Appendix B: Bijou Park Creek Restoration Project Preliminary Design Report

Bijou Park Creek Watershed Restoration Project –DRAFT Preliminary Design Report

Prepared for

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Bijou Park Creek Restoration Project Preliminary Design Report DRAFT

Table of Contents

Introduction 1
Background 1
2005 E. Pioneer Trail Watershed Hydrology Study 2
1984 Bijou Wildwood Erosion Control Project 2
Purpose: Goals and Objectives 2
Technical Advisory Committee and Public Engagement 3
Existing Conditions 3
Topography and Sub Drainage/ Watershed Conditions 3
Land Use 5
Soils and Vegetation 6
Sources of Pollutants 6
Introduced 6
Existing 7
Existing Stormwater Conveyance and Transport Processes 7
Keller Canyon Watershed 7
Bijou Park Creek Watershed 7
Hydrologic Design 11
Hydraulic Modeling 12
PCSWMM Analysis 12
HY8 Analysis 14
Hydraulic Modeling Results 15
..... 18
Existing Treatment Infrastructure 19
Curb and Gutter + Drain Inlet Sediment Traps 19
Treatment Basins 20
Natural Treatment: Meadows 20

DRAFT

Existing Flooding Problems 20
Upper Bijou Park Creek 21
Bijou Park Creek Meadow 23
Bijou Park Creek below Meadow 23
Design Development: Formulating & Evaluating Alternatives 24
Watershed Approach 24
Preferred Design Approach 25
Opportunities and Constraints 27
Projects Considered and Rejected due to Hydrology 27
Projects Considered and Rejected due to Site Constraints 28
Upper Ski Run Basin 28
Bijou Meadow Diversion 28
Proposed Projects 29
Needle Peak Localized Treatment 29
Ski Run Blvd Diversion 30
Upper Bijou Park Creek 30
Pioneer Crossing Culvert 31
Rockwood to Blackwood Ave 31
Bijou Park Creek Meadow Restoration 32
Bijou School Basin 33
Shirley to Whole Foods 34
Osgood Basin Expansion 34
Aloha Basin 35
Keller Canyon Bypass 36
30% Conceptual Designs by Project 37
Needle Peak Localized Treatment 37
Ski Run Diversion 38
Upper Bijou Park Creek 41
Pioneer Crossing Culvert 42
Rockwood to Blackwood (Heavenly Valley Mobile Home Park) 45
Bijou Park Creek and Floodplain Enhancement 47
Bijou School Basin 49
Shirley to Whole Foods 50

DRAFT

Osgood Expansion (Passive) 51
Keller Canyon Bypass 52
Aloha Basin 53
Wrap up and Recommendations for 65% Design 55
References Cited 56
Appendices 57

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Introduction

Background

In April 2019, the Wildscape Engineering, Inc. Team (Team) that includes Northwest Hydraulics Consultants (NHC), Nevada Tahoe Conservation District (NTCD), and Catalyst Environmental Solutions with support from Insite Land Surveys were contracted by the City of South Lake Tahoe to provide engineering design and planning services for the Bijou Park Creek Restoration Project. This is the second phase of a three phase effort (Figure 1) by the City of South Lake Tahoe to address water quality and flooding issues in the Bijou Park Creek Watershed. The first phase, Bijou Park Creek Stream Environment Zone (SEZ) Restoration included water quality and flood mitigation efforts in the commercial zone adjacent to Lake Tahoe and Ski Run Boulevards and was completed in 2018.

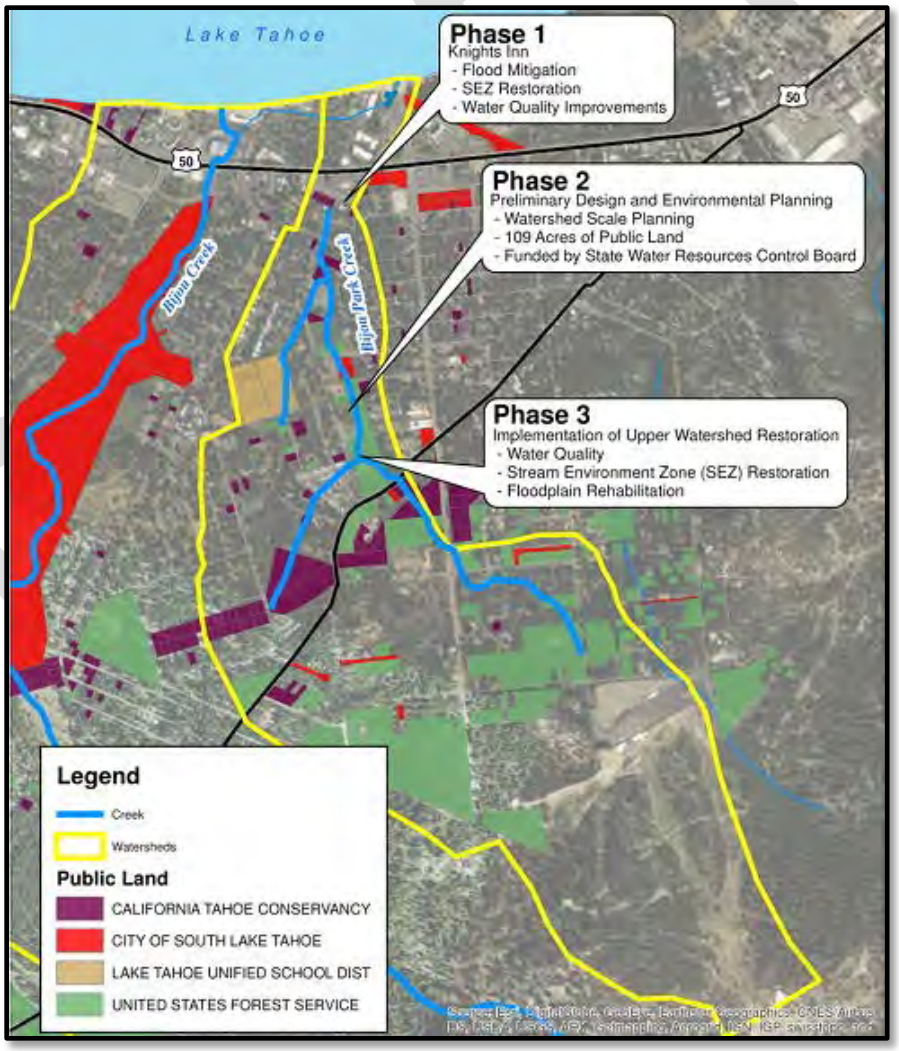


Figure 1. Bijou Park Creek Watershed Phased Improvement Efforts
(Source: Catalyst Environmental 2020)

Funding for this Phase 2 effort was made available through Proposition 1 from the State Water Resources Control Board Stormwater Grant Program to conduct preliminary planning and environmental review of a multi-benefit stormwater improvement project. In accordance with the Proposition 1 grant agreement, the project is to include:

- Stabilization of road shoulders that are vulnerable to erosion;
- Replacement of undersized storm drain pipe with appropriately sized pipes (perforated where technically feasible);
- Retention basin(s) that can store and treat storm water through sedimentation and infiltration; and
- Restoration of floodplain, while prioritizing the use of existing public land or easements.

Use of public land and collaboration with the City of South Lake Tahoe (CSLT), California Tahoe Conservancy (Conservancy), and U.S. Forest Service (USFS) is a critical part of this project.

The approximately 850-acre drainage area for the Bijou Park Creek Restoration Project [Figures 2 and 3] ranges from forested ski slopes at the uppermost portion of the watershed including the Heavenly Ski Resort (California Lodge) parking lot transitioning to residential and commercial areas through the mid to lower portions of the watershed, with arterial and neighborhood roads and interspersed public lands and open space. The adjacent Keller Canyon watershed is connected to this watershed via the city storm drainage network at Markoffer Way and Keller Road adding 365 acres of drainage area to the project near its terminus. The Bijou Park Creek watershed ultimately discharges to Lake Tahoe at Ski Run Marina via an underground network of often undersized and degraded conveyance pipes.

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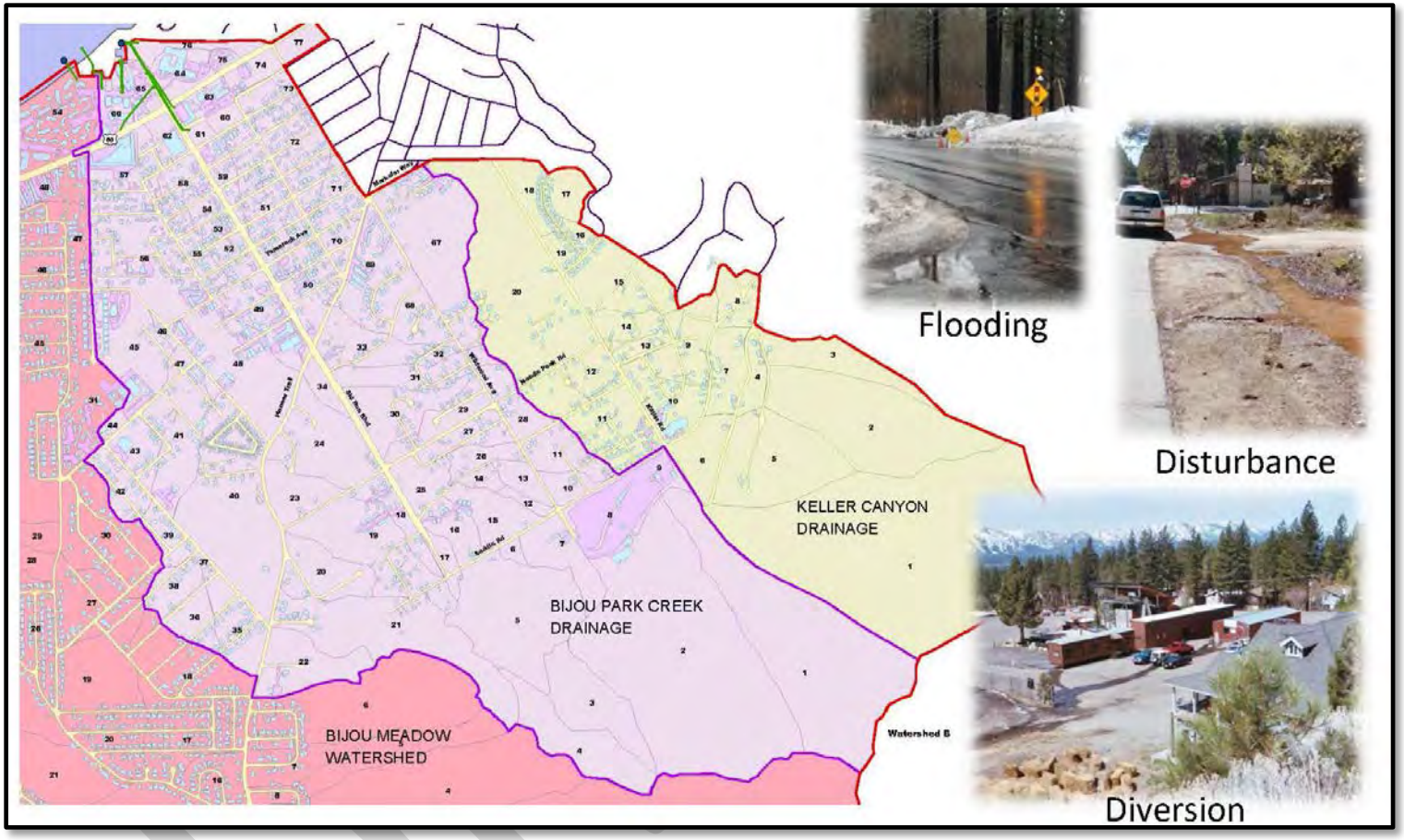


Figure 2. Bijou Park Creek Watershed opportunities. *(WS Map Source: Lumos and Associates, 2005)*



Figure 3. Bijou Park Creek Watershed Catchment Areas.

Water quality improvement and flooding alleviation are being addressed as part of this project. Flooding problem areas include the following.

- Pioneer Trail at Charlesworth Court
- Blackwood Road - Heavenly Valley Mobile Home Park
- Below Blackwood Road including at Werner Salas, Vanda Lee Way, Shirley and Bill Avenues

Relevant past studies and concurrent projects include the 2005 E Pioneer Trail Watershed Hydrology Study (Lumos & Associates), 1987 Bijou Wildwood Erosion Control Project (Brown and Caldwell), the Conservancy's ongoing development of the South Tahoe Greenway Shared Use Trail and TRPA's recently started Ski Run Mountain to Marina Green Infrastructure planning project focused on stormwater pollution prevention and small scale green infrastructure opportunities within developed parcels of the watershed.

While there have been studies and Environmental Assessments for individual storm water improvement projects in the Bijou Park Creek watershed, this project takes a broader perspective in selecting stormwater quality and flooding improvement projects and carrying them to the 30 percent design milestone. The existing conditions foundation for this project relies heavily on the work completed as part of the East Pioneer Trail Watershed Hydrology Study by Lumos and Associates Inc. with support from Toby Hanes who led the hydrology analysis at the time and continues to lead the hydrology and hydraulic analysis under this effort.

2005 E. Pioneer Trail Watershed Hydrology Study

The 2005 E. Pioneer Trail Watershed Hydrology Study (Study) provided the existing conditions setting and understanding as the basis for investigation of project opportunities and alternatives development. While some of the information provided in the study required field verification, due to the time gap since report completion, its comprehensive background and analysis afforded the team the ability to start immediately with more focused investigations and analysis. The Study covered three drainage areas Keller Canyon, Bijou Park Creek, and Bijou Meadow and used the HEC-HMS model (U.S. Army Corps of Engineers Hydrologic Modeling System https://www.hec.usace.army.mil/) to estimate peak flows at various points in the watershed. The study characterized the quality of stormwater and identified opportunities and constraints relative to reducing flood peaks and improving the quality of stormwater. In addition, it identified potential projects and private parcels that, through their acquisition would provide opportunities to restore Stream Environment Zones (SEZs) and improve stormwater quality. The data provided on drainage, hydrology, SEZ condition, impervious areas, utilities, and pollutant and sediment sources fed directly into the projects considered and proposed here.

1984 Bijou Wildwood Erosion Control Project

The 1984 Bijou Wildwood Erosion Control Project was the initial erosion control project tackled by the CLST in response to the Lahontan Regional Water Quality Control Board's prohibitions on discharges of silt and sediment in 1971 (Brown and Caldwell 1984). The project targeted the reduction of flooding and transport of fine sediment to Lake Tahoe via source control and treatment of restored SEZ. This resulted in the installation of culverts, check dams, cross valley berms, and numerous other measures within the project area. Many of the aging and non-functioning infrastructure elements installed by this project are now being replaced, upgraded, or removed by the current proposed projects.

Purpose: Goals and Objectives

The purpose of this preliminary design report is to explain the reasoning, data and analysis that went into the chosen projects. In addition, it specifically addresses the Preferred Design Approach (PDA) including Source Control, Hydrologic Design, and Treatment. Hydrologic and hydraulic modeling on a watershed scale guided the design and enabled projects to be evaluated using a watershed approach. The Existing Conditions background from the 2005 E Pioneer Trail Hydrology Study afforded this project to begin with a watershed wide perspective and proceed with the next step of Formulating and Evaluating Alternatives (FEA) as required by the Storm Water Quality Improvement Committee (SWQIC) guidelines.

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Technical Advisory Committee and Public Engagement

Gathering insight and input from agencies and the community is an importance element of alternatives analysis. For this reason informal and formal meetings were conducted in the field and remotely (due to Covid-19 distancing requirements) with representative agencies, landowners and the public. A Technical Advisory Committee (TAC) was formed and a meeting was held on April 17th, 2020 to introduce the project and engage with public landowners and regulatory agencies early in the design process. A diverse group of stakeholders from the following agencies comprise the TAC: CSLT, Tahoe Regional Planning Agency (TRPA), California State Water Resources Board, Lahontan RWQCB, Conservancy, USDA Forest Service Lake Tahoe Basin Management Unit (LTBMU), Tahoe Resource Conservation District (TRCD), South Tahoe Public Utility District (STPUD), Heavenly Ski Resort, and US Environmental Protection Agency (EPA). A two week comment period followed the April TAC meeting. The discussion and comments resulting from the meeting are attached in Appendix X. Additional informal meetings were conducted in the field and by phone with CSLT, LTBMU, Conservancy, TRPA and Heavenly Ski resort representatives to examine and discuss specific areas of interest including existing treatment facilities, SEZ condition, and future project collaboration and assimilation. A second TAC meeting will be held in late summer 2020 to review and collect feedback on the Draft Preliminary Design Report and 30% concept plans.

CEQA is being completed concurrently with the preliminary design process and consequently a public scoping meeting was conducted to introduce the project and solicit feedback from community members. The public scoping meeting was held virtually on June 24th, 2020 with assistance from CSLT staff who provided several channels to provide public comment including phone calls, live chat, email and written comment. Public comments brought attention to a number of concerns that are addressed further in the CEQA document and in individual project design descriptions.

Existing Conditions

The following section summarizes the existing physical and biological conditions of the Bijou Park Creek watershed based on past and current studies and provides an overview of the hydrology and hydraulic analysis and results that were done in support of alternatives development.

Topography and Sub Drainage/ Watershed Conditions

The Bijou Park Creek Watershed as shown in Figure 3 extends from the steep rocky terrain of the slopes of Heavenly Ski Resort down to the outfall into Lake Tahoe at Ski Run Marina. As shown in Figures 2 and 4 east of the Bijou Park Creek watershed is Keller Canyon watershed of which roughly 260 acres of its upper watershed are currently redirected to Bijou Park Creek as a result of the Heavenly Valley parking lot construction (Lumos 2005). This artificial increase in drainage area has led to increased conveyance demand and flooding issues.

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Figure 4. Current and historical drainage patterns in the Bijou Park Creek Watershed. *(Source: Catalyst Environmental 2020).*

Just below Heavenly Ski Resort, Bijou Park Creek descends via a mix of open channel and piped flow through low density residential areas where it encounters numerous restrictions at road crossings and a confined floodplain as it approaches higher density development in the lower portion of the watershed. Eventually the creek outfalls into the recently restored stream corridor at the Bijou Marketplace (Whole Foods) development. The lower portion of the watershed encompasses medium to high density residential and commercial development with a mix of curb and gutter and unpaved road shoulders. The storm drainage network collects and conveys stormwater to a storm drain main along Ski Run Blvd that outfalls into Osgood Basin.

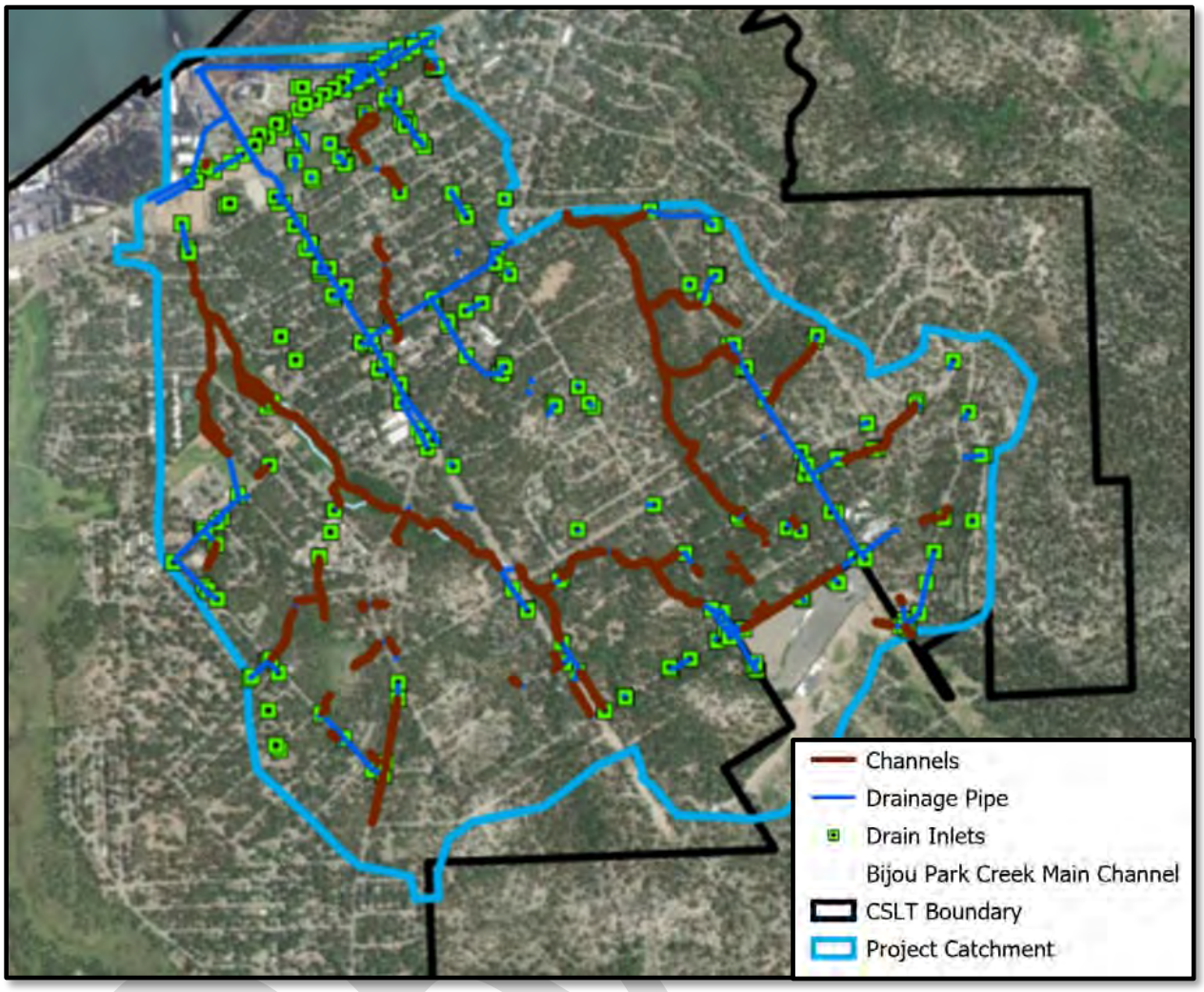


Figure 5. Existing Stormwater Infrastructure

Land Use

A large portion of land use in the watershed is open space, especially higher in the watershed. Lower down there is a mixture of low and medium density residential followed by commercial development along Highway 50 and Ski Run Blvd north of Pioneer Trail. Heavenly Ski Resort California Base Area is located at the top of watershed. While the slopes and parking lot are significant contributors of sediment the resort installed and manages a series of StormFilter treatment vaults to treat the resulting runoff. A comprehensive study was done to quantify the pollutants coming from the resort and can be found in Appendix X (Heavenly Discharge Report). In addition, a Pollutant Load Reduction Model (PLRM) was run to identify sources of sediment, the associated land use map and model output can be found in Appendices X and X (PLRM LandUse, PLRM Output).

Public Lands

A significant portion of the lands interspersed throughout the watershed are owned by the CTC and the LTBMU. The majority of the land that the Bijou Park Creek channel flows through is publicly owned,

the exception being a residential area the creek passes through before daylighting into the Bijou Marketplace (i.e. Whole Foods) SEZ Restoration area adjacent to Highway 50. Osgood and Wildwood basins in the lower watershed are owned by the City of South Lake Tahoe. A map of public lands is attached as Appendix X (Public Lands).

Soils and Vegetation

Soils in the project area are primarily Cagwin Rock Outcrop Complex (5-15% slope) (CaD) and Elmira Loamy Course Sand, Wet Variant (Ev) (Web Soil Survey, 2005 Lumos). A geotechnical investigation was conducted in October 2019 at three sites to evaluate infiltration capacity and ground water levels. Borings were taken at Osgood basin, Elva Court and along Herbert Ave. These results are discussed in the proposed project descriptions and details can be found in the Boring Logs (Appendix X)

The proposed project sites are primarily located on forested public lands owned by the Conservancy and LTBMU. Field surveys of plant communities and of dominant vegetation communities in support of CEQA were performed in October 2019. Vegetation communities on these lands consist of Jeffrey Pine forest (~28 acres), Aspen groves (~3.8 acres), willow thickets (~4.1 acres), and wet meadow (~2.8 acres). Details on dominant species can be found in the Biological Resources Report (Appendix X) prepared by Catalyst Environmental Solutions.

A more in-depth investigation of vegetation types specific to the SEZ areas to be enhanced was conducted to inform salvage and reuse, revegetation and biotechnical treatment opportunities for project designs including a species list can be found in Appendix X (Existing Conditions Vegetation).

Sources of Pollutants

Fine sediment is the primary pollutant of concern. It is defined as particles less than 20 microns in size.

Introduced

The major contributor of fine sediment includes the dispersal of sand and other material for traction along the highly traveled route to and from Heavenly Ski Resort. In general, stormwater pollution associated with the use of road abrasives can be considered a chronic problem because of their routine use during the winter and the propensity for the applied abrasives to generate fine sediment through crushing by vehicles.



Figure 6. Heavily sanded routes on the way to Heavenly Ski Resort.

The City of South Lake Tahoe's Snow and Ice Removal Plan guides deicing operations which occur when conditions require. Typically sanding occurs

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first in priority areas when a light snow falls to prevent dangerous conditions. Deicing consists of applying a mixture of two parts sand to one part salt to priority areas as shown in Appendix X (City Sanding Patterns Heavenly Valley). In addition to deicing, the City applies anti-icing, a mixture of water and salt brine, to the roads prior to a storm when proper conditions occur. Changing sanding frequency is challenging as weather is difficult to predict and sanding is a key component of protecting public safety during storm events.

Existing

During large precipitation events and high flows sediment can be mobilized through scour on unpaved road shoulders, steep slopes, and natural channels. Steep, sparsely vegetated slopes, and cut banks are often sources of sediment. Earthen disturbed road shoulders from vehicle traffic and snow removal equipment can allow for mobilization of sediment.

Erosion from road cut slopes and unpaved roads remains a problem in many areas within the upper watershed. These areas are problematic because of the coarse soils and minimal precipitation during the short growing season limiting revegetation efforts. The East Pioneer Trail Watershed Hydrology Study (Lumos 2005) details erosion problems in the watershed. Erosion from unpaved road shoulders can be considered to be a chronic problem because of their continued disturbance from roadside parking. Erosion from slopes with little vegetative cover is more episodic in nature, due to the generally high infiltration rates and low melt rates, in comparison to intense winter frontal storms or less frequent summer thunderstorms.

Existing Stormwater Conveyance and Transport Processes

Keller Canyon Watershed

Water draining from Keller Canyon is redirected into a storm drain pipe which originates near the intersection of Keller Road and Markoffer Way. It is conveyed down Markoffer Way, crossing Pioneer Trail and then eastward along Tamarack Avenue to a junction with the Ski Run Boulevard storm drain. That drain originates on the south side of Pioneer Trail and runs along the east side of Ski Run Boulevard to Paradise Avenue, where it discharges into the Osgood Basin.

Bijou Park Creek Watershed

Surface Runoff

The majority of the watershed is not developed with respect to stormdrains. In general, runoff is typically conveyed along road shoulders and then into stream corridors. Some of the road shoulders have low asphalt berms, but in many locations, particularly in the lower portions of the watershed, the road shoulders remain undeveloped and are subject to disturbance and compaction associated with on-street parking where it occurs.

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Bijou Park Creek

Bijou Park Creek originates from runoff coming from the Heavenly Ski Resort Parking lot and adjacent surface runoff. The creek flows through low density fairly steep residential areas below the Heavenly Valley base facilities and crosses Ski Run Boulevard via a pipe just below Needle Peak Drive where it flows freely through Conservancy and LTBMU lands before entering swales on either side of Charlesworth Court. It crosses Pioneer Trail in a silted in and undersized culvert that outlets into a broad, wet meadow or Stream Environment Zone (SEZ). After crossing Pioneer Trail there has been some obvious manipulation of the creek and SEZ, including intermittent earthen berms set perpendicular to the flow path and redirection of the main channel. The alteration of this meadow is described in more detail in the section below. The stream continues northward along the meadow in an open channel until it enters a pipe that flows under an apartment complex parking lot before crossing Tamarack Ave via a culvert, and back into the open meadow and across Werner Salas Dr via another culvert and then enters a 24-inch pipe at Shirley Ave. From Shirley Avenue crossing it flows along a lot line on the north side of the road and enters into a 24-inch diameter culvert in the backyard of a residence. From there, it is conveyed between lots on the south side of Bill Avenue, continues under Bill Avenue and through a residential lot on the north side of Bill Avenue and discharges into a large recently restored stream corridor which flows around the east side of the Whole Foods market. The stream corridor discharges into a 24-inch stormdrain that is conveyed to and across Highway 50 and combines with runoff generated in the lower eastern portion of the watershed. Higher flood flows within the stream corridor enter a 24-inch overflow pipe that flows eastward and ties into a 24'x36' box culvert under Ski Run Boulevard.

Bijou Park Creek SEZ and Meadow

Bijou Park Creek was modified during a joint U.S. Forest Service/Soil Conservation Service conducted in 1985 (Figures 7 and 8). The project resulted in the construction of some low cross-valley berms in the meadow and stream channel construction likely intended to prevent channel incision and achieve greater opportunity for floodplain deposition. One of the cross-valley berms occurs within 30 feet upstream of the trailer park outfall, at which point there is a small drop structure to convey the creek over the berm the other earthen berms are capped with asphalt at the spillways.

The LiDAR-based topography used in the HECRAS hydraulic model simulations does not indicate the current location of the channel in the area of the trailer park outfall likely due to the small channel dimensions. The simulation shows most initial flow occupying the east side of the valley and then spreading toward the west as the discharge increases. Reconnaissance of the area does indicate remnant flow paths on the east side of the valley.

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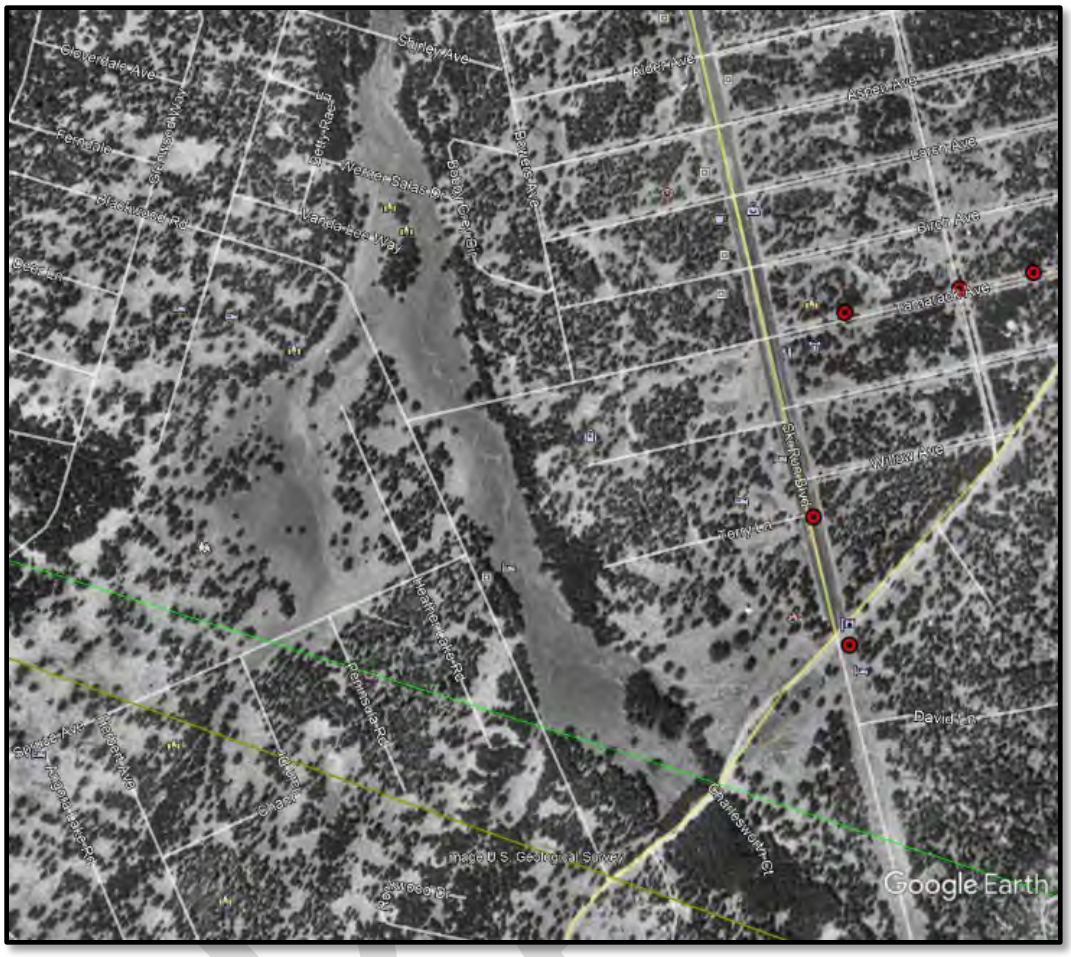


Figure 7. 1940 Aerial Image Bijou Park Creek pre-direct modification.

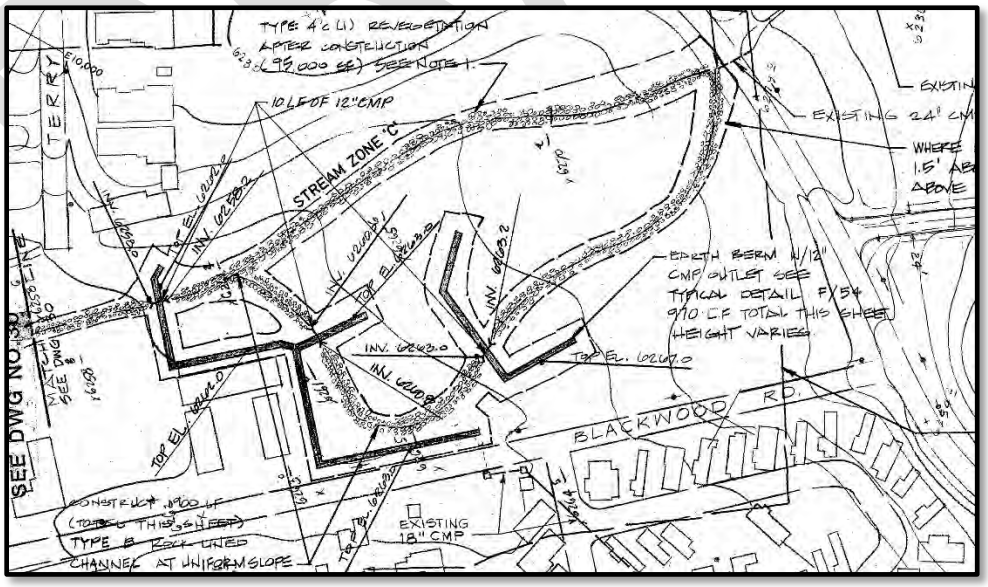


Figure 8. Bijou/Wildwood ECP Elements in SEZ along Blackwood
(Brown and Caldwell 1985)

Inspection of the 1940 aerial photograph (Figure 7), which was prior to the development of Heavenly Valley Ski Resort, does not clearly indicate a channel in the vicinity of the trailer park outfall, although a single-thread channel is clearly apparent beginning approximately 200 feet upslope of Spruce Avenue. Above that point, there appear to be multiple weakly defined channels occupying primarily the east side of the valley although there is evidence of a channel trace extending upstream westward to the approximate location of the trailer park outfall. These channel traces become progressively weaker in an upstream direction.

Bijou Marketplace

Figure 9 shows the arterial stormdrains within the project area covered in the hydrology and hydraulic analysis performed by NHC and introduced in the following sections. As introduced above lower Bijou Park Creek outfalls into the Bijou Marketplace restored stream corridor in the northwest portion of the project area where it is conveyed across Highway 50 to its confluence with the Ski Run storm drain at the vault in Ski Run Boulevard on the north side of Highway 50. A high flow bypass at Bijou Marketplace routes excess flows directly to Ski Run where Osgood outfalls. Drop inlets and laterals within the Bijou Marketplace commercial center drain to onsite stormwater infiltration basins that overflow into the recently restored stream corridor described above.

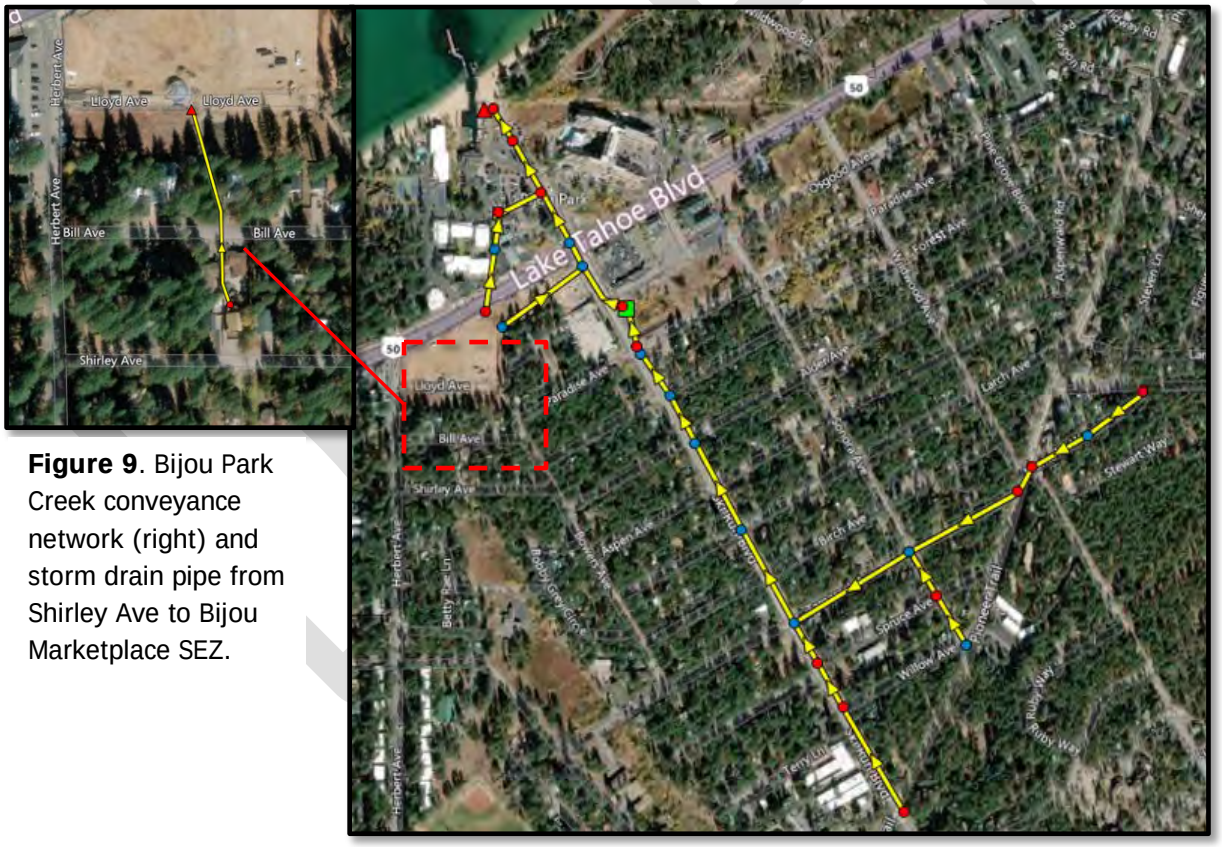


Figure 9. Bijou Park Creek conveyance network (right) and storm drain pipe from Shirley Ave to Bijou Marketplace SEZ.

Osgood Basin to the Lake

The bulk of the lower watershed to the east of the Bijou Park Creek Meadow drains into a storm drain system along Ski Run Boulevard which enters a small treatment basin, the Osgood Basin. Bijou Park Creek and all of the water entering the Osgood Basin, then combine and enter into twin 48-inch diameter concrete pipes that extend to a large vault on the east side of the Ski Run Marina itself. That vault also serves as the terminus of the Wildwood Basin watershed. Three 48-inch diameter pipes extend from the vault to the marina bulkhead where all of the runoff from the Bijou Park and Wildwood watersheds is discharged into Lake Tahoe.

Wildwood Watershed

Figure 10 shows the Wildwood Basin stormdrain high flow bypass. Runoff from the Wildwood subwatershed, which adjoins the Bijou Park Creek watershed on the east, flows into three stormwater treatment basins on the south side of Highway 50 treating a drainage area of approximately 111 acres. Water from the basins flows down Wildwood Avenue and across Highway 50 where it enters a vault. In general, lower flows are discharged into a series of three shallow wetland treatment basins located along the back side of the Lake Tahoe Vacation Resort. Discharge from the final basin enters the large vault next to the Ski Run marina. Flows in excess of the capacity of the treatment basins enters a 36-inch diameter bypass culvert, which also discharges into the marina vault. There are several cross-connections between this pipe and the basins which can allow for additional inflow into the basins or discharge back into the bypass stormdrain.



Figure 10. Wildwood Basin storm drain high flow bypass.

Hydrologic Design

In order to evaluate the hydraulic capacity of existing infrastructure and to design for the 10- and 100- year recurrence events as required by the CSLT design standards hydrologic modeling was completed to determine potential peak flows at key points in the watershed. While the conventional HEC-HMS was used to compute peak flows in past studies of this watershed (i.e. E. Pioneer Study) a calibration error was discovered to have caused unreliable results and so an alternative method was pursued using analog basins. See Appendix X for the full hydrology technical memo discussing the

calibration error and how it skewed the prior peak flow results as well as the Analog Basin approach method used to achieve the peak flow results for 30% designs presented in Table 1 below.

Table 1. Estimated Recurrence Interval Peak Flows Using the Analog Basin Method.

	Peak Flow (cfs)					
Analysis Point	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Keller Canyon @ Markoffer	3.2	6.7	9.9	13.7	20.1	27.1
Needle Peak @ Ski Run	2.9	6.1	9.0	12.5	18.7	25.2
Osgood Basin	4.9	10.1	14.3	19.2	28.3	37.8
Osgood Basin w/o Keller Canyon	2.2	4.3	6.2	8.4	12.6	16.8
Trailer Park Outfall	1.5	3.4	5.1	7.1	10.7	14.5
Bijou Park Creek @ HWY 50	6.1	11.8	16.9	23.0	33.7	44.4
Bijou Meadow at Lake Tahoe	12.2	22.3	31.5	42.4	61.8	80.8
Wildwood Basin ABV HWY 50	2.2	4.5	6.2	8.5	12.5	16.6

1. Includes flows exceeding the capacity of the Needle Peak culvert (approx. 36 cfs).
2. Not modeled, estimated by subtraction of Keller Canyon @ Markoffer
3. From FEMA floodplain mapping.
4. Not in scope of study.

The estimates provided in the table may be subject to some revision during the next stage of the design process, either to revise the chosen set of analogs, or to provide for a "safety factor" in recognition of the uncertainty inherent in any method used to derive flood flow estimates.

Hydraulic Modeling

NHC used various computer models to evaluate existing peak flow and conveyance conditions and flood potential in the watershed. The modeling software PC Storm Water Management Model (PCSWMM) and HY-8 Culvert Hydraulic Analysis Program were used to evaluate existing pipe and culvert capacities in order to identify where upsizing or upgrades are needed and to evaluate the hydraulic capacity of proposed improvements. The Hydraulic Engineering Center – River Analysis System (HEC-RAS) 2-Dimensional model was used to document the extent and depth of inundation on the Bijou Park Creek meadow at various flows, although it had its limitations due to the Lidar topographic surface not displaying some of the modified channel features due to their small size.

PCSWMM Analysis

Model Description

PCSWMM 2019 Professional 2D (Version 7.2) model developed by CHI, Inc. is used to evaluate stormdrain networks. For this project, it was used to determine the capacity of the existing stormdrains at various locations. PCSWMM is a fairly sophisticated model that handles unsteady flow through stormdrains, ponds and weirs. In a stormdrain network, each lateral or inflow point, is assigned its own input hydrograph. The program computes the water surface elevation and energy

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grade line within the stormdrain continuously at all points through the entire storm period represented by the input hydrograph.

Input

The program input requires information on the size, dimensions and roughness of each pipe segment along with its slope. NHC gathered pipe information and surveyed the rim elevation at all manholes for the entire Markhoffer/Tamarack/Ski Run stormdrain network. The invert elevations for the pipes were determined by measuring the distance from the manhole rim to the invert, and subtracting that distance from the surveyed rim elevation. Culvert inlet and outlet elevations were surveyed directly for the culvert extending from downstream of Shirley Avenue to the Bijou Marketplace stream restoration corridor. For the storm drain system on the lakeside (northwest) of Highway 50, we relied primarily on invert information gathered for the previous NHC report investigating the capacity of the stormdrains there (Bijou Park Creek Watershed Hydrologic and Hydraulic Analysis, NHC Inc. 2017). However, NHC resurveyed most of the rim elevations, verified the entrance and exit elevations of the pipes in the Ski Run vault where the flow from Bijou Park Creek and Osgood basin join and measured the invert elevation of one of the outfall pipes into the marina. We were unable to re-measure the invert elevations inside the Ski Run marina vault due to backwater inundation from high lake levels. Given routing of water to the Wildwood Basin is being considered under alternatives analysis data was collected to assess the capacity of the bypass pipe from Wildwood Basin out to Ski Run Marina. NHC surveyed the rim elevations of the vaults and manholes, took tape down measurements to the bypass pipe invert, and took elevation and dimension measurements of the weir within the vault on the north side of Highway 50.

Output

During the model run, if at any time or location (i.e. manhole) the energy grade line exceeds the manhole rim elevation, the model flags that manhole and caps the discharge flowing past that point. Therefore it is assumed that any incident of the water surface reaching the manhole rim elevation results in flows in excess of the pipe capacity and stormwater flowing out of the manhole and not re-entering the stormdrain at a point downstream. Figure 11 shows a snapshot of the SWMM output for the Ski Run Blvd stormdrain. Unfortunately, the model does not have the capability to perform this same “flagging” function at elevations below the manhole rim, which is desirable from the standpoint of determining the flow which matches the City’s criterion of passing the 10-year recurrence interval flow with the hydraulic grade line at 0.5 feet below the elevation of drop inlets and manholes (City of South Lake Tahoe Public Improvement and Engineering Standards, 2009).

NHC performed some sensitivity analysis by altering manhole elevations which generally resulted in flows of 5% to 10% less than those at which the grade line equaled the manhole rim elevation. But that approach sometime produced spurious results (see further discussion in Section **** Hydraulic Design Approach).

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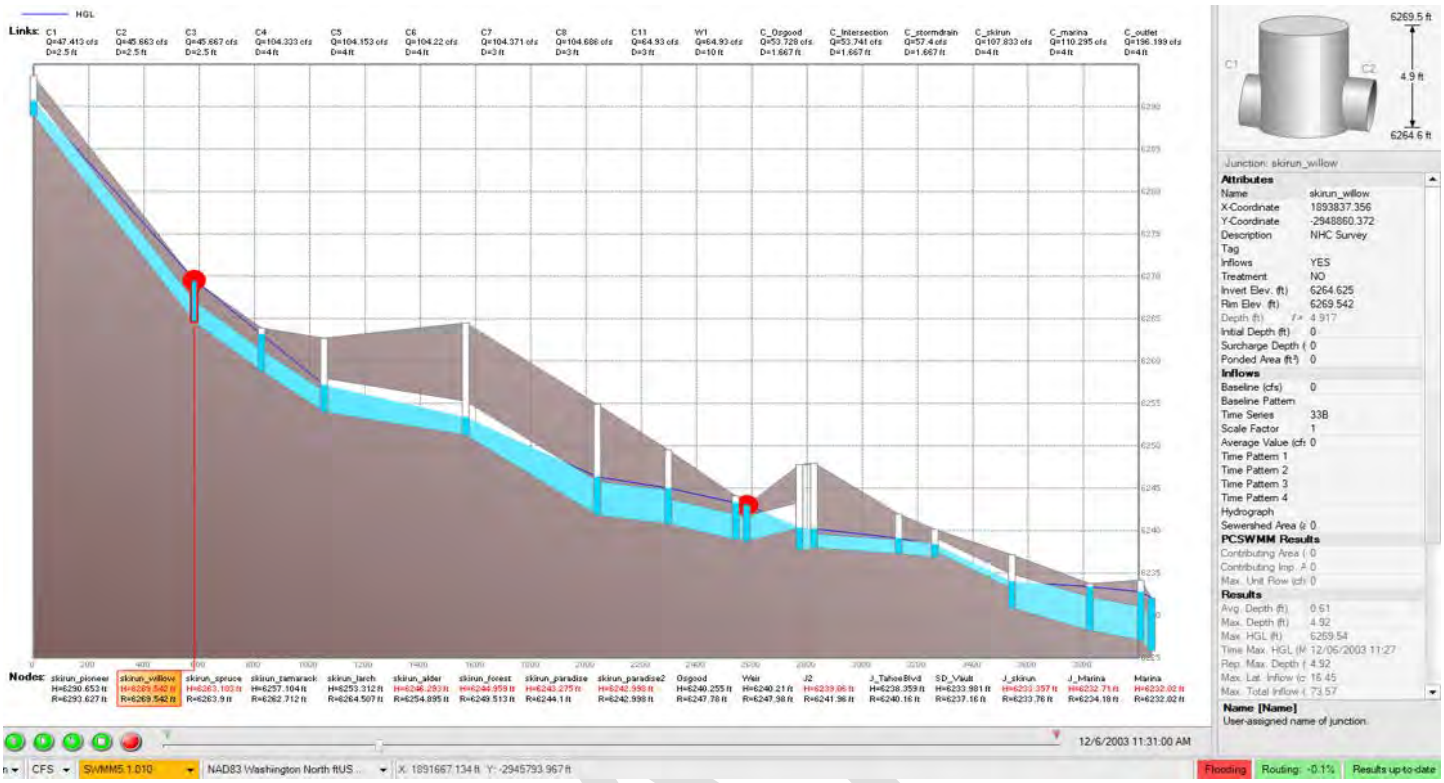


Figure 11. Example of PCSWMM Analysis Results for Ski Run Boulevard

HY8 Analysis

In some cases involving individual pipe segments, existing or proposed, a simplified analysis was appropriate wherein the capacity of the pipe was computed using the Federal Highway Administration's HY8 Version 7.60 based on the culvert's dimensions, roughness, and gradient, along with specifying the headwater and tailwater elevations. HY8 was used to compute the capacity of the Bijou Park Creek culvert crossing Ski Run Boulevard just below Needle Peak Road, the culvert extending from the downslope side of Shirley Avenue to the Bijou Marketplace stream restoration corridor, and a proposed new outfall into Bijou Park Creek Meadow. HEC-RAS 2D Hydraulic Analysis

Model Description

NHC applied the HEC-RAS 2D hydraulic model to assess the hydraulic characteristics of the Bijou Park Creek Meadow (US Army Corps of Engineers Hydrologic Engineering Center, HEC-RAS River Analysis System, 2D Modeling User's Manual, Version 5.0, 2016). Rather than compute water surface elevations as select cross-sections as is done in the 1-Dimensional HEC-RAS model, the 2D version performs calculations using a computational mesh that fully represents the topography of the study area. HEC-RAS then determines a cross-section along the edge of each cell within the domain based on the underlying terrain. A hydrograph may then be specified at some point internally or along the boundary of the mesh for routing across the surface. This approach allows for the handling of unsteady flow. The model output is a video which shows the extent and depth of inundation as the hydrograph is routed down the floodplain.

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Input

In our application of the model, the 1-foot contour mapping derived from the available 2010 LiDAR data was used as the basis for the meadow topography. The discharge point into the meadow was the existing stream crossing point on Pioneer Trail. Tributary inputs were not simulated. A 20-ft x20-ft grid was used for the model except for a small area upstream of Shirley Avenue. At Shirley Ave a 5-ft x 5-ft grid was used to better represent the flow confinement within the narrow channel that extends from upstream of Shirley Avenue to the inlet of the Shirley/Bill culvert that passes flow from the backyard of the lot on the north side of Shirley Avenue and discharges into the SEZ restoration area at the Bijou Marketplace commercial development. The model simulates the flow through the 24-inch diameter culvert under Shirley Avenue.

The downstream terminus is at the inlet to the Shirley/Bill culvert where the surface flow terminates. This abrupt boundary condition fails to accurately simulate the depth and lateral extent of the flow there and for that reason the model results should not be used for the area downstream of Shirley Avenue. Flow through the culverts on Tamarack, Werner Salas and Vanda Lee were also not represented. These pipes have a negligible influence on the meadow inundation during large flood events due to their minimal capacity (i.e. small diameter, minimal depth below the meadow surface and often very gentle grade) relative to the peak discharges simulated.

Output

The model output is a “video” of the routing of the input hydrograph through the modeled area over time that displays the changes in the depth and extent of flooding as a function of the changing inflow at the discharge point. This approach allows for the handling of unsteady flow. However, since floodplain mapping indicates the maximum lateral extent of the peak flow, a plan view “snapshot” from an unsteady flow model video does not produce equivalent results since the discharge varies over the reach. In order to overcome this difficulty, we inserted a “flat top” hydrograph with a steady peak for the flows of interest extending over several hours, such that the snapshot does indeed show the maximum lateral extent of flooding over the entire Bijou Park Creek meadow at the given flow. Another consideration is that the contour mapping used as the basis for the modeling does not display the elevations of structures such that figures showing the extent of flooding will not specifically exclude structures unless the foundation grading is above the water surface. The preliminary model results should be used with caution since it is only a representation of hydraulics of the floodplain. Subtle but important differences in topography may not be represented by the topographic data used, the model grid size, and variations in hydraulic roughness due to differences in vegetation type and density are not yet fully represented.

Hydraulic Modeling Results

Computed Storm Drain Capacities

Table 2 presents the capacity of the existing stormdrains as computed using PCSWMM at various locations described and shown in Figure 12. Appendix A contains the PCSWMM output.

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Table 2. Capacities of Existing Bijou Park Creek Stormdrains

Location	Capacity (cfs)	Notes
Bijou Park Creek		
Ski Run @ Needle Peak	30.9	24" RCP
Shirley/Bill	14.4	Headwater El. @ 1' BLW top of bank in open channel downstream of Shirley Ave.
Bypass to Ski Run Blvd	N/A	Discharge and direction varies depending on flows in Ski Run and Bijou Ck
At/Below Hwy 50 (Knight's Inn Arm)	23.5	w/o flow in Ski Run arm. Headwater depth = El. of Hwy 50 gutter flow line
	19.3	w/o flow in Ski Run arm. Headwater depth = exit invert El. of Shirley/Bill culvert
	22.7	Flow in Ski Run arm = 53.7 cfs, High Lake stand, headwater depth = to El. of Hwy 50 gutter flow line
	18.8	Flow in Ski Run arm = 52.4 cfs, High Lake stand, headwater depth = exit invert El. of Shirley/Bill culvert
Keller Canyon		
Markoffer and Keller	72.6	
Pioneer and Markoffer	37.0	
Tamarack @ Ski Run	24.8	
Ski Run to Lake		
@ Pioneer	57.1	
@ Willow	47.4	
@ Spruce	42.7	
@ Paradise 2	65.3	High lake stand
North of Hwy 50	126	High lake stand
BLW Bijou/Ski Run Vault	123	High lake stand
Wildwood High Flow Bypass	29.2	at Manhole #5 (closest to Marina), high Lake stand, and flow in Ski Run arm
	30.1	@ Hwy 50 vault, high lake stand, flows in Ski Run
	36.9	@ Wildwood Ave vault, high lake stand, flows in Ski Run
	43.9	at Wildwood Ave vault, with Lake at legal low water, independent, w/o flows in Ski Run arm

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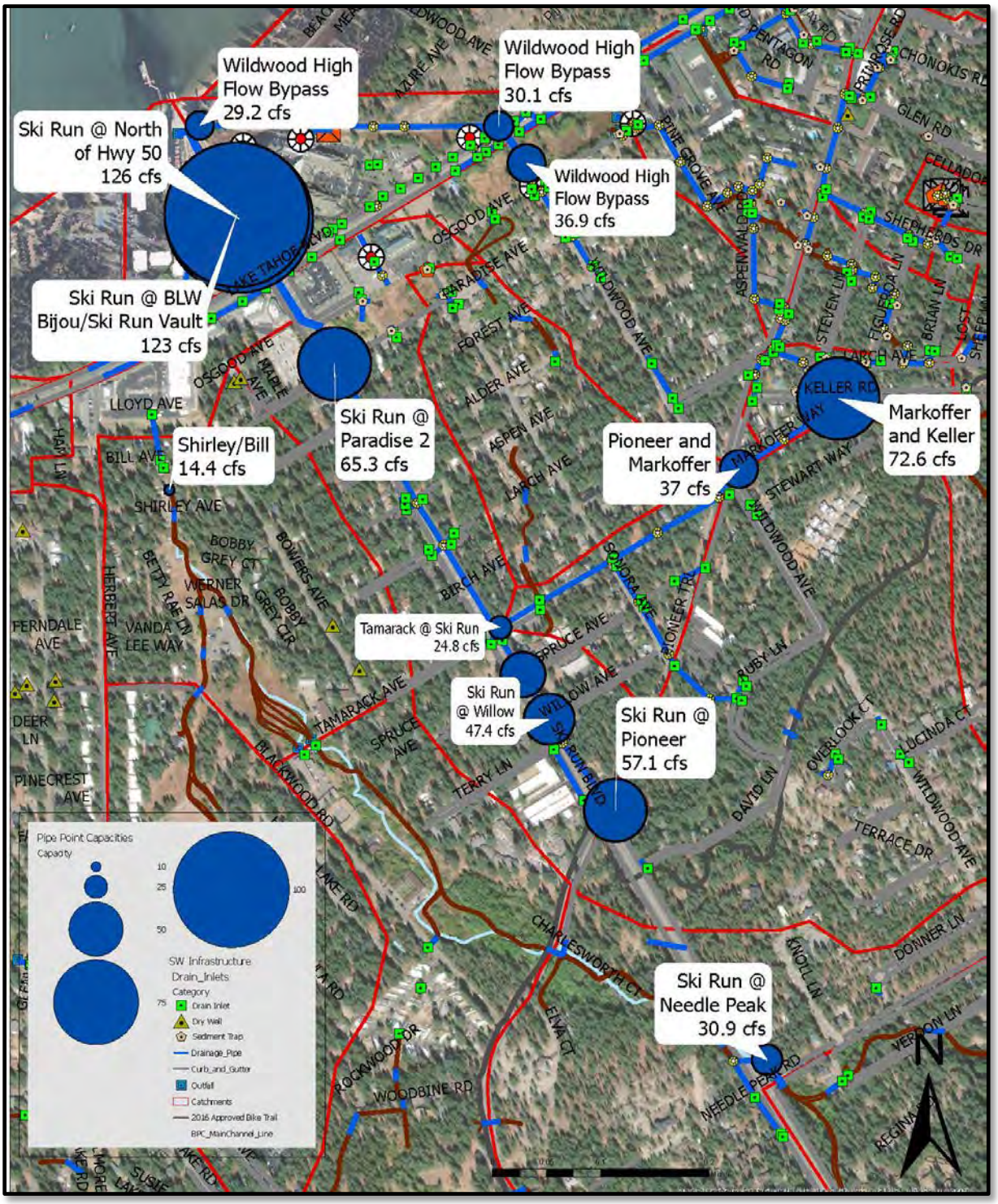


Figure 12 Existing Bijou Park Creek stormdrain pipe capacities.

Bijou Park Creek Meadow Floodplain

Figures 13 and 14 are views of the Bijou Park Creek Meadow at flows of 25 and 50 cfs, which are roughly equivalent to the estimated 25- and 100-year recurrence interval flood peaks (see Table 1).

Videos, plan views, and selected cross-sections at the peak flows have been provided to the CSLT for flow peaks of 25, 50, 75, 100, and 200 cfs.

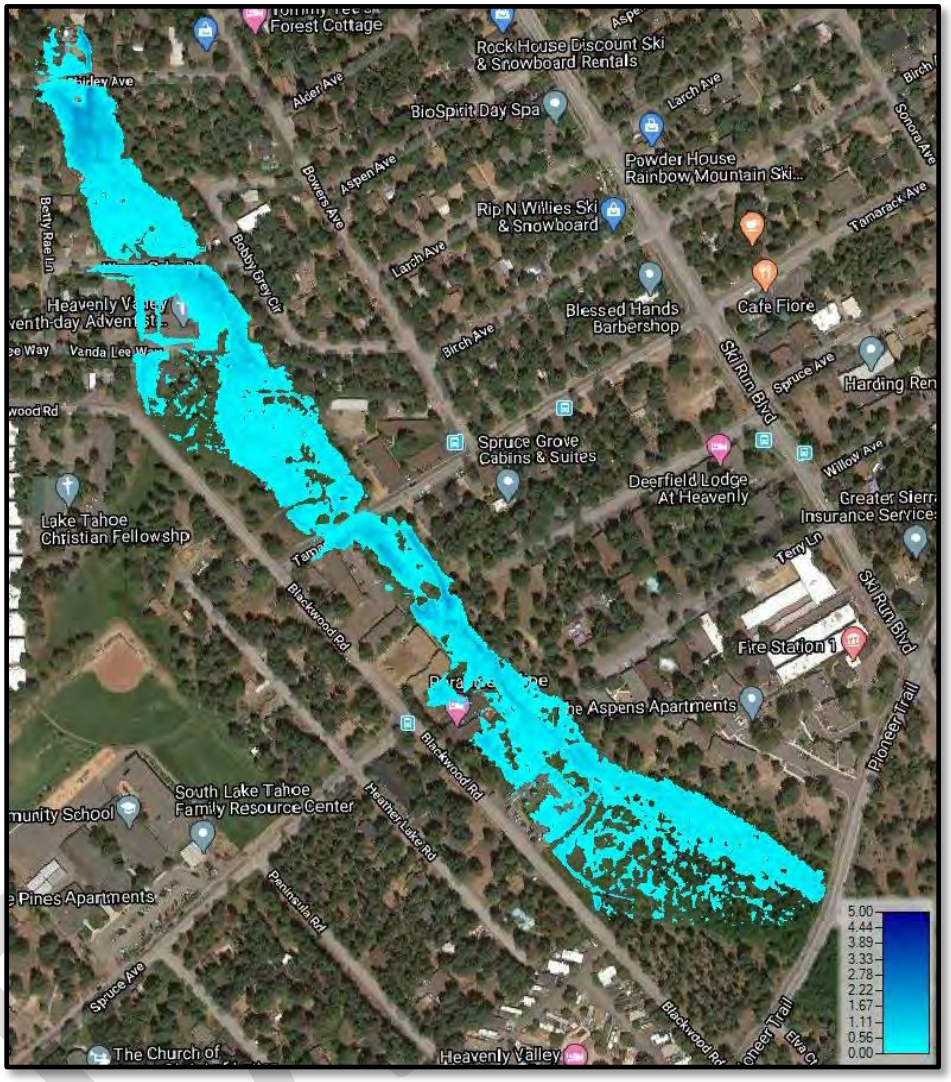


Figure 13. Bijou Park Creek Meadow 25-year flood inundation.

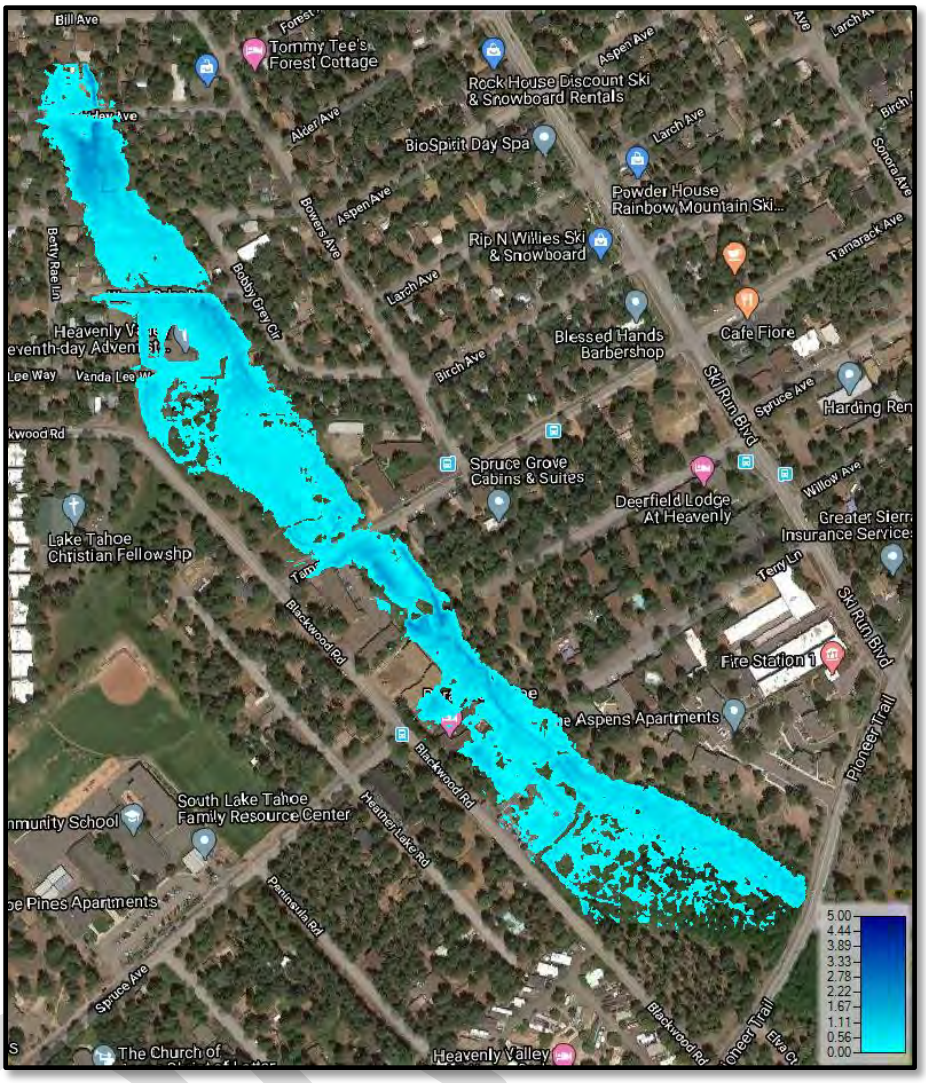


Figure 14. Bijou Park Creek Meadow 100-year flood inundation.

Existing Treatment Infrastructure

Curb and Gutter + Drain Inlet Sediment Traps

Once stormwater runoff is generated, there are a few treatment opportunities. Because of the low density of curb-and-gutter with existing storm drains, opportunities to remove sediment in drop inlet traps are limited, however there are some specific areas where sediment traps or sediment cans can be installed in-line with existing rolled curb or rocked swales. Additionally there are a few areas where new curb and gutter would provide stormwater improvement value and drain inlet or can type sediment traps are to be paired with those. Areas where additional sediment trap treatment would be of value include the upper watershed neighborhood streets above Needle Peak, Pioneer Crossing at Charlesworth and Spruce Avenue.

With regard to control of road abrasives, Heavenly Valley Ski Resort has installed an array of facilities to remove sediment from runoff generated on its parking facilities and base area. The City has installed roadside curbs in a number of locations, and there have been more recent projects to install curb-and-gutter treatments along Herbert Avenue and in the area of Paradise and Maple avenues. The City also undertakes measures to reduce the use of road abrasives and to utilize street sweeping to recover abrasives.

Currently, once runoff leaves Heavenly Valley property, there is no treatment prior to its discharge into the Ski Run Marina with the exception of the Bijou Park Creek SEZ areas above and below Pioneer Trail discussed under Natural treatment.

Treatment Basins

Currently, the only constructed stormwater treatment facility within Bijou Park Creek watershed is the Osgood Basin. Osgood Basin receives runoff from 503 acres, consisting of the Keller Canyon watershed and the majority of the denser residential development in the Bijou Park watershed. All the runoff in the project area except for the Bijou Park Creek watershed itself and the area between the lake shore and Osgood basin, flows into and through the Osgood Basin. Water exits the basin through twin 48-inch x 20-inch concrete box culverts to a junction vault on the north side of Highway 50 at the entrance to the Ski Run Marina. The basin is 0.49 acres and far undersized relative to various sizing rules for stormwater treatment basins. While it certainly traps some sediment, the hydraulic residence time is too short to provide any significant level of treatment. The pollutant removal efficiencies for fine sediment and nutrients are believed to be nearly negligible. The low treatment efficiency is further exacerbated by the delivery of typically high-quality runoff from the Keller Canyon watershed, which is relatively undeveloped and has a high base flow component. The mixing of stormwater from the Tamarack/Ski Run corridor with Keller Canyon reduces the pollutant influent concentrations and, because of the higher inflow rates into the basin, lowers the hydraulic residence time, and, therefore, the pollutant removal efficiency.

Natural Treatment: Meadows

Bijou Park Creek Meadow and the riparian area extending from Ski Run Boulevard to Pioneer Trail provides potential treatment. The upper Bijou Park area (i.e. between Ski Run and Pioneer) is mostly too steep to provide any treatment, however the lower Bijou Park Creek meadow (i.e. between Pioneer and Werner Salas) has large capacity potential to trap fine sediment, adsorb phosphorous and perform denitrification during periods where the meadow lacks snow cover and flow rates exceed the channel capacity. However, the percent of time when this treatment “window” exists as a result of overbanking, in comparison to episodes during which the creek carries substantial pollutant loads requires further investigation.

Existing Flooding Problems

The following discussion is limited to the principal flooding problems investigated as part of this scope of work. See Figure 15 for most problematic flooding locations in the watershed further described below. The increased frequency and magnitude of flooding is largely attributed to when Heavenly Ski

Resort was constructed, which, as previously mentioned, resulted in an approximate 45 percent increase in the Bijou Park Creek watershed area.

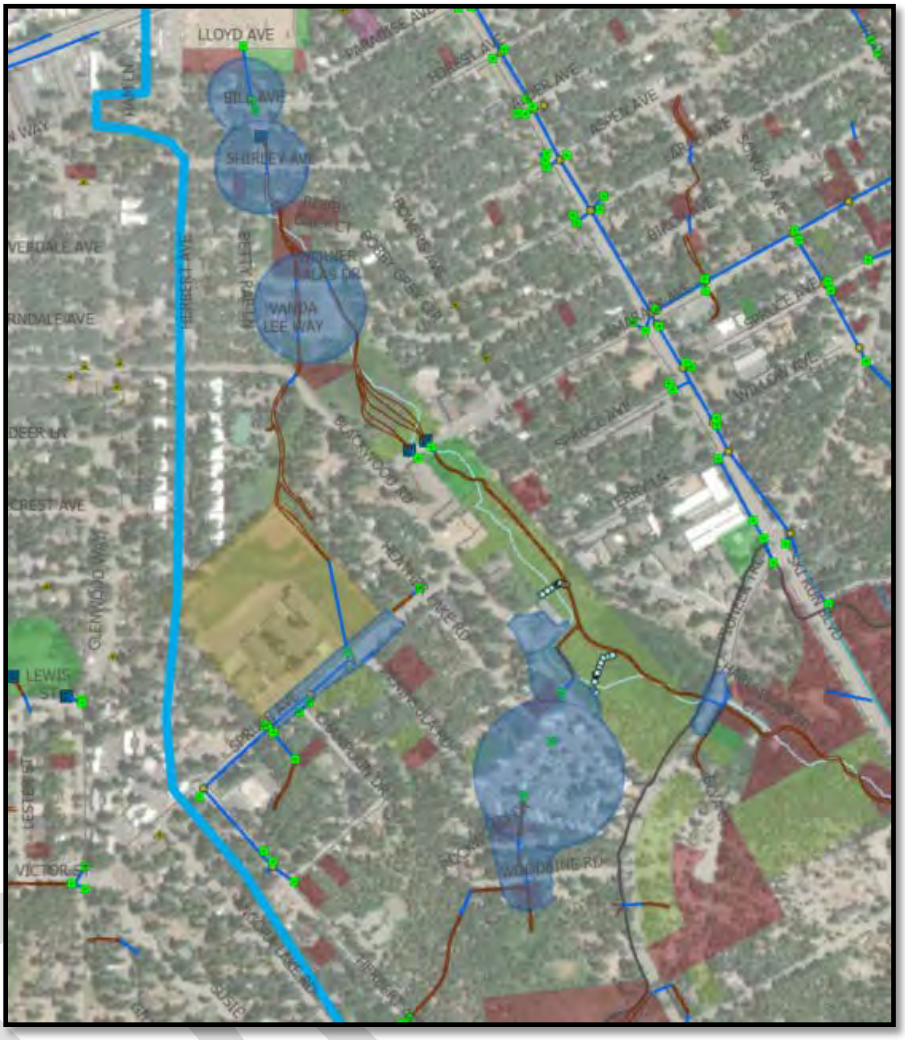


Figure 15. Flood prone areas shown in blue.

Upper Bijou Park Creek

One of the principal hydraulic features of the Bijou Park Creek watershed is the capacity of the 24-inch diameter culvert crossing Ski Run Boulevard below Needle Peak Road. This culvert conveys all the runoff in Bijou Park Creek generated upstream. Using HY-8 with a headwater depth of three feet above the pipe entrance, the computed capacity is 30.9 cubic feet per second (cfs). This high capacity, (and very high velocity) is attributable to the pipe's steep gradient and assumption of the headwater depth. Its outlet connects to a 36-inch diameter pipe. The hydraulic gradient exceeds the ground surface at the exit such that overflows from the pipe exit are a possibility. As an interim flood alleviation measure, the pipe entrance was recently covered with a steel plate with a smaller opening used to restrict the flow crossing Ski Run Boulevard, and thence into Bijou Park Creek meadow. In combination with this interim measure, depending on the amount of flow area blocked and the rate

of flow approaching the culvert, flows can overtop the culvert entrance and flow down the rolled curb and gutter along the east side of Ski Run Boulevard. This runoff would then enter the entrance to the Ski Run Boulevard storm drain, a 30-inch diameter pipe located just upslope of the Ski Run/Pioneer Trail intersection. Thus, any flow diverted from Bijou Park Creek meadow adds to the stormwater entering the Osgood Basin.

Specific major flooding issues along Bijou Park Creek include the Pioneer Trail crossing itself, which consists of a 24-inch diameter pipe prone to overflowing, leading to icing on the road. After crossing Pioneer Trail the creek enters a wooded SEZ area bordered by Blackwood Ave to the west and continues into Bijou Park Creek meadow which is described below.

A trailer park on the west side of Blackwood Avenue is one of the most flood-prone areas (Figure 16). An unnamed tributary to Bijou Park Creek, consisting principally of a vegetated swale that flows northward across Woodbine Road and Rockwood Drive and enters an 18-inch pipe at the south end of the trailer park. The culvert has several drop inlets within the trailer park. It ties into a 24-inch diameter pipe which passes under Blackwood Avenue and daylights to Bijou Park Creek where it runs along the western side of the meadow. The outfall is completely submerged, even when there is no flow entering the trailer park. As a result, water from Bijou Park Creek during dry periods flows backward across the road to some unknown distance within the trailer park. The area extending from Woodbine Road to Blackwood Avenue is essentially flat, such that during floods, backwater effects from Bijou Park Creek are believed to greatly exacerbate, and perhaps are the principal cause, of flooding within that area. The 100-yr flood inundation map (Figure 14) shows that in the absence of that outfall, flows from Bijou Park Creek would fail to flow over the crown of the road at Blackwood Avenue, which would thereby prevent backwater flooding in the trailer park.



Figure 16. (Left) flooding on Rockwood up drainage of the Mobile Home Park. (Right) Backwatering at culvert outlet on Blackwood.

Bijou Park Creek Meadow

Most of the Bijou Park Creek meadow, from Pioneer Trail to Shirley Avenue, is prone to flooding. The Bijou Park Creek channel within the meadow has a small capacity. It is small and sometimes ill-defined. Approximate channel dimensions are typically 4 to 8 feet wide and less than one foot deep. The meadow itself is nearly level in some areas and the earthen berms installed in the late 80s likely encouraged increased sediment deposition and aggradation over time. The creek tends to have a significant base flow component which keeps the water table in the meadow near the surface and is generally at the surface during the snowmelt runoff period. All of these factors contribute to a relatively high frequency of overbank flooding, and floodwaters tend to extend across the entire width of the meadow. From a water quality perspective, however, these same attributes approach the ideal stream environment zone for the removal of pollutants in stormwater runoff. Figures 13 and 14 show general inundation of the Bijou Park Creek meadow. Because of the high flooding potential associated with development within and adjacent to this wet meadow, any measures which would reduce flow entering the meadow would be of some benefit in lowering the magnitude and frequency of flooding there.

Downstream of the trailer park, a number of single and multi-family structures exist on and adjacent to the meadow and were typically constructed on or just slightly above the existing meadow surface. These structures are subject to flooding. Below Tamarack Avenue, Werner Salas Drive crosses the meadow and Vanda Lee Way encroaches into it. Structures within the meadow on those streets are directly within the floodplain, however given there isn't a Special Flood Hazard Area designation by the Federal Emergency Management Agency (FEMA) for Bijou Park Creek at this time homeowners aren't necessarily aware of the implications. The meadow now terminates at Shirley Avenue.

Bijou Park Creek below Meadow

The 24-inch diameter culvert at Shirley Avenue and the 24-inch culvert extending from downstream of Shirley Avenue, under Bill Avenue to the Bijou Marketplace stream restoration corridor restrict flows. Using SWMM, the capacity of the Shirley/Bill culvert was computed to be 14.4 cfs, with a headwater depth approximately one foot below the top of bank in the open channel on the north side of Shirley Avenue. Flows in excess of that amount will create backwater into the meadow upstream of Shirley Avenue and, depending on the discharge, create flooding along Shirley Avenue. It can also create flooding on Bill Avenue since, at that point the headwater depth is higher than the drop inlets on both sides of Bill Avenue such that water will exit the culvert and flow out onto Bill Avenue.

The stormdrains between Bijou Marketplace and Highway 50, and the Ski Run Marina vault also present a hydraulic constraint. The SWMM analysis indicates the stormdrain capacity below Highway 50 to be 18.8 cfs. Since there is the potential for backwater effects within the Ski Run Marina vault due to high flows discharging from the Osgood basin, the analysis was performed with high flows there and it was also assumed that Lake Tahoe was at its legal maximum elevation. The computed capacity is based on a headwater depth equal to the exit invert elevation of the Bill/Shirley culvert. At flow rates higher than 18.8 cfs, tailwater effects on the Bill/Shirley culvert would begin to further restrict its capacity.

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Part of the Bijou Marketplace project consisted of the installation of a 24-inch diameter bypass pipe that would convey stormwater from Bijou Park Creek restored SEZ prior to re-entering the storm drain system at Highway 50 and convey it to the west outlet pipe from the Osgood Basin. Based on a survey of the invert of the pipe entrance at Bijou Marketplace and the assumed tie-in elevation used in the original SWMM analysis performed as part of the 2017 Bijou Park Creek Watershed Hydrologic and Hydraulic Analysis (NHC Inc. 2017) the pipe has a very flat slope. While water would drain to the Ski Run Boulevard stormdrain if there were no flow from the Osgood Basin, the actual flow rate and direction is a function of the headwater and tailwater depths, which are controlled by the flow rates in Bijou Park Creek and the discharge exiting the Osgood Basin. The SWMM analysis indicates a probable maximum discharge toward the Ski Run pipe of less than 2 cfs.

Design Development: Formulating & Evaluating Alternatives

As introduced at the start the goals of this project are to improve water quality via source control, hydraulic design and treatment and secondarily mitigate flooding issues where possible. Approaches to achieve these goals are to include stabilization of road shoulders (source control), replacement of undersized conveyance pipes using perforated pipes when feasible (hydraulic design), expanding or creating stormwater infiltration basins and restoring or enhancing floodplain on existing public lands and CSLT easements. The individual project areas being carried forward in Section X highlight the goals achieved and approaches used.

Watershed Approach

The 2005 E Pioneer Trail Watershed Hydrology Study provided an in depth understanding of existing watershed conditions in addition to opportunities and constraints for water quality improvement. The results of this study informed the initial identification of potential projects. In addition, this project began with a field tour of treatment opportunity areas and areas that are commonly flooded and cause issues during high flows. The field tour was attended by representatives from Northwest Hydraulics Consultants (NHC) , the CSLT, Heavenly Valley Ski Resort, Conservancy, Catalyst (helping prepare CEQA), and the two engineering firms; Wildscape Engineering (WEI) and Nevada Tahoe Conservation District (NTCD).

Per the CSLT request, the formulating and evaluating alternatives process as guided by SWQIC began with the hydrologic and hydraulic analysis of the watershed. Although the existing watershed study provided useful data and conclusions, given that the study was completed 15 years ago it was important to revisit and reevaluate the content of the study. NHC in collaboration with Wildscape Engineering, identified data gaps and areas of uncertainty and spent additional time and effort to field truth and survey areas where needed to support the hydraulic analysis and design development. As mentioned above in the hydraulic modeling results, the supplemental field topographic survey focused largely on channel and pipe inverts provided the necessary data to estimate existing pipe capacities, pinpoint problem areas and quantitatively determine and assess the feasibility of proposed projects.

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Additionally input was collected outside of the core design team through participation with the TAC and public and continued collaboration with key public landowners and leads on overlapping project efforts.

Preferred Design Approach

Source Control

The initial consideration in design is preventing the mobilization of pollutants. As discussed in the Pollutant Sources section the primary contributors are soft road shoulders, scour during high flows, and the application of road abrasives. To address these issues consideration is given to limiting exposed earthen shoulders through various blockade elements or resurfacing, and stream restoration in areas where the channel is actively incising or eroding.

Because of the extensive needs in this particular watershed the list of potential projects to develop to 30 percent grew quite large rather quickly. As a result the bigger opportunity project areas were carried forward to 30 percent design while addressing soft road shoulders or channel scour source control measures became an element within them. On the same token, significant source control opportunities still remain for exposed road shoulders and therefore target locations for measures to prevent erosion should be mapped and design elements added in at the next (65%) design phase.

While road abrasives significantly add to the sediment load in runoff it is not feasible to completely eliminate their application as their safety and commercial benefits take priority. However, it is possible for the City's maintenance operation plan to aim towards minimizing the use of abrasives to what is necessary and avoid applying materials that more easily break down into fine sediments.

Hydraulic Design

In addition to modeling existing stormwater pipe capacities the same hydraulic design tools were used to predict the capacity of proposed projects. Table 3 gives the interpolated level of flood conveyance and therefore flood protection associated with each at the nearest downstream point where a design flow has been estimated. For existing stormdrains, the value is reflective of the most restrictive pipe segment. The recurrence interval flows are calculated by using the recurrence interval estimates from Table 1 (Analog Basin Method), applying a log transformation to linearize the data, and then using the resulting regression equation to find the recurrence interval associated with the pipe capacity. Additional information on this approach can be found in Appendix X. Table 3 reinforces what was introduced earlier that the existing Shirley/Bill and Highway 50 to Ski Run stormdrain pipes are significantly undersized.

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Table 3. Levels of Flood Conveyance/Protection for Existing and Proposed Facilities.

Facility	Existing (E) or Proposed (P)	Size	Capacity (cfs)	Recurrence Interval Flow Equivalent to Capacity (years)	Notes
Ski Run Blvd. culvert @ Needle Peak	E	24"	30.9	>100	
Shirley/Bill culvert	E	24"	14.4	9	Headwater El. @ 1' BLW top of bank in open channel downstream of Shirley Ave.
Bijou Park Ck HWY 50 to Ski Run vault	E	varies	18.8	16	Computed with flow in Ski Run arm = 52.4 cfs, High Lake stand, headwater depth = exit invert El. of Shirley/Bill culvert
Markoffer to Ski Run	E	varies	24.8	72	
Ski Run Blvd to Osgood	E		65.3	>100	
Wildwood Basins High Flow Bypass	E	36"	29.2	>100	at Manhole #5 (closest to Marina), high Lake stand, and flow in Ski Run arm
Wildwood Basins High Flow Bypass	E	36"	43.9	>100	@ Wildwood Ave vault, with Lake at legal low water, independent, w/o flows in Ski Run arm
Keller Canyon Bypass	P	24"	24.2	69	Computed for reinforced concrete pipe
Blackwood Ave. Trailer Park outfall realignment	P	24"	17.4	>100	

Treatment

While treatment is the last option per the Preferred Design Approach, given that one of the primary pollutants is applied road abrasives treatment is necessary to remove the resulting suspended fine sediment. In addition, the watershed has existing treatment basins that can be enhanced to increase their efficiency.

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Opportunities and Constraints

The first iteration of evaluating alternatives was organized via a matrix to weigh the benefits and constraints of each project with regards to water quality, flooding, engineering feasibility, cost, and impacts. Some overarching ideas that guided the design process are listed below and the matrix is provided in Appendix X. As the design process moved forward a few additional alternatives were added, some alternatives were expanded in size and some were considered and ultimately rejected. Evaluation of the feasibility of the proposed projects in the matrix caused changes in approach. Relocating Bijou Park Creek Eastward was changed to Bijou Park Creek Meadow Restoration with a stronger focus on enhancing the meadow and wetland on the available Forest Service parcel.

1. Public Land: The team focused on areas where projects could be implemented on public (CSLT, USFS) or Conservancy land. While there are many private properties in flood prone areas that would ideally be restored to active floodplain, the process of acquiring those properties is time and resource intensive without guaranteed results.

2. Flow Reduction down Bijou Park Creek: The diversion of the Keller Canyon headwaters into the Bijou Park Creek watershed exacerbates flooding within the Bijou Park Creek Meadow. Bijou Park Creek conveys flow from the top of the watershed at Needle Peak Road all the way down to the restored stream corridor at Bijou Marketplace. Reducing flow in the creek would greatly reduce flooding potential along its route particularly in areas of existing stormwater capacity constraints such as Shirley/Bill Avenues and from Highway 50 to the Ski Run Marina stormwater vault. This would also reduce the accompanying problems associated with any attempts to increase the capacity in the creek's highly restricted route through developed areas.

3. Water Quality Improvement through Retention and Infiltration: The primary pollutant of concern, fine sediment, can be removed to varying degrees through sedimentation, depending on the approach and design. Projects were identified that could slow the flow of water and provide sufficient time for sedimentation to occur. The optimum scenario is flow through a flat meadow where flow spreads out (slows down) and infiltrates taking advantage of the natural filtration of the soil matrix.

Projects Considered and Rejected due to Hydrology

The second iteration of the hydrology assessment showed that peak flows for the 100-year storm using the Analog basin method were much lower than originally thought based on the HEC-HMS. This allowed active system options to be dropped from consideration as they were only needed to prevent flooding during the modeled extremely high flows. Projects considered but rejected include:

- Osgood Expansion (active)
- Diversion to Bijou Meadow (active)
- Upper Ski Run Basin (active)

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Projects Considered and Rejected due to Site Constraints

Upper Ski Run Basin

A stormwater treatment basin was initially proposed to be constructed on the public parcel west and downstream of the Ski Run outlet below Needle Peak. After a more thorough field investigation it was determined and agreed by the design team that the steepness of the site made construction and operation of a basin difficult and didn't warrant the disturbance and costs necessary to ensure it could be built in a manner that would be stable and functional over the long term.

Instead it was agreed that pre-treatment sediment traps would be easier to install and maintain at the intersection of Needle Peak and Ski Run and additional sediment traps were further added along the road drainage above Needle Peak and so this bore out the Upper Needle Peak Localized Treatment project area.

In addition a significant head cut was observed along an even steeper section of the creek just below this area where rock check dams had been installed in the 1980s. It was determined that effort was better warranted in stabilizing the channel bed in this reach to prevent further erosion and sediment transport and so the Upper Bijou Park Creek project area also came out of rejecting the Upper Ski Run Basin.

Bijou Meadow Diversion

Bijou Meadow watershed (west of Bijou Park Creek watershed) has one of the largest meadows in the Tahoe Basin and also has a high SEZ to Contributing Area ratio. A significant portion of the Bijou Meadow upslope of the golf course tends to be relatively dry and would be highly efficient in treating imported stormwater. Because of the potential to provide a significant amount of stormwater treatment a diversion pipeline from Ski Run Blvd to Bijou Meadow to convey flow during flood events was seriously considered and evaluated during alternatives development. Design analysis included sizing the pipe, mapping out an alignment and profile, determining trench depths, configuring intake weir/vault and identifying whether to tie into existing CSLT stormdrain infrastructure or daylight at the meadow.

Despite the significant treatment potential for the following reasons the Bijou Meadow Diversion was ultimately rejected:

- Bijou Meadow resides within the regulatory FEMA 100-year floodplain with residential properties lining the entire east margin. The increase in discharge to the meadow associated with the diversion would need to be thoroughly examined and clearly demonstrated to the regulators and the public that there would be no net increase to flood risk. There would be added costs to develop a FEMA Effective Model and submit a Conditional Letter of Map Revision (CLOMR) to acquire permission to construct the diversion and public perception of the potential flood risk even if it is shown there is none, may continue to be a sizeable hurdle to get over.

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- The diversion requires over 4600 linear feet of pipe to reach Bijou Meadow necessitating subsurface investigations to determine the likelihood of encountering large subsurface boulders that could require several alignment redesigns or possibly blasting through them.

- A rough construction cost estimate was developed and showed that to construct this project element alone would be around $4.7 million.

Proposed Projects

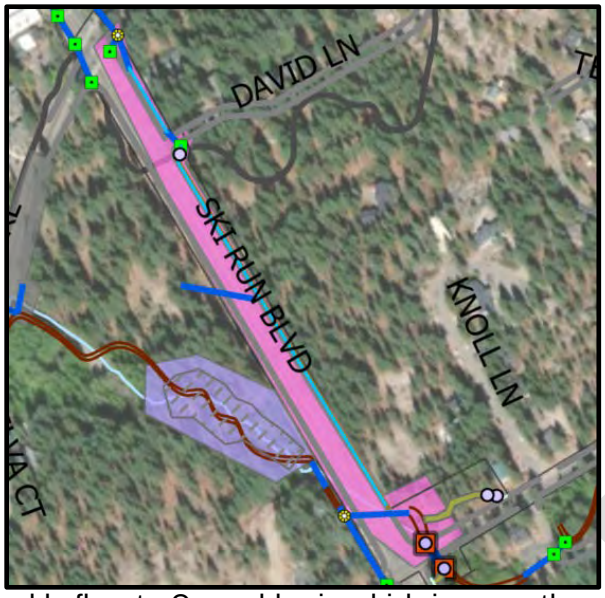
This section introduces the project elements carried forward in terms of goals, opportunities presented and design, construction and maintenance considerations. The next section describes each project design in more detail as it was developed to 30% detail.

Needle Peak Localized Treatment



Goal: Water Quality Improvement
Opportunity: Heavenly Ski Resort sanding route along Needle Peak Rd, Wildwood Ave, and Ski Run Blvd experiences high application of road abrasives. Identify collection points and install pre-treatment vaults/sediment traps to capture the larger sediment material before it's carried down Bijou Park Creek.
Considerations: Requires annual maintenance by CSLT staff.
Description: Install sediment vaults/traps (cans) within CSLT ROW at drain inlets and culvert outfalls along sanding route.
Construction Activity: Localized excavation and sediment trap installation, two to three weeks for construction.

