Evaluation of Historic Platte River Streamflow in Excess of State Protected Flows and Target Flows

Supplement to December 2010 Report

Nebraska Department of Natural Resources

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Evaluation of Historic Platte River Streamflow in Excess of State Protected Flows and Target Flows

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COPY: File

FROM: HDR-TFG Project Team

DATE: March 12, 2013

This Technical Memorandum (TM) discusses and summarizes the additional analyses conducted to supplement the original study effort and associated report, "Evaluation of Historic Platte River Streamflow in Excess of State Protected Flows and Target Flows" (HDR, 2010).

1.0 Background and Project Purpose

In December 2010, HDR Engineering and The Flatwater Group (HDR) concluded a study/report entitled "Evaluation of Historic Platte River Streamflow in Excess of State Protected Flows and Target Flows" (HDR, 2010). The purpose of the study was to:

- Evaluate the historic quantity of excess water in the Platte River;
- Develop a planning tool to estimate the rate of flow and the duration and frequency of water in excess of state protected flows[1] by reach; and
- Determine the quantity of water in excess of target flows based on wet, dry, and normal hydrologic classification.

The study included the area from the North Platte River just below Lake McConaughy and the South Platte River at Julesburg, Colorado, to the Platte River near Louisville, Nebraska. The study compared the amount of natural flow available in various specified reaches and then compared those flows to the computed demands for natural flow in the same specified reach.

Building upon this effort, the Nebraska Department of Natural Resources (DNR) and Platte River stakeholders requested additional analyses to investigate in greater

[1] Described by the Nebraska New Depletion Plan (Platte River Recovery Implementation Program Water Plan, Attachment 5, October 2006) as of October 2010 and established by water appropriations issued by the state. See original report (HDR, 2010) for further description.

detail the available natural flow, its characteristics, and means to present and utilize the results. The analyses included in this effort utilize terminology, approach, and methodology consistent with the original study. The reader is referred to the original study report (HDR, 2010) for further background information.

The sections of this technical memorandum are organized consistent with the analyses and consist of:

- Updating calculated natural flows to account for storage water transfers from Glendo Reservoir to Lake McConaughy;
- Extending the limits of the previous study to include the North Platte River above (upstream of) Lake McConaughy;
- Incorporating operational constraints to estimate the quantity of excess flow that could be utilized by a project;
- Developing graphics to present and illustrate study results;
- Developing a simplified analysis tool that can be used to estimate potential project impacts on excess flows upstream and downstream of a potential project;
- Evaluating historic precipitation, historic flows, and calculated natural flows to determine if a rainfall/excess flow correlation exists; and
- Developing criteria and evaluation/scoring matrix for evaluating conjunctive management projects.

2.0 Update to Calculated Natural Flows

A key simplifying assumption of the original study was that all historic flows recorded at the Lewellen, Nebraska, gage were natural flows. In reality, storage water from Glendo Reservoir has been moved to Lake McConaughy at the end of the irrigation season since 1992. Historic release data from the Bureau of Reclamation (BOR) for the Glendo storage water was provided by DNR. Table 1 summarizes the Glendo storage releases in acre-feet (AF) at the end of the irrigation season for the 1992-2011 period.

Table 1 – Glendo Storage Water Releases

Year	Date	Total Storage Release (AF)
2011	16-Sep	3,440
2010	9-Sep	2,449
2009	19-20-Sep	2,784
2008	12-14-Sep	4,388
2007	8-10-Sep	5,103
2006	6-Sep	516
2005	9-10-Sep	2,138
2004	19-20-Aug	1,730
2003	22-26-Sep	7,687
2002	26-30-Sep	10,437
2001	19-22-Sep	5,983
2000	26-29-Sep	5,741
1999	21-25-Sep	5,842
1998	24-30-Sep	4,662
1997	23-28-Sep	4,767
1996	25-30-Sep	4,818
1995	27-30-Sep	3,179
1994	29-Sep	6,051
1993	20-30-Sep	8,000
1992	22-25-Sep	2,423

The storage release data in table 1 was then used to adjust the historic Lewellen gage flows to calculate the natural flow hydrograph at Lewellen. This adjustment included:

1. The volume and duration of the annual release was used to estimate the daily release volume, assuming a constant release rate;
2. A 20% conveyance loss[2] was applied to the storage releases;
3. A 5-day lag was applied[3] to storage releases to account for travel time to the Lewellen gage;
4. The daily volumes resulting from the adjustments referenced above were subtracted from the historic Lewellen gage flows to calculate natural flow at Lewellen.

[2] Conveyance loss estimate based on discussions with DNR Bridgeport Field Office staff.

[3] Travel time estimate for storage releases based on 5 to 6 day travel time from Guernsey Reservoir to Lewellen based on discussions with DNR Bridgeport Field Office staff.

From a natural flow perspective, for the 1992-2008 period analyzed in the 2010 study, the average total September flow volume at Lewellen was 34,190 AF. The average annual Glendo storage releases for this same period was 1,980 AF. Based on these average values, application of the adjustment for Glendo storage releases results in a 5% reduction in calculated September natural flow volumes at Lewellen.

At Analysis Point #1 (North Platte River at Keystone Diversion), results from the 2010 analysis indicate calculated excess flows were available only two days total during September for the 1992-2008 period (one day each in two separate years).

Based on the limited impacts to both calculated natural flows and excess flows, the impact of the Glendo storage release adjustments to the results documented in the 2010 analyses are minimal. However, as part of this supplemental effort, the Glendo storage release adjustment was incorporated to generate a new natural flow hydrograph at Lewellen and then propagated downstream using the same methodology used in the original study to determine the natural flow hydrographs at each analysis point. See Attachment 1 for locations and descriptions of the analysis points (AP) used in the evaluation.

In addition to revising the natural flow hydrographs at each analysis point, two other modifications were made to the original analysis. The first modification extended the period of analysis from 1954-2008 in the original study to 1947-2010. The second modification involved use of the U.S. Fish and Wildlife Service (FWS) hydrologic classification for wet/dry/normal years for determining appropriate target flow demands. In the original study, each set of target flow demands based on hydrologic classification were applied (in addition to state protected flows) over the entire period of record. In this analysis, the historic designation of wet, dry, or normal[4] for each year was used to apply the appropriate corresponding target flow demand (in addition to the state protected flows).

3.0 Extension of Analysis Upstream to Lewellen

The Keystone Diversion served as the upstream analysis point on the North Platte River in the original study effort. As part of this supplement, the analysis of excess flow was extended upstream of Lake McConaughy to Lewellen (AP0).

3.1. Potential Demands at the Lewellen Analysis Point (AP0)

As described in the original report, the methodology for determining excess flows involves working upstream from the Louisville analysis point (AP13). Demands

[4] Annual designations for 1947-2005 determined by USFWS; 2006-2010 determined by PRRIP Executive Director's Office using USFWS methodology. See PRRIP- ED Office Draft "Hydrologic Condition Annual and Periodic Designations," dated 11/01/2011 for additional information on annual designation methodology.

