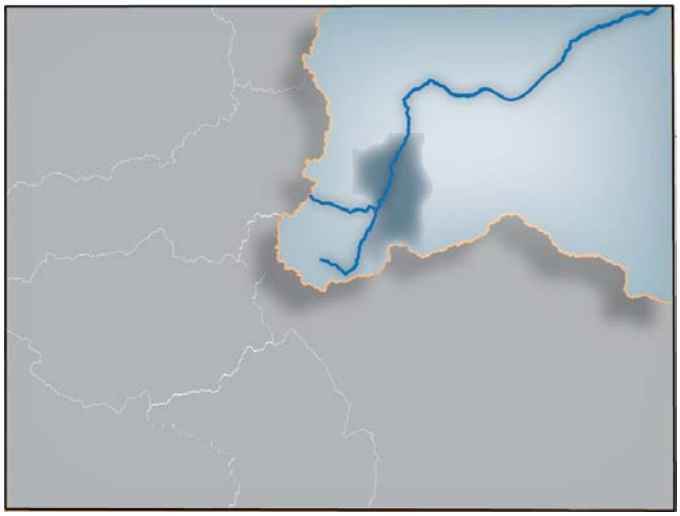

Appendix G – South Platte Basin Surface Water Availability Analysis

South Platte Basin Implementation Plan

South Platte Basin Roundtable/Metro Basin Roundtable

Enter Project Location

March 16, 2015

Technical Memorandum: South Platte Basin Surface Water Availability Analysis

March 11, 2015

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ACKNOWLEDGEMENTS

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1 Introduction and Background

During development of the Draft South Platte Basin Implementation Plan (SPBIP), the need to update current water availability data for the South Platte River Basin was identified. The Colorado Water Conservation Board (CWCB) and Colorado Division of Water Resources (DWR) are in the process of expanding the Colorado Decision Support System (CDSS) to the South Platte River Basin. The CDSS integrates water resources planning tools for Colorado's major water basins encompassing hydrologic and climatic data, water management documentation, and water allocation and crop consumptive-use models to evaluate alternative water management strategies, wide-ranging hydrologic conditions and potential water supply projects. The South Platte Decision Support System (SPDSS) will be a valuable tool to analyze current and future water availability in the South Platte River Basin. However, the SPDSS will not be available until after the Final SPBIP must be submitted to the CWCB (April 17, 2015). As defined in the Scope of Work for Phase 2 of the South Platte BIP, the purpose of this interim technical analysis is to refine available information associated with South Platte Basin water availability to advance discussion of potential water sources for conceptualization of economically viable projects and methods to meet future South Platte Basin water needs.

As defined in Task 1001 (*Surface Water Hydrology and Climate Change Impact Refinements)* of the approved Phase 2 Scope of Work, the HDR Team for the BIP conducted a Surface Water Availability Technical Workshop on October 16, 2014. Representatives of the Metro and South Platte Roundtables, CWCB staff, DWR staff, West Sage Water Consultants, and other consultants with expertise regarding surface water hydrologic modeling in the South Platte Basin attended the workshop. The workshop participants reviewed current surface water hydrologic modeling tools and identified two existing analysis tools as potentially useful in identifying surface water availability in the South Platte Basin.

1.1 Pilot Study

The HDR/MWH team researched the two existing technical analysis tools identified through the workshop approach presented above – a point flow model and a daily call chronology-based analysis tool – for estimating water availability on the mainstem of the South Platte River and its tributaries. To better understand the breadth and limitations of each tool, the team completed an evaluation and brief pilot study using a limited set of hydrologic data. Based on the results of the pilot study, it was determined that the combination of the two tools would be the best approach to developing preliminary estimates of potential water availability at various locations in the South Platte Basin. Roundtable representatives and the even broader range of potential readers of this Technical Memorandum, that represent widely variable perspectives, should recognize the limitations of the approach presented herein. This approach is considered a significant step forward in relation to the very constrained techniques possible in earlier State-sponsored characterizations of potential water availability.

1.2 Description of Existing Analysis Tools

The HDR/MWH team conducted meetings and other technical discussions with Roundtable representatives who indicated that previous analyses of South Platte River Basin water supplies prepared independently of the SPBIP work included development of two tools that might be useful in developing assessments useful for the SPBIP. Based on this input, the Wilson Water Group (WWG) and Brown and Caldwell (B&C) were consulted on the applicability of the analysis tools\methodologies they have

developed for determining surface water availability for their South Platte River Basin clients. This section describes these two existing tools and methods.

1.2.1 Point Flow Model

This tool, initially developed by B&C and Ken Fritzler for the Lower South Platte Water Conservancy District in conjunction with Colorado Corn Growers Association, Aurora Water, and Ducks Unlimited under an Alternative Transfer Method (ATM) grant with the State of Colorado, evaluates the daily exchange potential on the mainstem of the South Platte River between the Burlington Ditch diversion (Henderson area) and the Nebraska state line based on hydrologic data, diversion records and call records. This tool uses a detailed point flow modeling approach. The existing model was developed for the period of Water Year (WY) 2000 through WY 2010. Results from the Point Flow Model are used to estimate the exchange capacity at diversion structures and exchange potential between points along the mainstem of the South Platte River. The main limitations of this model are:

- In its current form, the Point Flow Model can only be used to estimate the available water geographic locations within the model extents (mainstem of South Platte River from the Burlington Ditch Diversion to the state line).
- The model is based solely on historical data and on administrative practices and hydrology of the WY 2000 to 2010 time period. Changes to administrative practices or hydrologic conditions outside the boundaries of the conditions during the WY 2000 – 2010 time period could impact water availability estimates derived from the model.
- Years in the model period (i.e., 2000 – 2010) reflect a wide variety of hydrologic conditions from very wet to relatively normal to very dry. Model results may be useful for gaining a preliminary understanding of ranges of unappropriated flows during this period but, due to the relatively short period of record, averages and other statistically-derived estimates will have relatively high levels of uncertainty.
- The model represents use of conditional and absolute water rights to the extent that they were exercised during WY 2000 to 2010. The model does not account for existing conditional water rights that could be used more fully in the future as they are perfected or absolute rights that might not have been fully utilized in the period of analysis. In addition, the model does not consider unused reusable return flows that might be utilized in the future.

Interpretation and use of all model results should account for these limitations.

1.2.2 Daily Call Chronology Method

The second methodology, initially developed by Wilson Water Group (WWG), processes the daily call chronology to determine water availability for a particular water right and applies the post-2004 call regime to historical hydrologic data to evaluate water availability. The original application of this methodology by WWG was within District 7 (Clear Creek). To assess the water available at a gage station for a new water right in the basin, this method calculates the available water at that gage as the minimum of the physical flow at that gage and the most downstream gage in the reach of interest if there are no calls impacting the district. If there is a call impacting the district, this method assumes that there is no additional water availability at the gage. This approach is simpler than developing a point-flow model, but does not explicitly account for water required downstream of the analysis reach during free river conditions and could overestimate available water without detailed information of operations and

downstream water requirements. This method is significantly limited by its level of detail, but provides useful information in the absence of more sophisticated tools. Figure 1-1 shows the decision tree to estimate water availability for a new water right using the Daily Call Chronology method.

This approach requires coupling stream gage information with in-depth knowledge of river operations, existing absolute and conditional water rights, transbasin diversions, reusable return flows, and other factors and, therefore, must be tailored for each specific application.

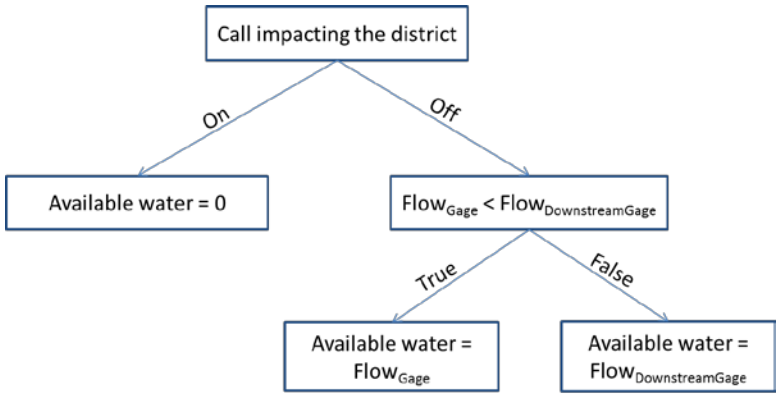


Figure 1-1: Daily Call Chronology Methodology Water Availability Decision Tree

2 Methodology

2.1 Overview of Water Availability Analysis

The surface water availability analysis described in the following sections was completed following the pilot study and the Roundtables' approval of Scope of Work #2 for Task 1001. The analysis evaluated the potential water availability in the South Platte Basin at the following stream gage locations:

Tributaries

1. Bear Creek at Morrison (06710500; BCRMORCO)
2. Big Thompson River near Loveland (BIGLOVCO)
3. Boulder Creek near Orodell (06727000; BOCORO)
4. Clear Creek at Golden (06719505; CLEGOLCO)
5. St. Vrain Creek at Lyons (06724000; SVCLYOCO)

Mainstem Points:

1. South Platte River at South Platte (PLASPLCO) located below confluence of North Fork South Platte and South Platte River
2. South Platte River below Chatfield Reservoir (PLACHACO)
3. South Platte River near Henderson (06720500; PLAHENCO)
4. South Platte River near Kersey (06754000; PLAKERCO)
5. South Platte River near Weldona (06758500; PLAWELCO)
6. South Platte River at Cooper Bridge near Balzac (06759910; PLABALCO)
7. South Platte River at Julesburg (Chan. 1, 2, 4)

Figure 2-1 shows the location of the analysis points. Five of the 12 analysis points are included in the Point Flow Model. The remaining seven points were analyzed using the Daily Call Chronology method. The Cache la Poudre River was not included in this study for several reasons including the location and magnitude of IPPs that would make use native Cache la Poudre water supplies, the comprehensive water management modeling that is being completed to support the EIS processes for these projects and limited budget and time for the SPBIP analyses.

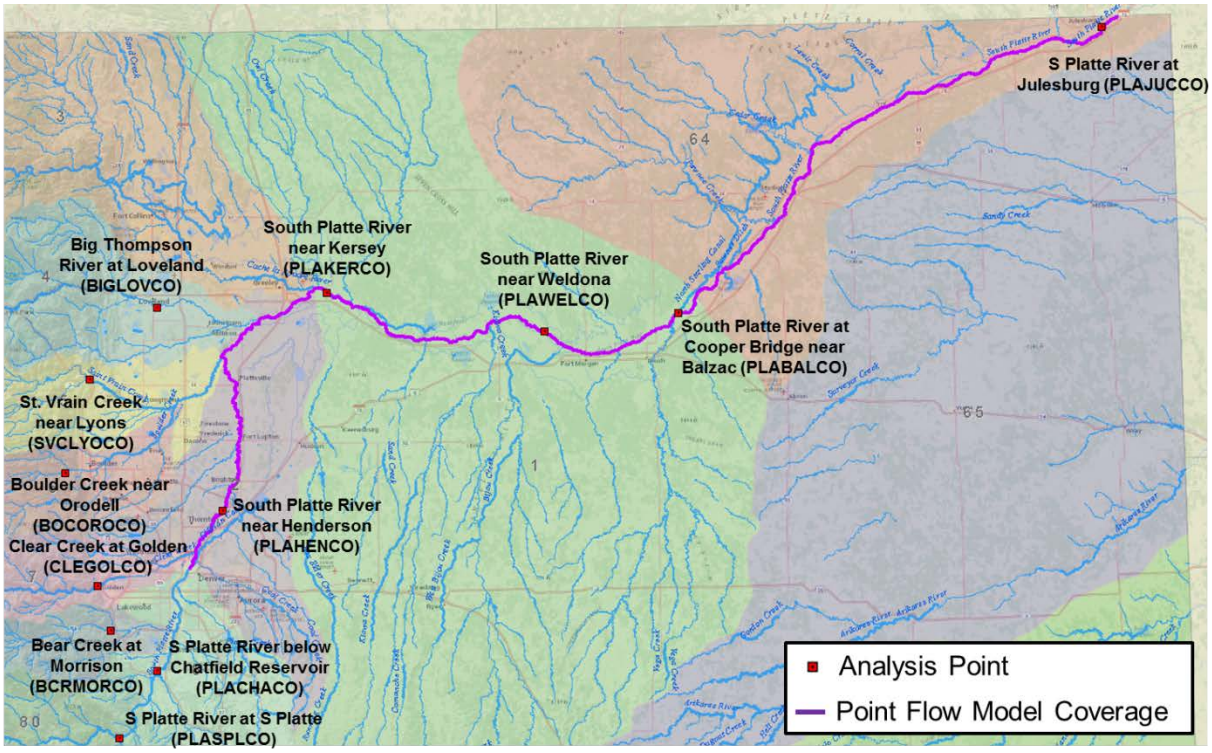


Figure 2-1: Selected Water Availability Analysis Points in the South Platte Basin

2.2 Preliminary Water Availability Estimates

The Point Flow Model and the Daily Call Chronology method were adapted and combined for this study. The Point Flow Model was used to develop preliminary estimates of water availability at the analysis points within in the Point Flow Model extents. The Daily Call Chronology method was used to calculate preliminary estimates of water availability for points not included in the Point Flow Model extents. A layered refinement approach was developed to estimate water availability using the available tools, methods, and information. The layered approach starts with a preliminary estimate of water availability at a given point using the tools described above, and then incorporates location-specific information and knowledge to refine the preliminary estimates.

The existing Point Flow Model was updated for this study by B&C and an independent consultant - Ken Fritzler – to extend the model period through August 2013. The resulting study period for the water availability analysis is October 1999 to August 2013. September 2013 was excluded from the study period due to the anomalous impacts of the historic flood event, and damaging flood water contributing to

missing and unreliable flow measurements. The study period is assumed to be representative of the current river administration and operations, and includes a range of representative hydrologic conditions.

2.2.1 Analysis Points Included in the Point Flow Model

Analysis points located on the mainstem of the South Platte River downstream of the Burlington Ditch diversion to just upstream of the state line are included in the Point Flow Model. The Point Flow Model provides estimates of water flowing past the diversion structures and flow gages during the study period. Potentially available water for a new water right is estimated by determining the minimum water available downstream from the point of interest to the state line. The minimum flow passing the analysis point and the subsequent downstream diversions, subtracting the compact requirements, was assumed to represent the water potentially available at the analysis point. When there is a compact call, it is assumed that there is no water available within the Basin. During periods of time when there is no call in effect from holders of downstream senior water rights, the water available on the mainstem is assumed to be equal to the minimum flow passing the selected diversion structure (i.e. analysis point) and the flow passing all of the diversion structures downstream to the state line, minus the minimum flow required by the South Platte River Compact. The South Platte River Compact requires flow at the state line to be 120 cubic feet per second (cfs) or greater between April 1 and October 15. In the event of a Compact call, all diversions and exchanges within Water District 64 junior to June 14, 1897 are curtailed. The closest diversion structure to the state line considered in this analysis is the Liddle Ditch. Therefore, available flow at the state line was assumed to be equal to the exchangeable flow at the Liddle Ditch minus 120 cfs between April 1 and October 15, and the exchangeable flow at the Liddle Ditch for the remainder of the year.

Compact Call OFF:

*Available Water at the Diversion Structure = **Minimum** of the Downstream Exchangeable Flows at the Diversion Structure and other downstream Diversion Structures **minus** flows required by the South Platte River Compact*

Compact Call ON:

Available Water at the Diversion Structure = 0

Figure 2-2: Decision Tree for Applying Compact Calls in Water Availability

2.2.2 Analysis Points Not Included in the Point Flow Model

To estimate water availability at locations not included in the Point Flow Model (mainstem points #1 and #2 and five tributaries considered in this analysis), an initial estimate of water availability at the analysis point is calculated using the measured flows and historical call chronology to identify days when there were no calls impacting the water district where the analysis point is situated. A number of layers of refinement are applied to the initial estimate to account for circumstances where actual water availability is not defined by simply the presence of a call and the physical flow at the analysis point. The main components included in the preliminary water availability estimate are as follows:

1. **Daily Call Chronology:** A daily call chronology for the most junior water right in Division 1 is developed from the call records on the CDSS website using the methods outlined by WWG (Wilson 2014). No water is assumed to be available at the analysis point on days when a call is impacting the water district in which the analysis location is situated.
2. **Physical Flow at Analysis Point:** For days when there is not a call impacting the water district, the physical flow at the analysis point is taken as the initial estimate of water availability. The physical flow at each streamflow gage is obtained from the CDSS website.

3. **Physical Flow at Downstream Gage:** The first layer of refinement accounts for diversions within the district, between the analysis point and the confluence with the mainstem. The most downstream gage on the tributary is used to account for downstream diversions within the district during free river conditions. If the physical flow at the downstream gage is less than the initial estimate of the water available, it is assumed that water is being diverted between the two gages, and the initial estimate of water available is equal to the physical flow at the downstream gage. Large contributions from tributaries between the two gages are identified to refine the estimated water available at the analysis point. In these cases, large contributions to the reach between the two gages, if measured, are discounted from the water available at the downstream gage.

4. **Intermediate Gages:** An additional layer of refinement incorporates the intermediate flow gages between the analysis point and the most downstream gage to better account for the inflows and diversions occurring between the analysis point and the downstream gage. If the minimum physical flow at an intermediate gage is less than the upstream or downstream physical flow for a particular day, the water available is reduced to the minimum physical flow at the intermediate gages.

5. **Mainstem Water Needs:** The final layer of refinement for the preliminary estimate accounts for diversions and inflows on the tributary and the mainstem to the state line below the most downstream tributary gage. This refinement consists of a check of the tributary water availability estimate against the water available in the Point Flow Model at the first downstream structure from the confluence with the mainstem. For a particular day, water available at the analysis point would be the minimum of water available at the analysis point and first downstream mainstem diversion structure represented in the Point Flow Model.

2.3 Further Refinements to Water Availability Estimates

Water availability estimates resulting from the Point Flow Model and Daily Call Chronology method were further refined by incorporating location-specific information gathered through conversations with South Platte Basin water providers, the Division Engineer, and South Platte and Metro Roundtable members. This section summarizes the efforts to further refine the preliminary water availability estimates.

2.3.1 Meetings with Water Providers and Utilities

The HDR/MWH team conducted meetings with water providers and utilities in the basin to discuss (1) model assumptions about basin water management operations, (2) Identified Projects and Processes (IPP) assumptions, and (3) significant conditional water rights. Analysis results were refined based on input provided by meeting attendees. Table 2-1 summarizes the participants and date of each meeting.

Table 2-1: Summary of Meetings with Water Provider and Utilities

Organization	Date of Meeting
South Metro Water Supply Authority	January 13, 2015
Aurora Water	January 15, 2015
Denver Water	January 21, 2015
Xcel Energy	January 21, 2015
Northern Water	January 23, 2015

These entities represent a sample of all the water providers and utilities in the basin. It should be noted that there are many other entities with similar operational considerations and conditional rights that should be explored to further refine the results of this study. The refinements and considerations raised by the water providers and utilities listed in Table 2-1 included:

- Storage releases
- Exchanges in the Metro area
- Increased use of reusable supplies that may decrease return flows
- Exchange of Colorado-Big Thompson (C-BT) water with Longmont for reusable Windy Gap water
- Implementation of identified projects and processes (IPPs)
- Compliance with the Platte River Recovery Program and the associated Tamarack Plan
- Compliance with the South Platte River Compact

The water providers provided the HDR/MWH team with information to help apply these refinements to the analysis results.

2.3.2 Meeting with Division Engineer

The HDR/MWH team also met with the Division Engineer for the South Platte Basin, Mr. David Nettles, Division 1 staff, and the Water Commissioners on January 20, 2015. The purpose of this meeting was to gain current water administration/water rights information relevant to each district of the basin. General refinements and considerations provided during this meeting included:

- Changes in flows and operations can be lagged by up to four days from the upstream extent of the study area to the downstream extent.
- Actual operations are sometimes different from what is documented within HydroBase.
- Reservoir releases and flows from transmountain diversions are minimal under free river conditions, but can occur.

- There are direct flow, storage, and exchange rights (both conditional and absolute) that may have been decreed but not fully exercised during the analysis period, which may result in over-estimation of future water availability.
- The official call time in the South Platte Basin is 8:00 a.m., however, occasionally calls occur at different times of the day, making interpretation of the call chronology more complex.
- The call record is typically "80% representative" of actual operations on a given day.
- During the winter, ice may constrain the ability of existing water rights to divert and artificially increase the estimate of available water during such periods.
- Voluntary diversion curtailments are often implemented to maintain free river conditions. This has the potential to artificially increase the apparent water availability.

Location-specific refinements were also provided for each water district. These refinements are discussed in the respective Water Availability Results (Section 3) subsections.

2.3.3 Implementation of Common Refinements

This section discusses handling of common refinements and operations affecting the water availability estimates for the analysis points. Table 2-2 summarizes the general aspects of the refinements and considerations for the water availability analysis, including assumptions and approach.

Table 2-2: Refinements Included in Water Availability Estimates Common to all Analysis Points

Feature	Description	Approach/Assumptions	Included in Current Analysis
Reservoir Storage between Analysis Points	Water stored in the reservoir will be measured at the upstream station.	Storage rights are part of the district call; therefore, during free river it is assumed that water measured in the upstream station will not be stored.	✓ Yes
Reservoir Releases between Analysis Points	Releases from storage that are not diverted in the district will be recorded at the downstream gage.	Reservoir releases during free river periods are rare; however, storage releases diverted in the mainstem downstream of the confluence with the mainstem are included in the Point Flow Model and reflected in the Point Flow Model water availability.	✓ Yes
Non-Native Water	Non-native water (i.e., trans-mountain water) flowing in the stream during free river conditions could increase the estimation of water available for new water rights	Non-native water diversion occurring in the reach covered by the Point Flow Model will be accounted in the preliminary estimates. Outside the Point Flow Model, diversion of non-native water between the analysis point and the downstream gage will be accounted for in the preliminary estimate, using the minimum between the two stations.	✓ Yes
Dry Points	Dry points are included in the Point Flow Model (PMF) simulation, but not in the reaches outside of the PFM (discussed in the following section).	It is assumed that dry points are not common in free river situations and that inflows downstream of the dry points are relatively small compared with the upstream flow such that it would not significantly bias the estimate.	✓ Yes (PFM)

Feature	Description	Approach/Assumptions	Included in Current Analysis
Unused Return Flows	Reusing non-native return flows is part of water user's future plans. In the analysis period not all the reusable return flows were used, creating a potential for being accounted as available water in the preliminary estimate. Unused return flows become natural flow and are available for other users. If historically diverted those flows are not part of the preliminary estimate of water availability.	Estimates of excess or unused non-native return flows, when available, are discounted from the preliminary water availability estimate downstream of the return location. Aurora Water provided daily estimates of unused return flows. Denver Water provided monthly estimates of the unused non-native return flows, including estimates from Moffat return flows that were not reused in the analysis period. These estimates were added as a refinement layer to the Point Flow Model water availability estimates since it is assumed that they affect the mainstem downstream of Metro Wastewater discharge.	✓ Yes

2.3.4 Common Refinements not Included in Analysis

This section lists the potential refinements common to all analysis points that were not included in the water availability estimates for various reasons. Table 2-3 summarizes the general aspects of the refinements and considerations for the water availability analysis, including assumptions and approach.

Table 2-3 Refinements not Included in Water Availability Estimates Common to all Analysis Points

Feature	Description	Approach/Assumptions	Included in Current Analysis
Conditional Water Rights	Conditional water rights, including rights for recharge and augmentation, that were not exercised during the analysis period, cause an over-prediction of future water available for a new water right.	Quantification of conditional water rights affecting the analysis points was not performed for this analysis. The water availability estimates will overestimate the future water available. The decreed volumes and rates of conditional water rights in the basin are shown in the table below.	✗ No
Future Water Exchanges	Future decreed exchanges would be considered senior to a new water right. These exchanges could limit the water available at the analysis points.		✗ No
Dry Points	Dry points in reaches outside the Point Flow Model with inflow downstream resulting in downstream flows greater than zero could overestimate water availability because the available water at the analysis point should be zero.		✗ No (Call Chronology)
Identified Projects and Processes (IPPs)	In-basin IPPs are planned projects that may reduce water availability in the future. As a new basin project starts diverting, water availability will be affected in the district of diversion and also in all districts downstream of the project diversion.	Quantification of IPPs that may affect future water availability at the analysis points was not performed for this analysis. As such, the water availability estimates will overestimate the future water available. A summary of in-basin projects that may affect future basin water availability in the basin are listed below. Estimated IPP average yields may not correlate to direct reductions in available water. In some cases, IPPs account for the same available water. Further refinements are necessary.	✗ No

A considerable amount of the potential water availability identified as part of this analysis may already be requested associated with conditional water rights for future projects that have not yet been perfected but have a fixed priority date. If these conditional rights were not exercised during the analysis period, water associated with these rights may appear to be available to a new water right in this analysis. Given the limitations of the available tools, and the uncertainty as to if and how these water rights may be exercised in the future, the effects of these conditional water rights are not quantified as part of this study. For general reference, the total rates and volumes of conditionally decreed water rights are presented in Table 2-4 for each Water District in the South Platte Basin. It is important to note that the rates and volumes presented in Table 2-4 may, in some cases, be associated with the same water right, and therefore should not be considered as additive.

Table 2-4: Conditional Water Rights

Water District	Sum of Conditionally Decreed Rate (cfs)	Sum of Conditionally Decreed Volume (ac-ft/year)
1	14,490	939,887
2	14,686	532,195
3	33,176	434,420
4	529	57,759
5	5,616	353,982
6	1,852	146,357
7	3,474	77,544
8	13,398	1,073,548
9	161	17,350
23	737	240,898
48	29	44,536
49	3	75
64	2,442	490,176
65	14	600
80	111	17,054
Total	90,719	4,426,381

As with conditional water rights, absolute water rights not exercised during the analysis period could lead to overestimation of available water. A portion of the conditional water rights summarized in Table 2-4 are likely associated with IPPs planned for the South Platte Basin. Planned IPPs without decreed conditional water rights will compete for water with a new water right, so the remaining water available after the planed IPPs are in place will be less than the water available in this analysis. Again, due the limitations of the available tools, and the uncertainty as to if and how the IPPs may be operated in the future, the effects of IPPs are not quantified as part of this study. For general reference, IPPs potentially affecting future water availability in the South Platte Basin are summarized in Table 2-5. It is important to note that while IPPs will likely decrease future water availability for a new water right, the estimated yields presented in Table 2-5 represent annual aggregates and do not directly correlate to reductions in annually available flows.

Table 2-5: Identified Projects and Processes Potentially affecting Water Availability Estimates

Project	SWSI 2010 Type*:	Estimated Annual Yield (ac-ft/year)	Sponsor(s)	Water District
Westminster Agreement	RIB	2000	City of Brighton	2
Northglenn Conservation	C	600	City of Northglenn	2
Northglenn New Storage Projects	FIB	1500	City of Northglenn	2
Northglenn Reuse Plan	R	700	City of Northglenn	2
Thornton Conservation	C	3500	City of Thornton	2
Thornton Reuse	R	2000	City of Thornton	2
Thornton Northern Project	RIB	13500	City of Thornton	1,3
South Platte and Beebe Draw Well Project - Reuse	R	3200	City of Brighton	2
Prairie Waters Project	R	15700	Aurora	2
ACWWA Reuse Flow Project	R	3520	ACWWA, SMWSA	2
Halligan Reservoir Enlargement	FIB	7000	City of Fort Collins	3
Greeley Conservation	C	3000	City of Greeley	3
Milton Seaman Reservoir Enlargement	FIB	6600	City of Greeley	3
Longmont Conservation	C	3500	Longmont	5
Northern Integrated Supply Project	RIB	40000	Erie, City of Lafayette, Left Hand Water District, City of Fort Morgan, City of Dacono. Town of Eaton. Town of Windsor. City of Fort Lupton, Fort Collins - Loveland Water District, Central Weld County Water District, Town of Evans, Morgan County Quality Water, Town of Severance, Town of Firestone, Town of Frederick,	1,3
Union Pumpback Pipeline	R	4950	Longmont	5
Union Reservoir Enlargement	RIB	1770	Longmont	5
Erie Reclaimed Water	R	5390	Erie	6
Highway 93 Lakes	RIB	500	Arvada	7
Westminster Gravel Storage	FIB		Westminster	7
Consolidated Mutual Water District Reservoir Construction			Consolidated Mutual Water Company	7
Castle Rock Conservation	C	3350	Town of Castle Rock	8
Alternative Northern Water Supply Project	R	2500	Town of Castle Rock	8
Plum Creek Diversion & WPF Upgrades	R	4100	Town of Castle Rock	8
ASR Pilot Phase Storage	FIB		Town of Castle Rock	8
ASR Future Storage	FIB		Town of Castle Rock	8
Chatfield Reservoir Storage Reallocation Project	RIB	8500	Aurora, Brighton, Central Colorado WCD, Colorado Division of Parks and Outdoor Recreation, Denver Botanic Gardens at Chatfield, Western Mutual Ditch Company, Castle Pines Metro District, Castle Pines North Metro District, Centennial WSD, Center of Colorado WSD, Mount Carbon Metro District, Perry Park Country Club, Roxborough WSD, South Metro Water Supply Authority, Town of Castle Rock	8
Centennial Conservation	C	1764	Centennial Water and Sanitation District	8
Rueter Hess Reservoir Enlargement	RIB	14810	Parker Water and Sanitation District, Castle Rock, Castle Pines North, Stonegate	8
Denver Water Reuse	R	1750	Denver Water	8
Downstream Reservoir Exchanges	R	12000	Denver Water	8
Chatfield Pump Station	FIB	3000	Denver Water	8
South Platte Protection Plan	FIB		Denver Water	8

*C=conservation, FIB = Firming in-basin, R=reuse, RIB=Regional in-basin

3 Results

This section describes the results of the water availability analyses. The Point Flow Model was used to directly estimate the water availability at mainstem analysis points #3 through #7 located downstream of the Burlington Ditch diversion. Water availability at the remaining mainstem points (#1 and #2) and the five tributaries was estimated based on the Daily Call Chronology method and the layered refinements described previously.

Water availability estimates in this section include a number of refinement elements based on historical records and operations; however, there are elements not included in this analysis, for example, conditional water rights, future exchanges and impacts from IPP's, that would result in the future water available for a new water right being smaller when those additional elements are included.

The estimates in this section represent availability at the individual analysis points and are non-additive. Analysis points are located in the same basin, so some of them are hydrologically connected. Therefore, water that is available upstream, if not diverted, will be part of the water available at the downstream analysis points. The results presented in this section should be viewed individually for each analysis point and careful consideration of dependencies should be exercised when attempting to infer combined basin-wide availability.

Results in this section are presented for the period of analysis (i.e., WY 2000 to 2013) for the year by year analyses, including the days without a call, daily hydrograph, annual volumes and physical flows. A major change in basin administration regime after WY 2003 is evident in results. Water availability analysis is focused on WY 2003 -2013 because this period is considered to be more representative of the current and future conditions.

3.1 Bear Creek at Morrison

3.1.1 Analysis Point Description

The water available on Bear Creek is estimated at the DWR streamflow gage near Morrison. The Bear Creek at Morrison gage is located 180 feet upstream of the bridge on State Highway 8 and 0.2 miles upstream from Mount Vernon Creek in District 9. The Bear Creek analysis point is not included in the Point Flow Model. Table 3-1 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-1.

Table 3-1: Bear Creek at Morrison Preliminary Estimate Features

Analysis Point	District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
Bear Creek at Morrison (06710500; BCRMORCO)	**9**	**Bear Creek at Sheridan (06711500; BCRSHECO)**	**Bear Creek Above Bear Creek Lake Near Morrison (06710605;BCRABLCO)**	**Barr Lake/Burlington Ditch (0200802)**

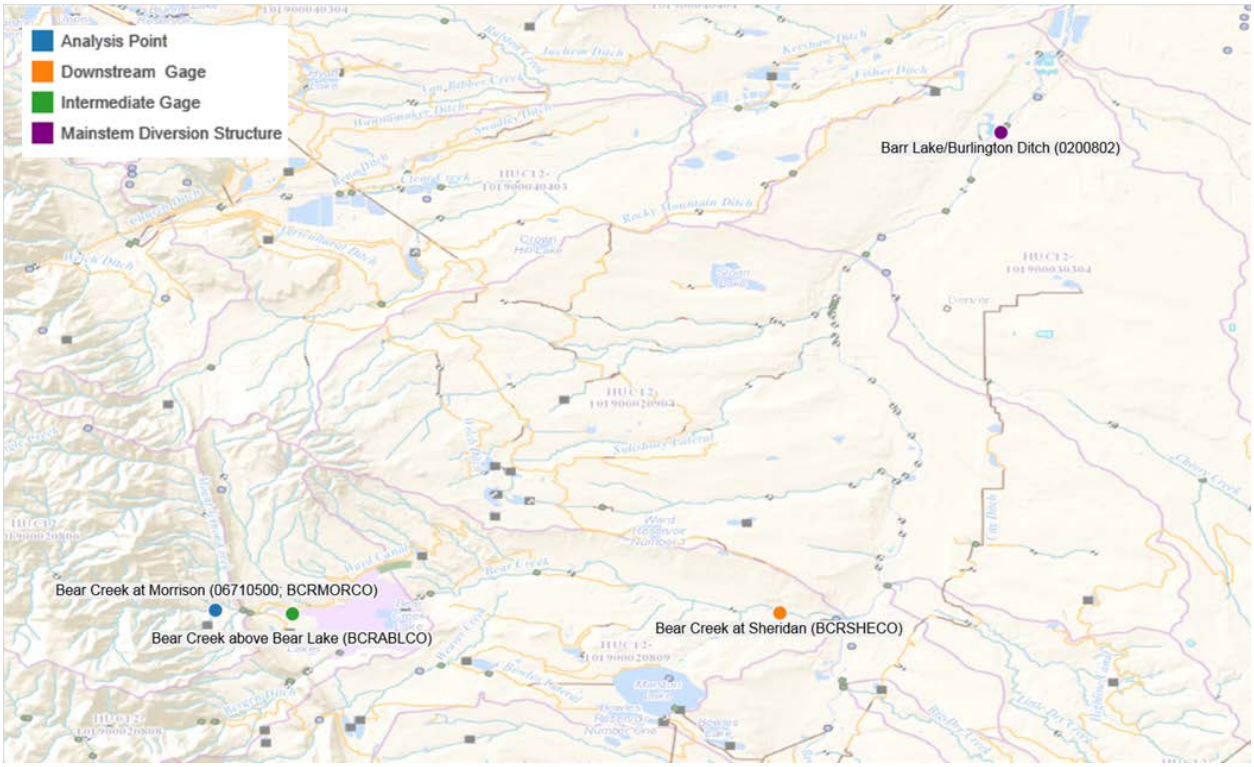


Figure 3-1: Bear Creek Analysis Point and Preliminary Estimate Supporting Points

3.1.2 Water Availability Refinement

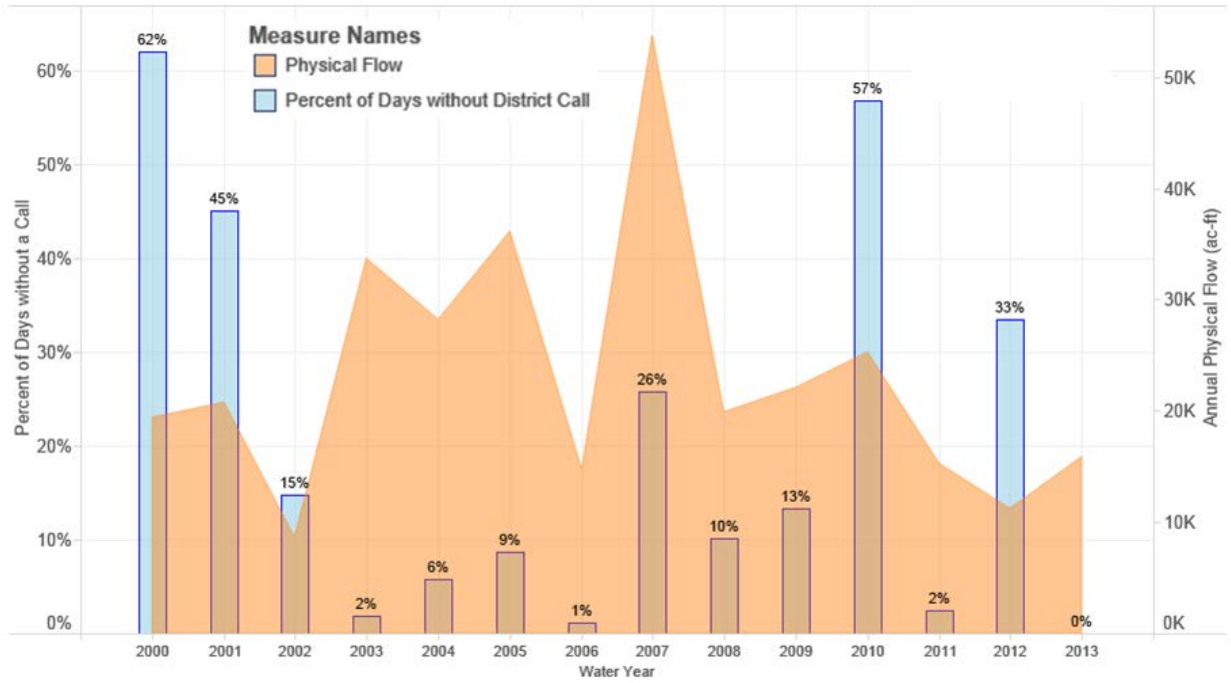
This section documents refinement layers applied to the preliminary water availability estimate in Bear Creek. Table 3-2 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-2: Refinement Layers for Bear Creek Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Bear Creek Reservoir Releases	Division 1	Releases from storage are going to be recorded in the downstream gage.	Diversion of water released from the reservoir is included in the Point Flow Model and in the preliminary estimate, assuming that no significant inflows downstream of the storage diversion exist in this Bear Creek reach.	✓ Yes

3.1.3 Water Availability Results

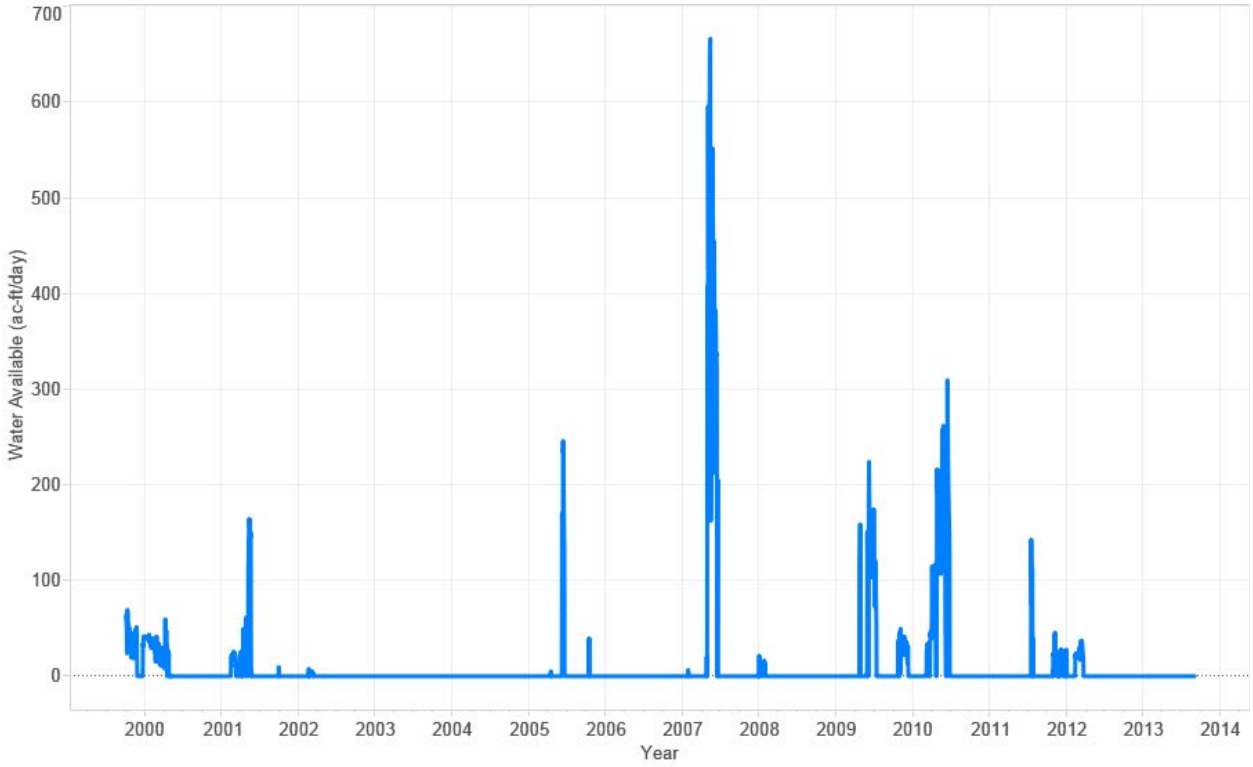
This section summarizes the results of the water availability analysis for the Bear Creek analysis point. The percent of days with a call impacting the district is shown in Figure 3-2. The analysis assumes that there is no water available on days when there is a call impacting the district.



