ATTACHMENT C4: SUSTAINABILITY AND RESILIENCY ASSESSMENT

Attachment to the State Water Resources Control Board
2021 Drinking Water Needs Assessment
Cost Assessment Methodology Appendix C
https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/needs/2021_needs_assessment.pdf

SCOPE AND OBJECTIVES

For some HR2W list systems, the Cost Assessment Model identified multiple potential solutions based on systems' identified challenges and additional site-specific information. For these systems, the Cost Assessment Model needed to select one of the potential modeled solutions for the aggregated cost estimate. For the HR2W list systems, the State Water Board recognized that the lowest-cost modeled solution may not always be the best long-term solution for a system and the community it serves. The State Water Board worked in partnership with the Sacramento State University Office of Water Programs (OWP) to incorporate a Sustainability and Resiliency Assessment (SRA) into the Cost Assessment Model. The SRA compared modeled solutions across a range of technical, economic, and environmental indicators of long-term solution viability. This attachment summarizes the framework, methodology, and implementation of the SRA.

SRA SUMMARY

The SRA utilizes sustainability and resiliency metrics to assess modeled long-term solutions for HR2W list systems. A cumulative SRA score is generated from this assessment. When a HR2W list system has more than one potential model solution, the SRA uses the cumulative score to rank potential modeled solutions from more sustainable to least sustainable.

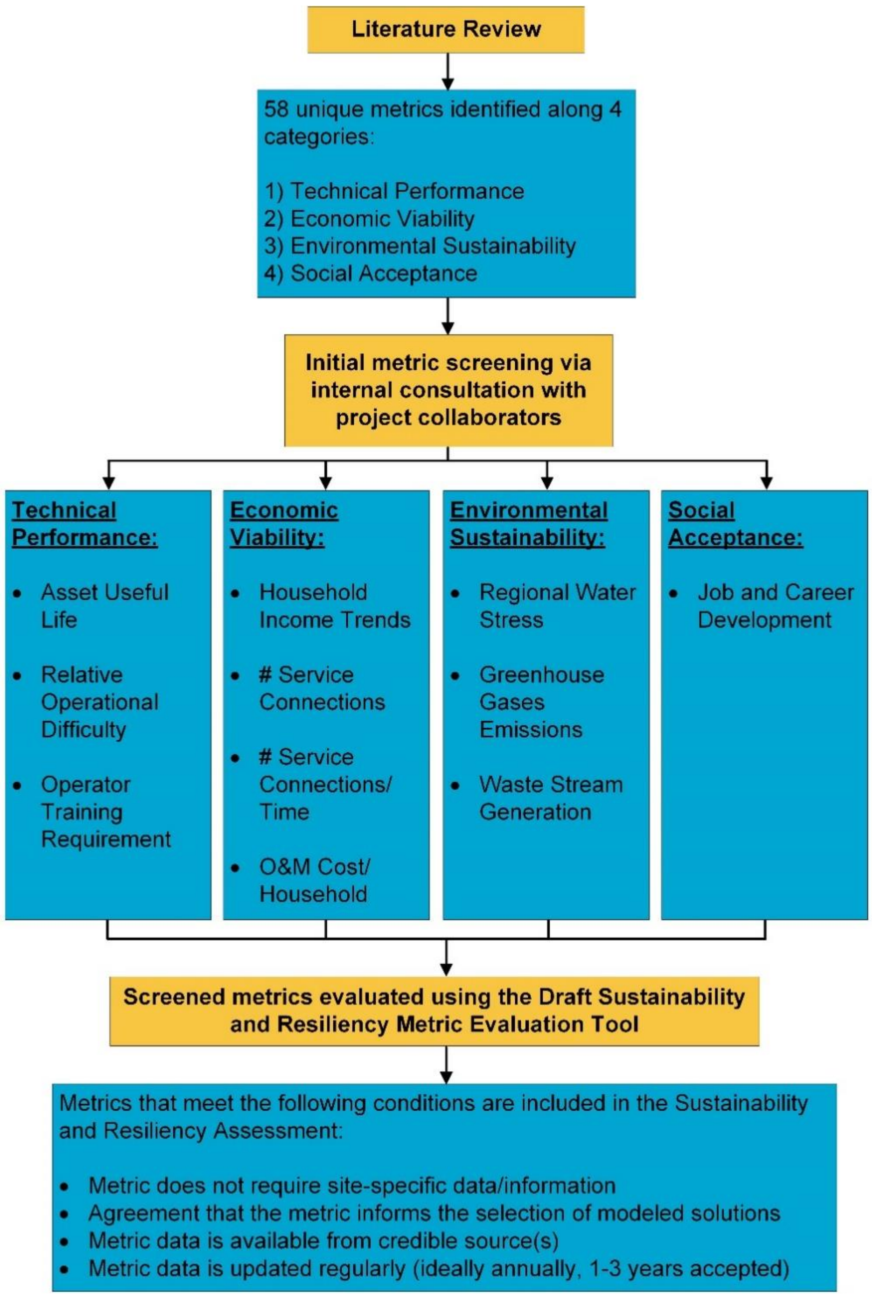
Metric identification and selection began by conducting a literature review to identify potential metrics used as sustainability and resiliency indicators in previous studies, screening the identified metrics based on project relevance and best professional judgement, and selecting a final set of metrics to be used in the assessment.

A method was then developed to apply scores to the selected metrics. Metric scores were combined, resulting in a final SRA score for each potential modeled solution for each system on the HR2W list. The following sections further describe the metric selection and scoring methodology, as well as how the SRA was implemented.

METRIC IDENTIFICATION AND SELECTION

Many frameworks that represent sustainability factors and impacts for long-term water system performance are available within the academic literature. A reproducible framework, however, must also incorporate implementation considerations, such as the availability of data, replicability over time, and input from stakeholders. Identification and selection of the SRA metrics therefore involved a series of tasks (Figure C4.1) resulting in metric selection that was both representative of SRA objectives and practical for annual use in the Cost Assessment. Specific details for each step are described below.

Figure C4.1: Methodology for Identifying and Selection SRA Metrics



LITERATURE REVIEW

A literature review was conducted to identify up-to-date, comprehensive methodologies for evaluating small drinking water system sustainability. Reviewing the content of 29 published papers published between 1987 and 2019 yielded a list of 58 unique metrics that are potentially applicable for tracking sustainability and resiliency of the HR2W list systems' modeled solutions. The 58 metrics were organized into four categories representing various measures of sustainability and resiliency:

Technical Performance Metrics: Measure the capacity of a modeled solution to execute its primary function (i.e., providing safe and affordable access to drinking water) sustainably in the long term. Technical performance metrics may also measure the formal, information-based routines, procedures, and processes needed for maintaining water quality standards and accessibility.

