GUIDELINES

FOR THE TREATMENT AND

USE OF RECYCLED WATER

Prepared by

Hawaii State Department of Health
Wastewater Branch

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(Replaces November 22, 1993 Version)

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I. INTRODUCTION

A combination of growing population and limited potable water resources is reducing the availability and quality of our drinking water supplies. In addition, problems resulting from the disposal of wastewater continue to appear. Therefore, wastewater management practices that protect, conserve and fully utilize water resources are vital to Hawaii. Increasing the safe use of recycled water can greatly assist in meeting water requirements of the State, enhance the environment, and benefit public health by preserving resources upon which public health protection is based. The Department of Health has long been an advocate for water reuse as long as it does not compromise public health and our valuable water resources. Promotion of the use of recycled water is one of the Department's high priority goals.

Water reuse has moderately increased in Hawaii. From November 1993 when the reuse guidelines was first adopted as a policy by the Department of Health to December 2001, recycled water use has more than doubled. During the past eight years, recycled water use has increased from 10 MGD to 23 MGD. The number of wastewater treatment facilities producing recycled water now totals 39 facilities. Of these 39 facilities, eleven are R-1 facilities which produce the highest quality recycled water while the remaining facilities produce R-2 and R-3 waters. In an effort to assure that the reuse guidelines can be properly implemented, the Department is preparing amendments to Hawaii Administrative Rule, Title 11, Chapter 62, entitled Wastewater Systems. Highlights to the proposed rule amendments that impact reuse include:

- Incorporating into the rule basic reuse requirements now contained in these guidelines;
- Including definitions for recycled water as well as technical effluent requirements for recycled water;
- Including language into the rule that excludes R-1 water spills onto the ground from enforcement actions provided Best Management Practices are implemented;
- Providing NPDES permit coverage for R-1 facilities in the event of an inadvertent spill into state waters;
- Including spill protocol revisions for R-1 water which include deleting the requirements for a) press releases; b) disinfection; and c) monitoring; and
- Adding language in the preamble that clearly states the Department's direction and policies regarding the use of recycled water.

To continually keep pace with the new technical developments in the field of water reuse, the Hawaii reuse guidelines are being revised. This second version continues to reflect the impact of new regulations regarding recycled water in the States of California and Florida. Eight years after the publication of the reuse guidelines, various sectors with reuse interest have given suggestions and recommendations to make this guideline more user friendly. The Department has made every effort to incorporate those recommendations. This second version contains several new features worth noting. The Department now allows the use of R-1 water for direct contact irrigation of edible crops eaten raw. The term "reclaimed water" has been changed to "recycled water." All words referring to "reclaimed" have been replaced with "recycled" in the entire text. The new revised 2000 edition of the National Water Research Institute's (NWRI) ultraviolet guidelines replaced the previous edition as reference for using UV as disinfection system. A new protocol for wastewater spills has been incorporated. New uses for recycled water have been added. The definitions for R-1, and R-2 have been revised per the recommendations of the HWEA. The "secondary plus full treatment process train" for the production of R-1 water has been deleted. Based on experience, direct and contact filtration treatment processes have been shown to reliably produce R-1 in the State. A method of estimating evapotranspiration (ET) has been added. And finally, the requirements for groundwater monitoring have been eliminated for the underlying aquifers that are not designated as "public drinking water aquifer."

DOH has initiated preparation of the GUIDELINES FOR THE TREATMENT AND REUSE OF RECYCLED WATER to fill out the skeleton of existing rules with additional details in an effort to better communicate with both the design teams, recycled water users and the public. Furthermore, DOH proposes to add more specificity to the above criteria in the form of guidelines in order to:

Protect public health, avoid public nuisance;

Prevent environmental degradation of aquifers and/or surface waters;

Delineate specific recycled water application with recycled water quality treatment;

Facilitate use of recycled water in greater amounts, by more readily available knowledge of the conditions under which DOH can attest to safety of uses of recycled water;

Facilitate acceleration of planning, design, permitting, and implementation of water reclamation projects.

A. The objective to protect public health, avoid public nuisance is achieved by:

1. Reducing concentration of pathogenic bacteria, parasites, and enteric viruses in the recycled water. Raw wastewater contains a variety of pathogenic organisms of human origin. Disinfection means a process which inactivates pathogenic organisms in water by chemical oxidants or equivalent agents or through the process of reverse osmosis when sufficiently demonstrated. Disease caused by these pathogenic organisms can occur as a result of:

(a) Ingestion of untreated water;

(b) Ingestion of improperly treated drinking water;

(c) Ingestion of infected aquatic food species from contaminated waters;

(d) Contact of the skin with contaminated water; and

(e) Contact with improperly disinfected recycled water in reuse applications.

2. Controlling chemical constituents in the recycled water; and/or

3. Limiting public exposure (contact, inhalation, ingestion) to the recycled water. This objective is addressed in these guidelines to provide flexibility to the design team:

(a) Where human exposure is likely in a reuse application, recycled water should be treated to a high degree prior to its reuse.

(b) Conversely where public access to a reuse site can be restricted so that exposure is unlikely, a lower level of treatment may be satisfactory, provided worker safety is not compromised.

B. The objective to prevent environmental degradation of aquifers and/or surface waters is achieved by:

1. Reducing concentration of pathogenic bacteria, parasites, and enteric viruses in the recycled water.

2. Controlling the concentration of organic compounds in recycled water that will eventually migrate to an aquifer used as a source for domestic water supply.

3. Controlling the concentration of inorganic chemicals, with the exception of nitrogen, in its various forms, by meeting all MCL of Hawaii Administrative Rules, Title 11 Chapter 20 "Rules Relating to Potable Water System," in the recycled water.

4. Controlling the concentration of biostimulants such as nitrogen and phosphorus. Typically there are two sources of biostimulants in irrigation, the recycled water and commercial fertilizer which is applied as a supplement.

5. The application of recycled water over an aquifer which is used as the domestic water supply will be restricted to deficit water budget.

Although increasing the use of water recycled from municipal wastewater can greatly assist in meeting water requirements of the state, the practice must be limited to areas that can safely accept the applied wastewater without adversely effecting potable aquifers. Criteria for acceptability not only include concentration levels of constituents and microbiologic parameters, but also hydrogeologic suitability of an area due to the highly permeable nature of soils and lavas of the state that permit rapid percolation of applied water into the aquifers. The need to protect water quality of the potable aquifers that underlie the vast majority of land development, is of the utmost importance. The following guidelines are designed specifically for those areas which can safely accept the applied wastewater, without endangering aquifers that supply drinking water.

C. The objective to delineate specific water application with recycled water quality treatment was categorized into the following three interrelated tasks:

1. Identification and characterization of the potential demands for recycled water:

   Table 3-1 is a summary list of suitable uses of recycled water. A detailed description is presented in the text of chapter III USES AND SPECIFIC REQUIREMENTS FOR RECYCLED WATER;

2. To assess the potential public health and environmental risks associated with the use of recycled water versus the level of treatment of the recycled water:

   The Ad Hoc Reuse Health Committee conducted a review of epidemiological and microbiological literature with respect to the appropriate uses of recycled water and advised DOH. Chapter III USES AND SPECIFIC REQUIREMENTS FOR RECYCLED WATER is a result of this process. The membership of this committee is presented in Appendix B;

3. Identification of treatment requirements for production of safe and reliable water that is suitable for its intended application.

   The Hawaii Water Environment Association, (HWEA) Reuse Technical Committee agreed to review engineering studies and literature associated with these guidelines and advise DOH. A particular focus has been on Chapter IV, TREATMENT DESIGN PARAMETERS; Chapter V, DESIGN PARAMETERS FOR THE DISTRIBUTION OF RECYCLED WATER; Chapter VI, ENGINEERING REPORTS AND SUBMITTALS FOR TREATMENT FACILITIES; Chapter VII, APPROVAL PROCESS FOR TREATMENT FACILITIES; and Chapter X, COMPLIANCE REPORTS AND SUBMITTALS. The membership of this committee is available in Appendix C;

D. The objective to facilitate use of recycled water in greater amounts, by more readily available knowledge of the conditions under which DOH can attest to safety of uses of recycled water, was addressed by the Ad Hoc Irrigation Committee and the Ad Hoc Reuse Users Committee.

The Ad Hoc Reuse Irrigation Committee has conducted a review of the available literature with respect to the appropriate planning, design and application of recycled water for irrigation. This committee has addressed the issues in Chapter VIII, ENGINEERING REPORTS AND SUBMITTALS FOR WATER REUSE PROJECTS; and Chapter IX, APPROVAL PROCESS FOR WATER REUSE PROJECTS. The membership of this committee is presented in Appendix D;

The Ad Hoc Reuse Users Committee has contributed operational experience in the use of recycled water in their review of operational concern which pertain to Chapter X, COMPLIANCE REPORTS AND SUBMITTALS and the monitoring plan in appendices E & F. This committee will continue their evaluation as the provisions of these guidelines are implemented. The membership of this committee is presented in Appendix G;

A concerted effort by committees and DOH to promote the reuse of recycled water by expanding the variety of uses and matching them with the appropriate level of treatment;

E. The objective to facilitate acceleration of planning, design, permitting, and implementation of water reuse projects is being addressed by the following: The submittals and approval processes for the treatment facility and water reuse projects have been separated into individual chapters. The reports and submittals for both treatment facilities and reuse projects have been sequenced into three (3) phases of review and comment; i.e., basis of design, engineering report and construction plans.

The Wastewater Branch typically reviews projects to determine whether the proposed treatment will meet the explicit standards. Since DOH has not established groundwater standards, it places a burden both on the Wastewater Branch and the design team to evaluate the effect of the project regarding historical groundwater quality trend, mass loading due to this project and the beneficial uses of the aquifer. This has not proved satisfactory. To assist the Wastewater Branch in evaluating and setting pertinent water parameter criteria for reuse projects over aquifers used for potable water supply, DOH proposes to establish a Groundwater Management Committee that will make such determinations on a demand basis. The membership of this committee is presented in Appendix A.

The purpose of the Groundwater Management Committee will be:

1. To determine target water quality criteria for the aquifer affected

by a specific water reclamation project (e.g., TDS shall not exceed 250 mg/l in well No. 47).

2. To determine mass loading application rates for target water quality parameters pertaining to a specific water reclamation project (e.g., TDS loading shall not exceed an annual total of 5,400 lbs/acre nor shall any monthly total exceed 800 lb/acre).
3. To determine the monitoring strategy for a specific water reclamation project.

DOH intends to establish by these guidelines, statewide reclamation criteria for each varying type of recycled water use. In order to evaluate the performance of reclamation facilities and water reuse projects, DOH intends to initiate a review, and update the water reuse criteria at least every five years or as necessary.

In the preparation and presentation of these guidelines, acknowledgement is given to numerous federal, state and local agencies, in their contributions to research, evaluation and regulations pertaining to water recycled from municipal wastewater. Recognition is given to the California Department of Health Services and the Florida Department of Environmental Regulations for their publications and regulations regarding water reclamation; the American Water Works Association, California-Nevada Section, for their publication "Guidelines for the Distribution of Nonpotable Water." Special recognition is given to the Ad Hoc Health Committee, the Hawaii Water Environment Association (HWEA), Reuse Technical Committee and the Ad Hoc Reuse Irrigation Committee for their expertise and commitment to this issue.

In order to assist the reader, the definition of terms is presented prior to the body of the guidelines.

II DEFINITIONS

"Aerosol" means a solid suspended in air with or without preceding evaporation.

"Airgap" means the unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood-level rim of the receptacle. The vertical distance shall be at least double the diameter of the supply pipe above the flood-level rim and in no case shall the gap be less than one inch.

"Alarm" means an instrument or device which continuously monitors a specific function of a treatment process and automatically gives warning of an unsafe or undesirable condition by means of visual and audible signals.

"ASTM" is an abbreviation for American Society of Testing and Materials.

"Approved Laboratory Methods" means sample collection, sample preservation, sample handling, holding times, chain-of-custody, analytical procedures, field and laboratory quality assurance/quality control specified in the latest edition of "Standard Methods for the Examination of Water and Wastewater", prepared and published jointly by the American Public Health Association, the American Water Works Association, and the Water Environment Federation, or EPA or EPA equivalent standards and which are conducted in approved laboratories. The latest edition means the 1990 edition or successor editions upon being published.

"Approved Use Area" means a site with well defined boundaries, designated by a drawing (in a user permit) approved by DOH to receive recycled water for an approved use and in conformance with these guidelines.

"Aquifer" means a geological formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well, tunnel or spring.

"Best Management Practices" or “BMPs” means the most effective, practicable schedules of activities, prohibitions of conduct, maintenance procedures, and other specifications of conduct to prevent or reduce pollution. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage.

"Biological treatment" means methods of wastewater treatment in which bacterial or biochemical action is intensified as a means of producing an oxidized wastewater.

"Coagulated wastewater" means oxidized wastewater in which colloidal and finely divided suspended matter have been destabilized and agglomerated up stream of a filter by the addition of suitable floc-forming chemicals or by an equally effective method.

"Contact" means the mode of transmission by which a person or animal has the opportunity to acquire an infected agent, pathogenic organism, by means of: inhalation, lesions in the skin, exposure to mucus membrane and skin or ingestion, such as placing objects in the mouth. It includes consumption of water with a volume less than 100 ml.

"Contaminant" means any substance or matter which causes, directly or indirectly, a detrimental physical, chemical, biological or radiological change in the existing water quality; used interchangeable with pollutant.

"Cooling Tower" means a device used to cool water and dissipate unwanted heat into the atmosphere through the evaporation of a portion of the water being cooled.

"Cross-Connection" means any physical arrangement whereby a public water supply is connected, directly or indirectly, with any other potable water supply system, sewer, drain, conduit, pool, storage reservoir, plumbing fixture, or other device which contains, or may contain contaminated water, sewage, or other waste or liquid of unknown or unsafe quality which may be capable of imparting contamination to the public potable water supply as a result of backflow. By-pass arrangements, jumper connections, removable sections, swivel or changeover devices, and other temporary or permanent devices through which, or because of which backflow could occur are considered to be cross-connections.

"Dairy animal" means an animal which produces milk that is consumed by humans, or used for products consumed by humans.

"Director" means the director of health or a duly authorized representative.

"Direct beneficial use" means the use of recycled water which has been transported from the point of production to the point of use without an intervening discharge to waters of the state.

"Disinfection" means a process which inactivates or removes pathogenic organisms in water by chemical or physical means.

"DOH" is an abbreviation for Hawaii State Department of Health.

"Drift" means the amount of water that escapes to the atmosphere as water droplets from a cooling system.

"Drip irrigation" means application of water from emitters, either on the surface or subsurface, that are part of the piping system alongside the plants being irrigated and that discharges at a rate not to exceed 2 gallons per hour per emitter.

"Subsurface drip irrigation" means application of recycled water at least 4 inches below the finished grade, by discharging it from orifices in piping.

"Emitter or dripper" means a flow control device which applies water at a single point and creates no spray or jet.

"Evaporative condenser" means a device similar to a cooling tower used to dissipate unwanted heat from an air conditioning system or industrial process through the condensation of gaseous refrigerants and the evaporation of some of the resulting liquid.

"F-specific bacteriophage MS2" means a strain of a specific type of virus which infects coliform bacteria, is obtained from the American Type Culture Collection (ATCC 15597B1), is grown on lawns of E. coli (ATCC 15597) as describe by Adams in 1959 (Adams, M. H. 1959. Bacteriophages. Interscience Publishers, Inc.), and is assayed by the plaque forming unit (PFU) method described by Adams in 1959 on Trypticase soy agar (Difco, Detroit, Michigan).

"Filter" means a unit for carrying out the process of filtration which consists of the combination of filter medium and suitable hardware for constraining and supporting the filter medium in the path of the water. For example, in the case of a cartridge filter, the filter includes both the cartridge and the housing.

"Filtered Effluent" means an oxidized effluent which under specified process conditions that have been demonstrated to the satisfaction of DOH to consistently and reliably produce an effluent that does not exceed 2 ntu at any time.

"Food crop" means any crop intended for human consumption.

"Formation" means a body of rock characterized by a degree of lithologic homogeneity or similarity which is prevailingly, but not necessarily, tabular and is mappable on the earth's surface or traceable in the subsurface.

"Graywater" means liquid waste from a dwelling or other establishment produced by bathing, washdown, minor laundry and minor culinary operations, and specifically excluding toilet waste.

"Groundwater" means water located underground in the zone of saturation that moves freely to points of discharge (e.g., springs) and withdrawal (e.g., wells and tunnels). Groundwater includes water impounded by dikes, perched on geologic strata or low permeability, or floating upon and displacing salt water. It includes water which comes from artesian and non-artesian sources, as well as the subflow of streams and underground streams.

"High efficiency drift reducer" means a feature of a cooling system or air conditioning system that prevents the rate of generation of drift from exceeding 0.00008 gallon drift per gallon water circulated through the system in the same period of time.

"Hose bib" means a faucet or similar device to which a common garden hose can be readily attached.

"Industrial Cooling" means cooling of material or air and does not include air conditioning for comfort of persons in a building.

"Injection" means the disposal or emplacement of fluids, either under pressure or by gravity flow, into a subsurface formation or formations.

"Injection Well" means a well into which subsurface disposal of fluid or fluids occur or is intended to occur by means of injection.

"Landscape Impoundment" means an impoundment in which recycled water is stored or used for aesthetic enjoyment or landscape irrigation, or which otherwise serves a similar function and is not intended to include public contact.

"Lysimeter" means a device for measuring percolation of water through soils and sampling soil water for chemical analyses.

"Microscopic Particulate analysis" means a standardized procedure for sample collection and microscopic examination to determine the occurrence, size and type of microorganisms and other particles. Comparison of quantitative numbers from analyses of raw and finished water samples can assist in determination of overall filtration efficiency.

"Mist" means droplets of water suspended in air, that are visible to the eye and fall more slowly than rain.

"Modal time" means the amount of time elapsed between the time that tracer, such as salt or dye, is injected into influent at the entrance to a chamber and the time that the highest concentration of the tracer is observed in water where it is discharged from the chamber.

"Multibarrier treatment" means a series of wastewater treatment processes that provide for both removal and inactivation of waterborne pathogens.

"Multiple unit" means two or more units of a treatment process which operate in parallel and serve the same function.

"Municipal wastewater" means waste discharged from a community sewerage system, that is comprised of wastewater derived from ordinary human habitation or human activities including, but not limited to, wastewater from dwellings, hotels, hospitals, and comfort stations or a mixture of domestic wastewater and waste from industry or other activity and/or waste or water from other sources.

"Nephelometric turbidity unit or NTU" means a measurement of turbidity as determined by the ratio of the intensity of light scattered by the sample to the intensity of incident light as measured by the method 2130 B. in Standard methods for the examination of Water and Wastewater, 20th ed.; Eaton, A.D., Clesceri, L.S., and Greenberg, A.E., Eds; American Public Health Association: Washington, DC, 1995; p.2-8.

"Native enteric animal virus" means a virus that infects the intestine of humans, which is present in wastewater as a result of discharge of sewage into the sewer system.

"Nonpotable" means not suitable for drinking by humans.

"Nonrestricted recreation impoundment" is an impoundment of recycled water in which no limitations are imposed on body-contact water sport activities. Nonrestricted recreation impoundment does not include swimming pools where water is recirculated for disinfection.

"Overspray" means water which is transmitted through the air to a location other than where the direct application of recycled water is intended.

"Oxidized wastewater" means wastewater in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen.

"Particle counter" means an instrument which both counts and sizes particles, usually one particle at a time, typically by blocking or scattering of a narrow beam of light.

"Particle size" means the size of a particle as determined by its smallest projected dimension, usually expressed in micrometers (microns).

"Pathogen" means any agent, especially a microorganism, capable of causing disease.

"Person" means any individual, partnership, firm, association, public or private corporation, the State or any of its political subdivisions, trust estate or any other legal entity (as the same meaning as defined in section 342D-1, HRS).

"Peak Dry Weather Design Flow" means the arithmetic mean of the maximum peak flow rates sustained over some period of time (for example three hours) during the maximum 24-hour dry weather period. Dry weather period is defined as periods of little or no rainfall.

"Ponding" means retention of piped water on the surface of ground or man-made surface for a period of 2 hours following the cessation of an approved recycled water use activity such that potential risk to the public health may result.

"Potable" means suitable for drinking by humans.

"Power Source" means a source of supplying energy to operate unit processes.

"Purveyor" means one who sells or gives recycled water to an end user, or to an intermediary other than a public or private entity providing water service.

"Purveyor Supervisor" means the person(s) delegated by the distributor of the recycled water who is responsible for operation and maintenance of the treatment and distribution facilities of recycled water, prevention of cross-connection, and surveillance of all recycled water users.

"Recycled water" means treated wastewater that by design is intended or used for a beneficial purpose."

"Recycled water system" means a facility which conveys to users or applies or otherwise uses recycled water. Recycled water systems are subdivided into distribution and use systems. Recycled water systems include all piping, storage, and repressurization facilities to deliver recycled water to users, but exclude treatment works.

"R-1 Water (Significant reduction in viral and bacterial pathogens)" means recycled water that is at all times oxidized, then filtered, and then exposed, after the filtration process, to:

A. A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least resistant to disinfection as polio virus may be used for purposes of demonstration; and

B. A disinfection process that limits the concentration of fecal coliform bacteria to the following criteria:

 (1) The median density measure in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and

 (2) The density does exceed 23 per 100 milliliters in more than one sample in any 30-day period; and

 (3) No sample shall exceed 200 per 100 milliliters.

"R-2 Water (Disinfected Secondary-23 Recycled Water)" means recycled water that has been oxidized, and disinfected to meet the following criteria:

A. Fecal coliform bacteria densities as follows:

 (1) The median density measured in the disinfected effluent does not exceed 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and

 (2) The density does not exceed 200 per 100 milliliters in more than one sample in any 30-day period.

"R-3 Water (Undisinfected Secondary Recycled Water)" means oxidized wastewater.

"Reclamation or Treatment facility" means an arrangement of devices, structures, equipment, processes and controls which produce a recycled water suitable for the intended reuse.

"Residence" means a home and the land surrounding the home within the property line of land owned by the home owner; and includes a dwelling, yard area of dwelling, and other place resided in and frequented by children (e.g., day care center, school, park, playground, school yard); and includes a dwelling, yard area of a dwelling, and other place intended especially for persons who are physiologically infirm, ill, or attempting to recuperate from illness (e.g., a hospital, rest home, convalescent center).

"Restricted recreational impoundment" is a body of recycled water in which recreation is limited to fishing, boating and other non-body-contact water recreational activities.

"Runoff" means flow of water along the surface of the ground or other natural or manmade surfaces, including but not limited to pedestrian walkways, streets, playground surfaces, and grassy slopes.

"Secondary sedimentation" means the removal by gravity of settleable solids remaining in the effluent after the biological treatment process.

"Spray irrigation" means application of recycled water to crops to maintain vegetation or support growth of vegetation by spraying it from sprinklers, micro-sprinklers or orifices in piping.

"Standby power source" means an automatically actuated self-starting alternate energy source maintained in immediately operable condition and of sufficient capacity to provide necessary service during failure of the normal power supply.

"Standby replacement equipment" means reserved parts and equipment which can be placed in operation within a 24-hour period to replace broken-down or worn-out units.

"Standby unit process" is an alternate unit process or an equivalent alternative process which is maintained in operable condition and which is capable of providing comparable treatment for the entire design flow of the unit for which it is a substitute.

"State Waters" has the meaning defined in HRS section 342D-1, and includes drainage ditches, whether or not water is always flowing in them.

"Surface Irrigation" means application of recycled water by means other than spraying such that contact between the edible portion of any food crop and recycled water is prevented.

"Swimming Pool" means an artificial basin, chamber or tank used, or intended to be used, for swimming, diving, or recreative bathing or as a spa.

"Tertiary sedimentation" means the removal by gravity of settleable solids remaining in the secondary effluent after the chemical treatment process.

"Theoretical detention time" means the value obtained by dividing the volume of a chamber, through which fluid flows, by the flow rate expressed in amount of fluid volume per unit of time.

"Turbidity" means a measure of the ability of a solution to scatter light. Light scattering is usually caused by the presence of small particles.

"User (customer)" means any person, firm, corporation, association or agency receiving recycled water service.

"Underground Injection Control (UIC)" means the underground injection control program under Part C of the Safe Drinking Water Act (P.L. 93-523), Chapter 340E HRS, and HAR Chapter 11-23.

"Underground Injection Control Line (UIC Line)" means the line on the DOH's USGS maps which separates, in plan view, exempted aquifers and USDW.

"Unit Process" means an individual stage in the wastewater treatment sequence which performs a major single treatment operation.

"User Supervisor" means a person designated, by the owner or manager of the property upon which recycled water will be applied, who will carry-out the responsibility of the owner or manager of the property for: (a) installation, operation and maintenance of system that enables recycled water to be used; (b) prevention of potential hazards; (c) implementation and compliance with provisions of these guidelines and other associated documents; and (d) coordination with the cross-connection control program with the supplier of drinking water.

"Vector Control" means the prevention and control of vectors and pests (mosquitoes, flies, rats etc.) of public health significance.

"Wastewater Branch" means the branch of DOH that receives and reviews certain specific water reclamation system and facility documents submitted for comment and/or approval. The address for the Wastewater Branch is:

State of Hawaii
Department of Health
Wastewater Branch
919 Ala Moana Blvd.
Honolulu, HI 96814

"Water Reuse" means the treatment of wastewater to a quality that makes it suitable for one or more beneficial uses and the subsequent use of the treated water.

III USES AND SPECIFIC REQUIREMENTS FOR RECYCLED WATER

There are three categories of recycled water:

R-1 Water (Significant reduction in viral and bacterial pathogens);

R-2 Water (Disinfected secondary-23 recycled water, which means secondary treatment with disinfection to achieve a median fecal coliform limit of 23 per 100 ml based on the last seven days for which analyses have been completed); and

R-3 Water (Undisinfected secondary recycled water).

A. USES FOR R-3 WATER

1. Recycled water used for the purposes cited below in paragraph 2 of this section shall be at all times R-3 Water or recycled water with concentrations of potentially pathogenic organisms lower than those of R-3, such as R-2 and R-1 Waters.

2. R-3 Water is suitable for, from a public health standpoint, and shall be restricted to, the following purposes:

    a. Surface, drip, subsurface irrigation of feed, fodder and fiber crops, and pasture for animals not producing milk for human consumption;

    b. Surface, drip or subsurface irrigation of non-food bearing tree, provided no irrigation with recycled water occurs for a period of

14 days prior to harvesting or allowing access by the general public;

c. Surface, drip or subsurface irrigation of seed crops that are not eaten by humans;

d. Surface, drip or subsurface irrigation of orchards and vineyards where the recycled water does not come into contact with the edible portion of the crop;

e. Surface irrigation or drip irrigation of ornamental nursery stock and sod farms provided no irrigation with recycled water occurs for a period of 14 days prior to harvesting, retail sale, or allowing access by the general public;

f. Surface, drip or subsurface irrigation of a food crop which must undergo extensive commercial, physical or chemical processing determined by DOH to be sufficient to destroy pathogens, before it is suitable for human consumption. This is allowed no later than 30 days before harvest;

g. Application within a reclamation facility for the following:

   (1) Non-spray irrigation of landscape not contacted by the general public;

   (2) Polymer dilution water;

   (3) Mechanical seal water for gas compressors;

   (4) Cooling water for gas compressors and internal combustion engines;

   (5) Dilution water for chlorination;

   (6) Mechanical seal water and cooling water for sludge pumps;

   (7) Heat exchangers: air, water and oil cooling;

   (8) Odor and gas absorption;

   (9) Centrifuge flushing; and

   (10) Flushing grit and sludge pipes; or

h. Such other uses as approved by DOH.

B. USES FOR R-2 WATER

1. Recycled water used for the purposes cited in paragraph 2 of this section shall be at all times R-2 Water or recycled water with concentrations of potentially pathogenic organisms lower than those of R-2 and R-1 Waters.

2. R-2 Water is suitable for, from a public health standpoint, the purposes cited under R-3 Water in these guidelines and shall be restricted to the following purposes:

   a. Subsurface irrigation:

      (1) Landscape and turf on parks, elementary school yards;

      (2) Residential property where managed by an irrigation supervisor;

      (3) Golf courses;

      (4) Vineyards and orchards (e.g., banana, papaya);

      (5) Food crops that are above ground and not contacted by recycled water; and

      (6) Pastures for milking and other animals.

   b. Any form of irrigation for:

      (1) Fodder crops (e.g., alfalfa) and fiber crops;

      (2) Sod not installed by the general public;

      (3) Trees grown for timber or firewood, and Christmas trees, whether or not they are harvested by the general public;

      (4) Trees and vines that do not have food crops on them when irrigated;

      (5) Seed crops that are not eaten by humans;

      (6) Food crops which must undergo extensive commercial, physical or chemical processing determined by DOH to be sufficient to render it free of viable pathogenic agents, before it is suitable for human consumption;

      (7) Landscape on cemeteries, and around freeways;

(8) Other landscape vegetation and non-edible plants. This is allowed only where:

(a) The public would have access and exposure to irrigation water similar to that which would occur along a freeway or on a cemetery; and

(b) access is controlled so the irrigated area cannot be used as if it were a part of a park, school yard or athletic field;

(9) Landscaping of developments under construction, with no access by the public during establishment period, no overspray, and where workers use appropriate protective equipment and clothing;

c. Surface, drip or subsurface irrigation of ornamental plants for commercial use. This is allowed only if plants are harvested above any portion contacted by recycled water. Subsurface irrigation shall be supplied for the growth of all material used in the production of leis or other flowers used in human apparel;

d. Use in an industrial process that does not generate mist, does not involve facial contact with recycled water, and does not involve incorporation into food or drink for humans or contact with anything that will contact food or drink for humans;

e. Water jetting for consolidation of backfill material around underground pipelines except potable water pipelines;

f. Dampening unpaved roads and other surfaces for dust control;

g. Dampening soil for compaction at construction sites, landfills, and elsewhere;

h. Washing aggregate and making concrete;

i. Dampening brushes and street surfaces during street sweeping;

j. A source of supply for a landscape impoundment without a decorative fountain; and

k. Flushing sanitary sewers; or

l. Such other uses as approved by DOH.

3. During a state of emergency at the recycled water use area as declared by the Governor, R-2 may be used in the place of potable water or R-1 Water,

for water purposes cited in the following items "a" through "c" of this paragraph:

a. It may be used until no later than 10 days before harvest for any form of irrigation to ornamental plants to be sold potted;

b. It may be used until no later than 10 days before harvest for surface drip irrigation of a food crop. This is allowed if the edible portion is never eaten raw without peeling, and is at least two feet above the height reached by drip irrigation and at least two feet above the ground surface, and no food crop is harvested that has contacted irrigation water or the ground; and

c. It may be used until no later than 10 days before harvest for surface or drip irrigation of a food crop. This is allowed if the crop will only be cooked at a commercial cannery or subjected to chemicals that kill microorganisms (e.g., canned pineapple, and roasted coffee beans).

C. USES FOR R-1 WATER

1. Recycled water used for the purposes cited below in paragraph "2" of this section shall be at all times R-1 Water.

2. R-1 Water is suitable for, from a public health standpoint, the purposes cited under R-2 Water, and R-3 Water in these guidelines and shall be restricted to the following purposes:

   a. Any form of irrigation for food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop;

   b. Any form of irrigation served by fixed irrigation system supplied by buried piping for turf and landscape irrigation of:

      (1) Golf courses;

      (2) Parks, playgrounds, school yards, athletic fields;

      (3) Residential property where managed by an irrigation supervisor; and

      (4) Roads sides and medians;

   c. Any form of irrigation for pasture where milking animals, and other animals graze;

d. Any form of fire fighting from outdoor hydrants, fire trucks, or aircraft;

e. Cooling saws while cutting pavement;

f. Spray washing of electric insulators on utility poles;

g. High pressure water blasting to clean surfaces;

h. Drinking water for animals may be accepted if it will not be given to dairy animals, and the applicant demonstrates to the satisfaction of DOH there will be no unreasonable risk of occurrence of adverse effects on the animal related to chemical constituents or radioactivity;

i. Supply for commercial and public laundries for clothing and other linens;

j. Industrial cooling in a system that does not have a cooling tower, evaporative condenser, or other feature that emits vapor or droplets to the open atmosphere or to air to be passed into a building or other enclosure occupied by person;

k. Supply for addition to a cooling system or air conditioning system with a cooling tower, evaporative condenser, or other feature that emits vapor or droplets to the open atmosphere or to air to be passed into a building or other enclosure occupied by a person, when all of the following shall occur:

  (1) A high efficiency drift reducer is used and the system is maintained to avoid greater rate of generation of drift than that with which a high efficiency drift reducer is associated;

  (2) A continuous biocide residual, sufficient to prevent bacterial population from exceeding 10,000 per milliliter, is maintained in circulating water; and

  (3) The system is inspected by an operator, capable of determining compliance with this subdivision, at least once per day;

l. In the absence of one or more of the three conditions in paragraph "k" above, it is suitable for addition to such a cooling or air conditioning system when the purveyor of R-2 Water uses has demonstrated to the satisfaction of DOH that the probability of intestinal infection with virus will not exceed 1 in 10,000 under the specific conditions of use and that growth of Legionella will be controlled to avoid a concentration that could pose a significant hazard to health;

m. Industrial process that does not generate mist or facial contact with recycled water unless personal protective equipment is worn;

n. Water jetting for consolidation of backfill material around potable pipelines and for compaction of soil backfill above such pipelines. When there is a shortage of potable water and such use had been approved for a specific project by the public water system agency that owns the pipeline, and by DOH and conforms with the following conditions:

   (1) The public water system that owns the pipeline shall have access and opportunity to have its inspector on the job site while recycled water is being used;

   (2) Recycled water shall be used in the pipeline trench only when the pipeline is filled with the highly chlorinated water for new main disinfection and is used under pressure;

   (3) The new main disinfection procedure, including checking chlorine residual and collecting bacteriological samples, shall be completed after the use of recycled water in the pipeline trench has ceased;

   (4) Precautions shall be taken to minimize opportunities for any recycled water to enter a pipeline under construction (e.g., keeping ends of pipe lengths covered, etc.); and

   (5) For other than "hot taps," an appropriate buffer zone of at least 50-foot radius, shall be established to reduce the risk of contamination to the existing water supply line;

o. Flushing toilets and urinals in types of buildings and institutions approved by DOH and where counties have adopted a provision in their plumbing code pertaining to the use of a dual water supply within a building;

p. A source of supply for a decorative fountain if the recirculating water does not support growth of microorganisms from the surrounding environment that could infect either the respiratory or digestive system of mammals;

q. A source of supply for:

   (1) A restricted recreation impoundment; and

(2) Basins at fish hatcheries;

r. Washing of hard surfaces e.g., parking lots and sidewalks; or

s. A use other than those cited in this section may be accepted if DOH is satisfied that there will be no unreasonable risk of occurrence of events wherein humans would not take appropriate sanitary precaution when coming in contact with recycled water.

3. There may be recycled water uses where additional level of pathogen reduction is warranted.

D. PRECAUTIONS FOR ALL USES OF RECYCLED WATER

1. The provisions of this section shall be complied with when any recycled water is used on an approved use area. Use of recycled water without an approval from DOH is prohibited;

2. The purveyor of recycled water shall provide a copy of these guidelines to the users (i.e. property managers) to whom it provides recycled water, and shall obtain their agreement in writing to comply with all applicable provisions of these guidelines;

3. Signs shall be posted where recycled water is used pursuant to the PUBLIC EDUCATION and EMPLOYEE TRAINING PLAN specified in Chapter VIII;

4. Best Management Practices shall be taken to prevent ponding of recycled water;

5. Recycled water shall always be managed to avoid conditions conducive to proliferation of mosquitoes and other vectors, and to avoid creation of a public nuisance or health hazard;

6. Best Management Practices shall be used to mitigate discharge, runoff, or overspray beyond the approved use area boundaries;

7. Spray of recycled water shall not be allowed to contact an external drinking water fountain;

8. The following precautions pertain to the use of R-1 Water only:

   a. There shall be no irrigation within a minimum of 50 feet of any drinking water supply well;

   b. The outer edge of an impoundment shall be located at least 100 feet from any drinking water supply well; and

c. Drainage shall be controlled to prevent recycled water from coming within 50 feet of a drinking water supply well;

9. When R-2 WATER is used, spray irrigation of landscape or crops shall be limited so that the outer periphery of the irrigated area is not within 500 feet of:

   a. A residence property; or

   b. A place where public exposure could be similar to that at a park, elementary school yard or athletic field;

10. The following precautions pertain to the use of R-2 Water only:

    a. There shall be no irrigation within a minimum of 100 feet of any drinking water supply well;

    b. The outer edge of the impoundment shall be located at least 300 feet from any drinking water supply well; and

    c. Drainage shall be controlled to prevent recycled water from coming within 100 feet of a drinking water supply well;

    d. Spray irrigation shall be performed during periods beginning when the area is closed to the public and the public is absent from the area, and end at least one hour before the area is open to the public. Subsurface irrigation may be performed any time;

11. Whether the discharge is from a tank truck, sprinkler, or other device, or runoff, the application of R-2 WATER shall be controlled by complying with the following:

    a. Creation of visible mist is minimized;

    b. Direct, overspray, or runoff, is confined to the approved use area;

    c. Direct, overspray, or runoff does not contact or enter a dwelling, food handling facility, passing vehicle, or a place where the public may be present;

    d. Direct, overspray, or runoff does not contact a drinking fountain, a table, a chair, bench, barbecue area, a yard at a residence, or an area with frequent human contact; and

    e. Direct, overspray, or runoff shall not be allowed to contact or enter a place where access and exposure to wetted surface, could be similar to that at a park, playground, or school yard;

12. The following precautions pertain to the use of R-3 Water only:

    a. There shall be no irrigation within a minimum of 150 feet of any drinking water supply well;

    b. The outer edge of the impoundment shall be located at least 1000 feet from any drinking water supply well; and

    c. Drainage shall be controlled to prevent recycled water from coming within 150 feet of a drinking water supply well; and

13. R-3 Water shall be controlled to comply with the following:

    a. Mist shall not be created;

    b. Recycled water shall not be sprayed unless approved by DOH;

    c. Runoff shall be confined to the recycled water use area;

    d. Runoff does not contact or enter a dwelling, food handling facility, passing vehicle, or a place where the public may be present;

    e. Runoff does not contact a yard at a residence, or an area with frequent human contact; and

    f. Runoff does not contact or enter a place where access and exposure to a wetted surface could be similar to that at a park, playground, or school yard.

