Memorandum

To: Water Supply Advisory Committee members

From: Karen Raucher and Robert Raucher, Stratus Consulting Inc.; and Gary Fiske, Gary Fiske and Associates

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Subject: Scenario planning exercise

The scenarios developed for use in this month's exercise are provided in Attachment 1. This memorandum provides background information that will be useful for you to understand as you engage in this exercise. Please bring questions about these materials to the meeting, as the material itself will not be presented.

During last month's scenario planning exercise, the Water Supply Advisory Committee (WSAC) developed a basic understanding of how to build portfolios that meet the demand-supply gap for three scenarios: drought and DFG-5 fish flows, climate change and DFG-5, and climate change and City-proposed fish flows. You will notice that for this month's scenario exercise, only two of these scenarios are presented: drought and climate change. However, each scenario now includes the potential for either of the fish flow requirements to be selected. This has been done to help you understand how to use "adaptive management" strategies, including sign points and trigger points, as one strategy to handle uncertainties (i.e., as an alternative to creating additional scenarios, we are adding realistic complexities and useful approaches to the portfolio planning exercise).

This month's exercise will also include information that allows you to consider how to take advantage of a current Capital Improvement Plan (CIP) as an opportunity to leverage funding a new plan (or, in contrast, helps you consider the risk of developing stranded assets). And, you will have updated and improved information about the consolidated alternatives to use in your deliberations and portfolio development.

Important disclaimer: Ultimately, WSAC members will decide if they want to build adaptive plans, identify additional scenarios, perform regrets analysis, and how to include the CIP in their portfolios. The examples provided below and the suggested activities are for learning purposes only.

Adaptive Management

One objective of developing a plan under large future uncertainty is to ensure that the plan is either *robust* (i.e., meets your objective under a range of possible future conditions) or is *flexible* (i.e., can be easily modified to meet your objective as conditions unfold and some uncertainties are resolved). The Dutch are leaders in developing adaptive management strategies (also referred

to as “adaptive pathways”). The “youtube” video at the link below, developed by Dutch researchers, does an excellent job of concisely and simply explaining adaptive management (it is short, running about 3 minutes).

https://www.youtube.com/watch?v = ZvA2lt9_SD4

Additional information about how to build adaptive plans is provided in the next several sections.

Using Signposts and Trigger Points: Building Adaptive Pathways

Signposts and trigger points can be built into potential plans (e.g., portfolios) developed for scenarios, as a way to handle large uncertainty regarding future events that are exogenous (i.e., events that will occur that are outside of the influence of the community).

- ***Signposts*** refer to the *parameters that need to be monitored* to reveal whether adaptively switching to a revised plan is needed. For example, a signpost may be based on the level of water left in the reservoir as of a given calendar date. It is akin to including a fuel gauge in an automobile so that you can monitor whether you need to alter your route to refuel.

- ***Trigger points*** refer to the specific parameter values that signal that it is time to modify your plan (i.e., *when* to trigger a change in policy so that you have adequate time to respond to the changing circumstances). An example would be a specific value for reservoir levels that triggers a move to curtailments, or the announcement of which Habitat Conservation Plan (HCP) flow requirements will indeed be implemented and enforced, and the associated changes that may be needed to adapt to the new regime. (It is akin to when the fuel gauge in your car clicks on the yellow light indicating you need to adapt your route to refuel).

This is an especially useful technique for events that do not lend themselves easily to the use of probabilities (e.g., the probability this event will occur is unknown, but plausible enough that it needs to be included in the plan). A simple example of an event which may occur that can be handled through the use of signposts and trigger points is the future decision setting the HCP requirements surrounding fish flows.

Although we saw in last month’s meeting that fish flow regulations can be handled as separate scenarios (e.g., you can build a scenario that allows you to build a portfolio for city proposed flows, and another scenario that allows a portfolio to be built for DFG-5 flows), it can sometimes be more illustrative (and easier) to just identify that you have no control over this event and, rather than build two separate portfolios, just build one that is either robust across both possible futures, or one that is flexible and adaptive to respond well to either potential future.