Economic Viability Metrics: Measure the affordability of a modeled solution for residents and the capacity of the system's owner/operator to manage and maintain its operation in the long term. Traditionally, economic viability studies have focused on the normalized cost of treatment (cost/water unit). However, the SRA's intent was to look beyond just unit cost. Therefore, this effort focused on identifying metrics with a more expansive perspective – those that indicate the long-term ability of a community to afford a modeled solution.

Environmental Sustainability Metrics: Measure the environmental impacts of modeled solutions during operation. The environmental sustainability of a modeled solution is assessed by weighing benefits against its negative impacts on the environment. While metrics in other categories focus on public water systems and the customers they serve, metrics in this category highlight the need to consider the lifetime environmental impacts of operations. Generation of waste streams, greenhouse gas emissions, and regional ecological considerations are all important potential components to environmental sustainability.

Social Acceptance Metrics: Measure a community's willingness to adopt a modeled solution based on its perceived effectiveness and benefits. Social acceptance is difficult to gauge due to local context and difficulty in measuring determinants of community approval within the literature, many criteria for social acceptance that were identified as relevant were also addressed through other steps in the overall Needs Assessment.

The number of metrics identified by the literature review within each category, and their study sources, are summarized in Table C4.1.

Table C4.1: Summary of Metrics and their Literature Sources

Criteria Categories	Number of Metrics Identified	Literature Sources
Technical Performance	25	Cornejo et al. 2019[1] Jones et al. 2019[2] Fuller et al. 1996[3] Kumar et al. 2016[4] Pagsuyoin et al. 2015[5]
Economic Viability	10	Cornejo et al. 2019[6] Fuller et al. 1996[7] Jones et al. 2019[8] Khera et al. 2013[9] Kumar et al. 2016[10] Pagsuyoin et al. 2015[11]

[1] Cornejo, Pablo K, Jennifer Becker, Krishna Pagilla, Weiwei Mo, Qiong Zhang, James R Mihelcic, Kartik Chandran, Belinda Sturm, Daniel Yeh, and Diego Rosso. 2019. "Sustainability metrics for assessing water resource recovery facilities of the future." Water Environment Research 91 (1):45-53.

[2] Jones, Christopher H, John Meyer, Pablo K Cornejo, William Hogrewe, Chad J Seidel, and Sherri M Cook. 2019. "A new framework for small drinking water plant sustainability support and decision-making." *Science of The Total Environment* 695:133899.

[3] Fuller, Sieglinde, and Steve Petersen. 1996. "Life-cycle costing manual for the federal energy management program, NIST Handbook 135."

[4] Kumar, Shivendra, Andrew Groth, and Ljubo Vlacic. 2016. "A tool for evaluation of lifecycle cost of water production for small-scale community projects." *Water Policy* 18 (3):769-782.

[5] Pagsuyoin, Sheree A, Joost R Santos, Jana S Latayan, and John R Barajas. 2015. "A multi-attribute decision-making approach to the selection of point-of-use water treatment." *Environment Systems and Decisions* 35 (4):437-452.

[6] Cornejo, Pablo K, Jennifer Becker, Krishna Pagilla, Weiwei Mo, Qiong Zhang, James R Mihelcic, Kartik Chandran, Belinda Sturm, Daniel Yeh, and Diego Rosso. 2019. "Sustainability metrics for assessing water resource recovery facilities of the future." *Water Environment Research* 91 (1):45-53.

[7] Fuller, Sieglinde, and Steve Petersen. 1996. "Life-cycle costing manual for the federal energy management program, NIST Handbook 135."

[8] Jones, Christopher H, John Meyer, Pablo K Cornejo, William Hogrewe, Chad J Seidel, and Sherri M Cook. 2019. "A new framework for small drinking water plant sustainability support and decision-making." *Science of The Total Environment* 695:133899.

[9] Khera, Rajiv, Pat Ransom, and Thomas F Speth. 2013. "Using work breakdown structure models to develop unit treatment costs." *Journal-American Water Works Association* 105 (11): E628-E641.

[10] Kumar, Shivendra, Andrew Groth, and Ljubo Vlacic. 2016. "A tool for evaluation of lifecycle cost of water production for small-scale community projects." *Water Policy* 18 (3):769-782.

[11] Pagsuyoin, Sheree A, Joost R Santos, Jana S Latayan, and John R Barajas. 2015. "A multi-attribute decision-making approach to the selection of point-of-use water treatment." *Environment Systems and Decisions* 35 (4):437-452.

Criteria Categories	Number of Metrics Identified	Literature Sources
Environmental Sustainability	16	Cornejo et al. 2019[12] Godskesen et al. 2018[13] Jolliet et al. 2003[14] Santos et al. 2016[15] Pagsuyoin et al. 2015[16]
Social Acceptance	7	Cornejo et al. 2019[17] Hunkeler 2006[18] Hutchins and Sutherland 2008[19] Santos et al. 2016[20] Pagsuyoin et al. 2015[21]

[12] Cornejo, Pablo K, Jennifer Becker, Krishna Pagilla, Weiwei Mo, Qiong Zhang, James R Mihelcic, Kartik Chandran, Belinda Sturm, Daniel Yeh, and Diego Rosso. 2019. "Sustainability metrics for assessing water resource recovery facilities of the future." *Water Environment Research* 91 (1):45-53.

[13] Godskesen, Berit, M Hauschild, H-J Albrechtsen, and Martin Rygaard. 2018. "ASTA—A method for multi-criteria evaluation of water supply technologies to Assess the most SusTainable Alternative for Copenhagen." *Science of the total environment* 618:399-408.

[14] Jolliet, Olivier, Manuele Margni, Raphaël Charles, Sébastien Humbert, Jérôme Payet, Gerald Rebitzer, and Ralph Rosenbaum. 2003. "IMPACT 2002+: a new life cycle impact assessment methodology." *The international journal of life cycle assessment* 8 (6):324.

[15] Santos, Joost, Sheree Ann Pagsuyoin, and Jana Latayan. 2016. "A multi-criteria decision analysis framework for evaluating point-of-use water treatment alternatives." *Clean Technologies and Environmental Policy* 18 (5):1263-1279.

[16] Pagsuyoin, Sheree A, Joost R Santos, Jana S Latayan, and John R Barajas. 2015. "A multi-attribute decision-making approach to the selection of point-of-use water treatment." *Environment Systems and Decisions* 35 (4):437-452.

[17] Cornejo, Pablo K, Jennifer Becker, Krishna Pagilla, Weiwei Mo, Qiong Zhang, James R Mihelcic, Kartik Chandran, Belinda Sturm, Daniel Yeh, and Diego Rosso. 2019. "Sustainability metrics for assessing water resource recovery facilities of the future." *Water Environment Research* 91 (1):45-53.

[18] Hunkeler, David. 2006. "Societal LCA methodology and case study (12 pp)." *The International Journal of Life Cycle Assessment* 11 (6):371-382.

[19] Hutchins, Margot J, and John W Sutherland. 2008. "An exploration of measures of social sustainability and their application to supply chain decisions." *Journal of cleaner production* 16 (15):1688-1698.