For the analysis period, the majority (80 percent) of the days had a call impacting the district. Nine of the 14 water years had less than 15 percent of the days without a call, with seven years having less than 10 percent of the days without a call. There is no appreciable relationship between wet years and the percent of days without calls in this tributary.

Figure 3-2: Percent of Days without a Call Impacting District 9 and Annual Physical Flow at Bear Creek Analysis Point

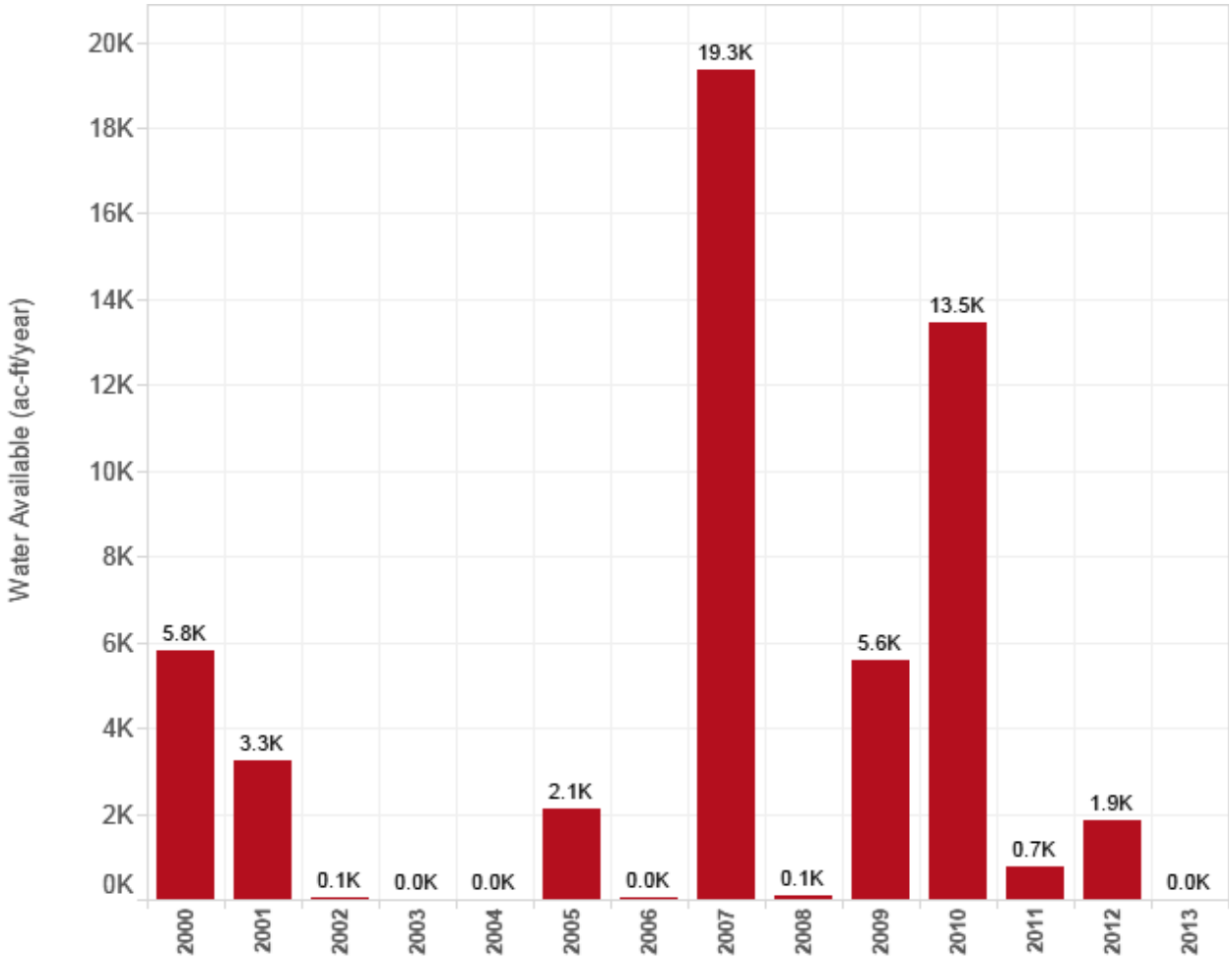
The water availability results reflect the preliminary estimate as well as the additional refinements included in the analysis (Table 3-2). Figure 3-3 shows a daily hydrograph of the water available in Bear Creek at Morrison for the analysis period.



The hydrograph shows prolonged periods where there are only negligible volumes of water available (e.g. 2001-2004). In the wetter years, such as 2007, water is available for relatively short periods of time with peaks exceeding 600 ac-ft per day. The longest periods of consecutive days of estimated water available were observed between 2009 and 2010.

Figure 3-3: Water Available in Bear Creek

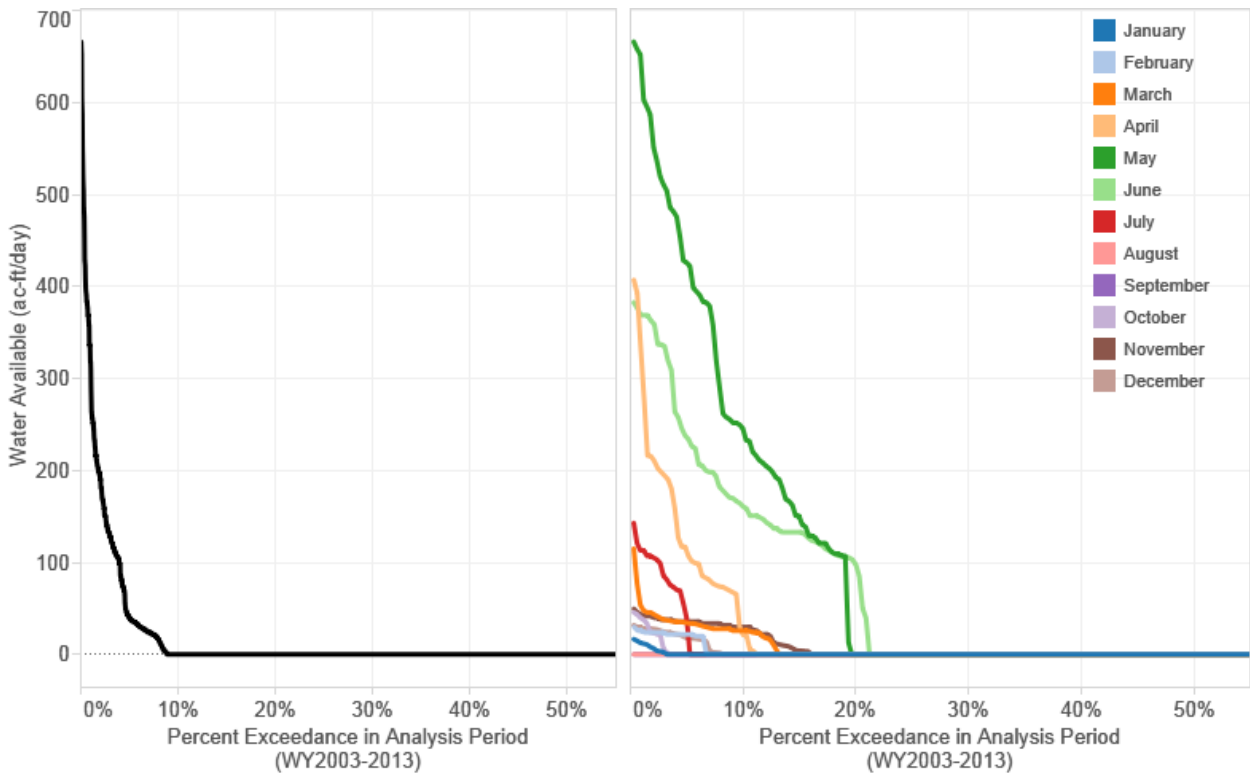
The sum of the annual water available in Bear Creek at Morrison for each water year (starting October 1st) is shown in Figure 3-4.



The analysis shows that there was no water available in 2003, 2004 and 2013 and there was negligible water available in 2002, 2006, and 2008. 2007 had the most water available followed by 2010, with all the other years having less than 6,000 ac-ft of annual water available.

Figure 3-4: Annual Water Available in Bear Creek

Two exceedance plots for the water available in Bear Creek at Morrison are shown below in Figure 3-5. An exceedance plot of daily available flows for the entire analysis period is shown on the left and an exceedance plot for each calendar month in the analysis period is shown on the right. The exceedance plot shows the percent of time the water available exceeded a given volume. Table 3-3 shows selected values from the exceedance plots for relative comparison.



The exceedance plot for the analysis period shows that 12 percent of the days have water available in Bear Creek at Morrison. The left plot indicates that 4 percent of the days in the analysis period have more than 100 acre-feet per day of water available and less than two percent of the days have more than 200 acre-feet of water available.
The monthly exceedance plot shows March has the largest percent of days with available water (23 percent). The largest amounts of daily flows were available in May and June with peak flows in May nearing 700 ac-ft per day. Days in months between August and January have less than 10 percent of the days in the month with water available, except by November that has 17 percent of the days with water available.

Figure 3-5: Percent Exceedance for Bear Creek

Table 3-3: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	40	0	0
January	0	0	0
February	22	0	0
March	34	26	0
April	107	21	0
May	426	246	0
June	234	161	98
July	40	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	36	30	4
December	18	0	0

3.2 Big Thompson River at Loveland (BIGLOVCO)

3.2.1 Analysis Point Description

The gage is located on the south side of the city of Loveland. The drainage area is 531 square miles and contains data since 1979. The Big Thompson River at Loveland analysis point is not included in the Point Flow Model. Table 3-4 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-6.

Table 3-4: Big Thompson River at Mouth Preliminary Estimate Features

Analysis Point	District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
Big Thompson River at Loveland (6741510; BIGLOVCO)	4	Big Thompson River at mouth near LaSalle (06744000; BIGLASCO)	None	Lower Latham Ditch

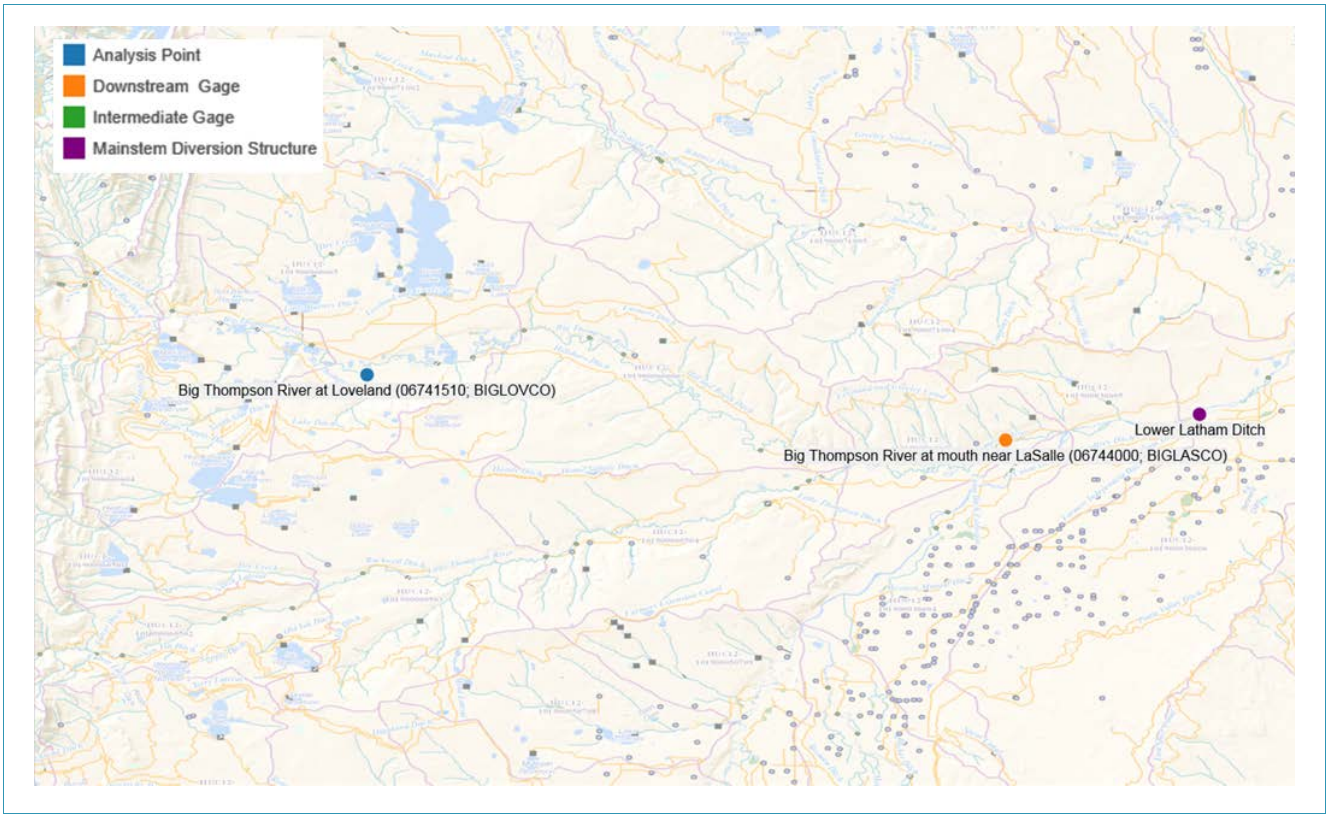


Figure 3-6: Big Thompson River Analysis Point and Preliminary Estimate Supporting Points

3.2.2 Water Availability Refinement

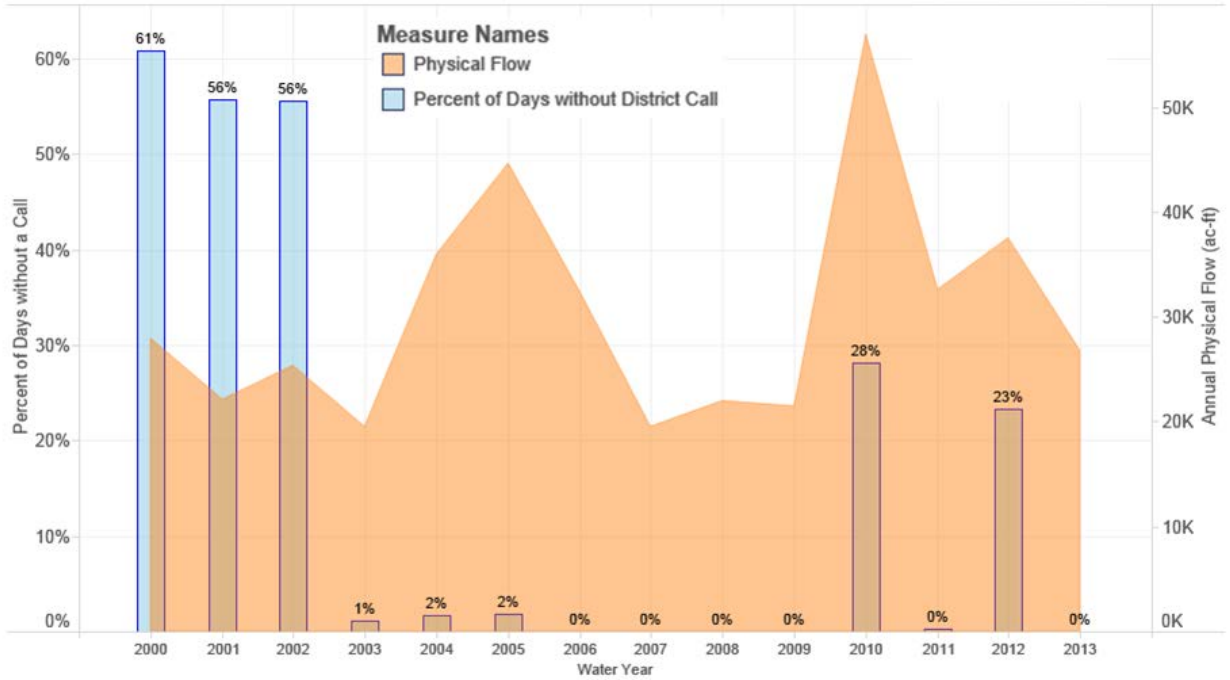
This section documents identified features that could affect the preliminary water availability estimate in the Big Thompson River. Table 3-5 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-5: Refinement Layers for Big Thompson Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
C-BT Deliveries	Division 1	C-BT deliveries diverted in the Big Thompson could overestimate water available.	In general C-BT deliveries are turned off during free river conditions, so it is assumed that they do not affect the water availability estimate	✓ Yes
Buckhorn Creek Inflows	Division 1	Relative large inflows occur upstream of the analysis point.	Available water from this source will be part of the available water at the analysis point	✓ Yes

3.2.3 Water Availability Results

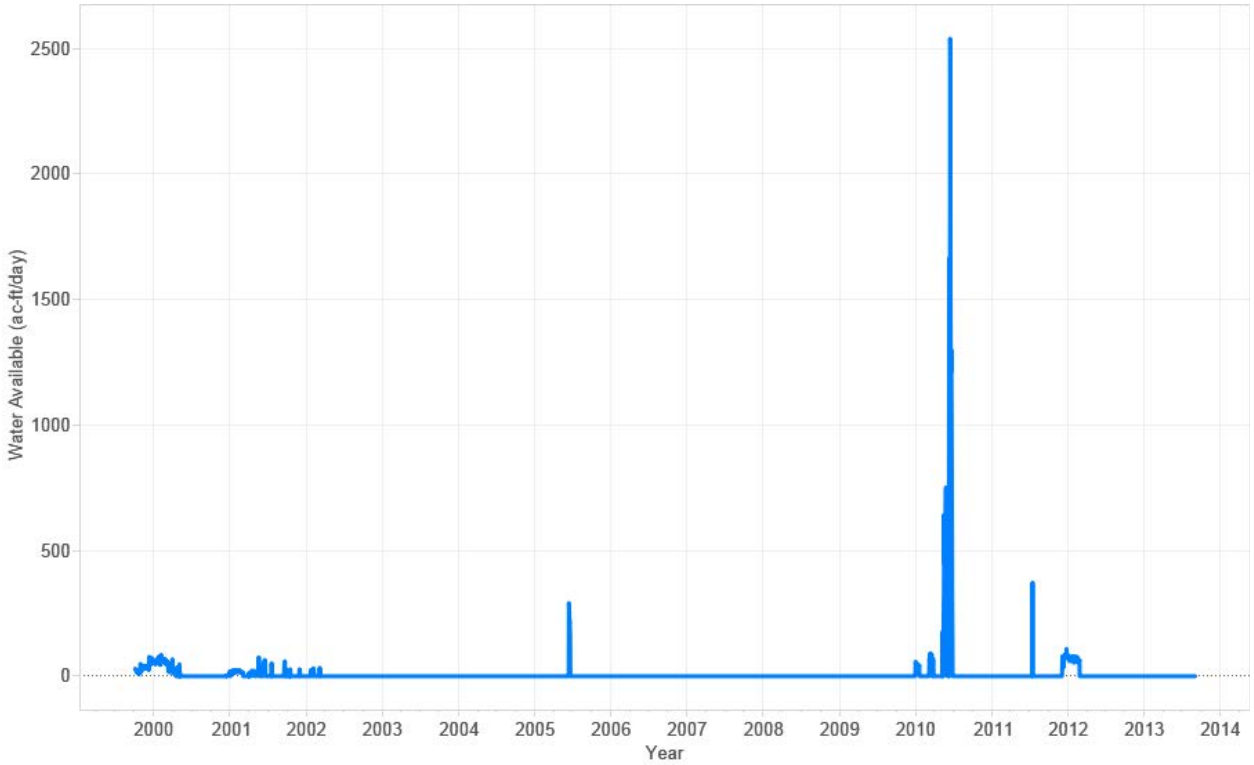
The percent of days with a call impacting district 4 is shown in Figure 3-7. The analysis assumes that there is not water available at the analysis point in days when there is a call impacting the district.



A different call regime at this analysis point is visible prior 2003. For the analysis period, there is a period of seven consecutive years with practically no days with water available due to calls. The maximum percent of days without water available is about 60 percent for the 2000 water year. 2012 is the only year in the recent call regime that has more than 20 percent of days with water available and annual flows less than 45,000 ac-ft.

Figure 3-7: Percent of Days without a Call Impacting District 4 and Physical Flow at Big Thompson

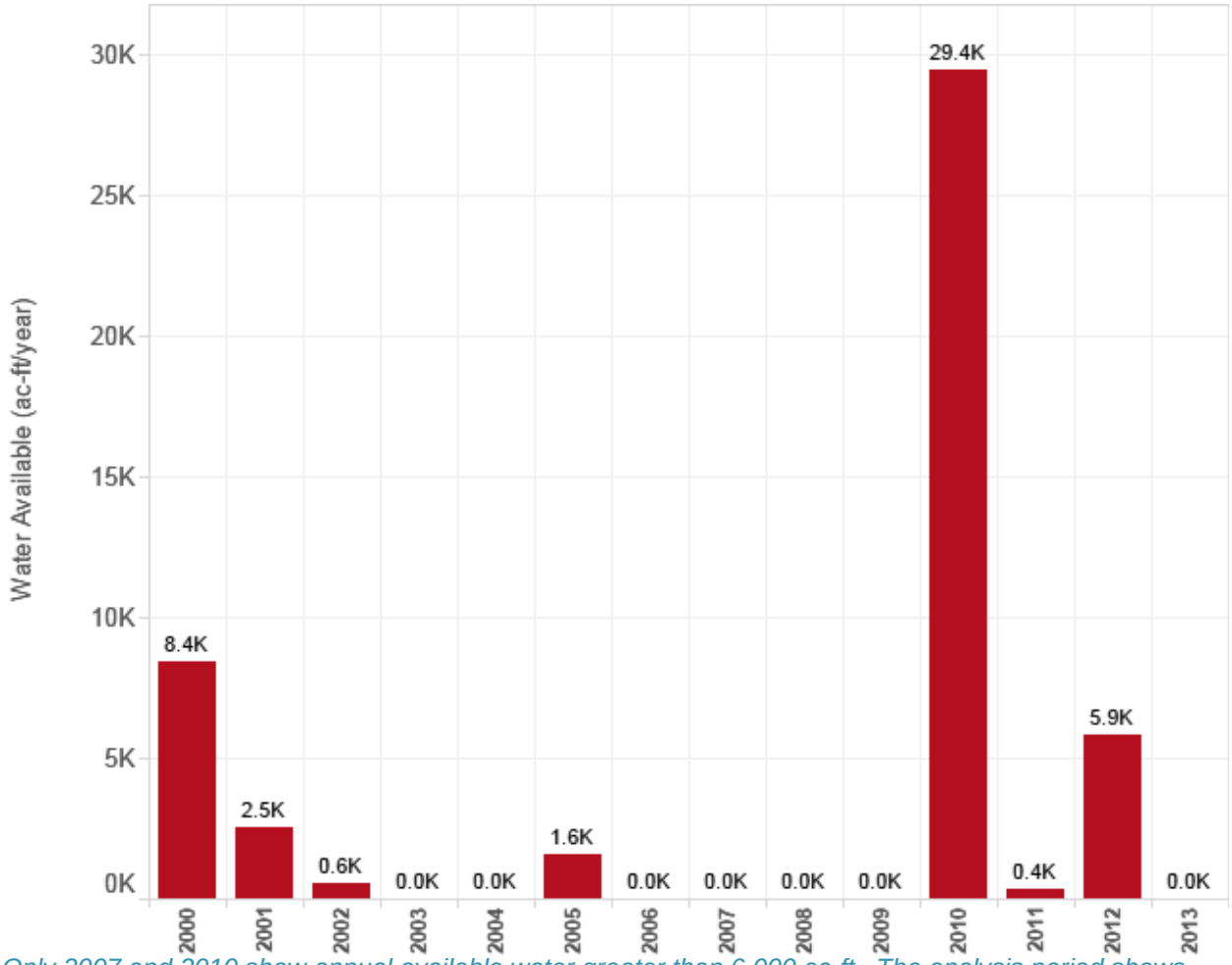
The water availability results reflect the preliminary estimate and the additional refinements included in the analysis. Figure 3-8 shows a hydrograph of the estimated water available in the Big Thompson for the analysis period.



The hydrograph shows prolonged periods where there is no water available (e.g. 2006-2009). Large peaks of water available occur in relatively short periods of time, e.g., in 2010. When water is available at this analysis point it is almost always less than 450 ac-ft per day.

Figure 3-8: Water Available in the Big Thompson River at Loveland

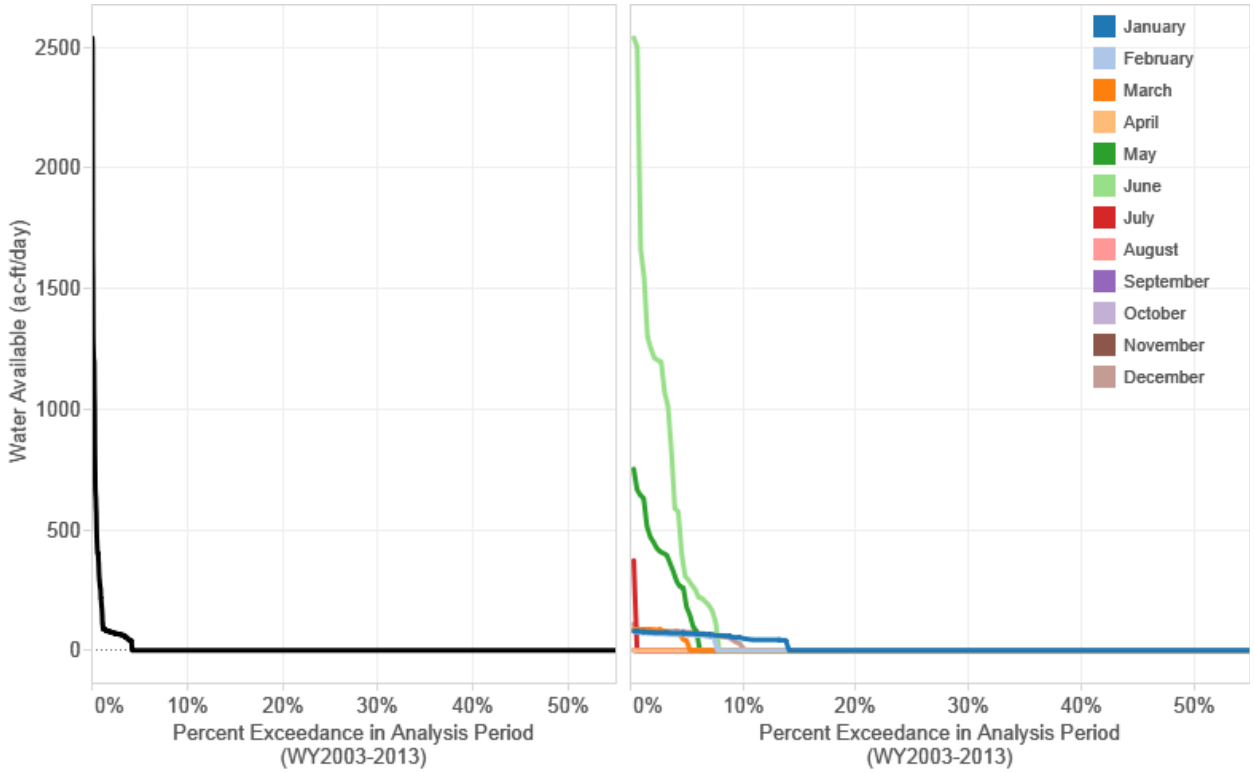
The annual water available in Big Thompson at Loveland for each water year (starting October 1st) is shown in Figure 3-9.



Only 2007 and 2010 show annual available water greater than 6,000 ac-ft. The analysis period shows sequences of up to four consecutive years with no water available.

Figure 3-9: Annual Water Available in Big Thompson River

Daily and monthly exceedance plots for the water available in Big Thompson River are shown below in Figure 3-10. Table 3-6 shows selected values from the exceedance plots for relative comparison.



About 10 percent of the days in the analysis period have water availability. May and June are the months with largest water availability at this analysis point. Several months have some water available in about 20 percent of the study period, but the amounts available are less than 100 ac-ft per day.

Figure 3-10: Percent Exceedance for Big Thompson River

Table 3-6: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	0	0	0
January	69	1	0
February	63	0	0
March	41	0	0
April	0	0	0
May	179	0	0
June	292	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	75	10	0

3.3 Boulder Creek near Orodell (06727000; BOCOROCO)

3.3.1 Analysis Point Description

The analysis point is located on Boulder Creek 0.3 miles downstream from the City of Boulder's Boulder Canyon Hydroelectric Facility and 1.1 miles upstream from Fourmile Creek, or 8.5 miles east of Barker Reservoir and 2.6 miles west of the Boulder Public Library which is adjacent to the Boulder Creek at Boulder, CO (BOCOBOCO) stream gage. The drainage are to the analysis point is 102 square miles. The Boulder Creek near Orodell analysis point is not included in the Point Flow Model. Table 3-7 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-11.

