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I. INTRODUCTION

The Platte River Recovery Implementation Program (Program) was initiated on January 1, 2007 between Nebraska, Wyoming, Colorado, and the Department of the Interior to address endangered species issues in the central and lower Platte River Basin. The species considered in the Program, referred to as "target species", are the whooping crane (*Grus americana*), piping plover (*Charadrius melodus*), interior least tern (*Sterna antillarum*), and pallid sturgeon (*Scaphirhynchus albus*).

Monitoring of central Platte River water quality near Program lands is relevant to the productivity and diversity of native fish and other aquatic species supportive of the interior least tern, piping plover, and whooping crane. Ultimately, these baseline data will be used to assess Priority Hypotheses as described in Table 2 of the Adaptive Management Plan (AMP) (PRRIP 2006).

EA Engineering, Science, and Technology, Inc. (EA) was contracted by the Program to develop a Water Quality Monitoring Protocol (Protocol) and implement the Protocol in 2009, 2010, and 2011 to collect the baseline data. Data collected included: stage/discharge, five water quality parameters (temperature, turbidity, dissolved oxygen, pH, and specific conductance), and representative water samples for analysis of metals (dissolved copper, dissolved lead, dissolved nickel, total selenium, total calcium, and total magnesium) and the bacterium *Escherichia coli (E. coli)*.

I.A. Purpose

The purpose of the Platte River water quality monitoring is to characterize the water quality in the central and lower Platte River during the 13-year First Increment (2007-2019); forming the basis for assessing the influence of the Program and Program-covered activities on Platte River water quality.

For each of the three baseline line monitoring years (2009, 2010, and 2011) the Protocol defined data collection procedures to obtain scientifically credible data, and was developed to:

- Determine current baseline water quality conditions in the central and lower Platte River.
- Determine temporal variations in water quality along the central and lower Platte River.
- Determine variations in water quality in response to changes in discharge.
- Determine spatial variations in water quality along the central and lower Platte River.

Implementation of the Protocol in 2009, 2010, and 2011 included:

- Collection and evaluation of data.
- Summarization of results.
- Evaluation of variations due to temporal, discharge, and spatial differences.

Platte River water quality data were summarized and presented in annual data summary reports. These annual reports present a summary of the monitoring activities, results of the discrete water sample analysis (metals and bacteria), flow data collected by the U.S. Geological Survey (USGS) and Nebraska Department of Natural Resources (NDNR), water quality data collected by EA, and assessment of the quality of the data collected. Summary statistics of the water quality data were generated and the data was assessed for temporal, spatial, and flow variations. Figures, tables, raw data, field data sheets, etc., for the intra-year data summaries are presented in the following documents:

2009 - Platte River Recovery Implementation Program. Annual Data Summary Report, Platte River Water Quality Monitoring, 2009 Monitoring Season, August 2010 (PRRIP 2010).

2010 - Platte River Recovery Implementation Program. Annual Data Summary Report, Platte River Water Quality Monitoring, 2010 Monitoring Season, January 2012 (PRRIP 2012a).

2011 - Platte River Recovery Implementation Program. Annual Data Summary Report, Platte River Water Quality Monitoring, 2011 Monitoring Season, February 2012 (PRRIP 2012b).

I.B. Three-Year Data Summary

The purpose of this report is to present a summary of the three years of Platte River water quality data collected during the 2009 - 2011 monitoring seasons. These three years of Platte River water quality data are considered "baseline" data that will be used as a standard to evaluate the effects of future Program actions on Platte River water quality. Water quality data in this summary will be presented to evaluate inter-year parameter variability by location to describe baseline water quality values temporally and spatially. Regression models were developed to evaluate the relationship of Platte River discharge to the measured water quality parameters.

II. METHODS AND PROCEDURES

The methods and procedures described in the following sections are applicable and relevant to the three baseline years of the Platte River water quality monitoring designed to document water quality and detect water quality trends in the central and lower Platte River. The area of interest included the central Platte River (Lexington to Chapman, Nebraska) and the lower Platte River (Chapman to confluence with the Missouri River). Water quality was measured using *in-situ* continuous water quality sondes (sondes), discharge measurements from established gaging stations, and collection of discrete water samples at monitoring locations. Photographs of typical field activities are included in Appendix A.

II.A. Monitoring Locations

Monitoring locations on the Platte River were selected to determine the range and variation of water quality parameters within the central and lower Platte River. Specific focus was given to the central Platte River as the habitat-improvement activities of the Program are related to this river reach. Existing stream gaging stations maintained by the USGS and NDNR were used to select monitoring locations; listed in Table 1 and illustrated on Figure 1. Sondes were co-located with the existing stream gaging stations.

Table 1. Spatial Monitoring Matrix

Monitoring Location No.	Platte River Locations	Discharge	Water Quality	Analytical
1	Lexington	NDNR	EA	EA
2	Overton	USGS	EA	EA
3	Odessa	NDNR	EA	EA
4	Kearney	USGS	EA	EA
5	Shelton	NDNR	EA	EA
6	Grand Island	USGS	EA	EA
7	Duncan	USGS	EA	EA
8	Louisville	USGS	EA	EA

Notes:
NDNR – Nebraska Department of Natural Resources
USGS – United States Geological Survey
EA – EA Engineering, Science, and Technology, Inc.

II.B. Parameters of Interest

Water quality data were categorized into three groups:

- **Discharge** – Discharge is the measurement of stream flow and is expressed as the amount of water that passes a fixed point over time and is typically represented as cubic feet per second (cfs). River stage and/or gage height was collected in feet (ft).

- **Continuous Water Quality Monitoring** – Continuous water quality data included temperature, turbidity (optical sensor), dissolved oxygen by optical dissolved oxygen (ODO) and Luminescent Dissolved Oxygen (LDO) technology, pH, and specific conductance.

