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MEMORANDUM

TO: Water Quality Board

THROUGH: Walter L. Baker, P.E.

FROM: Scott Daly

DATE: August 8, 2016

SUBJECT: Request for Water Quality Board to approve a hardship grant for a maximum of $1,000,000 to conduct research for support of Phase 2 of the Utah Lake Water Quality Study

The Division of Water Quality is conducting a two-phased water quality study on Utah Lake to determine the role of excess nutrients on impairments to the aquatic life and recreational beneficial uses and to determine appropriate nutrient levels in the lake. Hardship Grant funding is requested to assist the Division in obtaining contractual assistance to complete Phase 2 tasks defined below following an overview of ongoing Phase 1 efforts.

Phase 1 Overview

DWQ initiated Phase 1 of the Utah Lake study in 2015 in response to nutrient related impairments identified in DWQ's Integrated Report and in response to harmful algal bloom events on Utah Lake in recent years.

Phase 1 of the study consists of five work elements led by DWQ staff and representative stakeholder subcommittees. DWQ anticipates completing the majority of the Phase 1 work elements in 2016 and launching a Phase 2 study to identify appropriate nutrient management scenarios in winter 2016-2017.

Phase 1 work elements and related progress are discussed below with additional information available in the attached work plan document and the DWQ project webpage (http://deq.utah.gov/locations/U/utahlake/utahlake.htm):

1) Stakeholder Outreach and Public Involvement

DWQ is committed to a stakeholder and public involvement process to facilitate transparent decision making with engaged stakeholders to help guide decisions and outcomes for the Utah

Lake Water Quality project. The plan is built on the belief that good stakeholder participation in a water quality project involves: 1) informed Water Quality Subgroup members who understand the elements of the scientific principles and regulatory process that underpin DWQ's decisions; 2) purposeful public meetings at appropriate milestones in the project; and 3) transparent and documented public input into DWQ and partners' work products.

DWQ assembled a large group of stakeholders representing a broad range of interests in the watershed including representatives from local municipalities, POTWs, and state and local governments. In addition to this group, DWQ created a subgroup of stakeholders to inform decisions for each of the following work elements: data and information management, beneficial use assessment, nutrient loading, and model development. These subgroups are responsible for defining the lakes' hydrologic and ecological processes, data gaps and future research needs, and alternatives that are politically, financially, and technically feasible.

2) Data and Information Management

This element will consolidate and synthesize all data sources, make it available to stakeholders, and coordinate ongoing and future monitoring activities on Utah Lake. DWQ has met with the Data and Information Management Subgroup to coordinate ongoing monitoring activities and identify data sources available to this study. This information is currently being compiled into a centralized database that will be the foundation for data analysis for the beneficial use assessment, load analysis and modeling work elements.

3) Beneficial Use Assessment

This work element will evaluate all available data in the context of the lake's designated beneficial uses and its existing uses, including the narrative water quality standard. The initial results of this work are reflected in the 2016 Integrated Report. The report is available for public comment on our website through September 9th, 2016 (http://www.deq.utah.gov/ProgramsServices/programs/water/wqmanagement/assessment/currentIR2016.htm). Forthcoming work on this element will include an investigation of appropriate recreational use designations to protect recreational users and an assessment of aquatic life use designation to include evaluation of early life stages. DWQ will also evaluate TDS and cyanotoxins to assess support of the agricultural and secondary water uses, respectively.

4) Load Analysis

DWQ is developing a bulk phosphorus load analysis to update estimates developed during the initial study completed in 2008. As requested by the POTW community, the loading estimate would provide more detailed estimates of tributary loading to the lake and more accurately account for wet-weather events and low flow conditions. We intended to apply a load duration curve approach using tributary and Discharge Monitoring Report data to characterize loading for spring runoff, storm runoff, low flow periods, and seasonal load distributions. This work will be completed in the coming months as data become available.

5) Model Selection and Development

DWQ has been working with the modeling subgroup of stakeholders to determine the most appropriate approach for simulating water quality in Utah Lake. DWQ evaluated a number of potential water quality models to determine their ability to simulate water quality dynamics observed in Utah Lake while utilizing current available datasets. The final documentation for this

selection process, detailing the preferred approach, was completed and circulated to the modeling subgroup.

However, we have momentarily delayed work on this effort to determine if a proposal by the University of Utah will meet the needs of DWQ and the Utah Lake stakeholder group. The University of Utah recently received a grant from the EPA to characterize eutrophication in the Jordan River and Utah Lake watersheds in response to climate change. The proposal utilizes the same suite of modeling tools proposed by DWQ and we are working with the University of Utah to develop a collaborative model package to meet the needs of DWQ and stakeholders and to avoid development of competing products.

DWQ will meet with the water quality model stakeholder subgroup in late August to determine the best path for collaboratively completing this work.

Phase 2 Overview

Phase 2, scheduled to begin in early 2017, will further investigate water quality conditions in Utah Lake and will result in one of three alternatives: 1) Total Maximum Daily Load, 2) Site Specific Nutrient Criteria, or 3) Use Attainability Analysis, should it be determined that nutrient concentrations in the lake are being attenuated naturally thus obviating the need for a more extensive nutrient control strategy.

The water quality model developed in Phase 1 will serve as the primary tool to evaluate the water quality and ecological responses expected from a reduction of nutrient inputs and the carp removal effort. This will require a greater understanding of the unique biological, physical, and chemical interactions in the Utah Lake system.

The research questions presented below generalize the areas of research intended for this funding request. These questions will be fully developed by the Utah Lake Stakeholder group at the completion of Phase 1.

What is the ecological influence on water quality conditions in Utah Lake?

- How do carp populations influence water clarity and nutrient cycling?
- Is it feasible and desirable to shift Utah Lake from a turbid water stable state to clear water stable state?
- Do historical nutrient conditions recorded in the paleo record demonstrate a shift in ecological condition?
- What are realistic ecological endpoints for Utah Lake?

What are the characteristics of nutrient loading to Utah Lake

- What are the origin, timing, and magnitude of nutrient loading from point and nonpoint sources in the watershed?
- How will nutrient loading characteristics change with increasing population and urbanization?
- How does biological uptake and nutrient cycling influence tributary nutrient loading seasonally?

What is the role of internal lake processes on nutrient cycling and biological availability?

- What is the influence of phosphorus mineralization on in-lake nutrient concentrations?
- How do the physical properties of Utah Lake (wave action, temperature, turbidity) influence water quality?
- What is the role of the food web on nutrient cycling in Utah Lake?
- How does legacy loading of nutrients from lake bed sediments influence water column nutrients?

What are the appropriate beneficial uses for Utah Lake?

- What is the desired water quality condition of Utah Lake for recreational users?
- Do recreationists change behavior based on water quality conditions?

Can Harmful Algal Blooms (HAB) be predicted in Utah Lake?

- What is the linkage between in-lake nutrients and presence of harmful cyanobacteria?
- What indicators of water quality physical characteristics can be used to predict HABs?
- How can satellite imagery be used in conjunction with in-lake monitoring sondes to monitor and predict blooms?