(state protected flows and target flows) are placed on the computed natural flow hydrograph at each analysis point. This approach is the same as the original study (see page 10 of the 2010 HDR report for a description of how the demands were determined and applied). When natural flows exceed the applied demands, excess flows are available at the current analysis point. When natural flows do not meet the applied demands at an analysis point, then excess flows are not available at the current analysis point and excess flows at upstream gages, accounting for travel time lag, are also set to zero. Using this approach to link the results from downstream analysis points to the upstream basin, the demands from Louisville to Keystone are already reflected at the Lewellen analysis point; therefore the only additional demand to be represented at Lewellen is that of Lake McConaughy. Lake McConaughy demands include the storage demand of Lake McConaughy and the Kingsley Dam hydropower demand.

A. Lake McConaughy Storage Demand

Two Lake McConaughy storage demands were considered. The first scenario applied zero storage demands at Lewellen. The second storage demand considered the available storage in Lake McConaughy on October 1 of each year and applied this demand at Lewellen until the reservoir was either full (according to Federal Energy Regulatory Commission maximum elevation targets), or until the effective end of the storage season. For this analysis, July 1 was assumed to be the effective end of the storage season corresponding to when full irrigation deliveries typically begin drawing down the reservoir. The annual computed excess flow volumes and number of days of excess flow availability for each of these two storage demand scenarios are illustrated in figures 1 and 2.

In comparing figures 1 and 2 and tables 2 and 3, a minimal difference is observed. Specifically, the inclusion of the Lake McConaughy storage demand results in a reduction in the annual total volume of available excess flow of 10,660 AF and 6 fewer days of available excess flow in Water Year 1986. In tables 2 and 3, the difference can be seen in the average natural flow values and event counts in the month of October. These results indicate that excess flows are typically available only when Lake McConaughy is at full storage levels. Based on these results under maximum storage demand conditions, scenarios involving intermediate storage demands or storage demands in conjunction with hydropower demands were not further evaluated.