Ski Run Blvd Diversion

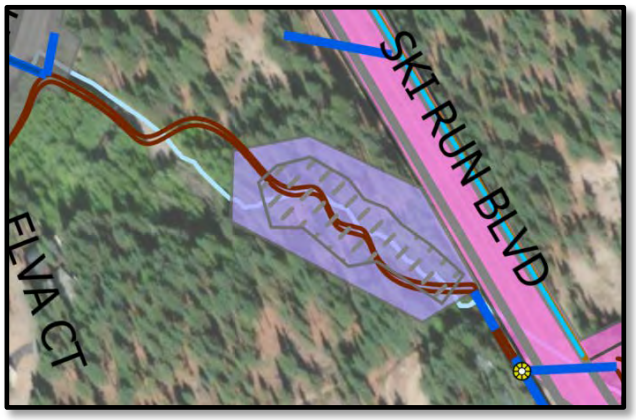


Goal: Flood Alleviation
Opportunity: Limit the capacity of the Bijou Park Creek watershed culvert across Ski Run Boulevard to reduce flooding within the lower Bijou Park Creek meadow. This will also lower the treatment efficiencies of the Osgood Basin. Since it is expected that only during flood events would some flow be diverted down Ski Run Blvd, the actual effect on the annual treatment efficiency of the existing and proposed Osgood basins is marginal, given the short duration and limited occurrence of such events.
Considerations: Adding water to the Ski Run Blvd storm drain system requires building a new stormdrain with potential utility conflicts. In also adds flow to Osgood basin which is currently undersized. A vegetated swale isn't feasible given the cut bank and large conifers that border the east side of Ski Run and a perforated pipe would compromise the integrity of the roadway.

Description: Limit flow in Ski Run Blvd culvert and divert down Ski Run Blvd to subsequently limit flow in Bijou Park Creek.

Construction Activity: Install new underground 24-inch pipe or asphalt swale along east side Ski Run Boulevard. Construct new vault at inlet to configure split flow. Upgrade pipe or install culvert at David Lane crossing. Tie into existing 30-inch storm drain pipe at Pioneer Trail. Requires trenching, pipe installation, backfilling and paving within the ROW. Up to 6 weeks of construction.

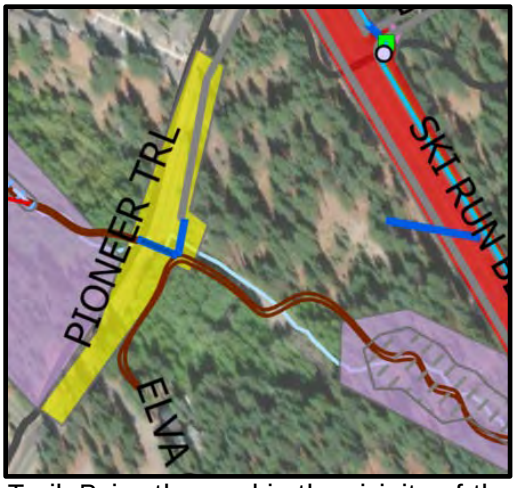
Upper Bijou Park Creek



Goal: SEZ enhancement and water quality improvement
Opportunity: Restore creek function and prevent further incision and limit excessive sediment transport along a steep reach of the creek
Considerations: Sensitive habitat with challenging access.
Description: Remove remnants of gabion structures and install cascade boulder step pools to restore stream gradient.
Construction Activity: Localized excavation and boulder placement. Biotechnical bank stabilization treatments. Two to three weeks for construction.

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Pioneer Crossing Culvert



Goal: Flooding Alleviation and Water Quality Improvement

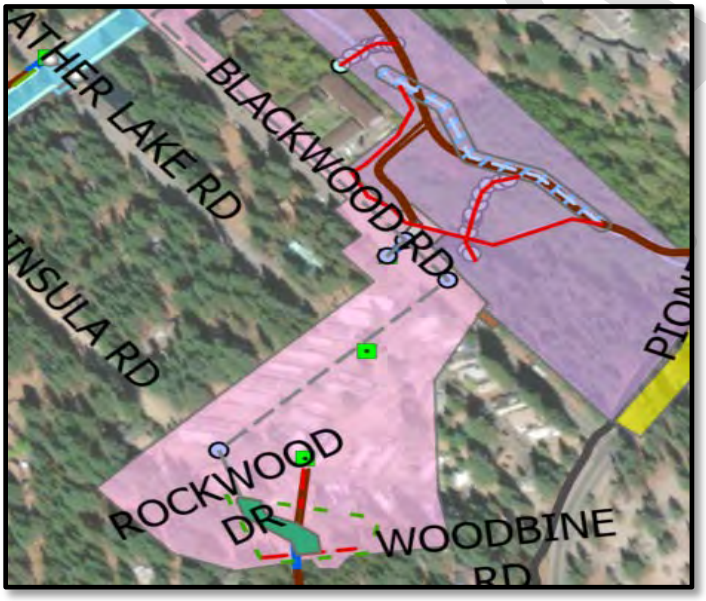
Opportunity: Flooding occurs at intersection between Charlesworth Court and Pioneer Trail due to an undersized and silted in culvert installed in 1987.

Considerations: Gas lines and a sewage gravity main are buried near and perpendicular to the culvert crossing alignment. Conveyance needs to be maintain along a private Charlesworth Ct residence.

Description: Replace culvert crossing Pioneer Trail at Charlesworth Court and incorporate pre-treatment. Current pipe is undersized and causes flooding of Pioneer Trail. Raise the road in the vicinity of the crossing to eliminate ponding and road surface degradation.

Construction Activity: Requires trenching, pipe placement and backfilling in ROW, grading and paving and traffic control with 2 to 3 weeks of construction.

Rockwood to Blackwood Ave



Goal: Flood Alleviation

Opportunity: Frequent flooding occurs near Woodbine Rd and Rockwood Dr. The flow is then directed North eastward under the trailer park and subsequently under Blackwood Rd where it outfalls into a USFS parcel joining Bijou Park Creek. Backwater effects occur at the submerged outfall causing flooding in the trailer park. Reduce flooding on Rockwood Drive and in the Heavenly Valley Mobile Home Park. Improve water quality by reducing flooding in the Heavenly Valley Mobile Home Park, which will also reduce stormwater capture of urban pollutants.

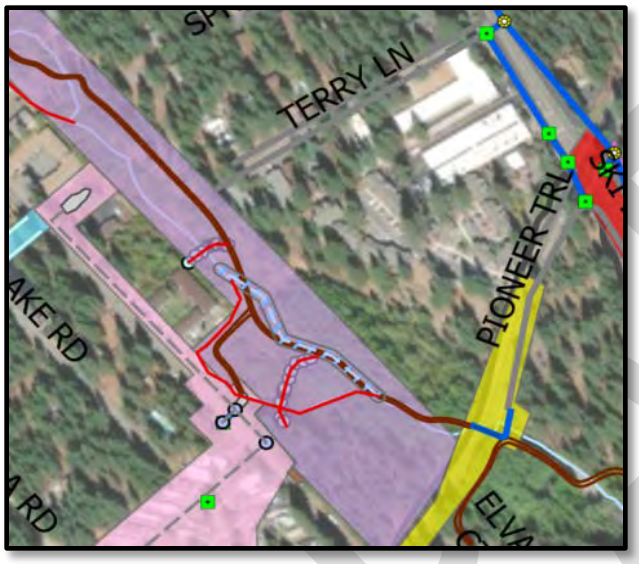
Considerations: The existing trailer park at the intersection of Blackwood Avenue and Pioneer Trail and along Woodbine Avenue and Rockwood Drive is on nearly level ground and is especially prone to flooding since the outfall of the local storm drain serving that area is submerged well below Bijou Park Creek, allowing water from Bijou Park Creek to flow backward within the existing culvert under the trailer park. Construction of a new trailer park outfall will prevent the backwater effects associated with the currently submerged outfall and will greatly reduce flooding within the trailer park. It may not eliminate flooding in the vicinity of Woodbine Avenue and Rockwood Drive given

the slightly higher elevations in that area which will have a greater influence on the extent of flooding there.

Description: Decommission portion of Rockwood Drive and install vegetated swale to convey 100-year flow to new concrete vault/drop structure. Install subsurface 18 to 24 inch RCP along roadway within Mobile Home Park. Cap and abandon existing pipe within Mobile Home Park. Extend new pipe (or convey via roadside ditch) down Blackwood to daylight onto SEZ at Spruce Avenue.

Construction: Requires swale excavation, grading and revegetation, trenching, pipe placement, backfilling and paving. Approximate 6 week construction period

Bijou Park Creek Meadow Restoration



Goal: SEZ Floodplain Enhancement and Water Quality Improvement

Opportunity: Bijou Park Creek Meadow is a functioning SEZ with floodplain areas that provide effective water quality treatment, however channel alterations and cross-valley berms installed many years ago alter flow and redirect in areas where the berm has degraded. Eliminating the artificial reaches and restoring an appropriately sized central channel hydraulically connected to its floodplain will allow for continued sediment deposition and help reduce the backwater flooding effect on the Mobile Home Park.

Description: Restore natural function of stream and meadow by removing man made barriers to flow and perform minor regrading, revegetation and install biotechnical floodplain roughness features where beneficial to hydraulically reconnect the main channel to floodplain, activate secondary channels and avoid private property.

Considerations: The Bijou Park Creek Meadow, which has a persistently high water table and is a high-functioning SEZ is not an appropriate location for stormwater treatment facilities such as treatment basins. The outlet from the trailer park is below creek level and the creek's presence causes backwater and flooding into the trailer park and all the way to Rockwood Dr.

Construction: Decommission west channel section. Construct new central channel section. Install log/willow floodplain roughness features. Breach or remove cross-valley berms and replace with buried rock/log and willow installations to hold grade. Replace road crossing culverts. Requires excavation, backfilling and site grading and some hauling of material. Trenching, pipe installation and backfilling in ROW. Approximately 6 to 10 week construction period

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Bijou School Basin



Goal: Water Quality Improvement and Flooding Alleviation

Opportunity: Shoulder ponding during storm events creates unsafe conditions in the neighborhood and around the school. Improve drainage by retrofitting an existing infiltration basin at SE corner of Spruce Avenue and Peninsula Road.

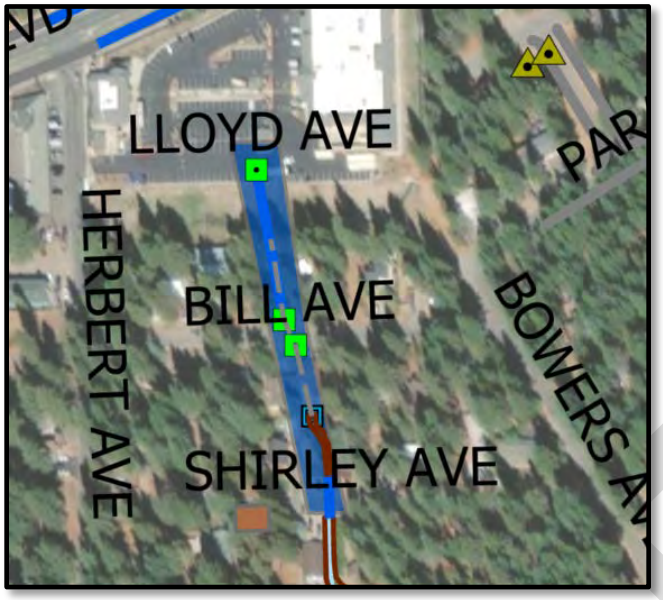
Considerations: Future multiuse paths are desired by the community along Spruce, connecting to various neighborhoods so stormwater improvements are designed to be compatible with 10-12' wide paved paths. There are many utilities in the soft shoulder on the NW side of Spruce where these paths will likely be placed.

Description: The preferred design will retrofit an existing basin on CTC property to create an infiltration basin with a shallow ponding area (a maximum of 2' in water depth) and a footprint no larger than 3,000 sq. ft. The swale entering the basin will also be regraded and resurfaced using rock, vegetation, or open cell pavers. The basin will overflow via a new sediment can/riser to the existing storm drain pipe that flows under the soccer field to a branch of Bijou Park Creek. The surface of the proposed rehabilitated basin will match the existing native vegetation that currently covers the parcel. Curb and gutter will be extended along Spruce to the northeast all the way to the intersection with Blackwood. Approximately 1,200 feet or rolled curb will be added. New curb and gutter on the south side of Spruce may have curb cuts with rock armoring to access the proposed basin. 6-8 drop inlets will be added within the road prism – the pavement of the road will have to be re-done and crowned per City standards and to send runoff into the gutter pans and associated drain inlets. Associated pipes will be added between the drainage inlets and along the south side of Spruce to send water to the basin. The pipe and outfall to the existing Bijou Park Creek tributary drainage will remain as is. The north side of Spruce will receive shoulder stabilization treatments in up to 4 areas for a total length of 700 feet. The shoulders are currently a sediment source and rock or vegetation could be used to stabilize the shoulders. The school should be coordinated with to maintain street width and overflow parking as necessary on stabilized shoulders where parking currently occurs. Open cell pavers may be used for shoulder stabilization in these areas.

Construction: Requires pipe trenching, installation and backfill, asphalt and concrete work for roadway, curb, gutter and drain inlets, and swale and basin excavation, grading and revegetation. 2 to 3 weeks construction period.

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Shirley to Whole Foods



Goal: Alleviate Flooding

Opportunity: Expand storm drain capacity between Shirley Ave to where it outfalls in the SEZ behind Whole Foods. The current 24" diameter pipe is undersized and the principal cause of flooding on Bill Ave, Shirley Ave, and upstream where homes are directly adjacent to the stream.

Considerations: Stormdrain is on private property and installation of culvert would cause land impacts during construction. Existing channel may need to be modified in a way to prevent excessive willow growth. Due to the proximity of private property this is a very challenging project as it requires the cooperation of landowners and most likely the acquisition of adjacent properties.

Description: Possibly expand conveyance of open channel starting at Shirley to where it enters pipe. Replace undersized 24-inch pipe with appropriately sized pipe from this location to daylight at new SEZ at Bijou Park Marketplace. Requires possible utility relocation, trenching, pipe placement and backfill, paving and concrete work.4 to 5 weeks for construction.

Osgood Basin Expansion



Goal: Improve Water Quality

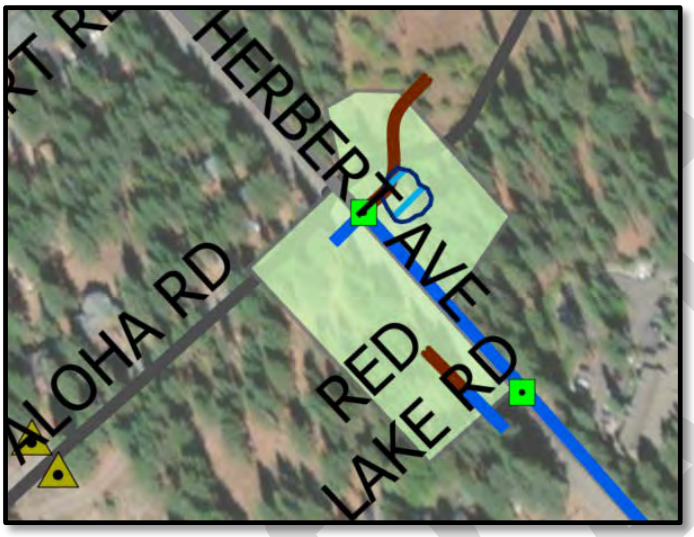
Opportunity: Construction of a new stormwater treatment basin to the east of the existing Osgood Basin will greatly benefit stormwater quality, especially in conjunction with construction of the Keller Canyon bypass.

Considerations: The undeveloped parcel to the east of Osgood Basin is approximately two feet lower than the Osgood Basin outlet, such that any stormwater routed to a new basin must be routed to the Wildwood Basin, thereby potentially increasing the flooding potential there. Because the low point along the edge of that parcel is 2.1 feet lower than the existing basin outlet weir, flows routed into a new basin cannot be drained out of the existing basin but must instead be routed over to the Wildwood basins to the east. As a result, there will be an increased flooding potential there. Subsurface investigation showed 4ft (?) to groundwater which is directly affected by lake level.

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Description: Expand the size and treatment capacity of Osgood Basin by installing a shallow wetland treatment area within the parcel to the east and connect to neighboring Wildwood Basin allowing it to accommodate increased flows from the Ski Run Diversion.
Construction: Install low flow bypass to east side of Osgood Basin and expand wetland area. Install a new piped overflow to tie into Wildwood Basin inlet. Requires shallow excavation, grading and revegetation, pipe trenching, placement and backfill, and paving. Approximate 8 week construction period

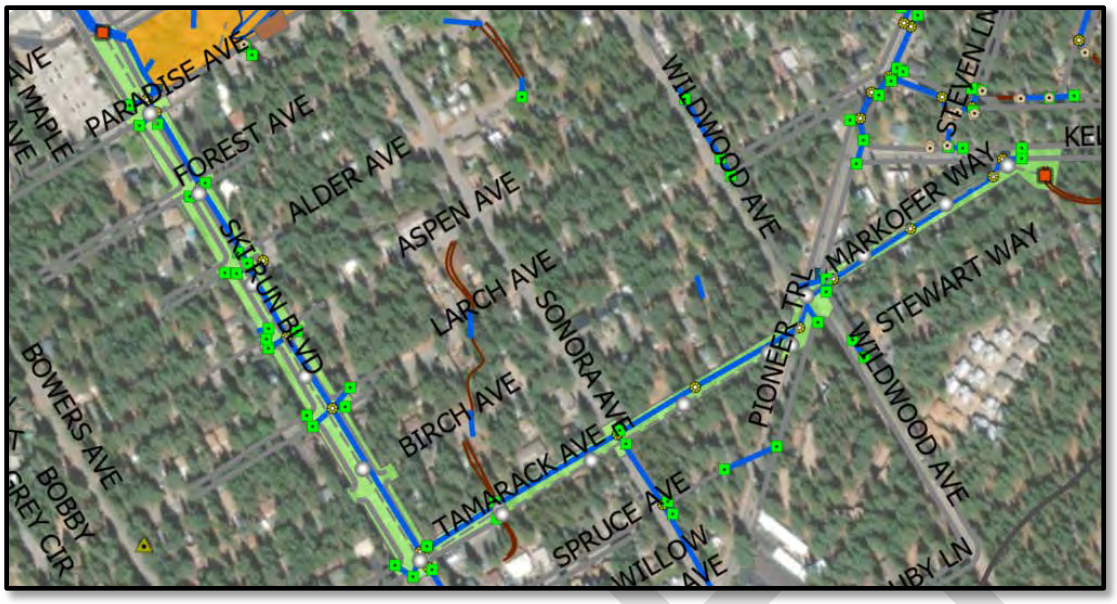
Aloha Basin



Goal: Improve Water Quality
Opportunity: The goal of this basin is to achieve water quality improvement for Lake Tahoe by capturing fine sediment particles as dictated by the Lake Tahoe TMDL. Preference is for offline infiltration basin due to focus on Lake Clarity Credits and flat topography.
Considerations: The proposed Tahoe Greenway Bike Path alignment crosses the existing drainage path.
Description: The preferred location for the basin is uphill of proposed Tahoe Greenway Bike Path. Approximately 3,000 sq. ft. of disturbance area is possible including utilization of the existing channel from the back of an existing drainage inlet. Minimum pipe size per CSLT standards is 18" and up to 2 18" pipes will be installed. Basins will be shallow to maximize Lake Clarity Credits in PLRM (up to 6 credits available). Basin volume is only 800 cu ft., but disturbance area is up to 3,000 sf to keep basins shallow due to class 1B land capability. Basins will be vegetated to match surrounding vegetation. If basin cannot be offline and flow back to the existing drainage inlet, the basin will outlet to the existing channel. The existing channel will be used as an emergency overflow if the basin is offline. Some rock will be needed in the existing channel for energy dissipation.
Construction: Construct new shallow basin. Install new18-inch pipe. Requires excavation, grading, pipe installation, backfilling and revegetation. Approximate 2 week construction period

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Keller Canyon Bypass



Goal: Improve Water Quality

Opportunity: Runoff from Keller Canyon is largely free from stormwater pollutants. The delivery of Keller Canyon runoff into the Osgood Basin reduces the pollutant removal efficiency there. The only stormwater treatment facility serving most of the urban area in the watershed is Osgood Basin, which is vastly undersized. Installing a new storm drain to convey Keller Canyon flows past the Osgood Basin would effectively reduce the contributing area to the basin by 28 percent. The objective of the bypass is not primarily to prevent the comingling of clean and polluted stormwater being discharged to the lake, but to reduce the influent flow rates into the Osgood Basin, which will increase the pollutant removal efficiency there. With a bypass in place, the pollutant loading rates into Osgood Basin will increase, which should also increase the basin's pollutant removal efficiency.

Considerations: Construction of a new underground pipe would require coordination with existing utilities.

Description: The preferred design will separate clean water originating from the upper watershed from untreated stormwater originating from residential and multifamily neighborhoods with a proposed 36" reinforced concrete stormwater pipe. This design will allow for more efficient removal of pollutants by the existing Osgood stormwater basin. The proposed pipe will begin in a proposed vault at the corner of Keller Rd and Markoffer Rd at the outlet of an existing rock lined channel. The proposed pipe will be installed adjacent to the existing pipe, which varies in size from 36"-48", in an alignment that minimizes potential utility main and later conflicts. The proposed pipe will be approximately XXX linear feet and need approximately 16 manholes at bends and to meet the City standard of 400-foot minimum placement. The proposed pipe will end in a vault proposed to be placed on the existing southernmost outlet pipe of the existing Osgood basin.

Construction: Install new underground 36-inch pipe following existing SD pipe alignment. Requires potential utility relocation, trenching, pipe and manhole installation and backfill, and paving. Approximately 8 week construction period

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30% Conceptual Designs by Project

The individual project elements introduced above were developed into 30% detail level concepts as described here and presented in the Bijou Park Creek Watershed Restoration 30% plan set that accompanies this report. Additional information on calculations supporting the design is provided in Appendix X. The underlying base map for the 30% plan set incorporated the following elements:

- 2010 Lidar topographic contours.
- Aerial images.
- GIS files provided by the CSLT of the stormdrain and roadway network, parcel boundaries, and drainage catchment areas.
- APN parcel labels.
- GIS files provided by STPUD of potable water and sanitary sewer utilities.
- Digitized utility locations based on PDF files provided by Liberty Utilities, Southwest Gas, Charter Communications and AT&T.
- TRPA land capability designations.

Needle Peak Localized Treatment

Description

In order to capture the larger sediment particles before they make their way down to Bijou Park Creek this project provides localized pre-treatment opportunities in the form of sediment traps or what is commonly referred to as “sed cans”. The sediment trap installations provide localized infiltration and deposition opportunities in and amongst existing conveyance channels and curb and gutter networks. These were selected in lieu of perforated pipes which aren’t a workable design for the majority of Bijou Park Creek project areas given they can promote road degradation in paved conveyance areas and in the less dense areas open water surface channels were a better choice.

Eight sediment traps set within rocked depressions for collection and increased infiltration opportunity are proposed at key locations along the main sanding route to Heavenly Ski Resort at and above Needle Peak. One critical installation is at the corner of Needle Peak and Ski Run that will be installed to intercept and pretreat runoff from the flowline on Ski Run above by positioning at the end of a rock-lined swale and inlet to the culvert crossing Needle Peak.

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Water Quality

This project will provide effective localized pre-treatment opportunities that should be easy to maintain.

Flooding

This project doesn't have any significant impact on flooding alleviation.

65% Design Tasks

- Field survey proposed sediment trap locations with a focus on adjacent gutter and pipes inverts in order to identify the correct tie in elevations
- Survey/map utilities in vicinity of proposed sediment traps and pothole if necessary

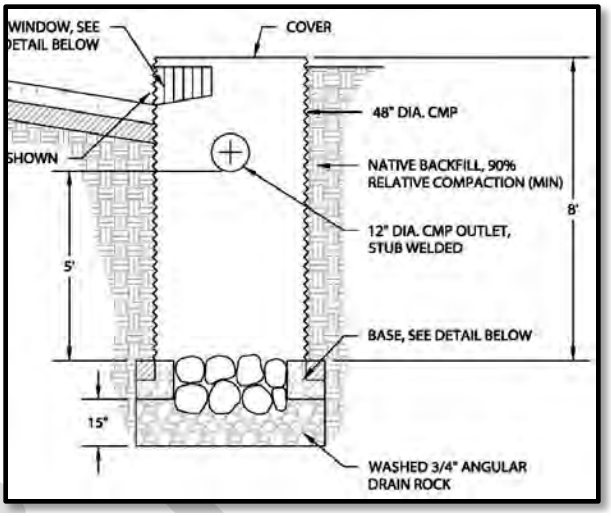


Figure 17. Typical Sediment Trap (can)
(Source: TRPA BMMP Handbook)

- Consider double sediment trap configurations and more sizeable rocked depressions for increased infiltration and pretreatment opportunity where there is available area.
- Confirm installation configurations will allow for easy maintenance access.

Ski Run Diversion

Description

As stated earlier, the goal in this location is to limit the flows from Bijou Park Creek from passing under Ski Run Boulevard and continuing down the main drainage to the lower problematic flooding areas by diverting a portion of the higher flows down Ski Run Blvd east. The diversion will alleviate flooding from Rockwood through the Heavenly Valley Mobile Home Park to Blackwood Road and along Bill and Shirley avenues. Expansion of Osgood Basin is needed in combination with the Ski Run Diversion given the increased flows and likely increased loading to the basin that is already undersized for adequate treatment albeit inclusion of the Keller Canyon clean water bypass offsets this demand.

Initial design options considered to achieve flow redirection in this location included the following:

- Constrict the existing culvert entrance, similar to what was recently done under an emergency situation and allow the water to rise and enter a new stormdrain pipe set at a slightly higher invert elevation to convey flow down Ski Run Boulevard.

- Replace and downsize the existing culvert from 24-inches to the minimum City standard size of 18-inches and configure in a vault with a new storm drain pipe invert set at a slightly higher elevation to convey flow down Ski Run Boulevard.

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Field investigations of the open channel that drains from Needle Peak to the existing 24-inch pipe inlet at Ski Run revealed a high degree of incision with several head cuts resulting in upwards of a 16 foot drop over 90 feet (Figure 18). As evidence of this the inlet of the existing pipe is roughly 9 feet below the road shoulder on Ski Run Blvd. Given that a new approach was developed to restore and regrade the open channel between the Needle Peak and Ski Run culverts to a more natural grade and thereby raise the culvert inlet at Ski Run approximately 2.5 feet. With this design approach there is the option to redirect the overflow down Ski Run Blvd east by either a subsurface pipe (Option 1) or surface flow via the curb and gutter (Option 2).



Figure 18. Drainage between Needle Peak and Ski Run Blvd: (Left photo) Needle Peak outlet and channel headcut. (Center) another channel headcut, (Right photo) Looking down from Ski Run Blvd at bottom of channel plunge pool and modified/reduced inlet to 24-inch CMP.

The 10-yr peak flow is 9.0 cfs and 100-yr 25cfs. So to split flow for concept designs the assumption was made that the 10-year or less would still be conveyed across Ski Run Boulevard to remain within Bijou Park Creek and any flows in exceedance of the 10-yr event, or upwards to 16 cfs would be redirected down Ski Run Blvd east where there are far fewer utility conflicts. Calculations showed a 24-inch diameter pipe would be sufficient to convey the additional overflow (Option 1). Option 2 would be to allow the overflow from a 10-year event or greater to spill over into the existing rolled curb and gutter along the east side of Ski Run given the road itself is wide and steep (~ 4 percent) and could potentially convey the less recurrent overflows. As a quick check to determine if the road and gutter could convey the 100-year, 16 cfs flow the road and gutter conveyance was considered at half full (1/4 of the road) and full flow (1/2 of the road). Under a half full scenario assuming a 3 inch depth at the curb there is 12 cfs of flow at 5 feet per second (fps). Under a full flow scenario assuming a 6 inch depth at the curb the flow is 58 cfs at 12 fps velocity, therefore a 16 cfs flow would be conveyed along an area slightly wider and deeper than the half full (or ¼ of the road) scenario demonstrating that the road and gutter have decent capacity to convey the flow, however there could be implications down drainage at David Lane and Pioneer given how fast the water will be moving. Currently both options are shown on the plans for consideration.

Option 1 requires roughly 124 linear feet of 18-inch HDPE pipe across Ski Run Blvd and 1380 linear feet of 24-inch HDPE pipe down the east side of Ski Run Blvd to connect via a new vault to the existing 30-inch storm drain pipe at Pioneer.

Water Quality

Decreases treatment efficiency at Osgood Basin by increasing the flow during storm events, however this can be offset by the decrease in flows to Osgood Basin via Keller Canyon clean water bypass project element. Provides some water quality improvement by stabilizing the incised surface water channel between Needle Peak and Ski Run.

Flooding

Decreases flooding along Bijou Park Creek by diverting flows over the 10 year event.

65% Design Tasks

Dependent upon whether Option 1 or 2 is carried forward, the following items need further consideration or action during the next stage of design.

- The current alignment across Ski Run Boulevard terminates within private property and the pipe slope is quite steep. Given this a new cross-street alignment for the 18-inch pipe should also be considered further down Ski Run to enable a gentler pipe slope and have the terminus tie more directly into the open channel within public property and avoid the private parcels all together. This would require the east vault to be relocated further down (northward) Ski Run Blvd to accommodate the split flow in the vicinity of the public owned parcels combined with upsizing the pipe segment up drainage. This alignment is currently shown as a dashed optional alignment in the plans.

- A field topographic survey should be done of the open channel section to develop a more accurate profile and cross-sections on which to overlay the 65% designs.
- Once Option 1 or 2 are chosen a pipe or curb and gutter profile and downstream vault detail can be added to the plans.

- The adequacy of the 30-inch pipe at Pioneer to convey the additional flow should be checked moving forward to 65% design development. The pipe sizes above Pioneer should be further refined as a check to see if they could be further downsized and still meet the conveyance requirements.

- If Option 2 is moved forward, the shoulder and gutter conveyance capacity should be analyzed in more detail. The rolled curb and gutter may need to be replaced with a standard vertical curb and gutter to provide for increased depth and capacity.

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Upper Bijou Park Creek

Description

Gabion structures and rock checks constructed over thirty years ago within this steep reach of Bijou Park Creek between Ski Run Boulevard and Charlesworth Court are largely gone or no longer functional and the reach has since undergone significant incision and widening in this area (Figure 19) that likely led to some of the sediment deposition visible in the swales and at the culvert crossing at Charlesworth and Pioneer below.

To restore and stabilize this reach over the long term, large boulders and possibly logs would be configured and keyed in to function as cascade boulder step pools allowing high energy flows to pass through without eroding the streambed or banks.

Water Quality

Interrupts channel degradation and resultant erosion and sediment transport, thereby improving water quality.

Flooding

Has no negative impact on flooding potential and provides a more stable surface water channel.

65% Design Tasks

- Survey channel reach to develop more accurate profile and cross sections for designs
- Determine construction access location that will be the least impactful
- Develop optimum channel slope and size and space boulder weirs accordingly

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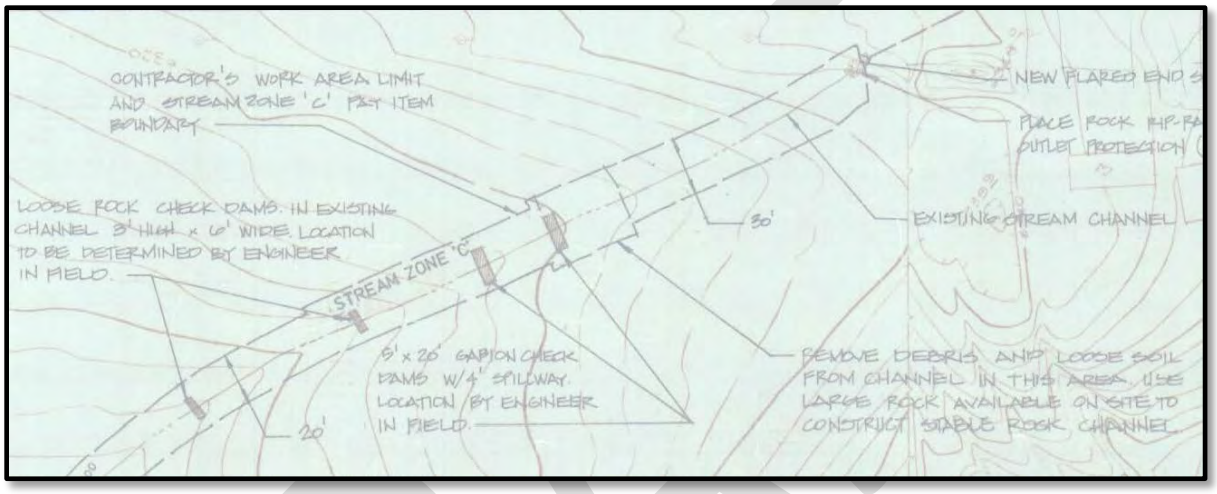


Figure 19. (Photo left) incised and widened channel section (photo below) scanned plan of rock checks and gabions installed in the late 1980s (*Source: Brown and Caldwell*).

Pioneer Crossing Culvert

Description

The existing 24-inch pipe at Charlesworth Court and Pioneer Trail Road is undersized and silted in causing nuisance flooding of Pioneer Trail. Upper Bijou Park Creek flows into the terminus of Charlesworth Court at the S/E end. Here the flow splits into a primary flow channel along a heavily vegetated swale/ditch on the east side of Charlesworth Court and secondarily (higher overflow) along the west side of Charlesworth Court where it enters a more distinct rock-lined and vegetated swale/ditch roughly 40 feet before the intersection with Pioneer. The swale on the east side of Charlesworth Court ties into an 18-inch corrugated metal pipe (CMP) that crosses Charlesworth Court westward and ties into the 24-inch CMP that crosses Pioneer Trail. It is assumed this 18-inch pipe ties into the 24-inch pipe that crosses Pioneer Trail given observed continuous flow upstream and downstream of Pioneer however the connection is not visible in the field due to the amount of deposition around the 24-inch pipe. The west swale drainage along Charlesworth Court enters the 24-inch pipe just upstream of where the pipe is secured by a small asphalt-capped berm. Just downstream of this berm, the 24-inch pipe has an opening cut into it to receive flows via the 18-inch CMP underneath Charlesworth Court and from the vegetated swale along the south side of Pioneer Trail. The degree of siltation is most noticeable in this location. The 24-inch pipe outlet on the north side of

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Pioneer Trail is also silted in with flows re-entering a surface water channel in the Bijou Park Creek SEZ. Neither pipe appears to have sufficient cover per City standards.



Figure 20. Pioneer Crossing Photos: (Upper left) Inlet to 24-inch pipe at berm on west side of Charlesworth Ct. (Upper right) Opening in 24-inch pipe between berm and Pioneer Trail Rd crossing, confluence of flows. (Lower left) ~18-inch culvert inlet on east side Charlesworth Ct. (Lower right) Looking south across Pioneer Trail towards Charlesworth Ct along 24-inch pipe alignment, note vegetated swales conveyed to 24-inch pipe from three locations.

Per calculations summarized below the existing culvert needs to be upsized to the equivalent of a 30-inch pipe. Pipe arch culverts and low wide box culverts were first considered to minimize the extent the road would need to be raised and reduce conflicts with the high density of utilities in the area. The road is proposed to be raised one to two vertical feet in the vicinity to further alleviate ponding and road degradation. The new pipe(s) designs will need to be compatible with the proposed California Tahoe Conservancy's (CTC) SLT Greenway Bike Trail alignment that runs along the north side of Pioneer Trail which will require a bridge or culverted crossing in this location. The land in this location is private however it is understood that the CTC has negotiated an easement with the landowner to construct and maintain the bike path.

Peak flows at this location were determined to be 10 cfs and 30 cfs for a 10-year and 100-year recurrence event respectively requiring a 30-inch pipe to convey a 10-year peak flow with no head.

Following further team discussion and field investigation in summer 2020 which revealed the degree to which the east Charlesworth swale channel is the primary channel the design was modified to split the conveyance into two locations across Pioneer Trail. An 18-inch pipe will remain across Charlesworth Court in order to divide the high flows that primarily come down the east side and provide for continued late season flow into the existing SEZ channel north of Pioneer. In order to sufficiently convey the anticipated peak flows and account for future siltation and preferential flow, two-24- inch pipes are proposed to be installed across Pioneer, one in a similar location as the current 24-inch culvert and the other in direct alignment with the east Charlesworth swale channel. The 18-inch cross culvert invert will be set slightly lower than the east Pioneer Trail 24-inch culvert invert so that the current channel and SEZ will continue to receive a portion of the late season low flow. The new east 24-inch culvert across Pioneer Trail will daylight into a heavily vegetated SEZ where discharge of these split high flows shouldn't cause damage and addition of late season flows will provide a watering benefit. The length of both new 24-inch pipes on the north side of Pioneer will be extended as appropriate through the design development process in order to accommodate the proposed CTC bike path and the outlets will have appropriately sized rock armoring to prevent any erosion or channel incision.

Given the amount of sedimentation observed in the vicinity of the existing 24-inch culvert on the west side, double sediment traps inset within a rock-lined depression or sump are proposed. A slot opening on the west trap will convey the south Pioneer swale drainage and a slot opening on the east trap will convey the west Charlesworth swale drainage. The 18-inch cross Charlesworth pipe inlet and the 24-inch west Pioneer culvert pipe outlet would tie into the east sediment trap.

Pioneer Trail Road is proposed to be raised 24 to 26 inches in the vicinity of the culvert crossings to provide for the required 8" of Class 2 AB and 18" of cover above the new culverts while eliminating the chance of disturbing existing utilities. Road raising and resurfacing will extend over an approximate 400 foot section to tie into existing grades to the east and west.

Construction Activities: Construction equipment could include pavement saws, dump trucks, excavators, backhoes, rollers, and similar equipment. Specialized equipment with low pressure tracks would be used off pavement to limit soil and vegetation disturbance. Lane closures with detours are possible. Construction activities will take up to 6 weeks to place improvements.

Staging Area: The main staging area would be located at the end of Charlesworth Ct on 4,000 square feet within the paved surface. This portion of the road does not provide access to any residential property and is owned by the CTC, parcel (028-141-046).

Water Quality

A small improvement to water quality will be made by incorporating a sediment trap (can) within a rocked depression at the west Pioneer culvert inlet.

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Flooding

Eliminates flooding by replacing the undersized and silted in 24-inch culvert at the intersection between Pioneer Trail and Charlesworth Court with two 24-inch culverts aligned with the drainages along Charlesworth Court and raising the roadway.

65% Design Tasks

- An additional culvert pipe on Ski Run that is believed to outlet to a small drainage northwest of the Bijou Park Creek channel and tie into Charlesworth Ct east swale needs to be further explored, mapped and integrated into the design.
- Field survey the channel above Charlesworth, the swales along Charlesworth and the culvert outfalls to the SEZ and model to validate flow volumes and routing.
- Conduct additional field reconnaissance of the new east culvert outlet drainage path to ensure this SEZ area has the right conditions to receive redirected flows
- Survey/map utilities in vicinity of proposed culvert crossings.
- Develop grading plan for roadway.
- Produce profiles for culvert crossings and roadway section
- Size/dimension rocked basin/sumps at culvert inlets.
- Pothole utilities in close proximity to culvert crossings.
- Continue to collaborate with Conservancy in order to adjust culvert outfall designs to be compatible with future bike path.

Rockwood to Blackwood (Heavenly Valley Mobile Home Park)

Description

The City is in the process of acquiring a parcel at the terminal end of Rockwood Drive. Since driveways and home access is only necessary for the first 100 feet of Rockwood Drive, the preferred alternative would remove approximately 150 feet of pavement and the existing culvert that travels beneath Rockwood Drive and install a turnaround for emergency vehicles and restore the remainder of the area to a native landscape with a wide swale to convey the existing drainage. Within the City right-of-way and the CTC parcel adjacent to Rockwood Drive, a 10 to 15 foot wide swale will be constructed to replace the existing channel and take a longer path that allows flow spreading. The channel would flow into a 24" HDPE storm drain near the boundary of the CTC parcel and the Heavenly Valley Mobile Home Park. In addition to the swale, grading will occur up to and around the existing residence that will be remove to create positive drainage towards the storm drain. Total disturbance from the grading will be approximately 18,600 SF with a net cut of approximately 410 cubic yards. This area will be vegetated with native vegetation and some existing trees and stumps will need removal. The existing channel on the CTC parcel will be decommissioned during the channel construction. Unused pipes will be capped with concrete in the vicinity of the Mobile Home Park and removed if under a City street.

610 feet of 24" dual-wall HDPE will be installed from the southern parcel boundary of the mobile home park to the northern boundary at Blackwood Road. The existing stormwater collection system for the mobile home park will be tied into the proposed 24" RCP using a manhole near the entrance to the

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mobile home park. Upon reaching Blackwood Road, the storm drain will then head north for 650 LF on the western edge of Blackwood Road to the intersection of Blackwood Road and Spruce Avenue where it will then cross the road and outlet on a parcel owned by the US Forest Service. The storm drain on Blackwood will be 24" HDPE for 394 LF and then be 24" RCP for the last two segments of pipe where coverage over the pipe will be less. Five 48" minimum diameter stormwater manholes will be necessary for turns throughout the entire line.

At the outlet a 225 LF vegetated drainage channel will be constructed out to the main drainage channel on the parcel to the east. The outfall into Bijou Park Creek's riparian area will be channelized and armored with rock and vegetation as needed.

A secondary outlet option has been identified at a privately-owned, undeveloped parcel on Blackwood Road located at APN 027-331-015. If a public entity can acquire the parcel or a drainage easement at this location, a shorter storm drain alignment could outlet to this parcel or run a storm drain to the Bijou Park Creek riparian area. Due to topography and the shorter storm drain alignment, this parcel would likely provide a superior location to route stormwater through than the US Forest Service parcel.

Local runoff on Blackwood is not addressed in this project and could be looked at with a future design iteration, specifically adding curb and drain inlets that connect to the proposed system. Furthermore, if pipe cover or lack of positive slope becomes an issue during future design iterations, a pipe alignment from the end of the new proposed channel at Rockwood through the corner of the Mobile Home Park and out Peninsula Avenue to the Bijou School outlet could be considered, but additional analysis is needed on the outlet and channel past the Bijou school.

Water Quality

This project will improve water quality by reducing flooding in the Heavenly Valley Mobile Home Park, which will thereby also reduce the collection of urban pollutants and sediments by stormwater.

Flooding

This project is designed to reduce flooding on Rockwood Drive and in the Heavenly Valley Mobile Home Park. As well, local flooding upstream of the project on Woodbine Road may be reduced better conveyance of storm water through the local watershed.

65% Design Tasks

- Survey/map utilities
- Find and map all utilities in mobile home park
- Pothole utilities at connections and crossings
- Complete additional survey at potential outfalls into the meadow
- Approach CTC/property owner about acquisition/easement
- Finalize feedback from CTC/City Fire and Police on turnaround at Rockwood
- Parcel boundary confirmation at Blackwood and for Mobile home park
- Special use permit for USFS
- Consider contribution of runoff on Blackwood and tying into system/shoulder stabilization

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- Reexamine backwater/tailwater boundaries in conjunction with changes to Bijou Park Creek

Bijou Park Creek and Floodplain Enhancement

Description



Figure 21. Straightened channel section along Blackwood Rd looking N/W.

Bijou Park Creek Meadow/SEZ has likely aggraded since the 1987 Wildwood Erosion Control Project elements were installed to promote deposition along the valley profile resulting in a high groundwater table and recurrent overbank opportunities today. Generally these results are a positive in regards to water quality treatment opportunities however the artificial nature and age of these installations (>30 years old) have introduced issues that are beginning to outweigh the benefits. For example the redirection of Bijou Park Creek to the west towards Blackwood has resulted in a straightened and narrowed channel (Figure 21) with un-natural ninety degree bends in the vicinity of Blackwood and the apartment complex downstream from the Heavenly Valley Mobile Home Park. This is a far cry from the likely braided channel condition that existed prior to development and is only exacerbating the flooding issues along Blackwood Avenue.

In order to maintain high groundwater levels and promote continued channel overbank and deposition opportunities in the floodplain further from developed areas and within a more geomorphically functional landscape this design would do the following:

- Backfill to eliminate the channelized section that veers towards Blackwood and restore a more centralized channel section as needed along this section.
- Regrade the areas along the backfilled channelized section to raise the areas immediately adjacent to the roadway and apartment complex one to two feet.
- Breach in target locations or eliminate the cross-valley berms and remove and dispose of the degraded asphalt spillway caps.
- Install large log and willow trenching/fencing within the footprint of any removed cross-valley berms and interspersed within the meadow surface to provide floodplain roughness and prevent any channel downcutting.
- Salvage and reuse willow root balls, willow stakes, wetland sod and native topsoil material in the designs.

The proposed new east culvert at Pioneer Crossing provides an opportunity to have a second easterly flow path that can tie into the centralized channel providing more overbank opportunities away from

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the Blackwood Rd area. Given the LiDAR surface run in the hydraulic model described earlier didn't have representation of the primary channel and flow paths that currently exist due to their small size, this design remains more conceptual until a more comprehensive topographic survey of the meadow and channel can be performed and the hydraulic model rerun. The Existing Conditions Vegetation (Appendix X) makes note of the quaking Aspen stand and obligate wetland species dominating the SEZ.

As a result of concerns expressed during public comment, this project area was recently expanded further to the northwest in order to include the undersized culverts that convey Bijou Park Creek across Werner Salas and Vanda Lee Way. As mentioned earlier these particular culvert inverts were not surveyed or modeled as part of this phase and so very conceptual designs are still being considered and those options are illustrated in the plans. These road sections and culverts reside within the low gradient floodplain resulting in the culverts becoming obsolete and flows spilling over the road sections during higher flow events. Increasing their capacity will require raising the road which will require a more porous opening of several pipes in parallel in order for the road not to function as a dam and further exacerbate flooding. Retrofitting the roads to function as a seasonal low water crossing is another option being explored at this time.

Water Quality

This project would maintain and likely improve water quality opportunities by maintaining a channel hydraulically connected to its floodplain and increasing floodplain overbank opportunities that stay in the floodplain and therefore don't mix with pollutants from the residential corridor.

Flooding

This project is designed to reduce flooding on Blackwood Drive in conjunction with the Rockwood to Blackwood project efforts.

65% Design Tasks

- Conduct field topographic survey of the channel, floodplain, secondary channels and culvert inverts from Pioneer culvert outlet to the north side of Vanda Lee Way to support updated modeling and design development
- Map extent of aspen growth (Figure 22) and fine tune plant community mapping to determine areas of avoidance and protection measures.
- Rerun hydraulic model with updated channel and floodplain cross-sections.
- Examine flow input from new east culvert at Pioneer Crossing and incorporate into designs in a manner to allow the creek to find its own path.
- Continue to check compatibility with Rockwood to Blackwood designs.



Figure 22. Aspen grove along a portion of BPC channel before its redirected westward.

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- Install groundwater monitoring wells to inform design and evaluate pre-and post-project conditions.
- Apply for Special Use Permit with LTBMU.
- Determine breach locations of cross-valley berms or full removal.
- Determine material, placement, size and orientation of floodplain roughness features.

Bijou School Basin

Description

The preferred design will retrofit and expand an existing basin on a USFS-owned property across the street from the Bijou School. The design will also include drainage improvements to the Spruce Avenue right-of-way for approximately 670 LF from the Bijou School to the Spruce Avenue-Blackwood Road intersection. Drainage improvements will include the construction of approximately 1,150 LF of concrete rolled curb and gutter, the repaving of Spruce Avenue with the crowning of the roadway per CSLT standards and the installation of a new storm drain system. Five new drainage inlets will be installed in the curb and gutter system, and one existing drainage inlet at the intersection of Heather Lake Road and Spruce Avenue will be retrofitted and connected to the proposed storm drain system. Approximately 575 LF of 18" RCP will be installed to connect the drainage inlets to the proposed basin. Storm drain pipes were designed using the rational method based on time of concentration to handle a 100 year storm.

The design of the basin is based on the goal of creating an adequate design capacity while minimizing the basin's impact area and excavation depths. A primary design constraint is the need to provide inlet and outlet elevations in the basin that allow for stormwater to be conveyed through the proposed upstream storm drain system in pipes with slopes that are designed to handle a 100 year storm and elevations that allow pipes to cross below the existing roadway. The basin, designed using the TRPA BMP Calculator and will have a ponding volume of 125 CY and will be shallow and vegetated with maximum grading of 3:1. It will have a maximum ponding depth of 18" with a total disturbance area of 4,500 SF and a total excavation of 400 CY. The maximum cut of the grading will be 58" and the maximum vertical height from the bottom of the basin to existing grade will be 63". The minimum freeboard height will be 20". Future analysis may consider PLRM in the design volume and surface area of the basin.

A sediment can outlet structure will be installed in the basin to provide overflow when conditions exceed the 18" proposed ponding depth. This outlet structure will outlet to a proposed 18" RCP that will connect to an existing storm drain manhole in the middle of Spruce Avenue. This manhole drains the existing storm drain system to a tributary to Bijou Park Creek located in a ditch adjacent to the school's baseball field approximately 400 feet to the north.

As a part of the proposed project, the north side of Spruce will also receive shoulder stabilization treatments in up to 4 areas for a total length of 700 feet. The shoulders are currently a sediment source and rock, vegetation, or pavers could be used to stabilize the shoulders. The school should be coordinated with to maintain street width and overflow parking/drop-off parking as necessary on

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stabilized shoulders where parking currently occurs. Open cell pavers may be used for shoulder stabilization in these areas and coordination with any future sidewalk or trail projects should be done prior to finalizing the treatments.

Water Quality

Increases water quality by providing localized treatment for stormwater on Spruce Avenue. As well, shoulder stabilization will reduce fine particle sediments in runoff.

Flooding

This project would alleviate flooding and shoulder ponding that occurs on Spruce Avenue.

65% Design Tasks

- Survey utilities and dip all SDMH in street
- Coordinate with school to finalize shoulder stabilization treatment
- Coordinate on potential multi-use paths
- Look into access for outlet drainage behind Bijou Fields – look into potential easements/acquisitions.

Shirley to Whole Foods

Expand storm drain capacity between Shirley Ave and where it outfalls in the SEZ behind Whole Foods. The current 24" diameter pipe is undersized and the principal cause of flooding on Bill Ave, Shirley Ave, and upstream where homes are directly adjacent to the stream.

In order to alleviate flooding by expanding the storm drain capacity between Shirley Ave to where it outfalls in the SEZ behind Whole Foods a 30-inch diameter HDPE pipe is proposed to replace the existing 24-inch pipe with the invert lowered to maintain sufficient cover. Calculations supporting the pipe design are provided in Appendix X. Due to the proximity of private property a new pipe installation in this area remains a very challenging endeavor as it requires the cooperation of landowners and acquisition or easements of adjacent properties.

In order to provide more immediate flood relief recognizing that installing a new pipe could take additional effort and time to work through the land ownership issues, the project boundary was recently expanded to the south to include additional improvements to the surface water channel and floodplain south of Shirley. As can be seen in Figure 23 this area is heavily vegetated with willows resulting in severely reduced flow conveyance and overflow into the street. To alleviate these issues, an improved surface



Figure 23. Channel where high flows avulse (to the right in photo) and add to flooding on Shirley.

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water channel with more wetland sod to prevent significant willow growth is being proposed.

Water Quality

May provide for small amount of water quality benefit via open channel improvements.

Flooding

This would alleviate flooding on Bill Ave, Shirley Ave and upstream.

65% Design Tasks

- Survey/map utilities in vicinity of crossing, pothole as needed
- Survey channel and floodplain further upstream (south of Shirley) to update the hydraulic model and develop designs
- Install two groundwater monitoring wells to inform design and evaluate pre-and post project conditions.
- Develop revegetation specification to direct willow removal and wetland sod planting that will ensure adequate sod growth to outpace and prevent willow growth.

Osgood Expansion (Passive)

In order to take advantage of existing infrastructure the project will expand the wetland treatment area within the eastern publicly owned parcels (i.e. Osgood East) to receive an 8 cfs volume of low flow via dual 8-inch or a single 15-inch pipe(s) installed within the existing berm and set with inlets at the end of the existing concrete forebay. Because the topography to the east is two feet lower than the outlet to Osgood West a new overflow spillway will be positioned on the northeast corner of Osgood East and connect to overflow pipes routed eastward to Wildwood Basin. Due to a high groundwater table, excavation depths will only be one to two feet and an elongated low flow channel will be constructed between the intake pipes and the overflow weir on the northeast end to increase residence time. A subsurface boring collected in this area and presence of obligate wetland species as provided in Appendices X and X give evidence to the presence of the high water table which will support an enhanced wetland feature.

When reviewing some of the prior documents again, there was mention that Osgood East was part of Osgood West at one time and so it may have infilled since then. Given that if Wildwood Basin presents any potential for flooding when accepting Osgood East, the opportunity to reconfigure Osgood West and East in their entirety to avoid overflow to Wildwood should be revisited.

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Water Quality

Increases Water Quality at Osgood since it increases the capacity of the basin. May reduce water quality at Wildwood since it increases loading of that basin.

Flooding

Has the potential to exacerbate flooding at Wildwood and Highway 50 since it increases loading of Wildwood basin. This will be fully examined at the next design phase.

65% Design Tasks

- Survey Osgood East and area over to Wildwood Basin to inform the model and designs.
- Develop and run a hydraulic model to examine whether proposed overflow into Wildwood Basin won't result in any increase to flood potential.
- Re-examine the potential to combine and reconfigure Osgood West and East together to avoid requiring overflow be conveyed to Wildwood.
- Install one to two groundwater monitoring wells to inform design and evaluate pre-and post-project conditions.

Keller Canyon Bypass

Description

Keller Canyon drainage area has very low development and consequently high water quality. This project would divert water to a separate storm drain system that bypasses Osgood basin and rejoins the existing storm drainage system at the outlet of Osgood Basin.

The preferred design proposes a new storm drain that will collect clean water originating in the upper watershed. This water is currently routed through the existing storm drain system that also collects untreated stormwater from urban and residential areas further down the watershed. The clean water will be conveyed through a storm drain approximately parallel to the existing system it is conveyed through and then connect back into the existing system in an existing box culvert in Ski Run Way just downstream of the Osgood Basin. The clean water will be collected from an existing CMP that it is routed beneath the driveway of the Whispering Pines Apartments on Keller Road. A vault will be placed in the shoulder near the intersection of Keller Road and Markoffer Road intercepting the existing pipe. The vault will mark the beginning of the new storm drain system and will also have a weir that will allow overflow into the existing system during large storm events exceeding the 100 year, 24 hour event.

The proposed storm drain was designed using a Q100 of 27.1 CFS and will run in an alignment of approximately 4,040 feet in length. The system will need approximately fifteen 60 inch diameter manholes located at bends and along straightaways where manholes will be placed at appropriate distances to ensure a maximum of 400 LF placement of pipe. The proposed pipes will primarily consist of dual-wall HDPE pipes of 24" and 30" diameter but may also consist of reinforced concrete pipes in

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areas where the depth of the pipe exceeds maximum allowable coverage for HDPE pipes. Due to the significant number of underground utility lines located throughout the project alignment, as well as the relatively shallow depth of the existing storm drain system, the proposed storm drain will generally run below existing utilities and storm drains. Depths of pipes will vary throughout the alignment with depths to the top of the pipe varying from 4 feet to nearly 19 feet.

From the proposed vault, the storm drain will continue in the shoulder to Markoffer Road, where it will cross below the existing storm drain while continuing along in northern portion of the paved road in a southwesterly direction toward Pioneer Trail. The storm drain will briefly head southwesterly on Pioneer Trail, where it will again drop below the existing storm drain. It will then continue along Tamarack Avenue in a southwestern direction in the southern portion of the paved roadway, as it heads towards Ski Run Blvd. Between Sonora Avenue and Ski Run Blvd, the alignment will be briefly routed in the northwestern direction, crossing below an existing water main, before then continuing to head southwest near below the center of Tamarack Avenue. At Ski Run Blvd, the storm drain will then head northwest below the center of the southeastern travel lane until reaching the existing box culvert located just downstream of the Osgood Basin. The proposed pipe will then end in a junction box or manhole pipe connection proposed to be placed on the existing southernmost outlet reinforced concrete box. At this location, treated water from the Osgood Basin will comingle with the bypassed water from Keller Canyon and continue to its existing outlet.

Water Quality

Increases treatment efficiency at Osgood by reducing loading of the basin.

Flooding

Does not directly address flooding.

65% Design Tasks

- Survey/Map utilities
- Pothole for utilities where proposed pipe will cross (10-12 locations)
- Find vault near Markoffer/Whispering Pines Apartments – perhaps use underground scanning
- Create detail for new vault near Markoffer/Keller and for tie in at Osgood outfall (30” pipe to RCB)
- HGL/EGL for pipe

Aloha Basin

Description

This project proposes a new infiltration basin on a CTC-owned parcel located at the corner of Herbert Avenue and Aloha Road. The Existing Conditions Vegetation (Appendix X) notes the presence of predominately mesic and upland vegetation with some species indicating a high water table.

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Presently, a drainage inlet on the northeast side of Herbert Avenue across from this parcel collects stormwater from the existing curb and gutter and storm drain system on the northeast side of the road. This system has a large catchment area that extends up to and across Pioneer Trail to Pony Express Road. As well, this inlet also collects stormwater from a portion of Aloha Road, which sheet flows down the roadway until it reaches the curb and gutter at the south side of the Aloha/Herbert intersection. Stormwater from the curb and gutter is then conveyed to the shoulder where it then drains into a 12" CMP that crosses below Herbert Avenue to the inlet. The drainage inlet outlets the collected stormwater directly to the parcel northeast of Herbert Avenue. Field observations noted this drainage inlet presently appears to be over capacity with backwatering in the inlet and in the 12" CMP across Herbert Avenue.

The proposed basin is designed to substantially decrease stormwater conveyance to the existing inlet and to the parcel to the northeast of Herbert Avenue by providing local treatment and infiltration for a large portion of the existing catchment area. The design of the basin is based on the goal of creating an adequate design capacity while minimizing the basin's impact area and excavation depths to maximize Lake Clarity Credits in PLRM (up to 6 credits available). A primary design constraint is the need to provide inlet and outlet elevations in the basin that allow for 18" RCP storm drains to cross below Herbert Avenue. As well, the basin grading will need to daylight at least 5' from the existing bike path on the parcel. The basin will have a design capacity of 800 SF, and be shallow and vegetated with maximum grading of 3:1. It will have a maximum ponding depth of 11" with a total disturbance area of 2,700 SF and a total excavation of 183 CY. The maximum cut of the grading will be 39" and the maximum vertical height from the bottom of the basin to existing grade will be 45". The minimum freeboard height will be 18".

The existing 12" storm drain below Herbert Avenue will be decommissioned and stormwater flows to that pipe will now be routed to the proposed basin for treatment. A new storm drain inlet will be installed in the curb and gutter on the northeast side of Herbert Avenue approximate 80 LF southeast of the existing inlet. The existing storm drain on the northeast side of Herbert Avenue will be connected to this inlet, and the portion of storm drain between the new inlet and old inlet will be decommissioned. The new inlet will outlet to a proposed 50 LF 18" RCP that will cross below Herbert to the basin.

A sediment can will be installed in the basin to provide overflow when conditions exceed the 11" proposed ponding depth. This sediment can will outlet to an 80 LF 18" RCP that crosses back below Herbert and into the parcel on the northeast side of the roadway. Approximately 100 LF of channel grading will be needed on the outlet parcel. This channel will extend approximately 50 LF downstream from the proposed outlet, and approximate 50 LF upstream to the existing drainage inlet, which will continue to outlet directly to this parcel, albeit with significantly reduced flows than under existing conditions. The channel will primarily be vegetated, however some rock will be needed for energy dissipation. A future project for consideration may route water further down Herbert to the storm drain system along Spruce and under the Bijou School field or consider some off-line infiltration at the drain inlet downstream of the Aloha Basin DI, just north of the intersection of Herbert and Woodland Rd.

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Water Quality

This project will improve water quality by providing treatment to stormwater in the basin.

Flooding

This project does not directly address flooding. However, it may have a positive impact on flooding in other downstream areas of the watershed by infiltrating stormwater in the basin. For example, the Rockwood to Blackwood project is located on the opposite end of meadow on the parcel across of Herbert from the basin, and the treatment of stormwater by the basin may reduce flooding in that project area.

65% Design Tasks

- Perform a survey and dip DIs
- Confirm utility locations and pipe sizes
- Revegetation mix for basin and channel

Wrap up and Recommendations for 65% Design

This phase took a watershed wide approach to identify and evaluate alternatives that would achieve water quality benefits, alleviate flooding and enhance SEZ and floodplain habitat. The end result was several distinct and sometimes dependent project elements in locations scattered throughout the 850 acre watershed. Now that the project areas and elements have been honed in on additional field data collection and analysis is recommended for the next phase, 65% designs.

In general, 65% design development will require additional field survey data to be collected in several of the project areas as described above to supplement the LiDAR data, with a particular focus on open channel profiles and cross sections to provide input to additional hydraulic modeling efforts. The next phase will also need to identify exact utility locations and conduct closer coordination with public landowners, regulatory agencies and community members. These tasks include total station surveying, potholing for utilities or requesting as-builts, continuing TAC meetings, public scoping meetings (CEQA) and outreach to collaborate on specific concurrent projects.

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Appendices

Appendix 1 ---------- Heavenly Discharge Report
Appendix 2 ---------- PLRM Land Use Map
Appendix 3 ---------- BPC PLRM Model Output
Appendix 4 ---------- Map of Public Lands
Appendix 5 ---------- Geotechnical Boring Logs
Appendix 6 ---------- Biological Resources Report
Appendix 7 ---------- Existing Conditions Vegetation
Appendix 8 ----------Hydrology Technical Memo
Appendix 9 ----------Project Decision Matrix
Appendix 10---------- Design Calculations

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Appendix 1
Heavenly Discharge Report

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Bijou Park Creek Evaluation Report

Heavenly Mountain Resort
Waste Discharge Requirements Associated with Lahontan Regional
Water Quality Control Board Order No. R6T-2015-0021
WDID 6A090033000

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Bijou Park Creek Evaluation Report

Heavenly Mountain Resort
Waste Discharge Requirements Associated with
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Table of Contents

SECTION 1 **Introduction** **1**

SECTION 2 **Background Information on Heavenly Stormwater Runoff** **3**

2.1 Location and Description of Heavenly Stormwater Runoff 3

2.2 Description of Bijou Park Creek Watershed 5

SECTION 3 **Summary of Ongoing Source Control Measures to Improve Stormwater Quality** **7**

3.1 Brine and Traction Sand Monitoring and Management 7

3.1.1 Brine and Traction Sand Practices 7

3.1.2 Deicer Application and Monitoring 8

3.1.3 Summary of Recent Actions to Reduce Chloride Loading 8

3.1.4 Modifications to Deicer and Traction Sand Application for 2016 9

3.2 Snow Conditioning Actions 9

3.2.1 Summary of Recent Actions 10

3.2.2 Recommended Future Improvements for Feasibility Evaluation 10

3.2.3 Snow Conditioning Tracking and Reporting 11

SECTION 4 **Heavenly Ski Resort Treatment Vault System Performance Evaluation** **12**

4.1 Overview of Treatment Vault System 12

4.1.1 Treatment System Effluent Water Quality Monitoring 15

4.1.2 Hydraulic Analysis 20

4.2 Stormfilter Treatment System Evaluation Findings 34

4.2.1 Recommended Improvements 35

4.2.2 Recommended System Maintenance 36

4.2.3 Recommended Sampling Protocol 37

SECTION 5 **Bijou Park Creek Chloride Monitoring Study** **39**

5.1 Background Information on Chloride Concentrations 39

5.2 Water quality Sampling locations and Sampling Methods 40

5.2.1 Water Quality Sampling Locations 40

5.2.2 Personnel and Procedures 41

5.2.3 Health and Safety Plan 42

5.2.4 Water Sample Collection, Handling, and Analysis 42

5.3 Water Quality Sampling Results and Data Analysis 42

5.3.1 Surface Water Discharge and Field Water Quality Parameters 43

5.3.2 Anion Results 46

5.3.3 Cation Results 50

5.3.4 Data Analysis 53
5.4 Consideration of Alternate Chloride Standard or Alternate Background Location for Bijou Park Creek 57
5.4.1 Effects of Chloride on Aquatic Biota 58
5.4.2 Requirements for Site Specific Standards 59
5.5 Bijou Park Creek Chloride Monitoring Study Conclusions and Path Forward 60
SECTION 6 **Summary of Findings and Recommendations 63**
6.1 Source Reduction Measures for Chloride 63
6.2 StormFilter System Improvements 64
6.3 Bijou Park Creek Chloride Monitoring Study Conclusions and Path Forward 64
SECTION 7 **References 66**

Figures

Figure 1-1: Location of Heavenly Mountain Resort

Figure 2-1: Stormwater Management System in the California Base Parking Lot

Figure 2-2: Overview of Bijou Park Creek Watershed

Figure 4-1: StormFilter System Configuration, California Base Parking Lot.

Figure 4-2: StormFilter System Configuration, Wildwood Avenue.

Figure 4-3: Turbidity sample results at California Base Lot Vault Sites (2011-2016) showing improved turbidity with increased system maintenance.

Figure 4-4: Design drawing of StormFilter vault and correction to baffle wall specification.

Figure 4-5: Hydraulic Profile of Treated Flows from High Flow Bypass Vault 1.

Figure 4-6: Hydraulic Profile of Treated Flows from High Flow Bypass Vault 7.

Figure 4-7: Turbidity sample results at California Base Lot Vault Sites relative to vault treatment system maintenance events (2011-2016).

Figure 4-8: Total Phosphorus sample results at California Base Lot Vault Sites relative to vault treatment system maintenance events (2011-2016).

Figure 4-9: Total Nitrogen sample results at California Base Lot Vault Sites relative to vault treatment system maintenance events (2011-2016).

Figure 4-10: Abrasive Particle Size Distribution (Cinders and Washoe Sand).

Figure 4-11: California Base Parking Lot StormFilter Treatment System Flows (2015-2016).

Figure 4-12: SNOTEL Precipitation Graph for Water Years 2011-2016.

Figure 5-1: Bijou Park Creek Water Quality Monitoring Locations

Figure 5-2: Surface Water Discharge

Figure 5-3: Field Measurements of Total Dissolved Solids

Figure 5-4. Field Measurements of Electrical Conductivity

Figure 5-5: Field Measurements of pH

Figure 5-6: Analytical Results for Total Alkalinity

Figure 5-7: Analytical Results for Chloride

Figure 5-8: Analytical Results for Bromide

Figure 5-9: Analytical Results for Nitrate

Figure 5-10: Analytical Results for Sulfate

Figure 5-11. Analytical Results for Iron

Figure 5-12: Analytical Results for Magnesium

Figure 5-13: Analytical Results for Sodium

Tables

Table 3-1 Annual Huck Salt Application Records (2011-2015).

Table 4-1: Heavenly Mountain Resort water quality data from influent station 43HVP-1a (North) (Water Years 2012-2016).

Table 4-2: Heavenly Mountain Resort water quality data from influent station 43HVP-1b (South) (Water Years 2012-2016).

Table 4-3: Heavenly Mountain Resort water quality data from effluent station 43HVP-2 (Water Years 2012-2016).

Table 4-4: Deicer Sieve Analysis.

Table 5-1: Summary of Surface Water Discharge and Field Water Quality Measurements

Table 5-2: Summary of Analytical Results for Anions

Table 5-3: Summary of Analytical Results for Cations

Table 5-4. Summary of Total Cation and Total Anion Balance Comparison

Table 5-5: Ratio of Measured vs. Calculated TDS

Table 5-6: Calculation of Site-Specific Chloride Targets Based on State of Iowa Methodology

Appendices

Appendix A Bijou Park Creek Chloride Monitoring Study - Field Data

Appendix B Bijou Park Creek Chloride Monitoring Study - Laboratory Analytical Reports

Appendix C Bijou Park Creek Chloride Monitoring Study - Piper Plots of Selected Analytical Results

Heavenly California Base Area Stormwater Runoff



Stormwater runoff flows from the Heavenly California Base Area to Bijou Park Creek, which flows to Lake Tahoe approximately 1.5 miles to the northwest. For public safety, Heavenly applies traction sand and deicing salts to the parking lot, access road, and City of South Lake Tahoe (CSLT) roads leading to the California Base Area. Heavenly acquired and restored a one-acre Stream Environment Zone (SEZ) located immediately south of Tamarack Road to improve downstream treatment and SEZ function. Heavenly also installed a StormFilter™ system to treat runoff from this area. The system was determined to be the best available technology (BAT) at the time and the effluent quality from the system was expected to meet effluent limitations for turbidity (TSS), total nitrogen (N), and total phosphorus (P). The system was not expected to be able to treat chloride in runoff. To date, monitoring data have not indicated significant improvement in the performance of the StormFilters™ despite significant investment by Heavenly in treatment systems to control and abate the discharge. The Lahontan Regional Water Quality Control Board (Board) and Heavenly adaptively manage and iteratively improve controls over time as necessary to comply with water quality objectives.

Source Control and StormFilter Optimization

To address the violations of relevant discharge and receiving water requirements in Bijou Park Creek, the Board required Heavenly to complete an engineering evaluation of the treatment facilities and Heavenly Mountain sampling procedures, evaluate road and parking lot source control opportunities, and implement appropriate operational adjustments to achieve compliance with the applicable water quality standards.

Source control measures continue to be tracked, monitored, and adaptively managed with the Board through Waste Discharge Requirements (WDRs). The report conducted a hydraulic analysis of the StormFilter™ system, and provides results of a thorough review of system design, as-built condition, and operations to date. System optimization, expected to improve N, P, and TSS compliance, includes:

- Continued upgrade of system monitoring and maintenance
- Improved seal at manhole covers
- Physical modifications to in-vault conditions
- Physical modifications to cartridge structures
- Improved sampling conditions
- Grain size analysis of TSS in the system influent and effluent

Fate and Transport of Chloride in Bijou Park Creek

The water quality objective for chloride in Bijou Park Creek is based on the limit for Lake Tahoe of 3.0 mg/L. Lake Tahoe is not impaired for chloride. The elevated concentrations in Bijou Park Creek are likely due to the application of deicing salts in the winter by Heavenly and the CSLT for public safety in the California Base Area and Bijou Park Creek Watershed. In the absence of contrary evidence, the excursions from water quality objectives due to the discharge do not appear to be at levels toxic to aquatic life (e.g., in Bijou Park Creek) or at levels that would otherwise impair the waters for beneficial uses.

The chloride fate and transport study identified increasing concentrations of chloride downstream from the discharge point at the headwaters of Bijou Park Creek and additional runoff sources.



Balancing Protective Chloride Levels and Public Safety

The Board acknowledges water quality degradation has occurred due to historic and ongoing operations at the Heavenly resort despite the application of available and practicable treatment and control systems. Where objectives or limits are violated, no additional degradation is authorized and the Board will continue to work with Heavenly to achieve compliance with objectives and limits. The facility is required to meet WDRs to prevent pollution and nuisance, and use of best practicable treatment or control measures to assure the highest water quality consistent with the maximum benefit to the people of the state will be maintained.

The report recommends the following conservative (protective) standards to be met at the compliance point at the headwaters of Bijou Park Creek to ensure no further degradation to the waters of Bijou Park Creek and be protective of aquatic life in the creek:

Chronic – 150 mg/l **Acute – 600 mg/l**

Either alternate chloride standards or more a representative background station is recommended.

SECTION 1

Introduction

Vail Resorts owns Heavenly Valley Limited Partnership which operates Heavenly Mountain Resort (Heavenly). The operation of Heavenly includes the California Base Area which includes a ski lodge, associated parking lots, and a small portion of the adjacent ski lifts and slopes (Figure 1-1). The City of South Lake Tahoe (City) owns the roads providing access to the California Base Area, except for the southernmost portion of Wildwood Avenue (south of Saddle Road) which is owned by Heavenly. Responsibility for maintaining the local road network is shared between Heavenly and the City.

The operation of the California portion of Heavenly requires a site-specific stormwater discharge permit through the California Regional Water Quality Control Board – Lahontan Region (Regional Board). In May 2015, the Regional Board adopted Board Order No. R6T-2015-0021 (WDID 6A090033000) which updated the Waste Discharge Requirements (WDRs) for the Heavenly Mountain Resort. The WDRs specified several compliance items that Heavenly was required to complete, as described in the report entitled *Heavenly Mountain Resort Time Schedule Order Compliance Items for Board Order No. R6T-2015-0021 WDID 6A090033000* (Compliance Items report) dated January 26, 2016 which was prepared by Dr. Daniel Tormey while he was employed by Ramboll Environ (Ramboll 2016). In an April 4, 2016 letter to Heavenly, the Regional Board accepted the Compliance Items report, and found that it complied with Board Order No. R6T-2015-0021. The Compliance Items report included the following four tasks that were developed to improve the water quality of the discharge from the California Base Area to Bijou Park Creek:

- StormFilter Improvements;
- Brine and Traction Sand Feasibility Study;
- Snow Conditioning Actions in the Heavenly Valley Creek watershed; and,
- Bijou Park Creek Chloride Monitoring Plan.

Collectively, these four components address improvement of water quality in Bijou Park Creek and surface waters affected by discharges from the California Base parking lot through a combination of source removal/substitution, water treatment, and evaluation of contaminant fate in area waters including consideration of site specific standards.

This report provides the results of the Compliance Item actions that were implemented in 2016. The report is focused on the hydraulic analysis of the StormFilter system and the Bijou Creek Chloride Monitoring Plan since these items are new studies that were conducted in 2016. In regards to the Brine and Traction Sand Feasibility Study and Snow Conditioning Actions, these items represent ongoing source control measures that were discussed in the Compliance Items report (Ramboll 2016) and, as such, this report provides only a summary of these ongoing actions. The remainder of this report is organized as follows:

- Section 2.0 provides background information on the stormwater runoff from the Heavenly California Base area and a description of the Bijou Park Creek watershed area;

- Section 3.0 presents a summary of the ongoing source control measures that Heavenly has implemented;
- Section 4.0 discusses the Heavenly Ski Resort Treatment Vault System performance evaluation;
- Section 5.0 discusses the Bijou Park Creek Chloride Monitoring study;
- Section 6.0 provides a summary of findings of the various Compliance Item actions and recommendations for the path forward based on these findings; and,
- Section 7.0 lists the references used in this report.



Figure 1-1: Location of Heavenly Mountain Resort

SECTION 2

Background Information on Heavenly Stormwater Runoff

The following provides background information on the stormwater runoff from the Heavenly California Base area and a description of the Bijou Park Creek watershed area.

2.1 LOCATION AND DESCRIPTION OF HEAVENLY STORMWATER RUNOFF

Heavenly is located south of Lake Tahoe and the property boundaries cover portions of both California and Nevada (Figure 1-1). Most of the California portion of the resort is within El Dorado County (>90%) and the remaining portion is in Alpine County. The California portion of Heavenly is located in the South Tahoe Hydrologic Area (HU 634.10) of the Lake Tahoe Hydrologic Unit and the Woodfords Hydrologic Area (HU 633.10) of the West Fork Carson River Hydrologic Unit in Section 1, T.12N., RI8E.; Sections 6 and 7, T.12N., R 19E.; and Sections 27, 35, and 36, T.13N., R 18E., MDB&M. The California Base Area is located south of Saddle Road, between Wildwood Avenue and Keller Road.

The California Base Area is an approximately 14-acre area (pictured at left) that includes the California Base Lodge, parking lot, Lower Maintenance Shop, Heavenly Tram, and access road. Stormwater and snow melt runoff from the parking lot, containing turbidity, nitrogen, phosphorous, and chlorides, is



discharged below the California Base Area after treatment in the StormFilter treatment vaults, the stormwater management system situated in the California Base parking area. The system treats a design flow of 14 cubic feet per second (cfs), corresponding to the Regional Board's 20-year, 1-hour design storm event for the Lake Tahoe Basin. Runoff above these levels is diverted around the treatment system, and is comingled with the treated effluent prior to discharge. Effluent from the treatment system and diverted flows discharge to Bijou Park Creek near its headwaters which are located immediately west of Wildwood Avenue between Saddle Road (to the south) and Needle Peak Road (to the north).

A map of the parking lot and the stormwater management system is provided in Figure 2-1, below.

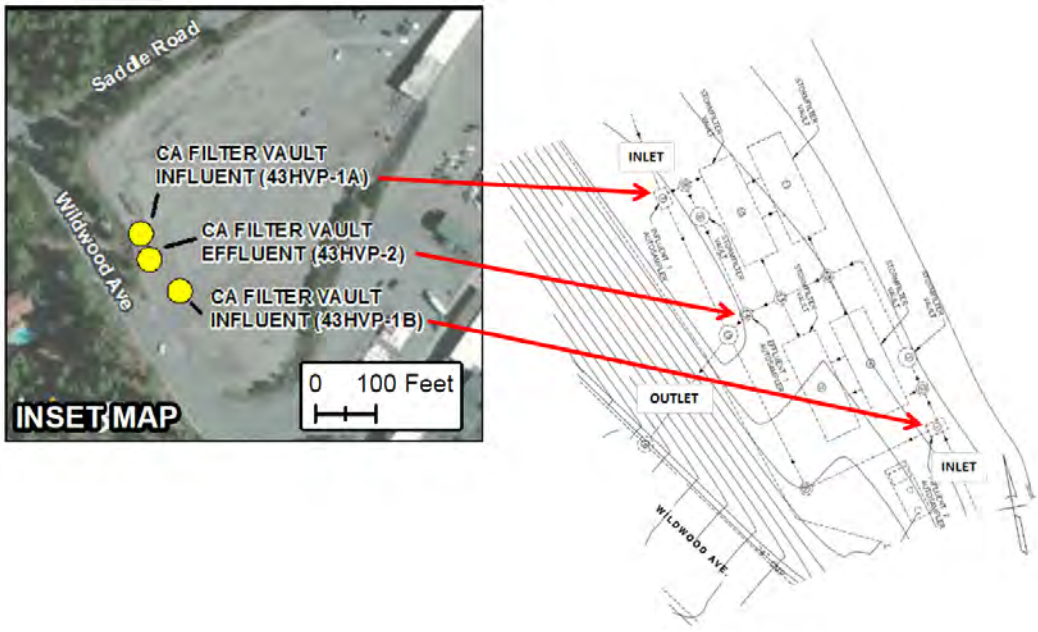


Figure 2-1: Stormwater Management System in the California Base Parking Lot

In the vicinity of the Heavenly California Base area, Bijou Park Creek also receives stormwater runoff from several other sources. Surface runoff and seepage from the adjacent ski slopes is captured and routed around the Heavenly California Base parking area, to comingle with the discharge from the treatment vaults. This runoff does not come in contact with anything but the slopes of the mountain situated upgradient of the Heavenly California Base parking area. Runoff from adjacent surface streets, Saddle Road and Wildwood Avenue, flow through a separate filter vault on Wildwood Avenue, and comingles with the discharge from the Heavenly stormwater management system near the headwaters of Bijou Park Creek. A portion of the runoff from adjacent surface streets does not pass through the Wildwood treatment vault. The streets are owned by the City of South Lake Tahoe, but Heavenly manages safe winter passage. In addition, groundwater is relatively shallow beneath the California Base Parking Lot area, and produces iron-rich seepage. Flow from the iron-rich springs situated near the base of the fill slopes located below the Heavenly California Base parking area also commingles with these other sources, and after crossing beneath Saddle Road, combines with seepage from small springs situated north of Saddle Road to form the headwaters of Bijou Park Creek.

The spring-fed headwaters of Bijou Park Creek, situated near the corner of Wildwood Avenue and Saddle Road, currently serve as the compliance point for meeting the water quality objectives specified in the WDRs. This same location consists of the point of discharge for the stormwater runoff to the creek. Accordingly, it is not possible to characterize background water quality in Bijou Park Creek (i.e., waters unaffected by the stormwater runoff) due to the inability to collect samples upstream of the compliance point. Therefore, the WDRs specify the use of samples from a monitoring point in Hidden Valley Creek as a surrogate to characterize the reference, unimpaired water quality in Bijou Park Creek. Although the Hidden Valley Creek reference location is appropriate for comparison to data collected along Heavenly Valley Creek, it may not be appropriate as a reference reach for Bijou Park Creek owing to differences in geomorphology, hydrology, and land use within the watershed.

2.2 DESCRIPTION OF BIJOU PARK CREEK WATERSHED

Bijou Park Creek drains an area of approximately 850-acres that extends from the top of the "face" at the Heavenly Ski Resort to Lake Tahoe near the Ski Run Marina. Land use in the watershed primarily consists of steep, undeveloped land in the upper watershed above the Heavenly California Base area and a mix of low- to high-density residential between the Heavenly base area and Lake Tahoe Boulevard (Lumos 2005).

The drainage primarily consists of a modified open channel from its crossing at Shirley Avenue upstream to its headwaters near the intersection of Wildwood Avenue and Saddle Road as shown in Figure 2-2 (Lumos 2005). The main portion of the channel along this reach runs parallel to Blackwood Road and then crosses Pioneer Trail near Charlesworth Court and Ski Run Boulevard near Needle Peak Road. The channel splits upstream of Needle Peak Road with one channel transitioning to the west toward Ski Run Boulevard and the other to the southeast toward Wildwood Avenue to the headwaters. Downstream of Shirley Avenue, the creek runs along the lot lines between Shirley and Bill Avenues and then transitions to a 24-inch diameter pipe down slope from Bill Avenue (Lumos 2005). The creek then enters a drop inlet into a 30-inch drainage pipe situated behind the Super 8 Motel, crosses underneath the Super 8 Motel and Highway 50, and enters the lower Ski Run Boulevard drainage system where it ultimately discharges to Lake Tahoe at the outfall of the Ski Run Marina (Lumos 2005).

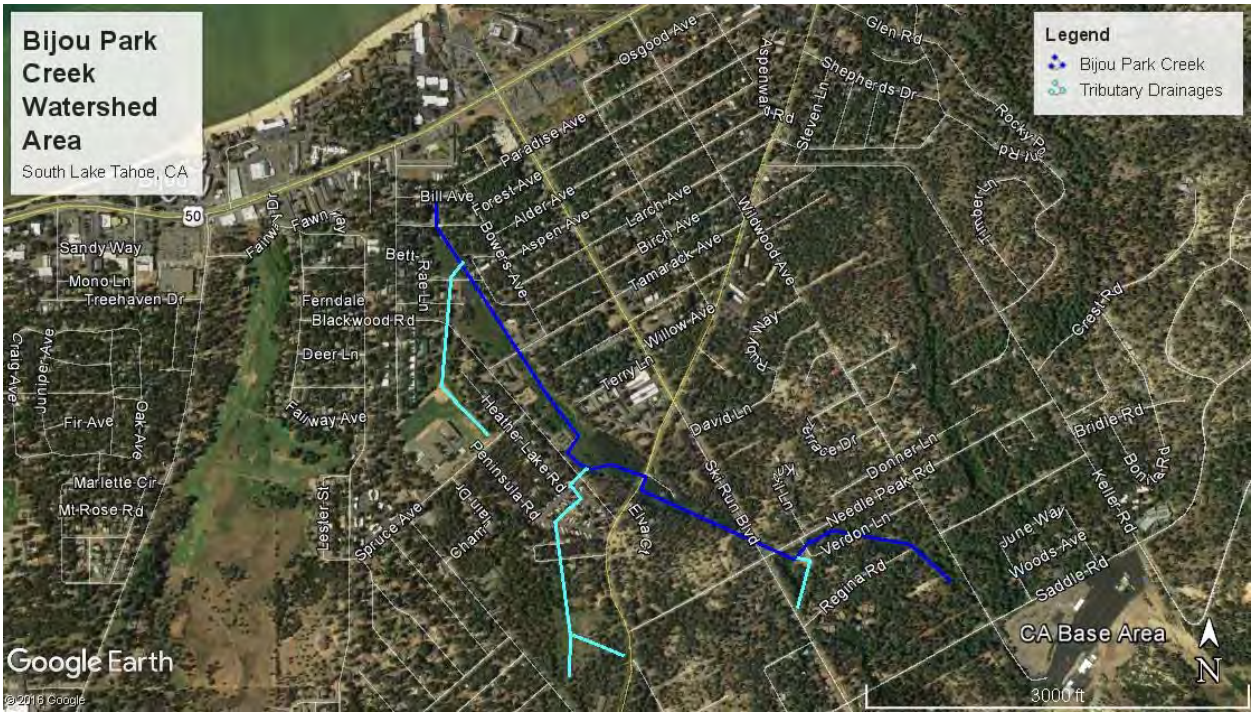


Figure 2-2: Overview of Bijou Park Creek Watershed

The creek includes two primary tributary drainages. One consists of swale (non-incised vegetated channel) that joins Bijou Park Creek near Werner Salas Drive (Lumos 2005). The swale flows around the east edge of the Bijou School through an open area and then crosses Blackwood Road upslope of lower Herbert Road. This system extends above Spruce Avenue into the area of Champlain Drive. The other drainage tributary consists of a swale system that enters the main channel of Bijou Park Creek through a

culvert under Blackwood Road on the downslope corner of the mobile home park located at Blackwood Road and Pioneer Trail (Lumos 2005). Flows enter the mobile home park through a very weakly incised channel/swale that crosses Woodbine Road and Rockwood Drive immediately upslope of the mobile home park. Upslope of Woodbine Road the swale becomes more diffuse with runoff originating from the area bounded by Woodbine Road, Pioneer Trail, and Herbert Avenue.

In regards to stormwater flows, most of the runoff upstream of Bill Avenue (located at the downstream end of the drainage near Highway 50) consists of surface drainage that is conveyed along road shoulders directly to natural channel system of Bijou Park Creek (Lumos 2005). The alignment and surface drainage connections downstream of Bill Avenue are routed to a stormwater drainage system (Lumos 2005).

SECTION 3

Summary of Ongoing Source Control Measures to Improve Stormwater Quality

This section provides a summary of the ongoing source control measures that Heavenly is using to improve the stormwater quality associated with their operations. These measures are categorized into two primary areas: 1) Brine and Traction Sand Monitoring and Management; and, 2) Snow Conditioning Management. These items are discussed in detail in the Compliance Items report (Ramboll 2016) and summarized in the sections below.

3.1 BRINE AND TRACTION SAND MONITORING AND MANAGEMENT

Heavenly applies traction sand and de-icing salts to the California Base parking lot for public safety. These products can lead to elevated chloride and TSS levels in stormwater runoff to Bijou Park Creek. Heavenly also applies deicers and abrasives to City roads providing access to the California Base Area, including Ski Run Boulevard, Needle Peak Road, Wildwood Avenue, and Saddle Road. These City roads are regulated under a Municipal National Pollutant Discharge Elimination System Stormwater Permit issued to the City (NPDES No. CAG616001). However, in the vicinity of the California Base parking lot, runoff from Wildwood Avenue and Saddle Road also reaches Heavenly's compliance sampling point on Bijou Park Creek.

The StormFilter treatment system cannot remove chlorides from runoff. As such, the WDRs require Heavenly to evaluate source reduction measures focused on reducing the loading of chloride to surface waters. Specifically, the WDRs require Heavenly to conduct a feasibility study to transition from applying rock salt to the parking area and access roads to applying liquid brine. Results from other agencies have shown that brine applications can significantly reduce the mass of sodium chloride applied to pavements and discharged to water while maintaining safe conditions on the roadways.

3.1.1 Brine and Traction Sand Practices

Heavenly applies deicers and abrasives to provide a safe route to and from the resort. While the City of South Lake Tahoe is responsible for snow removal and deicing application to allow access to the California Base Area Parking Lot and Lodge, Heavenly augments this service to provide additional plowing and application of deicer/abrasives to the roadway leading up to the entrance and parking lots. Additional coverage by Heavenly's plow/spreader truck allows for increased frequency and continual snow and deicer removal during treacherous driving conditions. Once the ski season commences and weather permits, Heavenly collects excess roadway materials from the parking lot and roadways leading up to the California base lodge.

Collection of the roadway and parking lot debris material typically occurs in the summer months. The roadway material is collected by a sub-contracted sweeper vehicle, and, in some instances, excess material in the parking lot can be collected with the use of a backhoe. All collected material is placed into rented ten cubic yard drop boxes. When these boxes are full, or when recovery is completed, the boxes are weighed and disposed of at the South Lake Tahoe Refuse transfer station.

As required by Heavenly's WDRs, daily and monthly logs record the following information:

- The location and dates of application, including street names if applied within the City of South Lake Tahoe;
- The amounts of each material applied daily with the subtotals for Heavenly properties and the City of South Lake Tahoe streets; and,
- Location of disposal facilities.

Heavenly is transitioning from the use of cinders to the use of Washoe Septic Sand or equivalent for traction sand. This practice meets the requirements of Caltrans' "Specification H".

3.1.2 Deicer Application and Monitoring

Beginning in the 2009 water year, Heavenly purchased a control sensor for the spreader truck that reports the amount of material applied to the roadways and parking lot. It also gages the road condition and temperature to control whether deicer/abrasive application is necessary.

Use of deicers depends on many factors, including the number of storms, duration of snow conditions, and timing of storms. For example, in 2008 (water years), 98,000 pounds of deicer was used, and this decreased to 17,000 pounds in 2009. During the very wet and long 2010 winter, there was a significant increase, up to 909,000 pounds. This example shows that deicer use correlates to water year type, making simple year by year comparisons misleading.

In the past, Heavenly has investigated alternatives to deicer and deicer application and storage practices. Magnesium chloride was examined, but it was found to be both a risk to human safety and an environmental hazard (Transportation Research Board 1991 and Champers 2008). This deicer combination is banned in Aspen, Colorado and been found to have adverse effects on the life cycles of micro and macro invertebrates (Lewis 1999). Calcium magnesium acetate (CMA) was also researched, but found to be prohibitively expensive and require greater quantities for success (Transportation Research Board 1991). In addition, acetate is a carbonaceous material that will exert an oxygen demand on natural water bodies. Heavenly therefore relied on a combination of sodium chloride and sand or cinders; this was the least harmful to the environment and water quality, although chloride levels in natural water supplies can be attributed to contamination resulting from road deicing (Talend 2009). It is the hope that in near future research will develop a viable organic salt substitute for application (Talend 2009).

3.1.3 Summary of Recent Actions to Reduce Chloride Loading

Heavenly continues to monitor best practices for deicer and traction sand application, and improve their practices. Between 2010 and 2015, Heavenly made the following changes to their practices:

- The mix of salt and cinders in the deicing materials was reduced from 33 percent salt to 25 percent salt in 2013, and has been further reduced to a 5:1 ratio of Washoe sand to salt starting in November of 2015, when abrasives use began for the 2015/2016 winter ski season;

- Reduced the number of areas receiving deicers to only include the following: Ski Run Boulevard, Wildwood, and Needle Peak, the Bus and drop off loop, the main guest and employee access drive in the lower lot, around the Tram base, and the entrance at Keller Avenue;
- The plowing equipment has been upgraded by adding a smaller spreader unit on a smaller flatbed truck. New for this coming year is the addition of a new spreader box mounted on the larger truck (see photo below). Both of these improvements will allow use of a Washoe Sand and Salt mix in a 5:1 ratio;
- Added a new smaller dump truck to the vehicle fleet. This has enabled Heavenly to more precisely address problem areas and to broadcast less material. The smaller truck is shown in the photo above;
- Added driver training to reduce the volume of deicers applied. Now, drivers only spread as needed, not each time they make a plow pass during a storm cycle. In addition, drivers now sand after the road has been plowed after a storm cycle; and,
- Documented and tracked salt use throughout the resort, as well as the abrasives used on the roadways and parking lot lanes.

3.1.4 Modifications to Deicer and Traction Sand Application for 2016

Heavenly will continue the actions described in the previous section; these have reduced salt use, and should have continued improvement through the increased management of deicer application. Heavenly is planning to test the feasibility of using liquid brine for pre-storm deicing. Heavenly expects to initiate this in water year 2016 (i.e., 2016/17 winter operating season). When implemented it should reduce the amount of plowing and sanding required, as well as producing safer walking surfaces during the thaw/freeze cycles that produce hazardous ice surfaces.

The success of these continuing improvements will be measured during the water quality sampling required in the WDRs monitoring program. The chloride study required by the WDRs should also detect improvements to chloride concentrations as a result of these actions of source reduction, material substitution, and improved management.

