

## 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<sup>1</sup> (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 Science Advisory Panel<sup>2</sup>. The monitoring requirements pertain to the production and use of recycled water for groundwater recharge reuse<sup>3</sup> 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-based CECs.”<sup>4</sup> CECs determined not to have human health relevance, but

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<sup>1</sup> For this Policy, CECs are defined to be chemicals in personal care products, pharmaceuticals including antibiotics, antimicrobials; industrial, agricultural, and household chemicals; hormones; food additives; transformation products, inorganic constituents; and nanomaterials.

<sup>2</sup> The Science 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 Science Advisory Panel](#), dated June 25, 2010.

<sup>3</sup> 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.

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

useful for monitoring treatment process efficacy, are referred to as “performance indicator CECs.” A performance indicator CEC is an individual CEC used for evaluating a family of CECs with similar physicochemical or biodegradable characteristics. The removal of an a performance indicator CEC through a treatment process provides an indication of removal of CECs with similar properties. The health-based CECs may also serve as performance indicator CECs.

A surrogate is a measurable physical or chemical property, such as chlorine residual or electrical conductivity, that can be used to measure the efficiency of trace organic compounds removal by 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-based 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 to remove CECs. **For this policy for groundwater recharge reuse, unit** ~~Treatment processes that removed designed to provide a barrier to~~ CECs include, ~~but RO are not limited to,~~ advanced oxidation processes (AOPs), ~~and soil aquifer treatment biologically active carbon, nanofiltration, and RO.~~ **AOPs are treatment processes involving the use of hydrogen peroxide and/or ozone, combined with ultraviolet light irradiation.** ~~In addition, S~~ **soil aquifer treatment<sup>5</sup> is a natural treatment process that provides a level of removal of CECs as water passes through soil, the vadose zone, and within an aquifer.** ~~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 State** Water Boards in consultation with CDPH.

Monitoring of health-based CECs or performance indicator CECs is not required for recycled water used for landscape irrigation due to the low risk for ingestion of the

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<sup>5</sup> 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 30-day travel time distance through the aquifer downgradient of the surface application area.

water.<sup>6</sup> ~~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.~~

### 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 in recycled water, beyond the requirements provided in this Policy except when:

- ~~recommended by CDPH~~ or;
- ~~requested by the project proponent~~; ~~or~~
- **required by an adopted regional salt and nutrient management plan.**

Table 1 provides the health-based CECs and performance indicator CECs to be monitored ~~for recycled water uses~~ along with their respective 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-based 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-based CECs required for monitoring may be revised. The method for evaluation of monitoring results for health-based CECs is provided in Section 4.2.

Quality ~~a~~Assurance and ~~q~~Quality ~~c~~Control measures shall be used for both collection of samples and laboratory analysis work. The project proponent shall develop a quality assurance project plan that includes the appropriate number of field blanks, laboratory blanks, replicate samples, and matrix spikes.

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<sup>6</sup> “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 Monitoring Trigger Levels (MTLs), because of reduced water ingestion in a landscape irrigation setting compared to drinking water.” MTLs are health-based screening level values for CECs for a particular water reuse scenario. MTLs were established in, [Monitoring Strategies for Chemicals of Emerging Concern \(CECs\) in Recycled Water – Recommendations of a Science Advisory Panel](#), dated June 25, 2010.

Table 1 – CECs to be Monitored

<u>Constituent</u>	<u>Constituent Group</u>	<u>Relevance/Indicator Type</u>	<u>Reporting Limit (µg/L)</u>
<b>GROUNDWATER RECHARGE REUSE - SURFACE APPLICATION</b>			
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	0.05
Sucralose	Food additive	Performance	0.1
<b>GROUNDWATER RECHARGE REUSE - SUBSURFACE APPLICATION</b>			
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	<u>0.05</u> <sup>1</sup>
Sucralose	Food additive	Performance	0.1
<b>LANDSCAPE IRRIGATION</b>			
<b>None</b>	--	--	--

