Draft Conceptual Models

Development of Water Quality Standards for Willard Spur

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Introduction

The overall objective of the proposed Willard Spur research program is to answer the question posed by the Water Quality Board:

> *What water quality standards are appropriately protective of beneficial uses of Willard Spur waters as they relate to the proposed POTW discharge?*

In other words, what actions, i.e., responses, should the Water Quality Board implement to manage and protect this water body? The answer to this question inherently includes elements of both science and policy of which the Science Panel is asked to address the science. The Steering Committee, Division of Water Quality (DWQ) and Water Quality Board will incorporate their values and responsibilities to shape the policy elements of the answer.

As is common in complex ecosystems such as found in Willard Spur, much information is needed to describe its characteristics and condition, the stressors to the ecosystem and their causes, how the ecosystem responds to these stressors, and finally to identify indicators that can be used to measure impacts to the system and determine if it is supporting its beneficial uses. Describing these relationships between human activities, the stressors they introduce, and the critical ecological endpoints is made all the more challenging by the lack of available data describing Willard Spur and limited time and resources.

We propose the development of conceptual models for Willard Spur as one means of focusing our efforts to address this challenge. Visualizing these relationships will help document information and processes we already understand and identify and prioritize those that will need further study. Indicators describing the condition can then be identified and used to develop implementable management responses that answer the Water Quality Board's question.

CH2M HILL and DWQ completed a cursory review of the literature to identify potential conceptual models that were applicable to the issues at hand in Willard Spur and develop them for use in this effort. The intent of the conceptual models included herein is to serve as a "straw-man", i.e., a starting point for discussion by the Science Panel. We anticipate that these models will change as part of this discussion.

Conceptual Models

There are many elements included in a conceptual model. They include pressures (i.e., causes), stressors, responses, beneficial uses, and modifying factors (i.e., factors that modify the impacts of a particular stressor Paul et al. (2002)). A preliminary review of possible indicators was completed but will require additional discussion to focus efforts on particular systems (wetlands, estuaries, etc.) and habitats (mudflats, shallow/mid-depth/deep emergent and submergent wetlands, etc.). Indicators will likely be a more significant topic of discussion as the conceptual models are further developed.

Figure 1 illustrates a draft conceptual model for hydrologic change as the stressor. Figure 2 illustrates a draft conceptual model for nutrients as the stressor. This section includes a brief description of each of these elements listed above.

Pressures

As previously described, the impetus for this project was the proposed discharge from the Perry/Willard Regional Wastewater Treatment Plant (PWRWTP) to Willard Spur. While the Willard lagoon system previously discharged its effluent using the same ditch and outfall location as now being used by the PWRWTP, the concerns expressed by stakeholders resulted from likely changes in hydrology and the nutrient load imposed by the PWRWTP proposed discharge. Thus the pressure on Willard Spur that will be addressed by this program, or the cause of potential impacts, can be defined to be the PWRWTP discharge.

It is important to note that there are other pressures, both "natural" and human caused, that impact Willard Spur. Examples of "natural" pressures include variations in the natural hydrologic cycle and climate, spread of invasive species, varying water level in Great Salt Lake, etc.. Examples of human caused pressures include development of upstream water resources for agriculture, municipal and/or industrial use, development along Willard Spur, urbanization of watershed, increasing recreational use, etc.. Each of these pressures has its own potential resulting stressors and response in Willard Spur. The responses to these pressures may be independent of the responses to PWRWTP's discharge, but more than likely they may interact with and modify the impacts of the stressors from PWRWTP's discharge (i.e., modifying factors). The Science Panel should consider the pressures involved and address the effect of potential modifying factors.

Stressors

Stressors are defined by Scheltinga et al. (2004) as follows: "Physical, chemical and biological stressors are major components of the environment that, when changed by human or other activities, can result in degradation to natural resources. Stressors can be:

- A component of the environment that transfers the impact of a pressure (e.g. human activity) to other parts of the environment by being changed from its natural state (e.g. nutrient concentrations changed from natural, habitat coverage less than natural or excess salt). These components of the environment are usually present in natural (healthy) ecosystems and are only considered stressors when they are different from natural; and