3.2 SNOW CONDITIONING ACTIONS

Snow conditioning materials, including salt, are used on terrain parks in the Heavenly Valley Creek watershed and appear to increase chloride levels, compared to values measured in Hidden Valley Creek. The WDRs note that the increase in chloride compared to the reference stream, Hidden Valley Creek, is slight and would not be expected to impair water quality for beneficial uses. However, because the levels of chloride in Heavenly Valley Creek are above applicable objectives, the WDRs require that Heavenly take source control actions to reduce the chloride loading. The WDRs also note that, although the Regional Board cannot authorize water quality degradation for Chloride above the existing objectives, it may consider site-specific objectives for Chloride in Heavenly Valley Creek at some future time.

3.2.1 Summary of Recent Actions

Snow conditioning and snowmaking enhancement monitoring is reported monthly and included with Heavenly's water quality monitoring Quarterly, Annual, and Comprehensive reports.

Snow conditioning typically entails the addition of huck salt to areas around the terrain park. Salt application is often used in the spring and during long periods of above average temperatures to lower the freezing point of water/ice/snow. The application of salt to the runs and areas around the terrain park lowers the temperature of the surface snow to prevent melting at night when temperatures do not reach freezing. This helps to maintain snow in areas of high traffic and usage (ramps, rails, boxes and landing areas). A summary of the 2011 to 2015 salt application is given in Table 3-1. In general, salt use has decreased year by year, with some spikes in use during events such as the USSA races in water year 2013.

Heavenly has taken the following actions to improve the application of snow conditioning materials. Heavenly does not use chemical additives for snow making. If in the future chemical additives are added for the snow making operation, this information will be provided. Snow conditioning materials are applied in quantities that minimize the discharge of pollutants to receiving waters while achieving the objectives of conditioning. During the last 5 years, there has been closer management control on salt use, with an emphasis on applying salt only when and where needed.

Salt usage has decreased substantially during this time period. However, at this time, we cannot distinguish the management actions taken during this time to reduce salt usage, from the reduced demand due to drier conditions during this period. The continuing monitoring program required by the WDRs will validate the benefits of these recent actions.

Table 3-1 Annual Huck Salt Application Records (2011-2015).

Water Year	Top of the Gondola	World Cup Race Course	Terrain Park	Adventure Peak – Tubing Area	CA Parking Lot Application [2]	Total Salt Usage
2011	250 lbs.	900 lbs.	3,360 lbs.	3,400 lbs.	-	7,910 lbs.
2012	300 lbs.	800 lbs.	1,962 lbs.	100 lbs.	-	3,162 lbs.
2013	450 lbs.	1,680 lbs.	4,160 lbs.	400 lbs.	-	6,690 lbs.
2014	80 lbs.	60 lbs.	2,840 lbs.	0 lbs.	-	2,980 lbs.
2015 [1]	16 lbs.	50 lbs.	418 lbs.	0 lbs.	544 lbs.	1,028 lbs.

[1] Results from the 2015 Water Year are through the 3rd Quarter (Oct. – July). However, application does not typically occur during the fourth quarter (Aug.-Sep.). Final 2015 Water Year deicer totals will be reported in the Environmental Monitoring Program Annual Report submitted in January 2016.

[2] The 2015 Water Year marked the first year that deicer/salt application near and around the CA lodge was tracked on a monthly basis. Application is needed to provide safe walking conditions during the ski season (slips/falls). Application has occurred in the past water years; however, the amounts were not recorded.

3.2.2 Recommended Future Improvements for Feasibility Evaluation

Starting in 2015, the use of salt use on walkways has been closely tracked and managed to use the smallest amounts feasible. Any time staff need to use more than 40 pounds in a given day, approval is

required from the facility Manager. In addition, the process of managing salt application to when and where it is needed will continue, with an emphasis on raising employee awareness of the importance of this issue. Before the winter season begins, the Heavenly environmental department will meet with the management and staff responsible for salt use to ensure tracking, and that materials used on mountain are consistent and the expectations of Heavenly and the WDRs. This clear signal of the importance of these actions will help key managers to communicate the importance of requirements down to the line level staff. The environmental department will also meet with management in spring of 2016, when salt use on the mountain typically begins to rise, to ensure everyone understands what is required.

In addition, Heavenly Terrain Parks does not stockpile salt. If weather predictions indicate a need for salt, then only that amount proposed for use is brought to the park.

3.2.3 Snow Conditioning Tracking and Reporting

Heavenly will continue to track and report the application of snow conditioning materials in the Quarterly, Annual, and Comprehensive water quality monitoring reports. Monitoring will continue, with comparison of chloride levels between Heavenly Valley Creek and the reference stream, Hidden Valley Creek. However, as discussed in Chapter 5 of this report, the Board may consider an alternate background location for evaluation of results from Bijou Park Creek. As with the discussion of deicer and traction sand changes, Heavenly will continue to track best practices, and apply them as indicated in an effort to meet the background chloride levels in area streams.

SECTION 4

Heavenly Ski Resort Treatment Vault System Performance Evaluation

This section discusses the ongoing performance of the StormFilter system. The StormFilter component seeks to optimize the removal of total nitrogen, total phosphorous, and total suspended sediment by the existing stormwater treatment system beneath the California Base parking lot. Because the StormFilter treatment system cannot directly remove chloride, the Brine, Traction Sand, and Snow Conditioning components are focused on material substitution or source removal actions that would reduce chloride loading to surface waters.

As currently operated and sampled, the StormFilter treatment system does not appear to be able to meet the water quality limitations prescribed to protect the receiving waters. As discussed in further detail below, various technical issues have prevented collection of reliable, representative samples from the treatment vaults with effluent samples often having higher concentrations of certain pollutants than influent samples. The WDRs require that Heavenly conduct an engineering evaluation and recommend measures to improve the performance of the Stormwater Management StormFilter with respect to further reductions in total nitrogen, total phosphorous, and total suspended sediment. The WDRs also require that Heavenly determine needed revisions to the sampling protocol to obtain representative samples of the discharge from the system.

Accordingly, this section presents the results of the engineering evaluation based on survey data of the existing treatment system components and system maintenance records. In addition, this section outlines system and operational modifications to improve system performance, with ongoing monitoring to validate improvements.

4.1 OVERVIEW OF TREATMENT VAULT SYSTEM

In 1991, Heavenly installed six underground water treatment vaults ranging from 4,000 to 12,000 gallons in size in the parking area as permitted under Board Order Number 6-91-36 to partially treat runoff from its parking lot before it enters Bijou Park Creek. These six drop inlet vaults act as sediment traps to allow some of the sediment associated with the stormwater runoff to settle out prior to discharge. In 2008 Heavenly added a series of StormFilter treatment system vaults that include filter canisters inside the vaults in the parking lot at the corner of Saddle Road and Wildwood Avenue. The StormFilter treatment system was determined to be the best available technology (BAT) at the time and the effluent quality was expected to meeting effluent limitations for turbidity, total nitrogen, and total phosphorus.

The existing StormFilter treatment system is designed to treat discharges from the California Base Area. The California Base Area is an approximately 14-acre area that includes the California Base Lodge, parking lot, Lower Maintenance Shop, Heavenly Tram, and access road. Stormwater and snow melt runoff from the parking lot is conveyed to the StormFilter treatment vaults where it is treated and discharged below the California Base Area. Water from the tram sump is also pumped to the

StormFilter treatment system and is discharged to the High Flow Bypass Vault 7 where it is routed to treatment vaults 10 and 11.

The stormwater treatment system was designed to capture and treat flows from rain and snowmelt runoff from snow storage areas within the approximate 14-acre site. Accordingly, the system treats a design flow of 14 cubic feet per second (cfs), corresponding to the Tahoe Regional Planning Agencies 20-year, 1-hr storm event for the Lake Tahoe Basin. Referring to Figure 4-1, the stormwater treatment system includes the high flow diversion vaults (numbers 1 and 7), the dry weather flow StormFilter manholes (3 and 9), and the primary StormFilter vaults (4, 5, 10 and 11). The automatic samplers are located in vaults 1 and 7 (influent) and manhole 14 (effluent).

The treatment system was designed to treat 14 cfs, and to divert flows above this rate around the treatment units; treated and diverted flow are comingled downstream of the treatment units but prior to discharge offsite. Specifically, at flows above 14 cfs, the system diverts untreated stormwater either across the included StormGate diversion weirs (structure numbers 1 and 7 in Figure 4-1 below). Flows from the site are fairly evenly divided so the system consists of two mirror image systems, each with a low flow structure and two larger treatment vaults. The system was tiered to allow for the maximum treatment of varying flows. The two small StormFilter manhole units (Manholes 3 and 9) shown in Figure 4-1 provide treatment for the dry weather flows (0.23 cfs each). The intent of these two manhole units (sacrificial filters) is to provide pretreatment and primary treatment for the more frequent low flow or nuisance-type runoff events including flows associated with the high groundwater table in the area of the parking lot. Treatment flows above the dry weather flows are routed to the first two large StormFilter vaults (structure numbers 4 and 10; Figure 4-1). Once those vaults reach treatment capacity, excess treatment flows are routed to the second large StormFilter vaults (structure numbers 5 and 11). A second system was installed in Wildwood Avenue to treat flows from the slope along Saddle Road and a short section of Wildwood Avenue. Flows from Wildwood Avenue are captured in a trench drain that crosses the road at the intersection of Wildwood Avenue and Saddle Road. These flows are conveyed directly to a StormFilter vault installed in Wildwood Avenue. Flows from the slope along Saddle Road are captured in a vegetated roadside channel and then conveyed to a StormGate manhole diversion structure. Treatment flows of 1.4 cfs are diverted to a Hydrodynamic Vortex pretreatment unit to remove coarse sediment. These flows are then routed to the StormFilter vault in Wildwood Avenue. In total, the system consists of 455 individual filter cartridges within the treatment vaults beneath the parking lot (Figure 4-1) and access road (Figure 4-2).

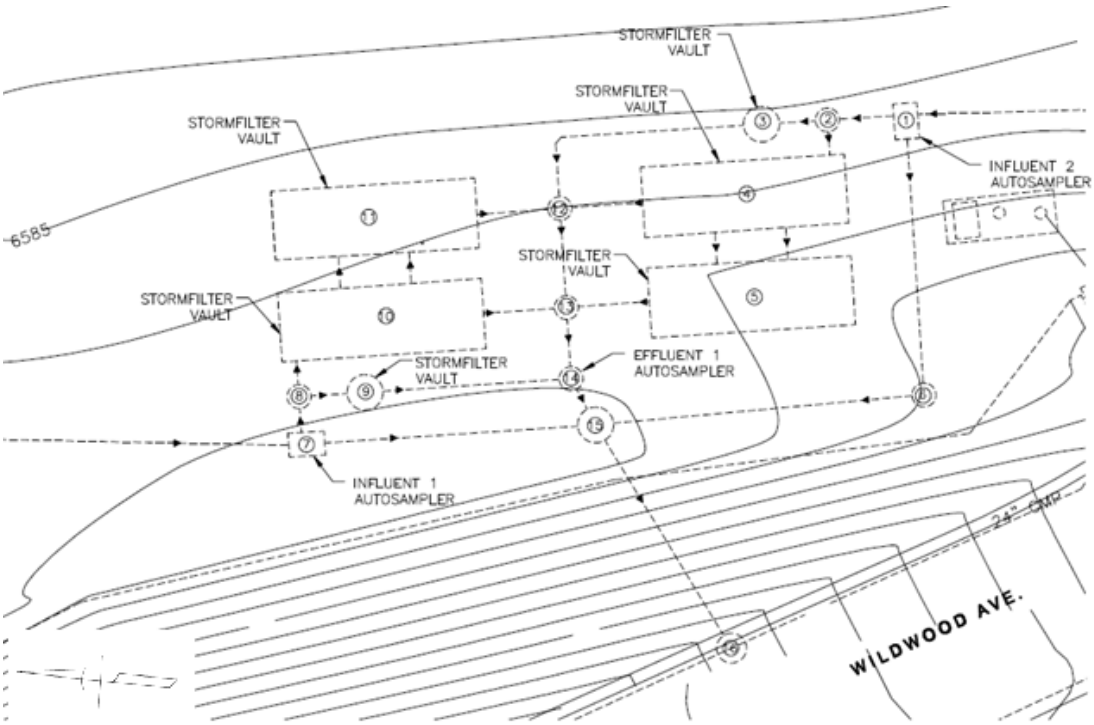


Figure 4-1: StormFilter System Configuration, California Base Parking Lot.

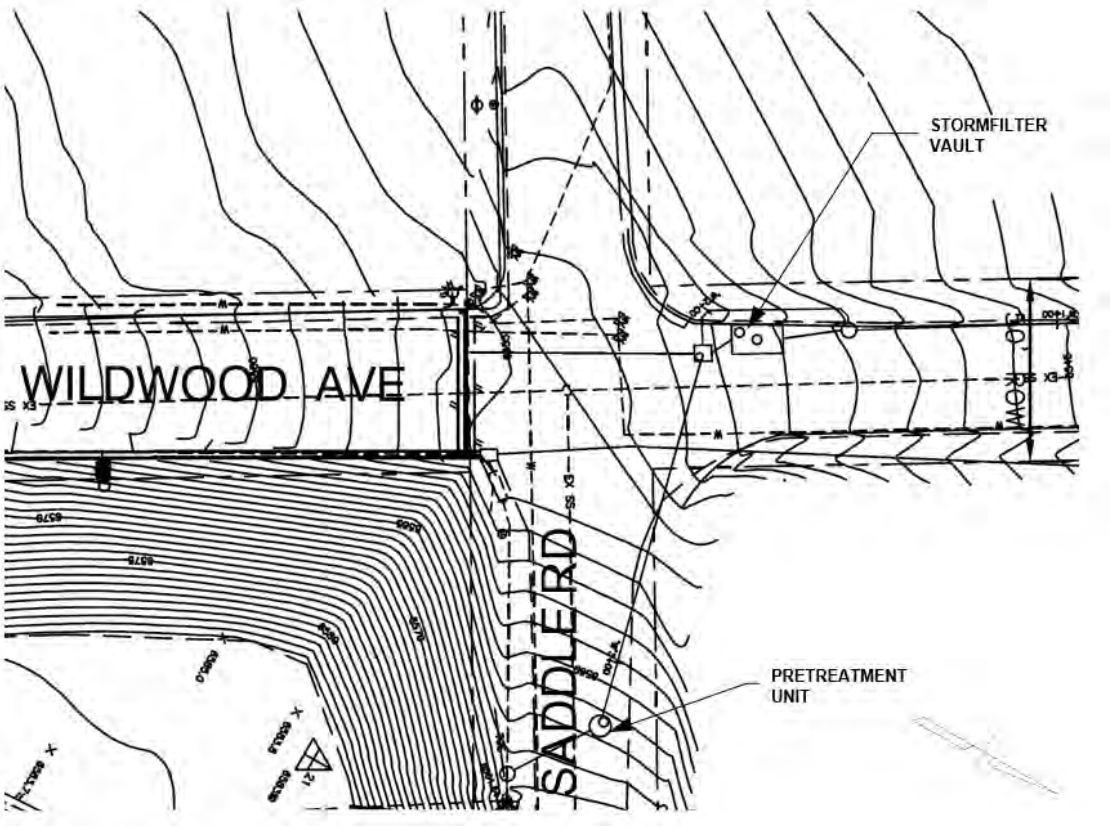


Figure 4-2: StormFilter System Configuration, Wildwood Avenue.

4.1.1 Treatment System Effluent Water Quality Monitoring

Since October 2008, water quality samples have been collected from the influent and effluent points of the StormFilter. The California Base parking lot StormFilter vault system collects storm and snow melt runoff from both the upper and lower parking lots. The Wildwood StormFilter vault system collects storm and snowmelt from the slope along Saddle Road and a small Portion of Wildwood Avenue. The amended monitoring program requires ten samples over the course of the water year; however, the lack of storms and timing of storm events prevented additional sample collection. In addition, various technical issues have prevented collection of reliable, representative samples from the treatment vaults. For example, effluent samples have contained higher concentrations of certain pollutants than the influent samples. It is possible that this results from influent samples not being collected at the same time as effluent samples; seeking to pair the timing more closely so that the same batch of water is being sampled will help in the improve the evaluation of the efficiency of the treatment system. Effluent greater than influent may also be due to sediment accumulation/resuspension as discussed in further detail below.

Tables 4-1, 4-2, and 4-3 provide a summary of the water quality data results for the water years from 2011 to the current 2015-2016 water year to date at the vault sample stations 43HVP-1a (north influent at High Flow Bypass Vault 7) and 43HVP-1b (south influent at High Flow Bypass Vault 1), and 43HVP-2 (effluent at Manhole 14) respectively. Two storm samples were collected during the 2015-2016 water year to date. Both of the samples collected for turbidity were below the not-to-exceed limit of 20 NTUs at the effluent site.

Figure 4-3 illustrates the trend in turbidity results at the vault sample sites (43HVP-1a [north influent, High Flow Bypass Vault 7], 43HVP-1b [south influent, High Flow Bypass Vault 1], and 43HVP-2 [effluent, Manhole 14]) from the 2012 water year to date. The trend suggests that turbidity has generally decreased with the implementation of improved maintenance of the vault system since September 2011 along with improvements made to the operation and maintenance of the parking lot (see discussion of *System Maintenance* below in Section 4.1.2.2).

With regards to phosphorus, both of the 2015-2016 water year samples slightly exceeded the total phosphorus not-to exceed state limit (0.10 mg/L); while one of the two samples collected slightly exceeded the not-to-exceed limit for total nitrogen (0.50 mg/L). Only one sample was analyzed for oil and grease and was below the state not-to-exceed limit (2.0 mg/L) for the 2015-2016 water year to date. These storm readings all reflect the first flush effect collecting and transporting constituents into and through the filter system. It should be noted that the result for the effluent sample turbidity was greater than the influent while only minor reductions in phosphorus and nitrogen were observed when comparing the influent sample result to the effluent sample results.

These data indicate that the treatment system, which was designed to meet these standards, is close to functioning as planned. Recent increases in system maintenance and source reduction/substitution are likely the cause. However, the system must now also meet the Lake Tahoe standards of 0.008 for phosphorous (or background value of 0.03 mg/L), 0.15 for total nitrogen, and 60 mg/L for total suspended solids.

Also of note is the significant difference in concentrations of chloride observed at the influent sample station 43HVP-1a (150 mg/L) when compared to chloride concentration observed at influent station

43HVP-1b (4 mg/L). The large difference could reflect significant differences in chloride loading between subsections of the parking lot. However, these samples were collected at different times of the day with the 43HVP-1b (High Flow Bypass Vault 1) sample collected several hours after the initial sample collected at 43HVP-1a (High Flow Bypass Vault 7). The effluent sample time does not directly correspond to the sampling events at 43HVP-1a (High Flow Bypass Vault 7) or 43HVP-1b (High Flow Bypass Vault 1). It's possible that the earlier influent samples represent the first flush effect for the storm event with influent water quality improving over time.

Table 4-1: Heavenly Mountain Resort water quality data from influent station 43HVP-1a (North) (Water Years 2012-2016).

Date	Time	Turbidity (NTU)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Chloride (mg/L)	Oil & Grease (mg/L)
2012 Water Year						
1/20/2012	14:00	23	0.099	1.55	120	<2.0
4/26/2012	8:10	59	0.057	0.72	97	<2.0
6/4/2012	17:20	61	0.11	0.75	89	<2.0
7/23/2012	14:00	460	0.30	4.20	130	8.3
8/14/2012	16:35	77	0.14	2.86	82	<2.0
2013 Water Year						
10/12/2012	10:50	13	0.15	1.29	41	<2.0
11/1/2012	9:00	19	0.081	2.03	44	<2.0
12/2/2012	14:50	100	0.13	0.87	31	7.2
5/6/2013	8:20	140	0.16	0.61	55	ND
2014 Water Year						
11/20/2013	16:40	61	0.14	1.40	28	1.1
1/29/2014	14:55	180	0.84	2.40	470	ND
3/26/2014	17:30	51	0.13	1.30	130	ND
4/25/2014	8:42	26	0.1	1.10	360	ND
5/20/2014	15:10	26	0.18	0.48	62	ND
8/4/2014	14:45	-	0.066	0.67	39	ND
8/11/2014	16:45	4.3	0.13	1.50	14	ND
8/25/2014	19:04	100	0.32	1.40	26	2.2
2015 Water Year						
11/22/2014	11:11	46	0.19	0.77	18	ND
12/2/2014	19:51	39	0.15	0.45	19	ND
2/8/2015	16:42	-	0.095	0.71	56	2.2
5/7/2015	12:58	24	0.084	0.78	43	ND
5/15/2015	8:10	5.6	0.041	0.69	61	ND
6/29/2015		-	-	-	-	-
7/8/2015	14:25	64	0.086	0.60	5	ND
2016 Water Year to Date						
11/3/2015	4:09-5:31	13	0.13	0.55	150	ND
11/3/2015	4:09-5:31	11.2	0.084	0.65	-	-
10/14/2016	13:18	35	0.15	1.8	18	ND
10/27/2016	13:30	28	0.13	0.33	12	ND

Table notes:

[1]No samples were collected during the Second Quarter of Water Year 2015-2016 due to no flow and low flow conditions.

[2]The collection of storm runoff samples were attempted during the Third Quarter Water Year 2015-2016; however, the northern automatic sampler did not record a sample. Due to an incomplete sample round, the remaining samples were not analyzed.

Table 4-2: Heavenly Mountain Resort water quality data from influent station 43HVP-1b (South) (Water Years 2012-2016)

Date	Time	Turbidity (NTU)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Chloride (mg/L)	Oil & Grease (mg/L)
1/20/2012	14:15	1000	0.043	2.1	250	<2.0
4/26/2012	8:25	8.4	0.094	0.80	140	<2.0
6/4/2012	17:30	63	0.11	0.53	20	<2.0
7/23/2012	13:40	420	0.24	3.34	52	41
8/14/2012	16:45	69	0.27	1.77	43	<2.0
2013 Water Year						
10/12/2012	10:15	35	0.1	1.15	28	<2.0
11/1/2012	9:25	14	0.093	0.58	47	<2.0
12/2/2012	14:20	53	0.087	0.35	7.5	2.2
5/6/2013	8:01	110	0.078	0.50	8.1	ND
2014 Water Year						
11/20/2013	16:35	33	0.093	1.00	8.2	ND
1/29/2014	14:36	2.3	0.64	2.30	800	3
3/26/2014	17:40	2.3	0.64	2.30	800	3
4/25/2014	8:29	170	0.13	1.40	310	ND
5/20/2014	15:00	27	0.2	0.33	11	ND
8/4/2014	14:25	-	0.13	2.10	14	ND
8/11/2014	16:35	4.1	0.074	1.60	5.7	ND
8/25/2014	18:54	39	0.14	1.20	1.2	2.3
2015 Water Year						
11/22/2014	13:18	30	0.096	0.49	18	ND
12/3/2014	17:30	34	0.14	0.48	20	ND
2/8/2015	No Sample Collected Due to Automated Sampler System Failure					
5/7/2015	12:48	27	0.072	0.78	27	ND
5/14/2015	22:22	19	0.046	0.70	11	ND
6/29/2015	18:03	260	0.7	9.70	11	ND
7/8/2015	14:22	24	0.096	24.0	2.4	ND
2016 Water Year to Date						
11/3/2015	9:30	8.9	0.066	0.32	4.0	ND
11/3/2015	9:30	10.9	0.059	0.27	-	-
10/14/2016	13:11	39	0.12	1.4	6.4	ND
10/27/2016	13:20	50	0.038	0.26	1.8	ND

Table notes:

[1]No samples were collected during the Second Quarter of Water Year 2015-2016 due to no flow and low flow conditions.

[2]The collection of storm runoff samples were attempted during the Third Quarter Water Year 2015-2016; however, the northern automatic sampler did not record a sample. Due to an incomplete sample round, the remaining samples were not analyzed.

Table 4-3: Heavenly Mountain Resort water quality data from effluent station 43HVP-2 (Water Years 2012-2016)

Date	Time	Turbidity (NTU)	Total Phosphorus (mg/L)	Total Phosphorus (mg/L)	Chloride (mg/L)	Oil & Grease (mg/L)
Lahontan Standards		20	0.10	0.5	N/A	2.0
2012 Water Year						
1/20/2012	13:45	54	0.11	1.14	160	<2.0
4/26/2012	7:55	78	0.079	0.77	120	<2.0
6/4/2012	17:10	81	0.10	0.702	56	<2.0
7/23/2012	13:25	290	0.16	2.71	98	11
8/14/2012	16:55	72	0.14	1.74	59	<2.0
2013 Water Year						
10/11/2012	9:00	31	0.23	1.62	41	<2.0
11/1/2012	8:45	20	0.094	0.642	46	<2.0
12/2/2012	14:40	110	0.13	0.833	22	7.9
5/6/2013	8:45	49	0.061	0.45	21	ND
2014 Water Year						
11/20/2013	16:55	47	0.11	1.2	22	1.0
1/29/2014	15:15	210	0.27	2.2	600	3.2
3/26/2014	17:35	49	0.09	1.2	140	ND
4/25/2014	8:50	61	0.098	1.2	320	ND
5/20/2014	15:25	31	0.18	0.42	27	ND
8/4/2014	15:00	-	0.21	2.1	18	ND
8/11/2014	16:50	5.8	0.23	1.6	15	ND
8/25/2014	19:15	65	0.32	1.3	9.8	ND
2015 Water Year						
11/22/2014	11:15	42	0.20	0.64	20	ND
12/2/2014	19:49	46	0.072	0.47	20	ND
2/8/2015	17:34	-	0.13	0.74	57	3.9
5/7/2015	12:58	-	0.070	0.74	-	ND
5/14/2015	23:23	26	0.030	0.78	24	ND
6/29/2015	18:13	220	0.30	4.4	17	ND
7/8/2015	14:27	24	0.15	0.88	4	ND
2016 Water Year to Date						
11/3/2015	7:06-8:33	16	0.12	0.51	16	ND
11/3/2015	7:06-8:33	18.9	0.114	0.46	-	-
10/14/2016	13:34	59	0.076	1.6	9.2	ND
10/27/2016	14:17	44	0.033	0.24	5.4	ND

Table notes:

[1]No samples were collected during the Second Quarter of Water Year 2015-2016 due to no flow and low flow conditions.

[2]The collection of storm runoff samples were attempted during the Third Quarter Water Year 2015-2016; however, the northern automatic sampler did not record a sample. Due to an incomplete sample round, the remaining samples were not analyzed.

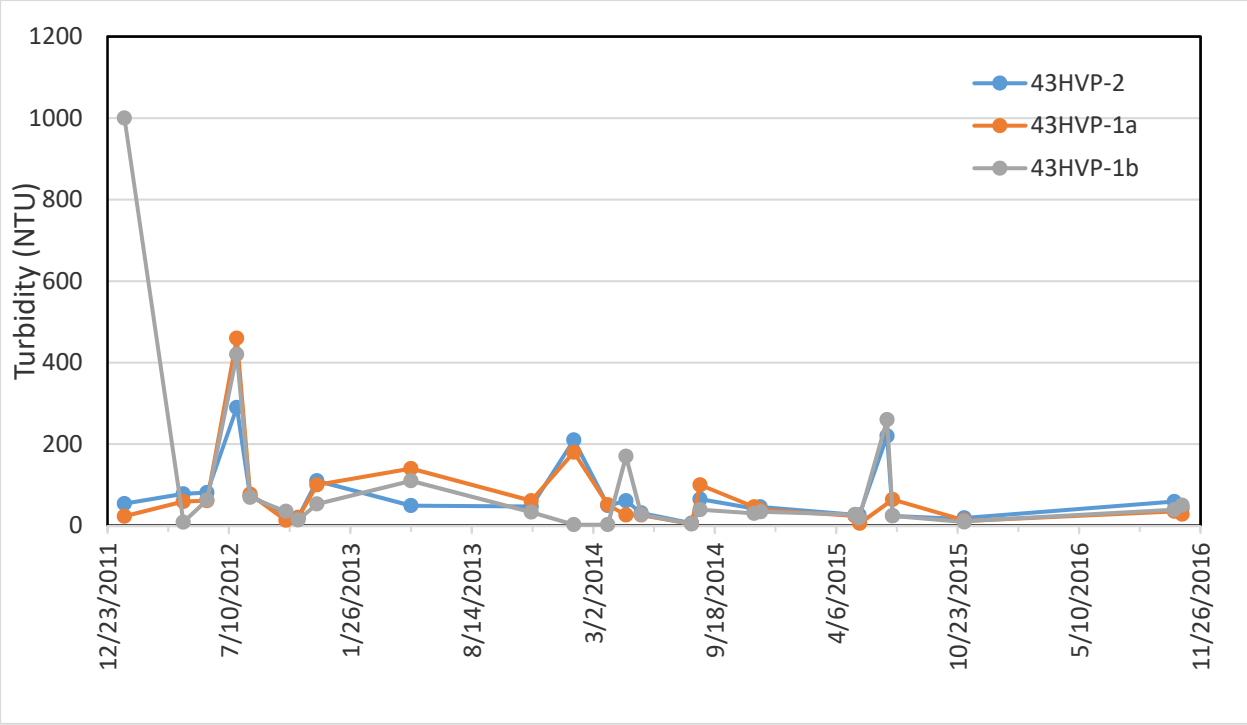


Figure 4-3: Turbidity sample results at California Base Lot Vault Sites (2011-2016) showing improved turbidity with increased system maintenance.

Chloride readings continue to be greater than the water quality standards at the vault effluent site as well as the other California stream monitoring locations. New regulations set forth in the Monitoring and Reporting Program (2015-0021) prompted Heavenly to switch from a 3:1 volcanic cinder/deicer mixture to a 5:1 Washoe Sand/deicer mixture for the 2015/2016 winter season. Improvements and upgrades to the application fleet of vehicles (dump truck and spreader truck) have allowed Heavenly to switch from the use of cinders to a Washoe Sand deicer mixture that is consistent with CalTrans practices in the Lake Tahoe Basin, and supported by Board staff. Monitoring results from the 2015/2016 winter months tentatively show improved water quality results with regards to chloride levels around the California Base Lodge water quality site 43HVP-2. Other factors that contribute to specific water quality results at the parking lot vault treatment system include improved vault maintenance (replacement of cartridges and cleaning sediment from vaults), relative runoff volumes (e.g. drought conditions), and decrease in application of deicer along upper parking lot pedestrian walkways.

4.1.2 Hydraulic Analysis

An inspection of the stormwater treatment system including the high flow diversion vaults, StormFilter vaults and the automatic monitoring vaults was performed from ground surface through manholes on December 15, 2015 and again on June 14, 2016. These inspections confirmed that an external high flow bypass structure exists (High Flow Bypass Vaults 1 and 7) as well as internal high flow bypasses in the sacrificial StormFilter vaults (Manholes 3 and 9). Treatment flows above the dry weather flows are routed to the first two large StormFilter vaults (structure numbers 4 and 10). Once those vaults reach treatment capacity, excess treatment flows are routed to the second large StormFilter vaults (structure numbers 5 and 11). The second large StormFilter vaults (structure numbers 5 and 11) do not have

internal high flow bypass structures and flows must exit the vault through the sub-drain manifold. This configuration is in contrast to the original design drawings that show a baffle wall that does not extend to the top of the vault which has led to previous speculation that flows could bypass treatment by flowing over the baffle walls. Figure 4-4 illustrates a correction to the original design drawing of the primary treatment vaults to show that the baffle wall extends to the top of the vault and would not allow for untreated flows to bypass into the outlet bays.

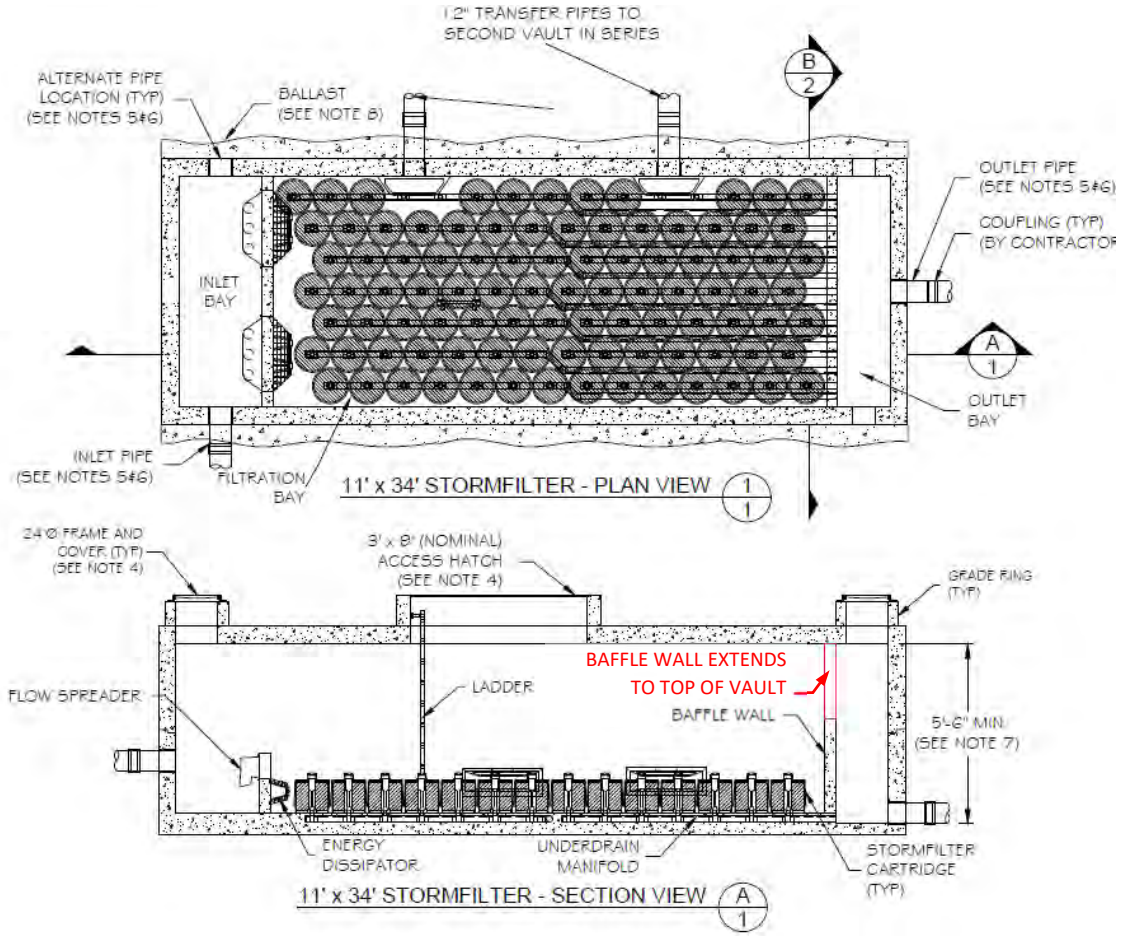


Figure 4-4: Design drawing of StormFilter vault and correction to baffle wall specification.

The Wildwood StormFilter vault is constructed slightly differently in that the baffle wall that separates the untreated water from the treated water outlet bay does not extend to the top of the vault as it does in the California Base StormFilter vaults and would allow for high flows to overtop and bypass the filter system. Flows to the sacrificial StormFilter vaults (Manholes 3 and 9) are controlled with the use of restrictor caps installed at the inlets that limit flows to a maximum of 0.23 cfs. In the event that the sacrificial filter cartridges cannot keep up with the design flow rate, untreated water that rises above the internal bypass outlet riser may exit the vault and comingle with treated water from the primary treatment vaults via Manholes 12, 13, and 14. Since the sacrificial StormFilter vaults are enclosed, covered and inaccessible during many sampling events, it is impossible to know whether or how often the sacrificial StormFilters are bypassing. Plugging the high flow outlet risers in the sacrificial StormFilter

vaults would make certain that untreated flows do not exit this portion of the treatment system, although this would require close monitoring to ensure that the filter cartridges are working properly and water is not backing up in these structures.

Our earlier assessment indicated that flows above the design flow of 14 cfs may be bypassed by the primary StormFilter treatment vaults. However, as installed, there is no such outlet for untreated flows to exit either of the second large StormFilter treatment vaults except through the filter cartridges and sub-drain manifold as shown in Figure 4-4. Rather, several factors likely reinforce each other to lead to excessive turbidity during flow events at or above the design flow, as follows:

1) At flows of 14 cfs or less, as the cartridges become more and more occluded, runoff backs up and develops an overpressure that may work to dislodge accumulated sediment and forcing it through the cartridges, thus leading to excessive turbidity in the discharge;

2) The cartridge filters effectively filter out sediments to a grain size of, at best, approximately 10 microns (based on laboratory analysis, although different results may be experienced in the field). The smaller suspended sediment will not be filtered out and will migrate through the cartridges into the discharge;

3) The filter cartridges in the primary vaults contain Zeolite, Perlite and Granular Activated Carbon (ZPG^{TM}) filtration media which has the potential to slump within the cartridge. If the media slumps more than approximately 20 percent, it may be possible for unfiltered stormwater to bypass across the top of the filter media but under the StormFilter hood which would result in untreated flows bypassing the treatment system; and,

4) The StormFilter cartridges were designed to form an imperfect seal with the cartridge base so that any accumulated water at the bottom of the vault will leak preferentially at a rate of approximately 0.5 gallons per minute (gpm) per cartridge, through the bottom of the cartridge. This is so that standing water that does not rise to the elevation required to activate the floats does not stagnate in the vaults. This water does not filter through the media and exits the vaults untreated along with any associated suspended sediments.

It is important to note that the system was designed for clear flows of up to 14 cfs. This means that the capacity of the system will decrease as the filter cartridges become spent and if the influent contains high concentrations of suspended sediment and contaminants. In the event that the filters are severely occluded, it may be possible for stormwater to backup and build up a hydraulic head over the filter cartridges within the primary StormFilter treatment vaults. As noted above, in this circumstance, it would be possible for flows to dislodge sediments and contaminants from the filter media as it passes through the cartridges and into the outlet bay, which underscores the importance of regular inspection and maintenance of the filter cartridges.

Effluent samples collected during storm events often contain relatively high turbidity levels that are frequently higher than the influent samples. During an inspection of the vault treatment system performed on September 12, 2016, fine sediment was observed to have accumulated in the outlet bays of the primary StormFilter treatment vaults (structure numbers 4, 5, 10, and 11) as well as in the Manholes 12, 13, and 14. As such, it is suspected that sediment with particle grain size around 10 µm or less is associated with treated water that has migrated through the filter cartridges, or is associated with untreated flows that have either leaked passed filter cartridges when the water level was not high enough to activate the floats or (more unlikely) bypassed across the top of the filter media but under

the StormFilter cartridge hood. The data analysis also indicates that the cause of the sediment accumulation must first be determined in order to optimize system performance. The cause could be due to the internal hydraulics being compromised and/or excessive sediment loading. The following sections summarize the analysis of these contributing factors to further assess options for optimizing the treatment system.

4.1.2.1 Hydraulic Profile

A field survey was performed on June 14, 2016 to determine the elevation of key control points within the treatment system. The surveyed elevations of these structures have been used to better understand the hydraulics of the treatment system and were used to develop an initial hydraulic profile of the system for flows originating from the High Flow Bypass Vault 1 and High Flow Bypass Vault 7 as illustrated in Figure 4-5 and Figure 4-6 respectively (refer to Figure 4-1 for a schematic of the vault treatment system).

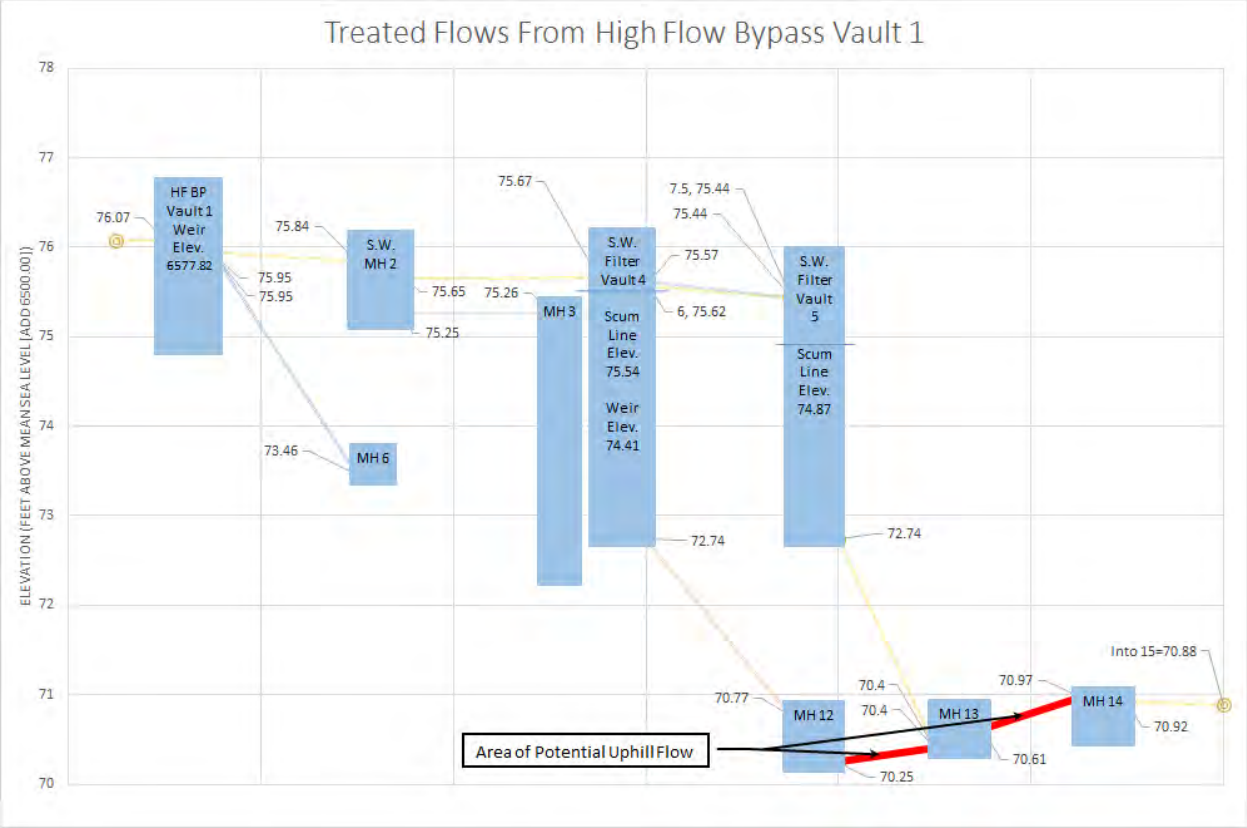


Figure 4-5: Hydraulic Profile of Treated Flows from High Flow Bypass Vault 1.

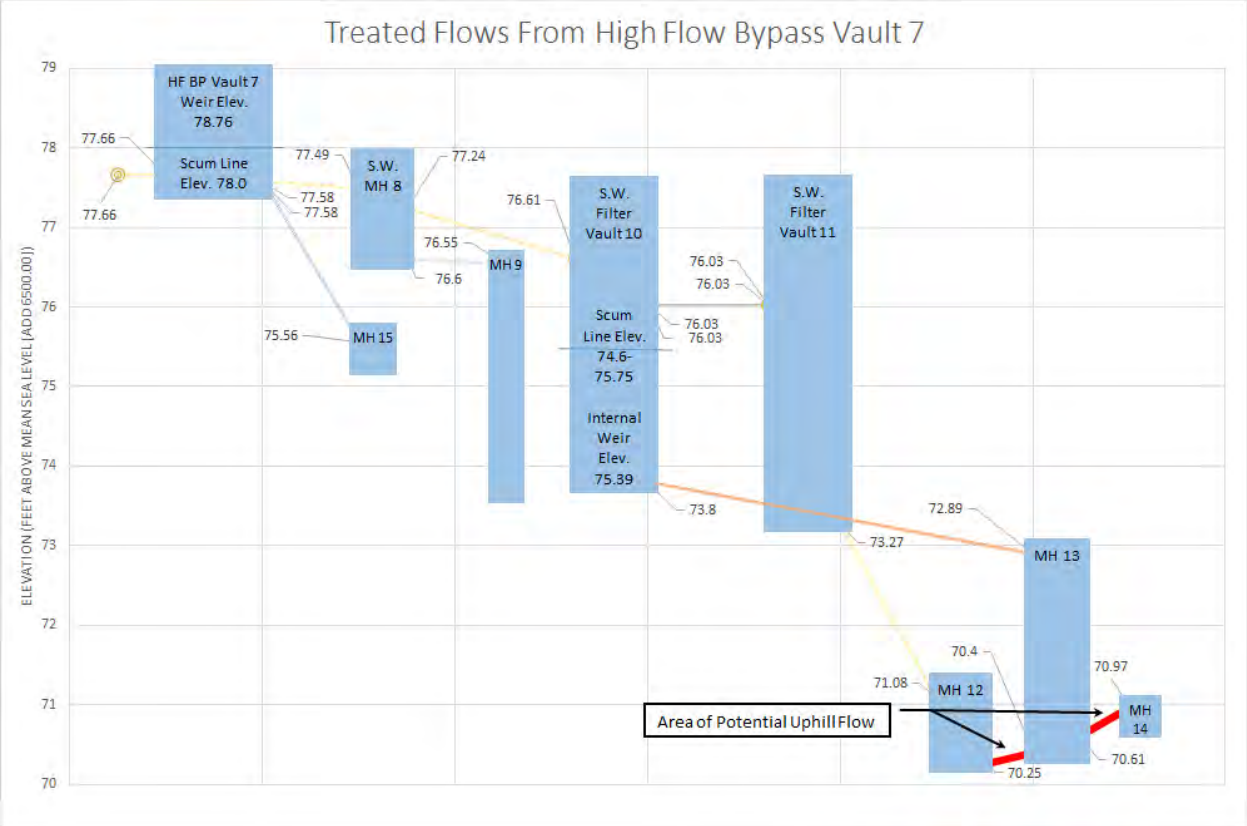


Figure 4-6: Hydraulic Profile of Treated Flows from High Flow Bypass Vault 7.

The above hydraulic profiles illustrate that influent should generally flow through the system as designed. One notable exception is the apparent gain in elevation from Manhole 12 to Manhole 13 to Manhole 14 based on survey data. Manholes 13 and 14 should be hydraulically downgradient from Manhole 12 rather than the uphill gradient as measured during the survey. This condition may be a result of post-construction settlement of the structure and could lead to standing water in the discharge line between Manholes 12, 13, and 14. There are internal high flow bypass structures within the sacrificial StormFilters (Manholes 3 and 9). As the sacrificial StormFilter cartridges are loaded throughout the season and the filter media becomes occluded, their filter capacity will decrease. This may result in flows backing up in the sacrificial StormFilter structures so that untreated flows would exit via the internal high flow bypass outlet to combine with the treated effluent from the primary StormFilter treatment vaults that is routed to Manholes 12, 13, and 14.

Any sediment in the untreated flows from the sacrificial StormFilters could accumulate in this zone of standing water caused by the hydraulic back-up in Manholes 12, 13, and 14, and then be re-suspended in subsequent flow events. In this way, the effluent concentration would be observed to be higher than the influent concentration. Heavenly employee, Frank Papandrea, observed standing water in Manholes 12 and 13 during an inspection conducted in August 2016. Standing water and accumulated sediment was also observed in these manhole structures during the maintenance event conducted in the summer of 2015. In addition, sediment has been observed in the outlet bays of the primary StormFilter treatment vaults (structure numbers 4, 5, 10, and 11).

This suggests that sediment is somehow migrating through the filter cartridges and into the treated water effluent. This may also be the source of accumulated sediment in Manholes 12, 13, and 14. Further inspection of Manholes 12, 13, and 14 and monitoring for standing water and accumulated sediment would be useful in determining if flows are backing up through this portion of the system frequently and if there is in fact an uphill gradient. Regular monitoring of any sediment accumulating in the outlet bays of the primary StormFilter vaults (structure numbers 4, 5, 10, and 11) will also be useful for determining if and how much sediment is migrating through the treatment system. Since this condition may result in re-suspended sediment in treated flows being sampled during high flow storm events, some retrofit may be required to return the gradient of Manholes 12, 13, and 14 to a downhill flow regime. In addition, flushing the underdrain system during regular maintenance events will help determine if and how much sediment is migrating through the filter cartridges and into the treated effluent flows.

The potential significance of the discolored lines, illustrated in Figures 4-5 and 4-6 was investigated. The scum (discolored) lines shown in the figure are those for Vaults 4, 5, and 10 as observed in June 2016. The scum lines in Vaults 4 and 10, below the outlet pipes to Vaults 5 and 11, indicate that this portion of the system is generally working as designed. The observed discolored line in Vault 5 also indicates that this secondary StormFilter treatment vault is filtering stormwater flows at an acceptable rate. Further, the discolored line observed in the High Flow Bypass Vault 7 suggests that there has not been a regular external bypass of flows during this last water year as discussed in *Flow Rates*, Section 4.1.2.4 below.

4.1.2.2 System Maintenance

In addition to the survey data supporting the hydraulic analysis above, we also investigated indications of high sediment loading rates and high water flow rates (during rain on storm or pure snowmelt conditions) as part of this study. Observation of cartridge loading rates in the coming water years will indicate if there is an uneven flow and load distribution through the system as described in greater detail in this section. There are high positive correlations between TSS and total phosphorus (71% correlation), ammonia nitrogen (95% correlation), and turbidity (75% correlation.). The correlations indicate that improving the removal of total suspended solids from the stormwater can be expected to also reduce phosphorus, nitrogen and turbidity. Removal of suspended solids is generally easier, more effective and less costly than targeting individual or dissolved chemical constituents. This analysis therefore focuses on sediment/TSS removal, as a surrogate for also reducing nitrogen and phosphorous.

Since installation, maintenance of the filter system has been problematic and limited due to inadequate monitoring of the system. In response, Heavenly has taken the following actions to improve the representativeness of the monitoring results and to better qualify StormFilter system performance:

1) Replaced vault covers with solid manhole lids to limit the infiltration of untreated surface runoff water and sediment into the vaults;

2) Removed deposited sediment from the bottoms of all vaults on an annual basis during summer months;

3) Executed a maintenance agreement and established a schedule for inspection and replacement of filter cartridges. As of October 2014, all 456 filter cartridges had been replaced in the system at least once; and,

4) Developed a plan to install remote rainfall sensors to trigger sampling during storm events to obtain more consistent and representative samples.

The WDRs note that there has not been improvement in the performance of the StormFilters despite these actions. Additional information is needed for Heavenly to determine how to improve the performance of the parking lot treatment facilities, evaluate additional source control measures (particularly for salt/chloride) that may be needed, and assess the appropriateness of compliance requirements given the limitations of the current technologies.

The following summarizes the maintenance of the StormFilter treatment system:

1) November 2009, marked the first time that the sacrificial filters (14 total) were replaced. They were not replaced again until autumn 2011. Since 2011, system cleanouts have been more frequent, and the sacrificial filters have been replaced annually due to sediment loading;

2) In September 2012, the sacrificial filters as well as the filters in the Wildwood vaults were replaced. A different phosphorus absorbent media was used in all fourteen sacrificial filters that were replaced in September 2013. The media was changed from Zeolite, Perlite and Granular Activated Carbon media (ZPG™) to a PhosphoSorb™ absorbent media in hopes to reduce total phosphorus exceedances;

3) In September 2013, 176 filters were replaced in the main treatment vaults for the first time since their installation in 2008. These additional filters were not installed with the newer media due to the additional associated cost;

4) In June 2014, an additional 221 cartridges were replaced. Fourteen of the 221 cartridges included the PhosphoSorb™ media and replaced the cartridges in the sacrificial filters. The remaining 207 cartridges did not include the newer media and replaced the cartridges in both the upstream and downstream parallel large vaults. The filter installation in June 2014 completed the first full cycle of filter replacement since initial installation;

5) On October 15th and 16th, 41 filters were replaced. Fourteen PhosphoSorb™ media filters were replaced in the sacrificial vaults, while 27 cartridges were replaced in the Wildwood vault; and,

6) In September 2016, the fourteen PhosphoSorb™ media filters were again replaced in the sacrificial vaults, while 93 cartridges were replaced in StormFilter Vault 10 and 27 cartridges were replaced in the Wildwood StormFilter vault. The sediment accumulated in all of the structures is removed annually.

Figures 4-7, 4-8, and 4-9 illustrate the sample results for Turbidity, Total Phosphorus, and Total Nitrogen respectively, relative to vault treatment system maintenance events. Comparing the water quality results with the annual PhosphoSorb™ media and filter replacement show slight improvements with regards to the minimum tested constituent values; however total phosphorus and total nitrogen levels are still above the not-to-exceed limits. In general, the constituent concentrations appear to decrease immediately following a maintenance event with continued annual maintenance and filter replacement showing some water quality improvement as exceedance and maximum constituent values (spikes) in the effluent (43HVP-2) have not risen significantly over time.

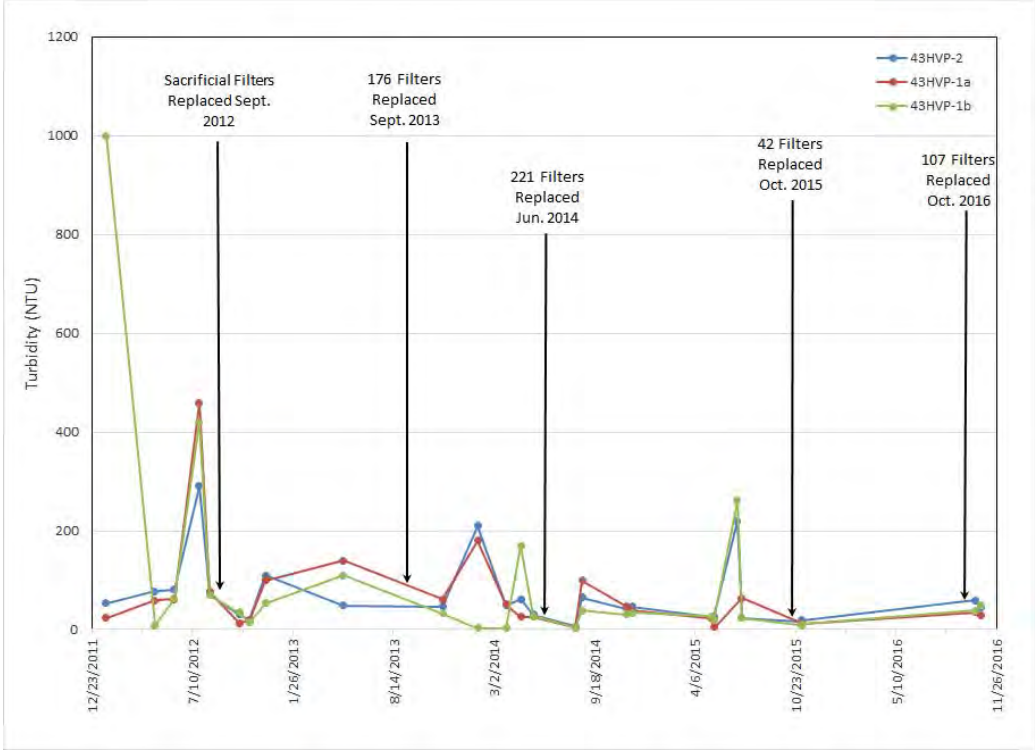


Figure 4-7: Turbidity sample results at California Base Lot Vault Sites relative to vault treatment system maintenance events (2011-2016).

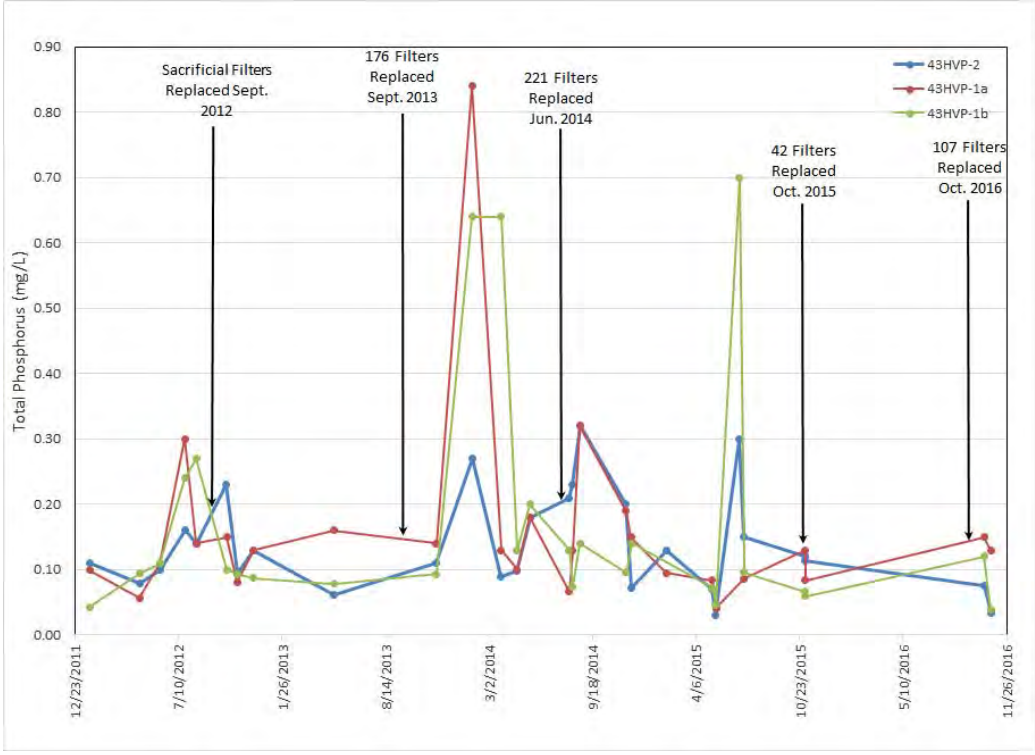


Figure 4-8: Total Phosphorus sample results at California Base Lot Vault Sites relative to vault treatment system maintenance events (2011-2016).

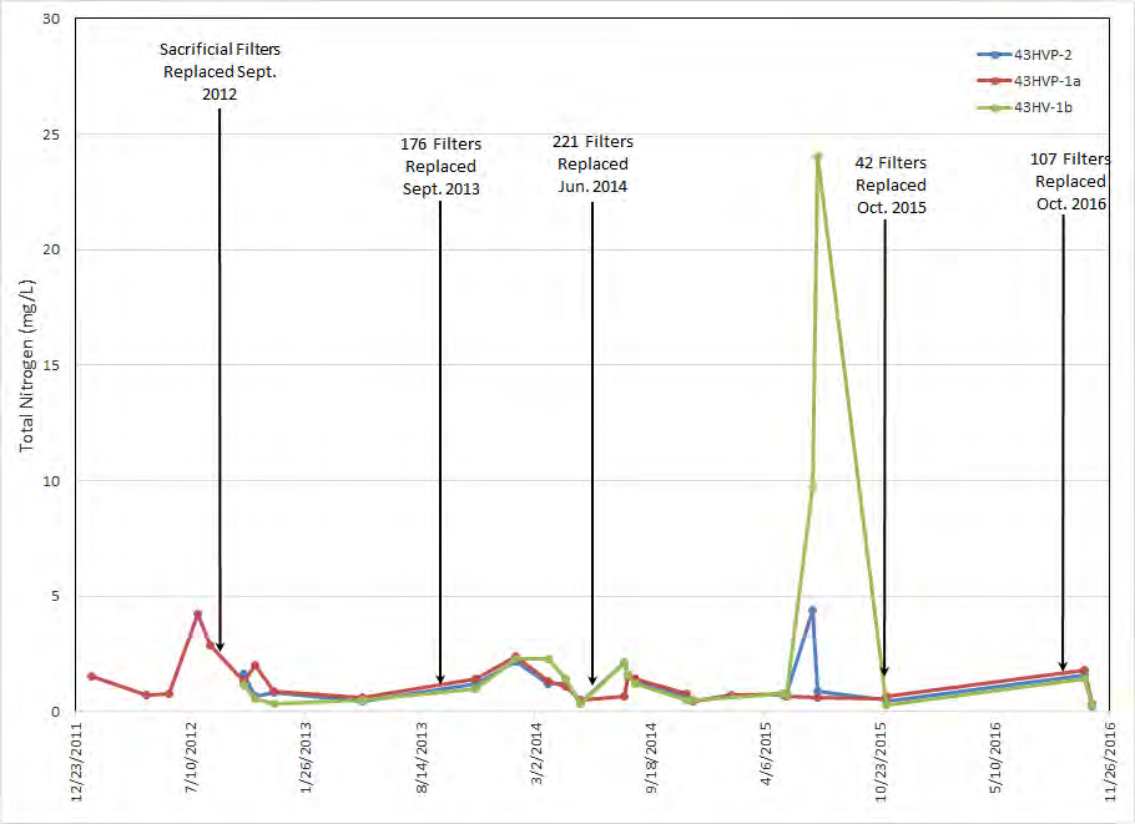


Figure 4-9: Total Nitrogen sample results at California Base Lot Vault Sites relative to vault treatment system maintenance events (2011-2016).

4.1.2.3 Sediment Load

The most recent inspection and maintenance of the vault treatment system took place on September 12 and 13, 2016. Based on the inspection reports, maintenance of Filter Vault 10 was recommended due to dark and impacted media in the StormFilter cartridges. Approximately four inches of sediment was removed from the bottom of the vault and all 93 cartridges were replaced. These cartridges were not replaced the previous year and appeared to be roughly 70 percent occluded at the time of replacement. In addition, maintenance of the sacrificial filters in Manholes 3 and 9 was recommended due to water draining very slowly through the sacrificial filters at Manhole 3 and a high scum line above the top of the sacrificial filters in Manhole 9. Approximately four inches of sediment was removed from each of these structures and the seven cartridges in each structure were replaced.

Maintenance of the primary StormFilter Vaults 4, 5, and 11 was not recommended in 2016 due to less than ½-inch of sediment and thin scum line partially up filters. The 2015 inspection report noted the minimal sediment accumulation in StormFilter Vault 4 as well, which suggests that StormFilter Vault 10 is receiving greater sediment loads (approximately four inches per year) than StormFilter Vault 4 (approximately ½-inch per year). However, the flows to StormFilter Vault 4 appear to be greater during larger storm events than those going to the StormFilter Vault 10 side of the system as discussed under *Flow Rates,* Section 4.1.2.4 below.

As discussed above under *Treatment System Effluent Water Quality Monitoring*, Heavenly has switched the abrasives used on the parking lot surface from a 3:1 volcanic cinder/deicer mixture to a 5:1 Washoe Sand deicer mixture. A grain size analysis was performed on the cinders used during the 2014/2015 winter season as well as the Washoe sand deicer used during the 2015/2016 season. These results along with the CalTrans "Spec H" with the particle grain size distribution for each of the abrasive mixtures is detailed in Table 4-4 with the respective particle size distributions illustrated in Figure 4-10.

The data in Table 4-4 show that the cinder aggregate contained too many fines material smaller than the #200 sieve (0.075 mm) and neither the cinders nor the Washoe sand deicers met the CalTrans "Spec H" standard specification. Monitoring results from the 2015/2016 winter months tentatively show improved water quality results with regards to chloride levels around the California Base Lodge water quality site 43HVP-2. However, the results of the 2016 inspection and maintenance activities indicate that the application of Washoe Sand has led to a greater load of fine to coarse-grained sand accumulating in the treatment vaults compared to the cinders. This results in an increase in sediment loading to the system.

Table 4-4: Deicer Sieve Analysis.

US Standard Sieve Size (inch)	Cinders % Passing	Washoe Sand % Passing	Specification
3/8	100	100	100
¼	97	100	90-100
#4	86	97	-
#8	53	49	40-80
#16	34	18	15-70
#30	24	7	-
#50	18	3	0-20
#100	13	2	-
#200	7.9*	0.9	0-3
Durability Index	90*	86*	>60

Table notes:

*Indicates out of specification.

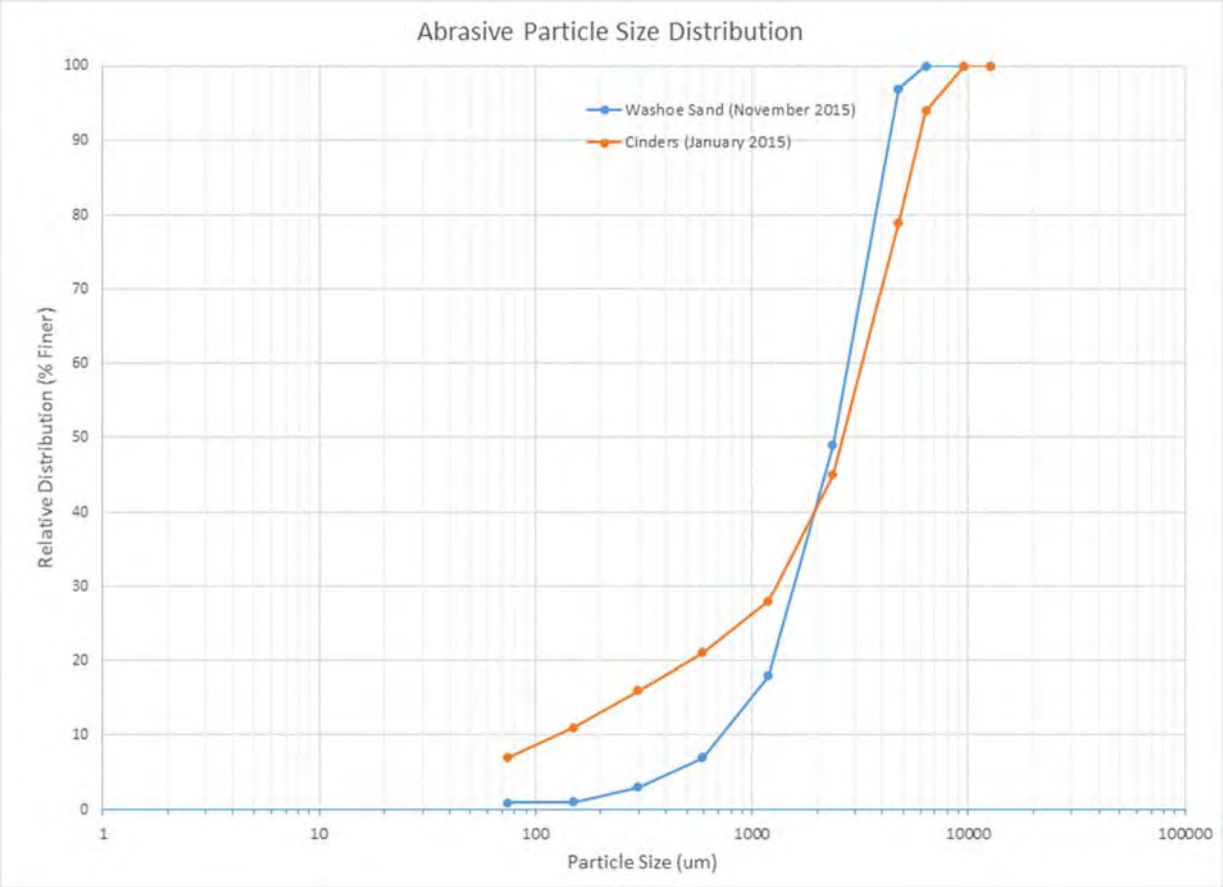


Figure 4-10: Abrasive Particle Size Distribution (Cinders and Washoe Sand).

The most recent maintenance activities conducted by Clean Harbors Environmental Services in August 2016 included removing sediment accumulated in the drop inlet vaults located throughout the parking lot. In total, approximately 20 cubic yards of solids, sediment, and debris were removed from these drop inlets located upstream from the StormFilter vault treatment system. In addition, approximately six inches of sediment was removed from the bottom of the south sacrificial StormFilter structure (Manhole 3) with four inches of sediment removed from the north sacrificial StormFilter structure (Manhole 9). Four inches of sediment was removed from the primary StormFilter Vault 10, and 12 inches of sediment was removed from the floor of the Wildwood StormFilter Vault. The loose sediment in the remaining vaults (4, 5, and 11) was removed on October 26, 2016. On October 26, 2016, Pacific Stormwater BMP Solutions also removed sediment accumulated in the 8-foot deep Hydrodynamic Vortex located at Saddle Road as well as repaired the weir wall in the Wildwood StormFilter vault that was allowing untreated water to bypass the filter cartridges.

It is important to note that snow removed from the parking lot is stored adjacent to the north side of the StormFilter treatment system. Stored snow typically includes any abrasives that were applied to the snow surface throughout the season. As the snow piles melt, the associated runoff includes any abrasives/deicers that had accumulated in the snow pile. Accordingly, the relative disproportionate amount of sediment observed in the north side of the treatment system (StormFilter Vault 10) may be due to abrasives/deicers that have accumulated in the snow pile and then delivered to the treatment system as it melts.

Another source of sediment in the effluent structures may also be a result of influent from the manhole covers. Although the manhole covers were recently replaced with solid manhole lids, they do not form a perfect seal and may allow water and fine sediment to infiltrate into the effluent system. Some studies show that typical manhole castings will allow an inflow rate from 0.20 to over 5 gpm during runoff events (as reported by the Massachusetts Department of Environmental Protection [http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/iiguidln.pdf] and others). Some of the manholes at Heavenly include a "NO FLOW IN FLOW" insert to collect any sediment that migrates through the lid. Previously, these were installed in the manholes for the outlet bays for StormFilter Vaults 4, 5, 10, and 11, and Manholes 12 and 13. However, some of these inserts are no longer present. It is recommended that every manhole that accesses the effluent structures includes an insert (e.g. Man Pan) complete with gasket. These inserts should be regularly cleaned (especially prior to removing the inserts when accessing the structure so that sediment is not inadvertently dumped into the effluent lines) and inspected to ensure that gaskets are properly installed and in good repair. Raising the manhole access structure above the surface of the asphalt would effectively eliminate the potential for flows to migrate into the effluent structures although operation of snow plows in the area of the raised lids would likely result in damage to the lids as well as to the plows.

In conclusion, the abrasives applied to the parking lot and erosion of the parking lot surface both appear to produce sediment loading rates that are high enough that there is a substantial amount of deposition within drop inlets as well as in the sacrificial and primary treatment vaults. Runoff from snow stored adjacent to the treatment system may be disproportionately loading the north side of the treatment system (StormFilter Vault 10) with sediment. The sediment accumulation appears to either clog or leak past the treatment filter cartridges and/or manhole covers, leading to sediment accumulating in the outlet bays and Manhole Structures 12, 13, and 14. The maintenance and filter replacement schedule appears to have improved system performance somewhat in the last four years. We recommend that the more frequent maintenance continue, and be based on systematic observations of key indicators of system degradation.

Specifically, all structures should be carefully inspected prior to and during maintenance activities with particular attention to the relative loading of sediment and standing water in each structure. Cartridges removed from each structure should be inspected to note loading patterns (e.g. sediment loading throughout cartridge or greater sediment accumulation at the bottom of the cartridges) and/or any slumping of filter media that would indicate if flows are being fully treated by the filters or are preferentially leaking through the filters. Comparing relative loading in the structures during each maintenance event will assist in determining if portions of the system are receiving greater loads than others. These factors will help determine the optimal protocol and thresholds for implementing maintenance of the system and/or if the filter cartridges should be replaced more frequently.

In addition to the frequent and systematic maintenance and filter change-out indicated by this analysis, we also recommend measures that are likely to reduce the sediment loading. Along with maintenance of the treatment system, maintenance of the areas contributing flows to the system should be considered. Of particular note is the degrading asphalt surface of the California Base Area parking lot. Abrasives are regularly applied to the parking lot surface which serves to compound the problem and increase the rate of degradation of the asphalt and erosion of the subgrade soils. The increased erosion in the small gullies formed in the asphalt surface lead to increased sediment loading to the treatment system. Regular inspection and maintenance of this area would reduce the likelihood that eroding

parking lot surface is contributing to TSS loads. Likewise, the entire contributing area should be maintained to ensure that eroding surfaces are not also contributing to sediment loads in stormwater flows. In addition, placement of stored snow in a manner that would promote more even flow and load distribution to the two sides of the treatment system would improve filter performance.

4.1.2.4 Flow Rates

The accumulated precipitation totals, snow water content, and daily precipitation increments for the 2011-2016 water years are shown in Figure 4-11. Data was taken from the National Resource Conservation Service, National Water and Climate Center website (http://www.wcc.nrcs.usda.gov). This graph represents accumulated precipitation and snow water content measured at SNOTEL Station 19L24S ("Heavenly Valley"), operated by the USDA Natural Resource Conservation Service. This station is located in the upper watershed of Heavenly Valley Creek near the current Sky Meadows monitoring station at latitude 38° 56' N, longitude 119° 54' W, and elevation 8,850 feet.

The vault treatment system was installed with a design flow of 14 cfs. As described above, the system consists of two mirror-image systems, each with a flow capacity of up to 7 cfs for the combined total design treatment flow of 14 cfs. This treatment capacity is based on a standard runoff calculation for the 20-year, 1-hour storm that would produce approximately 1.0 inch of rain (assuming impervious surfaces). The automatic samplers located in the High Flow Bypass Vaults 1 and 7 (influent) and Manhole 14 (effluent) continuously monitor flow rates (at 10 minute intervals) into and out of the treatment system. Flow data collected since February 2015 is presented in Figure 4-10. The influent data shown in Figure 4-10 illustrates that, with the exception of one event in July 2015, flows to each side of the system have been below the treatment capacity of 7 cfs with total flows remaining below 14 cfs. Of note is that it appears that the south side of the treatment system (StormFilter Vaults 4 and 5) seems to be receiving greater flows during the larger storm events than the north side of the treatment system (StormFilter Vaults 10 and 11). This situation is in contrast to the disproportionate sediment loading that has been observed in the north side of the system. Specifically, approximately four inches of sediment was removed from StormFilter Vault 10 in 2015 and again in 2016 although less than ½-inch of sediment was removed from StormFilter Vault 4 during those same years as discussed above.

Effluent data was only available for the period following the replacement of the Area Velocity Flow Module in the automatic sampler on April 20, 2016. Operation of the parking lot facility includes plowing accumulated snow and pushing snow to designated snow storage sites surrounding the parking lot. As such, the larger flows are typically associated with a combination of rainfall runoff from the parking lot and snowmelt runoff from snow storage sites.

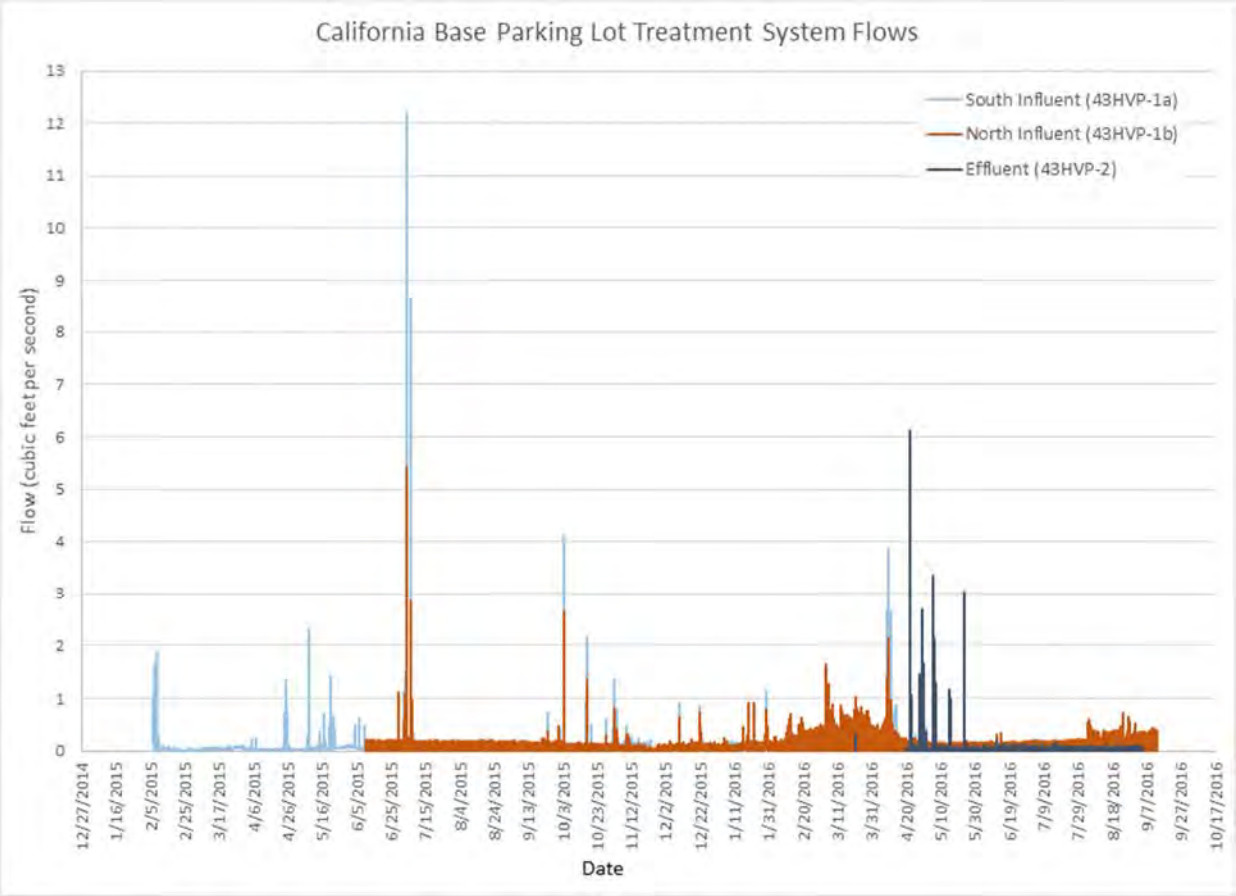


Figure 4-11: California Base Parking Lot StormFilter Treatment System Flows (2015-2016).

It is difficult to determine under what conditions the system design flows would be observed through the treatment system. Any storm event with a rainfall intensity of greater than 1-inch per hour is expected to result in runoff greater than 14 cfs through the vault treatment system. According to the SNOTEL data, there were roughly 3 days during the 2016 water year that had rainfall of 1 inch or greater during a 24-hour period. During the 2015 and 2014 water years, there were 3 days and 6 days respectively with rainfall of 1 inch or greater. The largest storm during the 2016 water year produced approximately 2.7 inches of precipitation during a 24-hour period. This rainfall runoff would be in addition to any flows associated with snowmelt in the contributing area.

Figure 4-12 shows that for the 2015 water year approximately 23 inches of total accumulated precipitation was observed for the Heavenly area with approximately 42 inches observed for the 2016 water year. The snow water content illustrated in Figure 4-12 is the amount of water contained within the snowpack; that is, it is the depth of water that would theoretically result if the snowpack melted instantaneously. These snow water content estimates assume a uniform snowpack depth and do not consider the snow water content associated with snow storage piles (including those located in the California Base Parking Lot during the snow season).

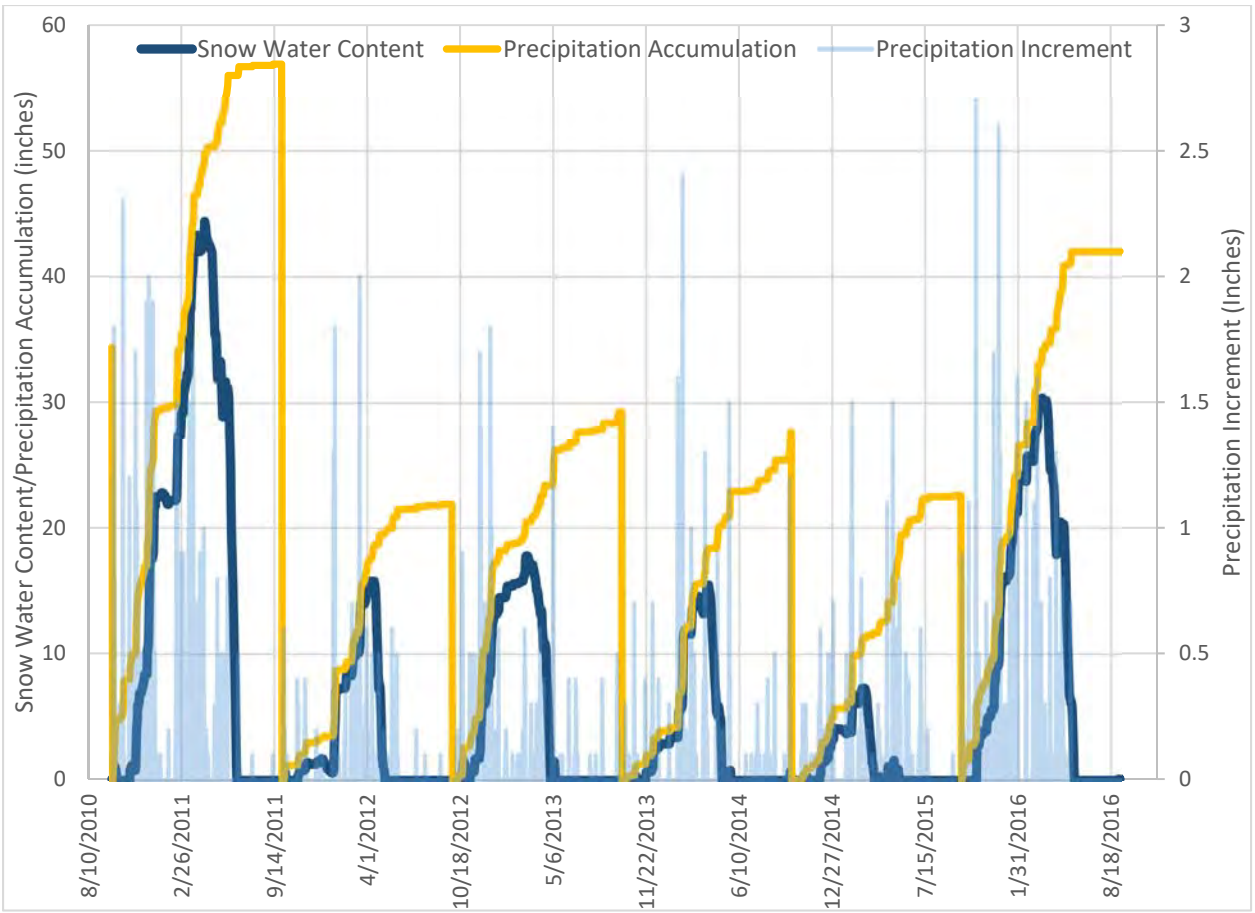


Figure 4-12: SNOTEL Precipitation Graph for Water Years 2011-2016.

4.2 STORMFILTER TREATMENT SYSTEM EVALUATION FINDINGS

As described above, the water quality monitoring data for StormFilter treatment system does not appear to be able to meet the water quality standards prescribed to protect the receiving waters as currently operated and sampled. This may be in part due to various technical issues have prevented collection of reliable samples from the treatment vaults. For example, effluent samples have contained higher concentrations of certain pollutants than the influent samples. It is possible that this results from influent samples not being collected at the same time as effluent samples; seeking to pair the timing more closely so that the same batch of water is being sampled will help in the improve the evaluation of the efficiency of the treatment system. Effluent concentrations greater than influent may also be due to resuspension of sediment migrating through the filter cartridges in the primary StormFilter vaults or associated with flows that may be bypassing the sacrificial StormFilter structures.

In response, Heavenly has taken the following actions to improve the representativeness of the monitoring results and to better qualify StormFilter system performance.

1) Replaced vault covers with solid manhole lids to limit the infiltration of untreated surface runoff water and sediment into the vaults;

2) Removed deposited sediment from the bottoms of all vaults on an annual basis during summer months;

3) Executed a maintenance agreement and established a schedule for inspection and replacement of filter cartridges. As of October 2014, all 456 filter cartridges had been replaced in the system at least once with the sacrificial filter cartridges in Manholes 3 and 9 having been replaced again in 2015 and 2016. The cartridges in the Wildwood Vault were replaced again in 2015 and 2016. Cartridges in the primary StormFilter Vault 10 were replaced again in 2016. Replacement of the cartridges in the primary StormFilter Vault 4 was not recommended in 2015 or 2016 due to minimal sediment in the vault and a thin scum line partially up the filters; and,

4) Developed a plan to install remote rainfall sensors to trigger sampling during storm events to obtain more consistent and representative samples.

The WDRs note that there has not been improvement in the performance of the StormFilters™ despite these actions. Additional information is needed to determine how to improve the performance of the parking lot treatment facilities, evaluate additional source control measures (particularly for salt/chloride) that may be needed, and assess the appropriateness of compliance requirements given the limitations of the current technologies. Accordingly, the following details the recommended next steps.

4.2.1 Recommended Improvements

Minor Structural Improvements. The data review indicates that there appears to be sediment migrating through the treatment system that accumulates in the effluent structures and negatively impacts effluent water quality sample results. The following summarizes the minor modification to the system that will reduce the sources of sediment to the treated water stream:

- *Replace Manhole Covers.* Although the manhole covers were recently replaced with solid manhole lids, they do not form a perfect seal and may allow water and fine sediment to infiltrate into the effluent system. Some of the manholes at Heavenly include a NO FLOW IN FLOW insert to collect any sediment that migrates through the lid. It is recommended that every manhole that accesses the effluent structures includes an insert (e.g. Man Pan) complete with gasket. These inserts should be regularly cleaned (especially prior to removing the inserts when accessing the structure so that sediment is not inadvertently dumped into the effluent lines) and inspected to ensure that gaskets are properly installed and in good repair. Raising the manhole access structure above the surface of the asphalt would effectively eliminate the potential for flows to migrate into the effluent structures although operation of snow plows in the vicinity of the raised lids would be limited.

- *Grout Sumps*. Raising the floor level in the outlet structures in the StormFilter Vaults 5 and 10 as well as in the effluent structures Manholes 12, 13, and 14 using a self-leveling concrete will eliminate areas where sediment can accumulate and be re-suspended in the effluent stream.

- *Reestablish Downhill Gradient in Manholes 12, 13, and 14*. Based on the survey data, there appears to be a possible uphill gradient from Manhole 12, 13, and 14. Reestablishing a downhill gradient through these structures by grouting a channel in the adjoining pipelines will eliminate any possible backup through the system and the potential for any stagnant

water and sediment accumulation in these structures that could negatively impact effluent water quality results.

- *Plug Sacrificial StormFilter Outlet Risers*. As the sacrificial StormFilters become occluded, the efficiency of the filter cartridges will decrease and may result in water levels to rise and surcharge over the outlet riser. Plugging the outlet riser in the sacrificial Manholes 3 and 9 will eliminate this pathway for untreated water to discharge into the treated water effluent line. However, this modification will require that these structures are closely monitored to ensure that water is not backing up and contributing constant groundwater flows to the primary StormFilter treatment vaults.

- *Eliminate Imperfect Seal in Cartridges*. As designed, the StormFilter cartridges form an imperfect seal with the cartridge base to leak preferentially at approximately 0.5 gpm per cartridge, through the bottom of the cartridge. This helps to eliminate stagnant water accumulated in the bottom of the vaults at levels that would not activate the floats and to reset the cartridges. Although not ideal since eliminating the imperfect seal will result in water stagnating at the bottom of the vaults, this would ensure that untreated water does not escape the treatment system.

Future Overall System Improvements. Future plans for improvements to the California Base Lodge should also include reevaluation of the water treatment technology to determine if there are any other effective options for treatment that would be practical to install in conjunction with the construction of the proposed lodge and parking lot improvements. This may also include designated snow storage facilities that can more efficiently collect and treat runoff from snowmelt.

4.2.2 Recommended System Maintenance

Continue Regular Maintenance Program. The data review indicated that there appears to be heavy sediment loading to the system as well as sediment migrating through the treatment system that accumulates in the effluent structures. This is indicative of a need for several minor changes to the treatment system as discussed above as well as for closer monitoring of the StormFilter cartridges and possibly changes made to the filter cartridge replacement schedule. Heavenly has recently initiated such a program, and it should continue as a major part of optimizing system performance to include the following elements:

1) Documenting which cartridges from which vaults are accumulating the most loading will help to determine if particular cartridges should be put on an accelerated maintenance schedule to prevent filter plugging that can contribute to unpermitted bypass of untreated stormwater. In particular, the sacrificial manhole StormFilters will take loading from all low flow events including any first flush stormwater before the upstream water level rises enough to flow into the main filter vaults.

   The sacrificial StormFilters in Manholes 3 and 9 would be expected to receive much higher TSS loading than the rest of the system and deplete faster than the filters in the main vaults. In addition, it appears that the north side of the treatment system is receiving a greater sediment load than the south side, likely attributed to snowmelt from the adjacent snow storage site. Evaluating options for more evenly distributing snow storage sites throughout the parking lot may help to promote more even flow and load distribution as well as better filter performance on both sides of the treatment system.

Alternatively, the replacement of cartridges in the StormFilter vaults on the north side of the system may need to be replaced on a more frequent schedule than the south side of the treatment system corresponding to the disproportional sediment load to the north-side vaults.

2) The need for maintenance is typically based on results of the annual inspection. The following Maintenance Decision Tree should be used as a general guide for triggering required maintenance:

   - Sediment loading on the vault floor is more than 4 inches of accumulated sediment.
   - Sediment loading on the top of the cartridges is more than ¼-inch of accumulation on the top of the cartridges;
   - There is more than 4 inches of static water above the cartridge bottom for more than 24 hours after the end of a rain event;
   - The pore space between the filter media granules is absent and the filters begin to plug;
   - There is a pronounced scum line (approximately ¼-inch thick) present above the top cap of the filter cartridges; and,
   - Hazardous Material Release. Maintenance is required if hazardous materials are released into the system (e.g. automotive fluids or other).

3) Proper maintenance of upstream facilities is important for the success of the StormFilter treatment system and improvement of downstream water quality. The six drop-inlet pre-treatment vaults upstream from the treatment system act as sediment traps and effectively reduce the sediment load to the StormFilter vaults. However, these drop-inlets will also accumulate static water during the dry months. This water will stagnate and could potentially be a source of increased nutrients and contaminants as runoff flows flush the stagnated water into the treatment system. Regularly pumping static water from these drop-inlets could help to improve water quality downstream. In addition, oil booms placed inside these drop-inlets reduce oil/grease in discharged flows. These booms should continue to be replaced annually.

Along with maintenance of the treatment system, maintenance of the areas contributing flows to the system should be considered. Of particular note is the degrading asphalt surface of the California Base Area parking lot. Abrasives are regularly applied to the parking lot surface which serves to compound the problem and increase the rate of degradation of the asphalt and erosion of the subgrade soils. The increased erosion in the small gullies formed in the asphalt surface lead to increased sediment loading to the treatment system. Regular inspection and maintenance of this area would reduce the likelihood that eroding parking lot surface is contributing to TSS loads. Likewise, the entire contributing area should be maintained to ensure that eroding surfaces are not also contributing to sediment loads in stormwater flows.

4.2.3 Recommended Sampling Protocol

Stagger Water Sample Times. Currently, the timing of samples collected at the inlet automatic sampler locations (High Flow Bypass Vaults 1 and 7) is not coordinated with the collection of the effluent sample (at Manhole 14). Collecting both inlet samples at the same time and staggering the collection of the effluent sample approximately 20 minutes after would be useful in gathering information that can be used to develop a stronger preventative maintenance program to improve TSS removal as well as the other correlated pollutants (nitrogen, phosphorus and turbidity.)

Specifically, collecting samples at the inlets simultaneously would be useful in determining if one side of the treatment system is receiving a greater load of pollutants than the other. By collecting effluent samples approximately 20 minutes after the collection of the inlet samples, we can better evaluate the same "slug" of water as it enters and leaves the system to in order to assess the system's treatment performance.

System Flow Rate Monitoring. The automatic samplers currently collect continuous flow rate data that is useful in determining if the system is functioning as intended as well as if there are any instances of system bypass (i.e. flows greater than 14 cfs). Flow rates into and out of the system as measured by the automatic sampler and by visual inspection should continue to be closely monitored in order to identify anomalies in system performance (e.g. backflow conditions, exceedance of system design flow, bypass, etc.).

