State of California—Health and Human Services Agency
Department of Health Services

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STATE OF CALIFORNIA
DIVISION OF DRINKING WATER
AND
ENVIRONMENTAL MANAGEMENT

TREATMENT TECHNOLOGY REPORT
FOR
RECYCLED WATER

January 2007

This document has been developed to serve as a reference source for those seeking information concerning technologies that have been recognized by the California State Department of Health Services (CDHS) as being acceptable for compliance with treatment requirements of the California Recycled Water Criteria. This is a "living" document that will be updated periodically as needed. Readers who find errors or omissions should contact Jeff Stone of the CDHS Recycled Water Unit at jstone1@dhs.ca.gov.

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STATE OF CALIFORNIA
DEPARTMENT OF HEALTH SERVICES
DIVISION OF DRINKING WATER
AND
ENVIRONMENTAL MANAGEMENT

TREATMENT TECHNOLOGY REPORT FOR RECYCLED WATER

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State of California
Department of Health Services
Division of Drinking Water

Treatment Technology Report for Recycled Water

January 2007

1. INTRODUCTION

The purpose of this document is to provide general reference information concerning those treatment technologies that are being utilized for meeting the filtration performance and disinfection requirements for compliance with the California Recycled Water Criteria (Title 22, et. seq.). The information contained herein was generated from a review of files and correspondence of the California State Department of Health Services (CDHS), and discussions with Field Operations Branch District Staff, SWRCB Staff, industry representatives and manufacturers. All referenced reports, letters and other documents are on file with the Department's Recycled Water Unit. This reference document may not reflect all treatment technologies in place in California, but will be updated as additional information is obtained.

The California Water Recycling Criteria (adopted December 2000) define Disinfected Tertiary Recycled Water as a wastewater, which has been oxidized and meets the following:

A. Has been coagulated* and passed through natural undisturbed soils or a bed of filter media pursuant to the following:

   1. At a rate that does not exceed 5 GPM/ft^2 in mono, dual or mixed media gravity or pressure filtration systems, or does not exceed 2 GPM/ft^2 in traveling bridge automatic backwash filters; and

   2. The turbidity does not exceed any of the following; a daily average of 2 NTU, 5 NTU more than 5% of the time within a 24-hour period, and 10 NTU at any time.

      *Note: Coagulation may be waived if the filter effluent does not exceed 2 NTU, the filter influent is continuously measured, the filter influent turbidity does not exceed 5 NTU, and automatically activated chemical addition or diversion facilities are provided in the event filter effluent turbidity exceeds 5 NTU.

OR

B. Has been passed through a micro., nano., or R.O. membrane following which the turbidity does not exceed any of the following: 0.2 NTU more than 5% of the time within a 24-hour period and 0.5 NTU at any time.

AND

C. Has been disinfected by either:

1. A chlorine disinfection process that provides a CT of 450 mg-min/l with a modal contact time of not less than 90 minutes based on peak dry weather flow, or

2. A disinfection process that, when combined with filtration, has been demonstrated to achieve 5-log inactivation of virus.

2. GENERAL GUIDANCE

The following guidance is consistent with the Water Recycling Criteria and will serve as the basis for CDHS review and acceptance of treatment technologies for compliance with the filtration and disinfection requirements of the Criteria.

FILTRATION

Filters meeting the definition of "filtered wastewater" under Section 60301.320 (a&b) and those demonstrating equivalency under Section 60320.5 ("Other Methods of Treatment") outlined in the Water Recycling Criteria are allowed the option of either disinfection approach outlined in Section 60301.230 without additional restrictions or requirements.

The Department considers a properly filtered and disinfected recycled water meeting the turbidity performance and coliform requirements outlined in the criteria to be essentially pathogen free. As noted by Asano et al.[(1)], "To achieve efficient virus removal or inactivation in tertiary treatment, two major criteria must be met: 1) the effluent must be low in suspended solids and turbidity prior to disinfection to prevent shielding of viruses and chlorine demand, and 2) sufficient disinfectant must be applied to the wastewater." Treatment requirements determined necessary to meet the disinfected tertiary – 2.2 criteria outlined in the Criteria include media filtration to reduce turbidity to less than a daily average of 2 NTU or membrane filtration to reduce turbidity to less than a daily average of 0.2 NTU, and disinfection to ensure a minimum CT of 450 milligram-minutes per liter at all times. This treatment scheme is intended to remove solids (including some pathogens)

and properly prepare the water for effective disinfection in order to achieve an approximately five-log reduction of virus.

However, with respect to many existing technologies, there has yet to be a demonstrated correlation between turbidity and pathogen concentration. The current turbidity performance standards for media and membrane filtration are based on achievable turbidity performance and do not assure any specific minimum level of pathogen removal. This is a recognized issue in the regulations that needs to be addressed by the Department and the water recycling industry.

Since the Pomona Virus Study[2], biological treatment has introduced additional variables into the picture, as the type of biological treatment can impact the particle size distribution and downstream filter and disinfection performance. However, the integration of these processes, into a process train, are not well understood at this time and must be addressed by industry and regulators. Nevertheless, it remains the intent of the Department to produce an essentially pathogen free effluent by maintaining a 5-log virus removal/inactivation barrier through filtration and disinfection.

Additional information concerning treatment technologies may be found in **Appendix A** (California Department of Health Services-Reduction of Virus and Bacteria by Filtration and Disinfection, October 2001).

It must be recognized that the Title 22 filtration performance requirements, as outlined under Section 60301.320, must be reliably met by all filtration technologies. It is suggested that recycled water producers develop and implement plant performance optimization plans and make a reasonable effort to minimize effluent turbidity levels. Furthermore, all treatment facilities should be operated in accordance with the manufacturer's recommendations and specific conditions of approval developed by CDHS.

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1. Asano, T.; Tchobanoglous, G.; and Cooper, R.C (1984), "Significance of Coagulation-Flocculation and Filtration Operations in Wastewater Reclamation and reuse", in Symposium Proceedings, The Future of Water Reuse, Water Reuse Symposium III, San Diego, California, August 26-31, 1984. American Waterworks Association Research Foundation.

2. County Sanitation Districts of Los Angeles County (1977), "Pomona Virus Study, Final Report", Prepared for Calif. State Water Resources Control Board, Sacramento, Calif., and USEPA, Washington, D.C

UV DISINFECTION

UV Disinfection Guidelines were first published in 1993 by the National Water Research Institute (NWRI). Since that time, the field of ultraviolet disinfection has taken great strides forward. As a result of the progress made in understanding the UV disinfection process, the CDHS and the NWRI agreed that it was time to revise and update the guidelines. NWRI and the American Water Works Association Research Foundation (AWWARF) pooled their resources in order to revise the original guidelines, which now cover water recycling and drinking water UV disinfection applications. As a result of these efforts the *"Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse"* were published by NWRI/AWWARF in December 2000 and revised as a Second Edition dated May 2003. CDHS endorses the May 2003 Guidelines and refers to them when evaluating UV disinfection proposals. One major recommendation of the guidelines is that all UV equipment (including previously approved equipment) be tested and validated under these new guidelines before being accepted by the Department. For existing systems approved under earlier guidelines, documentation of compliance with the May 2003 guidelines should be provided when permits issued by the Regional Water Quality Control Boards come up for renewal. It is believed that existing UV disinfection systems that were properly designed should comply with the elements of the revised guidelines.

The implication of the recommendations contained in the revised guidelines is that even the horizontal low-pressure low intensity UV systems must be validated before they are accepted for a UV disinfection application. Previously accepted UV technologies that were considered to be nonconforming under the 1993 guidelines will also have to be retested using the recommended testing procedure. The UV technologies listed herein include a note indicating whether compliance with the most recent 2003 guidelines has been demonstrated by the manufacturer.