Table 3-7: Boulder Creek near Orodell Preliminary Estimate Features

Analysis Point	Water District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
Boulder Creek near Orodell (06727000; BOCOROCO)	6	Boulder Creek at 75th St. near Boulder (BOCNORCO)	Boulder Creek at Boulder (BOCOBOCO)	Union Ditch (0200828)

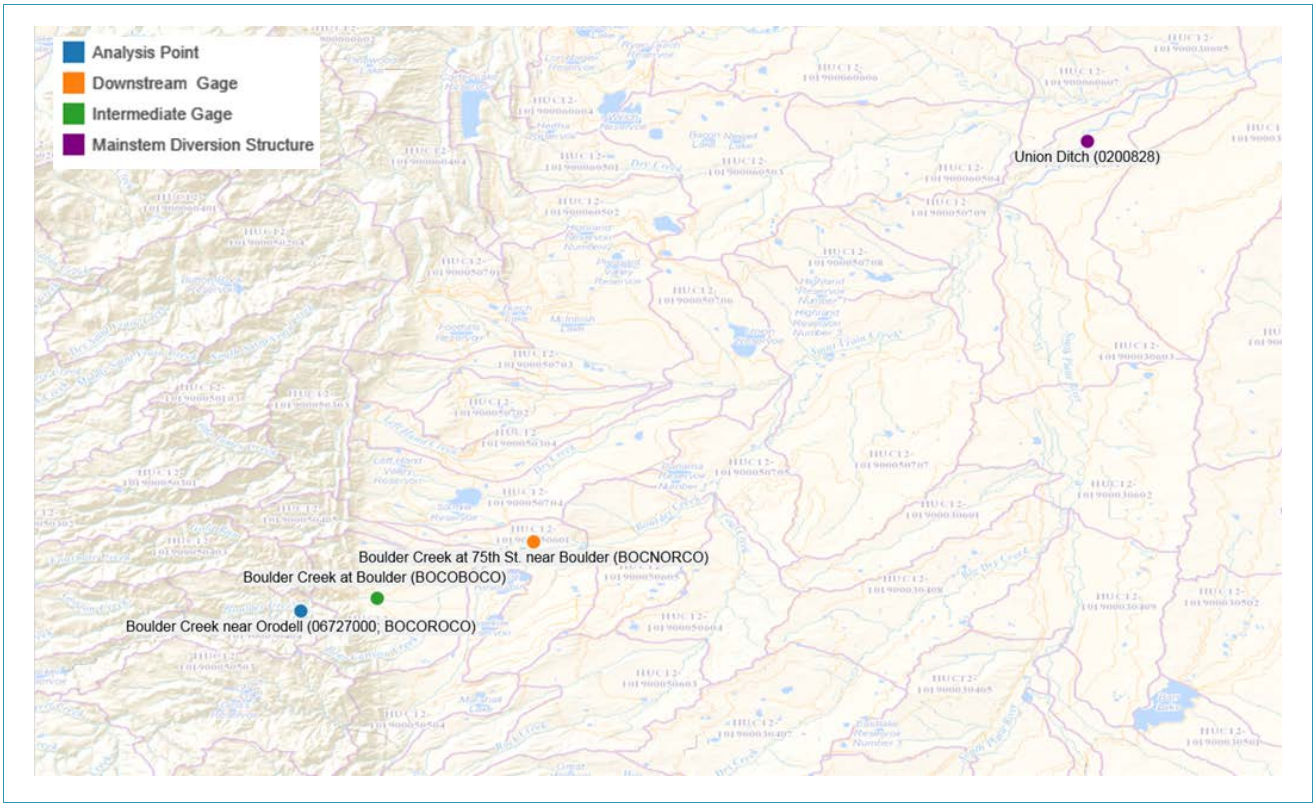


Figure 3-11: Boulder Creek Analysis Point and Preliminary Estimate Supporting Points

3.3.2 Water Availability Refinement

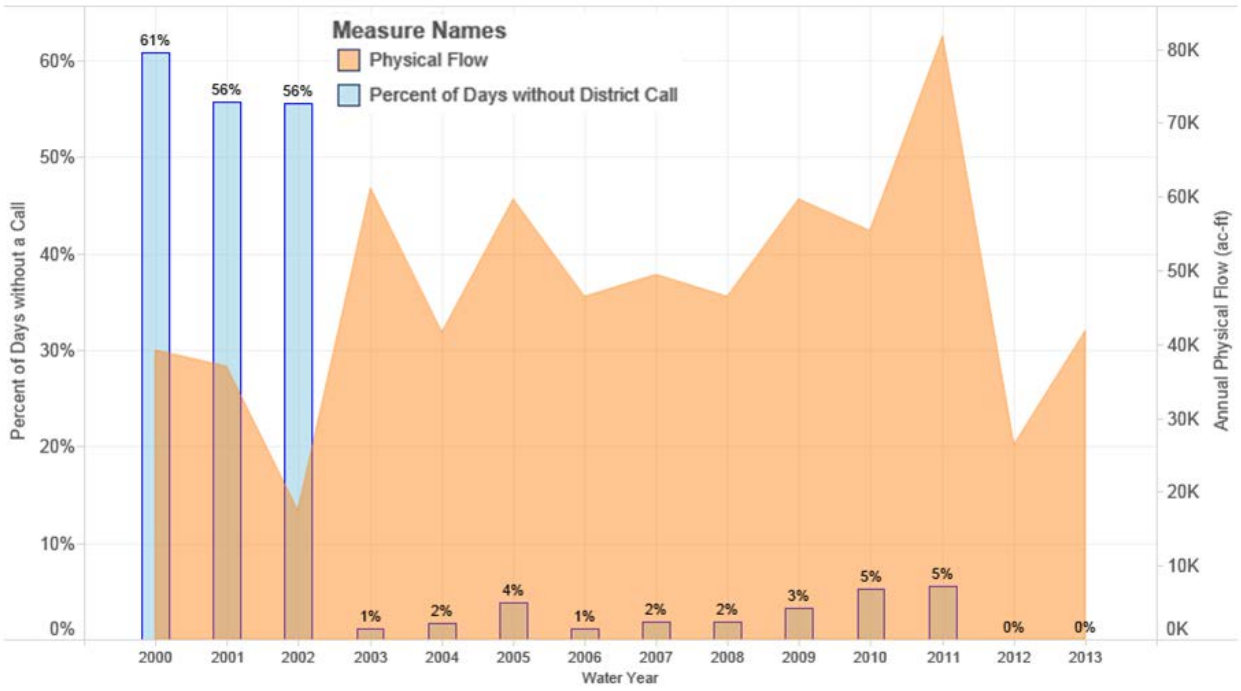
This section documents identified refinement layers affecting the preliminary water availability estimate in Boulder Creek. Table 3-8 provides the summary of the identified refinement layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-8: Refinement Layers for Boulder Creek Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Minimum In-stream Flow	Division 1	A minimum in-stream flow through City of Boulder would reduce the water availability at the analysis point	A minimum flow of about 15 cfs is assumed to be required at the analysis point.	✓ Yes
Conditional water rights and absolute rights that are not fully exercised	Division 1	Conditional water rights and absolute rights not fully exercised can bias the estimate of water available based on the historical operations. For this reason, there could be limited water available at this analysis point.		✖ No

3.3.3 Water Availability Results

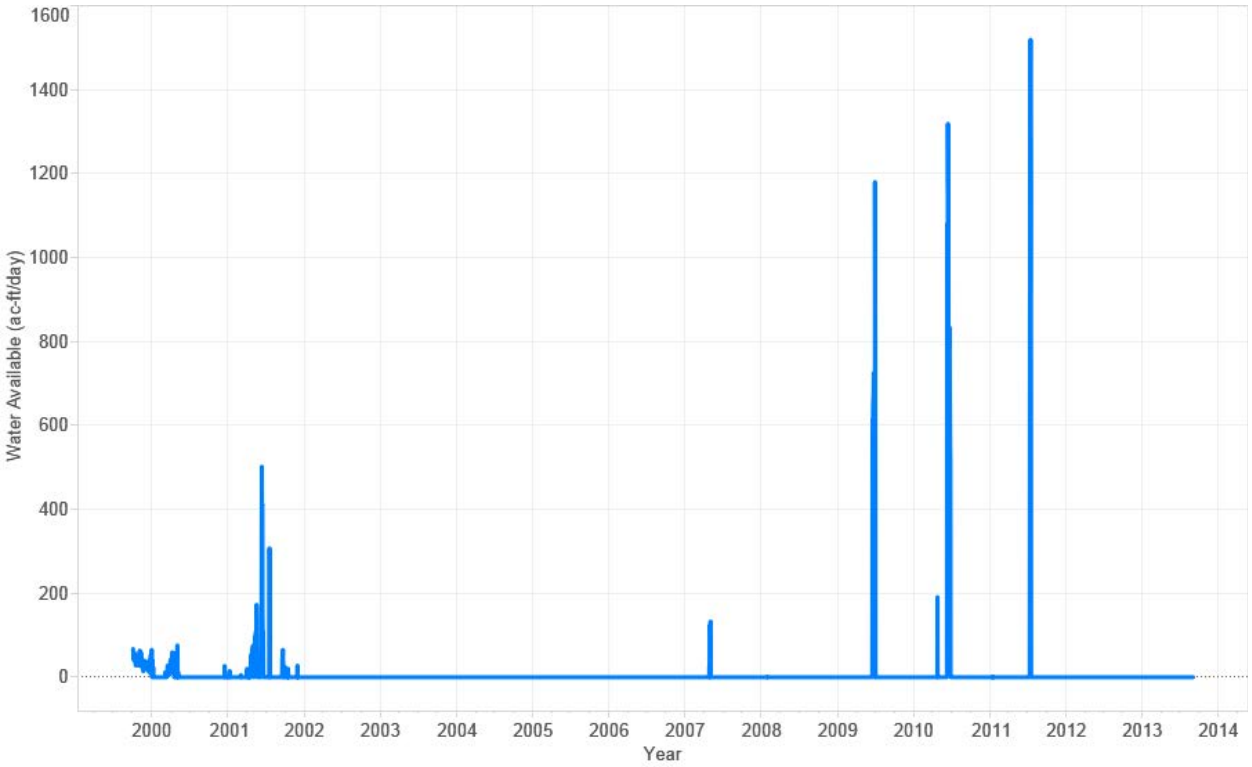
This section summarizes the results of the water availability for the Boulder Creek analysis point. The percent of days with a call impacting the district is shown in Figure 3-12. The analysis assumes that there is not water available in days when there is a call impacting the district.



With exception of the first three years of the analysis period, less than 5 percent of days are without a call for this water district. Low annual physical flows in 2012 seem to correlate with no water available during that year.

Figure 3-12: Percent of Days without a Call Impacting District 6 and Physical Flows a Boulder Creek at Orodell

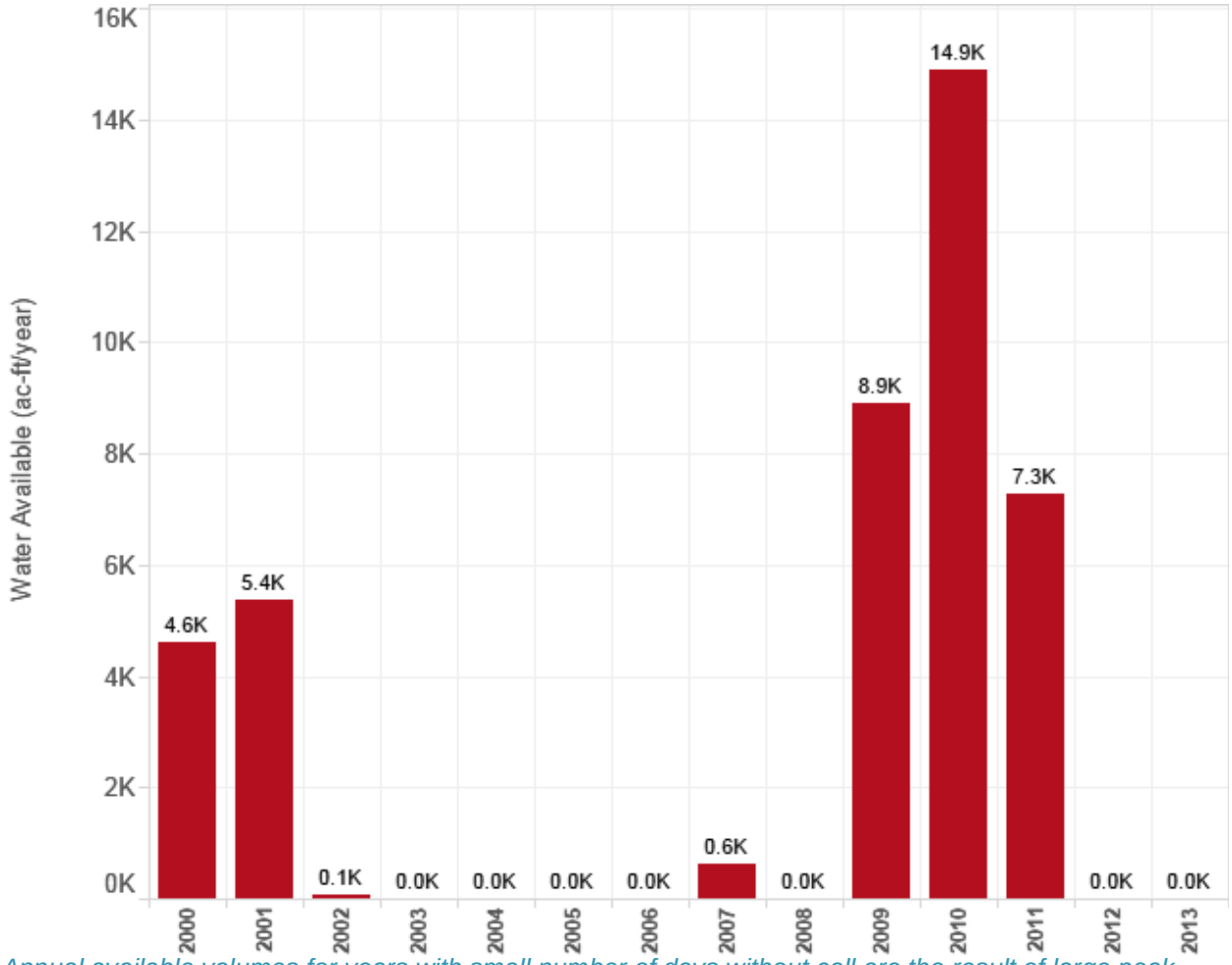
Figure 3-13 shows a hydrograph of the estimated water available in Boulder Creek for the analysis period, including the minimum flow requirement.



Water available at this analysis point follows two distinct patterns when looked in conjunction with the number of days with calls. Results show large peaks, near and above 1,200 ac-ft per day in years with limited days of days without a call, and more frequent water available with smaller magnitudes in years with a relatively lower number of days with a call.

Figure 3-13: Water Available in Boulder Creek at Orodell

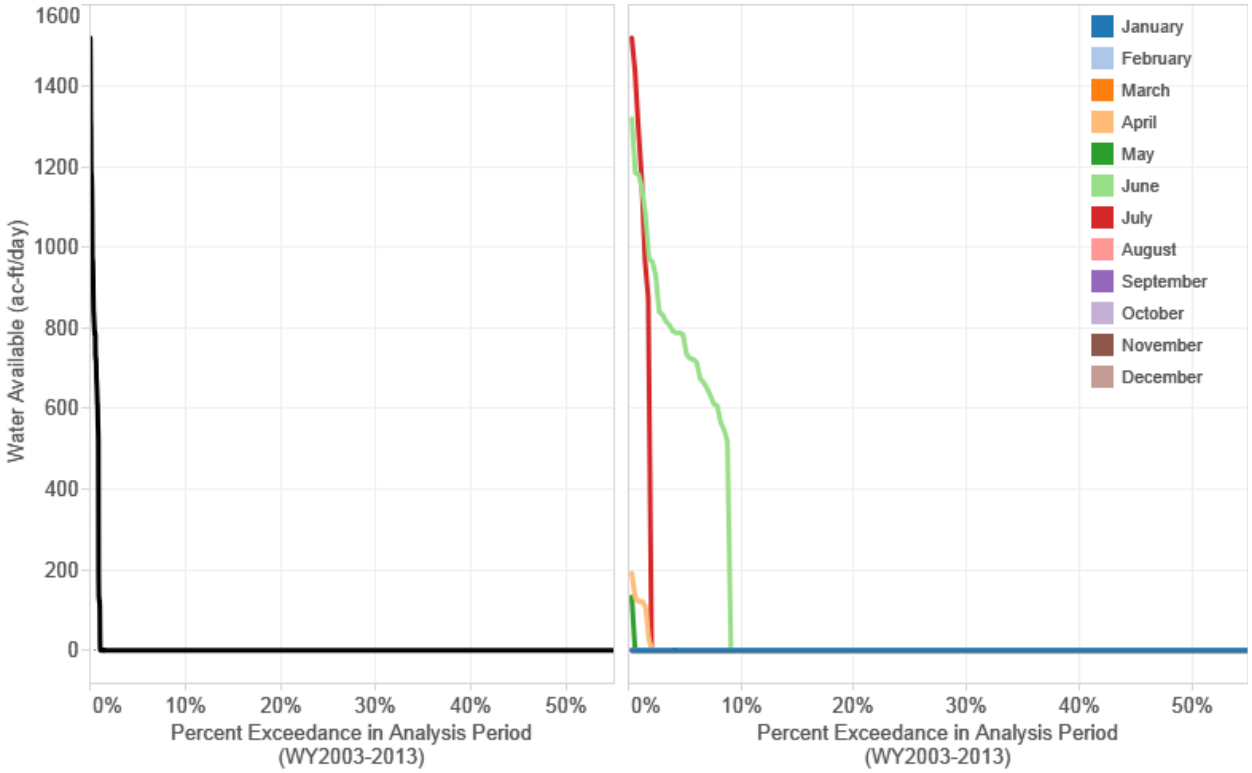
The sum of the annual water available in Boulder Creek at Orodell for each water year (starting October 1st) is shown in Figure 3-14.



Annual available volumes for years with small number of days without call are the result of large peak flows that are difficult to capture and use for long term water supply.

Figure 3-14: Annual Water Available in Boulder Creek at Orodell

Daily and monthly exceedance plots for the water available in Boulder Creek at Orodell are shown below in Figure 3-15. Table 3-9 shows selected values from the exceedance plots for relative comparison.



The overall exceedance plot shows that water is not available at this analysis point 95 percent of the days during the analysis period. Greater than 60 ac-ft per day is only available 1 percent of the days. June and July are the only months with water available greater than 200 ac-ft per day and June is the month with the largest percent of days with estimated water availability (9 percent).

Figure 3-15: Percent Exceedance for Boulder Creek at Orodell

Table 3-9: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	0	0	0
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	0	0	0
June	734	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	0	0	0

3.4 Clear Creek at Golden (06719505; CLEGOLCO)

3.4.1 Analysis Point Description

The water available on Clear Creek is evaluated at the USGS flow gage at Golden, CO. This site drains 394 square miles. The Clear Creek at Golden analysis point is not included in the Point Flow Model. Table 3-10 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-16.

Table 3-10: Clear Creek at Golden Preliminary Estimate Features

Analysis Point	District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
Clear Creek at Golden (06719505; CLEGOLCO)	7	Clear Creek at Mouth near Derby (06720000; CLEDERCO)	None	Fulton Ditch (0200808)

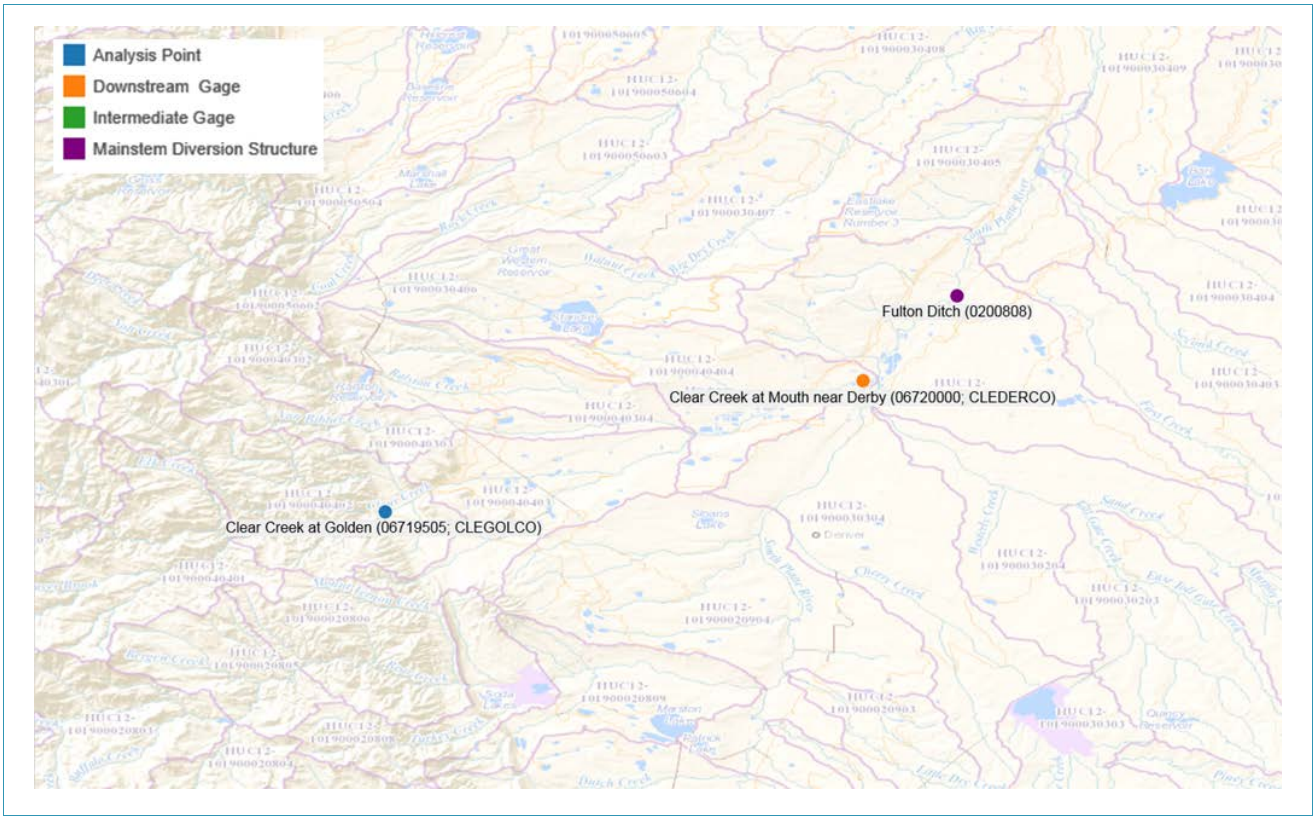


Figure 3-16: Clear Creek at Golden Analysis Point and Preliminary Estimate Supporting Points

3.4.2 Water Availability Refinement

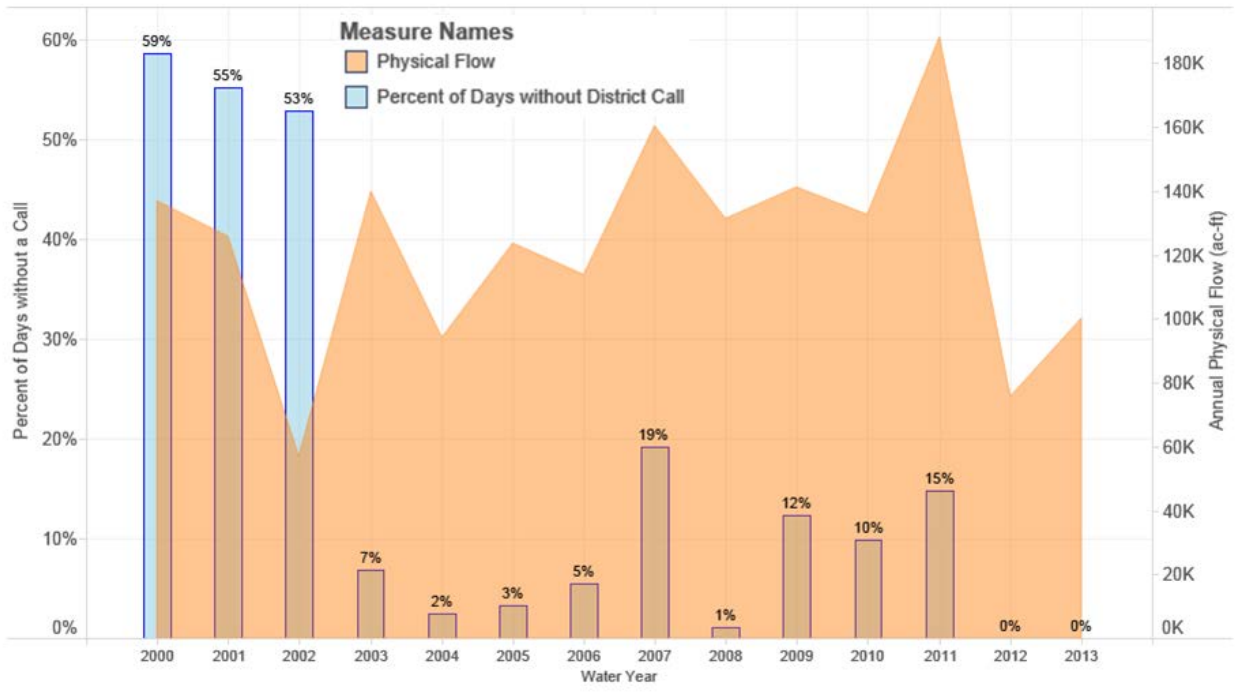
This section documents identified refinement layers affecting the preliminary water availability estimate in Clear Creek at Golden. Table 3-11 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-11: Refinement Layers for Clear Creek as Golden Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Non-native water	Division 1	Several non-tributary water diversions occur upstream of the analysis point (e.g., Straight Creek Tunnel, Vidler Tunnel, Henderson Mine, Berthoud Pass Ditch (rare), Jones Pass Ditch, Guanella Pass)	Water diversions between the analysis point and the downstream gage are accounted for in the preliminary estimate by using the minimum flow between the two points.	✓ Yes
Recreational In-channel Diversion	Division 1	The City of Golden holds a RICD water right for its kayak course downstream of the analysis point. The right is for up to 1000 cfs. While an RICD is a non-consumptive right, it is senior to any new water right developed upstream of the terminus of the RICD and would therefore reduce the available water at this location.		✗ No

3.4.3 Water Availability Results

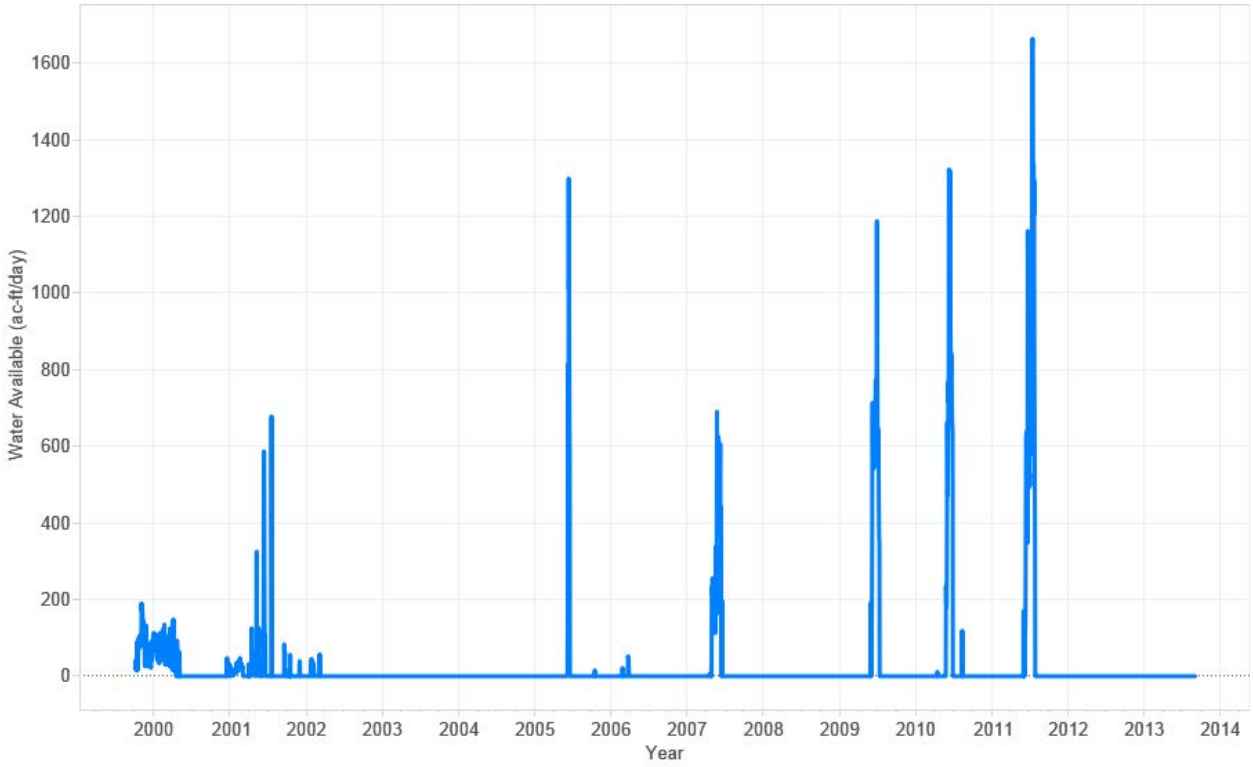
This section summarizes the results of the water availability for Clear Creek at Golden analysis point. The percent of days with a call impacting the district is shown in Figure 3-17. The analysis assumes that there is not water available in days when there is a call impacting the district.



Two trends of days without a call are observed in the historical data. The first three years of analysis show more than 50 percent of the days without a call, while the remaining years show less than 20 percent of days available. The call chronology shows four consecutive years with less than seven percent of the days having water available.

Figure 3-17: Percent of Days without a Call Impacting District 7 and Annual Physical Flow at Clear Creek at Golden

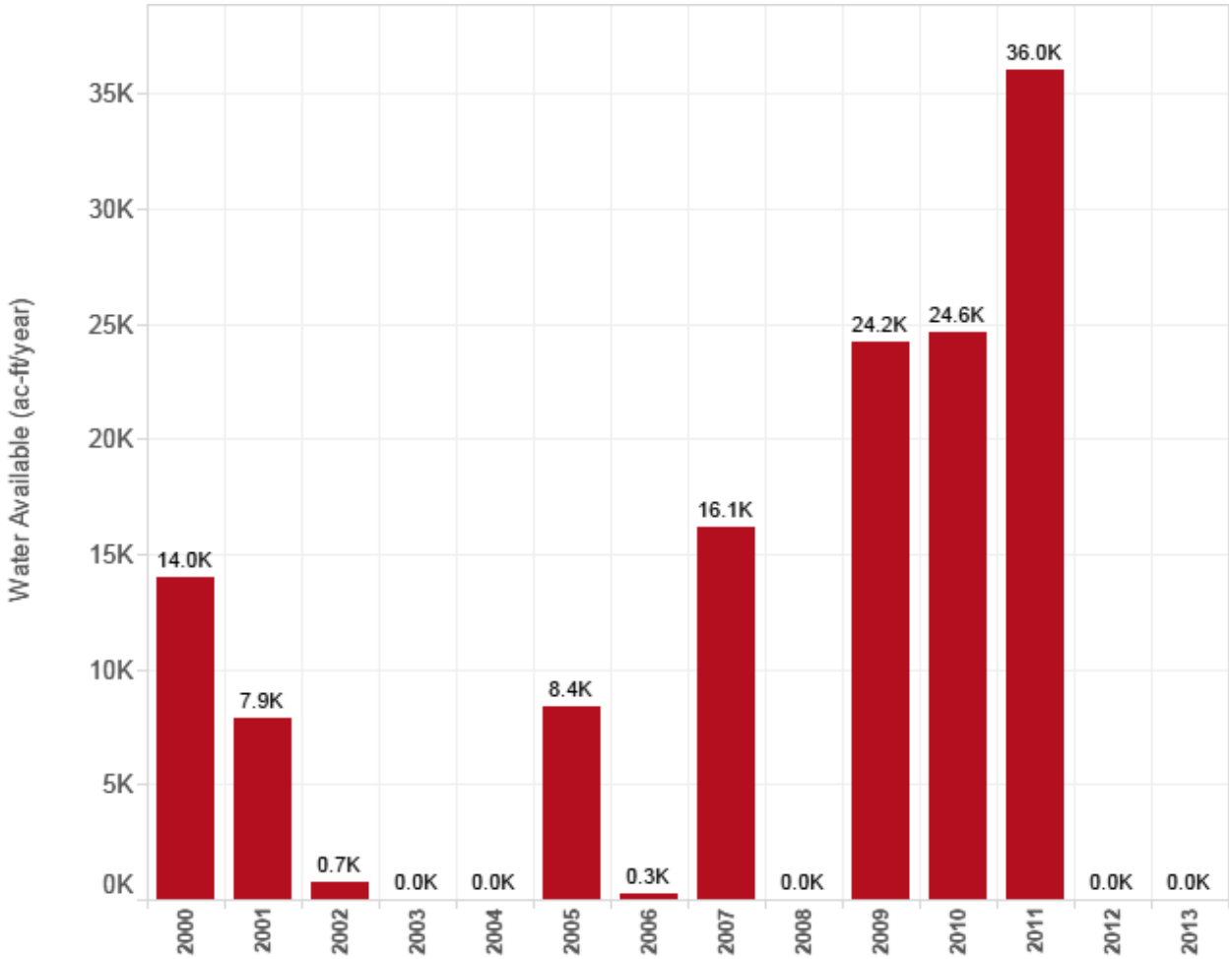
The water availability results reflect the preliminary estimate as well as the additional refinements included in the analysis. Figure 3-18 shows a hydrograph of the water available in Clear Creek at Golden for the analysis period.



Frequency of the daily water available is consistent with the percent of days without a call, showing more occurrences of water available the first three years of analysis. Despite the limited number of days per year with water available, peak water availability amounts ranging from 700 to 1,600 ac-ft per day are observed at this analysis point.

Figure 3-18: Water Available in Clear Creek at Golden

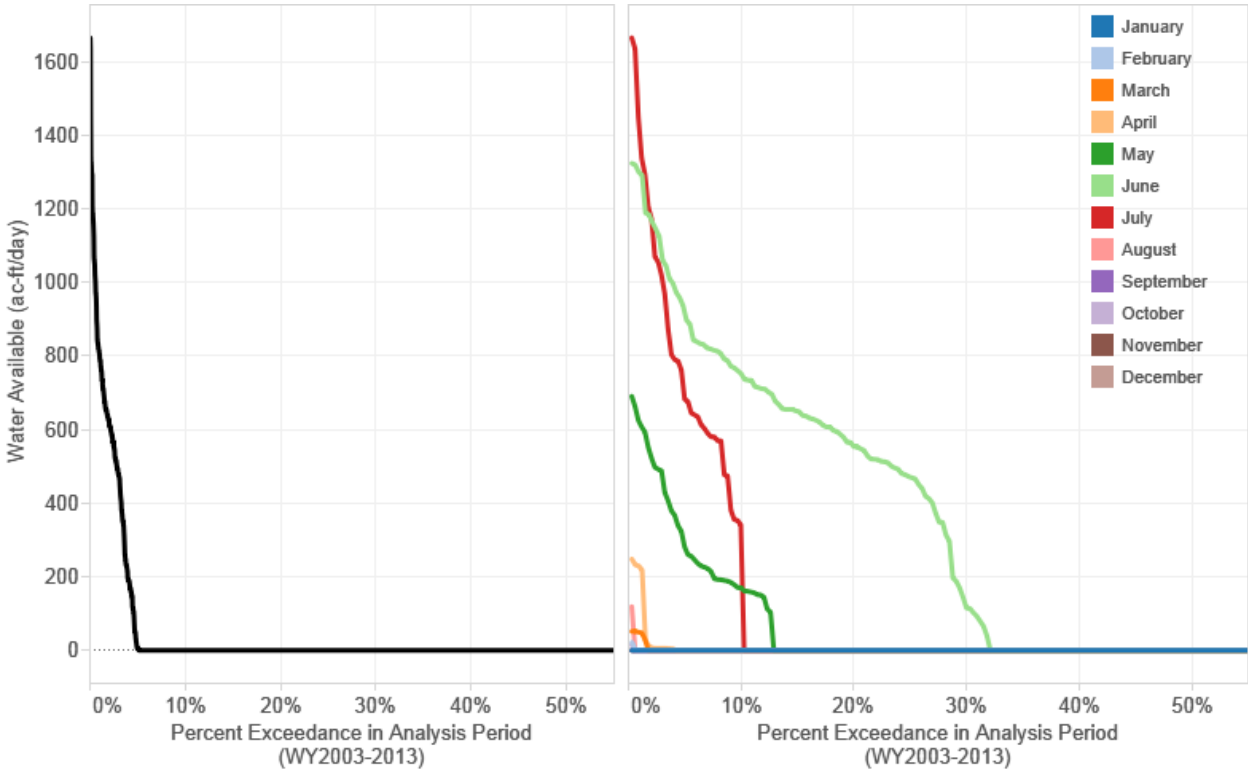
The sum of the annual water available in Clear Creek at Golden for each water year (starting October 1st) is shown in Figure 3-19.



The largest annual available water is shown in years between 2009 and 2011, with the largest volume available in the period corresponds to the year with the largest physical flow and about 85 percent of days with a call. Volumes of available water during the first three years is relatively small considering that the percent of days without a call is greater than 50 percent

Figure 3-19: Annual Water Available in Clear Creek at Golden

Daily and monthly exceedance plots for the water available in Clear Creek at Golden are shown below in Figure 3-20. Table 3-12 shows selected values from the exceedance plots for relative comparison.



Water is available on about 12 percent of the days in the analysis period, and the available flows are less than 250 ac-ft per day between 12 percent and 3 percent of the days. August is the month with less availability, showing available flows less than 1 percent of the days. July shows water available about 25 percent of the days with flow greater than 500 ac-ft/day 15 percent of the days. May June and July are the only months with available flows greater than 200 ac-ft per day 5 percent of the days.

Figure 3-20: Percent Exceedance for Clear Creek at Golden

Table 3-12: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	6	0	0
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	281	171	0
June	897	752	553
July	682	341	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	0	0	0

3.5 St. Vrain Creek at Lyons (06724000; SVCLYOCO)

3.5.1 Analysis Point Description

The analysis point is located at the St. Vrain at Lyons flow gage. The gage is 75 ft southwest of U.S. Highway 36 adjacent to State Highway 66 at southeast edge of Lyons, 400 ft upstream from St. Vrain Supply Canal, and 0.4 mi downstream from confluence of North and South St. Vrain Creeks. After the destruction of the September 2013 flood, gage was relocated 350 ft upstream to the pedestrian bridge. The St. Vrain Creek at Lyons analysis point is not included in the Point Flow Model. Table 3-13 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-21.