µg/L – Micrograms per liter

Analytical methods for laboratory analysis of CECs shall be selected to achieve the reporting limits presented in Table 1, ~~and shall be peer reviewed and published.~~ The analytical methods shall be based on methods published by the United States Environmental Protection Agency, certified by the California Department of Public Health, or shall be peer reviewed and published methods that have been reviewed by CDPH, including those published by voluntary consensus standards bodies such as the Standard Methods Committee and the American Society for Testing and Materials International. Any modifications to the published or certified methods shall be reviewed by CDPH and subsequently submitted to the Regional Water Board in an updated quality assurance project plan.

**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 **that shall** be considered for monitoring treatment of recycled water used for groundwater recharge reuse ~~and landscape irrigation.~~ **Other surrogates not listed in Table 2 may also be considered.**

Table 2: Surrogates

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

The project proponent shall propose surrogates to monitor on a case-by-case basis 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.~~ The Regional Water Board shall review and approve the selected surrogates in consultation with CDPH.

Where applicable, surrogates may be measured using on-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-based and performance indicator CECs and surrogates are detailed below.~~

**Monitoring locations for CECs and surrogates are described in this section.**

**2.1. Health-Based CEC Monitoring Locations**

**2.1.1. Groundwater Recharge Reuse - Surface Application**

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

- (1) Following tertiary treatment<sup>7</sup> prior to application to the surface spreading area; and
- (2) At monitoring well locations designated in consultation with CDPH within the distance groundwater travels from the application site in thirty days.

Monitoring locations for health-based 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-based CECs shall be conducted at a location following treatment by RO/AOPs ~~treatment~~ prior to discharge release into an aquifer.

**~~2.1.3. Landscape Irrigation~~**

**~~Monitoring of health-based 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 application to the surface spreading area; and
- (2) At monitoring well locations designated in consultation with CDPH within the distance groundwater travels from application site in thirty days.

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<sup>7</sup> Standards for disinfected tertiary recycled water presented in California Code of Regulations Title 22, section 60301.230 and 60301.320.

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

- (1) Following tertiary treatment prior to application to the surface application area; and
- (2) At monitoring well locations designated in consultation with CDPH within the distance groundwater travels from application site in thirty days.

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) Prior to treatment by RO/AOPs; and
- (2) Following treatment by RO/AOPs prior to release to the aquifer.

**For subsurface application, surrogates shall be monitored at locations proposed by the project proponent and approved by the Regional Water Board in consultation with CDPH.**

### **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-based 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-based CECs, performance indicator CECs, and surrogates in recycled water and

groundwater<sup>8</sup>; (2) determine ~~the treatment effectiveness of unit processes~~; (3) define the project-specific performance indicator CECs and surrogates to monitor during the baseline phase; and (4) specify the expected removal percentages for indicator CECs and surrogates. 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<sup>9</sup> 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-based CECs and performance indicator CECs listed in Table 1, and ~~the appropriate surrogates listed in Table 2~~ **(see Section 1.2)** 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 skip the initial monitoring phase and initiate the baseline monitoring phase requirements in 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, **such as finding a concentration of a health-based CEC above thresholds described in Table 7, (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~~ **may** be required to further evaluate the effectiveness of the treatment process. 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. If additional monitoring is required, the Regional Water Board shall consult with CDPH and revise the Monitoring and Reporting Program as appropriate. Evaluation of monitoring results and determination of appropriate response actions based on monitoring results are presented in Section 4.

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<sup>8</sup> **The identification of the occurrence of health-based CECs, performance indicator CECs, and surrogates in groundwater only applies to groundwater recharge reuse by surface application.**

<sup>9</sup> To be considered equivalent, data from prior assessment need not replicate the exact frequency and duration of the initial assessment phase requirements specified in Table 3, if the overall robustness and size of the data are sufficient to adequately characterize the surrogates and treatment performance under consideration.