14. Table 3-1 is an attempt to present in table form, many of the above mentioned suitable uses, class of recycled water and mode of application in a summary table. When using this summary table, one should check the written text in this section and in Section D "Precaution" for All Uses of Recycled Water for additional limitations associated with the use.

TABLE 3-1 SUMMARY OF SUITABLE USES FOR RECYCLED WATER

SUITABLE USES OF RECYCLED WATER	R1	R2	R3
IRRIGATION: (S)pray, (D)rip & Surface, S(U)bsurface, (A)LL=S D & U, Spray with (B)uffer, (N)ot allowed, /=or			
Golf course landscapes	A	U/B	N
Freeway and cemetery landscapes	A	A	N
Food crops where recycled water contacts the edible portion of the crop, including all root crops	A*	N	N
Parks, elementary schoolyards, athletic fields and landscapes around some residential property	A	U	N
Roadside and median landscapes	A	U/B	N
Non-edible vegetation in areas with limited public exposure	A	AB	U
Sod farms	A	AB	N
Ornamental plants for commercial use	A	AB	N
Food crops above ground & not contacted by irrigation	A	U	N
Pastures for milking and other animals	A	U	N
Fodder, fiber, and seed crops not eaten by humans	A	AB	DU
Orchards and vineyards bearing food crops	A	D/U	DU
Orchards and vineyards not bearing food crops during irrigation	A	AB	DU
Timber and trees not bearing food crops	A	AB	DU
Food crops undergoing commercial pathogen destroying process before consumption	A	AB	DU
SUPPLY TO IMPOUNDMENTS: (A)llowed (N)ot allowed			
Restricted recreational impoundments	A	N	N
Basins at fish hatcheries	A	N	N
Landscape impoundments without decorative fountain	A	A	N
Landscape impoundments with decorative fountain	A	N	N
SUPPLY TO OTHER USES: (A)llowed (N)ot allowed			

SUITABLE USES OF RECYCLED WATER	R1	R2	R3
Flushing toilets and urinals	A	N	N
Structural fire fighting	A	A	N
Nonstructural fire fighting	A	A	N
Commercial and public laundries	A	N	N
Cooling saws while cutting pavement	A	N	N
Decorative fountains	A	N	N
Washing yards, lots and sidewalks	A	N	N
Flushing sanitary sewers	A	A	N
High pressure water blasting to clean surfaces	A	N	N
Industrial Process without exposure of workers	A	A	N
Industrial Process with exposure of workers	A	N	N
Cooling or air conditioning system without tower, evaporative condenser, spraying, or other features that emit vapor or droplets	A	A	N
Cooling or air conditioning system with tower, evaporative condenser, spraying, or other features that emit vapor or droplets	A	N	N
Industrial boiler feed	A	A	N
Water jetting for consolidation of backfill material around potable water piping during water shortages	A	N	N
Water jetting for consolidation of backfill material around piping for recycled water, sewage, storm drainage, and gas; and electrical conduits	A	A	N
Washing aggregate and making concrete	A	A	N
Dampening roads and other surfaces for dust control	A	A	N
Dampening brushes and street surfaces in street sweeping	A	A	N

***Allowed under the following conditions:**

The turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes. The UV disinfection unit must conform to Appendix K: UV Disinfection Guidelines for R-1 Water.

E. GROUNDWATER RECHARGE

Groundwater recharge criteria and requirements are divided into categories. The classification is based on whether the recharge directly affects a non-potable or potable aquifer. For projects that are over an aquifer classified as potable, the application rates that exceed the consumptive evapotranspiration of the vegetative cover will be considered a recharge project. For projects that are over an aquifer classified as non-potable, where the design monthly (deep) percolation rate (DMPR) is greater than 20 percent of the maximum monthly application rate (MMAR) minus the DMPR, the project will be designated as a recharge project. In other words, when the design monthly application rate is greater than 1.2 times the vegetative consumption rate, then the project would be considered a recharge project. See Appendix E for additional monitoring requirements.

Recycled water used for groundwater recharge by surface or subsurface application shall be at all times of a quality that fully protects public health. The DOH evaluation of proposed groundwater recharge projects and expansion of existing projects will be made on an individual case basis where the use of recycled water involves a potential risk to public health.

The DOH evaluation will be based on all relevant aspects of each project, including the following factors: treatment provided; effluent quality and quantity, effluent or application spreading area operation; soil characteristics; hydrogeology; resident time; and distance to withdrawal.

This section is applicable to all waste, wastewater, or recycled water put in an impoundment lacking a liner impervious to water or recharging the groundwater that can be used for a potable water supply.

If in the future a community wishes to augment its potable water supply by recharging the potable water supply aquifer with recycled water, DOH will review such a request based on findings of a public hearing or a public referendum.

IV TREATMENT DESIGN PARAMETERS

From a public health standpoint, it is logical that a greater assurance of reliability should be required for a system producing recycled water for uses where direct or indirect human contact with recycled water is likely, than should be required for one producing wastewater effluent where the possibility of contact is remote.

A. TREATMENT PROCESSES

1. The production of R-1 Water used for the purposes cited in Chapter III of these guidelines shall at all times conform with the requirements specified in the definition of R-1 Water. Effluent other than from an activated sludge treatment process listed in Table 70-1 of the "Design Standards" [24], should not be used for the production of R-1 Water without a demonstration to the satisfaction of DOH that the effluent has undergone treatment that renders the concentration of potentially pathogenic organisms as low as that which can be achieved by chlorination of activated sludge effluent to meet the requirements specified in the definition of R-1 Water.

   The following are treatment processes used in Hawaii that have demonstrated treatment sufficient to reliably produce an effluent that meets the requirements specified in the definition of R-1 Water:

   a. Figure 4-1 presents a typical example of a treatment flow diagram for a secondary treatment plus direct filtration.

   b. Contact filtration is another alternative following secondary treatment with continuous chemical addition/coagulation. Similar to the direct filtration alternative, the contact filtration process configuration does not include an intermediate clarification step. Chemical addition-coagulation is accomplished through a rapid mixer or an in-line mixer mechanism with flocculation and aggregation occurring subsequently in the lower layers of the deep bed up-flow filter or the upper layers of a deep bed gravity filter. Figure 4.2 provides a typical example showing a treatment flow diagram.

2. The production of R-2 Water used for the purposes cited in Chapter III of these guidelines shall at all times conform with the requirements specified in the definition of R-2 Water.

3. The production of R-3 Water used for the purposes cited in Chapter III of these guidelines shall at all times conform with the requirements specified in the definition of R-3 Water.

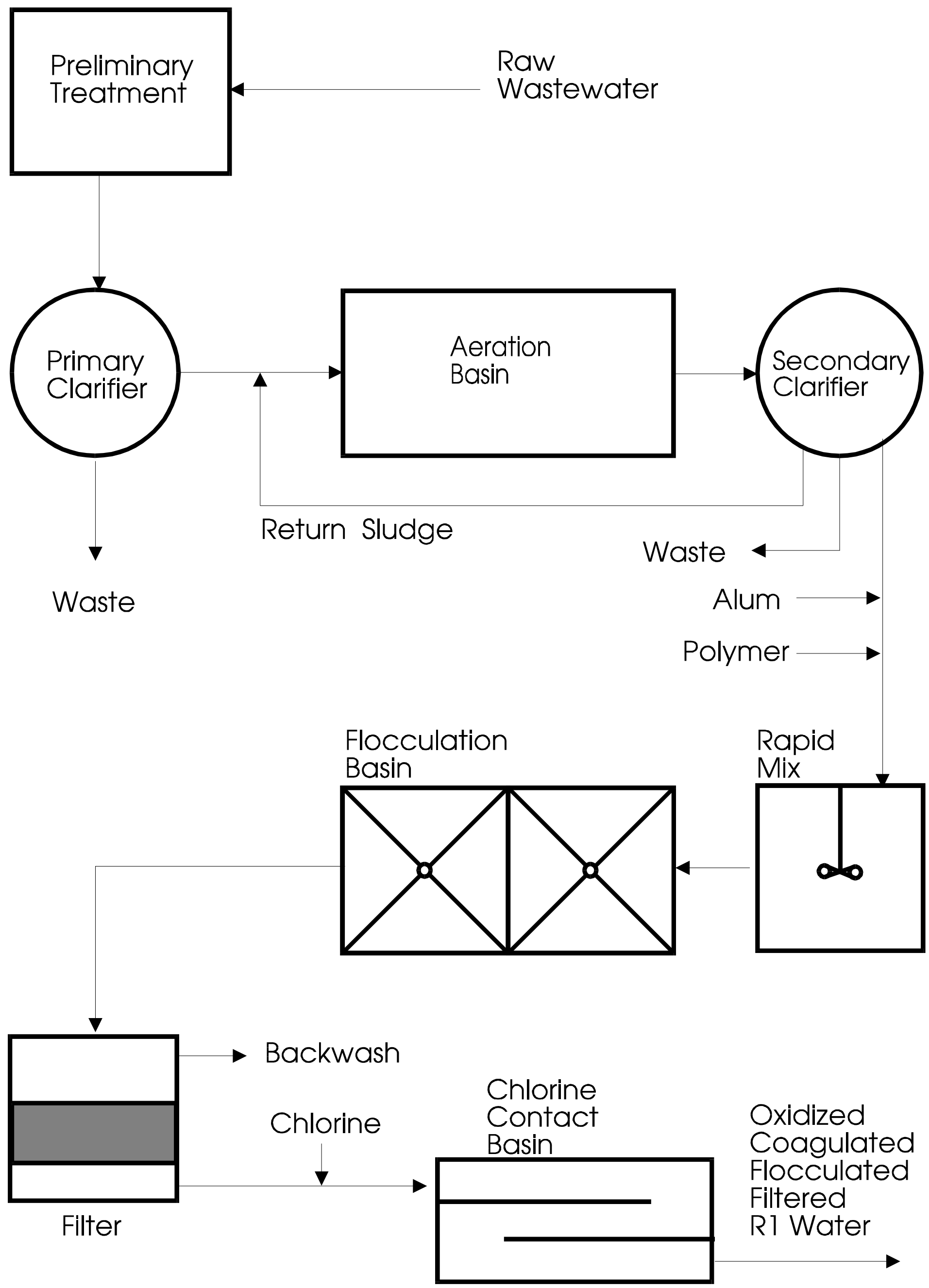


Figure 4-1
Treatment Flow Diagram
Secondary Treatment Plus Direct Filtration

B. SECONDARY TREATMENT UNIT REQUIREMENTS

Biological treatment means methods of wastewater treatment in which bacterial or biochemical action is intensified as a means of producing an oxidized wastewater. Oxidized wastewater is wastewater in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen. Secondary treatment unit shall meet the minimum design parameters found in Hawaii Administrative Rules (HAR) Chapter 11-62.

C. COAGULATION

Prior to chemical addition, the wastewater must have received at least secondary treatment. The main purpose of coagulation, in conjunction with flocculation, is to enhance particulate removal during the filtration process.

1. Chemical pretreatment facilities are required in all cases where granular media filtration is used for the production of R-1 water; even if a filtered effluent can meet the turbidity criteria under normal operating conditions without coagulant addition. For these water reclamation treatment facilities using granular media filtration requiring coagulation, the following guidelines are applicable:

   a. Continuous turbidity monitoring and recording of the secondary effluent is required such that the subsequent coagulant addition can be automatically adjusted to provide coagulant dosages under varying conditions.

   b. Coagulant, such as alum, lime, ferric chloride, or polymers are acceptable if it can be demonstrated that they are effective and reliable in meeting the filtered effluent and turbidity criteria.

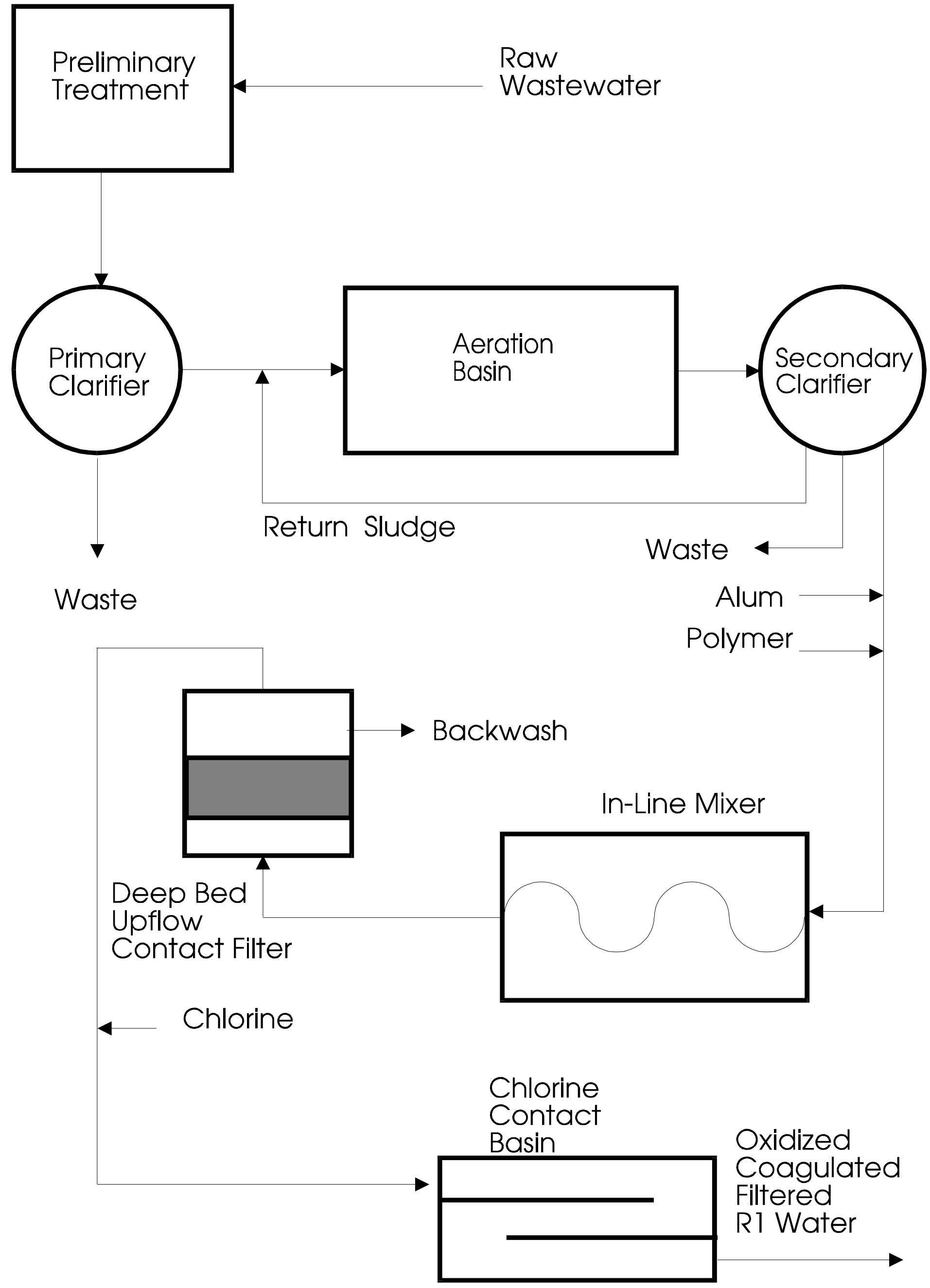


Figure 4-2
Treatment Flow Diagram
Secondary Treatment Plus Contact Filtration

c. Chemical pretreatment facilities including rapid mix or equivalent and flocculation basins, except in the cases of the contact filtration and membrane filtration processes, should be provided in the design to assure conformity with provisions of this section under all operating conditions, whether or not a filtered effluent can meet the filtered effluent criteria.

d. Adequate initial rapid mixing or equivalent should be provided to assure effective dispersion of the coagulant into the wastewater.

e. Low energy mixing should be provided after coagulant is added, and adequate residence time should be provided between the addition of coagulant and filtration process to assure that floc forms prior to filtration and does not form after filtration. Residence time required to accomplish that shall be determined by experiment. Flow turbulence and/or mixing should be controlled to prevent break-up of floc.

f. There should be adequate time after coagulant addition for a visible floc to form prior to filtration. This floc formation time varies for each wastewater and type of coagulant used. Floc formation may take five minutes or more, and the time required should be determined for each individual case. Long contact times may require some form of slow mixing to prevent settling of flocculated particles. Flow turbulence and/or mixing should be controlled to prevent break-up of floc. The addition of coagulant at a location that does not provide adequate contact time is not acceptable and may cause a deterioration of the effluent by inducing flocculation after filtration.

g. Wastewater influent can vary appreciably, and preliminary studies should be conducted to determine the optimum dose of coagulants and polymer for each proposed project.

2. The direct filtration process can be used for the production of R-1 Water if the coagulation/flocculation processes are continuous. All R-1 water reclamation facilities using direct filtration should have, at a minimum, two operating units per treatment process (coagulation or rapid mix, and flocculation). This is to assure complete and continuous treatment at all times, even if one of the units is shut down for repair, service or backwash. The following is a guideline for the chemical treatment in direct filtration process intending to produce R-1 Water:

   a. Rapid mix unit detention time should be less than 30 seconds; and

   b. Flocculation unit detention time should be between 20 to 45 minutes.

3. Chemical coagulation is not required for facilities intended to produce R-

1 water using membrane filtration and R-2 and R-3 waters.

4. All coagulation process units should be provided with the following features for uninterrupted coagulant feed:

    a. Standby feeders;

    b. Adequate chemical storage and conveyance facilities; and

    c. Adequate reserve chemical supply.

D. FILTRATION

1. Turbidity by itself is not intended to be a measure of pathogen removal. Turbidity is used as a measure of the coagulation-flocculation-sedimentation-filtration process effectiveness and as a means of assuring a quality effluent upon disinfection. Therefore, for R-1 Water the turbidity requirement specified below must be met:

    a. A continuous recording turbidimeter shall be installed and operated prior to and after the filtration process; and

    b. The filtered effluent turbidity shall not exceed 2.0 NTU. Filtered effluent with greater than 2.0 NTU shall be diverted to a backup disposal system acceptable to DOH;

    c. For R-1 application of edible crops, the turbidity of the influent to the filters is continuously measured, the influent turbidity does not exceed 5 NTU for more than 15 minutes and never exceeds 10 NTU, and that there is the capability to automatically activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes.

2. A continuous recording turbidimeter should be provided for the filtered effluent and may be provided for monitoring each filter to ensure that the filtered water meets the performance criteria. Rationale: Typically there are many filters in a treatment facility. If the 2 ntu is exceeded, the entire flow needs to be diverted from the intended use. Then the operator has the onerous task of determining what went wrong and to remedy the situation. For example, if only one of the up-flow filters has a malfunction, the operator would normally test each one either with a portable turbidimeter or some other piping configuration, until the correct one is identified. A standby filter can be brought on line and

the malfunctioning filter can be taken off line for diagnostic testing. After the backwash cycle, some filters require development prior to being brought on line. A turbidimeter is used to determine when the development of the filter is adequate to produce the desired product water.

3. Adequate standby filtration capacity should be provided which is capable of processing the peak flow at the approved filtration rate under the most stressful conditions. The most stressful condition is defined by peak flow with one or more filters in the backwash mode and one out of service. For example, if one filtration unit is capable of meeting the filtered effluent criteria during the peak flow conditions then one standby filtration unit of equal capacity is recommended and one filtration unit of equal capacity in backwash mode is recommended. If multiple filtration units are required in order to comply with the filtered effluent criteria during the peak flow conditions then, in addition there shall be at least one standby filtration unit of the equal capacity and at least one filtration unit in backwash mode. If any of the multiple filtration units differ in capacity, the standby filtration unit capacity shall be equal to the largest unit.

   There are a variety of filtration technologies potentially applicable to the production R-1 Water. Granular media filtration and membrane filtration have been successfully used and capable of meeting the R-1 criteria. Several, pre-engineered modular package plants that utilize rapid sand or multi-media filtration systems in conjunction with a number of other processes including coagulation, flocculation, dissolved air floatation, and sedimentation are available. Some of these package plants may meet the R-1 criteria. However, the protocol presented in the Guidelines for the Demonstration of Filtration Performance Criteria are presented in Appendix J shall be applied to testing the R-1 criteria for package plants or other filtration devices.

   Alternate technologies do not have the same level of performance history as granular media filtration systems. Thus, alternate filtration technologies must be evaluated not only from the standpoint of the product water quality, but also with consideration for the level of operational difficulty, operational constraints, reliability of the system components, and adaptability to various flow and loading conditions. The extent of pilot studies for alternate technologies will vary with system operational capability, flow and loading variability, and availability of data from similar applications.

4. Guidelines for the Demonstration of Filtration Performance Criteria are presented in Appendix J.

5. Filtration is not required for facilities intended to produce R-2 and R-3 Waters. However, new R-2 facilities constructed after May 30, 2002, will be required to install a continuous recording turbidimeter at a point after the secondary treatment. Continuous monitoring of the turbidity will

be required.

E. DISINFECTION

In Hawaii, wastewater effluent is most commonly disinfected by chlorine. However, chlorine is known to have serious toxic effects on aquatic life following discharge of chlorinated effluent to surface waters. In addition, chlorine can react with organics contained in wastewater to form various chlorinated hydrocarbons, such as trihalomethanes. Chloroform ($CHCl_3$), for example is a known animal carcinogen and a suspected human carcinogen. Chlorine gas is also highly volatile and deadly. The transportation, handling, and use of chlorine gas require a number of costly safety precautions. Therefore, DOH encourages the use of other disinfection processes and agents that can satisfy the effluent requirements.

1. Disinfection by means of chlorination:

   a. Level 1 Chlorination which meets the requirement of disinfection for R-1 Water and is exposed, after the filtration process, to chlorine in a well-baffled contact basin or pipeline that provides:

      (1) A chlorine contact time and residual, either or both of which differ from that cited in paragraph (2) below, that have been shown to the satisfaction of DOH to reliably reduce the number of plaque-forming units of F-specific bacteriophage MS2 per unit volume of water, added to the filter effluent in a demonstration project, to one ten-thousandth (1/10,000) of the initial concentration in the filter effluent throughout the range of qualities of effluent that will occur at the reclamation facility and that might influence efficacy of disinfection, or have been shown to the satisfaction of DOH to likewise reliably reduce the number of plaque-forming units of other virus added to the filter effluent, to one ten-thousandth (1/10,000) of the initial concentration when such other virus has been shown to the satisfaction of DOH to be at least as resistant to the form of disinfection being demonstrated as F-specific bacteriophage MS2; or

      (2) A theoretical chlorine contact time of 120 minutes or more and an actual modal contact time of 90 minutes or more throughout which the chlorine residual is 5 mg/l or greater, and the median number of fecal coliform bacteria in the effluent, as determined by approved laboratory methods, does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, number of fecal coliform bacteria does not exceed 23 per 100 milliliters more than one sample in any 30-day period, and no sample shall exceed 200

per 100 milliliters; and

(3) Automatic control of chlorine dosage and automatic, continuous measuring and recording of chlorine residual shall be provided. The chlorination facilities shall have adequate capacity to maintain a residual of 10 mg/l.

b. Level 2 Chlorination which meets the requirements of disinfection for R-2 Water and is exposed to chlorine in a well-baffled contact basin or pipeline that provides:

(1) A chlorine contact time and residual, either or both of which differ from that cited in paragraph (2) below, that have been shown to the satisfaction of DOH to reliably reduce the concentration of fecal coliform bacteria so that at some location in the treatment process the median number of fecal coliform bacteria in the effluent, as determined by approved laboratory methods, does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of fecal coliform bacteria does not exceed 200 per 100 milliliters in more than one sample in any 30-day period; or

(2) A theoretical chlorine contact time of 15 minutes or more and an actual modal contact time of 10 minutes of more throughout which the chlorine residual is 0.5 mg/l or greater, and the median number of fecal coliform bacteria in the effluent, as determined by approved laboratory methods, does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of fecal coliform bacteria does not exceed 200 per 100 milliliters in more than one sample in any 30-day period; and

(3) Automatic control of chlorine dosage and automatic, continuous measuring and recording of chlorine residual shall be provided. The chlorination facilities shall have adequate capacity to maintain a residual of 2 mg/l.

c. The following are minimum design parameters for all levels of chlorination:

(1) A high-energy rapid mix of chlorine should be provided at the point of application;

(2) Standby equipment of sufficient capacity should be available to replace the largest unit during shutdowns. Spare parts should be available for all disinfection equipment to replace parts which are subject to wear and breakage; and

(3) A high-energy rapid mix of chlorine should be provided at the point of application;

2. Disinfection by means of (UV) ultraviolet:

a. Level 1 ultraviolet disinfection which meets the requirement of disinfection for R-1 Water shall meet the applicable provisions of the UV Guidelines for Drinking Water and Water Reuse dated December 2000 or the latest version, published by the National Water Research Institute (NWRI) and the American Water Works Association Research Foundation (AWWARF) [250]. These guidelines were the update of the original 1993 *UV Disinfection Guidelines for Wastewater Reclamation in California and UV Disinfection Research Needs Identification*. These new guidelines are intended to be dynamic. As more operational experience is gained and as the technology advances, they will be updated.

The UV disinfection system must be able to meet the required inactivation levels for the target microorganisms established for R-1 water. DOH policy on reciprocity of UV equipment approved in California and detailed guidelines for the UV disinfection system design can be reviewed in Appendix K.

b. Level 2 ultraviolet disinfection which meets the requirement of disinfection for R-2 Water shall meet the minimum design parameters found in EPA's Municipal Wastewater Disinfection, Design Manual [33]. The UV disinfection system must be able to meet the required inactivation levels for the target microorganisms established for R-2 water. The University of Hawaii’ s Water Resources Research Center (WRRC) had evaluated treated wastewaters from various treatment facilities on Oahu for UV disinfection suitability [33a]. Design engineers and UV manufacturers interested in obtaining copies of the studies should contact the WRRC. The UV manufacturers may need to perform pilot or full-scale studies to meet the required bacterial inactivation for site-specific applications.

F. ALARMS

The ability to monitor operating parameters continuously is of fundamental importance in the operation of all water reclamation treatment facilities. Minimum instrumentation should consist of alarms at critical treatment units to alert an operator of a malfunction. This concept requires that the facility be attended constantly or that the alarms be telemetered to an operator on call.

1. In the following situations, if rapid attention to failure cannot be

assured, automatically actuated emergency control mechanisms should be installed and maintained for:

a. loss of power
b. high water levels
c. failure of pumps or blowers
d. high head loss on filters
e. high effluent turbidity
f. loss of coagulant or polymer feed
g. loss of chlorine residual

2. The alarms should be designed to record automatically all high and low priority conditions.

3. It is axiomatic that provisions must be available to otherwise treat, store or dispose of the wastewater until the corrections have been completed.

4. All required alarm devices should be independent of the normal power supply of the reclamation facility

5. The person to be warned should be the facility operator, superintendent, or any other responsible person designated by the management of the reclamation facility and capable of taking corrective action.

6. It is recommended that an individual alarm device sound at location and be connected to a master alarm to sound at the location where it can be conveniently observed by the operator.

7. Appendix K provides the monitoring and alarm design specific for UV disinfection system.

G. POWER SUPPLY

A standby power source shall be provided at all water reclamation treatment facilities and distribution pump stations. Standby power source means an automatically actuated self-starting, alternate energy source maintained in immediately operable condition and of sufficient capacity to provide necessary service during failure of the normal power supply.

1. The following requirements should be applicable to all water reclamation treatment facilities:

   a. For added reliability, D.C. control power switch over mechanisms should be installed together with a automatic starter.

b. Power distribution to main control centers or control panels within the plant for the critical loads should be supplied from motor control centers connected to in-plant unit substations.

c. Critical in-plant power loads should be divided within the motor control center by tie breakers.

d. The motor control center should be supplied with power at all times to treat the recycled water.

e. Instrumentation and control panels associated with the operation of process critical loads should be provided with similar redundancy.

f. It may be acceptable to connect non-critical process loads to only one power source. However, non-critical loads within a unit operation should be divided as equally as possible between motor control centers so that a single failure will not result in complete unit operation loss.

2. Appendix K provides the power supply reliability design specific for UV disinfection system.

H. FLEXIBILITY

Process piping, equipment arrangement, and unit structures should allow for efficiency and ease of operation and maintenance, and provide maximum flexibility of operation. Flexibility should permit the necessary degree of treatment to be obtained under varying conditions. All aspects of the facility design shall allow for routine maintenance of treatment units to prevent deterioration of the facilities effluent.

1. No pipes or pumps shall be installed that would circumvent critical treatment processes and possibly allow inadequately treated effluent to enter the recycled water distribution system.

2. The facility shall be capable of operating during:

   a. Power failures;

   b. Peak loads;

   c. Equipment failures;

   d. Treatment plant upsets; and

e. Maintenance shutdowns.

I. RELIABILITY

When process units are taken out of service for maintenance, repair, or unanticipated breakdown, multiple units or standby unit processes should be available to continue treatment.

Multiple units mean two or more process units such as tanks, basin compartments, blowers, or chemical feeders which are needed for parallel operation. The multiple units are a part of the normal treatment system and the total should be of sufficient capacity to enable effective operation with any one unit out of service.

Standby unit process is an alternate unit process or an equivalent alternative process which is maintained in operable condition and which is capable of providing comparable treatment for the entire applicable design or peak flow of the unit for which it is a substitute.

Both the multiple unit and standby unit found in the following documents shall be applicable to all reclamation facilities:

1. "Recommended Standards for Sewer Works" Great Lakes-Upper Mississippi River Board of State Sanitary Engineers (Ten-State Standards) 1991 Edition [28], and

2. "Recommended Standards for Water Works" Great Lakes-Upper Mississippi River Board of State Sanitary Engineers (Ten-State Standards) 1992 Edition [29].

J. OTHER METHODS OF TREATMENT

1. Methods of treatment, other than that cited in these guidelines specifying like treatment, shall be demonstrated to the satisfaction of DOH to assure a degree of treatment and reliability equivalent to the desired class of recycled water. This demonstration shall produce a wastewater effluent that meets disinfection and filtered effluent defined criteria throughout the range of qualities of wastewater that will occur at the reclamation facility and that might influence efficacy of disinfection.

2. The DOH shall consider both treatment effectiveness and reliability during evaluation of alternative treatment methods. If DOH deems that adequate data is not available to determine equivalency, studies will be required. DOH may specify that data shall be developed by investigators independent

of the project proponent, from studies conducted in Hawaii subject to oversight by DOH, by qualified researchers, consulting engineers, or others.

3. A proposal for the demonstration of equivalency for the production of recycled water shall be reviewed and approved by DOH. The proposal should include the following:

   a. Objective(s) of the demonstration project;

   b. A literature review, encompassing the breadth of the objective(s);

   c. The strategy or methodology to achieve the objective(s). This methodology should be evaluated with previous studies. The methodology shall have a control;

   d. Details on sampling strategy, protocol, analysis and reporting; and

   e. Project details and dates.

4. Conditional Acceptance

   Conditional acceptance of a treatment facility may be granted by DOH. The unit would be evaluated against the minimum performance and operation standards for a period of one year. Under this alternative, the system could be installed without any advance pilot or lab testing (other than that done to satisfy the requirements of the items "a" and "b" noted above and any additional testing done by the system manufacturer). Failure to meet the performance and operational standards will, however, result in an order to remove the failed system as well as for testing and installing a more proven system.

   The owner of the treatment facility may find this an attractive option where a manufacturer is willing to agree in writing to provide a money-back guarantee that the system will meet both performance, operation and maintenance expectations. In such an arrangement, it should be explicitly provided that the manufacturer or its designated representative be involved in routine operation and maintenance procedures (through a service contract) for the entire demonstration testing process. This approach is intended to guard against possible claims that inadequate owner/operator performance caused a performance failure.

K. STORAGE IMPOUNDMENTS

The reuse system shall include adequate storage impoundment(s) or a backup disposal system to prevent any overflows or discharges from the system when the irrigation system is not in operation or when wastewater effluent quantities exceed the irrigation requirements.

1. The following apply where recycled water is put in any impoundment used as a restricted recreational impoundment or landscape impoundment:

   a. Runoff shall be prevented from entering the storage impoundment unless the impoundment is sized to accept the runoff without discharge, or an NPDES permit has been issued for the discharge;

   b. There shall be no discharge of recycled water to any impoundment with less than two feet of freeboard; and

   c. To retain its contents, impoundment shall have liners impervious to water. An acceptable standard for clay liners over a non-potable aquifer is a minimum compacted thickness of 18 inches, compacted to 95% of maximum density with a permeability rate of 1×10^{-5} centimeters per second. An acceptable standard for clay liners over a potable aquifer is a minimum compacted thickness of 18 inches, compacted to 95% of maximum density with a permeability rate of 1×10^{-7} centimeters per second.

2. The time period of 20 days related to storage is subject to reduction, expansion, or elimination if the project proponent demonstrates to the satisfaction of the DOH that another time period is adequate or that less or no storage is needed. The record should be at least a 30-year period (if available) or statistically adjusted to a 30-year period (See example in Appendix H).

3. The design and operation of system storage capacity shall be sufficient to assure the retention of the recycled water under adverse weather conditions, harvesting conditions, maintenance of irrigation equipment, or other conditions which preclude reuse; and

4. The control of public access is left to the discretion of the owner. However, signs shall be posted that are consistent with the Public Education Plan of these guidelines.

L. EMERGENCY BACKUP SYSTEMS

Recycled water produced at the treatment facility that fails to meet the filtered effluent and disinfection criteria established in these guidelines shall not be discharged into the reuse system storage or to the reuse system. Such substandard recycled water (reject water) shall be either stored for subsequent additional treatment or shall be discharged to another reuse system requiring lower levels of treatment or to an effluent disposal conforming with Title 11 Chapter 62 Sections 11-62-25 & 26 and approved by DOH.

1. Emergency system storage shall not be required where another approved alternate reuse area is incorporated into the system design to ensure continuous facility operation in accordance with these guidelines. The emergency storage shall have sufficient capacity to ensure the retention of recycled water of unacceptable quality. At a minimum, this capacity shall be the volume equal to one day's flow at the average daily design flow of the reclamation facility, or the average daily design flow of the approved alternate reuse area whichever is less.

2. Emergency system storage shall not be required where an alternate effluent disposal system has been approved by DOH. Effluent disposal shall conform to Title 11 Chapter 62 Sections 11-62-25 & 26.

3. Provisions for influent wastewater flow equalization or storage should be evaluated in the engineering report, which is cited in Chapter VI "Engineering Reports and Submittals For Treatment Facilities".

4. Provisions for recirculating the rejected recycled water to other parts of the reclamation facility for additional treatment should be incorporated into the design.

5. Automatically actuated emergency storage or disposal provisions and diversion to an approved alternate reuse area by DOH for emergency reuse is required and shall include all necessary sensors, instruments, valves, and other devices to enable fully automatic diversion of untreated or partially treated wastewater to approved emergency storage or disposal in the event of treatment process failure or violation of operational parameters, and a manual reset to prevent automatic restart until the problem is corrected.

V. DESIGN PARAMETERS FOR THE DISTRIBUTION OF RECYCLED WATER

The provisions of this section shall be complied with when any recycled water is used. The information in this Chapter is based on the "Guidelines for the Distribution of Nonpotable Water" which were prepared and published by the California-Nevada Section, American Water Works Association [43]. For clarification, the distribution system will be delineated into two segments. The term transmission lines will be used for the piping from the treatment facility to the approved use area, and terminate after the meter which will be addressed in Section A. "Transmission Lines". The reuse distribution system on the site of the approved use area will be addressed in Section C. "On-site

Distribution System".

A. TRANSMISSION LINES

This section is intended to provide criteria for protection against the misuse of transmission facilities. Cross-connection control is needed to prevent a nonpotable main from mistakenly being connected to a potable water system. Therefore, the location, depth, mode of identification, and type of aboveground appurtenances such as air/vac assemblies, and drain assemblies are essential in order to avoid cross-connections or inappropriate uses.

1. Pressure requirements should be based on system design and practice. In any case, minimum pressure at the user's meter should be maintained at the peak demand hour. It is desirable that a pressure differential of 10 psi or greater be maintained with the potable water supply having the higher pressure.

2. Horizontal and vertical clearances between potable water and other utilities, namely recycled water lines shall conform with the "Water System Standards" Department of Water, County of Kauai; Board of Water Supply, City and County of Honolulu; Department of Water Supply, County of Maui; Department of Water Supply, County of Hawaii; Volume 1 [26]. Furthermore, the minimum easement or right-of-way widths, and minimum cover and requirements for non-potable shall also conform to this reference.

3. All new buried transmission piping in the recycled water system, including service lines, valves, and other appurtenances shall both be colored purple, suggested color Pantone 522 or equal, and embossed or be integrally stamped/marked "CAUTION: RECYCLED WATER-DO NOT DRINK," or be installed with a purple identification tape, or a purple polyethylene wrap, suggested color index 77742 violet #16, Pantone 512 or equal.

4. Existing potable or nonpotable water lines that are being converted to recycled use shall first be accurately located and tested in coordination with DOH. If required, the necessary actions to bring the water line and appurtenances into compliance with regulatory standards shall be taken. If the existing lines meet the approval of the water supplier and DOH, the lines shall be approved for recycled water. If verification of the existing lines is not possible, the lines shall be uncovered, inspected and identified prior to use.

