Kingston Wetland Restoration Project

Feasibility Study

Prepared for:

Clearwater River Watershed District

June 2012

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Wenck File #0002-174

Prepared for:

CLEARWATER RIVER WATERSHED DISTRICT
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June 2012

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I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

6-13-12

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Feasibility Study

for

Kingston Wetland Restoration

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Acronyms

CRWD	Clearwater River Watershed District
DNR	Department of Natural Resources
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
lbs/ yr	pounds per year
LiDAR	Light Detection and Ranging (aerial mapping of topography with high resolution)
RR	Release Rate (of phosphorus from wetland sediments)
SOD	Sediment Oxygen Demand
SWMM	Storm Water Management Model (A hydrologic and hydraulic computer model)
TMDL	Total Maximum Daily Load

1.0 Background & Purpose

The Kingston Wetland Complex is a riparian wetland of the Clearwater River Chain of Lakes within the Clearwater River Watershed District (CRWD) shown in Figure A.1. The MPCA found that the Clearwater River between Clear Lake and Lake Betsy, Reach ID 07010203–549 located in Meeker County, Minnesota, is impaired and does not meet Minnesota water quality standards for dissolved oxygen (DO). This reach was placed on the 303(d) impaired waters list in 2004 because monitoring data have revealed that DO concentrations sometimes fall below the state standard of 5 milligrams per liter (mg/L) which can impair aquatic habitat. The Total Maximum Daily Load (TMDL) Study completed for this reach showed that the sediment oxygen demand (SOD) and altered wetland hydrology in the Kingston Wetland Complex were contributing to the DO impairment. The study further showed that a reduction in the Kingston Wetland SOD and possibly a change in hydrology would be needed to meet the state standard.

Historically, the Clearwater River was straightened and ditched through the Kingston Wetland to facilitate drainage of fields for agriculture, the dominant land use in the watershed. In the early 1980s the CRWD undertook a project in the Kingston Wetland Complex to restore the wetland's assimilative capacity for particulate phosphorus and to improve water quality in downstream lakes. The project was part of the CRWD's 1980 Clearwater River Chain of Lakes Restoration Project through which average summer surface Total Phosphorus (TP) concentrations in Clearwater Lake improved from 400 µg/L to 40 µg/L.

The original Kingston Wetland Treatment System included a dike and ditch constructed around the wetland's perimeter to route the Clearwater River to the edges of the wetland to allow it to filter through the wetland and back into the main channel. A perpetual easement was secured on the property through the 1980 Clearwater River Chain of Lakes Restoration Project. The Project was designed to remove particulate phosphorus by restoring some hydrology to the wetland. The Project successfully improved water quality in all the downstream lakes over the past 30 years.

The Kingston Wetland Complex as it is today serves as a natural sink for particulate phosphorus and is somewhat protective of water quality in downstream lakes. However, the DO TMDL (Wenck 2010) showed that nutrients in wetland sediments impose an oxygen demand that reduces DO levels in the main channel and at times contribute soluble phosphorus to downstream lakes. The TMDL Implementation Plan (Wenck 2010) identified a restoration of the Kingston Wetland Complex to address these issues.

As such, the Clearwater River Watershed District applied for and was awarded a Federal 319 Grant to conduct a feasibility study and restoration of the Kingston Wetland Complex. The project workplan dated March 2011 is titled: *The Kingston Wetland Feasibility Study and Restoration TMDL Project QAPP* (Appendix B).

The project goal is to design and implement a Clearwater River and Kingston Wetland Complex restoration plan to improve dissolved oxygen concentrations in the Clearwater River, reduce nutrient loads to impaired Lakes Betsy, Union, Louisa, Marie, and Caroline, connect a recreational corridor, and improve riverine and wetland habitat. This report evaluates the feasibility of the project and the data collected to support design.

The specific project goals include:

- DO improvements which are to be achieved by mitigating sediment oxygen demand in the wetland complex.
- A 60% wetland SOD reduction and a 1,970 lbs/yr TP reduction to Lake Betsy and five other nutrient impaired lakes by preventing soluble phosphorus export from the riparian wetland. Improving the system will protect its existing phosphorus assimilative capacity and will help six nutrient–impaired lakes downstream meet their water quality standards while protecting two high value recreational waters: Clearwater and Grass Lakes.

The CRWD also seeks to improve the riparian wetland and main channel habitat by restoring the system to a pre–agrarian condition, re–establish a Clearwater River corridor to connect the upper agricultural watershed with the downstream recreational lakes area, and to engage local stakeholders by involving them in a technical advisory process. Further, the CRWD seeks to educate area residents through the distribution and posting of educational materials and by including project activities and achievements in its annual watershed tour.

A restored condition that is closer to native landscape is intended to provide wetland and riverine habitat to support a broader range of species while also transitioning the system from a ditched wetland system to a significant riverine recreational resource.

Based on data collected to date, these goals can be achieved by redirecting the low flow channel through the Kingston Wetland Complex which will enable high flows to access the floodplain and reduce the main channel low flow exposure to sediment oxygen demand and soluble phosphorus export in the wetland while maintaining the assimilative capacity of particulate phosphorus in higher flows.

This report assesses the feasibility of the goals outlined in the grant application and makes recommendations on the conceptual design elements, provides an estimate of probable costs and benefits from the project.

2.0 Data Analysis

2.1 DATA COLLECTED AND EVALUATED

2.1.1 LidAR, River and Wetland Morphometry, Survey and Hydraulic Data

- **LiDAR Data**: LiDAR data was provided for the area by the Minnesota DNR.
- **Survey & Hydraulic Data**: Surveying was conducted on the main channel of the Clearwater River and Kingston Wetland Complex as well as the culverts and structures upstream and downstream of the system that govern flow. Where structures were in place, shape, diameter and condition were also documented. Figure A.2 shows the locations of key structures within the wetland where these data were collected. Figure A.2 also depicts the existing drainage patterns through the wetland complex.

2.1.2 Hydrologic Data

Discrete measurements of stage and flow were measured at the locations shown on Figure A.3. Continuous stage data were also collected at CR 29.0 and CR 28.2. These data were converted to a hydrograph by development of a stage-discharge relationship for the areas. These data were collected to provide data for hydrologic and hydraulic model calibration and to aide in concept design of the wetland restoration.

2.1.3 Water Quality Data

Water quality data was collected in the main stem of the Clearwater River upstream and downstream of the Kingston Wetland Complex. Water quality data was also collected from four tributaries to the complex. Sample collection locations are indicated on Figure A.3. Sample collection occurred approximately every two weeks during April through October, 2011. Samples were paired with field measurements of flows and collected field parameters include DO, temperature, pH and conductivity. Samples were analyzed at MVTL Laboratories for the following parameters:

- Chlorophyll a (corrected for pheophytin).
- Total Phosphorus, TP (as P).
- Orthophosphate, SRP (as P).
- Total Suspended Solids, TSS.
- Volatile Suspended Solids, VSS.
- Alkalinity.

Data was also previously collected upstream and downstream of the wetland complex (at CR 29.0 and CR 28.2) in 2006. Additional historical water quality data, collected in 2001 to 2010, was also available for location CR 28.2.

2.1.4 Macro-Invertebrate Sampling

A baseline macro invertebrate survey is scheduled for summer of 2012 to be completed prior to construction. This will document the initial conditions prior to project construction. Additional sampling will be conducted following construction, once the channel and wetland have been vegetated to quantify any impacts of the project on the invertebrate population. The methods to be used are documented in the workplan for this study included as Appendix B to this report.

2.1.5 Sediment Sampling

Sediment samples were collected at two locations within the wetland and analyzed at Aquatic Restoration and Research, LLC for phosphorus release rates and SOD using the methods described in Appendix B. A report dated May 18, 2012 presented sediment release rates and SOD at each sample location as tabulated below. The numbers reported below are not subject to change; however a final report summarizing the sediment sampling results as a whole has not yet been received. Sample station locations are indicated on Figure A.3.

Table 2.1. Wetland Sediment Sampling Results

Station	SOD (g/m^2- day)	Rate of Phosphorous Release (mg/ m^2- day)
Site 1	1.09	18.5
Site 2	1.08	34.6

2.2 DATA ANALYSIS

Available data were evaluated with the objective of determining current hydrology of the wetland complex/river system as well as to evaluate existing water quality and phosphorus export (TP and SRP). The collected water quality data paired with the collected flow data indicates a strong correlation between flows and various water quality parameters. The differing water quality upstream and downstream of the wetland complex is also apparent. Both 2006 and 2011 water quality data was evaluated as these years represent varying conditions within the flow-through system. 2006 was a dry year compared to 2011 and subsequently represents significantly lower flow conditions. Therefore, the data presented in this section represents the spectrum of existing flow conditions.

2.2.1 Existing Conditions Hydrology and Flow Path Determination

The existing topography, wetland morphometry, channel morphology, and wetland function were determined by examining the wetland topographic and bathymetric data collected in the field; LidAR elevation data; and structure survey data. From these data sources, along with field observations, it is determined that water enters into the Kingston Wetland from the Clearwater River and surrounding tributaries through the existing bypass channel designed in the early 1980s (Figure A.2). The water from the existing channel filters into the wetland at various points indicated on Figure A.2. There are two locations where the banks have eroded away and flow from the existing bypass channel is being short circuited into the wetland. Most of the flow coming from the Clearwater River flows into and is routed through the wetland at these breakout locations (Figure A.2).

2.2.2 Dissolved Oxygen (DO)

A correlation between flow and dissolved oxygen is not apparent, however, Figures 2.1 and 2.2 below indicate that the dissolved oxygen concentration downstream of the wetland (CR 28.2) is significantly lower than that observed upstream (CR 29.0). In both data years, paired flow and dissolved oxygen concentrations were recorded from April to October.

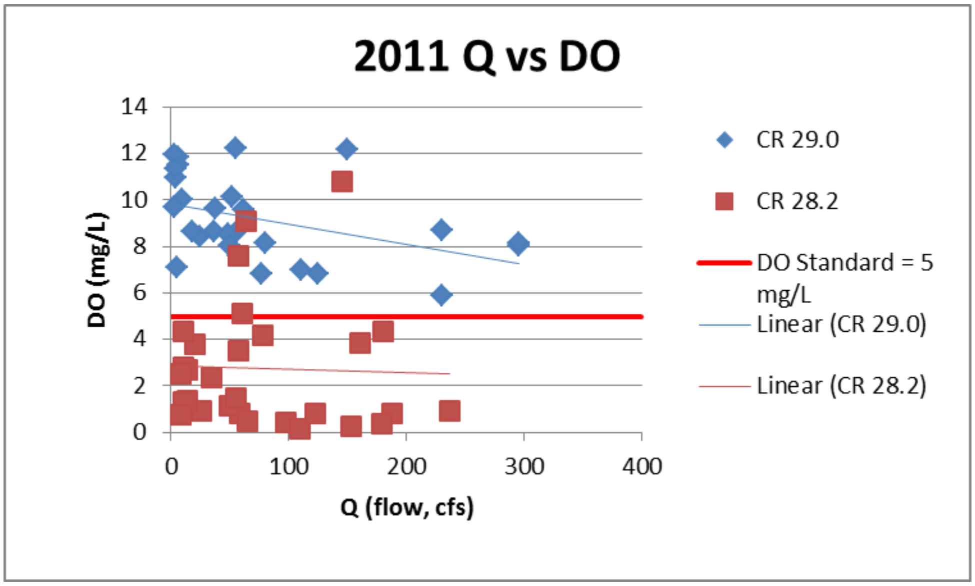

Figure 2.1. 2011 Flow and DO Concentrations

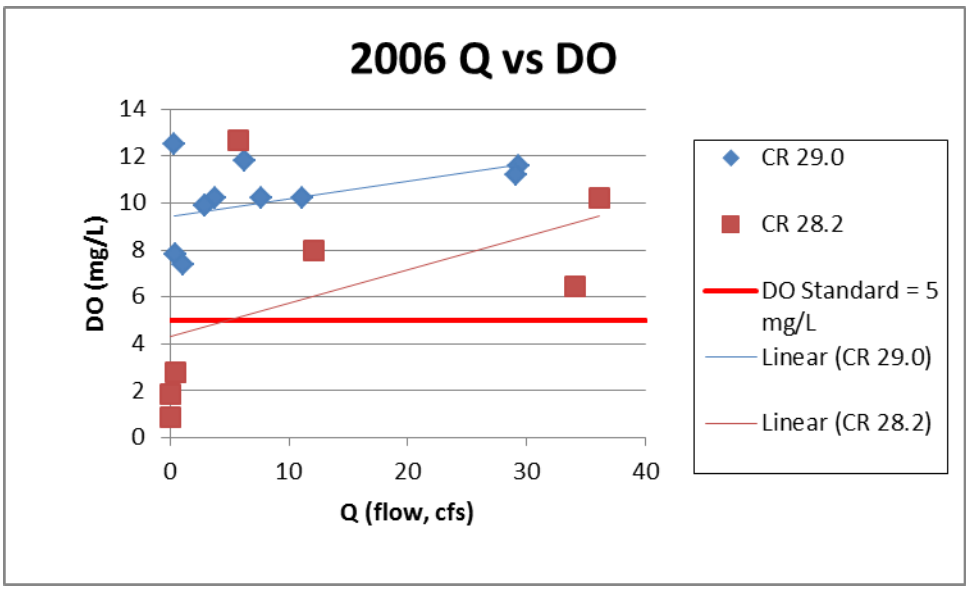

Figure 2.2. 2006 Flow and DO Concentrations

Figures 2.3 and 2.4 provide a time series of DO concentrations both upstream and downstream of the wetland complex for 2011 and 2006, respectively. Flow at CR 28.2 for both years is depicted as well. The 2011 data indicates that there is seasonal variation in the DO concentrations. As temperatures increase in the summer months, DO concentrations increase as well. The 2006 data does not indicate a strong seasonal variation, however, that may be attributed to the limited data available for that year.