In this approach, *all* scenarios recognize that some exogenous event may require the city to revisit the plan *and* thus the scenarios require building portfolios that include:

- Identifying the exogenous event(s) that requires the plan to be either robust or flexible in order to meet your objectives.
- If the plan will be *flexible*, then it is necessary for the portfolios to also:
  - Identify the signpost (the specific information that will be monitored) and the associated trigger point at which time the plan needs to make an adaptive adjustment
  - Analyze the cost and benefits associated with developing a flexible and adoptive plan as opposed to selecting a plan that addresses only one possible future
  - Identify the set of actions that need to be taken today, and in the future, to ensure any needed future adjustments are available (feasible) and cost-effective (for the purposes of this discussion, cost-effectiveness analysis includes financial, social, and environmental costs and benefits).

Below we provide insights into how signposts and trigger points can be used in scenario planning to handle the exogenous uncertainty surrounding fish flows and/or other key exogenous future events that may indicate it is time to "switch to plan B."

Signposts and Trigger Points for Fish Flows

Future regulations will require the City to meet specified flow regimes in order to protect and enhance local special status fish populations. This requirement represents an event (in this case a decision by state and federal officials) that is primarily beyond the control of the City. (Yes, the City can contest and provide input, but ultimately it does not get to make the final decision.)

Because an HCP requirement is an exogenous event, WSAC can only plan for how the City responds to the event. Every future scenario will be affected by the event, and the plan cannot be used to modify the event.

In order to create plans that are flexible and adaptive to this future, every portfolio built by WSAC needs to consider the possibility of two future fish-flow requirements. WSAC can handle this in two ways: it can opt to build one plan that is robust for either fish flow future, or build a plan that is flexible so that it can be modified to meet whichever future flow requirements unfold.

Figure 1 provides a simple illustration of how the climate change scenario looks if both fish flow regulations are included within the scenario as opposed to having two separate climate change scenarios (one for each HCP flow). In this example we see how two different plans are needed – either Plan A1 and Plan A2 – depending on which future is created by the event.

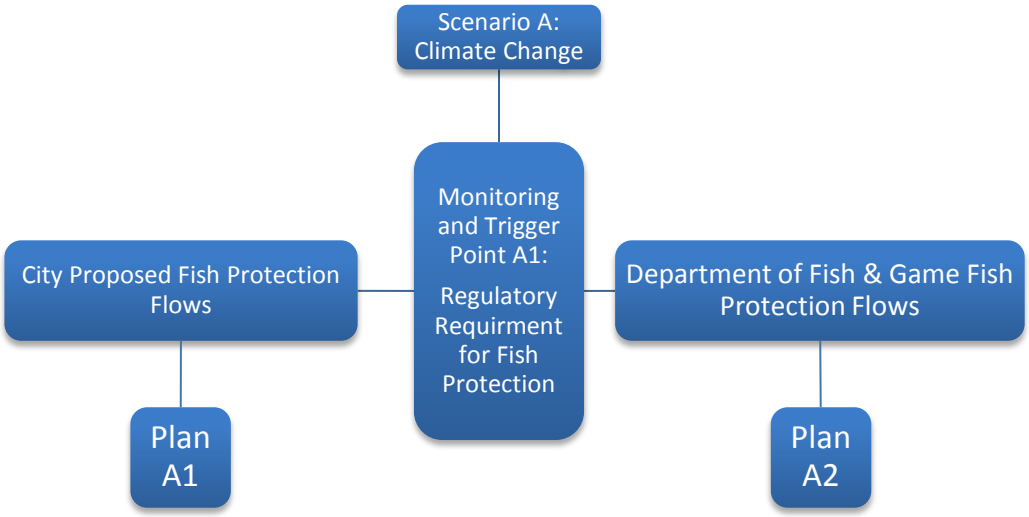

Figure 1. Schematic of monitoring and trigger point.

