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ATTACHMENT A

REQUIREMENTS FOR MONITORING CONSTITUENTS OF EMERGING CONCERN FOR RECYCLED WATER

The purpose of this attachment to the Recycled Water Policy (Policy) is to provide direction to the Regional Water Quality Control Boards (Regional Water Boards) on monitoring requirements for constituents of emerging concern[1] (CECs) in recycled municipal wastewater, herein referred to as "recycled water". The monitoring requirements and criteria for evaluating monitoring results in the Policy are based on recommendations from a Scientific Advisory Panel[2]. The monitoring requirements pertain to the production and use of recycled water for groundwater recharge reuse[3] by surface and subsurface application methods, and for landscape irrigation. The monitoring requirements apply to recycled water producers, including entities that further treat or enhance the quality of recycled water supplied by municipal wastewater treatment facilities, and groundwater recharge reuse facilities.

Groundwater recharge by surface application is the controlled application of water to a spreading area for infiltration resulting in the recharge of a groundwater basin. Subsurface application is the controlled application of water to a groundwater basin or aquifer by a means other than surface application, such as direct injection through a well.

The California Department of Public Health (CDPH) shall be consulted for any additional monitoring requirements for recycled water use found necessary by CDPH to protect human health.

1. CECS AND SURROGATES

Within this Policy, CECs of toxicological relevance to human health are referred to as "health-relevant CECs."[4] CECs determined not to have human health relevance, but useful for monitoring treatment process efficacy, are referred as "performance indicator CECs." An indicator CEC is an individual CEC used for evaluating a family of CECs

[1] For this Policy, CECs are defined to represent personal care products, pharmaceuticals including antibiotics and antimicrobials; industrial, agricultural, and household chemicals; hormones; food additives; transformation products, inorganic constituents; and nanomaterials.

[2] The Scientific Advisory Panel was convened in accordance with provision 10.b. of the Policy. The panel's recommendations were presented in the report; *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water – Recommendations of a Scientific Advisory Panel*, dated June 25, 2010.

[3] As used in this attachment, use of recycled water for groundwater recharge reuse has the same meaning as indirect potable reuse for groundwater recharge as defined in section 116275 of the Health and Safety Code (Water Code section 13561(c)), where it is defined as the planned use of recycled water for replenishment of a groundwater basin or an aquifer that has been designated as a source of water supply for a public water system.

[4] Determined through a screening process conducted by the CEC Scientific Advisory Panel; *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water – Recommendations of a Scientific Advisory Panel*, dated June 25, 2010.

with similar physicochemical or biodegradable characteristics. The removal of an indicator CEC through a treatment process provides an indication of removal of CECs with similar properties. The health-relevant CECs also serve as indicator CECs.

A surrogate is a measurable physical or chemical property, such as chlorine residual or electrical conductivity, that provides a direct correlation with the concentration of an indicator compound. Surrogates are used to monitor the efficiency of trace organic compound removal by a treatment process and/or provide an indication of a treatment process failure. In regards to surrogates, a reverse osmosis (RO) treatment process, for example, is expected to substantially reduce the electrical conductivity of the recycled water being treated; this reduction in the level of the surrogate also provides an indication that inorganic and organic compounds, including CECs, are being removed.

Recycled water monitoring programs used for groundwater recharge reuse shall include monitoring for: (1) human health-relevant CECs; (2) performance indicator CECs; and (3) surrogates. The purpose of monitoring performance indicator CECs and surrogates is to assess the removal efficiency of unit processes that provide treatment to CECs. Treatment processes designed to provide a barrier to CECs include, but are not limited to, advanced oxidation processes (AOPs), biologically active carbon, nanofiltration, and RO. In addition, soil aquifer treatment[5] is a passive treatment process that provides a level of removal of CECs. AOPs are treatment processes involving the use of hydrogen peroxide and ozone; commonly combined with ultraviolet light irradiation.