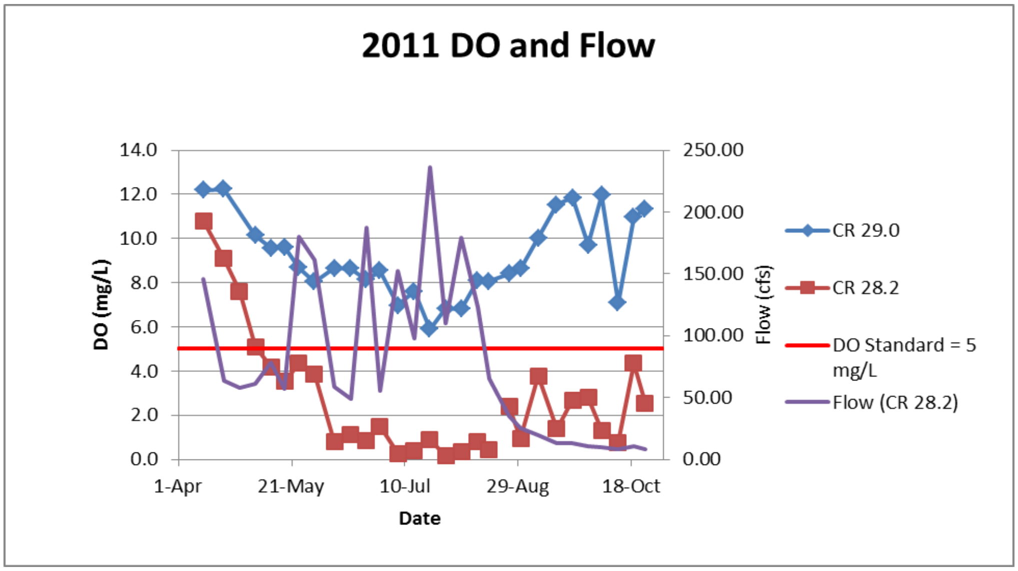

Figure 2.3. 2011 DO and Flow Time Series

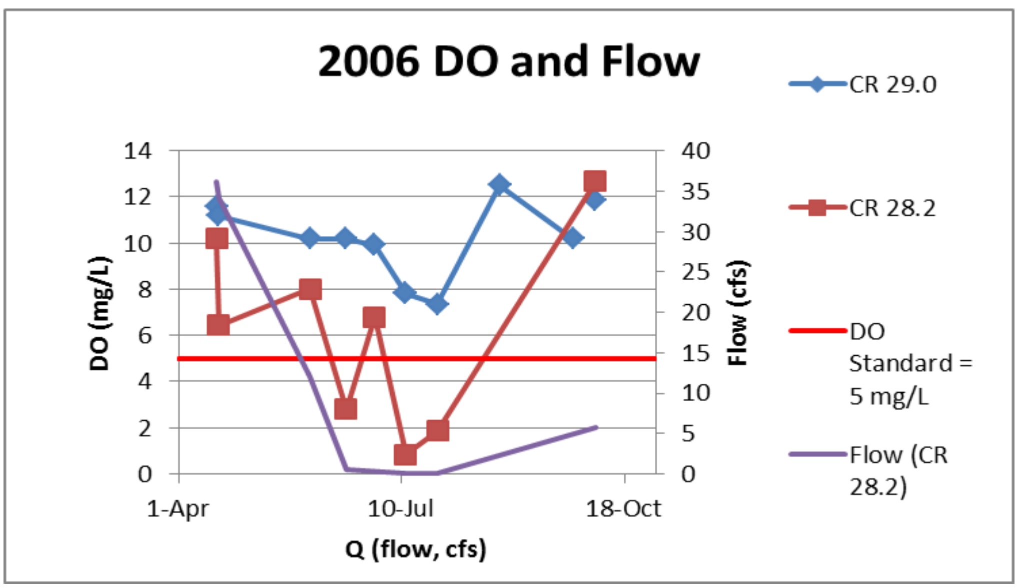

Figure 2.4. 2006 DO and Flow Time Series

The above relationships indicate that under existing conditions, flow through the wetland complex is depleted of dissolved oxygen. QUAL modeling conducted for the DO TMDL Study concluded that a multiplicity of factors contribute to oxygen depletion in the wetland. Modeling demonstrated that the lack of fall in this section of the river (CR 29.0 to Lake Betsy) limits re-aeration, but that this factor alone was not enough to account for all of the observed oxygen depletion occurring in the wetland complex. The second factor is sediment oxygen demand in the wetland. Data collected in 2011 further supports the findings of the TMDL.

2.2.3 Total Suspended Solids (TSS)

As the Clearwater River flows through the wetland complex, the wetland is acting as a settling basis and removing TSS from the system. 2011 data indicates the concentration of TSS upstream of the wetland is significantly greater than the concentration observed downstream. There is also a direct correlation apparent between flow and TSS upstream of the wetland (Figure 2.5).

It can be assumed that as TSS is removed in the wetland, particulate phosphorus is removed as well. Figure 2.6 presents a correlation between TP and TSS upstream of the wetland complex (2011 data). As TSS concentrations increase, TP concentrations increase respectively.

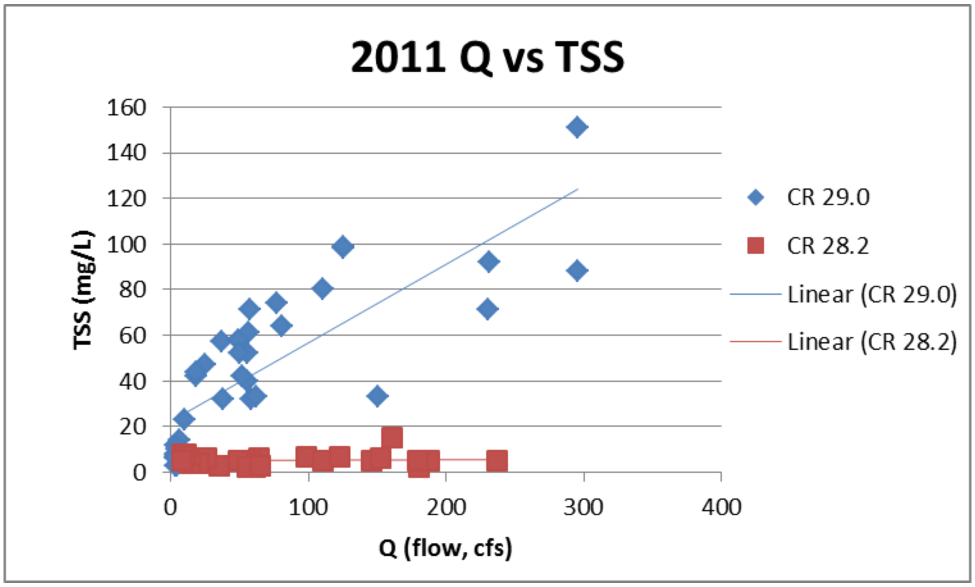

Figure 2.5. 2011 Flow and TSS Concentrations

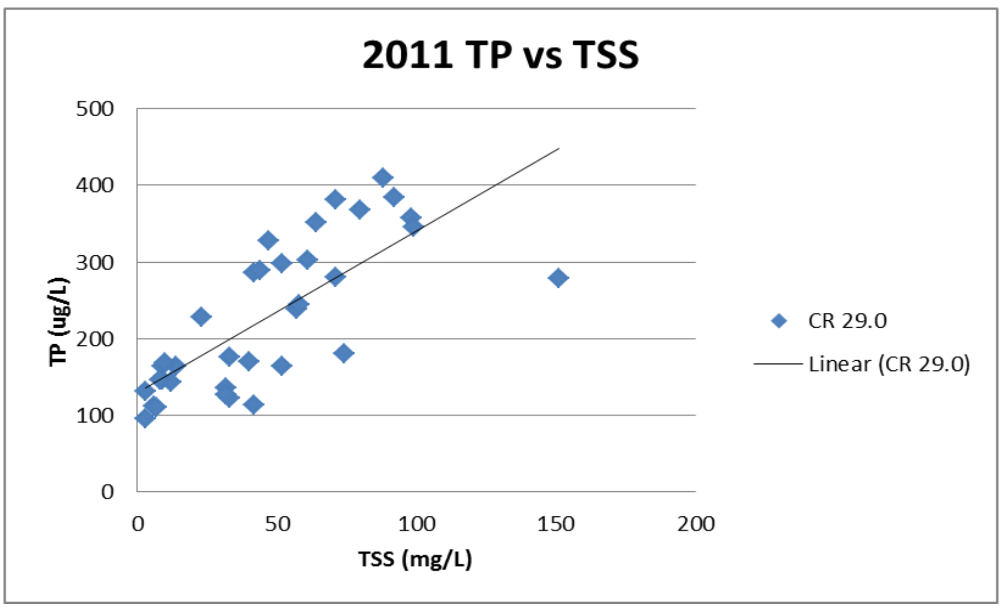

Figure 2.6. 2011 TP and TSS Concentrations Upstream of Kingston Wetland

2.2.4 Total Phosphorus (TP)

Figures 2.5 and 2.6 present the TP concentrations upstream and downstream of the wetland in 2011 and 2006, respectively. The observed data suggests that TP concentrations downstream of the wetland are often greater then upstream during warm, summer months when flows are low. Although the TP and TSS relationship (discussed above) indicates that particulate phosphorus settles out in the wetland, the higher TP concentration downstream of the wetland indicates that as the water flows through the wetland complex (accessing the phosphorus that natural accumulates in the wetland sediments), soluble phosphorus is exported from the wetland.