[20] Santos, Joost, Sheree Ann Pagsuyoin, and Jana Latayan. 2016. "A multi-criteria decision analysis framework for evaluating point-of-use water treatment alternatives." *Clean Technologies and Environmental Policy* 18 (5):1263-1279.

[21] Pagsuyoin, Sheree A, Joost R Santos, Jana S Latayan, and John R Barajas. 2015. "A multi-attribute decision-making approach to the selection of point-of-use water treatment." *Environment Systems and Decisions* 35 (4):437-452.

METRIC SCREENING

While established metrics from peer-reviewed literature offer the benefit of having been developed through thoughtful and deliberative analysis, a drawback of relying on such metrics is their rooting in other contexts. The metrics initially identified were assumed to be applicable for consideration as they were developed to evaluate other water system projects with similar objectives, regional characteristics, and involvement of stakeholders. While using existing literature streamlines the process of developing evaluation metrics, it may not incorporate all necessary context for meeting the objectives ofa specific project, in this case the SRA. Additional considerations of data availability and quality may have as much or more influence on what metrics are ultimately appropriate.

Therefore, after identifying possible metrics from the literature review, the list was narrowed to focus on practical sustainability and resiliency measures applicable to the Cost Assessment Model's scope at a state-wide level. The following criteria were used to identify a tentative list of metrics that could be further considered:

- Metrics are reflective of the non-monetizable aspects of the modeled water system solutions (the SRA was intended to evaluate feasibility beyond costs).
- Metrics are generally applicable on a statewide large-scale analysis and do not rely on unobtainable data on local-scale conditions, contexts, or considerations.

From here, the State Water Board and OWP at Sacramento State evaluated the remaining metrics as they relate to the objectives of the SRA and Needs Assessment project. Tables C4.2 through C4.5 present the resulting 11 preliminary Technical Performance, Economic Viability, Environment Sustainability, and Social Acceptance metrics that met the screening criteria and were nominated for further evaluation of applicability for the SRA. The tables also describe each metric's relationship to the concepts of sustainability and resiliency.

Table C4.2: Technical Performance Metrics that Passed the Screening Stage

Metric	Definition	Relationship to Sustainability and Resiliency
Asset Useful Life	The period of time that the asset is expected to function as designed	<u>Directly Proportional:</u> Higher values indicate higher degree of sustainability and resiliency
Relative Operational Difficulty	A measure of the difficulty and complexity of using a possible modeled solution to comply with water quality regulatory requirements	<u>Inversely Proportional:</u> Higher values indicate lower degrees of sustainability and resiliency
Operator Training Requirement	The grade level certification an operator must hold to operate a treatment/distribution system	<u>Inversely Proportional:</u> Higher values indicate lower degrees of sustainability and resiliency

Table C4.3: Economic Viability Metrics that Passed the Screening Stage

Metric	Definition	Relationship to Sustainability and Resiliency
Household Income Trends	Whether the income level of all households combined in a service area increases or decreases over a period of time	Directly Proportional: Upward trends indicate higher degrees of sustainability and resiliency
Number of Service Connections	The number of unique customers a water system serves	Directly Proportional: Higher values indicate higher degrees of sustainability and resiliency
Number of Service Connections Trends	Whether the number of water lines or pipes connected to a distribution supply main increases or decreases over time	Directly Proportional: Upward trends indicate higher degrees of sustainability and resiliency
Operation and Maintenance (O&M) Cost/Household	The costs per household for operating and managing a potential solution, including labor, energy, chemicals, staffing, spare parts, and facility management	Inversely Proportional: Higher values indicate a lower degree of sustainability and resiliency

Table C4.4: Environmental Sustainability Metrics that Passed the Screening Stage

Metric	Definition	Relationship to Sustainability and Resiliency
Regional Water Stress[22]	A measure of the ability of a potential solution to meet human and ecological water demand, considering aspects such as physical water availability, baseline water stress, water quality, source vulnerability, and drought risk	Inversely Proportional: Higher values indicate a lower degree of sustainability and resiliency
Greenhouse Gases	The amount of greenhouses gases emitted by a potential solution over its lifetime, predominantly due to energy	Inversely Proportional: Higher values indicate a lower degree of sustainability and resiliency

[22] Region would need to be defined but could include a system's jurisdiction, or multiple jurisdictions within an area, within a defined watershed or groundwater basin.

Metric	Definition	Relationship to Sustainability and Resiliency
	needs for groundwater pumping, centralized treatment and/or physical consolidation	
Waste Stream Generation	The amount of waste generated from a potential solution over its lifetime, including sludge, brine concentrates, Ion exchange resins, spent granular activated carbon, and non-greenhouse gas air emissions	Inversely Proportional: Higher values indicate a lower degree of sustainability and resiliency

Table C4.5: Social Acceptance Metrics that Passed the Screening Stage

Metric	Definition	Relationship to Sustainability and Resiliency
Job and Career Development	The number of jobs or opportunities for career development offered by a modeled solution	Directly Proportional: Higher values indicate a greater degree of sustainability and resiliency

SELECTION OF FINAL METRICS

To further evaluate the remaining 11 metrics for applicability and practicality for the SRA, each metric was rated based on four attributes:

- Availability of Any Required Site-Specific Data
- Applicability of the Metric in Informing or Influencing Sustainability and Resiliency of Solutions
- Availability and Usability of All Required Data
- Accuracy and Quality of All Required Data

A matrix was then developed to combine the ratings for each attribute and make an ultimate decision of whether or not to keep the metric for SRA implementation. The following subsections discuss the rating assignment for each attribute as well as the schema for the final decision.

AVAILABILITY OF ANY REQUIRED SITE-SPECIFIC DATA

Ratings for this attribute indicate whether any required site-specific data is readily available and accessible. The rating options for data availability were:

Readily Available: Any required site-specific data is readily available and accessible from a database. For example, data for the *Number of Service Connections* and *Asset Useful Life* metrics can be obtained from a State Water Board database and an U.S. EPA technical report, respectively, without further local-level data collection.

Not Readily Available: Any required site-specific data is not readily available or accessible. For instance, the *Greenhouses Gases Emissions* and *Job and Career Development* metrics require highly contextual local-level data and analysis for evaluation.

APPLICABILITY OF METRICS

Ratings for this attribute represent the degree that the proposed metric influences and informs the sustainability and resiliency of modeled solutions. The rating was based on the professional judgement of project team members and collaborators involved in this effort. The rating options for data applicability were:

- **Good**: There is general agreement that a metric influences and informs the selection of a modeled solution.
- **Fair**: There is debate whether a metric influences and informs the selection of a modeled solution.
- **Poor**: There is general agreement that a metric does not influence and inform the selection of a model solution.