Table 3-13: St Vrain Creek at Lyons Preliminary Estimate Features

Analysis Point	District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
St. Vrain Creek at Lyons (06724000; SVCLYOCO)	5	Difference between the St. Vrain at Mouth near Platteville (SVCPLACO) Gage and the Boulder Creek at 75th St. near Boulder (BOCNORCO)	None	Union Ditch

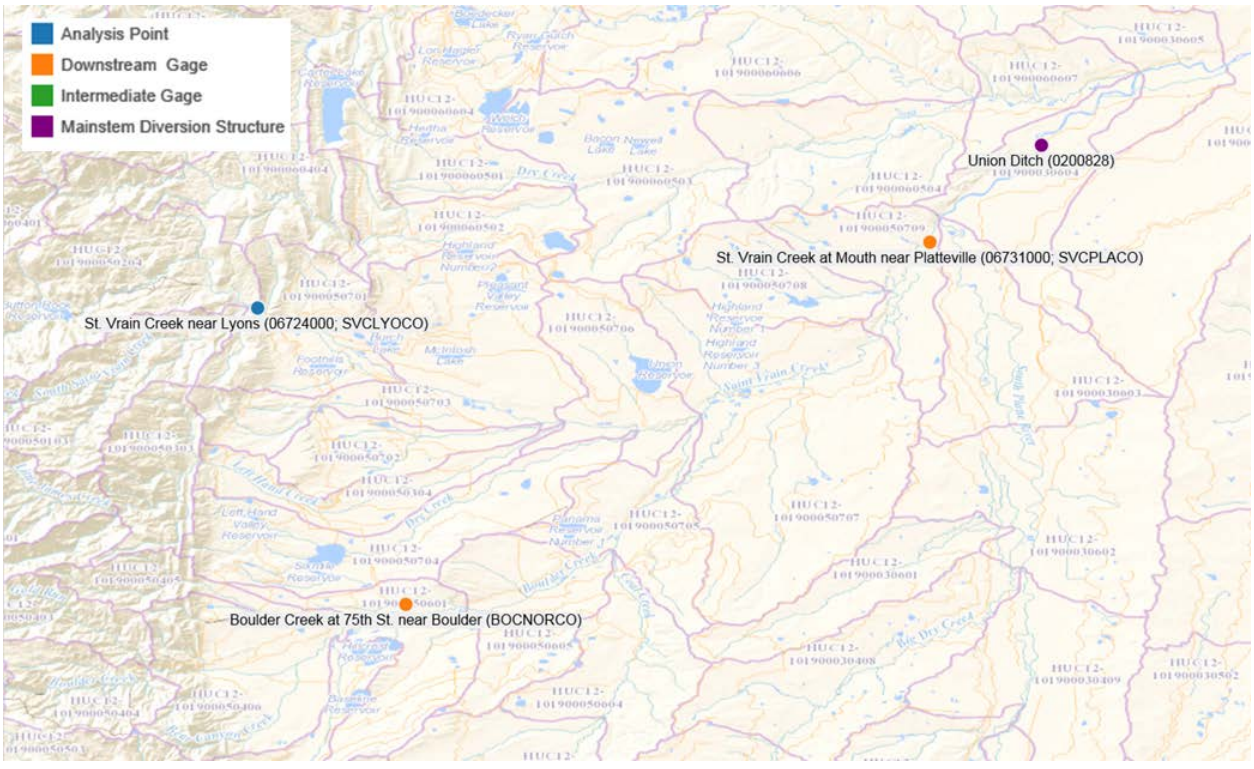


Figure 3-21: St. Vrain Creek Analysis Point and Preliminary Estimate Supporting Points

3.5.2 Water Availability Refinement

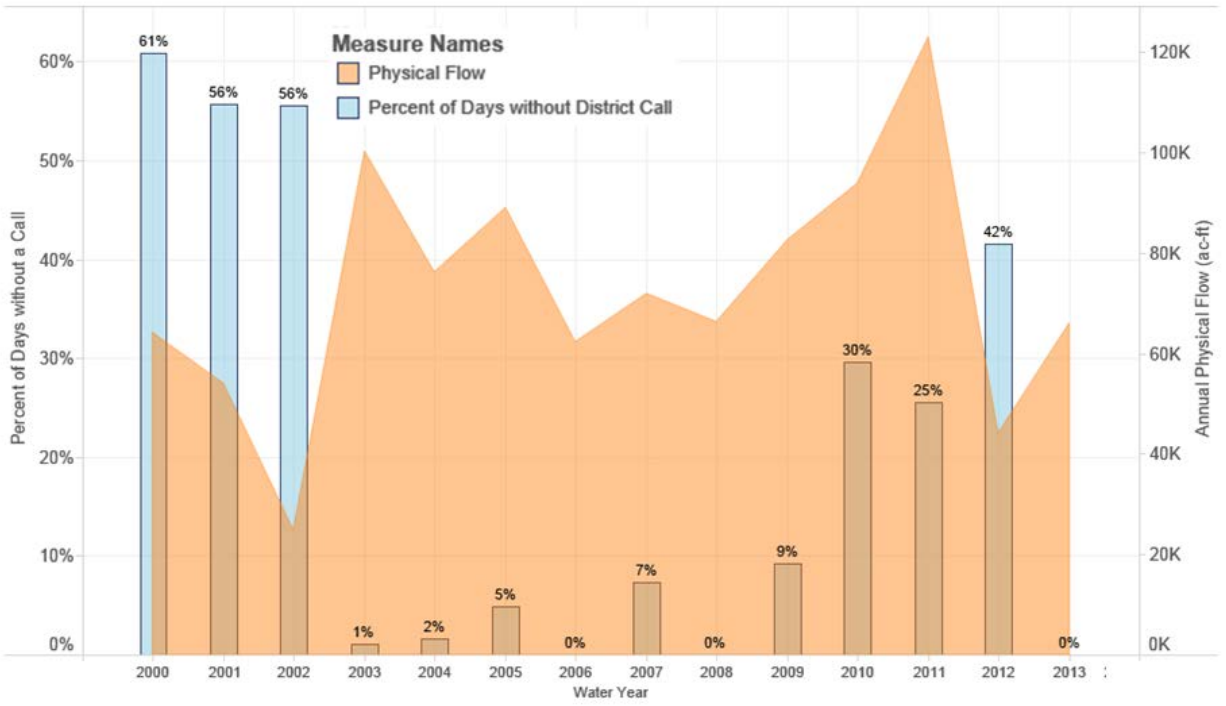
This section documents identified refinement layers affecting the preliminary water availability estimate in St. Vrain Creek. Table 3-14 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-14: Refinement Layers for St. Vrain Creek Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Major Tributary Flow	Division 1	Boulder Creek flows into the St. Vrain upstream of the SVCPLACO gage (i.e., downstream gage) and would influence the preliminary water availability estimate.	The Boulder Creek at 75th St. near Boulder measured flow is discounted from the flow at the downstream gage to refine the water availability in the St. Vrain analysis point.	✓ Yes
Beeman Return to St. Vrain	Excel Energy	Beeman Ditch tail returns water to the St. Vrain upstream of the SVCPLACO gage. These returns are diverted downstream of the St. Vrain confluence with the South Platte for augmentation. These additional flows at SVCPLACO will overestimate water available at the downstream station for this analysis point.	The historical diversion of these return flows is included in the Point Flow Model, thus these return flows are accounted for in the Point Flow Model and are not available for new water rights at the analysis point.	✓ Yes
Power Plants	Xcel Energy	Historically Excel has not used the maximum water allotted and this water will not be available for new water rights. Using historical records of flows at the gages overestimates the water available for a new water right.		✖ No
Longmont Reusable Effluent	Division 1	Unused reusable return from City of Longmont would overestimate water availability in the downstream gage.	No information collected	✖ No
Recreational In-Channel Diversion	Division 1	The City of Longmont holds a decreed RICD water right for up to 350 cfs white water park. While an RICD is a non-consumptive right, it is senior to any new water right developed upstream of the Longmont RICD terminus, and would therefore reduce the available water at this location.		✖ No

3.5.3 Water Availability Results

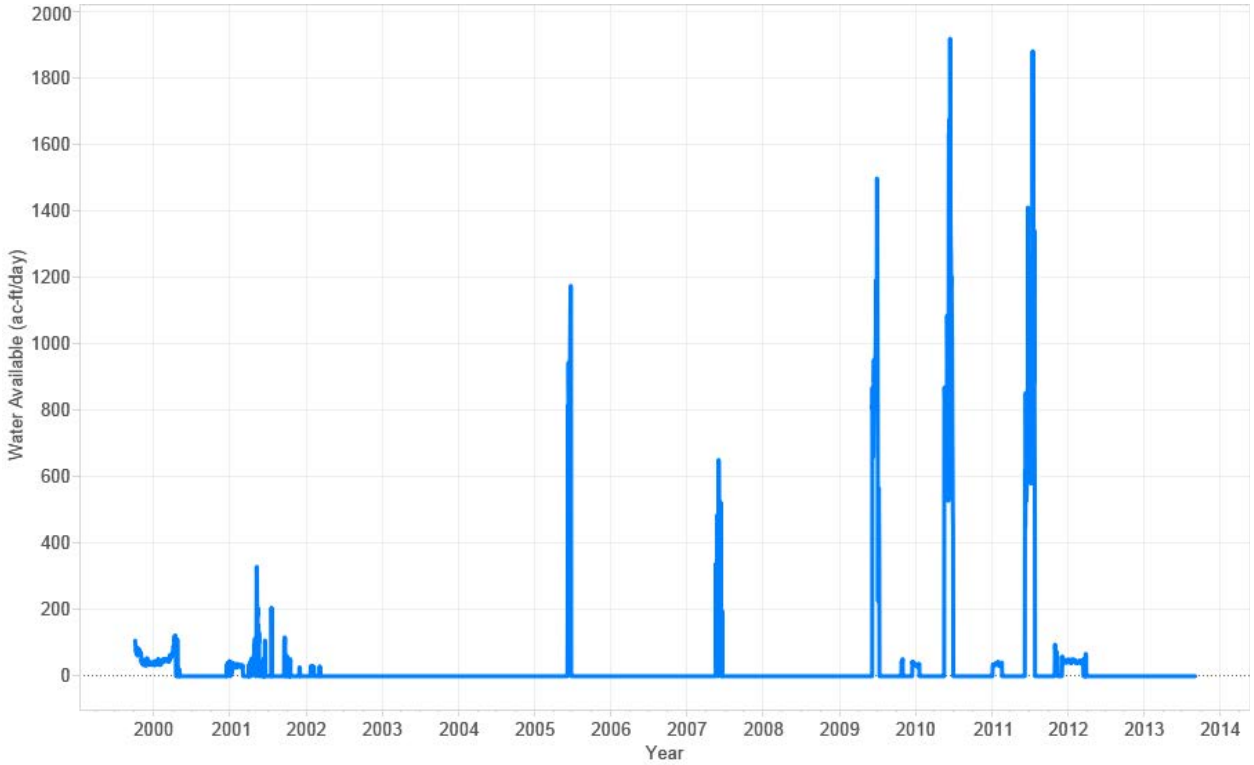
This section summarizes the results of the water availability for the St. Vrain Creek analysis point. The percent of days with a call impacting the district is shown in Figure 3-22. The analysis assumes that there is not water available in days when there is a call impacting the district.



A different call regime is observed at this analysis point after 2003. There is not a strong correlation between annual flows in this Creek and days without calls – seven consecutive years after 2002 have less than 10 percent of the days with water available.

Figure 3-22: Percent of Days without a Call Impacting District 5 and Annual Physical Flow at St. Vrain Creek Analysis Point

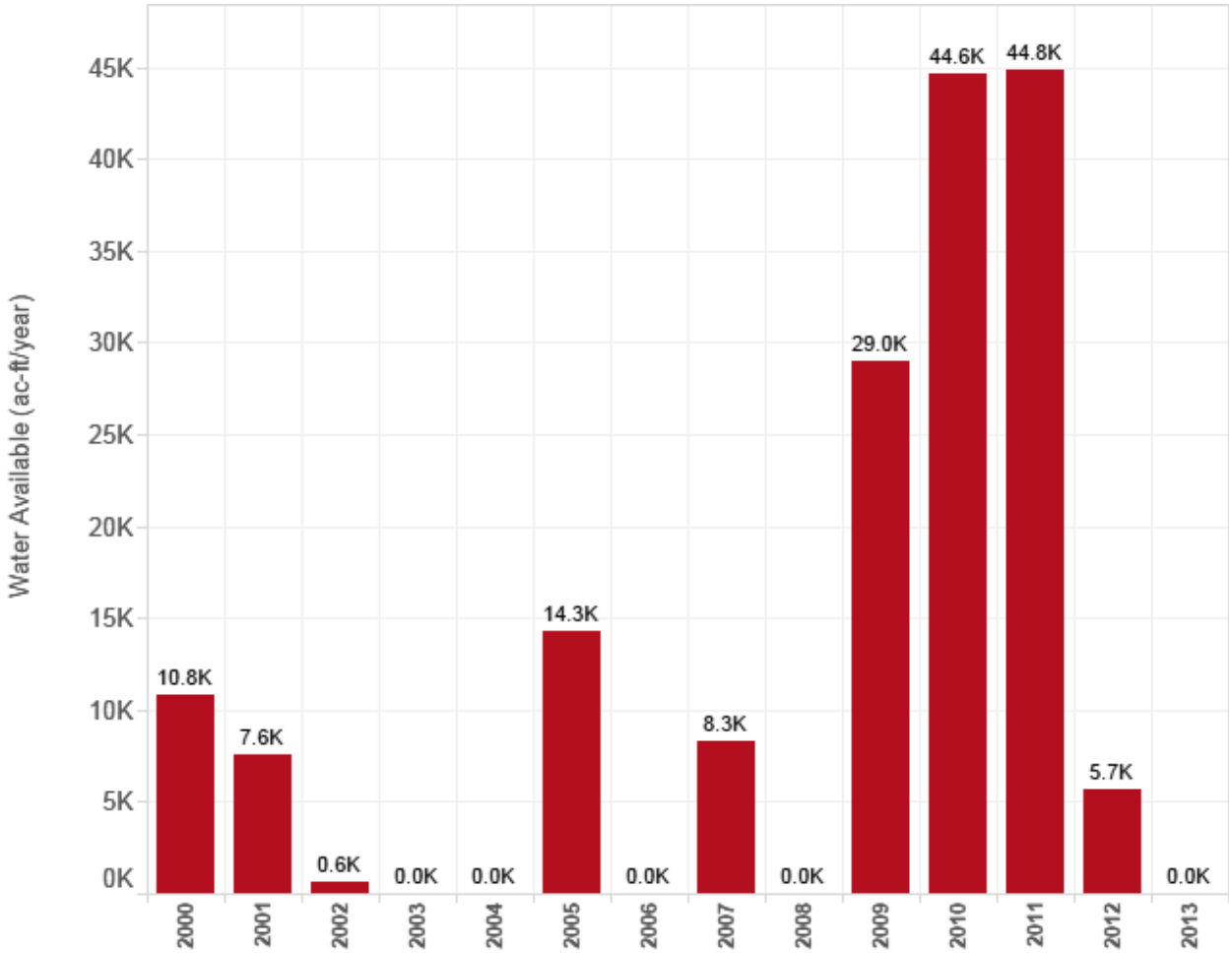
The water availability results reflect the preliminary estimate as well as the additional refinements included in the analysis. Figure 3-23 shows a hydrograph of the water available in St Vrain at Lyons for the analysis period.



Lower magnitude and more frequency characterize the available flows in the first three years. Infrequent larger peaks characterize the water availability after 2003.

Figure 3-23: Water Available in St. Vrain Creek at Lyons

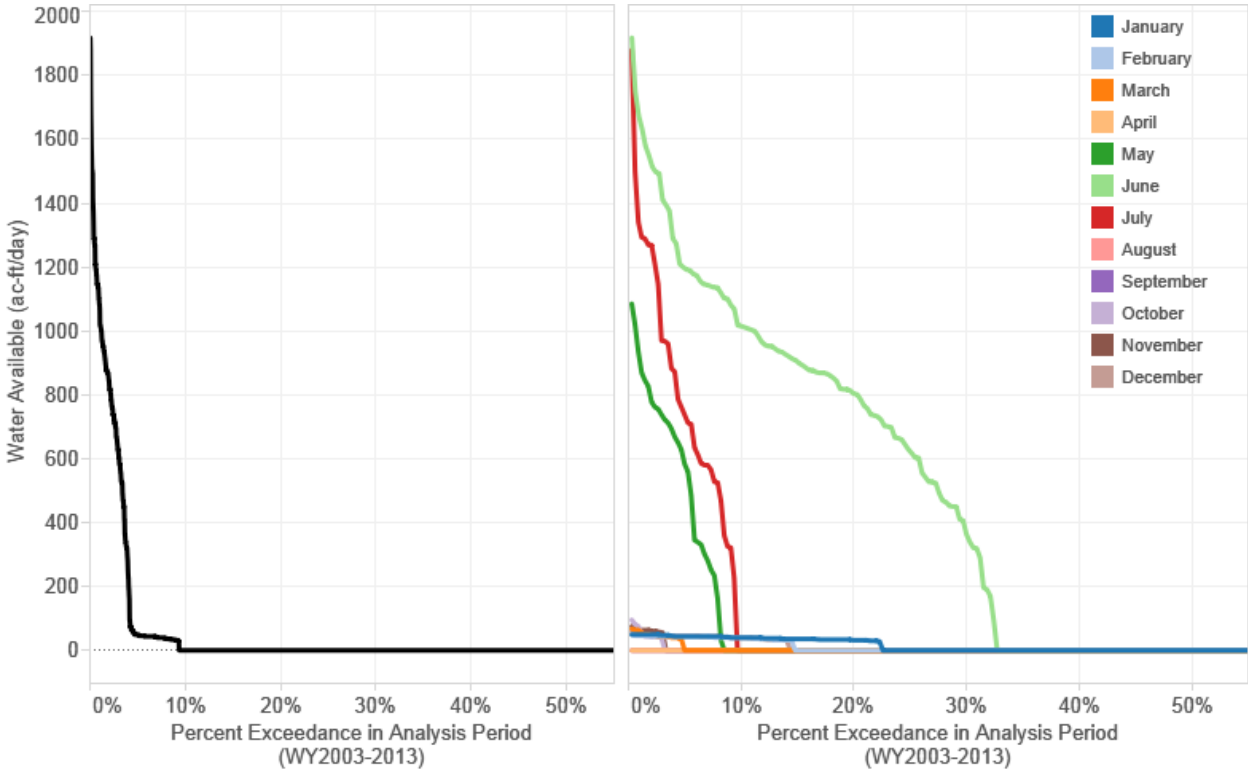
The annual water available in St. Vrain Creek at Lyons for each water year (starting October 1st) is shown in Figure 3-24.



The longest consecutive set of years with water available at this analysis point had volumes greater than 29,000 ac-ft per year for three years. Any other year with annual water available is less than about 15,000 ac-ft per year.

Figure 3-24: Annual Water Available in St. Vrain Creek

Daily and monthly exceedance plots for the water available in St. Vrain Creek at Lyons are shown below in Figure 3-25. Table 3-15 shows selected values from the exceedance plots for relative comparison.



Water is available at this analysis point about nine percent of the days between water years 2000 and 2013. The daily water availability is less than 100 ac-ft per day between nine and four percent of the days. May, June and July are the months with higher daily flows of water available. June is the only month with water available more than 20 percent of days and August has the least percent of days with available water.

Figure 3-25: Percent Exceedance for St. Vrain Creek

Table 3-15: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	50	0	0
January	44	40	32
February	44	40	0
March	0	0	0
April	0	0	0
May	583	0	0
June	1,192	1,016	803
July	738	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	46	40	0

3.6 South Platte River at South Platte (PLASPLCO)

3.6.1 Analysis Point Description

The water available in the South Platte River above Chatfield Reservoir is estimated using the DWR streamflow gage (PLASPLCO), located approximately 500 feet downstream from the confluence of the South and North forks of the South Platte River. The South Platter River at South Platte analysis point is not included in the Point Flow Model. Table 3-16 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-26.

Table 3-16: South Platte River at South Platte Preliminary Estimate Features

Analysis Point	District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
South Platte River at South Platte (PLASPLCO)	8	South Platte River at South Platte Confluence (PLADENCO)	South Platte below Strontia Springs (PLASTRCO) South Platte River Below Waterton (PLAWATCO) South Platte River below Chatfield Reservoir (PLACHACO) South Platte River below Union Ave at Englewood (PLAUNICO) South Platte River at Englewood (PLAENGCO)	Barr Lake/Burlington Ditch

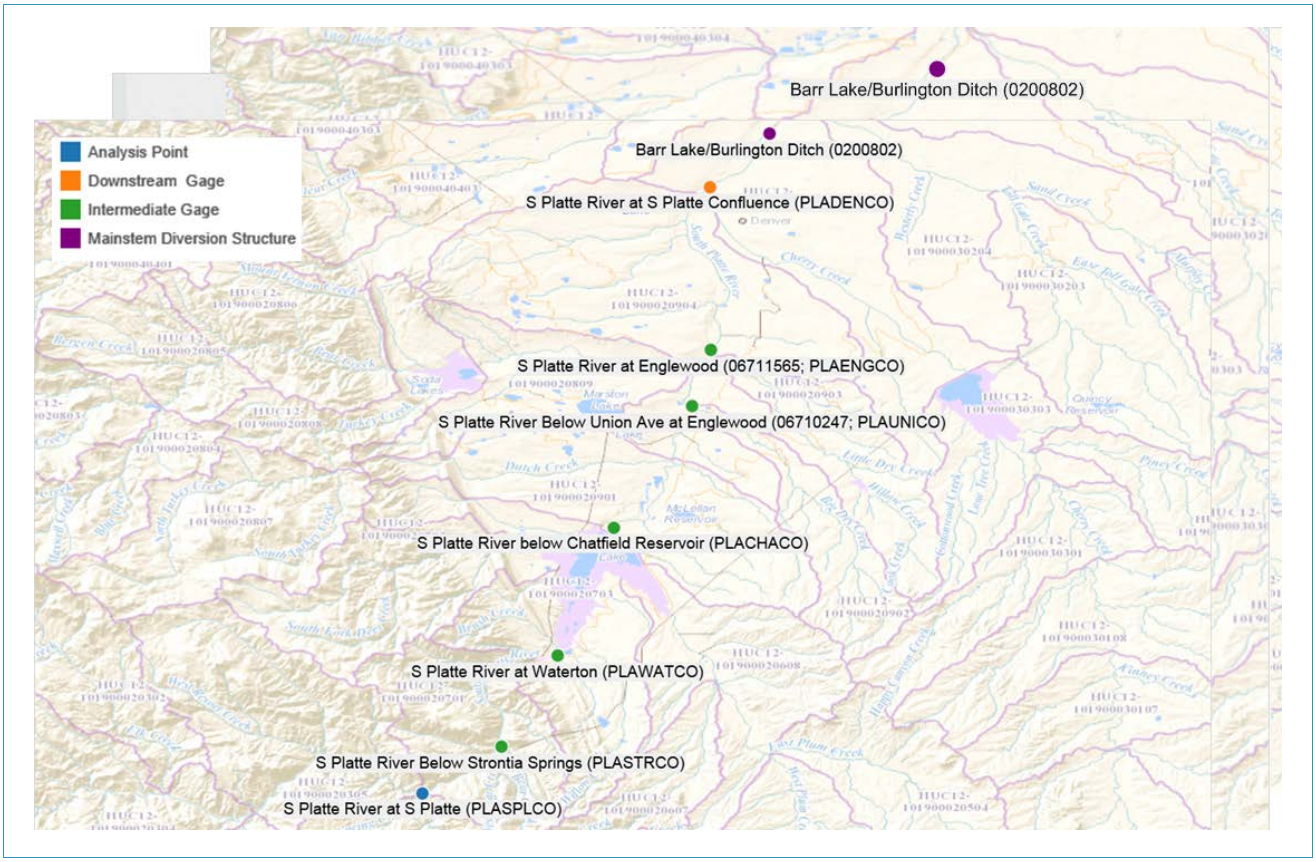


Figure 3-26: Upper South Platte Analysis Points and Preliminary Estimate Supporting Points

3.6.2 Water Availability Refinement

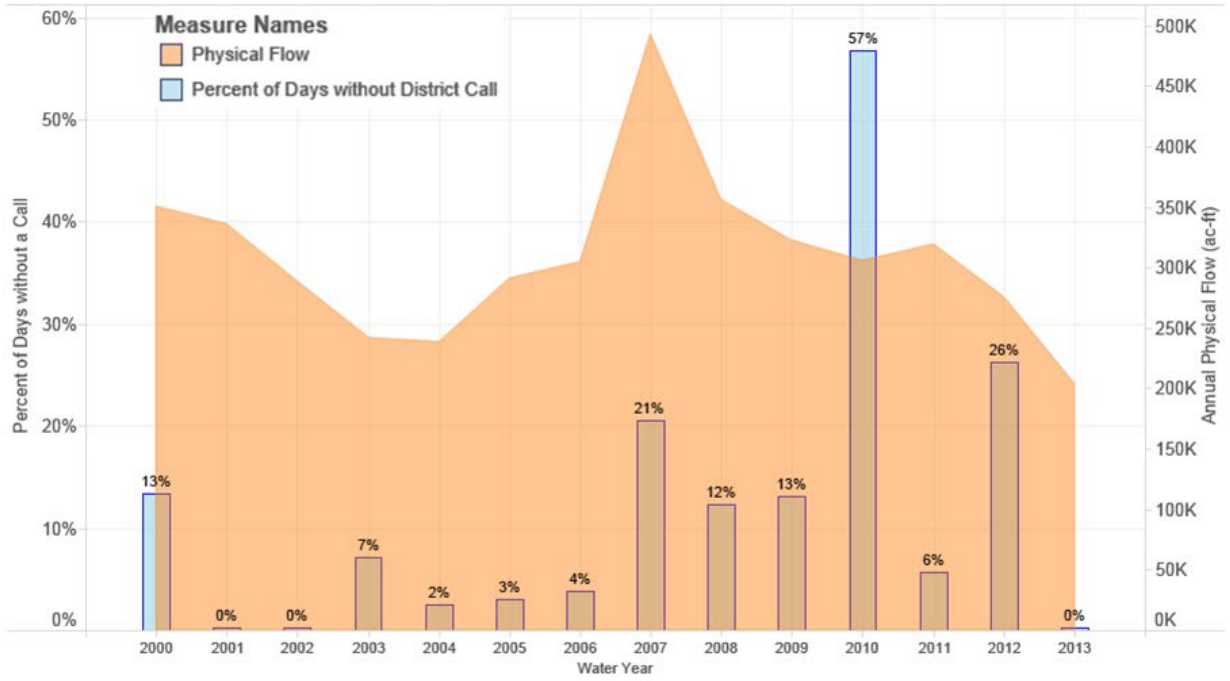
This section documents identified refinement layers affecting the preliminary water availability estimate in the upper South Platte. Table 3-17 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-17 Refinement Layers for the Upper South Platte Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Current Analysis
Chatfield Reservoir Accounting	Division 1	Detailed accounting of the water in and out of Chatfield reservoir allows refining estimate of natural flow available at the analysis point.	Natural flow above Chatfield from the Chatfield checklist is assumed to be suitable to refine the water available at the analysis point located about 7.5 miles upstream.	✓ Yes
Denver Water Simulated Flows	Denver Water	Simulated natural flows at the analysis point provide an upper limit at the actual analysis point location	A refinement layer was added using the simulated flows at the South Platte at South Platte gage.	✓ Yes
Non-Native flows	Division 1	Several transmountain diversions flow by the analysis point (e.g., Denver Water, Englewood and Aurora).	It is assumed that non-native flows are discounted the preliminary estimate by the natural flow layers described above.	✓ Yes
Strontia Springs Storage	Division 1	Strontia Springs is located downstream of the analysis point. Flows stored in Strontia reservoir in free river situations could overestimate available flows.	Chatfield checklist includes Strontia Springs storage.	✓ Yes

3.6.3 Water Availability Results

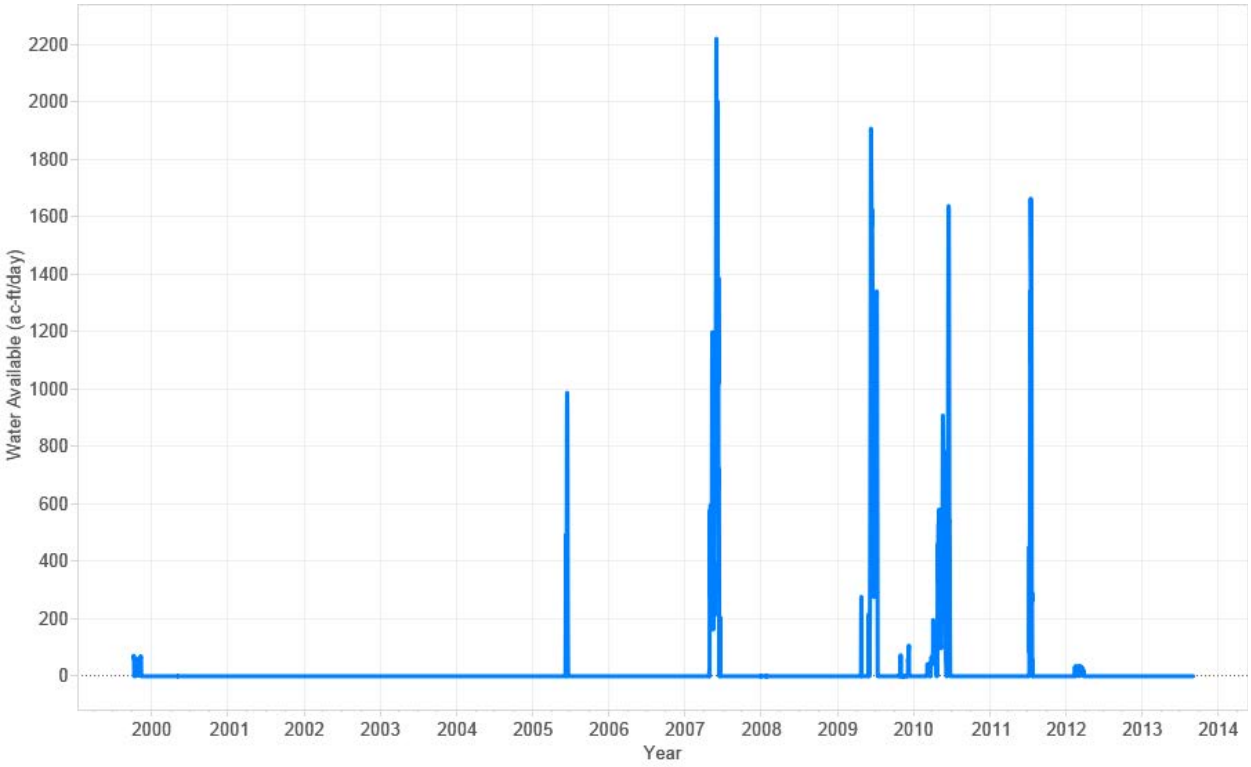
This section summarizes the results of the water availability for the upper South Platte River above Chatfield Reservoir analysis point. The percent of days with a call impacting the district is shown in Figure 3-27. The analysis assumes that there is not water available in days when there is a call impacting the district.



With exception of 2010 the percent of days without a call is less than 25 percent for the analysis period. There is not a strong correlation between the years with peak annual physical flows and the largest percent of days without a call, for example, 2010 shows almost 60 percent of the days without a call and annual flows in the midrange around 300,000 ac-ft per year.

Figure 3-27: Percent of Days without a Call Impacting District 8 and Annual Physical Flow at South Platte at South Platte

The water availability results include the preliminary estimate as well as the additional refinements included in the analysis. Figure 3-28 shows a daily hydrograph of the water available in the upper South Platte above Chatfield for the analysis period.



The hydrograph shows prolonged periods where there is no water available (e.g. 2001-2004). In the wetter years, such as 2007, water is available for relatively short periods of time with peaks exceeding 600 ac-ft per day. The longest periods of consecutive days of estimated water available were observed between 2009 and 2010.

Figure 3-28: Water Available in the Upper South Platte River

The annual water available at the upper South Platte River above Chatfield Reservoir for each water year (starting October 1st) is shown in Figure 3-29.

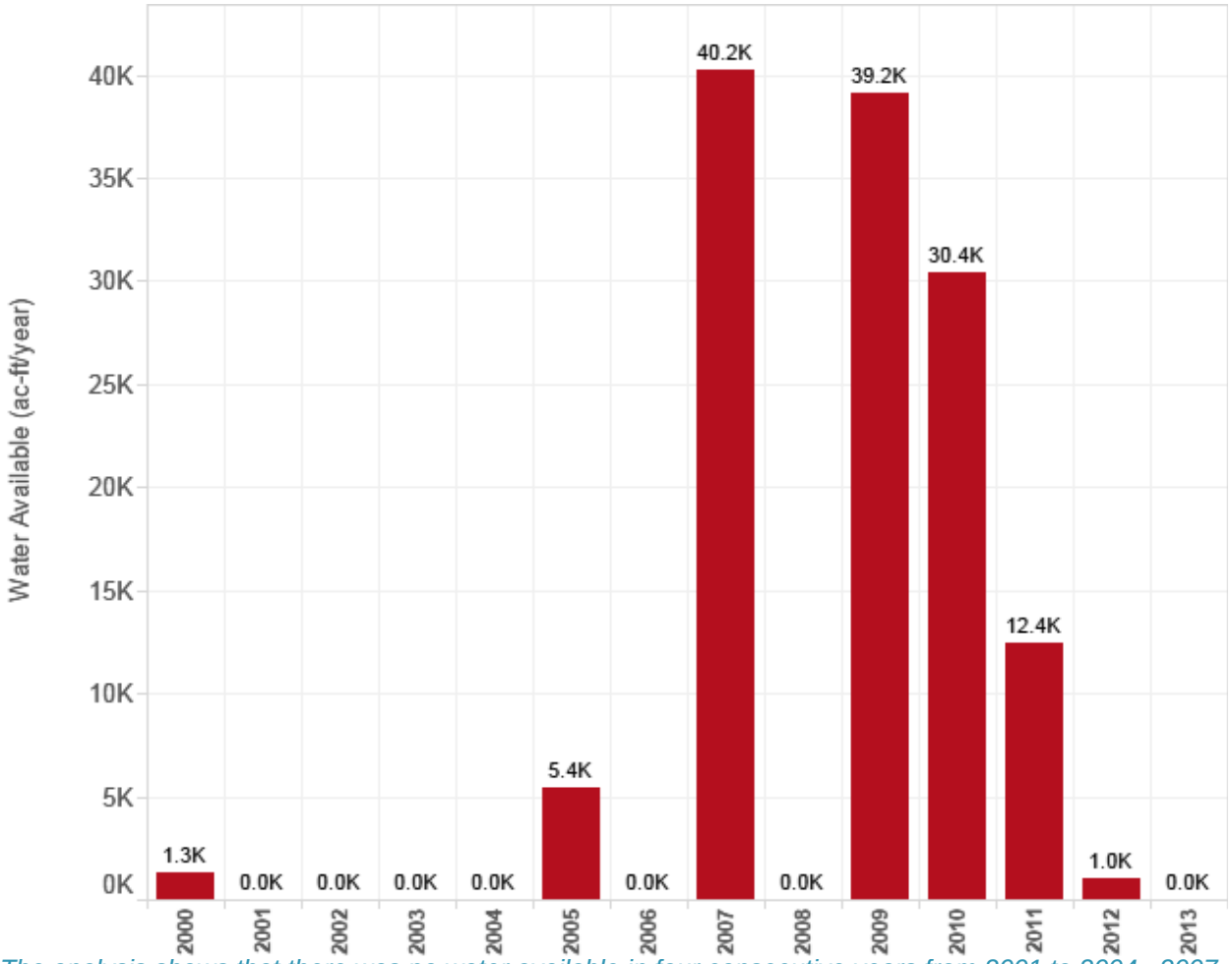
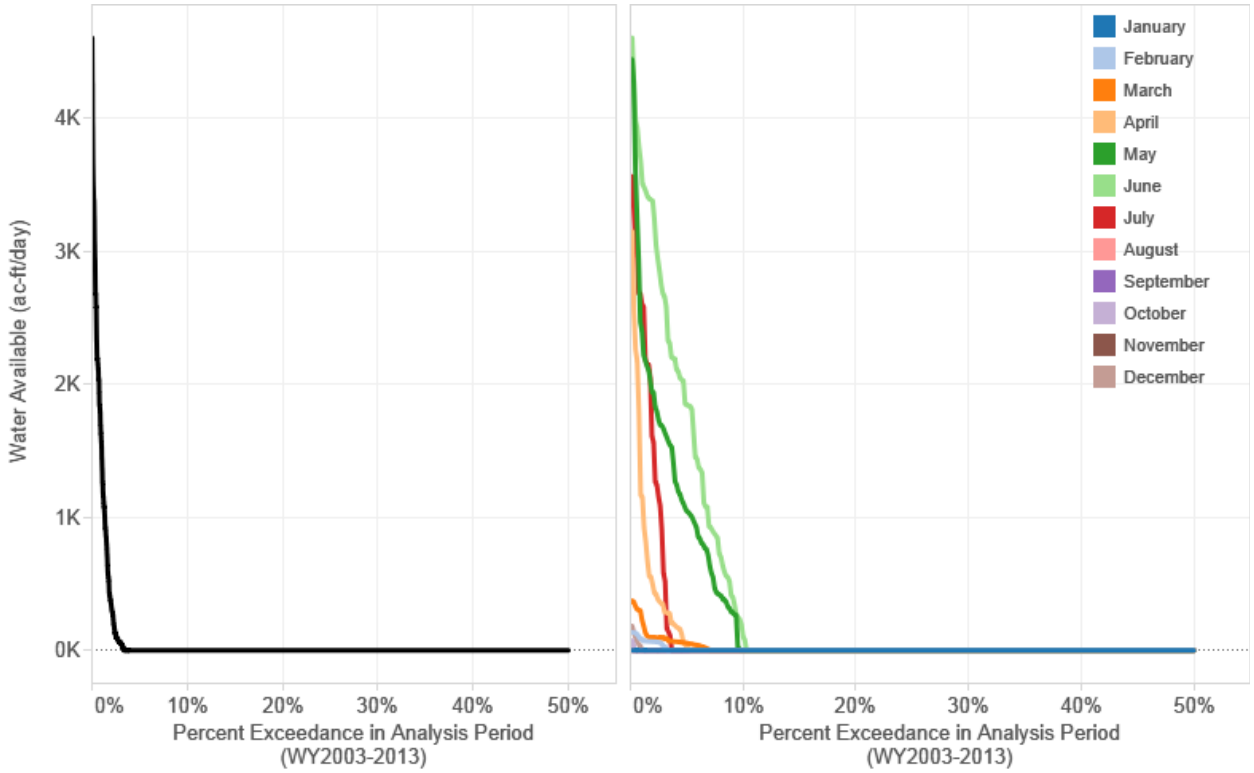


Figure 3-29: Annual Water Available in the Upper South Platte

Daily and monthly exceedance plots for the water available in the Upper South Platte are shown below in Figure 3-30. Table 3-18 shows selected values from the exceedance plots for relative comparison.