Figure 1 – Lewellen Analysis Point (AP0) with no storage demand

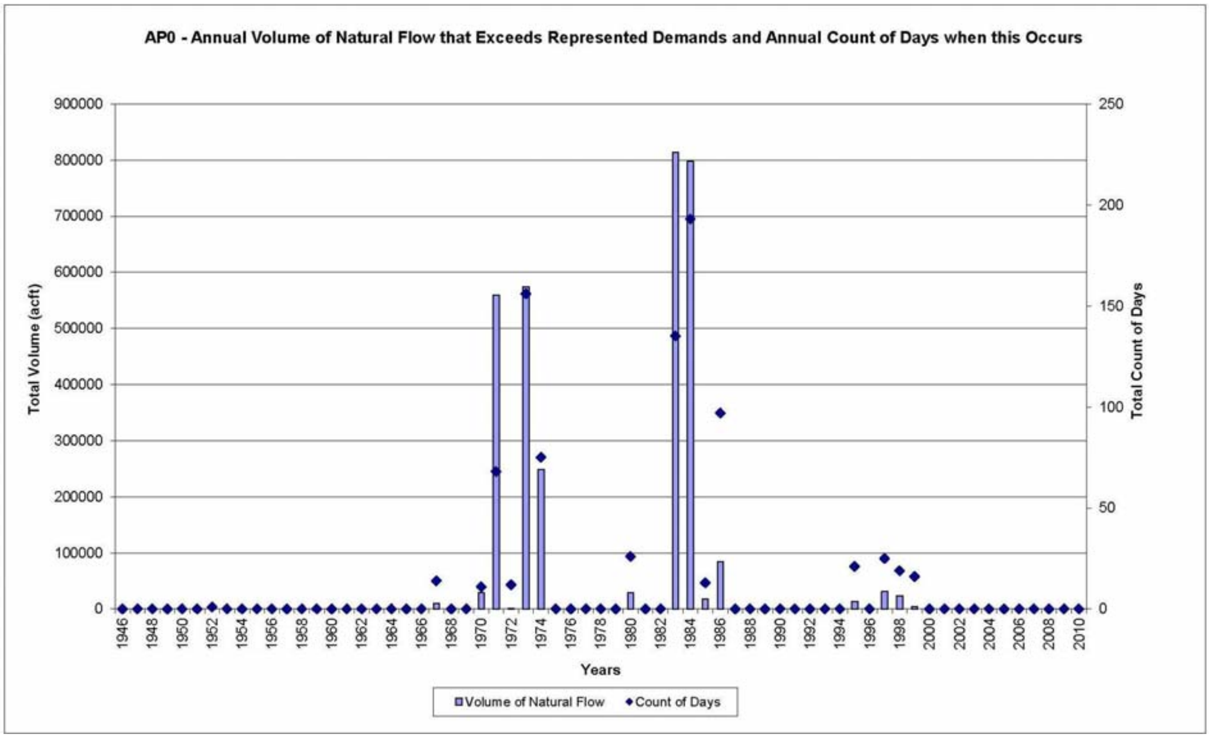


Figure 2 – Lewellen Analysis Point (AP0) with Lake McConaughy storage demand

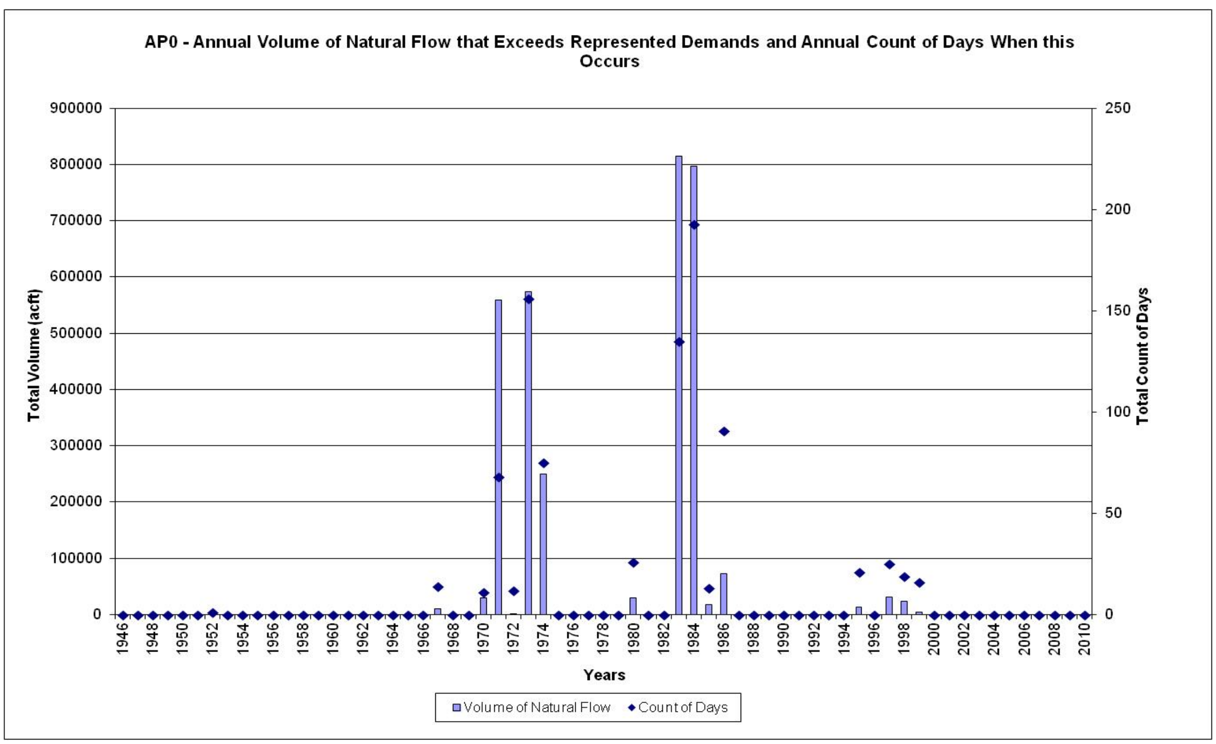


Table 2 – Summary of Lewellen Analysis Point (AP0) with no storage demand

Summary for WY 1947-2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Natural Flow Vol (AF)	5,673	27,813	149,667	192,949	259,527	305,774	213,337	132,428	132,607	57,402	21,386	5,371
Minimum Natural Flow Vol (AF)	0	0	0	0	0	0	0	0	0	0	0	0
Average Natural Flow Vol (AF)	112	435	5,022	5,021	10,861	17,127	3,711	2,223	3,464	1,360	374	117
# Years with Excess Natural												
>5,000 AF	1	1	4	5	5	8	4	2	4	2	1	1
>10,000 AF	0	1	4	3	5	7	1	1	3	2	1	0
>20,000 AF	0	1	2	2	4	7	1	1	2	2	1	0
>30,000 AF	0	0	2	2	3	4	1	1	2	2	0	0
Average # of Days With Excess Natural Flow	0	1	1	1	2	3	1	1	1	1	1	0
Number of Years with Zero (0) Excess Natural Flow	63	63	60	59	60	55	58	62	61	63	63	63

Table 3 – Summary of Lewellen Analysis Point (AP0) with Lake McConaughy storage demand

Summary for WY 1947-2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Natural Flow Vol (AF)	5,673	27,813	149,667	192,949	259,527	305,774	213,337	132,428	132,607	57,402	21,386	5,371
Minimum Natural Flow Vol (AF)	0	0	0	0	0	0	0	0	0	0	0	0
Average Natural Flow Vol (AF)	112	435	5,022	5,021	10,861	17,127	3,711	2,223	3,464	1,196	374	117
# Years with Excess Natural												
>5,000 AF	1	1	4	5	5	8	4	2	4	2	1	1
>10,000 AF	0	1	4	3	5	7	1	1	3	2	1	0
>20,000 AF	0	1	2	2	4	7	1	1	2	1	1	0
>30,000 AF	0	0	2	2	3	4	1	1	2	1	0	0
Average # of Days With Excess Natural Flow	0	1	1	1	2	3	1	1	1	1	1	0
Number of Years with Zero (0) Excess Natural Flow	63	63	60	59	60	55	58	62	61	63	63	63

B. Kingsley Hydropower Demand

The Kingsley Dam hydropower appropriation is 5,720 cubic feet per second (cfs) throughout the year. The hydropower demand is a non-consumptive use of water; therefore, this water may be used by downstream diverters. For this reason, the hydropower demand is adjusted to reflect this multi-use water. During the non-irrigation season, this demand is adjusted to account for the Keystone Diversion demand of 1,750 cfs that has already been considered in the excess flow computations and could be served by the Kingsley Dam hydropower releases. During the irrigation season, the Kingsley hydropower demand is adjusted to account for the Keystone Diversion demand of 1,750 cfs and the North Platte canals' demand of 522 cfs that could be served by the Kingsley Dam hydropower release.

3.2 Applied Demands at the Lewellen Analysis Point (AP0)

Based on the storage and hydropower demands discussed in sections A and B above, three demand scenarios were applied at the Lewellen Analysis Point:

1. No demands of Lake McConaughy are placed at Lewellen. Under this scenario, only demands applied at downstream analysis points are reflected in calculated excess flow at the Lewellen Analysis Point.
2. The full hydropower demand of Kingsley Dam is applied to the Lewellen Analysis Point. As discussed, these demands are adjusted as follows:
   a. Non- Irrigation Season
      (5,720 cfs) - (1,750 cfs) = **3,970 cfs**
   b. Irrigation Season
      (5,720 cfs) – (1,750 cfs) – (522 cfs) = **3,448 cfs**
3. The hydropower demand is limited to the physical capacity of the North Platte River channel at North Platte (approximately **1,600 cfs**).
   a. Non- Irrigation Season = **1,600 cfs**
   b. Irrigation Season
      (1,600 cfs) – (522 cfs) = **1,078 cfs**

4.0 Operational Constraints

Project operational constraints likely prevent full capture and usage of computed excess flows. To account for this, two primary operational constraints were considered in this evaluation.

4.1. Timing

The first operational constraint considers a project's inability to operate in real time. Delays in operational response, notice of excess flow availability, etc. require several consecutive days of excess flow availability for the excess flows to be utilized. Through discussions with stakeholders, three-day and seven-day continuous durations of excess flow availability were determined to be suitable to represent two operational response time scenarios for this evaluation.

To reflect the timing constraints, the computed daily excess flow volumes were screened for three-day and seven-day continuous excess flow availability. Excess flow events with continuous durations less than the scenario criteria (three or seven day) are not included in the total excess flow volume available at the analysis point.

4.2. Diversion Capacity

The second operational constraint considers the physical limitations to the capacity (either in diversion or conveyance) available at the point of diversion. Diversion capacity scenarios of 25 cfs, 50 cfs, 75 cfs, 100 cfs, and the limiting capacity of the existing diversion infrastructure were evaluated.

4.3. Analysis Points for Operational Constraints

The evaluation of operational constraints was limited to those analysis points where existing diversion infrastructure exists. Table 4 summarizes the analysis points for the operational constraint evaluation, in addition to the diversion capacity used for each analysis point. The diversion capacity was developed with water stakeholder input and is representative of the likely operational diversion capacity of the canal(s) at that analysis point.

Table 4 – Analysis Points for Operational Constraint Evaluation

Analysis Point	Existing Diversion Capacity (cfs)
APS1 – South Platte River at Western Canal	250
APS2 – South Platte River at Korty Canal	850
AP2 – N.P. below Keystone Diversion	350
AP3 – N.P. River below Birdwood Creek	105
AP4 – Tri-County Canal	2,250
AP5 – Gothenburg/30-Mile Canal	400
AP6 – Cozad Canal	290
AP7 – Dawson/Orchard-Alfalfa Canals	525

At each of these analysis points, the five diversion capacities were evaluated for both the three-day and seven-day continuous excess flow availability scenarios.