Ultimately, however, WSAC needs to recommend only one plan, but can build in adaptive strategies (e.g., contingent agreements) to accommodate future changes. In order to identify which plan to recommend, WSAC can use one of four basic approaches:

1. Recommend the plan that meets the future that is most likely to occur by using probabilities to select the future (this is only feasible if one knows the probabilities of future events)

2. Recommend the plan that meets the worst case so that the City has enough water under either outcome (a robust approach)

3. Recommend the plan for the best case, and hope for the best

4. Ensure that the plan is flexible and adaptable to handle either outcome (a flexible approach).

Building signposts and trigger points into your plan (i.e., portfolio) helps you create a plan that is flexible and adaptable to meet either future, provides insurance for the worst case, prevents the city from overspending if the best-case occurs, and does not require WSAC to rely on vague probabilities. Building plans that are adaptive also allows you to compare the costs and benefits associated with a robust plan with one that is flexible and adaptive. A regrets analysis (described in the next section) is a useful analytic technique that can be used to compare the costs and benefits associated with a robust plan versus an adaptive plan.

The first step in building plans that are adaptive is to identify the crucial element that could cause your plan to fail; in this example it is the fish-flow decision. Climate change itself may also require a signpost and trigger point. For example, changes in precipitation patterns or increases in temperatures beyond the ones used in your climate change projection analysis could trigger the need for a plan modification.

It is important to note that water supply plans are required to be revisited every five years as part of the State of California's Urban Water Management Planning (UWMP) requirements. By adding a specific set of monitoring and trigger points, WSAC is helping identify what should be reviewed in each UWMP update and may provide specific response recommendations.

Regrets Analysis

A regrets analysis is one technique for determining if it makes more sense to build a robust plan or a flexible and adaptive plan, when there are no useful probabilities to apply. A regrets analysis provides you with information you can use to:

- Compare the costs and benefits associated with both the robust and flexible plan
- Identify components of each plan that are the same, as well as where the two plans have approaches or elements that differ
- Identify the components and actions of the flexible plan that may need to be taken in the near-term in order to keep your longer-term options open.

In economic terms, a regrets analysis allows you to "minimize your maximize regret." In other words, a regrets analysis allows you to understand which decisions made now are likely to leave you in the worst possible position in the future, given the range of choices you have to make now about how you will cope with an uncertain future. This approach is especially useful for high-cost and largely irreversible decisions such as ones embodied in water supply planning, where choices made in the near-term may impose very high future costs if a community either under-prepares (e.g., resulting in large-scale water shortages) or over-prepares (e.g., resulting in expensive stranded assets). Another way of looking at this is that a regrets analysis helps

determine how much extra cost you may incur if you opt for an expensive robust plan, as opposed to a more flexible plan.

Figure 2 provides a simplified example of two plans, one that is robust and one that is adaptable and flexible.

Planning objective: Meet the peak season demand supply gap in 2030.

Assumptions:

- Under city flows the gap is 500 mgy
- Under DFG-5 the gap is 1,000 mgy.

Portfolio A: Robust	Portfolio B: Flexible and adaptive
Demand reduction actions: 200 mg Winter flow capture and storage: 400 mg North Coast water exchange: 400 mg	Demand reduction actions: 200 mg North Coast water exchange: 400 mg

Figure 2. An example of two types of portfolios.

This simplified figure shows that two components of the robust plan are the same as the ones needed for the flexible plan. This makes it easy to identify that regardless of the future, you will recommend both demand reduction actions and the North Coast water exchange. But, because you want your plan to be responsive to the potential need to address a larger demand-supply gap, you also need to identify the actions that have to be taken, and the point in time when they need to be taken, to keep the option for winter-flow capture and storage available if needed.