Water is available at this analysis point only two percent of the days in the analysis period. June and May are the months with the largest percent of days with water available, and together with April and July are the only months with water available greater than 200 ac-ft per day.

Figure 3-30: Percent Exceedance for the Upper South Platte

Table 3-18: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	0	0	0
January	0	0	0
February	0	0	0
March	56	0	0
April	41	0	0
May	1,047	0	0
June	1,841	100	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	0	0	0

3.7 South Platte River below Chatfield Reservoir (PLACHACO)

3.7.1 Analysis Point Description

The analysis point is located at the South Platte below Chatfield reservoir. The gage is located 815 ft. downstream from the outlet works of Chatfield Reservoir with a drainage area of approximately 3,000 square miles. The South Platte River below Chatfield Reservoir analysis point is not included in the Point Flow Model. Table 3-19 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-31.

Table 3-19: South Platte River below Chatfield Reservoir Preliminary Estimate Features

Analysis Point	District	Downstream Gage	Intermediate Gages	Mainstem Diversion Structure
South Platte River below Chatfield Reservoir (PLACHACO)	8	South Platte River at South Platte Confluence (PLADENCO)	South Platte River below Union Ave at Englewood (PLAUNICO) South Platte River at Englewood (PLAENGCO)	Barr Lake/Burlington Ditch

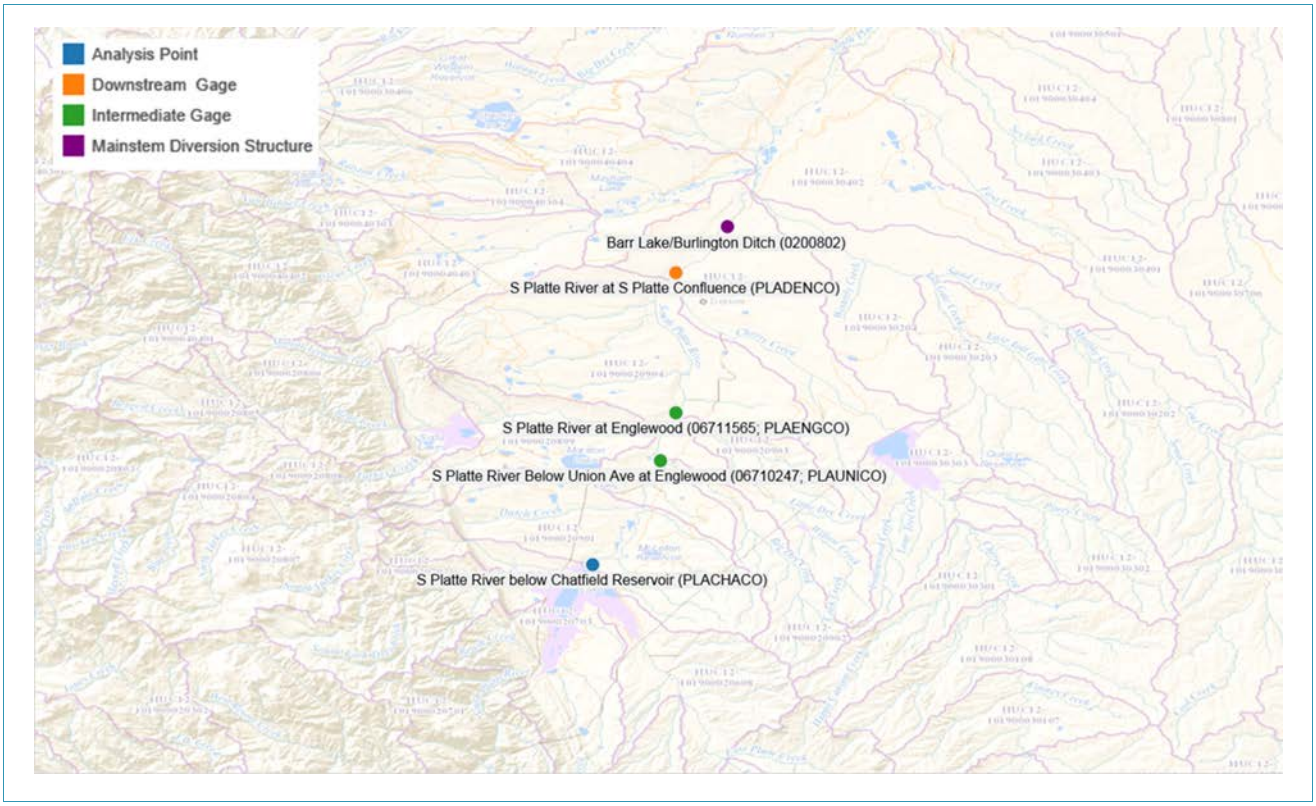


Figure 3-31: South Platte River below Chatfield Reservoir Analysis Point and Preliminary Estimate Supporting Points

3.7.2 Water Availability Refinement

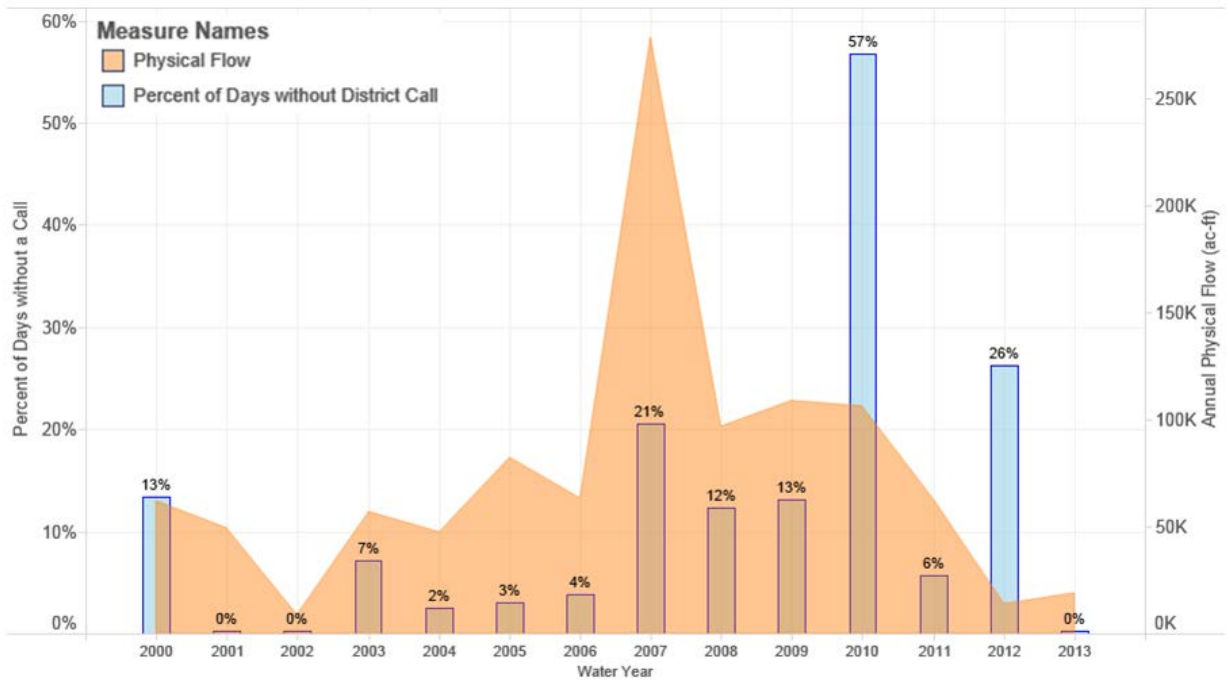
This section documents identified refinement layers affecting the preliminary water availability estimate in the South Platte River below Chatfield Reservoir. Table 3-20 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-20: Refinement Layers for the South Platte River below Chatfield Reservoir Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Chatfield Reservoir Releases	Division 1	Releases from Chatfield Reservoir included in the measured flow at the gage overestimate the water available. Required releases to ditches, to the river and the fish hatchery need to be considered in the calculation.	Chatfield checklist provides a water balance at the reservoir. Using the natural flow downstream of the reservoir as a refinement layer the preliminary estimate limits the water availability to natural flow downstream of the reservoir.	✓ Yes

3.7.3 Water Availability Results

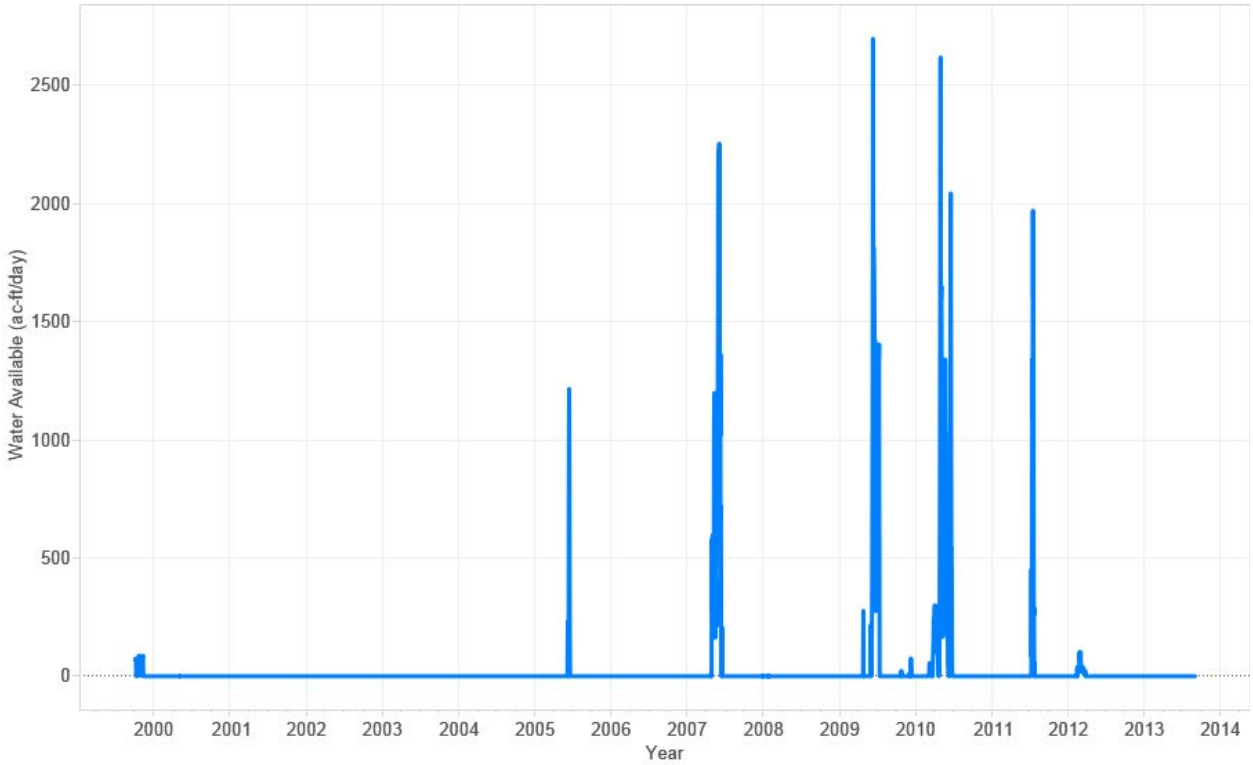
This section summarizes the results of the water availability for the South Platte River below Chatfield Reservoir analysis point. The percent of days with a call impacting the district and the annual physical flow at the gage is shown in Figure 3-32. The analysis assumes that there is not water available in days when there is a call impacting the district.



The percent of days without a call is less than 25 percent, except for 2010 when there was not a call in the district for more than 50 percent of the days. There not a strong correlation of high annual flows at the gage and the district calls.

Figure 3-32: Percent of Days without a Call Impacting District 8 and Annual Physical Flow at South Platte below Chatfield

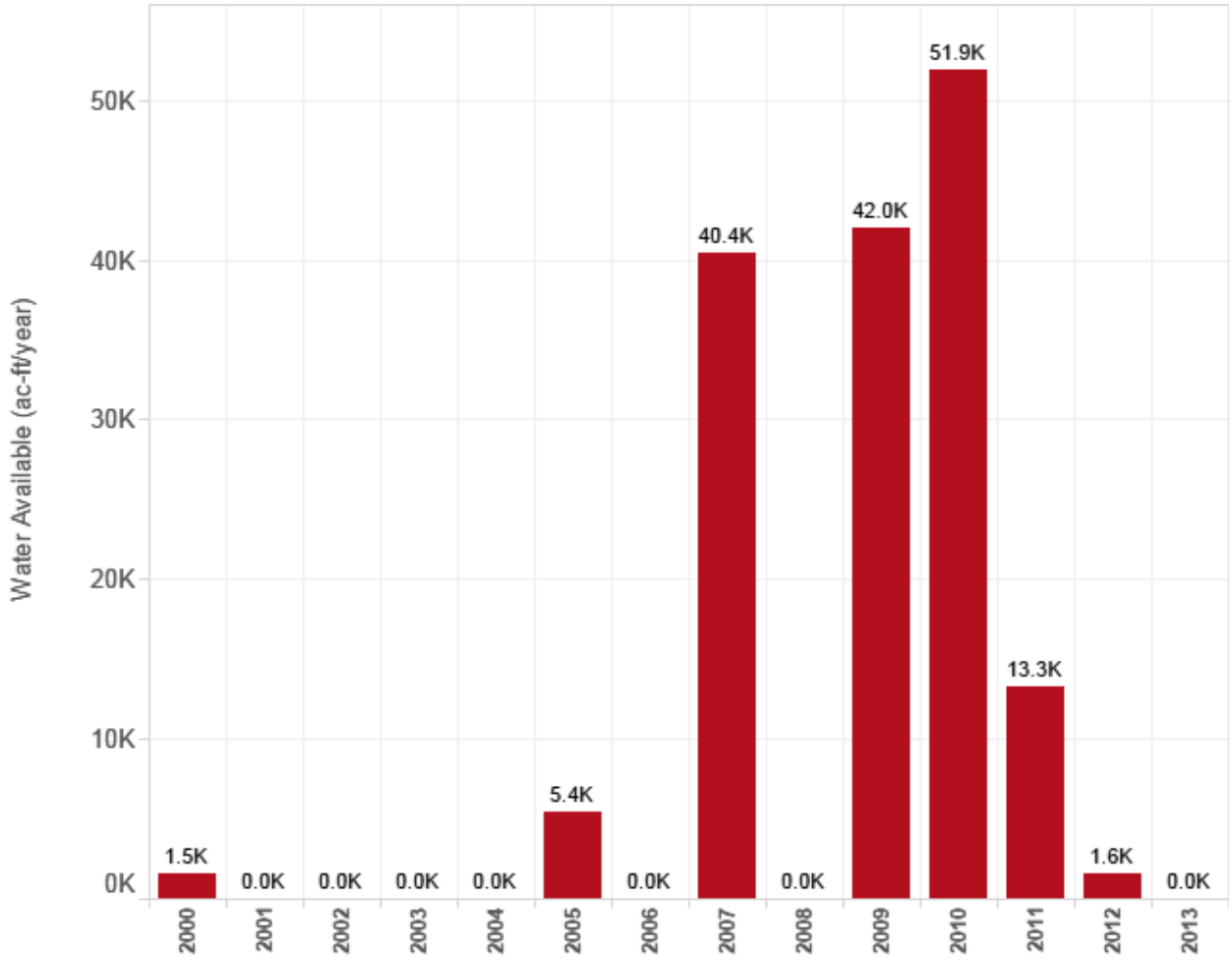
The water availability results reflect the preliminary estimate as well as the additional refinements included in the analysis (Table 3-19). Figure 3-33 shows a hydrograph of the water available in the South Platte River below Chatfield Reservoir for the analysis period.



There are five consecutive years with no water available. Water availability periods are concentrated in relatively small period of the year. The majority of the water available peaks with more than 1,000 ac-ft per day occur in June.

Figure 3-33: Water Available in the South Platte River below Chatfield Reservoir

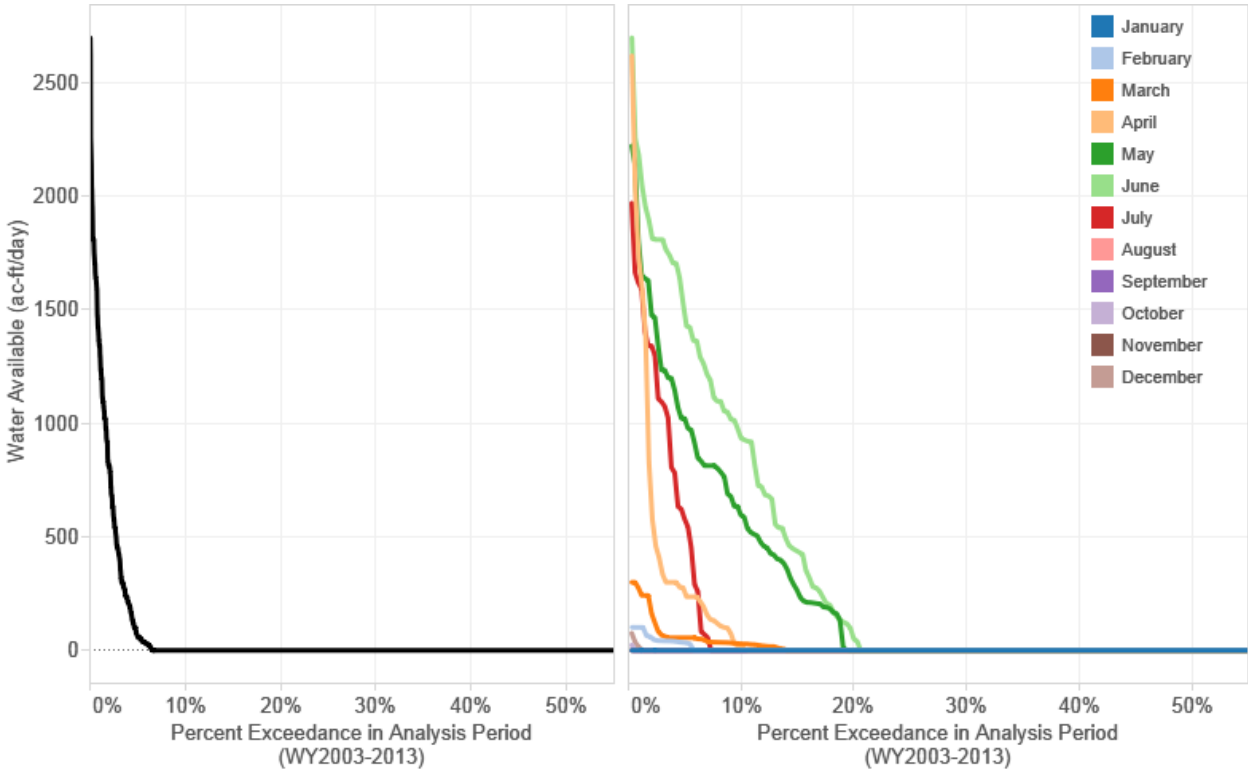
The sum of the annual water available in the South Platte River below Chatfield Reservoir for each water year (starting October 1st) is shown in Figure 3-34.



Annual water available follows the same pattern than the analysis point upstream of Chatfield Reservoir, with consecutive years without water available in the first years of the analysis and three years with annual volumes greater than 38,000 ac-ft.

Figure 3-34: Annual Water Available in the South Platte River below Chatfield Reservoir

Daily and monthly exceedance plots for the water available in the South Platte Reservoir below Chatfield Reservoir are shown below in Figure 3-35. Table 3-21 shows selected values from the exceedance plots for relative comparison.



Water is available at this analysis point only five percent of the days. The steep slope of the curve indicates rather large flows when there is water available, with half of the available days (i.e., 2.5 percent) having flows greater than 400 ac-ft per day. Peak flows greater than about 2,000 ac-ft per day are shown from April to May. May and June are the months with the largest percent of days with available water.

Figure 3-35: Percent Exceedance for the South Platte River below Chatfield

Table 3-21: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	62	0	0
January	0	0	0
February	34	0	0
236	56	29	0
April	236	20	0
May	1,021	596	0
June	1,428	933	50
July	578	0	0
August	0	0	0
September	0	0	0
October	2	0	0
November	0	0	0
December	0	0	0

3.8 South Platte River near Henderson (06720500; PLAHENCO)

3.8.1 Analysis Point Description

The analysis point is located on the South Platte, 315 feet upstream from the 1244th Avenue Bridge and 0.2 miles northwest of Henderson, CO. The gage has a drainage area of approximately 4,760 square miles. The South Platte River near Henderson analysis point is included in the Point Flow Model. Table 3-22 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-36.

Table 3-22: South Platte River near Henderson Preliminary Estimate Features

Analysis Point	District	First Downstream Diversion Structure
South Platte River near Henderson (06720500; PLAHENCO)	2	Brighton Ditch

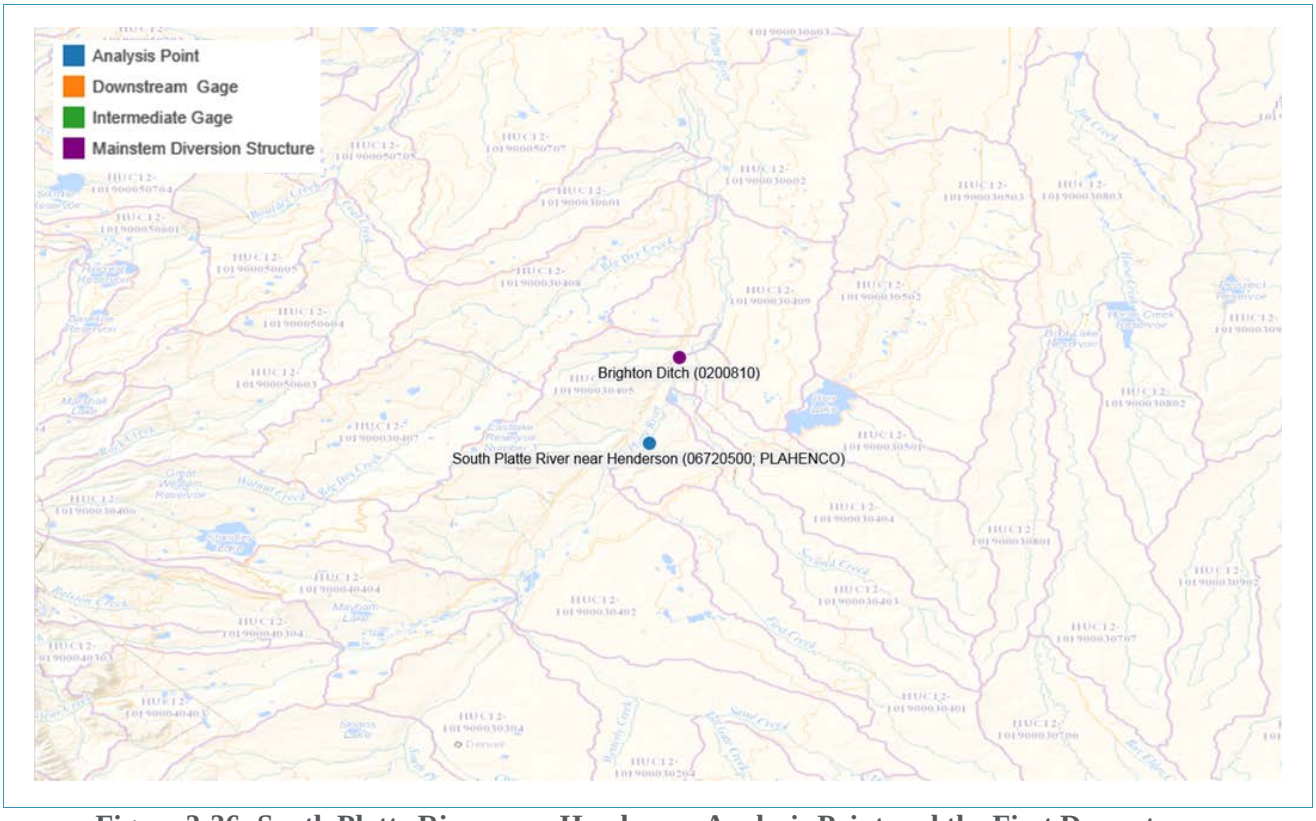


Figure 3-36: South Platte River near Henderson Analysis Point and the First Downstream Diversion Structure used in the Point Flow Model

3.8.2 Water Availability Refinement

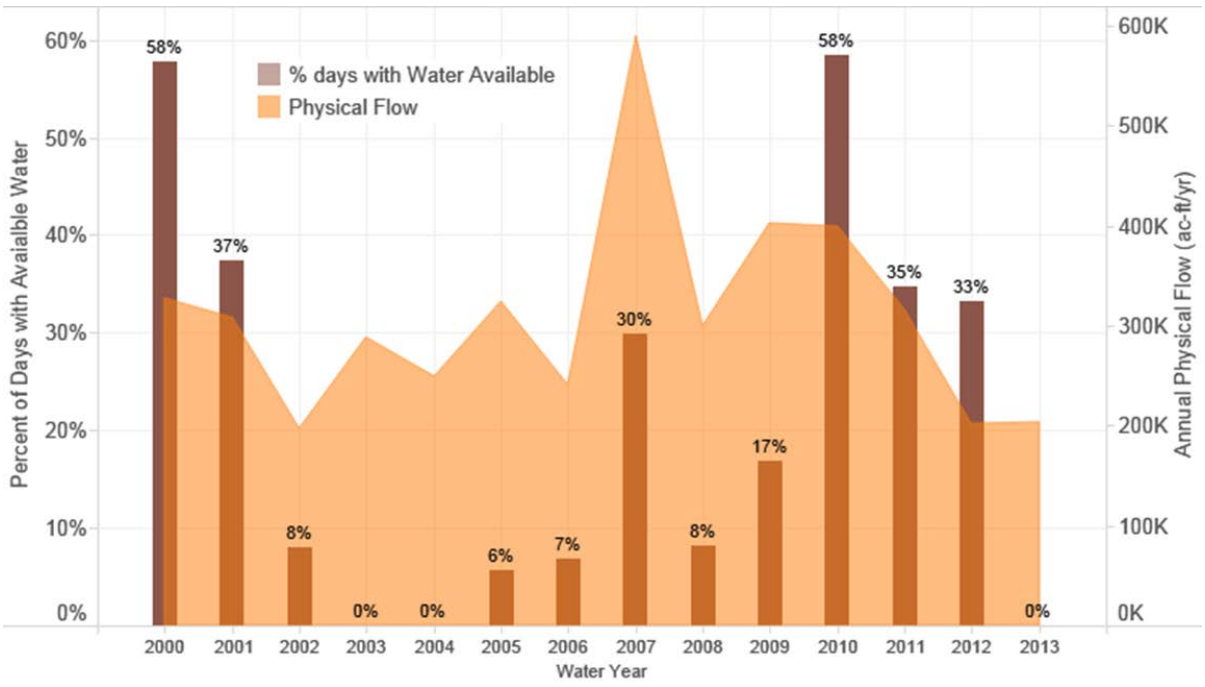
This section documents identified refinement layers affecting the preliminary water availability estimate in the South Platte River near Henderson. Table 3-23 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-23: Refinement Layers for the South Platte River near Henderson Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Unused Reusable Return Flows	Aurora Water	In the analysis period, the reusable water in the river that was not used by Aurora became part of the natural flow. These additional flows in the river can overestimate the water available, if they were not diverted by another water user. These reusable return flows will be used by Aurora in the future (e.g., WISE supply); thus should not be included in the future water available.	If unused returns were used/diverted they would not be part of the preliminary water availability estimate because the gage flows and the Point Flow Model will account for them. Daily time series of estimated excess reusable return flows from Aurora Water was used as a refinement layer for the mainstem downstream of Metro wastewater treatment discharge. It is assumed that the provided excess was not used at times of free river and therefore is discounted from the preliminary water availability estimate.	✓ Yes
Unused Reusable Return Flows	Denver Water	In the analysis period, the reusable water in the river that was not used by Denver Water became part of the natural flow. These additional flows in the river can overestimate the water available, if they were not diverted by another water user. These reusable return flows will be used by Denver in the future; thus should not be included in the future water available.	The historical reusable return flows that could not be exchanged upstream were used to refine the water availability estimate. It was assumed that these return flows were used by others in the periods of high demands, i.e., between April and October, and they were not used and were part of the calculated water available from November to March.	✓ Yes
Conditional Rights	Division 1	Conditional rights in this reach of the South Platte River are constantly increasing. These rights reduce the preliminary water availability estimate since that water will not be available for a new water right.		✖ No

3.8.3 Water Availability Results

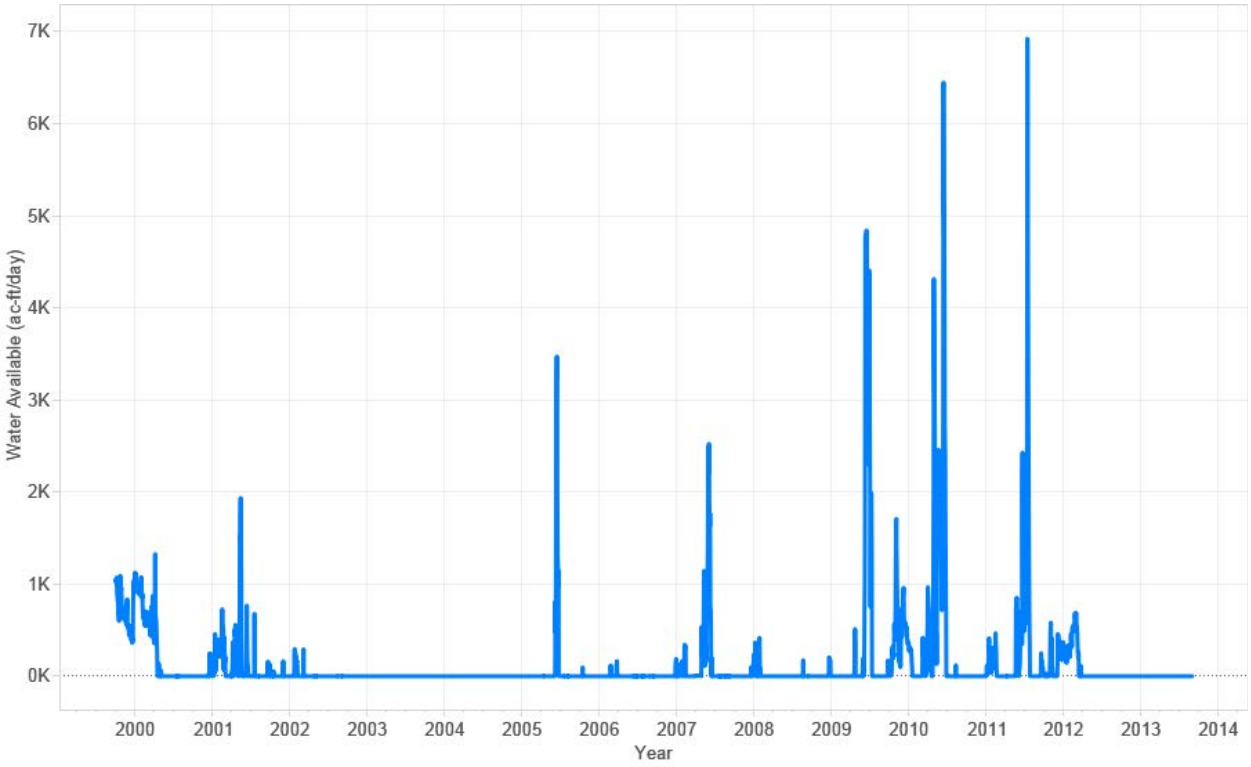
This section summarizes the results of the water availability for the South Platte River near Henderson analysis point. The water availability results reflect the preliminary estimate as well as the additional refinements included in the analysis. The percent of days with estimated water available is shown in Figure 3-37.



About half of the years in the analysis period have less than eight percent of days with water available. There is not a strong relationship between annual flow and the percent of days with water available, e.g., annual flows between 200,000 and 300,000 ac-ft per year range between zero and 35 percent of days with water available.

Figure 3-37: Percent of Days with Water Available and Annual Physical Volumes at South Platte River near Henderson

Figure 3-38 shows a hydrograph of the water available in the South Platte River for the analysis period.



Available water at this analysis point is spread out over the analysis period, with only few years not having any water available. Although there are few large peaks exceeding 4,000 ac-ft per day, there are also periods of consecutive days with water available and flows less than 1,000 ac-ft per day.

Figure 3-38: Water Available in the South Platte River near Henderson

The sum of the annual water available in the South Platte River near Henderson for each water year (starting October 1st) is shown in Figure 3-39.