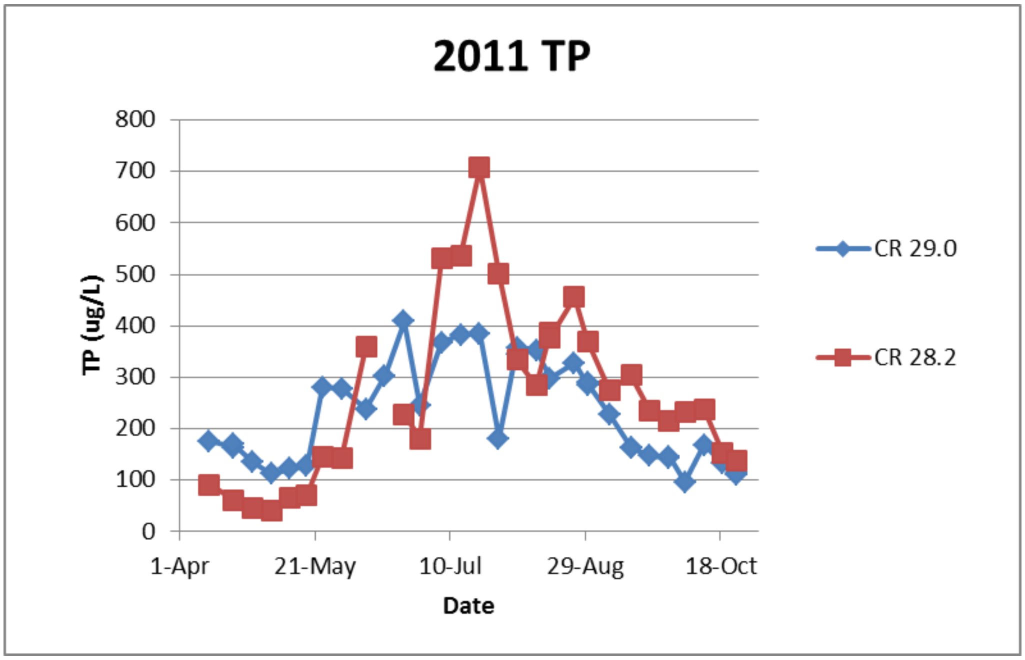

Figure 2.7. 2011 TP Concentrations

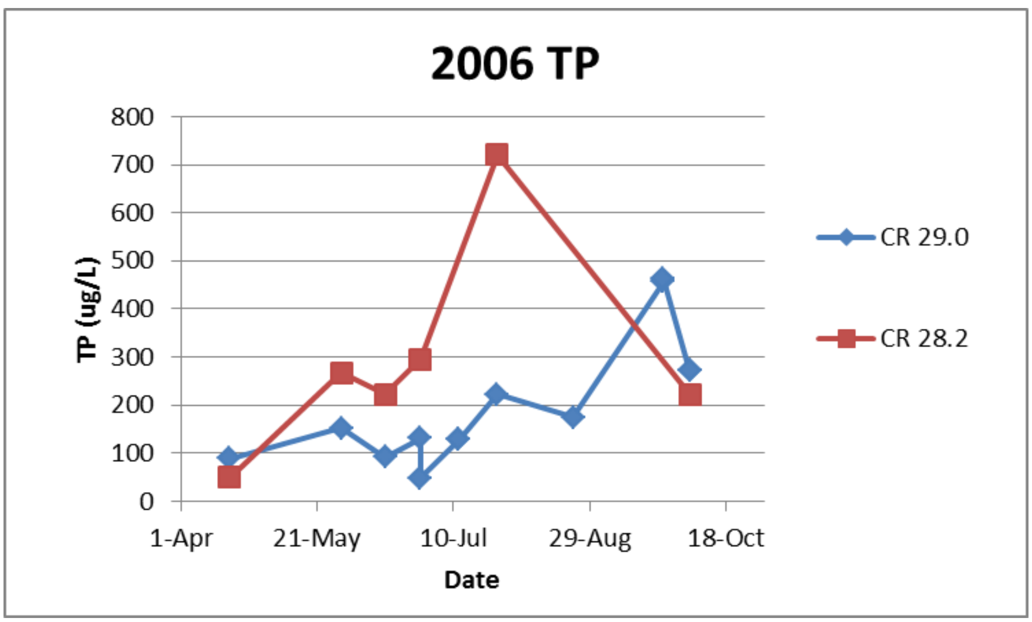

Figure 2.8. 2006 TP Concentrations

From the 2011 collected flow and TP concentration data at CR 29.0 (upstream) and CR 28.2 (downstream), flow weighted mean TP concentrations of 280 ug/L and 295 ug/L were calculated, respectively. The flow weighted mean concentrations correlate to annual TP loads of 22,658 lbs upstream and 24,606 lbs downstream of the wetland. Data collected in 2006 indicates flow weighted mean TP concentrations of 88 ug/L at CR 29.0 and 128.0 ug/L at CR 28.2; this correlates to a TP load of 527 lbs/yr and 1,107 lbs/yr, respectively. This data supports the assumption that phosphorus is being added to the water as it flows through the wetland complex.

2.2.5 Soluble Reactive Phosphorus (SRP)

From the 2006 and 2011 collected water quality data, the ratio of SRP to TP was calculated. The table below presents the average SRP/TP ratio from the collected data, as a percentage, both upstream and downstream of the wetland complex.

Table 2.2. SRP/TP Ratio

Sample Station	2006 SRP/TP (%)	2011 SRP/TP (%)
CR 29.0	68	46
CR 28.2	67	45

The SRP/TP ratio is similar at both stations for both data years.

Water quality data was collected in 2011 at four tributaries within the project study area. Paired flow and SRP concentration data collected at stations TW 27.8, TE 27.8, and T 27.3 were used to calculate flow weight mean SRP concentrations for each tributary. These three tributaries flow directly into the wetland. From the flow weighted mean concentrations, the total SRP load contribution to the wetland from the tributaries was calculated to be approximately 440 lbs/year in 2011.

3.0 Hydrologic and Hydraulic Modeling

In addition to physical data collection, the hydrology and hydraulics of the riverine/wetland system was also evaluated. Wenck Associates developed a one dimensional hydrologic and hydraulic model of the Kingston Wetland Complex using EPA's Storm Water Management Model (SWMM). SWMM is widely used for planning, analysis and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas, with many applications in non-urban areas as well. The model was calibrated to measured data from 2011 at the CR 28.2, CR 29.0, and Lake Betsy gauges.

The modeling approach taken in this study was to develop a working long term simulation model that provides a reasonable estimate of the year in and year out conditions for the wetland. Using the calibrated model with refined boundary conditions and input parameters, the model is used in the design process by determining the 1 inch, 2-year, and 10-year return interval responses to the system for both pre and post conditions.

Inputs to the model included surveyed topography and bathymetry of the wetland, surveyed pipe inverts for upland culverts, LiDAR surface contours, soil survey data, land use data, and Lake Betsy Bathymetry data. The modeling domain is shown in Figure A.4.

The following sections describe the development of the model and modeling results.

3.1 DESCRIPTION OF COMPUTER MODEL EPA-SWMM

The Environmental Protection Agency's, Stormwater Management Model (SWMM) is a general purpose urban hydrology and conveyance system hydraulics software. It is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each sub-catchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

3.2 DATA REQUIREMENTS

Modeling in SWMM requires a significant amount of input data in order to define the physical characteristics of the basin or basins and the associated boundary conditions that are being modeled. The resolution of the input data defines how accurate or robust the model is for use in planning analysis. The data requirements for the setup of this model are:

- Soils data.
- Land use data.
- Topographic data.
- Climatologic data.
- Cross Section data.

3.3 SOILS AND LAND USE

The most recent statewide Geographic Information Systems (GIS) data for soils and land use were obtained and isolated within the boundaries of the study watersheds. Soils data with the corresponding hydrologic soil group (A, B, C, or D) was derived from the most up to date Natural Resources Conservation Service (NRCS), Soil Survey Geographic (SSURGO) database (2003-2007). Figure A.5 shows the hydrologic soil group classifications within the watershed.

Land Use categories were developed from the 2009 National Agricultural Statistics Service (NASS) Land Cover database. Wetlands from the NWI database were incorporated into the NASS land use database as the wetland delineations in the NWI database are more accurate. Figure A.6 shows the distribution of land uses within the watershed.

3.4 TOPOGRAPHIC INFORMATION

Topographic Data used for modeling was previously discussed in Section 2.1.1.

3.5 CLIMATOLOGY INPUTS

Several climatology parameters are necessary inputs to the SWMM model. These parameters include rainfall data, temperature, wind speed, evaporation, snowpack, and abstractions. Snowpack is accounted for in the long term simulations; however, default parameters were used and are not discussed below. The following sections detail the climatology inputs used for the Kingston Model.

3.5.1 Rainfall, Temperature, and Snow

Long term rainfall and temperature data were obtained for the period of January 1, 1980 to December 24, 2011 using the Minnesota Climatology Working Group, Historical data retrieval site for the Kimball, MN area (http://www.climate.umn.edu/). The resolution of the data obtained from this site is accumulated daily precipitation (inches) and average daily maximum and minimum temperature (degrees Fahrenheit). This resolution is considered appropriate for the long term simulation calibration and results desired. Table 3.1 shows a summary of the annual precipitation for the years used in this analysis compared to a 32 year average annual precipitation of 31 inches (derived from the source data).

Table 3.1. Average annual rainfall for Kingston area

Year	Precip (in)	Variance from 32 Year Average	Year	Precip (in)	Variance from 32 Year Average
1980	25	-1.9	1996	20	-6.5
1981	28	1.2	1997	19	-8.1
1982	27	0.3	1998	29	2.1
1983	39	12.1	1999	22	-4.7
1984	27	0.0	2000	18	-8.7
1985	34	7.4	2001	25	-1.6
1986	38	10.9	2002	37	10.6
1987	14	-13.0	2003	20	-6.8
1988	16	-11.2	2004	29	2.1
1989	19	-7.7	2005	29	2.1
1990	40	12.9	2006	21	-5.5
1991	38	11.3	2007	24	-3.2
1992	19	-8.2	2008	23	-3.8
1993	33	6.4	2009	27	-0.1
1994	29	2.5	2010	34	7.2
1995	29	2.4	2011	30	3.0

Event storms such as the 1 inch, 2-year (2.7 inches), and 10-year (4.1 inches) 24 hour events were determined using the *Hydrology Guide for Minnesota* (USDA 1966). A cumulative hyetograph based on an SCS type II distribution was used in the model to estimate the full 24 hour rainfall distribution based on the total amounts discussed above. Figure 3.1 shows the SCS II unit hyetograph that was used to generate each event's distribution according to *Urban Hydrology for Small Watersheds Technical Release 55 (TR-55)* (SCS, 1986).

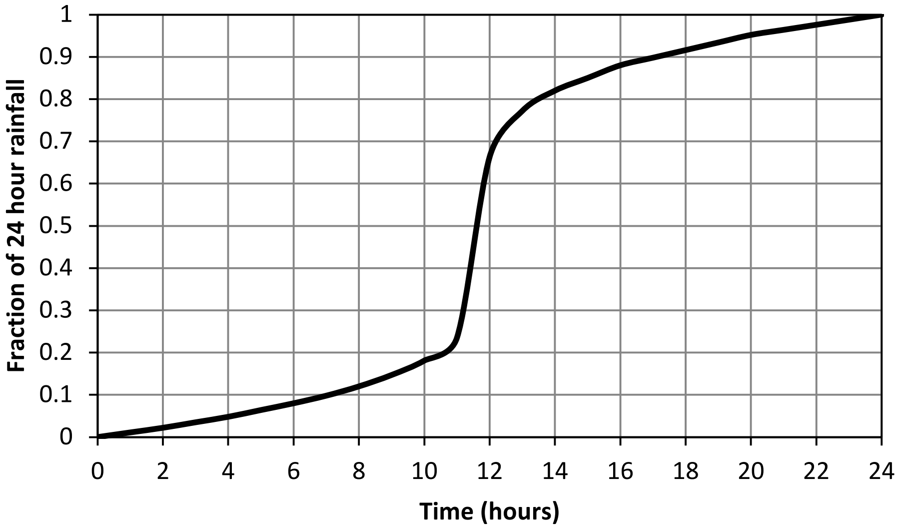

Figure 3.1. SCS type II unit hyetograph

3.5.2 Evaporation

Evaporation is handled in the model by using monthly pan evaporation data collected at the Saint Paul Campus Department of Soil, Water and Climate. This is a parameter that is adjusted in order to calibrate the model to measure. Table 3.2 shows the unadjusted values of pan evaporation and an estimate for lake evaporation based on a factor of 0.70 (standard pan coefficient for lakes).

Table 3.2. Monthly average pan and lake evaporation

Month	Pan Evaporation	Lake Evaporation
Jan	0.35	0.25
Feb	0.49	0.35
Mar	1.11	0.80
Apr	1.85	1.33
May	6.66	4.80
Jun	7.32	5.27
Jul	7.87	5.67
Aug	6.56	4.72
Sep	4.66	3.36
Oct	1.22	0.88
Nov	1.74	1.25
Dec	0.42	0.30

3.5.3 Losses

The loss approach used in this model is a Curve Number (CN) approach. Composite watershed curve numbers are generated for each subwatershed in the model. The approach used by

SWMM is adopted from the NRCS (SCS) Curve Number method for estimating runoff. The model assumes that the total infiltration capacity of a soil can be found from the soil's tabulated Curve Number. During a rain event this capacity is depleted as a function of cumulative rainfall and remaining capacity. The input parameters for this method are the curve number and the time it takes a fully saturated soil to completely dry (used to compute the recovery of infiltration capacity during dry periods). The curve number estimation approach is described in the next section.