5. Identification tape shall be prepared with white or black printing on a purple field, suggested color index 77742 violet #16, Pantone 512 or equal, having the words "CAUTION: RECYCLED WATER - DO NOT DRINK." The

overall width of the tape shall be at least three (3) inches. Identification tapes shall be installed on top of new transmission pipe longitudinally and shall be centered. The identification shall be continuous in their coverage on the pipe and shall be fastened to each pipe length no more than ten feet apart. Tape attached to sections of pipe before they are placed in the trench shall have flaps sufficient for continuous coverage. Other satisfactory means of securing the tape during backfill of the trench may be used if suitable for the work, as determined by the reclamation agency.

6. Valve boxes shall be the standard concrete or fiberglass box conforming with "Water System Standards" Volume 1 [26], and "Approved Material List and Standard Details for Water systems Construction", Volume 2 [27] with a special triangular, heavy-duty cover. All valve covers on offsite reclamation transmission water lines shall be of non-interchangeable shape with potable water covers and with a recognizable inscription cast on the top surface "Recycled Water".

7. All above ground existing and new facilities shall be consistently color-coded purple, suggested color index 77742 violet #16, Pantone 512 or equal and marked to differentiate recycled water appurtenances from potable water or wastewater.

8. Either an in-line type or end-of-line type drain (blow-off) assembly shall be installed for removing water or sediment from the pipe. The line tap for the assembly shall be no closer than 18-inches to a valve, coupling, joint, or fitting unless it is at the end of the line. Since there are restrictions on runoff and ponding and there may be restrictions on infiltration, the method for disposal of the drain water shall be presented to DOH for approval.

9. Meter boxes shall be installed as shown in the Standard Details for each approved reuse area. The type of meter box to be used, spacing, dimensions, and other details shall be as shown in the Standard Details State of Hawaii 1985, Volume 2.

10. Meters shall be approved, calibrated and/or purchased by the recycled water purveyor or it designee.

B. Pumping Facilities

Reclamation agencies with pumping facilities to transmit or distribute recycled water shall identify the type of water being conveyed, provide acceptable backflow protection, avoid release of recycled water and provide for proper drainage of the pump packing seal water.

1. All existing and new exposed and above ground piping, fittings, pumps, valves and other appurtenances shall be painted purple, suggested color index 77742 violet #16, Pantone 512 or equal. In addition, all piping shall be identified using an acceptable means of labeling reading "CAUTION: RECYCLED WATER-DO NOT DRINK." In a fenced pump station area, at least one sign shall be posted on the fence which conforms with the Public Education Plan in Chapter VIII of these guidelines.

2. Any potable water used as seal water for nonpotable water pump seals should be adequately protected from backflow.

3. The design of recycled water pump stations shall either conform with the reclamation agencies standards or Chapter 30 "Design Standards" of the Division of Wastewater Management Volume 1, [24].

C. On-site Distribution System

Reclamation water distribution systems may require special accessories. Because of suspended matter which may accumulate from open storage or other sources, water strainers may be required before any meter or other mechanical type of device such as a pressure-reducing valve. Since irrigation operations are frequently at night, automatic electronic controllers should be used on-site. Backflow prevention is required when a nonpotable water system shares a use area with a potable system. This must be accomplished with the approval by DOH or the potable water purveyor. Facility identification is as important as the separation consideration discussed earlier. Pipelines, equipment and irrigated areas shall be clearly identified.

1. Depending on the quality of the recycled water and the type of storage utilized, strainers may be required at the consumer's meter. Strainers can range in mesh size from 20 to 325. A mesh of 20 to 80 is normally adequate. An analysis of potential debris will aid in prescribing the optimum size. In order to reduce maintenance, material that will not plug on site irrigation nozzles should normally be allowed to pass. Strainers of the following types are generally satisfactory:

    a. Wye strainers: Not recommended for below-ground (in vaults) installations;

    b. Basket strainers: Suitable for above or below-ground (in vaults) installations; and

c. Filter strainers: Normally used above ground on drip irrigation systems.

2. Strainers are normally the same size as the line and can be installed either before or after the meter.

   a. Installation before the meter will protect the meter as well as the on-site system. Maintenance in this case is the responsibility of the water purveyor.

   b. Installation after the meter will not provide meter protection, and maintenance in this case is usually not the responsibility of the purveyor. It should be determined in advance whether there is a potential for debris in the water that would plug the screen in the meter.

3. Controllers are used to automatically open and close on-site distribution valves.

   a. They should be fully automatic.

   b. They should have multiple starting times that can be selected for any time of day, seven (7) days a week and should be equipped with moisture sensors to avoid activation during rainy periods.

   c. Station durations should be capable of delivering water from one minute to 60 minutes per each start time.

   d. An appropriate size drawing of the area served by the controller should be sealed in a plastic cover and placed in the controller and updated if the system is changed.

   e. Controllers of recycled water shall be color-coded to differentiate the recycled water from the potable water in accordance with Sections A-4 and A-6 of this chapter.

   f. Controllers should be labeled inside and outside, warning that the system is utilizing recycled water. The labels should also alert the system's owner/maintenance personnel of any important constraints on the operation of the system in accordance with Sections C-7 and C-9 of this chapter.

4. New on-site pipelines shall be identified as recycled water pipes by using a purple color code, suggested color Pantone 522 or equal for pipe and other appurtenances, suggested color index 77742 violet #16, Pantone 512 or equal for marking tapes, labels and signs, and markings,

differentiating them from potable water piping. The words "CAUTION: RECYCLED WATER - DO NOT DRINK," shall be printed on the pipe or identification tape. This statement shall be stamped on opposite sides of the pipe, repeated every three feet. All piping and valves shall also be appropriately labeled or continuously taped with appropriate identification.

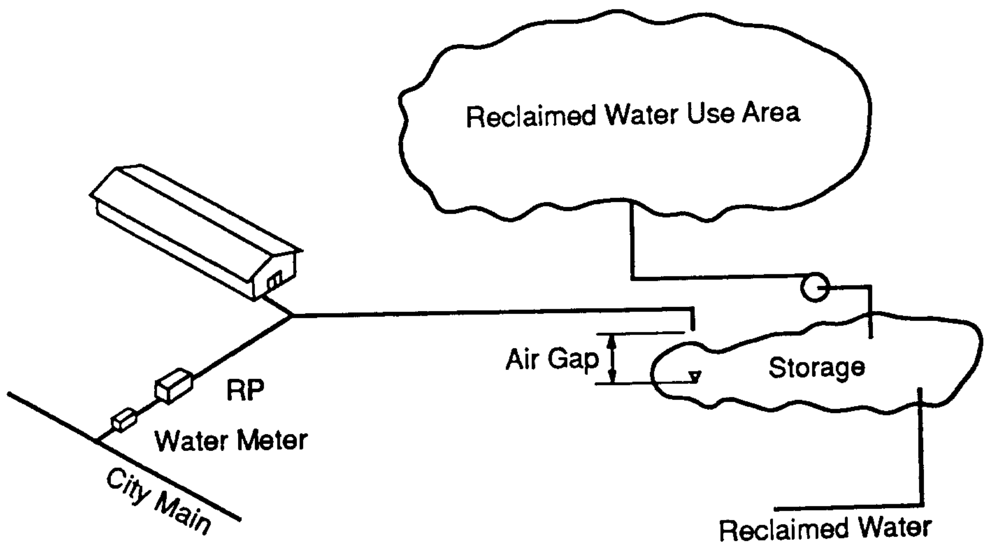
5. Identification tape shall be installed on pressure and/or non-pressure laterals. A purple tape, suggested color index 77742 violet #16, Pantone 512 or equal, with white or black lettering stating "CAUTION: RECYCLED WATER - DO NOT DRINK," shall be fastened directly to the top of the pipe. The tape shall run continuously the entire length of the pipe. The overall width of the tape shall be at least three (3) inches in width. It is recommended that the identification tape be locator type marking tape.

6. If a connection between potable and recycled water systems is necessary, an air gap (AG) approved by the potable water purveyor shall be provided to protect the potable water system.

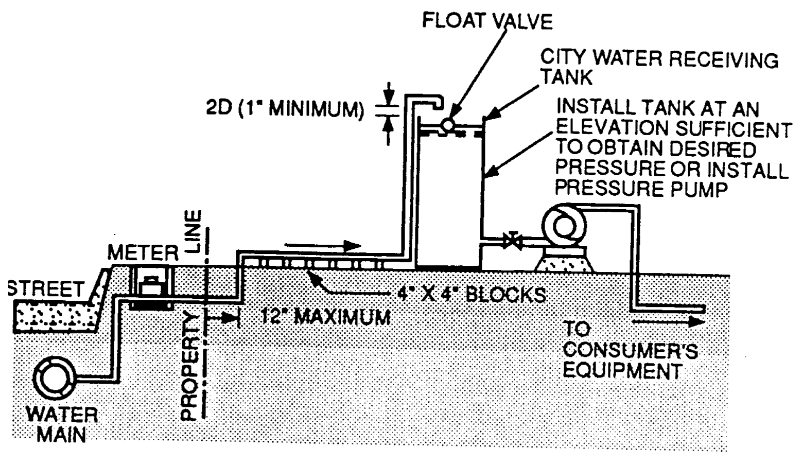
7. If a premise is supplied with both potable water and recycled water, then backflow protection with an approved air gap shall be provided at the potable water service connection. A reduced pressure principle devise (RPPD) backflow prevention may be provided only when approved by the DOH or the potable water purveyor. The following are current references:

   a. Cross-Connection and Backflow Control, Chapter 21 of Title 11 Administrative Rules; and

   b. Backflow Prevention Devices, "Water System Standards", Vol I [26].



8. Backflow prevention devices are not normally used on recycled water systems. However, a reclamation agency shall maintain the water quality in the recycled water distribution system. A backflow prevention device may therefore be needed at a specific meter where on-site exposures would impact the quality of the recycled water supply. If temporary potable water connections to the recycled water system are required, the connections shall be protected in the same manner as a permanent connection. Exceptions may be necessary under special circumstances, but in any case, shall not be allowed unless approved by both DOH and the potable water purveyor.



AIR-GAP SEPARATION

9. When existing potable or nonpotable water lines are being converted to recycled usage, the water lines shall be accurately located and tested in coordination with DOH. If required, the necessary actions to bring the water line and appurtenances into compliance with regulatory standards shall be taken. If the existing lines meet approval of the water supplier and DOH, the lines shall be approved for recycled water. If verification of the existing lines is not possible, the lines shall be uncovered, inspected and identified prior to use.

10. Hose bibs shall not be allowed on recycled water systems. Quick couplers that are different from those on the potable system may be used if hose connections are necessary. Hoses used with recycled water systems shall conform with the above color code and shall not be used with potable water systems. Signs shall be used to identify the recycled water quick coupling. When potable quick couplers are within 60 feet of the recycled system, both shall be equipped with appropriate signs.

11. When potable water is being supplied to an area also being supplied with recycled water, it is recommended that the potable water main also be identified. The identification tape should read "Drinking Water Line" and should be fastened directly to the top of new potable water pipe and run continuously the entire length of the pipe. This tape should be at least 3-inches in width. The color code should differentiate potable water from recycled water.

12. Horizontal, and vertical clearances between potable water and other utilities, namely recycled water lines shall conform with the "Water System Standards" Volume 1 [26]. Furthermore, the minimum easement or right-of way widths, and minimum cover and requirements for recycled shall also conform to this reference.

D. REQUIREMENTS FOR TRUCKING ALL RECYCLED WATER

1. The water reclamation purveyor, which provides recycled water for transport by truck, shall inspect trucks and appurtenances to ascertain that applicable provisions of this section are complied with.

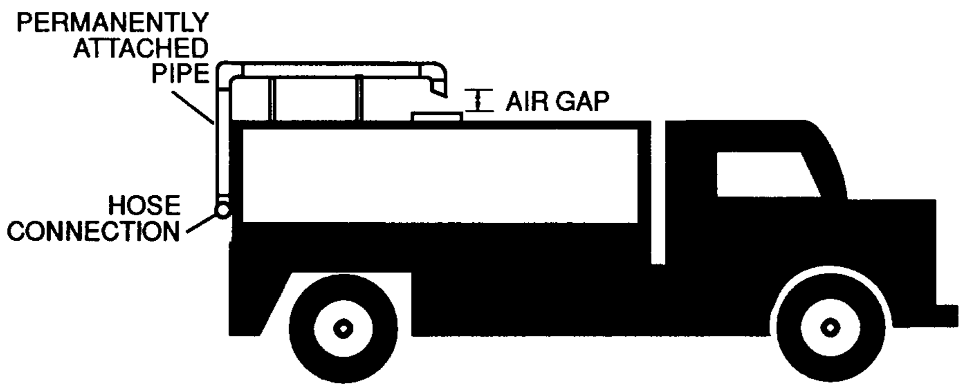
2. The vehicle and equipment that holds and conveys recycled water (e.g., tanks, hoses, pumps) shall be clearly labeled in a prominent location with language required for signs presented in section 1 of the PUBLIC EDUCATION PLAN. Wording and symbol shall be of sufficient size to be clearly read by a person 50 feet away from the wording.

3. The tank of a water-hauling vehicle shall not be used to transport recycled water if it has carried a pesticide, or radioactive substance, or hazardous waste. A tank that has carried un-chlorinated municipal wastewater, material from a septic tank or cesspool, or other potentially infectious substance shall not receive recycled water until it has been thoroughly cleaned and disinfected, and shown not to impart coliform bacteria to water. A tank shall be considered thoroughly cleaned and disinfected if all equipment surfaces intended for recycled water contact, including source fill-point equipment, containers, caps, tanks, hoses, valves, filters, and fittings shall be washed, rinsed and sanitized with an agent that disinfects. If household chlorine bleach (5% chlorine) is used to disinfect, approximately 24 ounces of chlorine bleach in 1,000 gallons of water should be used. The chlorine should be agitated thoroughly and allow contact with tank and hoses for at least 120 minutes for R-1 Water and 30 minutes for R-2 Water. The chlorine solution should run to waste through delivery hoses. The tank shall then be thoroughly rinsed with recycled water before filling.

4. Tanks of vehicles used for the transportation and distribution of recycled water shall have watertight valves and fittings, and shall not leak.

5. Hose of piping that has carried recycled water shall not be connected to a hydrant that is part of a domestic water distribution system. A tank of a water hauling vehicle that contains recycled water shall not receive water from a hydrant that is part of a domestic water system, or from any other part of a domestic water distribution system unless the applicant has written permission from the purveyor of domestic water to take such water and the tank receives water only through an air gap that is twice the diameter of the inlet pipe.

6. The tank of a water-hauling vehicle shall receive recycled water only from a dispenser above the tank, through an air gap that is twice the diameter of the inlet pipe.



7. Recycled water trucked to a residential lot shall not be put into piping, or a storage facility, that will remain after a day's use of recycled water, until all of the following agencies who have authority have reviewed and approved in writing a plan to undertake such a transfer: DOH, city and/or county plumbing/building authority and water supply authority. Until such a plan has been approved as described above, the applicant shall discharge recycled water directly from the truck onto the use area, or transfer it from the truck via temporary piping that:

   a. lies on the surface of the ground while in use;

   b. is removed when the day's transfer of use of recycled water is completed; and

   c. is clearly labeled with language required for signs pursuant to section 1 of the PUBLIC EDUCATION PLAN. Wording and symbol shall be of sufficient size to be clearly read by a person 50 feet away from the wording.

8. A tank truck used to carry recycled water shall not be subsequently used to carry potable water to be used for drinking water for humans, or for other purposes that require potable water.

VI ENGINEERING REPORTS AND SUBMITTALS FOR TREATMENT FACILITIES

The engineering reports shall contain sufficient information to assure DOH that the degree of treatment and reliability is commensurate with the proposed use, and that the transmission and use of the recycled water will not create a health hazard or nuisance. In order to expedite review and approval, DOH recommends the submittal of the following reports:

A. Basis of Design Report For The Treatment Facility;

B. Engineering Design Report For The Treatment Facility; and

C. Construction Plans For The Treatment Facility.

The reports and plans shall be prepared and stamped by a qualified engineer registered in the State of Hawaii and experienced in the field of wastewater treatment. The report shall clearly indicate the means for compliance with the rules in Title 11 Chapter 62 and with these guidelines.

A. BASIS OF DESIGN REPORT FOR THE TREATMENT FACILITY

For all projects except in the County of Kauai, the Basis of Design Report shall conform with Section 11 "Engineering Report" in Chapter 10 of Design Standards of the Division of Wastewater Management, Vol. 1 [24]. For projects in Kauai, the Basis of Design Report shall conform with Section 22, "Engineering Report," in Chapter 10 of Sewer Design Standards, Department of Public Works, County of Kauai [25].

1. Population and Flow Projections:

   Design average, maximum and peak wastewater flows shall be determined in accordance with Section 22, "Quantity of Wastewater," in Chapter 20 of Design Standards of the Division of Wastewater Management, Vol. 1 [24], all projects except in the County of Kauai. For projects in Kauai these flows shall be determined in accordance with Section 22, "Quantity of Wastewater," in Chapter 20 of Sewer Design Standards [24].

2. Wastewater Characterization:

   a. Determination of wastewater strengths and characteristics shall be based on field sampling and monitoring data for existing service areas, allowances for anticipated changes in existing service areas, and allowances for contributions from new service areas.

The allowances for newly-served domestic contributors should be not less than:

0.20 pounds per capita per day for BOD_5; and

0.20 pounds per capita per day for SS.

b. Determination of effluent characteristics shall be based on chemical analyses of the recycled water for all the pollutants listed in Appendix E; and

c. Projected non-domestic waste characterization shall be estimated based upon the nature of the projected commercial/industrial developments and estimates of water usage and process requirements. For all non-domestic sources contributing waste to the existing or proposed reclamation facility, the following information shall be submitted:

(1) A base map showing the location of the water reclamation facility and all non-domestic sources contributing wastes including all hazardous waste treatment, storage, or disposal facilities;

(2) A line drawing of the water flow through these facilities with a water balance, showing operations contributing wastewater to the water reclamation facility;

(3) A narrative identification of each type of process, operation or production area which contributes wastewater. The narrative shall identify the average flow which each process contributes, and describe the treatment the wastewater receives, including the ultimate disposal of any solid or fluid wastes other than by discharge. Any oil and water separator discharges shall be identified and described. A separate sheet containing the information above should be provided for each non-domestic user of the treatment works. In addition, for each source or process there should be a list of all EPA priority pollutants used and a listing of all Resources Conservation and Recovery Act (RCRA) hazardous wastes (including EPA hazardous waste identification number, e.g. F006) discharged to the collection system;

(4) Determination of sludge characteristics by conducting a priority pollutant scan for the sludge produced by the treatment facility.

3. Optimization for coagulants:

Wastewater can vary appreciably; therefore, preliminary studies shall be conducted to determine the estimated dosage range for coagulants and polymer for each proposed project utilizing R-1 Water. Furthermore, there should be adequate time after coagulant addition for a visible floc to form prior to filtration. This floc formation time varies for each wastewater and type of coagulant used. Floc formation may take five minutes or more, and the time required should be determined for each individual case. Long contact times may require some form of slow mixing to prevent settling of flocculated particles.

4. Water Reclamation Site Selection

   The following items shall be addressed:

   a. Maps depicting existing and proposed collection system;

   b. Maps showing the existing and proposed zoning and land use;

   c. Wind rose for proposed site;

   d. Availability of land area;

   e. Location with respect to floor plan; and

   f. Local soil characteristic, geology and topography.

5. Development and evaluation of treatment alternatives shall include the following:

   a. To review and evaluate treatment levels compatible with reuse proposals;

   b. To develop and evaluate treatment unit processes with respect to hydraulic and wastewater loadings; and

   c. To develop and evaluate alternatives and then select the most cost effective, environmentally sound system.

6. Establish and/or delineate the authority and responsibility for the following topics:

   a. Development of water reclamation standards (valve spacing), standard details, and standard construction notes;

   b. Development of a water reclamation meter program. It shall include a meter specification for all users, periodic meter calibration and meter reading;

   c. Address the development of rates and charges for the use of reclamation water, the meter and hookups;

d. Development of water reclamation service line charges;

e. Development of an inspection program to assure that all work on the water reclamation distribution system conforms with the construction plans and specifications;

f. Development of an inspection protocol that includes:

   (1) Placing pipe, fittings and structures;

   (2) Pouring concrete anchors and kicker blocks;

   (3) Placing and compacting the pipe zone backfill;

   (4) Backfilling balance of trench to grade and compaction tests;

   (5) Pressure testing all mains and services;

   (6) Disinfection and flushing;

   (7) Repaving trench cuts;

   (8) Raising valve box covers to finished grade; and

   (9) Installing service lines, meter boxes and meters.

g. Development of inspection standards that will require corrections and re-inspection and/or retesting;

h. The name of the entity that has authority to suspend the work wholly or in part for such time as it may deem necessary if the contractor fails to carry out orders given by the inspector, or to perform any required provisions of the plans and specifications;

i. Development of regulations or policies regarding cross connections and inspection program. If the customer is required to have the backflow device regularly tested by a tester certified by DOH, records of such annual tests, repairs, and overhauling shall be kept by the customer and copies forwarded to this cross-connection control inspector;

j. Development of sewer regulations or policies and industrial pretreatment regulations or policies. The industrial pretreatment regulations or policies shall be modeled after the National Pretreatment Standards to control pollutants that pass through or interfere with treatment processes. 40 CFR Part 403-General Pretreatment regulations for existing and New Sources of Pollution; and

k. The name and address of the owner of the treatment facility shall be provided. This will enable DOH to mail the subsequent approval letters to this address.

B. ENGINEERING DESIGN REPORT FOR THE TREATMENT FACILITY

The engineering design report should include the following material:

1. Summary of "Basis of Design Report";

2. Selection of Treatment Processes. The report shall include:

   a. A schematic of the treatment train;

   b. A description and necessary calculations for the significant treatment processes giving their size, capacity loading rates and/or contact times;

   c. A mass balance showing the inter-relationship of units; and

   d. A staging schedule of future changes, if major components or equipment are to be modified in stages.

3. The report shall specifically address how each of the "Treatment Design Parameters" contained in Chapter IV of these guidelines are incorporated in the design. Furthermore, based on the design parameters of the treatment units, the report shall develop operational parameters and conditions which will assist in the training of the personnel which will assure a reliable production of the optimal water quality for the designated product level, i.e., R-1, R-2 or R-3 Waters.

   a. All filtration design criteria shall be provided (filtration and backwash rates, filter depth, and media specifications). The expected turbidities of the filter influent (prior to the addition of chemicals) and the filter effluent must be stated. This section shall include the chemicals that will be used, the method of mixing, the point of application, and the dosages.

   b. The plant reliability features proposed to comply with the "Treatment Design Parameters" contained in Chapter IV, shall be described in detail. The discussion of each reliability feature must state under what conditions it will be actuated. When alarms are used to indicate system failure, the report must state where the alarm will be received, how personnel monitor the location, and who will be notified. The report shall state the hours the plant will be attended by qualified personnel.

c. Prior to the production of any recycled water, the actual residence time distribution in the disinfection unit(s) shall be determined. The protocol for determining the residence time distribution under various flow conditions should be described.

4. The operations plan shall incorporate the intended design parameters of the treatment units, the operation parameters and the training of the personnel to reliably produce the optimal water quality for the designated product level, i.e., R-1, R-2 or R-3 Waters.

   a. Chemical treatment is an important component for the production of R-1 Water using granular media filtration. However, coagulation and/or polymers are not required for the production of R-2 and R-3 Waters. The following is a summary for the addition of coagulants and polymers:

      (1) Continuous turbidity monitoring and recording of the secondary effluent prior to filtration and continuous measurement and recording of effluent flow are required such that the subsequent coagulant and polymer addition can be automatically adjusted to provide coagulant dosages under varying conditions.

      (2) Adequate initial rapid mixing shall be provided to assure effective dispersion of the coagulant into the wastewater.

      (3) Low energy mixing shall be provided after coagulant is added and residence time shall be provided between the addition of coagulant and filtration to assure that floc forms prior to filtration and does not form after filtration. Residence time required to accomplish that shall be determined by experiment. Flow turbulence and/or mixing shall be controlled to prevent breakup of floc.

      (4) There should be adequate time after coagulant addition for a visible floc to form prior to filtration. This floc formation time varies for each wastewater and type of coagulant used. Floc formation may take five minutes or more and the time required should be determined for each individual case. Long contact times may require some form of slow mixing to prevent settling of flocculated particles. Flow turbulence and/or mixing should be controlled to prevent break-up of floc. The addition of coagulant at a location that does not provide adequate contact time is not acceptable and may cause a deterioration of the effluent by inducing flocculation after filtration.

(5) Rapid mix unit detention times should be less than 30 seconds.

(6) Flocculation unit detention time should be at least 20 to 45 minutes.

(7) Sedimentation unit or alternate solid removal process detention time should be 1 to 4 hours. Sedimentation process should include other methods of solids removal such as dissolved air flotation, plate separation and up-flow-solids contact clarifiers.

(8) When the operating criteria for the chemical treatment necessary for production of R-1 Water cannot be met, the effluent shall be diverted either to a lower level of use, emergency storage or disposal.

(9) A continuous flow measuring and recording device is required to record any effluent diverted to a lower level of use, emergency storage or disposal.

b. All granular media filters should be operated in accordance with the following recommendations:

(1) If the effluent from the secondary clarifier exceeds the turbidity limit established by the design team or filter manufacturer, the flow shall be diverted.

(2) Filtration rates shall be increased gradually when placing filters back into service following backwash or any other interruption in the operation of the filter. The objective is to prevent the production of a mixed blend of high and low turbidity water to the user after the backwash process. For reclamation facilities with a full time operator present, this can be done every time filters are backwashed. For facilities using automatic backwash controls without an operator present, it will be necessary to demonstrate to DOH that proper treatment is provided when these filters come back on-line.

(3) To determine compliance with the performance standard of 2.0 ntu, continuous monitoring of the filtered effluent is required. Filtered effluent shall be diverted when its turbidity exceeds two (2) ntu or the turbidity meter or recorder malfunctions. The design team or filter manufacturer shall recommend an upper limit for turbidity in order to assure reliability of operation. If the effluent exceeds this limit prior to entering the filters, the flow shall be

diverted.

(4) Pressure filters shall be physically inspected and evaluated annually for such factors as media condition, mud ball formation, and short-circuiting. A written record of the inspection shall be maintained. If anomalies are noted during annual inspections, a follow-up inspection is required in order to assure that the problem is resolved or does not develop. Problems identified during the inspection of the filter media should be corrected through design modification. For example, if mud balls are commonly found during the annual inspection, the need to provide proper surface wash facilities must be evaluated and installed if necessary.

(5) In addition to the performance standard in paragraph 3 above, the filtered effluent turbidity level from each filter should be monitored daily with a continuous turbidity meter and recorder, or with a grab sampling program approved by DOH. If this monitoring indicates that any filter unit is not meeting the performance standard of 2.0 ntu, the filter shall be taken out of service and inspected to determine the cause of its inadequate performance. The filter unit shall not be returned to service until deficiencies have been corrected and operation tests have demonstrated that the filter unit meets the performance standards of this section.

c. All disinfection facilities using chlorine should be operated in accordance with the following recommendations:

(1) A supply of chemicals necessary to provide continuous operation of disinfection facilities shall be maintained as a reserve or demonstrated to be available. It is recommended that at least 30 days supply of chemicals be on hand at all times. If it is not possible to store this much chemical on site, then the ability to quickly obtain the needed chemical shall be documented. For systems that disinfect with ozone and generate the ozone on site, it is also necessary to have backup generation facilities or an alternate disinfection chemical available, should the generation of ozone be interrupted due to equipment malfunctions.

(2) Controls are required to automatically adjust the disinfected dosages under varying flow conditions. Suggested controls may either be a residual chlorine analyzer with recorder and/or a continuous flow measurement device with recorder. A residual chlorine analyzer could be installed at the end of the chlorine contact tank which transmits signals to the chlorine feed system. The chlorine feed system will dispense the required amount of chlorine to maintain criteria residual

in the contact tank.

(3) To determine compliance with the performance standards specified in Chapter IV, Section D, the disinfectant residual concentration of the recycled water shall be measured and recorded continuously.

(4) Effluent shall be diverted to emergency storage or disposal if the chlorine contact time is less than the performance standard, or residual concentration is less than the performance standards, or if the residual analyzer or recorder malfunctions.

(5) For production of both R-1 and R-2 Waters used for spray irrigation, daily samples shall be analyzed by an approved laboratory method for fecal coliform. R-2 fecal coliform sampling frequency may be reduced to weekly subject to the Director's approval. It shall be demonstrated that the R-2 effluent can meet the coliform limits continuously and with a higher degree of reliability. Continuous monitoring of the disinfecting agent's dosage and turbidity in relation to the fecal coliform could be an option for demonstration purposes. If daily samples of fecal coliform are used as an index, the following presents the violation and restoration protocol:

(a) Case 1: the daily median analyses for a 7-day period show that product water exceeds median value coliform criteria. Product water shall be diverted and shall not enter the transmission and/or distribution systems. The supervisor for the treatment facility shall immediately notify both the purveyor and user supervisors. The treatment operator will be required to check the operating parameters for the disinfection and filtration system. The date, analysis, operating parameters, names and times shall be noted in the log.

If the disinfection and filtration system is operating within operating parameters, the design engineer should be contacted for modifying the operating parameter. The design engineer shall analyze the problem and submit an addendum to the engineering design report and O&M plan addressing this issue.

The daily median analyses for a 7 day period showing that product water does exceeds median criteria value shall be submitted to DOH for review. If the problem is identified in the filtration or disinfection systems, the repair shall be initiated. The treatment facility supervisor shall describe and certify the completion of the repairs. After the confirmed results from one analysis show that product water does not exceed median criteria value for fecal coliform, the discharge of production water into the transmission and/or distribution system may be resumed.

(b) Case 2: the 23 per 100 milliliters coliform value was exceeded in more than one sample in any 30-day period. Product water shall be diverted and shall not enter the transmission and/or distribution systems Restoration protocol same as Case 1 above.

(c) Case 3: the confirmed results from one analysis show that product water exceeds the fecal coliform maximum criteria. Product water shall be diverted and shall not enter the transmission and/or distribution systems. Protocol same as Case 1 above.

(6) If the dosage of disinfecting agent and turbidity is continuously recorded, the following presents the violation and restoration protocol for R-2 Water:

(a) A numerical relationship shall be established between the daily fecal coliform values and the dosage of disinfecting agent and turbidity for at least a 60-day period.

(b) When either the dosage of disinfecting agent and turbidity exceed the values that were established the product water shall be diverted and shall not enter the transmission and/or distribution systems.

(c) A sample shall be taken to analyze fecal coliform and then the procedures in the above-mentioned paragraph 5 shall be followed.

(7) An emergency plan shall be developed and implemented in the event of disinfection failure to prevent delivery to an R-1, or R-2 distribution system of any undisinfected or inadequately disinfected effluent. The plan shall be posted in the reclamation facility or other place readily accessible to the facility operator.

5. The report shall describe a treatment monitoring program that complies with these guidelines and includes frequency and location of sampling. Where continuous analyses and recording equipment is used, the method and frequency of calibration shall be stated.

C. CONSTRUCTION PLANS FOR THE TREATMENT FACILITY

Requirements applicable to the preparation of construction plans for treatment facilities shall conform to Section 12.1 "Construction Plans-General" of Chapter 10, Design Standards of the Division of Wastewater Management, Vol. 1, [24] and the following:

1. General Layout:

   a. Location and size of proposed and future facility structures shall include the following;

      (1) Acreage and tax map key number(s) of the project site;

      (2) Plot plan drawn to scale showing the location of the proposed and any existing wastewater system and its distances from existing and proposed buildings, structures, legal boundaries, property lines, adjacent surface bodies of water, drinking water sources and existing public sewers within 2,000 feet of the nearest property line;

      (3) Treatment units, except as provided in paragraph (4), shall not be less than twenty-five feet from any property lines nor less than ten feet from any building and swimming pools; and

      (4) Completely enclosed, locked, and ventilated equipment rooms used to house items such as blowers, motors, pumps, electrical controls, and chemical feeders shall not be less than five feet from property lines or less than ten feet from dwelling unit(s).

   b. Site improvements pursuant to Section 45.0 Chapter 40, Design Standards of the Division of Wastewater Management, Vol. 2 [24];

   c. Schematic flow diagram showing the flow through various facility units and elements;

   d. Piping, material handled and direction of flow through pipes;

   e. Hydraulic profiles showing the flow of wastewater and recycle flows;

   f. Elevation of high and low water levels of any storage tank, basin or impoundment to which the facility can discharge effluent;

g. Requirements of Section 12.3.1 (Chapter 10), "Plans of Wastewater Pump Stations-General Layout;"

h. A bench mark with description and latest elevations; and

i. Basis of bearings with description.

2. Detailed Construction Drawings

a. Requirements of Section 12.3.2 (Chapter 10), "Plans of Wastewater Pump Stations-Detail Plans" [24];

b. Location, dimensions and elevations of all existing and proposed facility units;

c. Type, size, pertinent features, and rated capacity of all pumps, blowers, motors and other mechanical devices; and

d. Adequate description of any pertinent features not otherwise covered by specifications.

VII. APPROVAL PROCESS FOR TREATMENT FACILITIES

A. APPROVAL TO CONSTRUCT

1. Pursuant to Title 11 Chapter 62 Section 11-62-08 "Specific requirements for wastewater systems:" No person shall construct or expand a wastewater system without the approval of the director. When the following submittals conform both with the provisions in these guidelines and Title 11 Chapter 62, DOH will issue a letter to the owner(s), with a copy to the engineer(s) who prepared the reports and plans, stating that approval is given to commence construction:

a. Basis of Design Report For the Treatment Facility;

b. Engineering Design Report For the Treatment Facility; and

c. Construction Plans For the Treatment Facility.

B. CONSTRUCTION INSPECTIONS

1. Pursuant to Title 11 Chapter 62 Subchapter 2 "Wastewater treatment works" Section 11-62-23.1(d) Specific requirements for wastewater treatment works: No person shall operate a treatment works until the director has inspected and authorized it. Subsequently, no treatment works shall be inspected unless the following documents are provided:

   a. A written declaration signed and dated by the engineer responsible for the preparation of the operation and maintenance manual for the treatment works, that the operation and maintenance manual meets paragraph (2) [subsection "b" below] and that if the treatment works is operated in accordance with the manual, all applicable effluent requirements will be met; and

   b. An operation and maintenance plan (manual) shall be prepared by the engineer pursuant to Section 11-62-23.1 (d). The plan (manual) shall encompass the provisions in Chapter VII, Criteria For Monitoring Treatment Operations, and at a minimum, provide the details on the following:

      (1) Operation and maintenance instructions for each pump station and treatment unit or process under normal and emergency conditions such as power outage and equipment malfunction;

      (2) Operation and maintenance instructions for the disposal system including procedures for purging or chemical "shock loading" to prevent or eliminate biological growth in the subsurface disposal system;

      (3) List of required sampling frequencies and analyses to be conducted by the operator;

      (4) Troubleshooting, corrective, and preventive measures to be taken to maintain process control and treatment performance and to ensure that all equipment is kept in a reliable operating condition;

      (5) Start-up procedures;

      (6) Applicable state effluent requirements;

(7) Instructions on wasting and disposal of wastewater sludge;

(8) Manpower requirements needed to operate and maintain the treatment works;

(9) List of critical parts of the treatment works;

(10) "As-built" drawings of the treatment works;

(11) List of required daily activities, checks and observations;

(12) Logs or report forms for all operation and maintenance activities performed;

(13) Flow schematic diagrams with details of piping and valving;

(14) Plot plan of the treatment works and project site including all collection lines and equipment;

(15) Details on all safety equipment at the treatment works site, any applicable spare parts, maintenance and operation instructions; and

(16) Details on all monitoring equipment including spare parts, maintenance and operating instructions.

2. A contingency plan shall be prepare to assure that inadequately treated recycled water will not be delivered to the user. The report shall identify actions and precautions to be taken to protect the public health in the event inadequately treated water is delivered. The "Contingency Plan" shall include:

a. A list of conditions which would require an immediate diversion to take place;

b. A description of the diversion procedures;

c. Designation of the diversion unit(s);

d. A plan for the disposal or treatment of any inadequately treated effluent; and

e. A plan for notifying the recycled water user, the local Health Department office, and the local media of any treatment failure that could result in the delivery of inadequately treated wastewater to the use area which may be accessible to the public.

3. DOH will mail a letter to the owner(s) with a copy to the engineer(s) who prepared the O&M plan (manual) and/or contingency plan, stating that they conform both with the provisions in these guidelines and Title 11 Chapter 62, therefore, inspections for the reclamation facility may be scheduled at the earliest convenience.

   a. One dry inspection shall be scheduled after construction but with all units dry. The inspection will focus on measurements and location of equipment and components; and

   b. A start-up inspection shall be scheduled when the reclamation facility is fully operable. The inspection will focus on normal, emergency and contingency operation and procedures. Provision shall be made to test the automatic switching from normal power supply to stand-by power supply.

C. APPROVAL TO OPERATE A TREATMENT FACILITY

1. Pursuant to Title 11 Chapter 62 Section 11-62-08 "Specific requirements for wastewater systems":

   No person shall operate a wastewater system unless that person or the owner of the wastewater system is authorized by the director in accordance with the applicable provisions of Sections 11-62-23.1(e) and the applicable provisions of chapter 11-61, "Mandatory certification of operating personnel in wastewater treatment facilities". The following items shall be provided:

   a. The name, address, telephone number, grade and effective date of certification; and

   b. If the operation is contracted out, the above information with a copy of an executed contract.

2. Pursuant to Title 11 Chapter 62 Subchapter 2 "Wastewater treatment works" Section 11-62-23.1(e) Specific requirements for wastewater treatment works:

   No person shall operate a treatment works until the director has inspected and authorized it.

a. Any discrepancy between the constructed treatment works and information supplied pursuant to this chapter is sufficient reason to withhold approval to operate the treatment works.

b. Before operation of the treatment works, the owner shall resolve all discrepancies recorded as a result of the inspection conducted pursuant to paragraph (a).

c. Any changes to the approved plan shall be resubmitted to the director for approval before the final inspection.