AVAILABILITY AND USABILITY OF ALL DATA

The ratings for this attribute indicate whether the data associated with the metric is available in a final format that is ready for use in the SRA. In contrast to step 1, this criterion is not evaluating whether site-specific data is readily available, rather it is evaluating the availability of all associated data (regardless of their spatial levels), their format, and the degree of processing required for use in metric calculations. The ratings options were:

- **Good**: Data is readily available in a usable format and does not require significant data processing and/or analysis for use in the assessment.
- **Fair**: Data is not readily available in a usable format and requires significant processing and/or analysis for use in the assessment.
- **Poor**: Data is not available.

ACCURACY AND QUALITY OF ALL REQUIRED DATA

The ratings for this attribute indicate whether the data associated with the metric accurately reflects what the data is meant to measure or demonstrate. The ratings options were:

- **Good**: Data is obtained from credible source(s) and is updated annually.
- **Fair**: Data is obtained from credible source(s) and is updated less than annually but at least every three years
- **Poor**: Data is obtained from an unreliable source and/or is not regularly updated.

ATTRIBUTE COMBINATION SCHEME

Having defined ratings for each of the four attributes, a scheme was developed to combine the ratings to make an ultimate decision as to whether the metrics would be used in the SRA. The decision logic of whether or not to use the metrics for the SRA was:

- ***Yes***
  - Availability of Any Required Site-Specific Data: *Readily Available*
  - Applicability of Metrics: *Good*
  - Availability and Usability and Accuracy and Quality of All Required Data: both *Good, both Fair*, or combination of *Good* and *Fair*
- ***Maybe***
  - Availability of Any Required Site-Specific Data: *Readily Available*
  - Applicability of Metrics: *Fair*
  - Availability and Usability and Accuracy and Quality of All Required Data: both *Good*, both *Fair*, or a combination of *Good* and *Fair*
- ***No***
  - Availability of Any Required Site-Specific Data: *Readily Available*

  OR

  - Applicability of Metrics*: Poor*

  OR

  - Availability and Usability and Accuracy and Quality of All Required Data: both attributes have a rating of *Poor*

Table C4.6 shows the results of this rating scheme for each of the 11 preliminary metrics. The ratings for each attribute were based on the conclusions of discussions between the State Water Board and OWP at Sacramento State and on initial efforts to collect data required for each proposed metric.

Of the 11 preliminary metrics, the rating scheme resulted in the following seven metrics with *yes* or *maybe* decisions for inclusion in the SRA:

- Asset Useful Life
- Relative Operational Difficulty
- Operator Training Requirement
- Number of Current Service Connections
- Number of Current Service Connections/Time
- O&M Cost /Household
- Waste Stream Generation

Table C4.7 presents the preliminary data source(s), data properties, and methodologies for these seven metrics.

Table C4.6: Attribute Ratings and Decision for Including Metrics in SRA

Metric	Availability of Required Site-Specific Data	Applicability of Metric	Availability of All Required Data	Accuracy/Quality of All Required Data	Decision for Including in SRA
Asset Useful Life	Readily Available	Good	Good	Good	Yes
Relative Operational Difficulty	Readily Available	Good	Good	Fair	Yes
Operator Training Requirement	Readily Available	Good	Good	Good	Yes
Household Income Trends	Not Readily Available	Good	Poor/Fair	Poor/Fair	No
# Service Connections	Readily Available	Fair	Good	Good	Maybe
# Service Connections/ Time	Readily Available	Fair	Good	Good	Maybe
O&M Cost/ Household	Readily Available	Good	Good	Good	Yes
Regional Water Stress	Not Readily Available	Fair	Fair	Fair	No
Greenhouse Gases	Not Readily Available	Good	Fair	Fair	No
Waste Stream Generation	Readily Available	Good	Good	Good	Yes
Job & Career Development	Not Readily Available	Poor	Poor	Poor	No

Table C4.7: Data Characteristics for Seven Remaining Metrics

Metric	Data Variable	Data Source(s)	Data Type	Data Timeframe	Preliminary Methodology
Relative Operational Difficulty	Difficulty of Operating Potential Solution	Water Quality Treatment and Solution Matrix developed by State Water Board and OWP Staff State Water Board's Drinking Water Operator Certification Program	Categorical	Snapshot (at time of application)	Determine number and type of contaminants being treated Determine treatment solution for number and type of contaminants Assign score based on difficulty level of the treatment solution
Operator Training Requirement	Water Treatment Plant Operator Certification	State Water Board's Drinking Water Operator Certification Program SDWIS/State V3.21 Database (Drinking Water Watch dataset)	Categorical	Snapshot (at time of application)	Use the results of the Relative Operational Difficulty metric to infer Max Treatment Plant Classification Determine operator certification requirement from the Max Treatment Plant Classification, using the Drinking Water Operator Certification Assign score based on operator certification requirement
Asset Useful Life	Life Expectancy in Years for	Asset Management: A Handbook for Small and Small Drinking	Integer Values	Snapshot (at time of application)	Calculate the average useful life for relevant assets

Metric	Data Variable	Data Source(s)	Data Type	Data Timeframe	Preliminary Methodology
	Typical Equipment[23]	Water Systems (EPA 816-R-03-016)			Assign score based on the average useful life of assets
# Current Service Connections	# of Connections	State Water Board Electronic Annual Reports	Integer Values	2018	Assign score based on number of connections
# Service Connections/ Time	% Change in Number of Connections	State Water Board Electronic Annual Reports	Integer Values	2012-2018	Calculate % change in the number of service connections between 2012 and 2018 Assign score based on percent change in number of connections
O&M Cost/ Household	O&M Cost/ Household	State Water Board-Cost Assessment Model (SWB 2020)[24] Microsoft Bing Building Footprint Data (Microsoft 2018[25]) LandVision Tax	Continuous Values	Varied	Divide O&M costs for modeled solutions by the number of houses in a service area Assign score based on O&M Cost/Household

[23] Examples include water supply sources, pumping plants, and treatment plants.

[24] California State Water Resources Control Board. 2020 Long Term Solutions Cost Methodology for Public Water Systems and Domestic Wells (pp. 19-23, Rep.). Sacramento, CA. https://www.waterboards.ca.gov/safer/docs/draft_whitepaper_lt_solutions_cost_meth_pws_dom_wells_updated.pdf

[25] Microsoft. 2018. US Building Footprints. Accessed 23 Sep. 2020. https://github.com/Microsoft/USBuildingFootprints.

Metric	Data Variable	Data Source(s)	Data Type	Data Timeframe	Preliminary Methodology
		Assessor Data (LandVision 2020[26])			
Waste Stream Generation	Presence of Pollutants in Residuals	Drinking Water Treatment Plant Residuals Management Technical Report (EPA 820-R-11-003)	Continuous Values	Varied	Determine the presence of certain pollutants of concern in the waste stream based on the source water quality and type of source water treatment Assign score based on the number of contaminants present in the waste stream

[26] Landvision. 2020. Parcel Data (SmartParcels). Accessed 30 Sep. 2020. https://www.digmap.com/platform/smartparcels/.

