.

Sonoma Water Resiliency Study Work Plan

Phase 1 - Resiliency Study Work Plan Development

FINAL DRAFT

June 30, 2020

Sonoma Water

Contents

1. Introduction

The Sonoma County Water Agency (Sonoma Water) is a regional leader in water resources management. Sonoma Water strives to look forward, beyond today's issues, to anticipate ways to advance its mission. One of the most critical aspects of this mission is planning for, and ensuring, the long-term reliability and resilience of a regional water system. In conjunction with its retail customers[1], Sonoma Water is developing a forward-looking study of the resilience of the regional water system (Resiliency Study). The Resiliency Study seeks to identify the key factors impacting regional water supply resiliency, evaluate the current levels of resiliency, develop a decision support framework model and process, and identify promising opportunities for Sonoma Water and its retail customers to improve regional resilience in the future.

As part of these efforts, Jacobs has developed this work plan and scoping document (Work Plan) for the development of the Resiliency Study. The Resiliency Study has been conceived as being developed in three phases (Figure 1). This Work Plan represents Phase 1 of the project which focuses on the scoping of the Resiliency Study including the evaluation and selection of the decision support model (DSM) preliminary water supply scenario development, and the scope and schedule for Phase 2 of the project. Phase 2 implements the elements of the Work Plan including scenario quantification, DSM development and simulations, identification of potential water management strategies, and evaluation of regional resilience with and without new strategies. Phase 3 envisions continual modification and maintenance of the DSM and periodic updates to assess evolving resiliency challenges.

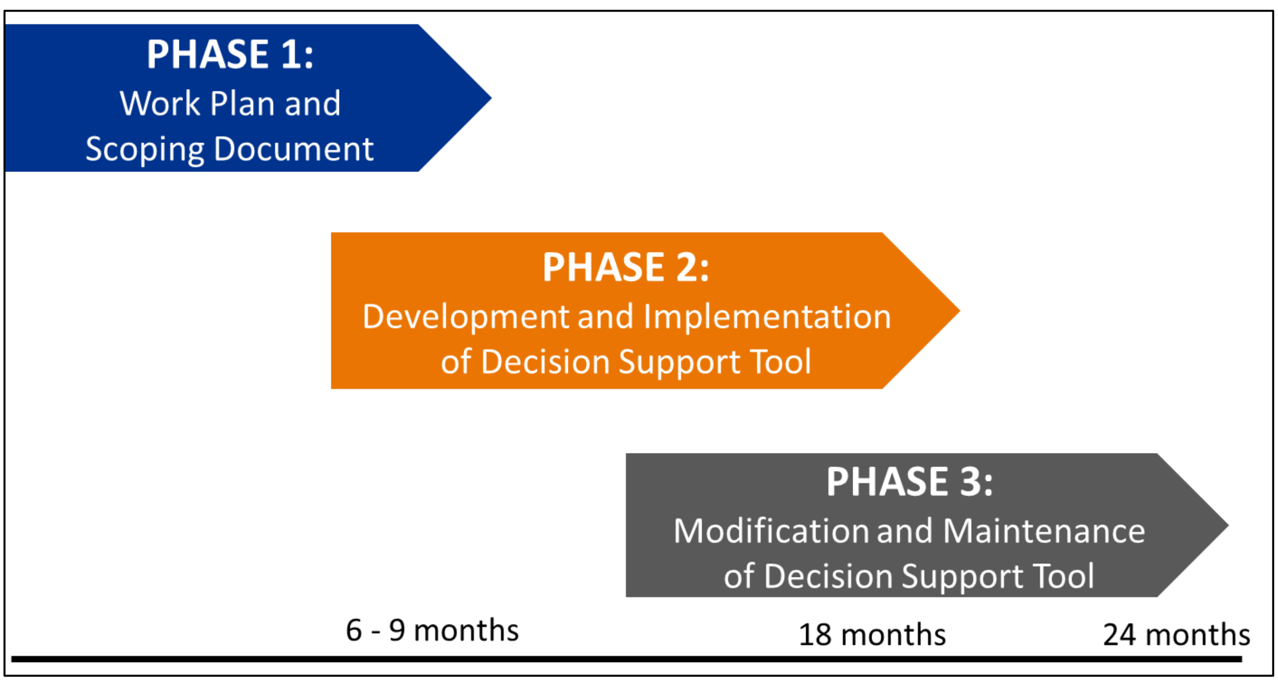

Figure 1. Graphical Overview of the Resiliency Study Phases.

The Resiliency Study Work Plan includes the following sections:

[1] Retail customers include City of Santa Rosa, Town of Windsor, Marin Municipal Water District, City of Cotati, City of Sonoma, City of Rohnert Park, Valley of the Moon Water District, City of Petaluma, and North Marin Water District.

- **Section 1 – Introduction:**

  Introduction to the Work Plan.

- **Section 2 – Study Vision and Goals**

  Describes the vision and goals for the development of the Resiliency Study.

- **Section 3 – Resiliency Planning Framework**

  Brief section that outlines the general resiliency planning approach that is proposed for the Resiliency Study.

- **Section 4 – Summary of Water Contractor Scoping Meetings**

  This section provides a high-level summary of the process and input received during scoping meetings with retail customers.

- **Section 5 – Key Drivers and Potential Water Supply Scenarios**

  This section identifies the key drivers potentially influencing current and future regional water resilience and suggest potential water supply scenarios.

- **Section 6 – Potential Water Supply Opportunities**

  Section 6 summarizes preliminary opportunities that were identified during the outreach meetings described in Section 4.

- **Section 7 – Evaluation and Selection of Decision Support Model Platform**

  Section 7 summarizes the evaluation and selection of the Decision Support Model platform for this Resiliency Study.

- **Section 8 – Proposed Approach for Phase 2 – Development of Regional Water Supply Resiliency Study**

  Section 8 outlines the proposed approach for conducting Phase 2 to develop the Resiliency Study including quantifying scenarios, DSM development and application, opportunities analysis, and strategy development.

- **Section 9 - References**

  References cited in this Work Plan.

2. Study Vision and Goals

Critical to establishing a robust Resiliency Study and planning process are framing discussions with key decision-makers to develop a common vision of the questions to be answered and desired outcomes of the study. Based on input from Project Team members (Sonoma Water and retail customer representatives) at initial chartering meetings and meetings with each individual retail customer, this section has been prepared to articulate the vision and goals of the Resiliency Study.

Sonoma Water manages and maintains a water supply and transmission system that provides naturally filtered Russian River water to nine cities and special districts that in turn delivers drinking water to more than 600,000 residents in portions of Sonoma and Marin counties. Sonoma Water provides drinking water to the following cities and special districts: City of Santa Rosa, Town of Windsor, Marin Municipal Water District, City of Cotati, City of Sonoma, City of Rohnert Park, Valley of the Moon Water District, City of Petaluma, and North Marin Water District. These retail customers also have local water supplies that are used to augment the regional water supply to meet the demands of their customers. These local supplies include surface water, groundwater, and recycled water sources. While these regional water systems are connected, primarily through connections to Sonoma Water’s transmission system, they are not operated or managed in a coordinated manner, especially in times of water shortage.