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-based 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 **and surrogates that exhibited reduction by unit processes detected during the initial assessment phase shall be selected for monitoring during the baseline monitoring phase.** ~~Surrogates that exhibited reduction through a unit process~~ and/or provided an indication of operational performance shall be selected for monitoring during the baseline monitoring phase. Those surrogates not reduced through a unit process are not good indicators of the unit's intended performance. For example, **soil aquifer treatmenta-filtration unit will may** not effectively lower electrical conductivity. Therefore, electrical conductivity **mayis not be** a good surrogate for **soil aquifer treatmenta-filtration unit.** 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. **If a performance indicator CEC listed in Table 1 is found not to be a good indicator, the project proponent shall propose an alternative performance indicator CEC representative of the constituent group to monitor. This performance indicator CEC shall be subject to approval by the Regional Water Board in consultation with CDPH.**

For existing groundwater recharge reuse projects, historic monitoring data may be used to assess removal of health-based 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, **such as finding a concentration of a health-based CEC above thresholds described in Table 7, (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 ~~may shall~~ be required to further evaluate the effectiveness of the treatment process. 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. If additional monitoring is required, the Regional Water Board shall consult with CDPH and revise the Monitoring and Reporting Program as appropriate. 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.

Table 3: Initial Assessment Phase Monitoring Requirements

<u>Recycled Water Use</u>	<u>Constituent</u>	<u>Frequency</u>	<u>Monitoring Point</u>
Groundwater Recharge Reuse- Surface Application	<u>Health-Based CECs and Performance Indicator CECs:</u> All listed in Table 1.	Quarterly <sup>1</sup>	- Following tertiary treatment prior to application to surface spreading area.  - At monitoring well locations designated in consultation with CDPH. <sup>1,2</sup>
	<u>Surrogates:</u> To be selected on a project-specific basis. <sup>3,4</sup>	<u>1<sup>st</sup> 3 months:</u> To be determined on a project-specific basis. <sup>2,3</sup>	- Following tertiary treatment prior to application to the surface spreading area.  - At monitoring well locations designated in consultation with CDPH. <sup>1,2</sup>
		<u>3-12 months:</u> To be determined on a project-specific basis. <sup>2,3</sup>	- Following tertiary treatment prior to application to the surface spreading area.  - At monitoring well locations designated in consultation with CDPH. <sup>1,2</sup>
Groundwater Recharge Reuse -Subsurface Application	<u>Health-Based CECs:</u> All listed in Table 1.	Quarterly <sup>1</sup>	Following treatment by RO/AOPs prior to release to aquifer.
	<u>Performance Indicator CECs:</u> All listed in Table 1.	Quarterly <sup>1</sup>	- Prior to RO treatment.  - Following RO/AOPs prior to release to aquifer.
	<u>Surrogates:</u> To be selected on a project-specific basis. <sup>4</sup>	To be determined on a project-specific basis.	<del>- Prior to RO treatment.</del>  <del>- Following RO/AOPs prior to release to aquifer.</del> <u>At locations approved by the Regional Water Board.</u> <sup>5</sup>
Landscape Irrigation	<u>Health-based CEC and Performance CECs:</u> <b>Not applicable</b>	<b>Not applicable</b>	<b>Not applicable</b>
	<u>Surrogates:</u> <b>To be selected on a project-specific basis.</b> <sup>3</sup>	<b>To be determined on a project specific basis.</b>	<b>Following tertiary treatment prior to distribution.</b>

**1- This is the initial monitoring frequency for the monitoring and reporting program. The Regional Water Board may require additional monitoring to respond to a concern as stated in Section 3.1.**

**2 - 4**—Groundwater within a 30-day travel time distance through the aquifer downgradient of the surface application area.

**32** – The monitoring frequency shall be determined by the Regional Water Boards in consultation with CDPH. The intent is to have increased monitoring frequency during the first three months and then decrease the frequency after three months.