3.6 RUNOFF PARAMETER INPUTS

There are several parameters that are required for the computation of runoff for each subwatershed in the model. These parameters include watershed area, infiltration method, overland flow slope, overland flow roughness coefficients, and detention storage estimates. Detention storage is specified as zero in the model as it is accounted for in the curve number estimate.

3.6.1 Watershed Delineation

Subwatersheds were delineated using contours developed from the LiDAR surface elevation data. The Kingston Wetland Complex watershed was broken up into forty two subwatersheds. Six of the subwatersheds are located in parts of Meeker County where LiDAR coverage was not available and delineation was completed using USGS 10ft contours. Figures A.7 and A.8 show the subwatersheds modeled and their respective flow patterns. Watershed areas are also listed in Table 3.3.

3.6.2 Curve Number and Impervious Fraction

Curve numbers and impervious fractions for the watersheds were estimated based on the Soil Conservation Service (SCS) Curve Number (CN) method described in *Urban Hydrology for Small Watersheds Technical Release 55 (TR-55)* (SCS, 1986). Both soils and land use data are essential for the development of an appropriate curve number to represent each watershed. A composite curve number was estimated for each watershed by using a weighted average as described by Equation 1.

$$CN_{comp} = \frac{\sum_{i=1}^{n} A_i CN_i}{\sum_{i=1}^{n} A_i} \qquad \text{Equation 1}$$

Where

A = Area of the respective land use and soil type within a subwatershed.

CN = Curve number assigned for a given land use and soil type within a subwatershed.

CN_{comp} = Composite curve number for the subwatershed.

The TR-55 provides some direction as to the appropriate impervious fractions for a given land use and hydrologic soil group. A composite impervious fraction that represents the entire watershed is estimated using equation 1 by substituting the associated impervious fraction for the curve number. Table 3.3 shows the composite curve number and impervious fraction estimated for each subwatershed in the model.

3.6.3 Watershed Width Estimation

The watershed characteristic width of the overland flow path for sheet flow runoff is one of the more difficult parameters to estimate. An initial estimate of the characteristic width for the Kingston subwatersheds was made by taking the subcatchment area divided by the average maximum overland flow length. The maximum overland flow length is the length of the flow path from the inlet to the furthest drainage point of the subcatchment. The flow path was estimated using the topography generated from the LiDAR dataset and/or the USGS 10ft contour data as applicable. Adjustments were made to the width parameter to calibrate the model. Table 3.3 shows the estimates for watershed width for each subcatchment.

3.6.4 Slope Estimation

The watershed slope was estimated using topography generated from the elevation data sources (liDAR and/or USGS 10ft contours). Flow paths and elevation drops were estimated on a reach by reach basis and an average was used to represent the watershed. The slope estimated for each watershed is tabulated in Table 3.3.

3.6.5 Roughness Estimation

Roughness is used in SWMM in its overland flow calculations. Roughness is defined separately for impervious and pervious areas in each subwatershed. The roughness values used for each of the watersheds were 0.06 and 0.17 to represent impervious and pervious surfaces, respectively.

Table 3.3. Model input parameters

Name	Area (acres)	Width (ft)	Slope (%)	CN	% Imp
S10	4606.4	6986	0.5	67	4.5
S15	102.2	713	0.5	63	5.9
S16	1412.9	5324	0.5	74	3.5
S17-A	477	2339	0.5	69	5.4
S17-B	890.4	2854	0.5	67	5.1
S17-C	102.1	1130	3.0	67	5.8
S17-D	426.4	2501	1.2	68	5.0
S18-A	456.4	2866	0.5	69	4.3
S18-B	239	1493	0.5	68	4.8
S18-C	152	1635	3.4	70	4.9
S18-D	45.9	893	1.0	70	4.9
S18-E	164.7	1042	2.6	68	5.7
S18-F	102.1	872	3.0	65	4.8
S18-G	50	904	4.0	64	5.0
S18-H	98	1451	3.3	66	5.3
S18-I	11.6	301	1.5	68	5.0
S19-A	82.8	532	1.8	67	5.8
S19-B	523.6	3574	2.5	68	4.0
S19-C	209.8	1954	3.0	63	4.4
S19-D	128.7	1554	2.2	64	4.2
S19-E	111.7	1277	2.1	61	3.8
S19-F	42.9	2193	5.0	67	4.7
S19-G	17.8	950	5.0	64	4.7
S19-H	5.1	305	10.0	86	0.7
S2	10853.1	11312	0.5	68	5.2
S21-A	802.4	2934	1.1	69	5.0
S21-B	127.1	1427	2.1	67	5.2
S27	9811	13379	0.5	54	4.9
S5	6801.3	15928	0.5	71	4.2
S6-A	701.2	5448	2.0	63	2.7
S6-B	85.6	1658	3.2	65	3.6
S6-C	149	3068	4.6	59	4.3
S6-D	325.9	3060	2.6	59	4.2
S6-E	41.9	990	3.4	49	4.8
S6-F	141.1	1124	1.6	68	5.1
SKW-1-A	632	1832	0.98	66	4.5
SKW-1-B	374	2391	1.7	67	4.8
SKW-2	405.7	1850	0.4	61	4.5
SKW-3	1508.2	4481	0.4	56	4.9
SKW-4-A	126.6	1402	1.0	65	5.3
SKW-4-B	217	1574	1.0	71	5.0
SKW-4-C	284.9	1876	1.8	66	4.7

3.7 CROSS SECTION DATA INPUTS

Areas that were modeled as a reach in the Kingston SWMM model were based on a set of cross section data derived from bathymetry and topographic data collected as previously described. A typical cross section as modeled is one that has a defined "channel" and a defined "overbank." A separate Manning's roughness coefficient was estimated for each area. Figure 3.3 shows a typical cross section as modeled. Roughness values defined throughout the model for channel and overbank were 0.03 and 0.035, respectively

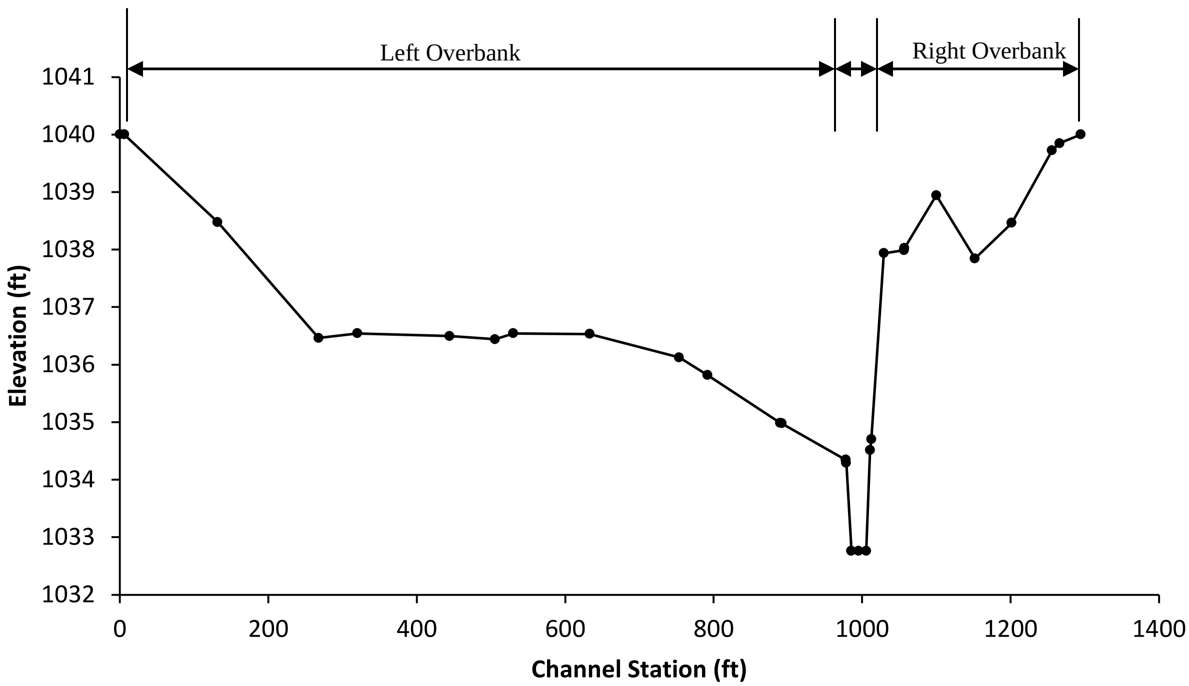

Figure 3.2. Typical cross section for reaches within the model

3.8 STORAGE AREAS

Storage areas were defined throughout the model. The Kingston Wetland Complex and Lake Betsy are both defined as storage areas within the model. Bathymetry data for Lake Betsy came from the DNR lake bathymetry database. Bathymetry for the Kingston Wetland Complex is based on survey data collected by Wenck. Figure 3.3 and 3.4 show the stage storage curves for the Kingston Wetland Complex and Lake Betsy as defined in the model. Nine Culverts were surveyed within the watershed and storage areas were defined upstream in order to provide the correct hydrologic and hydraulic responses from the model.