The Resiliency Study was conceived to better understand the existing and future water supply resiliency challenges facing the region and to increase regional resilience by adopting water supply options that more fully integrate the regional systems. Specifically, the Resiliency Study seeks to:

- Improve understanding of regional vulnerabilities due to water shortages
- Gain insights for new operational strategies and projects to improve regional resiliency
- Develop and apply a regional decision support model (DSM) to evaluate a range of water supply options to make the region more resilient to potential short- and long-term water shortages
- Continue DSM application on an on-going basis to support regional and local water supply planning efforts
- Improve regional position for grant funding opportunities, and
- Increased coordination between Sonoma Water and retail customers.

While the purpose of the Work Plan is to serve as a roadmap for identifying, evaluating, and recommending adaptation strategies, it is useful to envision the long-term desired outcomes of the Resiliency Study and the types of decisions that the study may support. Foremost, the Resiliency Study should help guide Sonoma Water and its retail customers on activities and investments to improve the resiliency of regional water supply system to potential natural and operational hazards.

The Resiliency Study could also support the following specific activities:

- Assist in developing long-range agency and local strategies for water supply system integration
- Support the development of prioritized projects and programs for inclusion in the capital planning plans of partner agencies
- Support the identification and leveraging of state and federal funding sources for implementation of specific adaptation measures

- Provide support for policy direction and agency engagement in resiliency efforts
- Provide specific, measurable indicators of current to improve confidence in making future resilience investment decisions
- Provide supporting metrics for monitoring resiliency improvements over time
- Provide a framework to inform engagement and coordination with related regional and state efforts

It is envisioned that several other types of water supply-related decisions can be supported from the final Resiliency Study. These may evolve over time, and may be yet unknown, but the current process will be developed using these listed supported decisions as guides for the eventual use of the information in the Resiliency Study.

3. Resiliency Planning Framework

Planning for regional water supply resilience requires a structured framework to ensure that scope and objectives are established early in the planning effort, that the range of vulnerabilities and risks are understood, that adaptation strategies are focused on improving resilience, and that communication of the value of pro-active resiliency planning and future investments is facilitated to technical and non-technical audiences. The general resiliency planning framework outlined in this Work Plan is shown graphically in Figure 2. The framework consists of five main steps: (1) problem understanding and scoping, (2) hazard understanding and mapping, (3) vulnerability and risk assessments, (4) adaptation options and strategy development, and (5) implementation and monitoring.

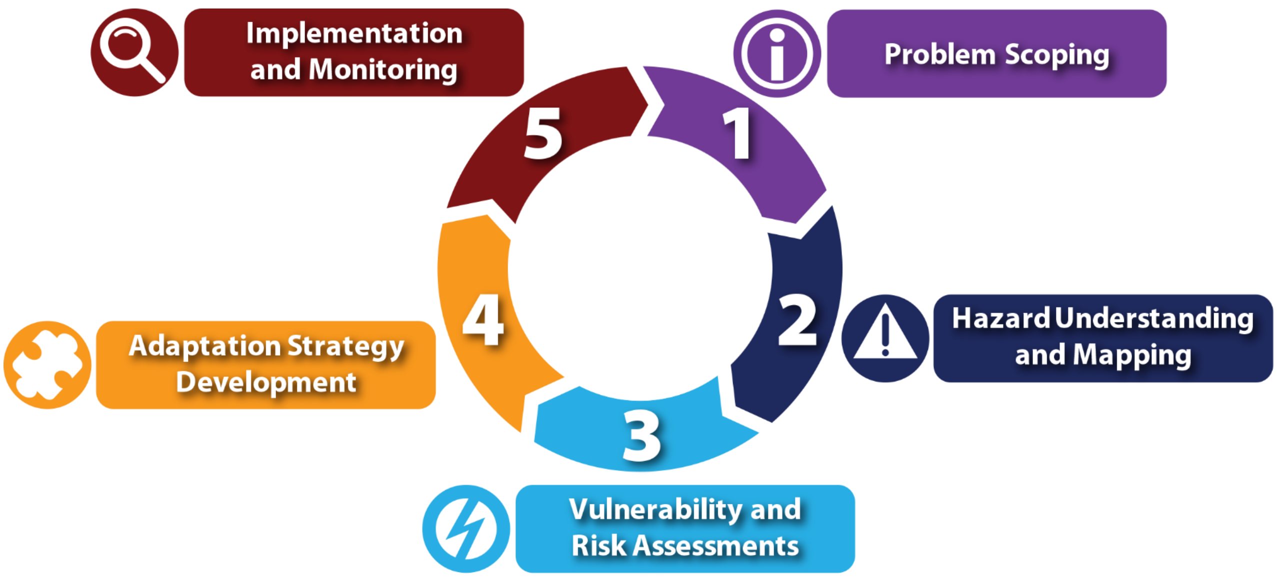

Figure 2. General Resiliency Planning Framework.

The key steps in overall framework are the following:

1. **Problem Scoping -** Frame the questions to be addressed and desired outcomes from both a technical and policy perspective. Identify the system, components, and bounds of the study.

2. **Hazard Understanding and Mapping -** Ensure understanding of historical vulnerabilities on system and identify the most important drivers and scale for the analysis. Understand future drivers of change, and their projections, scale, and uncertainty.

3. **Vulnerability/Risk Assessments -** Assess the vulnerability/risk of the system to current and future hazards (or drivers). Develop performance measures, metrics, and thresholds that can be used to measure system vulnerability. Prioritize risk areas resulting from this assessment and provide focus to areas in which adaptation measures should be considered.

4. **Adaptation Options and Strategies -** Based on an understanding of the baseline system vulnerability/risk, a wide range of infrastructure, operational, and policy options should be identified. Evaluation criteria are developed and applied for each option to capture economic, environmental, and

social attributes. Adaptation strategies should address improving resilience through an adaptive approach, identifying common or low-regret options, and identifying triggers for making other substantial investments in adaptation measures. Portfolios should be identified that implement a particular strategy.

5. **Implementation and Monitoring -** Implement selected strategies and ensure that physical, operational, and policy elements are consistently aligned with risk reduction strategies. Develop and implement a monitoring program that establishes parameters to measure over time to understand increasing or reducing risk and critical indicators and thresholds that would trigger further investment or investigations.

The Work Plan includes activities needed to address problem scoping, hazard understanding and mapping, vulnerability and risk assessments, and adaptation options and strategy development. The implementation and monitoring step are not included in the Work Plan, but these steps are expected to be developed once specific adaptation strategies are selected and the bundling of measures for implementation is completed.

4. Retail Customer Scoping Meetings

As part of the initial scoping phase of the Work Plan development, Jacobs participated in several outreach efforts to better understand Sonoma Water and Water Contractor perspectives on the project. Initial meetings with the Project Team members established the project purpose and outreach approach. Subsequently, individual meetings were held with each of the retail customers to discuss the goals and objectives of the Resiliency Study, and to receive input and guidance on the most critical uncertainties, opportunities to be explored, and contractor models/data that should be reviewed to understand the system. The retail customers provided valuable input relating recent risks to their system and also new, uncovered risks. While many critical uncertainties were common across all Sonoma Water's retail customers interviewed, several retail customers also identified local, specific uncertainties that were important.

During each of the retail customers meetings, the Jacobs team asked for and received input related to the four areas below:

- Study goals and objectives
- Potential water shortage scenarios
- Initial focus areas and opportunities
- Relevant models and data

In general, the retail customers were supportive of the effort and provide valuable information related to the understanding of their local water system, current and future risks, and an overview of the data and tools used to evaluate their system performance. The summary information provided by the retail customers has been included and integrated into each of the subsequent sections.