Because it can take a long time to get the required legal, permitting, and political approvals and rights of way, and because you want to be able to take this action in a timely fashion if and when needed, you need to identify anticipated timings and begin the process of getting approvals before you would need them. In other words, you are preparing in the near-term so that you can later add winter-flow capture and storage more expeditiously to your portfolio – if and when it is needed – in a way that it provides water to meet demands by the time when it is needed.

Figure 3 provides an example of a different set of trade-offs between a robust and flexible plan. In this example there are no overlaps between the two portfolios, making your deliberations and choices a bit more challenging.

Planning objective: Meet a demand supply gap in 2030.

Assumptions:

- Under city flows the gap is 500 mgy
- Under DFG-5 the gap is 1,000 mgy.

Portfolio A: Robust	Portfolio B: Flexible and adaptive
Aquifer storage and retrieval: 1,200 mgy	Demand reduction actions: 200 mg North Coast water exchange: 400 mg

Figure 3. Another example of two portfolios.

Figure 4 provides an example of a regrets analysis for the example provided in Figure 3. In this simple example you can easily see that all else being equal, selecting the robust plan, Plan A, provides the city with a way to meet the demand supply gap regardless of the fish-flow regulatory decision. Since Portfolio A has the same cost as Portfolio B (which meets demands only under the City fish flow proposal, but provides considerably higher yields, it is a preferred choice (although other factors, such as environmental or societal factors, also need to be weighed in the decision).

Planning objective: Meet a demand supply gap in 2030.

Assumptions:

- Under city flows the gap is 500 mgy
- Under DFG-5 the gap is 1,000 mgy.

Portfolio A: Costs	Portfolio B: Costs
Aquifer storage and retrieval: $1.75 M	Demand reduction actions: $0.75 M North Coast water exchange: $1 M

Figure 4. Regrets analysis for example provided in Figure 3.

Figure 5 illustrates a possible decision where there are considerable regrets. Given the choices provided in Figure 5, there are three possible outcomes, each with a unique set of regrets:

1. *Select the robust plan*. In this example the robust plan costs the City $400 million and provides 1,050 mg of additional water supply. Regardless of future flow requirements, the City spends this much and gets this much yield. However, if City flow requirements end up being adopted, then the robust plan ends up costing the City $200 million it didn't have to ($400 million for the total robust plan minus the $200 million needed to meet City flow needs) to meet the gap of 500 mg. However, the City also has significant additional water supplies so there are likely to be additional environmental and social

benefits; for example, curtailments are unlikely even if your flow estimates for climate change are off by a great deal.

2. *Select the flexible plan and City flows end up being selected.* In this case the City spends $200 million and has 500 mg of additional water supply. This represents a $200 million dollar savings (compared to selecting the robust portfolio) and exactly meets the targeted gap, if City flows are implemented.

3. *Select the flexible plan and DFG-5 ends up being selected*. In this case the City ends up spending $500 million and has 50 mg of water supply less than the robust plan. The flexibility built into this plan ends up costing the city $100 million and also yields 50 mg less in annual water supply, compared to the robust alternative.

Planning objective: Meet a demand supply gap in 2030.

Assumptions:

- Under city flows the gap is 500 mgy
- Under DFG-5 the gap is 1,000 mgy.

Portfolio A: Robust			Portfolio B: Flexible			
	Yield	Cost		Yield	Cost	Total Cost
Demand management	250 mg	$20 M	Demand management	250 mg	$20 M	$200 M
Indirect Potable Reuse	800 mg	$380 M	Winter flow	250 mg	$180 M	
			North Coast water exchange	500 mg	$300 M	$ 300 M
Total	1,050 mg	$400 M		1,000 mg	$500 M	$500 M

Figure 5. Regrets analysis for third example

In sum, building a flexible plan with signposts and trigger points and using a regrets analysis to compare the benefits and costs (note that a full-blown regrets analysis includes not only financial costs but environmental and social as well) informs the WSAC of the impacts associated with its recommended plan.

Attachment 1. Scenario Descriptions for use in May meeting