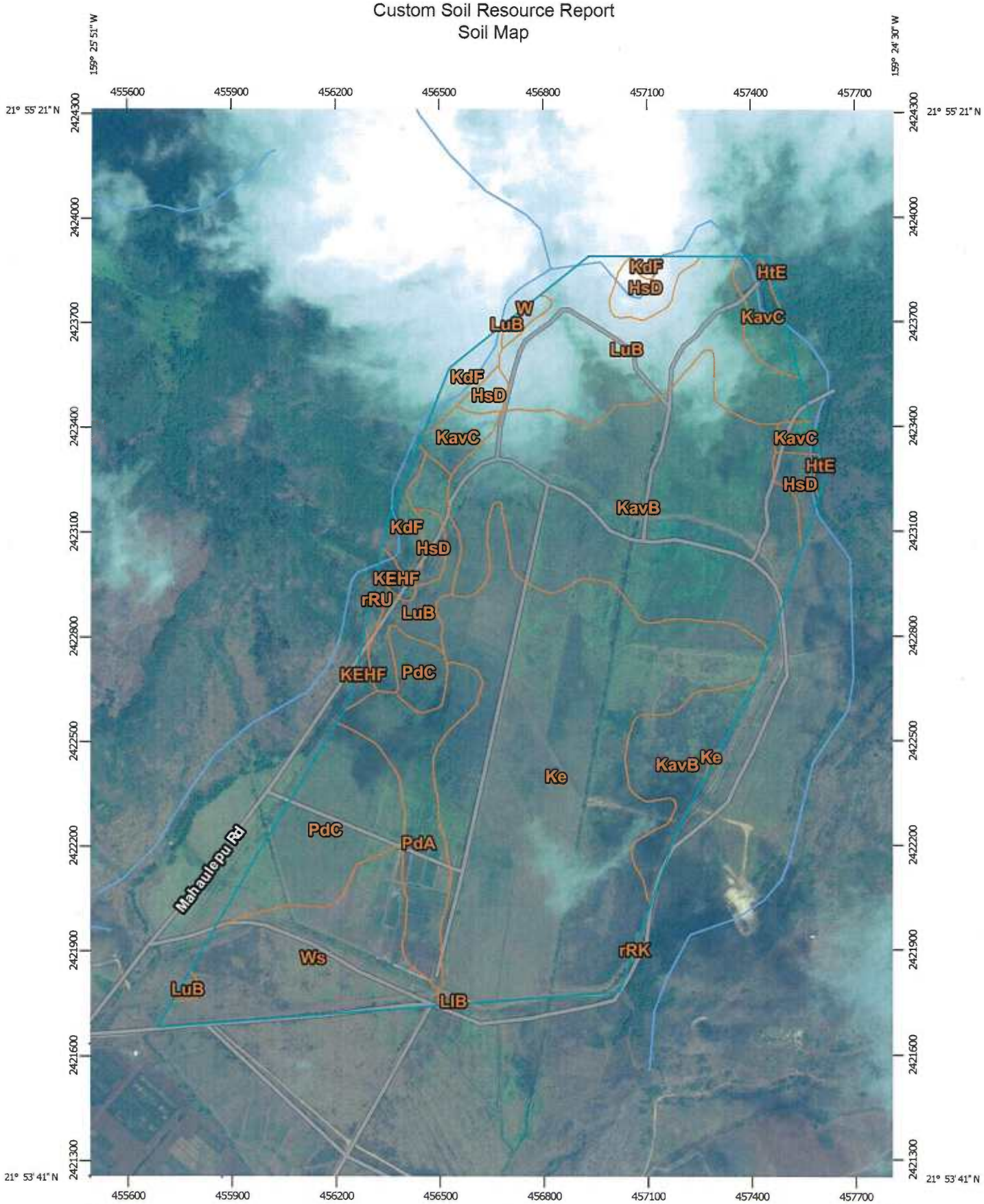
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:14,900 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 4N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Island of Kauai, Hawaii
Survey Area Data: Version 8, Dec 7, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 26, 2011—Oct 3, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Island of Kauai, Hawaii (HI960)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
HsD	Hanamaulu silty clay, 15 to 25 percent slopes	17.3	2.9%
HtE	Hanamaulu stony silty clay, 10 to 35 percent slopes	1.1	0.2%
KavB	Kaena clay, brown variant, 1 to 6 percent slopes	152.0	25.4%
KavC	Kaena clay, brown variant, 6 to 12 percent slopes	17.0	2.8%
KdF	Kalapa silty clay, 40 to 70 percent slopes	12.5	2.1%
Ke	Kalihi clay	182.6	30.5%
KEHF	Kalapa very rocky silty clay, 40 to 70 percent slopes	4.0	0.7%
LIB	Lihue gravelly silty clay, 0 to 8 percent slopes	0.5	0.1%
LuB	Lualualei clay, 2 to 6 percent slopes	78.2	13.1%
PdA	Pakala clay loam, 0 to 2 percent slopes	31.1	5.2%
PdC	Pakala clay loam, 2 to 10 percent slopes	45.0	7.5%
rRK	Rock land	0.0	0.0%
rRU	Rubble land	1.7	0.3%
W	Water > 40 acres	1.9	0.3%
Ws	Waikomo stony silty clay	54.0	9.0%
Totals for Area of Interest		**598.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas

for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of

the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas.* Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Island of Kauai, Hawaii