5. Key Risk Drivers and Potential Water Supply Scenarios

Projecting the future is always fraught with uncertainty. However, recent events from regional catastrophic wildfires to global pandemics have emphasized the need to envision future scenarios in order to increase resiliency of systems. Scenario planning is one approach that is commonly used to identify plausible future conditions, informed by science, that may impact the future performance of a system (Figure 3). The major drivers for future uncertainty and risk are identified and cataloged. From these, scenarios can be developed to explore the outcomes related to these drivers. For example, extended periods of low precipitation is a major driver for most water supply systems. Using the best information related to historical droughts and projections of future climate, one could develop a "severe drought" scenario that would stress the regional water system beyond the historical experience, and then develop measures to mitigate or adapt to the drought risk.

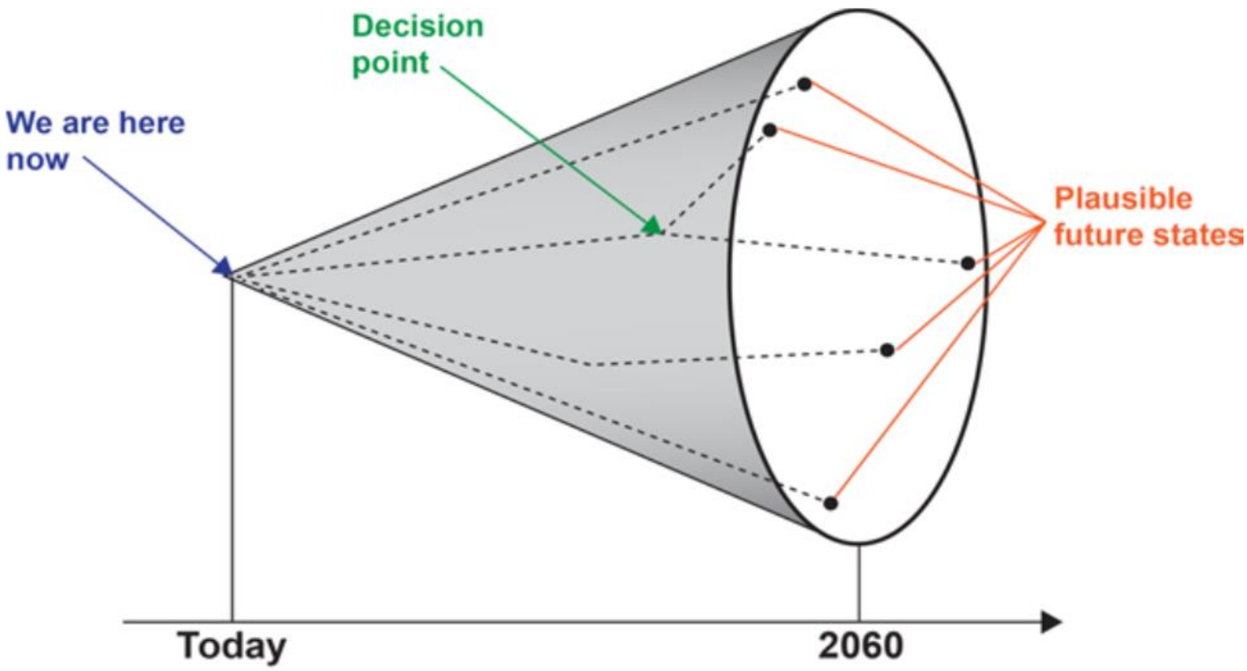

Figure 3. Cone of Uncertainty used to Identify Plausible Futures in Scenario Planning.

The use of scenario planning to envision plausible future scenarios is important to begin understanding and improving resilience. The process involves three main steps: (1) identify the key drivers of system risk, (2) rate drivers according to their importance and uncertainty to be sure the most critical drivers are prioritized, and (3) develop a set of scenarios that incorporate the key drivers. The use of these three steps to develop potential regional water supply shortage scenarios is summarized in the subsequent sections.

5.1 Key Risk Drivers

During meetings with Sonoma Water and retail customers, Jacobs collected information related to the major drivers of risk for each entity. Most retail customers voiced similar risk drivers, but also added more localized risk drivers due to their particular system, location within the watershed, agency size, political environment, or other factors. The drivers included in Table 1 below have been synthesized from the retail customer interview meetings.

The risk drivers have been categorized into "Natural System - N", "Population, Growth, and Land Use - P", "Regulatory, Policy, and Organizational – R", and "Infrastructure and Operations – I" areas as denoted by the letter in the table. In addition, each of the risk drivers have be classified as either "sudden" (0-6 months) or "gradual" (6-60 months) to indicate the rate at which the risk may occur. Phase 2 of the Resiliency Study will primarily focus on "sudden" risks but may also incorporate some of the more important "gradual" risks that capture longer-range impacts and to ensure that options that address risks at multiple time-scales are considered.

Table 1. Risk Drivers Summarized from Sonoma Water and Retail Customer Input

No.	Risk Driver	Risk Type	Potential Phase of Resiliency Study
N1	Wildfire	Sudden	Phase 2
N2	Earthquake	Sudden	Phase 2
N3	Drought	Sudden/Gradual	Phase 2
N4	Russian River Water Quality Contamination	Sudden	Phase 2
N5	Power Loss	Sudden	Phase 2
N6	Flooding	Sudden	Phase 2
N7	Sea Level Rise	Gradual	TBD
N8	Local Source Water Quality Contamination	Sudden	Phase 2
P3	Rapid Demand Growth	Sudden/Gradual	Phase 2 (TBD)
R1	Potter Valley Project Uncertainty (seismic/regulatory)	Sudden/Gradual	Phase 2
R2	New Russian River Treatment Regulations	Gradual	TBD
R5	SGMA Impacts on Groundwater Supply (City of Sonoma/VOMWD)	Gradual	Phase 2 (TBD)
R6	Changing Biological Opinions	Gradual	TBD
I5	Groundwater Well Operational Failures	Sudden	Phase 2
I6	Aging Infrastructure	Sudden/Gradual	Phase 2
I11	COVID-19 Workforce Response	Sudden/Gradual	TBD
I12	Operational Control Systems Disruption	Sudden	Phase 2

5.2 Ranking Drivers by Importance and Uncertainty

Initial scenarios should be crafted around the risk drivers that are most important to the system resiliency and also represent the largest sources of uncertainties. For several integrated studies, Jacobs has used an informal survey approach to have stakeholders rank the drivers based on importance and uncertainty. This process was successfully done to ascertain the key drivers on the Colorado River as part of a basin study involving nearly 100 stakeholders. Risk drivers that were identified as most important and most uncertain were then selected for the development of quantitative scenarios.

For the Sonoma Water Resiliency Study, we propose using a similar approach although with a much smaller stakeholder group. In fact, the stakeholder group could simply be the Project Team if desired. Or the group could be larger to include all Water Contractor members of the WAC/TAC. For this draft Work Plan, we have surveyed the four members of the Project Team and have averaged results for importance-uncertainty for each of the major drivers. The preliminary survey results are shown in Figure 4. In the figure, the drivers that were identified as most important and most uncertain plot to the upper right, while less important drivers plot to the left. The risk drivers that are encompassed by the large circle in the figure represent those that are likely (according to the survey respondents) to have a large impact on the system performance. These include drives such as drought, wildfire, earthquakes, growth and land use, Potter Valley Project outcome, power losses, source water quality changes, and others.