Agencies that are in the stages of planning or early design have the most flexibility and should be able to require completion of UV validation testing before they accept delivery of the UV equipment. Therefore, the agency can plan and begin the design work around a given UV system, but not allow delivery of equipment until validation testing is completed. This will allow comparison of the UV reactor design to the validation test results in order to ensure adequate sizing and performance of the UV system. This could be done as part of design review process, i.e., while the design is not yet complete.

If the design process has been completed and the contract for equipment has been signed, there will be fewer recourses for the utility. However, the utility can require a demonstration of performance or performance guarantee on the equipment for their own protection.

It is important to note that these are only “guidelines” and are therefore not limiting with respect to alternative approaches a manufacturer or project proponent may propose for consideration on a case-by-case basis. It is possible however that future regulations may be based on these guidelines.

Appendix B is an advisory memo dated November 1, 2004 that the Department sent to the Regional Water Quality Control Boards in California concerning the importance of cleaning of UV quartz sleeves and outlines recommendations to help ensure effective disinfection.

(Continued on next page)

3. FILTRATION TECHNOLOGIES

The following technologies have demonstrated their ability to meet the performance objectives of Title 22. The "STATUS" designation gives an indication as to which technologies have been given formal Departmental recognition. For projects proposing a technology which is not listed herein or whose "STATUS" is unknown, a review of the proposal should be conducted by the Recycled Water Unit prior to acceptance.

***NOTE**: The Department strongly recommends that when utilities consider a particular filtration technology, they carefully evaluate its appropriateness for their particular water being treated. The net production capacity of some technologies are especially sensitive to assumptions about how much flow can be processed per operating unit or module, and assuming a flow rate that is too high can result in a filtration plant that is too small to meet system capacity requirements. Depending on the treatment process being employed, consideration must be given to solids loading on the filter medium which can have a significant effect on loading/flux rate, TMP, filter run times, backwashing efficiency and other O&M and design elements. These concerns are best addressed by piloting the treatment process being considered to ensure it will meet the required treatment criteria outlined in the Water Recycling Criteria.*

Granular Media Type Filters

Dynasand **Status--Accepted**
Parkson Corporation
2727 N.W. 62nd Street
Fort Lauderdale, Florida 33340-8399
(305) 974-6610

Description: Upflow deep bed continuous backwash

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
	sand: 40	1.30	1.50

Acceptance / Reference:
- -Listed in the CDHS Direct Filtration Guidelines (1988)
- -Conditional acceptance letter dated 12/1/86 from CDHS
- -Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Letter dated 4/23/97 from the San Francisco District Office to the Sewerage Agency of South Marin
-Memo dated 7/18/97 from Mike Finn (CDHS) re: two performance studies (S.F. Bureau of water Pollution Control and Sewerage Agency of South Marin)

Comments: Classified as direct filtration.

Installations: Sewerage Agency of Southern Marin (Evaluation outlined in a Pilot Test Final Report for the Agency dated June 1989); San Francisco-Bureau of Water Pollution Control has a pilot unit at the Oceanside WWTP, and others.

WATERLINK SuperSand **Status--Accepted**
Waterlink Separations, Inc.
29850 N. Skokie Hwy. (U.S. 41)
Lake Bluff, Illinois 60044-1192
(847) 473-3700

Description: Upflow deep bed continuous backwash

Media configuration:

Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
sand: 40	1.30	1.50

Acceptance / Reference:
-Conditional acceptance letter dated 1/14/2000 from CDHS.
-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Note: Waterlink holds the patents for the design of the filter approved as the "DynaSand" marketed by Parkson Corp. under licensing agreements. Master file contains all documentation.

Comments: Classified as direct filtration.

Installations: Proposed for Delta Diablo Sanitation District (Pittsburg, CA), Coachella Valley and Escondido.

WESTECH TECHNASAND **Status--Accepted**
Westech Engineering, Inc.
3625 South West Temple
Salt Lake City, Utah 84119-0068
(801) 265-1000

Description: Upflow deep bed continuous backwash

Media configuration:

Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
sand: 40	1.30	1.50

Acceptance / Reference:
-Conditional acceptance letter dated 4/5/2002 from CDHS.
-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Note: Mftr. has indicated they will warrant the Technasand Filter to meet Title 22 filtration requirements. Same principle as the Parkson Dynasand. Master file contains all documentation.

Comments: Classified as direct filtration.

Installations: Proposed for Carmel Valley Ranch.

US Filter Astrasand **Status--Accepted**
US Filter Davco Products
1828 Metcalf Avenue
Thomasville, GA 31792
(229) 226-5733

Description: Upflow deep bed continuous backwash

Media configuration:

Media Depth (meters)	Effective Size (mm)	Uniformity Coefficient
sand: 1.5	1.0-1.5	1.50

Acceptance / Reference:
-Conditional acceptance letter dated 12/5/2005 from CDHS.

-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter media every three to four hours

Comments: Classified as direct filtration.

Installations: None Known

Centra-flo **Status--Accepted**
Applied Process Technology, Inc
35 Wellington Lane
Conroe, Texas 77304-1315
(963) 588-3458

Description: Upflow deep bed continuous backwash

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
	sand: 40	0.92-0.95	1.50

Acceptance / Reference:
-Conditional acceptance letter dated 3/14/2006 from CDHS.
-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter media every three to four hours

Comments: Classified as direct filtration.

Installations: None Known

Hydro-Clear **Status--Accepted**
U.S. Filter
Zimpro Environmental, Inc.
301 W. Military Rd.
Rothschild, WI 54474
(715) 359-7211

Description: Shallow pulsed bed filter

Media configuration:

Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
sand: 10-12	0.45	1.50

Acceptance / Reference:

- -Listed in the CDHS Direct Filtration Guidelines (1988)
- -Conditional acceptance letter dated 11/17/81 from CDHS.
- -Conditions of acceptance include: 1) minimum bed depth of 10-inches of sand with E.S. of 45 mm, 4) at least 6 minutes between pulses and no more than 25 pulses per filter run.
- -U.C. Davis Evaluation Report; "Evaluation of the Pulsed-Bed Filter For Wastewater Reclamation in California", 1981.

Comments: Classified as direct filtration

Installations: Moulton Niguel WD, San Luis Obispo, San Clemente, Rancho Murrieta, Fallbrook, and others.

Infilco-Degremont, Inc. **Status--Accepted**
Automatic Backwash (ABW)
P. O. Box 71390
Richmond, Va 23255-1390
(804) 756-7697

Description: shallow bed, traveling bridge

Media configuration:

Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
sand: 11	0.55	1.50

Acceptance / Reference:

- -Listed in the CDHS Direct Filtration Guidelines (1988)
- -U.C. Davis Evaluation Report; "Evaluation of the Enelco ABW Automatic Backwash Filter For Wastewater Reclamation in California", dated November 1988.

Comments: Loading rate limited to 2 gpm/ft^2; Max. influent turbidity <10 NTU.

Installations: Sacramento County, Sepulveda Water Reclamation, Folsom WWTP, Victor Valley WWRP, LA City-Tillman WRP, Shasta Lake WWTP, and others.

Aqua-Aerobic Systems, Inc. **Status--Accepted**
Automatic backwash filter (AquaABF)
P.O. Box 2026
6306 N. Alpine Road
Rockford, IL 61111
(815) 654-2501

Description: Shallow bed traveling bridge

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
sand:	11	0.55	1.50

Acceptance / Reference:
- -Listed in the CDHS Direct Filtration Guidelines (1988)
- -U.C. Davis Evaluation Report entitled "Evaluation of the Aqua-Aerobic Automatic Backwash Filter For Wastewater Reclamation in California" dated July 1986.

Comments: Loading rate limited to 2 gpm/ft^2; Max. influent turbidity <10 NTU.