HsD—Hanamaulu silty clay, 15 to 25 percent slopes

Map Unit Setting

Elevation: 200 to 700 feet
Mean annual precipitation: 60 to 100 inches
Mean annual air temperature: 72 to 73 degrees F
Frost-free period: 365 days

Map Unit Composition

Hanamaulu and similar soils: 100 percent

Description of Hanamaulu

Setting

Landform: Terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Basic igneous rocks

Typical profile

H1 - 0 to 11 inches: extremely acid, silty clay
H2 - 11 to 36 inches: very strongly acid, silty clay
H3 - 36 to 72 inches: very strongly acid, silty clay loam

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Farmland classification: All areas are prime farmland
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes

Map Unit Setting

Elevation: 200 to 700 feet
Mean annual precipitation: 60 to 100 inches
Mean annual air temperature: 72 to 73 degrees F

Frost-free period: 365 days

Map Unit Composition

Hanamaulu, stony, and similar soils: 100 percent

Description of Hanamaulu, Stony

Setting

Landform: Terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Basic igneous rocks

Typical profile

H1 - 0 to 11 inches: extremely acid, stony silty clay
H2 - 11 to 36 inches: very strongly acid, silty clay
H3 - 36 to 72 inches: very strongly acid, silty clay loam

Properties and qualities

Slope: 10 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

KavB—Kaena clay, brown variant, 1 to 6 percent slopes

Map Unit Setting

Elevation: 50 to 150 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Kaena variant and similar soils: 100 percent

Description of Kaena Variant

Setting

Landform: Fans
Landform position (two-dimensional): Toeslope

Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Formed in alluvium and colluvium

Typical profile

H1 - 0 to 10 inches: neutral, clay
H2 - 10 to 37 inches: neutral, stony clay
H3 - 37 to 54 inches: neutral, stony clay

Properties and qualities

Slope: 1 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 24 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Farmland classification: All areas are prime farmland
Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D

KavC—Kaena clay, brown variant, 6 to 12 percent slopes

Map Unit Setting

Elevation: 50 to 150 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Kaena variant and similar soils: 100 percent

Description of Kaena Variant

Setting

Landform: Fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Formed in alluvium and colluvium

Typical profile

H1 - 0 to 10 inches: neutral, clay
H2 - 10 to 37 inches: neutral, stony clay
H3 - 37 to 54 inches: neutral, stony clay

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 24 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D

KdF—Kalapa silty clay, 40 to 70 percent slopes

Map Unit Setting

Elevation: 200 to 1,200 feet
Mean annual precipitation: 60 to 100 inches
Mean annual air temperature: 68 to 73 degrees F
Frost-free period: 365 days

Map Unit Composition

Kalapa and similar soils: 100 percent

Description of Kalapa

Setting

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basic igneous rock

Typical profile

H1 - 0 to 10 inches: very strongly acid, silty clay
H2 - 10 to 60 inches: very strongly acid, clay

Properties and qualities

Slope: 40 to 70 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B

Ke—Kalihi clay

Map Unit Setting

Elevation: 50 to 100 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Kalihi and similar soils: 100 percent

Description of Kalihi

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basic igneous rock

Typical profile

H1 - 0 to 16 inches: neutral, clay
H2 - 16 to 70 inches: neutral, clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 24 to 60 inches
Frequency of flooding: Occasional
Frequency of ponding: Frequent
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Farmland classification: Prime farmland if protected from flooding or not frequently flooded during the growing season
Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D

KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes

Map Unit Setting

Elevation: 0 to 10,000 feet
Mean annual precipitation: 10 to 175 inches
Mean annual air temperature: 45 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Kalapa, very rocky, and similar soils: 75 percent
Rock outcrop: 25 percent

Description of Kalapa, Very Rocky

Setting

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basic igneous rock

Typical profile

H1 - 0 to 10 inches: very strongly acid, silty clay
H2 - 10 to 60 inches: very strongly acid, clay

Properties and qualities

Slope: 40 to 70 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B

Description of Rock Outcrop

Setting

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank, side slope, tread, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basalt