At present, this survey only includes results from the Project Team. However, if the survey were expanded, results could be compared by stakeholder groups (e.g. Sonoma Water, Project Team, all contractors, upper-lower contractors) to evaluate the robustness of the key drivers and those that are locally or user base-dependent.

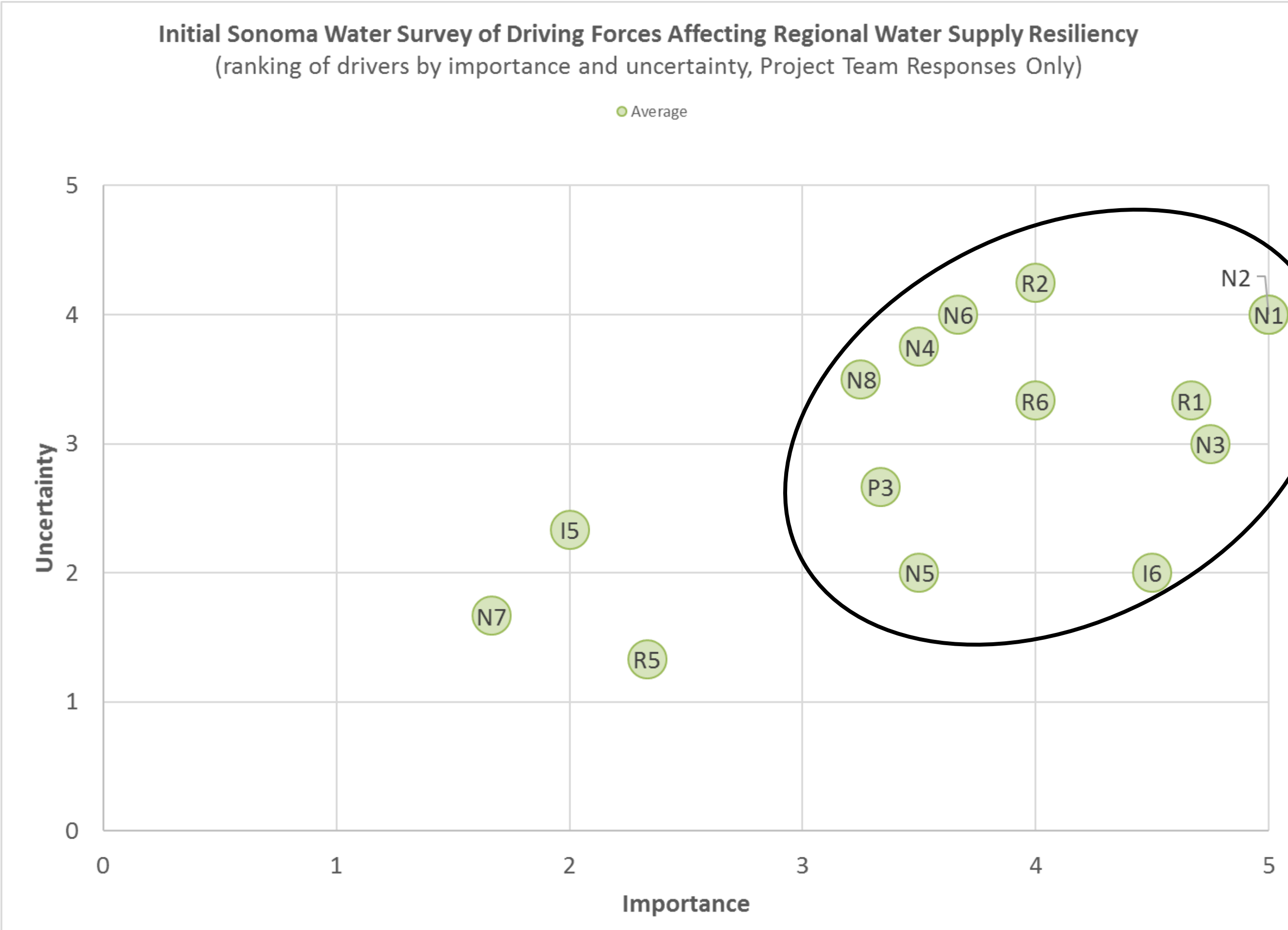

Figure 4. Average Results for the Risk Driver Survey Conducted by Project Team Members
(*Note: I11 and I12 risk drivers were not included in the initial survey and are thus not shown in the graphic)*.

5.3 Potential Resiliency Planning Scenarios

From the selected key drivers, resiliency planning scenarios can begin to be developed. Typically, some key drivers are combined to develop storylines around a plausible future that reflects how conditions may result. The storylines often help with specific scenario understanding and can help with communication to a broad range of stakeholders (including boards). The scenario then describes the quantitative measures that will be implemented in the DSM. These may include specific location, extent, and duration of critical uncertainties (e.g. seismic failure points, extent of power outage, fire extent and impact on water infrastructure/population, drought severity and duration, etc). The DSM would then evaluate the resiliency of the current system to absorb and/or recover from the impacts of these conditions. The DSM would subsequently be used to evaluate the benefits of various water supply strategies to reduce risk and increase the resiliency of the system under these same scenarios.

5.3.1 Drought Scenarios

Extreme drought derived from either future climate projections or synthetic sequence of historical variability based on projections. Scenarios would likely have greater hydrologic deficits and duration than historical droughts. The dry season would be extended based on future projections.

Related risk drivers:

N3	Drought and extended dry seasons

5.3.2 Wildfire Scenarios

Based on current wildfire fuel load in watersheds and climate-weather fire risks, an extreme fire scenario can be developed. Scenarios would build from information on recent fires and resulting impacts and would likely include fire risk in the Lake Sonoma watershed and subsequent post-fire sediment and organic carbon loading at storage reservoirs and water intakes.

Related risk drivers:

N1	**Wildfire**

5.3.3 Earthquake Scenarios

Substantial efforts have been made to characterize seismic risk on Sonoma Water's transmission system, and updates are underway. Based on results of the updated seismic risk assessment, multiple scenarios of transmission system failure would be considered. Failure points would be identified as well as anticipated duration of outage. At least one scenario would consider multiple coincident failures along the transmission system.

Related risk drivers:

N2	**Earthquake**
I6	**Aging Infrastructure**

5.3.4 Source Water Quality Contamination Scenarios

Impaired Russian River and local surface water quality that limits ability to divert for varying time durations (days to months). Anticipate development of acute contamination (e.g. contaminant released in river) and longer-term quality changes (e.g. future contaminants of concern or regulations impacting diversion). Local source water quality would be included at least one of these scenarios.

Related risk drivers:

N4	**Russian River Water Quality Contamination**
N8	**Local Source Water Quality Contamination**
R2	**New Russian River Treatment Regulations**

5.3.5 Power Loss Scenarios

Recent experience from the PSPS events in 2019 suggest the magnitude of the scenario. Outage scenario can be derived larger than those in 2019 to "stress test" the system. These scenarios could be combined with seismic and wildfire scenarios.

Related risk drivers:

N5	**Loss of power during shutoff events or fire emergencies (e.g. PSPS)**

5.3.6 Land Use and Development Scenarios

Rapid growth and rebound in water demand in certain areas. Acceleration of agricultural land being put into production.