3. Upon satisfactorily completing the above, DOH will mail a letter to the owner(s) with a copy to the engineer(s) who prepared the plans, stating that the reclamation facility conforms both with the provisions in these guidelines and Title 11 Chapter 62, and therefore approval to operate the reclamation facility may commence.

4. All existing reclamation facilities shall comply with the provisions in Chapter VI A.6. "Institutional Responsibilities", Chapter VI B.4. "Operational Plan", Chapter VI B.5 "Treatment facility Monitoring Plan" and Chapter X "Compliance Reports and Submittals".

D. PERFORMANCE AND COMPLIANCE INSPECTIONS

1. Pursuant to Title 11 Chapter 62 Subchapter 2 "Wastewater treatment works" Section 11-62-23.1(f) Specific requirements for wastewater treatment works:

   After the first year of operation, the owner of the treatment works shall submit to the director a written statement based on the professional judgment of the owner's engineer whether or not the treatment works is meeting the applicable effluent requirements of Section 11-62-26. If the treatment works is not meeting the applicable effluent requirements, the owner shall submit to the director a corrective action report containing:

   a. An analysis of the cause of the treatment works' failure to meet the effluent requirements and an estimate of the scope of the corrective action necessary to enable the treatment works to be in compliance;

b. A schedule for undertaking the corrective actions; and

c. A date by which the treatment works shall be in compliance with the applicable effluent requirements.

E. APPROVAL TO DEACTIVATE A TREATMENT FACILITY

1. Pursuant to Title 11 Chapter 62 Subchapter 2 "Wastewater treatment works" Section 11-62-23.1(h) Specific requirements for wastewater treatment works:

Upon abandoning, retiring or permanently discontinuing use of a treatment works, the owner shall render it safe by removing it or filling it completely with earth, sand, gravel or similar non-organic matter. All above ground portions of the treatment works shall be rendered safe and vector free. Electrical components shall be disconnected at the circuit breaker or source and all access openings sealed. Injection wells shall be abandoned in accordance with Chapter 11-23.

VIII. ENGINEERING REPORTS AND SUBMITTALS FOR WATER REUSE PROJECTS

The reports shall contain sufficient information to assure the DOH that the degree of treatment and reliability is commensurate with the proposed use, and that the distribution and use of the recycled water will not create a health hazard or nuisance.

A. Basis of Design Report for a Water Reuse Project

B. Engineering Design Report for a Water Reuse Project

C. Construction Plans for a Water Reuse Project

The reports and plans shall be prepared and stamped by a qualified engineer registered in the State of Hawaii and experienced in the field of irrigation systems. The report shall clearly indicate the means for compliance with the rules in Title 11 Chapter 62 and with these guidelines. The full Basis of

Design and Engineering Reports may be waived for smaller reuse projects such as dust control and landscape and irrigation areas less than five acres, on the approval of DOH. A simplified application form meeting the requirements of HAR 11-62 and the provisions of the reuse guidelines can be submitted to DOH in lieu of an engineering report.

A. BASIS OF DESIGN REPORT FOR A WATER REUSE PROJECT

For all reclamation projects, the data specified below shall be presented in the report. The report shall present descriptions of new or existing reuse areas, and existing and/or new distribution systems. The design should conform with the Guidelines for the Treatment and Use of Recycled Water. The necessity of any proposed deviation from the guidelines must be discussed in the report.

1. Provide the following information about the treatment facility:

    a. Name of WRTF;
    b. Tax Map Key (TMK) of WRTF;
    c. WRTF owner's name and address;
    d. Treatment process;
    e. Product water (e.g. R-1, R-2);
    f. Design flow;
    g. Date, permit (approval) to operator WRTF;
    h. Current flow;
    i. Date of current flow;
    j. A list of sources that contribute non-domestic wastewater to the treatment plant i.e., industries, commercial process water; and
    k. Annual mean values of the recycled water for the water quality parameters listed in Appendix H, Section IV, subsection a & b. For those parameters that are not sampled regularly, provide dated-paired grab or composite samples. Dates for the water quality sample shall not be older than 12 months from the date of the report. If the WRTF is a proposed facility, water quality data may be used from the comparable WRTF that is acceptable to DOH. Subsequently, in the 12 months after approval to operate the treatment facility, water quality samples mentioned above shall be taken and submitted to DOH.

2. Provide the following information pertinent to the proposed "approved use area"(s) (AUA):

    a. Site name;
    b. Site address;
    c. Site tax map key (TMK);
    d. Map, showing the exact boundaries (azimuth-distance) of the

proposed "approve use area";

e. Map, delineating the irrigated or wetted areas, and buffer zones, providing dimension for both;
f. Map, the names or labels (e.g. clubhouse, single residential unit) road and structures shown on a base map. The structures and fenced areas shall be labeled, e.g., residential, public access, restrictive access;
g. The area within the boundary of the approved use area;
h. The area irrigated or wetted;
i. Name of property owner;
j. Address of property owner;
k. Name of leaseholder of site (if applicable);
l. Address of leaseholder (if applicable);
m. Copy of lease (if applicable); and
n. All proposed areas which are not contiguous shall be described by items a through m.

3. Maps showing the general location of the existing and proposed transmission facilities and the distribution system layout shall be provided. The plans shall include the location of all existing and proposed water and sewer lines.

4. The report shall describe how the transmission and distribution systems will comply with the following:

   a. Provisions in <u>Cross-Connection and Backflow Control</u>, Chapter 21 of Title 11 Administrative Rules;

   b. Provisions in Backflow Prevention Devices, Water System Standards, Vol I [24];

   c. Provisions in Chapter V, Design Parameters of the Distribution of Recycled Water, in these guidelines; and

   d. Provisions for inspection of both the transmission and distribution systems. This may be with an arrangement with either the water or recycled water purveyor, or an engineer.

5. Base maps shall show present land uses and anticipated land uses within one mile of the site boundaries. The land use information shall be based on the approved county comprehensive land use plan.

   If expansion of the proposed facility is anticipated, the area likely to be used in the expansion shall be shown on the base maps.

6. The drainage of the area should be shown by a USGS topographical map which incorporates the project area and a project topographical map with contours no greater than 5 feet. Existing drainage and the proposed drainage improvements shall be addressed, specifically, how will the

project be designed to prevent the possibility of recycled water leaving the designated use area. Maximum grades for spray irrigation are limited to 7 percent for row crops, 15 percent for forage, turf and orchards, and 30 percent in forest. Sloping sites promote lateral subsurface drainage and make ponding and extended saturation of the soil less likely than on level sites.

7. The following topics regarding the types of vegetation cover selected should be addressed:

   a. How will the selective vegetation cover be established, monitored and maintained?

   b. What are the vegetation cultivation procedures, harvesting schedules and uses?

   c. What is buffer zone vegetation cover and how will it be maintained?

   d. What is the consumptive rate of the vegetation selected?

   Evaportranspiration (ET) is a combination of two separate processes whereby water is lost from the soil surface by evaporation and by crop transpiration. This is commonly called the crop water requirement. It is the amount of water used by the growing crop. For practical purposes, calculating the irrigation water requirement based on ET is referred to as consumptive use in these guidelines.

   The following procedures are developed for estimating expected losses of water through transpiration (T) by plants and evaporation (E) from plants, soil and surface water [224]. The combined loss for a cropped surface is commonly referred to as evapotranspiration (ET). With due caution, the use of evaporation pans to estimate crop water use for periods of a week or longer is warranted and widely practiced. Doorenbos and Pruitt [145] have suggested that potential evaporation, or also known as reference crop evapotranspiration (ET_0) in their terminology, can be related to pan evaporation (E_{pan}) by the pan coefficient (K_p) as

$$(ET_0) = (K_p) * (E_{pan})$$

   Doorenbos and Pruitt [145] have reviewed many studies of pan coefficients and expressed the average values as a function of relative humidity and wind speed.

   The definition of potential evaporation is very precise. It refers to the rate of evapotranspiration from an extended surface of short, green grass cover of uniform height, actively growing, completely shading the ground, and not short of water. Therefore, even when the water supply is adequate, evapotranspiration from a tall, rough crop surface or during the ripening stage when the crop is not actively growing may depart from the potential rate. The ratio between crop evapotranspiration and the reference crop evapotranspiration is known as the crop coefficient K_c. Doorenbos and Pruitt [145] have summarized crop coefficients for many crops.

The approach by Doorenbos and Pruitt [145] consists of two steps:

(1) An estimation of potential evapotranspiration, or reference crop evapotranspiration from pan evaporation under various climatic conditions; and

(2) An estimation of crop evapotranspiration for any species and stage of development by the crop coefficient.

$$(ET) = (K_c) * (ET_o)$$

Use of pan ratios have been measured for several crops in Hawaii. During the first five months from germination to the establishment of a full canopy of sugarcane, the ratio (at canopy level) increases from 0.40 to 1.01 [151]. After the establishment of full canopy, the ratio reaches a peak of 1.20 at 10 months and then declines gradually to 0.98 at 17 months. For furrow or sprinkler irrigated mature sugarcane, the ratio is 1.0 with a surface pan. Drip irrigated cane uses an average of 0.8 of the annual surface pan evaporation or 0.7 of the pan elevated to 5 ft. height, about 15 percent less than sprinkler or furrow irrigated cane.

Evapotranspiration by Bermuda grass is essentially the same as Class A pan evaporation when soil moisture stress is small [147]. As the soil moisture stress increases, the grass sod maintains high rates of water use until the soil moisture stress exceeds 1 bar, but it is unable to maintain these rates as the soil moisture stress increases toward the 15 bar level.

Pineapple evapotranspiration rate is only one-fifth that of pan evaporation [146]. The greatly reduced transpiration rate is largely due to daytime suppression of water exchange by the pineapple leaf. Lettuce and Chinese cabbage in the winter season have a pan ratio of 1.0. Under drip irrigation the pan ratio is about 0.60 for lettuce, and between 0.70 and 0.80 for Chinese cabbage [153].

Evaporation for Low Humic Latosols (Oxisols) in Hawaii at field moisture content is only one-third the rate from a pan [148]. Similar low evaporation rates have also been reported for tropical soils in Puerto Rico.

The concept of basing irrigations on ET_o values derived from automatic weather stations is a proven technology. In most golf courses in the State, ET from on-site weather stations is integrated into computer software (based on Modified Penman equation) that directly controls daily course irrigation schedules. Weather stations monitor meteorological variables that impact ET, including solar radiation, wind speed, humidity, and temperature. The resulting weather data are then input into meteorological models that estimate reference evapotranspiration, ET_o. This often leads to improved irrigation management, better turf quality, and lower operating costs.

However, the DOH realizes that small-scale users may not be able to afford to install a weather station with the associated sophisticated computer software and the automation of the irrigation system. For proposed irrigation of a golf course, pasture or turf landscape, the DOH may accept for water balance calculations the use of rainfall and pan evaporation data for estimating evapotranspiration. It has been shown that actual recorded irrigation water use of some golf courses in the State was within (+/-) 10 percent of the calculated water application rate using the evapotranspiration calculated from the difference of the recorded rainfall and pan evaporation data. In the absence of a weather data for a specific site, data from other similar sites in the State could be used upon the recommendation of an irrigation specialist experienced in designing irrigation systems in Hawaii.

While ET provides the estimate of the volume of water to apply and consequently the land area requirement for irrigation, the use of soil-moisture indicators for irrigation scheduling is also recommended. Soil-moisture monitoring device are most effectively used to determine when to irrigate.

It is important to note that ET methodologies described above are predictive models. For site-specific applications, ET may be verified by conducting actual field experimentation. The Department recognized that other methodologies for calculating ET are available. The irrigation engineer/specialist should demonstrate to the satisfaction of DOH that their methodology is consistent with the DOH objective of a *consumptive* irrigation.

8. Irrigation over a public drinking water aquifer shall not exceed consumptive rates. An appropriate monitoring/weather station and/or monitoring of the soil moisture content in relation to its holding capacity shall be established under applicable conditions, to substantiate consumptive rates. Description of the monitoring/weather station's operational features, including the station wind speed recorder, precipitation, and ET system shall be provided. Depending on the size of the irrigated area, the Department may waive this requirement. A written schedule of irrigation shall be established to serve as irrigation instructions for the operator. The written schedule

shall include instructions to clearly explain when irrigation shall not be conducted.

9. A design application rate will be used to calculate both the volume of the storage reservoir and/or an alternate disposal capacity. The design application rate is a function of:

   Evaporation rate
   Precipitation rate
   Deep percolation rate
   Macro Nutrient loading (N,P,K)
   TDS
   Other constituent loading limitations
   Peak design flow from reclamation facility

   Developing the design application rate is an iterative process. An initial value is selected from a water balance calculation. This rate is then compared to the macronutrient loading, TDS loading and other constituent loading limitations (see the following subsections). If the initial value exceeds these limitations, the design application rate is reduced and the process is repeated.

   The design application rate will be the smallest value of the maximum monthly application rate (MMAR). Maximum monthly application rates for each month shall be determined from the following water balance equation:

   MMAR = ET - P + Perc + Runoff

   Where
   MMAR =Maximum monthly application rate for each month (in/month)

   ET =Monthly mean evapotranspiration rate (in/month)

   P = Design precipitation rate (in/month)

   Perc = Design monthly (deep) percolation rate (DMPR) (in/month)

   Runoff = 0, no runoff permitted

10. Losses through the process of evaporation and gains from precipitation are two of the important parameters needed in design and evaluation of irrigation and storage projects. An analysis of storage needs for recycled water projects requires consideration not only of ET alone, but the monthly excess of ET over precipitation (P). The use of only normal or average values is not adequate due to the natural variation of both; hence, long-term records of ET and P are required. These two parameters are not independent. The cloudiness needed to produce precipitation reduces ET to lower than normal levels, while ET is greatest during clear

weather. Thus, a frequency distribution of (ET-P) cannot be developed by separate assessments of records of ET and of P, but rather (ET-P) data for a number of years should be available or generated. Normally in the calculation of a water balance, month-by-month mean precipitation values are subtracted from the ET values (ET-P) for the entire length of the record and the 90 percent probability of exceedance level would be determined by the formula 100 m/(n+1); where m is the ranking and n is the number of years. Limited monthly precipitation data is available for various periods. If the monthly precipitation data is not available, there is a summary of precipitation data for the State of Hawaii. Unfortunately this summary of precipitation data does not lend itself to the appropriate analysis. However, if the month-by-month precipitation data for a station in Hawaii is not available, the summary mean monthly precipitation values may be subtracted from mean monthly ET values and then multiplied by an adjustment factor in order to estimate the 90 percent probability. This adjustment factor should be based on historical data analysis (see Table H-4, Appendix H).

a. The ET and P data is available for selected sites in Hawaii in the following:

    (1) Pan Evaporation Data From Pan Evaporation: State of Hawaii 1894-1983 Report R74 [224];

    (2) The Department of Meteorology, School of Ocean and Earth Science and Technology, 2525 Correa Road, Room HIG 331, HNL HI 96822 (956-8775), has initiated the formation of a Hawaii climate data users organization. The level of data sharing is intended to complement the activities and function of the National Climatic Data Center; and

    (3) Summary mean precipitation data is presented in the "Rainfall Atlas Of Hawaii" [223].

b. The selection of an existing data station should maximize the following concerns:

    (1) The ability to match ET and P for the same station;

    (2) Proximity to the proposed project site;

    (3) Length of record; and

    (4) Appropriateness of climatic conditions in relation to the proposed site.

c. After selecting the station and finding the monthly-adjusted mean ET_o values for each year of record, the data can be tabulated in a manner similar to that shown in Table H-2 in Appendix H.

d. The crop coefficient K_c appropriate for the vegetative cover (see section 10 above) can be used to calculate the monthly mean values of ET.

e. The monthly adjusted mean precipitation values can be taken from the selected station.

11. To establish a maximum daily design (deep) percolation rate, 4 to 10 percent of the minimum soil permeability shall be used. Percentages on the lower end of the scale are recommended for variable or poorly defined soil conditions. The percentage to use is a judgment decision to be made by the design team. However, groundwater and drainage conditions should also be suitable. Soils which are poorly drained, or sites with seasonal high groundwater less than 5 feet from the surface or restrictive subsurface soil layers are not suitable for reuse irrigation without drainage improvements. Furthermore, a safety factor not exceeding 4 percent shall be applied to the field measured values of both vertical and horizontal hydraulic conductivity. In general, soils with a USDA Natural Resources Conservation Service permeability classification of moderate to moderately rapid (0.6 to 6.0 inches/hour) are suitable for reuse irrigation. The maximum daily (deep) percolation rate (MDPR) is determined as follows:

MDPR = percolation, inches/h (24h/d)(4 to 10%).

The design monthly (deep) percolation rate (DMPR) is determined by:

DMPR = MDPR x No. of operating days/month.

a. If any portion of the irrigated or wetted area of the proposed use area is located over an aquifer designated for public drinking water supply, the maximum monthly average application rate shall be calculated with the percolation component equal to zero.

b. If the conditions in "a" are not applicable, the water balance may include a percolation component. If the percolation component is used, one of the following procedures can be selected:

(1) A minimum of three (3) saturated vertical hydraulic conductivity tests shall be performed on the most limiting horizon of each soil series present. Percolation tests performed for individual wastewater systems are not acceptable. Acceptable methods for saturated hydraulic conductivity testing are presented in Appendix F; or

(2) The most limiting soil horizon should be determined from the soil survey information. The most conservative value from

the range of permeability should be used.

c. Because a given site may include several different soil types with significant percolation variation, it is possible for there to be different application rates for different areas of the site. DOH recommends that when this is the case, the fields be laid out to separate the soils with different percolation. However, if this is not done and a field includes more than one soil type, the application rate will be limited to the most restrictive soil percolation.

d. If the design monthly (deep) percolation rate (DMPR) is greater than 20 percent of the maximum monthly application rate minus the DMPR, the project will be designated as a recharge project. See Appendix E and F for additional monitoring requirements.

12. Nitrate concentration in percolate from a lysimeter in reuse irrigation systems should not exceed 10 mg/l. Percolate nitrate concentration is a function of nitrogen loading. The average monthly application rate shall be checked against nitrogen loading limitations. If, for the selected vegetative cover, best management practice and the average monthly application rate results in estimated nitrate percolate concentrations exceeding 10 mg/l, either the above variables need to be adjusted and/or supplemental water supply added. It has been reported to DOH that many golf courses have percolate concentrations higher than 10 mg/l, not due to effluent but fertilizer for the turf. DOH may consider the limiting percolate concentration on a case-by-case basis when the baseline concentration is higher than 10 mg/l.

    Total phosphorus concentration in percolate from a lysimeter in reuse irrigation systems should not exceed 1.0 mg/l. Percolate phosphorus concentration is a function of phosphorus loading. The average monthly application rate shall be checked against phosphorus loading limitations. If, for the selected vegetative cover, best management practice and the average monthly application rate results in estimated total phosphorus percolate concentrations exceeding 1.0 mg/l, either the above variables need to be adjusted and/or supplemental water supply added.

    Estimates of the quantity of N leached in a given situation can be made by N utilized by the crop from the total N applied and then using a reasonable estimate of denitrification and volatilization losses. An example is shown in Appendix H.

    Alternatively, phosphorus can stay in the top 12 inches (30 cm) of soil (clay loam) for nearly a decade, though studies have shown appreciable leaching occurs below 12 inch (30 cm) in sandier soil. Several studies noted an increase in topsoil phosphorous levels after 30 years of recycled water application. Potassium levels may increase; however, the rate of uptake by plants usually exceeds the rate of application. The amount of potassium that is held by the soil is dependent on the soil type. Table 8-1 presents nutrient uptake rates taken from Table 4-11 of the U.S. EPA Process Design manual: Land Treatment of Municipal wastewater [182], and other sources. In all cases, the source of vegetative macro nutrient uptake rate used for design shall be referenced.

Rationale: The relatively high nutrient content of recycled wastewater makes irrigation of turf and crops an attractive alternative. Generally, irrigation with recycled water shows increased levels of nitrogen, phosphorus, and potassium in the soil. Nitrogen is removed from the soil primarily by plant uptake; secondary factors are removal by volatilization, denitrification, and immobilization in complex organic form, and leaching into the aquifer. Leaching of nitrates into groundwater has been found in some cases of high nitrate loading.

Where recycled water is applied by sprinkler, and to a lesser extent by surface irrigation, some loss of N as ammonia is probable, since wastewaters are typically alkaline in reaction. Henderson et al. [176] suggested that volatilization loses during sprinkler irrigation of water with a pH of 7.5-8.5 would amount to less than 20 percent of the total applied. The possibility of gaseous ammonia absorption on leaf surfaces or soil may further reduce this loss.

There is evidence that nitrate is accumulating in the groundwater at specific sites in the State of Hawaii (Kunia on Oahu and Moloaa on Kauai, DOH records). However, the contribution of surface-applied N to these accumulations is not well defined. Both nitrate concentration and water movement in the soils are subject to a wide range

Table 8-1
Nutrient Uptake Rates
Lbs/ac-yr

Selected Crops	Nitrogen	Phosphorus	Potassium
Alfalfa	200-480	20-25	155-200
Brome grass	115-200	35-50	220
Coastal Bermuda grass	355-600	30-40	200
Kentucky Bluegrass	175-240	40	175
Orchard grass	225-310	20-45	225-315

Selected Crops	Nitrogen	Phosphorus	Potassium
Quack grass	210-250	25-40	245
Reed Canary grass	300-400	35-40	280
Ryegrass	175-250	55-75	240-290
Sweet Clover	155	20	90
Tall Fescue	135-290	25	270

in spatial variability; consequently, calculations of mass flow of nitrate through the soil are subject to considerable uncertainty.

Soil profile characteristics were found to be paramount in influencing the amount of nitrate moving past the root zone. Lund et. al. [184] reported significant correlations between soil nitrate concentrations below the root zone and clay content of the upper soil profile. Soils that have high water infiltration rates tend to be relatively low in organic mater and do not readily develop the anoxic conditions that are conducive to denitrification. Such soils are usually sandy and may have no layers in the profile that restrict water movement. High leaching of nitrate is probable under these conditions, particularly where N applied exceeds crop uptake to any significant degree. On the other hand, clayey soils or soils with slow water movement are likely to develop the anaerobic conditions that favor N loss through denitrification. Consequently, nitrate usually is leached less from a fine-textured soil than from a coarse-textured one with equal N input. Furthermore, the fraction of applied N leached increases with increasing levels of N input.

13. For reuse project over potable aquifers, the issue of setting a limit on TDS and nutrients concentrations either in the recycled water, the percolate in the lysimeter and/or in the groundwater has become a formidable task. In order to assist DOH, a Groundwater Management Committee has been established for the following purpose:

    a. To determine target water quality criteria for the aquifer affected by a specific water reclamation project (e.g., TDS shall not exceed 250 mg/l in well No. 47).

       Rationale: Based on (a) the identification of beneficial uses and historical groundwater quality, (b) the definition of transport and accumulation of potential contaminants in the affected aquifer(s), and (c) the determination of contaminant level to manage and/or maintain water quality of this aquifer.

    b. To determine mass loading application rates for target water quality parameters pertaining to a specific water reclamation project (e.g., TDS loading shall not exceed an annual total of 5,400 lbs/acre nor shall any monthly total exceed 800 lb/acre).

Rationale: Based on modeling techniques, determine mass loading for appropriate contaminants from a specific water reclamation project that will conform with the contaminant level set in the above paragraph "a". It is recommended that the design team conduct and verify the model to demonstrate their case. The resulting mass loading rates will, in turn, be used by the design team to demonstrate, through a water-balance analysis to the DOH, whether this loading application rate can be achieved without a supplemental water supply or additional treatment.

c. To determine the groundwater monitoring strategy for a specific water reclamation project.

Rationale: To incorporate the monitoring strategy necessary to monitor and evaluate this reclamation project within the context of the basin-wide monitoring strategy.

14. Other constituent loading limitations. The heavy metals of particular concern are copper, zinc, cadmium, chromium, lead, arsenic, nickel, and mercury. If the value of these metals, determined pursuant to the "Groundwater Monitoring Plan," exceeds 0.5 of the MCL value, that parameter will be monitored by a lysimeter. If the metal percolate concentration exceeds 0.5 of the MCL value, it shall be reported to DOH immediately and a plan for corrective action shall be received by DOH within 30 days.

Rationale: Copper, zinc and nickel generally do not produce problems to humans through the food chain because their levels of phytotoxicity to vegetation is attained before reaching levels that would be toxic to most mammals. Arsenic and mercury are usually inhibited from accumulating to hazardous levels in edible plant parts either by root barriers, diminished translocation, or both. One major concern in the application of recycled water is the possibility of heavy metal accumulation in the soil, which may lead to uptake by plants, livestock, and ultimately humans. The application of small amounts of heavy metal has a potential beneficial effect by correcting plant deficiencies; however, at higher levels these same metals may become phytotoxic.

15. The report shall describe all supplemental water supplies including:

a. Source;

b. Chemical Water Quality; (See Appendix E, Section II, subsection B & C);

c. Cross-connection and backflow control measures; and

d. Quantity available.

16. The monitoring plan shall conform with DOH Guidelines for Groundwater Monitoring Plan (GMP), see Appendix E; and the Guidelines for Monitoring System Construction Report (MSCR), See Appendix F.

17. Project Evaluation. An evaluation of the overall long-term effects of the proposed project on environmental resources in the area shall be provided. The evaluation shall include aspects such as changes in water table elevations due to natural fluctuations and the application of recycled water, prediction of the rate and direction of movement of applied recycled water, change in the area associated with the project, and similar information.

B. ENGINEERING DESIGN REPORT FOR A WATER REUSE PROJECT

1. The objective of the <u>Irrigation Plan</u> is to delineate Best Management Practices methods and controls to be used in the irrigation system to mitigate runoff or ponding. The owner/developer and all subsequent owners shall establish an irrigation plan and system which shall be presented to the DOH for its approval. The irrigation plan and system shall minimally describe the following components:

   a. The exact boundaries of the proposed use area. Within the proposed use area, delineate the areas to be irrigated (acres), with appropriate buffer zones, structures and hard surfaces, e.g., roads, parking lots, and sidewalks. The structures shall be labeled, e.g., residential, public access, restrictive access. If the plan encompasses phased development, outline and delineate each phase.

   b. Amount and type (i.e., R-1, R-2, or R-3) of recycled water available for irrigation, maximum average gallons per day and minimum average gallons per day.

   c. The location of the transmission line from the treatment facility to the proposed use area or storage reservoir:

      (1) Condition of the line, i.e., new or existing;

      (2) Pipe size and type;

      (3) Size and location of pumps (if needed) to transport the

recycled water to the proposed use area or reservoir;

(4) Design flow and pressure range; and

(5) Sufficient detail to demonstrate conformance with Chapter V "Design Parameters for the Distribution of Recycled Water" in these guidelines.

d. Storage reservoir or impoundment (if needed):

(1) Basis of Design;

(2) Drainage (runoff) controls;

(3) Lining;

(4) Access controls (fencing and signs);

(5) Design of outlet control;

(6) Provisions for an alternate supply of water; and

(7) Sufficient detail to demonstrate conformance with Section K Storage Impoundments, in Chapter IV "Treatment Design Parameters" in these guidelines.

e. The distribution network typically consists of supply lines, which deliver water to the field. Mainlines transport water within the field. Sublines-risers are control stations for the individual blocks. Submain lines distribute water to the lateral lines and lateral lines distributes water to the crop area:

(1) Size of pipe main, for each component and peak design flow;

(2) Meter location(s) in schematic form or drawing and capacity:

(a) Type of meter; and

(b) Type of recorder;

(3) Location in schematic form or drawing, of pump(s) and valves;

(4) Location in schematic form or drawing, of pressure gauge(s) and other sensors;

(5) Size of pump(s);

(6) Location in schematic form or drawing, and design of filters

(if used); and

(7) Sufficient detail to demonstrate conformance with Chapter V "Design Parameters for the Distribution of Recycled Water" in these guidelines.

f. Method of irrigation:

(1) Sprinklers

(a) Type of sprinkler

(b) Sprinkler radius

(c) Height of sprinkler (inches)

(d) Operating pressure

(e) Uniformity coefficient of irrigation distribution as it relates to crops and other plants

(f) Application rate

(g) Application period

(h) System Flow Capacity (gpm)

(i) Sprinkler patterns

(j) Irrigated area (acres)

(k) Control details

(2) Micro-irrigation systems:

(a) Micro sprinklers

(1) Type

(2) Sprinkler radius

(3) Height of sprinkler (inches)

(4) Operating pressure

(5) Uniformity coefficient of irrigation distribution

(6) Application rate

(7) Application period

(8) System Flow Capacity (gpm)

(9) Wetted irrigated area (acres)

(10) Sprinkler patterns

(11) Control details

(b) Emitters. The design should be made to achieve a completely uniform emitter flow by using different emitter sizes (orifice diameter or micro-tube length) or by using pressure-compensating emitters. The design should include:

(1) Type (surface or subsurface);

(2) Irrigation pattern with lengths (feet) and widths (feet) between piping and slope of pipes;

(3) Tubing diameter and thickness;

(4) Operating pressure;

(5) Uniformity coefficient of irrigation distribution;

(6) Design Capacity. This is defined as a flow rate per unit area, usually expressed as gallons per minute per acre (gpm/acre). It is determined by the water requirement, irrigation time, and irrigation application efficiency. It can be expressed as

$$Q_c = 450 d / T E_a$$

in which Q_c is the design capacity, in gpm/acre; and T is the irrigation time in hours; d is the irrigation application, in inches; and E_a is the irrigation application efficiency. The irrigation application, d can be determined by

$$d = C_u I$$

in which C_u is the consumptive use, in inches per day, and I is the irrigation interval, in days. The design capacity also indicates the acreage that will be irrigated by the available water resource.

(7) Depth below finished grade;

(8) Application rate;

(9) Application period;

(10) Irrigated area (acres);

(11) Method of flushing lines; and

(12) Control details;

(3) Surface Irrigation:

(a) Furrow or border spacing;

(b) Length of runs;

(c) Outlet controls; and

(d) Tail water controls.

g. If there is evidence that runoff due to excess application is leaving the approved use area, the Department will suspend the application of recycled water at the approved use area until adequate measures shall be designed to mitigate runoff of recycled water onto areas not under the control of the owner. The design criteria for the control measures shall incorporate the first 2 inches of precipitation within a 24-hour event as the intensity parameter in the rational (CIA) drainage equation.

h. Exterior drinking fountains shall be shown and called out on plan. If no exterior drinking fountains, picnic tables, sitting benches, food establishments, or other public facilities are present in the proposed use area, then it should be specifically stated on the plans that none exist or will be constructed.

i. Best Management Practices shall be used to mitigate runoff from the approved use area resulting from application of recycled water. Appropriate runoff collection and application facilities shall be provided and maintained if necessary to mitigate the discharge of surface runoff.

2. The objective of the <u>Management Reuse Plan</u> is to establish and delineate the responsibilities of operation and maintenance of the reuse system.

If the use of recycled water becomes the choice for this project, then the owner/developer and all subsequent owners shall develop and adhere to a Management Reuse Plan which shall address at a minimum, the following items:

a. The procedures, restrictions, and other requirements that are to be followed by the distributor and/or user must be described. The requirements and restrictions shall be codified into a set of rules and regulations. The "Rules and Regulations" shall be developed in accordance with Water Reclamation Guidelines. The procedures and restrictions shall include measures to be used to protect the public health, prevent cross-connections and address the appropriate precautions presented in Section D of Chapter III. The plan shall present a schedule for the adoption of enforceable procedures and restrictions to cover all the distributions systems and proposed use areas, and it shall identify the organization or organizations that would adopt them.

    (1) The plan shall also provide operation criteria for irrigation which encompasses the following:

        (a) The rationale for how to schedule irrigation;

        (b) How to tell when to stop irrigation;

        (c) How many fields can or should be irrigated at the same time;

        (d) Which fields should be irrigated first, second, etc.;

        (e) Sequence to follow in starting the irrigation system;

        (f) Sequence to follow in stopping the irrigation system; and

        (g) How to control flow and pressure.

    (2) Contingency Plan. The report shall identify the actions and precautions to be taken to protect public health in the event of a non-approved use. Notification protocol of the appropriate regulatory agencies and the exposed public as required shall be included in the plan. The plan must identify these non-approved uses and appropriate action to be taken, e.g., overspray, runoff of recycled water off the property, ponding of recycled water on the property (due to pipe breakage).

    (3) The purveyor of recycled water is responsible for quality of the recycled water. The purveyor is usually the owner of the

treatment facility. In order to assure quality control over the production of recycled water the treatment facility shall have a pretreatment policy. This policy will set limits on what can be discharged into the wastewater collection system based on the design parameters of the treatment facility. Certain commercial or industrial processes may require pre-treatment prior to discharging into the sewer collection system in order to meet this sewer protection policy.

(4) Unless otherwise specified, the user is responsible for maintaining all on-site facilities downstream of the user's service meter. Unless otherwise specified, all on-site facilities are under the ownership of parties other than the reclamation agency.

(5) The user of recycled water shall provide a complete copy of the Management Reuse Plan to the following as applicable: lessees of areas, landscape subcontractors, property manager, and community associations where recycled water is to be used.

(6) Inspection, supervision and employee training shall be provided by the user to assure proper operation of the recycled water system. The user shall maintain records of inspection and training.

(7) The report shall outline staffing and their assignments and responsibilities and provide maintenance procedures and frequency.

(8) The user shall maintain as-built plans of the approved use area showing all buildings, reclamation facilities, wastewater collection systems, and potable water systems and recycled water systems. Plans shall be updated as modifications are made.

b. A recycled water User Supervisor shall be appointed by the user. The user shall include in this submittal the following information regarding the individual designated as the User Supervisor: name, address, and telephone number at which this individual or designated representative can receive messages during "off hours.” The user is to notify the reclamation agency of a change in designation of the User Supervisor.

The User Supervisor should be aware of the entire system within his or her responsibility and of all applicable conditions of recycled water use. The User Supervisor shall be responsible for installation, operation, and maintenance of the recycled system, prevention of potential hazards, implementing these guidelines, and coordination with the cross-connection control program of the water purveyor or DOH.

3. The objective of a Public Education plan is to inform persons likely to come in contact with reclamation water where recycled water is in use. This plan shall encompass the following topics:

   a. All areas where recycled water is used shall be posted with conspicuous public information signs indicating pictorially, and with wording of sufficient size to be clearly read by the public. The following language should be used:

      (1) When recycled water other than R-1 Water is to be used, signs shall be posted similar to Figure 5-1:

      "R-2 --RECYCLED WATER USED IN SUBSURFACE IRRIGATION--DO NOT DRINK--WASH THOROUGHLY WITH SOAP AND DRINKING WATER IF CONTACT OCCURS"; or

      "R-2 --RECYCLED WATER USED IN SPRAY IRRIGATION--DO NOT DRINK--WASH THOROUGHLY WITH SOAP AND DRINKING WATER IF CONTACT OCCURS"; or

      "R-2--RECYCLED WATER USED FOR DUST CONTROL--DO NOT DRINK--WASH THOROUGHLY WITH SOAP AND DRINKING WATER IF CONTACT OCCURS"; and

      (2) When R-1 Water is used, signs shall be posted similar to figure 5-2:

      "R-1-RECYCLED WATER USED IN SPRAY IRRIGATION--DO NOT DRINK"; or

      "R-1-RECYCLED WATER USED IN DECORATIVE FOUNTAIN--DO NOT DRINK"; or

      "R-1-RECYCLED WATER USED IN LANDSCAPE IMPOUNDMENT--DO NOT DRINK".

   The Department may accept alternative signage and wording, or an educational program, provided the applicant demonstrates to the Department that an alternative approach will assure an equivalent degree of notification.

   b. Where recycled water is put in a restricted recreational impoundment or landscape impoundment, the impoundment shall have perimeter signs indicating pictorially and with words, that the wastewater stored is not safe for drinking or body contact i.e., (ATTENTION: RECYCLED WATER --NO SWIMMING OR OTHER ACTIVITY INVOLVING IMMERSION OF THE FACE -- NO WADING --DO NOT DRINK).

c. When recycled water other than R-1 Water is to be used for irrigation, the owner or lessee wishing to manage their irrigation system relating to health hazards associated with illicit use of

R-2--RECYCLED WATER USED IN SUBSURFACE

IRRIGATION-DO NOT DRINK-WASH
THOROUGHLY WITH SOAP & DRINKING WATER
IF CONTACT OCCURS

Figure 5-1

“CONSERVING OUR WATER
RESOURCES”

R-1--RECYCLED WATER USED IN SPRAY IRRIGATION--DO NOT DRINK

Figure 5-2

or exposure to recycled water by another party may install fencing or other barriers to restrict public access.

d. Tank trucks and other equipment used to distribute recycled water shall be clearly identified with public information signs.

e. Instructional guided tours of the recycled project for the public are recommended.

f. The plan shall indicate the location of any signs, barrier or fencing on the project with details (dimensions) of the signs.

g. Notification of the use of recycled water to the public media prior to opening is recommended.

4. An Employee Training Plan shall be prepared which encompasses the following topics:

a. The following provisions shall be made for workers who handle R-1 and R-2 Water or may be exposed to it.

(1) Workers shall be notified that recycled water is in use. Notification shall include the posting of conspicuous informational signs with wording of sufficient size to be clearly read at the work place, with language presented in paragraph (1) of the Public Education Plan. Where a worker's primary language is not English, this message will be provided to the worker in a form he can understand.

(2) Workers shall be informed orally and in writing that recycled water is not suitable for ingesting and that drinking recycled water may result in potential illness.

(3) Potable water shall be supplied for workers for drinking and washing hands and face. Where bottled water is provided, the water shall be in separate, boldly labeled, contamination-proof containers protected from recycled water and dust.

b. Provisions cited in items "(1)" through "(5)" below shall be made for workers who handle recycled water other than R-1 and R-2 Water, or who may be exposed to it.