This Policy provides CEC monitoring requirements for recycled water which undergoes additional treatment by soil aquifer treatment or RO/AOPs. CEC monitoring requirements for groundwater recharge reuse projects implementing treatment processes that provide control of CECs by processes other than soil aquifer treatment or RO/AOPs shall be established on a case-by-case basis by the Regional Water Boards in consultation with CDPH.

Monitoring of health-relevant CECs or performance indicator CECs is not required for recycled water used for landscape irrigation due to the low risk for ingestion of the water.[6] Monitoring programs for recycled water used for landscape irrigation, however, shall include monitoring for applicable surrogates, as presented in section 1.2, to evaluate the efficacy of filtration and disinfection systems.

[5] For evaluating removal of CECs, the treatment zone for soil aquifer treatment is from the surface of the application area through the unsaturated zone to groundwater, including groundwater within a two-week travel time distance through an aquifer downgradient of the surface application area.

[6] "For monitoring programs to assess CEC threats for urban irrigation reuse, none of the chemicals for which measurement methods and exposure data are available exceeded the threshold for monitoring priority. This is largely attributable to higher MTLs *(Monitoring Trigger Levels)* because of reduced water ingestion in a landscape irrigation setting compared to drinking water." *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water – Recommendations of a Scientific Advisory Panel*, dated June 25, 2010.

1.1. CECs for Monitoring Programs

This Policy provides requirements for monitoring CECs in recycled water used for groundwater recharge reuse. The Regional Water Boards shall not issue requirements for monitoring of additional CECs, beyond the requirements provided in this Policy, except when recommended by CDPH or when requested by the owner or operator of the groundwater recharge reuse project.

Table 1 provides the health-relevant CECs and performance indicator CECs to be monitored for recycled water uses along with their respective method reporting limits. All CECs listed for a recycled water application shall be monitored during an initial assessment monitoring phase, as described in Section 3.1. Based on monitoring results and findings, the list of performance indicator CECs required for monitoring may be refined for subsequent monitoring phases. The health-relevant CECs listed in Table 1 shall be monitored during the entirety of the initial assessment and baseline monitoring phases (Sections 3.1 and 3.2). Based on the results of the baseline monitoring phase and/or subsequent monitoring, the list of health-relevant CECs required for monitoring may be revised. The method for evaluation of monitoring results for health-relevant CECs is provided in Section 4.2.

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Table 1 – CECs to be Monitored

Constituent	Constituent Group	Relevance/Indicator Type	Method Reporting Limit (µg/L)
GROUNDWATER RECHARGE REUSE - SURFACE APPLICATION			
17β-estradiol	Steroid hormones	Health	0.001
Caffeine	Stimulant	Health & Performance	0.05
N-Nitrosodimethylamine (NDMA)	Disinfection byproduct	Health	0.002
Triclosan	Antimicrobial	Health	0.05
Gemfibrozil	Pharmaceutical	Performance	0.01
Iopromide	Pharmaceutical	Performance	0.05
N,N-Diethyl-meta-toluamide (DEET)	Personal care product	Performance	0.01
Sucralose	Food additive	Performance	0.1
GROUNDWATER RECHARGE REUSE - SUBSURFACE APPLICATION			
17β-estradiol	Steroid hormones	Health	0.001
Caffeine	Stimulant	Health & Performance	0.05
NDMA	Disinfection byproduct	Health & Performance	0.002
Triclosan	Antimicrobial	Health	0.05
DEET	Personal care product	Performance	0.01
Sucralose	Food additive	Performance	0.1
LANDSCAPE IRRIGATION			
None	--	--	--

µg/L – Micrograms per liter

Analytical methods for laboratory analysis of CECs shall be selected to achieve the method reporting limits presented in Table 1, unless the method reporting limit is found to be unachievable. In cases where a method reporting limit is found to be unachievable using readily available methodologies, an analytical method with a method reporting limit that is closest to the recommended method reporting limit with proven reliability shall be selected.