**4 – See Section 1.2 for guidance on selection of surrogates.**

**5 – See Section 2.2.2 for information on surrogate monitoring locations for subsurface application.**

Table 4: Baseline Phase Monitoring Requirements

<u>Recycled Water Use</u>	<u>Constituent</u>	<u>Frequency</u>	<u>Monitoring Point</u>
Groundwater Recharge Reuse – Surface Application	<u>Health-Based CECs:</u> All listed in Table 1.	Semi-Annually <sup>1</sup>	- Following tertiary treatment prior to application to the surface spreading area.  - At monitoring well locations designated in consultation with CDPH. <sup>24</sup>
	<u>Performance Indicator CECs:</u> Selected based on the findings of the initial assessment phase.		
Groundwater Recharge Reuse – Subsurface Application	<u>Surrogates:</u> Selected based on the findings of the initial assessment phase.	Based on findings of the initial assessment phase.	- Following tertiary treatment prior to application to the surface spreading area.  - At monitoring well locations designated in consultation with CDPH. <sup>42</sup>
	<u>Health-Based CECs:</u> All listed in Table 1.	Semi-Annually <sup>1</sup>	Following treatment by RO/AOPs prior to release to the aquifer.
	<u>Performance Indicator CECs:</u> Selected based on the findings of the initial assessment phase.	Semi-Annually <sup>1</sup>	- Prior to RO treatment.  - Following treatment by RO/AOPs prior to release to the aquifer.
Landscape Irrigation	<u>Surrogates:</u> Selected based on the findings of the initial assessment phase.	Based on findings of the initial assessment phase.	<del>- Prior to RO treatment.</del>  <del>- Following treatment by RO/AOPs prior to release to the aquifer.</del> <b>At locations approved by the Regional Water Board.<sup>3</sup></b>
	<u>Health-based CEC and Performance CECs:</u> <b>Not applicable</b>	<b>Not applicable</b>	<b>Not applicable</b>
	<u>Surrogates:</u> <b>To be selected on a project-specific basis.</b>	<b>To be determined on a project specific basis.</b>	<b>Following tertiary treatment prior to distribution.</b>

**1 – More frequent monitoring may be required to respond to a concern as stated in Section 3.2.**

**24 -** Groundwater within a 30-day travel time distance through the aquifer downgradient of the surface application area.

**3 – See Section 2.2.2 for information on surrogate monitoring locations for subsurface application**

### 3.3. Standard Operation Monitoring

Based on the findings of the baseline monitoring phase, monitoring requirements for health-based 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-based CECs may be revised to remove a health-based CEC from the list 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. If a performance indicator CEC is found not to be a good indicator, the project proponent shall propose an alternative performance indicator CEC representative of the constituent group to monitor. This performance indicator CEC shall be subject to approval by the Regional Water Board in consultation with CDPH.

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

Monitoring for health-based 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. 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. If evaluation of monitoring results indicates a concern, such as finding a health-based CEC above thresholds described in Table 7 or a decline in removal of a performance indicator CEC from the performance levels established during the initial and baseline monitoring phases, more frequent monitoring may be required to further evaluate the effectiveness of the treatment process. 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. If additional monitoring is required, the Regional Water Board shall consult with CDPH and revise the Monitoring and Reporting Program as appropriate. Evaluation of monitoring results and determination of appropriate response actions based on monitoring results are presented in Section 4.