Related risk drivers:

P3	**Rapid rebound in water demand**

5.3.7 Potter Valley Project (or Upper Watershed) Scenarios

Outcome of Potter Valley Project is unknown, but reduction in imported flows from the Eel River would be included in these scenarios. Imported volumes to the Russian River could range from zero to best current estimate of PVP process.

Related risk drivers:

R1	**Potter Valley Project Uncertainty**
R6	**Changing Biological Opinions**

5.3.8 Operational Outage Scenarios

Operational outages could be the result of other risk factors, but strategic selection of outages by Water Contractor region could facilitate risk identification and measurement. These outage events could be caused by infrastructure failures (e.g. well operational failures or aging infrastructure) or operational failures (e.g. control systems or standby power).

Related risk drivers:

I6	**Aging Infrastructure**
I12	**Operational Control Systems Disruption**
I5	**Groundwater Well Operational Failures**

5.3.9 Cascading Hazard Scenarios

Some hazards are interdependent on other hazards and a cascading hazard effect is plausible. For example, extreme drought would increase risk of wildfire, which could trigger loss of power and substantial water quality changes in watershed runoff. Similar relationships could be envisioned with seismic, fire, and power risks. Multiple scenarios would be included to explore the interdependency of various hazards.

6. Potential Water Supply Opportunities

As part of the scoping process and retail customer interviews, Jacobs collected initial information related to potential water supply opportunities to improve resilience. Table 2 provides examples of regional and sub-regional water supply opportunities suggested during the interview. These ideas were collected to assist the Jacobs team's understanding of the range and type of water supply opportunities that may be considered in Phase 2 to help in the DSM platform evaluation. During Phase 2, when the specific vulnerabilities/risks are better understood with respect to each scenario, a more comprehensive set of water supply opportunities will be developed.

Table 2. Examples of Regional and Sub-Regional Opportunities to Increase Resilience Summarized from Sonoma Water and Water Contractor Input

Examples of Regional Opportunities	Examples of Sub-Regional Opportunities
Regional groundwater bank	Improve ability to supply water to critical infrastructure (system isolation)
SGMA engagement	Interconnections between water systems
Regional generator pool program (sharing)	Ability to fill Lake Stafford with Sonoma Water supply
Increase production and delivery of reuse supply	Turn-out at Oakmont bypass
Increase system storage	Cross-connection between Ralphine and Kawana
Formalize emergency groups and mutual aid agreements	Recycled water storage
Transmission system loop or interconnections	Well operations with mobile generators
Sonoma Development Center water supply and treatment	Increase number of wells and production for health and safety supply levels
Support grant funding opportunities	Seismic retrofits at tanks and wells
Improve coordination of County land use policies	Maximize SW supply to Windsor during emergency (airport connection)
Improve shortage allocation policy/methodology	
Development of desalination supply	
Optimize system operations	

7. Evaluation and Selection of Decision Support Modeling Platform

In order to best satisfy the needs of the Resiliency Study project, Jacobs conducted an evaluation of various computer modeling platforms. Several existing modeling platforms could potentially be applied to develop the DSM for the Sonoma Water Resilience Study. The capabilities of these models cover a wide range of analysis categories: hydrology, system operations, hydraulics and hydrodynamics, water quality, lake and river temperature, groundwater, ecosystems, agricultural water use, economic optimization, and others. Due to the complex nature of the interconnected regional water system consisting of Sonoma Water and Water Contractor systems, a flexible modeling platform is vital to simulate the physical and operational processes on which the regional system is based.

Many of the anticipated questions and information needs as part of the Resiliency Study will require a greater exploration of the decision space and causal relationships that traditional water management models. Often existing tools are not well-suited for exploratory analysis due to issues such as long runtimes, lack of multi-disciplinary dynamic linkages, inability for non-modeler stakeholders to perform simulations, and lack of immediate graphical responses to specified management scenarios. It was under this guise that the DSM is being evaluated.

As part of initial meetings with the Project Team, and through subsequent interviews with the retail customers, a range of information needs and requirements for the Resiliency Study DSM were identified. The identified requirements for the Resiliency Study DSM are listed below:

- Represent Regional interconnected water system
- Incorporate surface water, groundwater, regional transmission system, and contractor systems
- Incorporate scenarios and uncertainty analysis
- Modular to represent different levels of geographic and system detail
- User interface for agency staff use
- Expandability
- Ability to integrate with other models (ResSim, groundwater, contractor models/data)

Jacobs evaluated multiple DSM platforms ranging from generalized system dynamics models to specialized water resource management models. For each of the DSM platforms, Jacobs evaluate the capability for over 20 criteria that we have found relevant on a range of projects. The specific DSM platform evaluation criteria include:

1. Implicit Water Resources Capabilities
2. Deterministic Simulation
3. Stochastic Simulation
4. Optimization
5. Customization
6. Re-Usable Objects/Libraries
7. Iteration
8. Data Exchange (including spreadsheets)

9. External Functions
10. Callable from Other Models
11. Graphics/animation
12. Arrays
13. Submodels/Layering
14. Equations Documentation
15. Scenario Analysis
16. Time/Units
17. Web Capabilities
18. Graphical Interface
19. Ease Implementation
20. User Base
21. GIS Linkage
22. Availability of Player Version
23. Cost
24. Customer Service

The review of the DSM modeling platforms is summarized in Figure 5. Jacobs has previous experience working with all of the models in this review. The DSM modeling platform evaluation, however, should not be considered entirely exhaustive, but provides a good selection of the state of modeling tools and capabilities. The rapid growth in the system dynamics field in the last two decades has created several new and more functional modeling platforms, such as Extend and GoldSim. Newer generation models such as AnyLogic provided advanced features like real-time Java translation and web-based JavaApplet features, but were found to score lower in ease of use and transparency. River-basin specific models such as WRIMS, RiverWare, WEAP, HEC-ResSim, and MIKE Basin were also evaluated. While the intrinsic water resource features of many these were considered valuable, it was believed that these modeling platforms did not provide enough flexibility for the purposes of the DSM for the Resiliency Study with primary purposes being operational strategy screening and dynamic user controls of complex regulatory restrictions.

The DSM modeling tools were evaluated by their capabilities across all 24 evaluation criteria and then also by their capabilities in relation to the project needs. For example, a modeling platform that matched or exceeded the project needs would be acceptable, but the selection of a tool that did not match the project needs for a specific evaluation feature would rate negatively. First, each modeling platform was rated between 1 and 4 based solely on their capabilities or features. The scale varies from of “1” indicating that the tool does not contain the feature, to “4” indicating that the platform includes the feature capability and does it very well. The scores were summed across all criteria. Goldsim, PowerSim, and AnyLogic ranked high under these criteria. Second, each modeling platform was rated between “1” and “4” based on how well their capabilities matched the features needed for the Resilience Study. The scale varies from “1” (not important or feature is not needed) to “4” (very important or feature needs to perform well). A calculation was done to rank the tools based on features that are needed for the Resiliency Study. Under this criterion, Goldsim, PowerSim, and AnyLogic consistently ranked higher than other tools .