If the United States Environmental Protection Agency (U.S. EPA) has approved an analytical method for analysis of a CEC or a surrogate, then the CEC or surrogate shall be analyzed in conformance with the analytical method. The CDPH shall be consulted for the use of analytical methods for CECs or surrogates that do not have analytical methods approved by U.S. EPA.

1.2. Surrogates for Monitoring Programs

Selection of appropriate surrogates shall be based on the types of treatment processes used, the recycled water use, and the measurable occurrence of surrogates in the treatment process. Table 2 presents a list of surrogates to be considered for monitoring treatment of recycled water used for groundwater recharge reuse and landscape irrigation.

Table 2: Surrogates

GROUNDWATER RECHARGE REUSE - SURFACE APPLICATION
Ammonia
Total Organic Carbon (TOC)
Nitrate
Ultraviolet (UV) Light Absorption
GROUNDWATER RECHARGE REUSE - SUBSURFACE APPLICATION
Electrical Conductivity
TOC
LANDSCAPE IRRIGATION
Chlorine Residual
Total Coliform
Turbidity

Surrogates shall be selected on a case-by-case basis and shall be appropriate for the treatment process or processes. For example, chlorine residual is not an appropriate surrogate for projects that do not use chlorine-based compounds for disinfection.

Where applicable, surrogates may be measured using in-line or hand-held instruments provided that instrument calibration procedures are implemented in accordance with the manufacturer's specifications and that calibration is documented.

2. MONITORING LOCATIONS

Monitoring locations for CECs and surrogates will depend on the unit treatment processes utilized and the recycled water use. Monitoring for CECs and surrogates shall be conducted before and after an individual treatment process or a combination of processes that provide removal of CECs; unit processes are presented in Section 1. Additionally, surface application recharge reuse projects relying on the process of soil aquifer treatment shall monitor for CECs in groundwater at a location prior to the point of extraction for drinking water supply. Monitoring locations for health-relevant and performance indicator CECs and surrogates are detailed below.

2.1. Health-Relevant CEC Monitoring Locations

2.1.1. Groundwater Recharge Reuse - Surface Application

For groundwater recharge reuse projects implementing surface application of recycled water, health-relevant CECs shall be monitored at these locations:

(1) Following tertiary treatment[7] prior to discharge to the surface application area;

(2) Either in the unsaturated zone or in the uppermost portion of the groundwater[8] underlying the surface application area; and

(3) Within groundwater at a location downgradient of the surface application area and upgradient of the point of extraction for drinking water supply.

Monitoring locations for health-relevant CECs for the phases of monitoring are presented in Tables 3 through 5.

2.1.2. Groundwater Recharge Reuse - Subsurface Application

For groundwater recharge reuse projects implementing subsurface application of recycled water, monitoring of health-relevant CECs shall be conducted at a location following RO/AOPs treatment prior to discharge into an aquifer.

2.1.3. Landscape Irrigation

Monitoring of health-relevant CECs is not required for municipal recycled water used for landscape irrigation.

2.2. Performance Indicator CEC and Surrogate Monitoring Locations

To allow evaluation of individual unit processes or a combination of unit processes that provide removal of CECs, performance indicator CECs and surrogates shall be monitored at the locations described below and presented in Tables 3 through 5.

2.2.1. Groundwater Recharge Reuse - Surface Application

For surface application practices, performance indicator CECs shall be monitored in recycled water and groundwater at these locations:

(1) Following tertiary treatment prior to discharge to the surface application area;

[7] Standards for disinfected tertiary recycled water presented in California Code of Regulations Title 22, section 60301.230 and 60301.320.

[8] Groundwater monitoring location situated within a two-week travel time (groundwater travel through the aquifer) downgradient of the surface application area.

(2) The unsaturated zone or the uppermost portion of the groundwater underlying the surface application area; and

(3) Within groundwater at a location downgradient of the surface application area and upgradient of the point of extraction for drinking water supply.