Sediment Characterization. Optimizing the reduction of TSS should also lower the turbidity, and concentrations of nitrogen and phosphorous in the discharge. This optimization will require an analysis of particle size distribution upstream and downstream of the StormFilters to better understand the particle size removal performance range relative to the site-specific stormwater character.

SECTION 5

Bijou Park Creek Chloride Monitoring Study

This section discusses the Bijou Park Creek Chloride Monitoring Plan that was implemented in 2016. The Bijou Park Creek water quality monitoring program involved the collection of water samples from nine locations during five monitoring events conducted between April 7, 2016 and June 1, 2016. The samples were collected from one location situated upstream of the Heavenly stormwater management system, from the effluent of the stormwater management system in the California Base parking area, from the stormwater management vault located along Wildwood Avenue, and six locations along Bijou Park Creek. The samples were submitted to a State of California certified laboratory and analyzed for the following: Total Dissolved Solids (TDS); major cations; alkalinity; chloride; nitrate; sulfate; and, bromide. The objectives of the study were as follows:

- Determine the concentrations of chloride and other inorganic constituents in Bijou Park Creek downstream of the Heavenly stormwater management system over a range of flows;
- If chloride is elevated above the water quality objective of 3.0 mg/l specified in the WDRs, then attempt to determine the source(s) of elevated chloride concentrations and the downstream fate of the chloride; and,
- Based on the results, propose appropriate next steps which could include no additional action, proposed measures to further reduce chloride concentrations, and/or a proposed alternate water quality objective for chloride.

The remainder of this section provides background information on chloride concentrations; the water quality sampling locations and sampling methods; the water quality monitoring results and data analysis; a discussion of the considerations for alternate chloride standards; and, the study conclusions and path forward.

5.1 BACKGROUND INFORMATION ON CHLORIDE CONCENTRATIONS

The water quality objective specified in the WDRs for chloride in Bijou Park Creek is 3.0 mg/l which is derived from the limit for Lake Tahoe. This objective is to be met at the specified compliance point located at the headwaters of Bijou Park Creek. Heavenly has collected water quality data at this location for eight years and, over that time, the mean annual concentration of chloride is approximately 98.0 mg/l compared with 0.6 mg/l for the reference stream, Hidden Valley Creek. These results indicate that concentrations of chloride chronically exceed natural levels found in the reference stream as well as the water quality objective specified in the WDRs. The likely source of the elevated chloride concentrations is the application of salt to the California Base parking area and associated roads during the winter months to prevent icing and ensure public safety.

The effects of the elevated chloride concentrations on Bijou Park Creek and Lake Tahoe are unknown; however, Lake Tahoe is not listed by the State of California Water Resources Control Board (SWRCB) as an impaired water body for chloride. For context, on a statewide level, the SWRCB has adopted the U.S. Environmental Protection Agency (USEPA) national ambient water quality criteria (AWQC) for chloride of 230 mg/l (chronic threshold) and 860 mg/l (acute threshold) (USEPA 1988). These criteria have been

established to be protective of aquatic life in surface water. Accordingly, while the measured concentrations of chloride at the compliance point exceed the water quality objective specified in the WDRs, they do not appear to threaten aquatic life or otherwise impair the waters for beneficial uses since the concentrations are far lower than the USEPA and SWRCB ambient water quality criteria.

5.2 WATER QUALITY SAMPLING LOCATIONS AND SAMPLING METHODS

5.2.1 Water Quality Sampling Locations

The water quality monitoring involved the collection of water samples from nine locations during five water quality monitoring events conducted between April 7, 2016 and June 1, 2016. The sample locations are shown in Figure 5-1 and the rationale for each location is as follows:

- CalBase-1 – this location is situated in the upper parking lot under a large manhole. The water consists of unfiltered base of the ski slope drainage prior to transitioning to the Heavenly California Base parking area. The objective of this location is to characterize stormwater runoff upstream of the parking area and the stormwater management system. This runoff is routed around the parking area and the stormwater management system;
- 43HVP-2 – this location consists of the effluent from the Heavenly stormwater management system and is used to characterize the discharge from the system and California Base parking area;
- WWF-3 – this location consists of the effluent from the vaults located along Wildwood Avenue and is used to characterize the discharge from these vaults which includes stormwater runoff that may have been routed around the Heavenly stormwater management system;
- 43BPC-4 – this location is situated at the headwaters of Bijou Park Creek, approximately 0.25-miles downstream of the culvert outlet that conveys runoff from the California Base parking area and the upper portion of Wildwood Avenue. This location represents the current compliance point for meeting the water quality goals specified the WDRs;
- BPC-R5 – this location is situated along Bijou Park Creek near the end of Regina Lane and was used to evaluate potential changes in water quality (and, if so, potential reasons for the changes) between the currently specified compliance point of 43BPC-4 and discharge to Lake Tahoe;
- BPC-V6 – this location is situated along Bijou Park Creek near Verdon Lane (approximately 50 feet upstream of Needle Peak Road) and was used to evaluate potential changes in water quality (and, if so, potential reasons for the changes) between the currently specified compliance point of 43BPC-4 and discharge to Lake Tahoe;
- BPC-C7 – this location is situated along Bijou Park Creek at the end of the Charlesworth Court cul-de-sac and was used to evaluate potential changes in water quality (and, if so, potential reasons for the changes) between the currently specified compliance point of 43BPC-4 and discharge to Lake Tahoe;

- BPC-B8 – this location is situated along Bijou Park Creek near the Blackwood Apartments (immediately upstream of the culvert crossing at Tamarack Avenue) and was used to evaluate potential changes in water quality (and, if so, potential reasons for the changes) between the currently specified compliance point of 43BPC-4 and discharge to Lake Tahoe; and,
- BPC-W9 – this location is situated along Bijou Park Creek immediately upstream of the culvert crossing at Werner Salas Drive and was used to evaluate potential changes in water quality (and, if so, potential reasons for the changes) between the currently specified compliance point of 43BPC-4 and discharge to Lake Tahoe.

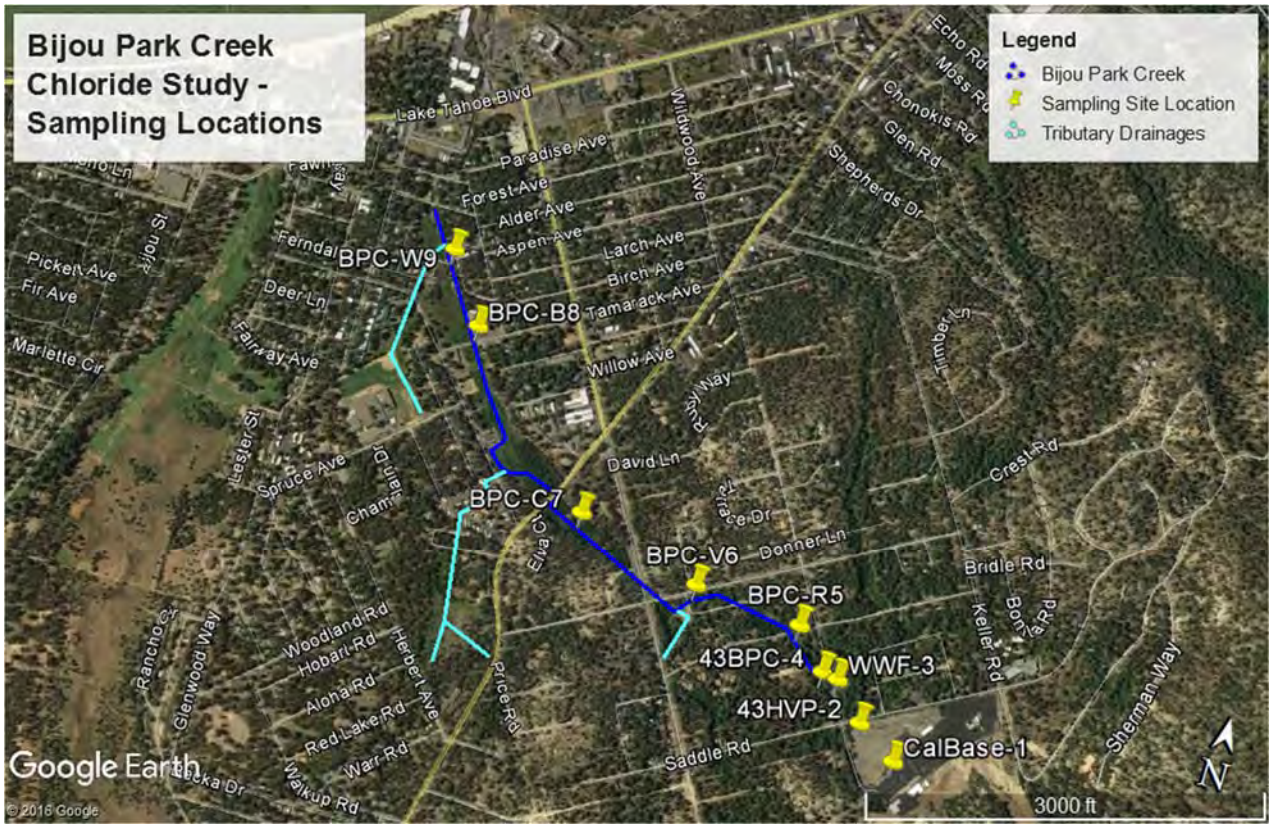


Figure 5-1: Bijou Park Creek Water Quality Monitoring Locations

5.2.2 Personnel and Procedures

All work was performed by qualified environmental scientists working under the supervision of a State of California Professional Geologist. These staff procured the sampling containers, collected field measurements of selected water quality parameters, collected the water samples, coordinated delivery of the samples to a certified analytical laboratory, and were involved in all phases of the work including data analysis and report preparation. All field procedures (e.g., sampling protocol, chain-of-custody, preparation of a Health and Safety Plan, etc.) follow El Dorado County and State of California guidelines at the time the work was performed.

5.2.3 Health and Safety Plan

A site safety plan was developed in conformance with the Occupational Safety and Health Administration (OSHA) guidelines set forth in "Hazardous Waste Operations and Emergency Response" (29 CFR 1910.120). The document was reviewed and signed by all field personnel performing work on the site. A copy was present on-site at all times and kept in an easily accessible location. In addition, a Job Safety Analysis (JSA) was completed prior to the start of work each day.

5.2.4 Water Sample Collection, Handling, and Analysis

At each sampling location, water samples were collected by immersing the sample containers in the stream/surface water body or, if the depth of flow was insufficient, submerging as much of the container as possible until the container was full. Care was taken not to entrain bottom sediment in the water. However, if flow depths were such that entrainment of sediment was unavoidable, then the sample was collected and the inclusion of bottom sediment was noted. Field measurements of water temperature, electrical conductivity, dissolved oxygen, pH, and temperature were collected at each sample location. In addition, the surface water discharge at the time of sampling was also noted.

All samples were collected using a pair of clean, dedicated nitrile surgical gloves. The sample containers were chemically preserved by a State of California certified laboratory prior the field activities. Following collection, all sample containers were labeled using a waterproof marker, and sample labels included the sampler's initials, location identification, and time. All samples were placed in individual Ziploc-type bags, sealed, and stored in coolers on ice to maintain samples at 4^{o}C prior to and during shipment to the analytical laboratory. Ice was sealed in double plastic bags. A chain-of-custody manifest was completed onsite and accompanied the samples to the lab. The samples were transferred to Western Environmental Testing Laboratory, a State of California certified laboratory, within 24-hours of collection.

The water samples were analyzed for Total Dissolved Solids (TDS) by EPA Method 160.1; alkalinity by EPA Method 310.2; chloride by EPA Method 300; nitrate by EPA Method 353.2; sulfate by EPA Method 300; bromide by EPA Method 300; and, metals (aluminum, calcium, iron, magnesium, manganese, potassium, silica, and sodium) by EPA Method 200.7.

5.3 WATER QUALITY SAMPLING RESULTS AND DATA ANALYSIS

This section discusses the water quality sampling results from the nine water quality monitoring locations during the five sampling events that were conducted between April 7 and June 1, 2016. The discussion of the results is organized as follows: surface water discharge and field water quality measurements; anion results; and, cation results. Following the summary of results, the data is analyzed to evaluate downstream geochemical trends, and correlations of these trends with physical changes to the channel and channel hydraulics. The objective of this section is to discern the environmental fate of chloride in the Bijou Park Creek watershed.

5.3.1 Surface Water Discharge and Field Water Quality Parameters

Surface water discharge and field water quality parameters were collected from each sample location during each sampling event. The results from each sampling location are summarized in Table 5-1. This section also discusses notable results.

In regards to surface water flows, the data generally indicates that flows were similar between the area upstream of the stormwater management system (CalBase-1) through the vault in Wildwood Avenue (WWF-3), and then increased between the Wildwood Avenue vault and the headwaters of Bijou Park Creek (43BPC-4). The increase in flows at the headwaters is likely due to the contribution of groundwater seepage and surface water runoff from adjacent areas. Downstream of the headwaters, the flow remained relatively stable through the sampling location near Charlesworth Avenue (BPC-C7) and then increased downstream at BPC-W9. The April 7, 2016 sampling event appears anomalous, with flows increasing closer to the headwaters. A graph of the surface water flow data is presented in Figure 5-2.

Figure 5-2: Surface Water Discharge

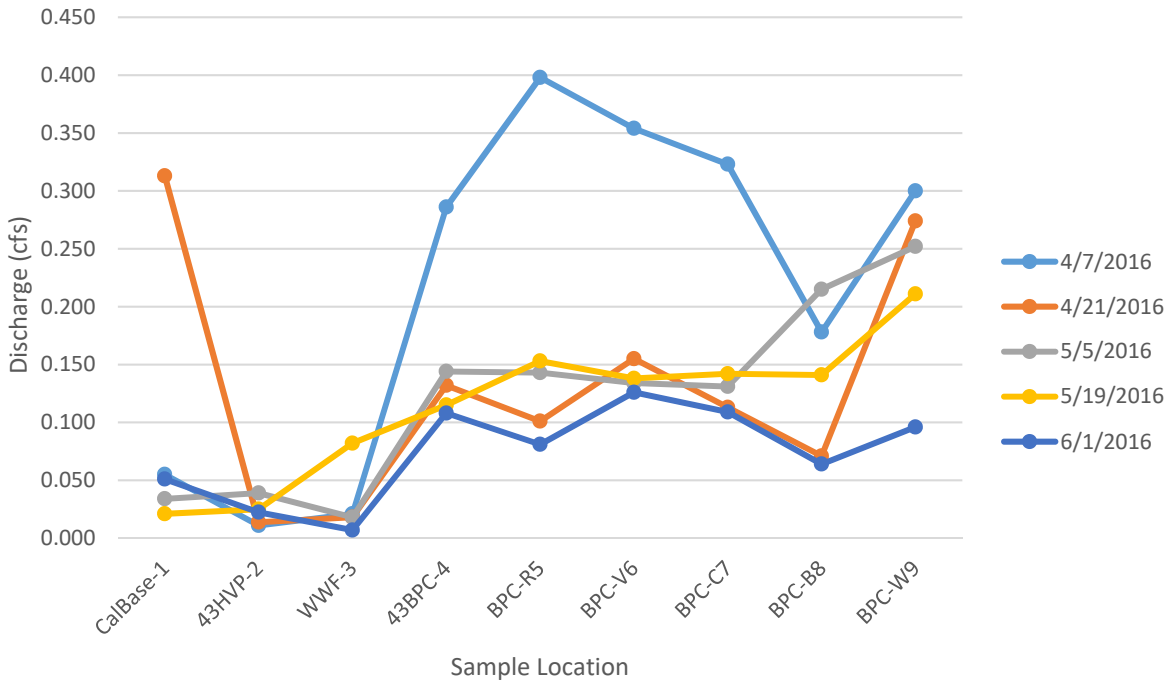


Table 5-1: Summary of Surface Water Discharge and Field Water Quality Measurements[1]

Sample Location[2]	Date	Time	Discharge[3] (cfs)	Total Dissolved Solids (mg/l)	Electrical Conductivity (uS/cm)	Dissolved Oxygen (mg/l)	pH	Temperature (deg F)
CalBase-1	4/7/16	10:00	0.055	384	825	8.2	7.3	48.3
43HVP-2	4/7/16	10:30	0.011*	352	701	6.6	7.3	49.9
WWF-3	4/7/16	11:40	0.021	354	716.0	7.0	8.2	52.1
43BPC-4	4/7/16	12:10	0.286	123	246	8.8	7.9	44.4
BPC-R5	4/7/16	13:00	0.398	166	332	8.6	8.1	46.0
BPC-V6	4/7/16	13:35	0.354	147	293	8.3	8.3	48.3
BPC-C7	4/7/16	14:00	0.323	209	419	8.2	8.3	50.9
BPC-B8	4/7/16	14:30	0.178	213	426.0	9.2	8.1	60.0
BPC-W9	4/7/16	15:00	0.300	216	432	5.8	7.8	63.4
CalBase-1	4/21/16	9:45	0.313	88	177	7.0	7.5	50.7
43HVP-2	4/21/16	10:20	0.014	356	712	7.0	7.5	49.6
WWF-3	4/21/16	11:10	0.018	279	558	5.9	8.1	52.3
43BPC-4	4/21/16	11:45	0.132	192	385	8.0	7.6	49.2
BPC-R5	4/21/16	12:35	0.101	203	407	8.1	7.9	50.2
BPC-V6	4/21/16	13:15	0.155	208	415	7.8	7.9	51.6
BPC-C7	4/21/16	14:05	0.113	240	480	7.6	7.8	55.1
BPC-B8	4/21/16	14:35	0.071	225	451	9.4	7.8	61.3
BPC-W9	4/21/16	15:05	0.274	233	467	5.9	7.4	65.6
CalBase-1	5/5/16	10:00	0.034	115	230	6.9	7.4	51.2
43HVP-2	5/5/16	10:40	0.039	321	638	5.8	7.6	49.5
WWF-3	5/5/16	11:05	0.018	285	585	6.2	8.1	50.2
43BPC-4	5/5/16	11:30	0.144	205	409	6.7	7.5	48.9
BPC-R5	5/5/16	11:55	0.143	211	423	7.2	7.8	48.1
BPC-V6	5/5/16	12:20	0.134	250	503	6.9	7.8	50.3
BPC-C7	5/5/16	12:45	0.131	229	458	7.0	7.8	46.5
BPC-B8	5/5/16	13:10	0.215	218	437	6.1	7.4	50.1
BPC-W9	5/5/16	13:30	0.252	218	437	6.1	7.4	50.1
CalBase-1	5/19/16	9:40	0.021	201	390	6.1	7.7	55.5
43HVP-2	5/19/16	10:00	0.025	402	806	6.2	7.6	55.2
WWF-3	5/19/16	10:30	0.082	340	670	6.4	8.0	54.6
43BPC-4	5/19/16	10:55	0.115	204	409	6.6	7.5	52.0
BPC-R5	5/19/16	11:30	0.153	120	238	7.9	7.8	52.7
BPC-V6	5/19/16	11:55	0.138	210	419	6.6	7.9	53.7
BPC-C7	5/19/16	12:25	0.142	238	476	6.7	7.7	54.7
BPC-B8	5/19/16	12:50	0.141	229	457	7.1	7.4	60.8
BPC-W9	5/19/16	13:15	0.211	235	471	6.4	7.4	66.3
CalBase-1	6/1/16	9:45	0.051	113	226	5.6	7.5	58.1
43HVP-2	6/1/16	10:00	0.022	274	548	5.5	7.7	57.5
WWF-3	6/1/16	10:35	0.007	327	654	5.6	8.1	56.6
43BPC-4	6/1/16	11:40	0.108	194	388	6.3	7.6	53.6
BPC-R5	6/1/16	12:04	0.081	198	397	6.3	8.0	54.8
BPC-V6	6/1/16	12:37	0.126	202	404	6.2	7.9	57.7
BPC-C7	6/1/16	13:08	0.109	263	471	5.8	7.7	57.9
BPC-B8	6/1/16	13:30	0.064	233	467	6.3	7.5	63.5
BPC-W9	6/1/16	14:00	0.096	245	490	5.7	7.4	73.9

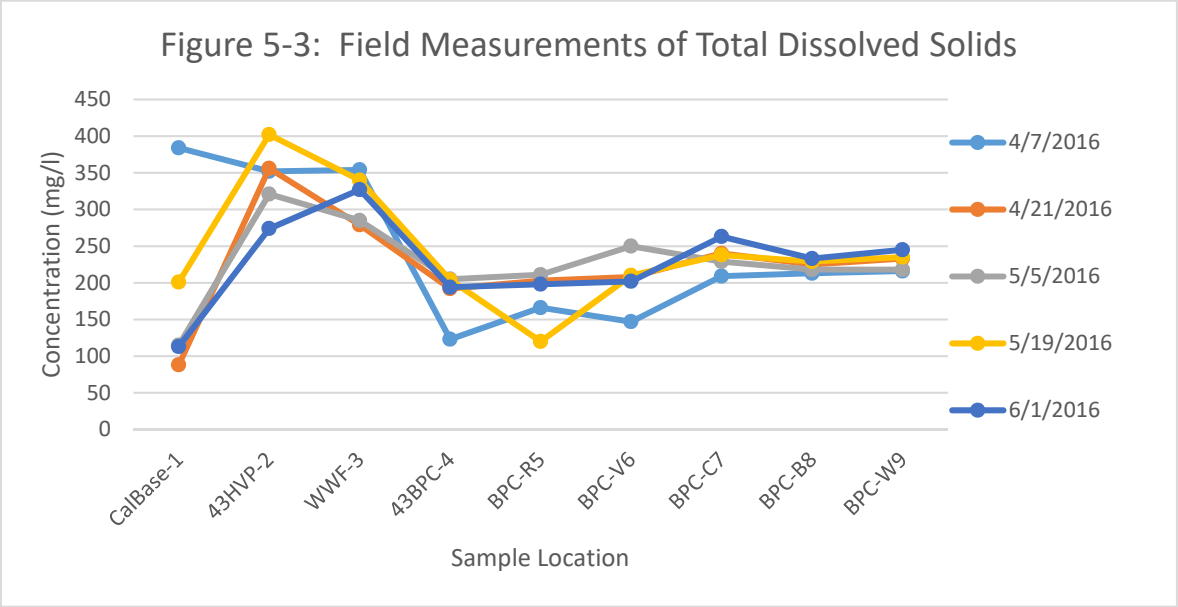
[1] Measurements made in the field at time of sample collection using a water quality probe.

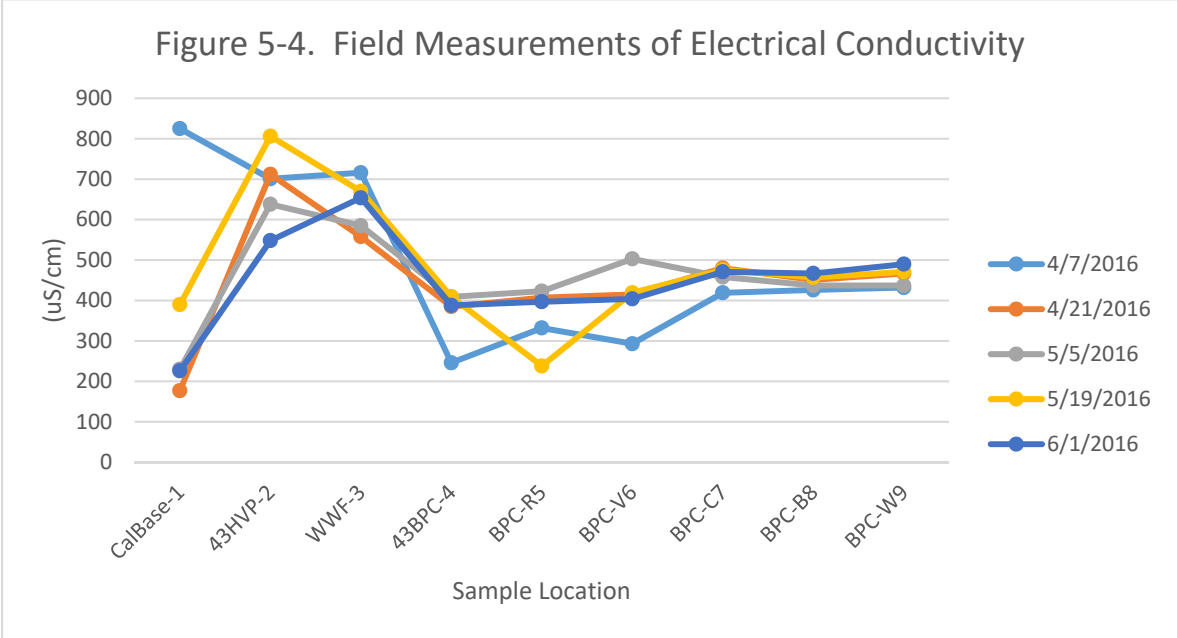
[2] Organized from upstream to downstream.

[3] Discharge calculated using either the depth, velocity, and flow measurements from auto-sampler or by measuring depth in culvert and using Manning's Equation.

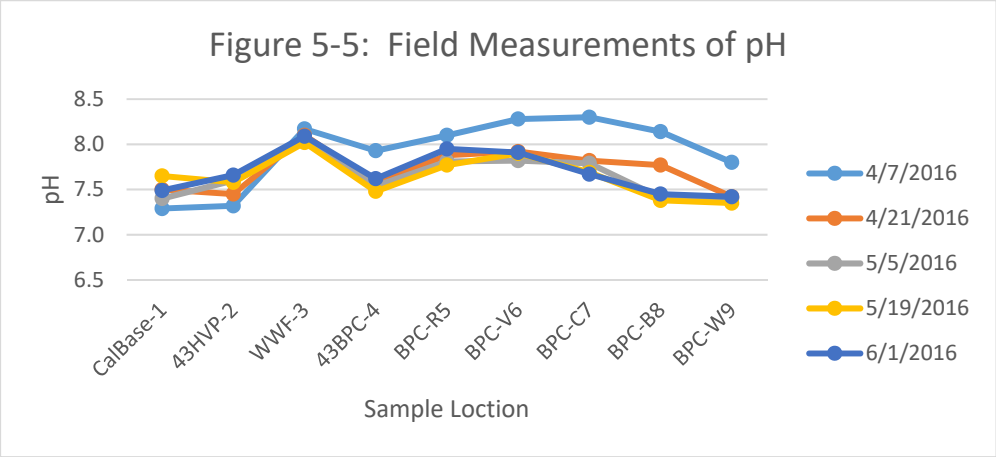
* Auto Sampler measurements incorrect due to malfunctioning sensor, flow estimated using manning's equation.

The collected field data for Total Dissolved Solids (TDS) and Electrical Conductivity (EC) show similar patterns. Both TDS and EC show a significant increase between the area upstream of the stormwater management system (CalBase-1) and the stormwater management system effluent (43HVP-2) with the increased concentrations continuing through the vault in Wildwood Avenue (WWF-3). The measurements for TDS and EC decrease significantly at the headwaters of Bijou Park Creek (43BPC-4) and remain relatively steady with a slight increasing trend downstream. Graphs of the TDS and EC data are presented in Figures 5-3 and 5-4, respectively.





The pH data generally indicates a significant increase between the stormwater management system effluent (43HVP-2) and the vault in Wildwood Avenue (WWF-3). The pH decreases between the vault and the headwaters of Bijou Park Creek (43BPC-4), and then increases and remains relatively steady between the sampling location at Regina Lane (BPC-R5) and Charlesworth Court (BPC-C7). The pH then generally decreases between Charlesworth Avenue and the most downstream location at Werner Salas (BPC-W9). A graph of the pH data is presented in Figure 5-5.



The field data are provided in Appendix A.

5.3.2 Anion Results

The analytical results for the analyzed anions (alkalinity, chloride, bromide, nitrate, and sulfate) at each sampling location are summarized in Table 5-2.

The results for total alkalinity show a significant increase between the area upstream of the stormwater management system (CalBase-1) and the stormwater management system effluent (43HVP-2) with the increasing concentrations continuing through the vault in Wildwood Avenue (WWF-3). The alkalinity decreases significantly at the headwaters of Bijou Park Creek (43BPC-4) and remains relatively consistent through the sample site at Regina Lane (BPC-R5). Downstream of Regina Lane, the alkalinity shows an increasing trend through the sampling location at Charlesworth Court (BPC-C7) and then the results decrease at the Blackwood Avenue sample site (BPC-B8) before increasing slightly at the most downstream location (BPC-W9). A graph of the alkalinity data is presented in Figure 5-6.

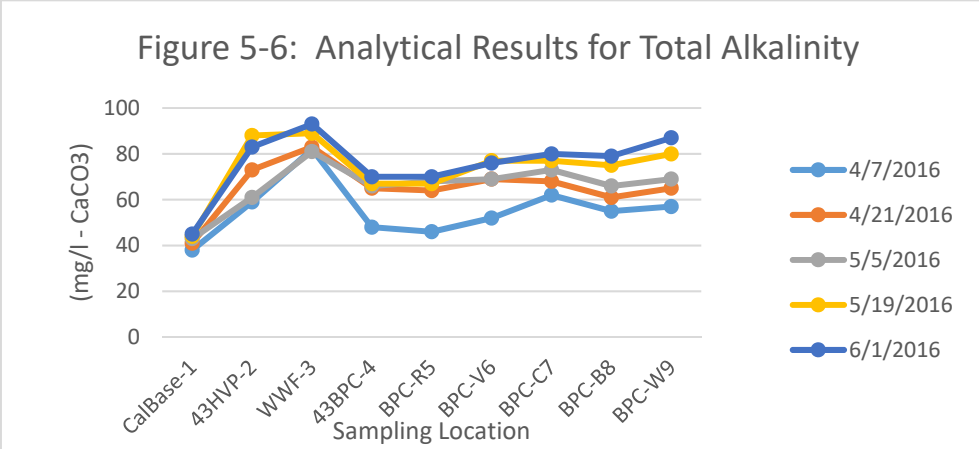


Table 5-2: Summary of Analytical Results for Anions

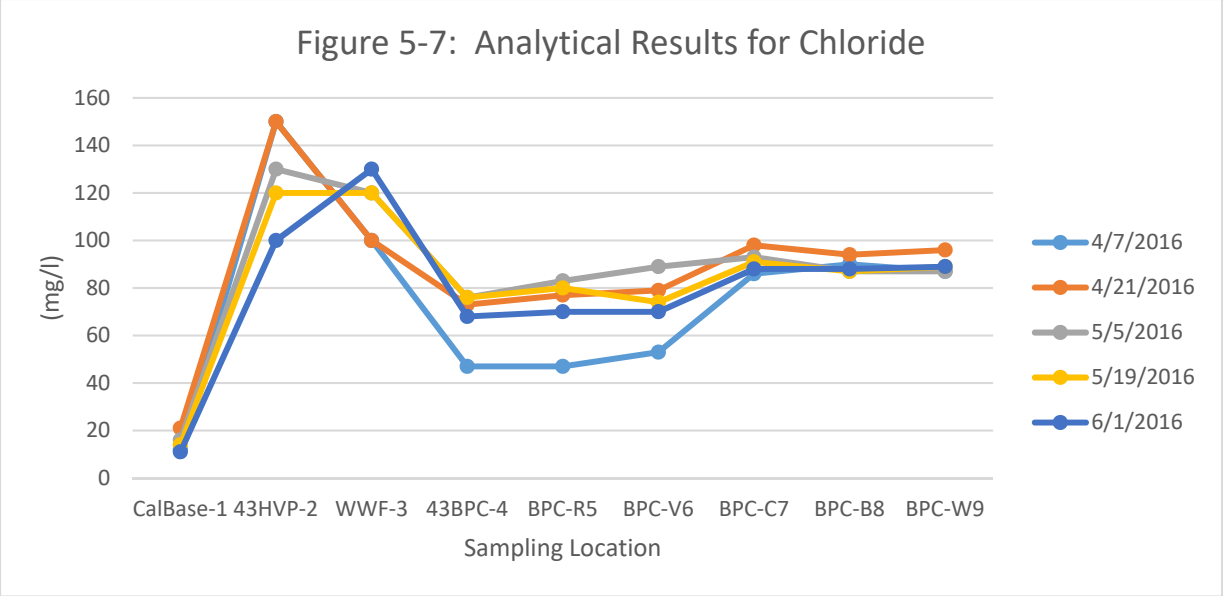
Sample Location[1]	Date	Time	Anions							
			Total Alkalinity (mg/l-CaCO3)	Bicarbonate (mg/l-CaCO3)	Carbonate (mg/l-CaCO3)	Hydroxide (mg/l-CaCO3)	Cl (mg/l)	Br (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)
CalBase-1	4/7/16	10:00	38	38	<1.0	<1.0	12	<0.10	1.6	2.7
43HVP-2	4/7/16	10:30	59	59	<1.0	<1.0	150	<0.10	0.66	4.0
WWF-3	4/7/16	11:40	82	82	<1.0	<1.0	100	<0.10	0.025	2.8
43BPC-4	4/7/16	12:10	48	48	<1.0	<1.0	47	<0.10	0.63	2.4
BPC-R5	4/7/16	13:00	46	46	<1.0	<1.0	47	<0.10	0.52	2.2
BPC-V6	4/7/16	13:35	52	52	<1.0	<1.0	53	<0.10	0.46	2.4
BPC-C7	4/7/16	14:00	62	62	<1.0	<1.0	86	0.13	0.29	2.8
BPC-B8	4/7/16	14:30	55	55	<1.0	<1.0	90	0.12	<0.010	2.5
BPC-W9	4/7/16	15:00	57	57	<1.0	<1.0	87	0.11	<0.010	2.0
CalBase-1	4/21/1	9:45	41	41	<1.0	<1.0	21	<0.10	1.6	3.0
43HVP-2	4/21/1	10:20	73	73	<1.0	<1.0	150	<0.10	0.62	5.5
WWF-3	4/21/1	11:10	83	83	<1.0	<1.0	100	<0.10	0.021	2.1
43BPC-4	4/21/1	11:45	65	65	<1.0	<1.0	73	<0.10	0.76	3.6
BPC-R5	4/21/1	12:35	64	64	<1.0	<1.0	77	<0.10	0.71	3.6
BPC-V6	4/21/1	13:15	69	69	<1.0	<1.0	79	<0.10	0.58	3.3
BPC-C7	4/21/1	14:05	68	68	<1.0	<1.0	98	0.15	0.22	2.7
BPC-B8	4/21/1	14:35	61	61	<1.0	<1.0	94	0.14	<0.010	2.0
BPC-W9	4/21/1	15:05	65	65	<1.0	<1.0	96	0.14	<0.010	1.3
CalBase-1	5/5/16	10:00	43	43	<1.0	<1.0	16	<0.10	0.92*	3.0
43HVP-2	5/5/16	10:40	61	61	<1.0	<1.0	130	<0.10	0.83	4.3
WWF-3	5/5/16	11:05	81	81	<1.0	<1.0	120	<0.10	0.018	1.9
43BPC-4	5/5/16	11:30	66	66	<1.0	<1.0	76	<0.10	0.63	4.0
BPC-R5	5/5/16	11:55	68	68	<1.0	<1.0	83**	<0.10	0.60	4.2
BPC-V6	5/5/16	12:20	69	69	<1.0	<1.0	89	0.33	0.57	31
BPC-C7	5/5/16	12:45	73	73	<1.0	<1.0	93	0.21	0.21	2.6
BPC-B8	5/5/16	13:10	66	66	<1.0	<1.0	87	0.18	<0.010	1.8
BPC-W9	5/5/16	13:30	69	69	<1.0	<1.0	87	0.16	0.019	1.2
CalBase-1	5/19/1	9:40	44	44	<1.0	<1.0	14	<0.10	0.79	3.0
43HVP-2	5/19/1	10:00	88	88	<1.0	<1.0	120	<0.10	0.28	5.9
WWF-3	5/19/1	10:30	89	89	<1.0	<1.0	120	<0.10	<0.010	1.6
43BPC-4	5/19/1	10:55	67	67	<1.0	<1.0	76	<0.10	0.61	4.0
BPC-R5	5/19/1	11:30	67	67	<1.0	<1.0	80	<0.10	0.58	3.8
BPC-V6	5/19/1	11:55	77	77	<1.0	<1.0	74	<0.10	0.43	3.4
BPC-C7	5/19/1	12:25	77	77	<1.0	<1.0	91	0.20	0.14	2.5
BPC-B8	5/19/1	12:50	75	75	<1.0	<1.0	87	0.19	<0.010	1.5
BPC-W9	5/19/1	13:15	80	80	<1.0	<1.0	89**	0.19	<0.010	<1.0
CalBase-1	6/1/16	9:45	45	45	<1.0	<1.0	11	<0.10	0.57	2.3
43HVP-2	6/1/16	10:00	83	83	<1.0	<1.0	100	<0.10	0.3	4.5
WWF-3	6/1/16	10:35	93	93	<1.0	<1.0	130	<0.10	0.014	1.1
43BPC-4	6/1/16	11:40	70	70	<1.0	<1.0	68	<0.10	0.48	3.7
BPC-R5	6/1/16	12:04	70	70	<1.0	<1.0	70	<0.10	0.46	3.4
BPC-V6	6/1/16	12:37	76	76	<1.0	<1.0	70	<0.10	0.4	2.7
BPC-C7	6/1/16	13:08	80	80	<1.0	<1.0	88	0.18	0.1	2.2
BPC-B8	6/1/16	13:30	79	79	<1.0	<1.0	88	0.18	<0.010	1.2
BPC-W9	6/1/16	14:00	87	87	<1.0	<1.0	89	0.18	<0.010	<1.0

[1] Organized from upstream to downstream.

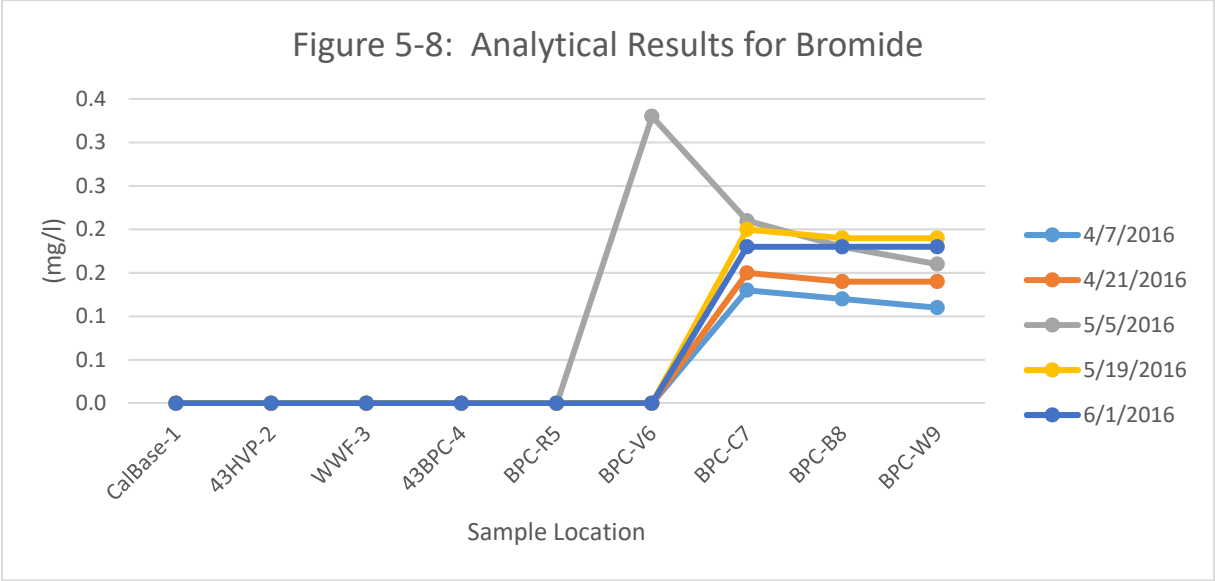
* The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference. The reported result should be considered an estimate.

** Spike recovery not calculated. Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered.

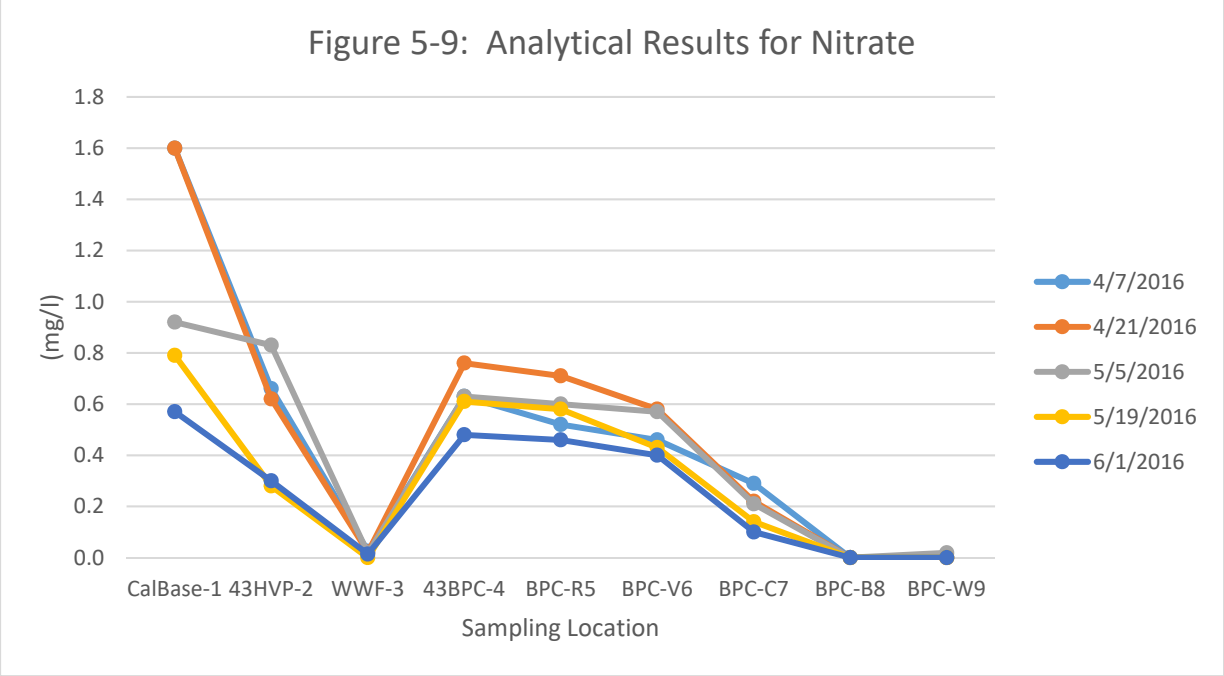
The results for chloride indicate that concentrations exceeded the objective of 3.0 mg/l specified in the WDRs at all of the sample locations during each sampling event. The lowest concentrations were recorded at CalBase-1 (upslope of the stormwater management system) ranging from 11 to 21 mg/l, and the highest concentrations were recorded at 43HVP-2 (stormwater management system effluent) and WWF-3 (vault in Wildwood Avenue) ranging from 100 to 150 mg/l. During each of the sampling events, the chloride concentrations decreased between WWF-3 and the headwaters of Bijou Park Creek (43BPC-4) where concentrations ranged between 47 and 76 mg/l. Downstream of 43BPC-4, the chloride concentrations at BPC-R5 and BPC-V6 were similar to the concentrations at 43BPC-4 (ranging between 47 and 83 mg/l), but increased between BPC-V6 and BPC-C7 where concentrations ranged between 86 and 98 mg/l. Note that this location of increased chloride concentration (BPC-C7) is also downstream of the tributary input that joins Bijou Park Creek approximately 150 feet downstream of BPC-V6; accordingly, the contributing flow must have higher chloride concentration than the upstream flow for this to be observed. This increase in concentrations continues downstream at BPC-B8 and BPC-W9 where chloride concentrations ranged between 87 and 96 mg/l. A graph of the chloride results is presented in Figure 5-7.



In regards to bromide, with the exception of a detection during the May 5, 2016 sampling event at BPC-V6, bromide was not detected above the method detection limit in any of the samples collected at BPC-V6 or the sample locations situated upstream (CalBase-1, 43HVP-2, WWF-3, 43BPC-4, and 43BPC-R5). However, bromide was detected during each of the sampling events at the sample sites located downstream of BPC-V6 (i.e., BPC-C7, BPC-B8, and BPC-W9) as shown in Figure 5-8. This change in bromide concentrations appears downstream of the tributary input that joins Bijou Park Creek approximately 150 feet downstream of BPC-V6, indicating that the chemistry of the contributing flow is different than that of the upstream waters.

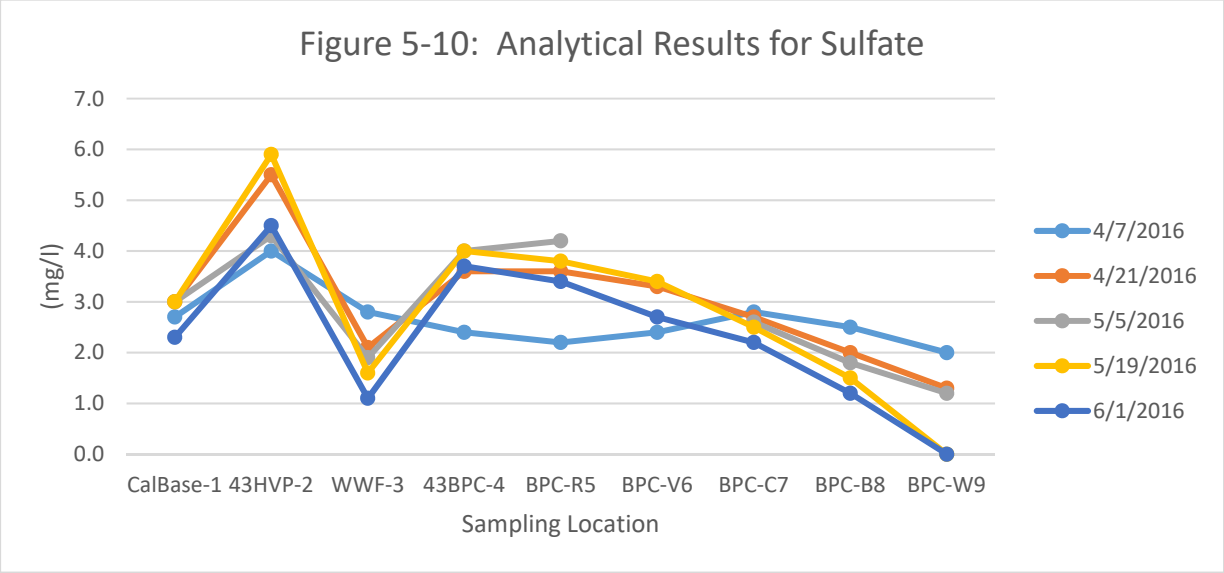


For nitrate, the analytical results indicate a significant decrease in concentrations from the area upstream of the stormwater management system (CalBase-1) and the stormwater vault in Wildwood Avenue (WWF-3). The concentrations then increase at the headwaters of Bijou Park Creek (43BPC-4) and then decrease slightly downstream to Verdon Lane (BPC-V6). Between Verdon Lane and Charlesworth Avenue (BPC-C7), the nitrate concentrations decrease and then reduce to non-detectable levels at the most downstream sampling locations, Blackwood Avenue (BPC-B8) and Werner Salas (BPC-W9). A graph of the nitrate results is presented in Figure 5-9.



The sulfate results indicate an increase between the area upstream of the stormwater management system (CalBase-1) and the effluent from the system (43HVP-2) and then a significant decrease at the

vault in Wildwood Avenue (WWF-3). The concentrations increase at the headwaters of Bijou Park Creek (43BPC-4) and then have a decreasing trend downstream as show in Figure 5-10.



The laboratory analytical reports are provided in Appendix B.

5.3.3 Cation Results

The analytical results for the analyzed cations (aluminum, calcium, iron, magnesium, manganese, potassium, and sodium) as well as silica and TDS at each sampling location are summarized in Table 5-3 below.

The results for iron show a significant increase between the California Base parking area and the headwaters of Bijou Park Creek (43BPC-4) likely due to the influence of iron-rich groundwater seepage. The iron concentrations generally decrease downstream between the headwaters and Verdon Lane (BPC-V6), then increase slightly at Charlesworth Avenue (BPC-C7) before decreasing to near the detection limit at Blackwood Road (BPC-B8) and Werner Salas (BPC-W9). A graph of the iron results is presented in Figure 5-11.

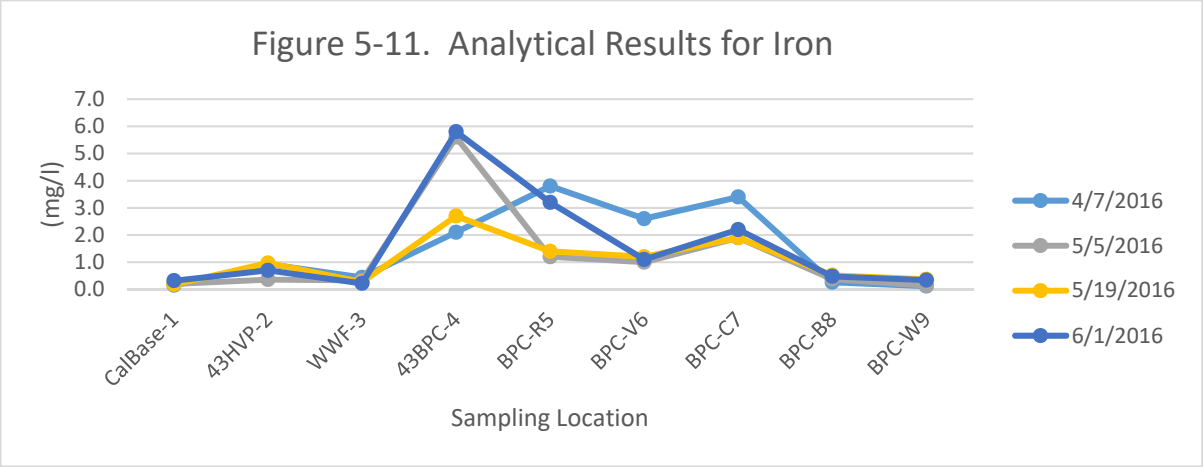


Table 5-3: Summary of Analytical Results for Cations

Sample Location[1]	Date	Time	Cations							Other	
			Al (mg/l)	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	Mn (mg/l)	K (mg/l)	Na (mg/l)	Silica (mg/l)	TDS (mg/l)
CalBase-1	4/7/16	10:00	0.150*	11	0.15	1.7	0.0058	2.3	13	19	47
43HVP-2	4/7/16	10:30	0.72*	38	0.93	6.3	0.073	4.7	86	32	340
WWF-3	4/7/16	11:40	0.08	33	0.44	8.4	0.035	4.6	65	30	270
43BPC-4	4/7/16	12:10	0.210	16	2.1	3.6	0.11	2.9	33	22	150
BPC-R5	4/7/16	13:00	0.190	16	3.8	3.7	0.12	2.8	32	22	140
BPC-V6	4/7/16	13:35	0.200	18	2.6	4.2	0.110	3.1	38	23	150
BPC-C7	4/7/16	14:00	0.32*	25*	3.4*	6.1*	0.17	4.3****	60**	30***	250
BPC-B8	4/7/16	14:30	<0.045	23	0.26	5.8	0.013	4.6	60	27	230
BPC-W9	4/7/16	15:00	<0.045	23	0.12	5.6	0.026	4.8	62	28	220
CalBase-1	4/21/1	9:45	0.110	14	0.08	2.1	<0.0050	3.1	16	21	110
43HVP-2	4/21/1	10:20	1.500	36	1.5	6.0	0.13	7.6	110	31	400
WWF-3	4/21/1	11:10	<0.045	35	0.23	8.4	0.020	5.9	58	26	300
43BPC-4	4/21/1	11:45	0.093	23	2.5	4.6	0.16	4.8	48	25	230
BPC-R5	4/21/1	12:35	0.100	23	1.8	4.6	0.12	3.6	44	26	240
BPC-V6	4/21/1	13:15	0.120	24	1.2	5.2	0.093	4.6	53	27	230
BPC-C7	4/21/1	14:05	0.14	27	1.7	6.1	0.14	5.4	62	27	280
BPC-B8	4/21/1	14:35	0.062	24	0.42	5.7	0.056	5.4	60	24	260
BPC-W9	4/21/1	15:05	0.063	24	0.18	5.6	0.044	5.4	60	25	270
CalBase-1	5/5/16	10:00	0.090	12	0.20	2.0	0.010	2.9	15	24	79*
43HVP-2	5/5/16	10:40	0.092	32	0.36	5.1	0.039	4.4	66	28	320
WWF-3	5/5/16	11:05	<0.045	35	0.33	8.2	0.021	4.5	51	27	330
43BPC-4	5/5/16	11:30	0.130	24	5.6	5.0	0.17	3.9	46	28	210
BPC-R5	5/5/16	11:55	0.077	25	1.2	5.3	0.12	3.9	48	28	230
BPC-V6	5/5/16	12:20	0.160	26	1.0	5.5	0.100	12	62	28	300
BPC-C7	5/5/16	12:45	0.20	27	1.9	6.2	0.15	4.2	53	28	260
BPC-B8	5/5/16	13:10	<0.045	23	0.38	5.8	0.034	4.6	57	25	230
BPC-W9	5/5/16	13:30	<0.045	23	0.14	5.8	0.030	4.3	56	25	240
CalBase-1	5/19/1	9:40	0.090	12	0.18	1.9	1.9	2.8	14	24	120
43HVP-2	5/19/1	10:00	0.140	27	0.97	5.0	0.14	4.4	88	30	330
WWF-3	5/19/1	10:30	<0.045	39	0.27	9.6	0.063	4.6	58**	28	370
43BPC-4	5/19/1	10:55	<0.045	24	2.7	5.0	0.16	3.8	48	29	250
BPC-R5	5/19/1	11:30	0.051	24	1.4	5.2	0.13	3.7	48	29	250
BPC-V6	5/19/1	11:55	0.076	23	1.2	5.4	0.098	4.7***	56	29	250
BPC-C7	5/19/1	12:25	0.19	26	1.9	6.1	0.14	5.2	63	29	280
BPC-B8	5/19/1	12:50	<0.045	25	0.52	6.0	0.052	5.1	60	25	280
BPC-W9	5/19/1	13:15	0.064	26	0.37	6.0	0.083	4.9	60	27	280
CalBase-1	6/1/16	9:45	0.065	10	0.32	1.8	0.012	2.4	12	25	110
43HVP-2	6/1/16	10:00	0.099	24	0.7	4.4	0.12	4.1	71	29	320
WWF-3	6/1/16	10:35	<0.045	41	0.22	9.9	0.029	4.7	57	27	380
43BPC-4	6/1/16	11:40	0.091	22	5.8	4.7	0.17	3.5	44	28	260
BPC-R5	6/1/16	12:04	0.064	23	3.2	5	0.12	3.8	47	30	240
BPC-V6	6/1/16	12:37	0.065	24	1.1	5.2	0.076	3.7	47	29	250
BPC-C7	6/1/16	13:08	0.16	26	2.2	5.9	0.15	4.0	54	29	280
BPC-B8	6/1/16	13:30	<0.045	25	0.48	5.8	0.076	3.7	53	25	280
BPC-W9	6/1/16	14:00	<0.045	28	0.34	6.1	0.071	4.0	56	28	290

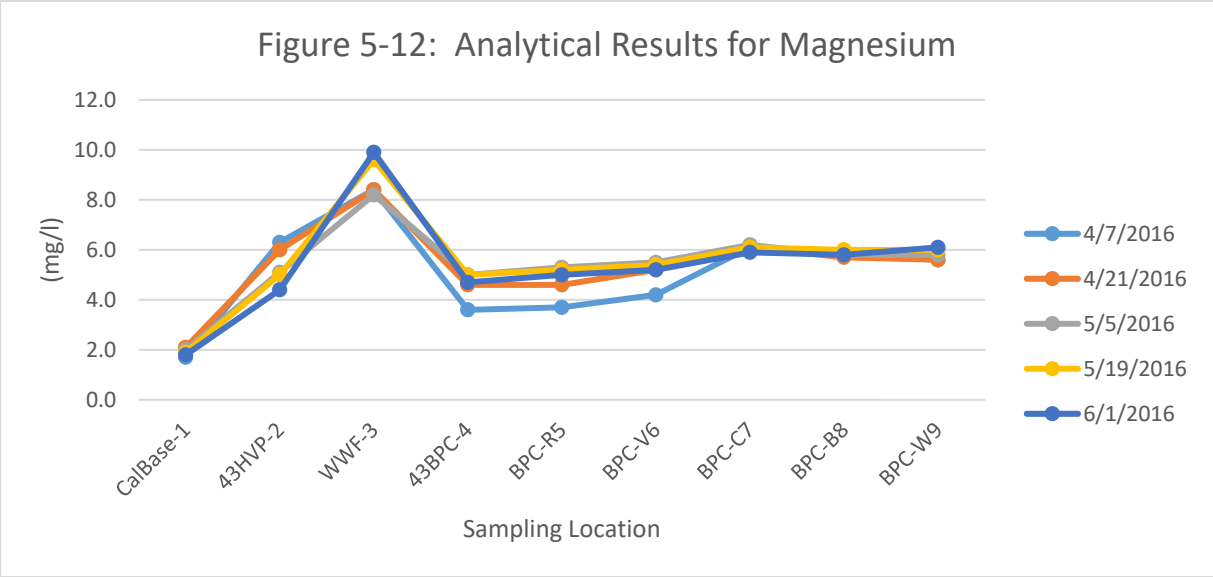
* The sample duplicate or matrix spike duplicate analysis demonstrated sample imprecision. The reported result should be considered an estimate.

** Spike recovery not calculated. Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered.

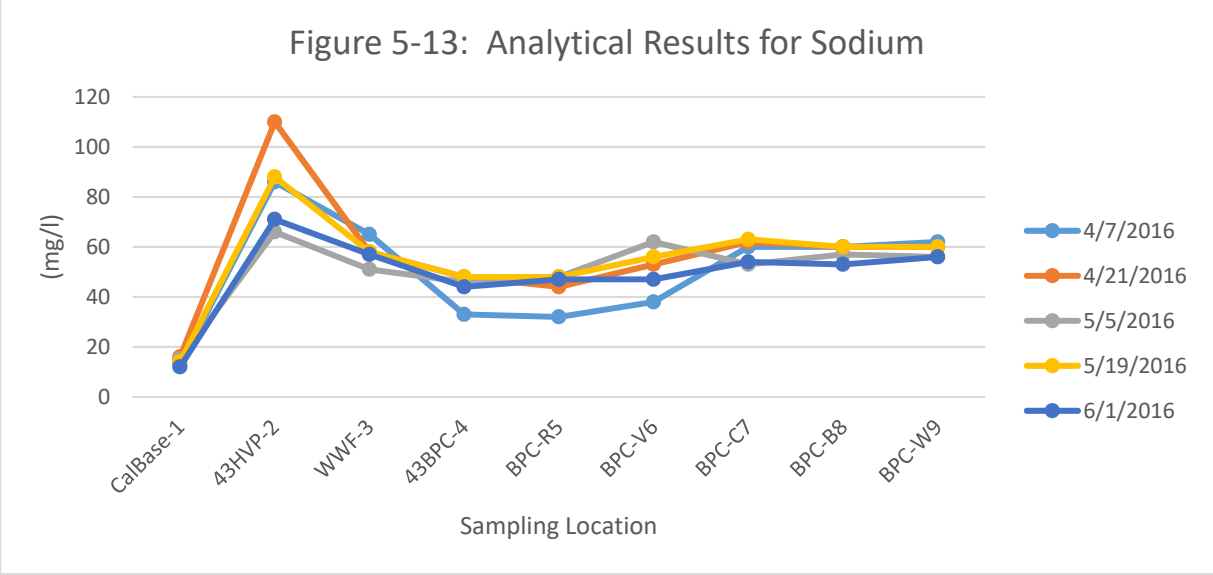
*** The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference. The reported result should be considered an estimate.

**** Reported value is estimated; The sample matrix interfered with the analysis.

The analytical results for magnesium indicate a significant increase between the area upstream of the stormwater management system (CalBase-1) and the vault in Wildwood Avenue (WWF-3). The concentrations decrease between Wildwood Avenue and the headwaters of Bijou Park Creek (43BPC-4) and then show a slight increasing trend downstream as shown in Figure 5-12.



The analytical results for sodium indicate a significant increase between the area upstream of the stormwater management system (CalBase-1) and the effluent from the system (43HVP-2). The concentrations decrease between the system effluent and the headwaters of Bijou Park Creek (43BPC-4) and then show a slight increasing trend downstream as shown in Figure 5-13.



The laboratory analytical reports are provided in Appendix B.

5.3.4 Data Analysis

This section discusses the quality of the data presents an analysis of the data with respect to water quality and chloride concentrations.

5.3.4.1 Data Quality Assessment

Two primary methods were used to assess the quality of the data. The first involved using the results for each sample location during each sampling event to calculate the charge balance. The charge balance was calculated by converting the cation and anion results from "mg/l" to milliequivalents per liter (mEq/l). When all the major anions and cations have been determined, the sum of the cations in milliequivalents per liter should equal the sum of the anions expressed in the same units. The difference between the two sums will generally not exceed 1 or 2 percent of the total of cations and anions in waters of moderate concentration (250-1,000 mg/l) as shown in Table 5-4. If the total of anions and cations is less than approximately 5.0 mEq/L, as they are with the analyses reported here, then a somewhat larger percentage difference can be tolerated (Hem 1989). For this study, the results indicate a difference in charge balance between -0.4% and 12.8% with 20 of the 45 samples within 5% or less and only two samples above 10%.

The other method used to check data quality was to determine the ratio of the TDS concentration as measured by the laboratory and the TDS concentration calculated using the cation and anion results. In theory, the measured and calculated TDS should be the same with a ratio of 1. For this study, the results indicate ratios between 0.5 and 1.2, compared to an acceptable range from 1.0 to 1.2 (Bartram 1996), as shown in Table 5-5. Over 75% of the samples (34 total) fall within this range, with the outliers primarily being samples from the California Base area.

The evaluation of the water quality results suggests that other anions may be present in the water, although the measured analytes are those that are typically found in waters of this type. However, overall, the results are acceptable for the objectives of this study, which is primarily concerned with relative changes in water chemistry downstream in Bijou Park Creek.

5.3.4.2 Downstream Effects Evaluation

The element chlorine is the most abundant of the halogens, and readily forms compounds of with metallic elements, alkali metals, and alkaline earth metals that are soluble in water and called chlorides. More than 75 percent of chlorides are found in the ocean. Chloride typically is not abundant in other surface waters, except in areas of evaporate rocks (salts), and where road salts or other human activity directly introduces chloride to water. Hem (1989), in the USGS paper Geochemistry of Natural Waters, notes that the chemical behavior of chloride in natural water is tame and subdued compared with the other major ions. Chloride ions do not significantly enter into oxidation or reduction reactions; form no important solute complexes with other ions unless the chloride concentration is extremely high; do not form salts of low solubility; are not significantly adsorbed on mineral surfaces; and, play few vital biochemical roles. In general, chloride is considered a "conservative ion" since the concentration in water tends to stay constant. As such, chloride ions move with the water through most soils and sediments with less loss than other tracers. In most studies of chloride fate and transport reported in Hem (1989), the chloride budget in most watersheds is dominated by either human input or by evaporate formations.

Table 5-4. Summary of Total Cation and Total Anion Balance Comparison

Sample Location[1]	Date	Time	Total Anions* (mEq/l)	Total Cations** (mEq/l)	Balance Check (% difference in Total Cations vs. Total Anions)
CalBase-1	4/7/16	10:00	1.18	1.34	6.3%
43HVP-2	4/7/16	10:30	5.50	6.41	7.6%
WWF-3	4/7/16	11:40	4.52	5.32	8.2%
43BPC-4	4/7/16	12:10	2.34	2.75	7.9%
BPC-R5	4/7/16	13:00	2.30	2.80	9.8%
BPC-V6	4/7/16	13:35	2.59	3.14	9.6%
BPC-C7	4/7/16	14:00	3.73	4.69	11.5%
BPC-B8	4/7/16	14:30	3.69	4.37	8.4%
BPC-W9	4/7/16	15:00	3.63	4.44	9.9%
CalBase-1	4/21/16	9:45	1.50	1.66	5.2%
43HVP-2	4/21/16	10:20	5.81	7.52	12.8%
WWF-3	4/21/16	11:10	4.52	5.13	6.3%
43BPC-4	4/21/16	11:45	3.44	3.89	6.1%
BPC-R5	4/21/16	12:35	3.54	3.65	1.5%
BPC-V6	4/21/16	13:15	3.68	4.13	5.7%
BPC-C7	4/21/16	14:05	4.18	4.80	6.9%
BPC-B8	4/21/16	14:35	3.91	4.45	6.4%
BPC-W9	4/21/16	15:05	4.03	4.43	4.6%
CalBase-1	5/5/16	10:00	1.39	1.51	4.3%
43HVP-2	5/5/16	10:40	4.98	5.03	0.5%
WWF-3	5/5/16	11:05	5.04	4.78	-2.7%
43BPC-4	5/5/16	11:30	3.55	4.03	6.3%
BPC-R5	5/5/16	11:55	3.80	3.95	2.0%
BPC-V6	5/5/16	12:20	4.55	4.83	3.0%
BPC-C7	5/5/16	12:45	4.14	4.40	3.1%
BPC-B8	5/5/16	13:10	3.81	4.24	5.4%
BPC-W9	5/5/16	13:30	3.86	4.18	4.0%
CalBase-1	5/19/16	9:40	1.35	1.53	6.1%
43HVP-2	5/19/16	10:00	5.27	5.77	4.6%
WWF-3	5/19/16	10:30	5.19	5.40	1.9%
43BPC-4	5/19/16	10:55	3.57	3.95	5.0%
BPC-R5	5/19/16	11:30	3.68	3.89	2.8%
BPC-V6	5/19/16	11:55	3.70	4.23	6.6%
BPC-C7	5/19/16	12:25	4.16	4.80	7.2%
BPC-B8	5/19/16	12:50	3.98	4.51	6.2%
BPC-W9	5/19/16	13:15	4.11	4.56	5.2%
CalBase-1	6/1/16	9:45	1.27	1.26	-0.4%
43HVP-2	6/1/16	10:00	4.58	4.81	2.5%
WWF-3	6/1/16	10:35	5.55	5.48	-0.6%
43BPC-4	6/1/16	11:40	3.40	3.82	5.8%
BPC-R5	6/1/16	12:04	3.45	3.89	5.9%
BPC-V6	6/1/16	12:37	3.55	3.83	3.8%
BPC-C7	6/1/16	13:08	4.13	4.38	2.9%
BPC-B8	6/1/16	13:30	4.09	4.15	0.8%
BPC-W9	6/1/16	14:00	4.25	4.46	2.4%

[1] Organized from upstream to downstream.

* Total anions were calculated by converting the concentrations of Bicarbonate, Chloride, Bromide, Sulfate, and Nitrate to "mEq/l" and summing the total for each sampling event at each sampling location.

** Total cations were calculated by converting the concentrations of Aluminum, Calcium, Magnesium, Manganese, Iron, Potassium, and Sodium to "mEq/l" and summing the total for each sampling event at each sampling location.

Table 5-5: Ratio of Measured vs. Calculated TDS

Sample Location[1]	Date	Time	Calculated TDS* (mg/l)	Lab Measured TDS (mg/l)	Ratio of Lab Measured TDS and Calculated TDS**
CalBase-1	4/7/16	10:00	86	47	0.5
43HVP-2	4/7/16	10:30	358	340	0.9
WWF-3	4/7/16	11:40	293	270	0.9
43BPC-4	4/7/16	12:10	158	150	0.9
BPC-R5	4/7/16	13:00	158	140	0.9
BPC-V6	4/7/16	13:35	176	150	0.9
BPC-C7	4/7/16	14:00	255	250	1.0
BPC-B8	4/7/16	14:30	246	230	0.9
BPC-W9	4/7/16	15:00	247	220	0.9
CalBase-1	4/21/16	9:45	106	110	1.0
43HVP-2	4/21/16	10:20	392	400	1.0
WWF-3	4/21/16	11:10	285	300	1.1
43BPC-4	4/21/16	11:45	224	230	1.0
BPC-R5	4/21/16	12:35	223	240	1.1
BPC-V6	4/21/16	13:15	239	230	1.0
BPC-C7	4/21/16	14:05	271	280	1.0
BPC-B8	4/21/16	14:35	252	260	1.0
BPC-W9	4/21/16	15:05	256	270	1.1
CalBase-1	5/5/16	10:00	102	79	0.8
43HVP-2	5/5/16	10:40	308	320	1.0
WWF-3	5/5/16	11:05	297	330	1.1
43BPC-4	5/5/16	11:30	233	210	0.9
BPC-R5	5/5/16	11:55	240	230	1.0
BPC-V6	5/5/16	12:20	296	300	1.0
BPC-C7	5/5/16	12:45	260	260	1.0
BPC-B8	5/5/16	13:10	244	230	0.9
BPC-W9	5/5/16	13:30	244	240	1.0
CalBase-1	5/19/16	9:40	99	120	1.2
43HVP-2	5/19/16	10:00	334	330	1.0
WWF-3	5/19/16	10:30	314	370	1.2
43BPC-4	5/19/16	10:55	233	250	1.1
BPC-R5	5/19/16	11:30	236	250	1.1
BPC-V6	5/19/16	11:55	243	250	1.0
BPC-C7	5/19/16	12:25	271	280	1.0
BPC-B8	5/19/16	12:50	255	280	1.1
BPC-W9	5/19/16	13:15	261	280	1.1
CalBase-1	6/1/16	9:45	92	110	1.2
43HVP-2	6/1/16	10:00	288	320	1.1
WWF-3	6/1/16	10:35	327	380	1.2
43BPC-4	6/1/16	11:40	222	260	1.2
BPC-R5	6/1/16	12:04	228	240	1.1
BPC-V6	6/1/16	12:37	229	250	1.1
BPC-C7	6/1/16	13:08	259	280	1.1
BPC-B8	6/1/16	13:30	250	280	1.1
BPC-W9	6/1/16	14:00	264	290	1.1

[1] Organized from upstream to downstream.

* Calculated TDS = 0.6Alkalinity + Na + K + Ca + Mg + Cl + SO4 + SiO2 + NO3 + Fe

** Ratio = Measured TDS/Calculated TDS

The findings of this study are consistent with the general characterization of chloride. Although no upstream samples are available for comparison, the application of salt for deicing purposes appears to be the source of chloride in the stormwater discharging from the California Base Parking area as well as in Bijou Park Creek given that concentrations increase downstream of its headwaters. As shown in Figure 5-7, the highest concentrations of chloride were detected in the stormwater treatment vaults (43HVP-2 and WWF-3) at concentrations ranging between 100 to 150 mg/l, and the concentrations decrease significantly (47 to 68 mg/l) at the headwaters of Bijou Park Creek, likely due to dilution associated with the input of groundwater seepage. As Bijou Park Creek flows downstream and accretes inflow from overland flow and tributary drainages, the concentration of chloride rises to a peak at Charlesworth Court (BPC-C7) with concentrations ranging from 88 to 98 mg/l. Downstream of Charlesworth Court, the concentration of chloride is more or less constant. The Charlesworth Court location also marks a discontinuity in several parameters including a decrease in pH and sulfate concentrations.

The increase in chloride concentrations downstream of BPC-V6 indicates the presence of an additional source or sources of chloride into Bijou Park Creek outside of the Heavenly California Base area. This conclusion is further supported by the anion and cation data, specifically the results for bromide and nitrate. With the exception of a detection during the May 5, 2016 sampling event at BPC-V6, bromide was not detected above the method detection limit in any of the samples collected at BPC-V6 or the sample locations situated upstream (CalBase-1, 43HVP-2, WWF-3, 43BPC-4, and BPC-R5). However, bromide was detected during each of the sampling events at the sample sites located downstream of BPC-V6 (i.e., BPC-C7, BPC-B8, and BPC-W9) as shown in Figure 5-8. The increase in bromide concentrations downstream of BPC-V6 also corresponds to a decrease in nitrate concentrations at BPC-C7, BPC-B8, and BPC-W9 as shown in Figure 5-9. Accordingly, this change in bromide and nitrate composition in conjunction with the increase in chloride concentrations suggests a separate chloride source area(s) downstream of BPC-V6 that is not affiliated with the Heavenly California Base area.

Inspection of the Piper plots provided in Appendix C indicate that the overall surface water characteristics are consistent within the studied portion of Bijou Park Creek. The changes noted for individual compounds indicates some variation in the sources of chloride, but not at a level that would lead to a major change in the chemistry of creek waters.

The likely source areas consist of tributary drainages that join the main channel of Bijou Park Creek downstream of BPC-V6 as shown in Figure 5-1. The most upstream of these tributaries appears to drain Ski Run Boulevard and joins the main channel approximately 150 feet downstream of BPC-V6 and approximately 170 feet upstream of Needle Peak Road (Lumos 2005). The other drainage that enters Bijou Park Creek within the study area consists of a swale system that enters the main channel through a culvert under Blackwood Road on the downslope corner of the mobile home park located at Blackwood Road and Pioneer Trail (Lumos 2005). Stormwater flows upstream of Bill Avenue (located at the downstream end of the drainage near Highway 50) are characterized as surface drainage that is conveyed along road shoulders directly to natural channel system of Bijou Park Creek (Lumos 2005). Accordingly, the likely source of elevated concentrations of chloride downstream of BPC-V6 is the runoff of salt from deicing operations conducted by others, downstream of the area operated by Heavenly.

In conclusion, chloride is a conservative anion, and, as stormwater runoff flows downstream from the California Base Parking area to Bijou Park Creek and downstream to Lake Tahoe, chloride does not

appear to react with or adsorb to other components of the system. The most significant change in concentration occurs at the headwaters of Bijou Park Creek, where the concentration of chloride decreases by more than 50% as a result of mixing with the spring-fed waters. From this point downstream, the increases in concentration are associated with inflow from other sources that are richer in chloride.

5.4 CONSIDERATION OF ALTERNATE CHLORIDE STANDARD OR ALTERNATE BACKGROUND LOCATION FOR BIJOU PARK CREEK

The four work products required by the WDRs consist of the following:

1. StormFilter Improvements;
2. Brine and Traction Sand Feasibility Study;
3. Snow Conditioning Actions for Heavenly Valley Creek; and,
4. Bijou Park Creek Chloride Monitoring Plan.

These four components act together to address improvement of water quality in Bijou Park Creek and surface waters affected by discharges from the California Base parking lot through a combination of water treatment, source removal, and evaluation of contaminant fate in area waters including consideration of site specific standards.

The StormFilter component seeks to optimize the removal of total nitrogen, total phosphorous, and turbidity by the existing water treatment system beneath the California Base parking lot. Because the StormFilter treatment system cannot directly remove chloride, the Brine and Traction Sand Feasibility Study and the Snow Conditioning Actions are focused on source removal actions that would reduce chloride loading to surface waters. Although continued source removal/substitution actions, taken together with expected improvements in the performance of the StormFilter treatment system, are expected to lead to further reductions in chloride, the results of this Bijou Park Creek Chloride Monitoring Study indicate that the area-wide use of salt for public safety imply that the 3 mg/l standard will not be met.

This chapter considers the designation of an alternate standard for chloride in Bijou Park Creek. As indicated in the WDRs, the existing levels of chloride do not appear to impair beneficial uses of either Bijou Park Creek or Lake Tahoe, although the measured levels exceed the chloride objective of 3 mg/l for Lake Tahoe. The results of the study indicate that the concentration of chloride increases downstream from the WDR compliance point at the headwaters of Bijou Park Creek likely due to the presence of an area-wide contribution of chloride to the creek, in part attributable to Heavenly operations and in part due to other sources. As such, Heavenly's water treatment, source removal, and material substitution appear insufficient to achieve the 3 mg/l chloride standard in Bijou Park Creek given the presence of sources outside of Heavenly's control. Accordingly, as discussed in the *Compliance Items* report, it appears appropriate to establish a mixing zone for the receiving water (Bijou Park Creek) or an alternate, site-specific standard in this reach of Bijou Park Creek. Given the presence of sources downstream of the headwaters of Bijou Park Creek, a mixing zone in Bijou Park Creek does not appear to be a viable approach.

Alternatively, a different background sample location could be selected that is more representative of the land use affecting Bijou Park Creek. Therefore, this section discusses the effects of chloride on aquatic biota along with established toxicity thresholds and evaluates whether either the application of an alternate, site-specific standard for chloride in Bijou Park Creek or use of a more representative background sample location may be appropriate.

5.4.1 Effects of Chloride on Aquatic Biota

While chloride occurs naturally at low levels in the aquatic environment, human sources are consistently identified as the primary source of elevated concentrations, including the identification by this study of deicing salts. In freshwater environments, elevated chloride levels can impact aquatic organisms by disrupting their osmoregulation leading to impaired survival, growth, and/or reproduction. Note that the SWRCB secondary maximum contaminant level (MCL) for chloride in drinking water is 250 mg/l.

The threshold levels for chloride effects vary across organisms and life stages (Findlay and Kelly 2011). In a survey of macroinvertebrates in urban streams, Cuffney et. al. (2010) found that chloride was frequently and strongly associated with indicators of poor macroinvertebrate communities, but also acknowledged that other measured and unmeasured factors co-varied with chloride including stream geomorphology, habitat availability, and other organic and inorganic compounds that are typically associated with urban runoff. Amphibians are identified as the most likely species to be impacted by chloride associated with deicers given their highly permeable skin, aquatic larval stages, and frequent use of roadside wetlands for breeding (Harless et al. 2011). The toxicity of road salts is highly variable between amphibian species with salamanders being the most intolerant to varying salt concentrations (Collins and Russell 2009). In regards to fish, the tolerance to chloride varies significantly with tolerance levels reported between 400 and 30,000 mg/l of sodium chloride (Siegel 2007).

In regards to toxicity thresholds, the USEPA established chloride levels in surface waters at 230 mg/l maximum chronic exposure for a four-day average concentration and 860 mg/l maximum acute exposure for a one-hour average concentration (USEPA 1988). These standards were established in 1986 and are presently used by the State of California SWRCB as statewide water quality objectives In 2009, the Iowa Department of Natural Resources and the USEPA conducted a study to assess the toxicity of chlorides on various sensitive species. The study findings recommended a final acute criterion of 682 mg/l and a chronic criterion of 406 mg/l. The study also determined that increased water hardness and sulfate ions buffer against potential toxic effects of chloride and developed the following equations for calculating acute and chronic criteria based on the influence of site specific water hardness and sulfate concentrations (Iowa DNR 2009):

- Acute Criteria Value (mg/l) = $(254.3) \times (WH)^{0.205797} \times (S)^{-0.07452}$
- Chronic Criteria Value (mg/l) = $(161.5) \times (WH)^{0.205797} \times (S)^{-0.07452}$

  where:
  - WH = Water Hardness (mg/l)
  - S = Sulfate (mg/l)

These equations have been adopted by the State of Iowa and USEPA Region 7 for the development of site-specific chloride criteria for aquatic life protection that is based on local water hardness and sulfate levels.

In 2003, the British Columbia Ministry of the Environment adopted the following criteria for chloride: the average concentration of 5 weekly measurements over a 30-day period for freshwater and aquatic life are not to exceed 150 mg/l with a maximum not to exceed 600 mg/l (Nagpal et al. 2003). The development of these guidelines included conservative safety factors comparable to the USEPA (1988) guidelines. As such, a safety factor of two was applied to determine the maximum chloride concentration of 1,204 mg/l from acute toxicity studies of the tubificid worm and a safety factor of five was used to determine the chronic toxicity concentration of 150 mg/l (Nagpal et al. 2003).

5.4.2 Requirements for Site Specific Standards

Site-specific water quality objectives are considered based on a number of factors including the circumstances associated with the need for a site-specific objective as well as the potential impacts to sensitive species and the environment (GLEC 2003). In regards to the need, the antidegradation review considers whether lowering water quality is necessary to allow important economic or social development and evaluates whether legal requirements for existing point sources and best management practices (BMPs) for nonpoint sources have been implemented. In this situation, the elevated concentrations of chloride are associated with the application of deicers during the winter months to improve public safety on the roadways. Heavenly is responsible for applying deicers at the California Base Area and City roads that provide access to their ski area including Ski Run Boulevard, Needle Peak Road, Wildwood Avenue, and Saddle Road. The application of deicers on City roads is regulated under a Municipal NPDES Permit issued to the City (NDPES Permit No. CAG616001).

Heavenly has explored the use of alternative deicers and has an ongoing adaptive management program under the WDRs for the facility. The program requires annual monitoring of salt use and water quality effects, and a 5-year comprehensive review during which adaptive management is applied. Therefore, in order to minimize impacts on the environment, Heavenly has implemented BMPs to reduce the amount of sodium chloride used in their deicing activities by: adjusting the ratio of sodium chloride and traction sand that is applied; reducing the number of areas receiving deicers; purchasing application equipment to more effectively apply the deicers; and, reducing the number of times that deicers are applied during and after a storm cycle. Implementation of these BMPs has reduced the loading of chloride in stormwater runoff, and Heavenly continues to explore opportunities to further reduce the use of sodium chloride. This situation appears to meet the conditions set forth in the antidegradation review as the source of the elevated chloride levels is associated with deicers that are needed to ensure public safety and Heavenly is implementing BMPs to minimize the application of sodium chloride.

It is important to note that Heavenly has an ongoing third-party BMP verification inspection program. Between 2014 and 2016, the BMPs across the Heavenly's operations are inspected every two weeks, and after significant storm events. During the last three summers, the third-party contractor, RCI, has verified and confirmed that all temporary (construction project related) BMPs and permanent BMPs (facilities, drainage structures, etc.) have been 100% effective and 100% implemented. This further highlights the commitment and efforts by Heavenly to meet its water quality goals.

As far as the potential degradation of water quality and potential impacts to sensitive species and the environment, the chloride objective of 3.0 mg/l that is specified in the WDRs is not based on potential impacts to aquatic life, but, rather, is derived from the limit for Lake Tahoe. As previously discussed, this target is much lower than water quality standards that have been developed by the USEPA and other

regulatory agencies to be protective of aquatic life. In addition, Lake Tahoe is not listed as an impaired water body for chloride. Accordingly, a revised, site-specific water quality objective for chloride that is based on protecting aquatic life appears warranted. Alternatively, establishing a new, more representative background sample location for comparison to the Bijou Park Creek compliance sampling, would also be warranted.

5.5 BIJOU PARK CREEK CHLORIDE MONITORING STUDY CONCLUSIONS AND PATH FORWARD

Heavenly has implemented various BMPs to improve water quality in the stormwater runoff from their California Base area. These BMPs include the construction of the stormwater management system in the California Base parking area to treat the runoff, additional improvements to enhance the effectiveness of the stormwater management system, and improved management of traction sand and brine application to significantly reduce the annual volume used. However, despite implementation of these BMPs, chloride concentrations in the effluent from the Heavenly stormwater management system remain elevated above the water quality objective of 3 mg/l specified in the WDRs. In addition, the findings of this study indicate the presence of additional sources of chloride downstream of the Heavenly California Base area that contribute to elevated levels of chloride throughout Bijou Park Creek, most likely due to the pervasive use of deicers in the area to ensure public safety during the winter months. CalTrans and NDOT have programs that focus on source reduction, but we have not seen other area-wide studies of chloride in urban-affected waters of the basin. This study suggests that the issue is basin-wide.

The results of this study indicate that a water quality objective that reflects site-specific considerations and more accurately represents potential toxicity to aquatic biota is warranted rather than the water quality objective of 3 mg/l that is specified in the WDRs. Given the presence of chloride sources downstream of the headwaters of Bijou Park Creek and throughout its watershed, a mixing zone in Bijou Park Creek does not appear to be a viable approach.

Accordingly, we recommend either the establishment of a site-specific water quality objective for chloride in Bijou Park Creek, or establishing an alternate background water quality sampling site that is better reflective of development of Bijou Park Creek. Site conditions appear to meet the conditions set forth in the antidegradation review since the source of the elevated chloride levels is associated with deicers that are needed to ensure public safety and Heavenly is implementing BMPs to minimize the application of sodium chloride. In addition, the current water quality objective is not based on potential impacts to aquatic life, but, rather, is derived from the limit for Lake Tahoe which is not listed by the SWRCB as an impaired water body for chloride. The current WDRs also note that, in the absence of contrary evidence, the measured levels of chloride in Bijou Park Creek would not appear to be toxic to aquatic life, or at levels that would otherwise impair the waters for beneficial uses.

The USEPA and SWRCB toxicity thresholds for chronic and acute chloride exposure for aquatic life are 230 mg/l and 860 mg/l, respectively. As discussed in Section 5.4.1, the State of Iowa has established chloride thresholds based on site-specific water quality conditions for water hardness and sulfate. As shown Table 5-6, the chronic threshold calculated using the Iowa methodology ranges from 310 to 445 mg/l and the acute threshold ranges from 489 to 701 mg/l. Lastly, the British Columbia Ministry of the Environment has established a chronic threshold of 150 mg/l and an acute threshold of 600 mg/l that

were developed using of conservative safety factors comparable to the USEPA guidelines (Nagpal et al. 2003).

Based on these thresholds for chloride that were established to be protective of aquatic biota and given that that Lake Tahoe is not listed by the SWRCB as an impaired water body for chloride, we propose the most conservative of these regulatory thresholds as the site-specific water quality objective for this permit. Specifically, we recommend that the WDRs be revised to specify a chronic water quality objective of 150 mg/l and an acute water quality of 600 mg/l for chloride to be met at the compliance point at the headwaters of Bijou Park Creek. These goals would ensure that there is no further degradation to the waters of Bijou Park Creek and would be protective of aquatic life in the creek.

As an alternative to a site-specific water quality objective, the background water quality sampling point could be reestablished at a location that is more representative of the land use conditions in the vicinity of Bijou Park Creek. Specifically, the background location would be selected to better represent the balance between the needs of public safety, and water quality objectives that are protective of the beneficial uses of receiving waters.

We appreciate consideration of this request and Heavenly is committed to continuing its use of BMPs and seeking ways to further reduce chloride concentrations in the effluent from their stormwater management system.

Table 5-6: Calculation of Site-Specific Chloride Targets Based on State of Iowa Methodology[1]

Sample Location[2]	Date	Calcium (mg/l)	Magnesium (mg/l)	Calculated Water Hardness[3] (mg/l)	Sulfate (mg/l)	Calculated Chronic Chloride Target Level (mg/l)	Calculated Acute Chloride Target Level (mg/l)
CalBase-1	4/7/16	11	1.7	34.5	2.7	311	489
43HVP-2	4/7/16	38	6.3	120.8	4.0	391	615
WWF-3	4/7/16	33	8.4	116.9	2.8	399	627
43BPC-4	4/7/16	16	3.6	54.8	2.4	345	543
BPC-R5	4/7/16	16	3.7	55.2	2.2	348	547
BPC-V6	4/7/16	18	4.2	62.2	2.4	354	557
BPC-C7	4/7/16	25	6.1	87.5	2.8	375	591
BPC-B8	4/7/16	23	5.8	81.3	2.5	373	587
BPC-W9	4/7/16	23	5.6	80.5	2.0	378	596
CalBase-1	4/21/16	14	2.1	43.6	3.0	324	510
43HVP-2	4/21/16	36	6.0	114.6	5.5	377	594
WWF-3	4/21/16	35	8.4	121.9	2.1	411	647
43BPC-4	4/21/16	23	4.6	76.4	3.6	358	564
BPC-R5	4/21/16	23	4.6	76.4	3.6	358	564
BPC-V6	4/21/16	24	5.2	81.3	3.3	365	575
BPC-C7	4/21/16	27	6.1	92.5	2.7	381	600
BPC-B8	4/21/16	24	5.7	83.4	2.0	381	600
BPC-W9	4/21/16	24	5.6	83.0	1.3	393	619
CalBase-1	5/5/16	12	2.0	38.2	3.0	315	496
43HVP-2	5/5/16	32	5.1	100.9	4.3	374	590
WWF-3	5/5/16	35	8.2	121.1	1.9	413	651
43BPC-4	5/5/16	24	5.0	80.5	4.0	359	566
BPC-R5	5/5/16	25	5.3	84.2	4.2	361	569
BPC-V6	5/5/16	26	5.5	87.6	31	314	494
BPC-C7	5/5/16	27	6.2	92.9	2.6	382	602
BPC-B8	5/5/16	23	5.8	81.3	1.8	382	602
BPC-W9	5/5/16	23	5.8	81.3	1.2	394	620
CalBase-1	5/19/16	12	1.9	37.8	3.0	314	495
43HVP-2	5/19/16	27	5.0	88.0	5.9	356	560
WWF-3	5/19/16	39	9.6	136.9	1.6	429	676
43BPC-4	5/19/16	24	5.0	80.5	4.0	359	566
BPC-R5	5/19/16	24	5.2	81.3	3.8	361	569
BPC-V6	5/19/16	23	5.4	79.6	3.4	363	571
BPC-C7	5/19/16	26	6.1	90.0	2.5	381	600
BPC-B8	5/19/16	25	6.0	87.1	1.5	393	619
BPC-W9	5/19/16	26	6.0	89.6	0.5	429	675
CalBase-1	6/1/16	10	1.8	32.4	2.3	310	489
43HVP-2	6/1/16	24	4.4	78.0	4.5	354	557
WWF-3	6/1/16	41	9.9	143.1	1.1	445	701
43BPC-4	6/1/16	22	4.7	74.3	3.7	355	560
BPC-R5	6/1/16	23	5	78.0	3.4	361	569
BPC-V6	6/1/16	24	5.2	81.3	2.7	371	584
BPC-C7	6/1/16	26	5.9	89.2	2.2	384	604
BPC-B8	6/1/16	25	5.8	86.3	1.2	399	628
BPC-W9	6/1/16	28	6.1	95.0	0.5	434	684

[1] State of Iowa equations to calculate chloride objectives:

- Acute Criteria Value (mg/l) = $(254.3) \times (WH)^{0.205797} \times (S)^{-0.07452}$
- Chronic Criteria Value (mg/l) = $(161.5) \times (WH)^{0.205797} \times (S)^{-0.07452}$

where:
WH = Water Hardness (mg/l)
S = Sulfate (mg/l)

[2] Organized from upstream to downstream.

[3] Water Hardness (CaCO3 equivalent) = $(2.5*[Ca^{2+}]) + (4.1*[Mg^{2+}])$

SECTION 6

Summary of Findings and Recommendations

This section provides a summary of the findings of the Compliance Item actions that were implemented in 2016 and recommendations for the path forward based on those findings. Specifically, the findings and recommendations are focused on: 1) ongoing source reduction measures for chloride; 2) improvements to the StormFilter system; and, 3) an alternate, site-specific compliance water quality standard for chloride in Bijou Park Creek or establishing an alternate background water quality sampling site that is better reflective of development of Bijou Park Creek.

6.1 SOURCE REDUCTION MEASURES FOR CHLORIDE

Two of the Compliance Item actions focused on source reduction for chloride within Heavenly's operations: 1) the Brine and Traction Sand Feasibility Study; and, 2) Snow Conditioning Actions in the Heavenly Valley Creek watershed. As described in Section 3, over the past 5 years, Heavenly has implemented various measures to reduce the use of deciers and traction sands as well as the use of salt for snow conditioning. These measures have successfully resulted in an overall decrease in the application of salt throughout their operations. In moving forward, Heavenly will continue the actions described in Section 3 including the monitoring and reporting activities to document the improvements. Heavenly is also planning on implementing the following additional measures to further reduce the use of salt in their operations:

- A feasibility study to evaluate the effectiveness of using liquid brine for pre-storm deicing. Heavenly expects to initiate this in water year 2016 (i.e., 2016/17 winter operating season). When implemented it should reduce the amount of plowing and sanding required, as well as producing safer walking surfaces during the thaw/freeze cycles that produce hazardous ice surfaces;
- Continued education of employees to raise their awareness of the importance of properly managing salt use. Before the winter season begins, the Heavenly environmental department will meet with the management and staff responsible for salt use to ensure tracking, and that materials used on mountain are consistent and the expectations of Heavenly and the WDRs. This clear signal of the importance of these actions will help key managers to communicate the importance of requirements down to the line level staff. The environmental department will also meet with management in the spring, when salt use on the mountain typically begins to rise, to ensure everyone understands what is required; and,
- Continuing to disallow the stockpiling of salt at the Heavenly Terrain Parks. If weather predictions indicate a need for salt, then only that amount proposed for use will be brought to the park.