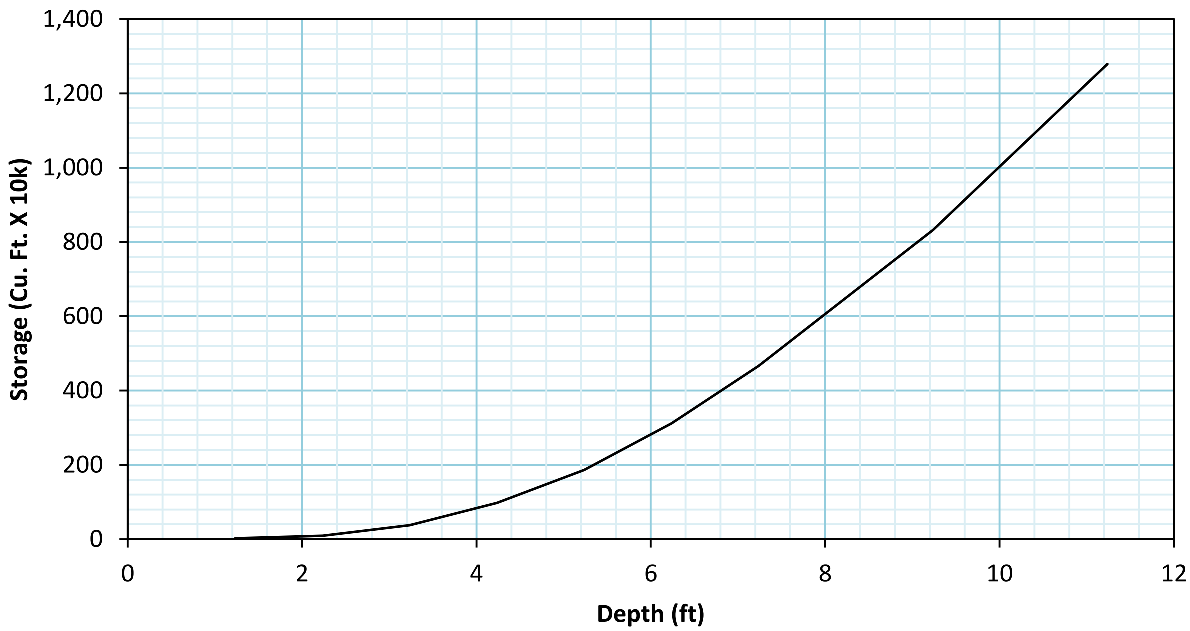

Figure 3.3. Depth vs storage volume curve for Kingston Wetland

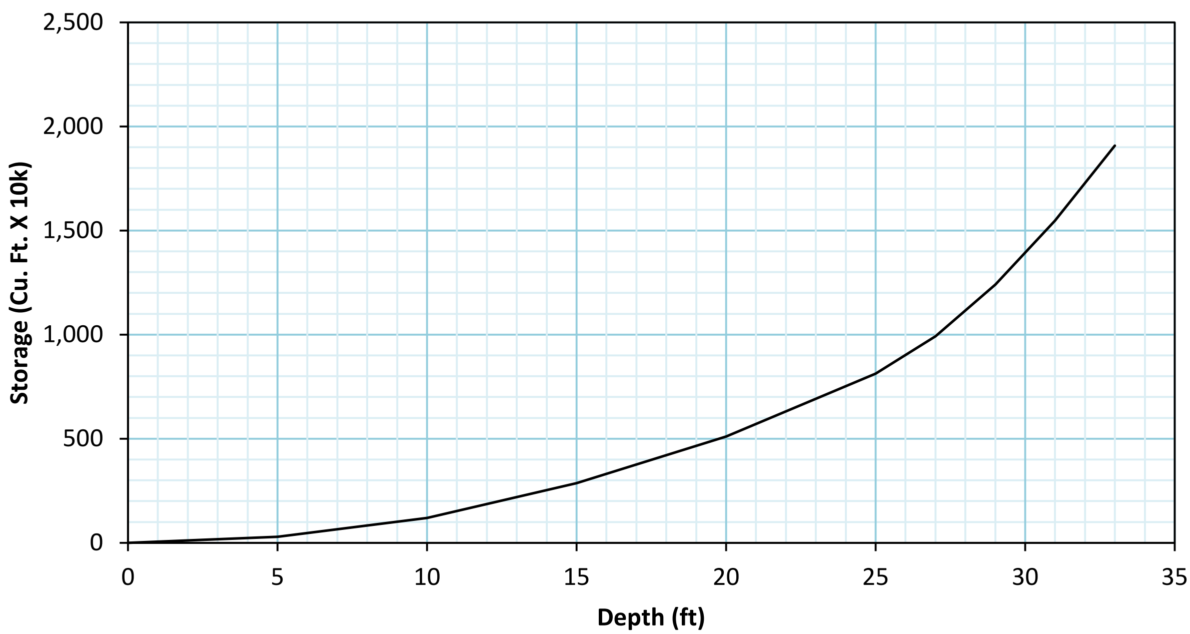

Figure 3.4. Depth vs storage volume curve for Lake Betsy

3.9 BOUNDARY CONDITIONS

The downstream boundary condition as defined in the model is set to a free flow condition in an outfall node. This boundary condition lets the model decide the outfall stage by using the minimum of critical flow depth and normal flow depth in the connecting conduit. The outfall location is 1,780 feet downstream of Lake Betsy at the 744th Avenue Bridge.

3.10 EXISTING CONDITIONS MODEL CALIBRATION

The Kingston SWMM model was calibrated to measurements taken from 4/7/2011 to 11/15/2011. The three calibration points were flow data collected at the CR 29.0 Gauge on the Clearwater River, stage data collected at the CR 28.2 gauge at the Kingston Wetland Complex, and stage data collected at Lake Betsy for water year 2011. The watershed characteristic width and the curve numbers were adjusted to fine tune the model until it had matched as best possible to the actual data.

3.11 EXISTING CONDITIONS MODEL FINDINGS

The existing conditions model in general calibrated well to flow at the CR 29.0 gauge location, reasonably matching existing flow conditions that were measured in 2011 (Figure 3.5). Calibration at the Kingston Wetland Complex was not as successful, though there is a reasonable relationship with the measured and the simulated data after June 30, 2011. Prior to June 30, 2011, one reason that the wetland storage does not match well, as indicated in Figure 3.6, may be due to pre-snow/ice melt conditions experienced late into the spring in 2011 and thus leaving the wetland at a higher water level to start. This is a condition that is beyond the capability of the model to handle. As the wetland fills with the wet early summer rains the behavior of the modeled wetland is more closely related to conditions that were measured. The model predicts the recession of the storm season relatively well at the Kingston gauge from August into the fall. The model does reasonably well at matching measured stage data at Lake Betsy (see Figure 3.7).

Both measured and modeled wetland responses shown in Figure 3.6 for 2011 storm events indicate that the wetland is not efficient as a storage area. Once the storms recede the wetland drains relatively quickly.

3.12 PROPOSED CONDITIONS MODEL SETUP

Evaluation of the water quality model yielded a conceptual design: a low flow channel designed to convey 50 cfs. The design was developed and optimized by using the hydrologic and hydraulic model. The calibrated model of existing conditions was modified to represent proposed conditions. Specifically, the storage node at the Kingston Wetland was replaced with cross sections through the wetland by occupying the historical channel that was bypassed with the existing morphology. More description on the design channel and its characteristics along with a typical section and plan view alignment will be discussed in the Concept Design Recommendations Section of this report (Section 4). The proposed channel was modeled using a roughness coefficient for the channel and overbank of 0.035 and 0.04, respectively. These roughness values are representative of a matured, vegetated channel. Eight watersheds to the south of the wetland including S6-E, S6-F, S6-B, S6-C, SKW-3, SKW-2, SKW1-A, SKW1-B (Figure A.8, 10% of the total drainage to the wetland) are intended to continue to filter into the wetland (as under existing conditions). The proposed conditions model was then set up to run the 1 inch, 2-year, and 10-year events to compare results with existing conditions, evaluating changes in wetland hydrology between existing and proposed conditions. The channel dimensions were modified to minimize impact.

3.13 PROPOSED CONDITIONS MODEL FINDINGS

The proposed conditions model was used to determine the stage versus time relationship as compared to the existing conditions model on an event basis. The events modeled included a 1 inch event, the 2-year event, the 10-year event, and the 100-year event. The 1 inch event storm is the bench mark storm for which 90% of the storms experienced in the region are equal to or less than. The 1 inch storm is completely contained in the typical proposed channel accessing the wetland only at the filter berm (discussed in the next section). The 2-year, 10-year, and 100-year event responses for proposed conditions match existing conditions reasonably well and does not increase flood elevations (Figures 3.8 through 3.10).

Under the proposed conditions, the wetland will still be receiving flow from eight of the southern watersheds. It is beyond the capabilities of the model to estimate how much flow will enter into the wetland through the proposed filter berm (discussed in Section 4). However, conceptually the water will flow through the filter berm bilaterally. When the wetland is low and the channel is high, the channel will flow into the wetland through the filter berm. Conversely once the wetland is full and the storms have passed, the wetland will slowly filter into the channel.

The total volume of water routed through the wetland in 2011 from the Clearwater River and eight southern tributary sources was 52,892 acre-ft. If the proposed condition channel bypasses 70% of the Clearwater flows and still receives all of the tributary flows, the net result when compared with existing conditions for the 2011 data is that out of the 52,892 acre-ft existing, 36,767 acre-ft bypasses the wetland and 16,125 acre-ft is still being routed through the wetland. The volume of water that is accessing the wetland will drain slower than in existing conditions because of the filter berm, thus keeping the wetland wetter longer.

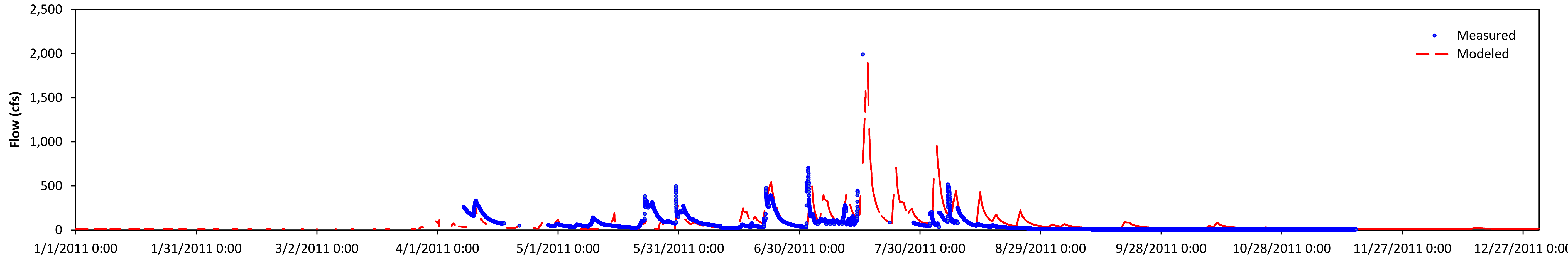

Figure 3.5. Existing conditions model calibration at gauge CR-29

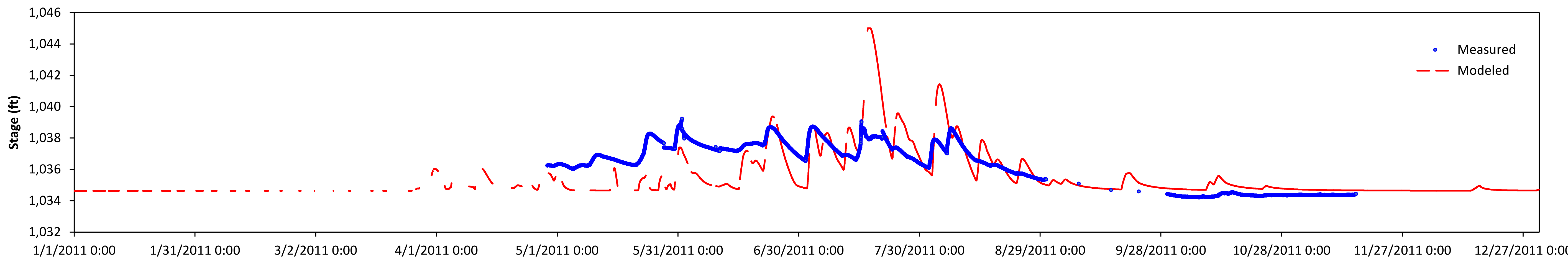

Figure 3.6. Existing conditions model calibration for stage (gauge CR 28.2)