What are the economic and social costs of HABs in Utah Lake?

- What was the total economic cost associated with the July 2016 HAB event?
- What indicators of water quality physical characteristics can be used to predict HABs?

What are the potential treatment options for HAB events in Utah Lake?

- Are there viable options for mitigating internal nutrient loads?
- Are there economically and environmentally viable treatment options for HABs?

DWQ intends to complete Phase 2 related research by 2019. Following completion of these studies, the results will be incorporated into either a site-specific standard, TMDL or Use Attainability Analysis.

UTAH LAKE WATER QUALITY WORK PLAN 2015-2019

Winter 2016

DWQ's next steps towards improving the water quality of Utah Lake

Utah Lake Water Quality Work Plan 2015-2019

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BACKGROUND

Utah Lake is a highly productive lake that experiences extensive algal blooms in the late summer and fall (Psomas and SWCA, 2007). Utah Lake is considered hypereutrophic which means it is very nutrient rich and can be characterized by frequent and severe nuisance algal blooms and low transparency. Concerns associated with elevated nutrient concentrations include the growth of nuisance phytoplankton and periphyton, low dissolved oxygen, elevated pH, and the potential for cyanotoxins from blue-green algae.
Utah Lake was listed on Utah's 2004 §303(d) list for exceedances of the state criteria for total dissolved solids (TDS) concentrations and exceedances of the pollution indicator value for total phosphorus. A TMDL study was initiated in 2004, and a validation and evaluation report (Psomas, 2005) and pollutant loading and impairment assessment report (Psomas and SWCA, 2007) were completed. Action on the TMDL was subsequently suspended to evaluate the effects of invasive carp removal by the Division of Wildlife Resources and to better understand the relationship between measured total phosphorus concentrations and observed impairments to the lake's designated beneficial uses.

Since the Utah Lake study was produced, 10 years of focused data collection on the lake and its tributaries will permit the Division of Water Quality to evaluate in more detail water quality effects on beneficial uses, water quality trends, and linkages to the management goals of Utah Lake. The Division of Water Quality (DWQ) has developed this workplan to chart the path forward towards evaluating the impairment on Utah Lake, developing tools that can be used to make water quality related decisions, and incorporate the work of stakeholders and partners also working on Utah Lake.

DWQ will spend 2015-2016 dedicated to confirming and validating impairments in Utah Lake by assessing chemical and biological transformations as reflected in phytoplankton, zooplankton and fish abundance data to determine changes in ecosystem health. With this robust data set, DWQ will produce a water quality model that reflects current advancements in predicting the effects of nutrients in shallow lake systems to help better identify water quality endpoints. Additionally, DWQ is dedicated to understanding the frequency, occurrence and impact of harmful algae blooms (HAB) in Utah Lake.

This document details the steps DWQ will take from 2015 through 2019 to better understand, assess and make informed management decisions to improve the health and function of Utah Lake.

OBJECTIVES

The key questions this workplan is designed to answer the following questions in two phases:

Phase 1:

1. What are the current water quality concerns in Utah Lake? Do the current data reflect historic impairments, or new water quality impairments exist in the lake? What trends do the water quality parameters indicate? Should the water body be delisted from the current TDS and phosphorus listings based on a full assessment of current conditions?
2. What are the connections amongst the water quality parameters and effects on aquatic life? Have water quality changes coincided with changes in fish populations, macroinvertebrate populations, phytoplankton and zooplankton species abundance?
3. Are the current uses of Utah Lake reflected in the current beneficial use of an infrequent primary contact (2B) waterbody? Does the recreational use survey (completed by Utah Lake Commission) support upgrading the Lake from a 2B to a frequent primary contact (2A) use?
4. What is the influence of nutrient loading, from both point and nonpoint sources, in driving the productivity of Utah Lake? How does nutrient loading vary by season and by hydrological condition? What are the current sources of nutrients, and the future expected sources, and how would changes in the nutrients affect water quality conditions of the lake?
5. What is the appropriate management goal for the lake, i.e. should the lake be clear or turbid? Has the lake ever been in a clear state, and if so, is restoration to a clear lake a desirable and achievable goal?
6. What is the quality of water, including nutrients, algae, and organic matter, that is exported from Utah Lake to the Jordan River.

Phase 2:

Following Phase 1, Phase 2 will be informed by data gathered and assessed during Phase 1, including all water quality data collected as well as a beneficial use assessment, a pollutant source and nutrient loading analysis, and a predictive water quality model. Three potential alternatives or a combination thereof for Phase 2 have been identified as A) a TMDL for Utah Lake based on current impairments, B) Site Specific Standards for impairments resulting from natural, un-alterable conditions that preclude attainment of state criteria, and/or C) a Use Attainability Analysis of Utah Lake's designated beneficial uses.

PHASE 1 SCOPE OF WORK

Task 1: Stakeholder Outreach and Public Involvement

DWQ has outlined a public involvement process to communicate current information and research and ensure collaborative decision making with engaged stakeholders to guide next research steps and water quality improvement actions for Utah Lake's future. This plan is built on the belief that good stakeholder participation in a water quality project involves 1) an informed Water Quality Subgroup who understands the elements of the scientific principles and regulatory processes that underpin DWQ's decisions; 2) purposeful public meetings at appropriate milestones in the project, and 3) transparent and documented public input into DWQ and partners' work products.

Water Quality Subgroup

The stakeholder community interested in the outcome of this workplan for Utah Lake is broad. The experience of stakeholders responsible for managing Utah Lake will be critical in identifying data gaps, understanding the watershed and lake's hydrologic and ecological processes, and developing a path forward that is politically, financially, and technically feasible. DWQ has initiated a Utah Lake Water Quality Subgroup, as defined in Table 1. To be added to this list, please contact DWQ directly.

Table 1. Utah Lake Water Quality Subgroup

Name	Affiliation	Email
Ann Merrill	Department of Natural Resources-Water Resources	annmerrill@utah.gov
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Ty Hunter	Utah State Parks	tyhunter@utah.gov
Tyler Murdock	Salt Lake City	tmurdock@utah.gov

The Water Quality Subgroup will contribute to the study in the following ways:

1) All technical documents and analyses will be provided to the Water Quality Subgroup before being finalized. Comments from the Water Quality Subgroup will be accepted in written form and DWQ will provide a comment response summary for each document.

2) Utah DWQ staff will present analytical methods and findings to the Water Quality Subgroup before being finalized. Meetings will be scheduled at key milestones in the Utah Lake water quality study. These milestones are included in Figure 2 at the end of this document.

3) Independent studies conducted by members of the Water Quality Subgroup may be incorporated into this work plan to provide a comprehensive understanding of Utah Lake water quality.

Stakeholder Consultation

DWQ will engage with stakeholder groups throughout the implementation of this workplan. In addition to the Utah Lake Commission, DWQ will consult with the Utah Lake POTW consortium when important documents and decisions arise. DWQ anticipates that through engaging the Utah Lake Commission, involved stakeholders can request additional engagement with their respective agency or group.