(1) Recycled water shall be managed, and spray and mist of recycled water shall be controlled, to minimize contact with workers.

(2) Potable water shall be supplied for workers for drinking and washing hands and face. Where bottled water is provided, the water shall be in separate, boldly labeled, contamination-

proof containers protected from recycled water and dust.

(3) Precautions shall be taken to avoid contamination of food taken by workers into recycled water use areas. Food shall not be taken into areas still wet with recycled water.

(4) Workers shall be notified orally and in writing that recycled water is in use and that it is not suitable for ingestion. Notification shall include the posting of conspicuous informational signs with wording of sufficient size to be clearly read, with language presented in paragraph (1) of the Public Education Plan. Where a worker's primary language is not English, this message will be provided to the worker in a form he can understand.

(5) Workers shall be informed orally and in writing that the recycled water used is not reliably free of organisms that can cause serious illness, and shall be informed of precautions and proper hygienic procedures to protect themselves. The employer or supervisor of a worker(s) shall inform the worker(s) to comply with the following:

(a) Workers shall wash hands with soap and water before eating, drinking, and smoking, and at the end of the work period, and shall not stand where visible mist can reach them;

(b) Gloves impermeable to water shall be worn if contact between hands and recycled water would otherwise occur;

(c) Employees shall keep fingers and hands away from the nose, mouth, and eyes, if fingers and hands have contacted recycled water;

(d) Workers with cuts or breaks in the skin shall cover the area with waterproof bandages or other waterproof cover before working with recycled water;

(e) Employees should be informed that inanimate objects such as clothes or tools can transport pathogenic organisms; and

(f) Employees should be required to always wear shoes or boots to protect their feet from pathogenic organisms in the soil or irrigation water.

c. Employee Training. The plan shall describe the training that the employees will receive to ensure compliance with the Water Reclamation Guidelines. The plan shall identify the entity that will provide the training and the frequency of the training.

5. Vector Control Plan. The following criteria are based on knowledge of mosquito ecology. It is important that the Vector Control Branch of DOH be notified and consulted about impending reuse projects. Coordination and cooperation is vital to avoid creation of unnecessary conditions conductive to mosquito production. Certain projects may require a contractual arrangement between the owner and the local mosquito control contractors. This contract should provide for ongoing surveillance and for control measures should these become necessary. The plan shall describe how each of the following will be implemented (if appropriate):

   a. Water Reclamation Impoundments

      (1) Impoundments may be any shape but should not have small coves or irregularities around their perimeters.

      (2) Impoundments should be designed to be emptied by gravity or pumping for clearing or drying and have graded bottoms so all water can be removed.

      (3) For impoundments with controlled access, side slopes of excavations and levees should be as steep as possible, consistent with soil characteristics and risk factors.

      (4) Where steep side slopes are not feasible and for impoundments with public access, the slopes should be lined with impervious material or periodically harvested or treated to achieve weed control.

      (5) Minimum top width of embankment should be 12 ft. and adequately constructed to support maintenance vehicular traffic.

      (6) An access ramp should be provided on an inside slope for launching a small boat for midge sampling and control.

      (7) Impoundments designed for long term storage should have a minimum storage depth of 4 ft. to inhibit aquatic vegetation.

      (8) A maintenance program for weed and erosion control along inner slopes is essential.

      (9) Accumulation of dead algae, vegetation and debris should be routinely removed from the impounded water surface and disposed of properly.

   b. Water Conveyance Facilities

(1) If ditches are used to convey recycled water, they must be maintained free of emergent, marginal and floating vegetation. New seasonal growth of vegetation in ditches must be controlled prior to irrigation of crops with recycled water.

(2) Ditches should be sized and graded for adequate flow and must not be used for water storage.

(3) Unpressured and low pressure pipelines should be designed to be emptied when not in use and should not be used for water storage because of the mosquito breeding potential in the partially filled pipes.

c. Wetlands

(1) Wetlands that are operated as shallow water areas (less than 1 foot) should be properly graded in order to facilitate drainage and ditched to provide access for mosquito fish. Deep-water impoundments should be provided for the low ends of the marsh. These impoundments serve as a holding facility for mosquito fish during times when shallow water areas are dewatered.

(2) In shallow water areas the type and density of vegetation are critical in determining the effectiveness of mosquito fish. To maintain fish predation, the vegetative growth may have to be periodically removed or harvested. Another alternative for controlling vegetation is to vary the depth of water to discourage certain plant species.

(3) Excess water at the low ends of sites used for wetland flooding or crop irrigation must be recycled, utilizing a return system. If discharge of recycled water is necessary, it must be in compliance with a NPDES permit requirements.

(4) Water control devices such as pumps, weirs, and floodgates should be of proper capacity to draw down the temporary impoundments within a time designated by the Vector Control Branch, DOH. Where possible a 48-hour draw down period is recommended to interrupt the mosquito life cycle.

Rationale. Hawaii Title 11-62 and the current emphasis on these water reclamation guidelines have serious prospects for mosquito production. Proposals for water reclamation and surface runoff or preventing waters from flowing directly into watercourses can create new mosquito sources. Kinds of proposals under consideration for the water reclamation projects are:

a. Impoundments for recycled water;

d. Development of wetlands.

The developing aquatic life stages of the mosquito occur in water-holding depressions, containers or other sites. A "mosquito source" is defined as a site suitable for mosquito development if left unmanaged.

The objective of mosquito control is to suppress the mosquito population below the threshold level required for disease transmission or nuisance tolerance level. Mosquito control is accomplish by one or a combination of three controls:

a. Manipulation of physical features;

b. Biological control; and

c. Use of chemicals.

Manipulation of physical features to prevent a mosquito source from developing is the most desirable long-term solution. This can be accomplished through project design and management.

The best known and most common biological control agents are the mosquito fish Gambusia affinis and the guppy, Poecilia reteculita. These species are widely distributed throughout the state and, in certain situations, where the dissolved oxygen level of the wastewater is sufficiently high, is helpful in keeping populations of mosquito larvae down to acceptable levels. The effectiveness of this species is influenced by such factors as density of aquatic vegetation, rate of larval production, number of fish per unit of water volume, and the availability of other organisms preferred by the fish.

Chemicals are useful for intermittent or emergency control, but are not recommended for repeated long-term use because of cost, environmental concerns and the mosquitoes' capability to develop physiological resistance to the chemicals.

6. Monitoring System Construction Report (MSCR) shall conform with the guidelines in Appendix F.

C. CONSTRUCTION PLANS FOR A WATER REUSE PROJECT

The format and general content of construction plans for water reuse projects shall conform to applicable requirements of Section 12 "Construction Plans" of Chapter 10, Design Standards of the Division of Wastewater Management, Vol. 1, [24], except for section 12.2. This section shall be substituted by Section 9-Construction Plans, Water System Standards, [26]. Additional required details include:

1. A bench mark with description and latest elevations;

2. Basis of bearings with description;

3. A description of, and a legend identifying all components of the irrigation system; and

4. Specifications and notes regarding color coding of pipes and appurtenances and tape conforming with provisions in Chapter V "Design Parameters for the Distribution of Recycled Water" in the guidelines.

IX APPROVAL PROCESS FOR WATER REUSE PROJECTS

A. APPROVAL TO CONSTRUCT

When the following submittals conform both with the provisions in these guidelines and Title 11 Chapter 62, DOH will issue a letter to the owner(s) with a copy to the engineer(s) who prepared the reports and plans, stating that approval is given to commence construction:

1. Basis of Design Report for the Water Reuse Project;

2. Engineering Design Report for the Water Reuse Project; and

3. Construction Plans for the Water Reuse Project.

B. CONSTRUCTION INSPECTION FOR A WATER REUSE PROJECT

1. Inspections for the transmission system shall be performed by the

party/agency delineated in Section A.6 Basis of Design Report for A Treatment Facility. An inspection report shall be submitted to DOH by the responsible party/agency, when the project is completed to the satisfaction of the responsible party/agency. Provisions for scheduling inspections shall be made with the party/agency.

2. Inspections of the reuse systems shall be performed by the design engineer. An inspection report shall be submitted to DOH by the design engineer, when the project is completed to the engineer's satisfaction.

   a. Provisions for scheduling inspections shall be made with the design engineer.

   b. The inspection will focus on measurements and location of equipment and components.

3. An operation inspection shall be conducted by DOH when the reclamation facility is fully operable. The inspection will focus on normal, emergency and contingency operation and procedures.

C. APPROVAL TO OPERATE A WATER REUSE PROJECT

1. Upon satisfactorily completing the above, DOH will mail a letter to the owner(s) with a copy to the engineer(s) who prepared plans, stating that the constructed water reuse project conforms both with the provisions in these guidelines and Title 11 Chapter 62, and therefore approval to operate this reclamation facility may commence.

2. All existing water reuse projects shall comply with the provisions in Chapter VIII, B. "Engineering Report for a Water Reuse Project," and Chapter X "Compliance Reports and Submittals".

D. PERFORMANCE INSPECTIONS

DOH will periodically conduct operation and maintenance inspections on the storage impoundments (and/or reservoirs), distribution system and the approved reuse area. The inspection will also include a review of the users records cited in Chapter X "Compliance Reports and Submittals".

E. APPROVAL TO DEACTIVATE A WATER REUSE PROJECT

1. If supply for this project is to be converted from recycled water to a potable water supply, the distribution system shall conform with the disinfection requirements for the distribution system of the potable water supply. A letter of intent shall be submitted to DOH prior to disinfection process delineating the following:

   (a) Contact person (name, telephone number, address) from the potable water supply agency who will write a letter to DOH certifying that this distribution system has met their requirements for a potable water use;

   (b) A description of the conversion process; and

   (c) A schedule of process including the anticipated date of certification letter and the date of the conversion.

2. If supply for this project is to be converted from recycled water to a non-potable water supply, a report shall be submitted to DOH describing all non potable water supplies. The water quality of the non-potable source shall conform with the definition and use prescribed for recycled water. For example if the bacterial water quality values of the non-potable water supply exceed those of the existing recycled water, the conversion will be denied. The description shall include:

   a. Source;

   b. Chemical Water Quality (see Appendix E, Section II, subsection B & C);

   c. Cross-connection and backflow control measures; and

   d. Quantity available.

F. OPERATIONAL PRECAUTIONS

Some restrictions are placed on the operation of recycled water system as a matter of good practice and to protect public health. The following restrictions apply to the use of recycled water:

1. Conditions which directly or indirectly cause a runoff outside the approved use area shall be mitigated using Best Management Practices.

2. Conditions which directly or indirectly cause ponding for a period of no more than 2 hours following the cessation of an approved reclamation water use activity either outside of or within the approved use area shall be mitigated using Best Management Practices.

3. Conditions which directly or indirectly permit direct spray or overspray to pass outside of the approved use area shall be mitigated using Best Management Practices.

4. Recycled water use shall be limited to uses explicitly approved by DOH in the currently effective user permit.

5. Reuse/disposal of recycled water for any purpose, including approved uses in areas other than those explicitly approved in the currently effective user permit issued by the operating agency and without prior written approval by DOH is not allowed.

6. Cross-connections resulting from the use of recycled water service, whether by design, construction practice, or system operations, shall be prohibited.

7. Standard hose bibs on recycled water systems are prohibited.

8. Any equipment or facilities such as tanks, temporary piping or valves, and portable pumps which have been used with recycled water shall be cleaned and disinfected before removal from the approved use areas for use at another job site. This disinfection and cleaning shall ensure the protection of the public health in the event of any subsequent use as approved by the User Supervisor. The disinfection process should be performed in his or her presence.

X COMPLIANCE REPORT AND SUBMITTALS

A. SAMPLING AND ANALYSIS

1. Compliance monitoring for disinfection systems will include both grab samples, and a variety of continuous on-line measurements. Samples for coliform bacteria, where required, shall be collected daily and at a time when wastewater characteristics are most demanding on the treatment facilities and disinfection procedures (i.e., during peak flow period).

   a. For disinfection using chlorine, the following continuous on-line measurement shall be recorded just prior to taking a grab sample for coliform bacteria:

      (1) Turbidity value prior to the disinfection process;

      (2) Chlorine analyzer value at the point of the grab sample; and

      (3) Flow rate.

   b. For disinfection using UV, see Appendix K, Section 6. Monitoring and Alarm Design.

   c. Where R-1 Water is produced, coliform bacteria samples shall be taken daily and analyzed by an approved laboratory method.

   d. Where R-2 Water is used for spray irrigation, the treatment facility shall take daily samples and analyze coliform bacteria by an approved laboratory method. The sampling frequency may be reduced to weekly (but not fewer than 5 samples per month) subject to the Director's approval.

   e. Where R-1 or R-2 Water is used for subsurface irrigation, weekly samples (but not fewer than 5 samples per month) shall be taken and analyzed by an approved laboratory method for fecal coliform.

   f. Suspended solids grab sample shall be taken weekly (but not fewer than 5 samples per month). The sample shall be taken prior to the disinfection process in order to correlate with the turbidity value. This sample shall also be taken at the same time of the coliform bacteria sample.

   Rationale. The required sampling program for compliance is consistent with the existing sampling program set forth in the reclamation water definition. The results of the suspended solids testing should ultimately be correlated to corresponding turbidity readings.

2. Turbidity analysis, where required, shall be performed by a continuous recording turbidimeter. The sampling for suspended solids shall be taken at a location so that the results can be analyzed with the results of the turbidity readings. If the turbidity limit either before or after the filter is exceeded, the max value and time for the period of duration shall be recorded.

3. The following flow measurement shall be on record:

   a. R-1 Recycled Water discharged to an approved use: daily total;

   b. R-2 Recycled Water discharged to an approved use: daily total;

   c. R-3 Recycled Water discharged to an approved use: daily total;

   d. Amount of effluent diverted to an approved effluent disposal: daily total; and

   e. Amount of effluent diverted to emergency storage: daily total.

4. Samples for BOD_5 should be taken at least weekly (but not fewer than 5 samples per month). Composite sampling is recommended.

5. Both type and amount of chemical coagulants and polymer shall be recorded monthly.

6. Both the type and amount of chorine disinfectant shall be recorded monthly.

7. Samples for F-Specific bacteriophage MS2, enteric viruses and other microorganisms, where required by the regulatory agency to indicate treatment efficacy during a pilot plant study or demonstration phase of operation, shall be collected at the frequency specified by the DOH and at a time when wastewater characteristics are most demanding on the treatment facilities and disinfection procedures. Samples of F-Specific bacteriophage MS2 shall be analyzed in accordance with a protocol approved by the DOH.

8. The sampling procedure for fecal coliform shall conform with the approved

laboratory methods and may encompass either the membrane filter (MF) or equivalent most probable number (MPN) methods. Results using MF shall be reported as confirmed colony forming units (CFU). Results using MPN shall be reported as confirmed MPN.

9. The producer may designate any location in the water reclamation treatment process from which all samples will be taken. Once the locations have been established, the descriptions of these locations shall be placed in the record.

10. All alarms shall be recorded with appropriate information, e.g., time, type, action taken, problem definition, corrective action.

B. CALIBRATION

Appropriate measurement devices and methods consistent with acceptable scientific practices shall be selected and used to insure the accuracy and reliability of measurements. The devices shall be installed, calibrated and maintained to insure that the accuracy of the measurements is consistent with the acceptable range of limits for that device. Devices selected shall be capable of measuring or analyzing with a maximum deviation of less than plus or minus 10 percent from the true value throughout the range of expected values.

The owner shall periodically calibrate and perform maintenance on all monitoring and analytical equipment used for the production or distribution of recycled water. This calibration and maintenance shall be performed at intervals which will ensure the accuracy of the measurements, but no less than the manufacturer's recommended intervals.

C. RECORD KEEPING - TREATMENT FACILITY

1. A time period denoted as daily, (e.g., 6:00 am to 5:59 am) shall be defined in the daily monitoring records. This period shall be consistently used for all parameters and for all days. The following is a summary of items that shall be recorded daily:

    a. The highest measurement of turbidity from the secondary clarifiers (only applicable to direct and contact filtration);

b. The lowest measurement for the operational UV dose;

c. The highest measurement of turbidity from filtered effluent (only applicable to R-1 Water);

d. The type and weight (in pounds) of coagulants and/or polymers used;

e. The high, low, and average flow measurements of recycled water produced;

f. The weight (in pounds) of chlorine used if applicable;

g. The lowest measurement of residual disinfection concentration in mg/l in the recycled water after the appropriated contact or modal time, if applicable; and

h. Confirmed fecal coliform.

2. The date and duration of each occurrence after the appropriate contact or modal time, when the disinfectant residual is less than the standard.
3. Inspection, supervision and employee training shall be provided by the user to assure proper operation of the recycled water system. Records of inspection and training shall be maintained by the user.

4. Operating records shall be maintained at the reclamation facility or a central depository within the operating agency. These shall include: all records of continuous monitoring requirements and all analyses specified in the reclamation criteria.

5. Records of items in Section A, B and C shall be maintained at the reclamation facility or a central depository within the operating agency. These records shall document all operational problems, equipment breakdowns and diversions to emergency storage or disposal and all corrective or preventive action taken.

6. Process or equipment failures triggering an alarm shall be recorded and maintained as a separate record file. The recorded information shall include the time and cause of failure and corrective action taken.

7. A quarterly summary of operating records, as specified above, shall be prepared and filed within 30 days.

8. The above required records shall be stored for at least 5 years.

D. RECORD KEEPING – WATER REUSE PROJECT

1. The following operations form is recommended for recording irrigation events.

2. DOH intends to prepare an annual summary report pertaining to reuse activities which will be available in May of each year. The users will be asked to submit a summary report for each approved use area before March 1 of each year. The following is an example of the reporting form for irrigation:

FLOWS (mg)	Reclamation	Supplemental	Total
Annual	____	____	_____
Max Month ( )	____	____	_____
Min Month ( )	____	____	_____

IRRIGATED AREAS	1	2	3	4	Total
Application Area (acres)	__	__	__	__	____
Type of vegetative cover	__	__	__	__	____
Type of application	__	__	__	__	____
Supplemental TN (lbs/yr)	__	__	__	__	____
Supplemental TP (lbs/yr)	__	__	__	__	____
Number of days irrigated	__	__	__	__	____
No. consecutive days no irrigation	__	__	__	__	____
Method of cropping	__	__	__	__	____

STORAGE VOLUME		Free Board Depth	Date
Minimum	____ mg	____ ft.	__/__/__
Maximum	____ mg	____ ft.	__/__/__

WATER BUDGET	Reported
Annual Precipitation (in)	____
Maximum Month (in) ..( ).......................	____
Minimum Month (in) ..( ).......................	____
Annual Evapotranspiration (in)	____
Maximum Month (in) ..( ).......................	____
Minimum Month (in) ..( ).......................	____
No. of consecutive days w precipitation >0.1 in	____
Dates --/--/-- to --/--/--	____

3. Guide: Annual will be defined as the calendar year e.g., from January 1, through December 31. The calculation of the annual flow volume applied would be the difference between the flow meter reading for recycled water on January 1st and December 31st.

The Maximum Month ( ) will be defined as the month when the maximum amount of recycled water is applied. The month can be identified by placing its number within parentheses. For example if August is the maximum month, the number eight is placed in the parentheses (8). Again the calculation of the monthly flow would be the difference between the flow meter reading for recycled water at the beginning of the month and the end of the month. The month with the greatest volume will be selected and the volume reported.

The Minimum Month ( ) will be defined as the month when the minimum amount of recycled water is applied. The month can be identified by placing its number within parentheses. The calculations are similar for the maximum month but the month with the least volume will be selected and the volume reported.

If a supplemental water supply is used for irrigation, the calculation is similar but using the flow meter readings from the supplemental water supply meter.

The total is the sum of the recycled and the supplemental water.

"Application Area" in acres is the total irrigated area or application area. The entire metered flow shall correspond with the total application area(s). If within an approved use area, there are metered irrigation blocks, the identification of the irrigation block shall conform with the approved plan. Record keeping for each individually metered irrigation area is recommended but not required if the vegetation cover is the same for all areas. In this case the summation of all the individually metered irrigated areas will suffice. Although a golf course may have different varieties of turf, it will be considered the same vegetation cover. If the vegetation cover is different, such as agricultural crops, records for each individually metered irrigation area shall be kept. The "Type of Application" may be subsurface drip (UD)) surface drip (D), spray irrigation (SP), furrow or floor (F) irrigation.

The amount applied should be recorded in pounds per year of supplemental (fertilizer) total nitrogen (TN) and total phosphorous (TN). The number of consecutive days is the period when no irrigation water, either recycled or supplemental was applied to any portion of the approved area. This may be used to size the appropriate storage requirement in the future. If there is water reclamation storage within the approved use area, report the maximum volume and the minimum volume, the free board (distance from the surface water to the top of the reservoir) in feet, during maximum and minimum volume and the dates. The "Method of cropping" refers to whether it is harvested and removed from the area (H) or whether it is harvested and not removed from the area or whether it is not harvested (N). These conditions will effect the nutrient balance.

"Annual Precipitation" is the total precipitation in inches for that year. Report the maximum and minimum monthly precipitation in inches. The month can be identified by placing its number within parentheses. For example if August is the maximum month, the number eight is placed in the parentheses (8). For those that have or require sensors to calculate "ET," the Hardgrave's equation [149,150] may be used which requires only temperature and solar energy and the crop coefficient (found in the design report). The units for "ET" are inches. The number of consecutive days with precipitation greater than 0.1 inch should be recorded. Again this may be used to size the appropriate storage requirement in the future.

4. This is a guide to completing the daily record-keeping form. If any portion of the approved reuse area is over an aquifer that is deemed appropriate for a potable water supply, a line should be drawn through (non-potable) at the top of the page (for example, OVER A ~~(NON-POTABLE)~~(POTABLE) AQUIFER). If within an approved use area, there are metered irrigation blocks, the identification of the irrigation block shall conform with the approved plan. Record keeping for each individually metered irrigation area is recommended but not required if the vegetation cover is the same for all areas. In this case the summation of all the individually metered irrigated areas will suffice. Although a golf course may have different varieties of turf, it will be considered the same vegetation cover. If the vegetation cover is different, such as agricultural crops, records for each individually metered irrigation area shall be kept.

   The date may be defined by the irrigation supervisor, but then consistently used for this form. For example, the irrigation day will be begin at 19:00 hours the day before to 18:59 of the date indicated. It is recommended that an entry be logged for each day. If there is no irrigation, it should be noted under "comments". For spray irrigation of R-2 waters, time at starting and stopping irrigation should be recorded, for example, 19:15 to 4:15 (9 hrs). For R-1 and R-3 waters, the daily total duration time will be sufficient.

   The metered flow data for recycled water will be recorded under "FLOW R". If supplemental water is also used the metered flow will be recorded under "FLOW S". The "Area" in acres is the total irrigated area or application area. The entire metered flow shall correspond with the total application area(s). "CYCLE" per day represents the number of application cycles.

   The "VOL" in g/ac-d is the total volume of water applied in one day. The units are in gallons per acre. By dividing the total flow (summing supplemental and recycled flows) by the "Area" irrigated. For those that have or require sensors to calculate "ET", the Hardgrave's equation may be used which requires only temperature and solar energy and the crop coefficient (found in the design report). The units for "ET" are inches.

"PRECIP" is the total precipitation in inches for that day.

"Ponding" is defined in the guidelines as the retention of piped (applied) water on the surface of ground or man-made surface for a period of 2 hour following the cessation of an approved recycled water use activity such that potential risk to the public health may result. Areas that are likely to pond shall be monitored and mitigative steps shall be taken to prevent ponding. These may include modification of the irrigation cycle, replacement of a segment of drip tubing with fewer emitters, etc. All incidents of ponding shall be noted under comments.

"Runoff" is defined in the guidelines as the flow of water along the surface of the ground or other natural or manmade surfaces, including but not limited to pedestrian walkways, streets, playground surfaces, and grassy slopes. Areas that are likely to produce runoff shall be monitored and mitigative steps shall be taken to prevent runoff. These may include modification of the irrigation cycle, construction of a berm, replacement of a segment of drip tubing with fewer emitters etc. All incidents of runoff other than those occurring in areas where BMP's are practiced should be noted under comments.

Under "CROP COND", the stress conditions of crop should be noted. Under "COMMENTS" the amount and type of fertilizer added it the "Area" shall be recorded. Each day there is no irrigation shall be noted. This may be used to size the appropriate storage requirement in the future. If there is water reclamation storage within the approved use area, the free board (distance from the surface water to the top of the reservoir) in feet should be noted.

5. Water volume and water quality data from the lysimeters and Water Quality data from monitoring wells shall be submitted to DOH pursuant to the schedule within the approve monitoring plan and shall be maintained at a central depository within the operating agency.

REUSE PROJECT ____ OVER A (NON-POTABLE) (POTABLE) AQUIFER

RECYCLED WATER SOURCE _______________________________ RECORDING PERIOD

SUPPLEMENTAL WATER SOURCE ___________________________ APPLICATION AREA

MEASUREMENTS									VISUAL OBSERVATIONS			
DATE	TIME IRRIGATED	FLOW S mg	FLOW R mg	AREA acre	CYCLE day	VOL g/ac-d	ET in	PRECIP in	PONDING	RUNOFF	CROP COND	COMMENTS

E. REPORTING PROTOCOL

1. Any spill or unauthorized discharge of untreated, partially treated or treated wastewater effluent and the cessation of same shall be reported pursuant to the "Protocol for Wastewater Spills" in Appendix I; and

2. Any discharge, runoff or overspray that extends beyond the boundaries of the approved use area and does not conform to BMPs, shall be reported pursuant to the "Protocol for Wastewater Spills" in Appendix I.

APPENDIX A

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APPENDIX E

GUIDELINES FOR GROUNDWATER MONITORING PLAN

(March 2002)

(Note: Groundwater Monitoring is not required for water reuse projects over underlying aquifers that are not designated as public drinking water aquifers.)

TABLE OF CONTENTS

I. INTRODUCTION

The purpose of this document is to establish consistency in groundwater monitoring efforts. These guidelines are to be used as <u>an example</u> for developing a Groundwater Monitoring Plan (GMP). A draft GMP shall be submitted to the DOH for review and comment.

The objective of a GMP is to formulate a strategy for the observation and surveillance of groundwater for possible sources of pollution. A monitoring plan is intended to facilitate the determination of stable ambient groundwater quality and to evaluate whether or not groundwater is being contaminated. It can also serve to provide data necessary to optimize irrigation systems and to evaluate remediation projects, landfill, injection well and UST operations, plus various other activities.

Where applicable, a groundwater monitoring system shall be designed and constructed in general accordance with the standards set forth in the American Society for Testing and Materials (ASTM) for Ground Water and Vadose Zone Investigations (D 18.21).

II. SYSTEM SIZE

A. General

The groundwater monitoring system may consist of a number of lysimeters and/or monitoring wells, depending on site size, site characteristics, location, method of discharge, and other appropriate considerations.

1. Number of Monitoring Wells

As a general guide, for project sites encompassing 500 acres or more, the minimum number of monitoring wells should be as follows:

(a) one well upgradient or otherwise outside the zone of influence of the discharge site;

(b) two wells downgradient of the discharge site or for land treatment operations, two wells downgradient of each drainage basin intersected by the site;

(c) one well within the wetted field area for each project whose surface area is greater than or equal to 1500 acres, or one well within the wetted field area for each drainage basin exceeding 1500 acres.

The monitoring wells should be constructed in compliance with the Commission on Water Resource Management's (CWRM) Hawaii Well Construction and Pump Installation Standards (HWCPIS). A permit should be obtained from the CWRM. If additional clarification on HWCPIS is needed, call CWRM at 587-3868 (Honolulu).

2. Number of Lysimeters

When lysimeters are utilized for projects that operate an irrigation system, as a general rule of thumb, the number of lysimeters that should be considered are as follows:

(a) one lysimeter per 200 acres;

(b) one lysimeter for project sites that have greater than 40 but less than 200 acres;

(c) additional lysimeters to (a) or (b) when necessary to address concerns of public health or environmental protection as related to variable characteristics of the subsurface or of the operations of the project.

III. DESIGN AND CONSTRUCTION OF A MONITORING SYSTEM

A. Design

Considerations of a monitoring well design shall encompass site geology/hydrogeology, geochemical environment, types of contaminants to be monitored for, anticipated well depths, type of well completion, drilling method selection, types of materials used in well construction and any down hole equipment to be used.

The potential paths of pollutant movement from the site should be estimated and monitoring wells should be placed to effectively and expeditiously detect contamination.

As part of the GMP, the findings of a hydrogeologic/soil site investigation shall be submitted to the DOH using the format presented in the Guidelines for Monitoring System Construction Report (MSCR). Within the draft MSCR, a clear relationship between the site characteristics and the proposed monitoring plan must be demonstrated.

The monitoring plan shall address the proposed monitoring system in detail, including the lysimeter/monitoring well design, method of construction, and selection of materials to be used. Lysimeter design should provide for quantitative mass balance determination. Detailed schematics of each lysimeter/monitoring well or well that will serve as the monitoring well shall be included.

The GMP shall present how the site characterization and selection of the preliminary monitoring components, locations, depths, materials (compositions and screen size) etc. have been integrated into the monitoring system.

The plan shall also provide a discourse on the environmental impacts of the project in association with the overall site evaluation. The environmental impacts shall minimally include the suitability of the site for the proposed activity, including an assessment of the potential for groundwater and surface water pollution, subsurface conditions adversely affecting vertical and lateral drainage, and soils or geologic structures not suitable for irrigation. Any potential adverse affects or limitations shall be examined and minimized.

Unless a cluster of monitoring wells of varying depths are planned, the screened interval portion of a monitoring well must be designed and placed in such a manner as to provide a representative discrete interval sample of the groundwater. The screened portion must be long enough to extend above the maximum level of groundwater fluctuation and below the groundwater table between five (5) to ten (10) feet.

Lysimeters shall be placed such that their tops are situated below the soil's root zone. The tops shall not exceed a depth greater that five (5) feet below the root zone unless lysimeters of deeper depths are made to compliment lysimeters of shallower depths by providing information over the entire soil/rock column.

Monitoring wells shall be provided surface protective measures. These measures shall include protection from the entry of surface water, physical damage and vandalism. To provide an adequate degree of security, wells should include locking casing caps and protective well covers for any stickup portion. Security may also dictate installation of bumper guards around casing stickups.

Finished monitoring wells shall be clearly and permanently marked. As part of the MSCR, color photographs of the final well configuration showing adequate security shall be provided to the DOH for each monitoring well.

B. Materials

Materials to be used in the construction of a monitoring well shall be based on determinations from site characterizations and historical groundwater quality. The materials used shall have minimal chemical interference on groundwater analyses.

Materials used for filter packs should be inert, such as silica sand or consist of material from the surrounding formation.

If neat cement is used in the construction of a monitoring well for filling annular spaces, it shall not be placed directly on top of a filter pack.

Bentonite shall not be mixed-in with neat cement (grout) for the purposes of filling annular spaces.

No solvent primer or cement shall be used for assembling thermoplastic monitoring well materials.

C. Construction

The construction of lysimeters/monitoring wells shall be performed in a manner that will prevent any chemical interference to the groundwater resulting from drilling operations, installation operations, and monitoring well development.

Monitoring well casing and screen manufacturing residues must be removed by cleaning, prior to installation in the bore hole.

Disturbance to the natural geologic environment should be kept to a minimum. Therefore, borehole diameters or excavations should be kept to a minimum size while in observance of the construction of an appropriate monitoring system.

D. OTHER

1. Siting

In pursuit of appropriate locations for the installation of monitoring system components, the proposed locations of the monitoring components should be considered as only preliminary. It is important to realize that it may be necessary to change the locations of some lysimeters or monitoring wells, depending upon the subsurface conditions encountered at the specific locale, or because of unanticipated land uses. As such, it is imperative that the surface and subsurface conditions at each monitoring component locale be adequately defined before the component is permanently installed.

The appropriateness of siting a monitoring system component at a specific locale shall be justified through a discussion in the GMP draft. Information obtained from field boring logs and other site evaluations should be used in determining the appropriate locations of monitoring components. Generally, lysimeters and monitoring wells, particularly the screened interval of the casing, should not be installed in relatively impermeable formations such as high plasticity clay pockets or massive unfractured rock formations. If undesirable subsurface conditions are encountered at any particular monitoring component location, the component should be relocated, taking into account the siting considerations referenced above, with the approval of the DOH.

The determination on the adequacy of subsurface conditions require that a geologist or a qualified geotechnician inspect the subsurface material and conditions to insure satisfactory performance of the lysimeters/monitoring wells <u>before</u> they are installed. The geologist or qualified geotechnician must log all borings or excavations as they are produced.

2. Use of Other Wells

The use of existing potable, irrigation, production or other water wells in lieu of monitoring wells for the purpose of ambient groundwater quality monitoring may be utilized when the DOH deems it appropriate. Generally, monitoring wells should be specifically designed, constructed, and dedicated for the sole purpose of groundwater evaluations. However, if it can be competently demonstrated that a particular existing well could yield a representative sample of the specific groundwater interval of interest, the DOH will consider the substitution of the subject well for monitoring purposes.

E. Monitoring System Construction Report

A Monitoring System Construction Report (MSCR) shall be submitted to the DOH after the monitoring system is constructed to document the specifics of the groundwater monitoring system. The MSCR shall follow the format set forth in the DOH's document "Guidelines for Monitoring System Construction Report."

A <u>draft</u> MSCR should be submitted after the preliminary site characterization has been determined and prior to beginning the construction of the monitoring system.

IV. BASELINE GROUNDWATER DETERMINATIONS

A. Sampling Standards

Sampling and analyses to determine the quality of the existing (intrinsic) groundwater shall be conducted. The execution of this determination shall include adherence to EPA or EPA equivalent standards for sample collection, sample preservation, sample handling, holding times, chain-of-custody, analytical procedures, and field and laboratory quality assurance/quality control (QA/QC). The results of the sample analyses must be contained in a sampling report. Proper well purging must be conducted prior to sampling and shall also be documented in the sampling report. The sampling report should clearly demonstrate how the above-mentioned EPA or EPA equivalent standards were met.

B. Baseline Sampling Parameters

1. Basic Parameters

The groundwater baseline characterization for the subject area shall be performed by analyzing the following basic parameters using either the specified methods or EPA approved equivalent methods.

	Parameter	**Method**
a.	specific conductivity	120
b.	field pH	150
c.	field temperature	170
d.	total dissolved solids	160
e.	total suspended solids	160
f.	chlorides	325
g.	nitrate-nitrite	353
h.	total Kjeldahl nitrogen	351
i.	total phosphorus	365

2. Ancillary Parameters

In addition to the basic parameters specified for use in determining the baseline character of the groundwater, the following is a list of contaminants from which the DOH may select to request quantified determinations for a particular project based on location relative to the Underground Injection Control (UIC) line, land use, management practices, method of discharge, or other appropriate considerations.

	Parameter	Method
a.	arsenic	200
b.	selenium	200
c.	mercury	245
d.	cadmium	200
e.	lead	200
f.	chromium	200
g.	barium	200
h.	copper	220
i.	antimony	200
j.	beryllium	200
k.	thallium	200
l.	total or fecal coliform	MPN/CFU
m.	fecal streptococcus	MPN
n.	turbidity	180
o.	biochemical oxygen demand (5 days)	405
p.	chemical oxygen demand	410
q.	alkalinity (as CaCO3)	310
r.	total organic carbon	
s.	volatile organic chemicals	624
t.	total organic halogens	
u.	total trihalomethanes	

3. Additional Parameters

Other relevant sampling requirements, not listed above, may be deemed necessary by the DOH based on the overall project review and evaluation.

C. Number of Baseline Samples

The groundwater baseline determinations shall consist of a minimum of two sampling events, separated by a minimum of a two-week time interval. The baseline determination will be considered established once generally stable values (+/- 10%) are obtained or a water quality trend has been established.

D. Baseline Reporting

The results from all of the required analyses shall be contained in the sampling report and shall be submitted to the Department along with the MSCR report. as referenced in Part III. E. above.

V. MONITORING FREQUENCY

A. General

Generally, the frequency and type of monitoring to be performed will vary according to the project location, method of discharge, depth to groundwater or other relevant considerations.

B. Reduction of Monitoring

It is anticipated that once DOH concurs that a clear quantifiable record has been established that indicates the subject activity has not caused significant health/environmental consequences, then the list and frequency of <u>basic parameters</u> for analysis may be reduced as approved by DOH.

C. Increase in Monitoring

If the monitoring of a given project indicates an increase of a substantial health/environmental threat, DOH may increase the frequency and scope of monitoring.

D. Lysimeters with Consumptive Irrigation

For irrigation up to consumptive rates within an area that could furnish recharge to an underground source of drinking water, the lysimeters shall be monitored for effluent capture after each specified irrigation event, within 12-24 hours of the event.

If effluent is found in any of the lysimeters that would indicate that consumptive irrigation was being exceeded, then a decrease in volume/area irrigation shall be immediately implemented. Records of lysimeter effluent quantity and the resultant decrease in irrigation quantity must be kept and provided to the DOH as part of any reporting requirements. Furthermore, if sufficient quantity is available, the effluent in the lysimeters must be collected and analyzed for the <u>basic parameters</u> of chlorides, total dissolved solids, nitrate-nitrite, total Kjeldahl nitrogen, and total phosphorus.

For consumptive irrigation within an area that does not furnish recharge to an underground source of drinking water, the guidelines for monitoring shall conform to the guidelines for non-consumptive irrigation.

E. Lysimeters without Consumptive Irrigation

For noncompliance irrigation within an area that does not furnish recharge to an underground source of drinking water, or within a specifically designated area that could furnish recharge to an underground source of drinking water, the lysimeters shall be sampled on a monthly basis for six months and then quarterly thereafter and analyzed for the basic parameters, if sufficient effluent quantity is available. The sampling shall be performed between 12-24 hours after the irrigation event.

F. Monitoring Wells For an Underground Source of Drinking Water

For project sites in part or wholly within an area that could furnish recharge to an underground source of drinking water, associated monitoring wells shall generally be sampled and analyzed for the basic parameters on a quarterly basis.