5.0 Description of Results and Plots

Results of the excess flow evaluations were compiled, and graphics were prepared to illustrate and communicate the results. Because of the numerous scenarios considered in this evaluation, the results are provided in electronic format. Specific electronic files are provided and their contents include:

- One compiled PDF file of this technical memorandum
- Two Microsoft Excel Workbooks that include the computations for the natural flow hydrograph at each analysis point and a summary of the natural flow hydrographs at each analysis point.
- Three Microsoft Excel Workbooks including the excess flow results (without operational constraints) for each analysis point. Analysis points 1-7 are included in one workbook, analysis points 8-13 are included in a second workbook, and analysis point 0 is included in the third workbook. Each workbook contains an individual worksheet for each analysis point. The Analysis Point 0 workbook contains individual worksheets for each of the demand scenarios referenced in Section 3.0 of this TM. Each worksheet contains the supporting data from the analysis, the plots of analysis results, and tabular summaries.
- One Microsoft Excel Workbook that is used to link the excess flow results from each analysis point to the rest of the analysis points, accounting for travel time.
- Eight Microsoft Excel Workbooks from the operational constraint analyses for each analysis point identified in table 4 are included that contain the supporting data from the analysis, the plots of analysis results, and tabular summaries. A separate worksheet for each scenario is included within each analysis point workbook.
- One Microsoft Access database file used in the demand query that is the engine of the analyses without operational constraints.
- Eight Microsoft Access database files used in the demand queries that are the engine of the analyses with operational constraints.
- One compiled PDF file of plots for the excess flow analyses without operational constraints.
- Eight compiled PDF files (one for each operational constraint analysis point) that include plots of excess flow results for each operational constraint scenario.

- Microsoft Excel Workbook containing the Simplified Analysis Tool (see Section 6.0 of this technical memorandum)

Table 5 summarizes the contents of the electronic submittal.

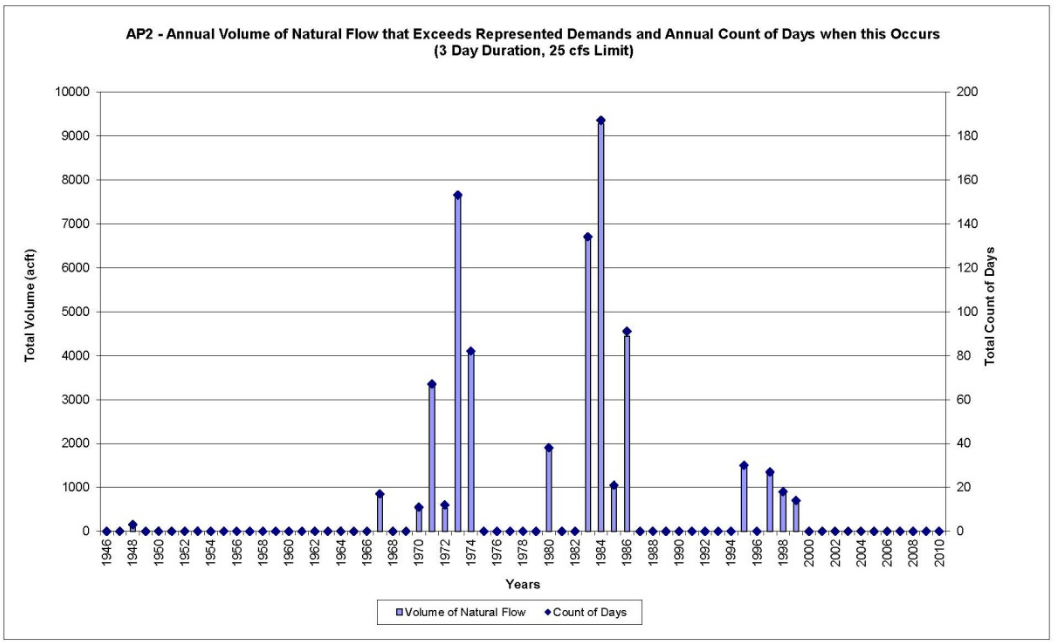
Table 5 – Contents of Electronic Submittal

Directory Name	File Names	Description
(no directory)	Final Technical Memorandum.pdf	PDF file of final technical memorandum
Natural Flow Excel Files	Daily_Natural_Flow_Computations_1947-2012.xlsx	Microsoft Excel Workbooks with computed daily natural flow hydrographs (raw data/computations and summary) at each analysis point
	Daily_Natural_Flow_Summary_1947-2010.xls	
(no directory)	ExcessNatFloVol_M2c_w_traveltime_LewellenUpdate2.xls	Microsoft Excel Workbook that links the excess flow at each analysis point to the rest of the analysis points accounting for travel time.
Excess Flow without Operational Constraints_Excel Files	Summary_NatFlow_Analysis_ap0.xlsm	Microsoft Excel Workbooks for analysis (without operational constraints) for each analysis point. Workbooks contain a worksheet tab for each analysis point designated in file title.
	Summary_NatFlow_Analysis_AP1-7.xlsm	
	Summary_NatFlow_Analysis_AP8-13.xlsm	
Excess Flow with Operational Constraints_Excel Files	Operational_NatFlow_Analysis_AP2.xlsm	Microsoft Excel Workbook files from the operational constraint analyses for each analysis point identified in table 4.
	Operational_NatFlow_Analysis_AP3.xlsm	
	Operational_NatFlow_Analysis_AP4.xlsm	
	Operational_NatFlow_Analysis_AP5.xlsm	
	Operational_NatFlow_Analysis_AP6.xlsm	
	Operational_NatFlow_Analysis_AP7.xlsm	
	Operational_NatFlow_Analysis_APS1.xlsm	
	Operational_NatFlow_Analysis_APS2.xlsm	
Excess Flow without Operational Constraints_Database Files	Platte River Natural Flows method2C_Final.mdb	Microsoft Access database files used in the demand queries.
Excess Flow with Operational Constraints_Database Files	Platt River Natural Flows method2C_AP2.mdb	Microsoft Access database files used in the demand queries for the analysis with constraints
	Platt River Natural Flows method2C_AP3.mdb	
	Platt River Natural Flows method2C_AP4.mdb	
	Platt River Natural Flows method2C_AP5.mdb	
	Platt River Natural Flows method2C_AP6.mdb	
	Platt River Natural Flows method2C_AP7.mdb	
	Platt River Natural Flows method2C_APs1.mdb	
	Platt River Natural Flows method2C_APs2.mdb	
Excess Flow without Operational Constraints_PDF Files	Excess Flow PDF Plots (no operation constraints)_all APs.pdf	One PDF file of compiled plots for the excess flow analysis without operational constraints for each analysis point.
Excess Flow with Operational Constraints_PDF Files	Ap2_Compiled.pdf	One compiled PDF file for each analysis point that includes plots for each operational constraint scenario.
	Ap3_Compiled.pdf	
	Ap4_Compiled.pdf	
	Ap5_Compiled.pdf	
	Ap6_Compiled.pdf	
	Ap7_Compiled.pdf	
	Aps1_Compiled.pdf	
	Aps2_Compiled.pdf	
(no directory)	Simplified Analysis Tool.xlsm	Microsoft Excel Workbook with simplified analysis tool as described in Section 6.0