Utah Lake Coordinator

DWQ supports the creation of a local watershed coordinator position for the Utah Lake watershed. DWQ recognizes the need for ensuring dedicated local representation and will explore options with partners to recruit and support a watershed coordinator position for the Utah Lake watershed in 2016.

Public Meetings

Public meetings will be the primary venue for the public to learn about the project, ask questions, and contribute knowledge. DWQ will organize and facilitate public meetings to be scheduled at key project milestones. Materials for public meetings will be based on DWQ work products for each milestone. Each public meeting will begin with a presentation of completed work followed by a presentation of next steps for the project. The meetings will conclude with an open discussion of the completed work and the methods proposed. The overall objective of each meeting is to present the progress and future direction of the project in an easy-to-understand format, while also soliciting ideas, data, information, and opinions from the public and stakeholders.

DWQ will use the Utah Lake Commission's comprehensive membership database as the main resource for inviting participants to these meetings. We will also engage board members from each of the POTWs surrounding Utah Lake to participate. Additionally, DWQ will use the Provo River Watershed Council's listserv and the Central Utah Water Conservancy District's listserv to publicize upcoming meetings at least one month in advance. A calendar of events related to Utah Lake Water Quality can be accessed at: http://www.deq.utah.gov/Divisions/dwq/water-quality-calendar.htm.

Deliverables:

1. Utah Lake Symposium/Workshop

2. Presentations to Utah Lake Water Quality Subgroup at key project milestones (estimated 1 presentation every 4-6 months once workshop begins)
3. Up to 2 public meetings/year
4. Meetings with key stakeholder groups as requested or necessary.
5. Comment response summary for all work products produced by DWQ and reviewed by the Utah Lake Water Quality Subgroup (Table 1).

Task 2: Data and Information Management

Various agencies and organizations have been monitoring the ecology and water quality of Utah Lake and its tributaries for many years. DWQ will compile all available data from partners and other groups into a data management system that can be used for the remainder of this workplan and by others for their own analyses. DWQ anticipates the development of four separate databases, one each for chemical data, hydrologic data, biological data, and physical data.

Data acquisition

Table 2 summarizes the sources of data that DWQ intends to acquire and compile for use in the Utah Lake water quality study. DWQ welcomes the submission of additional datasets provided by academic institutions, other agencies, and partners.

Table 2. Summary of data to be used in Utah Lake water quality study. . Other data will be used as deemed useful and important.

Data Type	Uses in Utah Lake Water Quality Study	Temporal Extent	Spatial Extent	Source
Water Chemistry Database				
Water Chemistry	Model Calibration/validation, load analysis, beneficial use assessment	1990-2012 and 1995-2014 (Number sites sampled during each month): 1995 (May, 1; July, 4; Sep, 3), 1997 (Jul, 5; Sep, 5), 1999 (Jul, 7; Aug, 5); 2001 (Jul, 5; Sep, 5), 2002 (Jun, 5; Aug, 5, Oct, 2), 2003 (Jul, 5), 2004 (Jun, 5; Jul, 6; Sep, 1), 2005 (Jun, 6; Jul, 6; Aug, 2; Sep, 5), 2006 (May, 6; Jun, 6; Jul, 6; Sep, 6), 2007 (Jun, 6; Jul, 6; Aug, 6; Sep, 5), 2008 (Jul, 7; Aug, 7; Sep, 8), 2009 (Jun, 8; Jul, 8; Aug, 8; Sep, 8; Oct, 8), 2010 (Jun, 8; Jul, 8; Aug, 8; Sep, 1), 2011 (Aug, 8; Sep, 8; Oct, 8), 2012 (May, 8; Jul, 8; Aug, 8; Sep, 8), 2013 (Jun, 7; Jul, 8; Sep, 8; Oct, 5), 2014 (Jun, 8; Jul, 7; Sep, 6; Nov, 6)	4917310, 4917320, 4917370, 4917390, 4917450, 4917500, 4917520, 4917600, 4917770	DWQ (Lenora Sullivan) * See Attachment 1 for more information.
			4994790, 4994950, 4994960, 4995038, 4995040, 4995120, 4995200, 4995250, 4995260, 4995410, 4995420, 4995440, 4995580, 4996000, 4996020, 4996030, 4996100, 4996190, 4996280, 4996310, 4996410, 4996550, 4996560, 4996570, 4996690, 5919850, 5919860	CUWCD and Payson, Salem, Spanish Fork, Springville, Provo WWTP
Sediment Core Data	Historic conditions of Utah Lake. Indicates whether it is possible to head towards a clear state or a turbid state.	Once	3 sites at Utah Lake Outlet (a, b, c). 10 more samples collected but not analyzed.	UVU (Eddy Cadet)
Hydrology Database				

Hydrology	Model calibration/validation, load analysis	Varied	09282000, 09312600, 09312700, 10147000, 10147500, 10148200, 10148400, 10148500, 10148510, 10149000, 10149400, 10149500, 10150000, 10150500, 10152000, 10152001, 10152500, 10152700, 10153000, 10153100, 10160800, 10161000, 10161500, 10162850, 10163000, 10164500, 10165500, 10166000, 10166430, 10166605	USGS *See Attachment 2 for more information.
Lake Level	Lake volume/area to determine relative biomass and density changes with carp removal. Also needed to better understand how physical changes in the structure and size of the lake (as well as drought) may relate to water quality and zooplankton.	Beginning in about the last part of April, 2014, daily readings are based on the CUWCD gage reading each morning.	Utah Lake Storage Content, Utah Lake Storage Content (Gage Reading)	Utah Division of Water Rights (Ben Anderson) http://www.waterrights.utah.gov/cgi-bin/dvrtview.exe?ModInfo=StationView&STATION_ID=503&RECORD_YEAR=2015
High Frequency Database				
Continuous sonde data in lakes (DO, pH, Temp, conductivity)	Beneficial use assessment	15 minute increments. September 2015-November 2015	4917310 (UTAH LAKE 0.5 MI W OF GENEVA DISCHARGE #15-A), 4917770 (UTAH LAKE OUTSIDE ENTRANCE TO PROVO BAY), 4917710 (UTAH LAKE 1 MI NE OF LINCOLN POINT #03)	DWQ (Suzan Tahir)