G. Increased Monitoring of Wells

If analytical results from a monitoring well indicate an increase from baseline determinations in two or more parameters, or in a parameter that DOH deems significant, then immediate resampling shall be performed. If the resample produces similar results, sampling of the monitoring well shall be conducted on a monthly basis or other appropriate schedule until an evaluation and determination is made by DOH.

VI. OTHER REQUIREMENTS

A. Other State or Local Agencies

The groundwater monitoring plan shall also adhere to any other state or local agency requirements for both monitoring and reporting. The adherence to these monitoring and reporting requirements shall be considered a keystone requirement of this monitoring guide.

B. Reevaluation/Modification of Monitoring/Reporting

This monitoring guide herein acknowledges that public health, environmental and operational conditions that affect the monitoring and reporting requirements could warrant a reevaluation of the requirements in order to address changing concerns and to establish relevant analyses. Modifications to the monitoring and reporting requirements resulting from reevaluations shall be approved by the DOH prior to implementation.

C. Reporting of Monitoring Data

Reporting of routine monitoring data shall be performed on a semi-annual basis. However, the DOH shall be notified when lysimeter/monitoring well analytical results indicate an increase in values for two or more parameters.

D. Reevaluation of Sample Frequency

More frequent sample collections and analyses may be warranted by the results of past analyses and by rationalization to achieve the objectives of representative and comprehensive groundwater and vadose zone water monitoring.

APPENDIX F

GUIDELINES FOR MONITORING SYSTEM CONSTRUCTION REPORT (MSCR)

(MARCH 2002)

The purpose of this document is to establish a specific format for a monitoring system construction report to document the construction of a particular monitoring system and/or the configuration of a system or part thereof that is already in place that will serve as same. Therefore, these guidelines should be used in preparation of a MSCR in conjunction with the DOH's Guidelines for Groundwater Monitoring Plan (GMP). The MSCR can also serve as an independent document.

In its entirety, the MSCR addresses a variety of information that DOH feels may be needed for its objectives in groundwater monitoring. The document is quite extensive and detailed because there is no one generic GMP and hence MSCR that is applicable to all projects. Therefore, only the portions that are applicable to a given project should be completed.

A draft MSCR shall be submitted to the DOH for review. The final report may include:

1. Facility/project name;

2. Facility/project location, including street address and zip code (or if no assigned address, island district, town, nearest road(s), and a determination of the nearest roadway intersections in miles and direction from the site);

3. Latitude/longitude coordinates of the project site (geometric center if project boundaries are irregular);

4. Ownership of facility/property, including name, address, phone number and <u>local</u> contact person;

5. Name and address of lessor (local contact if out-of-state) and written consent of property owner for the construction of a monitoring system;

6. Name and address of local legal facility/project contact;

7. Name, address, and phone number of monitoring system's design consultant;

8. Name, address, and phone number of the operator or proposed operator of the monitoring system;

9. Number and type of monitoring wells, lysimeters, and/or other components, including construction materials and procedures used for installation;

10. Nature and source of recycled wastewater or other irrigation water, or activity to be monitored (i.e. landfill, underground storage tank, etc.);

11. Proposed method and volume of water to be discharged;

12. Tax map key (TMK) number and map, showing location of project site, lysimeters/monitoring wells and/or other applicable monitoring system components;

13. Site size in acres;

14. USGS topographic quadrangle map (scale 1:24,000) delineating the site location and location of all monitoring system components and direction(s) of groundwater flow;

15. Physical characteristics of the area including;

    a. location;

    b. climate, including rainfall and pan evaporation data;

    c. site soil and geologic characteristics; and

    d. depth to groundwater;

16. Description of the monitoring system. It should include wells, lysimeters, or other components;

17. Logs maintained by a geologist for soil borings, excavations, monitoring wells, or other wells (if available), including a soil and geographic profile;

18. A discussion involving the appropriateness of siting a lysimeter/monitoring well or other monitoring system component at a specific locale, how it relates to the field boring logs, and the placement selection of the screened interval. Alternatively, a discussion involving the appropriateness of using some other well as a system component in lieu of a lysimeter/monitoring well;

19. A description of the procedure used for cleaning the monitoring well casing and screen or lysimeters, prior to installation. System shall also be appropriately cleaned, installed, and purged prior to use; and

20. Color photographs and date of the photo on the picture of the final well configuration for each monitoring well.

The MSCR shall be submitted to the DOH's EMD (Environmental Management Division).

APPENDIX G

AD HOC REUSE USERS COMMITTEE MEMBERS

(November 1993)

General Manager
Waikoloa Resort Utilities
HC02 Box 5050
Waikoloa, HI 96743

Grove Farm Properties, Inc.
P.O. Box 2069
Puhi Rural Branch
Lihue, HI 96766-7069

General Manager
Waialua Sugar Company, Inc.
P.O. Box 665
Waialua, HI 96791-0665

Charles R. Wilson, Colonel
Director of Public Works
Dept of the Army
Fort Shafter, Hawaii 96858-5000
(Contact: Cliff Takenaka)

Win Bui, Chairman,
Plantation Working Committee
Hawaiian Sugar Planters' Assoc.
99-193 Aiea Heights Dr.
Aiea, HI 96701-1057

General Manager
Silversword Golf Course
1345 Piilani Hwy
Kihei, HI 96753

APPENDIX H

SAMPLE CALCULATIONS

(November 1993)

The following example represents a hypothetical reclamation facility in Hawaii. The objective is to illustrate the basic computations required and the relationship between variables.

1. The treatment facility may be either a public or private facility that will treat the wastewater used in the project. Where more than one agency or party is involved in the treatment, the responsibilities of each party shall be described in a contract or memorandum of agreement.

   Happitime Resort Treatment facility is located at 2749 Fun Road, TMK: (1)-9-1-34. The design average flow for the production of R-1 Water is one (1) million gallon per day (mgd) with a peak flow of 4 mgd. These values were taken from the "Basis of Design report for the treatment facility.

2. State the treatment processes and quality of water that are required and will be provided for each use. Provide the annual mean values of the recycled water for the water quality parameters listed in Appendix E, Section II, subsection B & C. For those parameters that are not sampled regularly, provide dated-paired grab or composite samples.

   a. The proposed treatment facility consists of equalization basins, primary clarifiers, aeration basins, secondary clarifiers, flocculation basins, filtration basins and disinfection basins. The treatment facility will produce R-1 Water.

   b. The recycled water baseline characterization for the subject facility shall be performed by analyzing for the following basic parameters including any other parameters specific to a commercial or industrial discharge concern using either the specified methods or EPA approved equivalent methods.

	PARAMETER	INFLUENT	EFFLUENT
(1)	chlorides (250 mg/l)	94 mg/l	99 mg/l
(2)	field pH	7.7	8.1
(3)	field temperature	22.5 C	22.5 C
(4)	turbidity	-	2 NTU
(5)	dissolved oxygen (field)	0.1 mg/l	1.9 mg/l
(6)	total dissolved solids	281 mg/l	289 mg/l
(7)	total suspended solids	226 mg/l	26 mg/l
(8)	ammonia (N)	14.2 mg/l	6.4 mg/l
(9)	nitrate (10 mg/l)	8.7 mg/l	7.3 mg/l
(10)	nitrite (1 mg/l)	2.9 mg/l	1.3 mg/l
(11)	total Kjeldahl nitrogen	28.3 mg/l	11.4 mg/l
(12)	total phosphorus	18.1 mg/l	10.0 mg/l
(13)	orthophosphate	4.3 mg/l	4.1 mg/l
(14)	sulfide	5.2 mg/l	4.9 mg/l
(15)	sulfate	102 mg/l	92 mg/l
(16)	potassium	19 mg/l	18 mg/l
(17)	total coliform	9.34×10^7	17 MPN
(18)	fecal coliform	1.83×10^7	2 CFU
(19)	total organic carbon	215 mg/l	19 mg/l
(20)	BOD (5 days)	217 mg/l	20 mg/l
(21)	chemical oxygen demand	194 mg/l	18 mg/l
(22)	chlorine	ND	5.5 mg/l
(23)	alkalinity (as CaCO3)	50 mg/l	46 mg/l
(24)	iron (.3 mg/l)	0.02 mg/l	0.02 mg/l
(25)	aluminum (.2 mg/l)	0.12 mg/l	0.12 mg/l
(26)	arsenic (50 µg/l)	<10 µg/l	<10 µg/l
(27)	selenium (50 µg/l)	<0.5 µg/l	<0.5 µg/l
(28)	mercury (2 µg/l)	<0.1 µg/l	<0.1 µg/l
(29)	cadmium (5 µg/l)	<0.5 µg/l	<0.5 µg/l
(30)	lead (15 µg/l)	<0.5 µg/l	<0.5 µg/l
(31)	chromium (100 µg/l)	<10 µg/l	<10 µg/l
(32)	barium (2 mg/l)	<0.1 mg/l	<0.1 mg/l
(33)	silver (0.1 mg/l)	0.01 mg/l	0.01 mg/l
(34)	sodium	65 mg/l	66 mg/l
(35)	copper (1.3 mg/l)	0.01 mg/l	0.01 mg/l
(36)	nickel (0.1 mg/l)	0.01 mg/l	0.01 mg/l
(37)	antimony (6 µg/l)	<1 µg/l	<1 µg/l
(38)	beryllium (4 µg/l)	<1 µg/l	<1 µg/l
(39)	thallium (2 µg/l)	<0.5 µg/l	<0.5 µg/l
(40)	fluoride (4 mg/l)	0.04 mg/l	0.04 mg/l
(41)	cyanide (200 µg/l)	<200 µg/l	<200 µg/l
(42)	boron	0.13 mg/l	0.13 mg/l
(43)	fecal streptococcus	278	<1
(44)	volatile organic chem.	<0.5 µg/l	<0.5 µg/l

(45)	total organic halogens	<0.5 µg/l	<0.5 µg/l
(46)	total trihalomethanes	<0.5 µg/l	<0.5 µg/l

3. Industrial and Commercial Raw Wastewater. State the wastewater chemical quality, the proportion and type of industrial waste. Metal and priority pollutant analysis is required if the reclamation facility receives industrial or commercial process wastes.

   None. A copy of the sewer policy or ordinance encompasses industrial and commercial pretreatment components (see institutional plan).

4. Transmission and Distribution Systems. Maps showing the general location of the existing and proposed transmission facilities and the distribution system layout shall be provided. The plans shall include the location of all existing and proposed water and sewer lines. The report shall describe how the transmission and distribution systems will comply with the following:

   a. Both the transmission and the distribution lines will be new. Exhibit 1 (not presented in this sample) shows, in plan view, the location of the proposed transmission line and other existing buried utilities. Exhibit 2 (not presented in this sample) shows the layout of the proposed distribution, beginning from the meter at the property line. The material, location and precaution of use will conform with the provisions in Chapter V, Design Parameters of the Distribution of Recycled Water, in the reuse guidelines.

   b. A supplemental water supply is needed. Exhibit 3 (not presented in this sample) shows the location of supply line, the air gap and the high water elevation in the proposed storage reservoir. The air gap backflow prevention device will conform to both provisions in Cross-Connection and Backflow Control, Chapter 21 of Title 11 Administrative Rules; and with provisions in Backflow Prevention Devices, Water System Standards, Vol I 1985, Department of Water, County of Kauai; Board of Water Supply, City and County of Honolulu; Department of Water Supply, County of Maui; and the Department of Water Supply, County of Hawaii

5. Project use area. The exact boundaries (azimuth-distance) of the proposed use area and the tax map key. Provide

dimensions of the wetted area, and buffer zones. Provide labels for roads and structures shown on a base map. The structures and fenced areas shall be labeled, e.g., residential, public access, restrictive access.

See Exhibit 4 (not presented in this sample).

Although no buffer area is required, a 5 ft. and 100 ft. buffer will be used in some areas. The excluded 15 acres area encompasses structures, roads and landscape reservoirs. Only the 130 acres area irrigated by either spray (115 acres) and the subsurface drip (15 acres) will be used in the Table H-4.

Table H-1

SUMMARY OF IRRIGATED AREAS

AREA	SPRAY AREA	MINIMUM BUFFER	BUFFER AREA	AREA EXCLUDED	TOTAL AREA
A	15.3	100	4.4	8.8	108.80
B	21.6	5	1.4	2.4	7.40
C	17.8	0	0.0	0.0	0.00
D	20.5	0	0.0	0.0	0.00
E	17.6	100	3.9	8.9	108.90
F	22.2	100	5.3	9.9	109.90
TOTAL	115.00		15.00	30.00	160.00

6. Land use. These base maps shall show present land uses and anticipated land uses within one mile of the site boundaries. The land use information shall be based on the approved county comprehensive land use plan. If expansion of the proposed facility is anticipated, the area likely to be used in the expansion shall be shown on the base maps. See Exhibit 5 (not presented in this sample).

7. Use Area Drainage. Provide an area topographical map and a project topographical map with contours no greater than 5 feet. Describe the existing drainage and the proposed drainage improvements. Specifically discuss how the project will be designed to minimize the chance of recycled water

leaving the designated use area. Maximum grades for spray irrigation are limited to 7 percent for row crops, 15 percent for forage or turf and 30 percent in forest. Sloping sites promote lateral subsurface drainage and make ponding and extended saturation of the soil less likely than on level sites.

See Exhibit 6 (not presented in this sample). This a copy of the grading plan required by the City and County of Honolulu.

8. Soil series and soil survey information was taken from the Monitoring System Construction Report and reprinted here for background.

From General Soil Map [231, p. 6].
Lualualei-Fill land -Ewa association: Deep, nearly level to moderately sloping, well-drained soils that have a fine textured or moderately fine textured subsoils or underlying material, and areas of fill land; on coastal plains. Depth to seasonal high ground water 21 feet; i.e., FG 24 MSL, GW 3 MSL.

Lualualei soils have a surface layer of very dark grayish-brown, very sticky and very plastic clay that cracks widely upon drying. These soils are underlain by coral, gravel, sand, or clay at a depth below 40 inches. Fill land consists of various kinds of fill material. Ewa soils have a surface layer and subsoil of dark reddish-brown, friable silty clay loam. The substratum is gravelly alluvium or coral limestone.

Sheet number 44, HxA, HxB, WkA, HxA, Hxb [231].

The soil features affecting irrigation for the Honouliuli Soil series, (HxA, HxB) presented on page 173, indicate moderately slow permeability. On page 158, unified classification CL, permeability 0.2-63 inches per hour (in/hr), available water capacity 0.14-0.16 in/in of soil [231].

The soil features affecting irrigation for the Waialua Soil series (WkA) presented on page 199, indicates moderate permeability, slopes as much as 30 percent and stoniness in places. On page 167, unified classification MH-CH, permeability 0.63-2.0 inches per hour (in/hr), available water capacity 0.13-0.15 in/in of soil [231].

The irrigation project site is moderately well drained with seasonal high groundwater more than 20 feet below the surface.

See Exhibit 7 (not presented in this sample).

9. Vegetation Cover.

   a. Discuss how the selective vegetation cover will be established, monitored and maintained;

      Coastal Bermuda grass will be established by seed using spray irrigation with recycled water. The monitoring and controls are presented in the erosion control plan required by the City and County of Honolulu which is attached. A grounds staff of 7 will maintain the vegetation.

   b. Discuss vegetation cultivation procedures, harvesting schedules and uses;

      The coastal Bermuda grass will be cut by power mowers and clippings will be collected and composted on site.

   c. Discuss buffer zone vegetation cover and its maintenance.

      In areas where residential structures or structures with public access are susceptible to wind drift, a 60 to 100 foot buffer zone will be established using drip irrigation. The buffer zone will be planted with scrubs and trees to act as a physical barrier. In other areas a 5-foot buffer zone will be established and irrigated by drip irrigation.

   d. Provide the consumptive rate of the vegetation selected. The following are consumptive rate of vegetation derived from studies conducted in Hawaii:

      Ekern 1966, found that the evapotranspiration crop coefficient K_c for mature Bermuda grass ranged from 1.04 to 0.85 on the soil moisture stress increased. For the project, the value of 1.0 will be used.

10. Design Application rate will used to calculate both the volume of the storage reservoir and/or an alternative disposal capacity. The design application rate is a function

of:

Evaporation rate
Precipitation rate
Permeability rate
Macro Nutrient loading (N,P,K)
TDS
Other constituent loading limitations
Peak design flow from reclamation facility

Developing the design application rate is an iterative process. An initial value is selected from the water balance calculation. This rate is then compared to the macro nutrient loading, TDS loading and other constituent loading limitations (see the following subsections). If the initial value exceeds these limitations, the design application rate will be reduced and the process will be repeated.

The design application rate will be the smallest value of the maximum monthly application rate. Maximum monthly application rates for each month shall be determined from the following water balance equation:

MMAR = ET - P + Perc + Runoff

Where

MMAR = Maximum monthly application rate for each month (mm/month)

ET = Monthly mean evapotranspiration rates (mm/month)

P = Design precipitation rate (mm/month)

Perc = Design monthly percolation rate (DMPR) (in/month)

Runoff = 0, no runoff permitted

11. Methodology for Calculating Evaporation

a. The selection of station no. 727.00 was selected because:

(1) Both ET and P data are available at this station;

(2) This is the closest station and it is within a mile

of the site;

TABLE H-2
Pan Evaporation Station 727.00

Yr	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
62										7.79	7.56	4.38
63	4.36	5.83	7.36	8.9	9.45	10.04	10.72	9.81	9.31	8.59	6.89	5.37
64	6.61	7.71	6.72	8.27	10.44	9.71	10.2	11.02	10.04	9.8	7.02	6.01
65	5.72	7.13	7.72	7.45	7.13	10.02	9.86	10.33	8.36	8.6	6.8	6.6
66	6.89	4.79	7.78	8.0	8.06	10.49	10.97	10.31	9.35	8.16	6.18	5.81
67	5.58	5.76	6.51	7.15	7.81	8.11	9.9	8.65	8.9	7.61	7.12	6.45
68	5.58	5.53	6.94	7.36	8.68	10.04	10.23	9.99	9.3	7.53	6.39	5.8
69	7.12	6.38		9.5	8.96	8.3	10.58	11.02	8.38	7.12	6.24	6.25
70	5.93	6.51	8.7	9.64	9.35	9.32	10.77	11.48	9.18	8.53	7.23	7.72
71	5.67	6.22	7.54	7.09	9.15	8.98	9.91	9.75	8.59	7.51	6.66	5.95
72	5.44	6.32	5.87	8.23	8.76	7.85	9.24	8.83	8.13	7.23	6.77	5.62
73	5.74	6.39	8.70	8.63	9.53	8.41	9.56	9.6	7.63	7.91	6.03	5.94
74	5.55	6.17			7.7	7.9	8.36	7.9	6.09	7.21	5.61	6.69
75	6.61	5.9	7.42	7.84	8.27	9.91	10.97	10.65	8.66	8.18	6.62	5.13
76	5.81	6.61	7.51	8.15	8.4	8.46	9.36	9.05	7.36	7.33	5.78	5.66
77	5.23	6.10	9.18	8.06	9.53	8.55	9.82	9.15	8.63	8.14	6.5	5.87
78	5.76	5.89	7.31	7.99	8.04	8.51	9.87	7.09	8.7	7.3	5.34	6.69
79	5.96	4.53	7.11	7.7				10.61	9.22	8.34	7.65	6.24
80	5.68	5.34	8.79	8.16	8.7	8.33	9.11	8.26	7.10	6.81	5.6	
81	5.16	5.59	6.85	6.24	8.43	11.43	10.39	10.20	9.09	8.31	6.96	
82		5.4	6.54	6.57	7.72	6.36	8	8	7.47	7.22	10.05	5.86
83	6.05	6.10										

(3) Length of record for both ET and P exceeds 20 years; and

(4) The station and this site share similar climatic conditions.

b. After selecting the station no. 727.00, Table H-2 presents the monthly adjusted pan evaporation E_{pan} values for the period of record, taken from Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, Pan Evaporation, State of Hawaii, Report R74, June 1985, pages 99 and 100.

c. There were several months in which the pan evaporation data was not recorded. Thus, an effort is made to estimate the missing records. In a procedure used by the U.S. Environmental Data Service, but modified for pan evaporation data, at least three stations are selected with a normal annual pan evaporation within 10 percent.
A simple arithmetic average of the index stations will provide an estimate value for the missing station. If the normal annual pan evaporation at any of the index stations differ from that at the station in question by more than 10 percent, the normal-ratio method is used (For additional information on this method refer to page 69, Hydrology For Engineers, Linsley, Kohler, & Paulus, McGraw-Hill, 3 Ed, 1982).

d. Table H-3 presents the annual pan evaporation data for the entire record of four stations. The means of annual pan evaporation values were calculated and all are within 10 percent of the station 727.00. Therefore, the missing monthly pan evaporation values will be estimated by calculating the average value from at least three stations. Table H-4 contains the appropriate data to calculate the missing monthly pan evaporation values for station 727.00

e. The following procedures are developed for estimating expected losses of water through transpiration (T) by plants and evaporation (E) from plants, soil and surface water [224]. The combined loss for a cropped surface is commonly referred to as evapotranspiration (ET). With due caution, the use of evaporation pans to estimate crop water use for periods of a week or longer is warranted and widely practiced. Doorenbos and Pruitt

[145] have suggested that potential evaporation, also known as
reference crop evapotranspiration (ET_0) in their terminology, can be related to pan evaporation (E_{pan}) by the pan coefficient (K_p) as

$$(ET_0) = (K_p) * (E_{pan})$$

The ratio between crop evapotranspiration and the reference crop evapotranspiration is known as the crop coefficient K_c. Doorenbos and Pruitt [145] have summarized crop coefficients for many crops.

The approach by Doorenbos and Pruitt [145] consists of two steps:

(1) An estimation of potential evapotranspiration, or reference crop evapotranspiration from pan evaporation under various climatic conditions; and
(2) An estimation of crop evapotranspiration for any species and stage of development by the crop coefficient.

$$(ET) = (K_c) * (ET_o)$$

TABLE H-3
Annual Pan Evaporation (inches)

Station	702.20	310.10	314.00	415.00	727.00
	92.00	90.53	90.76	99.08	96.63
	86.47	91.16	91.47	94.49	103.55
	80.07	97.14	81.29	96.37	95.72
	80.92	121.98	77.34	80.72	96.79
	81.64	92.03	75.79	91.66	89.55
	88.98	103.97	90.19	77.63	93.37
	91.43	88.09	94.20	94.04	104.36
	80.65	85.48	93.18	91.43	93.02
	99.98	93.62	94.67	90.18	88.29
	110.84	104.30	100.22	113.23	94.07
	120.62	92.82	89.59	92.26	96.16
	113.22	96.18	85.58	108.46	89.48
	157.67	94.81	80.29	93.71	94.76
	119.41	97.71	80.89	107.84	88.49
	105.29	115.91	95.50	91.96	
	71.05	101.86	77.87	82.70	
		103.50		97.46	
		91.88			
		92.30			
		95.57			
		80.62			
MEAN	98.77	96.74	87.43	94.31	94.59

Table H-4
Estimating Missing Monthly Pan Evaporation
For Station 727.00

Station	MEAN	1/82	12/81	12/80	5/79	6/79	7/79	3/74	4/74	3/69
727.00	94.59									
702.20	98.77	4.34	5.66	5.00	13.46	16.71	21.60	6.28	7.31	6.34
310.10	96.74	5.58	5.19	4.55	8.52	9.41	9.97	6.75	7.89	7.31
314.10	87.43	4.85	5.94	5.00	8.58	7.99	8.34	6.92	8.33	
415.00	94.31	2.38	5.36	3.97	6.86	10.07	9.33	7.44	9.51	5.91
Estimate		4.29	5.54	4.63	9.36	11.05	12.31	6.85	8.26	6.52

The value of 1.0 will be used for both the pan coefficient K_p and the crop coefficient K_c using coastal Bermuda grass for this project.

f. Table H-5 shows both the estimated and actual record of monthly pan evaporation data in inches for station 727.00

12. Methodology for Calculating Precipitation

The monthly precipitation data for station 727.00 is not published but is available upon request from the Department of Land and Natural Resources, Division of Water Resource Management (587-0264). The period of record for this station ranged from 1911 to 1983. Table H-6 presents the monthly precipitation in inches.

13. Methodology for Calculating Evapotranspiration minus Precipitation

Losses through the process of evaporation and gains from precipitation are two of the important parameters needed in design and evaluation of irrigation and storage projects. An analysis of storage volume needs for recycled water projects requires consideration not only of ET alone, but the monthly excess of ET over precipitation (P). The use of only normal or average values is not adequate due to the natural variation
of both; hence, long-term records of ET and P are 0 required.

These two parameters are not independent. The cloudiness needed to produce precipitation reduces ET to lower than normal levels, while ET is greatest during clear weather. Thus, a frequency distribution of (ET-P) cannot be developed by separate assessments of records of ET and of P, but rather (ET-P) data for a number of years should be used or generated. Normally in the calculation of a water balance, month-by-month mean precipitation values are subtracted from the ET values (ET-P) for the entire length of the record and the 90 percent probability of exceedance level would be determined by the formula 100 m/(n+1); where m is the ranking and n is the number of years.

a. Table H-7 presents the monthly evapotranspiration minus the precipitation (ET-P). The negative values present the situation where the monthly mean precipitation is greater than the monthly mean evapotranspiration. The conservative interpretation of these negative values in the water budget means 100 percent storage or back up for the design of a reservoir or disposal method.

b. In Table H-8, a two-month rainy period using December and the following January (ET-P) values were first ranked to determine the 90 percent probability of exceedance. Thus, the 1962-1963 period presents the 90 percentile. This is followed by another analysis with a four-month period, November and December followed by January and February of the next year. The 1965-1966 period presents the 90 percentile. Finally, the annual monthly (ET-P) were ranked and 1978 values present the 90 percentile. The values presented in Table H-7 show that there may be one or two months in a row where precipitation is greater than ET during the "rainy season" months. The salient point is not what month(s) has a critical water balance but that any one or two months from November to April may pose a critical condition where storage capacity will be required. The values from the first analysis will be used in the Table H-9. For simplicity only the values of 1963 will be used.

14. Methodology for Calculating Permeability

a. The maximum monthly average application rate shall be calculated with the infiltration component equal to zero, if any portion of the wetted area of the proposed use area is located over an aquifer that is designate as a public drinking water supply. wa

Table H-5
Monthly Pan Evaporation (inches) Station 727.00

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
62										7.79	7.56	4.38	
63	4.36	5.83	7.36	8.90	9.45	10.04	10.72	9.81	9.31	8.59	6.89	5.37	96.63
64	6.61	7.71	6.72	8.27	10.44	9.71	10.20	11.02	10.04	9.80	7.02	6.01	103.55
65	5.72	7.13	7.72	7.45	7.13	10.02	9.86	10.33	8.36	8.60	6.80	6.60	95.72
66	6.89	4.79	7.78	8.00	8.06	10.49	10.97	10.31	9.35	8.16	6.18	5.81	96.79
67	5.58	5.76	6.51	7.15	7.81	8.11	9.90	8.65	8.90	7.61	7.12	6.45	89.55
68	5.58	5.53	6.94	7.36	8.68	10.04	10.23	9.99	9.30	7.53	6.39	5.80	93.37
69	7.12	6.38	6.52	9.50	8.96	8.30	10.58	11.02	8.38	7.12	6.24	6.25	96.37
70	5.93	6.51	8.70	9.64	9.35	9.32	10.77	11.48	9.18	8.53	7.23	7.72	104.36
71	5.67	6.22	7.54	7.09	9.15	8.98	9.91	9.75	8.59	7.51	6.66	5.95	93.02
72	5.44	6.32	5.87	8.23	8.76	7.85	9.24	8.83	8.13	7.23	6.77	5.62	88.29
73	5.74	6.39	8.70	8.63	9.53	8.41	9.56	9.60	7.63	7.91	6.03	5.94	94.07
74	5.55	6.17	6.85	8.26	7.70	7.90	8.36	7.90	6.09	7.21	5.61	6.69	84.29
75	6.61	5.90	7.42	7.84	8.27	9.91	10.97	10.65	8.66	8.18	6.62	5.13	96.16
76	5.81	6.61	7.51	8.15	8.40	8.46	9.36	9.05	7.36	7.33	5.78	5.66	89.48
77	5.23	6.10	9.18	8.06	9.53	8.55	9.82	9.15	8.63	8.14	6.50	5.87	94.76
78	5.76	5.89	7.31	7.99	8.04	8.51	9.87	7.09	8.70	7.30	5.34	6.69	88.49
79	5.96	4.53	7.11	7.70	9.36	11.05	12.31	10.61	9.22	8.34	7.65	6.24	100.07
80	5.68	5.34	8.79	8.16	8.70	8.33	9.11	8.26	7.10	6.81	5.60	4.63	86.51
81	5.16	5.59	6.85	6.24	8.43	11.43	10.39	10.20	9.09	8.31	6.96	5.54	94.19
82	4.29	5.40	6.54	6.57	7.72	6.36	8.00	8.00	7.47	7.22	10.05	5.86	83.48

TABLE H-6

Monthly Precipitation (inches) Station 727.00

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
62	4.82	3.46	4.77	1.69	1.45	0.36	0.03	0.06	0.11	2.13	0.12	3.46	22.46
63	9.14	0.76	9.19	10.04	1.17	1.29	0.20	0.25	1.32	0.71	0.06	2.09	36.22
64	2.60	0.49	3.29	1.06	0.06	0.06	0.19	0.13	0.07	0.07	8.06	5.63	21.71
65	2.90	0.31	0.14	0.60	3.73	0.07	0.71	0.28	1.22	5.01	13.52	5.83	34.32
66	0.41	6.45	0.90	0.16	0.52	0.05	0.25	0.16	0.39	0.79	7.89	1.12	19.09
67	0.83	2.60	5.57	0.35	0.88	1.31	2.21	0.98	0.85	0.43	1.09	6.73	23.83
68	6.93	3.41	1.86	1.14	1.12	0.04	0.23	0.00	3.37	3.20	4.29	10.06	35.65
69	13.85	0.14	0.89	0.19	0.47	0.14	0.21	0.00	0.81	0.14	4.24	0.50	21.58
70	2.07	0.49	0.02	0.39	0.68	0.04	0.68	0.02	0.44	1.76	4.62	0.80	12.01
71	12.46	2.25	1.53	2.07	0.85	1.64	0.05	0.15	0.73	2.05	1.26	1.37	26.41
72	6.18	4.39	2.91	4.13	0.16	0.78	0.00	0.13	1.77	2.25	0.79	2.91	26.4
73	1.33	0.45	0.14	0.36	0.32	0.00	0.21	0.02	0.34	0.64	2.89	5.58	12.28
74	4.91	2.11	1.84	4.85	1.22	1.99	0.25	0.04	0.66	2.25	1.71	0.21	22.04
75	6.13	4.12	1.50	0.52	1.32	0.04	0.22	0.05	0.20	0.40	10.62	0.52	25.64
76	0.80	16.66	0.74	0.86	0.05	0.11	0.24	0.12	0.08	0.17	0.42	0.16	20.41
77	0.87	0.16	2.05	1.45	7.15	0.82	0.01	0.11	0.00	0.17	0.13	2.02	14.94
78	2.10	0.09	0.41	4.55	4.82	0.91	0.14	0.58	0.05	9.48	4.28	2.43	29.84
79	2.33	0.84	0.37	0.76	0.22	0.24	0.04	0.11	0.72	0.43	0.18	2.78	9.02
80	11.74	2.58	1.20	0.46	0.62	1.56	0.16	0.25	0.10	0.37	0.26	5.69	24.99
81	0.76	1.23	0.03	0.04	0.13	0.42	0.15	0.90	0.10	0.33	0.35	4.51	8.95
82	12.64	1.81	4.31	1.60	1.75	2.41	0.04	0.74	0.10	11.60	4.65	4.17	45.82
83	0.57	0.26	0.38	0.7	0.14	0.16	0.34	0.14	1.65	0.22	0.32	0.76	5.64

Table H-7
Evapotranspiration Minus Precipitation (inches)
Station 727.00

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
62										5.66	7.44	0.92	
63	-4.78	5.07	-1.83	-1.14	8.28	8.75	10.52	9.56	7.99	7.88	6.83	3.28	60.41
64	4.01	7.22	3.43	7.21	10.38	9.65	10.01	10.89	9.97	9.73	-1.04	0.38	81.84
65	2.82	6.82	7.58	6.85	3.40	9.95	9.15	10.05	7.14	3.59	-6.72	0.77	61.40
66	6.48	-1.66	6.88	7.84	7.54	10.44	10.72	10.15	8.96	7.37	-1.71	4.69	77.70
67	4.75	3.16	0.94	6.80	6.93	6.80	7.69	7.67	8.05	7.18	6.03	-0.28	65.72
68	-1.35	2.12	5.08	6.22	7.56	10.00	10.00	9.99	5.93	4.33	2.10	-4.26	57.72
69	-6.73	6.24	5.63	9.31	8.49	8.16	10.37	11.02	7.57	6.98	2.00	5.75	74.79
70	3.86	6.02	8.68	9.25	8.67	9.28	10.09	11.46	8.74	6.77	2.61	6.92	92.35
71	-6.79	3.97	6.01	5.02	8.30	7.34	9.86	9.60	7.86	5.46	5.40	4.58	66.61
72	-0.74	1.93	2.96	4.10	8.60	7.07	9.24	8.70	6.36	4.98	5.98	2.71	61.89
73	4.41	5.94	8.56	8.27	9.21	8.41	9.35	9.58	7.29	7.27	3.14	0.36	81.79
74	0.64	4.06	5.01	3.41	6.48	5.91	8.11	7.86	5.43	4.96	3.90	6.48	62.25
75	0.48	1.78	5.92	7.32	6.95	9.87	10.75	10.60	8.46	7.78	-4.00	4.61	70.52
76	5.01	-10.05	6.77	7.29	8.35	8.35	9.12	8.93	7.28	7.16	5.36	5.50	69.07
77	4.36	5.94	7.13	6.61	2.38	7.73	9.81	9.04	8.63	7.97	6.37	3.85	79.82
78	3.66	5.80	6.90	3.44	3.22	7.60	9.73	6.51	8.65	-2.18	1.06	4.26	58.65
79	3.63	3.69	6.74	6.94	9.14	10.81	12.27	10.50	8.50	7.91	7.47	3.46	91.05
80	-6.06	2.76	7.59	7.70	8.08	6.77	8.95	8.01	7.00	6.44	5.34	-1.06	61.52
81	4.40	4.36	6.82	6.20	8.30	11.01	10.24	9.30	8.99	7.98	6.61	1.03	85.24
82	-8.35	3.59	2.23	4.97	5.97	3.95	7.96	7.26	7.37	-4.38	5.40	1.69	37.66

Table 8
(ET-P) 90 Percentile
Station 727.00

m	D+J	%	Rank	N+D+J+F	Rank	Annual	Rank
1	-3.86	5	9.86	8.65	21.34	60.41	92.35
2	7.29	10	9.62	21.34	21.16	81.84	91.05
3	3.20	15	9.61	8.98	19.68	61.40	85.24
4	7.25	20	9.44	-1.13	19.04	77.70	81.84
5	9.44	25	7.89	10.89	17.63	65.72	81.79
6	-1.63	30	7.51	6.52	13.04	57.72	79.82
7	-10.99	35	7.29	-2.65	12.64	74.79	77.70
8	9.61	40	7.25	17.63	12.64	92.35	74.79
9	0.13	45	7.12	6.71	11.17	66.61	70.52
10	3.84	50	6.96	11.17	10.89	61.89	69.07
11	7.12	55	3.84	19.04	8.98	81.79	66.61
12	1.00	60	3.34	8.20	8.65	62.25	65.72
13	6.96	65	3.20	12.64	8.20	70.52	62.25
14	9.62	70	1.00	-4.43	7.63	69.07	61.89
15	9.86	75	0.13	21.16	6.71	79.82	61.52
16	7.51	80	-1.63	19.68	6.52	58.65	61.40
17	7.89	85	-2.60	12.64	2.88	91.05	60.41
18	-2.60	90	-3.86	7.63	-1.13	61.52	58.65
19	3.34	95	-7.33	13.04	-2.65	85.24	57.72
20	-7.33	100	-10.99	2.88	-4.43	37.66	37.66

b. If the entire application area is over an aquifer that is not designated as a public drinking water supply, the water balance may include an infiltration component. The final infiltration component (DMPR) should be less than 20 percent of the consumptive rate of the vegetation (ET-P) by design. However, if the infiltration component (DMPR) is greater than 20 percent of the consumptive rate of the vegetation (ET-P), then the project is considered a recharge project. Both a pilot study and a monitoring program will be required. If the infiltration component is used, choose one of the following procedures:

(1) A minimum of three (3) saturated vertical hydraulic conductivity tests for the most limiting horizon of each soil series present shall be performed. Percolation tests performed for individual wastewater systems are not acceptable. Acceptable methods for saturated hydraulic conductivity testing are presented in Appendix F; or

(2) The most limiting soil horizon from the soil survey information shall be determined, and the most conservative value from the range of permeability shall be used. The most limiting soil horizon should be determined from the soil survey information.

c. Because a given site may include several different soil types with significant variation in their permeabilities, it is possible for there to be different application rates for different areas of the site. DOH recommends that when this is the case, the fields be laid out to separate the soils with different permeabilities. However, this is not done and a field includes more than one soil type, the application rate will be limited to the most restrictive soil permeability.

d. Using the "ring permeameter method" by Boersma (1965) [171] pp 3-23, the results from saturated hydraulic conductivity testing are presented in Table H-9.
Since the permeability for the Honouliuli Soil series, (HxA, HxB) showed to be the most limiting (smallest rate 0.12 in/hr), only the results from this series were used to calculate the mean.

e. The maximum daily permeability rate (MDPR) is determined as follows:

MDPR = percolation, in/hr (24 h/d)(4 to 10%);

0.19 in/d = 0.20 in/hr x 24 h/d x 0.04

Table H-9

SUMMARY OF SATURATED HYDRAULIC CONDUCTIVITIES TESTS

Loc	Perm (in/hr)	Safety Factor	MDPR (in/d)	Soil Series	Depth
A	0.14	0.04	0.13	HxA	2.5
B	0.12	0.04	0.12	HxA	2.5
C	0.34	0.04	0.33	HxA	3.5
D	1.04	0.1	2.50	WkA	3.5
E	1.17	0.1	2.81	WkA	3.5
F	0.82	0.1	1.97	WkA	2.5
Sum	0.60		0.58	HxA	
Mean	0.20		0.19	HxA	

The design monthly percolation rate (DMPR) is determined by:

DMPR = MDPR x No. of operating days/month

5.7 in = 0.19 in/d x 30 day

In Table H-9, if the DMPR value exceeds the ET-P by more than 20 percent, the DMPR is adjusted to 1.2 times the ET-P. Thus, since the ET-P values are low the DMPR rates will also be low. Otherwise, the project would need to conform with the conditions associated with a recharge project.