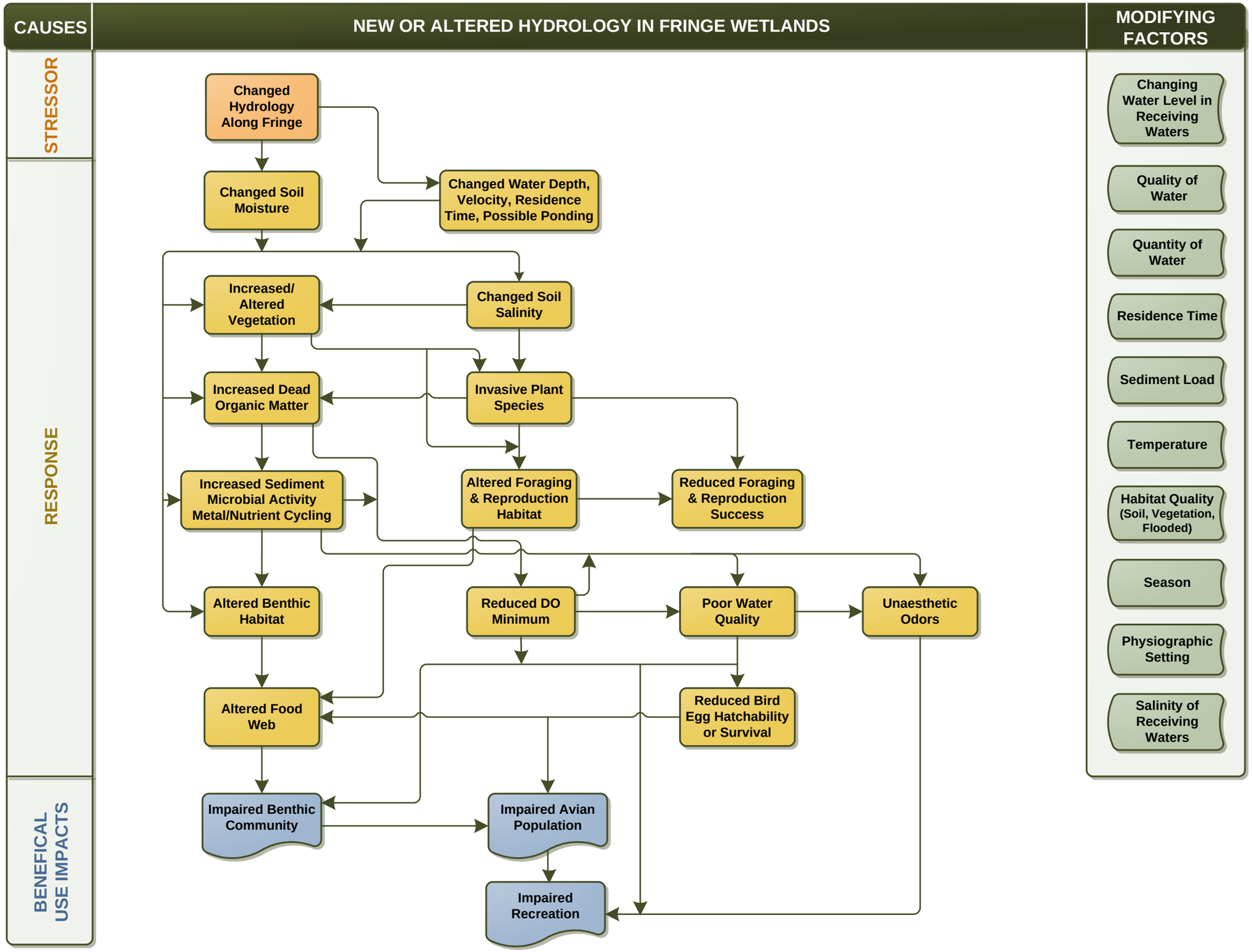
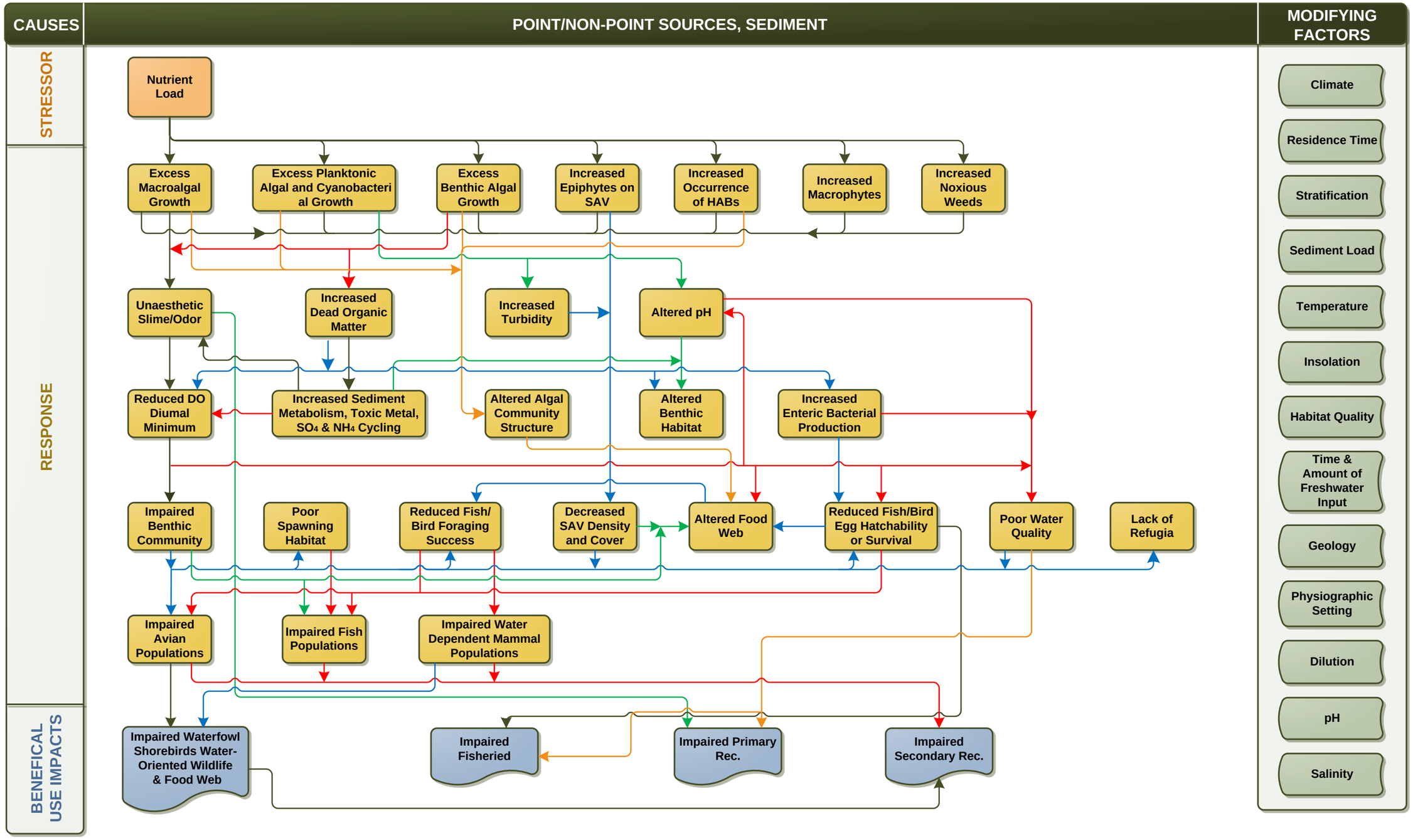