Based on the Resiliency Study needs and the modeling platform evaluation, Jacobs has selected the GoldSim modeling platform for the development of the DSM. The GoldSim dynamic platform was chosen based on the following features:

- Modeling flexibility
- Ability to incorporate surface water, groundwater, regional transmission system, and contractor systems
- Robust scenario and uncertainty capabilities
- Ability to scale complexity
- User friendly interfaces
- Expandability
- Ability to integrate with other models (Spreadsheets, DLLs, databases)
- Freely distributable player version

While it was believed that the DSM could potentially be developed using a number of modeling platforms, the inherent stochastic and iteration (looping) features of GoldSim were viewed favorably. The GoldSim system dynamics software enables simulation of complex processes through a build-up of simple object relationships, incorporates Monte-Carlo stochastic methods, and includes dynamic, interactive user interfaces. A “player” version of the DSM model can be distributed at no cost to stakeholders. The GoldSim software was also seen to have an aggressive research and development focus and has been very responsive to developer input. Jacobs has successfully developed and applied water resource models throughout the U.S. using GoldSim modeling platform, and it is noted that Marin Municipal Water District has currently developed a GoldSim model for their system.

Evaluation Features	Project Needs	GoldSim	PowerSim	Extend	Stella	AnyLogic	WRIMS	RiverWare	WEAP	HEC-Ressim	MODSIM	Mike Basin
Implicit Water Resources Capabilities	2	2	1	1	1	1	3	4	3	4	3	3
Deterministic Simulation	2	3	3	3	3	3	3	4	3	3	3	3
Stochastic Simulation	4	4	3	3	2	3	1	1	1	1	1	1
Optimization	3	3	3	3	2	2	2	2	1	1	1	2
Customization	3	3	3	3	3	4	4	3	2	2	2	3
Re-Usable Objects/Libraries	1	1	1	4	1	4	1	2	1	1	1	1
Iteration	2	4	1	1	1	2	2	2	1	1	1	1
Data Exchange (including spreadsheets)	4	4	3	3	3	3	2	3	3	2	2	3
External Functions	1	4	4	4	1	3	2	2	1	1	1	2
Callable from Other Models	1	1	2	2	1	3	1	2	1	1	1	1
Graphics/Animation	3	3	3	3	2	4	2	3	3	3	2	3
Arrays	2	3	2	2	2	2	1	1	1	1	1	1
Submodels/Layering	2	4	1	1	1	1	1	1	1	1	1	1
Equations Documentation	2	4	2	1	1	1	1	1	1	1	1	1
Scenario Analysis	4	4	2	3	2	2	2	2	2	2	2	2
Time/Units	2	4	4	1	1	1	2	3	3	3	2	3
Web Capabilities	1	1	2	2	1	4	1	1	1	1	1	1
Graphical Interface	4	4	4	3	2	3	2	3	3	3	2	3
Ease Implementation	3	4	4	2	2	2	2	3	3	3	2	3
User Base	3											
GIS Linkage	1	2	1	2	1	2	1	1	3	2	1	4
Availability of Player Version	4	4	4	4	4	4	1	1	1	1	1	1
Cost	2	2	2	2	2	2	2	2	2	2	2	2
Customer Service	3	3	2	2	2	2	2	2	2	2	2	2

Matches project needs
Exceeds project needs
Below project needs

Figure 5. Decision Support Modeling Platform Evaluation Matrix.

8. Proposed Approach for Phase 2 – Development of Regional Water Supply Resiliency Study

8.1 Planning Approach

The planning approach proposed to complete the Phase 2 of Resiliency Study includes 11 tasks in total. These tasks can generally be separated into 4 stages: (1) confirming process and developing tools, (2) evaluate baseline water supply resilience, (3) identify and evaluate performance of adaptation strategies, and (4) report preparation, stakeholder engagement, and project management. The specific tasks and stages are shown graphically in Figure 6 and are described in detail in the subsequent sections.

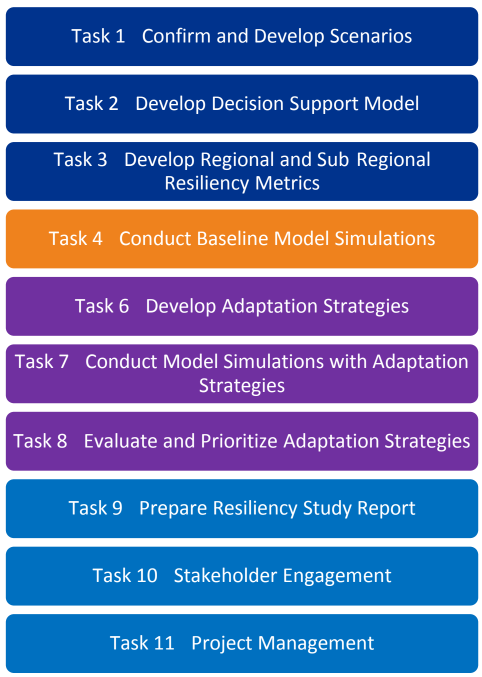

Figure 6. General Flow of Tasks for Resiliency Study (colors indicate groupings of tasks).

8.2 Task 1 – Confirm and Develop Water Supply Scenarios

Based on the information collected during the initial scoping meetings and results from the driving forces survey, Jacobs will confirm and develop detailed assumptions for a set of water supply resiliency planning scenarios. Risk drivers that were identified as having high importance and high uncertainty in the surveys will form the basis for the scenarios. Initial scenarios will focus on natural system-related hazards such as drought, wildfire, seismic, and source water quality risks. Additional scenarios will focus on infrastructure and operational hazards such as power loss and system outages, and regulatory and policy risks such as Potter Valley Project outcome, changes in land use and development, and changes in future water quality standards. Finally, a group of cascading hazard scenarios will be developed to address the interdependency of various hazards such as drought, wildfire, and water quality, or seismic, wildfire, and power risks.

For each of the selected resiliency planning scenarios, detailed assumptions related to extent, timing, frequency, and duration of the hazard will be developed. For example, seismic scenarios will be based on information available from Sonoma Water's "Natural Hazard Reliability Assessment Update" project that is currently underway. It is envisioned that seismic scenarios will include various sub-scenarios that differentiate in terms of seismic magnitude, affected region, water infrastructure damaged, and duration of outages. Similarly, multiple wildfire and drought sub-scenarios would be included to characterize the potential magnitude and severity of these risks.

For planning purposes, Jacobs has assumed that up to five scenarios, each consisting of up to three sub-scenarios (a total of 15 scenarios), will be developed to support Phase 2 of the Resiliency Study. The scenarios will be documented in a technical memorandum and included in the final study report.

8.3 Task 2 – Develop Regional and Sub-Regional Resiliency Metrics

An important aspect toward evaluating resiliency is the development of specific regional and sub-regional metrics that measure the degree of water supply resiliency. These metrics can be derived from specific level of service goals or from other water delivery reliability objectives and are used to assess current level of resiliency and performance of various strategies to increase resiliency. Regional water supply resiliency metrics are likely to include measures such as end-of-year storage in Lake Mendocino and Lake Sonoma, Russian River diversion capability, and Sonoma Water's transmission system flows and tank storage. Sub-regional metrics will be used to assess localized resiliency and may include measures such as contractor delivery reliability (or shortage), local system storage, and diversity of available supply.

Jacobs will work with Sonoma Water, the Project Team, and individual retail customers to develop specific and measurable resiliency metrics that will be used assess current and future resiliency performance. It is envisioned that ten to fifteen specific metrics will be developed to support the Resiliency Study.