Typical profile

H1 - 0 to 60 inches: , bedrock

Properties and qualities

Slope: 40 to 70 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D

LIB—Lihue gravelly silty clay, 0 to 8 percent slopes

Map Unit Setting

Elevation: 0 to 800 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Lihue, gravelly, and similar soils: 100 percent

Description of Lihue, Gravelly

Setting

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basic igneous dust

Typical profile

H1 - 0 to 12 inches: slightly acid, gravelly silty clay
H2 - 12 to 60 inches: slightly acid, silty clay

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B

LuB—Lualualei clay, 2 to 6 percent slopes

Map Unit Setting

Elevation: 10 to 120 feet
Mean annual precipitation: 18 to 30 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Lualualei and similar soils: 100 percent

Description of Lualualei

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

H1 - 0 to 10 inches: neutral, clay
H2 - 10 to 60 inches: neutral, clay

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: Rare
Available water storage in profile: Moderate (about 7.1 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D

PdA—Pakala clay loam, 0 to 2 percent slopes

Map Unit Setting

Elevation: 0 to 400 feet
Mean annual precipitation: 25 to 40 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Pakala and similar soils: 100 percent

Description of Pakala

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

H1 - 0 to 16 inches: very strongly acid, clay loam
H2 - 16 to 60 inches: moderately acid, silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: Occasional
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: B

PdC—Pakala clay loam, 2 to 10 percent slopes

Map Unit Setting

Elevation: 0 to 400 feet
Mean annual precipitation: 25 to 40 inches

Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition
Pakala and similar soils: 100 percent

Description of Pakala

Setting
Landform: Alluvial fans
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium

Typical profile
H1 - 0 to 16 inches: very strongly acid, clay loam
H2 - 16 to 60 inches: moderately acid, silty clay loam

Properties and qualities
Slope: 2 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups
Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B

rRK—Rock land

Map Unit Setting
Elevation: 0 to 6,000 feet
Mean annual precipitation: 15 to 60 inches
Mean annual air temperature: 57 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition
Rock land and similar soils: 55 percent
Rock outcrop: 45 percent

Description of Rock Land

Setting
Landform: Pahoehoe lava flows

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank, side slope, riser, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basalt

Typical profile

H1 - 0 to 4 inches: neutral, silty clay
H2 - 4 to 8 inches: neutral, silty clay
H3 - 8 to 20 inches: , bedrock

Properties and qualities

Slope: 10 to 70 percent
Depth to restrictive feature: 4 to 10 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 1.1 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D

Description of Rock Outcrop

Setting

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank, side slope, tread, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basalt

Typical profile

H1 - 0 to 60 inches: , bedrock

Properties and qualities

Slope: 10 to 70 percent
Depth to restrictive feature: 0 to 60 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D

rRU—Rubble land

Map Unit Setting

Elevation: 0 to 500 feet
Mean annual precipitation: 22 to 50 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Rubble land: 100 percent

Description of Rubble Land

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Mountainbase
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium and colluvium

Typical profile

H1 - 0 to 60 inches: , extremely stony material

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: A

W—Water > 40 acres

Map Unit Setting

Frost-free period: 365 days

Map Unit Composition

Water > 40 acres: 100 percent

Description of Water > 40 Acres

Properties and qualities

Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Ws—Waikomo stony silty clay

Map Unit Setting

Elevation: 0 to 360 feet
Mean annual precipitation: 35 to 60 inches
Mean annual air temperature: 73 to 75 degrees F
Frost-free period: 365 days

Map Unit Composition

Waikomo and similar soils: 100 percent

Description of Waikomo

Setting

Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Basalt

Typical profile

H1 - 0 to 14 inches: neutral, stony silty clay
H2 - 14 to 20 inches: slightly alkaline, stony silty clay loam
H3 - 20 to 30 inches: , bedrock

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.0 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Qualities and Features

This folder contains tabular reports that present various soil qualities and features. The reports (tables) include all selected map units and components for each map unit. Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Soil Features

This table gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Subsidence is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial

subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low*, *moderate*, or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Soil Features–Island of Kauai, Hawaii									
Map symbol and soil name	Restrictive Layer				Subsidence		Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Thickness	Hardness	Initial	Total		Uncoated steel	Concrete
		In	*In*		*In*	*In*			
HsD—Hanamaulu silty clay, 15 to 25 percent slopes									
Hanamaulu		—	—		0	—	None	High	High
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes									
Hanamaulu, stony		—	—		0	—	None	High	High
KavB—Kaena clay, brown variant, 1 to 6 percent slopes									
Kaena variant		—	—		0	—	None	Moderate	Low
KavC—Kaena clay, brown variant, 6 to 12 percent slopes									
Kaena variant		—	—		0	—	None	Moderate	Low
KdF—Kalapa silty clay, 40 to 70 percent slopes									
Kalapa		—	—		0	—	None	High	High
Ke—Kalihi clay									
Kalihi		—	—		0	—	None	High	Low
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes									
Kalapa, very rocky		—	—		0	—	None	High	High
Rock outcrop	Lithic bedrock	0	—	Indurated	0	—	None		