FIGURE 1
Conceptual Model for Hydrologic Change Stressor and Linkage to Impairment of Beneficial Uses



SOURCE: Sutula et al. 2007

FIGURE 2
Conceptual Model for Nutrients Stressors and Linkage to Impairment of Beneficial Uses

- A component of the environment that, when present, causes stressors on the ecosystems (e.g. litter or pest species). These components of the environment are not usually present in natural (healthy) ecosystems and are considered potential stressors when they are present in any amount. "

Potential stressors that could result from the PWRWTP discharge include hydrologic change and nutrients. Quantification of these stressors is a key element of the investigation and is already incorporated into the 2011 sampling plan (e.g., estimating discharge flows and nutrient loads to Willard Spur). It is important to note that nutrient concentration or water quality may not necessarily be the stressors in and of themselves. They are typically a measure of condition or a response to the nutrient load stressing the system. Also note that the stressor of hydrologic change may or may not be applicable depending upon where the PWRWTP outfall is finally located. The PWRWTP is evaluating an alternate discharge location near the Willard Bay tailrace. The Science Panel should confirm whether these are the stressors that should be addressed by this program.

Responses

The primary responses of concern that were previously identified by stakeholders are cultural eutrophication, or nutrient over-enrichment, and the propagation of invasive vegetation species, i.e., phragmites. Figures 1 and 2 illustrate draft conceptual models that describe possible pathways and relationships between a stressor, responses, and the beneficial uses for the stressors of hydrologic change and nutrients. It is important to note that the conceptual model for the stressor of hydrologic change was developed with the existing PWRWTP outfall (located in a mudflat area) in mind.