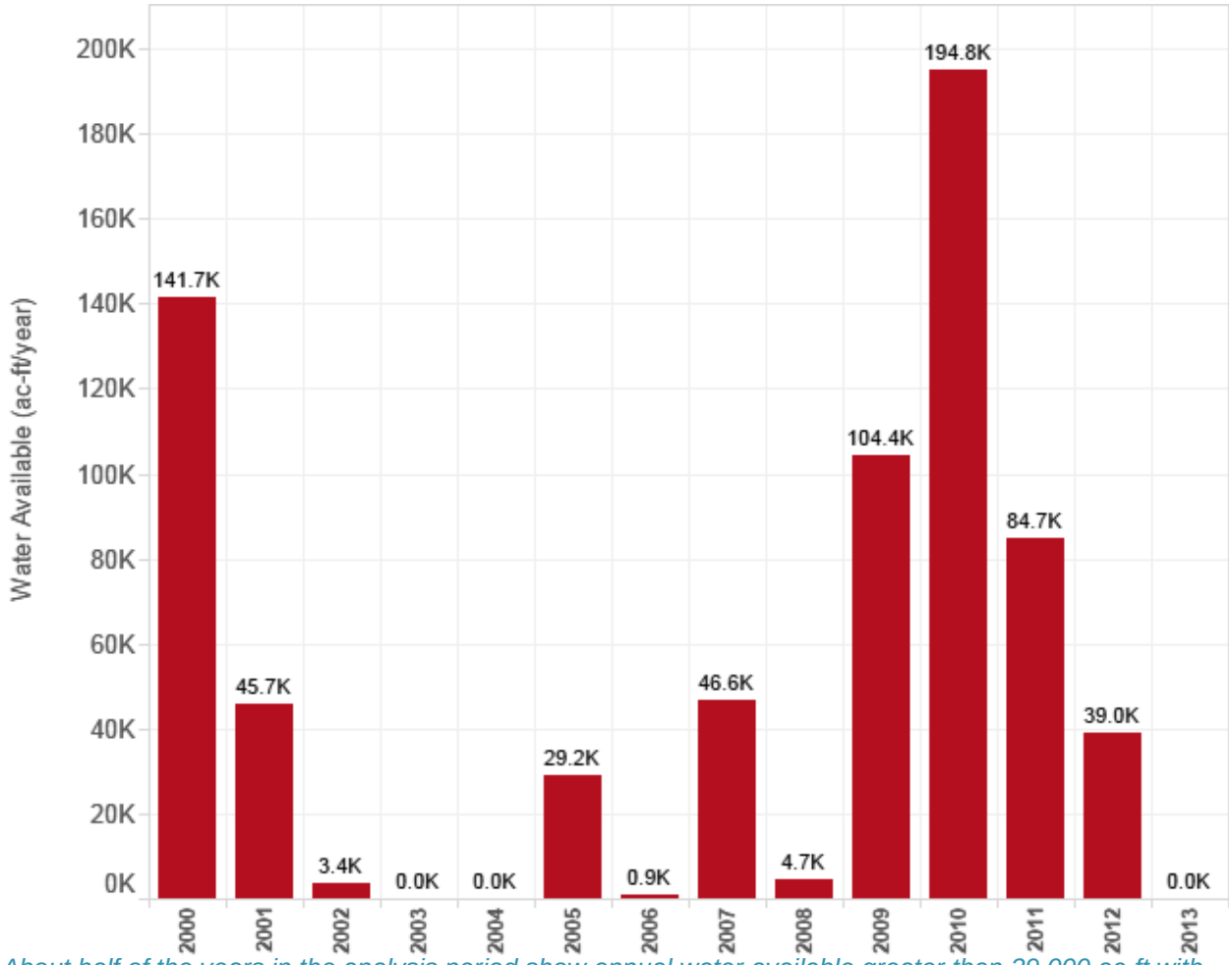
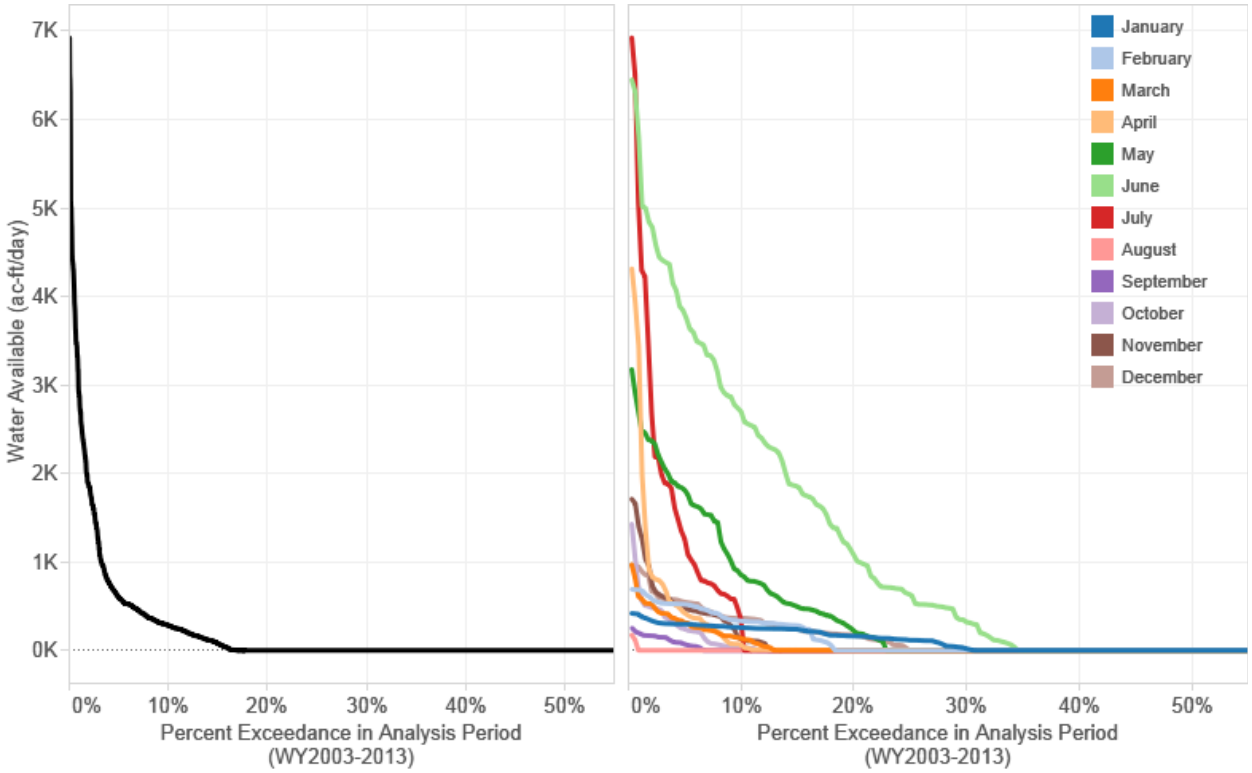


Figure 3-39: Annual Water Available in the South Platte River near Henderson

Daily and monthly exceedance plots for the water available in the South Platte River near Henderson are shown below in in Figure 3-40. Table 3-24 shows selected values from the exceedance plots for relative comparison.



There is water available at this analysis point 20 percent of the days in the analysis period with 10 percent of the days having water available greater than 400 ac-ft per day. Forty percent of the days in January have water available with available flows less than 1,000 ac-ft per day. April, May, June and July show the largest amounts of water available with June having the most water available.

Figure 3-40: Percent Exceedance for the South Platte River near Henderson

Table 3-24: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	599	282	0
January	297	257	162
February	518	332	0
March	313	140	0
April	407	65	0
May	1,813	853	192
June	3,749	2,698	1,077
July	1,260	355	0
August	0	0	0
September	67	0	0
October	244	33	0
November	462	129	0
December	546	363	175

3.9 South Platte River near Kersey (06754000; PLAKERCO)

3.9.1 Analysis Point Description

The analysis point is located on the South Platte on the downstream side of the Weld County Road 53 Bridge, 1.9 miles north of Kersey and 2.5 miles downstream from the mouth of the Cache la Poudre River. The gage has a drainage area of approximately 9,659 square miles. The South Platte River near Kearsey analysis point is included in the Point Flow Model. Table 3-25 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-41.

Table 3-25: South Platte River near Kersey Preliminary Estimate Features

Analysis Point	District	First Downstream Diversion Structure
South Platte River near Kersey (06754000; PLAKERCO)	1	Empire Ditch

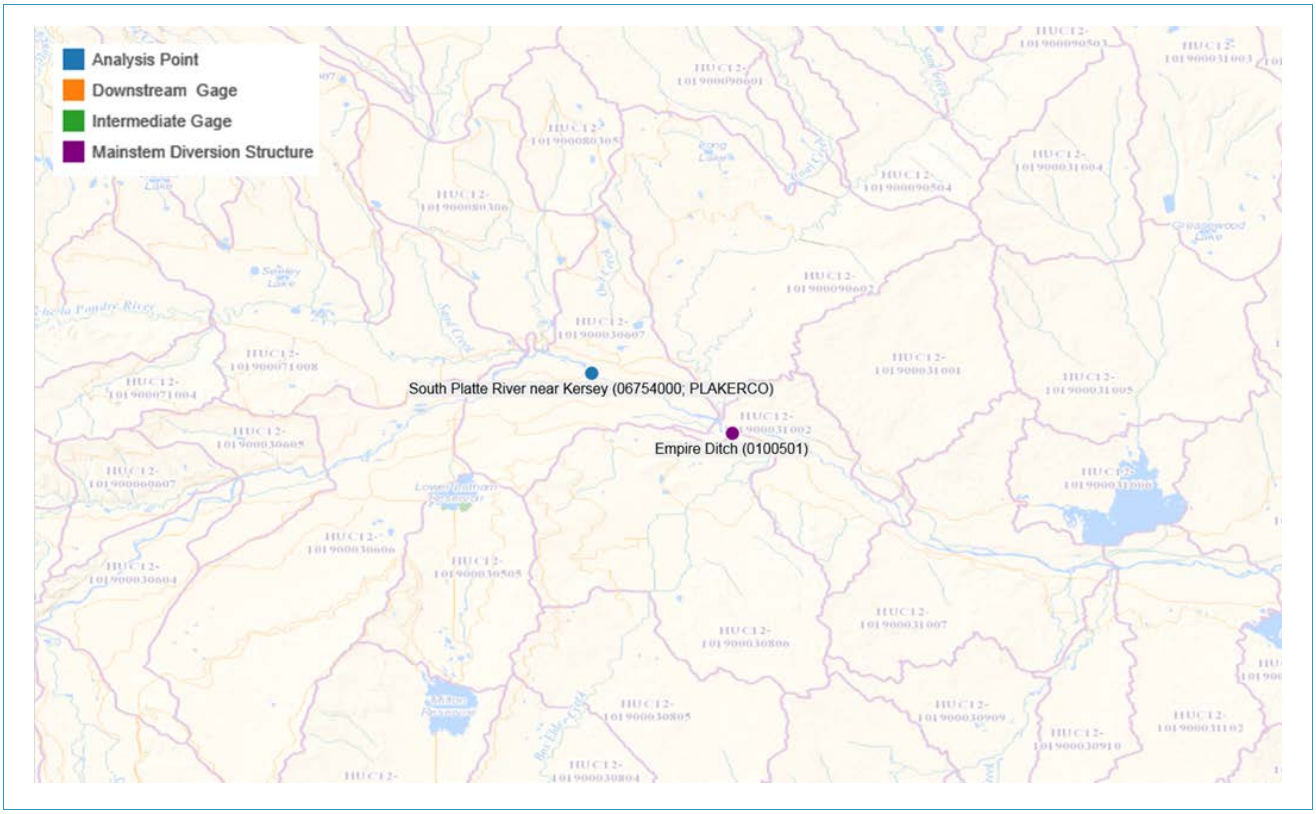


Figure 3-41: South Platte River near Kersey Analysis Point and the First Downstream Diversion Structure used in the Point Flow Model

3.9.2 Water Availability Refinement

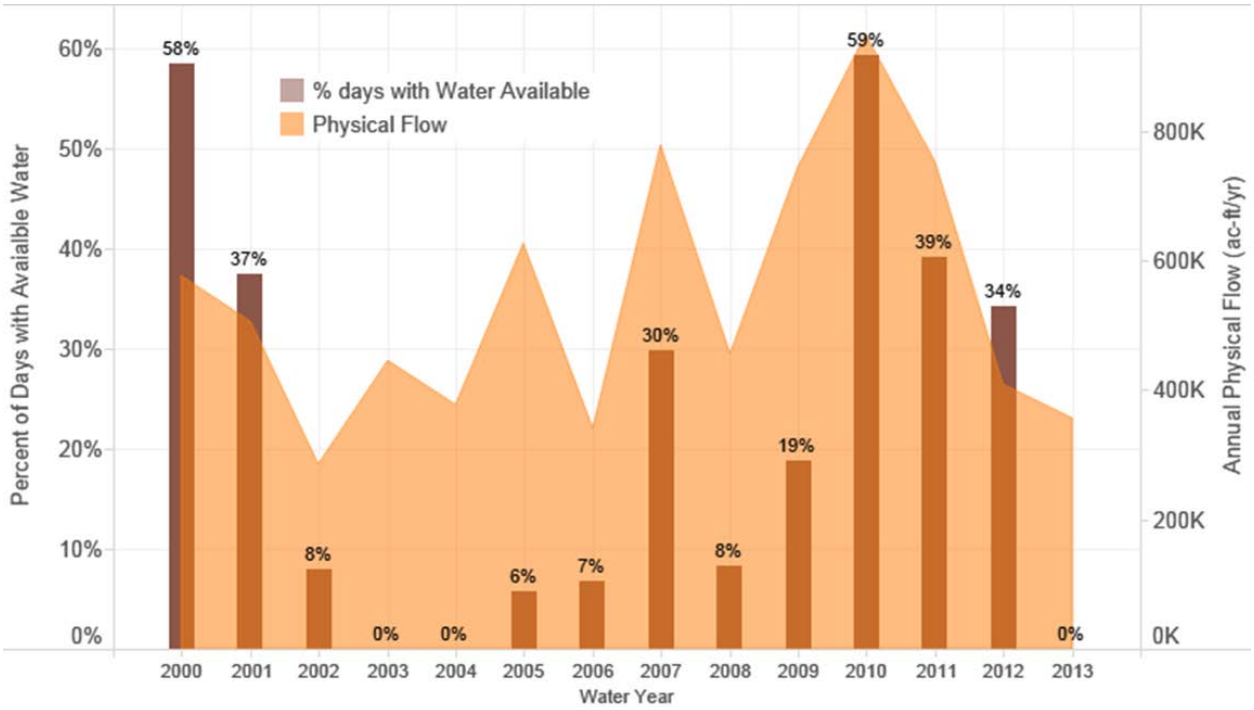
The preliminary water availability estimate in the South Platte River near Kersey is calculated based on the Point Flow Model results. Table 3-26 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-26: Refinement Layers for the South Platte River near Kersey Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Unused Reusable Return Flows	Aurora Water & Denver Water	See Table 3-23.	See Table 3-23.	✓ Yes
Conditional Rights (Augmentation)	Division 1	Conditional rights for augmentation in this reach of the South Platte River are going to be used in the future. These rights reduce the preliminary water availability estimate since that water will not be available for a new water right.		✗ No
C-BT Water (return flows)	Northern	Some C-BT releases could flow through this analysis point during free river conditions and if they are not diverted by water users downstream they would overestimate the water available preliminary estimate.	Not quantified	✗ No
Water Exchanges	Division 1	Historical water exchanges affecting the physical water at this point are captured in the Point Flow Model. Future exchanges from current filings will be senior to new water rights. These future exchanges would reduce the amount of water available at this point.	Historical diversion records used in the Point Flow Model include the operation of exchanges.	✓ Yes ✗ No
Cache Poudre River Water Availability		Water availability estimates at Kersey includes water from conditional and absolute water rights that were not fully utilized in the Poudre River in the period of study. Future water use in the Poudre river will reduce water available in the mainstem from Kersey downstream and need to be considered in future analysis.		✗ No

3.9.3 Water Availability Results

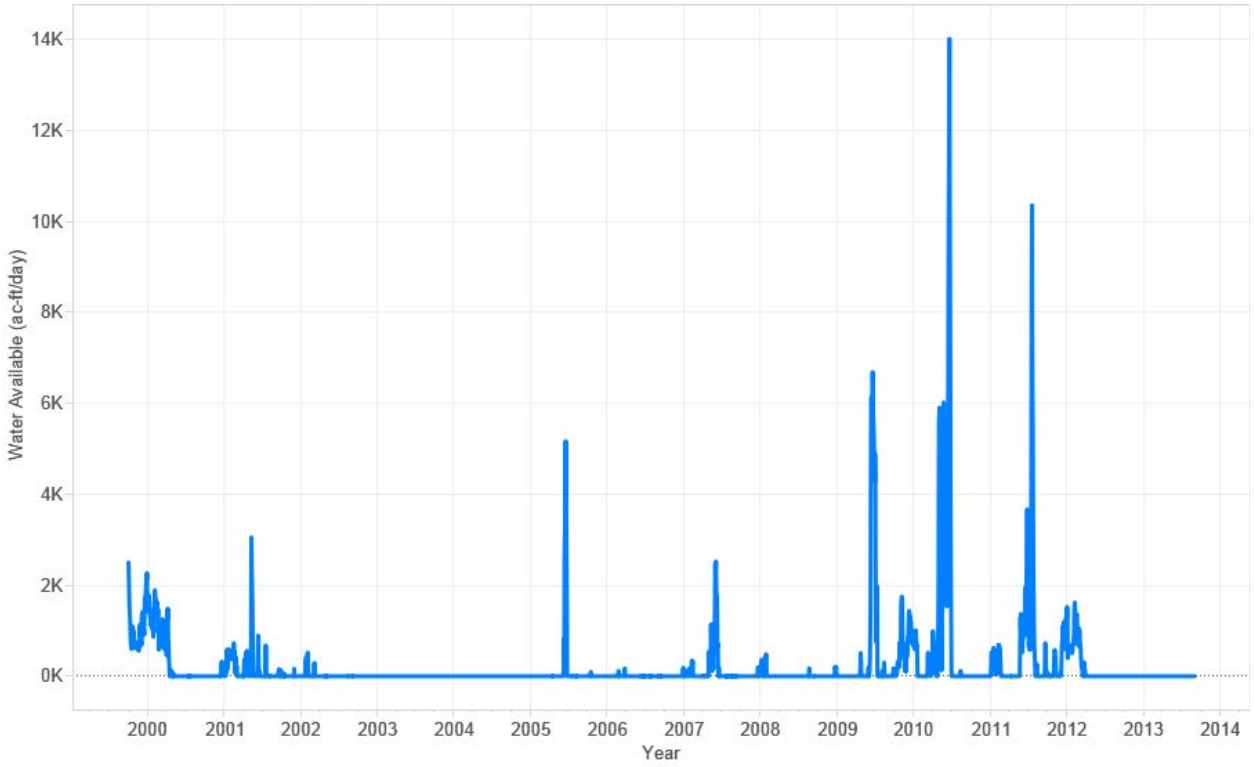
Water available at the South Platte River near Kersey analysis point is based on the Point Flow Model results and included refinements. The percent of days with water available from the Point Flow Model, including the additional refinements, and the annual physical water volume through the station are shown in Figure 3-42.



About half of the years in the analysis period have more than 30 percent of days with water available. With exception of 2012, years with annual flows around 400,000 ac-ft per year have water available less than 10 percent of the time.

Figure 3-42: Percent of Days with Water Available and Physical Annual Volumes at South Platte near Kersey

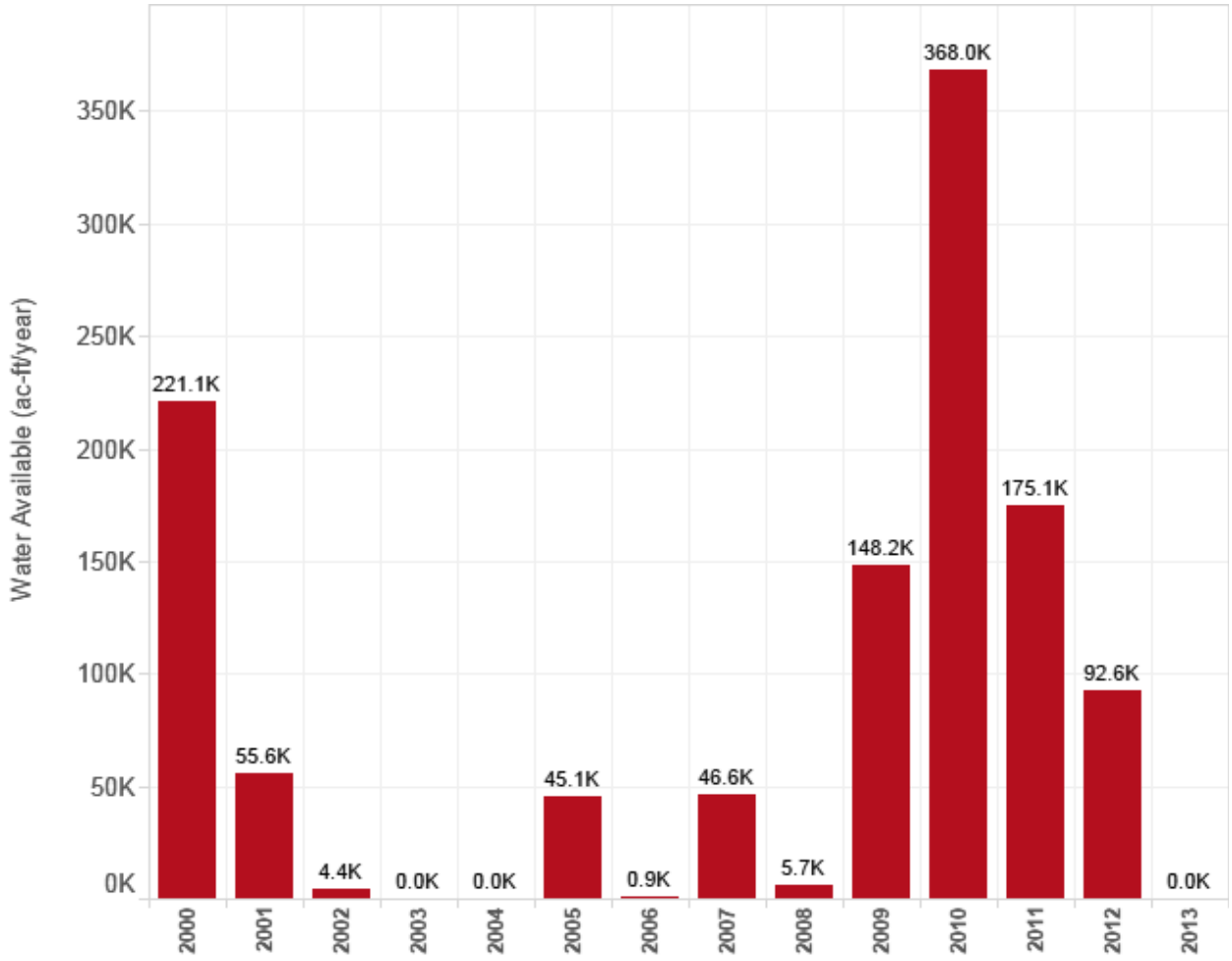
Figure 3-43 shows a hydrograph of the water available in the South Platte River near Kersey for the analysis period.



Periods with peaks of available water above 5,000 ac-ft per day and more extended periods of water available with less than 2,000 ac-ft per day are observed in the analysis period. Periods over two years with no water available are observed in the hydrograph.

Figure 3-43: Water Available in the South Platte River near Kersey

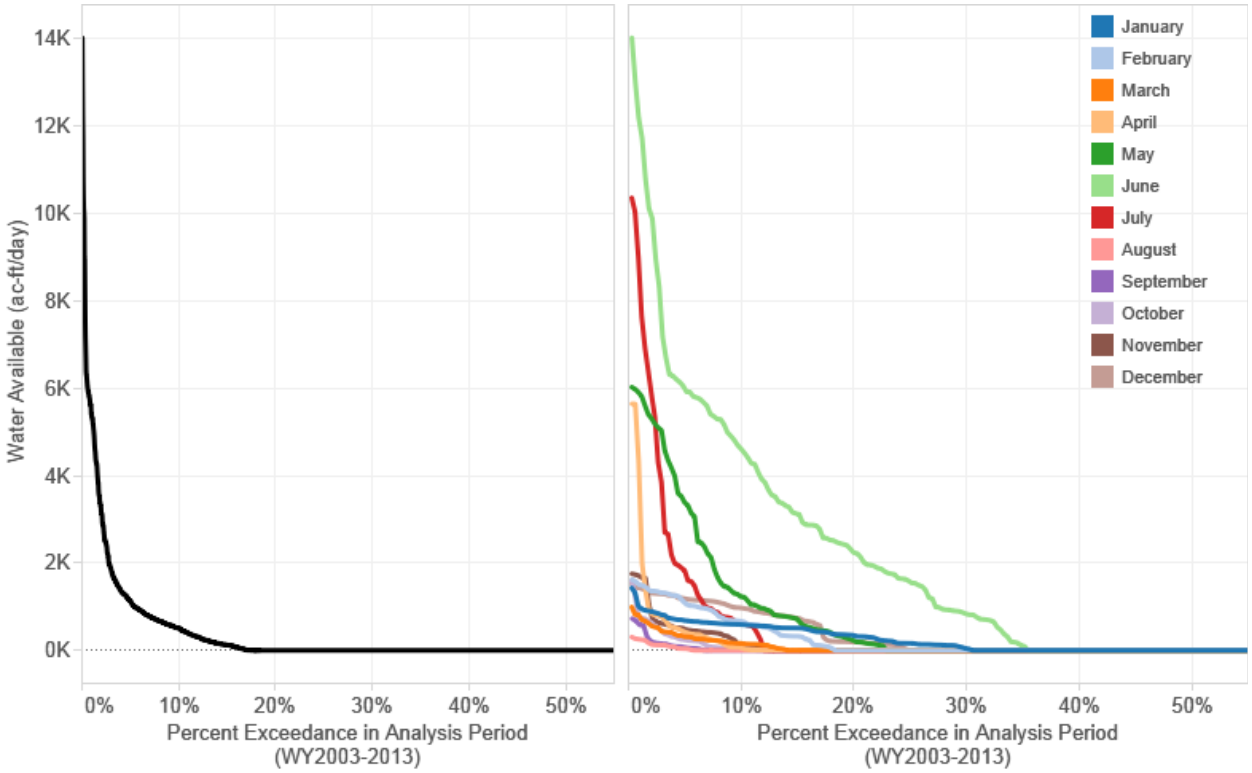
The sum of the annual water available in the South Platte River near Kersey for each water year (starting October 1st) is shown in Figure 3-44.



High variability in volumes of water available is observed in this analysis point, with seven years having volumes less than 6,000 ac-ft per year and periods of four consecutive years with available flows greater than 92,000 ac-ft per year.

Figure 3-44: Annual Water Available in the South Platte River near Kersey

Daily and monthly exceedance plots for the water available in the South Platte River near Kersey are shown below Figure 3-45. Table 3-27 shows selected values from the exceedance plots for relative comparison.



Water is available at this analysis point about 20 percent of the days, with flows greater than 2,000 ac-ft per day on only three percent of the days. June has the most volume of water available. It has 30 percent of the days with water available and the highest peak flows. January has the largest number of days with water available, with flows up to 2,000 ac-ft per day.

Figure 3-45: Percent Exceedance for the South Platte River near Kersey

Table 3-27: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	1,127	505	0
January	681	591	348
February	1,053	647	0
March	313	163	0
April	407	65	0
May	3,383	1,225	229
June	5,916	4,609	2,233
July	1,830	635	0
August	38	0	0
September	67	0	0
October	244	33	0
November	462	129	0
December	1,184	973	189

3.10 South Platte River at Weldona (06758500; PLAWELCO)

3.10.1 Analysis Point Description

The analysis point is located on the South Platte on the upstream, south side of the Colorado Highway 144, 3.1 miles southeast of Weldona. The gage has a drainage area of approximately 13,200 square miles. The South Platte River at Weldona analysis point is included in the Point Flow Model. Table 3-28 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-46.

Table 3-28: South Platte River at Weldona Preliminary Estimate Features

Analysis Point	District	First Downstream Diversion Structure
South Platte River at Weldona (06758500; PLAWELCO)	1	Weldon Valley Ditch

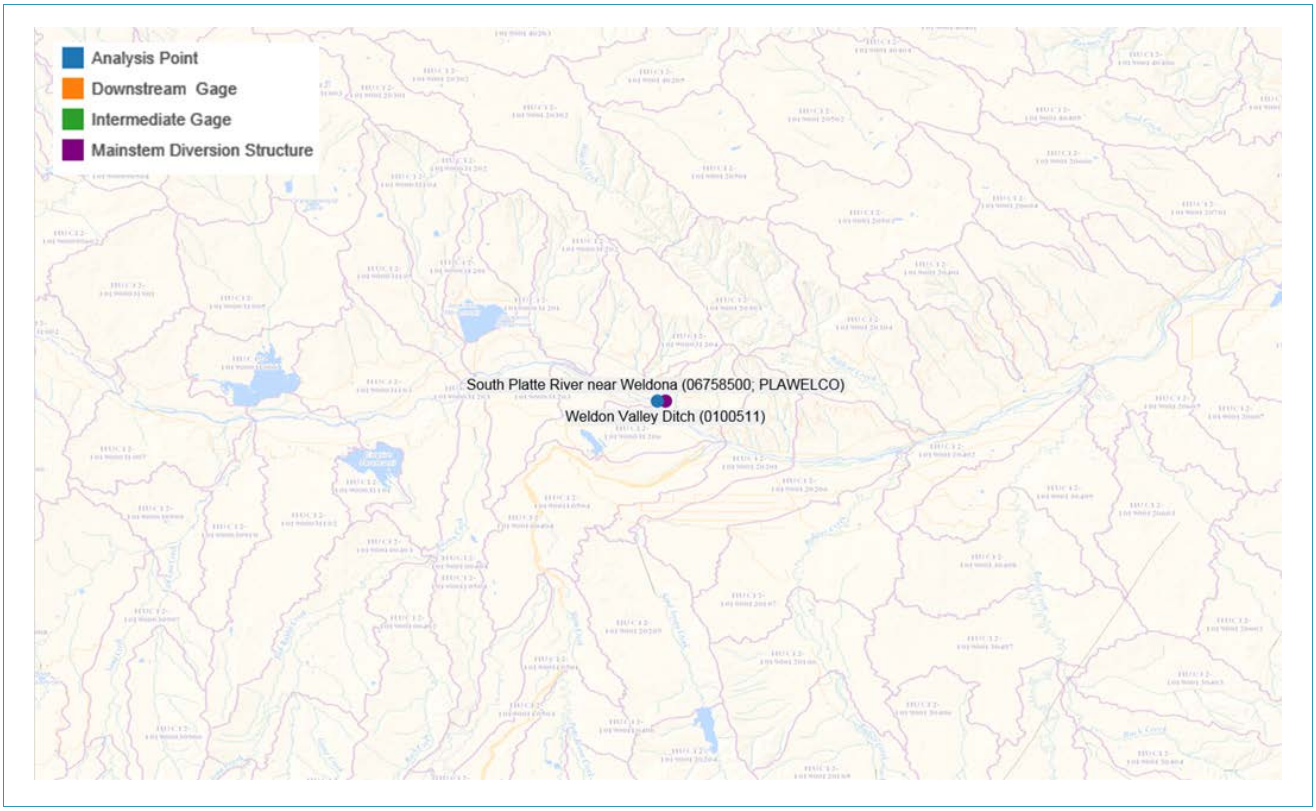


Figure 3-46: South Platte River at Weldona Analysis Point and the First Downstream Diversion Structure used in the Point Flow Model

3.10.2 Water Availability Refinement

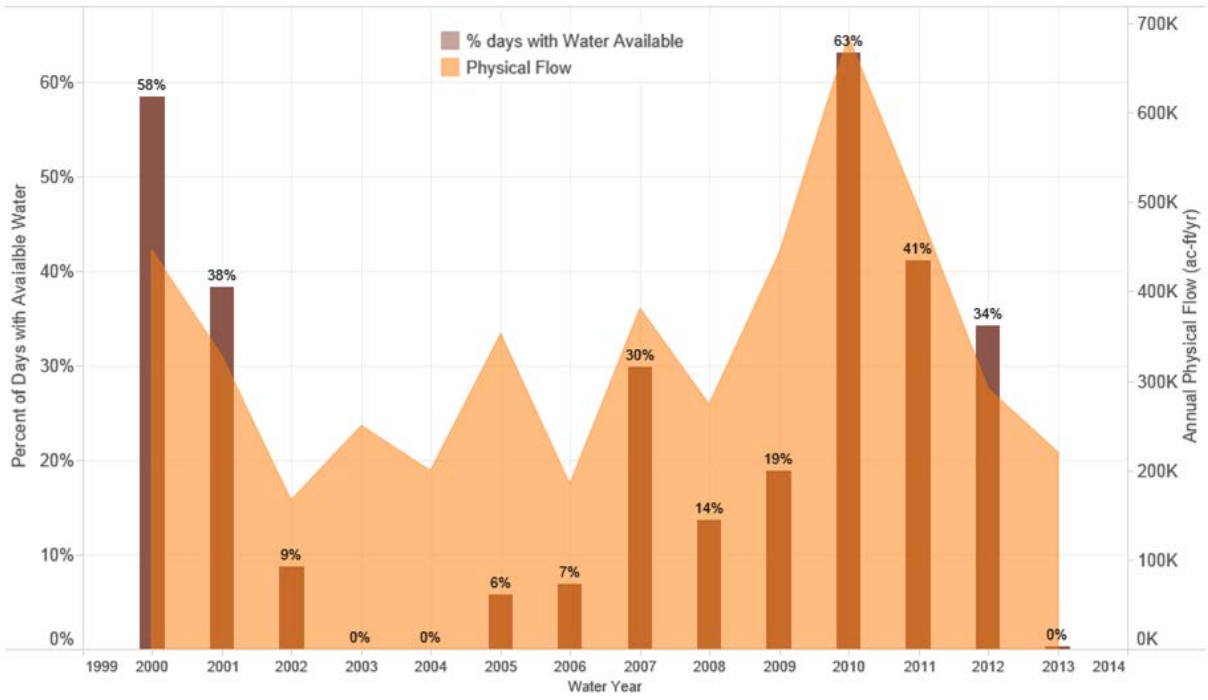
The preliminary water availability estimate in the South Platte River at Weldona is calculated based on the Point Flow Model results. Table 3-29 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis

Table 3-29: Refinement Layers for the South Platte River at Weldona Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Unused Reusable Return Flows	Aurora Water & Denver Water	See Table 3-23.	See Table 3-23.	✓ Yes
Conditional Rights (Augmentation)	Division 1	Conditional rights for augmentation in this reach of the South Platte River are going to be used in the future. These rights reduce the preliminary water availability estimate since that water will not be available for a new water right.		✗ No
C-BT Water (return flows)	Northern	Some C-BT releases could flow through this analysis point during free river conditions and if they are not diverted by water users downstream they would overestimate the water available preliminary estimate.	Not quantified	✗ No
Water Exchanges	Division 1	Historical water exchanges affecting the physical water at this point are captured in the Point Flow Model. Future exchanges from current filings will be senior to new water rights. These future exchanges would reduce the amount of water available at this point.	Historical diversion records used in the Point Flow Model include the operation of exchanges.	✓ Yes ✗ No
Cache Poudre River Water Availability		Water availability estimates at Kersey includes water from conditional and absolute water rights that were not fully utilized in the Poudre River in the period of study. Future water use in the Poudre river will reduce water available in the mainstem from Kersey downstream and need to be considered in future analysis.		✗ No

3.10.3 Water Availability Results

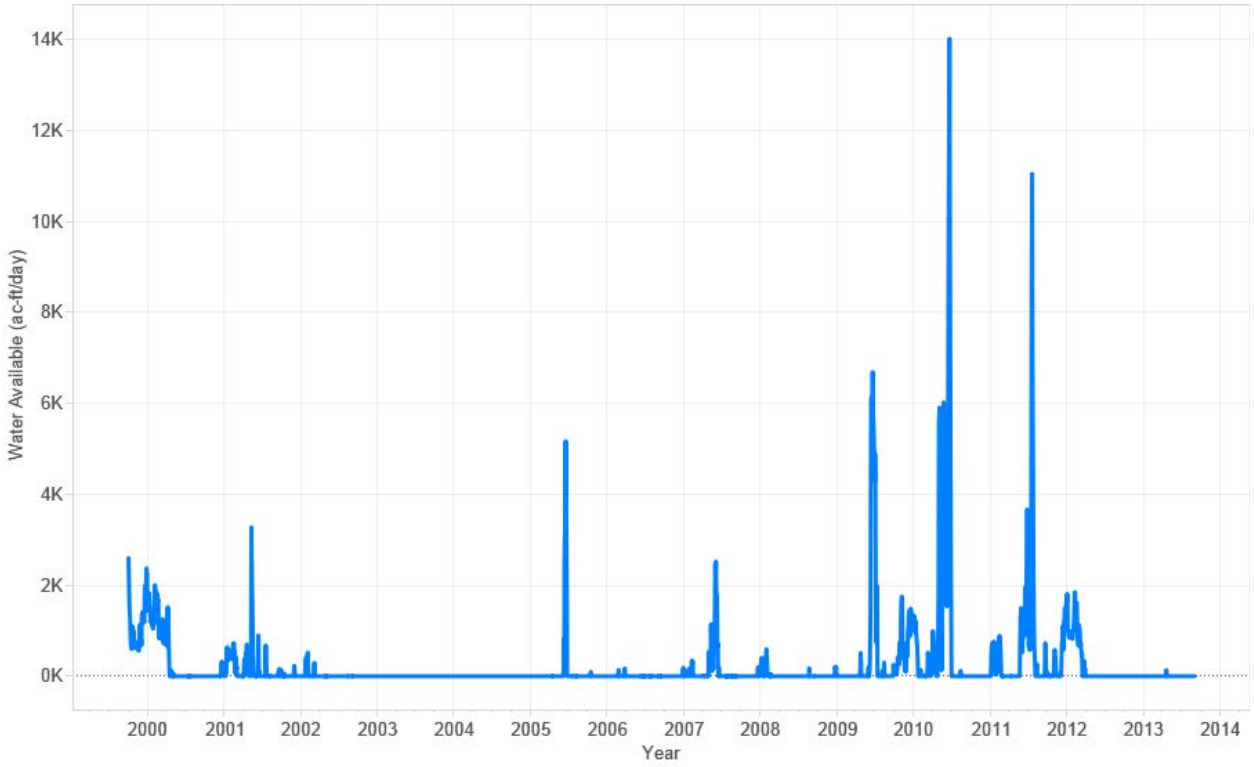
Water available at the South Platte River at Weldona analysis point is based on the Point Flow Model results and included refinements. The percent of days with water available from the Point Flow Model, including the additional refinements, and the annual physical water volume through the station are shown in Figure 3-47.