The success of these continuing improvements will be measured during the water quality sampling required in the WDRs monitoring program, and Heavenly will continue to track and report their source reduction measures in the Quarterly, Annual, and Comprehensive water quality monitoring reports.

6.2 STORMFILTER SYSTEM IMPROVEMENTS

As discussed in Section 4, Heavenly conducted an engineering evaluation of the StormFilter system to assess its current performance and effectiveness in meeting the water quality objectives outlined in the WDRs, and provide recommendations for improvements to better optimize the system. The results of the evaluation indicated that the StormFilter treatment system does not appear to be able to meet the water quality standards prescribed to protect the receiving waters as currently operated and sampled. Accordingly, as presented in Section 4.2, the following improvements have been recommended to optimize the effectiveness of the StormFilter system:

- Minor structural improvements including:
    - Replace manhole covers;
    - Grout sumps;
    - Reestablish downhill gradient in Manholes 12, 13, and 14;
    - Plug sacrificial StormFilter outlet risers; and,
    - Eliminate imperfect seal in cartridges.
- Continue regular maintenance program;
- Water quality sampling improvements including:
    - Staggering water quality sampling times;
    - Continued collection of continuous flow rate data:
    - Characterization of sediment collected in the system;

The success of these improvements will be measured during the water quality sampling required in the WDRs monitoring program, and Heavenly will continue to document these changes in the Quarterly, Annual, and Comprehensive water quality monitoring reports.

6.3 BIJOU PARK CREEK CHLORIDE MONITORING STUDY CONCLUSIONS AND PATH FORWARD

As discussed in Section 5, Heavenly has implemented various BMPs to improve water quality in the stormwater runoff from their California Base area. These BMPs include the construction of the stormwater management system in the California Base parking area to treat the runoff, additional improvements to enhance the effectiveness of the stormwater management system, and improved management of traction sand and brine application to significantly reduce the annual volume used. However, despite implementation of these BMPs, chloride concentrations in the effluent from the Heavenly stormwater management system remain elevated above the water quality objective of 3 mg/l specified in the WDRs. In addition, the findings of this study indicate the presence of additional sources of chloride downstream of the Heavenly California Base area that contribute to elevated levels of chloride throughout Bijou Park Creek, most likely due to the pervasive use of deicers in the area to ensure public safety during the winter months. CalTrans and NDOT have programs that focus on source reduction, but we have not seen other area-wide studies of chloride in urban-affected waters of the basin. This study suggests that the issue is basin-wide.

The results of this study indicate that a water quality objective that reflects site-specific considerations and more accurately represents potential toxicity to aquatic biota is warranted rather than the water quality objective of 3 mg/l. This current standard is not based on potential impacts to aquatic life, but, rather, is derived from the limit for Lake Tahoe. Lake Tahoe and tributary waters are not listed by the SWRCB as an impaired water body for chloride.

Given the presence of chloride sources downstream of the headwaters of Bijou Park Creek and throughout its watershed, a mixing zone in Bijou Park Creek does not appear to be a viable approach. Accordingly, we recommend either the establishment of a site-specific water quality objective for chloride in Bijou Park Creek, or establishing an alternate background water quality sampling site that is better reflective of development of Bijou Park Creek. In regards to an alternate, site-specific standard, we recommend that the WDRs be revised to specify a chronic water quality objective of 150 mg/l and an acute water quality of 600 mg/l for chloride to be met at the compliance point at the headwaters of Bijou Park Creek. These goals are based on conservative, established regulatory thresholds. Compliance with these thresholds would demonstrate no further degradation to the waters of Bijou Park Creek and would be protective of aquatic life in the creek as well as Lake Tahoe.

SECTION 7

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Appendix A

Bijou Park Creek Chloride Monitoring Study
Field Data





CONTENTS

PAGE	REFERENCE	DATE

4/7/16 CALBASE 1 10:00 AM

clear skies
0" precip in past 48 hrs
Collected 2 bottles (1L Chloride & Metals → preserved w/ HNO_3)

flow estimated by measuring depth in culvert
~~depth = 7.74 ft~~

$depth_{water}$: 0.06 ft
Culvert ϕ = 36" CMP

pH = 7.29
DO = 8.22 ppm DO
EC = 825 µs/cm
TDS = 384 ppm TDS
Temp 48.3 °F

Rite in the Rain

4/7/16 CA Vault Effluent

clear skies 10:30 AM

0" precip in past 48 hrs

Collected 2 bottles (1 L chloride & 250 mL metals → preserved w/ HNO_3)

Sensor measuring 0.20 fps

0.09 ft depth

need pipe size → 30" HDPE

Frank thinks reading low

→ may need to add 0.35 ft

pH: ~~7.70~~ 7.32

DO: 6.6 ppm 701

EC: ~~501~~ 705 µs/cm

TDS: ~~352~~ ppm

Temp: 49.9

4/7/16 Wildwood Vault 11:40

Had to change sampling location to outlet of same culvert @ sta 0+60 on As Built plans due to access issues & ease of sampling

Clear skies

59 precip in past 48 hrs

15" culvert Blue PVC (measured 14.25" ID of culvert

Depth = 1 cm = 0.033 ft

pH: 8.17

DO: ~~7.35~~ 7.0 ppm

EC: 716 µs/cm

TDS: 354 ppm TDS

Temp: 52.06 °F

2 bottles collected

1 x 1 L Chloride

& 1 x 250 mL metals preserved w/ HNO_3

Rite in the Rain

4/7/16 BIJOU PARK 12:10 pm

CLEAR SKIES
0% PRECIP
CREEK XS CLEAR

PH: 7.93
DO: 8.78 ppm
EC: 12416 µS
TDS: 123 ppm
TEMP: 44.4°F

3 BOTTLES COLLECTED

1 x 1L CHLORIDE
1x 250 mL METALS w/ HNO_3
1x 250 mL TKN w/ H_2SO_4

No snow cover, clear skies, XS clear

Sta	depth	vel	notes
3.9	0	0	REW, undercut
4.0	0.2	BW	
4.1	0.3	0.20	0.266 CS
4.2	0.3	0.82	

Rite in the Rain

Sta	depth	vel	notes
4.3	0.35	0.96	
4.4	0.3	1.55	
4.5	0.3	1.96	
4.6	0.3	1.87	
4.7	0.3	1.41	
4.8	0.3	0.50	
4.9	0.3	0.11	
5.0	0.3	BW	
5.2	0	0	LEW

4/07/2016 REGINA 1:00 PM

PARTLY CLOUDY
OK. PRECIP.
CREEK XS CLEAR / NO SNOW COVER
PH: 8.1
DO: 8.63 ppm
EC: 332 µS/cm
TDS: 166 ppm
TEMP: 46.0°F
2 BOTTLES

STA	DEPTH	VEL	NOTES
~~3.9~~	0	0	~~LEW~~
3.4	0.05	0.04	
3.5	0.10	0.11	
3.6	0.10	0.13	
3.7	0.20	0.43	
3.8	0.30	0.47	0.376 cfs
3.9	0.40	0.49	
4.0	0.45	0.62	
4.1	0.45	0.67	
4.2	0.50	0.55	
4.3	0.50	0.76	

Rite in the Rain

sta	depth	velocity	notes
4.4	0.50	0.80	
4.5	0.50	0.73	
4.6	0.55	0.68	
4.7	0.60	0.53	
4.8	0.55	0.57	
4.9	0.50	0.39	
5.0	0.50	0.23	
5.1	0.50	0.28	
5.3	0	0	LEW

4/07/2016 VERDON 1:35pm

clear skies,
0% precip in past 48hrs
creek xs clear, no snow cover
pH: 8.28
DO: 8.3 ppm
EC: 293 µs/cm
TDS: 147 ppm
Temp: 48.3 °F

2 bottles

sta	depth	vel	notes
2.9	0	0	REW
3.2	~~0.15~~ 0.05	0	BW
3.3	~~0.15~~ 0.05	0.02	
3.4	0.15	0.30	
3.5	0.2	0.60	
3.6	0.3	0.93	0.35 cfs
3.7	0.3	1.17	
3.8	0.3	1.22	
3.9	0.3	1.23	
4.0	0.3	1.23	
4.1	0.3	1.12	
4.2	0.3	1.09	
4.3	0.3	1.03	

Rite in the Rain

STA	DEPTH	VEL	NOTES
4.4	0.25	1.02	
4.5	0.2	0.86	
4.6	0.2	0.85	
4.7	0.15	0.35	
4.8	0.1	0.10	
5.0	0	0	LOW

4/7/16 CHARLESWORTH 2:00 PM

PARTLY CLOUDY
0% precip in past 48 hrs
creek XS clear, no snow cover
pH: 8.3
DO: 8.17 ppm
EC: 419 µs/cm
TDS: 209 ppm
Temp: 50.9°F
2 bottles

sta	depth	vel	notes
3.8	0	0	REW, cond or cut
4.0	0.20	0.04	
4.1	0.20	0.09	
4.2	0.25	0.30	
4.3	0.30	0.53	
4.4	0.35	0.71	
4.5	0.40	0.95	
4.6	0.45	1.21	
4.7	0.45	1.06	
4.8	0.45	0.97	
4.9	0.45	0.63	
5.0	0.45	0.28	
5.1	0.40	0.32	

Rite in the Rain

Stn	depth	velocity	notes
5.2	0.35	0.39	
5.3	0.30	0.43	
5.4	0.20	0.25	
5.6	0	0	LEW

4/9/16 BLACKWOOD 2:30 PM

Cloudy skies No snow cover

0" precip in past 48 hrs

collected 2 bottles

1x 1L chloride

1x 250 mL preserved w/ HNO_3

pH 8.14 TDS 213

D.O 9.57 ppm Temp 60.0

E.C 426 µS/cm

Stn	depth	wd	notes
5.1	0	0	REW
5.3	>0.05	0	
5.4	0.05	0.15	
5.5	0.05	0.29	
5.6	0.1	0.25	0.17 ♡
5.7	0.1	0.23	
5.8	0.15	0.71	
5.9	0.2	0.78	
6.0	0.2	0.62	
6.1	0.25	0.98	
6.2	0.25	0.82	
6.3	0.15	1.03	on rock
6.4	0.15	1.06	on rock
6.5	0.2	1.35	
6.6	0.25	0.58	

Kitty in the Rain

Sta	depth	vel	notes
6.7	0.25	0.51	
6.8	0.25	0.05	
6.9	0	0	LEW

4/7/16 WERNER 3:00pm

CLOUDY SKIES NO SNOW COVER
0" PRECIP IN PAST 48 HRS
2 BOTTLES
1 x L CHLORIDE
1 x 250 ML w/ HNO3

PH: 7.8
DO: 5.76
EC: 432
TDS: 216
TEMP: 63.4

STA:	DEPTH	VEL	NOTES
4.9	0	0	REW
5.0	0.10	0.94	
5.1	0.15	1.21	
5.2	0.20	1.51	
5.3	0.20	1.41	0:30
5.4	0.20	1.41	
5.5	0.20	1.50	
5.6	0.20	1.64	
5.7	0.20	1.63	
5.8	0.20	1.31	
5.9	1.20	1.25	

Rite in the Rain

Sta	depth	Velocity	notes
6.0	0.15	1.22	
6.1	0.15	0.85	
6.2	0.10	0.43	
6.3	0.10	0.19	
6.6	0	0	LOW

4/21/2016 CALBASE-1 9:45am

Partly cloudy skies
0" precip in past 48 hours
collected 2 bottles - 1L chloride & metals preserved w/ HNO_3

flow estimated by measuring flow in culvert

depth water: 0.14 ft
culvert: 36" ϕ CMP

pH: ~~7.49~~ 7.51
DO: ~~7.0~~ ppm DO
EC: ~~pS/cm~~ 177 µS/cm
TDS: 86 ppm TDS
Temp: 50.7°F

DO reading was very inconsistent; would increase and decrease while taking reading.

Rite in the Rain

4/21/2016 CA Vault Effluent 10:20am

Changed effluent sensor 4/20 + calibr, comment provided by Frank:
0.16 = 2" 0.18 = 2.25 inches set 4/20
partly cloudy skies
0" precip past 48 hrs
collected 2 bottles (1L chloride & 250 mL metals preserved w/ HNO_3

sensor measuring v = 0.09 ft/s
d = 0.177 ft

pH: 7.45
DO: 6.96 ppm DO
EC: 712 µs/cm
TDS: 350 ppm
Temp: 49.6°F

verified #14 on spec

4/21/2016 Wildwood 11:10am

Partly cloudy skies
0" precip in past 48 hrs
collected 2 bottles at site (1L chloride and metals → preserved w/ HNO_3

depth = ~~0.25 inches~~ 3/8"

pH: 8.11
DO: 5.90 ppm DO
EC: 558 µs/cm
TDS: 279 ppm
Temp: 52.3°F

Rite in the Rain

4/21/10 43BPC-41 BUOU PARK 11:45am

Partly Cloudy skies

.01" Precip last 48Hrs

No snow cover

Collected 3 bottles (1 L chloride: (2) 250 mL)

HNO_3 →

H_2SO_4

AIR TEMP: 64.3°F

pH: 7.57

DO: 8.02 ppm

EC: 385 µS/cm

TDS: 192 ppm

Temp: 49.15 °F

STA	DEPTH	VEL	NOTES
3.8'	0	0	REW / V-CUT
3.9	0.15	BW/0	
4.0	0.15	BW/0	
4.1	0.15	BW/0	
4.2	0.2	0.07	> STA 4.25 DEPTH 0.25' VEL = 0.68
4.3	0.25	0.82	
4.4	0.25	1.29	
4.5	0.20	1.35	
4.6	0.20	1.26	
4.7	0.20	0.79	

STA	DEPTH	VEL	NOTES
4.8	0.2	0.43	> STA 4.85 DEPTH 0.2 VEL = 0.40
4.9	0.2	0.08	
5.0	0.2	BW/0	
5.2	0	0	LEW

* ADDED 2 STATIONS TO GET 10 READINGS (STA: 4.85 & STA. 4.25)

Rite in the Rain

BPC+RS
4/21/16 REGINA 12:35pm

Partly Cloudy
0" Precip in last 48 Hrs
Collected 2 samples
(1L : 250 mL w/ HNO_3)
AIR TEMP: 65.0°F

pH: ~~7.88~~ ~~8.13~~ 7.88
DO: ~~8.05~~ 8.13
EC: 407 ms/cm
TDS: 203
TEMP: 50.18 °F

STA	DEPTH	VEL	NOTES
2.4	0	0	REW
2.7	0.05	0.18	W
2.9	0.10	0.51	
3.0	1.35	0.52	
3.1	0.35	0.30	
3.2	0.35	0.31	
3.3	0.35	0.41	
3.4	0.35	0.45	
3.5	0.35	0.37	
3.6	0.35	0.19	
3.7	0.40	0.08	
3.8	0.40	0.01	

Sta	depth	vel	notes
3.9	0.45	0	BW
4.0	0.45	0	BW
4.2	0	0	LEW, undercut

Rite in the Rain

4/21/2016 Verdon BPC-V6 1:15pm

Partly cloudy

0" precip in last 48hrs

2 bottles (1L & 250mL w/ HNO_3)

Air temp: 72.6°F

pH: 7.92

DO: 7.83 ppm

EC: 415 us/cm

TDS: 208 ppm

Temp: 51.57°F

STA	DEPTH	VEL	NOTES
2.7	0	0	REW
3.3	0.05	0	
3.4	0.05	0/BW	
3.5	0.10	0.36	
3.6	0.20	0.88	
3.7	0.20	1.07	
3.8	0.20	1.00	
3.9	0.20	1.03	
4.0	0.20	0.89	
4.1	0.20	0.83	
4.2	0.20	0.76	
4.3	0.15	0.62	
4.4	0.10	0.51	
4.8	0	0	LEW

BPC-LT

4/21/2016 Charlesworth 2:05pm

Partly cloudy skies

0" precip in past 48 hrs

2 bottles (1L chloride + 1,250mL metals preserved w/ HNO_3

air temp: 69.1°F

pH: 7.82

DO: 7.64 ppm DO

EC: 480 us/cm

TDS: 240 ppm

Temp: 55.07°F

Sta	depth	vel	notes
3.8	0	0	REW
4.0	0.05	0.26	
4.1	0.15	0	BW, vegetation in front of probe
4.2	0.2	0.06	
4.3	0.25	0.11	
4.4	0.30	0.10	
4.5	0.35	0.33	
4.6	0.35	0.50	
4.7	0.35	0.56	

Rite in the Rain

sta	depth	vel	notes
4.8	0.40	0.54	
4.9	0.40	0.35	
5.0	0.35	0.19	
5.1	0.30	~~0.30~~ 0.28	
5.2	0.10	0.35	
5.3	0.05	0.12	
5.5	0	0	LEW

4/21/16 BPC - BB BLACKWOOD D 2:35pm

PARTLY CLOUDY SKIES
0" OF PRECIP LAST 48 HRS
2 BOTTLES (1L + 250mL w/ HNO3)
AIR TEMP: 73.4°F

pH: 7.77
DO: 9.40
EC: 451
TDS: 225
TEMP: 61.25°F

STA:	DEPTH	VEL	NOTES
2.2	0	0	LEW
2.5	<0.05	0/BW	
2.6	0.05	BW	
2.7	0.05	BW	
2.8	0.05	0.11	
2.9	0.05	0.20	
3.0	0.15	0.26	
3.1	0.20	0.49	
3.2	0.20	0.81	
3.3	0.10	0.85	ROCK
3.4	0.10	0.87	ROCK

Rite in the Rain

Werner

4/21/2016 BPC-W9 3:05pm

Partly cloudy skies
0" precip in past 48 hrs
2 bottles (1L chloride, 1,250mL metals → preserved w/ HNO_3

air temp: 67.4°F

pH: 7.42
DO: 5.91 ppm DO
EC: 467 µs/cm
TDS: 233 ppm
temp: 65.56°F

STA	DEPTH	VEL	NOTES
3.5	0.10	0.87	Rock
3.6	0.10	0.76	Rock
3.7	0.20	0.30	
3.8	0.20	0/BW	
3.9	0.10	0/BW	
4.0	0.10	0/BW	
4.4	0	0	LEW

sta	depth	vel	notes
5.0	0	0	REW
5.2	0.05	0.39	
5.3	0.05	1.08	
5.4	0.10	2.11	
5.5	0.10	2.02	
5.6	0.10	2.09	
5.7	0.15	2.25	
5.8	0.20	2.06	
5.9	0.20	1.62	

Rite in the Rain

sta	depth	vel	notes
6.0	0.25	2.03	
6.1	0.20	1.60	
6.2	0.15	0.92	
6.3	0.10	0	BW
6.5	0	0	LEW

5/5/16 CAL BASE - 1 10:00 AM

PB, SS

Cloudy skies
0.01" precip in past 48 hrs
AIR TEMP: 48°F

pH 7.4
DO 6.9
EC 230 µS/cm
TDS 145 ppm
H_2O Temp: 51.2

collected 2 bottles

depth in culvert:
0.05' approximate 0.534

water smells sulfury

Rite in the Rain

5/5/16 Parking lot Vault 10:40

Effluent HVP-2

Cloudy skies

0.01" precip in past 48 hrs

Air temp: 50.7°F

pH: 7.6

DO: 5.77

EC: 638 us/cm

TDS: 321 ppm

H_2O temp: 49.46

2 bottles collected from Auto sampler

* velocity: 0.024 ft/s
+ depth: 0.299 ft
* flow: 0.042 cfs
* measured by auto sampler

0.039 cfs calculated

Rite in the Rain

5/5/16 Wildwood Vault 11:05
Effluent WWF-3
PB, SS

Cloudy skies, 0.01" precip in past 48 hrs, occasional rain drop

Air 49.5°F
pH 8.07
DO 6.15
EC 585
TDS 285
H2O Temp 50.2°F

Depth in culvert = 3/8 in 0.50 in
0.014 DS

piece of debris landed in chloride bottle

EX

Rite in the Rain

5/5/2016 Bijou 11:30am
PB, ES

Cloudy skies & raining
0.01" precip in past 48 hrs
Increased raindrops since previous sample

Air: 41.9°F
pH: 7.54
DO: 6.65
EC: 409
TDS: 205
H_2O temp: 48.9°F

Sta	depth	vel (ft/s)	notes
~~3.9~~ 3.8	0	0	REW
~~4.0~~ 3.9	0.1	0	BW
4.0	0.15	0	BW
4.1	0.15	0	BW
4.15	0.15	0.15	
4.2	0.2	0.38	
4.25	0.2	0.52	0.144 cfs
4.3	0.2	0.75	
4.4	0.2	0.93	
4.5	0.15	1.39	on top of rock

Rite in the Rain

Sta	depth	V	notes
4.55	0.2	1.40	
4.6	0.2	1.39	
4.7	0.2	0.99	
4.8	0.2	0.71	
4.9	0.2	0.60	
5.0	0.2	0.24	
5.2	0	0	LEW, undercut

5/5/16 REGINA 11.55
RB SZ

Cloudy, moderate rain
0.01" precip in past 48 hrs
0 in snow cover
Air temp: 44.2°F
pH: 7.81
DO: ~~7.16~~ 7.17
EC: 423
TDS: 211
H2O TEMP: 48.1°F

velocity units: ft/s

~~Sta~~	depth	vel	notes
~~3.4~~ 3.3	0	0	LEW
3.5	0.05	–	no reading
3.6	0.1	0.76	
3.7	0.3	0.71	
3.8	0.35	0.38	
3.9	0.35	0.30	
4.0	0.40	0.52	
4.1	0.40	0.52	
4.2	0.40	0.45	
4.3	0.35	0.34	
4.4	0.40	0.24	

0.143 CFS

Rite in the Rain

sta	depth	v	notes
4.5	0.4	0.18	
4.6	0.4	0.104	
4.7	0.45	0	BW
4.8	0.45	0	BW
4.9	0	0	LEW
Extra sample points checking			
3.4	0.05	-0.28	90° angle
3.5	0.10	-0.36	

5/5/16 VERDON 12:20 pm

P6,55

cloudy, light rain
0.01" precip in past 48 hrs
0% snow cover
AIR TEMP: 44.2
pH: 7.82
DO 6.89 ppm
EC 503 µS/cm
TDS 250 ppm
H2O temp: 50.3 °F

vel units: ft/s

Sta	depth	vel	notes
3.1	0	0	REW
3.4	0.05	0	too low
3.5	0.05	BW	
3.6	0.15	0.52	
3.7	0.20	0.64	0.134 C&?
3.8	0.20	0.88	
3.9	0.20	1.02	
4.0	0.20	1.06	
4.1	0.15	0.93	on root
4.2	0.20	0.82	
4.3	0.15	0.87	
4.4	0.1	0.69	
4.5	0.05	0.57	

Rite in the Rain

sta	depth	vel	notes
4.6	0.05	—	too low
4.7	0	0	LEW

5/5/10 CHARLESWORTH 12:45

PB, SS

Cloudy, light rain
0.01" precip in past 48 hrs
0% snow cover
AIR TEMP: 45.6°F
pH: 7.79 EC: 458 µS/cm
DO: 7.01 TDS: 229
H_2O TEMP: 46.48° F
velocity units: ft/s

sta	depth	vel	notes
3.0	0	0	LEW
3.2	0.2	0.04	
3.3	0.2	0.03	
3.4	0.25	0.06	
3.5	0.3	0.14	
3.6	0.35	0.13	D 3/8
3.7	0.40	0.04	
3.8	0.40	0.04	
3.9	0.4	0.07	
4.0	0.4	0.38	
4.1	0.4	1.0	
4.2	0.35	0.94	
4.3	0.3	0.43	
4.4	0.25	0.24	
4.5	0.2	0.17	
4.6	0.15	0.12	
4.8	0	0	

Right edge Rain
LEW

5/5/16 BLACKWOOD 1:10 pm
PB, SS

cloudy, intermittent light rain
0.01" in past 48 hrs
0% snow cover
AIR TEMP: 48.1 °F
pH: 7.51 EC: 424 µS/cm
DO: 6.93 ppm TDS: 212
H2O TEMP: 48.53
Velocity units: ft/s

* moved XS ~2' upstream to get away from water fall

Sta	depth	vel	notes
1.0	0	0	LEW
1.2	0.4	BW	
1.3	0.4	0.07	
1.4	0.4	0.64	
1.5	0.4	1.40	
1.6	0.35	1.16	
1.7	0.30	0.98	
1.8	0.20	0.59	
1.9	0.20	0.44	
2.0	0.20	0.32	
2.1	0.30	0.37	
2.3	0.30	0.22	
2.5	0.20	0.10	
2.7	0.15	BW	
2.9	0.05	BW	
3.5	0	0	REW

0.25 cfs

5/5/16 WERNER SALAS 1:30 PM
PB, SS

Cloudy, intermittent light rain
0.01" in past 48 hrs, 0% snow cover
AIR TEMP: 44.8 °F
pH: 7.41 EC: 437 µS/cm
DO: 6.1 ppm TDS: 218 ppm
H2O TEMP: 50.09
Vel units: ft/s

Sta	depth	vel	notes
4.7	0	0	REW
4.9	0.1	0.67	
5.0	0.15	1.23	
5.1	0.20	1.22	
5.2	0.20	1.10	
5.3	0.20	1.54	
5.4	0.20	1.88	
5.5	0.20	1.69	
5.6	0.20	1.50	
5.7	0.20	1.45	
5.8	0.15	0.87	
5.9	0.10	0.25	
6.0	0.05	BW	
6.2	0	0	LEW

0.25 cfs

Rite in the Rain

5/9/16 CAL BASE-1 9:40 AM PB, SS

Clear skies 0" precip
AIR TEMP. 67.4°F

pH: 7.65
DO: 6.1
EC 390
TDS 201
H_2O Temp 55.45°F

Flow depth in culvert
0.04' very approximate

0.021 cfs

5/19/16 HNP Vaults 10:00 AM PB, SS

Clear skies, 0" precip in 48 hrs
AIR TEMP: 71.7°F
~~DO~~ pH: 7.58
DO: 6.2 ppm
EC: 806 µs/cm
TDS: 402 ppm
H_2O TEMP: 55.2
Velocity: 0.13 ft/s
depth: 0.173 ft
flow: 0.025 cfs ✓ 0.025 cfs

Difficulty collecting full sample due to low depth in effluent

Rite in the Rain

5/19/16 Wildwood 10:30 AM PB, SS

Clear, 0" precip in past 48 hrs
AIR TEMP: 70° F
pH 8.02 DO: 6.40 ppm
~~ORP~~
EC: 670 µs/cm TDS: 340 ppm
H_2O Temp: 54.6

depth in culvert: 3/4"

0.082 cfs

5/19/16 BIBOU CREEK 10:55 AM
BELOW CA P-LOT

Clear SKIES, 0" precip in 48 hrs
AIR: 67.3° F
pH: 7.48
DO: 6.63 ppm
EC: 409 µs/cm
TDS: 204 ppm
H_2O Temp: 51.97° F
vel units: ft/s

sta	depth	vel	notes
4.0	0	0	REW, LE
4.1	0.1	-0.1	BW
4.2	0.1	-0.18	BW
4.3	0.15	0.09	
4.4	0.2	0.18	
4.5	0.2	0.72	
4.55	0.2	0.80	
4.6	0.2	1.06	
4.65	0.2	1.21	
4.7	0.2	1.25	0.115
4.75	0.2	1.10	
4.8	0.2	1.01	
4.9	0.2	0.81	
5.0	0.2	0.52	
5.1	0.2	0.10	
5.3	0	0	Rt. EW

5/19/16 REGINA 11:30 AM
PB, SS

Clear skies, 0" precip in 48 hrs
AIR TEMP. 67.6°F 0% snow cover
pH: 7.77 H_2O TEMP. 52.67°F
DO 7.93
EC 238
TDS 120
vel units: ft/s

Sta	depth	vel	notes
3.7	0	0	REW
3.9	0.10	0.65	
4.01	0.35	0.65	
4.2	0.35	0.37	
4.25	0.35	0.31	
4.3	0.35	0.25	
4.4	0.40	0.36	
4.5	0.40	0.43	
4.6	0.45	0.44	
4.7	0.45	0.34	
4.8	0.45	0.25	
4.9	0.45	0.06	
5.0	0.50	0.07	
5.1	0.40	0	
5.2	0.40	0	BW
5.3	0	0	LEW

0.153

5/19/16 NERDON 11:55 AM
PB, SS

cloudy, 0" precip in past 48 hrs
0% snow cover

AIR: 60.1°F
pH: 7.90 EC: 419 µS/cm
DO: 6.60 ppm TDS: 210 ppm
H_2O TEMP: 53.65
vel units (ft/s)

Sta	depth	vel	notes
5.0	0	0	REW
5.5	0.05	0.64	
5.6	0.10	0.92	
5.7	0.15	0.98	
5.8	0.20	0.99	
5.9	0.20	0.96	
6.0	0.20	0.87	
6.1	0.20	0.83	
6.2	0.20	0.78	
6.3	0.15	0.68	
6.4	0.10	0.60	
6.5	0.05	-0.1 too low	BW
6.6	<0.05		
6.8	0	0	LEW

0.140
0.138

Rite in the Rain

5/19/16 CHARLESWORTH 12:25
PB, 55
partly cloudy, 0" precip in 48 hrs
0% snow-cover
AIR: ~~71°F~~ 65.5° F
pH: 7.69 EC: 476 µS/cm
DO: 6.72 ppm TDS 238 ppm
H_2O TEMP: 54.74
Vel units: ft/s

Stn	depth	vel	notes
3.1	0	0	LEW
3.2	0.15	0.01	could be surface
3.3	0.20	BW	
3.4	0.20	-0.15	BW
3.5	0.25	-0.05	BW
3.6	0.30	0.04	
3.7	0.35	0.13	
3.8	0.40	0.13	
3.9	0.40	0.24	
4.0	0.40	0.57	
4.05	0.40	0.77	
4.10	0.40	1.00	
4.15	0.40	1.05	
4.2	0.40	1.08	
4.3	0.35	0.37	
4.4	0.30	0.08	
4.5	0.25	0.08	
4.6	0.20	0.05	

0.142 cfs

Additional (continued from prev.)

Stn	depth	vel	notes
4.7	0.15	0.04	
4.8	0.05	-0.17	BW
50	0	0	REW

5/19/16 BLACKWOOD 12:50 pm
cloudy, 0" precip PB, 55
AIR TEMP: 72.5°F
pH: 7.38 EC: 457 µS/cm
DO: 7.08 ppm TDS: 229 ppm
H_2O TEMP: 60.76°F (ft/s)

Stn	depth	vel	notes
1.1	0	0	LEW
1.3	0.50	-0.01	BW
1.4	0.50	0.13	
1.5	0.50	0.46	
1.6	0.50	0.58	
1.7	0.40	0.51	
1.8	0.40	0.41	
1.9	0.30	0.27	on rock
2.0	0.30	0.10	on rock
2.1	0.40	0.08	
2.2	0.40	0.24	
2.3	0.35	0.14	behind veg / rock
2.4	0.35	0.15	
2.5	0.35	0.25	
2.6	0.25	0.08	
2.7	0.25	0.02	
2.8	0.20	+0.04	BW kite in on Rain

0.141

Add (continued from end)

Sta	depth	vel	notes
2.9	0.2	-0.05	BW
3.9	0	0	REW

5/19/16 WERNER SALAS 1:15pm PB, SS

P.C.

~~Clear~~ skies, .0" precip in 48 hrs

AIR: 63.7°F

PH: 7.85 EC: 471 µS/cm

DO: 6.41 TDS: 235 ppm

H_2O TEMP: 66.3° F (ft/s)

Sta	depth	vel	notes
5.1	0	0	REW
5.2	0.05	0.66	
5.3	0.10	1.17	
5.4	0.15	1.31	
5.5	0.20	1.48	
5.6	0.20	1.32	
5.7	0.20	1.47	
5.8	0.20	1.42	
5.85	0.20	1.26	
5.90	0.20	1.43	
6.0	0.20	1.29	
6.1	0.10	0.97	
6.2	0	0	LEW

0.211 cfs

x pretty much measuring surface velocity

6/1/16 CAL BASE 2 9:45am IT, SB, FP

CLEAR SKIES

0" PRECIP LAST 48 HRS

AIR: 73.0°F

pH: ~~5.63 pH~~ 7.49 pH

DO: 5.55 ppm

EC: ~~137 µS/cm~~ 226 µS/cm

TDS: ~~69 ppm~~ 113 ppm

H_2O Temp: ~~56.30°F~~ 58.08°F

Water Elevation in Culvert: 0.06 ft.

2 samples collected (chloride + Nitrate)

1 L 250 mL

0.057 cfs

6/1/16 43HVP2 10:00 am IT, SB, FP

CLEAR SKIES

0" PRECIP LAST 48 HRS

AIR: 72.6°F

PH: 7.66

DO: 5.53 ppm

EC: 548 µS/cm

TDS: 274 ppm

H_2O Temp: 57.50°F

0.0224 cfs

Velocity: 0.203 ft, 0.209 ft, 0.208 ft

0.12 fps 0.09 fps Kill in the Rain.

0.14 fps

6/1/16 Wildwood Vault 10:36am
effluent Ivan, SB, EA
WF-3

clear, 0" precip 48 hrs prior
Air: 74.8°F
H2O: 55.04/56.56
PH: 8.09
DO: 5.58 ppm
EC: 654 uS/cm
TDS: 327 ppm

0.007 cfs

(in vault)
depth of flow: .02 feet

6/1/16 11:40 Bijou Park Creek
SB, Ivan 43 BPC-4
clear, 0" precip in 48 hrs. vel ft/sec
air: 74°F
H_2O: 53.59
PH: 7.62
DO: 6.26
EC: 388
TDS 194 ppm

cfs = .108

Sta	Depth	Vel	notes
3.9	.1	undercut	REW BW
4	.15		BW
4.1	.15		-.07 BW

6/1/16

SB, IVAN

Sta	Depth	vel	
4.2	.2	.04 ft/sec	
4.3	.8	.34	
4.4	.2	.53	
4.5	.2	.90	
4.6	.15	1.16	Rock
4.7	.15	1.06	Rock
4.8	.15	.94	Rock
4.9	.2	.64	
5	.2	.57	
5.1	.2	—	undercut
5.2	0	—	LEW undercut .2 ft

74.3°F 6/1/16 12:04p Regina SB, IVAN
clear, 0" precip in 48 hrs BPC, R5 ft/sec

sta	Depth	vel		notes
2.3				REW
2.6	.05	N/A		Rock
2.7	.05	~~1.17~~	BW	Temp: 54.78
2.8	.05	/	BW	PH: 7.95
2.9	.10	0.64		DO: 6.30
3	.30	0.36		EC: 397
3.1	.30	0.24		TDS: 198
3.2	.30	0.28		
3.3	.30	0.41		

CFS: .081

Rite in the Rain

Sta	Depth	Vel	Notes
3.4	.3	0.38	
3.5	.3	0.34	
3.6	.35	0.39	
3.7	.40	.01	
3.8	.4	-.04	BW
3.9	.4	-.15	BW
4	.45	-.10	BW
4.1	/	/	
4.2	/	/	LEW under

undercut .1 ft

6/1/16 Verdon BPCV6 Ivan, SB

air: 72°F clear 0 precip ft/sec 12:37pm

Sta	Depth	Vel	Notes
4.6	0	0	REW
4.8	.055	/	BW
4.9	.1	.59	
5	.15	0.87	
5.1	.15	.88	
5.2	.2	.87	
5.3	.2	.79	
5.4	.2	.74	
5.5	.2	.61	
5.6	.2	.66	
5.7	.2	.58	
5.8	.15	.46	
5.9	.05	.34	

pH: 7.91
DO: 6.18
EC: 404
TDS: 202
temp: 57.69°F

CFS: .126

Sta	Depth	Vel	
6	.05	/	BW
6.1	0	0	LEW

ft/sec

6/1/16 Charlesworth BPCL7 Ivan, SB

clear 0" precip in 48 hrs

air: 79°F 1:08pm

Sta	Depth	Vel	Notes
3.8	0	0	REW
4	.05	-.04	BW
4.1	.1	-.11	veg BW
4.2	.2	.19	
4.3	.25	.18	
4.4	.3	.40	
4.5	.3	.44	
4.6	.3	.51	
4.7	.3	.68	
4.8	.35	.68	
4.9	.3	.23	
5	.3	.18	
5.1	.3	.09	
5.2	.2	.03	
5.3	.2	.03	
5.4	.1	-.13	BW
5.5	0	0	LEW

pH: 7.67
DO: 5.83
EC: 471
TDS: 263
Temp: 57.94

CFS: .109

Rite in the Rain

6/1/16 Blackwood SB, IVAN
1:30pm BPCBB
air: 82°F
clear, 0" precip in 48 hrs

Sta	Depth	vel	notes
3.1			REW
3.2	.05	-.01	BW
3.3	.05	-.18	BW
3.5	.1	-.07	BW
3.7	.15	-.05	BW
3.8	.2	-.03	BW
3.9	.25	.07	
4.0	.3	.11	
4.1	.3	.03	veg
4.2	.3	.07	
4.3	.3	.02	veg
4.4	.3	-.01	BW veg
4.5	.3	.04	veg
4.6	.3	.37	
4.7	.3	.66	
4.8	.3	.60	
4.9	.4	.12	
5.0	.4	.02	
5.1	.4	-.09	BW
5.2	0	0	LEW

PH:	7.45
DO:	6.28
EC:	467
TDS:	233
Temp:	63.53°F
CFS:	.064

2:00pm
6/1/16 Werner Salas BPCW9 SB, IVAN
clear 0" precip in 48 hrs prior
air: 83°F

Sta	Depth	vel	Notes
4.9	/	/	REW
5	.05	.28	
5.1	.1	.62	
5.2	.15	.49	
5.3	.15	.81	
5.4	.15	.89	
5.5	.10	1.07	
5.6	.10	1.20	
5.7	.1	1.22	
5.8	.1	.78	
5.9	.15	.58	
6.0	.05	.60	
6.1	.05	ND-	
6.2	/	/	LEW

PH:	7.42
DO:	5.72
EC:	490
TDS:	245
temp:	73.85°F
CFS:	.096

Rite in the Rain

Appendix B

Bijou Park Creek Chloride Monitoring Study
Laboratory Analytical Reports



4/22/2016

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley

OrderID: *1604196*
Amended

Dear: Chris Donley

This is to transmit the attached analytical report. The analytical data and information contained therein was generated using specified or selected methods contained in references, such as Standard Methods for the Examination of Water and Wastewater, online edition, Methods for Determination of Organic Compounds in Drinking Water, EPA-600/4-79-020, and Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods (SW846) Third Edition.

The samples were received by WETLAB-Western Environmental Testing Laboratory in good condition on 4/7/2016. Additional comments are located on page 2 of this report.

This is an amended report that includes results for Chloride and Nitrate Nitrogen for sample 1604196-004 per client request. If you should have any questions or comments regarding this report, please do not hesitate to call.

Sincerely,

Andy Smith
QA Manager

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Western Environmental Testing Laboratory
Report Comments

Cardno - 1604196 Amended

Specific Report Comments

Due to confusion with the COC and client needs the analysis for Nitrate Nitrogen on sample 1604196-004 was performed past the EPA recommended holding time. We apologize for any inconvenience this may have caused.

Report Legend

B	--	Blank contamination; Analyte detected above the method reporting limit in an associated blank.
D	--	Due to the sample matrix dilution was required in order to properly detect and report the analyte. The reporting limit has been adjusted accordingly.
HT	--	Sample analyzed beyond the EPA recommended holding time.
J	--	The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.
M	--	The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference.The reported result should be considered an estimate.
N	--	There was insufficient sample available to perform a spike and/or duplicate on this analytical batch.
NC	--	Not calculated due to matrix interference or very high sample concentration.
QD	--	The sample duplicate or matrix spike duplicate analysis demonstrated sample imprecision. The reported result should be considered an estimate.
QL	--	The result for the laboratory control sample (LCS) was outside WETLAB acceptance criteria and reanalysis was not possible. The reported data should be considered an estimate.
S	--	Surrogate recovery was outside of laboratory acceptance limits due to matrix interference. The associated blank and LCS surrogate recovery was within acceptance limits.
SC	--	Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered.
U	--	The analyte was analyzed for, but was not detected above the level of the reported sample reporting/quantitation limit.

General Lab Comments

Per method recommendation (section 4.4), Samples analyzed by methods EPA 300.0 and EPA 300.1 have been filtered prior to analysis.

The following is an interpretation of the results from EPA method 9223B:
A result of zero (0) indicates absence for both coliform and Escherichia coli meaning the water meets the microbiological requirements of the U.S. EPA Safe Drinking Water Act (SDWA). A result of one (1) for either test indicates presence and the water does not meet the SDWA requirements. Waters with positive tests should be disinfected by a certified water treatment operator and retested.

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Western Environmental Testing Laboratory
Analytical Report

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley
Phone: (775) 588-9069 **Fax:** (775) 588-9219

Date Printed: 4/22/2016
OrderID: *1604196*
Amended

Customer Sample ID: 20160407 Cal Base - 1 **Collect Date/Time:** 4/7/2016 10:00
WETLAB Sample ID: 1604196-001 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	38		mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	38		mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	47		mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	ND		mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	12		mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	1.6		mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	2.7		mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	19		mg/L	1	0.10	4/12/2016	NV00925
Aluminum	EPA 200.7	0.15	M	mg/L	1	0.045	4/12/2016	NV00925
Calcium	EPA 200.7	11		mg/L	1	0.50	4/12/2016	NV00925
Iron	EPA 200.7	0.15		mg/L	1	0.020	4/12/2016	NV00925
Magnesium	EPA 200.7	1.7		mg/L	1	0.50	4/12/2016	NV00925
Manganese	EPA 200.7	0.0058		mg/L	1	0.0050	4/12/2016	NV00925
Potassium	EPA 200.7	2.3		mg/L	1	0.50	4/12/2016	NV00925
Sodium	EPA 200.7	13		mg/L	1	0.50	4/12/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/11/2016	NV00925

Customer Sample ID: 20160407 43HVP - 2 **Collect Date/Time:** 4/7/2016 10:30
WETLAB Sample ID: 1604196-002 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	59	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	59	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	340	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/11/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160407 43HVP - 2 **Collect Date/Time:** 4/7/2016 10:30

WETLAB Sample ID: 1604196-002 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
Chloride	EPA 300.0	150		mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.66		mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	4.0		mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	32		mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	0.72	M	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	38		mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	0.93		mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	6.3		mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.073		mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	4.7		mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	86		mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/14/2016	NV00925

Customer Sample ID: 20160407 WWF - 3 **Collect Date/Time:** 4/7/2016 11:40

WETLAB Sample ID: 1604196-003 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	82	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	82	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	270	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	100	mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.025	mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	2.8	mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	30	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	0.081	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	33	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	0.44	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	8.4	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.035	mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	4.6	mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	65	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/14/2016	NV00925

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Customer Sample ID: 20160407 43BPC - 4 **Collect Date/Time:** 4/7/2016 12:10

WETLAB Sample ID: 1604196-004 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	48	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	48	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	150	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	47	mg/L	1	1.0	4/11/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.63 HT	mg/L	1	0.10	4/11/2016	NV00925
Sulfate	EPA 300.0	2.4	mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	22	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	0.21	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	16	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	2.1	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	3.6	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.11	mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	2.9	mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	33	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/14/2016	NV00925

Customer Sample ID: 20160407 BPC - R5 **Collect Date/Time:** 4/7/2016 13:00

WETLAB Sample ID: 1604196-005 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	46	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	46	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	140	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	47	mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.52	mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	2.2	mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	22	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	0.19	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	16	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	3.8	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	3.7	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.12	mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	2.8	mg/L	1	0.50	4/14/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160407 BPC - R5 **Collect Date/Time:** 4/7/2016 13:00

WETLAB Sample ID: 1604196-005 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
Sodium	EPA 200.7	32	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/14/2016	NV00925

Customer Sample ID: 20160407 BPC - V6 **Collect Date/Time:** 4/7/2016 13:35

WETLAB Sample ID: 1604196-006 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	52	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	52	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	150	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	53	mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.46	mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	2.4	mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	23	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	0.20	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	18	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	2.6	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	4.2	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.11	mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	3.1	mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	38	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/14/2016	NV00925

Customer Sample ID: 20160407 BPC - C7 **Collect Date/Time:** 4/7/2016 14:00

WETLAB Sample ID: 1604196-007 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	62	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	62	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	250	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.13	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	86	mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.29	mg/L	1	0.010	4/8/2016	NV00925

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Customer Sample ID: 20160407 BPC - C7 **Collect Date/Time:** 4/7/2016 14:00

WETLAB Sample ID: 1604196-007 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
Sulfate	EPA 300.0	2.8		mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	30	M	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	0.32	M	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	25	M	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	3.4	M	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	6.1	M	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.17		mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	4.3	M	mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	60	SC	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/14/2016	NV00925

Customer Sample ID: 20160407 BPC - B8 **Collect Date/Time:** 4/7/2016 14:30

WETLAB Sample ID: 1604196-008 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	55	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	55	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	230	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.12	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	90	mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	2.5	mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	27	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	23	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	0.26	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	5.8	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.013	mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	4.6	mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	60	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/14/2016	NV00925

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Customer Sample ID: 20160407 BPC - W9 **Collect Date/Time:** 4/7/2016 15:00

WETLAB Sample ID: 1604196-009 **Receive Date:** 4/7/2016 17:20

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	57	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	57	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/12/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	220	mg/L	1	10	4/11/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.11	mg/L	1	0.10	4/11/2016	NV00925
Chloride	EPA 300.0	87	mg/L	1	0.10	4/8/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	4/8/2016	NV00925
Sulfate	EPA 300.0	2.0	mg/L	1	1.0	4/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	4/14/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	4/14/2016	NV00925
Calcium	EPA 200.7	23	mg/L	1	0.50	4/14/2016	NV00925
Iron	EPA 200.7	0.12	mg/L	1	0.020	4/14/2016	NV00925
Magnesium	EPA 200.7	5.6	mg/L	1	0.50	4/14/2016	NV00925
Manganese	EPA 200.7	0.026	mg/L	1	0.0050	4/14/2016	NV00925
Potassium	EPA 200.7	4.8	mg/L	1	0.50	4/14/2016	NV00925
Sodium	EPA 200.7	62	mg/L	1	0.50	4/14/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/14/2016	NV00925

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Western Environmental Testing Laboratory
QC Report

QCBatchID	QCType	Parameter	Method	Result	Units
QC16040307	Blank 1	Chloride	EPA 300.0	ND	mg/L
		Nitrate Nitrogen	EPA 300.0	ND	mg/L
QC16040352	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16040367	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Chloride	EPA 300.0	ND	mg/L
		Nitrate Nitrogen	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16040458	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L
QC16040461	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L
QC16040524	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16040525	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L

QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16040307	LCS 1	Chloride	EPA 300.0	10.3	10.0	103	mg/L
		Nitrate Nitrogen	EPA 300.0	0.503	0.500	101	mg/L
QC16040352	LCS 1	Silica	EPA 200.7	20.7	21.4	97	mg/L
		Aluminum	EPA 200.7	0.995	1.00	100	mg/L
		Calcium	EPA 200.7	9.93	10.0	99	mg/L
		Iron	EPA 200.7	0.993	1.00	99	mg/L
		Magnesium	EPA 200.7	9.83	10.0	98	mg/L
		Manganese	EPA 200.7	1.00	1.00	100	mg/L
		Potassium	EPA 200.7	10.1	10.0	101	mg/L
		Sodium	EPA 200.7	10.0	10.0	100	mg/L
QC16040367	LCS 1	Bromide	EPA 300.0	0.244	0.250	98	mg/L
		Chloride	EPA 300.0	9.75	10.0	97	mg/L
		Nitrate Nitrogen	EPA 300.0	1.92	2.00	96	mg/L
		Sulfate	EPA 300.0	24.3	25.0	97	mg/L

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QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16040434	LCS 1	Total Alkalinity	SM 2320B	99.9	100	100	mg/L
QC16040434	LCS 2	Total Alkalinity	SM 2320B	99.9	100	100	mg/L
QC16040434	LCS 3	Total Alkalinity	SM 2320B	100	100	100	mg/L
QC16040458	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	148	150	99	mg/L
QC16040458	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	142	150	95	mg/L
QC16040461	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	151	150	101	mg/L
QC16040461	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	142	150	95	mg/L
QC16040524	LCS 1	Silica	EPA 200.7	21.6	21.4	101	mg/L
		Aluminum	EPA 200.7	0.987	1.00	99	mg/L
		Calcium	EPA 200.7	10.0	10.0	100	mg/L
		Iron	EPA 200.7	1.01	1.00	101	mg/L
		Magnesium	EPA 200.7	10.1	10.0	101	mg/L
		Manganese	EPA 200.7	1.00	1.00	100	mg/L
		Potassium	EPA 200.7	10.2	10.0	102	mg/L
		Sodium	EPA 200.7	10.0	10.0	100	mg/L
QC16040525	LCS 1	Silica	EPA 200.7	21.6	21.4	101	mg/L
		Aluminum	EPA 200.7	0.987	1.00	99	mg/L
		Calcium	EPA 200.7	10.0	10.0	100	mg/L
		Iron	EPA 200.7	1.01	1.00	101	mg/L
		Magnesium	EPA 200.7	10.1	10.0	101	mg/L
		Manganese	EPA 200.7	1.00	1.00	100	mg/L
		Potassium	EPA 200.7	10.2	10.0	102	mg/L
		Sodium	EPA 200.7	10.0	10.0	100	mg/L

QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result	Units	RPD
QC16040434	Duplicate	Total Alkalinity	SM 2320B	1604164-001	186	186	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604164-001	186	186	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604164-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604164-001	ND	ND	mg/L as CaCO3	<1%
QC16040434	Duplicate	Total Alkalinity	SM 2320B	1604199-002	456	456	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604199-002	456	456	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604199-002	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604199-002	ND	ND	mg/L as CaCO3	<1%
QC16040434	Duplicate	Total Alkalinity	SM 2320B	1604199-009	203	204	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604199-009	203	204	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604199-009	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604199-009	ND	ND	mg/L as CaCO3	<1%
QC16040434	Duplicate	Total Alkalinity	SM 2320B	1604257-001	81.6	80.6	mg/L as CaCO3	1 %
		Bicarbonate (HCO3)	SM 2320B	1604257-001	81.6	80.6	mg/L as CaCO3	1 %
		Carbonate (CO3)	SM 2320B	1604257-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604257-001	ND	ND	mg/L as CaCO3	<1%
QC16040434	Duplicate	Total Alkalinity	SM 2320B	1604257-002	81.8	81.7	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604257-002	81.8	81.7	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604257-002	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604257-002	ND	ND	mg/L as CaCO3	<1%
QC16040434	Duplicate	Total Alkalinity	SM 2320B	1604257-007	99.4	98.7	mg/L as CaCO3	1 %
		Bicarbonate (HCO3)	SM 2320B	1604257-007	99.4	98.7	mg/L as CaCO3	1 %

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QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result		Units	RPD
		Carbonate (CO3)	SM 2320B	1604257-007	ND	ND		mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604257-007	ND	ND		mg/L as CaCO3	<1%
QC16040458	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604196-001	47.0	53.0		mg/L	12 %
QC16040458	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604196-002	344	334		mg/L	3 %
QC16040461	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604214-001	475	473	HT	mg/L	<1%
QC16040461	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604215-001	561	568		mg/L	1 %

QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
QC16040307	MS 1	Chloride	EPA 300.0	1604192-001	2.93		4.18	4.23	1.25	mg/L	100	104	1%
		Nitrate Nitrogen	EPA 300.0	1604192-001	ND		0.489	0.514	0.500	mg/L	98	103	5%
QC16040307	MS 2	Chloride	EPA 300.0	1604195-001	0.281		1.60	1.56	1.25	mg/L	105	102	3%
		Nitrate Nitrogen	EPA 300.0	1604195-001	0.027		0.548	0.548	0.500	mg/L	104	104	<1%
QC16040352	MS 1	Silica	EPA 200.7	1604196-001	19.5		43.0	42.2	21.4	mg/L	110	106	2%
		Aluminum	EPA 200.7	1604196-001	0.152	M	1.49	1.49	1.00	mg/L	NC	NC	NC
		Calcium	EPA 200.7	1604196-001	11.0		21.1	21.5	10.0	mg/L	101	105	2%
		Iron	EPA 200.7	1604196-001	0.153		1.16	1.16	1.00	mg/L	101	101	<1%
		Magnesium	EPA 200.7	1604196-001	1.72		11.6	11.6	10.0	mg/L	99	99	<1%
		Manganese	EPA 200.7	1604196-001	0.006		0.994	1.00	1.00	mg/L	99	99	1%
		Potassium	EPA 200.7	1604196-001	2.28		12.1	12.1	10.0	mg/L	98	98	<1%
		Sodium	EPA 200.7	1604196-001	13.4		23.6	23.5	10.0	mg/L	102	101	<1%
QC16040367	MS 1	Bromide	EPA 300.0	1604159-004	ND		0.295	0.297	0.250	mg/L	97	97	1%
		Chloride	EPA 300.0	1604159-004	ND		5.73	5.74	5.00	mg/L	106	107	<1%
		Nitrate Nitrogen	EPA 300.0	1604159-004	ND		2.07	2.07	2.00	mg/L	102	102	<1%
		Sulfate	EPA 300.0	1604159-004	14.7		24.6	24.6	10.0	mg/L	99	99	<1%
QC16040367	MS 2	Bromide	EPA 300.0	1604193-001	ND		0.269	0.268	0.250	mg/L	94	94	<1%
		Chloride	EPA 300.0	1604193-001	ND		5.31	5.31	5.00	mg/L	106	106	<1%
		Nitrate Nitrogen	EPA 300.0	1604193-001	ND		2.09	2.10	2.00	mg/L	103	103	<1%
		Sulfate	EPA 300.0	1604193-001	4.62		14.8	14.8	10.0	mg/L	102	102	<1%
QC16040524	MS 1	Silica	EPA 200.7	1604196-002	31.7		55.2	52.2	21.4	mg/L	110	96	6%
		Aluminum	EPA 200.7	1604196-002	0.722	M	2.39	2.26	1.00	mg/L	NC	NC	NC
		Calcium	EPA 200.7	1604196-002	37.7		47.0	44.1	10.0	mg/L	93	64	6%
		Iron	EPA 200.7	1604196-002	0.927		2.09	1.98	1.00	mg/L	116	105	5%
		Magnesium	EPA 200.7	1604196-002	6.28		16.4	15.6	10.0	mg/L	101	93	5%
		Manganese	EPA 200.7	1604196-002	0.073		1.05	1.00	1.00	mg/L	98	93	5%
		Potassium	EPA 200.7	1604196-002	4.67		15.8	15.0	10.0	mg/L	111	103	5%
		Sodium	EPA 200.7	1604196-002	86.0		98.2	91.2	10.0	mg/L	122	52	7%
QC16040525	MS 1	Silica	EPA 200.7	1604196-007	30.2	M	52.4	48.4	21.4	mg/L	NC	NC	NC
		Aluminum	EPA 200.7	1604196-007	0.320	M	1.67	1.58	1.00	mg/L	NC	NC	NC
		Calcium	EPA 200.7	1604196-007	25.2	M	33.7	32.2	10.0	mg/L	NC	NC	NC
		Iron	EPA 200.7	1604196-007	3.39	M	4.28	4.04	1.00	mg/L	NC	NC	NC
		Magnesium	EPA 200.7	1604196-007	6.12	M	15.7	15.3	10.0	mg/L	NC	NC	NC
		Manganese	EPA 200.7	1604196-007	0.168		1.14	1.11	1.00	mg/L	114	94	3%
		Potassium	EPA 200.7	1604196-007	4.32	M	15.1	14.5	10.0	mg/L	NC	NC	NC
		Sodium	EPA 200.7	1604196-007	60.1	SC	69.7	66.5	10.0	mg/L	NC	NC	NC

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EPA LAB ID: NV00932

WETLAB
WESTERN ENVIRONMENTAL TESTING LABORATORY
Specializing in Soil, Hazardous Waste and Water Analysis.

475 E. Greg Street #119 | Sparks, Nevada 89431 | www.WETLaboratory.com
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WETLAB Order ID. 1604196
Sparks Control #
Elko Control #
LV Control #
Report Due Date 4-21-16
Page 1 of 1

Client CARDNO
Address 295 HWY 50 suite 1
City, State & Zip Zephyr Cove 89448
Contact Chris Donley
Phone 775-588-9069 | Collector's Name
Fax | PWS/Project Name
P.O. Number | PWS/Project Number
Email chris.donley@cardno.com

Billing Address (if different than Client Address)
Company
Address
City, State & Zip
Contact
Phone Fax
Email

Turnaround Time Requirements
Standard X
5 Day* (25%) | 72 Hour* (50%)
48 Hour* (100%) | 24 Hour* (200%)
*Surcharges Will Apply

Samples Collected From Which State? NV CA X Other
Compliance Monitoring? Yes X No
Report to Regulatory Agency? Yes No X

Report Results Via PDF EDD Other
Standard QC Required? Yes No

SAMPLE ID/LOCATION	DATE	TIME	PRES TYPE *	SAMPLE TYPE **	NO. OF CONTAINERS	TDS (EPA 160.1)	Major Cations (EPA 200.8)	Alkalinity (EPA 310.2)	Chloride (EPA 300)	Nitrate (EPA 353.2)	Sulfate (EPA 300)	Bromide (EPA 300)	TKN	Turbidity	Spl. No.
20160407 CalBase-1	4/7/16	10:00	1,5	SW	2	X	X	X	X	X	X	X			1
20160407 43HVP-2		10:30			2	X	X	X	X	X	X	X			2
20160407 WWF-3		11:40			2	X	X	X	X	X	X	X			3
20160407 43BPC-4 B		12:10			3	X	X	X			X	X			4
20160407 BPC-R5		1:00			2	X	X	X	X	X	X	X			5
20160407 BPC-V6		1:35			2	X	X	X	X	X	X	X			6
20160407 BPC-C7		2:00			2	X	X	X	X	X	X	X			7
20160407 BPC-B8		2:30			2	X	X	X	X	X	X	X			8
20160407 BPC-W9	↓	3:00	↓	↓	2	X	X	X	X	X	X	X			9

1604 5
196 9

Instructions/Comments/Special Requirements:

Sample Matrix Key** DW = Drinking Water WW = Wastewater SW = Surface Water MW = Monitoring Well SD = Solid/Sludge SO = Soil HW = Hazardous Waste OTHER:

***SAMPLE PRESERVATIVES:** 1=Unpreserved 2=H2SO4 3=NaOH 4=HCl 5=HNO3 6=Na2S2O3 7=ZnOAc+NaOH 8=HCl/VOA Vial

Temp	Custody Seal	# of Containers	DATE	TIME	Samples Relinquished By	Samples Received By
12.2 °C	Y N (None)	18	4-7-16	17:20		
°C	Y N None					
°C	Y N None					
°C	Y N None					

WETLAB'S Standard Terms and Conditions apply unless written agreements specify otherwise. Payment terms are Net 30.

Client/Collector attests to the validity and authenticity of this (these) sample(s) and, is (are) aware that tampering with or intentionally mislabeling the sample(s) location, date or time of collection may be considered fraud and subject to legal action (NAC445.0636). ___ initial

To the maximum extent permitted by law, the Client agrees to limit the liability of WETLAB for the Client's damages to the total compensation received, unless other agreements are made in writing. This limitation shall apply regardless of the cause of action or legal theory pled or asserted. ___ initial

WETLAB will dispose of samples 90 days from sample receipt. Client may request a longer sample storage time for an additional fee. Please contact your Project Manager for details. ___ initial

301.2E

5/5/2016

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley

OrderID: *1604577*

Dear: Chris Donley

This is to transmit the attached analytical report. The analytical data and information contained therein was generated using specified or selected methods contained in references, such as Standard Methods for the Examination of Water and Wastewater, online edition, Methods for Determination of Organic Compounds in Drinking Water, EPA-600/4-79-020, and Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods (SW846) Third Edition.

The samples were received by WETLAB-Western Environmental Testing Laboratory in good condition on 4/21/2016. Additional comments are located on page 2 of this report.

If you should have any questions or comments regarding this report, please do not hesitate to call.

Sincerely,

Jennifer Delaney
QA Specialist

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Western Environmental Testing Laboratory
Report Comments

Cardno - 1604577

Specific Report Comments

None

Report Legend

B	--	Blank contamination; Analyte detected above the method reporting limit in an associated blank.
D	--	Due to the sample matrix dilution was required in order to properly detect and report the analyte. The reporting limit has been adjusted accordingly.
HT	--	Sample analyzed beyond the EPA recommended holding time.
J	--	The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.
M	--	The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference. The reported result should be considered an estimate.
N	--	There was insufficient sample available to perform a spike and/or duplicate on this analytical batch.
NC	--	Not calculated due to matrix interference or very high sample concentration.
QD	--	The sample duplicate or matrix spike duplicate analysis demonstrated sample imprecision. The reported result should be considered an estimate.
QL	--	The result for the laboratory control sample (LCS) was outside WETLAB acceptance criteria and reanalysis was not possible. The reported data should be considered an estimate.
S	--	Surrogate recovery was outside of laboratory acceptance limits due to matrix interference. The associated blank and LCS surrogate recovery was within acceptance limits.
SC	--	Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered.
U	--	The analyte was analyzed for, but was not detected above the level of the reported sample reporting/quantitation limit.

General Lab Comments

Per method recommendation (section 4.4), Samples analyzed by methods EPA 300.0 and EPA 300.1 have been filtered prior to analysis.

The following is an interpretation of the results from EPA method 9223B:
A result of zero (0) indicates absence for both coliform and Escherichia coli meaning the water meets the microbiological requirements of the U.S. EPA Safe Drinking Water Act (SDWA). A result of one (1) for either test indicates presence and the water does not meet the SDWA requirements. Waters with positive tests should be disinfected by a certified water treatment operator and retested.

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Western Environmental Testing Laboratory
Analytical Report

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley
Phone: (775) 588-9069 **Fax:** (775) 588-9219

Date Printed: 5/5/2016
OrderID: *1604577*

Customer Sample ID: 20160421 Cal Base - 1 **Collect Date/Time:** 4/21/2016 09:45
WETLAB Sample ID: 1604577-001 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	41	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	41	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	110	mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	21	mg/L	1	0.10	4/22/2016	NV00925
Nitrate Nitrogen	EPA 300.0	1.6	mg/L	1	0.010	4/22/2016	NV00925
Sulfate	EPA 300.0	3.0	mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	21	mg/L	1	0.10	4/26/2016	NV00925
Aluminum	EPA 200.7	0.11	mg/L	1	0.045	4/26/2016	NV00925
Calcium	EPA 200.7	14	mg/L	1	0.50	4/26/2016	NV00925
Iron	EPA 200.7	0.080	mg/L	1	0.020	4/26/2016	NV00925
Magnesium	EPA 200.7	2.1	mg/L	1	0.50	4/26/2016	NV00925
Manganese	EPA 200.7	ND	mg/L	1	0.0050	4/26/2016	NV00925
Potassium	EPA 200.7	3.1	mg/L	1	0.50	4/26/2016	NV00925
Sodium	EPA 200.7	16	mg/L	1	0.50	4/27/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/26/2016	NV00925

Customer Sample ID: 20160421 43HVP - 2 **Collect Date/Time:** 4/21/2016 10:20
WETLAB Sample ID: 1604577-002 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	73	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	73	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	400	mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/25/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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EPA LAB ID: NV00932

Customer Sample ID: 20160421 43HVP - 2 **Collect Date/Time:** 4/21/2016 10:20

WETLAB Sample ID: 1604577-002 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
Chloride	EPA 300.0	150	mg/L	1	0.10	4/22/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.62	mg/L	1	0.010	4/22/2016	NV00925
Sulfate	EPA 300.0	5.5	mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	31	mg/L	1	0.10	4/26/2016	NV00925
Aluminum	EPA 200.7	1.5	mg/L	1	0.045	4/26/2016	NV00925
Calcium	EPA 200.7	36	mg/L	1	0.50	4/26/2016	NV00925
Iron	EPA 200.7	1.5	mg/L	1	0.020	4/26/2016	NV00925
Magnesium	EPA 200.7	6.0	mg/L	1	0.50	4/26/2016	NV00925
Manganese	EPA 200.7	0.13	mg/L	1	0.0050	4/26/2016	NV00925
Potassium	EPA 200.7	7.6	mg/L	1	0.50	4/26/2016	NV00925
Sodium	EPA 200.7	110	mg/L	1	0.50	4/27/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/26/2016	NV00925

Customer Sample ID: 20160421 WWF - 3 **Collect Date/Time:** 4/21/2016 11:10

WETLAB Sample ID: 1604577-003 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	83	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	83	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/25/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	300	mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	100	mg/L	1	0.10	4/22/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.021	mg/L	1	0.010	4/22/2016	NV00925
Sulfate	EPA 300.0	2.1	mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	26	mg/L	1	0.10	4/26/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	4/26/2016	NV00925
Calcium	EPA 200.7	35	mg/L	1	0.50	4/26/2016	NV00925
Iron	EPA 200.7	0.23	mg/L	1	0.020	4/26/2016	NV00925
Magnesium	EPA 200.7	8.4	mg/L	1	0.50	4/26/2016	NV00925
Manganese	EPA 200.7	0.020	mg/L	1	0.0050	4/26/2016	NV00925
Potassium	EPA 200.7	5.9	mg/L	1	0.50	4/26/2016	NV00925
Sodium	EPA 200.7	58	mg/L	1	0.50	4/27/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		4/26/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160421 43BPC - 4 **Collect Date/Time:** 4/21/2016 11:45

WETLAB Sample ID: 1604577-004 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Phosphorous as P	SM 4500-P E	0.070		mg/L	1	0.010	4/29/2016	NV00925
Total Suspended Solids (TSS)	SM 2540D	5		mg/L	1	1	4/26/2016	NV00925
Total Alkalinity	SM 2320B	65		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	65		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	230		mg/L	1	10	4/26/2015	NV00925
Turbidity (Nephelometric)	EPA 180.1	18		NTU	1	0.10	4/22/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	ND		mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	73	SC	mg/L	1	0.10	4/22/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.76		mg/L	1	0.010	4/22/2016	NV00925
Nitrite Nitrogen	EPA 300.0	ND		mg/L	1	0.010	4/22/2016	NV00925
Sulfate	EPA 300.0	3.6		mg/L	1	1.0	4/25/2016	NV00925
Flow Injection Analyses								
Total Kjeldahl Nitrogen	EPA 351.2	0.22	M	mg/L	0.5	0.20	4/27/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	25		mg/L	1	0.10	4/26/2016	NV00925
Aluminum	EPA 200.7	0.093		mg/L	1	0.045	4/26/2016	NV00925
Calcium	EPA 200.7	23		mg/L	1	0.50	4/26/2016	NV00925
Iron	EPA 200.7	2.5		mg/L	1	0.020	4/26/2016	NV00925
Magnesium	EPA 200.7	4.6		mg/L	1	0.50	4/26/2016	NV00925
Manganese	EPA 200.7	0.16		mg/L	1	0.0050	4/26/2016	NV00925
Potassium	EPA 200.7	4.8		mg/L	1	0.50	4/26/2016	NV00925
Sodium	EPA 200.7	48		mg/L	1	0.50	4/27/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/26/2016	NV00925

Customer Sample ID: 20160421 BPC - R5 **Collect Date/Time:** 4/21/2016 12:35

WETLAB Sample ID: 1604577-005 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	64	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	64	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	240	mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	77	mg/L	1	0.10	4/22/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.71	mg/L	1	0.010	4/22/2016	NV00925
Sulfate	EPA 300.0	3.6	mg/L	1	1.0	4/25/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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EPA LAB ID: NV00932

Customer Sample ID: 20160421 BPC - R5 **Collect Date/Time:** 4/21/2016 12:35

WETLAB Sample ID: 1604577-005 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
Trace Metals by ICP-OES								
Silica	EPA 200.7	26		mg/L	1	0.10	4/27/2016	NV00925
Aluminum	EPA 200.7	0.10		mg/L	1	0.045	4/27/2016	NV00925
Calcium	EPA 200.7	23		mg/L	1	0.50	4/27/2016	NV00925
Iron	EPA 200.7	1.8		mg/L	1	0.020	4/27/2016	NV00925
Magnesium	EPA 200.7	4.6		mg/L	1	0.50	4/27/2016	NV00925
Manganese	EPA 200.7	0.12		mg/L	1	0.0050	4/27/2016	NV00925
Potassium	EPA 200.7	3.6	QD	mg/L	1	0.50	4/27/2016	NV00925
Sodium	EPA 200.7	44		mg/L	1	0.50	4/27/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/27/2016	NV00925

Customer Sample ID: 20160421 BPC - V6 **Collect Date/Time:** 4/21/2016 13:15

WETLAB Sample ID: 1604577-006 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	69		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	69		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	230		mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	ND		mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	79		mg/L	1	0.10	4/22/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.58		mg/L	1	0.010	4/22/2016	NV00925
Sulfate	EPA 300.0	3.3		mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	27		mg/L	1	0.10	4/28/2016	NV00925
Aluminum	EPA 200.7	0.12		mg/L	1	0.045	4/28/2016	NV00925
Calcium	EPA 200.7	24		mg/L	1	0.50	4/28/2016	NV00925
Iron	EPA 200.7	1.2		mg/L	1	0.020	4/28/2016	NV00925
Magnesium	EPA 200.7	5.2		mg/L	1	0.50	4/28/2016	NV00925
Manganese	EPA 200.7	0.093		mg/L	1	0.0050	4/28/2016	NV00925
Potassium	EPA 200.7	4.6	M	mg/L	1	0.50	4/28/2016	NV00925
Sodium	EPA 200.7	53	SC	mg/L	1	0.50	4/28/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/27/2016	NV00925

Customer Sample ID: 20160421 BPC - C7 **Collect Date/Time:** 4/21/2016 14:05

WETLAB Sample ID: 1604577-007 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	68		mg/L as CaCO3	1	1.0	4/26/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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EPA LAB ID: NV00932

Customer Sample ID: 20160421 BPC - C7 **Collect Date/Time:** 4/21/2016 14:05

WETLAB Sample ID: 1604577-007 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
Bicarbonate (HCO3)	SM 2320B	68		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	280		mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	0.15		mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	98		mg/L	1	0.10	4/23/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.22		mg/L	1	0.010	4/23/2016	NV00925
Sulfate	EPA 300.0	2.7		mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	27		mg/L	1	0.10	4/28/2016	NV00925
Aluminum	EPA 200.7	0.14		mg/L	1	0.045	4/28/2016	NV00925
Calcium	EPA 200.7	27		mg/L	1	0.50	4/28/2016	NV00925
Iron	EPA 200.7	1.7		mg/L	1	0.020	4/28/2016	NV00925
Magnesium	EPA 200.7	6.1		mg/L	1	0.50	4/28/2016	NV00925
Manganese	EPA 200.7	0.14		mg/L	1	0.0050	4/28/2016	NV00925
Potassium	EPA 200.7	5.4	M	mg/L	1	0.50	4/28/2016	NV00925
Sodium	EPA 200.7	62		mg/L	1	0.50	4/28/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/27/2016	NV00925

Customer Sample ID: 20160421 BPC - B8 **Collect Date/Time:** 4/21/2016 14:35

WETLAB Sample ID: 1604577-008 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	61	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	61	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	260	mg/L	1	10	4/26/2015	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.14	mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	94	mg/L	1	0.10	4/23/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	4/23/2016	NV00925
Sulfate	EPA 300.0	2.0	mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	24	mg/L	1	0.10	4/28/2016	NV00925
Aluminum	EPA 200.7	0.062	mg/L	1	0.045	4/28/2016	NV00925
Calcium	EPA 200.7	24	mg/L	1	0.50	4/28/2016	NV00925
Iron	EPA 200.7	0.42	mg/L	1	0.020	4/28/2016	NV00925
Magnesium	EPA 200.7	5.7	mg/L	1	0.50	4/28/2016	NV00925
Manganese	EPA 200.7	0.056	mg/L	1	0.0050	4/28/2016	NV00925
Potassium	EPA 200.7	5.4	mg/L	1	0.50	4/28/2016	NV00925
Sodium	EPA 200.7	60	mg/L	1	0.50	4/28/2016	NV00925

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Customer Sample ID: 20160421 BPC - B8 **Collect Date/Time:** 4/21/2016 14:35

WETLAB Sample ID: 1604577-008 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/27/2016	NV00925

Customer Sample ID: 20160421 BPC - W9 **Collect Date/Time:** 4/21/2016 15:05

WETLAB Sample ID: 1604577-009 **Receive Date:** 4/21/2016 17:19

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	65		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	65		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	4/26/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	270		mg/L	1	10	4/26/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	0.14		mg/L	1	0.10	4/25/2016	NV00925
Chloride	EPA 300.0	96	SC	mg/L	1	0.10	4/23/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND		mg/L	1	0.010	4/23/2016	NV00925
Sulfate	EPA 300.0	1.3		mg/L	1	1.0	4/25/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	25		mg/L	1	0.10	4/28/2016	NV00925
Aluminum	EPA 200.7	0.063		mg/L	1	0.045	4/28/2016	NV00925
Calcium	EPA 200.7	24		mg/L	1	0.50	4/28/2016	NV00925
Iron	EPA 200.7	0.18		mg/L	1	0.020	4/28/2016	NV00925
Magnesium	EPA 200.7	5.6		mg/L	1	0.50	4/28/2016	NV00925
Manganese	EPA 200.7	0.044		mg/L	1	0.0050	4/28/2016	NV00925
Potassium	EPA 200.7	5.4		mg/L	1	0.50	4/28/2016	NV00925
Sodium	EPA 200.7	60		mg/L	1	0.50	4/28/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		4/27/2016	NV00925

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Western Environmental Testing Laboratory
QC Report

QCBatchID	QCType	Parameter	Method	Result	Units
QC16040803	Blank 1	Turbidity (Nephelometric)	EPA 180.1	ND	NTU
QC16040853	Blank 1	Chloride	EPA 300.0	ND	mg/L
		Nitrate Nitrogen	EPA 300.0	ND	mg/L
		Nitrite Nitrogen	EPA 300.0	ND	mg/L
QC16040855	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16040909	Blank 1	Aluminum, Dissolved	EPA 200.7	ND	mg/L
		Calcium, Dissolved	EPA 200.7	ND	mg/L
		Iron, Dissolved	EPA 200.7	ND	mg/L
		Magnesium, Dissolved	EPA 200.7	ND	mg/L
		Manganese, Dissolved	EPA 200.7	ND	mg/L
		Potassium, Dissolved	EPA 200.7	ND	mg/L
		Silica, Dissolved	EPA 200.7	ND	mg/L
		Sodium, Dissolved	EPA 200.7	ND	mg/L
QC16040958	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16040960	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16040961	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16040965	Blank 1	Total Kjeldahl Nitrogen	EPA 351.2	ND	mg/L
QC16040977	Blank 1	Total Suspended Solids (TSS)	SM 2540D	ND	mg/L
QC16041040	Blank 1	Total Phosphorous as P	SM 4500-P E	ND	mg/L
QC16050025	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L
QC16050026	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L

QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16040803	LCS 1	Turbidity (Nephelometric)	EPA 180.1	5.20	5.00	104	NTU
QC16040853	LCS 1	Chloride	EPA 300.0	9.48	10.0	95	mg/L
		Nitrate Nitrogen	EPA 300.0	0.490	0.500	98	mg/L

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QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
		Nitrite Nitrogen	EPA 300.0	0.510	0.500	102	mg/L
QC16040855	LCS 1	Bromide	EPA 300.0	0.238	0.250	95	mg/L
		Sulfate	EPA 300.0	24.5	10.0	98	mg/L
QC16040873	LCS 1	Total Alkalinity	SM 2320B	100	100	100	mg/L
QC16040909	LCS 1	Aluminum, Dissolved	EPA 200.7	0.928	1.00	93	mg/L
		Calcium, Dissolved	EPA 200.7	10.2	10.0	102	mg/L
		Iron, Dissolved	EPA 200.7	0.915	1.00	92	mg/L
		Magnesium, Dissolved	EPA 200.7	9.58	10.0	96	mg/L
		Manganese, Dissolved	EPA 200.7	1.01	1.00	101	mg/L
		Potassium, Dissolved	EPA 200.7	11.1	10.0	111	mg/L
		Silica, Dissolved	EPA 200.7	18.7	21.4	87	mg/L
		Sodium, Dissolved	EPA 200.7	9.66	10.0	97	mg/L
QC16040958	LCS 1	Silica	EPA 200.7	20.8	21.4	97	mg/L
		Aluminum	EPA 200.7	0.960	1.00	96	mg/L
		Calcium	EPA 200.7	9.67	10.0	97	mg/L
		Iron	EPA 200.7	0.936	1.00	94	mg/L
		Magnesium	EPA 200.7	9.52	10.0	95	mg/L
		Manganese	EPA 200.7	0.957	1.00	96	mg/L
		Potassium	EPA 200.7	9.67	10.0	97	mg/L
		Sodium	EPA 200.7	9.84	10.0	98	mg/L
QC16040960	LCS 1	Silica	EPA 200.7	20.8	21.4	97	mg/L
		Aluminum	EPA 200.7	0.960	1.00	96	mg/L
		Calcium	EPA 200.7	9.67	10.0	97	mg/L
		Iron	EPA 200.7	0.936	1.00	94	mg/L
		Magnesium	EPA 200.7	9.52	10.0	95	mg/L
		Manganese	EPA 200.7	0.957	1.00	96	mg/L
		Potassium	EPA 200.7	9.67	10.0	97	mg/L
		Sodium	EPA 200.7	9.84	10.0	98	mg/L
QC16040961	LCS 1	Silica	EPA 200.7	21.0	21.4	98	mg/L
		Aluminum	EPA 200.7	0.986	1.00	99	mg/L
		Calcium	EPA 200.7	10.1	10.0	101	mg/L
		Iron	EPA 200.7	0.986	1.00	99	mg/L
		Magnesium	EPA 200.7	9.93	10.0	99	mg/L
		Manganese	EPA 200.7	0.989	1.00	99	mg/L
		Potassium	EPA 200.7	10.4	10.0	104	mg/L
		Sodium	EPA 200.7	9.96	10.0	100	mg/L
QC16040965	LCS 1	Total Kjeldahl Nitrogen	EPA 351.2	0.990	1.00	99	mg/L
QC16040977	LCS 1	Total Suspended Solids (TSS)	SM 2540D	201	200	101	mg/L
QC16040977	LCS 2	Total Suspended Solids (TSS)	SM 2540D	200	200	100	mg/L
QC16041002	LCS 1	Total Alkalinity	SM 2320B	100	100	100	mg/L
QC16041002	LCS 2	Total Alkalinity	SM 2320B	100	100	100	mg/L
QC16041040	LCS 1	Total Phosphorous as P	SM 4500-P E	0.246	0.250	98	mg/L
QC16050025	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	144	150	96	mg/L
QC16050025	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	153	150	102	mg/L
QC16050026	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	144	150	96	mg/L
QC16050026	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	153	150	102	mg/L

QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result	Units	RPD
QC16040803	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1604598-001	3.20	3.16	NTU	1 %
QC16040803	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1604617-002	5.43	5.41	NTU	<1%
QC16040873	Duplicate	Total Alkalinity	SM 2320B	1604592-001	192	192	mg/L as CaCO3	<1%

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QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result	Units	RPD
		Bicarbonate (HCO3)	SM 2320B	1604592-001	192	192	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604592-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604592-001	ND	ND	mg/L as CaCO3	<1%
QC16040873	Duplicate	Total Alkalinity	SM 2320B	1604595-001	130	129	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604595-001	130	129	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604595-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604595-001	ND	ND	mg/L as CaCO3	<1%
QC16040873	Duplicate	Total Alkalinity	SM 2320B	1604595-002	243	244	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604595-002	243	244	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604595-002	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604595-002	ND	ND	mg/L as CaCO3	<1%
QC16040873	Duplicate	Total Alkalinity	SM 2320B	1604595-003	113	112	mg/L as CaCO3	1 %
		Bicarbonate (HCO3)	SM 2320B	1604595-003	113	112	mg/L as CaCO3	1 %
		Carbonate (CO3)	SM 2320B	1604595-003	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604595-003	ND	ND	mg/L as CaCO3	<1%
QC16040977	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1604577-004	5.00	5.00	mg/L	<1%
QC16040977	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1604614-003	ND	ND	mg/L	<1%
QC16041002	Duplicate	Total Alkalinity	SM 2320B	1604596-001	157	157	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604596-001	157	157	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604596-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604596-001	ND	ND	mg/L as CaCO3	<1%
QC16041002	Duplicate	Total Alkalinity	SM 2320B	1604599-001	191	190	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604599-001	191	190	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604599-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604599-001	ND	ND	mg/L as CaCO3	<1%
QC16041002	Duplicate	Total Alkalinity	SM 2320B	1604596-002	118	118	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604596-002	118	118	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604596-002	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604596-002	ND	ND	mg/L as CaCO3	<1%
QC16041002	Duplicate	Total Alkalinity	SM 2320B	1604645-001	144	144	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604645-001	144	144	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604645-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604645-001	ND	ND	mg/L as CaCO3	<1%
QC16041002	Duplicate	Total Alkalinity	SM 2320B	1604628-001	169	170	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604628-001	169	170	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604628-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604628-001	ND	ND	mg/L as CaCO3	<1%
QC16050025	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604537-001	325	325	mg/L	<1%
QC16050025	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604577-001	113	116	mg/L	3 %
QC16050026	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604592-001	270	269	mg/L	<1%
QC16050026	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1604645-001	301	300	mg/L	<1%

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QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
QC16040853	MS 1	Chloride	EPA 300.0	1604577-004	73.1	SC	73.8	73.9	1.25	mg/L	NC	NC	NC
		Nitrate Nitrogen	EPA 300.0	1604577-004	0.760		1.16	1.17	0.500	mg/L	81	82	1%
		Nitrite Nitrogen	EPA 300.0	1604577-004	ND		0.116	0.117	0.125	mg/L	93	94	1%
QC16040853	MS 2	Chloride	EPA 300.0	1604577-009	95.6	SC	96.1	96.0	1.25	mg/L	NC	NC	NC
		Nitrate Nitrogen	EPA 300.0	1604577-009	ND		0.487	0.494	0.500	mg/L	97	98	1%
		Nitrite Nitrogen	EPA 300.0	1604577-009	ND		0.101	0.104	0.125	mg/L	81	83	3%
QC16040855	MS 1	Bromide	EPA 300.0	1604577-003	ND		0.271	0.274	0.250	mg/L	89	90	1%
		Sulfate	EPA 300.0	1604577-003	2.10		11.9	12.0	4.00	mg/L	98	99	1%
QC16040855	MS 2	Bromide	EPA 300.0	1604580-002	ND		0.316	0.316	0.250	mg/L	89	89	<1%
		Sulfate	EPA 300.0	1604580-002	55.1		64.5	64.6	4.00	mg/L	93	95	<1%
QC16040909	MS 1	Aluminum, Dissolved	EPA 200.7	1604608-007	ND		1.13	1.12	1.00	mg/L	110	109	1%
		Calcium, Dissolved	EPA 200.7	1604608-007	574	SC	554	567	10.0	mg/L	NC	NC	NC
		Iron, Dissolved	EPA 200.7	1604608-007	ND		0.897	0.898	1.00	mg/L	89	89	<1%
		Magnesium, Dissolved	EPA 200.7	1604608-007	185	SC	189	192	10.0	mg/L	NC	NC	NC
		Manganese, Dissolved	EPA 200.7	1604608-007	2.12		3.09	3.10	1.00	mg/L	97	98	<1%
		Potassium, Dissolved	EPA 200.7	1604608-007	15.8	M	33.6	34.8	10.0	mg/L	NC	NC	NC
		Silica, Dissolved	EPA 200.7	1604608-007	27.0		44.1	44.7	21.4	mg/L	80	83	1%
		Sodium, Dissolved	EPA 200.7	1604608-007	101		109	108	10.0	mg/L	80	70	1%
QC16040958	MS 1	Silica	EPA 200.7	1604577-005	26.1		43.4	47.7	21.4	mg/L	81	101	9%
		Aluminum	EPA 200.7	1604577-005	0.100		1.20	1.26	1.00	mg/L	110	116	5%
		Calcium	EPA 200.7	1604577-005	22.7		32.7	33.4	10.0	mg/L	100	107	2%
		Iron	EPA 200.7	1604577-005	1.76		2.73	2.93	1.00	mg/L	97	117	7%
		Magnesium	EPA 200.7	1604577-005	4.65		14.1	14.6	10.0	mg/L	94	100	3%
		Manganese	EPA 200.7	1604577-005	0.115		1.06	1.10	1.00	mg/L	94	99	4%
		Potassium	EPA 200.7	1604577-005	3.55	QD	13.2	17.7	10.0	mg/L	96	142	29%
		Sodium	EPA 200.7	1604577-005	43.7		54.1	65.7	10.0	mg/L	104	657	19%
QC16040960	MS 1	Silica	EPA 200.7	1604577-006	27.2		47.1	46.2	21.4	mg/L	93	89	2%
		Aluminum	EPA 200.7	1604577-006	0.119		1.23	1.20	1.00	mg/L	111	108	2%
		Calcium	EPA 200.7	1604577-006	24.3		33.4	33.3	10.0	mg/L	91	90	<1%
		Iron	EPA 200.7	1604577-006	1.19		2.12	2.11	1.00	mg/L	93	92	<1%
		Magnesium	EPA 200.7	1604577-006	5.15		14.6	14.6	10.0	mg/L	94	94	<1%
		Manganese	EPA 200.7	1604577-006	0.093		1.08	1.06	1.00	mg/L	99	97	2%
		Potassium	EPA 200.7	1604577-006	4.63	M	17.8	18.2	10.0	mg/L	NC	NC	NC
		Sodium	EPA 200.7	1604577-006	53.3	SC	67.0	67.7	10.0	mg/L	NC	NC	NC
QC16040961	MS 1	Silica	EPA 200.7	1604577-007	27.2		46.4	46.0	21.4	mg/L	90	88	1%
		Aluminum	EPA 200.7	1604577-007	0.138		1.28	1.26	1.00	mg/L	114	112	2%
		Calcium	EPA 200.7	1604577-007	27.1		36.2	35.7	10.0	mg/L	91	86	1%
		Iron	EPA 200.7	1604577-007	1.70		2.60	2.57	1.00	mg/L	90	87	1%
		Magnesium	EPA 200.7	1604577-007	6.06		15.4	15.3	10.0	mg/L	93	92	1%
		Manganese	EPA 200.7	1604577-007	0.138		1.11	1.11	1.00	mg/L	97	97	<1%
		Potassium	EPA 200.7	1604577-007	5.37	M	19.0	18.8	10.0	mg/L	NC	NC	NC
		Sodium	EPA 200.7	1604577-007	62.5		75.0	72.6	10.0	mg/L	125	101	3%
QC16040965	MS 1	Total Kjeldahl Nitrogen	EPA 351.2	1604449-001	0.254		1.48	1.41	1.00	mg/L	97	90	5%
QC16040965	MS 2	Total Kjeldahl Nitrogen	EPA 351.2	1604577-004	0.216	M	1.33	1.15	1.00	mg/L	NC	NC	NC
QC16041040	MS 1	Total Phosphorous as P	SM 4500-P E	1604531-001	0.017		0.276	0.272	0.250	mg/L	104	102	1%
QC16041040	MS 2	Total Phosphorous as P	SM 4500-P E	1604564-001	0.014		0.272	0.280	0.250	mg/L	103	106	3%

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Specializing in Soil, Hazardous Waste and Water Analysis

Lab Number 1604577

Report Due Date

Page 1 of 1

CLIENT REQUIREMENTS

Client	Cardno
Address	295 Hwy. 50 Suite 1
City, State & Zip	Zephyr Cove
Contact	Chris Donley
Phone	(775) 588-9069
Collector's Name	
Fax	
PWS/Project Name	
P.O. #	
PWS/Project Number	
Email	chris.donley@cardno.com

Billing Address (if different than Client Address)

Client	SAME
Address	
City, State & Zip	
Contact	
Phone	
Fax	
Email	

Turnaround Time Requirements		Reporting Results Via	
Standard	X	Fax	
5 Day*		PDF	X
3-Day*		EDD	X
48 Hour*		Mail Only	
24 Hour*		Other:	

Compliance Monitoring		Samples Collected From Which State?				Standard Level QC Required?				
Yes	X	NV		CA	X	Yes	X	No		*Surcharges will apply
No		Other:				*Level IV QC				

SAMPLE ID / LOCATION		DATE	TIME	SAMPLE TYPE	NO. OF CONTAINERS	Total Alkalinity	Anions (LL): Br, SO4, Cl, NO3	Metals (200.7): Al, Ca, Fe, Mg, Mn, K, SiO2, Na	TDS	Turbidity	TKN	TP	Nitrite (NO2)			SAMPLE NUMBER (LAB USE ONLY)
20160421 CalBase-1	CalBase	4/21	9:45	SW	2	X	X	X	X							1
20160421 43HVF-2	Vault Effluent		10:20	SW	2	X	X	X	X							2
20160421 WWF-3	Wildwood		11:10	SW	2	X	X	X	X							3
20160421 43BPC-4	Below CA Parking Lot		11:45	SW	3	X	X	X	X	X	X	X	X			4
20160421 BPC-R5	Regina		12:35	SW	2	X	X	X	X							5
20160421 BPC-V6	Verdon		1:15	SW	2	X	X	X	X							6
20160421 BPC-C7	Charlesworth		2:05	SW	2	X	X	X	X							7
20160421 BPC-B8	Blackwood		2:35	SW	2	X	X	X	X							8
20160421 BPC-W9	Werner Salas		3:05	SW	2	X	X	X	X			1604	1			9
												577	9			

Instructions/Comments/Special Requirements:

Sample Matrix/Type Key**: DW=Drinking water WW=Waste Water SW=Surfacewater MW=Monitoring Well SD=Solid/Sludge SO=Soil HW=Hazardous Waste OT=Other

SAMPLE RECEIPT CONDITIONS	DATE	TIME	SAMPLES RELINQUISHED BY	SAMPLES RECEIVED BY
Temperature 4.3 C	4/21/16	1719		
Custody Seals Intact? Y N None				
Number of Containers				

WETLAB'S Standard Terms and Conditions apply unless written agreements specify otherwise. Payment terms are Net 30 for established customers. Pre-payment is required for clients without an account.

Client/Collector attests to the validity and authenticity of this (these) sample(s) and, is (are) aware that tampering with or intentionally mislabeling the sample(s) location or date/time of collection will be considered fraud and may be subject to legal action (NAC445.0636)

Samples are discarded 90 days after receipt unless other arrangements have been made with the laboratory.

To the maximum extent permitted by law, the Client agrees to limit the liability of WETLAB for the Client's damages to the total compensation received, unless other arrangements are made in writing. This limitation shall apply regardless of the cause of action or legal theory pled or asserted.

5/18/2016

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley

OrderID: *1605181*

Dear: Chris Donley

This is to transmit the attached analytical report. The analytical data and information contained therein was generated using specified or selected methods contained in references, such as Standard Methods for the Examination of Water and Wastewater, online edition, Methods for Determination of Organic Compounds in Drinking Water, EPA-600/4-79-020, and Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods (SW846) Third Edition.