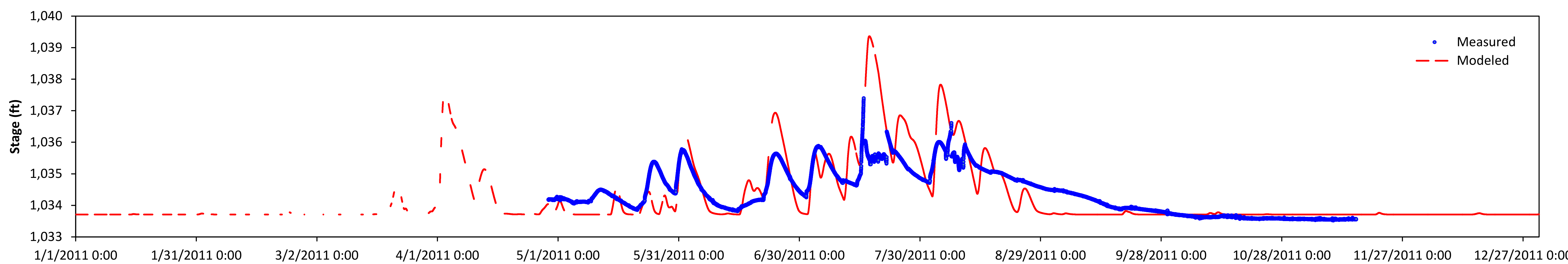

Figure 3.7. Existing conditions model calibration for stage at Lake Betsy

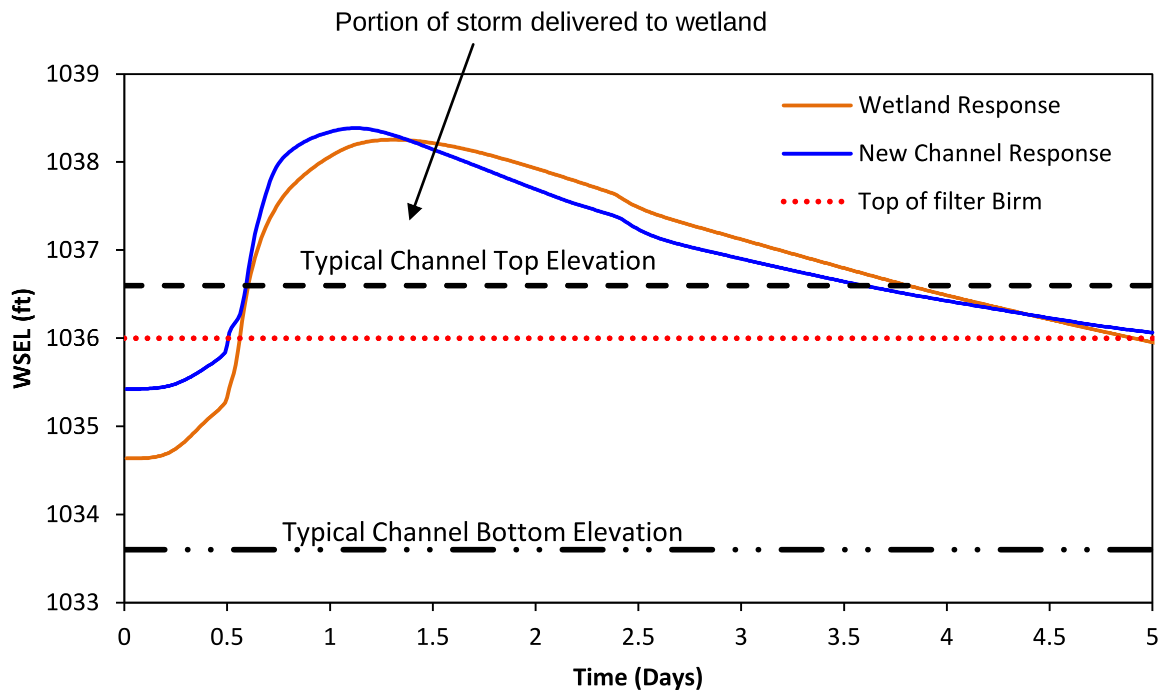

Figure 3.8. 2-year response for existing versus proposed conditions

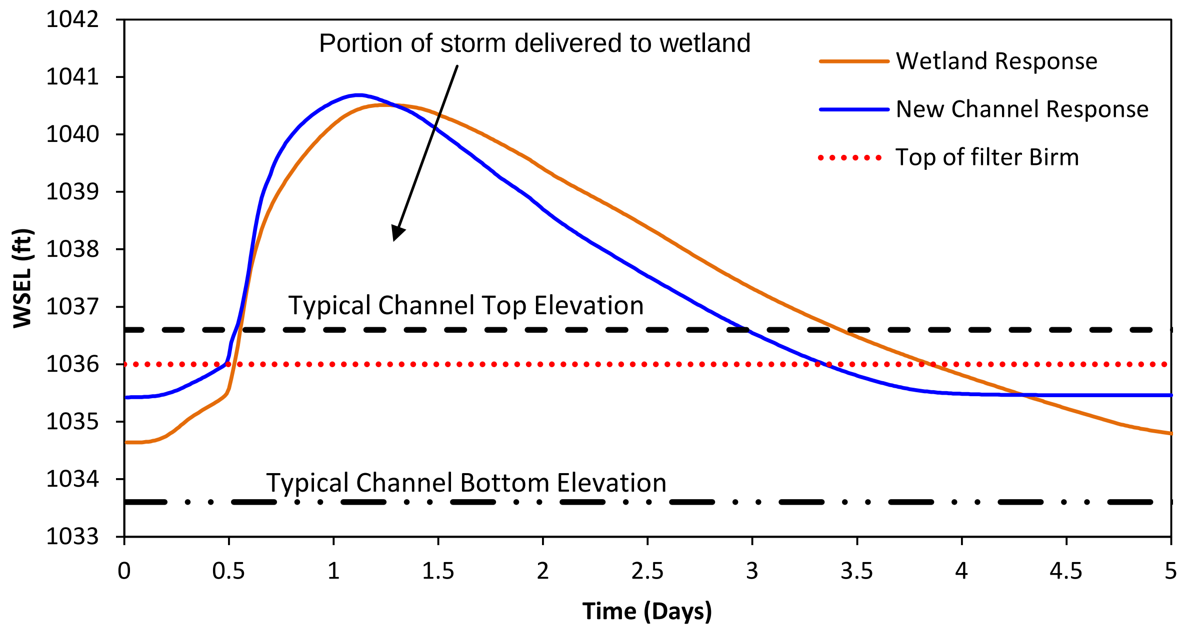

Figure 3.9. 10-year response for existing versus proposed conditions.

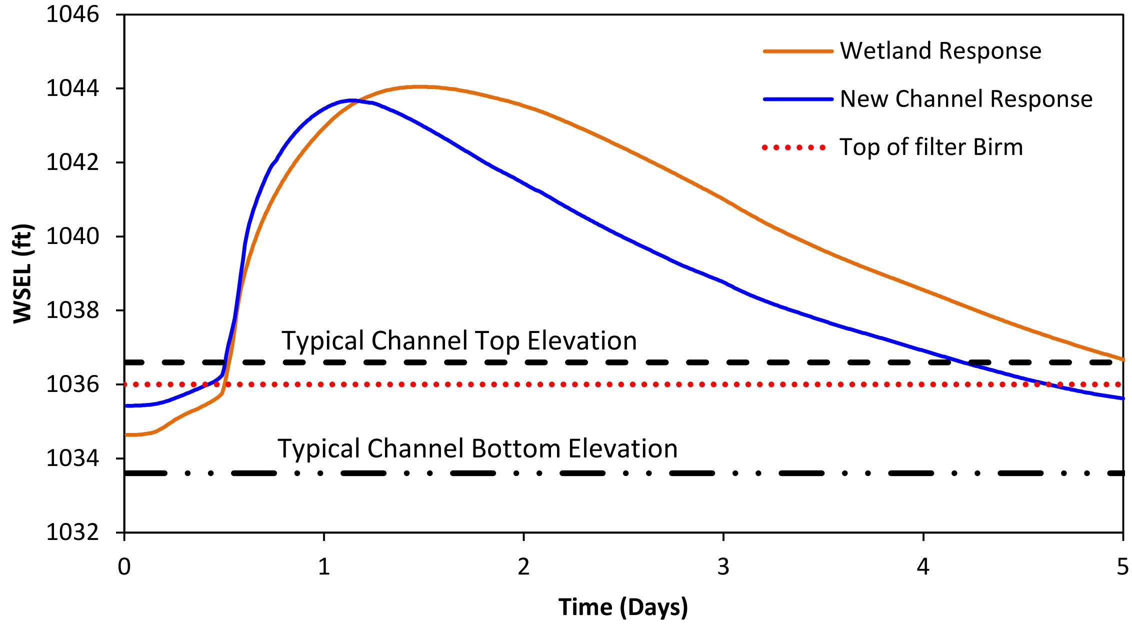

Figure 3.10. 100-year response for existing versus proposed conditions.

4.0 Concept Design Recommendations

The general concept of the proposed design for the Kingston Wetland Complex is to bypass and convey lower flows past the wetland as such to remove total phosphorus by not accessing the wetland as often. The design channel that is being proposed has a trapezoidal cross section with 8 ft bottom and 5:1 side slopes. It will occupy the unused historic channel alignment as shown in plan view in Figure A.9. The slope of the design channel shall be a very mild 0.04% to reduce channel forming velocities during higher events (see profile plots on Figures A.10, A.11, A.12, and A.13). Depths of water and velocities expected in the typical 3 foot section under various flows are shown in Table 4.1

Table 4.1. Design Flow, Normal Depth, and Velocity

Design Flow (cfs)	Normal Depth (ft)	Velocity (fps)
20	1.5	0.9
30	1.8	1.0
40	2.1	1.0
50	2.3	1.1
60	2.5	1.1
70	2.7	1.2
90	3.1	1.3
169	4.0	1.5
500	6.4	2.0
1000	8.5	2.3
2000	11.2	2.8

Based on the results shown in Table 4.1, the target depth of the typical channel should be designed to be no greater than 3 ft high on the wetland side and excavated to match existing grade on the upland side as shown in the typical design cross section in Figure A.14. There will likely be areas along the wetland side of the channel where 3 foot elevation is not achievable without adding fill. Since adding fill to the wetland is undesirable, these locations will be left lower than 3 feet and the 5:1 grade will be excavated to match existing ground similar to the proposed right side of the channel.

The design channel as shown in Table 4.1 can convey up to 90 cfs without accessing the wetland in most areas. However, since there will be areas where the channel is not 3 ft high, 50 cfs is chosen as the design flow of the channel. A percent exceedence probability analysis of the existing flows measured at CR-29.0 gauge indicates that 72% of the flows experienced will be greater than or equal to 50 cfs (approximately 78% are less than or equal to 90 cfs) (see Figure 4.1).

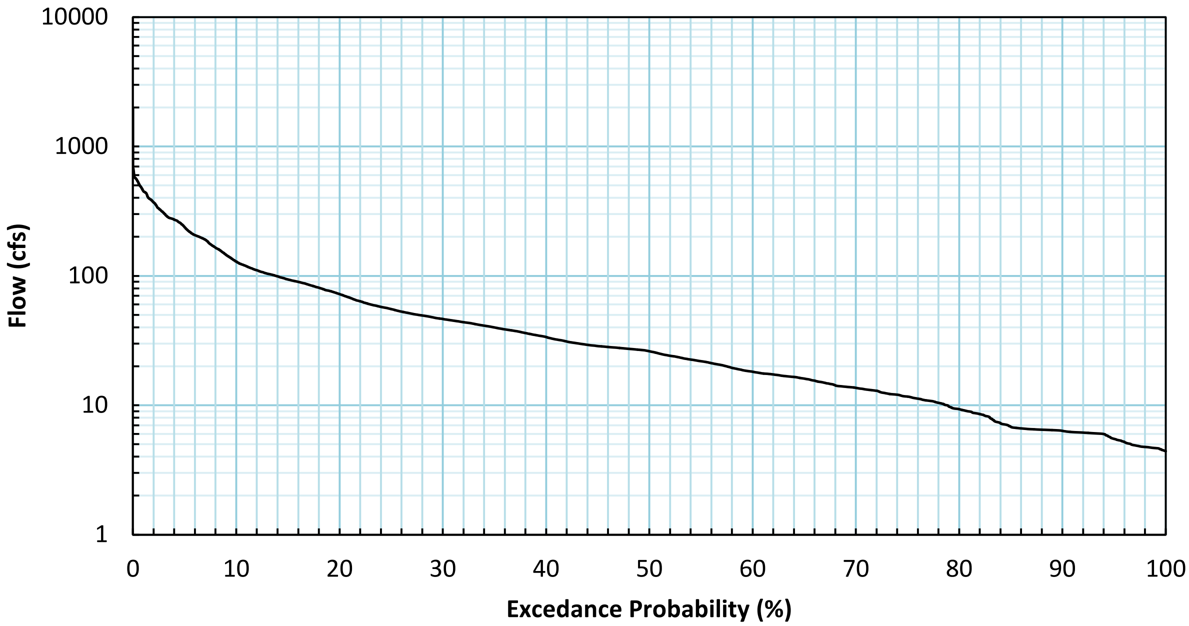

Figure 4.1. Percent exceedence probability curve at the CR-29.0 gauge.

Components of the design that are detailed in Figure A.10 include

- Excavation of the proposed channel at a 0.04% grade with an 8 foot bottom, 5:1 side slopes, to match existing grade on the upland side (north side), and either match existing grade or grade to a 3 foot depth on the wetland side (south side). (STA 44+50 to STA 92+00).
- Fill/block the existing bypass channel with structural grade fill to cut off flows from the river entering this channel (STA 47+00)
- Install a filter berm where the existing wetland enters into the channel (STA 82+10).
- Install a rock weir, plunge pool and riprap bank protection (STA 92+22)
- Install an access road on the north side of the channel or south side of the channel that will be used to maintain the rock weir structure.

5.0 Engineers Estimate of Probable Cost

The estimated cost of the conceptual project design is tabulated below in Table 5.1.