Installations: None known

US Filter Gravisand **Status--Accepted**
US Filter Davco Products
1828 Metcalf Avenue
Thomasville, GA 31792
(229) 226-5733

Description: Shallow bed traveling bridge

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
anthracite:	6	1.1 – 1.2	1.5
sand:	5	.55 - .65	1.5
support	-	.8 – 1.2	1.5

Acceptance / Reference:
-Conditional acceptance letter dated 11/08/05 from CDHS.
-Conditions of acceptance include: 1) media design specs. As noted above, Loading rate limited to 2 gpm/ft^2; Max. influent turbidity <10 NTU.

Comments:

Installations: None known

Tetra Technologies, Inc. **Status--Accepted**
Tetra-Denit.
1628 Tiburon Blvd.
Tiburon, CA 94920
(1-800-364-4617)

Description: Tetra Deep Bed-Denitrification Filters

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
Silica sand:	48-72	2.2	1.35

Acceptance / Reference:
-Conditional acceptance letter signed by M. Kiado (CDHS) re: LADWP dated 3/17/92
-Letter dated 10/6/97 from Parsons Engineering Science regarding LA-Glendale Water Reclamation Plant pilot study.

Comments: Mono-media granular sand; 4-6 foot depth; intended for direct filtration with chemical addition.

Installations: City of Los Angeles (Glendale WWTP), Lake Arrowhead CSD, Padre Dam MWD, Scotts Valley WD.

Centra-flo
Applied Process Technology **Status--Accepted**
35 Wellington Lane
Conroe, Texas 77304
(409) 539-4099

Description: Centra-flo Gravity Sand Filter
Downflow Continuous Wash Filter

Media configuration:

	Media Depth (inches)	Effective Size (mm) (graded)	Uniformity Coefficient
	sand: 40	0.5 – 3.0	1.50

Acceptance: CDHS letter dated January 6, 1999 for landscape irrigation

Comments: Pilot testing conducted at Union Sanitary District's Alvarado WWTP (1994); loading rate up to 4.4 GPM/ft^2.

Installations: Tejon Ranch Development '99 (I-5 @ Tejon Pass)

Fluidsand
Fluidyne Corporation **Status--Accepted**
2816 West First Street
Cedar Falls, IA 50613
(319) 266-9967

Description: Fluidyne Fluidsand Filter
Upflow Continuous Backwash Filter

Media configuration:

	Media Depth (inches)	Effective Size (mm) (graded)	Uniformity Coefficient
silica sand:	40	0.8 – 1.0	1.6

Acceptance / Reference:
- -Conditional acceptance letter dated 5/03/2000 from CDHS.
- -Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.
- -Engineering Report dated June 9, 1997 submitted by Questa Engrg. for the Canada Woods Reclamation Facility.

Comments: Classified as direct filtration. Designed for waters containing TSS up to 20 mg/l (per manufacturer); Performance data submitted by the manufacturer demonstrates this

technology's ability to comply with the turbidity performance standards. Design and operation conceptually similar to Dynasand.

Installations: Tenaya Lodge located in Fish Camp (Evaluated in a "facilities Review" report by Carollo Engineers dated September 1990). Canada Woods Development ('99) in the Monterey area (without SDHS approval). Castanoa Ranch ('99) in San Mateo County.

Hydrasand **Status--Accepted**

Andritz Ruthner, Inc.
1010 Commercial Blvd. So.
Arlington, Texas 76017
(817) 465-5611

Description: Upflow, continuous wash filter

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
silica sand:	40	1.3	1.5

Acceptance / References:

-Conditional acceptance letter dated June 23, 2000 from CDHS.

-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Report available entitled "Microbial Assessment of the Lanai Auxiliary Reclamation Facility to Produce Wastewater Effluent for Unrestricted, Non-potable Reuse" dated October 1998.

Comments: Mftr. has indicated they will warrant the Hydrasand Filter to meet Title 22 requirements. Same principle as the Parkson DynaSand.

Installations: None in California (proposed for City of Corona), installed in Trumansburg NY and Lanai City, HI.

Strata-Sand
Ashbrook Corporation **Status--Accepted**
11600 East Hardy
Houston, Texas 77093-1098
(281) 449-1324

Description: Strata-Sand Gravity Sand Filter
Downflow Continuous Wash Filter
Media configuration:

	Media Depth (inches)	Effective Size (mm) (graded)	Uniformity Coefficient
	sand: 40	multi-	AWWA B-100

Acceptance: Conditional acceptance letter dated July 29, 2003 from CDHS.

Comments: Performance report submitted dated June 11, 2003.

Installations: City of Oceanside (San Luis Rey WWTP)

Micromedia Filtration, Inc. **Status--Accepted**
30336 Esperanza
Rancho Santa Margarita, CA 92688
(949) 459-1466

Description: “Cleanstream” Continuous Backwash Up-flow Sand Filter

Media configuration:

	Media Depth (inches)	Effective Size (mm)	Uniformity Coefficient
silica sand:	40	0.9 – 1.3	1.5

Acceptance / References:
-Conditional acceptance letter dated September 26, 2006 from CDHS.
-Conditions of acceptance include: 1) media design specs. as noted above, 2) shall be preceded by a secondary wastewater treatment process that meets the definition of an “oxidized wastewater” in accordance with Section 60301.650.

-Performance evaluations conducted at Las Gallinas Valley Sanitary District and Santa Margarita Water District (Chiquita Water Reclamation Plant).

Comments: Same principle as the Parkson DynaSand.

Installations: None known

Volcano ***Status—NOT YET ACCEPTED***

Description: Continuous wash downflow sand filter

Acceptance / References:
-Documentation of CDHS approval does not exist. The Recycled Water Unit has no technical data on this process.

Comments: Future proposals for use of this filtration technology will require an acceptability assessment prior to approval.

Installations: Boulder Creek G.C. (Santa Cruz County), Sierra Heights WWTP (Santa Clarita), Carmel Valley WWTP, Shelter Cove (Humbolt)

Other Media Type Filters

Fuzzy Filter
Schreiber LLC **Status--Accepted**
100 Schreiber Drive
Trussville, Alabama 35173

Description: "Fuzzy Filter"-compressible plastic filter media
Upflow design

Media configuration:

	Media Depth (inches)	Effective Size (")	Uniformity Coefficient
Synthetic: Plastic	30 (variable)	(1.25")	1.50

Media is quasi spherical, highly porous and compressible

Acceptance / Reference:
-Conditional acceptance letter date February 24, 2003 from CDHS.

-Conditions of acceptance include: 1) media design specs. as noted above, 2) filtration rate not to exceed 30 gpm/ft^2, 3) all Title 22 installations shall have design changes as outlined by Schreiber in correspondence dated January 21, 2003 (i.e. - backwash with filtered water, wash outlet below filtered outlet, valving position alarms), 4) individual operations plans shall include recommended operational configurations (i.e. percent compression and loading rate) based on secondary quality.
-Evaluated by U.C. Davis (Report dated September 1996)

Comments: Evaluated at loading rates up to 30 GPM/ft^2; media configuration/porosity/depth varies based on percent compression; water passes through media rather than around media.

Installations: City of Yountville

Membrane Technologies

NOTE: Many of the membranes listed below were originally approved with maximum flux rates based on studies under which performance data was generated. However, references to maximum flux rates are no longer deemed necessary since they become self-limiting from a filter run and operational perspective. If operational parameters (e.g. flux, TMP) adversely impact filtration performance from a turbidity compliance or operational perspectives, process control measures will likely be necessary to reliably insure compliance.

ZENON
Zenon Environmental Services, Inc.
3239 Dundas Street West
Oakville, Ontario L6M 4B2
(905) 465-3030

Cycle-Let (Thetford) Status--Accepted

Description: Membrane (“Ultra") filtration (originally marketed as Thetford Cycle-Let); complete package unit including pretreatment, biological oxidation, membrane ultra-filtration, GAC and U.V.

Acceptance / References:
-CDHS acceptance memorandum to LARWQCB dated November 12, 1993 regarding the Water Gardens Project.