Table 5: Standard Operation Monitoring Requirements

Recycled Water Use	Constituent	Frequency	Monitoring Point
Groundwater Recharge Reuse - Surface Application	<u>Health-Based CECs:</u> <u>and Performance Indicator CECs:</u> Selected based on the findings of the baseline phase.	Semi-Annually or Annually <sup>1</sup>	<ul style="list-style-type: none"> <li>- Following tertiary treatment prior to application to the surface spreading area.</li> <li>- At monitoring well locations designated in consultation with CDPH.<sup>24</sup></li> </ul>
	<u>Performance Indicator CECs:</u> <b>Selected based on the findings of the baseline phase.</b>		
	<u>Surrogates:</u> Selected based on the findings of the baseline phase.	Based on findings of the baseline assessment phase.	<ul style="list-style-type: none"> <li>- Following tertiary treatment prior to application to the surface spreading area.</li> <li>- At monitoring well locations designated in consultation with CDPH.<sup>24</sup></li> </ul>
Groundwater Recharge Reuse - Subsurface Application	<u>Health-Based CECs:</u> Selected based on the findings of the baseline phase	Semi-Annually or Annually <sup>1</sup>	-Following RO/AOPs treatment prior to release to the aquifer.
	<u>Performance Indicator CECs:</u> Selected based on the findings of the baseline phase.	Semi-Annually or Annually <sup>1</sup>	<ul style="list-style-type: none"> <li>- Prior to RO treatment.</li> <li>- Following RO/AOPs prior to release to the aquifer.</li> </ul>
	<u>Surrogates:</u> <del>To be selected on a project-specific basis.</del> <u>Selected based on the findings of the baseline phase.</u>	-Based on findings of the baseline assessment phase.	<ul style="list-style-type: none"> <li><del>- Prior to RO treatment.</del></li> <li><del>- Following RO/AOPs prior to release to the aquifer</del></li> <li><b><u>At locations approved by the Regional Water Board.</u></b><sup>3</sup></li> </ul>
Landscape Irrigation	<u>Health-based CEC and Performance CECs:</u> Not applicable	Not applicable	Not applicable
	<u>Surrogates:</u> <del>To be selected on a project-specific basis.</del>	Based on findings of the baseline assessment phase.	Following tertiary treatment prior to distribution.

**1 - More frequent monitoring may be required to respond to a concern as stated in Section 3.3.**

**24 -** Groundwater within a 30-day travel time distance through the aquifer downgradient of the surface application area.

**3 – See Section 2.2.2 for information on surrogate monitoring locations for subsurface application**

#### **4. EVALUATION OF CEC AND SURROGATE MONITORING RESULTS**

This section presents the approaches for evaluating treatment process performance and health-based 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-based 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 shall be evaluated by determining the removal percentages for performance indicator CECs and surrogates. The removal percentage 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 and multiplied by 100.

$$\text{Removal Percentage} = \frac{[X_{in} - X_{out}]}{X_{in}} (100)$$

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

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

During the initial assessment, the recycled water project proponent shall monitor performance to determine removal percentages for performance indicator CECs and surrogates. The removal percentages shall be confirmed during the baseline monitoring phase. One example of removal percentages from Drews et. al. (2008) for each application scenario and their associated processes (i.e. soil aquifer treatment or RO/AOPs) is presented in Table 6. The established removal percentages for each project shall be used to evaluate treatment efficacy and operational performance.

##### **4.1.1. Groundwater Recharge Reuse – Surface Application**

For groundwater recharge reuse by surface application, the removal percentage shall be determined by comparing the quality of the recycled water applied to a surface spreading area to the quality of groundwater at monitoring wells. The distance between the application site and the monitoring wells shall be no more than the distance the groundwater travels in thirty days from the application site. The location of the monitoring wells shall be designated in consultation with CDPH. The removal percentage shall account for any effects from the presence of dilution water, such as potable water applied to the application site, storm water applied to the application site, or native groundwater, **and the presence of the CEC in the dilution water.** –**The**



**project proponent shall submit a proposal to the Regional Water Board and CDPH as part of its operation plan on how it will perform this accounting.**