8.4 Task 3 - Develop Decision Support Model

The Decision Support Model will be a foundational component of the Resiliency Study and will be used to evaluate baseline system resiliency and performance of various strategies. The DSM will include a representation of the entire regional water supply system extending from the Upper Russian River to water delivery systems in Sonoma and Marin counties. The simulated system will include the major water supply facilities of the Upper Russian River, Sonoma Water diversion and transmission facilities, and retail customer system facilities. The main system elements that will be included in the DSM are listed below:

- Surface water reservoirs
- River diversion facilities
- Transmission system facilities (aqueducts, pump stations, storage tanks)
- Local water supplies (groundwater, local surface water, recycled water)
- Local water delivery system (major pipelines, storage tanks, aggregated pressure zones)
- Groundwater basins
- Regional and local demands

Based on scoping meetings with Sonoma Water, the Project Team, and individual retail customers, the initial model will be developed based on the model schematic shown in Figure 7. The draft schematic shown in the figure was developed to represent the main Sonoma Water water supply and transmission system, interconnections with retail customer systems, simplified representations of each of the retail customers, and major groundwater basins. The schematic is considered draft and may require minor modifications during the model development task.

The DSM will be developed using GoldSim modeling platform. GoldSim makes available two versions of its software, the “pro” and the “player” versions. GoldSim models are developed with the GoldSim “pro” version of the software which gives the developer full control of the model design, including model equations, inputs and outputs, and manages which variables will be available for modification in the “player” version. The player version is free of charge and can be downloaded from the GoldSim website. The player version will allow users to change most input variables, to run scenarios, and process and view output results.

The DSM will be developed to simulate operations on daily time step with output summaries available for monthly and annual totals. Historical hydrology, aqueduct deliveries, and system flows will be used for model calibration. The calibration period will be selected after further review of the available records (particularly local delivery data) but will incorporate both long-term dry periods and the most recent period. Jacobs will seek consistency with information in Urban Water Management Plans related to available water supply and demands for each retail customer. The model will simulate water flow, storage, deliveries, and operations through a set of network water balance equations constructed in GoldSim. Jacobs has successfully applied numerous water supply models using GoldSim and will use similar methods for this model development. The groundwater basins identified in the system schematic will be modelled as simplified storage elements in the model.

The DSM will include multiple dashboards that will allow the user to control the simulation and scenarios and allow for review of model outputs during and after simulation. Water balance summaries and resiliency metric results will be available for the overall regional system as well as for each retail customer’s service area. Comparison of results across scenarios will be possible using the GoldSim scenario manager and through display of results in the DSM dashboards.

Once a final system schematic has been completed, Jacobs will collect historical data related to hydrology, water supply and demands, capacities and operations of major storage and diversion facilities, pipeline and pump station capacities, and deliveries. In addition, general operating rules derived from historical information, existing models, or operator conversations will be compiled for all major water facilities in order to develop DSM operational rules that emulate the primary operational modes of various systems. Integration of with other existing models will be explored by either dynamic (within simulation) or static (before/after simulation) depending on the needs. Based on the scoping meetings, it is expected that integration with other tools will be primarily static – transfer of model inputs and outputs. For example, a more complex reservoir operation could be provided by results from the HEC-ResSim models for the Russian River and used as a time series input to the DSM. Alternatively, DSM output for tank storage and deliveries to a specific contractor could be used as direct input into a local contractor hydraulic model.

The DSM will be developed using a top-down approach, where broad assumptions are first implemented, and details are added as needed. The model will be set up as a demand-driven model system where supplies are released to meet downstream system demands. Depending on the priority established in the model, retail customers could use local supplies first, then augment with Sonoma Water supplies, or switch priority.

Jacobs will prepare the DSM model (pro and player versions), conduct a historical period calibration simulation, and demonstrate model robustness through results analysis as part of this task.

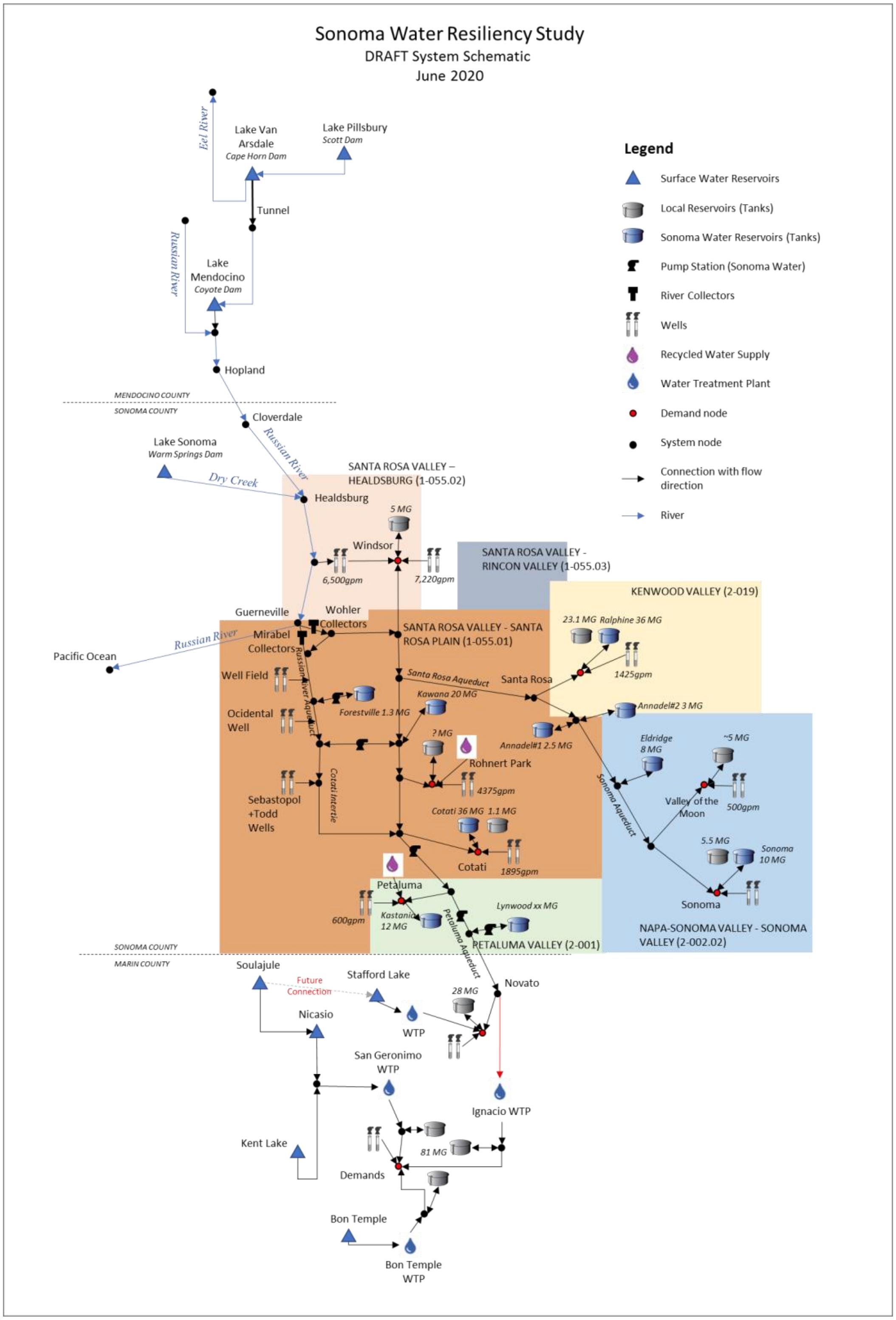

Figure 7. Initial Decision Support Model Water System Schematic.