- **Discrete Water Quality Monitoring –** Discrete water quality monitoring was separated into two groups: metals monitoring and *E. coli* monitoring. Metals monitoring included the collection of water samples for analysis of dissolved copper, dissolved lead, dissolved nickel, total selenium, total calcium, and total magnesium. Samples were collected and analyzed by TestAmerica of Cedar Falls, Iowa (a National Environmental Laboratory Accreditation Program (NELAP)-certified laboratory). *E. coli* monitoring included analysis of water samples for *E. coli* and coliform bacteria. Monitoring for *E. coli* was performed to assess the potential for increased pathogens in the central Platte River resulting from concentrated populations of waterfowl using the central Platte River due to Program activities. Sampling events were performed during periods of peak waterfowl use (February through March) and minimal waterfowl use (July through September). Samples were analyzed by Ward Laboratories, Inc. Kearney, Nebraska.

II.B.1. Frequency and Duration

The index period for the collection of continuous water quality monitoring data was from mid-March through November 2009 - 2011). The frequency and duration of data collection is listed below:

- **Discharge**
  - Existing gaging stations on the Platte River are operated continuously by the USGS and NDNR. River stage was measured continuously at these stations and discharge was estimated using rating curves. Data were recorded every 15 minutes at USGS gaging stations at Louisville, Duncan, Grand Island, Kearney, and Overton. The NDNR gaging stations at Shelton, Odessa, and Lexington recorded data every 30 minutes.

- **Continuous Water Quality Monitoring**
  - EA installed a sonde at Louisville, Duncan, Grand Island, Shelton, Kearney, Odessa, Overton, and Lexington, and provided operation and maintenance during the monitored periods. A data point was collected every 30 minutes.

  - Following installation, operation and maintenance of the sondes (including the downloading of data) was conducted bi-weekly in March and April, weekly from May through September, and bi-weekly during October and November.

- **Discrete Water Quality Monitoring (Metals)**
  - The index period for the collection of discrete water quality data was from April through October.
  - Representative water samples for analytical analysis of metals were collected at the eight monitoring locations, listed in Table 1, in April, June, August, and October during sonde maintenance.

- **Discrete Water Quality Monitoring (*E. coli*)**
  - Representative discrete water quality samples were collected in 2010 and 2011, at Lexington, Kearney, and Grand Island.
  - The index period was during periods of concentrated waterfowl populations, February through March (peak period), and during periods with minimal waterfowl populations, July through September (non-peak period).
  - A 2:1 or 5:1 and a 20:1 dilution of sterilized water with the sample was conducted at the laboratory to obtain counts of coliform and *E. coli* colonies in 100 mL of water.

II.C. Discharge and River Stage

Platte River discharge and stage measurements were obtained from existing gaging stations maintained by the USGS and NDNR (Table 1). River stage was measured continuously at these gaging stations and discharge was estimated using rating curves. The rating curves are maintained by the owning agency (USGS or NDNR). Periodic measurements of depth and flow rate by the respective agencies are used to adjust the rating curves, as needed.

II.D. Continuous Water Quality Monitoring

A sonde was co-located at gaging stations as described in Table 1. Two different manufactures of sondes were used to collect water quality data. The sondes collect the same data but were purchased at different times. The Hydrolab MS-5 data sondes were purchased utilizing a grant from the Nebraska Department of Environmental Quality (NDEQ) and were deployed at Lexington, Overton, Odessa, Kearney, Shelton, Grand Island, and Duncan. A Eureka Manta 2 was purchased by the Program and was deployed at Louisville. The data and units of measure collected by the respective sondes are listed in Table 2.

Table 2. Continuous Water Quality Parameters

Water Quality Parameter	Unit	Range	Accuracy	Resolution
Hydrolab MS-5				
Temperature	Degrees Celsius	-5 to +50ºC	± 0.10 ºC	0.01 ºC
Turbidity	Nephelometric Turbidity Units	0 to 3,000 NTU	± 1% up to 100 NTU ± 3% up to 100–400 NTU ± 5% from 400–3,000 NTU	0.1 NTU from 0-400 NTU 1 NTU for >400-3,000 NTU
Luminescent Dissolved Oxygen	mg/L	0 to 30 mg/L	± 0.01 mg/L @ ≤ 8 mg/L ± 0.02 mg/L @ > 8 mg/L	0.01 or 0.1 mg/L
pH	Standard Units	0 to 14 units	± 0.2 units	0.01 units
Specific Conductance	mS/cm	0 to 100 mS/cm	± 1% of reading; + 0.001 mS/cm	0.0001 mS/cm
Eureka Manta 2				
Temperature	Degrees Celsius	-5 to +50ºC	± 0.10 ºC	0.01 ºC
Turbidity	Nephelometric Turbidity Units	0 to 3,000 NTU	0-100 < 1% of reading 100-400 < 3% of reading over 400 < 5% of reading	0.1 NTU
Dissolved Oxygen	mg/L	0 to 25 mg/L	1% of reading or 0.02 mg/L, whichever is greater	± 0.01 mg/L
pH	Standard Units	0 to 14 units	± 0.2 units	0.01 units
Specific Conductance	mS/cm	0 to 100 mS/cm	1% of reading ± 1 count	0.1 mS/cm

II.D.1. Continuous Water Quality Sonde Installation

To maintain continuity of data and to minimize variability between data sondes, the same data sonde has been deployed at the same monitoring location for the three annual Platte River water quality monitoring periods. Prior to installation, each sonde was calibrated following the manufacturer's specification using calibration standards and documented on field data sheets. Each sonde was suspended on the downstream side of the bridge at the selected monitoring location. The datalogger, battery source, and sonde were housed in a section of PVC pipe (casing) and tethered to the bridge railing using heavy duty chain. The sonde was locked to the end of the chain and inserted into the casing. The cap for the casing had a hole large enough for the chain to pass through. The casing was attached to the chain by drilling a hole near the top of the casing and inserting a bolt through the casing, passing through the chain. The submerged section of the casing containing the sonde was slotted and/or perforated with circular holes and the bottom was open to prevent sediment accumulation. A second bolt was placed at the bottom of the casing to prevent the sonde from slipping through. A football-sized float was attached to the bottom of the casing to keep the sonde suspended just below the water surface (~6-inches) and to reduce the potential for burial of the sonde in bottoms sediments during decreasing flows and channel meandering. The sonde was retrievable for maintenance and data transfer by pulling up the chain to the bridge deck. Ribbon or flagging was placed every 5-feet on the chain to enhance visibility. The heavy duty chain was attached to the railing by wrapping the chain around the railing and locking the chain to itself at seven of the monitoring locations (Louisville, Duncan, Grand Island, Shelton, Odessa, Overton, and Lexington). At Kearney, the chain was secured to a steel plate that was attached to unused light standard bolts on the bridge railing.