Soil Features–Island of Kauai, Hawaii									
Map symbol and soil name	Restrictive Layer				Subsidence		Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Thickness	Hardness	Initial	Total		Uncoated steel	Concrete
		In	*In*		*In*	*In*			
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes									
Lihue, gravelly		—	—		0	—	None	Moderate	Moderate
LuB—Lualualei clay, 2 to 6 percent slopes									
Lualualei		—	—		0	—	None	Moderate	Moderate
PdA—Pakala clay loam, 0 to 2 percent slopes									
Pakala		—	—		0	—	None	Moderate	Moderate
PdC—Pakala clay loam, 2 to 10 percent slopes									
Pakala		—	—		0	—	None	Moderate	Moderate
rRK—Rock land									
Rock land	Lithic bedrock	4-10	—	Indurated	0	—	None	Moderate	Low
Rock outcrop	Lithic bedrock	0-60	—	Indurated	0	—	None	Moderate	Low
rRU—Rubble land									
Rubble land		—	—		0	—	None		
W—Water > 40 acres									
Water > 40 acres		—	—		0	—	None		
Ws—Waikomo stony silty clay									
Waikomo	Lithic bedrock	10-20	—	Indurated	0	—	None	Moderate	Low

Soil Features

This table gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of which significantly affect the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Subsidence is the settlement of organic soils or of saturated mineral soils of very low density. Subsidence generally results from either desiccation and shrinkage, or oxidation of organic material, or both, following drainage. Subsidence takes place gradually, usually over a period of several years. The table shows the expected initial subsidence, which usually is a result of drainage, and total subsidence, which results from a combination of factors.

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low*, *moderate*, or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Soil Features–Island of Kauai, Hawaii									
Map symbol and soil name	Restrictive Layer				Subsidence		Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Thickness	Hardness	Initial	Total		Uncoated steel	Concrete
		In	*In*		*In*	*In*			
HsD—Hanamaulu silty clay, 15 to 25 percent slopes									
Hanamaulu		—	—		0	—	None	High	High
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes									
Hanamaulu, stony		—	—		0	—	None	High	High
KavB—Kaena clay, brown variant, 1 to 6 percent slopes									
Kaena variant		—	—		0	—	None	Moderate	Low
KavC—Kaena clay, brown variant, 6 to 12 percent slopes									
Kaena variant		—	—		0	—	None	Moderate	Low
KdF—Kalapa silty clay, 40 to 70 percent slopes									
Kalapa		—	—		0	—	None	High	High
Ke—Kalihi clay									
Kalihi		—	—		0	—	None	High	Low
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes									
Kalapa, very rocky		—	—		0	—	None	High	High
Rock outcrop	Lithic bedrock	0	—	Indurated	0	—	None		

Soil Features–Island of Kauai, Hawaii									
Map symbol and soil name	Restrictive Layer				Subsidence		Potential for frost action	Risk of corrosion	
	Kind	Depth to top	Thickness	Hardness	Initial	Total		Uncoated steel	Concrete
		In	*In*		*In*	*In*			
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes									
Lihue, gravelly		—	—		0	—	None	Moderate	Moderate
LuB—Lualualei clay, 2 to 6 percent slopes									
Lualualei		—	—		0	—	None	Moderate	Moderate
PdA—Pakala clay loam, 0 to 2 percent slopes									
Pakala		—	—		0	—	None	Moderate	Moderate
PdC—Pakala clay loam, 2 to 10 percent slopes									
Pakala		—	—		0	—	None	Moderate	Moderate
rRK—Rock land									
Rock land	Lithic bedrock	4-10	—	Indurated	0	—	None	Moderate	Low
Rock outcrop	Lithic bedrock	0-60	—	Indurated	0	—	None	Moderate	Low
rRU—Rubble land									
Rubble land		—	—		0	—	None		
W—Water > 40 acres									
Water > 40 acres		—	—		0	—	None		
Ws—Waikomo stony silty clay									
Waikomo	Lithic bedrock	10-20	—	Indurated	0	—	None	Moderate	Low

Waste Management

This folder contains a collection of tabular reports that present soil interpretations related to waste management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Waste management interpretations are tools designed to guide the user in evaluating soils for use of organic wastes and wastewater as productive resources. Example interpretations include land application of manure, food processing waste, and municipal sewage sludge, and disposal of wastewater by irrigation or overland flow process.