Continuous sonde data in lakes (DO, pH, Temp, conductivity)	Beneficial use assessment	30 minute intervals. 8/30/2005-9/7/2005	Orem (near Powell Slough), Near Timpanogos WWTP Outlet (deep and shallow), Jordan River outlet (deep), Long Bar, Provo Bay (deep), Spanish Fork Delta	DWQ (Suzan Tahir)
Continuous sonde data in lakes (DO, pH, Temp, conductivity)	Beneficial use assessment	30 minute intervals. 9/18/2007-9/21/2007	Utah Lake Lincoln Beach, Provo Bay, Provo Bay Outlet, West of Timpanogos	DWQ (Suzan Tahir)
Continuous sonde data in lakes (DO, pH, Temp, conductivity)	Beneficial use assessment	30 minute intervals. 5/26/2008-6/13/2008	Jordan Outlet	DWQ (Suzan Tahir)
Biology Database				
Phytoplankton	Beneficial use assessment. Assess with chemical water quality to determine changes in ecosystem health.	1995-2014 (Number sites sampled during each month): 1995 (Sep, 1), 1997 (Sep, 1), 1999 (Aug, 1); 2001 (Sep, 4), 2005 (Sep, 4), 2006 (Sep, 3), 2007 (Aug, 1; Sep, 1), 2008 (Jun, 4, Jul, 7; Aug, 7; Sep, 7), 2009 (Jun, 7; Jul, 8; Aug, 7; Oct, 8), 2010 (Jun, 8; Jul, 8; Aug, 8;), 2011 (Aug, 8; Sep, 8; Oct, 8), 2012 (May, 8; Jul, 8; Aug, 1; Sep, 8)		USU (Jereme Gaeta)
Phytoplankton	Beneficial use assessment. Assess with chemical water quality to determine changes in ecosystem health.	Number of samples/year: 2005 (4), 2006 (5), 2007 (2), 2008 (23), 2009 (16), 2010 (24), 2011 (61), 2012 (25), 2013 (2)	Deer Creek Reservoir, Provo River, Jordanelle Reservoir, Utah Lake	Rushforth Phycology, DWQ (Suzan Tahir)

Zooplankton	Assess with chemical water quality to determine changes in ecosystem health	1995 (Jun-Oct), 1996 (Jun-Sep), 1997 (May-Oct), 1998 (Jun, Jul, Sep), 2002 (Jun-Dec), 2003 (Jan, Feb, Apr-Oct), 2004 (Feb-Apr, Jun-Sep, Nov), 2005 (Feb-Oct), 2008 (Sep-Nov), 2009 (Apr-Nov), 2010 (May-Oct), 2011 (Sep-Nov), 2012 (May, Jun), 2013 (May-Oct), 2014 (May, Jun, Aug-Oct), 2015 (May-Oct)	2002-2005, 2008-2010: 6 locations within Provo Bay. 2011-2015: 9 locations (each including a pelagic and littoral sampling station) within Utah Lake (as USU labels them 1E, 1W, 2E, 2W, 3E, 3W, 4E, 4W and PB)	USU *See Attachment 3 for more information.
Fish data	Overall species abundance			
Carp removal	Biomass reduction			June Sucker Recovery Implementation Program (Mike Mills)

Data Analysis

1. DWQ will identify, compile, review, and analyze data for Utah Lake and its tributaries from 1990 to present.
2. Statistical analyses of these data will be executed specific to potential changes in, and interactions among the water quality, phytoplankton, zooplankton and other biological and chemical ecosystem components. Statistical tests will be applied to determine what changes among variables are associated with changes in data and how they interrelate. A seasonal analysis will also be completed to identify seasonal variation in the pollutants and biological populations of concern and to explore whether multivariate mixed effects approaches (both linear and non-linear) may be more robust and appropriate approaches to detect changes not only among years, but temporal and seasonal.
3. Analyses will be conducted to evaluate possible water quality parameter trends.
4. Spatial or temporal gaps in the data will be identified to assess if any additional sampling that may be required and supplemental monitoring recommended. We also wish to determine relationships among water quality, zooplankton and phytoplankton with higher trophic levels (macroinvertebrates and fishes) in addition to anthropogenic drivers of change including carp removal and drought (lake level).

Database Development

1. In collaboration with stakeholders, DWQ will insure that all data collected by outside researchers, agencies and entities is accounted for and stored at a central location within DWQ. DWQ will review all relevant reports and literature to develop a synthesis document that summarizes relevant aspects of the ecosystem, water quality, fish management, and recreation. Other resources that should be incorporated into the synthesis should be provided to DWQ in fall 2015.
2. DWQ will gather all currently available data and house it in a DWQ Utah Lake Water Quality Management Database. This database will include past water chemistry, flow data, high frequency data, zooplankton, phytoplankton, fish and macroinvertebrate studies.
3. DWQ will use Excel to organize and maintain the database.

Online Database

DWQ will establish and utilize a website specific to Utah Lake water quality. It is found at:

http://www.deq.utah.gov/locations/U/utahlake/utahlake.htm

This page will be the central online location for items relating to the Utah Lake workplan, relevant data and literature, document drafts and public announcements and meetings. A link to the Excel database will be included with all relevant Utah Lake data.

Literature Review

DWQ will compile and review all available and relevant reports, studies and investigations completed for Utah Lake, its tributaries and watershed and develop a synthesis document. Included in this literature review will be a thorough evaluation of LaVere Merritt's paper "Utah Lake: A Few Considerations" (March, 2014) and a formal written response.

Deliverables:

1. The creation of Excel databases that includes all available water chemistry, flow data, high frequency data, zooplankton, phytoplankton, fish and macroinvertebrate studies for Utah Lake and tributaries.
2. A compilation and summary of all reports, studies and investigations relevant to Utah Lake and its tributaries. Summary and review of LaVere Merritt's 2014 paper.
3. Data gap analysis and summary of additional monitoring needs (determined as part of the Utah Lake Fall 2015 workshop and model development data gap analysis).

Actions/Decisions that will be informed:

A robust and complete data set will provide a solid foundation on which to build the predictive water quality model and determine trends in conditions over time. The model will also help identify gaps in data that will be collected in 2016. Additionally, it will also allow for an assessment of impairment, delisting and possible refinement of assessment unit areas.

A data gap analysis will be done to inform what is necessary to sample in summer 2016.

Combined with Task 3, these data analyses will inform the possible upgrading of the recreational use class designation to 2A (protected for frequent primary contact recreation where there is a high likelihood of ingestion of water or a high degree of bodily contact with the water. Examples include, but are not limited to, swimming, rafting, kayaking, diving, and water skiing.)

A thorough data analysis will also help to determine if Utah Lake is experiencing an ecosystem shift from a turbid state, dominated by free-floating algae that reduce water clarity and limits rooted aquatic vegetation growth to a clear water state, dominated by rooted aquatic plants that reduce resuspension of bottom sediments and potentially phosphorus update by cyanobacteria.

Task 3: Beneficial Use Assessment

Utah Lake is protected for the following designated uses:

2B Protected for infrequent primary contact recreation such as boating, wading, or similar uses.

3B Protected for warm water species of game fish, including the necessary aquatic organisms in their food chain.

3D Protected for other aquatic wildlife.

4 Protected for agricultural uses including irrigation of crops and stock watering.

Utah Lake was listed on Utah's 2002 303(d) list for exceedances of the state water quality pollution indicator threshold value for total phosphorus (TP) of 0.025 mg/L, and total dissolved solids (TDS) for irrigation and stock watering of 1,200 mg/L and 2,000 mg/L respectively (Utah Administrative Code R317-2-14). The warm water fishery beneficial use of the lake is identified as being impaired due to excess TP and blue-green algal dominance and the agricultural beneficial use is listed as impaired due to high concentrations of TDS.

Water quality data will be evaluated using DWQ's current assessment methods to determine whether the lake is violating Utah's numeric or narrative standards. In addition, supplementary data and information will be used to evaluate each use in Utah Lake.