II.D.2. Continuous Water Quality Sonde Operation and Maintenance

Operation and maintenance was performed on each sonde, including data transfer and calibration, approximately every 1- to 2-weeks depending on environmental conditions. During these visits, hand-held water quality meter measurements, sonde calibration records, and data transfer notes were recorded on the field data sheets.

Directions from the manufacturer for sonde calibration, maintenance, and data transfer were followed. Data was downloaded from the sonde to a field laptop before the data collected exceeded the memory capacity or battery life of the sonde. Files were named by Platte River location as listed in Table 1, followed by month, and day of data transfer (e.g., OVR06SEP). To ensure file integrity and to provide backup, all files were saved to the laptop hard drive and a portable USB jump drive while in the field. Following the transfer process, files were opened and reviewed to ensure successful transfer of all data before resetting the sonde. While on site, data was reviewed for missing data, outlier data, and logging errors so corrections could be made immediately, if needed. A field data sheet was filled out for each monitoring location visit to document activities related to sonde maintenance, calibration, setup, and data transfer.

The process for maintenance, data transfer, and calibration of the sondes is outlined below:

- **Measurement Using Hand-Held Meter** – Prior to retrieval of data from the sondes, the field crew collected and recorded duplicate water quality parameters using hand-held water quality meters (YSI-556 and Lamotte 2020e). Also, a meter was used to collect and record barometric pressure for calibration purposes.

- **Continuous Water Quality Sonde QA/QC** – Duplicate and known (spiked) parameter readings were taken for QC purposes. Duplicate water quality readings were collected by submerging hand-held meter probes in a 5-gallon bucket next to the sonde probes that were set to display real time readings and these values were recorded. Measurements of known (spiked) calibration standards were taken with the sonde during each maintenance visit to assess drift and/or accuracy of the sonde during the monitoring period. These QC measurements were recorded on the field data sheets.

- **Download Data From Continuous Sonde** – The field crew downloaded the data from the sonde to a laptop computer and a portable USB jump drive.

- **Review Continuous Water Quality Data** – After data transfer, data files were opened and reviewed for general data quality (i.e., proper logging interval, abnormal or missing data, data outliers, and missing parameters). If data recording issues were present, the deficiency was documented, the sonde adjusted/fixed, and the corrective action documented.

- **Re-deploy the Sonde** – As a final step, the field crew cleaned and calibrated the sonde following the manufacturer's specification using calibration standards. The documentation of the calibration included the drift of actual reading from the calibrated reading. Once calibrated, the datalogger was turned on and the sonde was re-deployed in the river.

II.D.3. Hand-Held Water Quality Instrument Operation

As part of Quality Assurance (QA) and Quality Control (QC), a second set of hand-held water quality instruments (capable of reading temperature, dissolved oxygen, pH, specific conductance, and turbidity) were calibrated and maintained to enable the collection of duplicate water quality parameters at the time of site visits. Manufacturer directions for operation, calibration, and maintenance was followed and documented on the field data sheets. These instruments were calibrated at the beginning of each field day prior to monitoring.

The hand-held meter that was used for calibrating specific conductance was designated for checking the accuracy of the water temperature probe. The hand-held meter was checked for accuracy against a mercury-in-glass calibration thermometer that is traceable to the National Institute of Standards and Technology (NIST) certification of its accuracy (Service ID Number 31010C; NIST 1988). A hand-held meter was also used to collect barometric pressure.

II.E. Discrete Water Quality Monitoring

II.E.1. Discrete Water Sample Collection (Metals)

One composite water sample was collected at each monitoring location for laboratory analysis of dissolved copper, dissolved lead, dissolved nickel, total calcium, total magnesium, and total selenium. The following procedures were used to collect representative samples during the discrete sampling events:

- Five grab samples that representative of the river flow were collected and composited at each monitoring location. The collection points were distributed evenly among multiple river channels or, when one channel existed, samples were taken near each bank and at three equidistant points between banks. When more than five channels existed, the samples were collected from the five channels with the most flow.

- Prior to sampling at each site, site water was used to rinse the sample container and composite container (Van Dorn bottle) at least three times.

- The samples were collected from the upstream side of the bridges.

- A sub-sample was collected at the first station at 1/3 of the water depth using a container. The sub-sample was poured into the compositing container. Four additional samples were taken at equally spaced representative stations and composited in the composite container.

- Once all predetermined stations were sampled and composited, the composite container was shaken/swirled to mix the composited sample. Two sample containers were required for each sample. The total metals sample was collected by pouring directly from the composite container into a pre-acidified/pre-labeled sample container. The dissolved metals sample container was filled from the composite container via a peristaltic pump using a new in-line 0.45-µm membrane filter capsule and tubing. Filtrate was discharged directly into the pre-acidified/pre-labeled sample container.

- The sample containers were placed in individual zip-seal bags and stored in a cooler with ice for shipment to the laboratory.

II.E.2. Discrete Water Sample Collection (*E. coli*)

E. coli samples from each station were collected near the south bank, or from the southern-most channel of the river, to provide sampling consistency. The southern-most channel is the channel that has flowing water and is at least 6-inches deep. A single grab sample of water was collected in a sterilized container obtained from the laboratory for *E. coli* analysis at each identified monitoring location. The following procedures were used to collect representative samples for *E. coli* monitoring:

- Samples were collected by wading into the river with the sampler facing upstream. The sampler remained stationary to permit disturbed substrates to be washed away to provide "fresh" water to collect the sample. The sample was then collected in a sterilized container using the following procedure:
    - Hold the sterilized container close to the water surface and remove the lid.
    - Partially submerge the sterilized sample container in the water column.
    - Remove the sample container from the water once it is filled and immediately replace the lid.