15. Methodology for Calculating the Maximum Monthly Application Rate

Table H-10 indicates that for the assumed site conditions, the most critical water balance months are January, March and April with a maximum month allowable application rate (MMAR) of 0.00 inches/month. The month ET-P values minus DMPR equals the MMAR. Because the monthly amount of precipitation was greater than the evapotranspiration, the ET-P value is negative. Furthermore, since the DMPR is limited to 1.2

times

Table H-10
WATER BALANCE FOR COASTAL BERMUDA GRASS
TRIAL NO. 1

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ET-P (in)	-4.78	5.07	-1.83	-1.14	8.28	8.75	10.52	9.56	7.99	7.88	6.83	3.28
DMPR (in)	0.00	1.01	0.00	0.00	1.66	1.75	2.10	1.91	1.60	1.58	1.37	0.66
MMAR (in)	0.00	6.08	0.00	0.00	9.94	10.50	12.62	11.47	9.59	9.46	8.20	3.94
WAR (in)	0.00	1.52	0.00	0.00	2.24	2.45	2.85	2.59	2.24	2.21	1.85	0.92
DAR (in)	0.00	0.22	0.00	0.00	0.32	0.35	0.41	0.37	0.32	0.31	0.27	0.13
VOL-D (mgd)	0.00	0.77	0.00	0.00	1.13	1.24	1.44	1.31	1.13	1.08	0.96	0.45
VOL-D (mg)	0.00	21.48	0.00	0.00	35.07	37.06	44.56	40.49	33.84	33.38	28.93	13.89
VOL-S (mgd)	0.00	0.77	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.45
VOL-S (mg)	0.00	21.48	0.00	0.00	31.00	30.00	31.00	31.00	30.00	31.00	28.93	13.89

the ET-P value, it too, is 0.00. Thus, from a design perspective, the amount of water to be stored or disposed of, is 100 percent or 1 mgd.

Weekly application rate (WAR) and the daily application rate (DAR) are derived from the MMAR. WAR equals MMAR times 7 divided by the days in the month. DAR equals MMAR divided by the days in the month. The rates MMRA times the approved use times a time period, either daily or monthly, equals the demand and/or the amount of water i.e., VOL-D (mgd) or VOL-D (mg). In this example VOL-D is calculated by multiplying MMAR (in) x area (130 acres) x 43560 sf/ac x 7.489 gal/cf x ft/12in x 1/1,000,000.

However, when the daily demand (VOL-D) for water is greater than the design flow of the treatment facility, supplemental water or water from storage may be needed. The water supplied (VOL-S) is derived from the MMRA but does not exceed the design average flow of the treatment facility.

16. Methodology for Calculating Nitrogen

Soil profile characteristics were found to be paramount in influencing the amount of nitrate moving past the root zone. Lund et al. reported significant correlations between soil nitrate concentrations below the root zone and clay content of the upper soil profile. Soils that have high water infiltration rates tend to be relatively low in organic matter and do not readily develop the anoxic conditions that are conducive to denitrification. Such soils are usually sandy and may have no layers in the profile that restrict water movement. High leaching of nitrate is probable under these conditions, particularly where N applied exceeds crop uptake to any significant degree. On the other hand, clayey soils or soils with slow water movement are likely to develop the anaerobic conditions that favor N loss through denitrification. Consequently, nitrate usually is leached less from a fine-textured soil than from a coarse-textured one with equal N input. Furthermore, the fraction of applied N leached increased with increasing levels of N input.

Estimates of the quantity of N leached in a given situation is a fraction of the total N applied, N utilized by the crop a reasonable estimate of denitrification and volatilization losses.

Nitrate concentrations in percolate from drainage lysimeters in reuse irrigation systems shall not exceed 10.0 mg/l.

Percolate nitrate concentration is a function of nitrogen loading and an environment that oxidizes the nitrogen forms to nitrate (NO_3). The average monthly application rate shall be checked against nitrogen loading limitations. If, for the selected vegetative cover, best management practice and the average monthly application rate results in an estimated nitrate percolate concentration exceeding 3 mg/l, either the above variables need to be adjusted and/or supplemental water supply added.

The following is a step-by-step process for calculating the values on Table H-11:

a. The monthly volumes of recycled water supplied are taken from Table H-10.

b. The total nitrogen (TN) input concentration is calculated from the following effluent concentration taken from water quality parameter reported in item 2 above:

   TN mg/l = (Total Kjeldahl nitrogen + nitrate + nitrite)
   20 mg/l = 11.4 mg/l + 7.3 mg/l + 1.3 mg/l

   The total nitrogen (T N) loading per acre-day (lbs/ac-d) can be calculated by multiplying the TN concentration by 8.34 and by the flow (1 MGD) and dividing by the number of irrigated acres. One can assume that the concentrations reported in item 3 represent the annual average concentrations in the recycled water leaving the treatment facility.

   N (lbs/ac-d) = (20 mg/l * 8.34 lbs-l/mg-Mg * MG/acres)

   1.28 (lbs/ac-d) = (20 mg/l * 8.34 * 1 MGD /130 acres)

   T N = 1.28 (lbs/ac-d) * number of days in the month

c. Nitrogen input from rainfall (RAIN) and fixation (lbs/acre) is a constant from the atmosphere of 5 lbs/acre-year.

d. Total Nitrogen Input (T N) (lbs/acre) equals the sum of the amount applied (USE) + input from rainfall (RAIN).

e. Ammonia Volatilization of ammonia applied (NH_3) (lbs/acre). Assume a monthly average ammonia concentration of 6.4 mg/l in the reuse stream leaving the treatment facility. Assumed losses to ammonia

TABLE H-11
NITROGEN BALANCE OF COASTAL BERMUDA GRASS
TRIAL NO. 1

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
NITROGEN (N) INPUT (lb/ac)													
USE	0.00	27.57	0.00	0.00	39.80	38.52	39.80	39.80	38.52	39.80	37.14	17.84	318.8
RAIN	0.42	0.38	0.42	0.41	0.42	0.41	0.42	0.42	0.41	0.41	0.42	0.41	5.0
T N	0.42	27.95	0.42	0.41	40.22	38.93	40.22	40.22	38.93	40.21	37.57	18.25	323.8
NITROGEN (N) OUTPUT (lb/ac)													
NH3	0.00	1.76	0.00	0.00	2.55	2.46	2.55	2.55	2.46	2.55	2.38	1.14	20.4
DE-N	0.06	4.19	0.06	0.06	6.03	5.84	6.03	6.03	5.84	6.03	5.64	2.74	48.6
UPTAKE	30.15	27.23	30.15	29.18	30.15	29.18	30.15	30.15	29.18	30.15	29.18	30.15	355.0
LEACHE	-29.79	-5.24	-29.79	-28.83	1.49	1.44	1.49	1.49	1.44	1.48	0.38	-15.78	-100.2
NITROGEN SUPPLEMENT IF NEEDED (lb/ac)													
SUP	29.79	5.24	29.79	28.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.78	109.4
ESTIMATED PERCOLATE NITROGEN (mg/l)													
PERC	0.00	0.00	0.00	0.00	0.80	0.73	0.63	0.69	0.80	0.83	0.24	0.00	

volatilization should not exceed 20 percent of the total ammonia applied. (6.4 mg/l *0.2 * 8.34 lbs-l-l/mg-Mg*MG/acres). Where recycled water is applied by sprinkler, and to a lesser extent by surface irrigation, some loss of N as ammonia is probable, since wastewaters are typically alkaline in reaction. Henderson et al. suggested that volatilization losses during sprinkler irrigation of water with a pH of 7.5-8.5 would amount to less than 20 percent of the total applied. In this example, although a small portion of the recycled water will be used for subsurface drip irrigation and would not be subject to volatilization losses, a separate analysis is not warranted. The possibility of the absorption of gaseous ammonia on leaf surfaces or soil may further reduce this loss. Both nitrate concentration and water movement in the soils are subject to a wide range in spatial variability; consequently, calculations of mass flow of nitrate through the soil are subject to considerable uncertainty.

f. For row and forage crop systems, assumed losses to denitrification of total nitrogen (DE-N) applied (lbs/acre) should not exceed 15 percent of the total nitrogen applied (T N).

g. Net Plant uptake (UPTAKE) and storage (lbs\acre) [171 page 4-16] for various vegetation is presented in Table H-12. The nitrogen uptake for coastal Bermuda grass of 355 lbs/ac yr will be used for the initial trail in Table H-11.

h. The nitrogen leached (LEACH) by percolate (lbs/acre) is equal to the total nitrogen input (T N) minus ammonia volatilization of ammonia applied (NH3) minus denitrification of total nitrogen applied (DE-N) minus net plant uptake and storage (UPTAKE).

i. Nitrogen supplement (SUP) to soil (lbs/acre) equals only the negative values for the nitrogen leached (LEACH) by percolate.

j. Estimated percolate (PERC) total nitrogen (mg/l) equals the sum the nitrogen leached (LEACH) and nitrogen supplement (SUP), times 4.416 divided by the Design Maximum Percolation Rate (DMPR). The 4.416 is derived from the following: 12 in/ft * acre/43560 sf * cf/7.48 gal * mg-MG/8.34 lb-l * 1,000,000 gal/ MG).

Based on the above-mentioned database and assumptions, the estimated percolate (PERC) concentration for total nitrogen in Table 11 does not exceed the 10 mg/l.

Furthermore, if this assumption is incorrect and the actual net N uptake by the coastal Bermuda grass results in exceeding the estimated percolation concentration of 10 mg/l, a component of the maximum application rate would have to be supplemented with a water supply that contains a concentration of TN less than in the recycled water.

The water balance shows that the consumptive demand in the summer time exceeds the supply by nearly 50 percent. If an objective is to assure a vigorous green landscape supplemental water will be needed. The results from Table H-10 demonstrate that if there is storage of recycled water, it could be during other periods. This would offset the need for supplemental supply. Additional work in this sample will focus on design of storage.

Table H-12

Nutrient Uptake Rates
Lbs/ac-yr

Selected Crops	Nitrogen	Phosphorus	Potassium
Alfalfa	200-480	20-25	155-200
Brome grass	115-200	35-50	220
Coastal Bermuda grass	355-600	30-40	200
Kentucky Bluegrass	175-240	40	175
Orchard grass	225-310	20-45	225-315
Quack grass	210-250	25-40	245
Reed Canary grass	300-400	35-40	280
Ryegrass	175-250	55-75	240-290
Sweet Clover	155	20	90
Tall Fescue	135-290	25	270

17. Methodology for Calculating Phosphorus

The amount of phosphorus in applied wastewaters is usually much higher than plant requirements. Fortunately, many soils have a high sorption capacity for phosphorus and very little of the excess passes through the soil.

The phosphorus sorption capacity of a soil profile depends on the amount of clay, aluminum, iron and calcium compounds present and the soil pH. In general, fine textured mineral soils have the highest phosphorus sorption capacity and coarse textured acidic or organic soils have the lowest.

For systems with coarse textured soils and limits on the concentration of percolate phosphorus, a phosphorus sorption test should be conducted using soil from the selected site. Two test sites shall be selected from each soil series and two soil samples shall be taken from each site: one representing the surface horizon and the other the subsurface horizon. The (assumed) test results for the Lualualei soil were the most conservative with a value of 7.0 pounds per acre. This test, described below, determines the amount of phosphorus
that the soil can remove during short application periods.

Table H-13 attempts to estimate a phosphorus balance. It uses the low range of the phosphorus uptake rate of 30 lbs/yr, presented in Table H-12. The results show that the phosphorus loading from recycled water is much greater than the phosphorus uptake of the coastal Bermuda grass. The estimate of percolate exceeds the 1.0 mg/l value during eight months.
Table H-14 demonstrates the relationship between the high range of the phosphorus uptake rate, 40 lbs/yr and the phosphorus loading from the recycled water. Here, the estimates of percolate do not exceed the value of 1.0 mg/l. Since both the loading and the estimates of percolate fall within the acceptable values, the design will proceed.

18. Methodology for Calculating Potassium

Potassium levels may increase; however, the rate of uptake by plants usually exceeds the rate of application. The amount of potassium that is held by the soil is dependent on the soil type. Table H-12 presents nutrient uptake rates taken from Table 4-11 of the U.S. EPA Process Design manual: Land Treatment of Municipal wastewater, [171] and other sources.

At this time DOH will not place a limit on the concentration of the percolate.

Table H-13

TRIAL NO. 1
PHOSPHORUS BALANCE FOR COASTAL BERMUDA GRASS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
PHOSPHORUS (P) INPUT (lb/ac)													
USE	0.00	13.79	0.00	0.00	19.90	19.26	19.90	19.90	19.26	19.90	18.57	8.92	159.4
PHOSPHORUS (P) OUTPUT (lb/ac)													
UPTAKE	2.55	2.30	2.55	2.47	2.55	2.47	2.55	2.55	2.47	2.55	2.47	2.55	30.0
FIXED	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	84.0
LEACH	-9.55	4.48	-9.55	-9.47	10.35	9.79	10.35	10.35	9.79	10.35	9.11	-0.63	45.4
PHOSPHORUS SUPPLEMENT IF NEEDED (lb/ac)													
SUP	9.55	0.00	9.55	9.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	29.18
ESTIMATED PERCOLATE PHOSPHORUS (mg/l)													
PERC	0.00	3.90	0.00	-0.02	5.52	4.94	4.34	4.78	5.41	5.80	5.88	0.00	

Table H-14

TRIAL NO. 2
PHOSPHORUS BALANCE FOR COASTAL BERMUDA GRASS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
PHOSPHORUS (P) INPUT (lb/ac)													
USE	0.00	8.27	0.00	0.00	11.94	11.55	11.94	11.94	11.55	11.94	11.14	5.35	95.6
PHOSPHORUS (P) OUTPUT (lb/ac)													
UPTAKE	3.40	3.07	3.40	3.29	3.40	3.29	3.40	3.40	3.29	3.40	3.29	3.40	40.0
FIXED	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	84.0
LEACH	-10.40	-1.80	-10.40	-10.29	1.54	1.27	1.54	1.54	1.27	1.54	0.85	-5.05	-28.4
PHOSPHORUS SUPPLEMENT IF NEEDED (lb/ac)													
SUP	10.40	1.80	10.40	10.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.05	29.18
ESTIMATED PERCOLATE PHOSPHORUS (mg/l)													
PERC	0.00	0.00	-0.01	-0.01	0.82	0.64	0.65	0.71	0.70	0.86	0.55	0.01	

19. Methodology for Calculating TDS

    For this example, DOH will not place a limit on the concentration of the percolate.

20. Methodology for Calculating Other Constituents

    None of the water quality concentration presented in item 2B pertaining to copper, cadmium, chromium, lead, arsenic, nickel, and mercury exceed 0.5 of the MCL value. If the metal percolate concentration exceeds 0.5 of the MCL value, it will be reported to DOH immediately. A plan for corrective action shall be received by DOH within 30 days.

21. In summary, phosphorus may be the limiting parameter when using the maximum monthly application rate and the high consumptive uptake rate.

22. Monitoring Plan. This monitoring plan shall conform with Hawaii State Department of Health (DOH) Guidelines for Groundwater Monitoring Plan, and Guidelines for Monitoring System Construction Report, See Appendix E and Appendix F.

23. It is the intent of these guideline to incorporate an element of storage, or disposal, to assure that recycled water will not be applied during periods when the ground is saturated, in order to prevent ponding and/or runoff. Thus, the maximum monthly application rate (MMAR) is intended to represent a conservative value in the design for the minimum size of the storage and/or disposal components. From the experience gained from existing reuse systems e.g., St Petersburg, Florida, systems need additional storage. At first, the producer is predominantly concerned with "disposal" of the product water. As more users invest and rely upon recycled water, they become a unified voice when their recycled water needs are not meet by the producer.

    In this example, the application area was fixed at 130 acres. However, for larger systems with perhaps multiple users and a goal to use a supplemental water supply as little as possible, the methodology shown in Table H-15 is suggested. Here, the difference between the volume demand (VOL-D) and the volume supplied (VOL-S) by the treatment facility is the amount either from supplemental water supply or storage (δ-STOR). This supplemental supply could either come from a potable water system or an irrigation well or agricultural delivery system. The change in storage volume (δ-STOR) is accumulated in the storage column (STORAGE.

Table H-15
Storage Volume Analysis

YR	MO	ET-P (in)	DMPR (in)	MMAR (in)	VOL-D (mg)	VOL-S (mg)	D-STOR (mg)	STORAGE (mg)
62	OCT	5.66	1.13	6.79	23.97	31.00	7.03	7.03
62	NOV	7.44	1.49	8.93	31.51	30.00	-1.51	5.51
62	DEC	0.92	0.18	1.10	3.90	31.00	27.10	32.61
63	JAN	-4.78	-0.96	0.00	0.00	31.00	31.00	63.61
63	FEB	5.07	1.01	6.08	21.48	28.00	6.52	70.14
63	MAR	-1.83	-0.37	0.00	0.00	31.00	31.00	101.14
63	APR	-1.14	-0.23	0.00	0.00	30.00	30.00	131.14
63	MAY	8.28	1.66	9.94	35.07	31.00	-4.07	127.07
63	JUN	8.75	1.75	10.50	37.06	30.00	-7.06	120.00
63	JUL	10.52	2.10	12.62	44.56	31.00	-13.56	106.44
63	AUG	9.56	1.91	11.47	40.49	31.00	-9.49	96.95
63	SEP	7.99	1.60	9.59	33.84	30.00	-3.84	93.11
63	OCT	7.88	1.58	9.46	33.38	31.00	-2.38	90.73
63	NOV	6.83	1.37	8.20	28.93	30.00	1.07	91.80
63	DEC	3.28	0.66	3.94	13.89	31.00	17.11	108.90
64	JAN	4.01	0.80	4.81	16.99	31.00	14.01	122.92
64	FEB	7.22	1.44	8.66	30.58	28.00	-2.58	120.34
64	MAR	3.43	0.69	4.12	14.53	31.00	16.47	136.81
64	APR	7.21	1.44	8.65	30.54	30.00	-0.54	136.27
64	MAY	10.38	2.08	12.46	43.97	31.00	-12.97	123.30
64	JUN	9.95	1.99	11.94	42.15	30.00	-12.15	111.15
64	JUL	10.01	2.00	12.01	42.40	31.00	-11.40	99.75
64	AUG	10.89	2.18	13.07	46.13	31.00	-15.13	84.63
64	SEP	9.97	1.99	11.96	42.23	30.00	-12.23	72.40
64	OCT	9.73	1.95	11.68	41.21	31.00	-10.21	62.18
64	NOV	-1.04	-0.21	0.00	0.00	30.00	30.00	92.18
64	DEC	0.38	0.08	0.46	1.61	31.00	29.39	121.57

24. The minimum storage duration has been determined as 20 day. The amount of daily storage will equal the maximum monthly application rate (MMAR). In this example the MMAR was negative (or zero) for three months. Thus, the amount to be stored will be the design flow of the treatment facility (1.0 mgd). This could be decreased by an analysis of daily precipitation data for a period of 30 years or greater. An acceptable methodology would focus on the number of consecutive days where precipitation was greater than some minimal value, i.e., 0.1 inch. If the results show 14 days, then the minimum duration of storage is 14 days. The next question is what would be the amount of water to be stored. Using this scenario where daily precipitation and evapotranspiration date is available, the water balance needs to be recalculated using the (ET-P) for a nominal period, say 90 days, which embeds the 14 day period construct a mass diagram for determining the amount of water to be stored. The smaller value of either the 90th percentile for this record for (ET-P) or the previous calculation shall be selected. In addition a safety factor is recommended to assure no problems with spillage, ponding and runoff.

    The methodologies presented in chapter 5 Irrigation with Recycled Municipal Wastewater, A Guidance Manual, California State Water Resources Control Board, Report Number 84-1, July 1984, are also acceptable.

    Since the minimum volume of storage would be 20 mgd and assuming a depth of 8 feet, the surface area for an open reservoir may be about 8 acres. Table H-16, incorporates the surface evaporation and precipitation components to refine the calculations form Table H-15. Two observation can be make from this analysis, a minimum of 20 days may not be adequate and a storage volume in excess of 20 mg would reduce the supplemental water needed.

Table H-16
Final Storage Volume Analysis

YR	MO	ET-P (in)	STOR ET-P (mg)	VOL-D (mg)	VOL-S (mg)	δ-STOR (mg)	STORAGE (mg)
62	OCT	5.66	1.18	23.97	31.00	8.20	8.20
62	NOV	7.44	1.55	31.51	30.00	0.04	8.24
62	DEC	0.92	0.19	3.90	31.00	27.29	35.54
63	JAN	-4.78	-1.00	0.00	31.00	30.00	65.54
63	FEB	5.07	1.06	21.48	28.00	7.58	73.12
63	MAR	-1.83	-0.38	0.00	31.00	30.62	103.74
63	APR	-1.14	-0.24	0.00	30.00	29.76	133.50
63	MAY	8.28	1.73	35.07	31.00	-2.35	131.15
63	JUN	8.75	1.82	37.06	30.00	-5.24	125.91
63	JUL	10.52	2.19	44.56	31.00	-11.37	114.55
63	AUG	9.56	1.99	40.49	31.00	-7.50	107.04
63	SEP	7.99	1.66	33.84	30.00	-2.18	104.86
63	OCT	7.88	1.64	33.38	31.00	-0.74	104.13
63	NOV	6.83	1.42	28.93	30.00	2.49	106.62
63	DEC	3.28	0.68	13.89	31.00	17.79	124.41
64	JAN	4.01	0.84	16.99	31.00	14.85	139.26
64	FEB	7.22	1.50	30.58	28.00	-1.08	138.18
64	MAR	3.43	0.71	14.53	31.00	17.19	155.37
64	APR	7.21	1.50	30.54	30.00	0.96	156.33
64	MAY	10.38	2.16	43.97	31.00	-10.80	145.53
64	JUN	9.95	2.07	42.15	30.00	-10.07	135.45
64	JUL	10.01	2.09	42.40	31.00	-9.31	126.14
64	AUG	10.89	2.27	46.13	31.00	-12.86	113.28
64	SEP	9.97	2.08	42.23	30.00	-10.15	103.13
64	OCT	9.73	2.03	41.21	31.00	-8.19	94.94
64	NOV	-1.04	-0.22	0.00	30.00	29.78	124.72
64	DEC	0.38	0.08	1.61	31.00	29.47	154.19

APPENDIX I

RESPONSES FOR WASTEWATER SPILLS, OVERFLOWS, AND DISCHARGES ("SPILLS")

(Revised March 2002)

Table of contents

1. Points of contact

Agency	Phone	Fax
Clean Water Branch (CWB)	586-4309	586-4352
Wastewater Branch (WWB)	586-4294	586-4352
Environmental Health Programs (EHP)		
Hawaii District Health Office	974-6006	974-6000
Kauai District Health Office	241-3323	241-3566
Maui District Health Office	984-8234	984-8222
State Hospital Operator (SHO)	247-2191	
Communications Office		586-4444

2. Spills from any facility into state waters, excluding R-1 water from recycled water systems

a. Applicability. Any wastewater spill which enters into state waters from a public or private wastewater system.

(1) "State waters" has the meaning defined in HRS section 342D-1, and includes drainage ditches, whether or not water is always flowing in them.

(2) Exclusion. Spill of R-1 water covered by Appendix J to HAR chapter 11-5, "NPDES General Permit Authorizing Discharges of R-1 Water from Recycled Water Systems". That general permit does not cover spills from treatment works.

b. Immediate notice to DOH. If a spill occurs during working hours:

(1) The wastewater system owner or its agent (owner/agent) shall immediately notify the CWB of any spill into state waters; and

(2) If a spill occurs on the neighbor islands, the owner/agent shall also immediately notify their respective district environmental health program chief.

If a spill occurs during non-working hours:

(1) Contact the state hospital operator; and

(2) The next working day notify the CWB and the respective district EHP chief with a follow-up call.

c. Press Release. The owner/agent shall immediately send out a press release for spills of a thousand gallons or more and for lesser spills if they present a substantial threat to public health. A press release shall comply with section 7. A press release is not required if the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

d. Disinfection. The owner/agent shall disinfect wastewater which is continuously being spilled into nearshore waters if sufficient disinfection contact time is available. Best judgment should be used in determining the amount of chlorine added to the discharge if chlorine is used as a disinfectant. Disinfection is not required if the owner/agent demonstrates that the spill was either R-1 or R-2 water and that BMPs as approved by the director were implemented.

e. Warning signs. The owner/agent shall immediately post warning signs in the area(s) likely to be affected by the spill and where public access is possible. Posting of warning signs is not required if the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

The director shall also assure that a sufficient number of warning signs have been posted and the locations are adequate. Authorization to remove the signs shall also come from the director.

f. Monitoring. The owner/agent shall conduct bacterial monitoring for any spill greater than 100 gallons or when public health may be threatened in accordance with section 8. Monitoring is not required if the owner/agent demonstrates that the spill was R-1 water and that BMPs as approved by the director were implemented.

g. Reporting. The owner/agent shall report to the CWB under section 9.a.

3. Spills into state waters of R-1 water from recycled water systems

a. Applicability. Any spills of R-1 water covered by Appendix J to HAR chapter 11-55, "NPDES General Permit Authorizing Discharges of R-1 Water from Recycled Water Systems."
   (1) "State waters" has the same meaning defined in HRS section 342D-1, and includes drainage ditches, whether or not water is always flowing in them.
   (2) Exclusion. The general permit does not cover spills from treatment works.

b. Requirements. Among other things, the general permit requires filing a Notice of Intent before any discharge, compliance with standard conditions in appendix A of chapter 11-55, implementation of best management practices (BMPs), monitoring of discharges, avoiding violations of water quality criteria, and specified reporting. The full statement of requirements appears in the general permit.

4. Spills to ground only - with public access

a. Applicability. Any wastewater spill from a wastewater system onto the ground and that does not enter state waters but is in an area which is or may be accessible to the public.

(1) In this appendix, the public includes hotel, apartment, and condominium residents and guests, or condominium apartment owners at their own condominium, and management personnel and building or facility staff, unless the person is specifically an operator of the wastewater system or a manager of the property.

(2) In this appendix, areas inaccessible to the public include areas:

    (a) Confined within a fenced or walled (six foot high with locked gate or door) area; and

    (b) Contact with the spill is limited to wastewater system operating personnel and management personnel for the property owner or lessee.

(3) Exclusion. Spills of R-1 water provided the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

b. Immediate notice to DOH. If a spill of a thousand gallons or more occurs during working hours:

(1) On Oahu, the wastewater system owner/agent shall immediately notify the WWB; or

(2) On the neighbor islands, the owner/agent shall immediately notify their respective district EHP chief.

If a spill of a thousand gallons or more occurs during non-working hours:

(1) Contact the state hospital operator; and

(2) The next working day notify the WWB or on the neighbor islands, the respective district EHP chief with a follow-up call.

c. Press release. The owner/agent shall immediately send out a press release for spills of a thousand gallons or more, and for lesser spills if they present a substantial threat to public health. A press release shall comply with section 7.

d. Disinfection. The owner/agent shall disinfect the wastewater that is spilled onto the ground if the wastewater remains ponded on the ground for any sufficient length of time or if the discharge continues for any significant duration. Disinfection is not required if the owner/agent demonstrates that the spill was R-2 water and that BMPs as approved by the director were implemented.

e. Warning signs. The owner/agent shall immediately post warning signs in the vicinity of the spill area.

f. Clean up. All spill sites shall be cleared of all debris and standing wastewater, and disinfected pursuant to section 4.d.

In areas containing standing wastewater which cannot be removed, the owner/agent shall limit public access by having barricades or other means.

g. Reporting. The owner/agent of a public wastewater system shall report to the WWB as follows:
(1) For spills of a thousand gallons or more, the owner/agent shall report to the WWB under section 9.a.
(2) For spills less than a thousand gallons, immediate notice and reporting are not required. A tabulated summary of all spills less than a thousand gallons each shall be submitted to the WWB on a quarterly basis in accordance with section 9.b.
(3) Exfiltration. Reporting of leaks or breaks in pipelines discovered during inflow/infiltration repair work is not required. These situations are considered exfiltration.

5. Spills to ground only - with no public access

a. Applicability. All wastewater spills from any public or private wastewater system that does not enter state waters and are in areas inaccessible to the public.
(1) The public and inaccessibility are described in section 4.a.
(2) Exclusion. Spills of R-1 water provided the owner/agent demonstrates the spill was of R-1 water and that BMPs as approved by the director were implemented.

b. Immediate notice to DOH. If a spill of a thousand gallons or more, and for spills occurring more than twice within a 12 month period within the confines or fence line of a wastewater system, the owner/agent shall notify the WWB within 24 hours.

c. Reporting. For spills of a thousand gallons or more, and for spills occurring more than twice within a 12 month period within the confines or fence line of a wastewater system, the owner/agent shall report to the WWB under section 9.a.

d. Recording. The owner/agent shall record and tabulate the date and time of the spill, the amount released, the cause(s) for the spill, clean up efforts, and remedial actions taken to prevent future spills for all spills greater than 50 gallons as they happen. The owner/agent shall keep the records and tabulations on site and make the records and tabulation available to the director for inspection and copying.

6. Spills to ground only - R-1 water only

a. Applicability. Spills of R-1 water provided the owner/agent demonstrates the spill was of R-1 water and that BMPs as approved by the director were implemented.

b. Notice to DOH.
   (1) For spills of a thousand gallons or more occurs, the wastewater system owner/agent shall notify the WWB at least by phone by the end of the next working day. The notice shall provide the information required by section 6.d(1), below.
   (2) For spills of less than a thousand gallons, but more than fifty gallons, next day notice is not required, but the wastewater system owner/agent shall record the information and report as required by section 6.d.

c. Advisory signs. For spills greater than fifty gallons, the owner/agent shall immediately post warning signs in the vicinity of the spill area.

d. Reporting. The owner/agent of a wastewater system shall report in writing to the WWB as follows:
   (1) Information of each spill shall include at least the spill's date, time, location, quantity, the reason for the spill, and any corrective action.
   (2) For spills more than fifty gallons, a tabulated summary shall be submitted to the WWB each year with the summary report required by section 11-62-28.

7. Press release

The press release shall describe the location of the spill, the amount of wastewater released, what caused the spill, and what is being done to correct the situation. Also, include a contact person and telephone number (including an after hours/weekend contact). At a minimum, the press release shall be faxed or telephoned to the following:

a. Associated Press (for radio dissemination) Phone: 536-5510;
b. Major statewide and island newspapers;
c. Major television news stations;
d. Department of Health, Communications Office, Oahu (Fax: 586-4444);
e. CWB if into state waters, otherwise WWB; and
f. For neighbor island spills, also include faxing the press release to the respective island DHOs.

8. Monitoring of state waters

Monitoring shall begin as soon as possible and be conducted in the receiving water area affected by the spill. Bacterial monitoring is not required if the owner/agent demonstrates that the spill was of R-1 water and that BMPs as approved by the director were implemented.

For spills entering fresh or brackish waters, the bacterial monitoring shall consist of sampling for the following indicator organisms:

a. Fecal coliform; and
b. Clostridium perfringens.

For spills entering marine waters, the bacterial monitoring shall consist of sampling for the following indicator organisms:

a. Enterococci; and
b. Clostridium perfringens.

Results of the bacterial monitoring shall be submitted to the director in care of the CWB immediately. Monitoring shall continue until notification to stop is received from the director. With the approval of the director, on a case-by-case situation, some protocol requirements such as sampling or sign posting may be waived. The director shall also be informed of the sampling stations and may modify the number of stations and site selection.

The director may require additional bacterial monitoring by the owner/agent to supplement their existing monitoring program, as may be necessary or appropriate.

9. Reporting

a. When required above, the owner/agent shall submit a written report of the details of the spill within five (5) calendar days of the incident to the director in care of the CWB or WWB as applicable. The director may waive the five day written reporting requirement on a case by case basis provided that the director receives a request for waiver prior to the due date of the report.

The report shall include the date and time of the spill, the amount released, the cause(s) of the spill, location where the spill entered state waters (storm drains, ditches, streams, etc.), clean up efforts, remedial actions to prevent future spills, a summary of the monitoring data, a map of the sampling locations and public notification procedures if applicable.

b. For spills not reported under section 9.a. and when required above, the owner/agent shall tabulate the following information: the date and time of the spill, the amount released, the cause(s) for the spill, clean up efforts, and remedial actions taken to prevent future spills. The owner/agent shall submit each quarter's tabulation to the WWB within 30 days after the quarter.

10. Modifications by the director

With the approval or under the direction of the director, response requirements may be increased, changed, reduced, or eliminated. For example, the director may require the owner/agent to post additional Warning Signs as needed or may assist in the removal of warning signs.

Situation	Immediate Notification to	Press Release[1] or*	Disinfect**	Warning Signs*	Clean Up[2]	Monitor*	Follow Up Written Report to
Into State Waters - All Wastewater Systems (Section 2)	CWB or EHP (SOSC/SHO)	yes	yes	yes	no	yes	CWB
Not Into State Waters w/Public Access - Public Wastewater Systems (Section 3)*	WWB or EHP (SOSC/SHO)[1]	yes	yes	yes	yes	no	WWB*&1
Not Into State Waters w/Public Access - Private Wastewater Systems (Section 4)*	WWB or EHP (SOSC/SHO)[1]	yes	yes	yes	yes	no	WWB*&1
Not Into State Waters w/o Public Access - All Wastewater Systems (Section 5)*	WWB[1]	no	yes	yes	yes	no	WWB*&1

*Except for proven R-1 water and BMP Compliance

**Except for proven R-2 water and BMP Compliance

[1]If spill greater than or equal to 1,000 gallons or spill may threaten public health

[2]Or barricade if clean up not possible

APPENDIX J

Guidelines for the Demonstration of Filtration Performance Criteria

(June 2001)

A. INTRODUCTION

1. Objectives

To demonstrate the efficiency of a non-membrane filtration technology (e.g. granular, cloth, or other synthetic media), a treatment facility will need to consistently and reliably achieve and produce an effluent that does not exceed 2 ntu at any time. For membrane filters (e.g., MF and UF) or Reverse Osmosis (RO) as part of the treatment process train upstream of UV disinfection, the effluent turbidity shall be equal to or less than 0.2 NTU 95 percent of the time, not to exceed 0.5 NTU.

To demonstrate that higher removal rates can be reliably achieved, the treatment facility shall consistently and reliably achieve and produce an effluent that does not exceed the required NTU.

2. Intent

The intent of this protocol is to present a process for demonstrations of technology applicability, but which is not so restrictive that the use of alternate technology is discouraged. The following criteria outline minimum prerequisites for alternate technology review.

a. System Component Evaluation for Leaching Contaminants

System components (such as cartridges, bags, membranes, housings and gaskets) shall undergo National Sanitation Foundation (NSF) standard 61, or equivalent, testing by a qualified third party acceptable to DOH. Such tests shall demonstrate that system components are not leaching or otherwise adding substances to the product water that would violate the R-1 criteria.

B. DEMONSTRATION STUDY GUIDELINES

1. Purpose

The primary purpose of these guidelines is to provide a consensus and standardized method to demonstrate the filtration criteria for the production of R-1 water.

2. Proposals

If a treatment facility elects to produce R-1 water, then a demonstration study should first be prepared that incorporates these guidelines, and submitted for approval to DOH. Demonstration studies under these guidelines should cover a 12 month time period and include all worst-case water quality conditions and quantity variations, unless worst-case conditions can be tested in a shorter time frame. In no case should the study cover less than a six month time frame.

3. Reporting

Quarterly progress reports of demonstration studies should be provided to DOH. The fourth quarter report should also serve as a final report for the demonstration study. All monitoring results are to be included in these reports. A final report incorporating all test results must be prepared and submitted to DOH. Turbidity measurements of product water prior to and after the filter shall be plotted and compared to facilitate evaluation of the test results. The report shall include but not limited to:

a. Turbidity test results showing the number of product water samples after the filter exceeding 2.0 ntu and the number of water samples which exceed 5 ntu prior to filtration (non-membrane filters).

b. Information on operational and performance characteristics, including:

- Special operator skills required (minor, moderate, major)

- Daily log of the number of hours devoted to operation

- Filter run length (gallons, days), and pressure drop at run termination.

- Type and amount of coagulant used to with various levels of influent turbidity. The time for mixing and flocculation should be recorded in order to select the optimal combination. This is optional if the influent is rejected to disposal or a lower approved use.

- For systems which can be backwashed, the procedure, along with any of its attendant chemicals, should be described. The ability to dispose of backwash waste in an environmentally sound manner should be evaluated.

- Record of the cause and duration of any system down-time recorded (e.g. for media replacement, backwashing, routine maintenance, repairs, breakdown and power failure).

4. Monitoring for Studies Demonstrating Higher Removal Efficiency

Water reclamation treatment facilities attempting to demonstrate higher removal efficiency should continuously analyze the effluent at the beginning of the filter run and then at least every four hours. After backwash and during the filter ripening period, samples should be collected of the filter effluent at least every 15 minutes. After the filter has stabilized (when the effluent turbidity reaches a minimum or becomes relatively stable), the samples of the filter effluent should be collected at least every four hours. Also, when the filtration rate is increased or after any other interruption event, monitoring of the filter should be increased to every 15 minutes until the filter has stabilized. During the study, individual filters should be evaluated for a minimum of 40 filter runs, and each of the filters should be evaluated individually during the course of the study to assess each individual filter's performance and identify any errant filters.