Agricultural Disposal of Wastewater by Irrigation and Overland Flow

Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage.

This table shows the degree and kind of soil limitations affecting the treatment of wastewater, including municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. In the context of this table, the effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

The ratings in the table are for waste management systems that not only dispose of and treat wastewater but also are beneficial to crops. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the tables indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Disposal of wastewater by irrigation not only disposes of municipal wastewater and wastewater from food-processing plants, lagoons, and storage ponds but also can improve crop production by increasing the amount of water available to crops. The ratings in the table are based on the soil properties that affect the design, construction, management, and performance of the irrigation system. The properties that affect design and management include the sodium adsorption ratio, depth to a water table, ponding, available water capacity, Ksat, slope, and flooding. The properties that affect construction include stones, cobbles, depth to bedrock or a cemented pan, depth to a water table, and ponding. The properties that affect performance include depth to bedrock or a cemented pan, bulk density, the sodium adsorption ratio, salinity, reaction, and the cation-exchange capacity, which is used to estimate the capacity of a soil to adsorb heavy metals. Permanently frozen soils are not suitable for disposal of wastewater by irrigation.

Overland flow of wastewater is a process in which wastewater is applied to the upper reaches of sloped land and allowed to flow across vegetated surfaces, sometimes called terraces, to runoff-collection ditches. The length of the run generally is 150 to 300 feet. The application rate ranges from 2.5 to 16.0 inches per week. It commonly exceeds the rate needed for irrigation of cropland. The wastewater leaves solids and nutrients on the vegetated surfaces as it flows downslope in a thin film. Most of the water reaches the collection ditch, some is lost through evapotranspiration, and a small amount may percolate to the ground water.

The ratings in the table are based on the soil properties that affect absorption, plant growth, microbial activity, and the design and construction of the system. Reaction and the cation-exchange capacity affect absorption. Reaction, salinity, and the sodium adsorption ratio affect plant growth and microbial activity. Slope, saturated hydraulic conductivity (Ksat), depth to a water table, ponding, flooding, depth to bedrock or a cemented pan, stones, and cobbles affect design and construction. Permanently frozen soils are unsuitable for waste treatment.

Report—Agricultural Disposal of Wastewater by Irrigation and Overland Flow

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Agricultural Disposal of Wastewater by Irrigation and Overland Flow–Island of Kauai, Hawaii					
Map symbol and soil name	Pct. of map unit	Disposal of wastewater by irrigation		Overland flow of wastewater	
		Rating class and limiting features	Value	Rating class and limiting features	Value
HsD—Hanamaulu silty clay, 15 to 25 percent slopes					
Hanamaulu	100	Very limited		Very limited	
		Too acid	1.00	Seepage	1.00
		Too steep for surface application	1.00	Too acid	1.00
		Too steep for sprinkler application	1.00	Too steep for surface application	1.00
		Low adsorption	0.78	Low adsorption	0.78
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes					
Hanamaulu, stony	100	Very limited		Very limited	
		Too acid	1.00	Seepage	1.00
		Too steep for surface application	1.00	Too acid	1.00
		Too steep for sprinkler application	1.00	Too steep for surface application	1.00
		Low adsorption	0.78	Low adsorption	0.78
		Large stones on the surface	0.37		
KavB—Kaena clay, brown variant, 1 to 6 percent slopes					
Kaena variant	100	Very limited		Somewhat limited	
		Slow water movement	1.00	Stone content	0.99
		Depth to saturated zone	0.09	Seepage	0.37
		Too steep for surface application	0.08	Depth to saturated zone	0.09
		Large stones on the surface	0.01		
KavC—Kaena clay, brown variant, 6 to 12 percent slopes					
Kaena variant	100	Very limited		Somewhat limited	
		Slow water movement	1.00	Stone content	0.99
		Too steep for surface application	1.00	Too steep for surface application	0.50
		Too steep for sprinkler application	0.22	Seepage	0.37
		Depth to saturated zone	0.09	Depth to saturated zone	0.09
		Large stones on the surface	0.01		