Beneficial Uses

Utah's waters are assigned one or more beneficial use classifications in Utah Administrative Code R317-2-6 and R317-2-12. Willard Spur waters are currently classified as Classes 2B, 3B and 3D for waters located within the boundaries of the Bear River Migratory Bird Refuge (see Figure 3) and Classes 5C and 5E for the remaining area. Classes 2B, 3B, and 3D currently have numeric water quality standards while Classes 5C and 5E only have narrative water quality standards. Note that only the legal boundary description of the Bear River Migratory Bird Refuge currently separates the different classes. See Table 1 for a summary of beneficial use classes for Willard Spur.

FIGURE 3
Beneficial Use Classification for Willard Spur

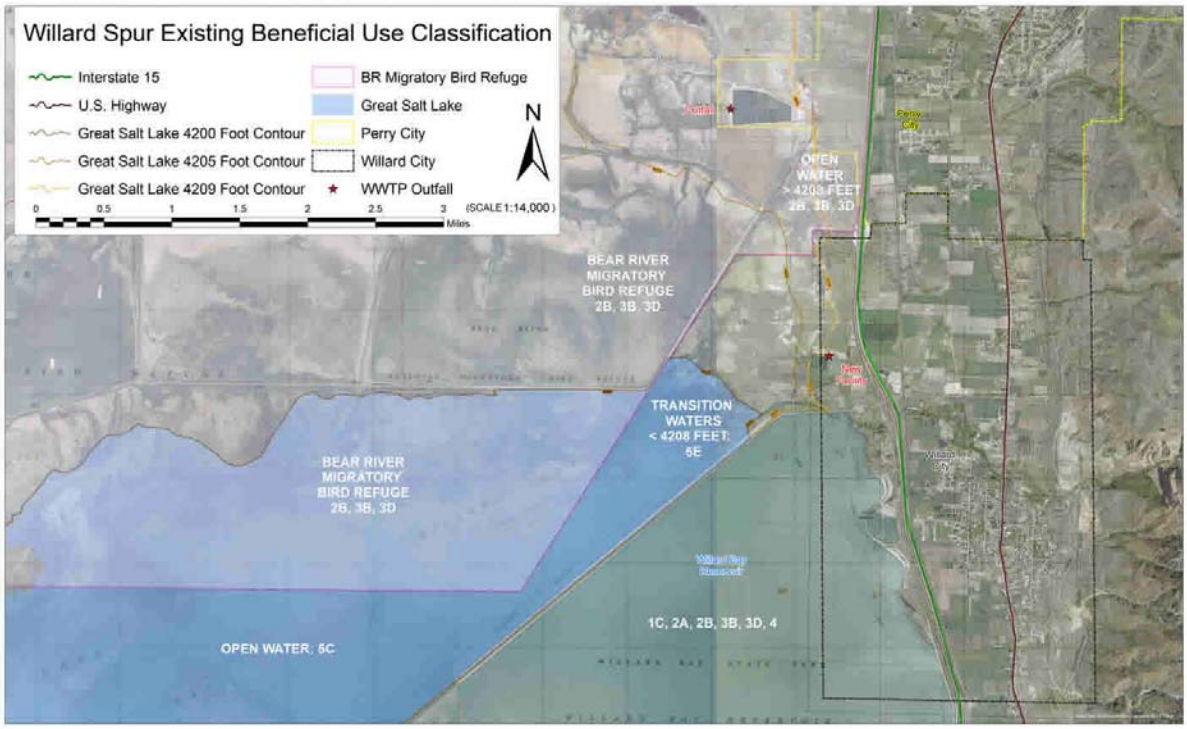


Table 1
Beneficial Use Classes for Willard Spur

Class	Use
2B	Protected for infrequent primary contact recreation. Also protected for secondary contact recreation where there is a low likelihood of ingestion of water or a low degree of bodily contact with the water. Examples include, but are not limited to, wading, hunting, and fishing.
3B	Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.
3D	Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.
5C	Open waters of Bear River Bay at or below an elevation of 4208 feet. Protected for infrequent primary and secondary contact recreation, waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain.
5E	Transitional waters on Great Salt Lake shoreline at or below an elevation of 4208 feet. Protected for infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain.