Table 5.1. Estimate of Probable Cost

				Wenck Cost Estimate	
Item	**Description**	**Qty**	**Unit**	**Unit Price**	**Item Total***
1	Mobilization and Demobilization	1	L.S.	$28,100.00	$28,100
2	Field Engineering	1	L.S.	$12,550.00	$12,600
3	Temporary Erosion and Sediment Control (Floating Silt Curtain)	1	L.S.	$2,500.00	$2,500
4	Temporary Sedimentation Basin (Includes cleaning/restoration following project completion)	1	L.S.	$2,500.00	$2,500
5	Temporary Construction Facilities and Utilities	1	L.S.	$1,500.00	$1,500
6	Clearing and Grubbing	13.0	AC	$2,000.00	$26,000
7	Channel Excavation**	18,000	C.Y.	$8.00	$144,000
8	Controlled Fill (Block current diversion channel; facilitate control structure installation)	600	C.Y.	$5.00	$3,000
9	Repair Dike Breeches	100	C.Y.	$5.00	$500
10	Limestone Filter Berm w/ Geotextile Wrap	175	C.Y.	$25.00	$4,400
11	Class II Riprap Control Structure, Bank Lining	350	C.Y.	$95.00	$33,300
12	Rock Riffles	350	C.Y.	$95.00	$33,300
13	Site Restoration	1	L.S.	$30,000.00	$30,000
* Rounded to the nearest $100					
** Dependent on limits of channel grading. Further grading upstream of channel may be required to achieve appropriate fall. Will be determined in final design					
				ESTIMATED CONSTRUCTION COST	***$321,700***
				Contingency (20%)	$64,300
				TOTAL ESTIMATED CONSTRUCTION COST	***$386,000***
				Engineering/Construction Observation(10%)	$38,600
				TOTAL ESTIMATED COST	***$424,600***

6.0 Regulatory Requirements

The Kingston Wetland Restoration project is proposed in a wetland over which state, federal, and local units of government have jurisdiction. The units of government that will require a permit or other permission to complete the work include:

- Meeker County Ditch Board
  The reach of the Clearwater River in the project area is considered a County Ditch and is under the jurisdiction of the Meeker County Ditch Board.
- Minnesota Department of Natural Resources (DNR)
  The Kingston Wetland and Clearwater River are listed as MN DNR Public Waters and therefore work within the Kingston Wetland and Clearwater River will require a Public Waters Permit.
- Minnesota Board of Water and Soil Resources (BWSR)
  The Kingston Wetland is under the jurisdiction of the Wetland Conservation Act (WCA), which is enforced by MN BWSR. Wetland impacts are regulated through WCA in Minnesota.
- Meeker County Soil and Water Conservation District (SWCD)
  Meeker County SWCD is the local unit of government (LGU) responsible for enforcing WCA in Meeker County.
- United States Army Corps of Engineers (ACOE)
  Since the Kingston Wetland and Clearwater River are tributary to "Waters of the US", they are under the jurisdiction of the ACOE. The ACOE regulates work that is done in wetlands if it includes fill, draining, or dredging.

6.1 WETLAND REGULATORY ACTIVITY

An initial meeting of Technical Evaluation Panel (TEP) comprised of representatives from Meeker County SWCD, Meeker County, MN BWSR, MN DNR, and the ACOE was convened on-site in October 2011 to provide TEP members with information about the project.

A concept plan was submitted to the TEP in May 2012 to gather comments or concerns prior to completing the application for the project. TEP comments will be incorporated into the permit application that will be prepared and submitted for the project.

A joint permit application will be prepared to submit to federal, state, and local units of government. The application will include sufficient information on the project to demonstrate how wetland impacts are being avoided and to quantify wetland impacts that are not able to be avoided as well as provide a plan to mitigate such impacts.

Following the submittal of the permit application, a comment period of at least 30 days will be placed on the application. Prior to the approval of the permit application, the TEP may request an additional site visit or meeting to discuss the project.

7.0 Conclusions/Project Benefits

Data collected for the TMDL study and for this feasibility study both indicated that changing the channel morphometry and flow path through the wetland may maintain the particulate phosphorus removal, while limiting the oxygen depletion and soluble phosphorus export incurred in the wetland complex. The data collected indicate that a low flow channel with riparian wetland, accessed only in particular design events, may achieve the target reductions of 60% reduction in wetland SOD and a TP reduction of 1,971 lbs/year. As documented in Section 3.0, the re-alignment of the channel and diversion of flows to bypass the wetland will not cause a change in wetland water levels, just a change in the system hydrodynamics. Use of the flow, morphometry, and water quality data to develop the design parameters was discussed in the previous sections. Expected water quality improvements following re-alignment of the channel are discussed below.

7.1 TOTAL PHOSPHORUS REDUCTIONS

As discussed in Section 4 and shown on Figure 4.1, the exceedance probability of flows for the Clearwater River at CR 29.0 indicates that a flow of 50 cfs is exceeded approximately 28% of the time. In other words, if a low flow channel were re-designed to carry 50 cfs, 72% of the flows that are currently being routed through the wetland (increasing SRP export and SOD) would flow instead through this redesigned channel. Flows in excess of 50 cfs would access the riparian wetland.

The 2011 collected flow and TP data, discussed above, suggests that by re-directing the flow regime to send main channel flow through a low flow channel and not through the wetland, a TP load reduction of approximately 1,400 lbs/yr could potentially be achieved (this is based on the calculated flow weighted mean concentration). The 2006 data suggests a TP load reduction of approximately 420 lbs/yr could potentially be achieved under similar upstream flow conditions.

Data indicate that the installation of an iron filter berm at the wetland outlet, as proposed in the concept design, would provide additional phosphorus removal, targeting the SRP. Filter berms are highly effective for SRP removal. If 28% of the flows are routed through the wetland under proposed conditions, and 90% of the SRP is removed by the filter berm, based on the SRP/TP ratios for 2006 and 2011, approximately 98 to 221 lbs/yr of SRP removal could be achieved. If 90% of the 440 lbs/year of SRP contributed by the tributaries which drain directly to the wetland (TW 27.8, TE 27.8, and T 27.3) is also removed by the filter berm, an additional 395 lbs/year of SRP removal could be achieved in flow conditions similar to those experienced in 2011.

Therefore, by re-configuration of the wetland hydro-dynamics to include a low flow channel (to accommodate 50 cfs) and installation of an iron filter berm, a total TP load reduction, based on 2006 and 2011 data, ranging from 913 to 2,016 lbs/yr can be achieved. This translates to TP load reductions of 8% and 46% for 2011 and 2006, respectively. The average annual flow volume (4,302 ac-ft/yr) and associated TP load (4,887 lbs/yr) was determined during modeling for the Lake Betsy Nutrient TMDL Study (Wenck, 2009). By interpolating between the load reductions conceivable for 2011 and 2006 flow conditions, it is anticipated that a 40% reduction in TP load could be realized under average flow conditions. This equates to a reduction of 1,955 lbs/yr under average flow conditions.

7.2 SOD REDUCTION/DO IMPROVEMENTS

Technologies to mitigate SOD are limited. The natural state of the channel and riparian wetland was likely a low flow channel with flow accessing the riparian wetland during high flow/wet weather events. Such a flow regime, which can be achieved by restoring this morphometry, would limit exposure to wetland SOD in critical conditions while still offering the wet weather/ high flow reduction in total phosphorus that benefits lakes downstream by allowing higher flows to access the floodplain wetland and its phosphorus assimilative capacity.

Based on the SOD reported at the sediment sampling stations within the wetland (Table 2.2), the average SOD in the wetland is 1.085 g/m2-day. Applying this rate over the surface area of the wetland assumed to interact with the existing flow path (approximately 133 acres) equates to a SOD of 1,287 lbs/day under existing conditions. Applying the SOD rate over the surface area of the re-designed channel equates to a SOD of 43 lbs/day. Considering that 28% of the flows through the new channel alignment will still contact the wetland, the total SOD expected under proposed conditions is 403 lbs/day. This equates to a reduction of 884 lbs/day or, in other words, an approximately 68% reduction in exposure to the wetland SOD under proposed conditions.

Based on the DO concentrations observed upstream and downstream of the wetland, and the reduction of exposure to SOD, it is intended that diverting flow from the wetland will preserve the upstream DO concentrations downstream.

8.0 Recommended Project Schedule

Sampling to determine the water and nutrient budget for the wetland complex occurred during the summer of 2011. Surveying was conducted during winter 2011 and 2012. Sediment sampling took place in spring 2012 and macroinvertebrate sampling is scheduled for late summer 2012.

Plans and specifications will be prepared during the summer of 2012 and finalized in the fall of 2012 with construction occurring during the 2012-2013 winter season. Final stabilization of the project will occur as conditions allow in spring 2013. Table 8.1 shows the project schedule and milestones for each year:

Table 8.1. Project Schedule

	2012							2013											
Activity	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Complete Modeling/Reporting	■																		
Restoration Design (Plans and Specifications)		■	■	■															
Bidding				■	■														
Restoration Construction Activities						■	■	■	■	■	■								
Final Stabilization/Vegetative Maintenance											■	■	■	■	■	■			
Operations and Maintenance Activities																			
Water Quality Effectiveness Monitoring/Data Assessment/Annual Reporting							■				■	■	■	■	■	■	■	■	■
Technical Information Program	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Final Project Report																			

	2014											
Activity	J	F	M	A	M	J	J	A	S	O	N	D
Complete Modeling/Reporting												
Restoration Design (Plans and Specifications)												
Bidding												
Restoration Construction Activities												
Final Stabilization/Vegetative Maintenance				■	■	■	■	■	■			
Operations and Maintenance Activities	■	■	■									
Water Quality Effectiveness Monitoring/Data Assessment/Annual Reporting				■	■	■	■	■	■	■	■	■
Technical Information Program	■	■	■	■	■	■	■	■	■	■	■	■
Final Project Report												

	2015											
Activity	J	F	M	A	M	J	J	A	S	O	N	D
Complete Modeling/Reporting												
Restoration Design (Plans and Specifications)												
Bidding												
Restoration Construction Activities												
Final Stabilization/Vegetative Maintenance												
Operations and Maintenance Activities	■	■	■									
Water Quality Effectiveness Monitoring/Data Assessment/Annual Reporting												
Technical Information Program	■	■	■									
Final Project Report								■				

9.0 Cited Work

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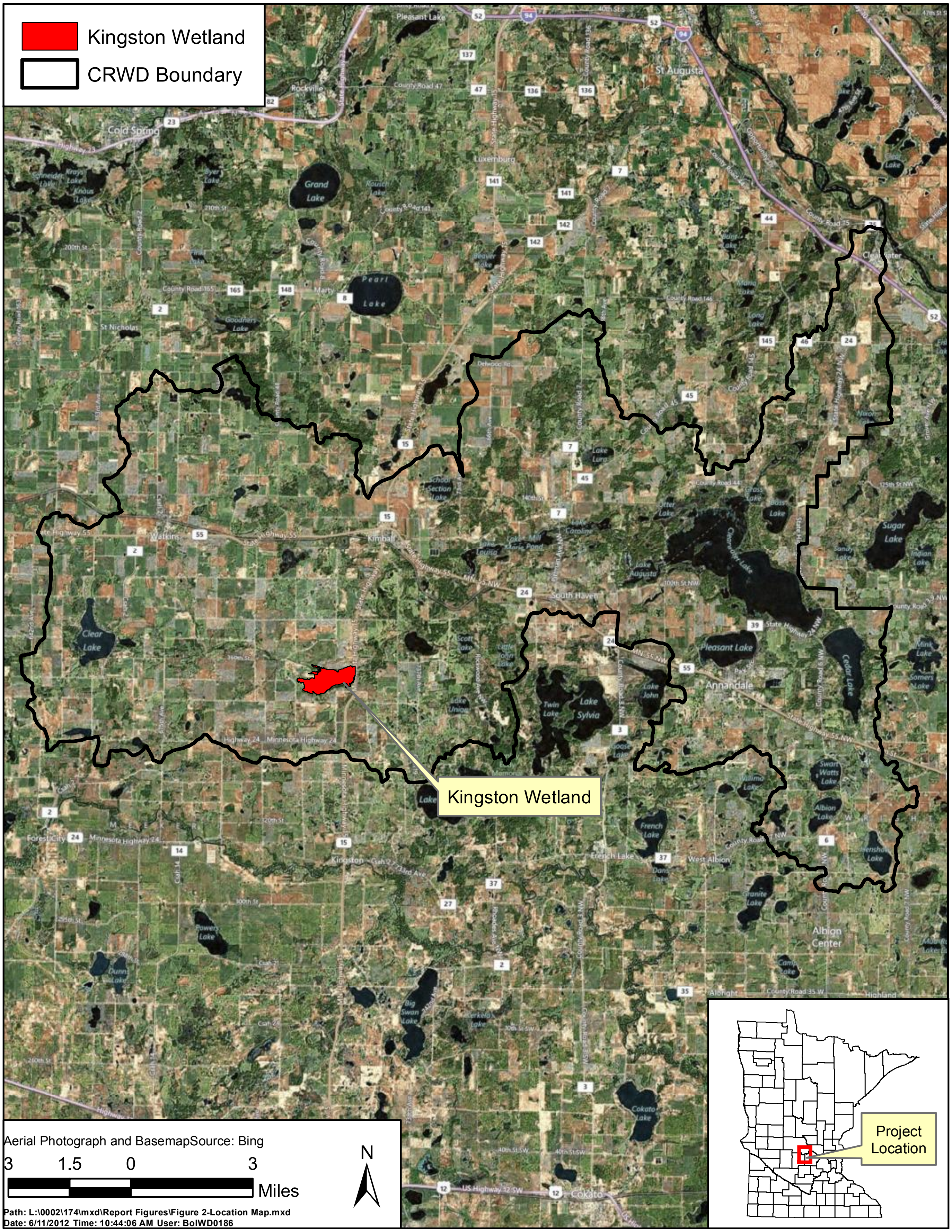
Appendix A