The samples were received by WETLAB-Western Environmental Testing Laboratory in good condition on 5/5/2016. Additional comments are located on page 2 of this report.

If you should have any questions or comments regarding this report, please do not hesitate to call.

Sincerely,

Jennifer Delaney
QA Specialist

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Western Environmental Testing Laboratory
Report Comments

Cardno - 1605181

Specific Report Comments

None

Report Legend

B	--	Blank contamination; Analyte detected above the method reporting limit in an associated blank
D	--	Due to the sample matrix dilution was required in order to properly detect and report the analyte. The reporting limit has been adjusted accordingly.
HT	--	Sample analyzed beyond the accepted holding time
J	--	The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit
M	--	The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference. The reported result should be considered an estimate.
N	--	There was insufficient sample available to perform a spike and/or duplicate on this analytical batch.
NC	--	Not calculated due to matrix interference
QD	--	The sample duplicate or matrix spike duplicate analysis demonstrated sample imprecision. The reported result should be considered an estimate.
QL	--	The result for the laboratory control sample (LCS) was outside WETLAB acceptance criteria and reanalysis was not possible. The reported data should be considered an estimate.
S	--	Surrogate recovery was outside of laboratory acceptance limits due to matrix interference. The associated blank and LCS surrogate recovery was within acceptance limits
SC	--	Spike recovery not calculated. Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered
U	--	The analyte was analyzed for, but was not detected above the level of the reported sample reporting/quantitation limit

General Lab Comments

Per method recommendation (section 4.4), Samples analyzed by methods EPA 300.0 and EPA 300.1 have been filtered prior to analysis.

The following is an interpretation of the results from EPA method 9223B:
A result of zero (0) indicates absence for both coliform and Escherichia coli meaning the water meets the microbiological requirements of the U.S. EPA Safe Drinking Water Act (SDWA). A result of one (1) for either test indicates presence and the water does not meet the SDWA requirements. Waters with positive tests should be disinfected by a certified water treatment operator and retested.

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Western Environmental Testing Laboratory
Analytical Report

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley
Phone: (775) 588-9069 **Fax:** (775) 588-9219

Date Printed: 5/18/2016
OrderID: *1605181*

Customer Sample ID: 20160505 CalBase-1
WETLAB Sample ID: 1605181-001
Collect Date/Time: 5/5/2016 10:00
Receive Date: 5/5/2016 16:30

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	43		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	43		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	79	QD	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	ND		mg/L	1	0.10	5/10/2016	NV00925
Chloride	EPA 300.0	16		mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.92	M	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	3.0		mg/L	1	1.0	5/11/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	24		mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	0.090		mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	12		mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	0.20		mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	2.0		mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.010		mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	2.9		mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	15		mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		5/10/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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EPA LAB ID: NV00932

Customer Sample ID: 20160505 43HVP-2 **Collect Date/Time:** 5/5/2016 10:40
WETLAB Sample ID: 1605181-002 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	61	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	61	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	320	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/10/2016	NV00925
Chloride	EPA 300.0	130	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.83	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	4.3	mg/L	1	1.0	5/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	0.092	mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	32	mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	0.36	mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	5.1	mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.039	mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	4.4	mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	66	mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/10/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160505 WWF-3 **Collect Date/Time:** 5/5/2016 11:05
WETLAB Sample ID: 1605181-003 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	81	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	81	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	330	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/10/2016	NV00925
Chloride	EPA 300.0	120	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.018	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	1.9	mg/L	1	1.0	5/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	27	mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	35	mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	0.33	mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	8.2	mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.021	mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	4.5	mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	51	mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/10/2016	NV00925

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Customer Sample ID: 20160505 43BPC-4 **Collect Date/Time:** 5/5/2016 11:30
WETLAB Sample ID: 1605181-004 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Phosphorous as P	SM 4500-P E	0.12	mg/L	1	0.010	5/11/2016	NV00925
Total Suspended Solids (TSS)	SM 2540D	8	mg/L	1	1	5/10/2016	NV00925
Total Alkalinity	SM 2320B	66	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	66	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	210	mg/L	1	10	5/6/2016	NV00925
Turbidity (Nephelometric)	EPA 180.1	31	NTU	5	0.50	5/5/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/11/2016	NV00925
Chloride	EPA 300.0	76	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.63	mg/L	1	0.010	5/6/2016	NV00925
Nitrite Nitrogen	EPA 300.0	ND	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	4.0	mg/L	1	1.0	5/11/2016	NV00925
Flow Injection Analyses							
Total Kjeldahl Nitrogen	EPA 351.2	ND	mg/L	1	0.40	5/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	0.13	mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	24	mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	5.6	mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	5.0	mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.17	mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	3.9	mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	46	mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/10/2016	NV00925

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EPA LAB ID: NV00932

Customer Sample ID: 20160505 BPC-R5 **Collect Date/Time:** 5/5/2016 11:55
WETLAB Sample ID: 1605181-005 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	68		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	68		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/9/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	230		mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	ND		mg/L	1	0.10	5/10/2016	NV00925
Chloride	EPA 300.0	83	SC	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.60		mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	4.2		mg/L	1	1.0	5/11/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	28		mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	0.077		mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	25		mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	1.2		mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	5.3		mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.12		mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	3.9		mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	48		mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		5/10/2016	NV00925

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Customer Sample ID: 20160505 BPC-V6 **Collect Date/Time:** 5/5/2016 12:20
WETLAB Sample ID: 1605181-006 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	69	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	69	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	300	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.33	mg/L	1	0.10	5/11/2016	NV00925
Chloride	EPA 300.0	89	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.57	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	31	mg/L	1	1.0	5/11/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	0.16	mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	26	mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	1.0	mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	5.5	mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.10	mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	12	mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	62	mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/10/2016	NV00925

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Customer Sample ID: 20160505 BPC-C7 **Collect Date/Time:** 5/5/2016 12:45
WETLAB Sample ID: 1605181-007 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	73	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	73	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	260	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.21	mg/L	1	0.10	5/11/2016	NV00925
Chloride	EPA 300.0	93	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.21	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	2.6	mg/L	1	1.0	5/12/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	5/11/2016	NV00925
Aluminum	EPA 200.7	0.20	mg/L	1	0.045	5/11/2016	NV00925
Calcium	EPA 200.7	27	mg/L	1	0.50	5/11/2016	NV00925
Iron	EPA 200.7	1.9	mg/L	1	0.020	5/11/2016	NV00925
Magnesium	EPA 200.7	6.2	mg/L	1	0.50	5/11/2016	NV00925
Manganese	EPA 200.7	0.15	mg/L	1	0.0050	5/11/2016	NV00925
Potassium	EPA 200.7	4.2	mg/L	1	0.50	5/11/2016	NV00925
Sodium	EPA 200.7	53	mg/L	1	0.50	5/11/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/10/2016	NV00925

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Customer Sample ID: 20160505 BPC-B8 **Collect Date/Time:** 5/5/2016 13:10
WETLAB Sample ID: 1605181-008 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	66	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	66	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	230	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.18	mg/L	1	0.10	5/11/2016	NV00925
Chloride	EPA 300.0	87	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	1.8	mg/L	1	1.0	5/12/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	25	mg/L	1	0.10	5/12/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	5/13/2016	NV00925
Calcium	EPA 200.7	23	mg/L	1	0.50	5/12/2016	NV00925
Iron	EPA 200.7	0.38	mg/L	1	0.020	5/12/2016	NV00925
Magnesium	EPA 200.7	5.8	mg/L	1	0.50	5/12/2016	NV00925
Manganese	EPA 200.7	0.034	mg/L	1	0.0050	5/12/2016	NV00925
Potassium	EPA 200.7	4.6	mg/L	1	0.50	5/12/2016	NV00925
Sodium	EPA 200.7	57	mg/L	1	0.50	5/12/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/11/2016	NV00925

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Customer Sample ID: 20160505 BPC-W9 **Collect Date/Time:** 5/5/2016 13:30
WETLAB Sample ID: 1605181-009 **Receive Date:** 5/5/2016 16:30

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	69	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	69	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/10/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	240	mg/L	1	10	5/6/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.16	mg/L	1	0.10	5/11/2016	NV00925
Chloride	EPA 300.0	87	mg/L	1	0.10	5/6/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.019	mg/L	1	0.010	5/6/2016	NV00925
Sulfate	EPA 300.0	1.2	mg/L	1	1.0	5/12/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	25	mg/L	1	0.10	5/12/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	5/13/2016	NV00925
Calcium	EPA 200.7	23	mg/L	1	0.50	5/12/2016	NV00925
Iron	EPA 200.7	0.14	mg/L	1	0.020	5/12/2016	NV00925
Magnesium	EPA 200.7	5.8	mg/L	1	0.50	5/12/2016	NV00925
Manganese	EPA 200.7	0.030	mg/L	1	0.0050	5/12/2016	NV00925
Potassium	EPA 200.7	4.3	mg/L	1	0.50	5/12/2016	NV00925
Sodium	EPA 200.7	56	mg/L	1	0.50	5/12/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/11/2016	NV00925

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Western Environmental Testing Laboratory
QC Report

QCBatchID	QCType	Parameter	Method	Result	Units
QC16050189	Blank 1	Turbidity (Nephelometric)	EPA 180.1	ND	NTU
QC16050277	Blank 1	Chloride	EPA 300.0	ND	mg/L
		Nitrate Nitrogen	EPA 300.0	ND	mg/L
		Nitrite Nitrogen	EPA 300.0	ND	mg/L
QC16050362	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16050363	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16050400	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L
QC16050404	Blank 1	Total Phosphorous as P	SM 4500-P E	ND	mg/L
QC16050414	Blank 1	Total Kjeldahl Nitrogen	EPA 351.2	ND	mg/L
QC16050417	Blank 1	Aluminum, Dissolved	EPA 200.7	ND	mg/L
		Calcium, Dissolved	EPA 200.7	ND	mg/L
		Iron, Dissolved	EPA 200.7	ND	mg/L
		Magnesium, Dissolved	EPA 200.7	ND	mg/L
		Manganese, Dissolved	EPA 200.7	ND	mg/L
		Potassium, Dissolved	EPA 200.7	ND	mg/L
		Silica, Dissolved	EPA 200.7	ND	mg/L
		Sodium, Dissolved	EPA 200.7	ND	mg/L
QC16050472	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16050473	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16050476	Blank 1	Total Suspended Solids (TSS)	SM 2540D	ND	mg/L

QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16050189	LCS 1	Turbidity (Nephelometric)	EPA 180.1	5.42	5.00	108	NTU
QC16050277	LCS 1	Chloride	EPA 300.0	9.44	10.0	94	mg/L
		Nitrate Nitrogen	EPA 300.0	0.477	0.500	95	mg/L
		Nitrite Nitrogen	EPA 300.0	0.469	0.500	94	mg/L
QC16050312	LCS 1	Total Alkalinity	SM 2320B	99.7	100	100	mg/L
QC16050362	LCS 1	Bromide	EPA 300.0	0.267	0.250	107	mg/L
		Sulfate	EPA 300.0	25.1	10.0	100	mg/L
QC16050363	LCS 1	Bromide	EPA 300.0	0.267	0.250	107	mg/L
		Sulfate	EPA 300.0	25.1	25.0	100	mg/L
QC16050375	LCS 1	Total Alkalinity	SM 2320B	100	100	100	mg/L

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QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16050400	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	145	150	97	mg/L
QC16050400	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	143	150	95	mg/L
QC16050404	LCS 1	Total Phosphorous as P	SM 4500-P E	0.255	0.250	102	mg/L
QC16050414	LCS 1	Total Kjeldahl Nitrogen	EPA 351.2	0.948	1.00	95	mg/L
QC16050417	LCS 1	Aluminum, Dissolved	EPA 200.7	1.02	1.00	102	mg/L
		Calcium, Dissolved	EPA 200.7	10.1	10.0	101	mg/L
		Iron, Dissolved	EPA 200.7	1.01	1.00	101	mg/L
		Magnesium, Dissolved	EPA 200.7	10.1	10.0	101	mg/L
		Manganese, Dissolved	EPA 200.7	1.01	1.00	101	mg/L
		Potassium, Dissolved	EPA 200.7	10.1	10.0	101	mg/L
		Silica, Dissolved	EPA 200.7	21.3	21.4	99	mg/L
		Sodium, Dissolved	EPA 200.7	10.1	10.0	101	mg/L
QC16050472	LCS 1	Silica	EPA 200.7	22.0	21.4	103	mg/L
		Aluminum	EPA 200.7	0.954	1.00	95	mg/L
		Calcium	EPA 200.7	9.92	10.0	99	mg/L
		Iron	EPA 200.7	1.06	1.00	106	mg/L
		Magnesium	EPA 200.7	10.3	10.0	103	mg/L
		Manganese	EPA 200.7	0.952	1.00	95	mg/L
		Potassium	EPA 200.7	10.7	10.0	107	mg/L
		Sodium	EPA 200.7	10.8	10.0	108	mg/L
QC16050473	LCS 1	Silica	EPA 200.7	22.0	21.4	103	mg/L
		Aluminum	EPA 200.7	0.954	1.00	95	mg/L
		Calcium	EPA 200.7	9.92	10.0	99	mg/L
		Iron	EPA 200.7	1.06	1.00	106	mg/L
		Magnesium	EPA 200.7	10.3	10.0	103	mg/L
		Manganese	EPA 200.7	0.952	1.00	95	mg/L
		Potassium	EPA 200.7	10.7	10.0	107	mg/L
		Sodium	EPA 200.7	10.8	10.0	108	mg/L
QC16050476	LCS 1	Total Suspended Solids (TSS)	SM 2540D	200	200	100	mg/L
QC16050476	LCS 2	Total Suspended Solids (TSS)	SM 2540D	202	200	101	mg/L

QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result		Units	RPD
QC16050189	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1605150-001	1.14	1.19		NTU	4 %
QC16050189	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1605181-004	31.4	31.2		NTU	1 %
QC16050312	Duplicate	Total Alkalinity	SM 2320B	1605247-001	902	910		mg/L as CaCO3	1 %
		Bicarbonate (HCO3)	SM 2320B	1605247-001	ND	ND		mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1605247-001	65.6	66.8		mg/L as CaCO3	2 %
		Hydroxide (OH)	SM 2320B	1605247-001	836	843		mg/L as CaCO3	1 %
QC16050312	Duplicate	Total Alkalinity	SM 2320B	1605211-009	202	200		mg/L as CaCO3	1 %
		Bicarbonate (HCO3)	SM 2320B	1605211-009	202	200		mg/L as CaCO3	1 %
		Carbonate (CO3)	SM 2320B	1605211-009	ND	ND		mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1605211-009	ND	ND		mg/L as CaCO3	<1%
QC16050375	Duplicate	Total Alkalinity	SM 2320B	1604375-001	149	149		mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1604375-001	149	149		mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1604375-001	ND	ND		mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1604375-001	ND	ND		mg/L as CaCO3	<1%
QC16050400	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1605104-002	51.0	58.0		mg/L	13 %
QC16050400	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1605181-001	79.0	68.0	QD	mg/L	15 %

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QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result		Units	RPD
QC16050476	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1605098-001	360	336	QD	mg/L	7 %
QC16050476	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1605181-004	8.00	8.00		mg/L	<1%

QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
QC16050277	MS 1	Chloride	EPA 300.0	1605181-001	15.9		17.2	17.2	1.25	mg/L	101	105	<1%
		Nitrate Nitrogen	EPA 300.0	1605181-001	0.919	M	1.30	1.31	0.500	mg/L	NC	NC	NC
		Nitrite Nitrogen	EPA 300.0	1605181-001	ND	M	0.091	0.094	0.125	mg/L	NC	NC	NC
QC16050277	MS 2	Chloride	EPA 300.0	1605180-003	0.999		2.29	2.32	1.25	mg/L	103	105	1%
		Nitrate Nitrogen	EPA 300.0	1605180-003	0.159		0.670	0.678	0.500	mg/L	102	104	1%
		Nitrite Nitrogen	EPA 300.0	1605180-003	ND		0.134	0.135	0.125	mg/L	103	104	1%
QC16050362	MS 1	Bromide	EPA 300.0	1605173-007	ND	D	2.69	2.68	0.250	mg/L	108	107	<1%
		Sulfate	EPA 300.0	1605173-007	508		613	626	4.00	mg/L	105	118	2%
QC16050362	MS 2	Bromide	EPA 300.0	1605181-005	ND		0.297	0.294	0.250	mg/L	110	109	1%
		Sulfate	EPA 300.0	1605181-005	4.16		14.2	14.4	4.00	mg/L	101	103	1%
QC16050363	MS 1	Bromide	EPA 300.0	1605269-001	ND		0.264	0.260	0.250	mg/L	103	101	2%
		Sulfate	EPA 300.0	1605269-001	ND		10.4	10.7	10.0	mg/L	103	106	3%
QC16050404	MS 1	Total Phosphorous as P	SM 4500-P E	1605122-001	0.293		0.546	0.549	0.250	mg/L	101	102	1%
QC16050414	MS 1	Total Kjeldahl Nitrogen	EPA 351.2	1605127-004	ND	M	1.46	1.07	1.00	mg/L	NC	NC	NC
QC16050414	MS 2	Total Kjeldahl Nitrogen	EPA 351.2	1605138-001	0.423	M	1.06	1.12	1.00	mg/L	NC	NC	NC
QC16050417	MS 1	Aluminum, Dissolved	EPA 200.7	1605139-005	ND		1.16	1.15	1.00	mg/L	115	114	1%
		Calcium, Dissolved	EPA 200.7	1605139-005	66.0		76.6	75.5	10.0	mg/L	106	95	1%
		Iron, Dissolved	EPA 200.7	1605139-005	ND		1.01	1.01	1.00	mg/L	101	101	<1%
		Magnesium, Dissolved	EPA 200.7	1605139-005	22.8		32.8	32.6	10.0	mg/L	100	98	1%
		Manganese, Dissolved	EPA 200.7	1605139-005	ND		0.998	1.00	1.00	mg/L	100	100	<1%
		Potassium, Dissolved	EPA 200.7	1605139-005	4.93		15.1	15.0	10.0	mg/L	102	101	1%
		Silica, Dissolved	EPA 200.7	1605139-005	32.7		53.3	53.1	21.4	mg/L	96	95	<1%
		Sodium, Dissolved	EPA 200.7	1605139-005	143		154	152	10.0	mg/L	110	90	1%
QC16050472	MS 1	Silica	EPA 200.7	1605181-008	25.0		45.2	45.4	21.4	mg/L	94	95	<1%
		Aluminum	EPA 200.7	1605181-008	ND		1.03	1.02	1.00	mg/L	99	98	1%
		Calcium	EPA 200.7	1605181-008	22.7		31.0	31.5	10.0	mg/L	83	88	2%
		Iron	EPA 200.7	1605181-008	0.382		1.36	1.39	1.00	mg/L	98	101	2%
		Magnesium	EPA 200.7	1605181-008	5.85		15.7	15.8	10.0	mg/L	98	100	1%
		Manganese	EPA 200.7	1605181-008	0.034		0.972	0.956	1.00	mg/L	94	92	2%
		Potassium	EPA 200.7	1605181-008	4.59		16.5	16.3	10.0	mg/L	119	117	1%
		Sodium	EPA 200.7	1605181-008	56.7		65.3	67.6	10.0	mg/L	86	109	3%
QC16050473	MS 1	Silica	EPA 200.7	1605181-009	24.6		47.7	45.6	21.4	mg/L	108	98	5%
		Aluminum	EPA 200.7	1605181-009	ND		1.07	1.01	1.00	mg/L	104	98	6%
		Calcium	EPA 200.7	1605181-009	22.6		33.5	31.5	10.0	mg/L	109	89	6%
		Iron	EPA 200.7	1605181-009	0.140		1.20	1.16	1.00	mg/L	106	102	3%
		Magnesium	EPA 200.7	1605181-009	5.78		16.5	15.8	10.0	mg/L	107	100	4%
		Manganese	EPA 200.7	1605181-009	0.030		1.01	0.963	1.00	mg/L	98	93	5%
		Potassium	EPA 200.7	1605181-009	4.28		16.4	15.9	10.0	mg/L	121	116	3%
		Sodium	EPA 200.7	1605181-009	56.4		69.0	66.1	10.0	mg/L	126	97	4%

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Specializing in Soil, Hazardous Waste and Water Analysis

Lab Number 1605.181
Report Due Date 5/19/16
Page 1 of 1

CLIENT REQUIREMENTS

Client	Cardno
Address	295 Hwy. 50 Suite 1
City, State & Zip	Zephyr Cove
Contact	Chris Donley
Phone	(775) 588-9069
Collector's Name	
Fax	
PWS/Project Name	
P.O. #	
PWS/Project Number	
Email	chris.donley@cardno.com

Billing Address (if different than Client Address)

Client	SAME
Address	
City, State & Zip	
Contact	
Phone	
Fax	
Email	

Turnaround Time Requirements		Reporting Results Via	
Standard	X	Fax	
5 Day*		PDF	X
3-Day*		EDD	X
48 Hour*		Mail Only	
24 Hour*		Other:	

Compliance Monitoring		Samples Collected From Which State?				Standard Level QC Required?				
Yes	X	NV		CA	X	Yes	X	No		*Surcharges will apply
No		Other:				*Level IV QC				

SAMPLE ID / LOCATION		DATE	TIME	SAMPLE TYPE	NO. OF CONTAINERS	ANALYSES REQUESTED: Total Alkalinity	Anions (LL): Br, SO4, Cl, NO3	Metals (200.7): Al, Ca, Fe, Mg, Mn, K, SiO2, Na	TDS	Turbidity	TKN	TP	Nitrite (NO2)	TSS		SAMPLE NUMBER (LAB USE ONLY)
20160505	CalBase-1	CalBase	5-5-16	10:00am	SW	2	X	X	X	X							1
20160505	43HWP-2	Vault Effluent	5-5-16	10:40am	SW	2	X	X	X	X							2
20160505	WWF-3	Wildwood	5-5-16	11:05am	SW	2	X	X	X	X							3
20160505	43BPC-4	Below CA Parking Lot	5-5-16	11:30am	SW	3	X	X	X	X	X	X	X	X	X		4
20160505	BPC-R5	Regina	5-5-16	11:55am	SW	2	X	X	X	X							5
20160505	BPC-V6	Verdon	5-5-16	12:20pm	SW	2	X	X	X	X							6
20160505	BPC-C7	Charlesworth	5-5-16	12:45pm	SW	2	X	X	X	X							7
20160505	BPC-B8	Blackwood	5-5-16	1:10pm	SW	2	X	X	X	X							8
20160505	BPC-W9	Werner Salas	5-5-16	1:30pm	SW	2	X	X	X	X							9

1605 5

Instructions/Comments/Special Requirements:

Sample Matrix/Type Key**: DW=Drinking water WW=Waste Water SW=Surfacewater MW=Monitoring Well SD=Solid/Sludge SO=Soil HW=Hazardous Waste OT=Other

SAMPLE RECEIPT CONDITIONS	DATE	TIME	SAMPLES RELINQUISHED BY	SAMPLES RECEIVED BY
Temperature 3.9 C	5/5/16	1630		
Custody Seals Intact? Y N (None)				
Number of Containers				

WETLAB'S Standard Terms and Conditions apply unless written agreements specify otherwise. Payment terms are Net 30 for established customers. Pre-payment is required for clients without an account.

Client/Collector attests to the validity and authenticity of this (these) sample(s) and, is (are) aware that tampering with or intentionally mislabeling the sample(s) location or date/time of collection will be considered fraud and may be subject to legal action (NAC445.0636)

Samples are discarded 90 days after receipt unless other arrangements have been made with the laboratory.

To the maximum extent permitted by law, the Client agrees to limit the liability of WETLAB for the Client's damages to the total compensation received, unless other arrangements are made in writing. This limitation shall apply regardless of the cause of action or legal theory pled or asserted.

6/20/2016

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley

OrderID: *1605580*
Amended

Dear: Chris Donley

This is to transmit the attached analytical report. The analytical data and information contained therein was generated using specified or selected methods contained in references, such as Standard Methods for the Examination of Water and Wastewater, online edition, Methods for Determination of Organic Compounds in Drinking Water, EPA-600/4-79-020, and Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods (SW846) Third Edition.

The samples were received by WETLAB-Western Environmental Testing Laboratory in good condition on 5/19/2016. Additional comments are located on page 2 of this report.

If you should have any questions or comments regarding this report, please do not hesitate to call.

Sincerely,

Jennifer Delaney
QA Specialist

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Western Environmental Testing Laboratory
Report Comments

Cardno - 1605580 Amended

Specific Report Comments

This amended report includes the corrected result for Chloride on sample 1605580-007. We apologize for the inconvenience this may have caused.

Report Legend

B	--	Blank contamination; Analyte detected above the method reporting limit in an associated blank
D	--	Due to the sample matrix dilution was required in order to properly detect and report the analyte. The reporting limit has been adjusted accordingly.
HT	--	Sample analyzed beyond the accepted holding time
J	--	The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit
M	--	The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference. The reported result should be considered an estimate.
N	--	There was insufficient sample available to perform a spike and/or duplicate on this analytical batch.
NC	--	Not calculated due to matrix interference
QD	--	The sample duplicate or matrix spike duplicate analysis demonstrated sample imprecision. The reported result should be considered an estimate.
QL	--	The result for the laboratory control sample (LCS) was outside WETLAB acceptance criteria and reanalysis was not possible. The reported data should be considered an estimate.
S	--	Surrogate recovery was outside of laboratory acceptance limits due to matrix interference. The associated blank and LCS surrogate recovery was within acceptance limits
SC	--	Spike recovery not calculated. Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered
U	--	The analyte was analyzed for, but was not detected above the level of the reported sample reporting/quantitation limit

General Lab Comments

Per method recommendation (section 4.4), Samples analyzed by methods EPA 300.0 and EPA 300.1 have been filtered prior to analysis.

The following is an interpretation of the results from EPA method 9223B:
A result of zero (0) indicates absence for both coliform and Escherichia coli meaning the water meets the microbiological requirements of the U.S. EPA Safe Drinking Water Act (SDWA). A result of one (1) for either test indicates presence and the water does not meet the SDWA requirements. Waters with positive tests should be disinfected by a certified water treatment operator and retested.

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Western Environmental Testing Laboratory
Analytical Report

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley
Phone: (775) 588-9069 **Fax:** (775) 588-9219

Date Printed: 6/20/2016
OrderID: *1605580*
Amended

Customer Sample ID: 20160519 CALBASE-1
WETLAB Sample ID: 1605580-001
Collect Date/Time: 5/19/2016 09:40
Receive Date: 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	44	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	44	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	120	mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/24/2016	NV00925
Chloride	EPA 300.0	14	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.79	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	3.0	mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	24	mg/L	1	0.10	5/25/2016	NV00925
Aluminum	EPA 200.7	0.090	mg/L	1	0.045	5/25/2016	NV00925
Calcium	EPA 200.7	12	mg/L	1	0.50	5/25/2016	NV00925
Iron	EPA 200.7	0.18	mg/L	1	0.020	5/25/2016	NV00925
Magnesium	EPA 200.7	1.9	mg/L	1	0.50	5/25/2016	NV00925
Manganese	EPA 200.7	0.0084	mg/L	1	0.0050	5/25/2016	NV00925
Potassium	EPA 200.7	2.8	mg/L	1	0.50	5/25/2016	NV00925
Sodium	EPA 200.7	14	mg/L	1	0.50	5/25/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/24/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160519 43HVP-2 **Collect Date/Time:** 5/19/2016 10:00
WETLAB Sample ID: 1605580-002 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	88	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	88	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	330	mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	120	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.28	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	5.9	mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	30	mg/L	1	0.10	5/25/2016	NV00925
Aluminum	EPA 200.7	0.14	mg/L	1	0.045	5/25/2016	NV00925
Calcium	EPA 200.7	27	mg/L	1	0.50	5/25/2016	NV00925
Iron	EPA 200.7	0.97	mg/L	1	0.020	5/25/2016	NV00925
Magnesium	EPA 200.7	5.0	mg/L	1	0.50	5/25/2016	NV00925
Manganese	EPA 200.7	0.14	mg/L	1	0.0050	5/25/2016	NV00925
Potassium	EPA 200.7	4.4	mg/L	1	0.50	5/25/2016	NV00925
Sodium	EPA 200.7	88	mg/L	1	0.50	5/25/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/24/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160519 WWF-3 **Collect Date/Time:** 5/19/2016 10:30
WETLAB Sample ID: 1605580-003 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	89	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	89	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	370	mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	120	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	1.6	mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	5/25/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	5/25/2016	NV00925
Calcium	EPA 200.7	39	mg/L	1	0.50	5/25/2016	NV00925
Iron	EPA 200.7	0.27	mg/L	1	0.020	5/25/2016	NV00925
Magnesium	EPA 200.7	9.6	mg/L	1	0.50	5/25/2016	NV00925
Manganese	EPA 200.7	0.063	mg/L	1	0.0050	5/25/2016	NV00925
Potassium	EPA 200.7	4.6	mg/L	1	0.50	5/25/2016	NV00925
Sodium	EPA 200.7	58 SC	mg/L	1	0.50	5/25/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/24/2016	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Customer Sample ID: 20160519 43BPC-4 **Collect Date/Time:** 5/19/2016 10:55
WETLAB Sample ID: 1605580-004 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Phosphorous as P	SM 4500-P E	0.034	mg/L	1	0.010	5/25/2016	NV00925
Total Suspended Solids (TSS)	SM 2540D	4	mg/L	1	1	5/25/2016	NV00925
Total Alkalinity	SM 2320B	67	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	67	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	250	mg/L	1	10	5/23/2016	NV00925
Turbidity (Nephelometric)	EPA 180.1	12	NTU	1	0.10	5/20/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	76	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.61	mg/L	1	0.010	5/20/2016	NV00925
Nitrite Nitrogen	EPA 300.0	ND	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	4.0	mg/L	1	1.0	5/21/2016	NV00925
Flow Injection Analyses							
Total Kjeldahl Nitrogen	EPA 351.2	ND	mg/L	0.5	0.20	5/26/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	29	mg/L	1	0.10	5/25/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	5/25/2016	NV00925
Calcium	EPA 200.7	24	mg/L	1	0.50	5/25/2016	NV00925
Iron	EPA 200.7	2.7	mg/L	1	0.020	5/25/2016	NV00925
Magnesium	EPA 200.7	5.0	mg/L	1	0.50	5/25/2016	NV00925
Manganese	EPA 200.7	0.16	mg/L	1	0.0050	5/25/2016	NV00925
Potassium	EPA 200.7	3.8	mg/L	1	0.50	5/25/2016	NV00925
Sodium	EPA 200.7	48	mg/L	1	0.50	5/25/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/24/2016	NV00925

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Customer Sample ID: 20160519 BPC-R5 **Collect Date/Time:** 5/19/2016 11:30
WETLAB Sample ID: 1605580-005 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	67	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	67	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	250	mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	80	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.58	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	3.8	mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	29	mg/L	1	0.10	5/25/2016	NV00925
Aluminum	EPA 200.7	0.051	mg/L	1	0.045	5/25/2016	NV00925
Calcium	EPA 200.7	24	mg/L	1	0.50	5/25/2016	NV00925
Iron	EPA 200.7	1.4	mg/L	1	0.020	5/25/2016	NV00925
Magnesium	EPA 200.7	5.2	mg/L	1	0.50	5/25/2016	NV00925
Manganese	EPA 200.7	0.13	mg/L	1	0.0050	5/25/2016	NV00925
Potassium	EPA 200.7	3.7	mg/L	1	0.50	5/25/2016	NV00925
Sodium	EPA 200.7	48	mg/L	1	0.50	5/25/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/24/2016	NV00925

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Customer Sample ID: 20160519 BPC-R6 **Collect Date/Time:** 5/19/2016 11:55
WETLAB Sample ID: 1605580-006 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	77		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	77		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	250		mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	ND		mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	74		mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.43		mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	3.4		mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	29		mg/L	1	0.10	5/27/2016	NV00925
Aluminum	EPA 200.7	0.076		mg/L	1	0.045	5/27/2016	NV00925
Calcium	EPA 200.7	23		mg/L	1	0.50	5/27/2016	NV00925
Iron	EPA 200.7	1.2		mg/L	1	0.020	5/27/2016	NV00925
Magnesium	EPA 200.7	5.4		mg/L	1	0.50	5/27/2016	NV00925
Manganese	EPA 200.7	0.098		mg/L	1	0.0050	5/27/2016	NV00925
Potassium	EPA 200.7	4.7	M	mg/L	1	0.50	5/27/2016	NV00925
Sodium	EPA 200.7	56		mg/L	1	0.50	5/27/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		5/26/2016	NV00925

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Customer Sample ID: 20160519 BPC-C7 **Collect Date/Time:** 5/19/2016 12:25
WETLAB Sample ID: 1605580-007 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	77	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	77	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	280	mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.20	mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	91	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.14	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	2.5	mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	29	mg/L	1	0.10	5/27/2016	NV00925
Aluminum	EPA 200.7	0.19	mg/L	1	0.045	5/27/2016	NV00925
Calcium	EPA 200.7	26	mg/L	1	0.50	5/27/2016	NV00925
Iron	EPA 200.7	1.9	mg/L	1	0.020	5/27/2016	NV00925
Magnesium	EPA 200.7	6.1	mg/L	1	0.50	5/27/2016	NV00925
Manganese	EPA 200.7	0.14	mg/L	1	0.0050	5/27/2016	NV00925
Potassium	EPA 200.7	5.2	mg/L	1	0.50	5/27/2016	NV00925
Sodium	EPA 200.7	63	mg/L	1	0.50	5/27/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/26/2016	NV00925

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Customer Sample ID: 20160519 BPC-B8 **Collect Date/Time:** 5/19/2016 12:50
WETLAB Sample ID: 1605580-008 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	75	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	75	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	280	mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.19	mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	87	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	1.5	mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	25	mg/L	1	0.10	5/27/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	5/27/2016	NV00925
Calcium	EPA 200.7	25	mg/L	1	0.50	5/27/2016	NV00925
Iron	EPA 200.7	0.52	mg/L	1	0.020	5/27/2016	NV00925
Magnesium	EPA 200.7	6.0	mg/L	1	0.50	5/27/2016	NV00925
Manganese	EPA 200.7	0.052	mg/L	1	0.0050	5/27/2016	NV00925
Potassium	EPA 200.7	5.1	mg/L	1	0.50	5/27/2016	NV00925
Sodium	EPA 200.7	60	mg/L	1	0.50	5/27/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		5/26/2016	NV00925

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Customer Sample ID: 20160519 BPC-W9 **Collect Date/Time:** 5/19/2016 13:15
WETLAB Sample ID: 1605580-009 **Receive Date:** 5/19/2016 17:45

Analyte	Method	Results		Units	DF	RL	Analyzed	LabID
General Chemistry								
Total Alkalinity	SM 2320B	80		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	80		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Carbonate (CO3)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Hydroxide (OH)	SM 2320B	ND		mg/L as CaCO3	1	1.0	5/20/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	280		mg/L	1	10	5/23/2016	NV00925
Anions by Ion Chromatography								
Bromide	EPA 300.0	0.19		mg/L	1	0.10	5/25/2016	NV00925
Chloride	EPA 300.0	89	SC	mg/L	1	0.10	5/20/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND		mg/L	1	0.010	5/20/2016	NV00925
Sulfate	EPA 300.0	ND		mg/L	1	1.0	5/21/2016	NV00925
Trace Metals by ICP-OES								
Silica	EPA 200.7	27		mg/L	1	0.10	5/27/2016	NV00925
Aluminum	EPA 200.7	0.064		mg/L	1	0.045	5/27/2016	NV00925
Calcium	EPA 200.7	26		mg/L	1	0.50	5/27/2016	NV00925
Iron	EPA 200.7	0.37		mg/L	1	0.020	5/27/2016	NV00925
Magnesium	EPA 200.7	6.0		mg/L	1	0.50	5/27/2016	NV00925
Manganese	EPA 200.7	0.083		mg/L	1	0.0050	5/27/2016	NV00925
Potassium	EPA 200.7	4.9		mg/L	1	0.50	5/27/2016	NV00925
Sodium	EPA 200.7	60		mg/L	1	0.50	5/27/2016	NV00925
Sample Preparation								
Trace Metals Digestion	EPA 200.2	Complete			1		5/26/2016	NV00925

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Western Environmental Testing Laboratory
QC Report

QCBatchID	QCType	Parameter	Method	Result	Units
QC16050867	Blank 1	Chloride	EPA 300.0	ND	mg/L
		Nitrate Nitrogen	EPA 300.0	ND	mg/L
		Nitrite Nitrogen	EPA 300.0	ND	mg/L
QC16050868	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16050946	Blank 1	Turbidity (Nephelometric)	EPA 180.1	ND	NTU
QC16050981	Blank 1	Total Phosphorous as P	SM 4500-P E	ND	mg/L
QC16051007	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16051008	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16051009	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16051030	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L
QC16051065	Blank 1	Total Kjeldahl Nitrogen	EPA 351.2	ND	mg/L
QC16051126	Blank 1	Total Suspended Solids (TSS)	SM 2540D	ND	mg/L
QC16051139	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L

QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16050867	LCS 1	Chloride	EPA 300.0	9.84	10.0	98	mg/L
		Nitrate Nitrogen	EPA 300.0	0.502	0.500	100	mg/L
		Nitrite Nitrogen	EPA 300.0	0.488	0.500	98	mg/L
QC16050868	LCS 1	Bromide	EPA 300.0	0.245	0.250	98	mg/L

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QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
		Sulfate	EPA 300.0	25.2	25.0	101	mg/L
QC16050879	LCS 1	Total Alkalinity	SM 2320B	99.7	100	100	mg/L
QC16050879	LCS 2	Total Alkalinity	SM 2320B	99.7	100	100	mg/L
QC16050946	LCS 1	Turbidity (Nephelometric)	EPA 180.1	5.00	5.00	100	NTU
QC16050981	LCS 1	Total Phosphorous as P	SM 4500-P E	0.247	0.250	99	mg/L
QC16051007	LCS 1	Silica	EPA 200.7	21.6	21.4	101	mg/L
		Aluminum	EPA 200.7	1.01	1.00	101	mg/L
		Calcium	EPA 200.7	10.9	10.0	109	mg/L
		Iron	EPA 200.7	1.10	1.00	110	mg/L
		Magnesium	EPA 200.7	10.8	10.0	108	mg/L
		Manganese	EPA 200.7	1.01	1.00	101	mg/L
		Potassium	EPA 200.7	9.71	10.0	97	mg/L
		Sodium	EPA 200.7	9.38	10.0	94	mg/L
QC16051008	LCS 1	Silica	EPA 200.7	21.2	21.4	99	mg/L
		Aluminum	EPA 200.7	1.03	1.00	103	mg/L
		Calcium	EPA 200.7	10.2	10.0	102	mg/L
		Iron	EPA 200.7	1.04	1.00	104	mg/L
		Magnesium	EPA 200.7	10.3	10.0	103	mg/L
		Manganese	EPA 200.7	1.01	1.00	101	mg/L
		Potassium	EPA 200.7	10.4	10.0	104	mg/L
		Sodium	EPA 200.7	10.5	10.0	105	mg/L
QC16051009	LCS 1	Silica	EPA 200.7	21.2	21.4	99	mg/L
		Aluminum	EPA 200.7	1.03	1.00	103	mg/L
		Calcium	EPA 200.7	10.2	10.0	102	mg/L
		Iron	EPA 200.7	1.04	1.00	104	mg/L
		Magnesium	EPA 200.7	10.3	10.0	103	mg/L
		Manganese	EPA 200.7	1.01	1.00	101	mg/L
		Potassium	EPA 200.7	10.4	10.0	104	mg/L
		Sodium	EPA 200.7	10.5	10.0	105	mg/L
QC16051030	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	149	150	99	mg/L
QC16051030	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	143	150	95	mg/L
QC16051065	LCS 1	Total Kjeldahl Nitrogen	EPA 351.2	0.925	1.00	92	mg/L
QC16051126	LCS 1	Total Suspended Solids (TSS)	SM 2540D	199	200	100	mg/L
QC16051126	LCS 2	Total Suspended Solids (TSS)	SM 2540D	198	200	99	mg/L
QC16051139	LCS 1	Silica	EPA 200.7	20.9	21.4	98	mg/L
		Aluminum	EPA 200.7	1.09	1.00	109	mg/L
		Calcium	EPA 200.7	10.1	10.0	101	mg/L
		Iron	EPA 200.7	1.01	1.00	101	mg/L
		Magnesium	EPA 200.7	10.1	10.0	101	mg/L
		Manganese	EPA 200.7	0.984	1.00	98	mg/L
		Potassium	EPA 200.7	10.5	10.0	105	mg/L
		Sodium	EPA 200.7	10.6	10.0	106	mg/L

QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result	Units	RPD
QC16050879	Duplicate	Total Alkalinity	SM 2320B	1605559-001	200	200	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1605559-001	200	200	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1605559-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1605559-001	ND	ND	mg/L as CaCO3	<1%
QC16050879	Duplicate	Total Alkalinity	SM 2320B	1605575-002	70.9	70.2	mg/L as CaCO3	1 %
		Bicarbonate (HCO3)	SM 2320B	1605575-002	70.9	70.2	mg/L as CaCO3	1 %

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QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result	Units	RPD
		Carbonate (CO3)	SM 2320B	1605575-002	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1605575-002	ND	ND	mg/L as CaCO3	<1%
QC16050879	Duplicate	Total Alkalinity	SM 2320B	1605580-005	67.5	67.5	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1605580-005	67.5	67.5	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1605580-005	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1605580-005	ND	ND	mg/L as CaCO3	<1%
QC16050946	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1605566-001	24.5	24.6	NTU	<1%
QC16051030	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1605577-003	298	300	mg/L	1 %
QC16051030	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1605580-003	366	354	mg/L	3 %
QC16051126	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1605582-002	ND	ND	mg/L	<1%
QC16051126	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1605601-002	ND	ND	mg/L	<1%

QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
QC16050867	MS 1	Chloride	EPA 300.0	1605579-004	0.725		1.96	1.96	1.25	mg/L	99	99	<1%
		Nitrate Nitrogen	EPA 300.0	1605579-004	0.090		0.592	0.589	0.500	mg/L	100	100	1%
		Nitrite Nitrogen	EPA 300.0	1605579-004	ND		0.130	0.128	0.125	mg/L	104	103	2%
QC16050867	MS 2	Chloride	EPA 300.0	1605580-009	89.2	SC	90.1	90.1	1.25	mg/L	NC	NC	NC
		Nitrate Nitrogen	EPA 300.0	1605580-009	ND		0.486	0.500	0.500	mg/L	96	99	3%
		Nitrite Nitrogen	EPA 300.0	1605580-009	ND		0.134	0.125	0.125	mg/L	107	100	7%
QC16050868	MS 1	Bromide	EPA 300.0	1605580-009	0.191		0.405	0.408	0.250	mg/L	86	87	1%
		Sulfate	EPA 300.0	1605580-009	ND		11.2	11.3	10.0	mg/L	104	105	1%
QC16050981	MS 1	Total Phosphorous as P	SM 4500-P E	1605538-001	0.010		0.247	0.248	0.250	mg/L	95	95	<1%
QC16051007	MS 1	Silica	EPA 200.7	1605580-001	24.4		45.8	46.0	21.4	mg/L	100	101	<1%
		Aluminum	EPA 200.7	1605580-001	0.090		1.28	1.26	1.00	mg/L	119	117	2%
		Calcium	EPA 200.7	1605580-001	11.8		21.9	21.8	10.0	mg/L	101	100	<1%
		Iron	EPA 200.7	1605580-001	0.176		1.21	1.21	1.00	mg/L	103	103	<1%
		Magnesium	EPA 200.7	1605580-001	1.91		12.0	12.0	10.0	mg/L	101	101	<1%
		Manganese	EPA 200.7	1605580-001	0.008		1.02	1.00	1.00	mg/L	101	99	2%
		Potassium	EPA 200.7	1605580-001	2.78		13.0	13.1	10.0	mg/L	102	103	1%
		Sodium	EPA 200.7	1605580-001	13.9		23.8	24.0	10.0	mg/L	99	101	1%
QC16051008	MS 1	Silica	EPA 200.7	1605580-002	30.4		52.4	53.5	21.4	mg/L	103	108	2%
		Aluminum	EPA 200.7	1605580-002	0.136		1.35	1.37	1.00	mg/L	121	123	1%
		Calcium	EPA 200.7	1605580-002	27.0		37.4	37.7	10.0	mg/L	104	107	1%
		Iron	EPA 200.7	1605580-002	0.971		2.05	2.08	1.00	mg/L	108	111	1%
		Magnesium	EPA 200.7	1605580-002	4.97		15.2	15.4	10.0	mg/L	102	104	1%
		Manganese	EPA 200.7	1605580-002	0.135		1.13	1.15	1.00	mg/L	100	102	2%
		Potassium	EPA 200.7	1605580-002	4.41		15.0	15.2	10.0	mg/L	106	108	1%
		Sodium	EPA 200.7	1605580-002	88.5		99.0	100	10.0	mg/L	105	115	1%
QC16051009	MS 1	Silica	EPA 200.7	1605580-003	27.8		49.6	48.4	21.4	mg/L	102	96	2%
		Aluminum	EPA 200.7	1605580-003	ND		1.13	1.12	1.00	mg/L	111	110	1%
		Calcium	EPA 200.7	1605580-003	39.1		51.6	48.7	10.0	mg/L	125	96	6%
		Iron	EPA 200.7	1605580-003	0.273		1.31	1.29	1.00	mg/L	104	102	2%
		Magnesium	EPA 200.7	1605580-003	9.57		20.0	19.5	10.0	mg/L	104	99	3%
		Manganese	EPA 200.7	1605580-003	0.063		1.04	1.04	1.00	mg/L	98	98	<1%
		Potassium	EPA 200.7	1605580-003	4.58		15.3	15.0	10.0	mg/L	107	104	2%
		Sodium	EPA 200.7	1605580-003	58.0	SC	71.6	66.5	10.0	mg/L	NC	NC	NC
QC16051065	MS 1	Total Kjeldahl Nitrogen	EPA 351.2	1605538-001	ND	U	0.938	0.940	1.00	mg/L	92	92	<1%
QC16051065	MS 2	Total Kjeldahl Nitrogen	EPA 351.2	1605710-003	ND	U	1.01	1.08	1.00	mg/L	98	105	7%
QC16051139	MS 1	Silica	EPA 200.7	1605580-006	28.9		47.1	46.9	21.4	mg/L	85	84	<1%

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
		Aluminum	EPA 200.7	1605580-006	0.076		1.17	1.19	1.00	mg/L	109	111	2%
		Calcium	EPA 200.7	1605580-006	23.2		31.6	31.1	10.0	mg/L	84	79	2%
		Iron	EPA 200.7	1605580-006	1.20		2.12	2.11	1.00	mg/L	92	91	<1%
		Magnesium	EPA 200.7	1605580-006	5.37		14.7	14.5	10.0	mg/L	93	91	1%
		Manganese	EPA 200.7	1605580-006	0.098		1.07	1.07	1.00	mg/L	97	97	<1%
		Potassium	EPA 200.7	1605580-006	4.72	M	17.8	17.4	10.0	mg/L	NC	NC	NC
		Sodium	EPA 200.7	1605580-006	55.5		67.0	65.6	10.0	mg/L	115	101	2%

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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Specializing in Soil, Hazardous Waste and Water Analysis

Lab Number 1605580
Report Due Date 6-3-16
Page 1 of 1

CLIENT REQUIREMENTS

Client	Cardno
Address	295 Hwy. 50 Suite 1
City, State & Zip	Zephyr Cove
Contact	Chris Donley
Phone	(775) 588-9069
Collector's Name	
Fax	
PWS/Project Name	
P.O. #	
PWS/Project Number	
Email	chris.donley@cardno.com

Billing Address (if different than Client Address)

Client	SAME
Address	
City, State & Zip	
Contact	
Phone	
Fax	
Email	

Turnaround Time Requirements		Reporting Results Via	
Standard	X	Fax	
5 Day*		PDF	X
3-Day*		EDD	X
48 Hour*		Mail Only	
24 Hour*		Other:	

Compliance Monitoring		Samples Collected From Which State?				Standard Level QC Required?				
Yes	X	NV		CA	X	Yes	X	No		*Surcharges will apply
No		Other:				*Level IV QC				

SAMPLE ID / LOCATION		DATE	TIME	SAMPLE TYPE	NO. OF CONTAINERS	Total Alkalinity	Anions (LL): Br, SO4, Cl, NO3	Metals (200.7): Al, Ca, Fe, Mg, Mn, K, SiO2, Na	TDS	Turbidity	TKN	TP	Nitrite (NO2)	TSS		SAMPLE NUMBER (LAB USE ONLY)
20160519 CALBASE-1	CalBase	5/19	9:40	SW	2	X	X	X	X							1
20160519 43HVP-2	Vault Effluent		10:00	SW	2	X	X	X	X							2
20160519 WWF-3	Wildwood		10:30	SW	2	X	X	X	X							3
20160519 43BPC-4	Below CA Parking Lot		10:55	SW	3	X	X	X	X	X	X	X	X	X		4
20160519 BPC-R5	Regina		11:30	SW	2	X	X	X	X							5
20160519 BPC-V6	Verdon		11:55	SW	2	X	X	X	X							6
20160519 BPC-C7	Charlesworth		12:25	SW	2	X	X	X	X			1605	5			7
20160519 BPC-B8	Blackwood		12:50	SW	2	X	X	X	X							8
20160519 BPC-W9	Werner Salas	↓	1:15	SW	2	X	X	X	X			580	9			9

Instructions/Comments/Special Requirements:

Sample Matrix/Type Key**: DW=Drinking water WW=Waste Water SW=Surfacewater MW=Monitoring Well SD=Solid/Sludge SO=Soil HW=Hazardous Waste OT=Other:

SAMPLE RECEIPT CONDITIONS	DATE	TIME	SAMPLES RELINQUISHED BY	SAMPLES RECEIVED BY
Temperature 5.8 C	5/19/16	1745		
Custody Seals Intact? Y N None				
Number of Containers 19				

WETLAB'S Standard Terms and Conditions apply unless written agreements specify otherwise. Payment terms are Net 30 for established customers. Pre-payment is required for clients without an account.

Client/Collector attests to the validity and authenticity of this (these) sample(s) and, is (are) aware that tampering with or intentionally mislabeling the sample(s) location or date/time of collection will be considered fraud and may be subject to legal action (NAC445.0636)

Samples are discarded 90 days after receipt unless other arrangements have been made with the laboratory.

To the maximum extent permitted by law, the Client agrees to limit the liability of WETLAB for the Client's damages to the total compensation received, unless other arrangements are made in writing. This limitation shall apply regardless of the cause of action or legal theory pled or asserted.

6/15/2016

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley

OrderID: *1606027*

Dear: Chris Donley

This is to transmit the attached analytical report. The analytical data and information contained therein was generated using specified or selected methods contained in references, such as Standard Methods for the Examination of Water and Wastewater, online edition, Methods for Determination of Organic Compounds in Drinking Water, EPA-600/4-79-020, and Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods (SW846) Third Edition.

The samples were received by WETLAB-Western Environmental Testing Laboratory in good condition on 6/1/2016. Additional comments are located on page 2 of this report.

If you should have any questions or comments regarding this report, please do not hesitate to call.

Sincerely,

Andy Smith
QA Manager

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Western Environmental Testing Laboratory
Report Comments

Cardno - 1606027

Specific Report Comments

None

Report Legend

B	--	Blank contamination; Analyte detected above the method reporting limit in an associated blank
D	--	Due to the sample matrix dilution was required in order to properly detect and report the analyte. The reporting limit has been adjusted accordingly.
HT	--	Sample analyzed beyond the accepted holding time
J	--	The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit
M	--	The matrix spike/matrix spike duplicate (MS/MSD) values for the analysis of this parameter were outside acceptance criteria due to probable matrix interference. The reported result should be considered an estimate.
N	--	There was insufficient sample available to perform a spike and/or duplicate on this analytical batch.
NC	--	Not calculated due to matrix interference
QD	--	The sample duplicate or matrix spike duplicate analysis demonstrated sample imprecision. The reported result should be considered an estimate.
QL	--	The result for the laboratory control sample (LCS) was outside WETLAB acceptance criteria and reanalysis was not possible. The reported data should be considered an estimate.
S	--	Surrogate recovery was outside of laboratory acceptance limits due to matrix interference. The associated blank and LCS surrogate recovery was within acceptance limits
SC	--	Spike recovery not calculated. Sample concentration >4X the spike amount; therefore, the spike could not be adequately recovered
U	--	The analyte was analyzed for, but was not detected above the level of the reported sample reporting/quantitation limit

General Lab Comments

Per method recommendation (section 4.4), Samples analyzed by methods EPA 300.0 and EPA 300.1 have been filtered prior to analysis.

The following is an interpretation of the results from EPA method 9223B:
A result of zero (0) indicates absence for both coliform and Escherichia coli meaning the water meets the microbiological requirements of the U.S. EPA Safe Drinking Water Act (SDWA). A result of one (1) for either test indicates presence and the water does not meet the SDWA requirements. Waters with positive tests should be disinfected by a certified water treatment operator and retested.

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Western Environmental Testing Laboratory
Analytical Report

Cardno
PO Box 1533
Zephyr Cove, NV 89448
Attn: Chris Donley
Phone: (775) 588-9069 **Fax:** (775) 588-9219

Date Printed: 6/15/2016
OrderID: *1606027*

Customer Sample ID: 20160601 CALBASE-1 **Collect Date/Time:** 6/1/2016 09:45
WETLAB Sample ID: 1606027-001 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	45	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	45	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	110	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	6/2/2016	NV00925
Chloride	EPA 300.0	11	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.57	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	2.3	mg/L	1	1.0	6/2/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	25	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	0.065	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	10	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	0.32	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	1.8	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.012	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	2.4	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	12	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 43 HVP-2 **Collect Date/Time:** 6/1/2016 10:00
WETLAB Sample ID: 1606027-002 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	83	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	83	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	320	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	6/2/2016	NV00925

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Customer Sample ID: 20160601 43 HVP-2 **Collect Date/Time:** 6/1/2016 10:00

WETLAB Sample ID: 1606027-002 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
Chloride	EPA 300.0	100	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.30	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	4.5	mg/L	1	1.0	6/2/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	29	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	0.099	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	24	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	0.70	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	4.4	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.12	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	4.1	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	71	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 WWF-3 **Collect Date/Time:** 6/1/2016 10:36

WETLAB Sample ID: 1606027-003 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	93	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	93	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	380	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	6/2/2016	NV00925
Chloride	EPA 300.0	130	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.014	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	1.1	mg/L	1	1.0	6/2/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	27	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	41	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	0.22	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	9.9	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.029	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	4.7	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	57	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

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Customer Sample ID: 20160601 43BPC-4 **Collect Date/Time:** 6/1/2016 11:40

WETLAB Sample ID: 1606027-004 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Phosphorous as P	SM 4500-P E	0.17	mg/L	1	0.010	6/9/2016	NV00925
Total Suspended Solids (TSS)	SM 2540D	14	mg/L	1	1	6/3/2016	NV00925
Total Alkalinity	SM 2320B	70	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	70	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	260	mg/L	1	10	6/3/2016	NV00925
Turbidity (Nephelometric)	EPA 180.1	48	NTU	10	1.0	6/2/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	6/2/2016	NV00925
Chloride	EPA 300.0	68	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.48	mg/L	1	0.010	6/2/2016	NV00925
Nitrite Nitrogen	EPA 300.0	ND	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	3.7	mg/L	1	1.0	6/2/2016	NV00925
Flow Injection Analyses							
Total Kjeldahl Nitrogen	EPA 351.2	0.28	mg/L	0.5	0.20	6/8/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	0.091	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	22	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	5.8	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	4.7	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.17	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	3.5	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	44	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 BPC-R5 **Collect Date/Time:** 6/1/2016 12:04

WETLAB Sample ID: 1606027-005 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	70	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	70	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	240	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	6/2/2016	NV00925
Chloride	EPA 300.0	70	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.46	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	3.4	mg/L	1	1.0	6/2/2016	NV00925

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Customer Sample ID: 20160601 BPC-R5 **Collect Date/Time:** 6/1/2016 12:04

WETLAB Sample ID: 1606027-005 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
Trace Metals by ICP-OES							
Silica	EPA 200.7	30	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	0.064	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	23	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	3.2	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	5.0	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.12	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	3.8	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	47	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 BPC-V6 **Collect Date/Time:** 6/1/2016 12:37

WETLAB Sample ID: 1606027-006 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	76	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	76	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	250	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	ND	mg/L	1	0.10	6/3/2016	NV00925
Chloride	EPA 300.0	70	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.40	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	2.7	mg/L	1	1.0	6/3/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	29	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	0.065	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	24	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	1.1	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	5.2	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.076	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	3.7	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	47	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 BPC-C7 **Collect Date/Time:** 6/1/2016 13:08

WETLAB Sample ID: 1606027-007 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	80	mg/L as CaCO3	1	1.0	6/2/2016	NV00925

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Customer Sample ID: 20160601 BPC-C7 **Collect Date/Time:** 6/1/2016 13:08

WETLAB Sample ID: 1606027-007 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
Bicarbonate (HCO3)	SM 2320B	80	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	280	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.18	mg/L	1	0.10	6/3/2016	NV00925
Chloride	EPA 300.0	88	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	0.10	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	2.2	mg/L	1	1.0	6/3/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	29	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	0.16	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	26	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	2.2	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	5.9	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.15	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	4.0	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	54	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 BPC-B8 **Collect Date/Time:** 6/1/2016 13:30

WETLAB Sample ID: 1606027-008 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	79	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	79	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	280	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.18	mg/L	1	0.10	6/2/2016	NV00925
Chloride	EPA 300.0	88	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	1.2	mg/L	1	1.0	6/2/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	25	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	25	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	0.48	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	5.8	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.076	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	3.7	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	53	mg/L	1	0.50	6/3/2016	NV00925

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Customer Sample ID: 20160601 BPC-B8 **Collect Date/Time:** 6/1/2016 13:30

WETLAB Sample ID: 1606027-008 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

Customer Sample ID: 20160601 BPC-W9 **Collect Date/Time:** 6/1/2016 14:00

WETLAB Sample ID: 1606027-009 **Receive Date:** 6/1/2016 16:23

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Total Alkalinity	SM 2320B	87	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Bicarbonate (HCO3)	SM 2320B	87	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Carbonate (CO3)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Hydroxide (OH)	SM 2320B	ND	mg/L as CaCO3	1	1.0	6/2/2016	NV00925
Total Dissolved Solids (TDS)	SM 2540C	290	mg/L	1	10	6/3/2016	NV00925
Anions by Ion Chromatography							
Bromide	EPA 300.0	0.18	mg/L	1	0.10	6/2/2016	NV00925
Chloride	EPA 300.0	89	mg/L	1	0.10	6/2/2016	NV00925
Nitrate Nitrogen	EPA 300.0	ND	mg/L	1	0.010	6/2/2016	NV00925
Sulfate	EPA 300.0	ND	mg/L	1	1.0	6/2/2016	NV00925
Trace Metals by ICP-OES							
Silica	EPA 200.7	28	mg/L	1	0.10	6/3/2016	NV00925
Aluminum	EPA 200.7	ND	mg/L	1	0.045	6/3/2016	NV00925
Calcium	EPA 200.7	28	mg/L	1	0.50	6/3/2016	NV00925
Iron	EPA 200.7	0.34	mg/L	1	0.020	6/3/2016	NV00925
Magnesium	EPA 200.7	6.1	mg/L	1	0.50	6/3/2016	NV00925
Manganese	EPA 200.7	0.071	mg/L	1	0.0050	6/3/2016	NV00925
Potassium	EPA 200.7	4.0	mg/L	1	0.50	6/3/2016	NV00925
Sodium	EPA 200.7	56	mg/L	1	0.50	6/3/2016	NV00925
Sample Preparation							
Trace Metals Digestion	EPA 200.2	Complete		1		6/3/2016	NV00925

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Western Environmental Testing Laboratory
QC Report

QCBatchID	QCType	Parameter	Method	Result	Units
QC16060108	Blank 1	Chloride	EPA 300.0	ND	mg/L
		Nitrate Nitrogen	EPA 300.0	ND	mg/L
		Nitrite Nitrogen	EPA 300.0	ND	mg/L
QC16060111	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16060112	Blank 1	Bromide	EPA 300.0	ND	mg/L
		Sulfate	EPA 300.0	ND	mg/L
QC16060132	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16060133	Blank 1	Silica	EPA 200.7	ND	mg/L
		Aluminum	EPA 200.7	ND	mg/L
		Calcium	EPA 200.7	ND	mg/L
		Iron	EPA 200.7	ND	mg/L
		Magnesium	EPA 200.7	ND	mg/L
		Manganese	EPA 200.7	ND	mg/L
		Potassium	EPA 200.7	ND	mg/L
		Sodium	EPA 200.7	ND	mg/L
QC16060149	Blank 1	Turbidity (Nephelometric)	EPA 180.1	ND	NTU
QC16060228	Blank 1	Total Suspended Solids (TSS)	SM 2540D	ND	mg/L
QC16060279	Blank 1	Total Dissolved Solids (TDS)	SM 2540C	ND	mg/L
QC16060323	Blank 1	Total Kjeldahl Nitrogen	EPA 351.2	ND	mg/L
QC16060370	Blank 1	Total Phosphorous as P	SM 4500-P E	ND	mg/L

QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
QC16060108	LCS 1	Chloride	EPA 300.0	9.99	10.0	100	mg/L
		Nitrate Nitrogen	EPA 300.0	0.475	0.500	95	mg/L
		Nitrite Nitrogen	EPA 300.0	0.459	0.500	92	mg/L
QC16060111	LCS 1	Bromide	EPA 300.0	0.254	0.250	102	mg/L
		Sulfate	EPA 300.0	25.2	25.0	101	mg/L
QC16060112	LCS 1	Bromide	EPA 300.0	0.254	0.250	102	mg/L
		Sulfate	EPA 300.0	25.2	25.0	101	mg/L
QC16060115	LCS 1	Total Alkalinity	SM 2320B	99.2	100	99	mg/L
QC16060132	LCS 1	Silica	EPA 200.7	20.8	21.4	97	mg/L
		Aluminum	EPA 200.7	1.02	1.00	102	mg/L
		Calcium	EPA 200.7	9.91	10.0	99	mg/L
		Iron	EPA 200.7	0.987	1.00	99	mg/L
		Magnesium	EPA 200.7	9.90	10.0	99	mg/L
		Manganese	EPA 200.7	0.996	1.00	100	mg/L
		Potassium	EPA 200.7	9.90	10.0	99	mg/L
		Sodium	EPA 200.7	10.1	10.0	101	mg/L
QC16060133	LCS 1	Silica	EPA 200.7	20.8	21.4	97	mg/L
		Aluminum	EPA 200.7	1.02	1.00	102	mg/L

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QCBatchID	QCType	Parameter	Method	Result	Actual	% Recovery	Units
		Calcium	EPA 200.7	9.91	10.0	99	mg/L
		Iron	EPA 200.7	0.987	1.00	99	mg/L
		Magnesium	EPA 200.7	9.90	10.0	99	mg/L
		Manganese	EPA 200.7	0.996	1.00	100	mg/L
		Potassium	EPA 200.7	9.90	10.0	99	mg/L
		Sodium	EPA 200.7	10.1	10.0	101	mg/L
QC16060149	LCS 1	Turbidity (Nephelometric)	EPA 180.1	5.48	5.00	110	NTU
QC16060228	LCS 1	Total Suspended Solids (TSS)	SM 2540D	201	200	100	mg/L
QC16060228	LCS 2	Total Suspended Solids (TSS)	SM 2540D	199	200	99	mg/L
QC16060279	LCS 1	Total Dissolved Solids (TDS)	SM 2540C	157	150	105	mg/L
QC16060279	LCS 2	Total Dissolved Solids (TDS)	SM 2540C	152	150	101	mg/L
QC16060323	LCS 1	Total Kjeldahl Nitrogen	EPA 351.2	0.940	1.00	94	mg/L
QC16060370	LCS 1	Total Phosphorous as P	SM 4500-P E	0.278	0.250	111	mg/L

QCBatchID	QCType	Parameter	Method	Duplicate Sample	Sample Result	Duplicate Result	Units	RPD
QC16060115	Duplicate	Total Alkalinity	SM 2320B	1606007-001	104	104	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1606007-001	104	104	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1606007-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1606007-001	ND	ND	mg/L as CaCO3	<1%
QC16060115	Duplicate	Total Alkalinity	SM 2320B	1606032-001	133	133	mg/L as CaCO3	<1%
		Bicarbonate (HCO3)	SM 2320B	1606032-001	133	133	mg/L as CaCO3	<1%
		Carbonate (CO3)	SM 2320B	1606032-001	ND	ND	mg/L as CaCO3	<1%
		Hydroxide (OH)	SM 2320B	1606032-001	ND	ND	mg/L as CaCO3	<1%
QC16060149	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1606032-001	0.432	0.427	NTU	1 %
QC16060149	Duplicate	Turbidity (Nephelometric)	EPA 180.1	1606028-001	0.509	0.509	NTU	<1%
QC16060228	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1605820-002	ND	ND	mg/L	<1%
QC16060228	Duplicate	Total Suspended Solids (TSS)	SM 2540D	1605835-002	8.00	7.67	mg/L	4 %
QC16060279	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1606027-003	383	386	mg/L	1 %
QC16060279	Duplicate	Total Dissolved Solids (TDS)	SM 2540C	1606027-009	291	294	mg/L	1 %

QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
QC16060108	MS 1	Chloride	EPA 300.0	1606030-001	51.2		56.3	56.1	1.25	mg/L	82	78	<1%
		Nitrate Nitrogen	EPA 300.0	1606030-001	1.37		3.74	3.71	0.500	mg/L	95	93	1%
		Nitrite Nitrogen	EPA 300.0	1606030-001	ND	D	0.641	0.627	0.125	mg/L	97	95	2%
QC16060108	MS 2	Chloride	EPA 300.0	1606031-001	51.1		57.0	56.9	1.25	mg/L	94	92	<1%
		Nitrate Nitrogen	EPA 300.0	1606031-001	1.32		3.74	3.73	0.500	mg/L	97	96	<1%
		Nitrite Nitrogen	EPA 300.0	1606031-001	ND	D	0.630	0.621	0.125	mg/L	95	93	1%
QC16060111	MS 1	Bromide	EPA 300.0	1606028-001	0.110		0.319	0.309	0.250	mg/L	84	80	3%
		Sulfate	EPA 300.0	1606028-001	3.29		13.3	13.4	10.0	mg/L	100	101	1%
QC16060111	MS 2	Bromide	EPA 300.0	1606027-001	ND		0.220	0.218	0.250	mg/L	88	87	1%
		Sulfate	EPA 300.0	1606027-001	2.31		12.3	12.4	10.0	mg/L	99	101	1%
QC16060112	MS 1	Bromide	EPA 300.0	1606027-008	0.176		0.411	0.412	0.250	mg/L	94	95	<1%
		Sulfate	EPA 300.0	1606027-008	1.17		11.1	11.1	10.0	mg/L	100	100	<1%
QC16060112	MS 2	Bromide	EPA 300.0	1606025-011	ND		0.238	0.248	0.250	mg/L	95	99	4%
		Sulfate	EPA 300.0	1606025-011	19.0		29.8	31.2	10.0	mg/L	108	122	5%
QC16060132	MS 1	Silica	EPA 200.7	1606027-001	24.8		47.1	45.8	21.4	mg/L	104	98	3%
		Aluminum	EPA 200.7	1606027-001	0.065		1.25	1.21	1.00	mg/L	118	114	3%
		Calcium	EPA 200.7	1606027-001	10.3		20.3	20.1	10.0	mg/L	100	98	1%

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

SPARKS
475 E. Greg Street, Suite 119
Sparks, Nevada 89431
tel (775) 355-0202
fax (775) 355-0817
EPA LAB ID: NV00925 - ELAP No: 2523

ELKO
1084 Lamoille Hwy
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EPA LAB ID: NV00926

LAS VEGAS
3230 Polaris Ave. Suite 4
Las Vegas, Nevada 89102
tel (702) 475-8899
fax (702) 622-2868
EPA LAB ID: NV00932

QCBatchID	QCType	Parameter	Method	Spike Sample	Sample Result		MS Result	MSD Result	Spike Value	Units	MS % Rec.	MSD % Rec.	RPD
		Iron	EPA 200.7	1606027-001	0.316		1.32	1.31	1.00	mg/L	100	99	1%
		Magnesium	EPA 200.7	1606027-001	1.81		11.8	11.7	10.0	mg/L	100	99	1%
		Manganese	EPA 200.7	1606027-001	0.012		1.02	1.00	1.00	mg/L	101	99	2%
		Potassium	EPA 200.7	1606027-001	2.41		12.5	12.4	10.0	mg/L	101	100	1%
		Sodium	EPA 200.7	1606027-001	12.0		22.2	21.8	10.0	mg/L	102	98	2%
QC16060133	MS 1	Silica	EPA 200.7	1606027-005	29.7		49.0	50.5	21.4	mg/L	90	97	3%
		Aluminum	EPA 200.7	1606027-005	0.064		1.19	1.19	1.00	mg/L	113	113	<1%
		Calcium	EPA 200.7	1606027-005	23.0		32.5	32.9	10.0	mg/L	95	99	1%
		Iron	EPA 200.7	1606027-005	3.20		4.15	4.22	1.00	mg/L	95	102	2%
		Magnesium	EPA 200.7	1606027-005	5.03		14.7	14.9	10.0	mg/L	97	99	1%
		Manganese	EPA 200.7	1606027-005	0.125		1.11	1.11	1.00	mg/L	98	98	<1%
		Potassium	EPA 200.7	1606027-005	3.81		13.7	13.8	10.0	mg/L	99	100	1%
		Sodium	EPA 200.7	1606027-005	46.7		55.7	56.2	10.0	mg/L	90	95	1%
QC16060323	MS 1	Total Kjeldahl Nitrogen	EPA 351.2	1606035-001	ND	M	0.874	1.03	1.00	mg/L	NC	NC	NC
QC16060323	MS 2	Total Kjeldahl Nitrogen	EPA 351.2	1605851-002	0.142	M,J	1.26	1.26	1.00	mg/L	NC	NC	NC
QC16060370	MS 1	Total Phosphorous as P	SM 4500-P E	1606002-002	0.205	M	0.521	0.534	0.250	mg/L	NC	NC	NC
QC16060370	MS 2	Total Phosphorous as P	SM 4500-P E	1606042-002	0.212	M	0.517	0.511	0.250	mg/L	NC	NC	NC

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL

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WETLAB
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Specializing in Soil, Hazardous Waste and Water Analysis

Lab Number 1606027
Report Due Date 6-15-16
Page 1 of 1

CLIENT REQUIREMENTS

Turnaround Time Requirements		Reporting Results Via	
Standard	X	Fax	
5 Day*		PDF	X
3-Day*		EDD	X
48 Hour*		Mail Only	
24 Hour*		Other:	

Compliance Monitoring		Samples Collected From Which State?				Standard Level QC Required?				
Yes	X	NV		CA	X	Yes	X	No		*Surcharges will apply
No		Other:				*Level IV QC				

Client	Cardno
Address	295 Hwy. 50 Suite 1
City, State & Zip	Zephyr Cove
Contact	Chris Donley
Phone	(775) 588-9069
Collector's Name	
Fax	
PWS/Project Name	
P.O. #	
PWS/Project Number	
Email	chris.donley@cardno.com

Billing Address (if different than Client Address)

Client	SAME
Address	
City, State & Zip	
Contact	
Phone	Fax
Email	

SAMPLE ID / LOCATION		DATE	TIME	SAMPLE TYPE	NO. OF CONTAINERS	ANALYSES REQUESTED: Total Alkalinity	Anions (LL): Br, SO4, Cl, NO3	Metals (200.7): Al, Ca, Fe, Mg, Mn, K, SiO2, Na	TDS	Turbidity	TKN	TP	Nitrite (NO2)	TSS		SAMPLE NUMBER (LAB USE ONLY)
20160601 CALBASE-1	CalBase	6/1/16	9:45	SW	2	X	X	X	X							1
20160601 43HVP-2	Vault Effluent		10am	SW	2	X	X	X	X							2
20160601 WWF-3	Wildwood		10:36	SW	2	X	X	X	X							3
20160601 43BPC-4	Below CA Parking Lot		11:40	SW	3	X	X	X	X	X	X	X	X	X		4
20160601 BPC-R5	Regina		12:04	SW	2	X	X	X	X							5
20160601 BPC-V6	Verdon		12:37	SW	2	X	X	X	X							6
20160601 BPC-C7	Charlesworth		1:08	SW	2	X	X	X	X							7
20160601 BPC-B8	Blackwood		1:30p	SW	2	X	X	X	X							8
20160601 BPC-W9	Werner Salas		2pm	SW	2	X	X	X	X							9

1606 5 027 9

Instructions/Comments/Special Requirements:

Sample Matrix/Type Key**: DW=Drinking water WW=Waste Water SW=Surfacewater MW=Monitoring Well SD=Solid/Sludge SO=Soil HW=Hazardous Waste OT=Other:

SAMPLE RECEIPT CONDITIONS	DATE	TIME	SAMPLES RELINQUISHED BY	SAMPLES RECEIVED BY
Temperature 18.7 C	6/1/16	4:25	Sarah Brown	
Custody Seals Intact? Y N None				
Number of Containers				

WETLAB'S Standard Terms and Conditions apply unless written agreements specify otherwise. Payment terms are Net 30 for established customers. Pre-payment is required for clients without an account.

Client/Collector attests to the validity and authenticity of this (these) sample(s) and, is (are) aware that tampering with or intentionally mislabeling the sample(s) location or date/time of collection will be considered fraud and may be subject to legal action (NAC445.0636)

Samples are discarded 90 days after receipt unless other arrangements have been made with the laboratory.

To the maximum extent permitted by law, the Client agrees to limit the liability of WETLAB for the Client's damages to the total compensation received, unless other arrangements are made in writing. This limitation shall apply regardless of the cause of action or legal theory pled or asserted.

Appendix C

Bijou Park Creek Chloride Monitoring Study
Piper Plots of Selected Analytical Results

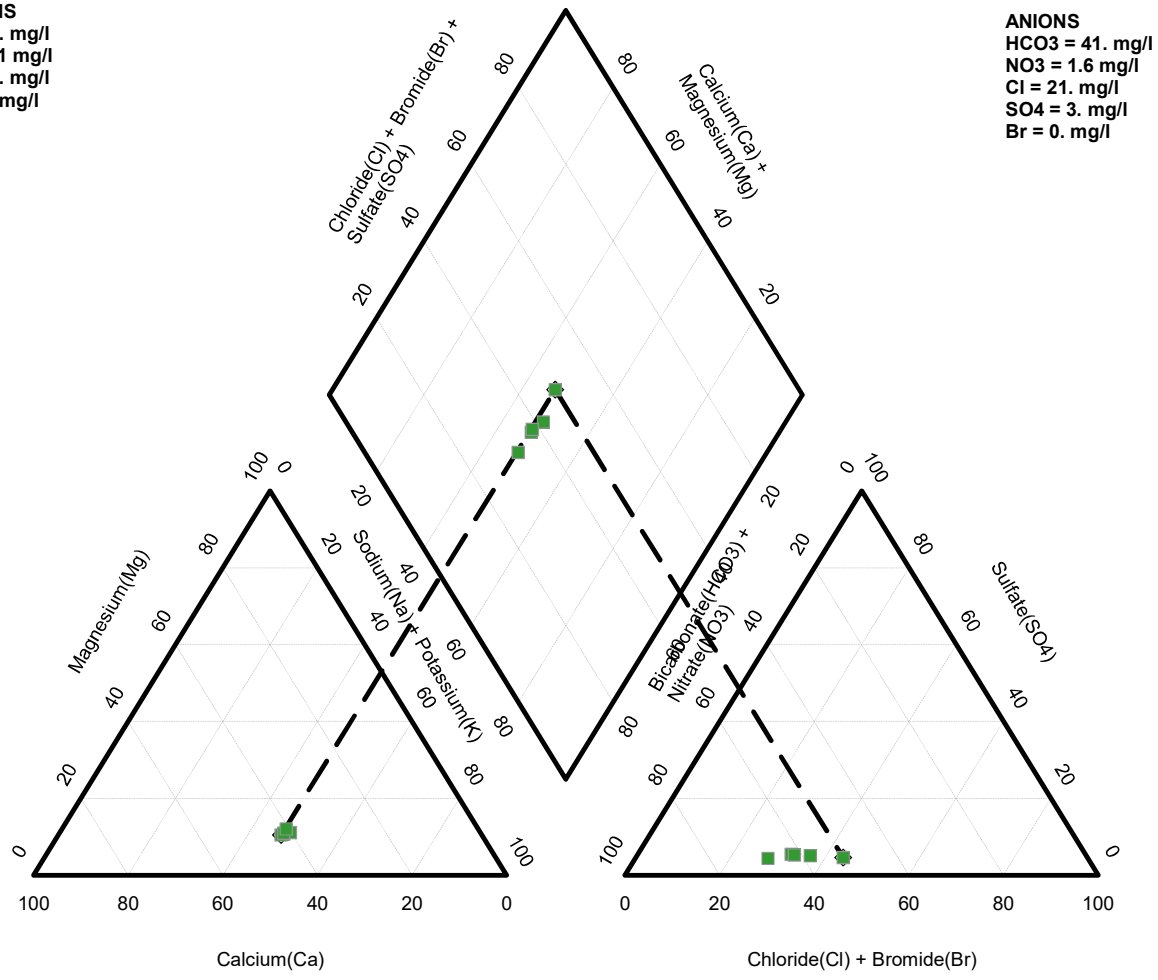




CalBase-1

CATIONS
Ca = 14. mg/l
Mg = 2.1 mg/l
Na = 16. mg/l
K = 3.1 mg/l

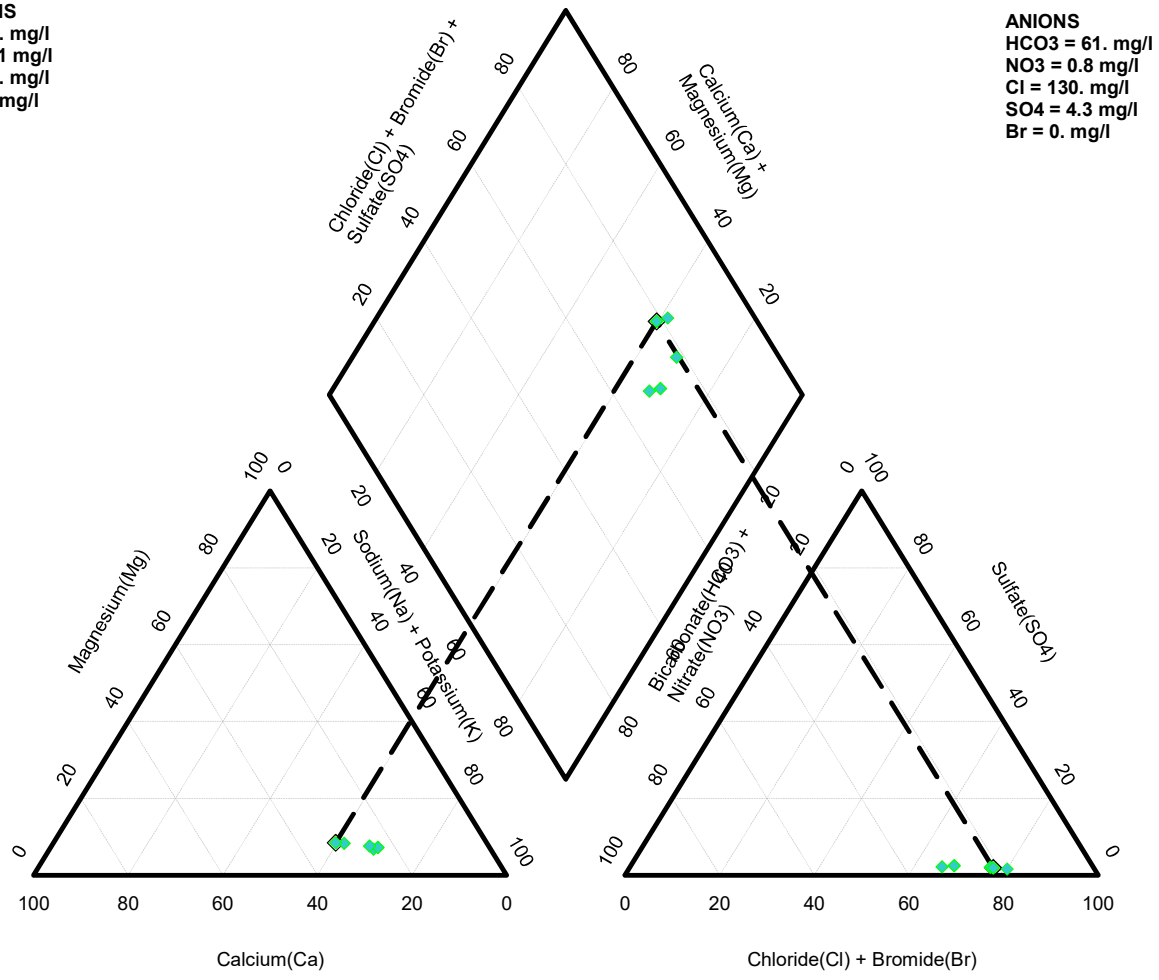
ANIONS
HCO3 = 41. mg/l
NO3 = 1.6 mg/l
Cl = 21. mg/l
SO4 = 3. mg/l
Br = 0. mg/l



43HVP-2

CATIONS
Ca = 32. mg/l
Mg = 5.1 mg/l
Na = 66. mg/l
K = 4.4 mg/l

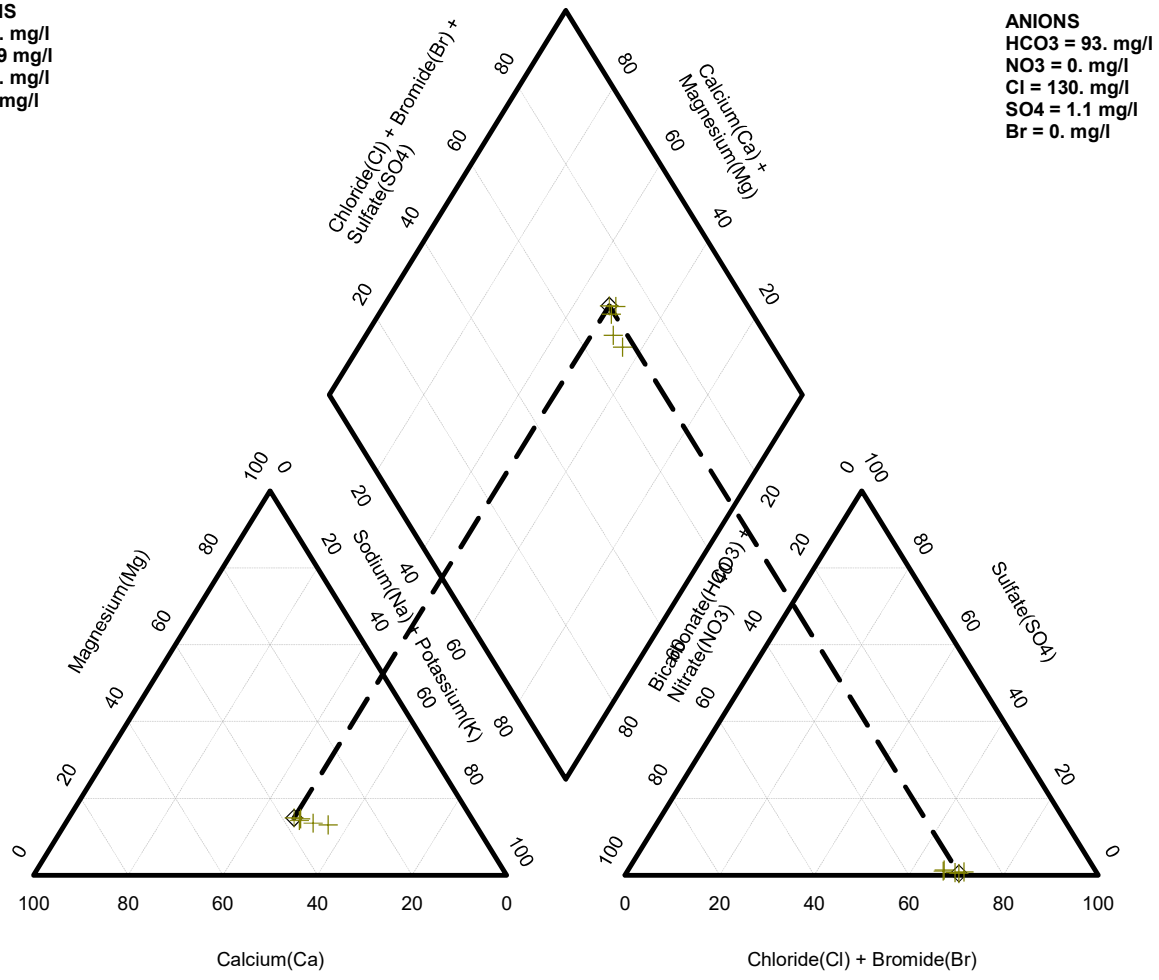
ANIONS
HCO3 = 61. mg/l
NO3 = 0.8 mg/l
Cl = 130. mg/l
SO4 = 4.3 mg/l
Br = 0. mg/l



WWF-3

CATIONS
Ca = 41. mg/l
Mg = 9.9 mg/l
Na = 57. mg/l
K = 4.7 mg/l

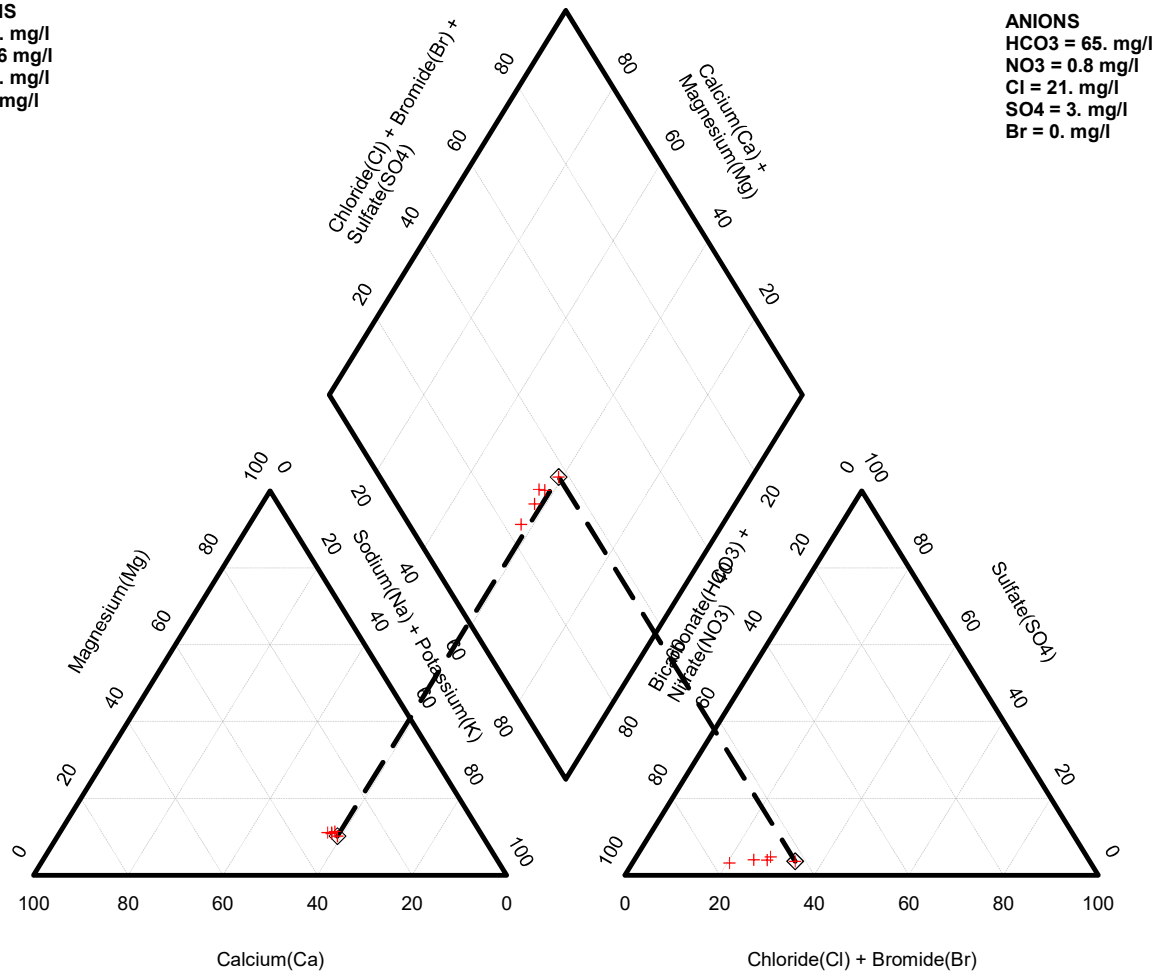
ANIONS
HCO3 = 93. mg/l
NO3 = 0. mg/l
Cl = 130. mg/l
SO4 = 1.1 mg/l
Br = 0. mg/l



43BPC-4

CATIONS
Ca = 23. mg/l
Mg = 4.6 mg/l
Na = 48. mg/l
K = 4.8 mg/l

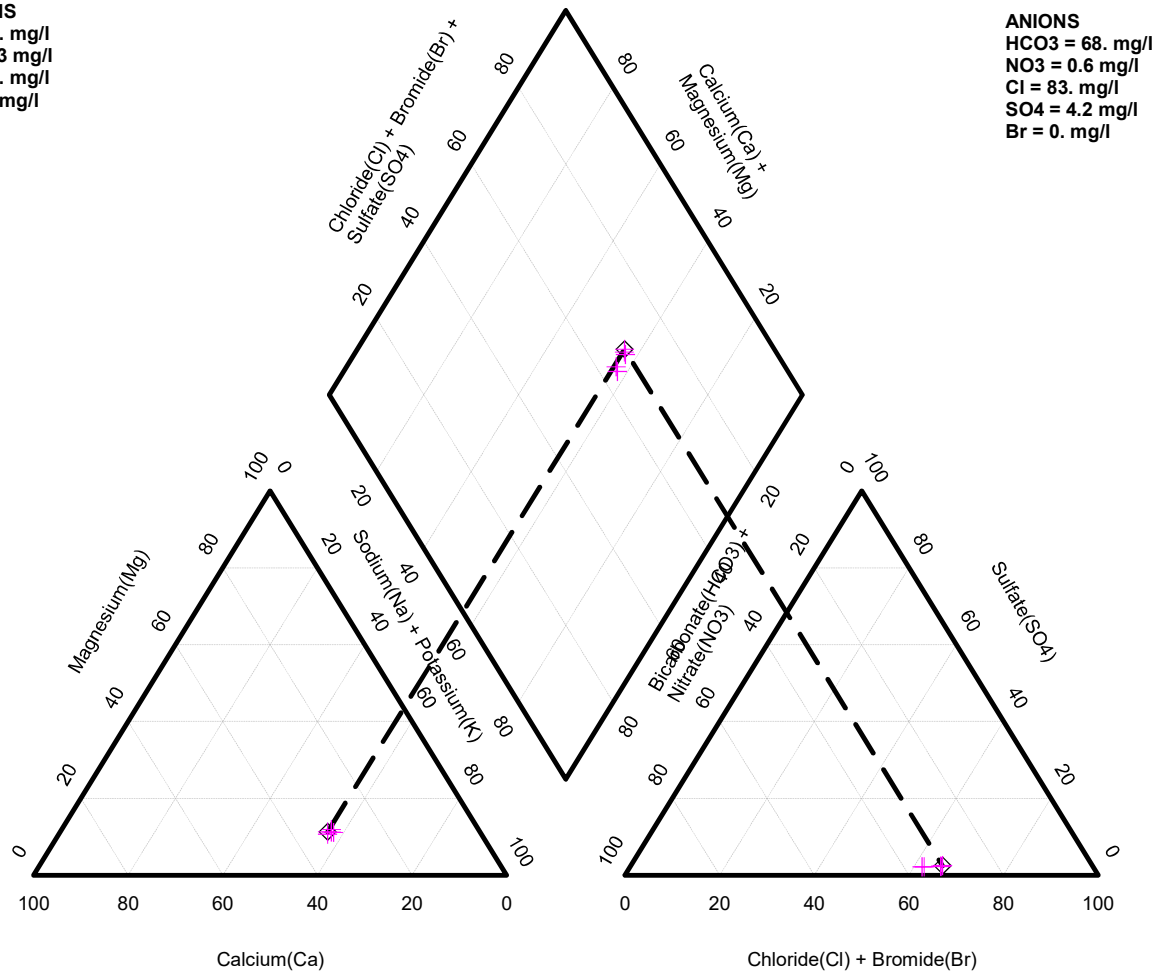
ANIONS
HCO3 = 65. mg/l
NO3 = 0.8 mg/l
Cl = 21. mg/l
SO4 = 3. mg/l
Br = 0. mg/l