Surrogates shall be monitored in recycled water and groundwater at these locations:

(1) Following tertiary treatment prior to discharge to the surface application area; and

(2) The unsaturated zone or the uppermost portion of the groundwater underlying the surface application area.

Monitoring locations for performance indicator CECs and surrogates for the phases of monitoring are presented in Tables 3 through 5.

2.2.2. Groundwater Recharge Reuse - Subsurface Application

For subsurface application, performance indicator CECs and surrogates shall be monitored in recycled water at these locations:

(1) Following upstream treatment units prior to treatment by RO;

(2) Following treatment by RO prior to treatment by AOPs; and

(3) Following treatment by AOPs prior to discharge to the aquifer.

2.2.3. Landscape Irrigation

For landscape irrigation, surrogates shall be monitored in municipal recycled water following treatment prior to distribution.

3. PHASED MONITORING REQUIREMENTS

The Regional Water Board shall phase the monitoring requirements for CECs and surrogates for groundwater recharge reuse projects. The purpose of phased monitoring is to allow monitoring requirements for health-relevant CECs, performance indicator CECs and surrogates to be refined based on the monitoring results and findings of the previous phase. An initial assessment monitoring phase, followed by a baseline monitoring phase, shall be conducted to determine the project-specific monitoring

requirements for standard operations. The initial assessment and baseline monitoring phases shall be conducted after CDPH approval for groundwater recharge reuse project operation.

3.1. Initial Assessment Monitoring Phase

The purposes of the initial assessment phase are to (1) identify the occurrence of health-relevant CECs, performance indicator CECs and surrogates in recycled water, the unsaturated zone, and groundwater, (2) determine the effectiveness of treatment of the unit processes[9], and (3) define the project-specific performance indicator CECs and surrogates to monitor during the baseline phase. The monitoring requirements for the initial assessment monitoring phase shall apply to the start-up of new facilities, piloting of new unit processes at existing facilities, and existing facilities where CECs and surrogates have not been assessed equivalent to the requirements of this Policy. The initial assessment monitoring phase shall be conducted for a period of one year.

During the initial assessment monitoring phase for the applicable recycled water application method, each of the health-relevant CECs and performance indicator CECs listed in Table 1, and the appropriate surrogates listed in Table 2, shall be monitored. Surrogates shall be selected to monitor individual unit processes or combinations of unit processes that remove CECs. Performance indicator CEC and surrogate monitoring results that demonstrate measurable removal for a given unit process shall be candidates for use in the monitoring programs for the baseline and standard operation phases. Monitoring requirements for the initial assessment phase are summarized in Table 3.

For existing groundwater recharge reuse projects, historic monitoring data may be used to assess the occurrence and removal of CECs and surrogates. Existing projects demonstrating prior assessment of CECs and surrogates equivalent to the initial assessment phase requirements of this Policy may not be required to conduct the initial monitoring phase and are eligible for baseline monitoring phase requirements (Section 3.2).

Monitoring results shall be evaluated following each sampling event to allow timely implementation of any response actions. If evaluation of monitoring results indicates a concern (i.e., the effectiveness of the treatment processes to achieve the expected degree of removal of CECs or the increased occurrence and/or concentrations of CECs) more frequent monitoring shall be required to further evaluate the effectiveness of the treatment process or the increased occurrence and/or concentrations of CECs. Additional actions also may be warranted, which may include but not be limited to resampling to confirm a result; additional monitoring; implementation of a source identification program; toxicological studies; engineering removal studies; and/or modification of facility operations. Evaluation of monitoring results and determination of appropriate response actions based on monitoring results are presented in Section 4.

[9] Unit processes that provide treatment or removal of CECs.

Following completion of the initial assessment monitoring phase, monitoring requirements shall be re-evaluated and subsequent requirements for the baseline monitoring phase shall be determined on a project specific basis.