-Report entitled "Evaluation of the Thetford Cycle-Let Reclamation System's Ability to Meet Title 22, prepared by Engineering-Science, dated August 1991.
-Report entitled "Thetford Systems Inc. Cycle-Let Wastewater Treatment and Recycling System – Water Garden Project, Santa Monica, CA" dated July 1993 prepared by CDM

Comments: Membrane approved has average pore size of .005 micron. Tested on municipal wastewater.

Installations: "Water Gardens" (Santa Monica), Sony Music Campus (Santa Monica).

ZeeWeed / Zenogem **Status--Accepted**

Description: Variant of the Cycle-Let, OCP Bio-reactor / Microfiltration process

Acceptance / References:
-Conditional acceptance letter from CDHS dated August 12, 1999
-Draft Final Report “California DHS Certification Testing-for Zenon (ZeeWeed) Membrane” prepared by Montgomery Watson (1/8/99).
-Final Report "Assessing the Ability of Membrane Bioreactor to Meet Existing Water Reuse Criteria (Zenon Environmental, Inc.)" prepared by Montgomery Watson (March 2001).

Comments: Includes 500a, 500b, 500c and 500d membrane systems. Approval based on use of the "OCP" (re-designated to “PVDF-UF” per letter from CDHS dated February 17, 2005) membranes only. Conditions of approval include: membrane integrity tests required. Tested in MBR process with high solids loading.

Installations: Unknown

ZeeWeed 1000 UF **Status--Accepted**

Description: Submerged Hollow Fiber Ultrafiltration Membrane

Acceptance / References:
-Conditional acceptance letter from CDHS for T-22 compliance dated October 12, 2001

-Report entitled “California Department of Health Services Certification Testing For Zenon ZeeWeed 1000 Membrane”, prepared by Montgomery Watson (June 2001). This report was prepared for demonstrating compliance with the California Surface Water Treatment Rule.

Comments: Approval based on use of the hollow fiber polymer “ZeeWeed 1000 UF Membrane” with a 0.02 micron nominal pore size. Conditions of approval require membrane integrity tests required. Tested on raw surface water.

Installations: Unknown

U. S. Filter / MEMCOR **STATUS--Accepted**
4116 Sorrento Valley Blvd.
San Diego, CA 92121
(619) 445-0578

Memcor Continuous Microfiltration (CMF)

Description: 0.2 micron *Polypropylene* Hollow Fiber Micro-Filtration - Pressure Filtration

Acceptance / References:
-Conditional acceptance letter from CDHS dated 1/10/2000
-Approved under the SWTR using 0.2 micron membrane.

Comments: Membrane integrity tests required. Tested on raw surface water.

Installations: West Basin MWD, Orange County Water District, City of Livermore, Dublin/San Ramon SD

Memcor Continuous Microfiltration (CMF)

Description: 0.1 micron *Polyvinylidene Fluoride* (PVDF) Hollow Fiber Micro-Filtration - Pressure Filtration

Acceptance / References:
-Conditional acceptance letter from CDHS dated 1/10/2000
-Approved under the SWTR using 0.2 micron membrane.

Comments: Membrane integrity tests required. Tested on raw surface water.

Installations: West Basin MWD, Orange County Water District, City of Livermore, Dublin/San Ramon SD

Memcor Continuous Microfiltration Submerged (CMF-S)

Description: 0.2 micron *Polypropylene* Hollow Fiber Micro-Filtration – Submerged/Vacuum Filtration

Acceptance / References:
-Conditional acceptance letter from CDHS dated 1/10/2000

Comments: Membrane integrity tests required. Tested on raw surface water.

Installations: Unknown

Memcor Continuous Microfiltration Submerged (CMF-S)

Description: 0.1 micron *Polyvinylidene Fluoride* (PVDF) Hollow Fiber Micro-Filtration – Submerged/Vacuum Filtration

Acceptance / References:
-Conditional acceptance letter from CDHS dated 1/10/2000

Comments: Membrane integrity tests required. Tested on raw surface water.

Installations: Unknown

U. S. Filter/Jet Tech Products-Memjet^{tm} STATUS--Accepted
1051 Blake
Edwardsville, KS 66111

Description: 0.1 micron *Polyvinylidene Fluoride* (PVDF) Hollow Fiber Micro-Filtration – SBR/Vacuum Filtration

Acceptance / References:
-Conditional acceptance letter from CDHS dated 10/7/2002

-Conditional acceptance letter from CDHS dated 11/18/05 concerning the “B30R’ module.

Comments: Membrane integrity tests required. Tested in MBR process with high solids loading.

Installations: Unknown

PALL Corporation **STATUS -- Accepted**
25 Harbor Park Drive
Port Washington, NY 11050 USA
(516) 484-3600

Description: PVDF Hollow Fiber Microza Microfiltration
0.1 micron (P/N XUSV-5203)

Acceptance / References:
-Conditional acceptance letter from CDHS dated 1/10/2000
-Approved for compliance under the SWTR based on report entitled “California Department of Health Services Certification Testing for Pall (Microza) Microfiltration Membrane” prepared by Montgomery-Watson (July 1999).
-Performance study conducted at OCWD Water Factory 21 (SLS Report 7725) “Long-Term Testing of Pall Microza 0.1 um MF System on Secondary Effluent at Water Factory 21, Fountain Valley, CA” (September 23, 1998).

Comments: Membrane integrity tests required. Tested on secondary effluent.

Installations: Unknown

PALL Corporation **STATUS -- Accepted**
25 Harbor Park Drive
Port Washington, NY 11050 USA
(516) 484-3600

Description: Microza Microfiltration using the following:
(P/N USV-5203)
(P/N USV-6203)
(UNA-620A)

Acceptance / References:
-Conditional acceptance letters from CDHS dated 7/19/2004

-Approved for compliance under the SWTR

Comments: Membrane integrity tests required. Tested on raw surface water.

Installations: Unknown

MITSUBISHI
Mitsubishi International Corp. **STATUS -- Accepted**
333 South Hope Street West, Suite 2500
Los Angeles, CA 90071

Description: Mitsubishi Membrane Bioreactor (MBR)
Sterapore HF 0.4 micron hollow fiber polyethylene

Acceptance / References:
-Conditional acceptance letter from CDHS dated April 23, 2001
-Report entitled "Assessing the Ability of Membrane Bioreactor to Meet Existing Water Reuse Criteria (Mitsubishi Rayon Co., Ltd.)" prepared by Montgomery-Watson (March 2001).

Comments: Membrane integrity tests required. Tested in MBR process with high solids loading.

Installations: Unknown

KUBOTA Corporation **STATUS -- Accepted**
Tokyo Head Office
1-3, Nihombashi-Muromachi 3-chome
Chuo-Ku Tokyo 103-8310

Description: Kubota Membrane Bioreactor (MBR); Type 510 and Type 515, 0.4 micron chlorinated polyethylene flat sheet membrane

Acceptance / References:
-Conditional acceptance letter for the Type 510 from CDHS dated March 18, 2003, amended April 29, 2004 for higher flux rate. Acceptance of the Type 515 membrane granted by letter dated July 5, 2005.

-Report entitled "Assessing the Ability of the Kubota Membrane Bioreactor to Meet Existing Water Reuse Criteria" prepared by Montgomery-Watson-Harza (February 2003).
-Conditional acceptance letter for the Type 515 from CDHS dated July 5, 2005.
-Report entitled "Equivalency of The Kubota Type 515 and Type 510 Membrane Cartridges" (2005).

Comments: Tested in MBR process with high solids loading.
Installations: Unknown

Ionics, Inc. **STATUS -- Accepted**
65 Grove Street
Watertown, Massachusetts 02472-2882 USA
(617) 926-2500

Description: Norit X-Flow Hollow Fiber Ultrafiltration 0.05 micron, Polyethersulfone Membrane

Acceptance / References:
-Conditional acceptance letter from CDHS dated 10/21/2003
-Approved for compliance under the SWTR based on report entitled "Draft Final Report, California Department of Health Services Certification Testing for Ionics UF Membrane" prepared by Montgomery-Watson (June 2001).
-Performance study conducted at Gwinnett County, Georgia using secondary effluent; "Membrane Pilot and Demonstration-Scale Treatment for Water Reclamation at Gwinnett County, Georgia" (CH2M HILL, 2001).