- Once the sample was processed, the Chain-of-Custody form was prepared as described in the Water Quality Protocol.

- Samples were hand-delivered to Ward Laboratories, Inc. at 4007 Cherry Ave., Kearney, NE for analysis within 6-hours of collection.

II.E.3. Analytical Methods

The analytical methods, required containers, volume, preservative, and holding times are listed in Table 3.

Table 3. Discrete Sampling Handling and Analytical Methods

Analyte	Field Preparation	Method	Container	Holding Time	Method Detection Limit	Reporting Limit	Preservation
Dissolved Metals							
Copper	0.45 µm filtered water	*SW 7211	1000- mL Plastic w/Teflon lined cap	6 months	0.0015 mg/L	0.005 mg/L	Cool, 4ºC HNO_3 to pH <2
Lead	0.45 µm filtered water	*SW 7421	1000- mL Plastic w/Teflon lined cap	6 months	0.001 mg/L	0.004 mg/L	Cool, 4ºC HNO_3 to pH <2
Nickel	0.45 µm filtered water	*SW 7521	1000- mL Plastic w/Teflon lined cap	6 months	0.00435 mg/L	0.01 mg/L	Cool, 4ºC HNO_3 to pH <2
Total Metals							
Selenium	Un-filtered Water	*SW 7740	1000- mL Plastic w/Teflon lined cap	6 months	0.00169 mg/L	0.005 mg/L	Cool, 4ºC HNO_3 to pH <2
Calcium	Un-filtered Water	*SW 6010B	1000- mL Plastic w/Teflon lined cap	6 months	0.0195 mg/L	1.0 mg/L	Cool, 4ºC HNO_3 to pH <2
Magnesium	Un-filtered Water	*SW 6010B	1000- mL Plastic w/Teflon lined cap	6 months	0.0104 mg/L	1.0 mg/L	Cool, 4ºC HNO_3 to pH <2
Bacteria							
E. coli	None	**SM 9223C	100 ml Sterilized Bottle	6 hours	1 colony per 100 ml	1 - 2,419 colonies per 100 ml	Cool, 4ºC

* SW – Solid Waste
**SM – Standard Methods

E. coli samples were analyzed utilizing IDEXX Quanti-Tray following Standard Methods 9223B: Chromogenic Substrate Coliform Test (American Public Health Association [APHA] 1995). *E. coli* counts were determined using Standard Methods 9221C: Estimation of Bacterial Density (APHA 1995).

II.E.4. Sample Labels

Every sample collected and submitted for analysis had a sample label uniquely identifying the sample and listing the parameters to be analyzed. Each label included the following information:

- Project Name – "PRRIP WQ Monitoring"

- Location Identification – e.g., Lex201104
  - Monitoring locations were identified as follows:
    Lexington – LEX
    Overton – OVR
    Odessa – ODS
    Kearney – KER
    Shelton – SHL
    Grand Island – GRI
    Duncan – DUN
    Louisville – LSV
  - For metals, the location identification was followed by the year and numerical abbreviation for the month sampled. e.g., 201104 – April 2011, 201105 – May 2011.
  - For *E. coli*, the location identification was followed by the day and the abbreviation for the month sampled. e.g., 15MAR – March 15, 2011, 24MAR – March 24, 2011.
- Date of sample collection
- Time of sample collection (military format)
- Analyses to be performed
- Preservative
- Samplers' initials

II.E.5. QC Sample Collection and Documentation

Metals

One duplicate water sample was collected at a randomly selected station during each discrete water quality sampling event. A sufficient volume of water was composited to fill a sample container for the environmental sample and concurrently for the duplicate sample. Duplicate samples were labeled as "Dup" followed by year and month sampled (e.g., DUP201104). An arbitrary sample time was placed on the container label and chain-of-custody. The actual location and sample time were recorded in the field book at the time of sampling.

One field blank was collected during each discrete water quality sampling event. Field blanks were labeled as "FB" followed by year and month sampled (e.g., FB201104). Field blanks were collected using the following procedures:

- The sampling container or Van Dorn bottle was rinsed three times with de-ionized water then rinsed one time with laboratory-grade water.

- The compositing container was rinsed three times with de-ionized water then rinsed one time with laboratory-grade water.

- Approximately 1.5 liters of laboratory-grade water was poured into the sampling container or Van Dorn bottle and then transferred to the composite container. The pre-acidified/pre-labeled total metals sample containers were then filled. For dissolved metals, the field crew drew the lab-grade water from the compositing container through a new filter and tubing into the pre-acidified/pre-labeled sample container.

- The containers were sealed in zip-seal bags and stored in a cooler with ice.

- Field blank samples were processed in the same manner as the environmental samples.

E. coli

One field blank was collected for each sampling event for QC using sterile water furnished by the laboratory to fill the sample container. The sampler filled the field blank container near a point on the river bank where the environmental sample was collected. The sample crew opened both containers simultaneously (sterile water and sample container), filled the sample container with sterile water and immediately replaced the lid. Field blank samples were labeled as “FB” followed by year and month sampled (e.g., FB201103) and handled the same as the environmental samples until delivered to the laboratory.

II.E.6. Chain-of-Custody

Each suite of samples collected was tracked and documented via a chain-of-custody record that was completed as samples were collected and submitted with the samples. Chain-of-custody records included the following:

- Project name – “PRRIP WQ Monitoring”
- Sample identification code – e.g. LEX201104
- Sample date for all samples
- Sample times for all samples (military format)
- Sample type (e.g. composite or grab)
- Required analysis for containers
- Sampler signature for sample collection
- Signature, date, and time relinquished

II.E.7. Field Book

The following information was documented in the field book or on the field data sheets:

- Date of sampling
- Field crew member names
- Location and sampling beginning and ending times
- Samples collected/work performed in field
- The rationale for choosing each composite location during discrete water sampling
- Duplicates or blanks collected with the location and sampling time

- Weather and site conditions
- Any irregularities encountered and lessons learned during the field effort

II.E.8. Sample Control and Handling

Sample control and custody is critical to maintain sample integrity for analysis and to track samples from time of collection to time of analysis. The following procedures were followed to maintain sample integrity:

- The sample containers were appropriately labeled and filled with a representative composite or grab water samples.