BPC-R5

CATIONS
Ca = 25. mg/l
Mg = 5.3 mg/l
Na = 48. mg/l
K = 3.9 mg/l

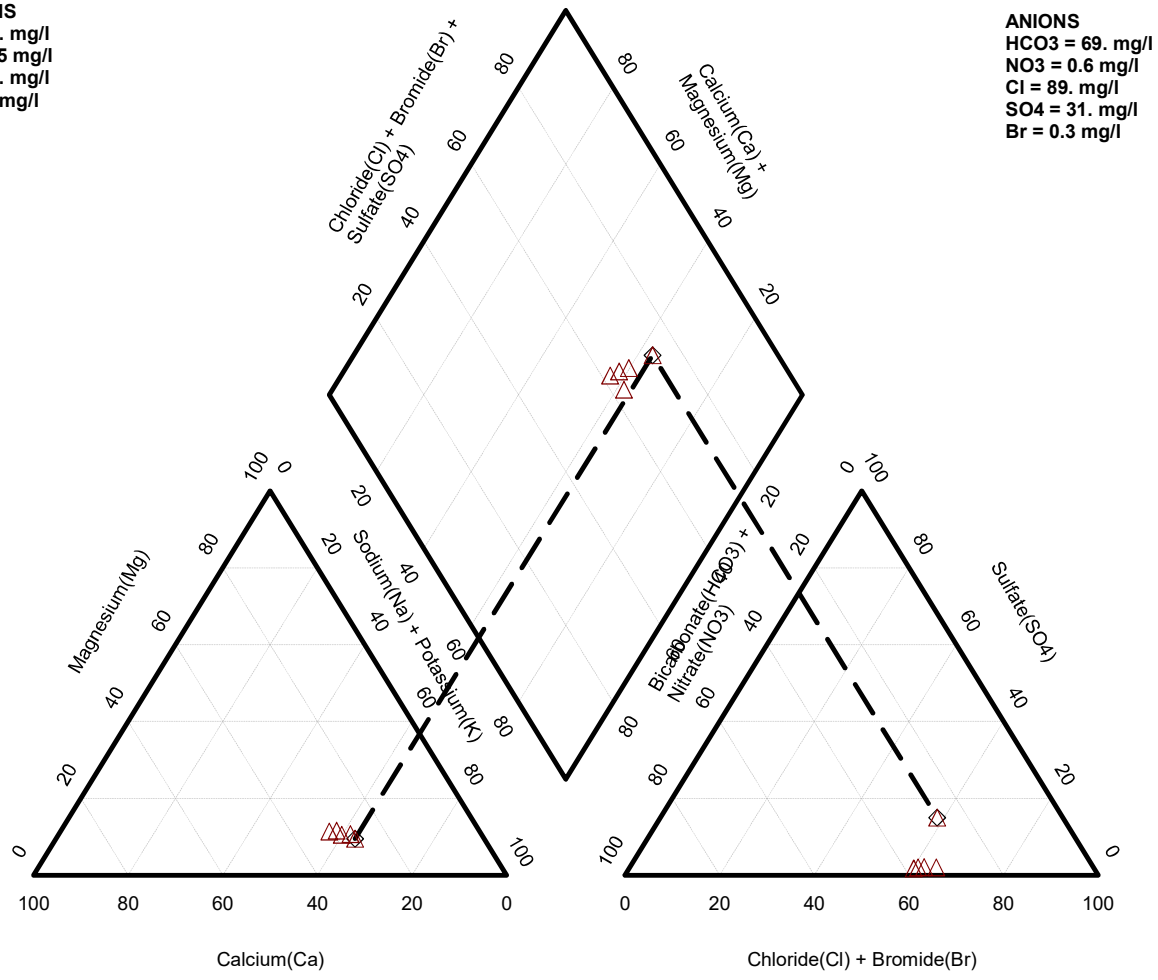
ANIONS
HCO3 = 68. mg/l
NO3 = 0.6 mg/l
Cl = 83. mg/l
SO4 = 4.2 mg/l
Br = 0. mg/l



BPC-V6

CATIONS
Ca = 26. mg/l
Mg = 5.5 mg/l
Na = 62. mg/l
K = 12. mg/l

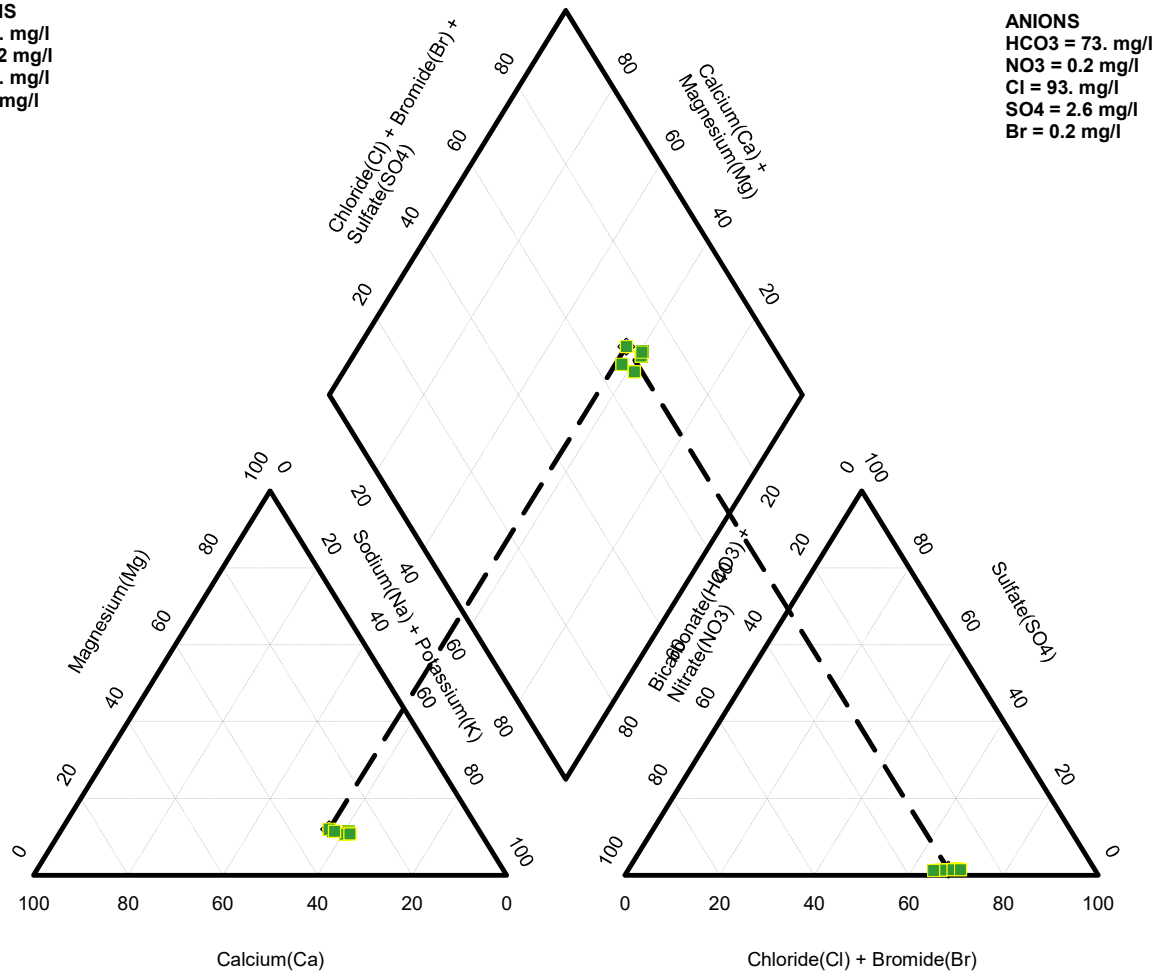
ANIONS
HCO3 = 69. mg/l
NO3 = 0.6 mg/l
Cl = 89. mg/l
SO4 = 31. mg/l
Br = 0.3 mg/l



BPC-C7

CATIONS
Ca = 27. mg/l
Mg = 6.2 mg/l
Na = 53. mg/l
K = 4.2 mg/l

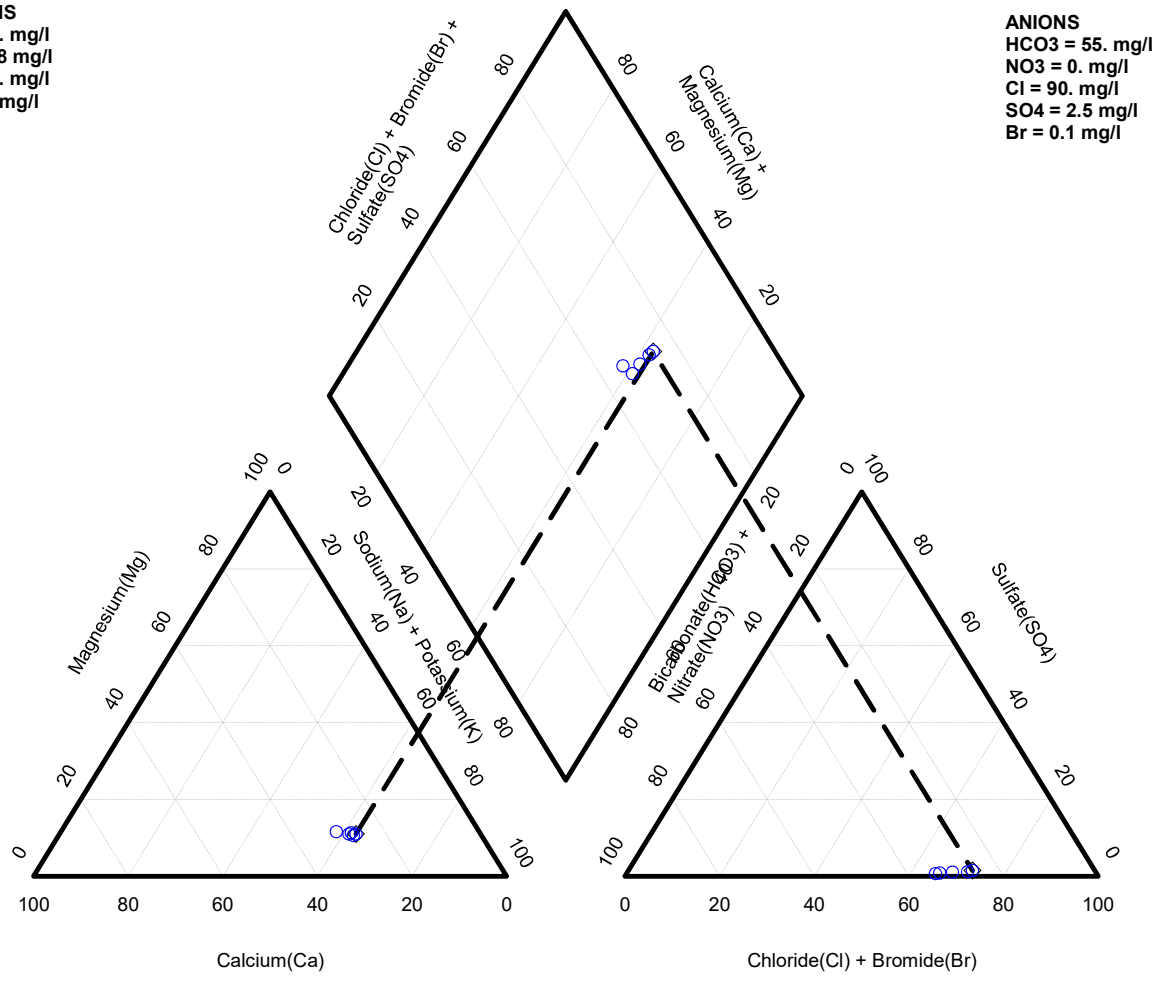
ANIONS
HCO3 = 73. mg/l
NO3 = 0.2 mg/l
Cl = 93. mg/l
SO4 = 2.6 mg/l
Br = 0.2 mg/l



BPC-B8

CATIONS
Ca = 23. mg/l
Mg = 5.8 mg/l
Na = 60. mg/l
K = 4.6 mg/l

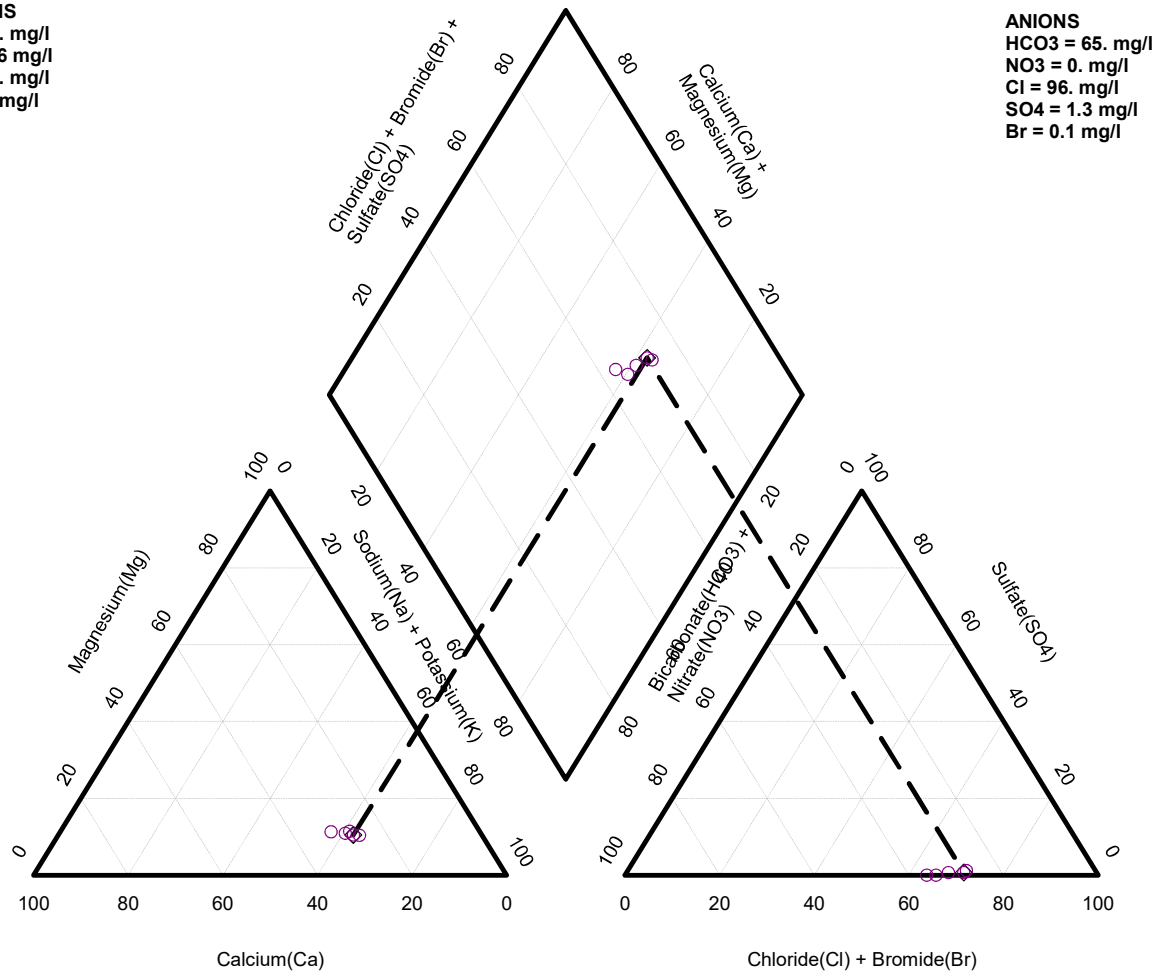
ANIONS
HCO3 = 55. mg/l
NO3 = 0. mg/l
Cl = 90. mg/l
SO4 = 2.5 mg/l
Br = 0.1 mg/l



BPC-W9

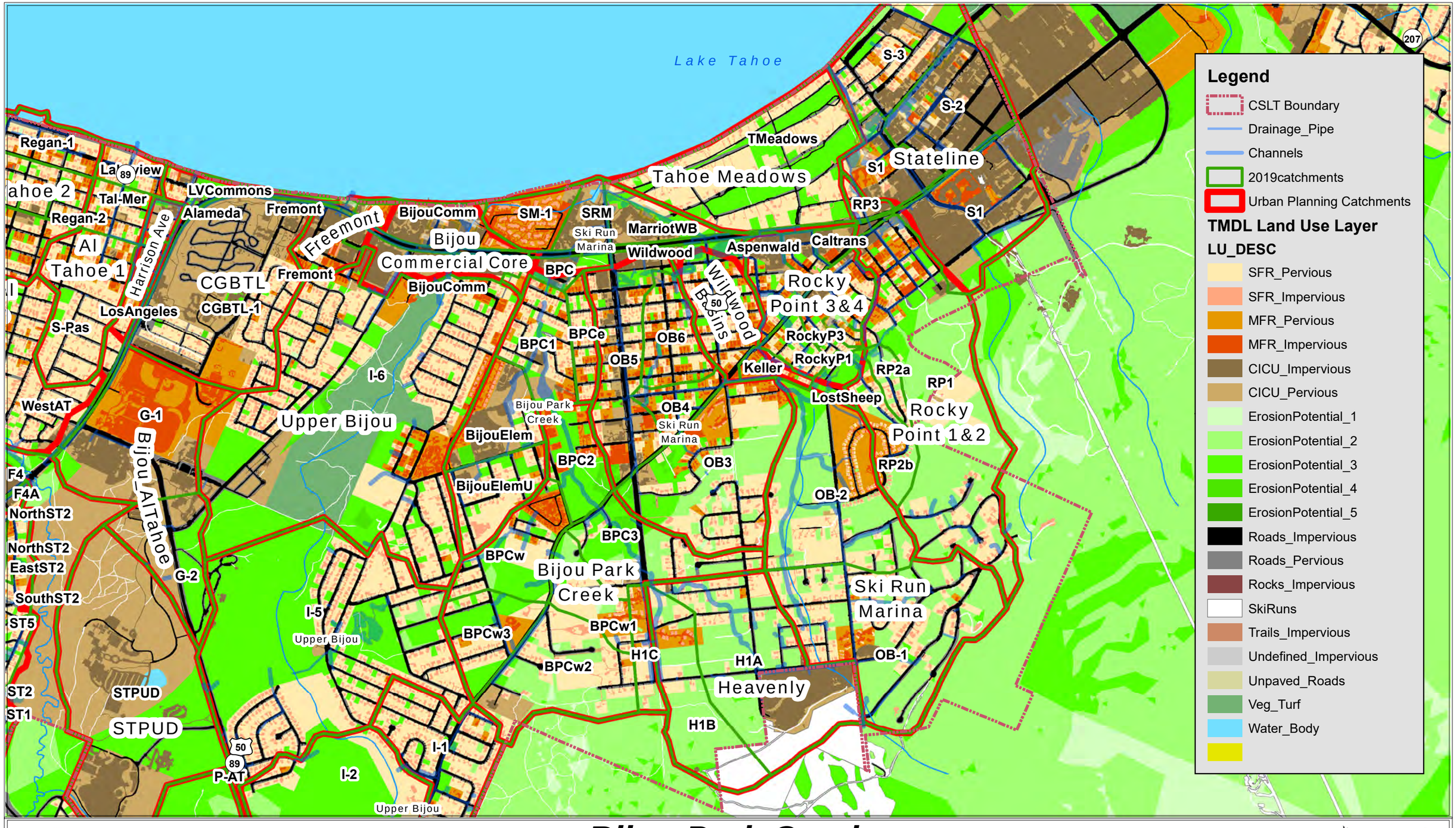
CATIONS
Ca = 24. mg/l
Mg = 5.6 mg/l
Na = 60. mg/l
K = 5.4 mg/l

ANIONS
HCO3 = 65. mg/l
NO3 = 0. mg/l
Cl = 96. mg/l
SO4 = 1.3 mg/l
Br = 0.1 mg/l



Appendix 2
PLRM Land Use Map

DRAFT



Legend

- CSLT Boundary
- Drainage_Pipe
- Channels
- 2019catchments
- Urban Planning Catchments

TMDL Land Use Layer

LU_DESC

- SFR_Pervious
- SFR_Impervious
- MFR_Pervious
- MFR_Impervious
- CICU_Impervious
- CICU_Pervious
- ErosionPotential_1
- ErosionPotential_2
- ErosionPotential_3
- ErosionPotential_4
- ErosionPotential_5
- Roads_Impervious
- Roads_Pervious
- Rocks_Impervious
- SkiRuns
- Trails_Impervious
- Undefined_Impervious
- Unpaved_Roads
- Veg_Turf
- Water_Body

Department Of
Public Works
Engineering

Bijou Park Creek

Pollutant Load Reduction Model: Land Use Input

Lake Tahoe TMDL

0 0.125 0.25 0.5
Miles

Jason Burke
City of South Lake Tahoe
9/6/2019

Appendix 3
BPC PLRM Model Output

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	Catchment Name	Volume (acre-feet/yr)	FSP (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	Notes
Bijou Park Creek	BPCw1	1.7	555	3	11	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPCw2	4.2	1957	8	31	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPCw3	4.2	1957	8	31	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	H1A	27	16004	57	200	Road Condition unchanged, no attempt to reflect Filters
Bijou Park Creek	H1B	2.5	1139	5	29	Road Condition unchanged
Bijou Park Creek	H1C	3.5	1865	7	29	Road Condition unchanged
Bijou Park Creek	BPCw	5	1745	8	37	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPC2	3.5	1361	6	27	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPC3	5.9	5570	17	54	Road Condition unchanged
Bijou Park Creek	Bijou ElemU	6	2262	10	41	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	Bijou Elem	8.4	4097	16	59	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPC1	6.5	3218	13	47	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPCe	1.9	600	3	13	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
Bijou Park Creek	BPC	5.4	2798	10	38	Road Contion 3.0 (reflects improved sanding and recovery efforts since 2004)
	Total	**85.7**	**45128**	**171**	**647**	

Various Model Runs for the Heavenly Parking Lot - Trying to account for Filters

Bijou Park Creek	H1A	27	13538	48	168	30% Parcel BMP
						Using WDR 2018 Annual Report - annual Average effluent (Table 2-10)
						http://www.trpa.org/wp-content/uploads/Heavenly-MMP-Annual-Report-2018-Full-Copy.pdf
Modeling filters as stormwater treatment with effluent concentrations from Heavely WDR monitoring report						NTU 27.6, TSS 15.4 TN 0.54 TP 0.15
Bijou Park Creek	H1A	27	7681	29.8	105.5	max treatment 0.479 cfs
Bijou Park Creek	H1A	27	10254	38.6	136	max treatment 0.211 cfs

Appendix 4
Map of Public Lands

DRAFT

Bijou Park Creek Restoration Project Public Land

WILDSCAPE ENGINEERING

0 0.13 0.25 0.5 Miles

Public Land in CSLT
OWNER_NAME
- CALIFORNIA TAHOE CONSERVANCY
- CITY OF SOUTH LAKE TAHOE
- LAKE TAHOE UNIFIED SCHOOL DIST
- SLT SUCCESSOR AGENCY
- STPUD
- UNITED STATES OF AMERICA
- Project Extent Catchments
- SLT_Boundary
- Bijou Park Creek Main Channel

N

Appendix 5
Geotechnical Boring Logs

DRAFT

Bear Engineering Group, Inc.
Earth Science Consultants

October 8, 2019
Proj No. 134-2019-.01

Carol Beahan
Wildscape Engineering, Inc.
3079 Harrison Ave Ste 5,
South Lake Tahoe, CA 96150

Subject: Subsurface Exploration (Boring Logs)
South Lake Tahoe

Dear Carol;

As you requested we have prepared the Log of Borings for your review. **Field Exploration**

Field exploration of the site was conducted on October 7, 2019, a total of three Borings at the locations described in the Log of Borings. The borings were drilled by a track mounted drilling unit using a 4-inch solid stem auger. Samples were gathered by driving a 2-inch Modified California Sampler at 18-inch intervals into underlying soil using a 140-pound hammer free falling 30-inches. The number of blows required to drive the sampler was recorded in 6-inch penetration intervals. The last 12 inches of penetration is provided on the Log of Borings as penetration resistance per foot. Blow counts provided have been corrected for energy efficiency. Soil description and identification is provided in accordance with (ASTM 2488). Soil infiltration rates provided are considered to be approximate.

It has been a pleasure to be of service to you on this project. Should you have any questions concerning the discoveries, recommendations, or conclusions of the attached report, please contact this office at your earliest convenience.

Very truly yours,

Bear Engineering Group, Inc.
Mark L. Schroeder

Mark L. Schroeder, P.E., M.S.G.E.
Principal Engineer

Bear Engineering Group

Earth Science Consultants

Page 1 of 1

Boring No. B1

Date: 10-7-19

Project No. 134-2019-01

Client: Carol Beahan (Wildscape Engineering, Inc.)

Boring Depth: 16 ft.

Ground Elev.

Location: Osgood Basin

Latititude:

Driller: HIllside Drilling

Longititude:

Drilling Type: Solid Stem Auger

Elev. (ft.)	Depth (ft.)	Sample No.	Blow Count	Lithology	Description	Dry Unit Wt. (pcf)	Moisture Content %	Plasticity Index	Unconfined Compression (psf)	% Passing #200
		1	8		Silty-sand, with trace sub-rounded gravels, medium brown, loose FILL Approx. Infiltration Rate 1.28 in/hr.					
	5				Silt, with organics wet, gray/brown, soft, some apparent cohesion, estuary type deposit, Approx. Infiltration Rate .2 to .3 in/hr.					
	10	2	38		Silty sand, tan/orange, wet, moderately cemented medium to dense, coarse-grained **NATIVE** Approx. infiltration ..2 to .4 in/hr. **GROUNDWATER** at 13 ft. increasing to about 4 ft. within 5 to 10 min.					
	15				Boring terminated at 16 ft..					
	20									
	25									
	30									

Compression Strength Penetrometer (tsf) □

Shear Strength Torvane (tsf) ○

Sym. Denotes what test was taken falling between column denotes approx. strength in tsf.

1 2 3 4 5 6

Bear Engineering Group

Earth Science Consultants

Page 1 of 1

Boring No. B2

Date: 10-7-19

Project No. 134-2019-01

Client: Carol Beahan (Wildscape Engineering, Inc.)

Boring Depth: 15 ft.

Ground Elev.

Location: Elva Court

Latititude:

Driller: HIllside Drilling

Longititude:

Drilling Type: Solid Stem Auger

Elev. (ft.)	Depth (ft.)	Sample No.	Blow Count	Lithology	Description	Dry Unit Wt. (pcf)	Moisture Content %	Plasticity Index	Unconfined Compression (psf)	% Passing #200
	5	1	12		Sand, with gravels, medium brown, loose FILL Approx. Infiltration Rate 1.68 in/hr.					
	10	2	50/4"		HARDER DRILLING (Increased torque) @ 7 ft. Sand, medium brown, with white granite deposits moderately weathered, medium coarse, NATIVE					
	15	3	50/1"		Granite rock deposits NO recovery					
					Boring terminated at 15 ft.					
	20									
	25									
	30									

Compression Strength Penetrometer (tsf) □

Shear Strength Torvane (tsf) ○

Sym. Denotes what test was taken falling between column denotes approx. strength in tsf.

1 2 3 4 5 6

Bear Engineering Group

Earth Science Consultants

Page 1 of 1

Boring No. B3

Date: 10-7-19

Project No. 134-2019-01

Client: Carol Beahan (Wildscape Engineering, Inc.)

Boring Depth: 14 ft.

Ground Elev.

Location: Herbert

Latititude:

Driller: HIllside Drilling

Longititude:

Drilling Type: Solid Stem Auger

Elev. (ft.)	Depth (ft.)	Sample No.	Blow Count	Lithology	Description	Dry Unit Wt. (pcf)	Moisture Content %	Plasticity Index	Unconfined Compression (psf)	% Passing #200
		1	6		Sand, medium brown, moist, loose medium coarse Approx. Infiltration Rate					
	5	2	16		Sand, white/ brown, moist, moist to slightly wet fine coarse with trace 1/64" rounded gravels Approx. Infiltration Rate 1.28 in/hr. **GROUNDWATER** at 10 ft. increasing to about 7 ft. within 5 to 10 min.					
	10	3	29		Silty sand, tan/orange, wet, medium to dense, coarse-grained NATIVE Approx. infiltration .5 to .9 in/hr.					
	15				Boring terminated at 14 ft.					
	20									
	25									
	30									

Compression Strength Penetrometer (tsf) □

Shear Strength Torvane (tsf) ○

Sym. Denotes what test was taken falling between column denotes approx. strength in tsf.

1 2 3 4 5 6

Appendix 6
Biological Resources Report

DRAFT

Bijou Park Creek Watershed Restoration Project
Biological Resources Report

December 10, 2019



Prepared By:

Catalyst ENVIRONMENTAL SOLUTIONS

Prepared For:

WILDSCAPE ENGINEERING

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Table of Contents

SECTION 1 Introduction 1
SECTION 2 Methods 1
2.1 Project Setting 1
SECTION 3 Project Description 3
SECTION 4 Existing Biological Communities 6
4.1 Jeffrey Pine Forest 6
4.2 Aspen Groves 6
4.3 Willow Thickets 6
4.4 Wet Meadows 6
SECTION 5 Vertebrate Species Observed 9
SECTION 6 Special Status Species and Habitats 10
6.1 Special Status Plants 10
6.2 Special Status Animals 11
6.3 Riparian and Wetland Areas 11
SECTION 7 Conclusions 18
7.1 CEQA Environmental Checklist Questions 18
SECTION 8 References 22

Figures

Figure 1. Project Location. 4
Figure 2. Habitat Survey Area and Project Components. 5
Figure 3. Vegetation Communities Observed within the Construction Footprint 8
Figure 4. National Wetlands Inventory Results for the Project Area 12

Tables

Table 1. CNDDB Special Status Species Recorded within Five Miles of the Project Area. 13

SECTION 1 Introduction

The Bijou Park Creek Watershed Restoration Project (Project) has been proposed by the City of South Lake Tahoe (City) to address frequent flooding and stormwater management challenges in the Bijou Park Creek watershed. The City has contracted Wildscape Engineering, Inc. to prepare a restoration design plan and conduct environmental review under the California Environmental Quality Act (CEQA) and the Tahoe Regional Planning Agency (TRPA) for the Project. This biological technical report was prepared in order to develop a site-specific understanding of the potential presence of plant and animal species, as well as habitat types, and will be used to assist in the development of the CEQA analysis for biological resources for the proposed Bijou Park Creek Project. This level of assessment is meant to guide the City in making initial determinations for compliance with CEQA and TRPA, recommendations for further study, and/or mitigation, restoration, and enhancement opportunities.

The watershed is highly altered due to construction of the Heavenly Ski Resort California Base Lodge parking lot, which truncated a portion of the Keller Canyon drainage at Saddle Road, rerouting approximately 260 acres of drainage area from the Keller Canyon watershed to the Bijou Park Creek watershed. Bijou Park Creek now receives more water and at higher flow rates than the creek can convey, resulting in flooding of adjacent roads and residential properties. In addition to the peak high flow volumes, the waters entering Bijou Park Creek tend to be sediment laden, exacerbating aggradation of the channel within the Stream Environment Zone (SEZ[1]). The City routinely performs sediment removal and utilizes sediment settling channels. The creation of stormwater treatment infiltration basins is severely limited by the persistently high water table in the area.

To develop a site-specific understanding of the potential species and type/quality of habitat present in the Project Area, professional biologists performed a habitat-level biological survey as well as a desktop review of the California Natural Diversity Database (CNDDB) for historical sensitive species records was conducted for the Project Area.. This report presents the findings of that survey.

[1] An SEZ is a designation unique to the Lake Tahoe Region and defines an area that provides a variety of highly valued services, including water quality maintenance through nutrient cycling and sediment retention, flood attenuation, infiltration and groundwater recharge, open space, scenic and recreational enjoyment, wildlife habitat, and wildfire abatement, among other functions and values. SEZs include perennial, intermittent, and ephemeral streams; wet meadows, marshes, and other wetlands; riparian areas, beaches, and other areas expressing the presence or influence of surface or ground water.

SECTION 2 Methods

This biological technical report was prepared through both desktop analysis and reconnaissance-level biological survey. The purpose of the field survey was to characterize existing biological communities and to determine if suitable habitat for special status plant and animal species is present. The potential for impacts to special status species were determined based on a comparison of existing habitat conditions and presence of unique habitat features, proximity of the project area to reported occurrences, and geographic range of special status species.

Resources consulted included:

- California Natural Diversity Database (CNDDB)/Spotted Owl Viewer in BIOS 5 (CDFW 2019a)
- CNDDB RareFind 5 (CDFW 2019a)
- A Manual of California Vegetation, 2nd Edition (Sawyer et al. 2009)
- California Native Plant Society (CNPS) Inventory of Rare and Endangered Vascular Plants of California online inventory (CNPS 2019)
- CDFW List of Fully Protected Animals (CDFW 2019b)
- CalFlora Information on Wild California Plants (CalFlora 2019)
- 2015 Threshold Evaluation (TRPA 2016)
- Trees and Shrubs of the Pacific Northwest (Turner and Kuhlmann 2014)
- The Cornell Lab of Ornithology All About Birds (Cornell University 2019)
- Lake Tahoe Watershed Assessment (USDA 2000)
- 2015 Heavenly Mountain Resort Epic Discovery Project EIR/EIS (TRPA et al. 2015)

The CNDDB searches were based on a five-mile radius of the Project Area.

The project footprint used for this survey included the full extent of all potential work areas in South Lake Tahoe in the vicinity of Bijou Park Creek as provided by Wildscape Engineering on October 7, 2019 (Figure 1). The survey consisted of observing all the potential work areas on foot, photographing and evaluating the habitat present, and documenting all plant and animal species that were identifiable at the time of the field visit. The survey was conducted with the aid of binoculars. Visual cues, calls, songs, and direct observations were used to identify wildlife species. The number of species observed on the sites is limited due to activity period and seasonal nature of wildlife, rarity of some species, limited field surveys, and extent of the area surveyed.

Field surveys were completed on October 17, 2019 by Emily Merickel, M.S., Project Scientist, and Jo Anna Beck, M.S., Environmental Scientist, from Catalyst Environmental Solutions (Catalyst) with assistance from Meryl Kruskopf, E.I.T., Staff Engineer from Wildscape Engineering.

2.1 PROJECT SETTING

The project is located in the city of South Lake Tahoe in El Dorado County, California (Figure 1). The city is located on the south shore of Lake Tahoe on the southern end of the Tahoe Basin. The majority of the project footprint is located in the city between Bijou Meadow and Ski Run Boulevard with some smaller potential projects located closer to Lake Tahoe Boulevard (Highway 50) (Figure 2). The approximate footprint of each site is shown in Figure 1. Representative photographs are included as Attachment A.

The city is in a mountainous environment. There are three primary watersheds that drain the project area, all of which drain to Lake Tahoe at various outfalls. Bijou Park Creek is an intermittent stream that

flows west through a residential neighborhood. Adjacent land uses include single-family homes, apartment buildings, restaurants, shopping centers, and a school.

SECTION 3 Project Description

The proposed Project would improve flood control through the installation of culverts and gravity flow off-line retention/infiltration basins, as well as drastically reduce the need for sediment removal within the Bijou Park Creek SEZ. The Project includes several potential engineering and design options to address these concerns. Proposed project activity footprints were surveyed, including:

1. *Bijou Meadow Diversion* – This project proposes to relieve flow pressure to Bijou Park Creek by diverting flows at a point west of Ski Run Blvd and north of Needle Peak Rd via an underground pipe which would convey excess waters westward through mainly upland areas and release those waters to ~~the~~ Bijou Meadow ~~complex~~ and Bijou Creek.
2. *Aloha Basin* – A local treatment option in the vicinity of Herbert and Aloha Avenue.
3. *Bijou Park Creek Enhancement* – This project would focus on restoration of the degraded stream conditions in Bijou Park Creek west Pioneer Trail as it travels parallel to Blackwood Rd, an area of frequent flooding. Restoration activities would include hydrological modifications to the creek channel as well as revegetation and replacement of undersized culverts.
4. *Pioneer Crossing Culvert Replacement* – The culvert is undersized and would be replaced. ~~It is located in the Bijou Park Creek SEZ near Charlesworth Ct.~~
5. *Burke's Bypass* – Excess drainage from the corner of Needle Peak Rd. and Ski Run Blvd. will be routed to the Bijou Park Creek wetland complex on the west side of Ski Run Blvd.
6. *Bijou School Basin* - A new basin is proposed for a currently upland area at Spruce Ave and Peninsula Rd to address frequent flooding at the Bijou Community School and adjacent properties.
7. *Osgood Expansion* – The existing Osgood Basin would be improved and expanded and some water would be rerouted to nearby Wildwood Basin.
8. *Keller Bypass* - Divert some flow north towards Lake Tahoe and existing stormwater management basins from the southeast corner of Keller Rd and Markoffer Way.
9. *Rockwood to Blackwood Drainage Improvements* – The culverts that convey stormwater runoff in the vicinity of the Heavenly Valley Mobile Home Park and adjacent homes are undersized and frequent flooding occurs between Woodbine Rd. and Rockwood Dr. as well as between Rockwood and the property line fence at the back of the park. A new underground culvert would be installed under or around the residences and outfall into Bijou Park Creek SEZ.



Figure 1. Project Location.

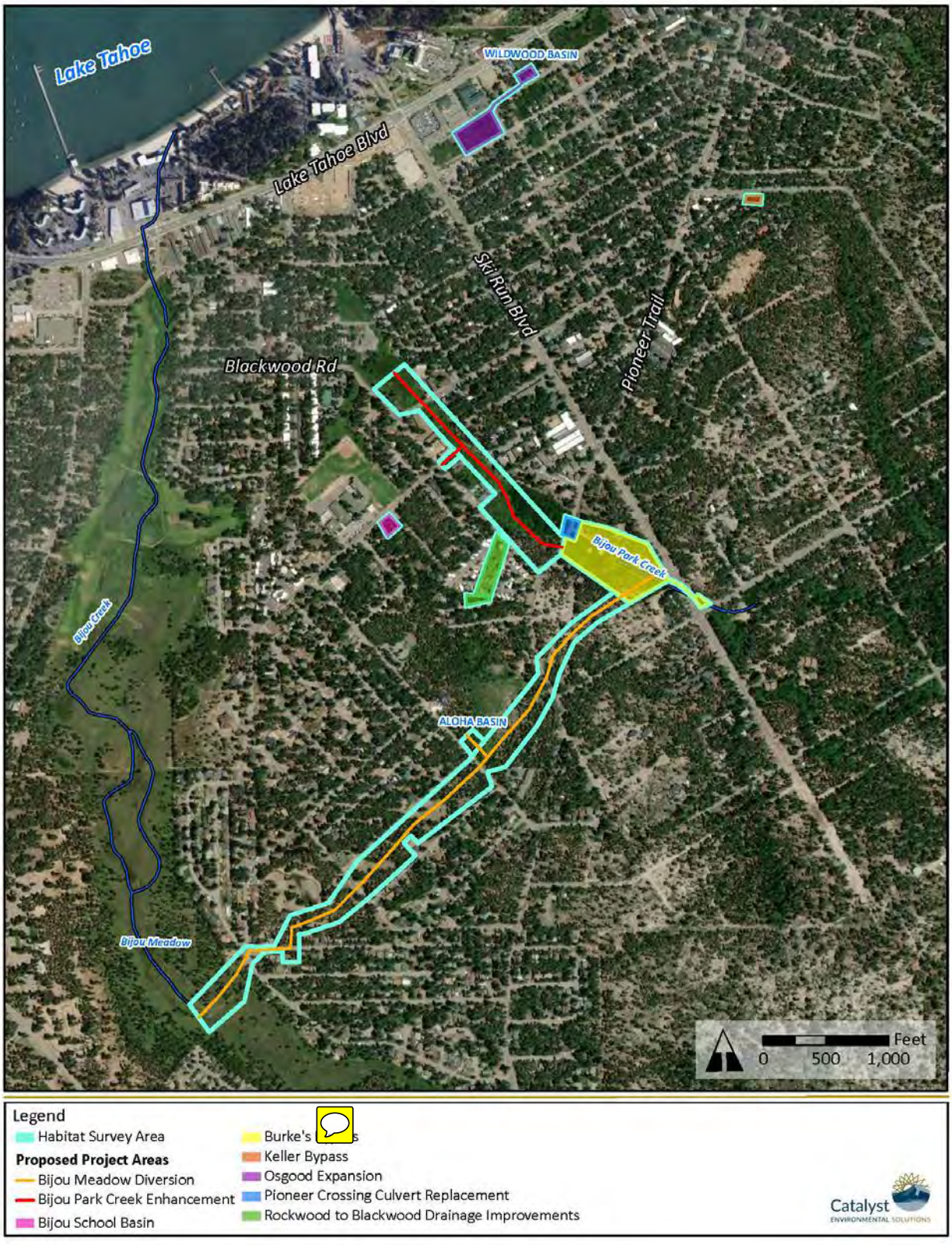


Figure 2. Habitat Survey Area and Project Components.

SECTION 4 Existing Biological Communities

The project area supports several distinct biological communities, including Jeffrey Pine Forest, quaking aspen groves, willow thickets, and wet meadows. Vegetation alliances described below generally follow Sawyer *et al*. (2009). Residential homes and properties bordered the entire project footprint. The following summarizes the biological communities observed during the field survey. Estimated acreages of each community within the proposed construction footprints are provided; however, these estimates are for reference purposes only and are based on a combination field observation and aerial imagery interpretation.

4.1 JEFFREY PINE FOREST

Upland habitat within the project area was dominated by Jeffrey pine (*Pinus jeffreyi*) Forest with variable understory mixes of basin big sagebrush (*Artemisia tridentata*), young lodgepole pine (*Pinus contorta spp. murrayana*), grasses, Wood's rose (*Rosa woodsii* var. *ultramontane*), and woodland strawberry (*Fragaria vesca*). The majority of the Bijou Creek Diversion footprint traverses Jeffrey Pine Forest, later giving way to open wet meadow at Bijou Meadow. The upland edges of the Bijou Park Creek Restoration footprint are also dominated by Jeffrey Pine Forest. Jeffrey Pine Forest accounts for approximately 28 acres of the potential project footprint.

4.2 ASPEN GROVES

Quaking aspen (*Populus tremuloides*) comprised approximately 20% of the Bijou Park Creek Restoration footprint. Aspen trees were closely associated with the creek, particularly where the creek channel was incised, and an obvious wetland or riparian fringe was present. The understory of the aspen groves consisted of Sierra currant (*Ribes nevadense*) and thick mats of *Carex* sp. immediately adjacent to the creek. Jeffrey pine saplings were present towards the upland edge of the aspen groves. Sporadic mountain alder (*Alnus incana* ssp. *tenuifolia*) were observed within the aspen groves as well. Aspen groves accounted for approximately 3.8 acres of the surveyed construction footprint.

4.3 WILLOW THICKETS

Willow thickets comprised the northwestern portion of the Bijou Park Creek Restoration footprint. Lemmon's willow (*Salix lemmonii*) and shining willow (*Salix lucida* spp. *lasiandra*) were present in the shrub and tree canopies with grasses and Wood's rose in the understory. Willow thickets accounted for approximately 4.1 acres of the surveyed construction footprint.

4.4 WET MEADOWS

Wet meadows occurred interspersed with aspen groves and willow thickets and accounted for approximately 0.4 acres of the Bijou Park Creek Restoration footprint. Bijou Meadow, the terminus of the proposed Bijou Meadow Diversion, was classified as a wet meadow, although no saturation was observed during this survey. Evidence of annual flooding and drainage patterns were apparent. The meadow was dominated by grass species with scattered Jeffrey pine and lodgepole pine present along the meadow fringes. Approximately 2.8 acres of Bijou Meadow falls within the potential construction footprint.

Osgood and Wildwood basins were also classified as wet meadows. These areas receive runoff from the neighborhood and standing water was present. Willow, aspen, and lodgepole pine were present in the tree canopy of these basins and *Rosa* sp., grasses, and sedges were abundant in the shrub and herbaceous strata.



Figure 3. Vegetation Communities Observed within the Construction Footprint.

SECTION 5 Vertebrate Species Observed

Birds were the most abundant and active animals observed during the field survey. Some mammals or signs were also observed. Due to the time of year and air temperature (35-50° Fahrenheit/1.6-10° Celcius), we did not expect to observe amphibians or reptiles without engaging in a more targeted sampling effort. Likewise, no sampling for fish was conducted. Direct or indirect observations of vertebrate wildlife within the Project Area included the following:

Birds

- American Robin (*Turdus migratorius*)
- Dark-eyed Junco (*Junco hyemalis*)
- Hairy Woodpecker (*Leuconotopicus villosus*)
- Mountain Chickadee (*Poecile gambeli*)
- Red-tailed Hawk (*Buteo jamaicensis*)
- Steller's Jay (*Cyanocitta stelleri*)
- Yellow-rumped Warbler (*Setophaga coronata*)

Mammals

- black bear scat (*Ursus americanus*)
- chipmunk (*Tamias* sp.)
- Douglas squirrel (*Tamiasciurus douglasii*)
- mule deer scat (*Odocoileus hemionus*)
- raccoon scat (*Procyon lotor*)

Amphibians and Reptiles

- No amphibians or reptiles were observed during the field survey.

Fish

- No fish were observed during the field survey.

SECTION 6 Special Status Species and Habitats

In California, special status species include those plants and animals that are afforded legal protection under the federal and California Endangered Species Acts (ESA and CESA, respectively) and other regulations. Consideration of these species must be included during project evaluation in compliance with CEQA and in consultation with state and federal resource agencies. Special status species in California include, but may not be limited to:

- Species listed or proposed for listing as threatened or endangered under the federal ESA.
- Species designated as a sensitive, special-interest, or threshold species by TRPA.
- Species listed or proposed for listing as threatened or endangered under the CESA.
- Species that are recognized as candidates for future listings by agencies with resource management responsibilities such as USFWS, NOAA's National Marine Fisheries Service (NMFS), and CDFW.
- Species defined by CDFW as Species of Special Concern.
- Species classified as Fully Protected by CDFW.
- Plant species, subspecies, and varieties defined as rare or threatened by the California Native Plant Protection Act (California Fish and Game Code § 1900 et seq.).
- Plant species listed by the California Native Plant Society (CNPS) as List 1 and 2 and some List 3 plants under CEQA (CEQA Guidelines §15380).
- Species that otherwise meet the definition of rare, threatened, or endangered pursuant to §15380 of the CEQA guidelines.

The CNDBB database was the primary tool used to identify a list of potential special status species that could occur in the project area. Twenty-three special status species have been mapped within five miles of the project area. None of these species was observed during the survey; however, some may occur based on the presence of suitable habitat (Table 1).

In recognition of the importance of wildlife to the Lake Tahoe Basin, the TRPA established in Resolution 82-11 the adopted environmental threshold standards for wildlife. There are two indicator reporting categories in wildlife threshold category: 1) special interest species, and 2) habitats of special significance. Special interest species include bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), golden eagle (*Aquila chrysaetos*), peregrine falcon (*Falco peregrinus*), northern goshawk (*Accipiter gentilis*), and mule deer as well as the broad category of waterfowl. Habitats of Special Significance include habitats consisting of deciduous trees, wetlands, and meadows.

6.1 SPECIAL STATUS PLANTS

The background literature review identified the potential presence of a number of special status plant species within five miles of the Project Area (Table 1). These species were evaluated based on the suitability of habitat observed during the field survey in addition to proximity and age of recorded sightings. Status and life history characteristics of special status plant species as well as potential for occurrence within the Project Area are described in Table 1.

No special status plant species were identified within the Project Area during the field survey. Based on the background literature review and field survey, one species, upswept moonwort (*Botrychium*

ascendens), was identified as having more than a low potential to occur in the Project Area. Measures to avoid impacts to upswept moonwort should be developed during project planning.

6.2 SPECIAL STATUS ANIMALS

The background literature review identified the potential presence of a number of special status animal species within five miles of the Project Area (Table 1). These species were evaluated based on the suitability of habitat observed during the field survey in addition to proximity and age of recorded ss. Status and life history characteristics as well as potential for occurrence within the Project Area are described in Table 1.

No special status animal species were observed during the field survey, with the exception of mule deer droppings. Mule deer are considered a Special Interest Species by TRPA because they are a native wildlife species that is aesthetically pleasing to residents and visitors. Mule deer have no additional protections under federal or state regulations. Based on the background literature review and field survey, four species, Long-eared Owl (*Asio otus*), Sharp-shinned Hawk (*Accipiter striatus*), western bumblebee (*Bombus occidentalis*), and Willow Flycatcher (*Empidonax trailii*), were identified as having more than a low potential to occur in the Project Area. Of these species, Willow Flycatcher is the only species listed as endangered by the CESA. Western bumblebee is a candidate for listing under the CESA. Long-eared owl is a CDFW Species of Special Concern and Sharp-shinned Hawk is on the CWFW Watch List. Measures to avoid impacts to these species should be developed during project planning.

6.3 RIPARIAN AND WETLAND AREAS

Riparian and wetland areas are categorized as Habitats of Special Significance in the Lake Tahoe Basin (TRPA 2016). These riparian habitats (meadows, marshes, and deciduous riparian areas) provide habitat for a diverse assemblage of wildlife species in the Lake Tahoe Basin. The project footprint of the Bijou Park Creek Restoration Project falls within the Bijou Park Creek SEZ and largely consists of these sensitive habitats.

Bijou Park Creek and its riparian fringe and associated wet meadows are likely considered jurisdictional Waters of the United States (WoUS) and Waters of the State (WoS). These areas are mapped as Palustrine Scrub-Shrub (PSS), Palustrine Forested (PFO), and Palustrine Emergent (PEM) wetlands by the USFWS National Wetlands Inventory (NWI) (USFWS 2019) (Figure 4). In addition, Osgood and Wildwood basins both appear to provide wetland functions. Bijou Meadow is a wet meadow with riverine and PEM wetlands mapped by the NWI. Other potential jurisdictional features are present south of the Heavenly Valley Mobile Home Park between Woodbine Rd and Rockwood Drive, and between Rockwood Drive and the property line fence of the park.

Wetlands and waters are regulated by the U.S. Army Corps of Engineers (Corps) under Section 404 of the federal Clean Water Act (CWA). Any construction resulting in fill or loss of wetland or waters, as well as work in waters, will require a permit from the Corps. Under Section 401 of the CWA, the Corps is required to meet state water quality regulations prior to granting a section 404 permit. This is accomplished by application to the State Water Quality Control Board for Section 401 certification that requirements have been met.

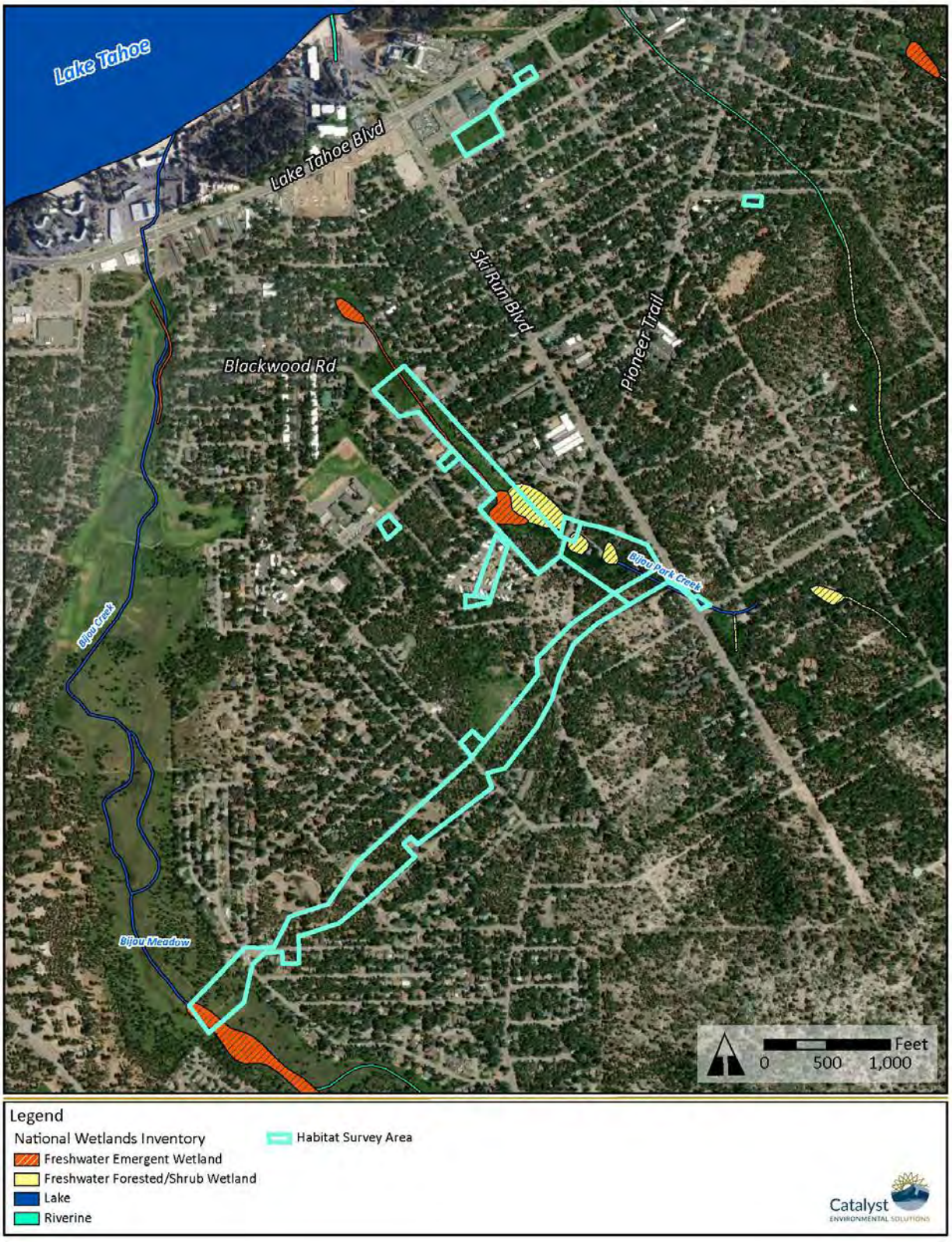


Figure 4. National Wetlands Inventory Results for the Project Area.

Table 1. CNDDB Special Status Species Recorded within Five Miles of the Project Area.

Common Name	Scientific name	Most Recent Record	Federal Status	State Status	Rare Plant Rank[A]	CDFW Status[B]	Habitat Requirements	Likelihood of occurrence in the Project Area
Plants								
Broad-nerved hump moss	*Meesia uliginosa*	2014	None	None	2B.2	NA	Fens, peat bogs, boreal-low alpine areas (Dillingham 2005).	Not Expected No suitable high pH wetland habitats present in the Project Area.
Galena Creek rockcress	*Arabis rigidissima var. demota*	2015	None	None	1B.2	NA	Sandy to rocky soils or outcrops derived from granitic or volcanic materials. Can occur in drainageways, near meadow edges, or in other moisture accumulating microsites, generally in dry openings in fir, pine, or aspen communities (NDCNR 2019).	Low Potential to Occur Jeffrey Pine Forest and aspen groves in the Project Area may support this species; however, recordings of this species within 5 miles of the Project Area occur above 8,500 feet elevation.
Marsh skullcap	*Scutellaria galericulata*	2014	None	None	2B.2	NA	Wetlands and meadows (CNPS 2019b).	Low Potential to Occur Potions of the Project Area consist of open wet meadows; however, all local observations of this species are associated with Tallac and Taylor creek marshes or Emerald Bay near Lake Tahoe.
Mingan moonwort	*Botrychium minganense*	2017	None	None	2B.2	NA	Coniferous forests and marshy areas such as swamps (CalFlora 2019).	Low Potential to Occur Although suitable habitat may be present, this species is very uncommon throughout most of its range.
Scalloped moonwort	*Botrychium crenulatum*	2016	None	None	2B.2	NA	Freshwater wetlands and meadows (CalFlora 2019).	Low Potential to Occur Species is very uncommon throughout most of its range.
Tahoe draba	*Draba asterophora var. asterophora*	2015	None	None	1B.2	NA	Rocky habitat in Lodgepole Forest and Subalpine Forest (CNPS 2019b).	Not Expected No suitable rocky, alpine habitat is present in the Project Area.
Tahoe yellow cress	*Rorippa subumellata*	2016	None	Endangered	1B.1	NA	Sandy beach shorelines of Lake Tahoe (CDFW 2013).	Not Expected No suitable beach habitat in the Project Area. This species was not observed during the survey.

Common Name	Scientific name	Most Recent Record	Federal Status	State Status	Rare Plant Rank[A]	CDFW Status[B]	Habitat Requirements	Likelihood of occurrence in the Project Area
Upswept moonwort	*Botrychium ascendens*	2010	None	None	2B.3	NA	Yellow pine forests, seeps, roadsides, disturbed sites (CalFlora 2019).	Moderate Potential to Occur Jeffrey Pine forest throughout the Project Area may provide suitable habitat. Species has been mapped within 0.5 miles of the Project Area.
Watershield	*Brasenia schreberi*	2002	None	None	2B.3	NA	Wetlands, ponds, lakes, slow-moving streams (CalFlora 2019).	Low Potential to Occur No permanent ponds or suitable standing water is present in the Project Area except a small pool near Blackwood Road where water backs up behind a concrete retaining wall.
Insects								
Western bumblebee	*Bombus occidentalis*	1975	None	Candidate Endangered	NA	None	Meadows with flowering plants present in spring, summer, and fall. Overwinter in underground burrows.	Moderate Potential to Occur Bijou Meadow likely provides the necessary floral abundance for this species.
Fish								
Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi*	1939	Threatened	None	NA	None	Wide range of habitats, including lakes and streams (UC Davis 2019).	Not Expected Permanent, flowing streams are not present in the Project Area. Bijou Park Creek was dry throughout much of the project area and undersized culverts create fish passage barriers upstream (CalFish 2019).
Lahontan mountain sucker	*Catostomus platyrhynchus*	2012	None	None	NA	Species of Special Concern	Clear mountain streams with a moderate gradient and a stream substrate composed of boulders, sand, or rubble. May also live in large rivers, turbid streams, and lakes (UC Davis 2019).	Not Expected Permanent, clear, flowing streams are not present in the Project Area. Bijou Park Creek was dry throughout much of the Project Area.
Amphibians								
Northern leopard frog	*Lithobates pipiens*	1970	None	None	NA	Species of Special Concern	Grasslands, wet meadows, potholes, forests, woodland, brushlands, springs, canals, bogs, marshes, reservoirs. Generally prefers permanent	Low Potential to Occur Wet meadows and flowing water associated with Bijou Park Creek may provide suitable habitat; however, CNDDB records are >40 years old and associated with Fallen Leaf Lake approximately 4 miles west of the Project Area.

Common Name	Scientific name	Most Recent Record	Federal Status	State Status	Rare Plant Rank[A]	CDFW Status[B]	Habitat Requirements	Likelihood of occurrence in the Project Area
							water with abundant aquatic vegetation (Nafis 2016).	
Sierra Nevada yellow-legged frog	*Rana sierrae*	1935	Endangered	Threatened	NA	Watch List	Montane riparian habitats in pine forests and wet meadows above 6,000 feet elevation (Nafis 2016).	Low Potential to Occur Species has not been recorded within 5 miles of the Project Area since 1913 when the species was identified at Fallen Leaf Lake and 1935 when it was identified at Cold Creek/Star Lake area.
Southern long-toed salamander	*Ambystoma macrodactylum sigillatum*	2014	None	None	NA	Species of Special Concern	Alpine meadows, high mountain ponds and lakes (Nafis 2016).	Low Potential to Occur Large bodies of standing water that would support breeding and foraging for this species were not present in the Project Area. Last recorded observation of the species within 5 miles of the Project Area was at Fallen Leaf Lake.
Birds								
Bank Swallow	*Riparia riparia*	1976	None	Threatened	NA	None	Nests in colonies in vertical banks of dirt or sand, usually along rivers or ponds (Audubon 2019).	Not Expected No suitable nesting habitat is present for this species in the Project Area.
California Spotted Owl	*Strix occidentalis occidentalis*	2016	Candidate	None	NA	Species of Special Concern	Breeds and roosts in old-growth forests with large old trees and snags, high basal areas of trees, dense canopies (>70% canopy closure), multiple canopy layers, and downed, woody debris (Shuford and Gardali 2008).	Low Potential to Occur The Project Area lacks old-growth forest and forest of appropriate density and complexity. Nests, breeding pairs, and individual observations have been frequently recorded in the vicinity, but at higher elevations (e.g., Tahoe Mountain and north of Trimmer Peak) and outside of the urban area.

Common Name	Scientific name	Most Recent Record	Federal Status	State Status	Rare Plant Rank[A]	CDFW Status[B]	Habitat Requirements	Likelihood of occurrence in the Project Area
Long-eared Owl	*Asio otus*	2015	None	None	NA	Species of Special Concern	Nests in conifer, oak, riparian, pinyon-juniper, and desert woodlands that are either open or are adjacent to grasslands, meadows, or shrublands (Shuford and Gardali 2008).	Moderate Potential to Occur Suitable nesting and foraging habitat is present, particularly in the Bijou Meadow area of the Project. Species is considered uncommon during spring, summer, and winter but common in fall by the Tahoe Institute for Natural Science (TIN 2016).
Northern Goshawk	*Accipiter gentilis*	1981	None	None	NA	Species of Special Concern	Old-growth forests consisting of ponderosa pine, Jeffrey pine, white fir, and lodgepole. Large snags and downed logs that provide habitat for prey. Sensitive to urbanization (Shuford and Gardali 2008).	Low Potential to Occur The Project Area lies within a mixed residential and commercial area that likely deters this species. The Project Area also lacks extensive old-growth forest.
Osprey	*Pandion haliaetus*	1993	None	None	NA	Watch List	Nests near clear, open water. Preys mostly on fish (Audubon 2019).	Not Expected No suitable nesting or foraging habitat is present for this species in the Project Area.
Sharp-shinned Hawk	*Accipiter striatus*	2004	None	None	NA	Watch List	Mixed or coniferous forests, open deciduous woodlands, thickets, edges. Feeds mostly on small birds in dense cover (Audubon 2019).	Moderate Potential to Occur Suitable nesting and foraging habitat is present. Species is considered uncommon during spring, summer, and winter but common in fall by the TIN (2016).
Willow Flycatcher	*Empidonax trailii*	2004	None	Endangered	NA	None	Shrubby vegetation in meadow and riparian communities with high water tables, standing water, and willow trees between 6.5 and 13 feet in height. Prefer stands greater than 1 acre in size (USDA 2019).	Moderate Potential to Occur Willow thickets of adequate size and density to support breeding pairs are present in some portions of the Bijou Park Creek Restoration Area project footprint. Species is considered rare by the TIN (2016); however, species has historically occurred approximately 0.5 miles west in the riparian zone of Trout Creek. Although that record is old (1935), more recent records (2004) of the species are available for the Tallac and Taylor

Common Name	Scientific name	Most Recent Record	Federal Status	State Status	Rare Plant Rank[A]	CDFW Status[B]	Habitat Requirements	Likelihood of occurrence in the Project Area
								Creek, approximately 5 miles west of the Project Area.
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	1935	None	None	NA	Species of Special Concern	Cattail and tule marshes near relatively deep water (Shuford and Gardali 2008).	Not Expected No cattail or tule marshes are present in the Project Area to support breeding or foraging.

Notes:

[A] California Rare Plant Rank (CNPS 2019)
1B – rare, threatened, or endangered in California or elsewhere

2B – rare, threatened, or endangered in California but more common elsewhere

Threat Ranks

0.1 – Seriously threatened in California (over 80% of occurrences threatened/high degree and immediacy of threat)

0.2 – Moderately threatened in California (20-80% of occurrences threatened/moderate degree and immediacy of threat)
0.3 – Not very threatened in California (less than 20% of occurrences threatened/low degree and immediacy of threat or no current threats known)

[B] CDFW
Watch List – This classification is for taxa that were previously SSCs but no longer merit SSC status or which do not meet SSC criteria but for which there is concern and a need for additional information to clarify status.
Species of Special Concern – This classification is for a species, subspecies, or distinct population of an animal native to California that is extirpated from the State, or is listed as Federally-, but not State-, threatened or endangered, or meets the State definition of threatened or endangered but has not formally been listed, or is experiencing serious (noncyclical) population declines or range retractions, or has naturally small populations exhibiting high susceptibility to risk from any factor(s) that could lead to declines that would qualify it for State threatened or endangered status.

SECTION 7 Conclusions

The City seeks to address frequent flooding and stormwater management challenges in the Bijou Park Creek watershed and will evaluate several potential engineering solutions. Portions of the Project may be constructed in environmentally sensitive areas, including jurisdictional waters and wetlands, quaking aspen groves, willow thickets, and Jeffrey pine forest with moderate potential to support up to five special status plant and animal species. The field survey and this report represent a preliminary assessment of potential biological resource issues and are meant to guide the City in planning and design, as well as provide preliminary analysis of potential impacts. Since the project is in the initial planning states and engineered plans and construction specifications have not been developed, additional analysis may be required to determine the full extent of impacts.

The following discussion includes a preliminary assessment of the impacts of these proposed activities and is organized following the CEQA Environmental Checklist. Measures or recommendations to avoid or minimize impacts to biological resources are provided.

7.1 CEQA ENVIRONMENTAL CHECKLIST QUESTIONS

a) *Would the project have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS?*

As shown in Table 1, there are four special status species (Willow Flycatcher, Long-eared Owl, Sharp-shinned Hawk, and upswept moonwort) with moderated potential to occur in the project area. The exact effects are dependent on which proposed project components are selected to proceed; however, general impacts are discussed here.

The project purpose is to restore function of the Bijou Park Creek Watershed via a suite of separate but interrelated engineering solutions. Construction activities for any of the proposed project components could adversely affect these species through increased noise, ground disturbance, vegetation removal, and the presence of continuous human activity; however, these impacts would be temporary. Following completion of construction activities, disturbed upland areas would be restored to their natural condition. Restored wetland and riparian areas would be improved by the project actions and quality of habitat for riparian species would increase, a beneficial impact to riparian species. Furthermore, the proposed project actions are all within the City and therefore resident species are already acclimated to the elevated levels of noise, human activity, and disturbance associated with an active residential and commercial community. However, in order to minimize the potential for adverse effects during construction activity, the following measures are recommended:

The Bijou Creek Diversion would impact Jeffrey Pine Forest and could result in removal of mature trees as well as temporary ground disturbance during installation of the underground water diversion pipe. Recommended mitigation measures for this proposed project include:

- Conduct a botanical survey for upswept moonwort during the flowering season (July and August) following the CNPS Botanical Survey Guidelines (CNPS 2001) to determine its presence in the Project Area and develop measures to avoid impacts to the species. Pre-construction surveys may later be required.

- If vegetation clearing activities must occur during the bird breeding season (February 1st through August 31st), a qualified biologist should conduct a pre-construction nesting bird survey within the immediate project vicinity no more than 48 hours prior to vegetation clearing. If clearing does not occur within 48 hours of the survey, the area should be resurveyed. Nesting bird surveys should include thorough assessment of any large pine trees that will be removed as they may provide nesting habitat for owls and hawks. If active nests are found, then a qualified biologist should establish an adequate buffer zone (on a species by species, case by case basis) in which construction activities are prohibited until the nest is no longer active. Depending on the species, permitting agencies my impose additional conditions for protection of nesting birds.

The Bijou Park Creek Restoration Project would impact sensitive riparian areas that could provide habitat for Willow Flycatcher. Restoration of the creek would ultimately result in improved habitat for this species; however, the project may include vegetation removal and trimming as well as hydrological modifications that would temporarily disturb the species. Recommended mitigation measures include:

- Conduct protocol-level surveys for Willow Flycatcher and schedule construction activities to avoid the breeding season (June through August) following existing guidance (Bombay et al. 2000).
- Avoid or limit removal of willow trees and shrubs.

b) Would the Project have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFW or USFWS?

The entire Bijou Park Creek Restoration Area and the portion of the Bijou Creek Diversion that falls within Bijou Meadow would be directly impacted by the proposed projects. Substantial ground disturbance and vegetation removal would occur during construction of either of these projects; however, both projects would ultimately result in improvements to the quality and function of these riparian and wet meadow areas by providing better control of the waters that maintain them. In order to reduce the potential for adverse effects to riparian areas during construction, the following measures are recommended:

- Implement Best Management Practices (BMPs) (e.g., silt fencing, straw waddles, and gravel bags) during construction to prevent additional sedimentation to the creeks and meadows.
- Minimize the removal of existing riparian vegetation and re-plant disturbed areas with native vegetation following project completion.
- Adhere to management practices, conditions, and measures as determined during other permitting processes, including CWA 401 certification, CDFW 1600 permit application (Lake and Streambed Alteration Notification), and development of construction Stormwater Pollution Prevention Plan (SWPPP).

c) Would the Project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the CWA (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?

The entire Bijou Park Creek Restoration project, the portions of the Bijou Creek Diversion that are within Bijou Meadow, and all proposed culvert replacements, basin improvements, and bypasses would

directly or indirectly impact likely protected wetlands; however, these projects would ultimately result in improvements to the quality and function of these wetlands and waters. The proposed watershed restoration activities may result in temporary placement of fill within jurisdictional wetlands. Prior to any construction, a jurisdictional waters delineation of the Project area, including Bijou Park Creek and Bijou Meadow should be conducted using methods established in the 1987 Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987) and appropriate Regional Supplement to the Corps of Engineers Wetland Delineation Manual (Arid West or Western Mountains, Valleys, and Coast Region). Permits should be obtained from USACE, the Regional Water Quality Control Board (RWQCB) and the TRPA. Following construction activities, the restoration project would include replanting of native vegetation and would achieve an improvement of the hydrology of the Bijou Park Creek watershed such that the quantity and quality of water flowing through jurisdictional areas is improved and the wetland functional value is increased. While the project would ultimately result in beneficial improvements to wetlands and waters, the following construction-related mitigation measures are recommended:

- Implement Best Management Practices (BMPs) (e.g., silt fencing, straw waddles, and gravel bags) during construction to prevent additional sedimentation to the creeks and meadows.
- Minimize the removal of existing riparian vegetation and re-plant disturbed areas with native vegetation following project completion.
- Adhere to management practices, conditions, and measures as determined during other permitting processes, including CWA 401 certification, CDFW 1600 permit application (Lake and Streambed Alteration Notification), and development of construction SWPPP.

d) Would the project interfere substantially with the movement of any native resident or migratory fish or wildlife species or with the established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

Wildlife movement corridors facilitate movement of species between large patches of natural habitat. Much of the project footprint lies between and near residential developments. Bijou Park Creek and the Bijou Creek Diversion pathways likely function as wildlife corridors by providing a path of travel for wildlife that allows them to avoid direct contact with yards and homes. In addition, both areas are heavily vegetated and may be used for nesting by migratory birds, which are protected under the federal Migratory Bird Treaty Act (MBTA; U.S. Code, Title 16 §§ 703-712). The MBTA governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests. Compliance with the MBTA ensures that no significant impacts to migratory birds occur.

Implementation of project construction activities could result in temporary adverse effects to fish and wildlife movement within the Bijou Park Creek and Bijou Creek Diversion corridors. As discussed previously, the increased noise and presence of heavy equipment could adversely affect these species through increased noise, ground disturbance, vegetation removal, and the presence of continuous human activity; however, these impacts would be temporary. Ultimately, the robustness of the riparian corridor and its connectivity and usefulness as a wildlife corridor and nursery site would be increased by the restoration of the watershed.

Following completion of construction activities, disturbed upland areas would be restored to their natural condition. Restored wetland and riparian areas would be improved by the project actions and

quality of habitat for riparian species would increase, a beneficial impact to riparian species. As the proposed project actions are all within the City, resident species are already acclimated to the elevated levels of noise, human activity, and disturbance associated with an active residential and commercial community. In order to minimize the potential for adverse effects during construction activity, the following measures are recommended:

- If vegetation clearing activities must occur during the bird breeding season (February 1st through August 31st), a qualified biologist should conduct a pre-construction nesting bird survey within the immediate project vicinity no more than 48 hours prior to vegetation clearing. If clearing does not occur within 48 hours of the survey, the area should be resurveyed. Nesting bird surveys should include thorough assessment of any large pine trees that will be removed as they may provide nesting habitat for owls and hawks. If active nests are found, then a qualified biologist should establish an adequate buffer zone (on a species by species, case by case basis) in which construction activities are prohibited until the nest is no longer active. Depending on the species, permitting agencies my impose additional conditions for protection of nesting birds.

e) Would the project conflict with any local policies or ordinances protections biological resources, such as a tree preservation policy or ordinance?

The TRPA requires a permit to remove trees greater than 14 inches diameter at breast height (DBH) as well as any trees or shrubs that are within a SEZ. Construction of the Bijou Creek Diversion may require removal of trees within the Jeffrey Pine Forest where the new underground pipe would be laid. The number and size of trees to be removed has not yet been determined. Restoration-related construction within the Bijou Park Creek SEZ would likely result in removal of some trees in order to restore degraded areas of the creek. All tree removals associated with the project would be subject to TRPA permitting rules and contingent on approval from TRPA. Coordination with TRPA during the permitting process will ensure compliance with local policies and ordinances.

f) Would the project conflict with the provisions of an adopted Habitat Conservation Plan (HCP) Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?

No HCPs, Natural Community Conservation Plans, or other local, regional, or state habitat conservation plans exist for the project area. The nearest applicable HCP is the draft Placer County Conservation Plan (PCCP). The draft PCCP covers the northwest corner of the Lake Tahoe Basin. Therefore, the Project would not conflict with the provisions of any adopted habitat conservation plans.

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Appendix A

Site Photos







Photo 1. *Dense willow thickets transition to Jeffrey Pine Forest within the proposed Bijou Park Creek Restoration Area. View looking west.*



Photo 2. *Jeffrey Pine Forest transitions abruptly to wetland and quaking aspen groves in the Bijou Park Creek Restoration Area west of Ski Run Blvd. View looking north.*



Photo 3. *Bijou Park Creek immediately downstream of Ski Run Blvd. View looking north.*



Photo 4. *Jeffrey Pine Forest with basin big sagebrush understory is the dominant vegetation community throughout most of the proposed Bijou Creek Diversion to Bijou Meadow. View looking southwest.*



***Photo 5**. Bijou Meadow is a wet meadow associated with Bijou Creek and the terminus of the proposed Bijou Creek Diversion. View looking north.*



Photo 6. *Wet meadow on the east side of Blackwood Road. Blackwood Road is subject to frequent flooding. Aspen groves and willow thickets also visible. View looking northeast.*



***Photo 7**. Wet area prone to significant flooding of the Heavenly Valley Mobile Home Park on the other side of the fence as well as the adjacent homes. View looking north towards the headwall from Rockwood Drive.*



***Photo 8**. Standing water east of Blackwood Road immediately downslope from the Heavenly Valley Mobile Home Park is semi-permanent due to excessive runoff and previous engineering attempts to control flooding to the Blackwood Rd, including a concrete berm. View looking southeast.*



***Photo 9**. Osgood Basin looing north toward Lake Tahoe Blvd from Paradise Ave.*



Photo 10. *Wildwood Basin looking northeast toward Wildwood Ave. from Osgood Ave.*

Appendix 7
Existing Conditions Vegetation

DRAFT

WESTERN BOTANICAL SERVICES, INC

TECHNICAL MEMORANDUM

To: Carol Beahan, P.E.
Wildscape Engineering
1901 Lisa Maloff Way, Suite 108
South Lake Tahoe, CA 96150

From: Julie Etra, Western Botanical Services, Inc.

Date: November 5, 2019

RE: BIJOU PARK CREEK WATERSHED RESTORATION PROJECT
VEGETATION RESOURCES: EXISTING CONDITIONS

1. INTRODUCTION

This Technical Memorandum documents existing vegetation communities and evaluates their current condition and potential constraints or opportunities as they relate to the Bijou Park Creek Watershed Restoration Project. The current Scope of Work (Scope) and subsequent analysis is intended to support a 30% level of engineering design, focusing on potential drainage improvements including water quality treatment basins. This document does not evaluate occurrence(s) of threatened, endangered, or sensitive plants species, nor does it document presence of jurisdictional wetlands or Waters of the United States (WOUS), as those investigations are being done by other consultants and were not included in this Scope.

The field surveys were conducted by botanist and erosion control specialist Julie Etra on October 18, and included three locations for potential drainage improvements and water quality treatment basins, as defined by Wildscape Engineering.

2. METHODS

2.1. Field Surveys

All parcels in the Scope of Work were thoroughly surveyed on foot and all taxa identified to the lowest taxonomic level possible (Table 1). The survey was conducted in late October, a suboptimum time for maximum species identification but adequate for determining dominant species and to meet the objectives of the survey.

Parcels surveyed included:

1. Forest Service parcel located on the northwest corner of Pioneer Trail and Blackwood Road;
2. Proposed 'East Osgood Basin', Paradise Avenue and Osgood Avenue; and
3. Proposed 'Aloha Basin', Red Lake Road and Herbert Avenue.

3. RESULTS

This section contains descriptions of the site conditions at each parcel. A species list by location is included in Table 1.

3.1 Pioneer Trail and Blackwood Road

This site includes Stream Environment Zone (SEZ), and most likely jurisdictional wetlands. A large stand of quaking aspen (Photo 1) dominates the parcel, which is fringed by a stand of Nebraska sedge on the west side. Other obligate wetland plants occur throughout the parcel. The parcel has had numerous mad-made modifications over the decades and is not pristine. Previous flood control improvements have been implemented in various locations.

3.2 East Osgood Basin

Although a berm separates the existing Osgood basin from the potential new basin, this site is for the most part dominated by obligate and FAC WET (FACW) species, as defined by the U.S. Army Corps of Engineers Wetlands Delineation Manual ("1987 Manual", Environmental Laboratory 1987) and The Western Mountains, Valleys, and Coast Region Supplement (the 'Supplement'), particularly on the western and eastern portions of the parcel where there is an existing small pond and what appears to be a man-made channel or swale, respectively. Obligate wetland species are defined occurring almost always (estimated probability 99%) under natural conditions in wetlands. FACW species are defined as species that usually occur in wetlands (estimated probability 67%-99%) but are occasionally found in non-wetlands.

The constructed berm is dominated by introduced species as part of past revegetation efforts. The swale consists of dense growth of common spike-rush, an obligate wetland species, indicating saturated soils for most of the growing season. At the time of this survey, soils were dry. Approximately 25 willows were counted in the vicinity of this swale. In addition to these willows, good stands of rhizomatous wetland graminoids could easily be salvaged and replanted as part of a construction project. Non-cohesive material can be salvaged as topsoil and organic matter and re-used as part of revegetation efforts.

3.3 Aloha Basin

Vegetation is dominated by mesic and transitional upland meadow species, with lodgepole pine, a FAC species (defined as equally likely to occur in wetlands or non-wetlands, with an estimate of probability 34%-66%) in the overstory. No Jeffrey pines were located. Along with the presence of several species of willows, vegetation may be indicative of a high-water table. In addition, a vegetated swale along Herbert Avenue is dominated by wetland species. Reusable resources, if indeed any drainage improvements are designed and implemented for this parcel, include isolated willows and native topsoil and organic matter. Stands of salvageable wetland sod do not occur at this site.

Table 1. Bijou Park Creek Species List

Family	Scientific Name	Common Name	Location		
			Blackwood	Osgood	Aloha
ASTERACEAE	*Artemisia tridentata ssp vaseyana*	Mtn. sagebrush	✓		
	Cirsium arvense	Bull thistle	✓		
	Madia glomerata	Tarweed	✓		
	Symphyotrichum spathulatum	Western aster	✓		✓
	Tragopogon dubius	Oysterplant		✓	
BRASSICACEAE	*Nasturtium officinale*[1]	Watercress			
	Rorippa curvisiliqua	Curve pod yellow cress	✓		
CYPERACEAE	*Carex athrostachya*	Slender beak sedge	✓		
	Carex douglasiii	Douglas' sedge			
	Carex nebrascensis	Nebraska sedge	✓	✓	
	Carex pellita	Wooly sedge			✓
	Carex rossii	Ross' sedge	✓		
	Cares sp.	Sedge	✓		
	Carex utriculata	Beaked sedge	✓		
	Eleocharis palustris	Common spike-rush		✓	
	Scirpus microcarpus	Panicled bulrush	✓		
FABACEAE	*Astragalus cicer*	Cicer milvetch		✓	
	Lupinus breweri	Brewer's lupine	✓		
	Lupinus polyphyllus	Large-leaved lupine	✓	✓	
	Melilotus sp.	Sweet blossom clover		✓	
	Trifolium repens	White Dutch clover		✓	
GROSSULARIACEAE	*Ribes nevadense*	Sierra currant	✓		
JUNCACEAE	*Juncus balticus*	Baltic rush	✓	✓	
	Juncus ensifolius	Equitant rush	✓		
LAMIACEAE	*Mentha arvensis*	Field mint	✓		
MALVACEAE	*Sidalcea oregana*	Oregon checkermallow	✓		
ONAGRACEAE	*Epilobium angustifolium*	Fireweed			✓
	Epilobium brachycarpum	Willow herb		✓	
	Epilobium ciliatum	Fringed willowherb	✓		
PINACEAE	*Pinus contorta*	Lodgepole pine	✓		✓
	Pinus jeffreyi	Jeffrey pine	✓		

[1] Not verified

Family	Scientific Name	Common Name	Location		
			Blackwood	Osgood	Alo-haAlo-haAl
POACEAE	*Agropyron desertorum*	Crested wheatgrass	✓	✓	
	Agrostis exarata	Spike bentgrass	✓		
	Agrostis stolonifera	Creeping bentgrass	✓		✓
	Alopecurus pratensis	Meadow foxtail	✓	✓	
	Bromus carinatus	California brome	✓		
	Bromus inermis	Smooth brome	✓		✓
	Bromus tectorum	Cheatgrass	✓		
	Deschampsia danthoniodes	Annual hairgrass		✓	
	Deschampsia cespitosa	Tufted hairgrass	✓		
	Elymus elymoides	Squirreltail	✓		✓
	Elymus glacuas	Blue widrye	✓		
	Horduem brachyantherum	Meadow barley	✓		
	Leymus triticoides	Creeping wildrye	✓	✓	
	Phleum pratense	Timothy	✓		✓
	Poa pratensis	Kentucky bluegrass	✓	✓	✓
	Thinopyrum intermedium	Intermediate wheatgrass	✓	✓	
POLYGONACEAE	*Rumex crispus*	Curly dock	✓	✓	
RANUNCULACEAE	*Thalictrum fendleri*	Meadow rue	✓		
RHAMNACEAE	*Ceanothus cordulatus*	Whitethorn	✓		
ROSACEAE	*Amelanchier alnifolia*	Saskatoon serviceberry			✓
	Fragaria vesca ssp. americana	Woodland strawberry	✓	✓	✓
	Geum macrophyllum	Large-leaved avens	✓		
	Potentilla gracilis	Slender cinquefoil	✓	✓	✓
	Purshia tridentata	Bitterbrush	✓	✓	
	Rosa woodsii	Woods' rose	✓	✓	✓
SALICACEAE	*Populus tremuloides*	Quaking aspen	✓	✓	
	Salix geyeriana	Geyer's willow	✓		
	Salix lemmonii	Lemmon's willow	✓	✓	
	Salix lasiandra	Shining willow			✓
	Salix lutea	Pacific willow		✓	
	Salix scouleriana	Scouler's willow			✓
SCROPHULARIACEAE	*Mimulus guttatus*	Seep monkeyflower	✓	✓	



Photo 1. Pioneer Trail and Blackwood Road, aspen and Stream Environment Zone (SEZ)



Photo 2. Blackwood Road: solid stand of Nebraska sedge (*Carex nebrascensis*), a jurisdictional wetland indicator species



Photo 3. Drainage and flood control channel near Blackwood Road



Photo 4. Potential ‘East Osgood Basin’, from southwest looking northeast. Note ponding water.



Photo 5. Potential 'East Osgood Basin', north corner, showing transition from wetland to mesic vegetation



Photo 6. Potential 'East Osgood Basin', southeast corner, swale with obligate wetland vegetation and surrounding salvageable willows



Photo 7. Potential ‘Aloha Basin’, mesic, transitional vegetation



Photo 8. Wetland vegetation in swale along Herbert Avenue and adjacent to the potential ‘Aloha Basin’

Appendix 8
Hydrology Technical Memorandum

DRAFT

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nhc
northwest hydraulic consultants

PEAK FLOW ESTIMATES FOR BIJOU PARK CREEK WATERSHED BASED ON EMPIRICAL DATA

Prepared as a Subconsultant to:

Wildscape Engineering
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For

The City of South Lake Tahoe
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By

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1 INTRODUCTION

The initial version of this report was issued on September 9, 2019. Since that time, several other points in the project vicinity have been analyzed and included in this final version. As originally proposed, hydrologic design of possible stormwater quality and/or flood reduction measures for the Bijou Park Creek Watershed Restoration Project would be based upon modeled prediction of flows using HEC-HMS. The model for the watershed was developed by Lumos & Associates, Inc. (Lumos) in 2005 as one of the core products of the East Pioneer Trail Watershed Hydrology Study. Northwest Hydraulic Consultants (NHC) has updated the model to the current version and incorporated NOAA Precipitation Atlas 14 precipitation frequency estimates. Lumos followed El Dorado County drainage manual procedures in developing the model, although it appears that the actual selection of model parameters was left to the discretion of the Lumos modeling team.

As part of the current project, various potential improvement measures have been identified, and the Lumos model has been used to assess the effectiveness of the measures in, for example, reducing downstream flood flows. As a specific example, one possible flood reduction measure under consideration is restricting flows from the upper reaches of Bijou Park Creek from crossing Ski Run Boulevard at a culvert near Needle Peak Boulevard. As a first step, the hydraulic capacity of the existing 24-inch diameter culvert was determined and compared to the HEC-HMS output for the flow predicted to reach it. Table 1 on the following page shows the computed pipe capacity in comparison to the predicted flows reaching it. The highlighted green row shows that the pipe has a capacity equivalent to a 2.51-year recurrence interval flood, which is only slightly larger than the average annual peak flow. In contrast, the predicted 10-year recurrence interval flow is 164 cubic feet/second (cfs), while the 100-year recurrence interval flow is 484 cfs. Based on this analysis, one would conclude that the pipe already severely restricts flows from continuing their normal course downstream and that restricting flows in the pipe would have no benefit in reducing downstream flooding.

Table 1. Comparison of Culvert Capacity Versus Predicted Flows using 24" Ski Run Pipe as Example.

Ski Run - 24"		*Capacity*	30.87 cfs	
p(x)	1/p(x)	Q (cfs)	log (Q)	Norm(p(x))
0.50	2	28.8	1.459	0.000
0.10	10	163.8	2.214	1.282
0.01	100	483.8	2.685	2.326
0.500	2	28.8	1.459	0.000
0.398	2.51	30.87	1.490	0.051
0.200	5	90.2	1.955	0.842
0.100	10	163.8	2.214	1.282
0.050	20	238.7	2.378	1.645
0.020	50	364.7	2.562	2.054
0.010	100	483.8	2.685	2.326

The flows computed by the model appear to be far beyond the normal experience of flood events at South Lake Tahoe. Given that the drainage area for the culvert is approximately one-half square mile, the 10-year and 100-year recurrence interval flows on a square mile basis would be approximately, 328 and 968 cfs respectively. The predicted 100-year recurrence interval flow is well outside the body of observed maximum discharges in California as reported on the "Creager Enveloping Curve of Maximum Peak Discharges in California" (see attached Figure 1, "Magnitude and Frequency of Floods in California" U.S. Geological Survey, 1977), and, if fact, approaches the limit of the maximum floods ever recorded anywhere in the state up to 1977 on a discharge/square mile basis.

The above analysis leads us to conclude that the HEC-HMS model, as configured by Lumos & Associates, Inc. appears to have a significant upward bias in the predicted flows. Using those predictions as the sole basis on which to conclude that individual measures have merit in improving stormwater quality or in reducing downstream flood impacts is, therefore, not advised.

As a check on the modeled flows, we are presenting flow estimates derived by several techniques described in Section 2. Our primary focus was to assess the utility of estimating flows based on observed annual peak flows from various gaged watersheds in the Lake Tahoe Basin, or on the east side of the Carson Range. These analog basins were chosen based on their proximity, size, and period of record. They represent the smallest continuously gaged basins in proximity to South Lake Tahoe which share the climatic regime and geology of the Bijou Park Creek watershed. Gaged basins on the west side of Lake Tahoe have a significantly different climatic regime and lack the granitic geology of the Carson Range such that they are far more responsive than watersheds in the Carson Range and therefore were excluded as being analogs to Bijou Park Creek. Table 2 lists the basins judged to be suitable analogs. Figure 1 shows the locations of the gages. They occur within a rectangle roughly 21 miles long and 5 miles wide. The author is personally familiar with all the stream gages, either through his professional experience within the Tahoe Basin or as a field hydrologist for the U.S. Geological Survey in Carson City.

Of course, each watershed is unique in terms of its geology, physiography, and climatic regime, however, geology and climatic regime may be the most important factors in controlling hydrologic response. With the exception of Franktown, Daggett, and the North Fork of Kings Canyon, all the gages are in the Tahoe Basin and are located in a narrow elevation range above lake level. In contrast, Franktown Creek is at elevation 7470 feet, whereas Daggett Creek and the North Fork of Kings Canyon

Creek are at elevations 5,100 and 5,500 feet, respectively. Nearly all the basins share the same granitic geology, although both Third and Incline Creek drain areas extending toward Mount Rose are not strictly comparable, both with respect to geology, elevation range and vegetation. Those two basins are also the largest within the set. All basins shown have a sufficiently long period of record with which to perform a flood frequency analysis, although the 20 years of record for Eagle Rock Creek and Edgewood Creek approach the minimum, especially with regard to using the skew computed based on the recorded observations. Obviously, a longer period of record provides greater confidence in the computed flood frequencies, particularly for events with longer return periods.

Table 2. Analog Gaged Basins.