Agricultural Disposal of Wastewater by Irrigation and Overland Flow–Island of Kauai, Hawaii					
Map symbol and soil name	Pct. of map unit	Disposal of wastewater by irrigation		Overland flow of wastewater	
		Rating class and limiting features	Value	Rating class and limiting features	Value
KdF—Kalapa silty clay, 40 to 70 percent slopes					
Kalapa	100	Very limited		Very limited	
		Too acid	1.00	Too acid	1.00
		Too steep for surface application	1.00	Too steep for surface application	1.00
		Too steep for sprinkler application	1.00	Seepage	0.49
		Slow water movement	1.00		
Ke—Kalihi clay					
Kalihi	100	Very limited		Very limited	
		Ponding	1.00	Ponding	1.00
		Slow water movement	0.62	Flooding	1.00
		Flooding	0.60	Seepage	1.00
		Depth to saturated zone	0.09	Depth to saturated zone	0.09
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes					
Kalapa, very rocky	75	Very limited		Very limited	
		Too acid	1.00	Too acid	1.00
		Too steep for surface application	1.00	Too steep for surface application	1.00
		Too steep for sprinkler application	1.00	Seepage	0.49
		Slow water movement	1.00		
Rock outcrop	25	Not rated		Not rated	
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes					
Lihue, gravelly	100	Somewhat limited		Very limited	
		Slow water movement	0.50	Seepage	1.00
		Too steep for surface application	0.08		
LuB—Lualualei clay, 2 to 6 percent slopes					
Lualualei	100	Very limited		Very limited	
		Ponding	1.00	Ponding	1.00
		Slow water movement	1.00	Flooding	0.40
		Too steep for surface application	0.08	Seepage	0.37

Agricultural Disposal of Wastewater by Irrigation and Overland Flow–Island of Kauai, Hawaii					
Map symbol and soil name	Pct. of map unit	Disposal of wastewater by irrigation		Overland flow of wastewater	
		Rating class and limiting features	Value	Rating class and limiting features	Value
PdA—Pakala clay loam, 0 to 2 percent slopes					
Pakala	100	Very limited		Very limited	
		Ponding	1.00	Seepage	1.00
		Too acid	1.00	Ponding	1.00
		Flooding	0.60	Too acid	1.00
				Flooding	1.00
PdC—Pakala clay loam, 2 to 10 percent slopes					
Pakala	100	Very limited		Very limited	
		Too acid	1.00	Seepage	1.00
		Too steep for surface application	0.68	Too acid	1.00
		Flooding	0.60	Flooding	1.00
rRK—Rock land					
Rock land	55	Very limited		Very limited	
		Slow water movement	1.00	Seepage	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
		Droughty	1.00	Too steep for surface application	1.00
		Too steep for surface application	1.00		
		Too steep for sprinkler application	1.00		
Rock outcrop	45	Not rated		Not rated	
rRU—Rubble land					
Rubble land	100	Not rated		Not rated	
W—Water > 40 acres					
Water > 40 acres	100	Not rated		Not rated	
Ws—Waikomo stony silty clay					
Waikomo	100	Very limited		Very limited	
		Large stones on the surface	1.00	Depth to bedrock	1.00
		Droughty	1.00	Stone content	1.00
		Depth to bedrock	0.99	Seepage	1.00
		Slow water movement	0.50		
		Too steep for surface application	0.08		

Water Features

This folder contains tabular reports that present soil hydrology information. The reports (tables) include all selected map units and components for each map unit. Water Features include ponding frequency, flooding frequency, and depth to water table.

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely

grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
HsD—Hanamaulu silty clay, 15 to 25 percent slopes										
Hanamaulu	B	High	Jan-Dec	—	—	—	—	None	—	None
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes										
Hanamaulu, stony	B	Medium	Jan-Dec	—	—	—	—	None	—	None
KavB—Kaena clay, brown variant, 1 to 6 percent slopes										
Kaena variant	D	Medium	January	2.0-5.0	>6.0	—	—	None	—	None
			February	2.0-5.0	>6.0	—	—	None	—	None
			March	2.0-5.0	>6.0	—	—	None	—	None
			April	2.0-5.0	>6.0	—	—	None	—	None
			November	2.0-5.0	>6.0	—	—	None	—	None
			December	2.0-5.0	>6.0	—	—	None	—	None
KavC—Kaena clay, brown variant, 6 to 12 percent slopes										
Kaena variant	D	High	January	2.0-5.0	>6.0	—	—	None	—	None
			February	2.0-5.0	>6.0	—	—	None	—	None
			March	2.0-5.0	>6.0	—	—	None	—	None
			April	2.0-5.0	>6.0	—	—	None	—	None
			November	2.0-5.0	>6.0	—	—	None	—	None
			December	2.0-5.0	>6.0	—	—	None	—	None

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
KdF—Kalapa silty clay, 40 to 70 percent slopes										
Kalapa	B	Very high	Jan-Dec	—	—	—	—	None	—	None
Ke—Kalihi clay										
Kalihi	D	Negligible	January	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			February	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			March	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			April	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			May	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			June	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			July	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			August	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			September	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			October	—	—	0.1-0.8	Very brief	Frequent	Very brief	Rare
			November	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
			December	2.0-5.0	>6.0	0.1-0.8	Very brief	Frequent	Very brief	Occasional
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes										
Kalapa, very rocky	B	Very high	Jan-Dec	—	—	—	—	None	—	None
Rock outcrop	D	—	Jan-Dec	—	—	—	—	None	—	None
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes										
Lihue, gravelly	B	Low	Jan-Dec	—	—	—	—	None	—	None