The plots to illustrate the analysis results include:

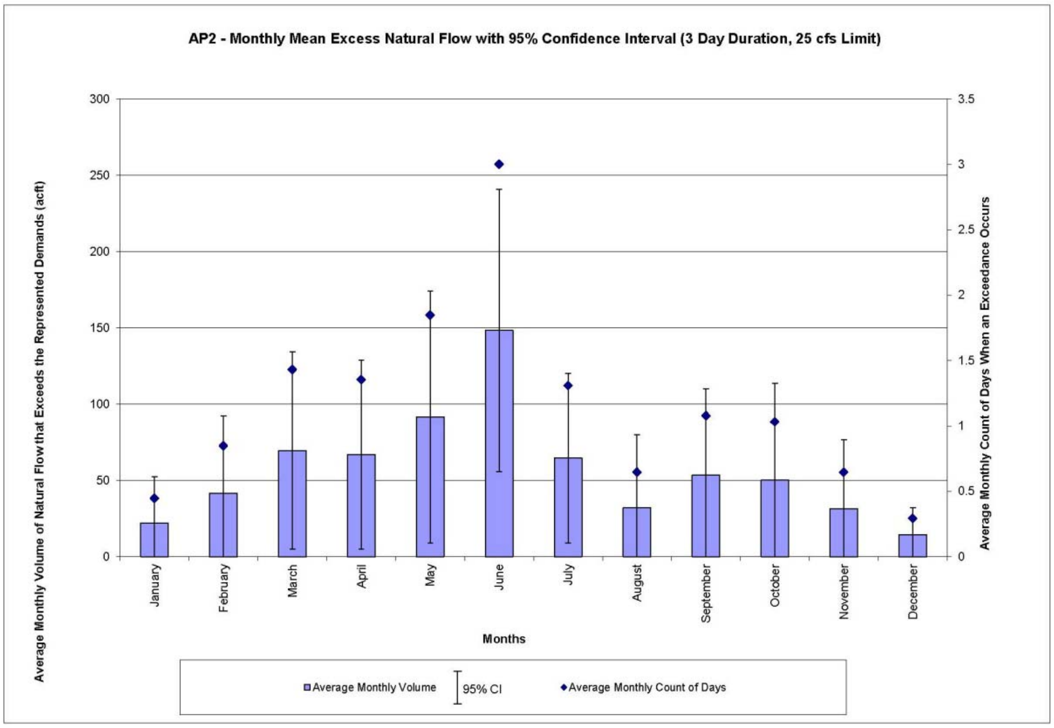
- Annual excess flow volumes – Computed excess flows on an annual basis throughout the 1947 -2010 period. These plots illustrate both the volumes of excess flow computed for each year and the total number of day(s) excess flows were available for each year. The plots are useful in assessing annual volumes as well as annual variability.

Figure 3 – Example Annual Excess Flow Volume Plot



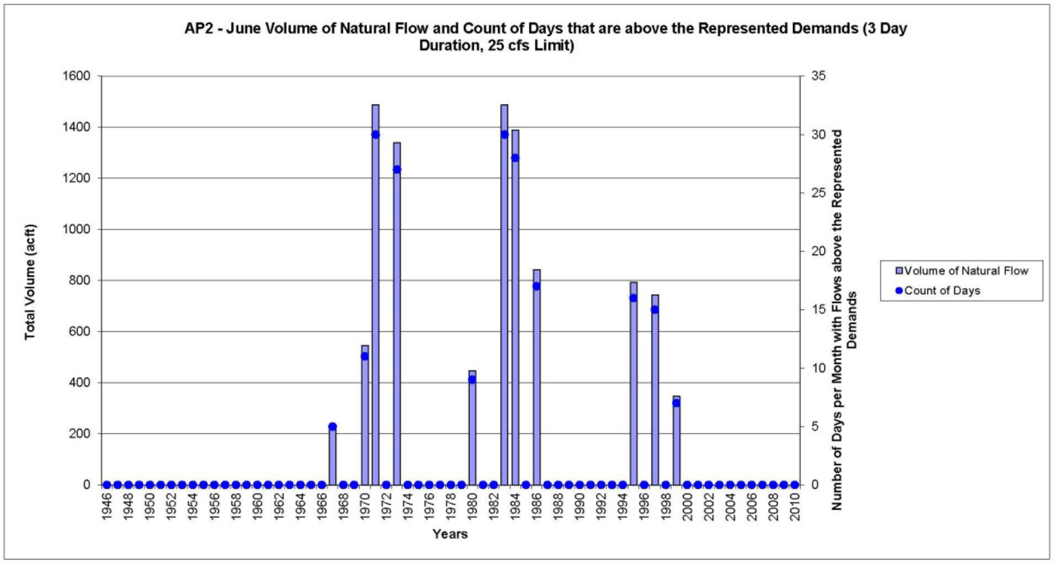
- Monthly mean excess flow volumes – Computed mean excess flows for each month over the period of record. These plots illustrate the monthly mean volume of excess flow, the average number of days during each month excess flows were available, and the 95% confidence interval to give the user an idea of the variability in monthly data over the period of analysis. These plots are useful in assessing the mean monthly volumes of excess flow, the variability of monthly excess flows, and the variability in excess flow availability seasonally and throughout the year.