- The containers were placed in a zip-seal bag in an upright position in a cooler containing ice. The field crew kept the cooler out of direct sunlight and secured in a vehicle to prevent loss of samples/cooler.

- After all samples were collected, the sample containers were cross-checked with the chain-of-custody to ensure required sample information matched.

- Aged ice and water were removed from the cooler and replaced with double-bagged fresh ice along with sample containers and a container labeled temperature blank.

- A completed chain-of-custody was placed in a zip-seal bag and taped to the inside of the cooler lid.

- The field crew placed signed and dated custody seals over the cooler opening prior to sealing with tape.

Once the cooler was sealed with tape, it was delivered to an overnight shipping company for delivery to the laboratory.

III. DATA SOURCE SUMMARY

The three annual water quality monitoring programs were initiated on March 26 and terminated October 2, 2009, on March 23 and terminated on November 24, 2010 and on March 22 and terminated on November 23, 2011. Water quality data sondes were co-located near existing USGS or NDNR stage/discharge monitoring locations (gages).

III.A. Data Collected from USGS

The USGS maintains the National Water Information System (NWIS) website that provides access to water data for locations throughout the United States. EA accessed the USGS website on a monthly basis from March through December to download stage/discharge data from gaging stations located on the Platte River for Louisville, Duncan, Grand Island, Kearney, and Overton. Data that was obtained from USGS is considered provisional data and is subject to revision.

III.B. Data Collected from NDNR

NDNR collects and reports flow data for streams, canal and pump diversions, and storage in reservoirs at locations throughout Nebraska. The data is gathered through Field Offices and the program is coordinated through NDNR's Planning and Assistance Division. EA utilized information from gaging stations located on the Platte River near Shelton, Odessa, and Lexington. Data that was obtained from NDNR is considered provisional data and is subject to revision.

III.C. Data Collected by EA

As part of the data summarization process it was necessary to determine if the water quality data were representative of river conditions. The field data sheets were reviewed to identify variables which may have affected data quality. Several of the field sheets described conditions that may have affected the sondes ability to collect representative water quality data. Issues which affected water quality data and were evident in the water quality values logged are presented in the respective "Annual Data Summary Reports" (PRRIP 2010, 2012a, and 2012b). Those issues included:

- The measurement cell on the specific conductance probes would fill with sediment at the electrodes, even in high velocity areas of the river, which decreased the functionality of the probe resulting in depressed specific conductance readings.
- Algal growth occluded the optical lenses on the turbidity and dissolved oxygen probes, resulting in elevated turbidity and erratic dissolved oxygen readings.
- Aquatic insects of the Order Trichoptera colonized on the probes affecting pH, specific conductance, dissolved oxygen, and turbidity readings.
- Parameter specific probes on the sondes would malfunction or fail resulting in missing data.
- Sondes were found partially buried in bottom sediments due to decreasing river flows or channel meander, affecting specific conductance, dissolved oxygen, and turbidity.

III.D. Data Quality Control Summary

The Quality Control Summary describes the results of the data quality evaluation performed on the water quality parameters collected during the three-year baseline program. Data quality was evaluated in the respective "Annual Data Summary Reports" (PRRIP 2010, 2012a, and 2012b). Overall the quality of the Platte River water quality data collected was found to be of sufficient quality to characterize the water quality during each monitoring period. The quality of the data collected and analyzed was assessed using the elements of precision, accuracy, representativeness, completeness, and comparability.

IV. THREE-YEAR BASELINE DATA SUMMARY

Water quality data collected during the three baseline years were combined into one database and assessed to describe Platte River water quality absent of Program actions. This database will be used to determine if future Program actions have a statistically significant effect on Platte River water quality.

IV.A. Summary Statistics

Intra-year summary statistics were completed after the data had been reviewed to ensure the data summarized were representative of water quality in the central and lower Platte River. All data was loaded into a Microsoft® Access 2010 database for manipulation of the data and summarized and/or statistical analyses performed using R statistical software (http://www.r-project.org/) or Microsoft® Excel 2010. Summarization included a tabular presentation of instantaneous and daily observations (number (N), mean, maximum, minimum, and standard deviation) for each parameter and is presented in the respective "Annual Data Summary Reports" (PRRIP 2010, 2012a, and 2012b). Annual summary statistics are presented in Appendix C.

Data was graphed to present temporal, spatial and flow variation and/or similarity. Appendix B presents the following graph sets.

- Figure B-1 through B-6 presents temporal data in a series of line graphs for each parameter by monitoring location. Weekly parameter means are graphed for the three Platte River baseline years.
- Figures B-7 through B-12 presents spatial data in a series of annual box-plots for each parameter by monitoring location. Box-plots present annual minimum, 25th, 50th, 75th percentile; and maximum parameter values of a parameter for the three Platte River baseline years.
- Figures B-13 through B-18 present spatial data in a series of monthly box-plots for each year by parameter and monitoring location. Box-plots present monthly minimum, 25th, 50th, 75th percentile; and maximum values of a parameter by month for the three Platte River baseline years.
- Figure B-19 through B-23 presents water quality data relative to discharge data in a series of scatter plots (i.e., X-axis presents discharge, Y-axis presents parameter value). Weekly mean discharge and water quality value are plotted and a regression model was fit to the data. The results of the regression model are discussed in further detail in Section IV.B.3.