Eight of the 14 years in the analysis period have less than 30 percent of days with water available. Three of these years have no water available. There is a weak relationship between the annual flow and the percent of days with water available.

Figure 3-47: Percent of Days with Water Available and Physical Annual Volumes at South Platte at Weldona

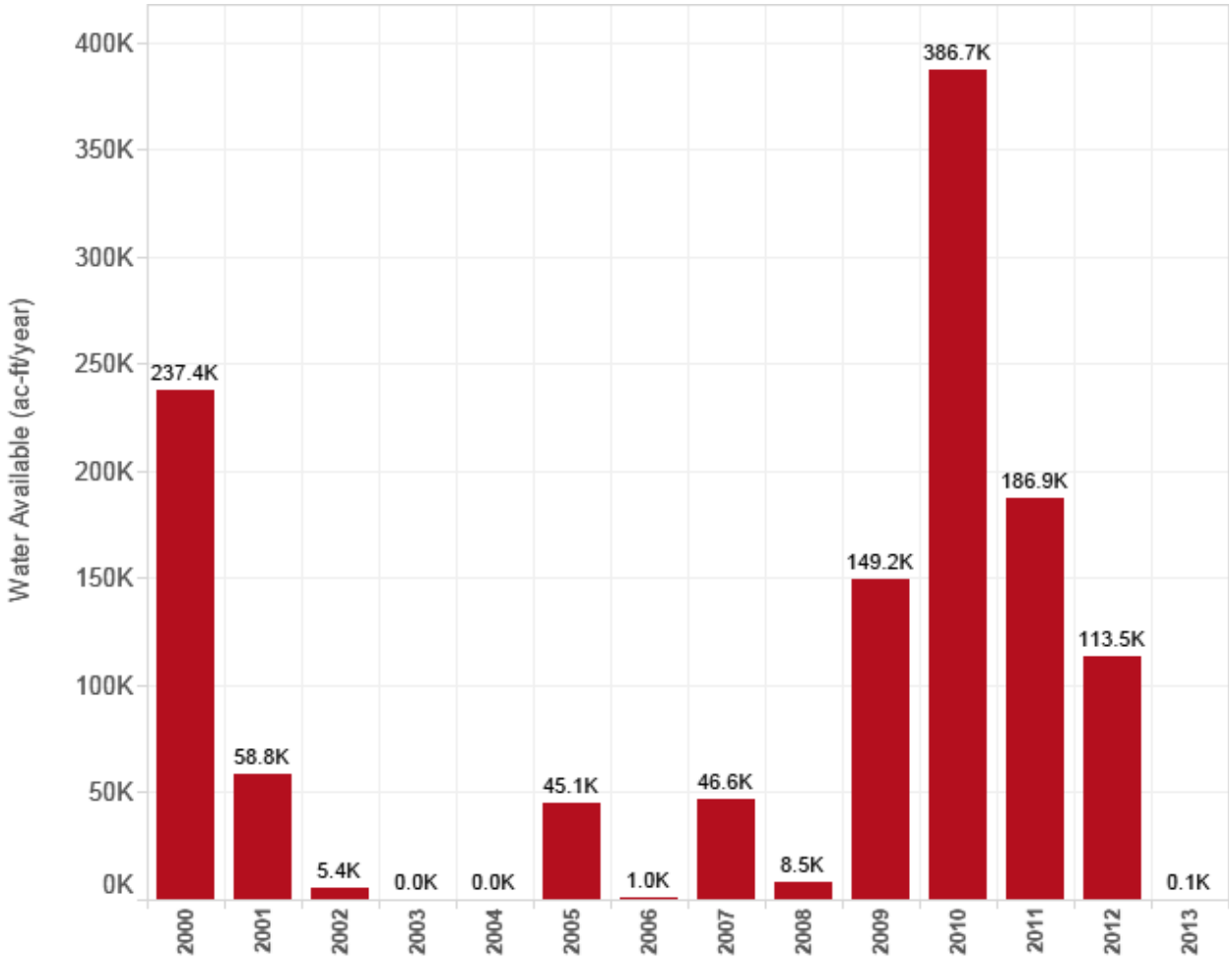
Figure 3-48 shows a hydrograph of the water available in the South Platte River at Weldona for the analysis period.



Available water at this analysis point is characterized by periods with peaks of available water above 5,000 ac-ft per day and more extended periods of water available with less than 2,500 ac-ft per day. Periods over two years with no water available are observed in the hydrograph.

Figure 3-48: Water Available in the South Platte River at Weldona

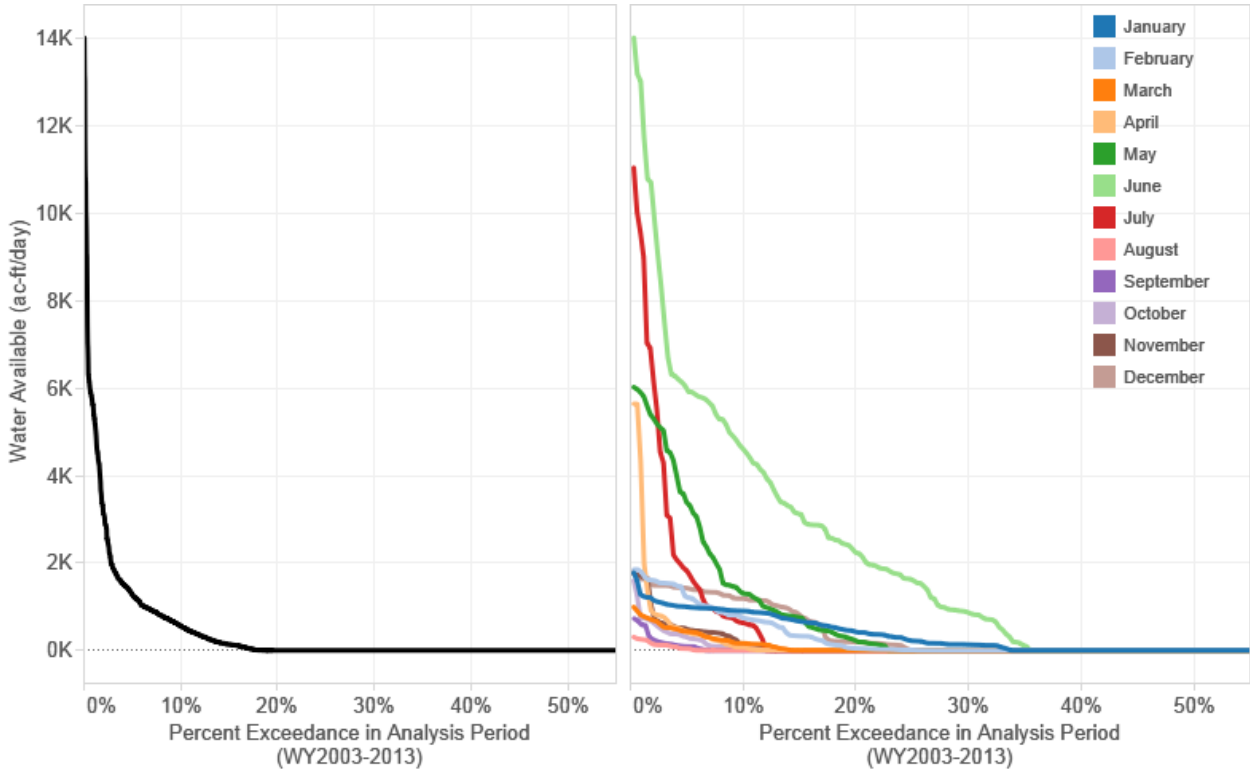
The sum of the annual water available in the South Platte River at Weldona for each water year (starting October 1st) is shown in Figure 3-49.



Nine of the 14 years in the analysis period show annual water available less than 60,000 ac-ft per year. Two of these years show no water available.

Figure 3-49: Annual Water Available in the South Platte River at Weldona

Daily and monthly exceedance plots for the water available in the South Platte River at Weldona are shown below in Figure 3-50. Table 3-30 shows selected values from the exceedance plots for relative comparison.



Water is available at this analysis point nearly 20 percent of the days, with flows greater than 2,000 ac-ft per day on only three percent of the days. June, followed by July, has the most volume of water available. June has 35 percent of the days with water available and the highest peak flows.

Figure 3-50: Percent Exceedance for the South Platte River at Weldona

Table 3-30: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	1,277	553	0
January	998	900	426
February	1,199	743	45
March	433	163	0
April	407	72	0
May	3,383	1,302	229
June	5,916	4,609	2,233
July	1,830	635	0
August	38	0	0
September	89	0	0
October	307	52	0
November	412	129	0
December	1,425	1,184	189

3.11 South Platte River at Cooper Bridge near Balzac (06759910; PLABALCO)

3.11.1 Analysis Point Description

The analysis point is located on the South Platte River, 0.7 miles downstream from the North Sterling Canal diversion structure and 4.1 miles from Snyder, CO. The gage has a drainage area of approximately 16,600 square miles. The South Platte River at Cooper Bridge near Balzac analysis point is included in the Point Flow Model. Table 3-31 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-51.

Table 3-31: South Platte River at Cooper Bridge near Balzac Preliminary Estimate Features

Analysis Point	District	First Downstream Diversion Structure
South Platte River at Cooper Bridge near Balzac (06759910; PLABALCO)	1	Prewitt Inlet Canal

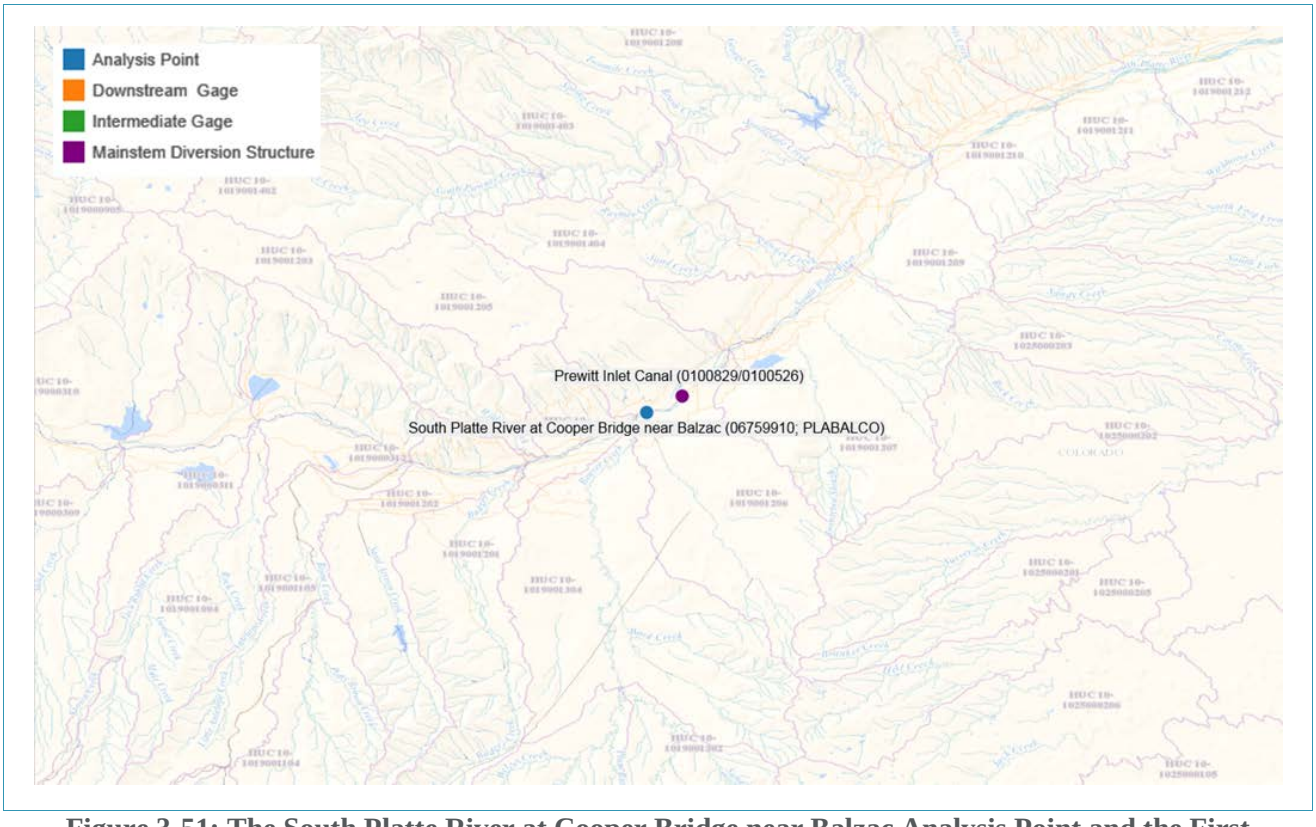


Figure 3-51: The South Platte River at Cooper Bridge near Balzac Analysis Point and the First Downstream Diversion Structure used in the Point Flow Model

3.11.2 Water Availability Refinement

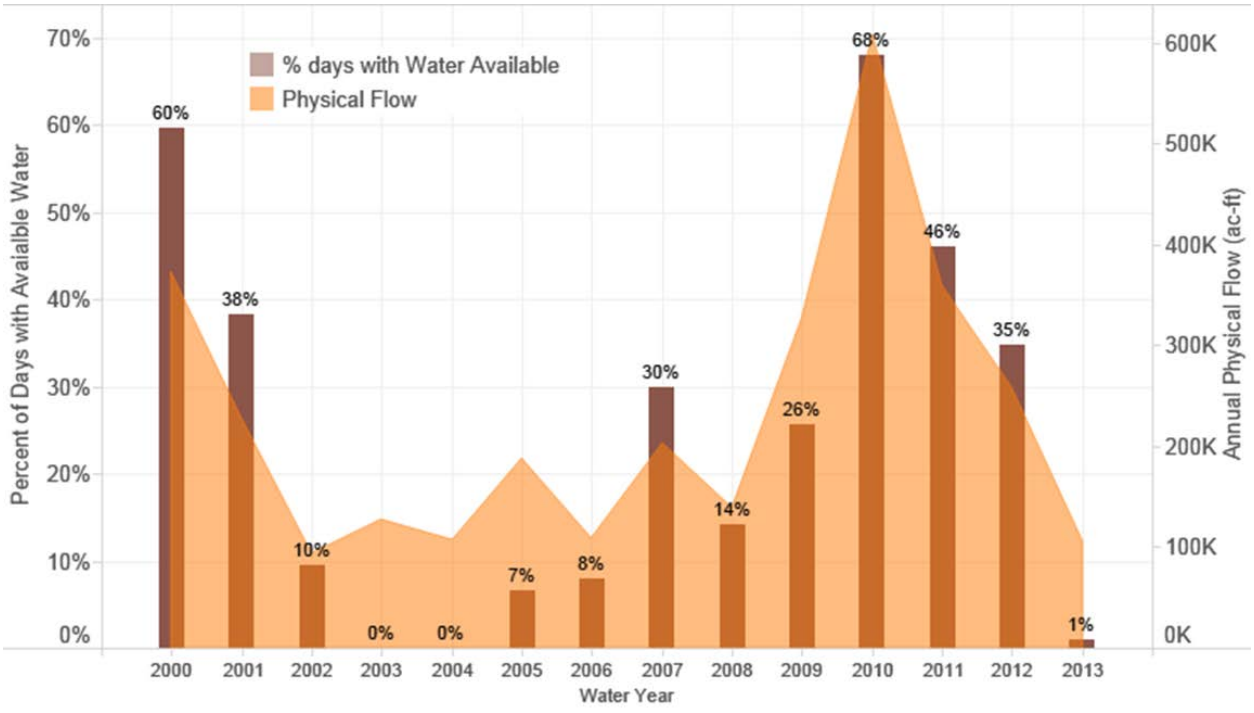
This section documents identified refinement layers affecting the preliminary water availability estimate in the South Platte River near Balzac. Table 3-32 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-32: Refinement Layers for the South Platte River at Cooper Bridge near Balzac Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
River Gains and Dry Up Points	Division 1	The river gains about 10 cfs per mile upstream of the analysis point. The river could have water at this point even having dry up point upstream.	The Point Flow Model simulates dry up points using the call chronology, as well as gains and losses to the system based on flows at control points, i.e., flow gauges.	✓ Yes
Unused Reusable Return Flows	Aurora Water & Denver Water	See Table 3-23.	See Table 3-23.	✓ Yes

3.11.3 Water Availability Results

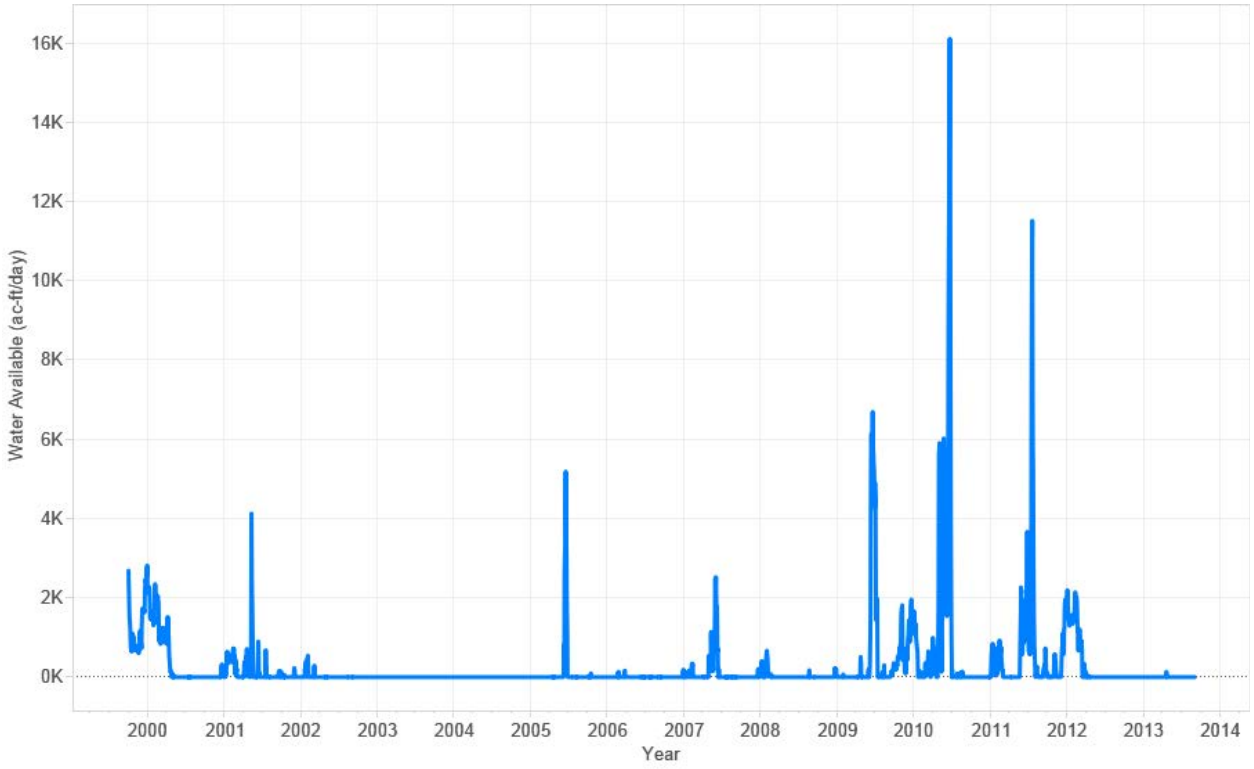
Water availability for the South Platte River at Cooper Bridge near Balzac analysis point is based on the Point Flow Model results and the additional refinements. The percent of days with available water based on the Point Flow Model and additional refinements is shown in Figure 3-52.



There are years with no water available at this location. About half of the years in the analysis period show less than 14 percent of days with water available. In general, there is a visible correspondence of high flow years and the percent of days with water available, with years with annual flows greater than 250,000 ac-ft a year having more than 30 percent of days with water available.

Figure 3-52: Percent of Days with Water Available and Annual Flows for the South Platte River near Balzac

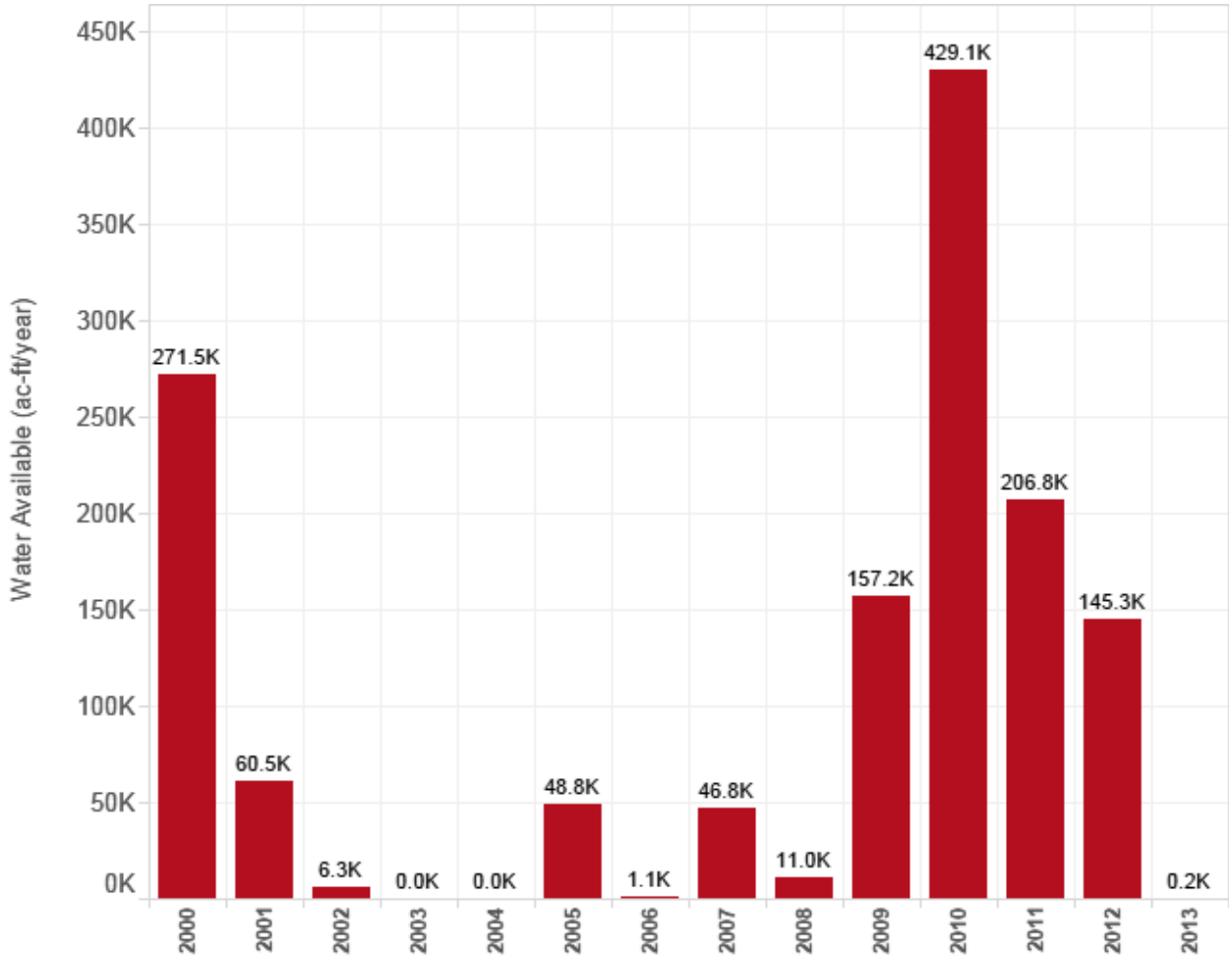
Figure 3-53 shows a hydrograph of the water available in the South Platte River at Cooper Bridge near Balzac for the analysis period.



Available water at this point shows short periods with peaks of available water above 5,000 ac-ft per day and more extended periods of water available with less than 3,000 ac-ft per day. Extended periods of over two years with no water available are observed in the hydrograph.

Figure 3-53: Water Available in the South Platte River at Cooper Bridge near Balzac

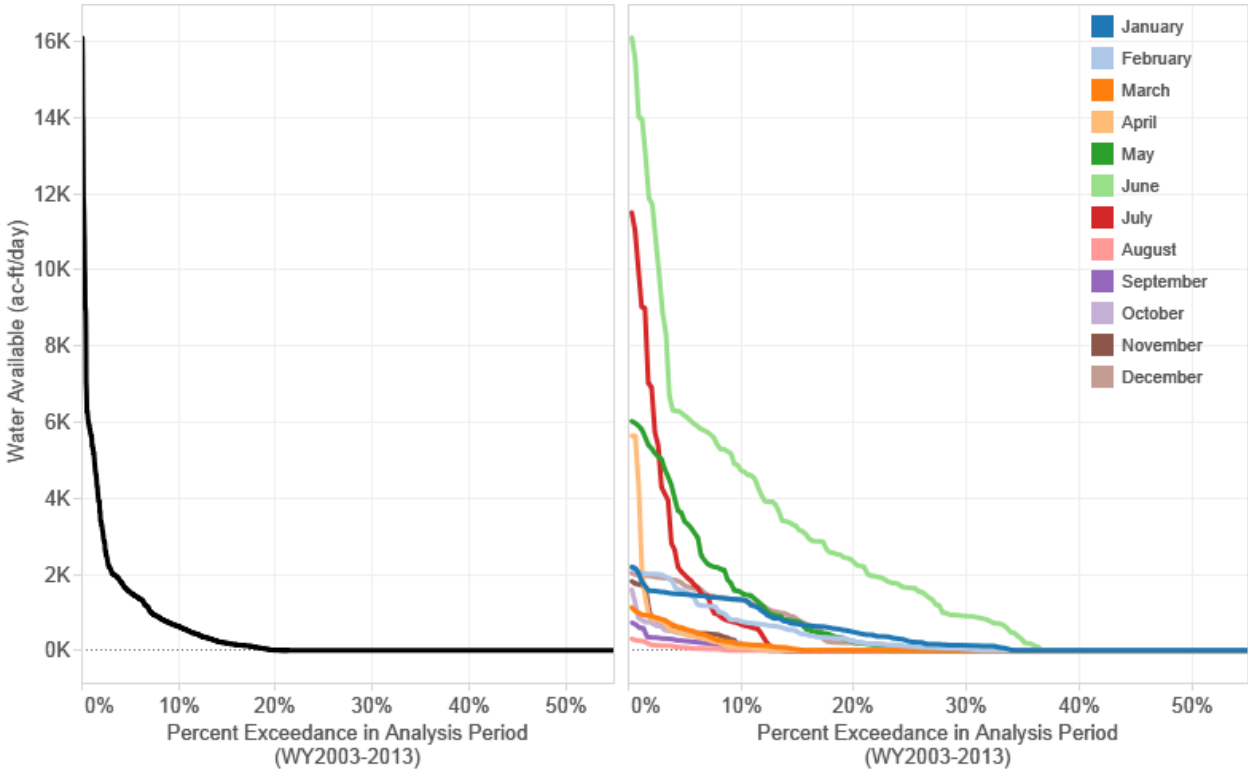
The sum of the annual water available in the South Platte River at Cooper Bridge near Balzac for each water year (starting October 1st) is shown in Figure 3-54.



High variability in volumes of water available is observed in this analysis point, with a span of seven years that has five years with volumes less than 12,000 ac-ft per year and periods of four consecutive years with available flows greater than 145,000 ac-ft per year.

Figure 3-54: Annual Water Available in the South Platte River at Cooper Bridge near Balzac

Daily and monthly exceedance plots for the water available in the South Platte River at Cooper Bridge near Balzac are shown below in Figure 3-55. Table 3-33 shows a comparison of the values from the exceedance plots for selected percent exceedance values.



Results show water availability for the South Platte at the Cooper Bridge near Balzac for about 20 percent of the days in the analysis period. Flows greater than 2,000 ac-ft per day are available only 2 percent of the days. June is the month with the largest percent of days with water available. April through July are the only months with daily flows available greater than 3,000 ac-ft/day.

Figure 3-55: Percent Exceedance for South Platte at Cooper Bridge near Balzac

Table 3-33 : Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	1,532	629	6
January	1,472	1,338	484
February	1,535	761	255
March	570	163	0
April	407	73	0
May	3,383	1,534	241
June	6,140	4,723	2,321
July	1,987	676	0
August	73	0	0
September	297	115	0
October	449	197	0
November	51	136	0
December	1,702	1,321	194

3.12 South Platte River at Julesburg (PLAJUCCO)

3.12.1 Analysis Point Description

The analysis point is located in the South Platte River at Julesburg. This location has multiple flow gages operated by DWR due to the braided condition of the channel. The combined flow was used to represent the physical flow at this point. The point is located near the bridge of Highway 385 crossing the South Platte River south of Julesburg CO in Sedgwick County, 0.9 miles southeast of the Town of Julesburg, 3.0 miles upstream from Colorado-Nebraska State line, and 7 miles downstream from Lodgepole Creek. The drainage area to the analysis point is about 23,820 square miles. The South Platte River at Julesburg analysis point is included in the Point Flow Model. Table 3-34 shows the summary of the features used for the preliminary water availability estimate for this analysis point. The locations of the gages used for the preliminary water availability estimate are shown in Figure 3-56.

Table 3-34: South Platte River at Julesburg Preliminary Estimate Features

Analysis Point	District	First Downstream Diversion Structure
South Platte River at Julesburg (06764000; PLAJUCCO)	64	Liddle Ditch

Figure 3-56: The South Platte River at Julesburg Analysis Point and the First Downstream Diversion Structure used in the Point Flow Model

3.12.2 Water Availability Refinement

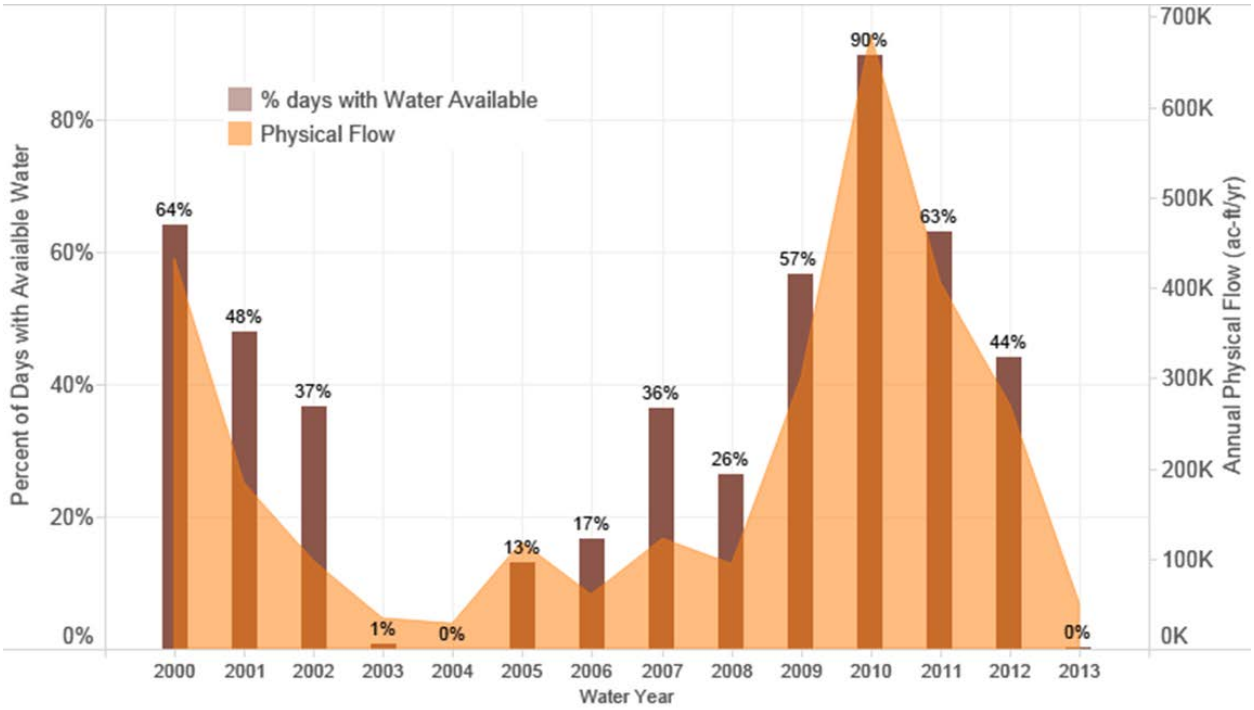
This section summarizes identified refinement layers affecting the preliminary water availability estimate in the South Platte River at Julesburg. Table 3-35 provides the summary of the identified layers including the source, the description and potential effect and if it is included in the current analysis.

Table 3-35: Refinement Layers for the South Platte River at Julesburg Analysis Point

Feature	Source	Description	Approach/Assumptions	Included in Estimate
Interstate Compact Requirements	Division 1	The requirements of the South Platte Compact of 1928 require flow at the state line to be 120 cubic feet per second (cfs) or greater between April 1 and October 15. Diversions in district 64 and exchanges junior to June 14, 1897 are curtailed in an effort to meet this requirement. Bypass call in district 64 can affect water availability in the district upstream.	When there is a compact call, it is assumed that there is no new water available within the Basin. When there is not a call, the water available in the mainstem is assumed to be equal to the minimum exchangeable flow at the diversion structure and all of the diversion structures downstream to the state line on the mainstem up to the point when a compact call would be triggered, i.e., the required flow at the state line is approximated by the exchangeable flow at the Liddle Ditch minus 120 cfs between April 1 and October 15.	✓ Yes
Unused Reusable Return Flows	Aurora Water & Denver Water	See Table 3-23.	See Table 3-23.	✓ Yes
Platte River Recovery Implementation Program (PRRIP)	Division 1	Flow requirements for the recovery program will reduce the water available for new water rights. Additionally, the Tamarack recharge credits may artificially increase the apparent water availability at the Julesburg gage, whereas, these flows associated with these credits would not be available for diversion by a new water right.	Constraints associated with associated with PRRIP and Tamarack recharge credits were not addressed explicitly in the water availability calculations. These constraints will result in a reduction in water availability at this location, and should be considered as part of future refinements.	✗ No

3.12.3 Water Availability Results

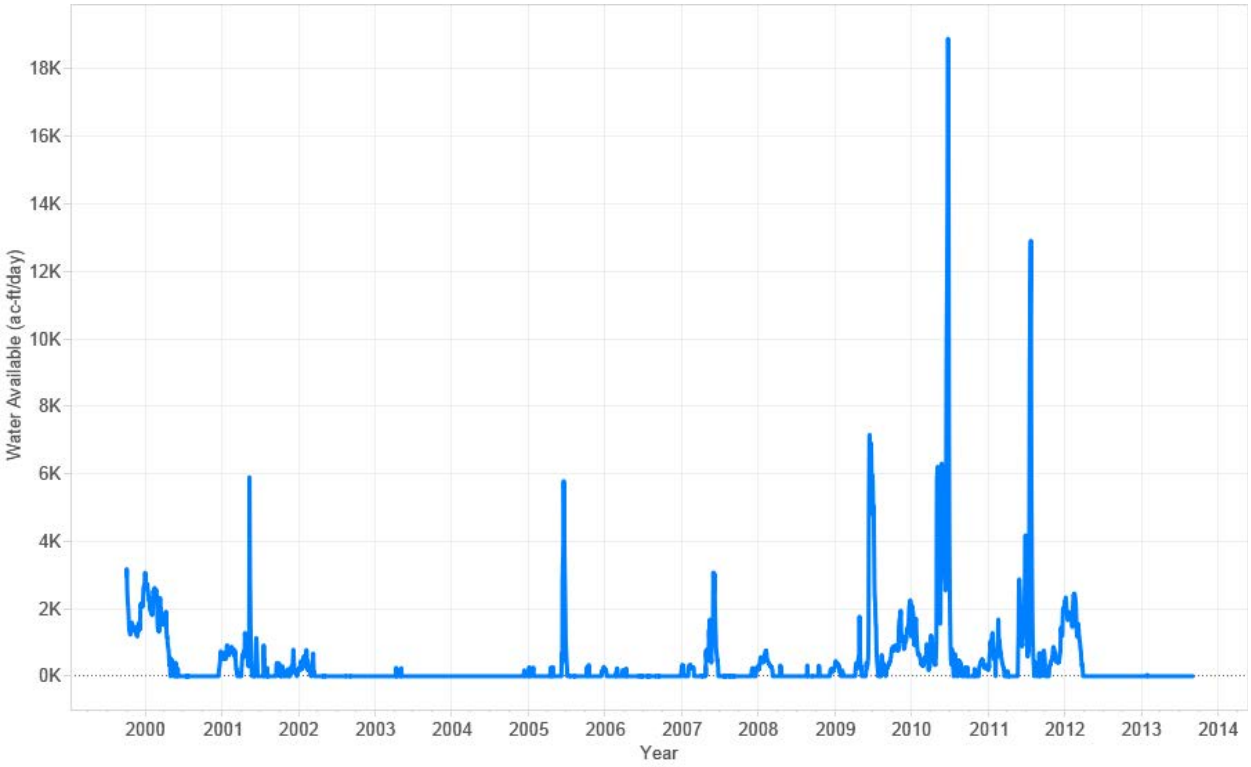
This section summarizes the results of the water availability for the South Platte River at Julesburg analysis point. Water availability is derived from the Point Flow Model results and the additional refinements. The percent of days with water available and the physical flow at the analysis point is shown in Figure 3-57.