8.5 Task 4 – Conduct Baseline Model Simulations

Baseline model simulations will be conducted using the DSM developed under Task 3 and the scenarios developed under Task 1. These baseline model simulations will implement the relevant changes (shocks) to the system to simulate the resiliency planning scenarios. The baseline scenario will be initially developed based on historical flow data and historical operations but could include changes from historical conditions that better represent future conditions around year 2040 to be consistent with upcoming UWMPs.

Jacobs has assumed that up to 15 simulations will be required to test the baseline system performance under each of the scenarios. Depending on the scenario complexity, these simulations could be simulated using batch processes. The baseline resiliency will be summarized by the assessing the resiliency metrics under each scenario as compared to a target or reference value.

8.6 Task 5 – Develop Resiliency Options

As described in previous sections of this Work Plan, Jacobs collected initial information related to potential water supply opportunities to improve resilience. Jacobs and the Project Team will review the specific areas of poor baseline performance and compile a more focused list of potential resiliency options that seek to address performance shortfalls. Resiliency options will likely include groundwater banks, improved interconnections between systems, storage, and alternative water supply projects. In addition, some options will be identified to address broad regional resiliency, while others may primarily address sub-regional performance. A reduced list of resiliency options will be developed and confirmed with the Project Team.

Once the list of resiliency options is confirmed, Jacobs will develop detailed assumptions associated with each option in order to implement in the DSM. For planning purposes, Jacobs has assumed that up to 25 resiliency options will be proposed and approximately 10 options will be selected for implementation in the DSM. The resiliency options will be documented in a technical memorandum and included in the final study report.

8.7 Task 6 – Conduct Simulations with Resiliency Options

Using the same approach as the Baseline model simulations, the DSM will now be used to simulate the performance of the system under the scenarios ***with*** the inclusion of the resiliency options identified in Task 5. These simulations may initial require some iteration to ensure that the options are optimized to address the specific resiliency challenge. Final simulations may be batched to reduce the time required for completion.

Jacobs has assumed that up to 10 (batch) simulations will be required to test the system performance with the resiliency option implementation under each of the planning scenarios. The resiliency will be summarized by the assessing the resiliency metrics under each scenario as compared to a target or reference value, and comparisons to the baseline performance will be conducted.

8.8 Task 7 – Evaluate and Prioritize Resiliency Options

Following the adaptation strategy development and DSM simulations with and without resiliency options, it is important to analyze the option performance and prioritize those options that best meet resiliency goals. Jacobs proposes to perform this in two main steps. The first step is to compile the option characteristics such as option cost, feasibility, legal or permitting challenges, and implementation complexity. The second step is to then integrate resiliency performance (metric improvements) with certain characteristics (e.g. cost) to better understand the option performance and to facilitate comparisons between various options.

Jacobs will build from approaches being used in the Climate Adaptation Plan to assist in the evaluation and prioritization of resiliency options. Two small workshops with Project Team and retail customer members are assumed to facilitate the evaluation and prioritization of resiliency options.

8.9 Task 8 – Prepare Resiliency Study Report

The approach, process, results and findings will be documented into the overall Resiliency Study report. In general, the report will summarize the work products of each of the tasks and integrate findings into a roadmap to move towards implementation. for moving forward. The report will generally include the following elements:

- Scenario planning approach
- Water supply scenarios
- DSM model development
- Baseline resiliency
- Resiliency options
- Evaluation and prioritization of resiliency options
- Roadmap for improving resilience

A separate report documenting the technical details of the DSM development and assumptions will accompany the study report as an appendix. Included in this technical appendix will also be an instruction guide for users of the model. The content and level of detail for each section will depend on Sonoma Water and Project Team direction. Jacobs will prepare an outline of the study report early in the Phase 2 effort to ensure the appropriate level of information is compiled and tailored for the audience needs of the final report.

For planning purposes, Jacobs has assumed that the final Resiliency Study report will be less than 150 pages in length and that draft and final versions will be submitted for review.

8.10 Task 9 – Stakeholder Engagement

As part of the resiliency planning effort, various types of stakeholders will need to be engaged. These stakeholders may include members of Sonoma Water staff or board, retail customers, other county departments, and external stakeholders. As part of other projects for Sonoma Water, Jacobs has made some progress at engaging stakeholders to understand and support the water resiliency. We recommend that an engagement plan be developed at the onset of Phase 2 to identify the specific internal and external stakeholders, set the objectives for stakeholder engagement, and propose the method and timing of communication with various stakeholders.

For planning purposes, Jacobs has assumed that internal stakeholders will primarily consist of Sonoma Water and retail customer members and that the WAC/TAC will be the primary venue to engage this group. External stakeholders could include local, state and federal agencies, research institutions, and the general public. We have assumed quarterly meetings to update the WAC/TAC of progress and findings, and up to five periodic meetings with external stakeholders to inform of the study and broad conclusions.

Methods of communication will vary depending on the stakeholder type and the stage of the project. The Project Team will hold regularly scheduled in-person and conference call meetings. Other stakeholders may be engaged in facilitated workshops or periodic in-person meetings, while others may be engaged through web-based sharing methods or website updates.

8.11 Task 10 - Project Management

Project management activities will include timely coordination with Sonoma Water and Project Team members, schedule and budget management, and meeting coordination. Jacobs will perform these functions for the duration of the Phase 2 effort.

9. Phase 2 Programmatic Schedule

As part of the Work Plan development a programmatic schedule has been prepared to assist Sonoma Water in planning for the Phase 2 of the Resiliency Study. Ten main tasks have been identified to complete this effort as shown in Table 12. These tasks include scenario development, model development and application, water supply strategy development and evaluation, stakeholder engagement, and preparation of the Resiliency Study report. Also included are regular meetings and project management activities.

A draft programmatic schedule has been prepared as shown in Table 12. The tasks related to scenario, resiliency planning metrics, and DSM development could be completed within 6 months from project start. Baseline model simulations and an assessment of current resiliency performance could be completed within 9 months from project start. Water supply strategy development, evaluation, and prioritization are anticipated to be completed within 12 months from project start, and the final study report is expected to be completed 18 months from project start. It is likely possible to accelerate this schedule should this be desirable, but alignment of the technical tasks and outreach efforts should be considered.

Table 12. Draft Programmatic Schedule for Phase 2 of the Sonoma Water Resiliency Study

Description	Estimated Completion (after Notice-to-Proceed)
Task 1 – Confirm and Develop Scenarios	3 months
Task 2 – Develop Decision Support Model	6 months
Task 3 – Develop Resiliency Metrics	4 months
Task 4 - Conduct Baseline Model Simulations	9 months
Task 5 - Develop Resiliency Options	11 months
Task 6 - Conduct Model Simulations with Resiliency Options	13 months
Task 7 - Evaluate and Prioritize Resiliency Options	15 months
Task 8 - Prepare Resiliency Study Report	18 months
Task 9 - Stakeholder Engagement	throughout
Task 10 - Project Management	throughout