IV.B. Statistical Analysis

The data set for the six Platte River water quality parameters monitored during the three Platte River baseline years at eight monitoring locations was subjected to statistical analysis to assess the variation and/or similarity of the water quality data. Three statistical analyses were performed to evaluate the three-year data set:

1. Friedman's Test tested the null hypothesis that a given year did not differ significantly from the other two years; e.g., was temperature at Lexington the same or different over the three year period? Friedman's test is a nonparametric test that is similar to the commonly-used two-way ANOVA test to compare the means of more than two populations, but does not require the underlying distributions of the data to be normal and symmetric (Gilbert 1987).

2. Wilcoxon Sign Rank Test was used to compare weekly parameter means for all three years among monitoring locations to determine whether there were groups of stations with similar observations.
3. A regression model compared weekly mean water quality to weekly mean discharge and was used to evaluate which parameters show a consistent relationship to river flow.

IV.B.1. Friedman's Test

The Platte River water quality data sets were compared across the years to determine whether there are any significant differences between the data sets year-to-year. For each water quality parameter and monitoring location, Friedman's test was used to compare weekly mean values for the three year baseline period. The observations were grouped by week (similar to a paired t-test), and only weeks with observations in all three years were included.

Results are summarized in Table 4 and include a test statistic, F, and the number of weeks compared (n). The shaded cells indicate parameters and stations where a parameter value from at least one was different than one or both of the other years at the 95 percent confidence level.

Table 4. Freidman's Test Results Comparing the Magnitude of 2009, 2010, and 2011 Water Quality Weekly Mean Values

Location	Temperature, °C	Specific Conductance, mS/cm	pH	Turbidity, NTU	Dissolved Oxygen, mg/L	Discharge, cfs
Lexington	F=5, n=26	F=26, n=21***	F=6, n=22	F=14, n=22**	F=1, n=24	F=52, n=28***
Overton	F=6, n=28	F=39, n=27***	F=21, n=28***	F=11, n=28*	F=18, n=28**	F=54, n=29***
Odessa	F=12, n=28*	F=29, n=26***	F=4, n=28	F=15, n=26**	F=0, n=28	F=60, n=31***
Kearney	F=7, n=28	F=21, n=25***	F=1, n=27	F=10, n=26	F=0, n=28	F=54, n=29***
Shelton	F=6, n=28	F=34, n=23***	F=14, n=28**	F=7, n=28	F=8, n=28	F=52, n=28***
Grand Island	F=2, n=28	F=32, n=26***	F=7, n=28	F=4, n=27	F=4, n=28	F=53, n=29***
Duncan	F=6, n=28	F=29, n=25***	F=7, n=28	F=5, n=27	F=4, n=24	F=52, n=29***
Louisville	F=5, n=26	F=28, n=26***	F=14, n=22**	F=9, n=24	F=1, n=26	F=37, n=29***

Shaded cells and asterisks indicate test results that were significant at the 99.9% (***), 99% (**), or 95% (*) confidence levels after a Bonferroni correction for performing eight tests for each parameter.

- **Temperature –** Year-to-year variations in water temperature at seven of the eight monitoring locations were similar. Only the Odessa station exhibited annual temperatures that were significantly different among years at the 95% confidence level.

- **Specific Conductance** – Year-to-year specific conductance varied significantly among the three baseline years at the 99.9% confidence level at all eight monitoring locations.

- **pH –** Year-to-year variation in pH was similar between the three baseline years at Lexington, Odessa, Kearney, Grand Island, and Duncan. It was significantly different among years at Shelton and Louisville at the 99% confidence level and at Overton at the 99.9% confidence level.

- **Turbidity –** Year-to-year turbidity was similar between the three baseline years at the downstream monitoring locations at Kearney, Shelton, Grand Island, Duncan, and Louisville. Turbidity at the three upstream monitoring locations varied significantly at the 95% confidence level at Overton and at the 99% confidence level at Lexington and Odessa.

- **Dissolved Oxygen –** Year-to year dissolved oxygen at seven of the eight monitoring locations were similar. Only at the Overton station did annual dissolved oxygen values vary significantly (99% confidence level) among years.

- **Discharge –** Year-to-year discharge was significantly different between the three baseline years at the 99.9% confidence level at all eight monitoring locations.

IV.B.2. Wilcoxon Sign Rank Test

Weekly means for all three years were compared among stations to determine whether there were groups of stations with similar observations and to assess spatial variation between monitoring locations. Because all of the data sets were non-normal, the non-parametric Wilcoxon signed rank test was used to identify which data sets are significantly different or similar to each other. Paired, two-sided tests were performed for all pairs of stations for each parameter. Because multiple statistical tests were performed for each parameter, a Bonferroni correction was applied to reduce the likelihood of a Type I error. Test results suggesting stations were similar were grouped (i.e., if Station 1 was similar to both Stations 2 and 3, and station 2 and 3 are similar to each other, then a group was created consisting of Stations 1, 2, and 3.)

Table 5. Wilcoxon Sign Rank Test Groupings Comparing Values at each Location using Three Years of Weekly Mean Observations

Temperature, C (n=72)			
Location	**mean**	**Groups[a]**	
Lexington	20.24	a	
Overton	20.53		b
Odessa	20.44		b
Kearney	20.37	a	b
Shelton	20.98		
Grand Island	21.30		
Duncan	21.48		
Louisville	21.76		

Specific Conductance, mS/cm (n=51)				
Location	**mean**	**Groups[a]**		
Lexington	0.883	a		
Overton	0.894	a	b	c
Odessa	0.917		b	c
Kearney	0.902	a	b	c
Shelton	0.917		b	
Grand Island	0.902	a		c
Duncan	0.881	a		c
Louisville	0.684			

pH (n=48)				
Location	**mean**	**Groups[a]**		
Lexington	8.16	a		
Overton	8.21	a		
Odessa	8.24	a		
Kearney	8.25	a	b	
Shelton	8.33		b	
Grand Island	8.40			
Duncan	8.51			c
Louisville	8.56			c

Turbidity, NTU (n=45)				
Location	**mean**	**Groups[a]**		
Lexington	29.0	a		
Overton	32.8	a		
Odessa	50.2		b	
Kearney	44.3			
Shelton	61.1		b	c
Grand Island	68.3			c
Duncan	77.3			c
Louisville	236.7			

Dissolved Oxygen, mg/L (n=57)				
Location	**mean**	**Groups[a]**		
Lexington	7.86	a		
Overton	7.94	a		
Odessa	8.01	a		
Kearney	7.90	a		
Shelton	8.04	a		
Grand Island	8.40			c
Duncan	8.79		b	
Louisville	8.59		b	c

Discharge, cfs (n=72)				
Location	**mean**	**Groups[a]**		
Lexington	1649			
Overton	2739	a	b	
Odessa	2685	a		
Kearney	2801		b	
Shelton	2937			c
Grand Island	3005			c
Duncan	3477			
Louisville	13196			

[a]Stations were grouped as similar if Wilcoxon signed rank test results indicated the paired weekly observations were not different at the 95% confidence interval after a Bonferroni correction.