Modifying Factors

As described above, there are often other factors, i.e., pressures, which can modify the impacts of a particular stressor. For example, the high spring runoff experienced in Willard Spur in 2011 flooded PWRWTP's outfall area, may have diluted its effluent, and created flow conditions in Willard Spur that were not conducive for typical responses to nutrient

loads. It would be helpful to identify other similar potential modifying factors and quantify them. Figures 1 and 2 include a list of potential modifying factors for each stressor.

The Science Panel should consider the role of these factors in determining how vulnerable Willard Spur is to PWRWTP's possible stressors and how they affect the risk of impairing Willard Spur's beneficial uses.

Indicators

Various assessment frameworks have been developed for wetlands and estuaries (Moss et al. 2006, Scheltinga et al. 2004, Sutula et al. 2007, 2011, Thompson and Gunther 2004, US EPA 2001, 2008, 2010); even for impounded wetlands of Great Salt Lake (UDWQ 2009). All rely on the identification of indicators that provide quantitative information about the impacts of a particular stressor and describe the condition of the ecosystem. While these researchers identify and provide commentary on numerous possible indicators, they all agree that it is critical that indicators be linked directly to beneficial uses for the indicator to be useful for management action and it is preferable that multiple indicators are beneficial for a robust assessment of eutrophication.

A draft report published on the internet by Sutula et al. 2011 documents a detailed review of indicators by the State of California for use in developing nutrient numeric endpoints for California's estuaries. They defined their criteria used for their review of indicators for their assessment framework for California estuaries as follows:

Indicators should:

- *Have a clear link to beneficial uses*
- *Have a predictive relationship with causal factors such as nutrient concentrations/loads and other factors known to regulate response to eutrophication (hydrology, etc.). This relationship could be empirical (modeled as a statistical relationship between load/concentration and response or modeled mechanistically through tools such as a simple spreadsheet or dynamic simulation models).*
- *Have a scientifically sound and practical measurement process*
- *Must be able to show a trend either toward increasons and/or decreasing eutrophication with an acceptable signal:noise ratio.*

It would be beneficial if indicators also:

- *Were easy to understand to a non-technical audience (unambiguous)*
- *Provide early warning of emerging problems*
- *Were adaptable for use at a range of spatial scales*
- *Can be used to diagnose multiple causative factors, not necessarily just eutrophication*
- *Show detectable trends in both directions (improving or degrading)*

We suggest that the Science Panel should consider similar criteria for developing indicators for this program.

Next Steps

This memorandum provides a "straw man" for consideration. The Science Panel should consider whether further development of conceptual models is warranted and, if so, how this "straw man" should be revised. The conceptual models can then be used to identify potential indicators and studies that should be completed to define them.

References

Moss, A., M. Cox, D. Scheltinga, and D. Rissik. 2006. Integrated Estuary Assessment Framework. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. 2006.

Scheltinga, D.M, R. Counihan, A. Moss, M. Cox and J. Bennett. 2004. User's Guide to Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. Revised version December 2004.

Sutula, M., C. Creagar and G. Wortham. 2007. Technical Approach to Develop Nutrient Numeric Endpoints for California Estuaries. Southern California Coastal Water Research Project Technical Report 516. March 2007.

Sutula, M., P. Fong, J. Kaldy, K. McLaughlin, D. Gillett, M. Howard, C. Madden, L. Green, R. Kennison, J.A. Ranasinghe and N. Beck. 2011. Review of Indicators for Development of Nutrient Numeric Endpoints in California Estuaries. Southern California Coastal Water Research Project Draft Technical Report 646. April 2011.

Thompson, B. and A. Gunther. 2004. Development of Environmental Indicators of the Condition of San Franciso Estuary. A report to the San Francisco Estuary Project. SFEI Contribution 113. San Franciso Estuary Institute, Oakland, CA. May 2004.

UDWQ. 2009. Development of an Assessment Framework for Impounded Wetlands of Great Salt Lake. Utah Department of Environmental Quality, Division of Water Quality. Draft Report November 2009.

U.S. EPA. 2001. Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters. U. S. EPA, Office of Water. EPA 822-B-01-003. October 2001.

U.S. EPA. 2008. Nutrient Criteria Technical Guidance Manual: Wetlands. U. S. EPA, Office of Water. EPA 822-B-08-001. June 2008.

U.S EPA. 2010. Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters. U.S. EPA, Office of Water. November 2010.