Comments: Acceptance specific to the Ionics filtration technology tested using the Norit X-Flow S225, 0.05 micron, polyethersulfone hollow fiber membrane. Membrane integrity tests required. Tested on secondary effluent.

Installations: Unknown

Koch Membrane Systems **STATUS -- Accepted**
850 Main Street
Wilmington, MA 01887

Description: Koch Membrane Systems Puron™ Membrane Bioreactor (MBR) utilizing the Polyethersulfone hollow fiber KMS-L1 membrane with nominal 0.05 micron pore size. Submerged membrane operates under vacuum.

Acceptance / References:

-Conditional acceptance letter from CDHS dated May 4, 2006.
-Report entitled "Assessing the Ability of the Puron™ Membrane Bioreactor to Meet Existing Water Reuse Criteria" prepared by Montgomery-Watson-Harza (March 2006).

Comments: Tested in MBR process with high solids loading.

Installations: Unknown

Huber Technology, Inc. **STATUS -- Accepted**
9805 Northcross Center Court, Suite H
Huntersville, NC 28078

Description: Huber Vacuum Rotation Membrane VRM® Bioreactor (MBR) utilizing the Polyethersulfone flat sheet NADIR P-150F ultrafiltration membrane with nominal pore size of 0.038 micron. Submerged membrane operates under vacuum.

Acceptance / References:

-Conditional acceptance letter from CDHS dated June 22, 2006.
-Report entitled "Assessing the Ability of the Huber Vacuum Rotation Membrane VRM® Bioreactor and Membrane Clearbox® to Meet Existing Water Reuse Criteria" prepared by Montgomery-Watson-Harza (April 2006).

Comments: Tested in MBR process with high solids loading.

Installations: Unknown

Parkson Corporation **STATUS -- Accepted**
2727 N.W. 62nd Street
Fort Lauderdale, FL 3340-8399

Description: Dynalift™ Membrane Bioreactor (MBR) utilizing external PVDF tubular membranes with a nominal pore size of 0.03 micron. Submerged membrane operates under pressure and is placed externally from the bioreactor.

Acceptance / References:

-Conditional acceptance letter from CDHS dated September 7, 2006.

-Report entitled "Assessing the Ability of the Dynalift™ Membrane Bioreactor to Meet Existing Water Reuse Criteria" prepared by Montgomery-Watson-Harza (July 2006).

Comments: Tested in MBR process with high solids loading.

Installations: Unknown

Cloth Filter Technologies

AQUA AEROBIC Systems, Inc. **Status--Accepted**
6306 N. Alpine Rd.
Rockford, IL 61130-0026
(815) 654-2501

Description: **Submerged Cloth-Media Rotating Disk Filter (Utilizing the 102 needle felt fabric)**

Acceptance / References:

-Conditional acceptance letter from CDHS dated June 29, 2001 and amended September 24, 2002.

-Report entitled "Evaluation of the Aqua-Aerobic Systems Cloth-Media Disk Filter (CMDF) for Wastewater Recycling Applications in California" prepared by UC Davis (March 2001).

-Report entitled "Evaluation of Aqua-Aerobics Systems AquaDisk Filter Technology at Orange County Water District, Fountain Valley, California" (February 25, 2000).

Comments: Utilizes the "102 needle felt fabric", operates under vacuum. Conditions of acceptance: loading rate not to exceed 6 gpm/ft^2; Acceptance of this technology is contingent on it being complimented with a disinfection process which is compliant with Section 60301.230 (T-22); acceptance limited to the random woven NF-102 needle felt cloth media having openings ranging from 10 to 30 microns and a thickness of 3.8 mm; influent turbidity not exceed 10 NTU more than 5-percent of the time within a 24-hour period; Operations plan shall specify minimum FTW cycle following high pressure wash based on displacement of two filtrate volumes and effluent turbidity below 2 NTU; scheduled inspections of cloth conditions; ensure adequate sludge wasting; Turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

Description: **Submerged Cloth-Media Rotating Disk Filter (Utilizing the PA-13 nylon pile fabric)**

Acceptance / References:

-Conditional acceptance letter from CDHS dated May 6, 2002) and amended on September 24, 2002

-Report entitled "Use of PA-13 Pile Fabric, Supplement to: Evaluation of the Aqua-Aerobic Systems Cloth-Media Disk Filter (CMDF) for Wastewater Recycling Applications in California" prepared by UC Davis (February 2002).

Comments: Utilizes the "PA-13 nylon pile fabric", operates under vacuum. Conditions of acceptance: loading rate not to exceed 6 gpm/ft^2; Acceptance of this technology is contingent on it being complimented with a disinfection process which is compliant with Section 60301.230 (T-22); acceptance limited to the PA-13 nylon pile fabric (as tested); influent turbidity not exceed 10 NTU more than 5-percent of the time within a 24-hour period; scheduled inspections of cloth conditions; ensure adequate sludge wasting; turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

Description: **Submerged Cloth-Media Rotating Disk Filter (Utilizing the MMK2-13 acrylic pile fabric)**

Acceptance / References:

-Conditional acceptance letter from CDHS dated July 21, 2006.

-Report entitled "Comparative Evaluation of the Aqua-Aerobic Systems, Inc. MMK2-13 Acrylic Pile Filter Media To Meet California's Title 22 Reuse Criteria (April 2006).

Comments: Utilizes the "MMK2-13 acrylic pile fabric", operates under vacuum. Conditions of acceptance: loading rate not to exceed 6 gpm/ft^2; Acceptance of this technology is contingent on it being complimented with a disinfection process which is compliant with Section 60301.230 (T-22); Operations plan shall specify minimum FTW cycle following high pressure wash based on displacement of two filtrate volumes and effluent turbidity below 2 NTU; scheduled inspections of cloth conditions; ensure adequate sludge wasting; Turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

Description: **Submerged Fixed Cloth-Media Filter -AquaDiamond Filtration System (Utilizing the NF 102 Needle Felt or the PA-13 nylon pile fabric)**

Acceptance / References:
- -Conditional acceptance letter from CDHS dated May 12, 2004) and amended on September 24, 2002
- -Design and process control report on file.

Comments: Same filtration principle as the rotating disk filters noted above but differs in design and operation; Utilizes the NF 102 needle felt or the PA-13 nylon pile fabric, operates under vacuum.
Conditions of acceptance: loading rate not to exceed 6 gpm/ft^2; filtration process must be complimented with a disinfection process which is compliant with Section 60301.230 (T-22); acceptance limited to the NF needle Felt or the PA-13 nylon pile fabric (as tested); influent turbidity not exceed 10 NTU more than 5-percent of the time within a 24-hour period; scheduled inspections of cloth conditions; ensure adequate sludge wasting; turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

U.S. Filter-Kruger Products **Status--Accepted**
401 Harrison Oaks Blvd., Suite 100
Cary, North Carolina 27513

Description: **Cloth-Media Disk Filter - Hydrotech (Utilizing the PET mono-filament filter fabric)**

Acceptance / References:
- -Conditional acceptance letter from CDHS dated October 2, 2003.
- -Report entitled "Evaluation of the Hydrotech Filter for Compliance With Title 22 For Recycled Water Applications" prepared by Water 3 Engineering, Inc. (August 2003).