3.2. Baseline Monitoring Phase

Based on the findings of the initial assessment monitoring phase, project-specific performance indicator CECs and surrogates shall be selected for monitoring during the baseline monitoring phase. The purpose of the baseline monitoring phase is to assess and refine which health-relevant CECs, performance indicator CECs and surrogates are appropriate to monitor removal of CECs and treatment system operational performance for the standard operation of a facility. Performance indicator CECs detected during the initial assessment phase shall be selected for monitoring during the baseline monitoring phase. Surrogates that exhibited reduction by a unit process and/or provide an indication of operational performance shall be selected for monitoring during the baseline monitoring phase. The baseline monitoring phase shall be conducted for a period of three years following the initial assessment monitoring phase. Monitoring requirements for the baseline phase are summarized in Table 4.

For existing groundwater recharge reuse projects, historic monitoring data may be used to assess removal of health-relevant CECs, performance indicator CECs and surrogates. Existing projects that can demonstrate prior assessment of CECs and surrogates equivalent to the initial assessment phase and baseline phase requirements of this Policy may be eligible for standard operation monitoring requirements (Section 3.3).

Monitoring results shall be evaluated following each sampling event to allow timely implementation of any response actions. If evaluation of monitoring results indicates a concern (i.e., the effectiveness of the treatment processes to achieve the expected degree of removal of CECs or the increased occurrence and/or concentrations of CECs) more frequent monitoring shall be required to further evaluate the effectiveness of the treatment process or the increased occurrence and/or concentrations of CECs. Additional actions may also be warranted, which may include, but not be limited to, resampling to confirm a result; additional monitoring; implementation of a source identification program; toxicological studies; engineering removal studies; and/or modification of facility operation. Evaluation of monitoring results and determination of appropriate response actions based on monitoring results are presented in Section 4.

Following the baseline operation monitoring phase, monitoring requirements shall be re-evaluated and subsequent requirements for the standard operation of a project shall be determined on a project-specific basis.

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Table 3: Initial Assessment Phase Monitoring Requirements

Recycled Water Use	Constituent	Frequency	Monitoring Point
Groundwater Recharge Reuse – Surface Application	Health-Relevant CECs and Performance Indicator CECs: -All listed in Table 1	Quarterly	-Following tertiary treatment prior to discharge. -Uppermost groundwater or unsaturated zone beneath application area[1]. -Downgradient of application area prior to the point of extraction for water supply[2].
	Surrogates: -All, as appropriate for the treatment process	1st 3 months: Weekly	-Following tertiary treatment prior to discharge. -Uppermost groundwater or unsaturated zone beneath application area[1].
		3-12 months: Weekly	-Following tertiary treatment prior to discharge.
		3-12 months: Monthly	-Uppermost groundwater or unsaturated zone beneath application area[1].
Groundwater Recharge Reuse – Subsurface Application	Health-Relevant CECs: -All listed in Table 1	Quarterly	-Following RO/AOPs treatment prior to discharge to aquifer.
	Performance Indicator CECs: -All listed in Table 1	Quarterly	-Prior to RO treatment. -Following RO treatment. -Following AOPs prior to discharge to aquifer.
	Surrogates: TOC Electrical Conductivity	Initial 400 hours of operation: Daily Continuously	-Prior to RO treatment. -Following of RO treatment. -Following AOPs prior to discharge to aquifer.
	Surrogates: TOC Electrical Conductivity	Following initial 400 hours of operation: Weekly Continuously	
Landscape Irrigation	Health-Relevant CECs and Performance Indicator CECs: Not applicable	Not applicable	Not applicable
	Surrogates: Total Coliform Turbidity Chlorine Residual	Daily Continuously Continuously	-Following tertiary treatment prior to distribution.

1 - Groundwater within a two-week travel time distance through the aquifer downgradient of the surface application area.

2 - A location at a distance greater than a two-week travel time through the aquifer from the surface application area, prior to extraction for potable water supply.