#### **4.1.2. Groundwater Recharge Reuse – Subsurface Application**

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

#### **4.1.3. Landscape Irrigation**

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

Table 6: Monitoring Trigger Levels and Removal Percentages

<u>Constituent/ Parameter</u>	<u>Relevance/Indicator Type/Surrogate</u>	<u>Monitoring Trigger Level (micrograms/liter)<sup>1</sup></u>	<u>Removal Percentages (%)<sup>2</sup></u>
<b>GROUNDWATER RECHARGE REUSE - SURFACE APPLICATION<sup>3</sup></b>			
17β-estradiol	Health	0.0009	-- <sup>4</sup>
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 <sup>5</sup>
Ammonia	Surrogate	--	>90
TOC	Surrogate	--	>30
Nitrate	Surrogate	--	>30
UV Absorption	Surrogate	--	>30
<b>GROUNDWATER RECHARGE REUSE - SUBSURFACE APPLICATION<sup>6</sup></b>			
17β-estradiol	Health	0.0009	--
Caffeine	Health & Performance	0.35	>90
NDMA	Health & Performance	0.01	25-50, >80 <sup>7</sup>
Triclosan	Health	0.35	--
DEET	Performance	--	>90
Sucralose	Performance	--	>90
Electrical Conductivity	Surrogate	--	>90
TOC	Surrogate	--	>90
<b>LANDSCAPE IRRIGATION</b>			
<b>Chlorine Residual</b>	<b>Surrogate</b>	--	--
<b>Total Coliform</b>	<b>Surrogate</b>	--	--
<b>Turbidity</b>	<b>Surrogate</b>	--	--

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 Science Advisory Panel](#), dated June 25, 2010.

2 –The removal percentages presented in this table are from work by Drewes et.al. (2008) and provide an example of performance for that specific research. Project specific removal percentages will be developed for each groundwater recharge reuse project during the initial and baseline monitoring phases.

3 - Treatment process: Soil aquifer treatment. The stated removal percentages are examples and need to be finalized during the initial and baseline monitoring phases for a given site.

4 – Not applicable

5 - Sucralose degrades poorly during soil aquifer treatment. It is included here mainly as a tracer.

6 - Treatment process: Reverse osmosis and advanced oxidation process.

7- For treatment using reverse osmosis, removal percentage is between 25 and 50 percent. For treatment using reverse osmosis and advanced oxidation processes, removal percentage is greater than 80 percent.

**4.2. Evaluation of Health-Based CEC Results**

The project proponent shall evaluate health-relevant CEC monitoring results. To determine the appropriate response actions, the project proponent shall compare measured environmental concentrations (MECs) to their respective monitoring trigger levels<sup>10</sup> (MTLs) listed in Table 6 to determine MEC/MTL ratios. The project proponent shall compare the calculated MEC/MTL ratios to the thresholds presented in Table 7 and shall implement the response actions corresponding to the threshold.

For surface application, the results shall be evaluated for groundwater collected from the monitoring wells. For subsurface application projects, results shall be evaluated for the recycled water released to the aquifer.

Table 7: MEC/MTL Thresholds and Response Actions

MEC/MTL Threshold	Response Action
If greater than 75 percent of the MEC/MTL ratio results for a CEC are less than or equal to 0.1 during the baseline monitoring phase and/or subsequent monitoring -	A) <b>After completion of the baseline monitoring phase,</b> consider requesting removal of the CEC from the monitoring program.
If MEC/MTL ratio is greater than 0.1 and less than or equal to 1 -	B) Continue to monitor.
If MEC/MTL ratio is greater than 1 and less than or equal to 10 -	C) Check the data. Continue to monitor.
If MEC/MLT ratio is greater than 10 and less than or equal to 100 -	D) Resample immediately and analyze to confirm CEC result. Continue to monitor.
If MEC/MLT ratio is greater than 100 -	E) Resample immediately and analyze to confirm result. Continue to monitor. Contact the Regional Water Board and CDPH to discuss additional actions.  (Additional actions may include, but are not limited to, additional monitoring, toxicological studies, engineering removal studies, modification of facility operation, implementation of a source identification program, and monitoring at additional locations.)

<sup>10</sup> Monitoring Trigger Level (MTL): Health-based 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 Science Advisory Panel](#), dated June 25, 2010.