Comments: Utilizes the PET mono-filament, 2:2 twill weave, 11 micron (+/-2.0) mesh opening, 523.2 (n/inch), 60 micron thickness, wt. rating of 1.48 oz./sq.yd., stabilized finish.
Conditions of acceptance: loading rate not to exceed 6 gpm/ft^2; Acceptance of this technology is contingent on it being complimented with a disinfection process which is compliant with Section 60301.230 (T-22); influent turbidity not to exceed 10

NTU more than 5-percent of the time within a 24-hour period; scheduled inspections of cloth conditions; Turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

4. DISINFECTION TECHNOLOGIES

Gaseous chlorine or hypochlorite is the most commonly used disinfectant, however alternative technologies are recognized as being acceptable. On-site chlorine generators are also available for industry use.

ULTRAVIOLET

Trojan Technologies, Inc.
3020 Gore Rd.
London, Ontario Canada N5V 4T7

Description:
- UV 4000 (Medium Pressure/ Low Intensity) — **Status—Accepted***
- UV 3000 (Low Pressure/ Low Intensity) — " **
- UV 3000+ (Low Pressure/ High Output) — " ***

Acceptance/References:

-Conditional acceptance letter from CDHS dated September 8, 1995 for UV4000.

-Conditional acceptance letter from CDHS dated July 3, 2003 for UV 3000+ (including modified end-of-lamp-life factor of 0.82). Amended October 30, 2003, October 24, 2005 (concerning lamp spacing), October 5, 2006 (concerning sleeve fouling factor of 0.95).

-"Trojan System UV4000 UV Disinfection Pilot Study. Riverside, California", May 1995

-"Equivalency of the Trojan System UV4000 and System UV3000 in Meeting California Wastewater Reclamation Criteria at Pacifica, California", June 1994

-"Technical Review: Ultraviolet Disinfection of Wastewater to California Wastewater Reclamation Criteria (Title 22, Division 4, Chapter 3, of the California Code of Regulations) Using Trojan Technologies' System UV4000 (High Intensity UV Lamp Technology", August 1995.

Comments: Acceptance for the UV4000 conditioned on 1) continuous monitoring/recording of filter effluent turbidity (pre UV), daily coliform monitoring (disinfected effluent) and 3) provide UV dose of at least 100 mW-sec/cm^2 under worst operating conditions at peak daily instantaneous flow with a minimum of three banks in operation and a UV dose of at least 140 mW-sec/cm2 with a minimum of four banks in operation, subject to all of the conditions indicated in the NWRI Guidelines.

Installations: City of Pacifica, City of Vallejo, Central Contra Costa S.D., City of Corona, City of San Diego (South Bay WRF), Western Riverside RWF, Olivenhain WD, City of Santa Rosa

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

****Acceptance granted under the December 2000 NWRI/AWWARF Guidelines.**

*****Acceptance granted under the May 2003 NWRI/AWWARF Guidelines**

PCI-Wedeco Environmental Technologies, Inc. Status—Accepted*
One Fairfield Crescent
West Caldwell, NJ 07006

-Specktrotherm 33-TAK UV

Description: (Low pressure/High Intensity)

Acceptance/References
- -Conditional acceptance letter dated 3-31-98 from CDHS and follow-up letter dated 5/21/99 transferring approval from Aquafine to Wedeco).
- -Tested at OCWD as the AWES-Spectrotherm TAK UV System

Comments: Currently marketed as the PCI-Wedeco Spectrotherm 33 TAK UV System. Requires UV dose of 160 mWs/cm^2 at max. week flow, 120 mWs/cm^2 at peak flow (max. day), and an average of $\geq$160 mWs/cm^2 and conform to NWRI Guidelines.

Installations: Leucadia CWD(proposed)

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

Wedeco - Ideal Horizons LCI-20L Status—Accepted*

Description: (Low pressure/High Intensity)
Model LCI-20L

Acceptance/ References

-Conditional acceptance letter from CDHS dated 2-23-99 for Tejon Ranch.
-Report entitled “Ultraviolet Dose Bioassay of the Ideal Horizons Horizontal Lamp Disinfection System” by HydroQual, Inc. (September 1998).

Comments:

Installations: Tejon Ranch Development (I-5 @ Tejon Pass)

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

Wedeco - Ideal Horizons TAK 55 Status—Accepted**

Description: (Low pressure/High Intensity/open channel)
TAK 55

Acceptance/References
-Conditional acceptance letter dated 12-4-01 from CDHS.
-Report entitled “Wedeco-Ideal Horizons Low-Pressure, High Intensity Ultraviolet Disinfection System Pilot Study at Orange County Water District” by CH2M Hill (November 2000)
-Revised end-of-lamp age factor for SLR 32143 HP lamp modified from 0.91 to 0.88 at 10,074 hours per letter from CDHS dated May 19, 2005.

Comments:

Installations: Unknown

****Acceptance granted under the December 2000 NWRI/AWWARF Guidelines.**

Wedeco - Ideal Horizons TAK 55HP Status—Accepted***

Description: (Low pressure/High Output/open channel)
TAK 55HP

Acceptance/References
-Conditional acceptance letter dated 11-24-03 from CDHS.

-Report entitled “Wedeco Ultraviolet Technologies TAK 55HP Validation Report by Carollo Engineers (October 2003).
-Revised end-of-lamp age factor for SLR 32143 HP lamp modified from 0.91 to 0.88 at 10,074 hours per letter from CDHS dated May 19, 2005.

Comments:

Installations: Unknown

*****Acceptance granted under the May 2003 NWRI/AWWARF Guidelines.**

Aquionics **Status—Accepted***
Aquionics, Inc.
21 Kenton Lands Rd.
Erlanger, Ky 41018

Description: (Medium Pressure/In-line)

Acceptance/Reference:
-Conditional acceptance letter dated 2-28-00 from CDHS.
-CH2M Hill, "Aquionics Medium Pressure, High-Intensity Ultraviolet Disinfection System Pilot Study at Orange County Water District" by CH2M Hill (May 1999)

Comments:

Installations: Unknown

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

Service Systems International, Ltd. **Status—Accepted***
2800 Ingleton Avenue
Burnaby, B.C. Canada, V5C 6G7

ULTRAGUARD UV System

Description: (Open Channel/Low Pressure/High Intensity/vert. lamp)

Acceptance/Reference:
-Conditional acceptance letter dated 2-1-00 from CDHS.

-Report: Chen, C. L.; El Jacj, Z; Kuo, J., UV Inactivation of Bacteria and Coliphages in Tertiary Effluent Using Low-Pressure High-Intensity Lamps, November 18, 1999, County Sanitation Districts of Los Angeles County.

Comments:

Installations: Unknown

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

Aquaray
Ondeo-Degremont
2924 Emerywood Parkway
P.O. Box 71390
Richmond, VA 23255-1390

Aquaray 40 VLS **Status—Accepted*****

Description: Vertical lamp/low Pressure/low intensity

Acceptance: Conditional acceptance letter dated 10/24/97 from CDHS with follow-ups dated 10/23/03, 2/23/04, 4/13/04 and 10/6/03.

Comments: Evaluation memo dated 4/30/97 from SDHS concerning transmittance restriction be set at >55%.

Installations: Scotts Valley, Town of Windsor, Dublin/San Ramon CSD

*****Acceptance granted under the May 2003 NWRI/AWWARF Guidelines.**

Aquaray 40 HO VLS **Status—Accepted*****

Description: Vertical lamp/low Pressure/high intensity

Acceptance: Conditional acceptance letter dated 2/23/04.

Comments: Evaluation memo dated 4/30/97 from SDHS concerning transmittance restriction be set at >55%.

Installations: Unknown

*****Acceptance granted under the May 2003 NWRI/AWWARF Guidelines.**

UltraTech Systems
15 Kay Fries Drive
Stoneypoint, NY 10980

Terminator **Status—Accepted***

Description: Vertical/Low Pressure/Low Intensity

Acceptance/References
-Conditional acceptance letter dated October 23, 2000 from CDHS
-Report entitled “Ultraviolet Dose Bioassay of the Ultratech Systems Vertical Lamp Disinfection System (65% Transmittance)” by HydroQual, Inc. (February 2000).