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Table 4: Baseline Phase Monitoring Requirements

Recycled Water Use	Constituent	Frequency	Monitoring Point
Groundwater Recharge Reuse – Surface Application	Health-Relevant CECs: - All listed in Table 1 Performance Indicator CECs: -Selected based on the findings of the initial assessment phase	Semi-Annually	-Following tertiary treatment prior to discharge. -Uppermost groundwater or unsaturated zone beneath application area[1]. -Down gradient of application area prior to the point of extraction for water supply[2].
	Surrogates: -Selected based on the findings of the initial assessment phase	Weekly	-Following tertiary treatment prior to discharge.
		Quarterly	-Uppermost groundwater or unsaturated zone beneath application area[1].
Groundwater Recharge Reuse – Subsurface Application	Health-Relevant CECs: -All listed in Table 1	Semi-Annually	-Following RO/AOPs treatment prior to discharge to aquifer.
	Performance Indicator CECs: -Selected based on the findings of the initial assessment phase	Semi-Annually	-Prior to RO treatment. -Following RO treatment. -Following AOPs prior to discharge to aquifer.
	Surrogates: -TOC -Electrical Conductivity	Weekly Continuously	-Prior to RO treatment. -Following RO treatment. -Following AOPs prior to discharge to aquifer.
Landscape Irrigation	Health-Relevant CECs and Performance Indicator CECs: -Not applicable	Not applicable	Not applicable
	Surrogates: -Total Coliform -Turbidity -Chlorine Residual	Daily Continuously Continuously	-Following tertiary treatment prior to distribution.

1 - Groundwater within a two-week travel time distance through the aquifer downgradient of the surface application area.

2 - A location at a distance greater than a two-week travel time through the aquifer from the surface application area, prior to extraction for potable water supply.

3.3. Standard Operation Monitoring

Based on the findings of the baseline monitoring phase, monitoring requirements for health-relevant CECs, performance indicator CECs and surrogates may be refined to establish project-specific requirements for monitoring the standard operating conditions of a groundwater recharge reuse project. Monitoring requirements for the standard operation phase are summarized in Table 5. The list of health-relevant CECs required for monitoring may be revised if monitoring results meet the conditions of the minimum threshold level presented in Table 7. Performance indicator CECs and surrogates detected during the baseline phase and that exhibited reduction by a unit process and/or provided an indication of operational performance shall be selected for monitoring of standard operations.

Monitoring locations for the standard operation phase shall be the same as the locations used for the baseline monitoring phase.

Monitoring for health-relevant CECs and performance indicator CECs shall be conducted on a semi-annual basis, unless the project demonstrates consistency in treatment efficacy in removal of CECs, treatment operational performance, and appropriate recycled water quality[10]. These projects may be monitored for CECs on an annual basis. Monitoring frequencies for CECs and surrogates for standard operation monitoring are presented in Table 5.

Monitoring results shall be evaluated following each sampling event to allow timely implementation of any response actions. Evaluation of monitoring results and determination of appropriate response actions based on monitoring results are presented in Section 4.

[10] Consistent recycled water plant operation should produce final effluent for groundwater recharge use containing health-relevant CEC concentrations that are consistently less than 5 times the ratio of measured concentration (MC) to monitoring trigger level (MTL) or MC/MTL. See Section 4.2.

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Table 5: Standard Operation Monitoring Requirements