Figure 4 – Example Mean Monthly Excess Flow Volume Plot



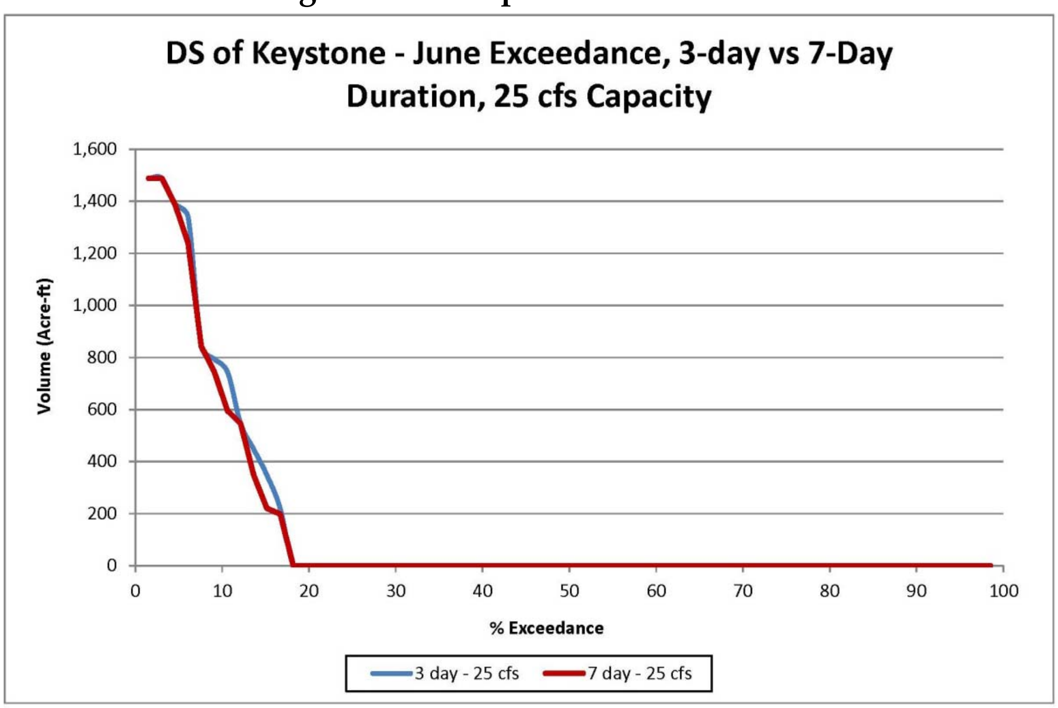
- Monthly excess flow volumes – Computed monthly excess flows throughout the 1947-2010 period. These plots illustrate the monthly volume of excess flow over the period of analysis and the total number of days during the month for each year that excess flow was available. These plots are useful in assessing the monthly volumes of excess flow and the variability of those monthly volumes through the 1947-2010 period.

Figure 5 – Example Monthly Excess Flow Volume Plot



- <u>Exceedance plots</u> - For the operational constraint analysis, exceedance plots are included that indicate the probability of a specific volume of excess flow being exceeded in any given year. The three-day and seven-day exceedance curves are included on the same plot to allow the user to evaluate the benefits of optimizing operations to capitalize on shorter duration excess flow events.

Figure 6 – Example Exceedance Plot



The graphics were prepared to assist decision makers by answering questions such as:

- When should a project operate to maximize its benefits?
- What size of recharge facility is required (based on volumes of excess flow available)?
- Is a dedicated diversion (increased diversion capacity) required to better capture and utilize excess flows?
- Based on historical flows, what annual volume can be anticipated, and what is the variability in excess flow availability?
- Can more water be diverted with better operations (reduce the three-day or seven-day continuous excess flow requirements)?

6.0 Simplified Analysis Tool

A new appropriated use will have impacts to available excess flows that propagate both upstream and downstream and may have impacts to other projects under consideration. To that end, a simplified analysis tool using Microsoft Excel has been created to coarsely determine the interactions of multiple projects.

The tool includes computed available excess flow data for each analysis point. The user can then enter one or more new uses (and estimated returns – both quantity and estimated timing of return flow) at any of the analysis points. The tool will estimate the impacts to available excess flows at downstream analysis points based on the use and return estimates and at each upstream analysis point based on the new "appropriated use" scenario entered by the user. Items of note regarding this simplified analysis tool include:

1. The spreadsheet contains a "read me example" tab at the end that illustrates how to use the tool.
2. For partitioning impacts of a new Platte River use to the North and South Platte Rivers, the historic contributions of each to total Platte River flows at North Platte was determined. The ratio of South Platte River flows to North Platte River flows at North Platte was calculated based on the historic gage record for each at North Platte, as well as the ratio of each returning to the river from the North Platte hydropower return on the Sutherland system. The computed ratio used to partition new Platte River uses was 77% for the North Platte River and 23% for the South Platte River.
3. Computed excess flows at Lewellen (AP0) for each of the three Kingsley demands described in Section 3.0 is included in the simplified analysis tool.

4. Monthly average excess flow values over the period of analysis (without operational constraints) were used to develop the simplified analysis tool. To remove a portion of the bias that large excess flow events have on the monthly averages, the monthly excess flow volume used in computing average values was capped at 30,000 AF. This cap was based on the probable maximum capacity of any new project being limited to 1000 AF/day. This capacity was developed with water stakeholder input as a reasonable maximum volume of water that could be diverted by a potential project and is equivalent to a diversion rate of 500 cfs.
5. Monthly averages were developed for wet/dry/normal hydrologic conditions to allow the user to gage project interaction during varying climatic conditions.

7.0 Runoff Correlation

An evaluation of historic precipitation and flow records, in conjunction with computed excess flows, was conducted to determine if a correlation between rainfall events and increases in river flows and/or computed excess flows can be detected.

Peak observed rainfall events from the Kingsley, North Platte, and Grand Island weather stations were compiled. The data were sorted to identify the top twenty precipitation events at each station with respect to total storm depths. Next, the historic gage records for the same time period were qualitatively assessed to determine if the precipitation events produced noticeable increases in stream flow. Finally, the computed excess flow values for the respective precipitation event time period were reviewed to determine if the event resulted or contributed to excess flows. Tables 6, 7, and 8 summarize the results of this analysis.

Table 6 – Kingsley Weather Station

Kingsley Weather Station[5]						
Date	Total Rainfall Depth (in)	# days	Daily Average Rainfall (in)	Peak Daily Rainfall (in)	Flow Increase @ Sutherland Gage (cfs)	Excess Flow Available
6/13/2007	5.48	4	1.4	3.55	600	N
7/7/2002	5.42	2	2.7	5.25	1200	N
6/10/1998	5.28	4	1.3	2.52	350	N
4/21/1971	4.38	3	1.5	3.66	500	Y
5/14/1999	3.47	2	1.7	3.05	150	Y
6/27/1999	3.43	3	1.1	2.21	500	Y
7/8/1961	3.4	1	3.4	3.40	2000	N
6/24/1966	3.39	2	1.7	2.18	500	N
8/1/1975	3.31	3	1.1	3.18	600	N
6/9/1951	3.18	4	0.8	2.33	600	N
8/8/1950	2.9	4	0.7	2.26	100	N
6/2/1988	2.82	3	0.9	2.16	200	N
5/15/1982	2.69	4	0.7	2.18	200	N
5/16/1958	2.69	4	0.7	2.33	300	N
7/10/2001	2.64	2	1.3	2.31	-	N
9/4/1999	2.6	1	2.6	2.60	2000	N
5/8/1998	2.52	3	0.8	2.30	150	N
5/1/1983	2.52	3	0.8	2.14	-	Y
6/26/1989	2.51	3	0.8	2.14	1000	N
7/18/1951	2.25	1	2.3	2.25	100	N