Three of the seven metrics were selected for final inclusion in the SRA with no modification to their definitions or intent as derived from the literature review. These metrics are:

- Relative Operational Difficulty
- Operator Training Requirements
- Waste Stream Generation

An additional metric was also selected for inclusion in the SRA with a modification to its original definition:

- O&M Cost/Connection

In the initial conception of this metric, the goal was to assess the affordability of the operation and maintenance costs of modeled treatment solutions on a household level. However, a more rigorous examination of household-related data in California (i.e. tax assessor data, building footprint data) showed that this data was too site-specific and was not available on a statewide level for use in this assessment.

As an alternative to household data, the number of water service connections is a data point that is standardized, available on a statewide level, and regularly reported and updated in California. Consequently, a revised version of the metric – O&M Cost/Connection – that evaluates the operation and maintenance costs of modeled treatment solutions per connection was included in the SRA.

Of the last remaining seven metrics, the following three metrics were also excluded from the SRA:

- Number of Service Connections
- Number of Service Connections/Time
- Asset Useful Life

The Number of Service Connections and Number of Service Connections/Time metrics were not included in the SRA because they do not influence the system-centric sustainability and resiliency evaluations, given that the assessment evaluates the long-term efficacy and viability of modeled solutions within each given system. In addition, the Asset Useful Life metric was not included in the assessment because an accurate evaluation of the metric required site-specific data that is not readily available on a statewide level. Additionally, some aspects of asset useful life, such as asset replacement costs, are already included in the cost estimates developed for the Cost Assessment Model.

Table C4.8 lists the final four metrics selected for use in the SRA.

Table C4.8: SRA Metrics and Definitions

SRA Metric	Definition
O&M Cost/Connection	O&M cost estimates of a potential solution divided by the # connections in a water system

SRA Metric	Definition
Relative Operational Difficulty	Technical complexity of treating water to comply with water quality standards. Dependent on number and complexity of treatment processes
Operator Training Requirements	Grade-level certification required to operate a treatment and distribution system. Dependent on contaminant type and associated treatment processes
Waste Stream Generation	Difficulty of managing residuals created by a treatment solution. Dependent on whether a waste stream is generated, type of waste stream (solid vs. liquid), and residual properties (e.g. hazardous, special disposal required)

METRIC SCORING

A unique scoring matrix was developed for each of the selected metrics. These metric-specific scoring matrices were developed by the State Water Board and OWP at Sacramento State in collaboration with State Water Board staff.

The following sections describe in detail the evaluation and scoring methodology for each the final sustainability and resiliency metrics employed in the SRA.

O&M COST/CONNECTION

O&M Cost per connection is calculated by dividing the O&M cost of a modeled solution for a water system by the number of connections the water system serves.

For a given system, O&M cost/connection values for applicable modeled solutions are normalized to a common range of values from 0 to 100 with lower normalized values reflecting lower O&M cost/connection and higher normalized values reflecting higher O&M cost/connection.

The following Minimum-Maximum (Min-Max) Normalization method is used:

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Where x is the original value (i.e., the actual O&M cost divided by the system’s number of connections), min (x) is the value of the least costly modeled solution for the given system, and max (x) is the value of the most costly modeled solution, and x’ is the resulting normalized value.

After normalizing the O&M cost/connection values, ordinal scores are assigned to the normalized O&M cost/connection values using the scoring logic presented in Table C4.9.

From an affordability perspective, a higher ordinal score indicates a lower O&M cost/connection and therefore reflects higher sustainability and resiliency. Alternatively, a lower score indicates a higher O&M cost/connection which reflects lower sustainability and resiliency.

Table C4.9: O&M Cost/Connection Scoring Logic

Normalized Value	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Ordinal Score	5	4.5	4	3.5	3	2.5	2	1.5	1	0.5

RELATIVE OPERATIONAL DIFFICULTY

The relative operational difficulty (ROD) of a system refers to the complexity of treating water to comply with water quality regulatory requirements. Both the number and complexity of treatment processes determine the difficulty of operation.

California Code of Regulations Section 64413.1, Classification of Water Treatment Facilities, was used to evaluate the difficulty of operation for all treatment solutions. Using these regulations, an estimated raw facility treatment score was calculated for each treatment solution. The score is a function of the type of contaminant(s) in violation of an MCL and the system's primary water source type (i.e. groundwater, surface water).

For parameters that required site-specific data, an estimated score was assigned based on assumptions related to the primary water source type. These assumptions were necessary to assign raw facility treatment scores without the need for site-specific data and were determined through internal consultation between water treatment professionals involved in the Drinking Water Needs Assessment.

In systems where surface water is the primary water source, the following factors were assumed based on discussions with State Water Board technical experts:[27]

- Median coliform density (MPN) between 1 and 100 per 100 mL
- Turbidity between 15 and 100 NTU
- Conventional filtration and filter backwash were used for surface water filtration treatment.

In systems, where groundwater is the primary water source, the following factors were assumed:

- Median coliform density (MPN) less than 1 per 100mL

[27] Based on discussions with State Water Board staff members Eugene Leung, P.E. and Michelle Frederick, P.E.

- Turbidity less than 15 NTU
- Chlorine was used for disinfection without activation credit

For both systems with surface water and groundwater primary water sources, flow was assumed to be less than 2 million gallons per day.

Non-treatment solutions, such as physical consolidation, were assumed to have no adverse impact on the complexity of operation, since it is assumed that the receiving system has the capacity to adequately treat the HR2W systems' water quality needs.

Scores assigned for various water quality and source water conditions are shown in Table C4.10, along with results from a case study for a groundwater-reliant system with a Nitrate violation.

Table C4.10: Case Study for Determining a Raw Facility Treatment Score for a Groundwater-Reliant System with Nitrate MCL Violations

Water Quality and Source Water Condition	Score Earned for this Condition	Case Study Score
(1) Source Water		
Groundwater and/or purchased treated water meeting primary and secondary drinking water standards, as defined in Section 116275 of the HSC.	2	2
Water that includes any surface water or groundwater under the direct influence of surface water.	5	--
(2) Influent Water Microbiological Quality, Median Coliform Density, Most Probable Number Index (MPN)		
Less than 1 per 100 mL	0	0
1 through 100 per 100 mL	2	--
Greater than 100 through 1,000 per 100 mL	4	--
Greater than 1,000 through 10,000 per 100 mL	6	--
Greater than 10,000 per 100 mL	8	--
(3) Influent Water Turbidity, Maximum Influent Turbidity Level, Nephelometric Turbidity Units (NTU)		
Less than 15	0	0
15 through 100	2	--
Greater than 100	5	--
(4) Influent Water Perchlorate, Nitrate and Nitrite, Nitrate and Nitrite Data Average		