Comments:

Installations: Unknown

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

See: Appendix A
Appendix B

Alt. Tech. disk – Recycle Water Technology listing 01-07.doc

APPENDIX A

Recognized Filtration and Disinfection Technologies
For Recycled Water

CALIFORNIA DEPARTMENT OF HEALTH SERVICES
REDUCTION OF VIRUS AND BACTERIA BY FILTRATION AND DISINFECTION
(October 2001)

Title 22 of the California Code of Regulations (Recycled Water Criteria) require extensive treatment of wastewater that is to be used for irrigation of parks and playgrounds or for spray irrigation of food crops. Recycled water for such irrigation is to be oxidized, filtered, and disinfected. Section 60301.320 defines filtered wastewater and Section 60301.230 defines disinfected tertiary recycled water. Additionally, Section 60320.5 allows for "other methods of treatment" provided they are found acceptable to the Department.

Treatment equivalent to that stipulated in sections 60301.320 and 60301.230 is prescribed to greatly reduce the concentration of viable enteric viruses in wastewater. Such a reduction makes it very unlikely that a person would contaminate his hands with a virus when touching a surface wet with reclaimed water. Enteric viruses are excreted by individuals with an intestinal virus infection. They can cause incapacitating disease states in susceptible persons. Those disease states include meningitis, hepatitis, and others.

Capability of Treatment That Sections 60301.320 and 60301.230 Cite

The County Sanitation Districts of Los Angeles County (CSDLAC, 1977) determined the capability of treatment that sections 60301.320 and 60301.230 cite, to reduce the concentration of viable virus in activated sludge effluent. CSDLAC added laboratory-cultured poliovirus and 150 milligrams of alum coagulant per liter of the activated sludge effluent and passed it through pilot-scale treatment facilities comprised of a clarifier and a sand filter to meet the turbidity limits that section 60301.320 cites in the definition of filtered wastewater: turbidity shall not exceed 2 turbidity units as a daily average and shall not exceed 5 turbidity units more than five percent of the time. Filter effluent was chlorinated in a chamber with a two-hour theoretical contact period and a 90-minute actual, modal contact period.

Such treatment reduced the concentration of virus plaque-forming units to 1/100,000th of the concentration in wastewater upstream from the filter, when the chlorine residual was at least 5 milligrams per liter and at least sufficient to reduce the concentration of total coliform bacteria to less than 2 per hundred milliliters. Sections 60301.320 and 60301.230 require that disinfection shall limit the concentrations of total coliform bacteria in the effluent so that the median of consecutive daily samples does not exceed 2.2 per hundred milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed.

Equivalent Treatment By Granular Media Bed Filtration and Disinfection

Section 60320.5 of Title 22 allows the regulatory agency to accept processes other than those that Sections 60301.320 and 60301.230 cite if the applicant demonstrates to the satisfaction of DHS that the other processes will assure an equal degree of treatment. DHS deems other treatment equivalent to that cited in sections 60301.320 and 60301.230 when: (1) a proponent demonstrates that the proposed alternative treatment consistently reduces the concentration of viable virus to a level 1/100,000th of the concentration of seeded virus in influent to the filter; and (2) the proponent will provide reliability features equivalent to those that Title 22 cites, and will comply with all other applicable stipulations of Title 22.

Past demonstrations are sufficient to allow DHS to accept the combination of granular media bed filtration and disinfection of oxidized wastewater as equivalent to treatment that sections 60301.320 and 60301.230 cite, when the following four conditions are obtained:

(1) coagulant is added when the turbidity of the oxidized wastewater (i.e. secondary effluent) exceeds 5 NTU for more than 15 minutes (or exceeds 10 NTU at any time) upstream from the filter;

(2) the turbidity of filter effluent does not exceed a daily average of 2 NTU, 5 NTU more than 5 percent of the time, and 10 NTU at any time;

(3) the concentration of viable total coliform bacteria in the final effluent does not exceed 2.2 per hundred milliliters as a median in samples taken in seven consecutive days, and does not exceed 23 per hundred milliliters in more than one sample in a 30-day period; and

(4) the disinfection process complies with (a) or (b) below:

(a) if chlorination is used it provides a CT (chlorine concentration times modal contact time) value not less than 450 milligram-minutes per liter at all times with a modal contact time at least 90 minutes at the peak daily flow rate; or

(b) if ultraviolet light irradiation is used, the design and operation of the UV light disinfection process complies with the stipulations of the NWRI/AWWARF document cited below under the heading References Cited.

Demonstration With Other Filtration and Disinfection Processes

The particle size distribution (PSD) of secondary sewage treatment effluent filtered by a membrane, cloth, or similar medium will differ significantly from that of effluent of a granular media bed filter, insofar as PSD affects the effectiveness of the downstream disinfection process. The term "size distribution" refers to the number of particles per milliliter in each of several specific ranges of sizes. Polycarbonate membrane laboratory filters with pore sizes of 12, 8, 5, 3, 1, and 0.1 micron can be used (Levine, et al., 1985; NCC, 1984), with minimal equipment requirements. A particle counter can be used to determine PSD for the following size ranges, in microns: 1.2 to 2, 2 to 5, 5 to 10, 10 to 20, 20 to 50, 50 to 100, 100 to 200, and larger than 200 (Stahl et al., 1994).

If a filter other than a granular media bed filter is proposed to be used and the use of reclaimed water requires equivalence with treatment that section 60301.320 or 60301.230 cites, the proponent must undertake a demonstration to show DHS what operating conditions guarantee that the filter and disinfection process will consistently reduce the concentration of virus to 1/100,000th of the virus concentration in wastewater upstream from the filter and limit the concentration of total coliform bacteria to comply with concentrations that sections 60303 and 60313(b) cite. The demonstration will involve operation of the filter and disinfection process under the following conditions:

- the filter receives the type of wastewater from which recycled water is proposed to be produced;

- the range of qualities of wastewater received by the filter includes qualities that are expected to occur when recycled water is produced, and are the most challenging to the

effectiveness of the filter and disinfection process (e.g., concentration of suspended solids is at the maximum);

- laboratory-grown viruses are added to the wastewater upstream from the filter;

- samples are taken upstream from the filter and downstream from the disinfection process for determination of numbers of plaque-forming units of virus per volume of sample;

- samples are taken of wastewater upstream and immediately downstream from the filter for determination of concentration of total suspended solids;

- turbidity of the filter effluent is continuously measured by a continuous recording turbidimeter;

- samples of disinfected effluent are taken for determination of the concentration of total coliform bacteria;

- additionally if disinfection is by chlorination, samples are taken of wastewater upstream from the filter for determination of concentration of ammonia and samples of disinfected effluent are taken for determination of concentration of chlorine residual;

- additionally if disinfection is by UV irradiation, fluid transmittance at 254 nm (% T) and flow rate of filter effluent are continuously measured and recorded;

- The greatest appropriate time between backwashes, or other actions that renew filter yield or efficacy, is determined by experiment, with turbidity of filter effluent allowed to range as high as needed for economically practicable treatment (but not to exceed 2 NTU as a daily average, 5 NTU more than 5 percent of the time, or 10 NTU at any time); and

A test run is comprised of one continuous operation between two consecutive backwashes (or other actions that renew filter yield or efficacy). A demonstration shall have at least three test runs during which the quality and/or flow rate of influent to the filter is most challenging for the disinfection process.

Qualities most challenging to UV disinfection might include high concentration of suspended solids, high turbidity and low transmittance. Qualities most challenging to chlorine disinfection might include high concentration of suspended solids, high turbidity and high chlorine demand.

If the proponent wants to propose a CT value or minimum chlorine contact time that differs from that cited above under the heading Equivalent Treatment By Granular Media Bed Filtration and Disinfection, or a UV dose that differs from what the NWRI/AWWARF Guidelines cite, the proponent shall perform as many test runes as necessary to construct a dose-response curve for virus reduction. The curve shall show the required value(s) of such parameters at which the concentration of viable viruses in the disinfected effluent is reduced to 1/100,000TH of the concentration in the influent to the filter.