A positive relationship between the annual physical flow and the percent of days with water available is observed at this analysis point. About half of the years have water available in more than 40 percent of the days. There are two consecutive years with practically no water available in the analysis period.

Figure 3-57: Percent of Days with Water Available and Physical Flow at the South Platte at Julesburg

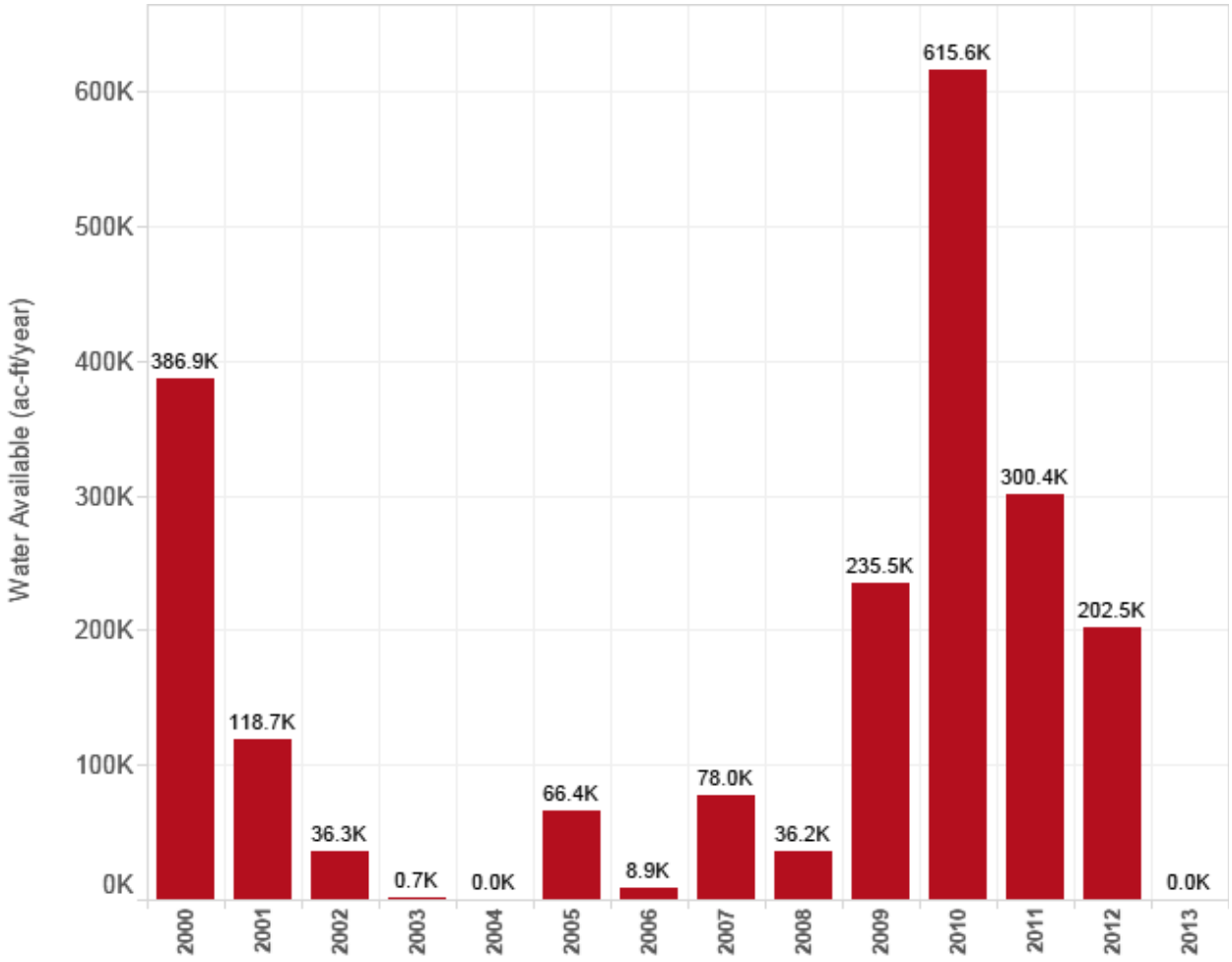
Figure 3-58 shows a hydrograph of the water available in the South Platte River at Julesburg for the analysis period.



The longer periods of water available are shown at this analysis point compared to other points that were analyzed. There are extended periods of water avaialbility with flows less than 2,000 ac-ft per day and shorter periods with sustained flows above 5,000 ac-ft per day.

Figure 3-58: Water Available in the South Platte River at Julesburg

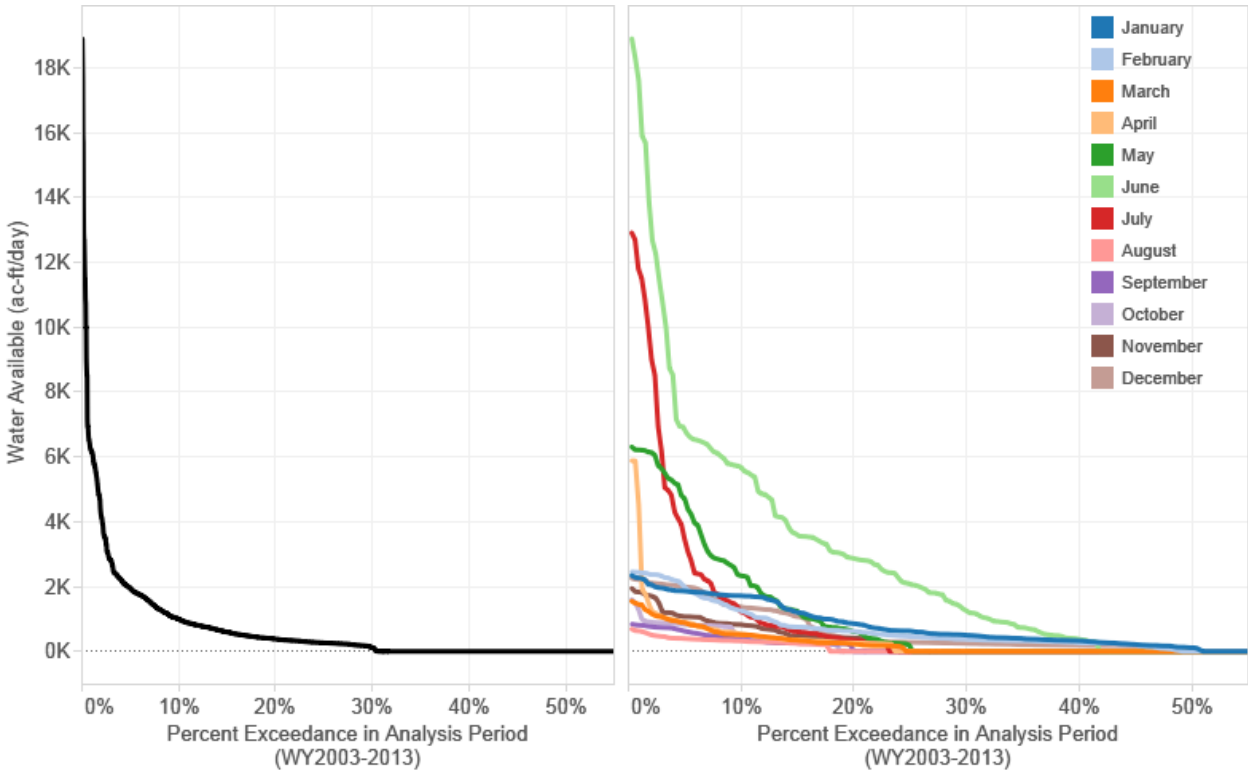
The sum of the annual water available in the South Platte River at Julesburg for each water year (starting October 1st) is shown in Figure 3-59.



Years with percent of days with available water greater than 50 percent show annual volumes of available water greater than 235,000 ac-ft per year. Years with total annual flows around 50,000 ac-ft per year show practically no water available for new water rights.

Figure 3-59: Annual Water Available in the South Platte River at Julesburg

Daily and monthly exceedance plots for the water available in the South Platte River at Julesburg are shown below in Figure 3-60. Table 3-36 shows selected values from the exceedance plots for relative comparison.



Water is available about 35 percent of the days in the analysis period for this analysis point. January, February and December have available water more than 50 percent of the days. Except April, May, June and July, the exceedance curve slopes are flat with water available less than 2,000 ac-ft per day. June shows water available 36 percent of the days and the highest peak of available water.

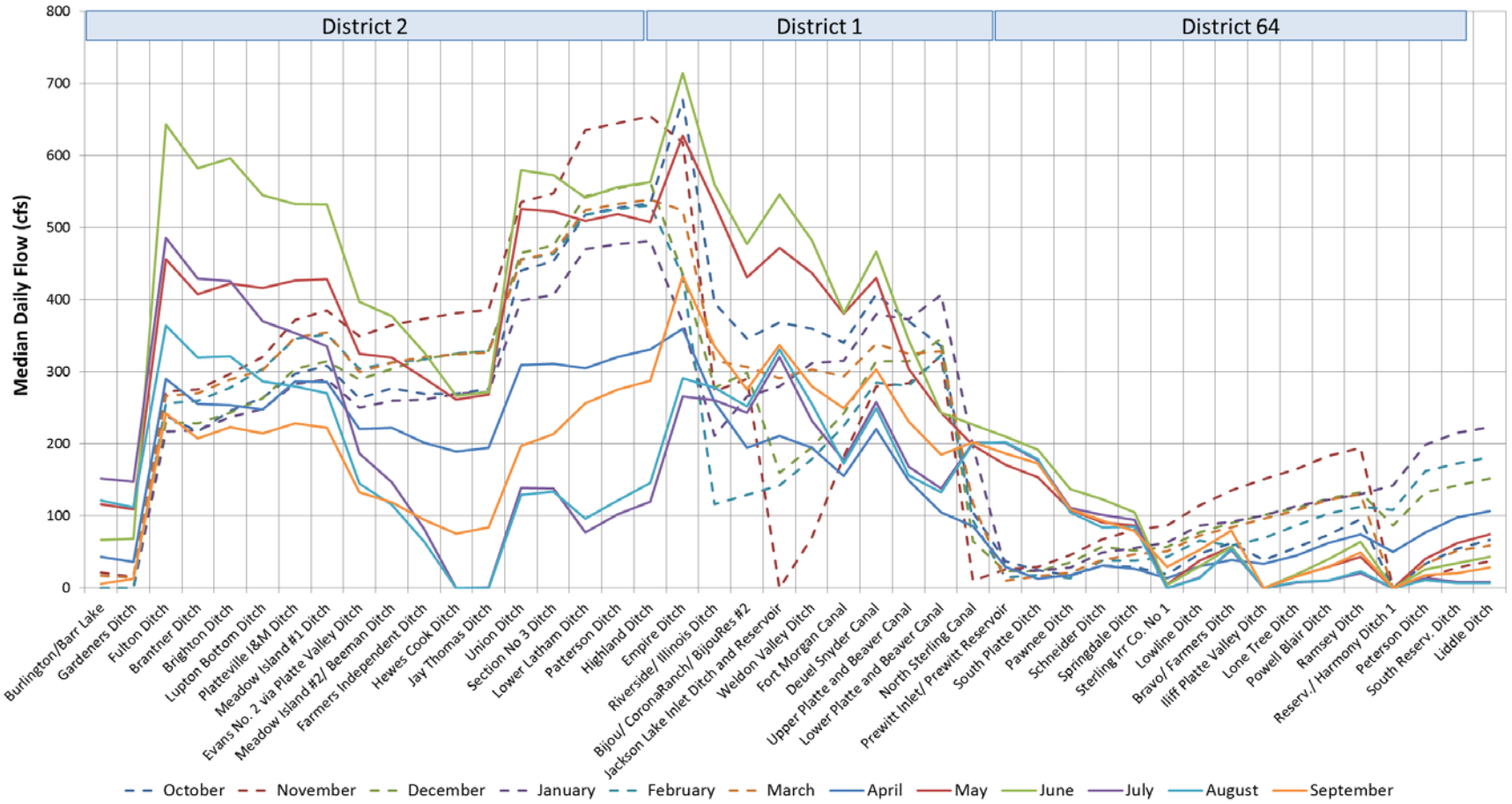
Figure 3-60: Percent Exceedance for the South Platte River at Julesburg

Table 3-36: Water Availability for Selected Percent Exceedance Values

	5% Exceedance (ac-ft/day)	10% Exceedance (ac-ft/day)	20% Exceedance (ac-ft/day)
Analysis Period (WY2003-2013)	1,913	995	380
January	1,1857	1,717	857
February	1,931	1,254	622
March	886	511	229
April	879	546	236
May	4,716	2,332	608
June	6,729	5,679	2,868
July	3,457	1,218	395
August	392	321	0
September	619	352	0
October	829	503	0
November	1,070	827	412
December	1,988	1,375	384

4 South Platte Mainstem Exchange Capacity

Exchangeable flows were calculated by the Point Flow Model for the diversion structures in the mainstem. These are used to analyze the general exchange conditions in the South Platte River and identify points that would potentially limit or control future exchanges. The median of the values is assumed to be representative of the typical exchange capacity for each point. Figure 4-1 shows the median monthly exchangeable flows from 2000 to 2013 at each of the diversion structures. The goal of this plot is to provide a visual representation of the exchange capacity from upstream to downstream and to show timing and location of potential exchanges, as well as points that are more likely to constrain future exchanges. The exchange potential from a downstream point to an upstream point can be approximated by the minimum exchangeable flows between the two points in Figure 4-1.



The October thru March months, plotted with dashed lines, and April to September months, plotted with solid lines, each show similar behaviors within their groupings since October thru March is storage dominated season and the remaining months are irrigation dominated. Exchange through the Prewitt inlet diversion is very limited between October and April yet shows moderate exchangeable flow during the summer months. That pattern is reversed downstream toward the Powell Blair Ditch. Exchanges through the Hewes Cook Ditch structure seem extremely reduced for July and August, and it is likely to act as a limiting point for other months represented by solid lines. Exchanges upstream of Fulton Ditch are likely to be controlled by low flows at Burlington and Gardeners Ditches. June is the month with higher exchange capacity, while July is among the months with the lowest capacity.

Figure 4-1: Median Exchangeable Flow for the South Platte Diversion Structures (2000-2013)

5 Water Quality Considerations

Water quality data were compiled and summarized for several locations within the study area to provide a better understanding of the water quality trends and potential drinking water treatment considerations relevant to the potentially available water. Two parameters were selected as general indicators of water quality: total dissolved solids (TDS) and nitrate. TDS was selected because it is an aggregate indicator of the presence of a broad array of contaminants associated with municipal discharges and agricultural return flows. Nitrate was selected due to the potential for violation of a primary drinking water standard, and the challenges associated with its treatment.

TDS and nitrate concentrations were compiled where data were available and average concentrations over the period of record were used to provide a general understanding of water quality constituent levels at each location. In locations were TDS data were not available, specific conductance was used to approximate TDS concentrations. A commonly used conversion factor of 0.67 (Stevens 2014) was applied to convert specific conductance (μS/cm) to TDS (mg/L).

5.1 Water Quality Trends

In general, water quality in the South Platte Basin tends to degrade in the downstream direction; especially between the Denver Metro Area and the Colorado/Nebraska state line. This degradation is illustrated by the increasing concentrations of TDS and nitrate. Average TDS concentrations on the tributaries range between approximately 150 mg/L and 450 mg/L. On the mainstem of the South Platte, TDS concentrations increase steadily from an average of approximately 220 mg/L just below Chatfield Reservoir to an average of approximately 1250 mg/L at Sterling. The spatial variation of average TDS concentration is illustrated on Figure 5-1.

Similarly, nitrate concentrations generally increase between the Denver Metro Area and the Colorado/Nebraska state line. Average nitrate concentrations on the tributaries upstream of the Metro Area are less than 1 mg/L. On the mainstem of the South Platte, nitrate concentrations increase from an average of approximately 0.2 mg/L just below Chatfield Reservoir to an average of approximately 6.2 mg/L at Kersey, then, decrease to an average of approximately 2.7 mg/L at Sterling. The spatial variation of average nitrate concentration is illustrated on Figure 5-2.

While sufficient data is not available to characterize the seasonal variations in water quality, it is expected that TDS and nitrate concentrations would vary seasonally with changes in flow. TDS levels are likely to decrease during periods of high runoff, when unappropriated waters may be available.

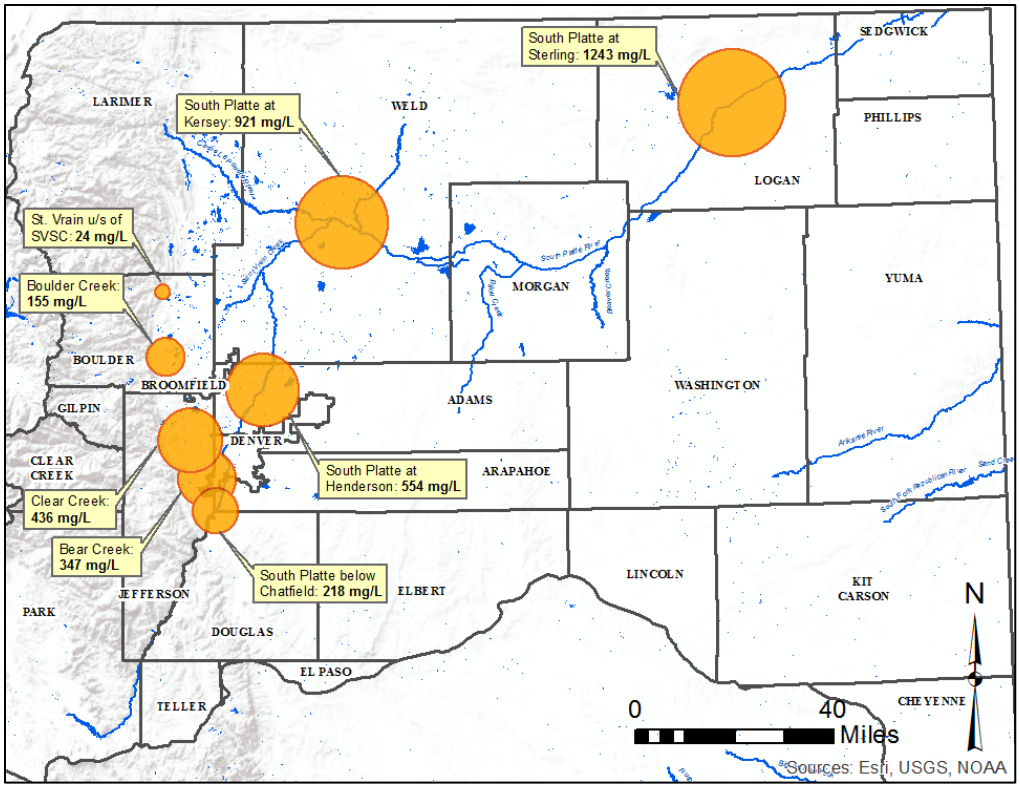


Figure 5-1: Average TDS Concentrations at Selected Locations in South Platte Basin

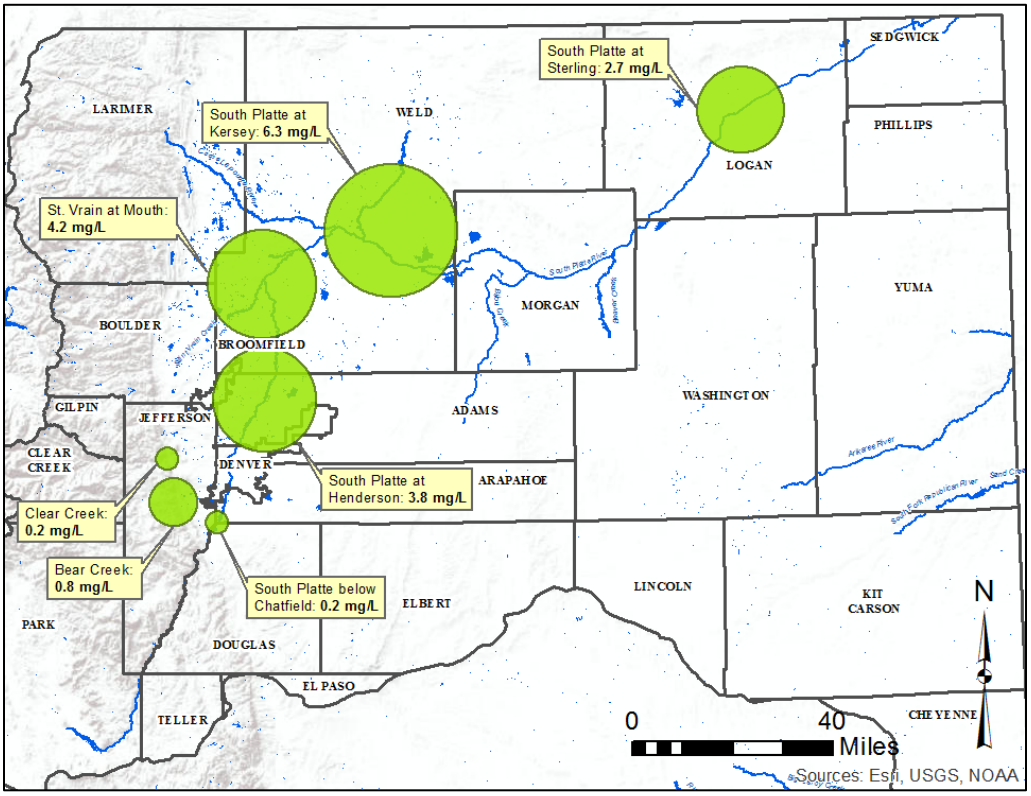


Figure 5-2: Average Nitrate Concentrations at Selected Locations in South Platte Basin

5.2 Treatment Considerations

Tributary water and water near Chatfield is of good quality, and can be treated with conventional treatment for municipal use. Water quality degrades as water flows downstream toward the state line. At Henderson, average TDS levels are approximately 500 mg/L and at Sterling, TDS levels are around 1200 mg/L. The elevated levels of TDS at these locations become a challenging treatment issue. TDS is a secondary drinking water regulation, meaning that it is a non-mandatory water quality standard, but a guideline to improving the aesthetic condition of the drinking water. The secondary maximum contaminant level (SMCL) for TDS is 500 mg/L, and water exceeding this amount will typically taste salty. To make water palatable, TDS must be treated or diluted.

Raw waters with TDS values greater than the SMCL of 500 mg/L may require additional treatment or blending. Assuming that conventional treatment is in place, reverse osmosis (RO) membrane filtration would have to be added to obtain desired TDS removal. Water treatment with RO generates a concentrate stream or brine that requires disposal by deep well injection or zero liquids discharge technologies. This option may be constrained by the loss of water and the lack of feasible brine disposal options. During brine disposal, a percentage of supply is lost when brine is disposed of during deep well injection. RO plants disposing of brine without a brine recovery system loose approximately 20-30% of water by volume to brine streams. Plants equipped with brine recovery systems can increase recovery and produce much less brine. For example, the brine recovery system at ECCV decreases the water lost to brine disposal to 8% of water by volume. However, this requires more equipment and greater costs. Ongoing research is continuing to improve the amount of water lost to brine disposal. The relationship of the improvement in recovery to the reduction of water lost is illustrated in Figure 5-3.

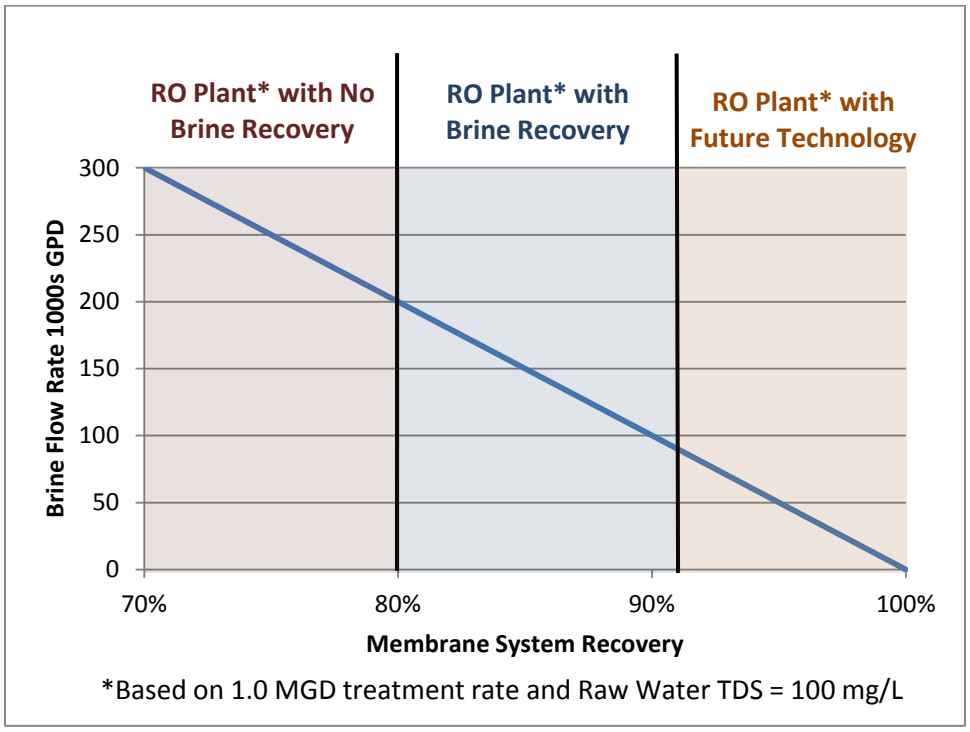


Figure 5-3: Relationship between Recovery and Water lost to Brine Disposal

Dilution requires a large volume of water low in TDS, or "blend water", but avoids the use of RO and the consequent issues with brine disposal. However, the quantities of water required to accomplish blending are frequently not available. The large amount of water necessary for blending is illustrated in Figure 5-4 using a TDS level of 1200 mg/L (similar to TDS levels at Sterling) and lowering it to an accepted TDS level of 500 mg/L as an example. As the graph shows, for a project using 30,000 AF of low quality South Platte water, 70,000 AF-210,000 AF of blend water would be necessary to lower the TDS to desired levels. The lack of high quality blend water can limit the use of low quality supplies.

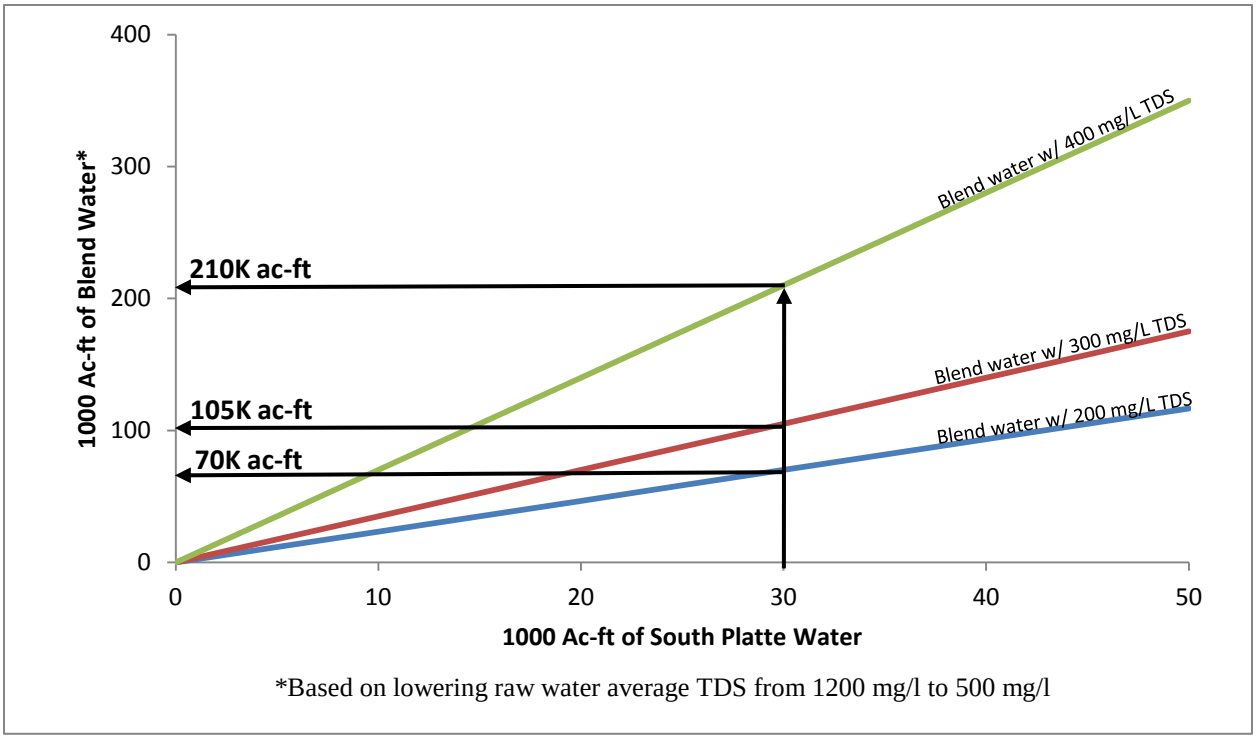


Figure 5-4: Amount of Blend Water Necessary to utilize water with an Average TDS level of 1200 mg/L

Nitrate is regulated under the Safe Drinking Water Act (SDWA) with a primary MCL of 10 mg/L as nitrogen. Nitrate is an acute contaminant, and a single confirmed detection above the MCL is classified as a violation. Nitrate concentrations exceeding the MCL were not observed from the available water quality data, but nitrate concentrations approaching regulatory levels were measured in some mainstem locations. The U.S. Environmental Protection Agency (EPA) considers ion exchange, reverse osmosis, and electrodialysis reversal (EDR) acceptable potable water treatment methods for nitrate removal (EPA 2010). These technologies produce high-strength brine residuals, with limited disposal options. Because of the lack of cost-effective residual disposal options for nitrate treatment residuals, water sources with high levels of nitrate contamination may prove to be prohibitively costly to develop. A detailed analysis would need to be done to identify the need for nitrate treatment.

6 Conclusions

This preliminary assessment of water availability at 12 locations in the South Platte River Basin provides general information on the magnitude, timing, and frequency of unappropriated flows. The technical approach for this analysis was selected with input from many representatives of the South Platte Basin and Metro Roundtables and their water resource consultants. The approach updates an existing point-flow model and complements it with a daily call chronology analysis. This analysis was authorized by the Roundtables to gain a better general understanding of the water availability, specifically the frequency and magnitude on a finer scale that than average annual values presented in SWSI 2010, and the potential challenges in making greater use of potentially unappropriated water supply in the South Platte Basin solely to inform the BIP development and to help a broad range of water interests understand the highly variable nature of South Platte basin flows. Although a more detailed analysis should be performed prior to any future project development, this analysis clearly highlights the frequency of water availability and can assist with determining the types of projects that can be feasibly considered.

Water availability estimates in this analysis include a number of refinement elements based on historical records and operations; however, there are elements not included in this analysis, for example, conditional water rights, future exchanges and impacts of IPP's, that would result in future water available being smaller when those elements are included. The estimates represent availability at the individual analysis points and are non-additive. Analysis points are located in the same basin, so some of them are hydrologically connected. Therefore, water that is available upstream, if not diverted, will be part of the water available at the downstream analysis points. The results presented herein should be viewed individually for each analysis point and careful consideration of dependencies should be exercised when attempting to infer combined basin-wide availability.

Boulder Creek and Big Thompson River have the most sporadic and least volume of remaining water availability of the 12 tributaries analyzed. Clear Creek and St. Vrain Creek have the largest annual potential water availability, although, water is only available 6 out of 11 years (2003 to 2013). The annual percent of days with a call in the tributary districts shows a distinct change in pattern around 2003. This change is primarily associated with changes in basin water administration rather than changes in hydrologic conditions.

Potential water availability at the flow gages titled "South Platte River at South Platte" (located below confluence of North Fork South Platte and South Platte River) and "South Platte River below Chatfield Reservoir" show the most sporadic water availability of the mainstem analysis points on an annual basis with multiple consecutive years without any water available. Water availability increases in the downstream direction along the South Platte mainstem, with an increased number of days with water potentially available and greater flows potentially available. Downstream of Henderson, there is an increase in the magnitude and frequency of water availability compared to the upper basin (upstream of Chatfield Reservoir) analysis points. However, water is only available 7 out of 11 years (2003 to 2013) and annual volumes greater and 80K ac-ft per year is only available 3 out of 11 years during this period.

In years of drought and subsequent drought recovery, it is expected that little to no water would be available to new water rights anywhere in the South Platte Basin, especially when the analysis presented herein is considered in relation to the implementation of currently Identified Projects and Processes (IPPs) and conditional water rights not included in the current analysis. Years with potential water availability

show large peaks in flow that present significant challenges to either immediately using the water or being able to store it for future use. The practicality of capturing these peaks should be carefully considered when evaluating the water available to meet future demands. Multi-year cycles between dry and wet periods were observed in the analysis period. Evaluation of longer time periods (as can be done when with the SPDSS when it's available) will likely show even greater challenges in developing projects that could reliably develop such intermittent flows with such dramatic, but infrequent, peak flows. Based on the intermittent nature of water availability for new water rights in the South Platte Basin, very large storage-to-yield ratios for new reservoirs, especially new "off-stream" reservoirs, could be required to capture and use the available water. These ratios are an effective measure of the hydrologic and economic feasibility of new projects to make use of potentially available, but infrequent, water supplies.

This preliminary analysis of water availability does not include assessment of the effects of future water diversions, conditional water rights, or return flows, associated with IPPs. Analysis of remaining water availability, after the implementation of IPPs, was explored with Roundtable representatives. These analyses would require significant assumptions and approximations in the context of the schedule and budget for the SPBIP and would involve a high degree of uncertainty. Considering the limitations of the currently available methods to simulate very dynamic current and potential future hydrologic conditions, assessment of the effects of IPPs is deferred to when a more robust tool, such as the SPDSS, becomes available.

7 Recommendations

Increased future use of water by conditional water rights and IPPs, and other basin-wide complexities, should be considered as part of future work. A model that allows considering simultaneous use of water, including legal administration, planned facilities capacities and ability to operate storage and water supply would be necessary for this analysis. A comprehensive Decision Support System is currently being developed for the South Platte River Basin (SPDSS) by the Colorado Water Conservation Board (CWCB). This integrated system of hydrologic data, water allocation and crop consumptive use modeling and other related tools can be used to develop much more detailed and reliable estimates of water availability under a wider range of potential future hydrologic conditions and a much broader range of current and future water management procedures and scenarios. The CWCB estimates that the SPDSS (excluding the Cache la Poudre River Basin) might be available for initial use in early 2016. Once this system is available, it is recommended that the water availability analysis presented herein be updated and further refined.

8 References

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