In general, the grouping results (Table 5) show that stations located close to each other were similar. For pH, turbidity, and dissolved oxygen, the stations are grouped fairly consistently in the river-flow direction. For water temperature, the downstream stations are not grouped as similar. Although, water temperature differences are very small, they are consistently increasing in the downstream direction week-to-week so that there is little overlap between the values at these stations. Specific conductance groups are not as clear-cut because of the large amount of variability in this parameter, with the exception of Louisville where specific conductance is significantly different from all of the upstream stations. For discharge, the groupings reveal that the low-flow (Lexington) and high flow (Duncan and Louisville) stations are different from those in the middle of this river reach.

IV.B.3. Regression Model

Weekly mean water quality observations for the entire baseline monitoring period (March to November for the three baseline years) were compared to weekly mean discharge at each station. Scatter plots (Figure B-19 through B-23) and simple linear regression models (Table 6) were developed to evaluate which parameters show a consistent relationship to river flow. The discharge at all stations was examined to determine if log-scaling was necessary to fit a valid statistical model, only the Louisville station required log-scaled discharge because of a few extremely high flow events.

Table 6. Regression Model Comparing Weekly Mean Water Quality to Weekly Mean Discharge; water quality = $\beta_0 + \beta_1$(discharge). March to November 2009, 2010, and 2011.

Parameter	Location	R^2	slope	p-value	Significance[a]
Water Temperature	Lexington	0.078	1.1E-03	0.006	**
	Overton	0.024	5.4E-04	0.127	
	Odessa	0.021	4.9E-04	0.146	
	Kearney	0.030	5.6E-04	0.087	
	Shelton	0.018	4.5E-04	0.190	
	Grand Island	0.017	4.4E-04	0.200	
	Duncan	0.017	3.9E-04	0.191	
	Louisville (log discharge)[b]	0.027	5.11	0.111	
Specific Conductance	Lexington	0.053	-1.2E-05	0.031	*
	Overton	0.250	-2.4E-05	<0.001	***
	Odessa	0.127	-1.6E-05	<0.001	***
	Kearney	0.062	-1.0E-05	0.014	*
	Shelton	0.171	-1.5E-05	<0.001	***
	Grand Island	0.198	-1.6E-05	<0.001	***
	Duncan	0.024	-4.6E-06	0.127	
	Louisville (log discharge)[b]	0.050	-0.105	0.028	*
pH	Lexington	0.013	-1.5E-05	0.287	
	Overton	0.272	-5.7E-05	<0.001	***
	Odessa	0.116	-3.5E-05	0.001	***
	Kearney	0.153	-3.6E-05	<0.001	***
	Shelton	0.244	-4.7E-05	<0.001	***
	Grand Island	0.094	-2.9E-05	0.002	**
	Duncan	0.089	-2.4E-05	0.003	**
	Louisville (log discharge)[b]	0.601	-1.01	<0.001	***

Parameter	Location	R^2	slope	p-value	Significance[a]
Turbidity	Lexington	0.251	4.5E-03	<0.001	***
	Overton	0.009	8.5E-04	0.342	
	Odessa	0.010	1.1E-03	0.331	
	Kearney	0.007	1.4E-03	0.398	
	Shelton	0.072	-4.0E-03	0.008	**
	Grand Island	0.013	-1.9E-03	0.257	
	Duncan	0.007	-1.9E-03	0.402	
	Louisville (log discharge)[b]	0.358	769	<0.001	***
Dissolved Oxygen	Lexington	0.127	-3.2E-04	<0.001	***
	Overton	0.083	-2.6E-04	0.004	**
	Odessa	0.038	-1.4E-04	0.053	
	Kearney	0.052	-1.6E-04	0.023	*
	Shelton	0.074	-1.9E-04	0.007	**
	Grand Island	0.066	-1.7E-04	0.010	*
	Duncan	0.074	-1.5E-04	0.008	**
	Louisville (log discharge)[b]	0.211	-3.29	<0.001	***

[a] Significance column indicates if relationship is significant at the 99.9% (***), 99% (**) or 95% (*) confidence level.

[b] For all Louisville analyses, the discharge was log-scaled.

The regression results show a large amount of scatter in the relationship between each of the water quality parameters and discharge. This is apparent in the scatter plots (Figure B-19 through B-23) as well as the low R^2 values from the linear regressions (Table 6). This suggests that other variables besides discharge are also important in influencing each of the water quality parameters, even if discharge has a significant influence on some of the parameters. The column labeled "slope" indicates whether the relationship between the water quality parameter and discharge is positive or negative. Together with the p-value and significance columns, these results show whether the parameter significantly increases or decreases when discharge changes. Looking across stations, the results suggest that specific conductance, pH, and dissolved oxygen all decrease when discharge increases. For water temperature, a significant relationship was only identified at Lexington, showing an increase in temperature with increased discharge. The temperature scatter plots show that temperatures during high flow weeks are high, while there is no relationship during mid-and-low flows. This is consistent with the annual patterns of temperature and discharge (Figure B-1 and Figure B-6). There is no consistent pattern for turbidity, but at three stations there is a significant relationship between turbidity and discharge (Lexington is positive, Shelton is negative, and Louisville is positive). The scatter plots once again demonstrate that it is the highest flow events that are influencing these trends – at Lexington and Louisville the highest flows have relatively high turbidity while at Shelton the highest flows have low turbidity.