Aquatic Life

DWQ will analyze temperature, DO, pH, toxic metals, phytoplankton and zooplankton data, and trophic state grab sample data along with available high frequency data to evaluate if requirements for warm water aquatic species and organisms are currently being supported.

Recreation

In 2013, the Utah Lake Commission conducted a survey on the uses of Utah Lake. The data from this report will characterize the current recreational uses in Utah Lake, and whether the 2B beneficial use classification for infrequent contact such as wading and boating sufficiently classifies the lake's uses, or if there needs to be a use class change to a 2A beneficial use classification for frequent contact such as swimming.

Additionally, an evaluation of chlorophyll a, phytoplankton and cyanobacteria data will be performed to determine if nuisance algae and harmful algae blooms have direct and indirect effects on recreational uses or public perceptionsof the uses of the lake.

Secondary Water Uses

Utah Lake water is utilized extensively for agricultural and secondary irrigation, both from within the watershed and from its outflow into the Jordan River. An evaluation of water quality data associated with TDS and cyanotoxins will be conducted to assess if irrigation and stockwatering uses are currently being protected.

Deliverables:

1. Beneficial use assessment report that addresses aquatic life, recreational use and agricultural water uses.

Actions/Decisions that will be informed:

1. The assessment of data will determine whether current impairments to designated beneficial uses occur, and whether the waterbody should remain listed on the State's 303(d) list.
2. The beneficial use assessment will inform whether Utah Lake should be split into more than one assessment unit for purposes of standards development, TMDLs, and impairment determinations.
3. The beneficial use assessment will inform the public health advisory process for Harmful Algae Blooms (HAB) for faster sampling response and communications to the public when HABs re-occur.

Task 4: Source and Nutrient Loading Analysis

A substantial amount of new data has been collected since the 2007 analysis on nutrient loading conducted by PSOMAS. DWQ will compile, review, and analyze this new data and update the loading analysis to incorporate a broader set of hydrologic conditions and nonpoint sources. The revised analysis will be based on the most recent water quality and hydrologic data available for tributaries to Utah Lake, as well as DMR data available for each of the POTWs. DWQ will calculate the important statistical measures such as minimum and maximum values, mean, median, and variance. Seasonal and trend analyses will also be completed to identify seasonal variation in the pollutants of concern and long term water quality trends.

The following four hydrologic conditions will be defined for tributaries to Utah Lake using USGS continuous flow gage data and precipitation data from Utah Lake's watershed:

- Spring melt and runoff
- Storm events (summer and fall)
- Rain on snow events
- Base flow

Median water quality concentrations for each tributary will be calculated separately for each of the four hydrologic periods. Median water quality data associated with each hydrologic condition will be paired with daily flow values for each tributary to develop a more refined loading analysis for phosphorus and nitrogen into Utah Lake. These load analyses will also be a primary input to the Utah Lake water quality model (see Task 5). In addition to tributary loads, data for wastewater treatment plants that discharge into Utah Lake or its tributaries will be used to parse the proportion of the total load that is associated with point source discharges. Finally, work is under way to develop a method to estimate the nutrient load that runs off directly to the lake, rather than through a tributary or wastewater discharge.

Deliverables:

1. The water and nutrient budget completed for Task 4 will be used to support the model build and calibration (Task 5), when possible.
2. Updated water budget and flow data for Utah Lake and tributaries. Written characterization and evaluation of the water quality and flow data for the tributaries within the watershed, as well as calculated current loads specific to distinct hydrologic events (spring runoff, storms and dry weather) from the tributaries and permitted discharges using available water quality, hydrologic, and meteorological data. Water inflows will be estimated using empirical models for several small ungauged tributaries.
3. Loading analysis to identify and quantify the watershed sources of pollutants.
4. Calculate pollutant loads apportioned to each source
5. Estimate a watershed-wide water budget.
6. Summarize load by season and hydrologic condition including spring runoff, wet weather, and dry weather

Actions/Decisions that will be informed:

1. The assessment of data will help determine whether there are current impairments to designated beneficial uses and whether the waterbody should remain listed on the State's 303(d) list.
2. Date input to build the predictive water quality model.
3. Form the basis of pollutant load allocations
4. Working alongside stakeholders, identify additional monitoring or future studies.

5. Identify hot spots of pollutant loading that need to be addressed through regulatory or voluntary programs.

Task 5: Model Development

DWQ will develop a water quality model for Utah Lake to evaluate the relationship between nutrients and degradation of beneficial uses, specifically nuisance algae, and to evaluate the effects of alternative nutrient loading scenarios. DWQ will work with stakeholders to select the most appropriate model to simulate nutrient dynamics within Utah Lake. Examples of models that will be considered include the Water Quality Simulation Program (WASP) supported by EPA (Wool et al., 2005) and CE-QUAL-W2 (Cole and Wells, 2003). The need for additional research and experiential work where it may benefit this study will also be explored. DWQ will work in partnership with stakeholders to determine prioritization and funding of these studies. Such studies could include long term placement of data sondes to assess diurnal and seasonal fluctuations and recommendations for establishing nutrient targets in Utah Lake.

Following is a list of key processes that would ideally be represented in a nutrient model of Utah Lake:

- Mixing
    a. Vertically fully mixed
    b. Lateral mixing between bays/open water
- Nutrient cycle
    a. P cycle
    b. N cycle
    c. Si cycle
- Phosphorus internal loading dynamics
    a. Adsorption/desorption
    b. Settling/resuspension
    c. Hysteresis associated with P load reduction
    d. Phosphorus outputs to receiving waters (Jordan River)
- DO
    a. Decomposition of organic matter
    b. Diel fluctuation due to photosynthesis and respiration
- pH
    a. Inorganic carbon
    b. Diel fluctuation due to photosynthesis
- Harmful algal bloom (HAB) formation
    a. Diatoms
    b. Green algae
    c. Blue-green algae (cyanobacteria)
    d. Algal succession from greens to blue-greens
- Transition from turbid state to clear state, and vice versa
    a. Transparency
    b. Phytoplankton
    c. Macrophytes
- Food web dynamics

a. Zooplankton
b. Benthivorous fish (carp)
c. Biodiversity/June Sucker protection

Deliverables:

1. *Utah Lake Model Selection Technical Memorandum* summarizing available data, models considered, selection criteria, evaluation results, and recommended model.
2. *Utah Lake Model Development and Calibration Report* with model build and calibration methods and results, including recommendations for supplemental data collection to support model calibration and validation.
3. Validated model to identify appropriate water quality endpoints for various parameters of concern, including nutrients and TDS.
4. *Nutrient Scenario Technical Memorandum* with methods and results of alternative nutrient management scenario analysis including effects on key lake parameters including nutrient concentrations, algal concentrations, and algal composition. The model will be used to simulate nutrient management scenarios including reduced nutrient loading from the tributary watershed and POTWs. Nutrient management scenarios could be incorporated into a possible future TMDL.