Recycled Water Use	Constituent	Frequency	Monitoring Point
Groundwater Recharge Reuse – Surface Application	Health-Relevant CECs and Performance Indicator CECs: -Selected based on the findings of the baseline phase	Semi-Annually or Annually	-Following tertiary treatment prior to discharge. -Uppermost groundwater or unsaturated zone beneath application area[1]. -Downgradient of application area prior to the point of extraction for water supply[2].
	Surrogates: -Selected based on the findings of the baseline phase	Weekly	-Following tertiary treatment prior to discharge.
		Quarterly	-Uppermost groundwater or unsaturated zone beneath application area[1].
Groundwater Recharge Reuse – Subsurface Application	Health-Relevant CECs: - Selected based on the findings of the baseline phase	Semi-Annually or Annually	-Following RO/AOPs treatment prior to discharge to aquifer.
	Performance Indicator CECs: - Selected based on the findings of the baseline phase	Semi-Annually or Annually	-Prior to RO treatment. -Following RO treatment. -Following AOPs prior to discharge to aquifer.
	Surrogates: -TOC -Electrical Conductivity	Weekly Continuously	-Prior to RO treatment. -Following RO treatment. -Following AOPs prior to discharge to aquifer.
Landscape Irrigation	Health-Relevant CECs and Performance Indicator CECs: -Not applicable	Not applicable	Not applicable
	Surrogates: -Total Coliform -Turbidity -Chlorine Residual	Daily Continuously Continuously	-Following tertiary treatment prior to distribution.

1 - Groundwater within a two-week travel time distance through the aquifer downgradient of the surface application area.

2 - A location at a distance greater than a two-week travel time through the aquifer from the surface application area, prior to extraction for potable water supply.

4. EVALUATION OF CEC AND SURROGATE MONITORING RESULTS

This section presents the approaches for evaluating treatment process performance and health-relevant CEC monitoring results. Monitoring results for performance indicator CECs and surrogates shall be used to evaluate the operational performance of a treatment process and the effectiveness of a treatment process in removing CECs. For evaluation of health-relevant CEC monitoring results, a multi-tiered approach of thresholds and corresponding response actions is presented in Section 4.2. The evaluation of monitoring results shall be included in monitoring reports submitted to the Regional Water Board and CDPH.

4.1 Evaluation of Performance Indicator CEC and Surrogate Results

The effectiveness of a treatment process to remove CECs under normal operating conditions shall be evaluated by determining the percent removal, or removal differential, for performance indicator CECs and surrogates. Removal differential is the difference in the concentration of a compound in recycled water prior to and after a treatment process (e.g., soil aquifer treatment or RO/AOPS), divided by the concentration prior to the treatment process.

$$\text{Removal Differential } (\Delta X) = [X_{in} - X_{out}]/X_{in}$$

X_{in} - Concentration in recycled water prior to a treatment process

X_{out} - Concentration in recycled water after a treatment process

To provide an indication of an appropriate level of treatment, calculated removal differentials shall be compared to expected removal differentials for a treatment process. The expected removal differentials for performance indicator CECs and surrogates for each groundwater recharge reuse application scenario and their associated treatment processes (i.e., soil aquifer treatment or RO/AOPS) are presented in Table 6. The expected removal differentials are provided for the purposes of evaluating treatment efficacy and operational performance. Calculated removal differentials equal to or greater than the expected removal differentials provide an indication that treatment processes are operating effectively. Conversely, calculated removal differentials less than the expected removal differentials provide an indication that treatment processes may not be operating as expected or to technical specifications. If the removal differential is less than expected, assessment of the treatment processes may be warranted. The expected removal differentials provided shall not be used as compliance requirements.

4.1.1. Groundwater Recharge reuse – Surface Application

For groundwater recharge reuse by surface application, the removal differential shall be determined by comparing the recycled water quality in the discharge to a surface application area to the recycled water quality in the unsaturated zone or the uppermost groundwater beneath the surface application area, taking into account any dilution from other sources.

4.1.2. Groundwater Recharge reuse – Subsurface Application

For groundwater recharge reuse using subsurface application, the removal differential shall be determined by comparing recycled water quality before treatment by RO/AOPs and after treatment prior to discharge to the aquifer.

4.1.3. Landscape Irrigation

For landscape irrigation projects, determination of removal differentials is not required for surrogates.