Water Quality and Source Water Condition	Score Earned for this Condition	Case Study Score
Less than or equal to the MCL as specified in Table 64431-A (CCR 2021a)[28]	0	--
Greater than the MCL	5	5
(5) Influent Water Chemical and Radiological Contamination, Contaminant Data Average		
Less than or equal to the MCL	0	0
Greater than the MCL	2	--
5 times the MCL or greater	5	--
(6) Surface Water Filtration Treatment		
Conventional, direct, or inline	15	--
Diatomaceous earth	12	--
Slow sand, membrane, cartridge, or bag filter	8	--
Backwash recycled as part of process	5	--
(7) The points for each treatment process utilized by the facility and not included in condition (6) that is used to reduce the concentration of one or more contaminants for which a primary MCL exists, pursuant to Table 64431-A (CCR 2021a),[29] Table 64444-A (CCR 2021c),[30] and Table 4 of Section 64443 (CCR 2021b),[31] shall be 10. Blending shall only be counted as a treatment process if one of the blended sources exceeds a primary MCL.	10	20
(8) The points for each treatment process not included in conditions (6) or (7) that is used to reduce the concentration of one or more contaminants for which a secondary MCL exists, pursuant to Tables 64449-A and 64449-B (CCR 2021d),[32] shall be 3. Blending shall only be counted as a treatment process if one of the blended sources exceeds a secondary MCL.	3	--
(9) The points for each treatment process not included in conditions (6), (7), or (8) that is used for corrosion control or fluoridation shall be 3.	3	--
(10) Disinfection Treatment		

[28] Cal. Code Regs. tit. 22, § 64431 (CCR 2021a)

[29] Cal. Code Regs. tit. 22, § 64431 (CCR 2021a)

[30] Cal. Code Regs. tit. 22, § 64444 (CCR 2021c)

[31] Cal. Code Regs. tit. 22, § 64443 (CCR 2021b)

[32] Cal. Code Regs. tit. 22, § 64449 (CCR 2021d)

Water Quality and Source Water Condition	Score Earned for this Condition	Case Study Score
Ozone	10	--
Chlorine and/or chloramine	10	--
Chlorine dioxide	10	--
Ultra violet (UV)	7	--
(11) Disinfection/Oxidation Treatment without Inactivation Credit		
Ozone	5	--
Chlorine and/or chloramine	5	5
Chlorine dioxide	5	--
Ultra violet (UV)	3	--
Other oxidants	5	--
(12) The points for any other treatment process that alters the physical or chemical characteristics of the drinking water and that was not included in conditions (6), (7), (8), (9), (10), or (11) shall be 3.	3	--
(13) The points for facility flow shall be 2 per million gallons per day or fraction thereof of maximum permitted treatment facility capacity, up to a maximum of 50 points; except that for facilities utilizing only blending, the points shall be based on the flow from the contaminated source and the dilution flow required to meet the MCL(s) specified in Tables 64431-A (CCR 2021a),[33] 64444-A (CCR2021c),[34] 64449-A (CCR 2021d),[35] 64449-B (CCR 2021d),[36] and Table 4 of Section 64443 (CCR 2021b).[37]	50 max	2
Total Points	--	**34**

After calculating the raw facility treatment score, the following operating criteria were identified as factors affecting Relative Operational Difficulty:

- Does the treatment process require filter backwash?
- Does the treatment process require media regeneration?
- Does the treatment process require access to the customer's home to install and maintain the treatment equipment?

[33] Cal. Code Regs. tit. 22, § 64431 (CCR 2021a)

[34] Cal. Code Regs. tit. 22, § 64444 (CCR 2021c)

[35] Cal. Code Regs. tit. 22, § 64449 (CCR 2021d)

[36] Cal. Code Regs. tit. 22, § 64449 (CCR 2021d)

[37] Cal. Code Regs. tit. 22, § 64443 (CCR 2021b)

- Does the treatment process require scheduling with customers to install and maintain treatment equipment?

The Division of Drinking Water's *Worksheet for Determining Required Operator Training was* used as an analytical framework to guide the assignment of ordinal scores based on the raw facility treatment score and the considerations presented in the operating criteria. Ordinal scores ranging from 1 to 5 are assigned to potential modeled solutions with higher ordinal scores indicating higher sustainability and resiliency and lower ordinal scores indicating lower sustainability and resiliency. Table C4.11 presents the relative operational difficulty scoring matrix that shows potential modeled solutions with their assigned ordinal scores. The table also justifies the assignment of ordinal scores to their respective solutions.

Table C4.11: Relative Operational Difficulty (ROD) Scoring Matrix

Solution	ROD Score	Description	Justification
Physical Consolidation	5	No impact on operational difficulty	Score presupposes no operational difficulty based on the assumption that the receiving system has the capacity to addresses the HR2W list systems' water quality needs.
Blending	4	Low operational difficulty	Score assumes low operational difficulty since the process requires adequate mixing but does not need media replacement or regeneration.
Wellhead Disinfection	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
Surface Water Treatment Plant	1	Very High operational difficulty	Score assumes high operational difficulty due to the multi-step treatment train that leads to a raw treatment score 63 and the need for filter backwash.
Arsenic Wellhead Treatment (< 500 Connections)	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
Arsenic Wellhead Treatment (> 500 Connections)	3	Moderate operational difficulty	Score assumes moderate operational difficulty since the raw treatment score is 21 and operation requires filter backwash.
Nitrate Wellhead Treatment	2	High operational difficulty	Score assumes high operational difficulty since the raw treatment

Solution	ROD Score	Description	Justification
			score is 34 and operation requires media regeneration.
Uranium Wellhead Treatment	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
Radium Wellhead Treatment	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
Fluoride Wellhead Treatment	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
Perchlorate Wellhead Treatment	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
Iron/Manganese Wellhead Treatment	3	Moderate operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
VOCs/TCP Wellhead Treatment	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
DBPs Wellhead Treatment	4	Low operational difficulty	Score assumes low operational difficulty since the raw treatment score is 21 and no operation criteria are applicable.
POU	2	High operational difficulty	Score assumes high operational difficulty since the raw treatment score is 21 and maintenance of RO membranes requires scheduling of household visits and access to household infrastructure.
POE	3	Moderate operational difficulty	Score assumes high operational difficulty since the raw treatment score is 21 and maintenance of GAC filters requires scheduling of household visits.

Solution	ROD Score	Description	Justification
Multi-component treatment systems	1	Very High Operational Difficulty	Score assumes very high operational difficulty because the raw treatment score for systems with multiple COCs will be > 40 and treatment train will likely meet some of the other specified operating criteria.

OPERATOR TRAINING REQUIREMENTS

Operator training requirement (OTR)s are defined as the grade level certification an operator must hold to operate the system's treatment and distribution system. The grade level certifications required for potential modeled solutions were determined using the raw facility treatment score from the California Code of Regulations Section 64413.1, Classification of Water Treatment Facilities.