5. Monitoring for Studies Demonstrating Effectiveness of an Alternative Technology

Where the intent of the study is to demonstrate the effectiveness of an alternative technology, DOH may reduce the above monitoring requirements commensurate with the nature of the technology.

6. Other Parameters to be Analyzed

During the analysis, the flow rate (instantaneous), total flow, operating pressure, pressure differential, pH, temperature, turbidity, filter rate, filter age, coagulant type fecal coliform and F-specific bacteriophage MS2 should be measured and recorded. Also the date, time, sampler/analyst name, and any other pertinent events should be noted.

7. Sensors

For on-line analysis, the same type of sensor (same make and concentration range) should be used for effluent sample both prior and after the filter.

8. Continuous Sampling

To minimize the number of particles introduced by piping and sampling tubing, locate the on-line sensor sampling point as close to the source as possible, minimizing the length of piping between the source and the sensor. Pumped samples are not recommended since particle aggregation will be dispersed. Also, valves, fittings, and restrictions should not be placed upstream of the sensor, if possible, as they, too, may impart particles into the effluent or break apart aggregates of particles. Sample flow rate should be measured after the sample has passed through the sensor. Flow control is also mandatory, due to the sensitivity of the measurement to even subtle flow changes, and the manufacturer's requirement for flow should be followed.

9. Quality Assurance Program

A formal, written quality assurance (QA) program should be included in the proposal, addressing the issues of instrument calibration, maintenance, and cleaning. The treatment facility should strictly adhere to the manufacturer's requirements and recommendations. Appropriate documentation of these activities is to be included in the study report.

Further, water reclamation treatment facilities should perform daily checks on the their instruments. The QA program should also include an analysis of whether various data meet certain standards.

10. Data Collection

If possible, the turbidity meter should be linked directly to a computer to help eliminate errors in data handling. However, the treatment facility should check and verify computer-generated data as it would in any quality assurance program.

11. Errors

Errors can be the result of a number of factors, and a number of examples follow. Air bubbles can be a source of error. Placing sample under a vacuum is not recommended. It may actually induce air bubbles. As part of quality assurance, calibration and cleaning is crucial for maintaining an accurate and precise instrument and analyses. Thus strict adherence to this guideline is important in order to obtain and maintain quality measurements.

APPENDIX K

UV DISINFECTION GUIDELINES FOR THE PRODUCTION OF R-1 WATER

(June 2001)

1. INTRODUCTION

Ultraviolet (UV) Disinfection. These are the updated version of the guidelines published by the National Water Research Institute on November 1993 for the design of UV disinfection system for the production of tertiary recycled water or R-1 waters. The new guidelines entitled "Ultraviolet Disinfection: Guidelines for Drinking Water and Water Reuse" were published on December 2000. They were prepared by an international panel of experts convened by the National Water Research Institute (NWRI)and the American Water Works Association Research Foundation (AWWARF). These 2000 guidelines were developed to provide a common basis for the evaluation and implementation of UV disinfection technologies. As a minimum, manufacturers are required to demonstrate the efficacy of their equipment as outlined in Chapter Three "Protocols" of the 2000 NWRI UV guidelines. The test facilities and set-up must be acceptable to DOH. The validation must be conducted by a qualified party (other than the manufacturer) who is accepted by DOH. A registered engineer, independent from the manufacturer, with experience or training in UV equipment testing, must witness the test program. When testing is complete, the results shall be summarized in a report and shall be submitted to DOH. This performance-based testing approach is directed toward quantifying the inactivation of target microorganisms (i.e. MS-2 bacteriophage) by UV equipment. For a copy of the 2000 UV guidelines please contact the NWRI. The address is:

10500 Ellis Avenue
P.O. Box 20865
Fountain Valley, CA 92728-0865
(714) 378-3278 (Phone)

Most of the contents of this Appendix were taken verbatim from the 2000 UV guidelines. It provides the key elements involved in the design of the UV disinfection system to assist the UV manufacturer and the design engineer to comply with the R-1 UV disinfection system design. These design criteria must be addressed in the required engineering report. The intent of these guidelines is to ensure that the UV equipment in combination with the filtration process is able to meet the 5 log (99.999 percent) inactivation of the target organism (i.e. MS-2 bacteriophage) and the fecal coliform limits during the full-scale operation of the disinfection unit.

The State of Hawaii would accept performance testing of the UV equipment in the State of California. A letter from the California Department of Health and Services certifying that the UV equipment meets the requirements of the 2000 NWRI UV Guidelines for Water Reuse and a copy of the Engineering Report shall be submitted to the State of Hawaii Department of Health.

If the UV manufacturer decides to conduct the pilot test in Hawaii, in addition to meeting the NWRI/AWWARF UV Guidelines all horizontal (parallel to flow) and vertical (perpendicular to flow) low-pressure, low-intensity and low-pressure, high-output lamp system lamp systems' pilot-scale units shall have a minimum 5 by 4 lamp array to be considered for use in scale-up from pilot-scale to full-scale. This is required to ensure validation for distribution of flow around the lamp sleeves and reactor walls. The Department may also accept full-scale testing of the UV unit to eliminate some of the scale-up problems from pilot to full-scale.

2. DEFINITIONS

"Ambient Temperature" means the outside temperature of a given piece of equipment that is operated on a continuous basis.

"Ballast" means an electromagnetic or electronic device used to provide power to the UV lamps.

"Bank or UV Lamp Bank" means one or more UV modules that the entire flow for a given reactor train must pass through.

"Bioassay" means a biological test used to assess the effectiveness of UV disinfection of the inactivation of microorganisms.

"Collimated-beam Apparatus" means a device used to collimate (make parallel) a source of light.

"Delivered UV Dose" means the dose that is assigned to the UV test reactor based on reactor validation testing. The delivered dose is equivalent to that measured with the collimated-beam apparatus for the same degree of inactivation of the target microorganism.

"Design UV Dose" means the delivered UV dose required for a specific log inactivation of the target microorganism. The design UV dose is used for sizing UV disinfection systems.

"Disinfection channel" means a channel in which either horizontal or vertical arrays of UV lamps are placed for the disinfection of water.

"Fouling Factor" means the reduction in available UV output due to changes in transmittance of the enclosure (i.e. quartz sleeve) separating the UV lamp from the liquid. The reduction in available UV output is determined by comparison to a new and clean enclosure.

"Germicidal Wavelength" means the germicidal range of the electromagnetic spectrum (i.e. wavelengths between 200 and 300 nm).

"Ground Fault Interrupter or GFI" means a device that measures and trips at low leakage electrical current to ground.

"Lamp Age Factor" means the reduction in available UV output at the end of UV lamp life as compared to a new UV lamp, after the appropriate burn-in period.

"Level control device" means any device such as a weir or counter balanced level controller used to maintain the liquid level in the disinfection channel between a minimum and maximum level throughout the complete flow range.

"Maximum week flow" means the maximum seven day flow based on a running seven day average. The maximum week flow should be based on a minimum of one years worth of flow data.

"Media Filtration" means the filtration process using granular, synthetic, or cloth media to remove residual suspended solids.

"Microfiltration" means a pressure-driven membrane process that separates micrometer-diameter and submicrometer-diameter particles (down to approximately 0.1 micrometer-diameter size) from a feed stream by using a sieving mechanism. The smallest particle size removed is dependent on the pore size rating of the membrane.

"Module" means the basic building block of a UV disinfection system. It is comprised of one or more UV lamps with a common electrical feed.

"Operational UV Dose" means the UV dose that is established based on the results of the equipment validation testing. The operational UV dose can be used to make most efficient use of the UV disinfection system (e.g., reduce power demand, reduce number of reactors or reactor trains on-line) while maintaining the design UV dose.

"Peak Flow" means a flow rate of a given magnitude that is sustained for a specific period of time. Because it is difficult to compare numerical peak flow rate values from different treatment plants, peak flow rate values are normalized by dividing by the long-term average flow rate. The resultant ratio is known as a peaking factor.

"Performance Validation Protocol" means a procedure whereby the performance of UV equipment is validated.

"Quartz Sleeve" means an outer jacket of quartz glass used to protect the UV lamp.

"Quartz Sleeve Fouling" means the formation of material on the quartz sleeve, which causes a reduction in the UV intensity emitted from the quartz sleeves.

"Reactor" means an independent combination of single or multiple bank(s) in series with a common mode of failure (e.g., electrical, cooling, cleaning system, etc.).

"Reactor Train" means a combination of reactors in series, including inlet, outlet, and level controlling arrangements (if applicable).

"Reactor Train Inlet" means the inlet arrangement used to direct the flow to a UV reactor train.

"Reactor Train Outlet" means the outlet arrangement used to direct the flow out of a UV reactor train.

"Reverse Osmosis" means the separation (removal) of particulate, colloidal matter, and dissolved solids from a liquid using a thin membrane. The membrane acts as a barrier that will selectively retain certain constituents found in the liquid.

"Standby Bank" means a bank of UV lamps that is used as a standby (substitute) for the operating banks.

"Treatment Process Train" means the assemblage or grouping of treatment units together to achieve a specified treatment objective.

"Ultraviolet Disinfection" means the inactivation of microorganisms by exposure to UV radiation.

"UV Disinfection System" means the combination of reactor trains with associated controls and instrumentation.

"UV Intensity" means the intensity of UV radiation over a wavelength range of 200 to 300 nm.

"UV Intensity Probe" means a device used to measure the intensity of UV radiation striking a UV sensor within a UV reactor.

"UV lamp" means a germicidal lamp used to produce UV irradiation in the range of 200 to 300 nm.

"Ultraviolet (UV) radiation" means a band of nonionizing electromagnetic radiation having wavelengths from 5 to 400 nanometers (nm). Wavelengths that are effective for microorganism inactivation are in the range from 200 to 300 nm. The most effective range is between 250 and 275, with the optimum being between 260 and 265 nm.

"UV Transmittance of Fluid" means the ability of a fluid to transmit UV radiation. Factors known to affect UV transmittance of a fluid include: dissolved organics, dissolved iron, color (textile dyes) and turbidity. UV transmittance is quantified by spectrophotometric measurement at wavelengths between 200-300 nm using a 1- cm pathlength. The wavelengths to be measured are determined by the output spectrum of the lamp (e.g. low pressure at 254 nm, medium pressure from 200-300 nm).

"UV 254 Absorbance" means the absorbance of electromagnetic radiation at a wavelength 254 nm by a liquid through a 1-cm pathlength.

"Uninterruptible Power Supply or UPS" means methods used to provide a continuous power supply to a treatment process.

"Velocity Profiles" means a measure of the variability of the flow velocity across a cross-section perpendicular to the flow.

3. UV DOSE

The UV dose is defined as the product of UV intensity, expressed in milliwatts per square centimeter (mW/cm^2), and the exposure time of the fluid particle to be treated, expressed in seconds (s). The units of UV dose are expressed as milliwatt seconds per square centimeter ($mW.s/cm^2$), which is equivalent to millijoules per square centimeter (mJ/cm^2). Currently, it is only possible to accurately characterize the UV dose when using a collimated-beam apparatus because both the intensity reaching the fluid elements and the exposure time can be accurately quantified. Non-ideal hydraulics and non-uniform intensity profiles result in distribution of doses being applied in continuous flow reactors, the terms "delivered UV dose", "design UV dose", and "operational UV dose" will be used hereafter. These terms are defined Section 2 of this Appendix.

The design of a UV disinfection system depends on the type of filtration technologies preceding it. The following minimum criteria shall be used for these three types of filtration:

Media Filtration

When using non-membrane filtration (e.g. granular, cloth, or other synthetic media) as part of the treatment process train upstream of UV disinfection, the following performance criteria shall apply:

- The design UV dose shall be at least 100 mJ/cm^2 under maximum day flow.
- The filtered UV transmittance shall be 55 percent or greater at 254 nanometers (nm).
- The filtered effluent is diverted when its turbidity exceeds two (2) NTU.

Collimated-beam apparatus testing on site-specific filtered wastewater, in accordance with the equipment validation protocol (see Chapter Three of the NWRI UV guidelines), shall be conducted to confirm compliance with the indigenous indicator microorganism (e.g., total or fecal coliform bacteria). The minimum design UV dose under the maximum day flow condition shall be either 100 mJ/cm^2 or a delivered dose corresponding to the collimated-beam apparatus dose required for achieving indigenous indicator microorganism inactivation, whichever is greater.

Membrane Filtration

When using membrane filtration (e.g., MF and UF) as part of the treatment process train upstream of UV disinfection, the following performance criteria shall apply:

- The design UV dose shall be at least 80 mJ/cm^2 under maximum day flow.
- The effluent turbidity shall be equal to or less than 0.2 NTU 95 percent of the time, not to exceed 0.5 NTU.
- The filtered effluent UV transmittance shall be 65 percent or greater at 254 nm.

Reverse Osmosis (RO)

When using RO as part of the treatment process train upstream of UV disinfection, the following performance criteria shall apply:

- The design UV dose shall be at least 50 mJ/cm^2 under maximum day flow.
- The effluent turbidity shall be equal to or less than 0.2 NTU 95 percent of the time, not to exceed 0.5 NTU.
- The permeate UV transmittance shall be 90 percent or greater at 254 nm.

Rationale

Establishing the UV dose involves determining the UV inactivation of a selected microorganism under controlled batch conditions. For equipment performance validation, MS-2 is recommended. The benefits of MS-2 include high resistance to UV, nearly first order inactivation kinetics over the range of UV doses typically used for disinfection, ease of seeding and enumeration, consistent and reproducible assay results, non-pathogenicity to humans, and the inability to photoreactivate. For the purpose of standardization, the delivered UV dose is defined as achieving the same degree of MS-2 inactivation in a continuous flow reactor as is achieved in a collimated-beam apparatus reactor equipped with a low-pressure, non-ozone producing mercury lamp. Details *are provided in Chapter III of the 2000 NWRI UV Guidelines.*

Based on experience, when UV disinfection systems are used with granular medium filtration, it has been found that coliform bacteria inactivation often governs the design requirements. Particulate matter shields bacteria from UV light to various degrees. While the delivered dose of 100 mJ/cm^2 is typically adequate to inactivate total coliform to less than 2.2 MPN/100 mL, in light of variability that has been observed in reuse systems, collimated beam testing with actual filtered effluent is required to confirm the impact of particle-associated coliform on UV disinfection effectiveness. Five-log$_{10}$,(inactivation of poliovirus can be achieved with a UV dose of 50 mJ/cm^2; therefore, the design UV dose of 100 mJ/cm^2 is suggested to account for variability in the effluent quality.

When using MF or UF, the impact of particles is eliminated and viruses are the pathogen of concern. Five-log$_{10}$ inactivation of poliovirus can be achieved with a UV dose of 50 mJ/cm^2; therefore, the design UV dose of 80 mJ/cm^2 is suggested to account for variability in the effluent quality.

When using RO for filtration, at least two log$_{10}$ of viruses will be removed through the RO process. Three-log$_{10}$ inactivation of poliovirus can be achieved with a UV dose of about 30 mJ/cm^2; therefore the design UV dose of 50 mJ/cm^2 is suggested to account for variability in the effluent quality.

The UV transmittance and turbidity requirements represent experience from a number of operating facilities. This does not preclude the use of UV in systems with water-quality characteristics outside these limits. In order to use UV in these instances, the performance of the UV reactor must be validated under poor water-quality conditions.

Design Conditions

The design UV dose must be based on the following design conditions:

1. The UV lamp output at 50 percent of nominal (new) UV lamp output (after an appropriate burn-in period), unless the manufacturer establishes the lamp age factor for the time period that corresponds to the lamp change-out time intervals specified in the Engineering Report. The lamp age factor shall be verified in accordance with the protocols in Chapter 3 of the 2000 NWRI UV Guidelines.

2. Eighty percent transmittance through the quartz sleeve for manually cleaned systems, excluding the transmittance characteristics of the quartz sleeve.

3. Eighty percent transmittance through the quartz sleeve for automatic mechanical or chemical cleaning systems, excluding the transmittance characteristics of the quartz sleeve, unless test data are provided to substantiate a higher value in accordance with the protocols in Chapter 3 of the 2000 NWRI UV Guidelines. The cleaning frequency will be based on the manufacturer's recommendation.

4. If transmittance data (a minimum of three samples per day spaced equally over the operating period) have been collected for a minimum period of 6 months, including wet weather periods, the 10-percentile UV transmittance value can be used. The UV transmittance measurements shall be at 254 nm wavelength.

Rationale

Based on lamp testing data, it appears that the operating conditions for water reuse UV disinfection systems result in an accelerated decrease in UV lamp intensity when compared to those tested in air. The lamp age factor of 0.5 is representative of conventional low-pressure lamps after 1 year of service. This age-value is recommended for all lamp systems unless data are collected in accordance with the protocols in Chapter 3 to substantiate a different design value. For polychromatic lamps, the impact of lamp age and fouling on lamp output characteristics and individual wavelengths emitted are not known. Therefore, the same factors are assumed for polychromatic lamps until additional data are available.

4. Reactor Design

Because of the numerous system configurations that are available (e.g., open channels, closed conduits, various lamp orientations, etc.), UV facilities will have different scale-up, layout, and mechanical redundancy requirements.

Reactor trains should be designed with approach, inlet, and outlet conditions that promote plug flow (i.e., minimal longitudinal mixing, effective lateral mixing) within the irradiated zone. There must be reliable flow distribution among multiple reactor trains proportional to reactor train flow capability. Inlet approach conditions should allow sufficient distance to establish a uniform velocity field upstream of the first reactor in a reactor train, unless an alternate velocity field can be measured and demonstrated to provide satisfactory performance in accordance with the protocols in Chapter Three of the NWRI UV 2000 guidelines. The outlet condition should ensure that hydraulic behavior within the last reactor is not adversely affected by any outlet fluid-level control device or pipefittings.

Regardless of the equipment utilized, the standby equipment and reliability features that are described in Section 5 of this Appendix must be integrated in the design of the UV disinfection system.

Hydraulic Constraints

The design of the reactor train(s) inlet and outlet are the responsibility of the UV manufacturer and should be characterized using velocity profiles. Hydraulic testing, including the measurement of velocity distribution profiles, must be performed as part of the UV validation testing (see Chapter 3 of the 2000 NWRI UV Guidelines). The inlet and outlet velocity profiles must be maintained between the validated UV equipment and full-scale installation. Maintenance of velocity profiles may require the use of facilities for modifying the flow pattern, such as perforated plate diffusers or other devices (similar or in addition to those used during validation testing), as part of the full-scale reactor train. The reactor train shall be designed to operate at the same approach velocity range used for equipment validation (see Chapter Three of the 2000 NWRI UV Guidelines).

For full-scale reactors that use more lamps than the reactors used for validation testing, velocity profiles shall be established in accordance with the Chapter 3 protocols of the 2000 NWRI UV Guidelines. For these reactors, it must be demonstrated that the mean measured velocity at any measured cross-sectional point (excluding momentum boundaries [i.e., stationary surfaces such as reactor walls]) does not vary by more than plus or minus 20 percent from the theoretical average velocity (i.e., flow divided by the cross-sectional area), unless an alternate velocity field can be measured and demonstrated for both pilot- and full-scale reactors to provide satisfactory performance.

Scale-up of pilot data for full scale design is allowable only for those systems where velocity profiles can be adequately quantified for both the equipment used for validation testing and for the full-scale reactor. It is not permitted to scale-up the pilot reactor if the velocity profiles cannot be quantified adequately. In such instances, only modular arrangements of the validated reactor can be implemented in full-scale operation. A minimum of two reactors in series shall be used in equipment validation testing (see Chapter Three of the 2000 NWRI UV Guidelines).

In the layout of the UV disinfection system, the following hydraulic factors (based on the equipment validation test results) must be addressed:

1. The required approach length and conditions prior to the first reactor.

2. The downstream length following the last reactor before the fluid-leveling device (if applicable) or other piping elements (e.g., valves, bends).

3. The spacing between multiple UV reactors. The spacing must allow for maintenance and access in addition to adequate hydraulic performance.

4. Any device, reactor component, or other feature that is used to accomplish or enhance effective uniform velocities.

5. The presence and operation of any cleaning device/mechanism.

Rationale

Based on currently available information, excessive longitudinal mixing in the irradiated zone promotes the broadening of dose distribution. Similarly, inadequate lateral mixing can promote a wide dose distribution where some fluid elements may receive an inadequate UV dose. A properly designed inlet structure and approach will help ensure that uniform flow conditions are imposed on the first reactor in a UV reactor train. Concurrently, a properly designed outlet structure or piping will ensure that outlet conditions do not adversely affect fluid behavior within the last reactor. Uniform flow distribution is typically desirable, but does not guarantee adequate hydrodynamic behavior in the irradiated zone.

Reactor Train Layout Constraints

The number of reactor trains included must consider the hydraulic limitations and turndown ratios for the given UV disinfection system. Multiple reactor trains may be required to accommodate large variations from low-flow to peak-flow conditions. The sizing and layout of reactor trains must ensure that the reactor train velocities are within the velocity range that the equipment was validated for. Critical design elements include:

1. Reactor walls shall be consistent with the manufacturer's recommendations.

2. It must be possible to isolate each reactor train during maintenance.

3. Concrete channels shall be adequately lined or coated to ensure that organisms do not become embedded within crevices. All material exposed to UV radiation shall be UV resistant.

4. The upstream and downstream portions of the UV reactor and the sections between reactors must be water and light tight (e.g., covered) and must prevent external runoff or other materials from entering the UV reactor train.

Rationale

Extreme flow conditions (i.e., low and peak flow), which may exceed the velocity ranges acceptable for a given reactor design, can be mitigated by the use of multiple reactor trains. Because lamps may break during maintenance, the ability to isolate a reactor during maintenance would aid in containing contaminated water. Variations in reactor walls can result in regions of low UV intensity that would aid in passing inadequately disinfected fluid elements. Lining of concrete channels would aid in preventing microorganisms from growing within crevices of the channel, which could adversely affect disinfection performance. Reactor train(s) must be sealed or covered to avoid the growth of algae containing biofilms and to protect the health of personnel.

Cleaning System Constraints

As part of the UV disinfection system, the cleaning system must deal effectively with site-specific water-quality effects (e.g., precipitation and fouling due to iron, calcium, aluminum, manganese, and other inorganic and organic constituents). Site-specific testing is recommended when iron, calcium, aluminum, manganese, and magnesium concentrations are present at concentrations relative to saturation limits. The fouling test can be done on a scale sufficient to include the smallest modular size of the commercial cleaning device.

Rationale

The effectiveness of a UV disinfection system is, in part, *maintained by the performance of the cleaning system. Iron, calcium, aluminum, manganese, and magnesium have been observed to impact the effectiveness and frequency of cleaning requirements. Site-specific testing is recommended when any of these constituents are present at concentrations that can result in the fouling of quartz sleeves.*

5. Reliability Design

Because regulatory standards associated with unrestricted water reuse are stringent, special attention must be devoted to the reliability of any proposed UV disinfection system, including standby equipment, water-quality reliability, operation and maintenance, power-supply and reliability, electrical safety, and design for seismic loads.

Standby Equipment

The UV disinfection system should be designed to convey the design UV dose (see section 3) under worst-case operating conditions (e.g., flow rate, water quality) to the pathogen passing through the reactor train. At a minimum, two reactors must be simultaneously operated in any on-line reactor train. Standby UV equipment must be provided by one of the following options:

- A standby reactor per reactor train.
- A standby reactor train.

As an alternative to standby equipment, adequate storage or other contingency arrangements can be provided to deal with the flow during UV disinfection system failure and must be described in the required Engineering Report. The storage or backup disposal shall meet the requirements of Hawaii Administrative Rules (HAR) Chapter 11-62 and Chapter IV, Sections K & L of these guidelines.

The UV disinfection system must be capable of applying the required design UV dose with any failed or out-of-service reactor. Failure can be due to any number of conditions including, but not limited to, failure of the power supply, cleaning mechanism, and cooling system for electrical components.

Rationale

System component failure can be expected with any treatment process. The UV disinfection system must be capable of producing *disinfected reclaimed water during any component failure prior to distribution. A minimum of two operating reactors per train ensures that some disinfection occurs until the standby reactor is brought on-line in the event that one of the on-line reactors fails.*

Feed Water Quality Reliability

In the event that the upstream treatment process produces water unsuitable for UV disinfection (e.g., excessive turbidity, low transmittance), the contingency plan addressed in the Engineering Report shall be implemented.

Rationale

UV influent of poor quality may not be properly disinfected.

Operation and Maintenance

The operation and maintenance procedures for the UV disinfection system shall be included in the Engineering Report. Operators should receive specific training on the operation of UV disinfection systems.

Lamp breakage and the resulting release of mercury into the water stream is a concern with UV disinfection systems using mercury vapor lamps. A reactor train shall be isolated from the flow stream during maintenance and repair. A contingency plan must be developed as a part of the Engineering Report to address the lamp breakage issues and must be implemented upon lamp breakage.

Rationale

Reliable operation requires proper training and the timely maintenance, replacement, and calibration of system components. The presence of mercury is of concern because it can be detrimental to public health and aquatic life.

Power Supply Reliability

To ensure a continuous supply of power, the UV disinfection system must be provided with standby power and a looped power-distribution system (should one of the power supply lines fail). The disinfection system components of the same type (i.e., banks) must be divided among two or more power-distribution panel boards or switchboards to prevent a common mode of failure. Storage or alternate disposal methods of improperly treated or disinfected water must be available if continuous power supply, including standby power, is not provided.

The UV disinfection system design must account for the technology being utilized. Special consideration must be provided for:

1. *Short-term power interruptions*. If the UV disinfection system cannot be immediately restarted upon a short-term power interruption, a UPS must be considered with the design. If UPS facilities are not provided, a contingency plan (i.e., storage) must be provided.

2. *Ambient temperature*. The facility design must provide for the effect of ambient temperature on ballast cooling and other electrical components.

3. *System harmonics*. The facility must address the impact of electrical harmonics generated by the UV disinfection on the plant power supply and other electrical systems.

Rationale

Because the UV disinfection system cannot operate without electrical power, reliable power supply and backup power are essential to ensure continuous disinfection (unless the reclamation plant has alternative reliability provisions or disinfection capabilities). Using multiple panel boards or switchboards would allow part of the system to remain on-line, even if one of the power-distribution panel boards or switchboards should fail.

Electrical Safety Design

All UV disinfection systems shall be provided with GFI circuitry.

Rationale

GFI circuitry is required to minimize hazard to personnel in the event of lamp breakage or any other circumstance that could create direct electrical contact with water.

Seismic Design

The UV disinfection facilities (e.g., building, structures, piping) should be designed in accordance with the seismic design requirements applicable for the seismic loads characteristic of the region in which the system is utilized. These same seismic standards shall apply to structures where UV replacement equipment is stored on-site.

Rationale

Seismic design considerations are particularly important for UV disinfection systems because of the fragile components (especially lamps and quartz sleeves) used in the systems. The seismic safety design of the UV disinfection system should be at least equivalent to the design of the reclamation facilities prior to disinfection. This provision will ensure that whenever the plant is capable of producing effluent, the UV disinfection system will provide adequate disinfection.

6. Monitoring and Alarm Design

The ability to monitor operating parameters continuously is important in the operation of a UV disinfection system to ensure that adequate disinfection is provided. The continuous monitoring of parameters used to adjust the operational UV dose, UV disinfection system components, and proper calibration of on-line monitoring equipment are critical to maintaining the effectiveness of UV disinfection systems.

Continuous Monitoring

The following parameters must be monitored continuously:

1. Flow rate.
2. UV intensity.
3. UV transmittance.
4. Turbidity.
5. Operational UV dose.

UV Disinfection System

Monitoring of the following UV disinfection system components shall be provided:

1.Status of each UV reactor, On/Off.

1. Status of each UV lamp, On/Off.

2. UV intensity measured by at least one probe per reactor.

3. Lamp age in hours.

4. Cumulative number of reactor On /Off cycles.

5. Cumulative UV disinfection system power consumption.

6. Reactor power set point (for systems with variable power input to lamps).

7. Liquid level in the UV disinfection reactor trains (for all UV disinfection systems with free water surfaces and for installations where UV lamps can be exposed to air).

8. GFI.

Verification and Calibration of Monitoring Equipment

UV intensity probe readings shall be verified (and calibrated, as necessary) at least monthly, using a reference UV intensity probe (see Chapter Three "Protocols" of the 2000 NWRI UV Guidelines). The location of the on-line intensity probe(s) and the reference probe must be identical to those in the UV reactor used for performance validation. The calibration of turbidity and UV transmittance monitoring equipment shall be in accordance with manufacturers' recommendations. In addition, laboratory measurements of the UV transmittance of grab samples shall be used to verify the accuracy of on-line transmittance monitoring equipment on a weekly basis.

Rationale

Flow rate, UV transmittance, and UV intensity measurements are needed to establish the operational UV dose. Continuous determination of the operational UV dose is technologically feasible and is consistent with the current requirement for continuous chlorine residual monitoring. The procedure for establishing the operational UV dose shall be included in the Engineering Report. Turbidity and UV transmittance monitoring data can be used to initiate responses to deteriorating UV influent quality. The depth of water in the reactor train must be controlled carefully to prevent the depth of water above the top UV lamps from exceeding a predetermined design maximum value (for UV disinfection systems with free water surface), which could result in inadequate disinfection, and to prevent lamps from being out of the flow and losing the effect of their UV radiation due to low water levels. The status of each UV reactor and UV lamp is needed to provide on-line monitoring of the operation of the UV disinfection system. UV intensity and lamp age are used to determine the need for cleaning and/or change-out of the lamps. GFI can be caused by a number of factors, including lamp breakage.

Alarms

To protect public health, both high-priority and low-priority alarms are required for the operation of a UV disinfection system. If left unattended, high-priority alarm conditions will compromise the performance of the UV disinfection system. Although low-priority alarm conditions will not compromise the performance of the UV disinfection system, corrective measures must be instituted before high-priority conditions occur. The set point for these alarms will vary as a function of specific site conditions. The set point should allow for adequate response time based on the importance of the alarm and subsequent consequences. The settings for the alarms shall be specified in the engineer's report. As a minimum, the following high-priority and low-priority alarms are required:

High-priority Alarms

- Adjacent lamp failure - when two or more adjacent lamps fail.
- Multiple lamp failure - when more than 5 percent of the lamps in a reactor fail.
- Low-low UV intensity - when the intensity probe reading drops below a predetermined set point.
- Low-low UV transmittance - when the influent water reuse UV transmittance drops below a predetermined set point.
- High-high turbidity - when the influent turbidity to the disinfection unit exceeds a predetermined set point.
- Low-low operational UV dose - when the operational UV dose drops below the predetermined set point.
- High water level - when the water level in the UV reactor train exceeds a predetermined water level (for UV disinfection systems with free water surface).
- Low water level - when the water level in the reactor or reactor train falls below a predetermined water level.
- GFI.

Rationale

The low-low operational UV dose, low-low UV intensity, and high-high turbidity shall activate the contingency plan response, regardless of the cause. For other high priority alarms, the operational UV dose should be increased by activating a standby reactor(s) or reactor train(s) (i.e., when the UV disinfection performance is being compromised).

Low-priority Alarms

- Individual lamp failure (if a single lamp is less than 5 percent of the total lamps in a reactor) - the location of the lamp is to be indicated by reactor and lamp sequence.
- Low UV intensity - when the intensity probe reading drops below a predetermined set point.
- Low UV transmittance - when the influent UV transmittance drops below a predetermined set point.
- High turbidity - when the influent turbidity exceeds a predetermined set point.
- Low operational UV dose - when the operational UV dose drops below the predetermined set point.

Rationale

For the low operational UV dose and low UV intensity alarms, the UV dose should be increased by automatically activating a standby reactor(s) or reactor train(s). The operator then needs to investigate and address the cause for the alarm. Other low-priority alarms indicate that maintenance is required. For example, a low UV transmittance alarm causes a low-priority alarm, requiring the operator to investigate the problem. The operator may activate a standby reactor(s) or reactor train(s) during investigation or repair, as appropriate.

When variable output lamps are used for the UV disinfection system offering a dose-based control strategy, the Engineering Report will describe the methodology for complying with the high-priority and low-priority alarms.

UV Alarm Records

All high- and low-priority alarm conditions shall be automatically recorded.

7. Field Commissioning Test

The following items shall be tested and verified before initiating the production of recycled water:

1. Electrical components.
2. Inlet/outlet velocity distribution (if full-scale reactors use more lamps than the reactors used for validation testing).
3. Water level.
4. Flow split between reactor trains.
5. Controls and alarms.
6. Instrument calibration.

A report documenting and detailing the field-commissioning test results shall be submitted for review to DOH.

Rationale

The commissioning test is critical to ensure the proper operation of the UV disinfection system and its conformance with design.

8. Performance Monitoring.

Performance monitoring for UV disinfection systems shall include microorganism sampling and the continuous on-line measurements delineated in section 6.

Microorganism Sampling

Routine monitoring based on representative samples should include the following:

- Coliform bacteria and/or

- Other microorganisms, as required.

The samples for coliform bacteria and other microorganisms shall be collected downstream of the UV disinfection system at a time when water reuse characteristics are most demanding on the treatment and disinfection facilities. The sampling frequency shall be consistent with permit requirements.

Rationale

The required sampling program for performance compliance shall be consistent with the sampling requirements specified by the DOH.

Monitoring of Operational UV Dose

The operational UV dose delivered by the UV disinfection system is to be determined and monitored continuously as described in section 6.

Rationale

Continuous determination of the operational UV dose, in conjunction with the other continuous monitoring data, is comparable to monitoring chlorine residual in chlorine disinfection systems. The operational UV dose can be used to make most efficient use of the UV disinfection system while maintaining the design UV dose.

9. Engineering Report

For water reuse facilities that have not submitted an engineering report, a complete engineering report shall be prepared by a registered engineer experienced in the field of wastewater treatment and submitted to the DOH prior to the implementation of a UV disinfection system.

For existing water reuse facilities for which an engineering report acceptable to the DOH has been submitted and for which UV is proposed for disinfection, the following types of reports may be required:

1. A complete, updated engineering report may be required if, since submission of the last engineering report, changes or modifications have occurred in the production of reclaimed water (e.g., treatment processes, plant reliability features, monitoring, or operation and maintenance procedures), reclaimed water transmission and distribution system, or reclaimed water

use area (e.g., type of reuse, use area controls, or use area design). The necessity to submit a complete, updated engineering report in lieu of an abbreviated report that only addresses the UV disinfection system will be at the discretion of DOH.

2. An abbreviated engineering report in which only the UV disinfection system and related treatment and reliability features is addressed is acceptable only if the proposed modifications solely involve disinfection processes (e.g., replacing or enhancing existing disinfection facilities with UV disinfection facilities). However, the engineering report should provide an evaluation of how well the UV disinfection system will integrate in the treatment process train.

UV Disinfection System Design Basis

Provide a schematic and detailed description of the UV disinfection system. Provide sufficient detail to clearly show that the design and operational requirements conform with validation protocol and scale-up requirements, when applicable. As a minimum, the following information should be provided:

1. Reactor and reactor train layout and dimensions, inlet and outlet configuration, reactor train velocity range, and any devices used to modify the flow within the pipes or channels.

2. Description of the UV reactor; number, manufacturer, and type of UV lamps (including arc length); ballast; modules; banks; and electrical facilities.

3. Sleeve configuration and characteristics (e.g., sleeve material, sleeve diameter, sleeve thickness, and spacing).

4. Monitoring and controls, including the number, location, and function of monitoring equipment.

5. The water level relative to the UV lamps and level control device.

6. The anticipated number of reactor trains under low- and peak-flow conditions and the corresponding inlet and outlet velocity ranges.

7. Details of the bioassay experiments and the procedure used to derive the operational UV dose.

8. Applicable seismic design codes.

The equipment validation report shall be appended along with a description of how the information contained within the validation report was used in the layout, scale-up, and design of the UV disinfection system. A certificate shall be provided by the manufacturer to verify that the equipment supplied with respect to lamp spacing, type of lamp, quartz sleeve characteristics, and ballasts (as required above) is identical to the technology used in the validation testing.

Monitoring

The engineering report must describe a monitoring program. Where continuous analyses and recording equipment are used, the method and frequency of calibration must be stated. Items to be described in the monitoring section include:

1. The monitoring system used to determine and record the operational UV dose, including equipment and procedures used to monitor and record flow, UV intensity, and UV transmittance.

2. The method of monitoring the water level for open channel systems.

3. The method of monitoring lamp outages.

4. The sampling location and frequency for collecting microbial samples.

Reliability

The proposed UV disinfection system reliability features must be described in detail. When alarms are used to indicate system failure, the report must state where the alarm will be received, how the location is staffed, and who will be notified. The report must also state the hours that the plant will be staffed and operated.

Contingency Plan

The report must contain a contingency plan that delineates the actions to be taken for the following conditions:

1. Lamp breakage (mercury release).
2. Low-low operational UV dose, low-low UV intensity, or high-high turbidity alarms.
3. Failure of the upstream treatment processes or the UV

disinfection system.

4. Power supply interruptions.

The person or persons responsible for implementing the contingency plan must be identified along with the methods used to notify them. A plan for notifying the reclaimed water users, the responsible regulatory agencies, and other agencies, as appropriate, of any treatment failures that could result in the delivery of inadequately treated wastewater to the use area should be included as part of the contingency plan.

Operator Certification and Training

A description of the program to be implemented for training treatment plant personnel in the operation and maintenance of the UV disinfection system must be defined.

Operation and Maintenance

The engineering report must include an operations plan for system operation and maintenance. This plan should include a description of the control system, alarm functions, records, and reports. The plan should outline procedures and the frequency for sleeve cleaning, lamp replacement, maintenance of system components, and the frequency for calibrating the monitoring equipment. The location, access, and quantity of a backup supply of lamps and other critical components should be identified.

APPENDIX L

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