Station Name	ID	Drainage Area (square miles)	Period of Record (Yrs)
Eagle Rock Creek Near Stateline, NV	103367592	0.63	20
Edgewood Creek at Stateline, NV	10336760	5.91	20
Logan House Creek Near Glenbrook, NV	10336740	2.09	28
Glenbrook Creek at Glenbrook, NV	10336730	4.11	35
Incline Creek Near Crystal Bay, NV	10336700	6.74	35
Third Creek Near Crystal Bay, NV	10336698	6.05	45
Franktown Creek Near Carson City, NV	10348460	3.24	44
Daggett Creek Near Genoa, NV	10310400	3.82	47
North Fork of Kings Canyon Creek Near Carson City, NV	10311090	1.83	22

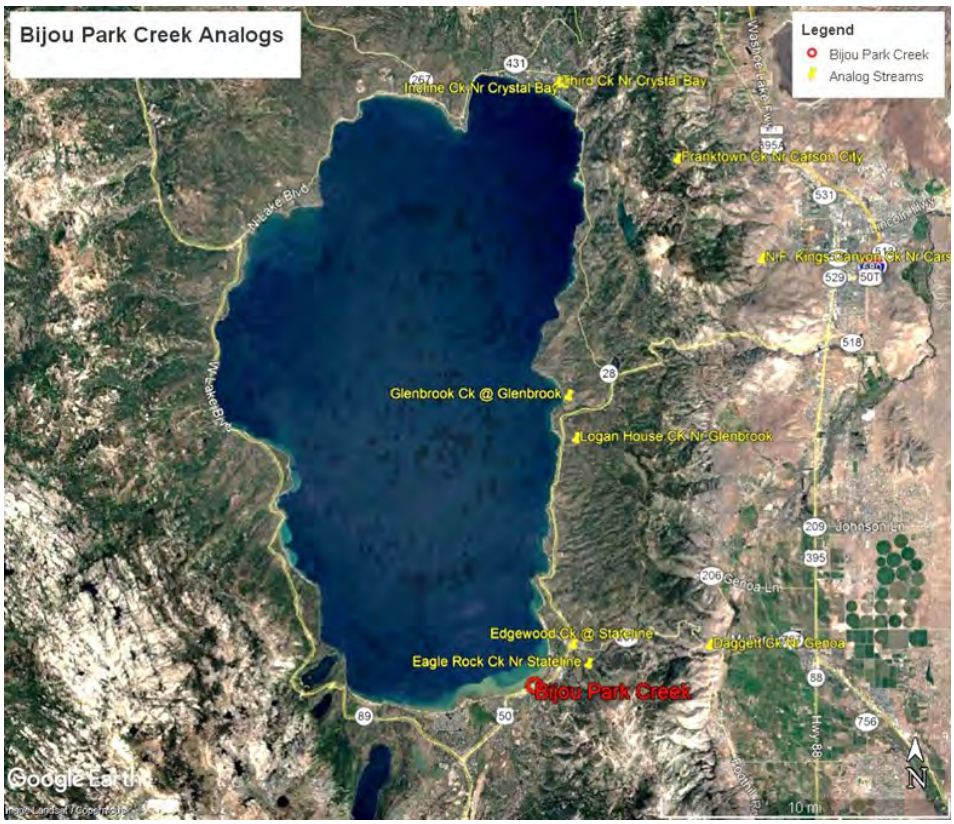


Figure 1. Location of Gages

2 METHODS

We investigated three methods to compute peak flow estimates at various points of interest within the Bijou Park Creek watershed. Although the first method, as described below, was judged to provide the most reliable results we present two other approaches in order to both provide a more comprehensive analysis and to contrast the first method's results with a readily available "off-the-shelf" technique. The first method performed flood frequency analyses on analog basins. This was done using the Corps of Engineers HEC SSP software, which fits the annual peak flow data to a Log Pearson Type III probability distribution. For this analysis, the procedures following Bulletin 17B (Guidelines for Determining Flood Flow Frequency, U.S. Geological Survey,1982) were used. The skew coefficient, a parameter of the Log Pearson Type III probability function, was determined using the actual data. There is a risk of considerable error in using the "station" skew when the period of record is small e.g. less than 15 years since the odds that the data set is truly representative of the long-term distribution decrease as the period of record gets smaller. Although Eagle Rock Creek and Edgewood Creek both have relatively short period of record with which to compute the basin skew, they are the closest to Bijou Park Creek and may, in fact, be the most accurate analogs, and were, therefore, kept as part of the data set.

The results derived from HEC SSP for each analog basin were then adjusted to the drainage area(s) for the point of interest within the Bijou Park Creek watershed using the equation given in "Magnitude and Frequency of Floods in California" (1977).

A second set of estimates was computed using regional regression equations derived for the Sierra Nevada region contained within the U.S. Geological Survey "StreamStats" software. This is a web-based program through which an ungaged basin is automatically delineated and equation parameters are computed. The regression equations are based on annual peak flow data for stations within the Sierra Nevada region. While the number of stations used to derive the regression equations is large, so is the variance in watershed response, such that use of this method is judged to be significantly less reliable than flood estimates derived from nearby analog basins. The web-based software is deficient for small basins (< 1 square mile) and for basins where development has altered drainage routes from their original, topographic based, patterns, since the software does not provide a topographic component to the mapping function from which alterations in the drainage area can be accurately made. Both conditions exist within the Bijou Park Creek watershed and in the adjacent Wildwood basins watershed, such that the results lack some precision because the software does not allow for precise computation of drainage area.

A third set of peak flow estimates was derived using the output from the flood frequency analysis results for the analog basins, normalizing the results on the basis of drainage area, and then plotting the relationship between drainage area, and discharge/square mile. This was performed for the 10 and 100-year recurrence intervals as given below in Figures 2 and 3. The regression equation was used to compute flows at the points of interest in Bijou Park Creek for the 10-year recurrence interval while interpolation of the best fit line was used for the 100-year recurrence interval flows.

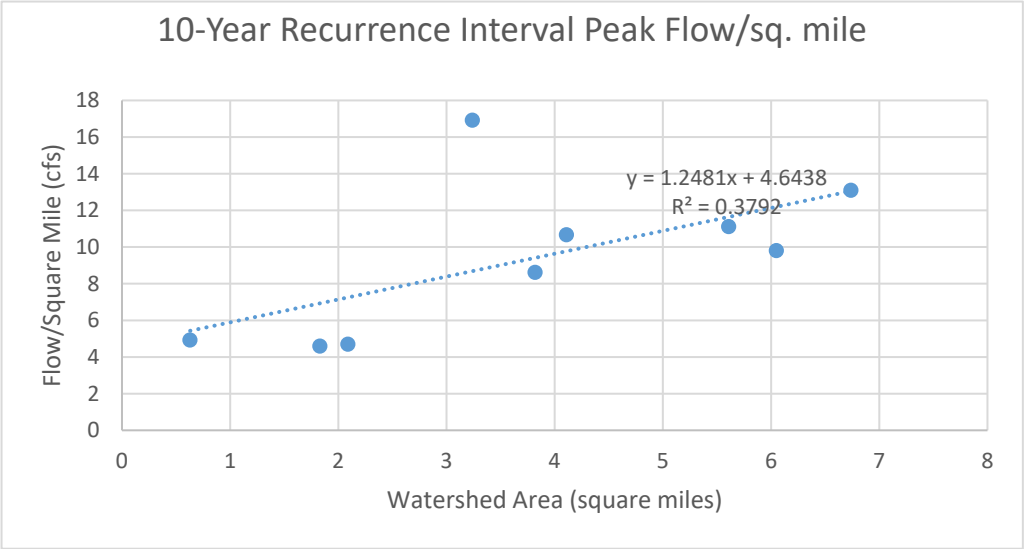


Figure 2. Relationship between 10-Year Peak Flow Estimate for Analog Basins and Drainage Area.

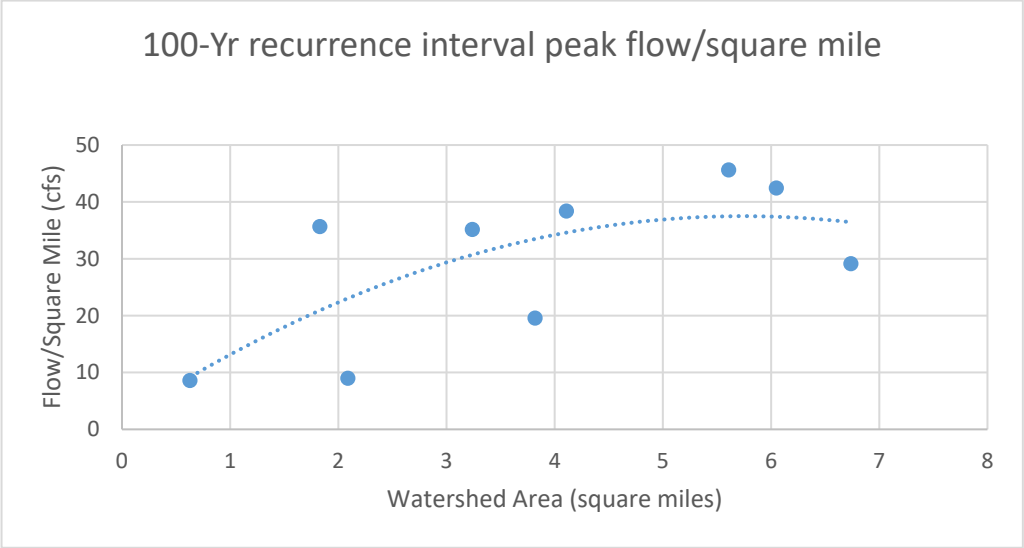


Figure 3. Relationship Between 100-Year Peak Flow Estimate for Analog Basins and Drainage Area.

If there were no relationship between drainage area and peak flow/square mile, then these plots should just be represented by a scatter of points with no discernable pattern. Yet, in both figures, a linear to curvilinear relationship exists, as given by the best fit trend lines. Admittedly, the relationship is not strong, although it is stronger for the 10-year recurrence interval. On the other hand, it cannot be dismissed that a relationship does indeed exist. The typical expectation is that the peak flow/square mile tends to diminish as the basin size increases. However, this rule of thumb is affected by scale,

wherein the comparisons are typically made between basins on scales of 10s of square miles versus 100s of square miles. In this case all the data points represent small watersheds and the increasing, rather than diminishing, trend probably reflects the fact that probability for an intense storm falling on a very small basin is smaller than for slightly larger basins. We would expect the "normal" relationship to appear as the watershed size grew, and, indeed, there is some evidence of the response peaking and beginning to diminish for the 100-year recurrence interval.

3 RESULTS

Table 3 gives the results of the fitting of the annual peak flow data to a Log Pearson Type III probability distribution and the estimated peak flow in cubic feet/second (cfs) for each recurrence interval. The variation in estimates is primarily a reflection of difference in the sizes of the basins, as given in Table 2, but also reflects the individual characteristics of each basin.

Table 3. Flood Frequency Analysis Results for Analog Basins.

Basin Name	Size	**Recurrence Interval**					
		2	5	10	25	50	100
	(sq. miles)	Peak Flow (cfs)					
Eagle Rock Ck NR Stateline	0.63	1.6	2.4	3.1	3.7	4.6	5.4
Edgewood Ck @ Stateline	5.61	17.2	38	62.3	98	171.2	255.7
Loganhouse Ck NR Glenbrook	2.09	3.7	7.2	9.8	12.5	16	18.7
Glenbrook Ck @ Glenbrook	4.11	10.3	26.2	43.8	67.6	111.9	157.7
Incline Ck Nr Crystal Ban, NV	6.74	33.1	63	88.2	116.4	159.2	196.2
Third Ck Nr Crystal Bay	6.05	55	100.7	135.2	170.5	218.7	256.5
Franktown Ck NR Carson City, NV	3.24	20.5	39.5	54.8	71.1	94.6	113.8
Daggett Ck NR Genoa, NV	3.82	13.1	23.7	32.9	43.4	59.9	74.6
North Fork Kings Canyon Ck	1.83	2.3	4.6	8.4	15.3	34.8	65.2

At this time there are seven analysis points within, or adjacent to, the Bijou Park watershed that represents locations where diversions, bypasses, treatment basins or drainage structure enlargement are being considered:

1. Keller Canyon at Markoffer
2. Ski Run culvert at Needle Peak Avenue
3. Osgood Basin watershed
4. Osgood Basin watershed, excluding Keller Canyon
5. Trailer Park outfall on Blackwood Avenue
6. Bijou Park Creek at Highway 50
7. Bijou Meadow at Lake Tahoe
8. Wildwood Basins above Highway 50

The watershed area for all the above except the Osgood Basin watershed was computed from the subbasins within the HEC-HMS model, or as given in the East Pioneer Watershed Hydrology Study (Lumos and Associates, Inc. 2005). For Osgood basin, the watershed area is as given in Urban Catchment Monitoring to Evaluate Tahoe TMDL Tools (2nd Nature and NHC, 2014). Flow estimates for each location using the analog basins was computed by adjusting the estimates given in Table 3 using the area-adjustment equation given in "Magnitude and Frequency of Floods in California", (1977). Next, the mean of those estimates for all the analogs was computed. We evaluated the impact of considering the highest and lowest values to be "outliers" and excluded from the computation of the mean, but that exercise yielded nearly the same values as using all the analog basins in the computation. Table 4 gives the mean estimated peak flow at the eight analysis points using the analog basins.

Table 4. Peak Flow Estimates (cfs) for Various Recurrence Intervals Using Mean Value from Analogs.

Analysis Point	Size	**Recurrence Interval**					
		2	5	10	25	50	100
	(sq. miles)	Peak Flow (cfs)					
Keller Canyon @ Markoffer	0.57	2.8	6.1	9.1	12.8	19.2	26.1
Needle Peak @ Ski Run	0.52	2.6	5.7	8.5	11.9	17.9	24.4
Osgood Basin	0.79	3.7	7.9	11.8	16.5	24.6	33.4
Osgood Basin w/o Keller Canyon	0.22	1.2	2.7	4.2	5.9	9.0	12.4
Trailer Park Outfall	0.25	1.3	3.1	4.7	6.6	10.0	13.7
Bijou Park Creek @ HWY 50	0.99	4.5	9.6	14.2	19.8	29.6	40.0
Bijou Meadow at Lake Tahoe	2.16	9.0	18.1	26.5	36.6	54.2	72.8
Wildwood Basins ABV HWY 50	0.21	1.1	2.6	4.0	5.7	8.6	11.9

Table 5 gives the peak flow estimates at the analysis points derived using the regional regression equations as reported in "StreamStats."

Table 5. Peak Flow Estimates (cfs) for Various Recurrence Intervals Derived from Regional Regression Equations.

Analysis Point	**Recurrence Interval**					
	2	5	10	25	50	100
	Peak Flow (cfs)					
Keller Canyon @ Markoffer	14	28	41	61	82	103
Needle Peak @ Ski Run	11	23	33	49	66	83
Osgood Basin	17	35	52	76	103	129
Osgood Basin w/o Keller Canyon	5	11	16	23	32	40
Trailer Park Outfall	4	8	12	18	24	31
Bijou Park Creek @ HWY 50	20	40	59	87	117	147
Bijou Meadow at Lake Tahoe	25	51	75	110	148	186
Wildwood Basins ABV HWY 50	*	*	*	*	*	*

* Reliable estimate not available using *StreamStats* because topographic drainages have been altered.

Table 6 gives the results using the third method described in the section above with the values were derived using the best fit lines as given in Figures 2 and 3.

Table 6. Peak Flow Estimates (cfs) for the 10 and 100 Recurrence Interval Floods from Figures 1 and 2.

Analysis Point	Recurrence Interval	
	10	100
	Peak Flow (cfs)	
Keller Canyon @ Markoffer	3	5
Needle Peak @ Ski Run	3	5
Osgood Basin	4	9
Osgood Basin w/o Keller Canyon	1	2
Trailer Park Outfall	1	2
Bijou Park Creek @ HWY 50	6	14
Bijou Meadow at Lake Tahoe	16	50
Wildwood Basins ABV HWY 50	1	2

Of the three methods, we judge that the results provided in Table 4, using the mean of the results from the analog basins, represents the most accurate estimates. The results using the regional regression equations within "StreamStats" are typically 3-4X greater than the estimates using what are judged to be local analogs. This is not unexpected since the StreamStats results are based on data from the entire Sierra Nevada region, whereas the analog basins are all within the Carson Range which is typically composed of deeply weathered granitics, and therefore tend to have a dampened hydrologic response.

Although we cannot completely discount the results from the third method, as given in Table 6, they are largely based on a single data point; Eagle Rock Creek Near Stateline (which is a tributary of Edgewood Creek) since all of the analysis points within Bijou Park Creek have a drainage area of less than a square mile. Within the data set, Eagle Rock Creek and Loganhouse Creek have the most dampened hydrologic response and it is uncertain how representative they may be for Bijou Park Creek. For that reason, the estimates in Table 6 are only reported to one significant figure.

Given the extent of urbanization within the Bijou Park Creek and Bijou Meadow watersheds, the estimates given in Tables 4 through 6 need to be revised upward to account for the increased runoff generated from impervious and compacted surfaces. In certain cases, influence of urbanization might actually be positive should the development occur largely at the bottom of the watershed for short duration storms. In such cases runoff from the lower, more responsive end of the watershed would exit prior to peak contributions from the upper portion of the watershed, such that there is a "desynchronization" effect which would tend to lower peak flows during shorter duration event. In general, however, urbanization makes the watershed more "flashy" and increases peak flows. Correction factors to account for the effects of urbanization are given in "Magnitude and Frequency of

Floods in California" (1977) which were derived from Rantz, 1971, "Suggested Criteria for Hydrologic Design of Storm-Drainage Facilities in the San Francisco Bay Region, California". The correction factors are based on the extent of development and the percent of developed storm drains within the watershed. The estimated percentage of each for each analysis point is given in Table 7, based on professional judgement.

Table 7. Estimated Percent of Urbanization and Developed Storm Drain Infrastructure.

Analysis Point	% Urbanized	% Developed Drainage
Keller Canyon @ Markoffer	10	10
Needle Peak @ Ski Run	10	5
Osgood Basin	23	15
Osgood Basin w/o Keller Canyon	60	20
Trailer Park Outfall	15	5
Bijou Park Creek @ HWY 50	25	5
Bijou Meadow at Lake Tahoe	25	5
Wildwood Basins ABV HWY 50	60	30

Table 8 gives the correction factors taken from the nomographs within "Magnitude and Frequency of Floods" to account for the effects of urbanization on the previously derived peak flow estimates.

Table 8. Correction Factors Applied to Peak Flow Estimates to Account for Urban Development.

	Recurrence Interval					
Analysis Point	2	5	10	25	50	100
Keller Canyon @ Markoffer	1.15	1.1	1.08	1.07	1.05	1.04
Needle Peak @ Ski Run	1.12	1.08	1.06	1.05	1.04	1.03
Osgood Basin	1.32	1.27	1.21	1.17	1.15	1.13
Osgood Basin w/o Keller Canyon	1.85	1.57	1.48	1.42	1.40	1.36
Trailer Park Outfall	1.15	1.11	1.09	1.08	1.07	1.06
Bijou Park Creek @ HWY 50	1.35	1.23	1.19	1.16	1.14	1.12
Bijou Meadow at Lake Tahoe	1.35	1.23	1.19	1.16	1.14	1.12
Wildwood Basin ABV HWY 50	1.9	1.72	1.55	1.5	1.45	1.4

It should be noted that only a few of the analog basins can be considered truly devoid of any urbanization. Therefore, there is some risk that application of the correction factors may "double account" for urbanization effects. Tables 9 and 10 summarize the results of the three methods for the 10 and 100-year recurrence interval flows and compare them to the predicted flows as generated by the HEC-HMS model. The values derived from the analog basins and from Figures 1 and 2 have been adjusted using the factors given in Table 8. The estimates computed using HEC-HMS directly accounts for urbanization effects. It is not known to what degree *Streamstats*-based estimates include the effects of urbanization based on the basins used to derive the equations. Those estimates were also not adjusted. All HEC-HMS estimates are taken from the updated model using the NOAA Precipitation Atlas 14, except for the Bijou Meadow, which is the flow associated with the most recent FEMA mapping of the Bijou Meadow floodplain. The flow estimates there can be expected to be considerably higher if the updated Lumos model were used along with the NOAA 14 precipitation atlas input.

Table 9. Comparison of HEC-HMS Estimates Versus Estimates Derived Via the Three Methods Utilizing Empirical Data for the 10-Year Recurrence Interval.

Analysis Point	HEC-HMS	Mean of Analogs	Regional Regression	From Figure 2.
Keller Canyon @ Markoffer	141	9.9	44.3	3
Needle Peak @ Ski Run	164	9.0	35.0	3
Osgood Basin	309 [1]	14.3	52	5
Osgood Basin w/o Keller Canyon	168 [2]	6.2	16.0	1
Trailer Park Outfall	64	5.1	13.1	7
Bijou Park Creek @ HWY 50	137	16.9	70.2	19
Bijou Meadow at Lake Tahoe	93 [3]	31.5	74.9	10
Wildwood Basin ABV HWY 50	-[4]	6.2	-[5]	2

1. Includes flows exceeding the capacity of the Needle Peak culvert (approx. 36 cfs).
2. Not modeled, estimated by subtraction of Keller Canyon @ Markoffer
3. From FEMA floodplain mapping
4. Not in scope of study.
5. Unreliable using StreamStats because topographic drainages have been modified.

Table 10. Comparison of HEC-HMS Estimates Versus Estimates Derived Via the Three Methods Utilizing Empirical Data for the 100-Year Recurrence Interval.

Analysis Point	HEC-HMS	Mean of Analogs	Regional Regression	From Figure 3.
Keller Canyon @ Markoffer	517	27.1	107	5
Needle Peak @ Ski Run	483	25.2	85	5
Osgood Basin	1,009 [1]	37.8	178 [1]	10
Osgood Basin w/o Keller Canyon	492 [2]	16.8	40	3
Trailer Park Outfall	182	14.5	32	2
Bijou Park Creek @ HWY 50	345	44.8	165	16
Bijou Meadow at Lake Tahoe	344 [3]	80.8	186	56
Wildwood Basin ABV HWY 50	-[4]	16.6	-[5]	3

1. Includes flows exceeding the capacity of the Needle Peak culvert (approx. 36 cfs).
2. Not modeled, estimated by subtraction of Keller Canyon @ Markoffer
3. From FEMA floodplain mapping.
4. Not in scope of study.
5. Unreliable using StreamStats because topographic drainages have been modified.

4 DISCUSSION AND RECOMMENDATIONS

Tables 9 and 10 show a very large to sometimes extreme range in the peak flow estimates. The overall difference between the HEC-HMS results and the estimates derived via the three methods is that the flow prediction computed by HEC-HMS is a "synthetic" estimate based on a modeled hydrologic response to a design storm whereas the other three methods use empirical data from observed peak flows. The estimates based on the mean of the analogs can be argued are the most accurate predictor since they are derived from actual peak flow observations from gaged basins in the vicinity. However, there is still sizeable uncertainty associated with those estimates, particularly for the 100-year event, since the period of record for all the analogs is, at best, approximately half that period. Another factor to consider is that all of the empirically derived estimates are based on the historic record which does not account for the possible future effects of climate change. It is recommended that the "Mean of the Analogs" be used as the basis for designing storm water improvements for the Bijou Park Creek watershed restoration project.

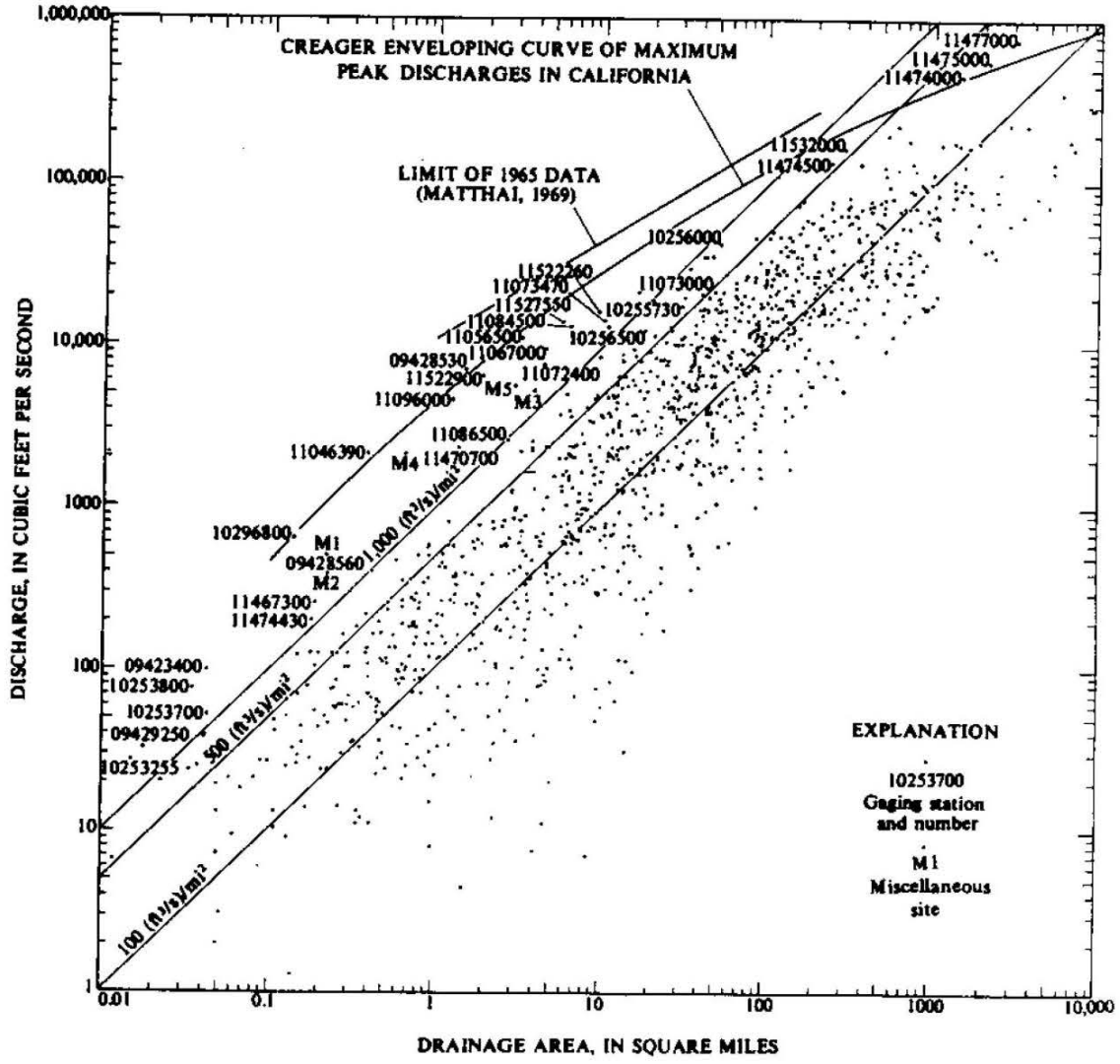


FIGURE 1.--Maximum peak discharges in relation to drainage area.

From: "Magnitude and Frequency of Floods in California," 1977, A.O. Waananen and J.R. Crippen, U.S. Geological Survey, Water Resources Investigations 77-21.

Appendix 9
Project Decision Matrix

DRAFT

Project	Water Quality	Flooding	Engineering Feasibility	Cost	Utilities	Impacts	Advantages	Constraints	Description
Keller Canyon Bypass	+	o	-	-	-	+	Decrease loading to Osgood basin	Construction of new underground pipe, potential utility conflicts	Construct new stormdrain pipe to collect Keller Canyon runoff and bypass the Osgood basin.
Ski Run Diversion	-	+	+	+	-	+	Decrease flow down Bijou Park Creek in high flow events	Adds flow to Osgood basin which is already undersized	Restrict water in culvert crossing Ski Run and divert down Ski Run Blvd
Osgood Expansion (passive)	+	-	+	o	-	-	Increase water treatment efficiency of basin	Any water flowing into East parcel would need to exit at Wildwood basin increasing flood risk	Expand Osgood basin to the East, outlet would need to be to Wildwood basin due to existing grading.
Osgood Expansion (active)	+	o	+	-	-	+	Direct control over flow of water to proposed east basin and prevent potential flooding	Complexity and reliability of an active system (sensors, maintenance etc.)	Use an Active system to prevent potential flooding at Wildwood Basin
Diversion to Bijou Meadow (passive)	+	+	-	-	-	-	High efficiency water quality treatment due to directing flow to large, flat, dry meadow, flood reduction downstream	Construction intensive and high disturbance to build diversion pipeline, potential utility conflicts and granitic subsurface	Construct diversion pipeline to bring Bijou Park Creek flow during flood events to Bijou Meadow
Diversion to Bijou Meadow (active)	+	o	-	-	-	+	Control over when water is diverted	Technical complexity of active system	Use Active system to control flow of water to Bijou Meadow
Upper Ski Run Basin (route to Osgood)	+	o	+	-	o	+	Increased water treatment, reduce first flush effect	Grading in steep area, creating a basin near SEZ	Build retention basin near Ski Run crossing
Upper Ski Run Basin (active)	+	o	+	-	o	+	Control over water entering basin	Grading in steep area, complexity of active system	Install active system for upper ski run basin
Aloha Basin (passive)	+	o	-	-	o	+	Reduce flow to Bijou Meadow and potential flooding lower down	Moving water from diversion to basin	Basin to remove and infiltrate wate from Bijou Meadow Diversion pipeline
Pioneer Crossing Pipe Replacement	o	+	+	+	o	+	Decrease flooding on Pioneer Trail	Pipe size could encroach on road base	Replace undersized culvert crossing Pioneer Trail with 2 36" diameter pipes
Relocate Trailer Park Outfall	o	+	-	+	-	+	Reduce flooding in Trailer Park and near Woodbine Ave	Decommissioning old pipe, private property	Replace and reroute pipe under trailer park
Relocate Bijou Park Ck Eastward	o	+	+	+	o	-	Reduce flooding at outlet from Trailer Park	Potential disturbance of existing SEZ, permitting through USFS	Minor regrading to reroute Bijou Park Creek away from Trailer Park outfall to east side of USFS parcel
Shirley to Whole Foods Concrete box/channel	o	+	+	+	-	+	Eliminate flooding on Shirley and Bill Ave	Private property	Replace undersized culvert

Appendix 10

Design Calculations

Table of Contents

Hydrology 4
City Design Standards 5
California Code of Regulations 6
Ski Run Diversion 6
Design Flows 6
Manning's Equation 6
Utilities 9
Pioneer Crossing 9
Design Flows 9
HY-8 11
Utilities 16
Shirley to Whole Foods 17
Design Flows 17
HY- 8 17
Top of Ground Analysis (Excel) 21
Utilities 22
Osgood Expansion 22
Keller Clean Water Bypass 22
Design Flows 22
Manning's Equation 23
Utilities 25
Aloha Basin 26
Design Flows 26
Basin Design 26
Utilities 27
Bijou School 27
Design Flows 27
Basin and Pipe Design 28
Utilities 29

Rockwood to Blackwood 30
Design Flows 30
Manning's Equation For Pipes 30
Manning's Equation For Channels 32
Utilities 33

General Design Approach

Hydrology

Design flows were based on the hydrological analysis done by Toby Hanes of northwest hydraulic consultants (nhc) and presented in the report "Peak Flow Estimates for Bijou Park Creek Watershed Based on Empirical Data". Further discussion on hydrological modeling and estimates can be accessed in that report.

All pipe and culvert design flow estimates were obtained from the Analog Basin Method discussed in Hydrology Report (Appendix X). In cases where none of the Analysis Points were sufficiently close to the project area, additional methods were used to modify the existing flows to estimate the 10 and 100 year events to obtain a design flow for the project. These modifications are addressed on a case by case basis in the supporting calculation for each of the Project locations included below. The tables below provide the flow estimates and modifying urban development factors used in the design calculations.

Table 4. Peak Flow Estimates (cfs) for Various Recurrence Intervals Using Mean Value from Analogs.

Analysis Point	Size	Recurrence Interval					
		2	5	10	25	50	100
	(sq. miles)	Peak Flow (cfs)					
Keller Canyon @ Markoffer	0.57	2.8	6.1	9.1	12.8	19.2	26.1
Needle Peak @ Ski Run	0.52	2.6	5.7	8.5	11.9	17.9	24.4
Osgood Basin	0.79	3.7	7.9	11.8	16.5	24.6	33.4
Osgood Basin w/o Keller Canyon	0.22	1.2	2.7	4.2	5.9	9.0	12.4
Trailer Park Outfall	0.25	1.3	3.1	4.7	6.6	10.0	13.7
Bijou Park Creek @ HWY 50	0.99	4.5	9.6	14.2	19.8	29.6	40.0
Bijou Meadow at Lake Tahoe	2.16	9.0	18.1	26.5	36.6	54.2	72.8
Wildwood Basins ABV HWY 50	0.21	1.1	2.6	4.0	5.7	8.6	11.9

"Table 8 gives the correction factors taken from the nomographs within "Magnitude and Frequency of Floods" to account for the effects of urbanization on the previously derived peak flow estimates"

Table 8. Correction Factors Applied to Peak Flow Estimates to Account for Urban Development.

	Recurrence Interval					
Analysis Point	2	5	10	25	50	100
Keller Canyon @ Markoffer	1.15	1.1	1.08	1.07	1.05	1.04
Needle Peak @ Ski Run	1.12	1.08	1.06	1.05	1.04	1.03
Osgood Basin	1.32	1.27	1.21	1.17	1.15	1.13
Osgood Basin w/o Keller Canyon	1.85	1.57	1.48	1.42	1.40	1.36
Trailer Park Outfall	1.15	1.11	1.09	1.08	1.07	1.06
Bijou Park Creek @ HWY 50	1.35	1.23	1.19	1.16	1.14	1.12
Bijou Meadow at Lake Tahoe	1.35	1.23	1.19	1.16	1.14	1.12
Wildwood Basin ABV HWY 50	1.9	1.72	1.55	1.5	1.45	1.4

City Design Standards

The City of South Lake Tahoe Public Improvement and City Engineering Standards 2009 were used to size pipes and place manholes. The following requirements from section 5.09 Design Criteria and Standards on page 48 were used:

Design standards used for pipe sizing and manhole placement:

- Culverts and storm drains shall be designed to carry the peak flow resulting from the 10-year recurrence interval design storm with no head (i.e. a ratio of height of water at inlet (H) to diameter of pipe (D) = 1.0) (5.09.A.1)
- Minimum cover over culverts and storm drains shall be 1.5 feet. Culverts and storm drains shall not extend into the road structural section. (5.09.A.3.)
- To prevent sedimentation, the minimum design flow velocity allowable in any closed conduit system shall be 2.5 feet per second. The maximum design flow velocity in any closed conduit system is 14 fps. Velocities exceeding 14 fps shall be reviewed on a case-by-case basis by the City Engineer. Velocities shall be computed using the Manning equation unless an alternative method is approved by the Engineer (i.e. pressure flow condition). (5.09.A.7)
- The maximum spacing between storm drain manholes shall be 400 feet. (5.09.A.11)
- The minimum storm drain pipe diameter to be used in the City right-of-way shall be 18 inch. (5.09.A.13)

Design standards used for alignment to avoid utilities (Section 6.02 pg. 54):

- Water lines located 6 feet from the road centerline in the center of the travel lane.
- All other utilities shall be located outside the edge of pavement in the road shoulder or within a utility easement SD 07.
- Sanitary sewer located 6 feet from road centerlines.

California Code of Regulations

The California Code of Regulations (updated in 2020) was used to place storm drain in relation to potable water utilities. In particular the following requirements where adhered to:

- New water mains and new supply lines shall be installed at least 4 feet horizontally from, and one foot vertically above, any parallel pipeline conveying storm drainage. (CCR 64572)

Design Calculations

Ski Run Diversion

Design Flows

Needle Peak @ Ski Run (10yr) = 8.5 cfs
Needle Peak @ Ski Run (100yr) = 24.4 cfs

And applying:

Urban Dev Factor (10 yr) = 1.06
Urban Dev Factor (100yr)= 1.03

8.5 x 1.06 = 9.01 cfs
24.4 x 1.06 = 25.86 cfs

To continue supplying the existing Bijou Park Creek SEZ with sufficient flows to maintain the ecological integrity of the area the 10 yr flow (~9 cfs) will continue to flow down the existing channel. Ski Run diversion will mitigate flood events by diverting flows over the 10 year event and will be designed to accommodate up to the ~100 year event.

Design flow = 100 yr flow – 10 yr flow = 25cfs – 9 cfs = **16 cfs**

Manning's Equation

2010 LiDAR was used to obtain the slope/profile of the diversion alignment from the corner of Needle Peak and Ski Run to Pioneer Trail. See excel graph below where blue is the surface profile from the LiDAR and the red line is potential pipe alignment using the equation:

Y (elevation) = 6352.92 (inlet invert) - 0.0465x

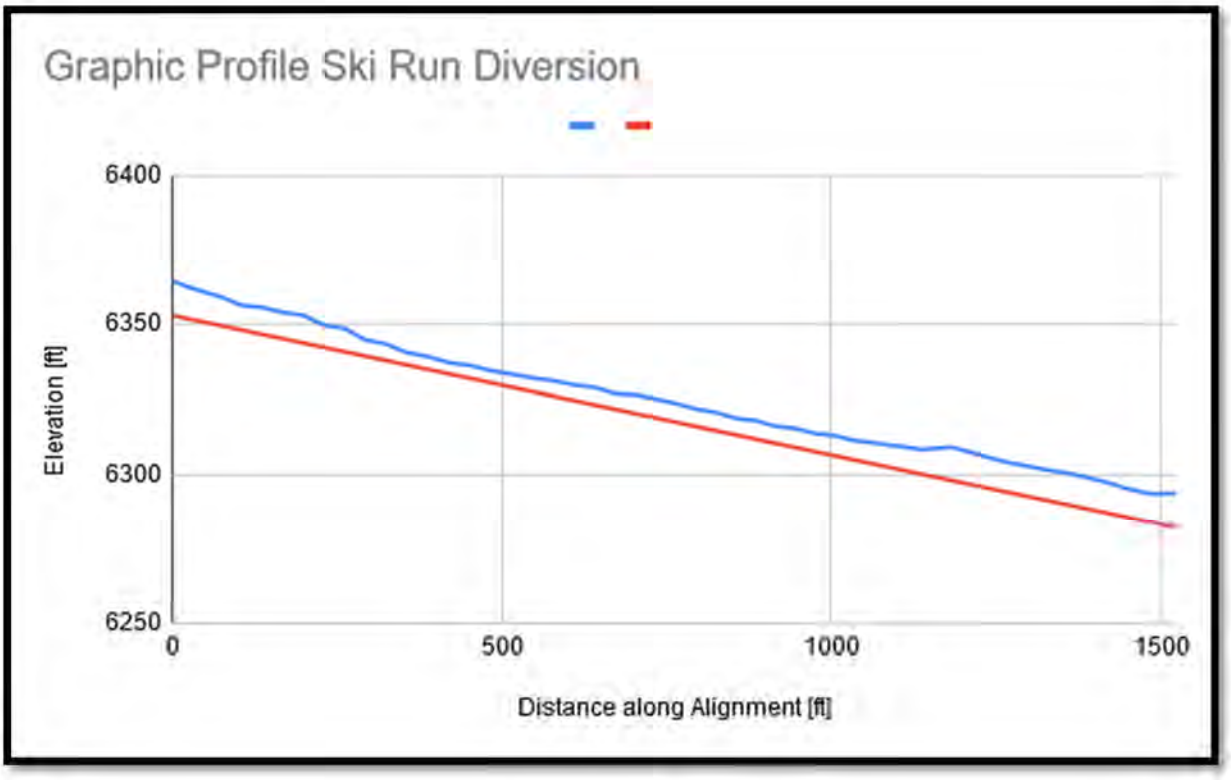
To solve Manning's equation, depth of pipe flow and diameter were tried in iterations until discharge was ~ 16cfs. Below are the results of a 2 foot pipe diameter with a depth of flow of 0.9 ft. To calculate curb and gutter flow the cross section was assumed to be triangular. The road was measured in ArcGIS to be approximately 80 feet wide with the road crown at 40 ft. A 6-inch curb was assumed.

Road Full flow

$A = .5 * h * w = 0.5 * 0.5 * 40 = 10\ ft2$

Road Half flow

$A = 0.5 * h * w = 0.5 * 0.25 * 20 = 2.5\ ft2$



Manning's			**For Curb/Gutter Flow**	
Total Slope	0.04652451555			
Max cfs	16			
diameter [ft]	2			
radius[ft]	1		Full Flow	Half Full
slope	0.04		0.04	0.04
roughness	0.015	concrete pipe	0.02	0.015
depth of flow [ft]	0.9		0.5	0.5
angle (radians)	2.941257811			
Area [sqft]	1.371130162		10	2.5
Wetted Perimete	2.941257811		40.5	20.25
Hydraulic Radius	0.4661713627		0.247	0.1234567901
Discharge Q [ft3/	16.37698999		58.6566925	12.31426044
Velocity [ft/s]	11.94415413		5.86566925	4.925704176

Manning's Equation:

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [SI]$$

Where:

- Q = Flow Rate, (ft^3/s)
- v = Velocity, (ft/s)
- A = Flow Area, (ft^2)
- n = Manning's Roughness Coefficient
- R = Hydraulic Radius, (ft)
- S = Channel Slope, (ft/ft)

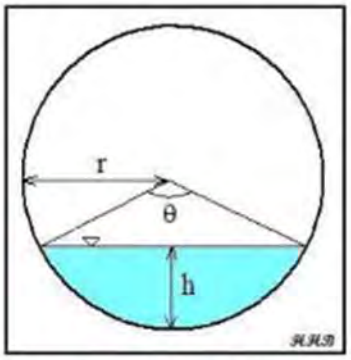


Figure 1. Partially Full Pipe Flow Parameters (Less than Half Full)

$$r = \frac{D}{2} \qquad h = y$$

$$\theta = 2\arccos\left(\frac{r-h}{r}\right)$$

$$A = \frac{r^2(\theta - \sin\theta)}{2}$$

$$P = r\theta$$

$$R_h = A/P$$

Utilities

STPUD Water

- Pressurized Water Main running down East side Ski Run Blvd offset from road, 8" diameter
- 2 Laterals 1 fire, 1 drinking water perpendicular to alignment
- Intersection of David Ln. Pressurized water main perpendicular to alignment along David Ln.
- Water Main running along East side Ski Run to Pioneer intersection

STPUD Sewer

- GravityMain running down East side of Ski Run Blvd, in road. 6 " diameter and perpendicular at David Ln
- Laterals perpendicular to alignment

Gas Line

- Perpendicular to alignment along David Ln.

Pioneer Crossing

Design Flows

For continuity, the 10- and 100-year peak flow estimates for Bijou Park Creek where it enters the culvert crossing at Pioneer Trail were determined by linearly extrapolating from the peak flow values at Ski Run and Needle Peak provided via the Analog Basin method. This method was deemed appropriate for preliminary design of this location given both areas have similar topographical and land cover properties. It was assumed that all flow at Ski Run/Needle Peak is conveyed to where it crosses Pioneer Trail.

Starting with 10-yr and 100-yr storms (0.52 sq mile drainage area) per Table X in the report:

Needle Peak @ Ski Run (10yr) = 8.5 cfs
Needle Peak @ Ski Run (100yr) = 24.4 cfs

And applying:

Urban Dev Factor (10 yr) = 1.06
Urban Dev Factor (100yr)= 1.03

8.5 x 1.06 = 9.01 cfs
24.4 x 1.06 = 25.86 cfs

Linearly Scaling by Area Method - for Increase in Drainage Area below Ski Run/Needle Peak Analysis Point

The Hydrology memo referenced drainage areas used in the 2005 E Pioneer Hydrology Study.
The area of 0.52 square miles was taken from the Appendix 7 HEC-HMS output for catchment 24B.

The contributing area of 0.03 square miles between Ski Run/Needle Peak intersection and Pioneer at Charlesworth Court was obtained be analyzing aerial imagery and LiDAR generated contours in ArcGIS.

Additional Drainage Area = 0.03 square miles
Existing modeled Area = 0.52 square miles

0.52 + 0.03 = 0.55
0.55/0.52 = 1.057 scaling factor

9.01 x 1.057 = 9.53 cfs
25.86 x 1.057 = 27.33 cfs

30% Design Flows for Pioneer Crossing

10 yr = 9.5 cfs
100 yr = 27.3 cfs

As a check to this method the Rational Method was applied to the additional drainage area below Ski Run/Needle Peak and then added. It's important to note that this piece meal approach uses two different time of concentrations (t_c) and should be considered only as a rough check. The results were as follows. Additional detail on the calculations applying Rational Method to the additional drainage areas below Ski Run/Needle Peak can be provided upon request.

10 yr = 9.74 cfs
100 yr = 25.89 cfs

Rounding up for design purposes:
10 yr = 10 cfs
100 yr = 30 cfs

HY-8

Assumptions: It was assumed that the designed outfall channel/tailwater will be at the same grade as the outfall invert. While the existing pipe is silted in and the inverts cannot be measured the top of pipe was surveyed and 2 feet subtracted to obtain the inverts. We are assuming that this full 2 feet of space is available (no utility conflicts) for pipe replacement. The modeling reflects replacing the pipe at the current grade and alignment and raising the road by 2 feet to provide sufficient cover. Tailwater data, as described below, is obtained by using LiDAR data and visual observation of photos and the channel on site. Future iterations of design would require field measurements to model the tail water condition more accurately.

Included below is the HY-8 run for a single 24 inch pipe since that is the size in the design. Other pipe sizes were modeled and the results are available upon request.

Input Summary

Discharge Data

Minimum Flow: 1.00 cfs (placeholder for low flow/ dry season)

Design Flow: 10.0 cfs (10yr peak flow, see hydrologic calculations above)

Maximum Flow: 30.0 cfs (100yr peak flow, see hydrologic calculations above)

Tailwater Data

Channel is too small to be detected by LiDAR but it was used to get approximate slope. Visual inspection of the image below and survey data were used to define the tailwater channel cross section.

Channel Type: Irregular Channel (sloped sides to rectangular cross section)

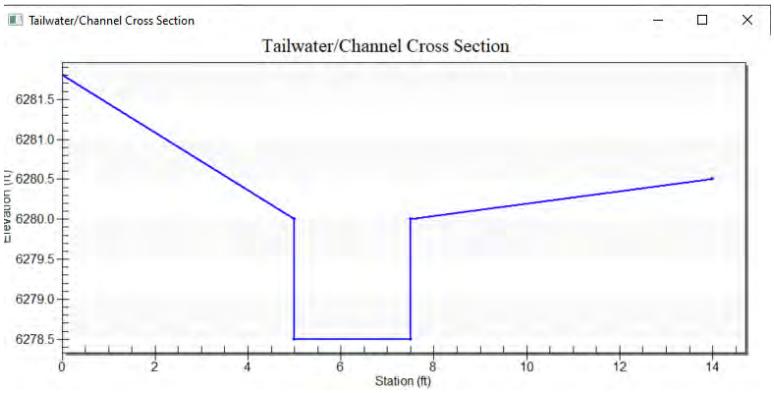


Table X. Approximated Tailwater Channel Cross-Section

No.	Station (ft)	Elevation (ft)	Manning n
1	0	6281.8 (.2 ft below road level)	0.0600 (moderate vegetation)
2	5.0	6280.0 (1.8/5 = 36% slope)	0.06
3	5.0	6278.5 (1.5ft deep channel)	0.04 (sandy gravely substrate)
4	7.5	6278.5 (2.5 ft wide channel)	0.04
5	7.5	6280.0	0.06
6	14	6280.5 (.5/6.5 = 8% slope)	-

Channel Slope: 0.03 (From LiDAR, although seems high)

Mannings n (channel): 0.04 channel, 0.06 overbank

Channel Invert Elevation: 6278.5 (outlet pipe invert: survey top of pipe – 2ft)

Roadway Data

Roadway Profile Shape: Constant Roadway Elevation (assuming flat roadway no berm as placeholder)

First Roadway Station: 0

Crest Length: 100 ft

Crest Elevation: 6284.51 (from survey edge of pavement at culvert inlet + 2 ft)

Roadway Surface: Paved

Top Width: 45 ft (adjusted based on survey length of pipe 48.6ft)

Culvert Data

Shape: Circular

Material: Concrete

Diameter: 2.0 ft

Embedment Depth:

Manning's n: 0.014

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: No

Site Data

Site Data Input Option: Culvert Invert Data

Inlet Station: 0

Inlet Elevation: 6279.6 (survey top of pipe – 2 ft)

Outlet Station: 48.6 ft (from survey)

Outlet Elevation: 6278.5 (survey top of pipe – 2ft)

Number of Barrels: 1

Slope elevations are derived from Lake Tahoe Basin LiDAR, August 2010

Horizontal Coordinates

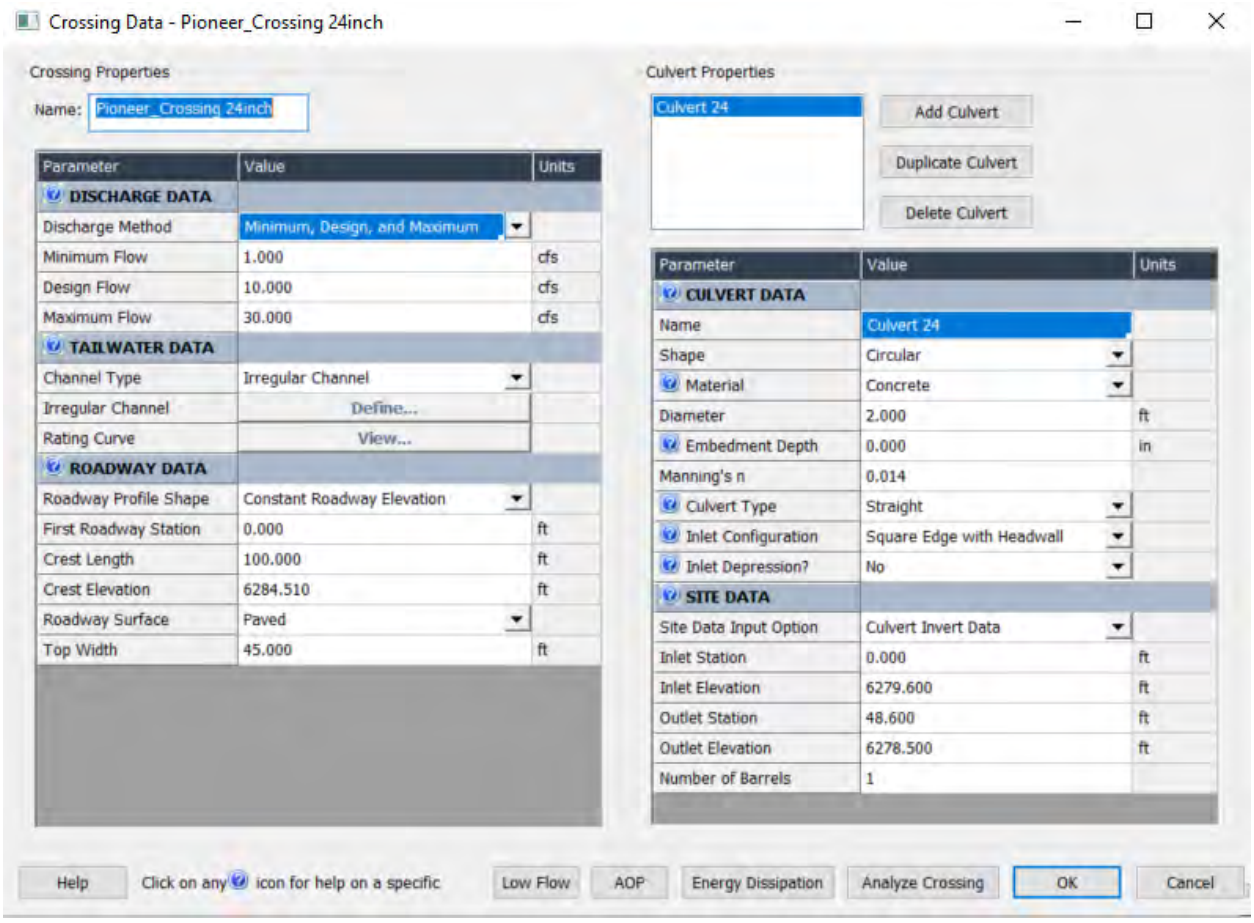
UTM Zone 10N NAD83 Meters [EPSG: 26910]

Vertical Coordinates

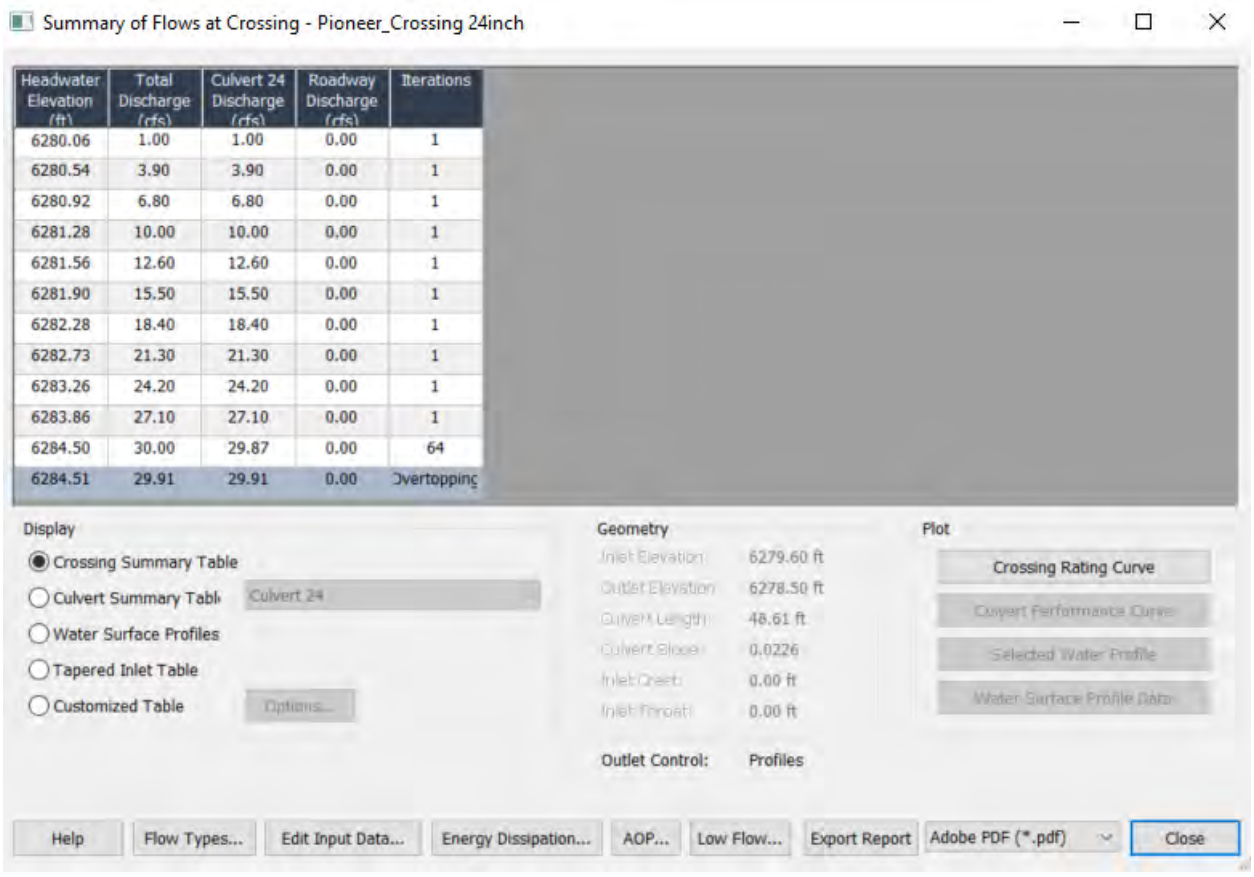
NAVD88 [EPSG: 5703]

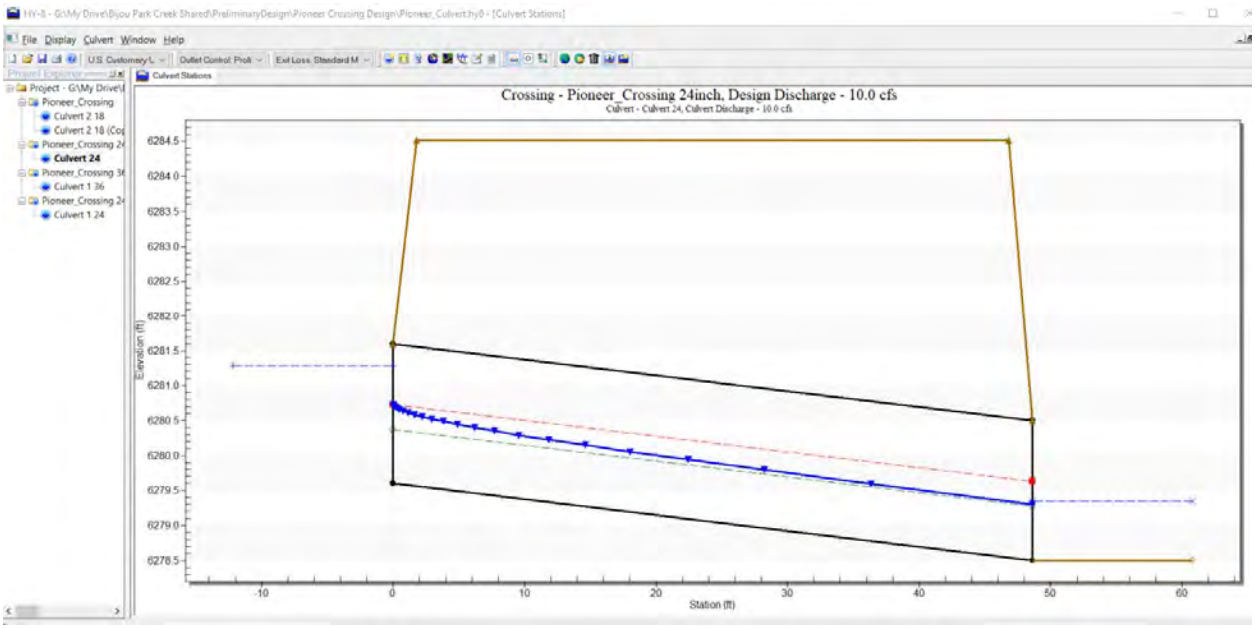
Survey points were collected using a total station on July 30th, 2020 by Insite Land Surveys.

Summary of Input Data



HY-8 Output





Conclusion: a 24 inch pipe can easily convey the design flows at the current grade/ alignment without head

Utilities

1. Potential Utility Conflicts
    a. STUPD Water
        i. Pressurized Main running down Charlesworth Court and crossing Pioneer about 30 feet NE. Also running perpendicularly to culvert crossing along both sides of Pioneer Trail.
        ii. Lateral to CTC Parcel on South corner about 30 feet south of crossing up Charlesworth court.
    b. STPUD Sewer
        i. Gravity Main Running down Charlesworth Court and along South side of Pioneer Trail.
        ii. Downstream invert of section coming down Charlesworth: sGravityMain: 6278.104233
        iii. Laterals from sewer line to CTC parcel, ~100 ft away from culvert
    c. Gas Lines
        i. Running down both sides of Pioneer Trail crossing perpendicularly. Also coming down Charlesworth Court and turning along Pioneer. So up to three gas lines crossing the culvert perpendicularly.
    d. AT&T and Liberty
        i. Both have aerial lines running along the South side of Pioneer Trail

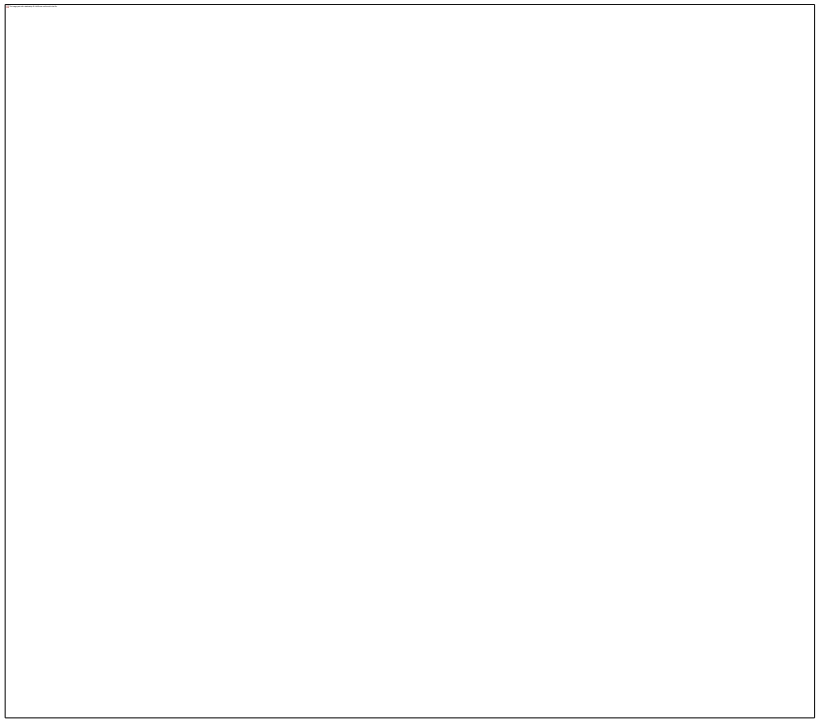


Figure 1 Pressurized Water Main Locations (pink)

Shirley to Whole Foods

Design Flows

It is assumed that there is a negligible flow increase between the outlet of the storm drainage pipe into the Whole Foods Restoration area and just downstream at Hwy 50.

Bijou Park Creek @ HWY 50 from Table X

10 yr = 16.9

100 yr = 44.4

And applying:

Urban Dev Factor (10 yr) = 1.19
Urban Dev Factor (100yr)= 1.12

16.9 * 1.19 = 20.1 cfs

44.4 * 1.12 = 49.7 cfs

HY- 8



Assumptions: The channel enters the pipe in the backyard of 027-113-033 which then goes North under the adjacent house where it connects to a junction at Bill Ave and changes direction but continuing North to a second junction just South of the boundary of the Whole Foods Restoration area. A short pipe then outfalls into the restoration area. This whole system is being modeled as a culvert so there would be additional losses at the junctions that are not being taken into account. In addition the tailwater is based on the gutter flow line downstream at highway 50. It is assumed that during a flood the maximum allowable elevation is .5 ft below where it would flood the highway and that tailwater elevation will be maintained upstream through the restoration area to where this system outlets.

<u>Discharge Data</u>

Min flow: 1 cfs (not particularly important for our purposes)

Design flow: 20 cfs (10 yr storm)

Max flow: 50 cfs (100 yr storm)

Tailwater Data

Pipe ends at junction before out letting into wholefoods restoration area. The analysis is done assuming that the restoration area is full of water and there is a constant water elevation in the pipe conveying water there. The tailwater configuration is the junction so the channel invert elevation is less relevant since it's the bottom of the manhole.

Channel Type: Enter Constant Tailwater Elevation

Channel Invert Elevation: 6237.74 (from nhc survey data, this is the outlet pipe invert)

Constant Tailwater Elevation: 6240.03 (gutter flowline at hwy 50 minus 0.5 feet, from nhc SWMM spreadsheet, this is the maximum allowable headwater since over 6240.53 the highway begins to flood)



Figure 2 Culvert inlet (in back yard between Shirley and Bill Ave)

Roadway Data (a back yard)

Roadway Profile Shape: Constant Roadway Elevation

First Roadway Station: 0 (arbitrary)

Crest Length: 100 ft (arbitrary)

Crest Elevation: 6243.26 (top of open channel next to residence)

Roadway Surface: Gravel (approximate)

Top Width: 200 ft (arbitrary)

Figure 3 Where "top of open channel" point was taken

Culvert Data



Shape: Circular

Material: Concrete

Diameter: 2.5 ft

Embedment Depth: 0

Manning's n: 0.016 (according to nhc SWMM model)

Culvert Type: Straight

Inlet Configuration: Grooved end projecting

Inlet Depression: No

Site Data

Site Data Input Option:

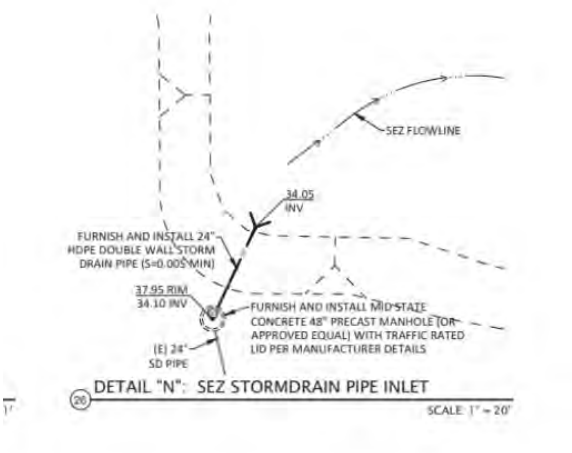
Inlet Station: 0

Inlet Elevation: 6239.720 (nhc survey data)

Outlet Station: 264 ft (measured in ArcGIS along GIS SW layer connecting inlet to outlet nhc survey points)

Outlet Elevation: 6237.740 (nhc survey data, compare to 6238.1 of Marketplace plan set, different vertical coordinate systems so conversion could be off)

Number of Barrels: 1



From Whole Foods Restoration Area plan set, convert to NAD 1988 by adding 3.9ft

Summary of Flows at Crossing - Design (New)

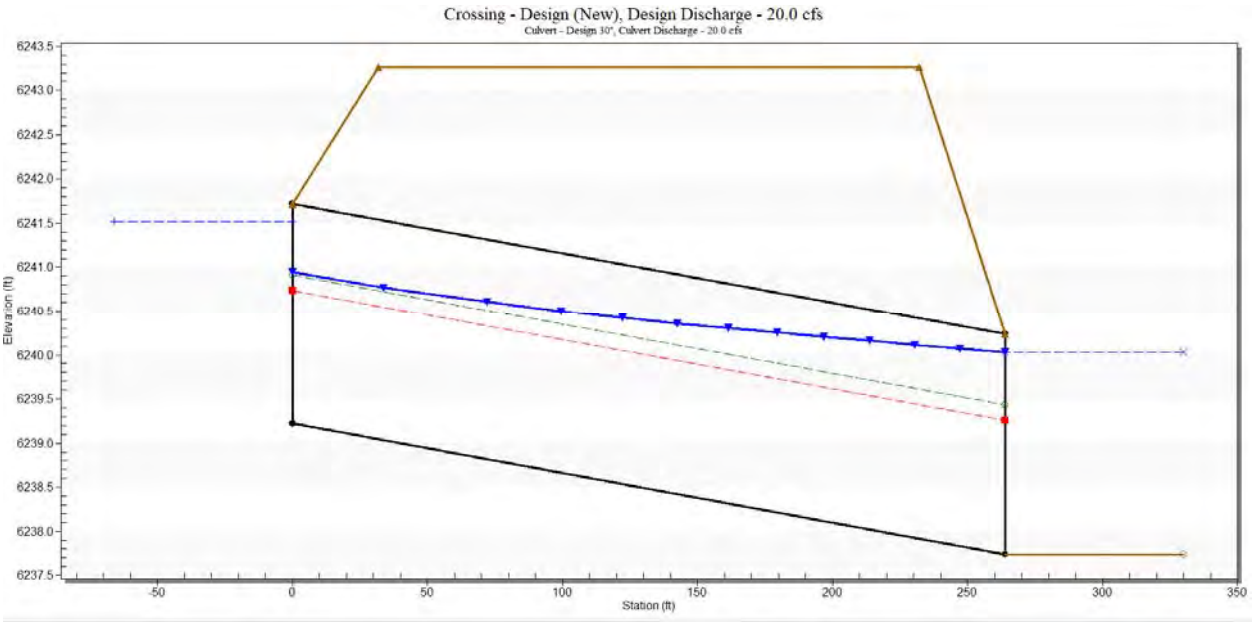
Headwater Elevation (ft)	Total Discharge (cfs)	Design 30" Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6240.04	1.00	1.00	0.00	1
6240.37	5.90	5.90	0.00	1
6240.82	10.80	10.80	0.00	1
6241.20	15.70	15.70	0.00	1
6241.52	20.00	20.00	0.00	1
6241.97	25.50	25.50	0.00	1
6242.90	30.40	30.40	0.00	1
6243.29	35.30	32.25	2.91	19
6243.32	40.20	32.38	7.57	4
6243.34	45.10	32.49	12.50	4
6243.36	50.00	32.58	17.20	3
6243.26	32.10	32.10	0.00	Overtopping

Display
- (•) Crossing Summary Table
- ( ) Culvert Summary Tabl — Design 30"
- ( ) Water Surface Profiles
- ( ) Tapered Inlet Table
- ( ) Customized Table — Options...

Geometry
- Inlet Elevation: 6239.22 ft
- Outlet Elevation: 6237.74 ft
- Culvert Length: 264.00 ft
- Culvert Slope: 0.0056
- Inlet Crest: 0.00 ft
- Inlet Throat: 0.00 ft
- Outlet Control: Profiles

Plot
- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

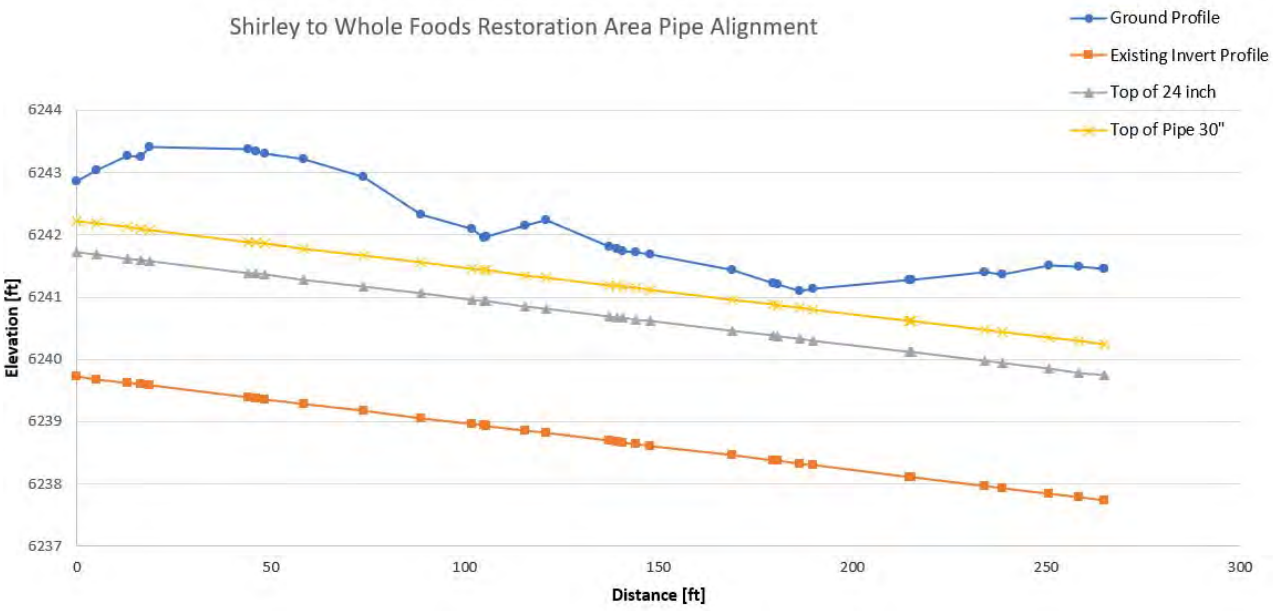
Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Low Flow... | Export Report | Adobe PDF (*.pdf) | Close



Conclusion: A 30 " pipe could successfully convey the 10 yr storm (~20 cfs).

Top of Ground Analysis (Excel)

Using LiDAR topography and invert survey data previously discussed an analysis was done to look at ground cover if the existing invert was maintained. If the pipe is upsized the invert would need to be lowered to maintain sufficient cover. Excel tables and additional information is available upon request.



Utilities

STPUD Water

- Pressurized Distribution Main on North side of Shirley and Bill (Steel 5.4 OD, Diameter 6”,
- Line on Bill will be replaced 2021 according to Brent at STPUD

STPUD Sewer

- Gravity Main (asbestos cement, Upstream invert 6241.45839, Downstream invert 6238.18167, Diameter 6”)
- 2 Gravity mains on Shirley, 1 on Bill
- 1 Gravity main running parallel to open Channel

Gas Line

- No gas lines within 100ft

No Liberty or AT&T infrastructure in project boundary.



Pink = Sewer Gravity Main, Blue = Water Pressurized Main

Osgood Expansion

Keller Canyon Bypass

Design Flows

Keller Canyon @ Markoffer (10yr) = 9.1 cfs
Keller Canyon @ Markoffer (100yr) = 26.1 cfs

And applying:

Urban Dev Factor (10 yr) = 1.08
Urban Dev Factor (100yr)= 1.04

9.1 x 1.08 = 9.8 cfs
26.1 x 1.04 = 27.1 cfs

To reduce flow to the Osgood basin as much as possible, the peak flow selected was the 100 year recurrence interval. The alignment was chosen to follow the existing storm drain from Markoffer to

Osgood basin and minimize utility conflicts and maintain separation with potable water. To minimize conflicts, the proposed pipe has to cross the existing storm drain in 2 locations and therefore, the proposed pipe is generally lower than the existing storm drain.

Manning's Equation

2010 LiDAR was used for the street elevation. The profiles of the existing storm drain were imported from the City's GIS inventory and cross-checked with as-built plans from the Bijou/Wildwood Erosion Control Project. Minimum and maximum slopes with the minimum pipe size were examined to meet the City's velocity standards and convey the 100 year peak flow. Tables showing these calculations are below. Since HDPE is generally less expensive than RCP, it was used throughout the alignment, but RCP values are also provided and could be used interchangeably based on the minimum and maximum slopes used in the pipe alignment.

SUMMARY	**Min Slope**	**Max Slope**
24" RCP	1.43%	3.75%
24" HDPE	1.22%	3.20%
30" RCP	0.44%	2.80%
30" HDPE	0.37%	2.37%

Calculation Tables

	Min. Slope, 24" RCP		**Max. Slope, 24" RCP**	
Slope (ft/ft)	**1.43%**		**3.75%**	
Pipe Size, diameter (ft)	2	proposed 24" RCP	2	proposed 24" RCP
pipe radius	1		1	
Manning's n	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle		circle	
Bottom Width (ft)	n/a		n/a	
Side Slope (xH:1V)	n/a		n/a	
P= Wetted Perimeter [ft]	6.28		6.28	
A= Cross sectional flow area [ft^2]	3.14		3.14	
R= Hydraulic Radius = A/P	0.50		0.50	
Velocity [ft/sec]	8.6	needs to be between 2.5 and 14	14.0	

Maximum existing Q [cfs]	**27.1**	meets min. CFS, and within velocity	**43.9**	meets max. velocity and min. CFS

	Min. Slope, 24" HDPE		Max. Slope, 24" HDPE	
Slope (ft/ft)	**1.22%**		**3.20%**	
Pipe Size, diameter (ft)	2	proposed 24" HDPE	2	proposed 24" HDPE
pipe radius	1		1	
Manning's n	0.012	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition	0.012	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle		circle	
Bottom Width (ft)	n/a		n/a	
Side Slope (xH:1V)	n/a		n/a	
P= Wetted Perimeter [ft]	6.28		6.28	
A= Cross sectional flow area [ft^2]	3.14		3.14	
R= Hydraulic Radius = A/P	0.50		0.50	
Velocity [ft/sec]	8.6	needs to be between 2.5 and 14	14.0	
Maximum existing Q [cfs]	**27.1**	meets min. CFS, and within velocity	**43.9**	meets max. velocity and min. CFS

	Min. Slope, 30" RCP		Max. Slope, 30" RCP	
Slope (ft/ft)	**0.44%**		**2.80%**	
Pipe Size, diameter (ft)	2.5	proposed 30" RCP	2.5	proposed 30" RCP
pipe radius	1.25		1.25	
Manning's n	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle		circle	
Bottom Width (ft)	n/a		n/a	
Side Slope (xH:1V)	n/a		n/a	
P= Wetted Perimeter [ft]	7.85		7.85	
A= Cross sectional flow area [ft^2]	4.91		4.91	
R= Hydraulic Radius = A/P	0.63		0.63	

Velocity [ft/sec]	5.6		14.0	
Maximum existing Q [cfs]	**27.3**	meets min. velocity	**68.8**	meets max. velocity, fails min. CFS

	Min. Slope, 30" HDPE		Max. Slope, 30" HDPE	
Slope (ft/ft)	**0.37%**		**2.37%**	
Pipe Size, diameter (ft)	2.5	proposed 30" HDPE	2.5	proposed 30" HDPE
pipe radius	1.25		1.25	
Manning's n	0.012	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition	0.012	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle		circle	
Bottom Width (ft)	n/a		n/a	
Side Slope (xH:1V)	n/a		n/a	
P= Wetted Perimeter [ft]	7.85		7.85	
A= Cross sectional flow area [ft^2]	4.91		4.91	
R= Hydraulic Radius = A/P	0.63		0.63	
Velocity [ft/sec]	5.5	needs to be between 2.5 and 14	14.0	
Maximum existing Q [cfs]	**27.1**	meets min. CFS, and within velocity	**68.6**	meets max. velocity and min. CFS

Utilities

CSLT Storm Drain

- Existing storm drain varying from 36” CMP to 48” x 24” reinforced concrete box to 42” x 29” and 57” x 38” elliptical CMP travels a similar alignment of the proposed bypass – primarily in road shoulder after crossing Pioneer Trail. Manholes delineate this alignment. Key manholes at crossings should be dipped prior to the next design iteration.
- There are 13 locations where the proposed pipe must cross under an existing storm drain.

STPUD Sewer

- Gravity Sewer runs primarily down one lane of the road for the entire alignment varying in size from 6”-8.” Gravity sewer along Ski Run is running away from the Lake which necessitated a deeper storm drain in some areas.
- There are 10 locations where the proposed pipe must cross under a sewer main.
- Laterals exist perpendicular to the entire alignment and the proposed pipe will travel below them.

STPUD Water

- Pressurized Water Main runs primarily down one lane of the road for the entire alignment varying in size from 4”-19” – the 19” number may be an error in the STPUD GIS database and should be confirmed in the next iteration of design.
- There are 10 locations where the proposed pipe must cross under a water main.
- Laterals exist perpendicular to the entire alignment and the proposed pipe will travel below them.

Gas Line

- Exists parallel to the alignment. There are 12 locations where the proposed pipe must cross under the gas line.

Fiber Optic/Communication

- Exists parallel to the alignment along Ski Run Blvd and may require relocation or bracing during construction. For the next iteration of design, the location of the Fiber Optic should be verified and the proposed pipe alignment could be adjusted to avoid it.

Power

- Overhead electric exists in parallel to the proposed alignment and should not interfere. No required pole holding was assumed in the cost estimate.
- Underground power exists along Ski Run Blvd and is not in conflict with the proposed alignment.

Aloha Basin

Design Flows

Aloha is a local treatment project and did not have detailed hydrology performed. However, analysis using the Pollutant Load Reduction Model (PLRM) was performed by the City with assistance from NTCD and the catchment BPCw2 was found to contribute 1957 lbs of FSP annually to Lake Tahoe which is the equivalent of 10 Lake Clarity Credits. The contributing area calculated from an aerial and the 2010 LiDAR is approximately 20,000 sq ft. Using a simple rational method, the Q25 was assumed to be 0.41 cfs using an inch over water over the paved catchment.

Basin Design

2010 LiDAR was used and no surveys were completed in this location. The LiDAR was field checked using tape measures, where possible. Since the catchment was small, the minimum allowable pipe size of 18 inches was chosen and conveyance and velocities were checked using a quick calculation. The basin’s primary treatment is through infiltration and so a focus was placed on surface area over volume. Infiltration treatment with higher surface areas typically results in higher FSP sequestration in the Lake Clarity Crediting Program. A table below shows the basin calculation.

Proposed Basin Sizing	Value	Notes
Q20 (TRPA/Regional WQCB)	0.41	cfs (conservative rational method based on 1" over paved contributing of 20000 sf and 0.9 coeff)
Volume (1 hr)	1487.60	cu ft - multiply by 3600 sec in hr

Infiltration Rate	3.00	"/hr - slightly lower than mapped 4" Ksat but chosen due to higher groundwater in proximity
Basin area	2700	sf
Infiltration treatment	675	cf (1 hr of time x Ksat x surface area)
Volume remaining	813	cf (total vol - vol infiltrated)
volume of basin	800	cf
Volume overflowing	13	sf
Volume overflowing	0	ac-ft

Utilities

CSLT Storm Drain

- Existing storm drain travels down Herbert and the size is unknown since the DI was filled with water during the site investigation.
- Existing 12" CMP crosses Herbert near the basin location and will have to be decommissioned.

STPUD Sewer

- Gravity Sewer runs primarily down the center of Herbert and will not interfere.

STPUD Water

- Pressurized Water Main runs down Herbert and should be avoidable. The location should be confirmed for the next design iteration.

Gas Line

- Gas runs down Herbert and depth should be confirmed during next design iteration since it crosses the 2 proposed pipes.

Fiber Optic/Communication

- Fiber runs down Herbert and depth should be confirmed during next design iteration since it crosses the 2 proposed pipes.

Power

- Overhead electric exists in parallel to the proposed alignment and should not interfere.

Bijou School Frontage Drainage Improvements

Design Flows

Spruce Ave. near the Bijou Community School is a local treatment project and did not have detailed hydrology performed by nhc. The contributing area was calculated from an aerial and the 2010 LiDAR is approximately 0.76 acres. Using a the rational method, the Q10 and Q100 were calculated for the 24 hour event for pipe sizing and the Q25 was calculated for the 1 hour duration event for basin sizing. The table below shows the rational method calculation for the design flows.

Rational Method - Spruce Ave.

Item	Value	Units	Notes
Slope	0.04	ft/ft	
Velocity (20.32s^0.5)	4.064	f/s	
Length	625	ft	
ToC (length/3600*V)	0.04	hrs	
ToC_min	2.56	minutes	
Intensity_10	3.37	in/hour	24 hr storm
Intensity_100	5.54	in/hour	24 hr storm
C	0.95		assume for pavement
Area	0.76	acres	
Q_10 (24 hr)	2.44	cfs	
Q_100 (24 hr)	4.02	cfs	

Basin and Pipe Design

2010 LiDAR was used and no surveys were completed in this location. The LiDAR was field checked using tape measures, where possible. Mannings was used to check the pipe capacity and the minimum 18 inch RCP was found to have more than enough capacity for the 100 year event. The basin's primary treatment is through infiltration and so a focus was placed on surface area over volume. This also improves safety for children in the area. Infiltration treatment with higher surface areas typically results in higher FSP sequestration in the Lake Clarity Crediting Program. A table below shows both the pipe and basin calculations.

Spruce Ave Storm Drain	value	notes
Q10 (cfs)	**2.44**	calc'd
Q100 (cfs)	**4.02**	calc'd
Length (ft)	322	
	Min. Slope, 18" RCP	
Slope (ft/ft)	0.50%	
Pipe Size, diameter (ft)	1.5	proposed 18" RCP
pipe radius	0.75	
Manning's n	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle	
Bottom Width (ft)	n/a	
Side Slope (xH:1V)	n/a	
P= Wetted Perimeter [ft]	4.71	
A= Cross sectional flow area [ft^2]	1.77	
R= Hydraulic Radius = A/P	0.38	

Velocity [ft/sec]	4.2	needs to be between 2.5 and 14
Maximum existing Q [cfs]	**7.4**	meets min. CFS, and within velocity

Spruce Basin Sizing	Value	Notes
Q20 (TRPA/Regional WQCB)	1.41	cfs (conservative rational method based on 1" over paved contributing of 68412 sf and 0.9 coeff)
Volume (1 hr)	5088.50	cu ft - multiply by 3600 sec in hr
Infiltration Rate	4.00	"/hr - slightly lower than mapped 12.7" Ksat but chosen to be conservative
Basin area	4480	sf
Infiltration treatment	1493	cf (1 hr of time x Ksat x surface area)
Volume remaining	3595	cf (total vol - vol infiltrated)
volume of basin	3400	cf
Volume overflowing	195	sf
Volume overflowing	0	ac-ft

Utilities

CSLT Storm Drain

- Existing storm drain travels down the center of Spruce and the proposed improvements will tie into the existing system.
- The existing system's elevations should be verified during the next iteration of design.
- Existing DI should be examined for efficiency and updating them should be examined during next iteration of design.

STPUD Sewer

- Gravity Sewer runs primarily down the center of Spruce and a minimum of three crossings are necessary.

STPUD Water

- Pressurized Water Main runs down the northwest side of Spruce and 2 crossings are necessary.

Gas Line

- Gas runs down Spruce in the vicinity of the water main and 2 crossings are necessary.

Fiber Optic/Communication

- Underground fiber optic runs perpendicular to the proposed pipe in a few locations and its location should be confirmed.

Power

- Overhead electric exists in parallel to the proposed alignment and should not interfere. Future path projects at the school may examine underground these power lines for additional shoulder space.

Rockwood to Blackwood

Design Flows

Trailer Park Outfall (10yr) = 4.7 cfs
Trailer Park Outfall (100yr) = 13.7 cfs

And applying:

Urban Dev Factor (10 yr) = 1.09
Urban Dev Factor (100yr)= 1.06

4.7 x 1.09 = 5.1 cfs
13.7 x 1.06 = 14.5 cfs

The area from Woodbine through the Heavenly Valley Mobile Home Park and down Blackwood Ave is relatively flat. There is a drop of less than a foot from Rockwood to Blackwood near the mobile home park entrance and a drop of roughly 7 feet from Rockwood to Blackwood at the intersection of Spruce Ave. Since flooding is the primary concern in this area, the 100 year design flow was used to size the pipes in this area. Pipe outfalls should be away from the side of the road to prevent interference with snow removal.

Manning's Equation For Pipes

2010 LiDAR was used for the street elevation and survey was completed in July 2020 to check points such as pipe outlets and channel flowlines. Since HDPE is generally less expensive than RCP, it was used throughout the alignment, but RCP was used where the 1.5 minimum cover could not be met. The tables below show the conveyance, slopes, and velocities for the 24" segments of pipe in the design.

Culvert to Spruce - RCP - road slope	**value**	**notes**
Q10 (cfs)	**5.10**	from nhc Table 9
Q100 (cfs)	**14.50**	from nhc Table 10
Length (ft)	633	needs intermediate DI/MH because >400'
Upper Elevation (ft)		
Lower Elevation (ft)		
Slope (ft/ft)	0.96%	taken from road slope minus .01 elevation change across intermediate DI/MH
Pipe Size, diameter (ft)	2	proposed 24" RCP
pipe radius	1	
Manning's n	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle	
Bottom Width (ft)	n/a	

Side Slope (xH:1V)	n/a	
P= Wetted Perimeter [ft]	6.28	
A= Cross sectional flow area [ft^2]	3.14	
R= Hydraulic Radius = A/P	0.50	
Velocity [ft/sec]	7.1	needs to be between 2.5 and 14
Maximum existing Q [cfs]	**22.2**	exceeds required 100 year event frequency;

Culvert to Spruce - RCP low slope	**value**	**notes**
Q10 (cfs)	**5.10**	from nhc Table 9
Q100 (cfs)	**14.50**	from nhc Table 10
Length (ft)		
Upper Elevation (ft)		
Lower Elevation (ft)		
Slope (ft/ft)	0.50%	min
Pipe Size, diameter (ft)	2	proposed 24" RCP
pipe radius	1	
Manning's n	0.013	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle	
Bottom Width (ft)	n/a	
Side Slope (xH:1V)	n/a	
P= Wetted Perimeter [ft]	6.28	
A= Cross sectional flow area [ft^2]	3.14	
R= Hydraulic Radius = A/P	0.50	
Velocity [ft/sec]	5.1	
Maximum existing Q [cfs]	**16.0**	exceeds required 100 year event frequency;

Culvert to Spruce - HDPE	**value**	**notes**
Q10 (cfs)	**5.10**	from nhc Table 9
Q100 (cfs)	**14.50**	from nhc Table 10
Length (ft)		
Upper Elevation (ft)		
Lower Elevation (ft)		
Slope (ft/ft)	0.35%	min slope
Pipe Size, diameter (ft)	2	proposed 24" HDPE
pipe radius	1	

Manning's n	0.012	value for ave Concrete; Appendix 19.A, Lindeburgh: Civil Engineering Reference Manual, Tenth Edition
Shape	circle	
Bottom Width (ft)	n/a	
Side Slope (xH:1V)	n/a	
P= Wetted Perimeter [ft]	6.28	
A= Cross sectional flow area [ft^2]	3.14	
R= Hydraulic Radius = A/P	0.50	
Velocity [ft/sec]	4.6	
Maximum existing Q [cfs]	**14.5**	exceeds required 100 year event frequency;

Manning's Equation For Channels

2010 LiDAR was used for elevations of the surrounding area of the channels. For the area between Rockwood Dr. and the mobile home park, a survey was completed to confirm ground elevations in July 2020. The channel design was based on available area and the Mannings Equation for trapezoidal channels. A channel was also designed for the two outfall options presented and this channel must have a minimum slope of 0.6%. The slope according to the LiDAR and survey was roughly 2.5%.

Trapezoid MANNINGS CALCULATOR - Rockwood Channel		
input	value	units
trapezoidal side slope (s)	2	unitless
depth of water (y)	0.67	ft
base of trapezoid	10	ft
cross sectional area (A_c)	7.5978	ft2
wetted perimeter (P)	16.7	ft
channel slope (S)	0.01	ft/ft
hydraulic radius (R)	0.455	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.03	
mean velocity (v)	2.93	ft/s
channel flow (Q)	22.26	cfs

Outlet Channel near Spruce	**value**	**notes**
Q10 (cfs)	**5.10**	from nhc Table 9
Q100 (cfs)	**14.50**	from nhc Table 10
Length (ft)		
Upper Elevation (ft)		
Lower Elevation (ft)		

Slope (ft/ft)	2.46%	existing slope from ground shots 2.46%, min ~0.59%
Channel Size: Trapezoidal	10' top, 2' bttm, 2' ft deep, filled 1.5 ft	
Manning's n	0.035	
Shape	Trapezoidal	
Bottom Width (ft), b	2	
Side Slope (xH:1V)	2':1	
angle of Incline, θ, degrees	26.00	1:1 = 45deg; 2:1 = 26.6deg; 3:1 = 18.4deg
wetted depth, d	1.50	
P= Wetted Perimeter [ft]	5.93	b+ 2*(d/sin θ)
A= Cross sectional flow area [ft^2]	4.91	(b+(d/tanq))*d
R= Hydraulic Radius = A/P	0.83	
Velocity [ft/sec]	5.9	should be between 2 and 6 fps
Maximum Q [cfs]	**28.88**	Passes over 100 year

Utilities

Overall, utilities in the Heavenly Valley Mobile Park are not confirmed and should be confirmed at the next design iteration. They were placed on the plan sheets based on field observation.

CSLT Storm Drain

- An existing culvert under Rockwood will be decommissioned
- An existing culvert and 2 Dis on Blackwood will be decommissioned
- The mobile home storm drain will be tied into the proposed system, but locations should be potholed at the next design iteration.

STPUD Sewer

- Gravity sewer from the house to be demolished at the end of Rockwood will need to be capped. A SSMH may need to be relocated. Coordination with STPUD should occur at the next design iteration.
- Gravity sewer travels down the center of Blackwood and the proposed storm drain will cross in one location. The proposed pipe is shallow in this location so there should be no conflict.
- Laterals should be mapped in the mobile home park.

STPUD Water

- Pressurized Water Main runs down the opposite side of Blackwood from the proposed pipe. The proposed pipe will have to cross the water main in one location.
- Laterals should be mapped in the mobile home park.

Gas Line

- Gas runs down the opposite side of Blackwood from the proposed pipe. The proposed pipe will have to cross the water main in one location.

- Laterals should be mapped in the mobile home park.

Fiber Optic/Communication

- Underground fiber optic runs down Blackwood and its location should be confirmed at the next design iteration. It currently shows up in three locations on the engineering plan and was provided by the utility provider.
- Overhead telephone exists and should not interfere.