These documents will include the following specifics:

1. Update Water Quality Model
    a. Model selection and scoping with stakeholders
    b. Compilation of existing data
    c. Data gap analysis
    d. Model build
    e. Model calibration and validation
    f. Model calibration report
    g. Nutrient scenario analysis
    h. Summary report

2. Update Water Budget and flow data: Gather all existing information on inflows and outflows on Utah Lake from 2003 to present.
    a. Pollutant load analysis
    b. Experimental work
    c. Additional monitoring
    d. Assess if Utah Lake is experiencing an ecosystem shift as a result of Carp removal efforts

An assessment of whether additional experimental work and data collection is necessary will be informed by the results of the load analysis (Task 4), data compilation (Task 2) and the model development associated with this Task 5.

Actions/Decisions that will be informed:

1. Water quality endpoints for Utah Lake that would inform necessary nutrient reductions.
2. Determine inflows, outflows, influence of evaporation, discharges and effects on the Jordan River.
3. Loading analysis results will be used to identify management strategies for addressing existing and future water quality concerns resulting from human activities. The results will be used to indicate problem areas or 'hot spots' under existing and future land use conditions.

4. Experimental work will help to answer questions that current data or modeling may not be able to assess.
5. DWQ is developing an assessment methodology for assessing high frequency and continuous data sets. A broader sample set will allow a more comprehensive data analysis.
6. End goals for realistic expectations for Utah Lake will be determined.

PHASE 2 SCOPE OF WORK

After completing gathering and assessing data during Phase 1, a beneficial use assessment, a source and nutrient loading analysis and developing a nutrient model, decisions for Phase 2 will be informed. Three alternatives in Phase 2 have been identified as A) a TMDL for Utah Lake based on potential current impairments, B) Site Specific Standards for Utah Lake if impairments indicate this alternative is best or C) a Use Attainability Analysis for different uses identified for Utah Lake. Phase 1 will also inform additional experimental work and data collection in Phase 2.

Alternative A: TMDL for Utah Lake

If confirmed impairments on Utah Lake are identified, there would be cause to initiate a TMDL (Total Maximum Daily Load). A TMDL identifies the total pollutant loading that a waterbody can receive and still meet water quality standards and/or support its designated beneficial uses, and specifies a pollutant allocation to specific point and nonpoint sources. TMDLs account for all the sources of a pollutant, including: discharges from wastewater treatment facilities; runoff from homes, agriculture, streets or highways; and atmospheric deposition. In addition to accounting for past and current activities, TMDLs must consider future growth that may increase pollutant loads.

Tasks:

1. TMDL Development with stakeholder involvement
   a. Determination of the pollutant(s) of concern.
   b. Calculation of the lake's assimilative capacity.
   c. Quantification of the pollutant sources to the lake.
   d. Predictive analysis of pollution in the lake and determination of total allowable pollutant load.
   e. Allocation (with a margin of safety) of the allowable pollutant load among the different sources in a manner that water quality standards and beneficial uses are supported.
2. Possible Off-ramp to Technology Based Phosphorus Effluent Limits (TBPEL)

Deliverables:

1. Approved TMDL for Utah Lake.

Actions/Decisions that will be informed:

1. Nonpoint load allocations and implementation strategies; point-source waste load allocations and permit limits

Alternative B: Site Specific Standards for Utah Lake

In some locations, the nationally recommended aquatic life criteria may be considered under- or overprotective if the species in a waterbody have different sensitivities than those reflected in the national criteria data set. For this reason, site specific criteria may be developed to address such conditions.

Site specific standards may be established should natural, un-alterable conditions in Utah Lake preclude attainment of state criteria. Site specific standards provide a level of protection to their respective designated beneficial uses in a specific waterbody by taking into account the biological, chemical and physical conditions at the site.

Tasks:

1. Define the site boundaries.
2. Determine the effect of biological, physical, or chemical characteristics on sensitivity or bioavailability and toxicity.
3. Calculate numerical criteria by applying the recalculation procedure, the water-effect ratio procedure, or the resident species procedure.
4. Possible Off-ramp to Technology Based Phosphorus Effluent Limits (TBPEL)

Deliverables:

1. Site specific standard approved by EPA

Actions/Decisions that will be informed:

1. If impairment is confirmed, a TMDL may not be needed and a site specific standard could be established.

Alternative C: Use Attainability Analysis

Waters must be protected for the most sensitive of their uses. The first part of the Use Attainability process is to determine what uses exist for each water body segment (as to be performed in Phase 1, Task 3 in the Beneficial Use Assessment.) Upon this assessment, the most sensitive use, that which requires the most stringent water quality criteria, must be acknowledged as a designated use and therefore must be protected. Uses that currently exist, or have existed since November 25, 1975, cannot be removed or downgraded.

A Use Attainability Analysis (UAA) reviews and potentially modifies a waterbody's designated uses, when the uses have not existed since 1975 or are un-attainable. It is a scientifically based assessment of the beneficial uses that a water body could support, given reasonable effluent limits and implementation of best management practices. If the existing uses have associated criteria that are less stringent than the designated uses, then the next step is to determine if the designated uses are attainable if all best management practices and effluent limits are in place and effective. If the designated use is shown to be unattainable, the final step is to determine what the highest attainable use would be if all practices and effluent limits were in place. This process constitutes the body of the UAA and is followed by the agency's rulemaking process to change the designated use(s). These designations are reviewed every three years to determine if the designation is still appropriate.

Tasks:

1. Determine if a Use Attainability Analysis (UAA) is appropriate for Utah Lake. A UAA considers the physical, chemical, biological, and economic use removal criteria described in EPA' s water quality

standards regulation (40 CFR 131.10(g)(1)-(6)). Under 40 CFR 131.10(g) states may remove a designated use which is not an existing use, as defined in § 131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:

a. Naturally occurring pollutant concentrations prevent the attainment of the use; or
b. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
c. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
d. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or
e. Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
f. Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

2. Possible Off-ramp to Technology Based Phosphorus Effluent Limits (TBPEL)

Deliverables:

1. UAA approved by the U.S. EPA

Actions/Decisions that will be informed:

1. If impairment is confirmed, a TMDL may not be needed and a UAA could be developed with a subsequent change to the lake's designated beneficial uses.