During each test run, viruses shall be added to wastewater in numbers sufficient to determine whether the concentration in disinfected effluent is less than 1/100,000th of the concentration in wastewater upstream from the filter. The viruses added to wastewater upstream from the filter shall be F-specific bacteriophage MS2, polio virus, or other virus that is at least as resistant to disinfection as polio virus. F-specific bacteriophage MS2 is a strain of a specific type of virus that infects coliform bacteria that is traceable to the American Type Culture Collection (ATCC 15597B1) and is grown on lawns of E. coli (ATCC 15597). Chlorine residual in samples of chlorinated effluent taken for determination of concentrations of virus plaque-forming units and total coliform bacteria shall be neutralized with a reducing agent approved by DHS, when those samples are taken.

The proponent shall submit to DHS a proposed protocol for all work to be undertaken in the demonstration. The proponent will undertake the demonstration only pursuant to a protocol DHS has approved.

The demonstration must identify operating conditions that consistently achieve that virus reduction and compliance with the above-cited limits on the concentration of total coliform bacteria. The regulatory agency will cite those operating conditions and will stipulate that they will be maintained.

The combination of a filtration process and a separate disinfection process provides multiple barriers to limit the concentration of viable viruses somewhat when the other malfunctions. DHS will not accept filtration alone, or disinfection alone, as complying with Title 22.

REFERENCES CITED

Levine, A.D., Tchobanoglous, G., and Asano, T., “characterization of the Size Distribution of Contaminants in Wastewater: Treatment and Reuse Implications,” Journal Water Pollution Control Federation, July 1985, pages 805-816.

NCC (Nuclepore Corporation Catalog), “Innovations in Membrane Filtration,” Pleasanton, California, 1984.

National Water Research Institute / American Waterworks Association Research Foundation), Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, December 2000. That document is available for purchase from National Water Research Institute, P.O. Box 20865, Fountain Valley, CA 92728-0865, telephone (714) 378-3278.

Stahl, J.F., Kuo, J.F., Chen, C., and Horvath, R.W., “Evaluation of Four Different Tertiary Filtration Plants for Turbidity Control”, presented at 65th Annual Conference of Water Environment Federation, September 20-24, 1992, New Orleans (paper published in November/December 1994 issue of the Journal of the Water Environment Federation).

APPENDIX B

State of California **Department of Health Services**

Memorandum

Date: November 1, 2004

To: Regional Water Quality Control Boards Executive Officers

From: David P. Spath, Ph.D., P.E., Chief
Division of Drinking Water and
Environmental Management
1616 Capitol Avenue, MS 7400
449-5577

Subject: Cleaning of UV Quartz Sleeves

In recent years the use of ultraviolet (UV) radiation for disinfection of recycled water has increased significantly. As a relatively new technology for wastewater disinfection the Department of Health Services has been attempting to learn more about the operation of these UV facilities at recycled water plants. It has recently come to our attention that at some recycled water plants these UV facilities may be operated in a manner that could significantly compromise the disinfection treatment barrier. Specifically, we have been advised that these recycled water plants are following the practice of using the detection of coliform organisms in the treated effluent as a basis for determining how frequently to clean the quartz sleeves that protect the UV lamps. As the appropriate regulatory agency we are requesting that the Regional Water Quality Control Boards (RWQCB) look into this situation. In addition, we are recommending that the RWQCBs establish a more conservative set of requirements for all recycled water plants practicing UV disinfection to ensure that an appropriate disinfection treatment barrier is achieved. The following provides a brief discussion of the issue including background information, the problem that exists and our recommended requirements.

Background

Cleaning the quartz sleeves of a UV system is critical to ensuring the proper functioning of a UV system. Because the UV lamp is surrounded by a quartz sleeve, any coating on the surface of the quartz sleeve will reduce the transmission of UV into the wastewater thereby reducing the quantity of UV reaching or penetrating the wastewater for the purpose of disinfection. Unless this reduction in UV transmission is compensated for in the design and operation of the UV facility, the UV disinfection barrier can and will be reduced (compromised) concomitantly, i.e., the amount of disinfection being delivered will not be sufficient to meet minimum dose delivery requirement.

The National Water Research Institute (NWRI)/American Water Works Association Research Foundation (AWWARF) UV disinfection guidelines recognize this issue and recommend a 0.8 sleeve fouling factor be used in the design of UV systems. This increases the minimum dose delivery requirement in a linear manner, increasing the number of lamps required to achieve the minimum delivered dose during operation with the realization that quartz sleeve fouling is a never ending process.

Unless the UV system is operated using a sensor on the outside of a quartz sleeve for controlling the delivered dose, one does not know when or how much of an impact fouling has on UV dose delivery. Therefore, the delivered dose requirement is increased by the quartz sleeve-fouling factor to account for quartz sleeve fouling over time. While this accounts for quartz sleeve fouling in the design of the system, this approach assumes the quartz sleeve never exceeds a level of fouling that would reduce the UV dose delivery by 20 percent at any time. Such an approach is fine as long as the UV transmission through the quartz sleeve is not reduced by more than 20 percent. Unfortunately in actual operation, unless the quartz sleeve fouling rate has been established, one does not know when the limits of this fouling factor have been exceeded.

What the NWRI/AWWARF guidelines do not establish is the frequency with which the quartz sleeves should be cleaned to remove any scale or film that has been deposited on the sleeve. This is not a deficiency of the guidelines, but a reflection of inexact science and incomplete understanding of the nature of quartz sleeve fouling.

Problem

The problem that has resulted is that some water recycling plants may be using the presence of coliform organisms in the treated effluent as an indicator to determine when the quartz sleeves should be cleaned. In our opinion this is problematic. The recycled water coliform limit for filtered secondary effluent was established at a time when chlorination was used almost exclusively to provide disinfection. This limit along with requirements for total chlorine residual and contact time was established to ensure effective inactivation of viral pathogens. UV radiation, while very effective at inactivating coliform bacteria, is a much less effective viricide than chlorine. Therefore, the quantity of UV needed to meet the coliform discharge limits of less than 2.2/100mL is significantly less than the minimum dose delivery to inactivate viruses, as required in the NWRI/AWWARF UV Disinfection Guidelines.

The guidelines call for a minimum UV dose delivery requirement of 100 mJ/cm^2 for standard media filtered secondary effluents. Typical coliform concentrations in media filtered secondary effluents run about 10^4-10^6 MPN/100mL. The minimum UV delivered dose needed to achieve a 4 to 6 log reduction of coliforms is about 10-20 mJ/cm^2. Since 4 to 6 logs of inactivation should reduce the coliforms to nondetectable levels, this means that if coliforms are being detected the dose delivery in the system is probably around 10-20 mJ/cm^2 which is 5 to 10 times below the minimum dose delivery

recommended by the UV guidelines as the minimum needed for an effective disinfection barrier.

Recommended Requirements

Based on the preceding discussion we are recommending the following requirements be established by the RWQCBs:

Include a provision in permits for water recycling treatment plants employing UV disinfection that requires the water recycling plant operator to establish quartz sleeve cleaning frequencies that ensure the minimum required UV dose delivery is consistently met.

Include a provision in water-recycling permits that requires water recycling plant operators use a fixed cleaning frequency to define the quartz sleeve cleaning intervals, and not use the presence of coliform organisms in the treated effluent as a factor to determine cleaning intervals. Because the water quality parameters for establishing fouling rates are not known and because of the site-to-site variability in wastewater quality, the Department further recommends that such cleaning frequencies be established on a site-specific basis.

Include a provision in water-recycling permits that specifies the minimum delivered UV dose that must be maintained (as recommended by the NWRI/AWWARF UV Disinfection Guidelines), in addition to the coliform standard.

If you have any questions concerning this matter, please contact Dr. Rick Sakaji with this Department at (510) 849-5050.