The raw facility treatment scores calculated for the Relative Operational Difficulty metric were used to assess operator training levels (T1 to T5), which were then used to assign ordinal scores as follows:

- 5 (higher sustainability) = No additional certification required
- 4 = Operators requires a T1 certification
- 3 = Operators require T2 certification
- 2 = Operators require T3 certification
- 1 (lower sustainability) = Operators require T4 or T5 certification

For the purpose of this assessment, all systems with inorganic, radiological, and organic contaminants are assumed to be groundwater-reliant systems. Systems with DBP violations can either be surface water or groundwater-reliant systems.

Table C4.12 presents the operator training requirement scoring matrix showing the operator certification level required for each potential modeled solution and its equivalent ordinal score. Ordinal scores range between 1 and 5, with higher ordinal score indicating higher sustainability and resiliency and lower ordinal scores indicating lower sustainability and resiliency.

Table C4.12: Operator Training Requirement (OTR) Scoring Matrix

Solution	Operator Certification Level: Surface Water	Operator Certification Level: Groundwater	OTR Score: Surface Water	OTR Score: Groundwater
Physical Consolidation	None Required	None Required	5	5

Solution	Operator Certification Level: Surface Water	Operator Certification Level: Groundwater	OTR Score: Surface Water	OTR Score: Groundwater
Blending	N/A[38]	T2	N/A	3
Wellhead Disinfection	N/A	T2	N/A	3
Surface Water Treatment Plant	T4	N/A	1	N/A
Arsenic Wellhead Treatment (< 500 Connections)	N/A	T2	N/A	3
Arsenic Wellhead Treatment (> 500 connections)	N/A	T2	N/A	3
Nitrate Wellhead Treatment	N/A	T2	N/A	3
Uranium Wellhead Treatment	N/A	T2	N/A	3
Radium Wellhead Treatment	N/A	T2	N/A	3
Fluoride Wellhead Treatment	N/A	T2	N/A	3
Perchlorate Wellhead Treatment	N/A	T2	N/A	3
Iron/Manganese Wellhead Treatment	N/A	T2	N/A	3
VOCs/TCP Wellhead Treatment	N/A	T2	N/A	3
DBPs Wellhead Treatment	T3	T2	2	3
POU	N/A	T2	N/A	3
POE	N/A	T2	N/A	3

[38] Not Applicable

Solution	Operator Certification Level: Surface Water	Operator Certification Level: Groundwater	OTR Score: Surface Water	OTR Score: Groundwater
Multi-component treatment systems	T4	T3	1	2

WASTE STREAM GENERATION

Waste Stream Generation is defined as the difficulty of managing residuals created as a byproduct of the application of treatment solutions. The type of waste stream generated and disposal considerations required are a function of both the contaminant(s) of concern and the treatment process applied to those contaminants.

The following considerations were selected as factors that affect and determine waste stream generation scores:

- Whether a treatment process generates a solid waste stream
- Whether a treatment process generates a liquid or solid waste stream
- Whether testing is required to determine if residuals are hazardous and need special disposal considerations
- Whether waste streams are generated at multiple locations
- Whether the treatment train has multiple processes that generate residuals

Based on these considerations, ordinal scores of one through five were assigned as shown in Table C4.13. Scores for each type of modeled solution were then assigned based on these definitions.

Table C4.13: Waste Stream Generation Score Definitions for SRA Scoring

Ordinal Score	Definition
5	No waste stream generated
4	Treatment produces non-hazardous waste stream with no special disposal considerations
3	Treatment produces a waste stream that is hazardous OR has special disposal considerations
2	Treatment produces a waste stream that is hazardous AND has special disposal considerations
1	Multiple treatment technologies producing waste streams

Table C4.14 presents the waste stream generation scoring matrix, showing potential modeled solutions with their assigned ordinal scores. The table also justifies the assignment of ordinal score to their respective solutions Ordinal scores range between 1 and 5, with higher ordinal score indicating higher sustainability and resiliency and lower ordinal scores indicating lower sustainability and resiliency.

Table C4.14: Waste Stream Generation (WSG) Scoring Matrix

Solution	WSG Score	Justification
Physical Consolidation	5	No waste stream generated
Blending	5	No waste stream generated
Wellhead Disinfection	5	No waste stream generated
Surface Water Treatment Plant	4	Generates a non-hazardous solid waste stream
Arsenic Wellhead Treatment	3	Generates a hazardous solid waste stream that require special disposal considerations
Arsenic Wellhead Treatment	3	Generates a hazardous solid waste stream that require special disposal considerations
Nitrate Wellhead Treatment	2	Generates a hazardous solid and liquid waste streams that require special disposal considerations
Uranium Wellhead Treatment	3	Generates a potentially hazardous solid waste stream that require special disposal considerations
Radium Wellhead Treatment	3	Generates a potentially hazardous solid waste stream that require special disposal considerations
Fluoride Wellhead Treatment	4	Generates a non-hazardous solid waste stream
Perchlorate Wellhead Treatment	3	Generates a potentially hazardous solid waste stream that requires special disposal considerations
Iron/Manganese Wellhead Treatment	4	Generates a solid, non-hazardous waste stream
VOCs/TCP Wellhead Treatment	4	Generates a solid, non-hazardous waste stream
DBPs Wellhead Treatment	4	Generates a solid, non-hazardous waste stream
POU	2	Generates decentralized liquid waste streams that may require special disposal considerations

Solution	WSG Score	Justification
POE	3	Generates decentralized non-hazardous solid waste streams, waste management requires travel
Multi-component Treatment	1	Multiple waste streams that may be hazardous and require special disposal considerations

SRA IMPLEMENTATION

The application of the Sustainability and Resiliency Assessment followed a three-step process:

1. Identifying which potential modeled solutions are applicable for a given HR2W list system
2. Scoring each SRA metric for each modeled solution for each HR2W list system
3. Aggregating the metric scores to calculate a total SRA score for each modeled solution for each HR2W list system

IDENTIFYING POTENTIAL MODELED SOLUTION IN A HR2W LIST SYSTEM

For the long-term solution Cost Model, there were three general types of potential modeled solutions: physical consolidation, source treatment, and point of use (POU) or point of entry (POE) treatment.

Physical consolidation was considered a potential modeled solution for a given system if that system was within three miles of an existing, viable system. Applicable source treatment solutions or POU/POE treatment solutions for a given system were selected based on the type of contaminants, number of contaminants, and number of service connections. Table C4.15 lists all the potential modeled solutions and their associated treatment technologies (where applicable).