[5] NWS COOP ID # 254455; Latitude 41.2097, Longitude -101.6706

Table 7 – North Platte Weather Station

North Platte Weather Station[6]						
Date	Total Rainfall Depth (in)	# days	Daily Average Rainfall (in)	Peak Daily Rainfall (in)	Flow Increase @ Brady Gage (cfs)	Excess Flow Available
5/30/2007	5.1	2	2.6	3.34	1400	N
6/17/1956	3.87	2	1.9	2.43	2000	N
5/29/1973	3.72	4	0.9	2.23	1800	Y
6/6/1965	3.7	2	1.9	2.45	650	N
6/19/1993	3.45	3	1.2	3.22	250	N
6/10/1974	3.31	4	0.8	2.59	650	N
9/16/1963	3.24	2	1.6	3.11	200	N
7/28/1979	3.1	2	1.6	2.30	1000	N
5/30/1962	2.97	3	1.0	2.32	500	N
5/9/1957	2.89	2	1.4	2.78	300	N
10/29/2000	2.86	2	1.4	2.71	200	N
6/24/1966	2.78	2	1.4	2.76	250	N
6/12/1984	2.75	2	1.4	2.41	1400	Y
5/14/1958	2.66	3	0.9	2.48	1100	N
8/13/1988	2.59	1	2.6	2.59	200	N
4/12/1974	2.46	1	2.5	2.46	600	Y
8/21/1964	2.43	2	1.2	2.33	-	N
7/12/1997	2.21	1	2.2	2.21	400	N
8/10/1968	2.2	1	2.2	2.20	700	N
7/31/1975	2.08	1	2.1	2.08	900	N

[6] NWS COOP ID # 256065; Latitude 41.121, Longitude -100.669

Table 8 – Grand Island Weather Station

Grand Island Weather Station[7]						
Date	Total Rainfall Depth (in)	# days	Daily Average Rainfall (in)	Peak Daily Rainfall (in)	Flow Increase @ Grand Island Gage (cfs)	Excess Flow Available
6/15/1967	10.12	9	1.1	3.20	14700	Y
5/12/2005	7.22	3	2.4	6.50	5600	Y
9/2/1977	5.89	2	2.9	5.62	500	N
6/25/1968	5.51	3	1.8	3.09	2900	Y
7/10/1991	5.45	3	1.8	3.08	130	N
7/9/1950	5.41	2	2.7	4.65	1470	Y
6/16/1990	4.18	2	2.1	4.17	600	N
8/30/1977	4.12	1	4.1	4.12	500	N
6/4/1980	4.06	5	0.8	2.74	2000	Y
8/11/1997	3.91	2	2.0	3.22	2500	Y
4/28/1964	3.63	4	0.9	2.61	1300	Y
6/1/1991	3.46	1	3.5	3.46	2300	Y
5/5/2001	3.46	4	0.9	2.59	1000	Y
6/30/1971	3.25	2	1.6	3.14	-	Y
9/29/1965	3.24	4	0.8	2.89	1600	Y
11/16/1996	3.14	3	1.0	2.60	1500	Y
5/22/1961	3.06	4	0.8	2.93	4000	Y
9/9/1989	3.02	2	1.5	3.01	1000	Y
7/17/1993	2.93	3	1.0	2.79	1200	Y
7/11/1961	2.8	1	2.8	2.80	-	N

While a statistical analysis was not conducted on this data, several conclusions can be drawn from this relatively simple analysis:

1. There does not appear to be a strong correlation between large precipitation events and excess flow, particularly at the Kingsley and North Platte stations where large precipitation events resulted in relatively minor flow events. The potential reasons for this are numerous and include storm areal extents, antecedent moisture conditions, land use and soil types, time of year, appropriation demands, etc.

[7] NWS COOP ID # 253395; Latitude 40.9611, Longitude -98.3136

2. Consistent with the analysis of Lake McConaughy storage demands, the occurrence of excess flows in the upper reaches of the study extents are more likely to be dictated by Lake McConaughy releases than by local precipitation events.
3. The strength of the correlation does vary spatially. As evidenced by the results at Grand Island, as you move east along the Platte River, it is more likely that large precipitation events will produce noticeable increases in streamflow and have a greater potential to result in excess flows. Again, a multitude of factors in addition to the precipitation event likely contribute to this response.
4. Precipitation events are just one of a multitude of factors to be considered by stakeholders when trying to optimize project operations to best capture and utilize available excess flows.

8.0 Project Evaluation Matrix

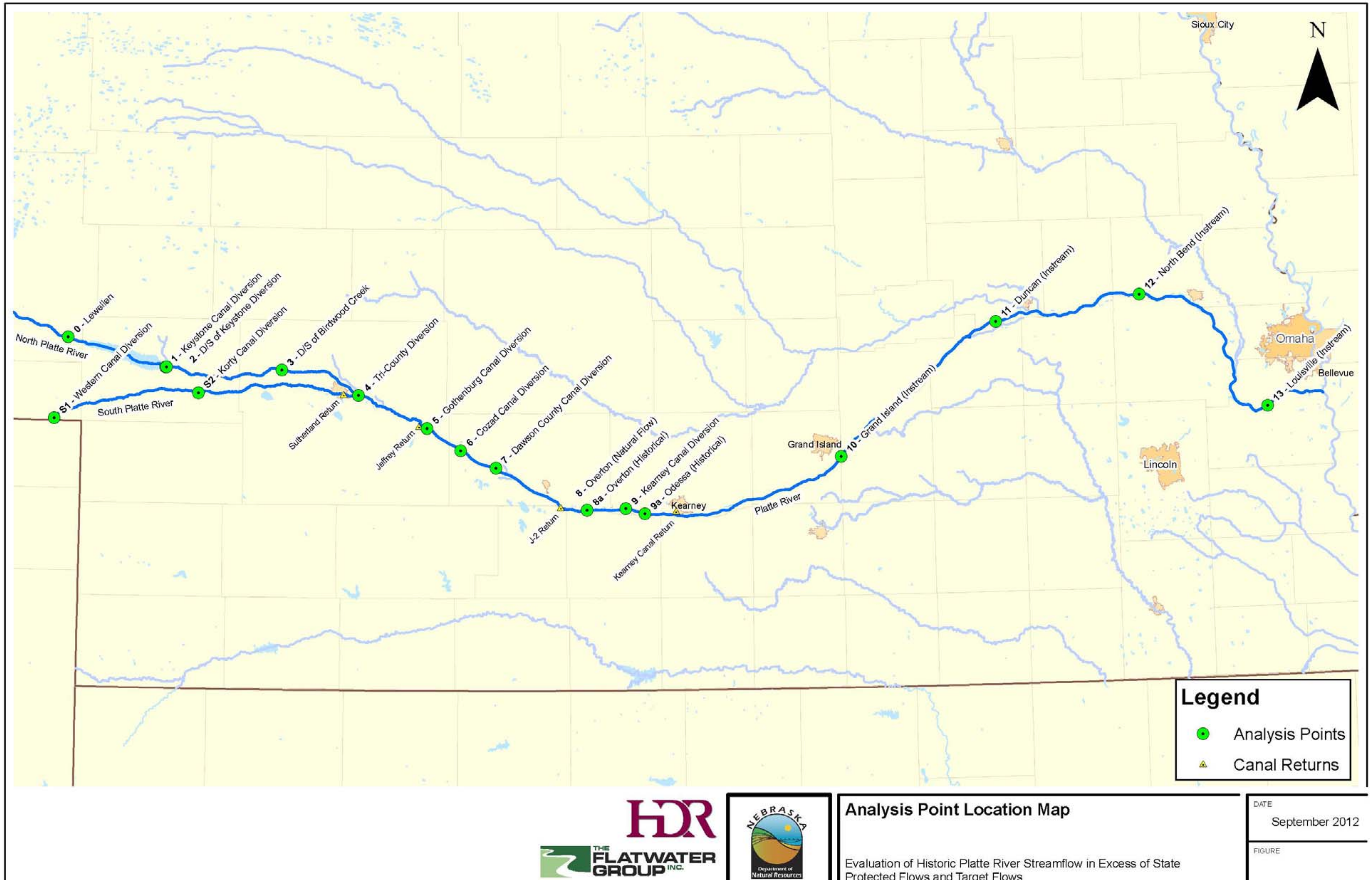
A project evaluation matrix has been developed to assist decision makers in evaluating potential projects on a consistent and common basis. The evaluation criteria included in the matrix were developed in conjunction with DNR and water stakeholders. These criteria are meant to represent the key factors to be considered when evaluating conjunctive management projects for implementation. Conjunctive Management projects involve the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various water needs.[8]