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
LuB—Lualualei clay, 2 to 6 percent slopes										
Lualualei	D	Very low	January	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			February	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			March	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			April	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			May	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			June	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			July	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			August	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			September	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			October	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			November	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			December	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
PdA—Pakala clay loam, 0 to 2 percent slopes										
Pakala	B	Very low	January	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			February	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			March	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			April	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			May	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			June	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			July	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			August	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			September	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			October	—	—	0.1-0.8	Very brief	Rare	Very brief	Rare
			November	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional
			December	—	—	0.1-0.8	Very brief	Occasional	Very brief	Occasional

Water Features–Island of Kauai, Hawaii										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
PdC—Pakala clay loam, 2 to 10 percent slopes										
Pakala	B	Medium	January	—	—	—	—	None	Very brief	Occasional
			February	—	—	—	—	None	Very brief	Occasional
			March	—	—	—	—	None	Very brief	Occasional
			April	—	—	—	—	None	Very brief	None
			May	—	—	—	—	None	Very brief	Rare
			June	—	—	—	—	None	Very brief	Rare
			July	—	—	—	—	None	Very brief	Rare
			August	—	—	—	—	None	Very brief	Rare
			September	—	—	—	—	None	Very brief	Rare
			October	—	—	—	—	None	Very brief	Rare
			November	—	—	—	—	None	Very brief	Occasional
			December	—	—	—	—	None	Very brief	Occasional
rRK—Rock land										
Rock land	D	Very high	Jan-Dec	—	—	—	—	None	—	None
Rock outcrop	D	—	Jan-Dec	—	—	—	—	None	—	None
rRU—Rubble land										
Rubble land	A	Low	Jan-Dec	—	—	—	—	None	—	None
W—Water > 40 acres										
Water > 40 acres	—	—	Jan-Dec	—	—	—	—	None	—	None
Ws—Waikomo stony silty clay										
Waikomo	D	Low	Jan-Dec	—	—	—	—	None	—	None

Water Management

This folder contains a collection of tabular reports that present soil interpretations related to water management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Water management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Irrigation - General and Sprinkler

This table shows the degree and kind of soil limitations that affect irrigation systems on mineral soils. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Irrigation systems are used to provide supplemental water to crops, orchards, vineyards, and vegetables in area where natural precipitation will not support desired production of crops being grown.

Irrigation – general evaluates a soil's limitation(s) for installation and use of non-specific irrigation methods and is intended to provide initial planning information. Additional interpretations provide more specific information. This interpretation does not apply if the crop planned for irrigation is rice or other crops with unique plant physiological characteristics (such as cranberries). The ratings are for soils in their natural condition and do not consider present land use.

The soil properties and qualities important in design and management of irrigation systems are sodium adsorption ratio, depth to high water table, available water holding capacity, permeability, slope, calcium carbonate content, ponding, and flooding. Soil properties and qualities that influence installation are stones, depth to bedrock or cemented pan, and depth to a high water table. The properties and qualities that affect performance of the irrigation system are depth to bedrock or to a cemented pan, the sodium adsorption ratio, salinity, and soil reaction.

Irrigation, sprinkler (close spaced outlets drops) evaluates a soil for installation and use of sprinkler irrigation systems equipped with close spaced outlets on drops. The ratings are for soils in their natural condition and do not consider present land use.

Sprinkler irrigation systems equipped with low pressure spray nozzles mounted on close spaced drops apply water close to the ground surface. These systems are generally found on linear move or center pivot systems and they have separate slope criteria from other sprinkler systems due to their higher application rate which increase risk of runoff and irrigation-induced erosion on steeper slopes. Examples of these types of systems include Low Pressure in Canopy (LPIC), Low Energy Precision Application (LEPA), Low Elevation Spray Application (LESA), and Mid-Elevation Spray Application (MESA) systems. These types of irrigation systems are generally suitable for small grains, row crops, and vegetables.

The soil properties and qualities important in the design and management of sprinkler irrigation systems utilizing close spaced spray nozzles on drops are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, permeability, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface texture, surface rocks, salinity, sodium adsorption ratio, wetness, erosion potential, and available water holding capacity.

Irrigation, sprinkler (general) evaluates a soil for installation and use of sprinkler irrigation systems excluding those equipped with close spaced outlets on drops. The ratings are for soils in their natural condition and do not consider present land use.

Sprinkler irrigation systems apply irrigation water to a field through a series of pipes and nozzles and can be either solid set or mobile. Generally, this type of irrigation system is suitable for small grains, row crops, vegetables, and orchards.