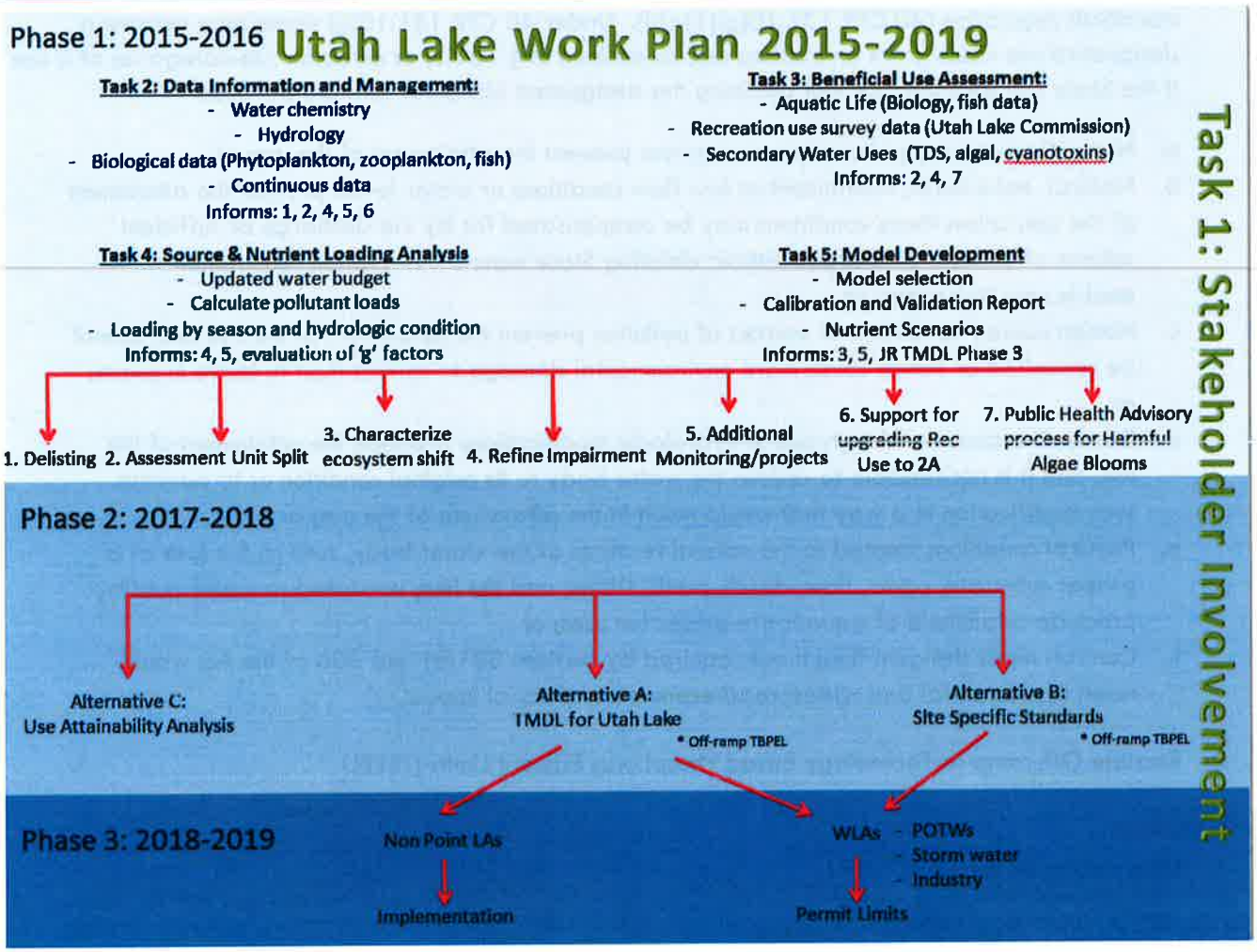

Figure 1: Draft flow chart of Utah Lake Workplan 2015-2019.

SCHEDULE:

Utah Lake Workplan 2015-2016

Division of Water Quality

	Objectives	2015			2016											
Task	Phase 1	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	**Stakeholder Outreach and Public Involvement**															
	Technical Advisory Committee															
	Utah Lake Workshop															
	Stakeholder Consultation															
	Utah Lake Coordinator															
	Public Meetings															
2	**Data and Information Management**															
	Data Acquisition															
	Database Development															
	Online Database															
	Supplemental Monitoring															
	Literature Review and Synthesis															
3	**Beneficial Use Assessment**															
	Aquatic Life															
	Recreation															
	Secondary Water Uses															
4	**Source and Nutrient Loading Analysis**															
	Updated water budget and flow data															
	Watershed-wide water budget															
	Loading analysis															
	Loading by season															
	Pollutant loads from each source calculated															
5	**Model Development**															
	Compile existing data															
	Model Selection and Scoping															
	Data Gap Analysis and Data Collection															
	Model Build															
	Model Calibration and Validation															
	Model Calibration Report Preparation															
	Supplemental Data Collection															
	Nutrient Scenario Analysis															
	Nutrient Report Preparation															
Alternative	Phase 2															
1	TMDL For Utah Lake															
2	Site Specific Standard															
3	Use Attainability Analysis															

Figure 2: Schedule for 2015 and 2016 of Utah Lake Workplan activities.

ROLES OF DWQ AND PARTNERS

Task	Lead	Partner(s)
Task 1: Stakeholder Outreach and Public Involvement	DWQ: Carl Adams (carladams@utah.gov)	Utah Lake Commission (Eric Ellis; eric@utahlakecommission.org)
Task 2: Data and Information Management	DWQ: Suzan Tahir (stahir@utah.gov)	DWQ: Lenora Sullivan (lenoras@utah.gov), Central Utah Water Conservancy District; Payson, Salem, Spanish Fork, Springville and Provo Waste Water Treatment Plants; Utah Valley University: Eddy Cadet (cadeted@uvu.edu), Weihong Wang (Weihong.Wang@uvu.edu); USGS; Utah Division of Water Rights: Ben Anderson (benanderson@utah.gov); Utah State University: Jereme Gaeta (jereme.gaeta@usu.edu); Rushforth Phycology: Sarah Rushforth (Sarah@rushforthphycology.com), Sam Rushforth (samrushforth@gmail.com); June Sucker Recovery Implementation Program: Mike Mills (mikem@cuwcd.com)
Task 3: Beneficial Use Assessment	DWQ: Jake Vander Laan (jvander@utah.gov)	Contractor (TDB)
Task 4: Source and Nutrient Loading Analysis	DWQ: Scott Daly (sdaly@utah.gov)	Jordan River/Farmington Bay Water Quality Council: Theron Miller (theron.miller12@gmail.com), Contractor
Task 5: Model Development	DWQ: Nick VonStackelberg (Nvonstackelberg@utah.gov)	Jordan River/Farmington Bay Water Quality Council: Theron Miller (theron.miller12@gmail.com); LaVere Merritt (merrittlb@gmail.com); Contractor (TBD)