Table C4.15: Modeled Solutions and their Applicable Treatment Technologies

Solution	Treatment Technology
Physical Consolidation	N/A
Blending	N/A
Wellhead Disinfection	Chlorination
Surface Water Treatment Plant	Filtration and Chlorination
Arsenic Wellhead Treatment (< 500 Connections)	Activated Alumina (AA)

Solution	Treatment Technology
Arsenic Wellhead Treatment (> 500 connections)	Coagulation and Filtration
Nitrate Wellhead Treatment	Strong Base Ion Exchange (SBA-IX)
Uranium Wellhead Treatment	Strong Base Ion Exchange (SBA-IX)
Radium Wellhead Treatment	Cation Exchange
Fluoride Wellhead Treatment	Activated Alumina (AA)
Perchlorate Wellhead Treatment	Strong Base Ion Exchange (SBA-IX)
Iron/Manganese Wellhead Treatment	Coagulation and Filtration
VOCs/TCP Wellhead Treatment	Granular Activated Carbon (GAC)
DBPs Wellhead Treatment	Granular Activated Carbon (GAC)
POU	Reverse Osmosis (RO)
POE	Granular Activated Carbon (GAC)
Multi-component treatment systems	Applicable combination of above wellhead and/or decentralized treatment options

For HR2W list systems with water quality violation(s) for only one contaminant, treatment options considered either source treatment or decentralized treatment, in addition to physical consolidation where applicable. POU/POE treatment was not considered viable for systems with over 200 connections or for certain contaminants of concern, such as Radium, Perchlorate, or Iron. Table C4.16 lists the types of single-analyte violations found in HR2W list systems and their associated source treatment and decentralized treatment technologies.

Table C4.16: Single-Analyte Violations and Their Treatment Technologies

Violation	Source Treatment	Decentralized Treatment
ARSENIC (< 500 Connections)	Arsenic Wellhead Treatment (< 500 Connections)	POU (RO)
ARSENIC (> 500 Connections)	Arsenic Wellhead Treatment (< 500 Connections)	N/A
NITRATE	Nitrate Wellhead Treatment	POU (RO)
URANIUM	Uranium/Radium/Gross Alpha Wellhead Treatment	POU (RO)
RADIUM	Uranium/Radium/Gross Alpha Wellhead Treatment	N/A

Violation	Source Treatment	Decentralized Treatment
GROSS ALPHA PARTICLES	Uranium/Radium/Gross Alpha Wellhead Treatment	N/A
FLUORIDE	Fluoride Wellhead Treatment	POU (RO)
PERCHLORATE	Perchlorate Wellhead Treatment	N/A
IRON	Iron and Manganese Wellhead Treatment	N/A
MANGANESE	Iron and Manganese Wellhead Treatment	N/A
1,1-DICHLOROETHYLENE	VOC/TCP Wellhead Treatment	POE (GAC)
1,2-DIBROMO-3-CHLOROPROPANE	VOC/TCP Wellhead Treatment	POE (GAC)
1,2,3-TRICHLOROPROPANE (TCP)	VOC/TCP Wellhead Treatment	POE(GAC)
ETHYLENE DIBROMIDE (EDB)	VOC/TCP Wellhead Treatment	POE (GAC)
TOTAL HALOACETIC ACIDS (HAA5)	DBP Wellhead Treatment	N/A
TTHM	DBP Wellhead Treatment	N/A
TURBIDITY	Surface Water Treatment Plant	N/A
TURBIDITY	Wellhead Disinfection	N/A
ALUMINUM	Surface Water Treatment Plant	N/A
ALUMINUM	Wellhead Disinfection	N/A
E. COLI	Surface Water Treatment Plant	N/A
E. COLI	Wellhead Disinfection	N/A
SWTR (surface water)	Surface Water Treatment Plant	N/A
GWR	Wellhead Disinfection	N/A

Systems with multiple contaminants in violation can require a combination of treatment processes to meet water quality standards. Table C4.17 shows all possible combinations of contaminants from the HR2W list and provides guidelines for selecting the appropriate treatment solutions. If more than one wellhead treatment or POU/POE device are needed, the solution was considered as “Multi-component Treatment”.

Table C4.17: Treatment Solutions for HR2W Systems with Multiple Analyte Violations

Contaminant Combination	Wellhead Treatment	Decentralized Treatment
Inorganic (POU)	Multi-component Treatment	POU
Inorganic (POU) + Inorganic (no POU)	Multi-component Treatment	N/A
Inorganic (POU) + Organic	Multi-component Treatment	Multi-component Treatment
Inorganic (no POU) + Organic	Multi-component Treatment	N/A
Organic	VOC/TCP Wellhead Treatment	POE
Organic + DBPs	VOC/TCP Wellhead Treatment	N/A
DBPs	DBP Wellhead Treatment	N/A
Biological/Surface Water	Surface Water Treatment Plant	N/A
Arsenic, Iron, + Manganese	Iron and Manganese Wellhead Treatment	N/A
GWR + Any other contaminants	Multi-component Treatment	N/A

Below are examples of some of the guidelines outlined in Table C4.17:

- A system with TCP and EDB violations can use GAC to address both either as a wellhead or POE treatment. Therefore, the two possible treatment solutions are "VOC/TCP Wellhead Treatment" and "POE".
- A system with both nitrate and uranium can use SBA-IX as wellhead treatment or RO as POU. However, SBA-IX may require multiple resin types. Therefore, the two possible treatment options are "Multi-component Treatment" and "POU".
- A system with nitrate and TCP violations will require either both SBA-IX and GAC as wellhead treatment or both RO and GAC as POU/POE treatment. There will be two treatment solutions both scored as "Multi-component Treatment" for the technical and environmental metrics that will be differentiated by their O&M cost per connection scores.
- A system with arsenic, iron, and manganese violations only requires coagulation and filtration wellhead treatment. Therefore, there is only one possible treatment solution "Iron and Manganese Wellhead Treatment". Although arsenic can be treated with POU, POU is not considered for iron and manganese treatment.

EVALUATING APPLICABLE MODELED SOLUTIONS

Following the selection of applicable modeled solutions for HR2W list systems, the solutions were scored for each of the four selected SRA metrics.

For systems with single-analyte violations, solutions were scored for the applicable analyte wellhead treatment or POU treatment. This also applied to systems with multiple contaminants that could be addressed using the same source treatment or decentralized treatment. For example, certain combinations of inorganic contaminants – such as Nitrate, Uranium, Arsenic, and Fluoride – can be treated with the same wellhead treatment or POU treatment technologies. In these scenarios, the modeled treatment solutions are scored according to the applicable wellhead treatment or POU/POE treatment solutions.

For systems with multiple-analyte violations that require multiple treatment processes, the solution was scored for "multi-component treatment." Wellhead treatment solutions for systems with multiple constituents that can be treated with SBA-IX (Nitrate, Perchlorate, and Uranium), are also scored as "Multi-component Treatment", given that multiple SBA-IX resins that have affinities to address all contaminants of concern will likely be necessary for effective treatment.

AGGREGATING TOTAL SUSTAINABILITY AND RESILIENCY SCORES

Following the identification of applicable modeled solutions and their evaluation against the SRA metrics, the solutions' scores are summed using simple addition to calculate the total SRA score for each applicable modeled solution.

The total SRA score for any solution ranged from 4 to 20. A modeled solution's total SRA score reflects its overall sustainability and resiliency relative to other applicable solutions fora given system. A solution with a higher score reflects better sustainability and resiliency than a solution with a lower score.