IV.C. Metals and Bacteria

A total of 96 discrete water samples were collected from the eight water quality monitoring locations and analyzed for dissolved and total metals during the three year baseline water quality monitoring period. Table 7 presents a summary of the analytical results for metals in water samples collected from the Platte River.

Table 7. Summary of Total and Dissolved Metals, 2009, 2010, and 2011.

Parameter	Analysis	Detects	Non-Detects	% Detected	Average	Minimum	Maximum
Total Metals mg/L							
Calcium	96	96	0	100.0%	72.9	50.2	98.7
Magnesium	96	96	0	100.0%	23.8	13	31.1
Selenium	96	11	85	11.5%	0.00231 J	0.00177 J	0.00414 J
Dissolved Metals mg/L							
Copper	96	10	86	10.4%	0.00211 J	0.00153 J	0.0034
Lead	96	3	93	3.1%	0.00302 J	0.00244 J	0.00417
Nickel	96	20	76	20.8%	0.00430 J	0.00264	0.00762 J
J – Estimated value							

Analytical results for each sampling event are presented in the respective annual data summary reports referenced in Section I.A.

Total Calcium was reported above the laboratory reporting limit in all 96 samples submitted for analytical analysis. Concentrations ranged from a low of 50.2 mg/L to a high of 09.7 mg/L and averaged 72.9 mg/L.

Total magnesium was reported above the laboratory reporting limit in all 96 the samples submitted for analytical analysis. Concentrations ranged from a low of 13 mg/L to a high of 31.1 mg/L and averaged 23.8 mg/L.

Total selenium was reported as non-detect in 85 of the 96 samples submitted for analytical analysis. Eleven samples had total selenium reported as estimated (J) and no samples were reported at concentrations greater than the laboratory reporting limit. Concentrations ranged from an estimated low of 0.00177 mg/L to an estimated high of 0.00414 mg/L and averaged an estimated 0.00231 mg/L.

Dissolved copper was reported as non-detect in 86 of the 96 samples submitted for analytical analysis. Three samples had dissolved copper concentrations higher than the laboratory reporting limit and seven samples had dissolved copper reported as estimated (J). Concentrations ranged from an estimated low of 0.00153 mg/L to a reported high of 0.0034 mg/L and averaged an estimated 0.00211 mg/L.

Dissolved lead was reported as non-detect in 93 of the 96 samples submitted for analytical analysis. One sample had dissolved lead higher than the laboratory reporting limit and two samples had dissolved lead reported as estimated (J). Concentrations ranged from an estimated low of 0.00244 mg/L to a reported high of 0.00417 mg/L and averaged an estimated 0.00302 mg/L.

Dissolved nickel was reported as non-detect in 76 of the 96 samples submitted for analytical analysis. Eighteen samples had dissolved nickel reported at a concentration higher than the laboratory reporting limit and two had dissolved nickel reported as estimated (J). Concentrations ranged from a low of 0.00264 mg/L to an estimated high of 0.00762 mg/L and averaged an estimated 0.00430 mg/L.

IV.D. Bacteria

A total of 36 water samples were collected from Lexington, Kearney, and Grand Island and analyzed for coliform and *E. coli* bacteria in 2010 and 2011. In general three sampling events were completed during early spring and three events during the summer for six discrete sampling events at the three locations for each monitoring year. Table 8 presents a summary of the analysis of coliform and Table 9 presents a summary of *E. coli* bacteria during the 2010 and 2011.

Table 8. Summary of coliform, 2009, 2010, and 2011.

	Lexington	Kearney	Grand Island	All
	Coliform Bacteria, col/100mL	Coliform Bacteria, col/100mL	Coliform Bacteria, col/100mL	Coliform Bacteria, col/100mL
N	12	12	12	36
Average	6,868	8,542	11,913	9,108
Minimum	51	103	1,300	51
Maximum	>48,384	>48,384	48,383	>48,384

Table 9. Summary of *E. coli*, 2009, 2010, and 2011.

	Lexington	Kearney	Grand Island	All
	E. coli Bacteria, col/100mL	*E. coli* Bacteria, col/100mL	*E. coli* Bacteria, col/100mL	*E. coli* Bacteria, col/100mL
N	12	12	12	36
Average	190	420	1,984	865
Minimum	0	0	40	0
Maximum	917	1,202	7,746	7,746

Bacteria results for 12 sampling events are presented in the respective annual data summary reports referenced in Section I.A.

The 36 water samples analyzed for coliform bacteria had an average of 9,108 colonies per 100 ml (col/100ml) and counts ranged from 51 col/100ml to > 48,384 col/100ml. Average coliform colonies and minimum number observed progressively increased as samples were collected further downstream. Maximum coliform colonies were consistently equal to or greater than the number quantifiable by the analytical method at all three sampling locations.

The 36 water samples analyzed for *E. coli* bacteria had an average of 865 colonies per 100 ml (col/100ml) and counts ranged from 0 col/100ml to 7,746 col/100ml. Average *E. coli* colonies and the maximum number observed progressively increased in the downstream samples.

V. DATA QUALITY CONTROL SUMMARY

The quality of the Platte River data collected and analyzed was assessed using the elements of precision, accuracy, representativeness, completeness, and comparability. Water quality data collected and evaluated included temperature, specific conductance, pH, turbidity, dissolved oxygen, and discharge. Analytical data collected and analyzed included dissolved copper, dissolved lead, dissolved nickel, total selenium, total calcium, total magnesium, coliform and *E. coli* bacteria. Overall, the Platte River water quality data collected was found to be of sufficient quality to characterize water quality during the baseline monitoring period. Data quality for each of the three years of baseline water quality monitoring were evaluated and presented in their respective “Annual Data Summary Reports” (PRRIP 2010, 2011, and 2012).

VI. REFERENCES

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