Attachment 1: Utah Lake Water Quality Sampling Stations

Utah Lake Sampling Stations

Monitor Org	Station ID	Monitoring Location Name	Sample Type	Flow	Gage Name
		Tributaries and Wastewater Treatment Plants			
CUWULT	4994790	JORDAN R AT UTAH L OUTLET U121 XING	4	UDWR	05 JORDAN NARROWS (TOTAL)
CUWULT	4994950	SPRING CK BL LEHI MILL POND	4		
CUWULT	4994960	AMERICAN FK CK 2.5MI S OF AM FK CITY	4	USGS	10164500 (Location in canyon)
CUWULT	4995038	Timpanogos Effluent below constructed duck ponds	4		
CUWULT	4995040	TIMPANOGOS WWTP	4	WWTP	DMR or MOR
CUWULT	4995120	LINDON DRAIN AT CO RD XING AB UTLAKE	4		
CUWULT	4995200	US Steel Geneva 001 to Utah Lake	4		
CUWULT	4995250	OREM WWTP	4	WWTP	DMR or MOR
CUWULT	4995260	POWELL SLOUGH AB OREM WWTP	4		
WWTP	4995410	PAYSON WWTP	4	WWTP	DMR or MOR
CUWULT	4995420	BEER CK AB PAYSON WWTP AT U115 XING	4		
WWTP	4995440	SALEM WWTP	4	WWTP	DMR or MOR
CUWULT	4995580	SPANISH FORK R AB UTAH L (LAKESHORE)	4	USGS	10150500 (Location in canyon)
CUWULT	4996000	DRY CK @ CR 77 XING AB UTAH LAKE	4		
WWTP	4996020	SPANISH FORK WWTP	4	WWTP	DMR or MOR
CUWULT	4996030	DRY CK AB SPANISH FK WWTP	4		
CUWULT	4996100	HOBBLE CK AT I-15 BDG 3MI S OF PROVO	4	USGS	10153100 (Location near mouth)
CUWULT	4996190	SPRING CK UPRR XING 1.7MI SE OF PROVO GOLF CSE	4		
WWTP	4996280	SPRINGVILLE WWTP	4	WWTP	DMR or MOR
CUWULT	4996290	SPRING CK AB SPRINGVILLE WWTP - DROPPED	4		
CUWULT	4996310	SPRING CK BL FISH HATCHERIES AND AB SPRINGVILLE WWTP	4		
CUWULT	4996410	IRONTON CANAL AB KUHNIS BYPRODUCTS	4		
CUWULT	4996550	MILLRACE CK BL PROVO WWTP	4		
CUWULT	4996560	PROVO WWTP	4	WWTP	DMR or MOR
CUWULT	4996570	MILLRACE CK AB PROVO WWTP	4		
CUWULT	4996690	PROVO R AT U114 XING	4	USGS	10163000 (Location near mouth)
CUWULT	5919850	BENJAMIN SLOUGH AT 6400 SOUTH	4		
CUWULT	5919860	BEER CK AB UTAH LAKE	4		
		Utah Lake			
DWQ	4917310	UTAH LAKE 0.5 MI W OF GENEVA DISCHARGE #15-A	2, 23, 27, 29		
DWQ	4917320	UTAH LAKE 0.5 MI W OF GENEVA DISCHARGE #15-B (4917310 Duplicate)	2		
DWQ	4917370	UTAH LAKE 1 MI EAST OF PELICAN POINT	2, 29		
DWQ	4917390	UTAH LAKE 1 MI WEST OF PROVO BOAT HARBOR	2, 29		
DWQ	4917450	UTAH LAKE AT MIDDLE OF PROVO BAY	2, 29		
DWQ	4917500	UTAH LAKE 3 MI WNW OF LINCOLN BEACH	2, 29		
DWQ	4917520	UTAH LAKE 2 MI E OF SARATOGA SPRINGS #12	2, 29		
DWQ	4917600	UTAH LAKE GOSHEN BAY SOUTHWEST END	2, 29		
DWQ	4917770	UTAH LAKE OUTSIDE ENTRANCE TO PROVO BAY	2, 29		
		Utah Lake Level		UDWR	UTAH LAKE STORAGE CONTENT (GAGE READING)
		Utah Lake Storage		UDWR	UTAH LAKE STORAGE CONTENT

Attachment 2: Stream gage information for Utah Lake tributaries.

USGS Stream Gages in Utah County

Agency	Site ID	Site Name	Location	Status	Begin Date	End Date
USGS	09282000	STRAWBERRY TUNNEL AT WEST PORTAL, NR THISTLE	Mountain			
USGS	09312600	WHITE R BL TABBYUNE CRK NR SOLDIER SUMMIT, UT	Mountain			
USGS	09312700	BEAVER CREEK NEAR SOLDIER SUMMIT, UTAH	Mountain			
USGS	10147000	SUMMIT CREEK NEAR SANTAQUIN, UTAH	Mountain			
USGS	10147500	PAYSON CREEK ABV DIVERSIONS, NEAR PAYSON, UTAH	Mountain			
USGS	10148200	TIE FORK NEAR SOLDIER SUMMIT, UT	Mountain			
USGS	10148400	NEBO CREEK NEAR THISTLE, UTAH	Mountain			
USGS	10148500	SPANISH FORK AT THISTLE, UTAH	Mountain			
USGS	10148510	SPANISH FORK BLW HALLS FALLS NR SPANISH FORK, UTAH	Mountain			
USGS	10149000	SIXTH WATER CRK AB SYAR TUN NR SPRINGVILLE, UT	Mountain			
USGS	10149400	DIAMOND FORK ABV RED HOLLOW NR THISTLE, UT	Mountain			
USGS	10149500	DIAMOND FORK BELOW RED HOLLOW, NEAR THISTLE, UT	Mountain			
USGS	10150000	DIAMOND FORK NEAR THISTLE, UTAH	Mountain			
USGS	10150500	SPANISH FORK AT CASTILLA, UT	Canyon	Active	5/1/1919	
USGS	10152000	SPANISH FORK NEAR LAKE SHORE, UTAH	Valley	Inactive	1/1/1904	5/10/1988
USGS	10152001	SPANISH FORK AT MOUTH NEAR LAKE SHORE, UTAH	Valley	Inactive	3/13/1978	4/8/1982
USGS	10152500	HOBBLE CR NR SPRINGVILLE UTAH	Valley	Inactive	10/1/1908	9/30/1974
USGS	10152700	MAPLE CREEK NEAR MAPLETON, UTAH	Canyon	Inactive	10/1/1964	10/31/1972
USGS	10153000	MAPLE CREEK NR SPRINGVILLE, UT	Canyon	Inactive	10/1/1911	12/31/1913
USGS	10153100	HOBBLE CREEK AT 1650 WEST AT SPRINGVILLE, UTAH	Valley	Active	11/15/2008	
USGS	10160800	NO FK PROVO RIV AT WILDWOOD UTAH	Mountain			
USGS	10161000	PROVO RIVER AT VIVIAN PARK, UTAH	Mountain			
USGS	10161500	SOUTH FORK PROVO R AT VIVIAN PARK, UTAH	Mountain			
USGS	10162850	ROCK CREEK OVERFLOW EAST OF HIWAY 189 NR PROVO, UT	Mountain			
USGS	10163000	PROVO RIVER AT PROVO, UT	Valley	Active	10/1/1903	
USGS	10164500	AMERICAN FK AB UPPER POWERPLANT NR AMERICAN FK, UT	Canyon	Active	1/1/1927	
USGS	10165500	DRY CREEK NEAR ALPINE, UTAH	Canyon	Inactive	7/1/1947	9/30/1955
USGS	10166000	FORT CREEK AT ALPINE, UTAH	Canyon	Inactive	7/1/1947	9/30/1955
USGS	10166430	WEST CANYON CREEK NEAR CEDAR FORT, UT	Canyon	Active	7/1/1965	
USGS	10166605	JORDAN RIVER AT LEHI BRIDGE NEAR LEHI, UTAH	Valley	Inactive	10/1/1985	2/28/1987