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Table 6: Monitoring Trigger Levels and Expected Removal Differentials

Constituent/ Parameter	Relevance/Indicator Type/Surrogate	Monitoring Trigger Level (micrograms/liter)[1]	Expected Removal Differential (%)
GROUNDWATER RECHARGE REUSE - SURFACE APPLICATION[2]			
17β-estradiol	Health	0.0009	--
Caffeine	Health & Performance	0.35	>90
NDMA	Health	0.01	--
Triclosan	Health	0.35	--
Gemfibrozil	Performance	--	>90
Iopromide	Performance	--	>90
DEET	Performance	--	>90
Sucralose	Performance	--	<25
Ammonia	Surrogate	--	>90
TOC	Surrogate	--	>30
Nitrate	Surrogate	--	>30
UV Absorption	Surrogate	--	>30
GROUNDWATER RECHARGE REUSE - SUBSURFACE APPLICATION[3]			
17β-estradiol	Health	0.0009	--
Caffeine	Health & Performance	0.35	>90
NDMA	Health & Performance	0.01	25-50, >80[4]
Triclosan	Health	0.35	--
DEET	Performance	--	>90
Sucralose	Performance	--	>90
Electrical Conductivity	Surrogate	--	>90
TOC	Surrogate	--	>90
LANDSCAPE IRRIGATION			
Chlorine Residual	Surrogate	--	--
Total Coliform	Surrogate	--	--
Turbidity	Surrogate	--	--

-- - Not applicable

1 - Monitoring trigger levels for groundwater recharge reuse and landscape irrigation applications were established in *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water – Recommendations of a Scientific Advisory Panel*, dated June 25, 2010.

2 - Treatment process: Soil aquifer treatment

3 - Treatment process: Reverse osmosis and advanced oxidation process

4 - 25-50% for treatment utilizing reverse osmosis; >80% for treatment utilizing reverse osmosis and advanced oxidation process.

4.2. Evaluation of Health-Relevant CEC Results

The recycled water producer or groundwater recharge reuse agency shall evaluate health–relevant CEC monitoring results to determine the appropriate response actions. The producer or recharge agency shall conduct the evaluation by comparing measured CEC concentrations (MC) to their respective monitoring trigger levels[11] (MTL) listed in Table 6 to determine MC/MTL ratios. The producer or recharge agency shall compare the calculated MC/MTL ratios to the thresholds presented in Table 7 and shall implement the response actions corresponding to the threshold.

Table 7: MC/MTL Thresholds and Response Actions

MC/MTL Threshold	Response Action
If greater than 75 percent of the MC/MTL ratio results for a CEC are less than or equal to 0.1 during the baseline monitoring phase and/or subsequent monitoring -	A) Consider requesting removal the CEC from the monitoring program; confer with CDPH and the Regional Water Board.
If MC/MTL ratio is greater than 0.1 and less than or equal to 1 -	B) Continue to monitor.
If MC/MTL ratio is greater than 1 and less than or equal to 10 -	C) Check the data and conduct action B.
If MC/MLT ratio is greater than 10 and less than or equal to 100 -	D) Resample immediately, analyze to confirm CEC result, and conduct action C.
If MC/MLT ratio is greater than 100 and less than or equal to 1000 -	E) Conduct action D and implement a source identification program, and monitor at additional location(s) closer to the point of extraction for water supply and/or a point in the distribution system to confirm that attenuation of CECs is occurring subsequent to the downgradient monitoring location (Section 2) and to confirm the magnitude of assumed safety factors associated with removal efficiency. The recharge reuse agency also shall contact CDPH and the Regional Water Board and evaluate the need for additional actions, which may include, but are not limited to, additional monitoring, toxicological studies, engineering removal studies and/or modification of facility operation to reduce CEC concentrations.
If MC/MTL ratio is greater than 1000 -	F) Conduct action E and immediately confer with CDPH and the Regional Water Board to determine the required response action. Monitor to confirm effectiveness of corrective action(s) to reduce CEC levels below at least an MC/MTL ratio of 100.

[11] Monitoring Trigger Level (MTL): Health-relevant screening level value for a CEC for a particular water reuse scenario. MTLs were established in, *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water – Recommendations of a Scientific Advisory Panel*, dated June 25, 2010.