The soil properties and qualities important in the design and management of sprinkler irrigation systems are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, permeability, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface rocks, salinity, sodium adsorption ratio, wetness, and available water holding capacity.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design. The irrigation interpretations are not designed or intended to be used in a regulatory manner.

Report—Irrigation - General and Sprinkler

[The information in this table provides irrigation interpretations for mineral soils. Onsite investigation may be needed to validate the interpretations and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Irrigation - General and Sprinkler–Island of Kauai, Hawaii							
Map symbol and soil name	Pct. of map unit	Irrigation (general)		Irrigation, Sprinkler (close spaced outlet drops)		Irrigation, Sprinkler (general)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
HsD—Hanamaulu silty clay, 15 to 25 percent slopes							
Hanamaulu	100	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.44	Surface clay	0.88	Surface clay	0.88
		Rapid water movement	0.40	Water Erosion	0.50	Too acid	0.44
		Seepage	0.18	Too acid	0.44		
HtE—Hanamaulu stony silty clay, 10 to 35 percent slopes							
Hanamaulu, stony	100	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.44	Surface clay	0.88	Surface clay	0.88
		Rapid water movement	0.40	Too acid	0.44	Too acid	0.44
		Seepage	0.18	Water Erosion	0.32		
KavB—Kaena clay, brown variant, 1 to 6 percent slopes							
Kaena variant	100	Not rated		Not Rated		Not Rated	
KavC—Kaena clay, brown variant, 6 to 12 percent slopes							
Kaena variant	100	Not rated		Not Rated		Not Rated	
KdF—Kalapa silty clay, 40 to 70 percent slopes							
Kalapa	100	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.04	Water Erosion	1.00	Surface clay	0.98
				Surface clay	0.98	Slow water movement	0.61
				Slow water movement	0.61	Too acid	0.04
				Too acid	0.04		
Ke—Kalihi clay							
Kalihi	100	Not rated		Not Rated		Not Rated	

Irrigation - General and Sprinkler–Island of Kauai, Hawaii							
Map symbol and soil name	Pct. of map unit	Irrigation (general)		Irrigation, Sprinkler (close spaced outlet drops)		Irrigation, Sprinkler (general)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
KEHF—Kalapa very rocky silty clay, 40 to 70 percent slopes							
Kalapa, very rocky	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope, sprinkler irrigation	1.00
		Too acid	0.04	Water Erosion	1.00	Surface clay	0.98
				Surface clay	0.98	Slow water movement	0.90
				Slow water movement	0.90	Too acid	0.04
				Too acid	0.04		
Rock outcrop	25	Not rated		Not Rated		Not Rated	
LIB—Lihue gravelly silty clay, 0 to 8 percent slopes							
Lihue, gravelly	100	Somewhat limited		Somewhat limited		Somewhat limited	
		Seepage	0.18	Surface clay	0.98	Surface clay	0.98
		Slope	0.09	Slope	0.86		
		Rapid water movement	0.02				
LuB—Lualualei clay, 2 to 6 percent slopes							
Lualualei	100	Very limited		Very limited		Very limited	
		Ponding	1.00	Ponding	1.00	Ponding	1.00
		Slope	0.09	Surface clay	1.00	Surface clay	1.00
		Low water holding capacity	0.01	Slope	0.86	Slow water movement	0.61
				Slow water movement	0.61	Low water holding capacity	0.01
				Water Erosion	0.01		
PdA—Pakala clay loam, 0 to 2 percent slopes							
Pakala	100	Not rated		Not Rated		Not Rated	
PdC—Pakala clay loam, 2 to 10 percent slopes							
Pakala	100	Not rated		Not Rated		Not Rated	
rRK—Rock land							
Rock land	55	Not rated		Not Rated		Not Rated	
Rock outcrop	45	Not rated		Not Rated		Not Rated	
rRU—Rubble land							
Rubble land	100	Not rated		Not Rated		Not Rated	

Irrigation - General and Sprinkler–Island of Kauai, Hawaii							
Map symbol and soil name	Pct. of map unit	Irrigation (general)		Irrigation, Sprinkler (close spaced outlet drops)		Irrigation, Sprinkler (general)	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
W—Water > 40 acres							
Water > 40 acres	100	Not rated		Not Rated		Not Rated	
Ws—Waikomo stony silty clay							
Waikomo	100	Very limited		Very limited		Very limited	
		Low water holding capacity	1.00	Low water holding capacity	1.00	Low water holding capacity	1.00
		Depth to hard bedrock	1.00	Content of large stones	1.00	Content of large stones	1.00
		Content of large stones	1.00	Depth to hard bedrock	0.99	Depth to hard bedrock	0.99
		Slope	0.09	Slope	0.86	Surface clay	0.50
		Rapid water movement	0.02	Surface clay	0.50		

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