Evaluation criteria include a combination of qualitative and quantitative metrics. The criteria were not prioritized as part of this effort, however it was noted by stakeholders during the matrix development **that the ability for a project to meet multiple goals (satisfy depletion offsets, help get back to 1997 depletion levels, assist in meeting target flows, etc.) was considered one of the most important criteria**.

The project evaluation matrix is included in Attachment 2 and includes a companion list of definitions for the evaluation criteria.

[8] Coe, JJ, provides following definition: "Conjunctive use of surface and groundwaters can be defined as the management of surface and groundwater resources in a coordinated operation to the end that the total yield of the system over a period of years exceeds the sum of the yields of the separate components of the system resulting from an uncoordinated system." Journal of Irrigation and Drainage Engineering, 116, 3, pp 427-443, *Conjunctive Use – Advantages, Constraints, and Examples*, 1990

Attachment 1 – Analysis Point Location Map



N
Sioux City
Omaha
Bellevue
Lincoln
Grand Island
Kearney
North Platte River
South Platte River
Platte River
0 - Lewellen
1 - Keystone Canal Diversion
2 - D/S of Keystone Diversion
S1 - Western Canal Diversion
S2 - Korty Canal Diversion
3 - D/S of Birdwood Creek
4 - Tri-County Diversion
Sutherland Return
5 - Gothenburg Canal Diversion
Jeffrey Return
6 - Cozad Canal Diversion
7 - Dawson County Canal Diversion
J-2 Return
8 - Overton (Natural Flow)
8a - Overton (Historical)
9 - Kearney Canal Diversion
9a - Odessa (Historical)
Kearney Canal Return
10 - Grand Island (Instream)
11 - Duncan (Instream)
12 - North Bend (Instream)
13 - Louisville (Instream)
Legend
Analysis Points
Canal Returns
HDR
THE FLATWATER GROUP INC.
NEBRASKA
Department of Natural Resources
Analysis Point Location Map
Evaluation of Historic Platte River Streamflow in Excess of State Protected Flows and Target Flows
DATE
September 2012
FIGURE

Attachment 2 – Conjunctive Management Project Evaluation Matrix

Evaluation Criteria	Project A	Project B	Project C
Water Source			
Water Source and appropriation status (existing, modification to existing, new)			
Volume/rate of excess flows available			
Duration/occurrence of excess flow available			
Frequency/reliability/certainty of excess flow availability			
Benefits			
Credits from project (depletion offsets, etc.)			
Compatibility with GWMPA and Nebraska New Depletions Plan			
Interaction/multi-purpose benefits of project			
Local/regional benefits, including secondary benefits			
Infrastructure			
• Existing infrastructure utilized			
• New infrastructure required			
• Modifications to existing infrastructure/operations required			
Impacts			
• Environmental impacts (cultural, wetlands, T&E species)			
• Infrastructure impacts			
• Water quality impacts			
Costs			
• Project capital costs			
• Project O&M costs			
• Cost/AF of credit			

Water Source

- Water Source and appropriation status: Identify water source (groundwater, surface water, or co-mingled) and whether this is an existing or new appropriation.
- Volume/rate of excess flows available: Characterize quantity of water available or intended to be used for project.
- Duration/occurrence of excess flow available: Characterize when and for what anticipated length of time flows are available.
- Frequency/reliability/certainty of excess flow availability: Characterize the reliability of the water for the project based on historic flows.

Benefits

- Credits from project: Identify/estimate depletion offsets, mitigation credits, target flow credits, etc. that are attributable to the project.
- Compatibility with GWMPA and Nebraska New Depletions Plan: How does the project adhere/compliment GWMPA and Nebraska New Depletions Plan?
- Interaction/multi-purpose benefits of project: Identify multiple direct benefits of the project to the water resources system, such as water quality, increase in wet water in the river/stream, habitat benefits, recreational benefits, etc.
- Local/regional benefits, including secondary benefits: Identify local/regional benefits, including secondary benefits such as hydropower, increased crop production/revenue, etc.

Infrastructure

- Existing infrastructure utilized: Identify the existing infrastructure intended for use by the project, includes existing canals, reuse pits, storage facilities, pumping, irrigation equipment, diversion structures/gates, etc.
- New infrastructure required: Identify new infrastructure required for the project, such as new canals/conveyance, reuse pits, storage facilities, pumping, irrigation equipment, diversion structures/gates, etc.
- Modifications to existing infrastructure/operations required: Identify modifications to existing infrastructure required for the project (focus on water resources, utilities, etc. identified in next section).

Impacts

- Environmental impacts (cultural, wetlands, T&E species): Identify items such as physical impacts of facilities, effects of water diversion/application, groundwater pumping effects, energy consumption and generation, health and social aspects, land and vegetation.
- Infrastructure impacts: Identify potential impacts to infrastructure such as farmsteads, land acquisition, homes, roads, and field access.
- Water quality impacts: Identify potential water quality impacts, such as reduced dilution to pollutants in surface waters, introduction of new pollutants with groundwater return flows, or increased water quality by diluting degraded water quality in a depleted aquifer.

Costs

- Project capital costs: Estimate of capital costs including land required for the recharge facilities and the construction and material costs for the facility itself including diversion, conveyance and recharge basin(s) elements.

- Project O&M costs: Estimate of O&M costs for project. O&M costs generally increase over current operation of existing facilities due to additional facilities and an extended diversion season.
- Cost/AF of credit: One example of a metric relating cost/benefit of project – in this case a value for the net water yield of a project ($/AF) is used. Other metrics may be more appropriate depending on the project.