Figures



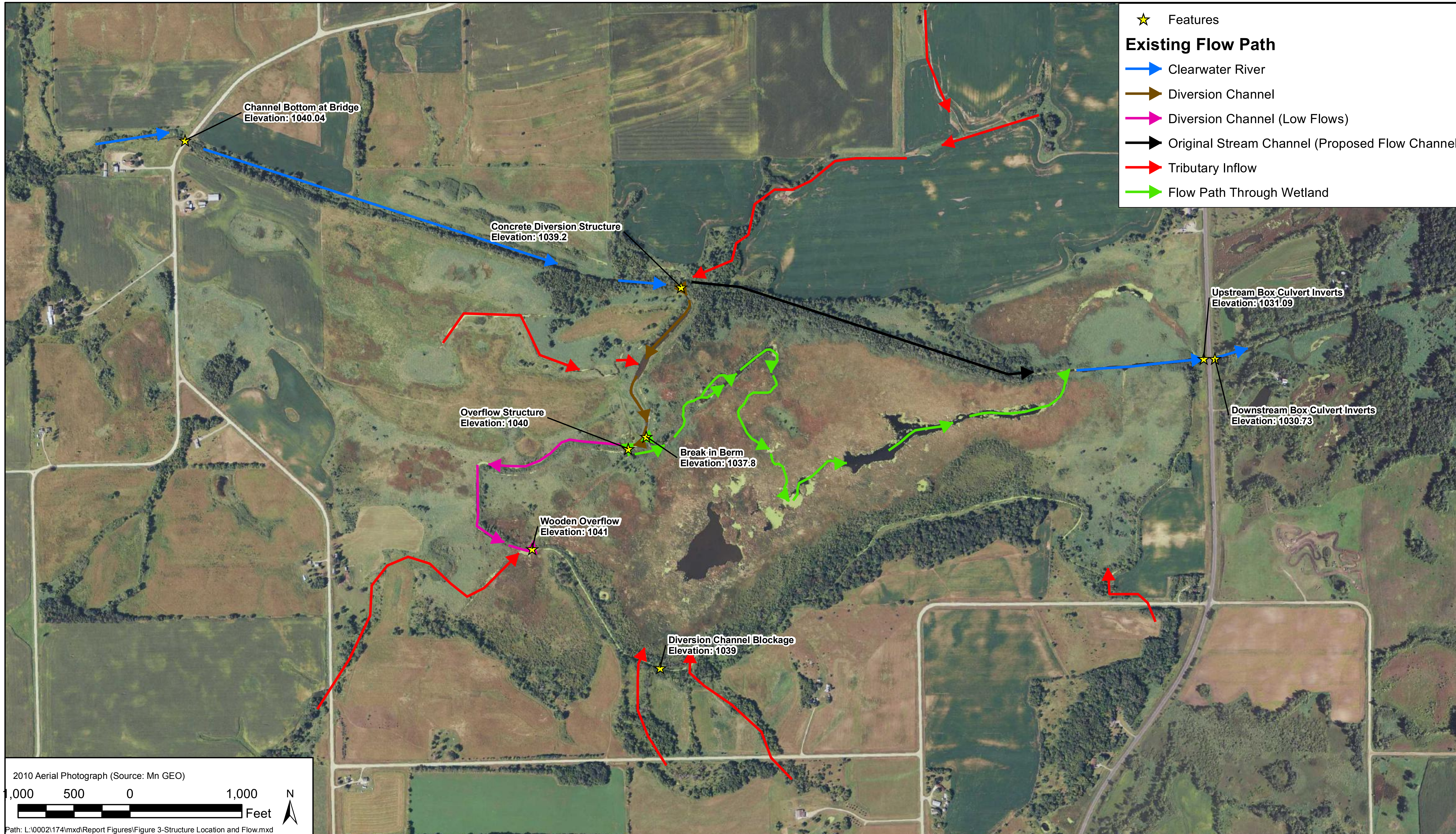
CLEARWATER RIVER WATERSHED DISTRICT

Project Location

Wenck
Engineers - Scientists
Business Professionals
www.wenck.com
1800 Pioneer Creek Center
Maple Plain, MN 55359-0429
1-800-472-2232

MAY 2012

FIGURE A.1



CLEARWATER RIVER WATERSHED DISTRICT

Structure Location and Flow Path

Wenck

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Business Professionals
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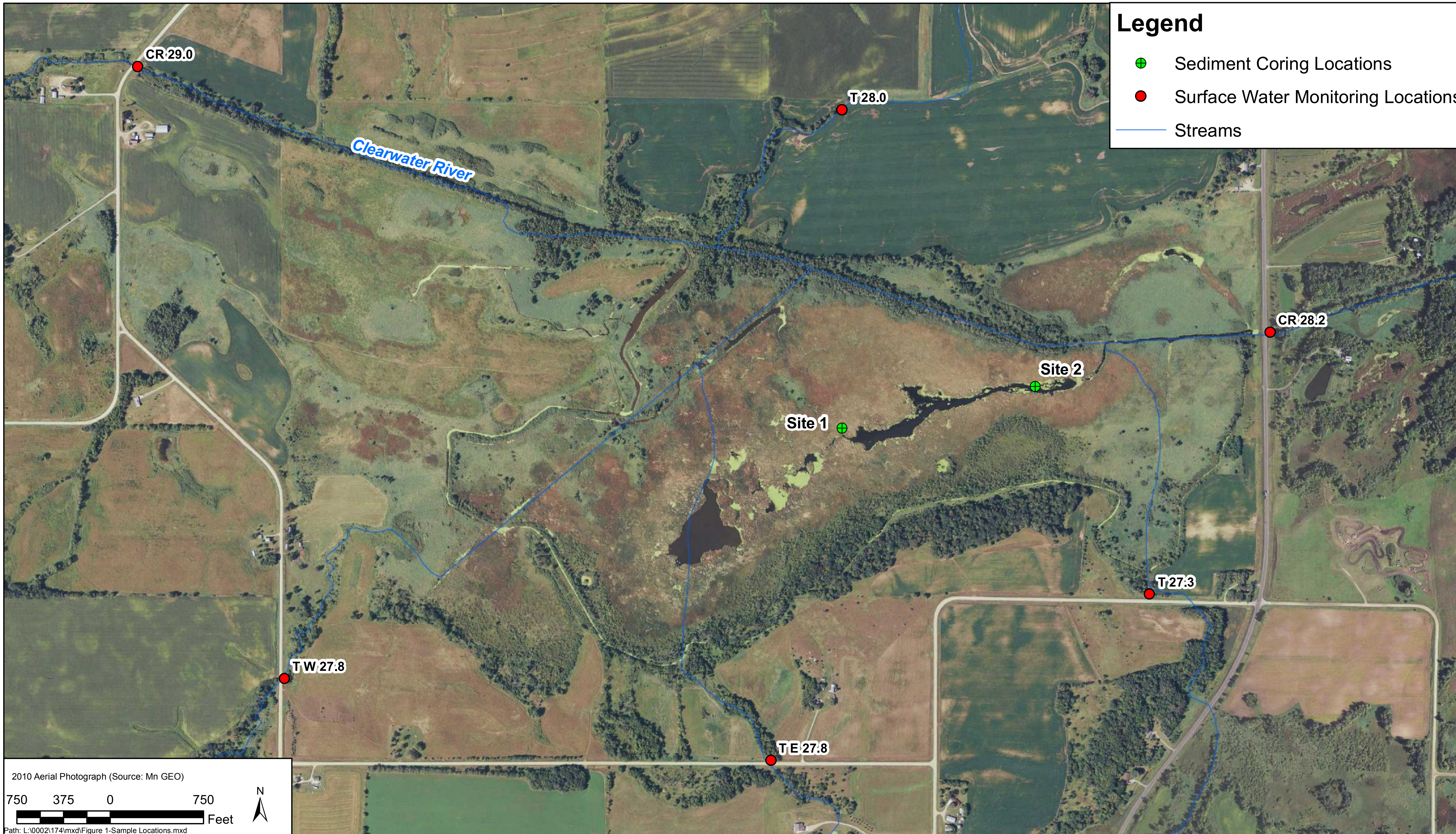
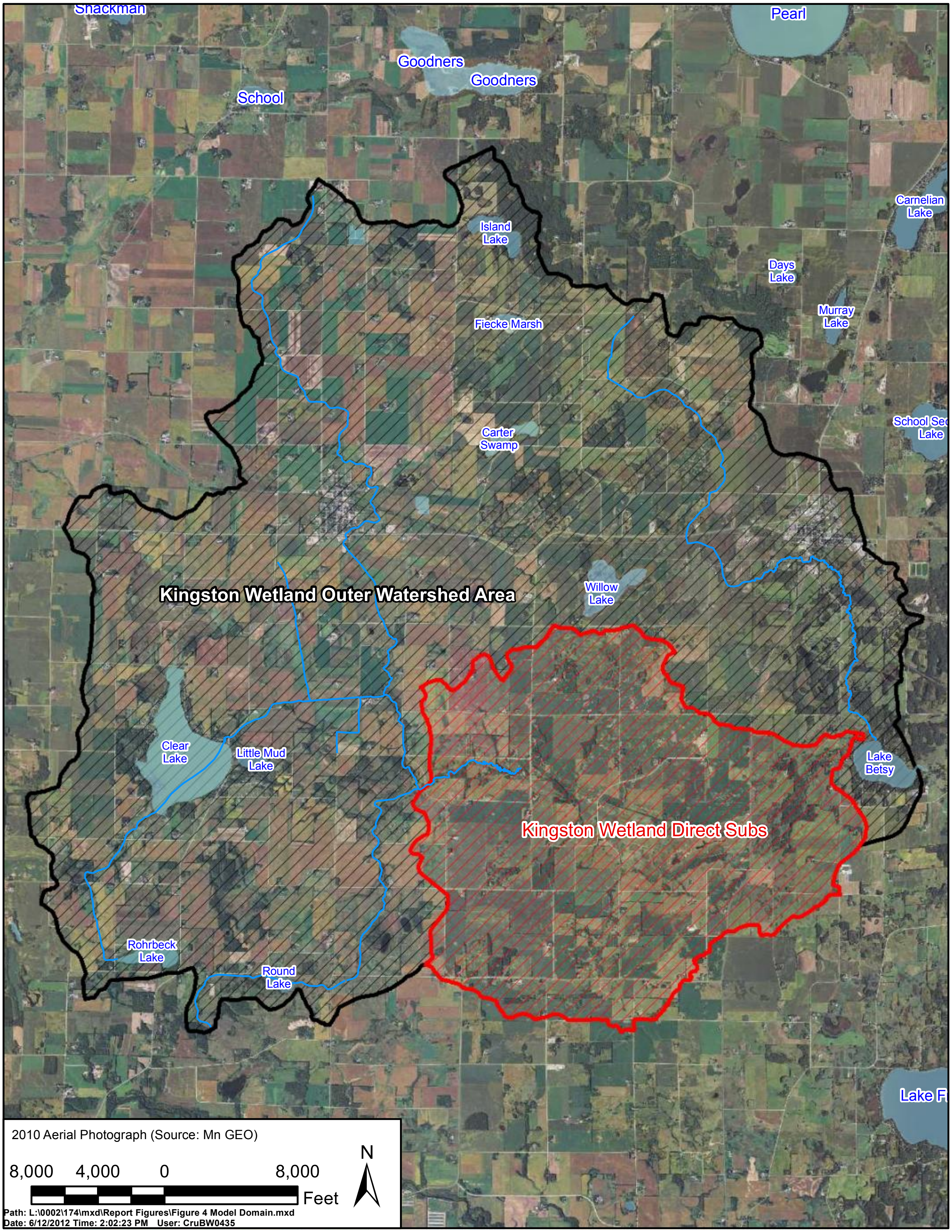
Maple Plain, MN 55359-0429
1-800-472-2232

MAY 2012

Figure A.2



CLEARWATER RIVER WATERSHED DISTRICT	Wenck Engineers - Scientists Business Professionals www.wenck.com 1800 Pioneer Creek Center Maple Plain, MN 55359-0429 1-800-472-2232	JUN 2012
Monitoring Locations		Figure A.3



CLEARWATER RIVER WATERSHED DISTRICT

Modeling Domain

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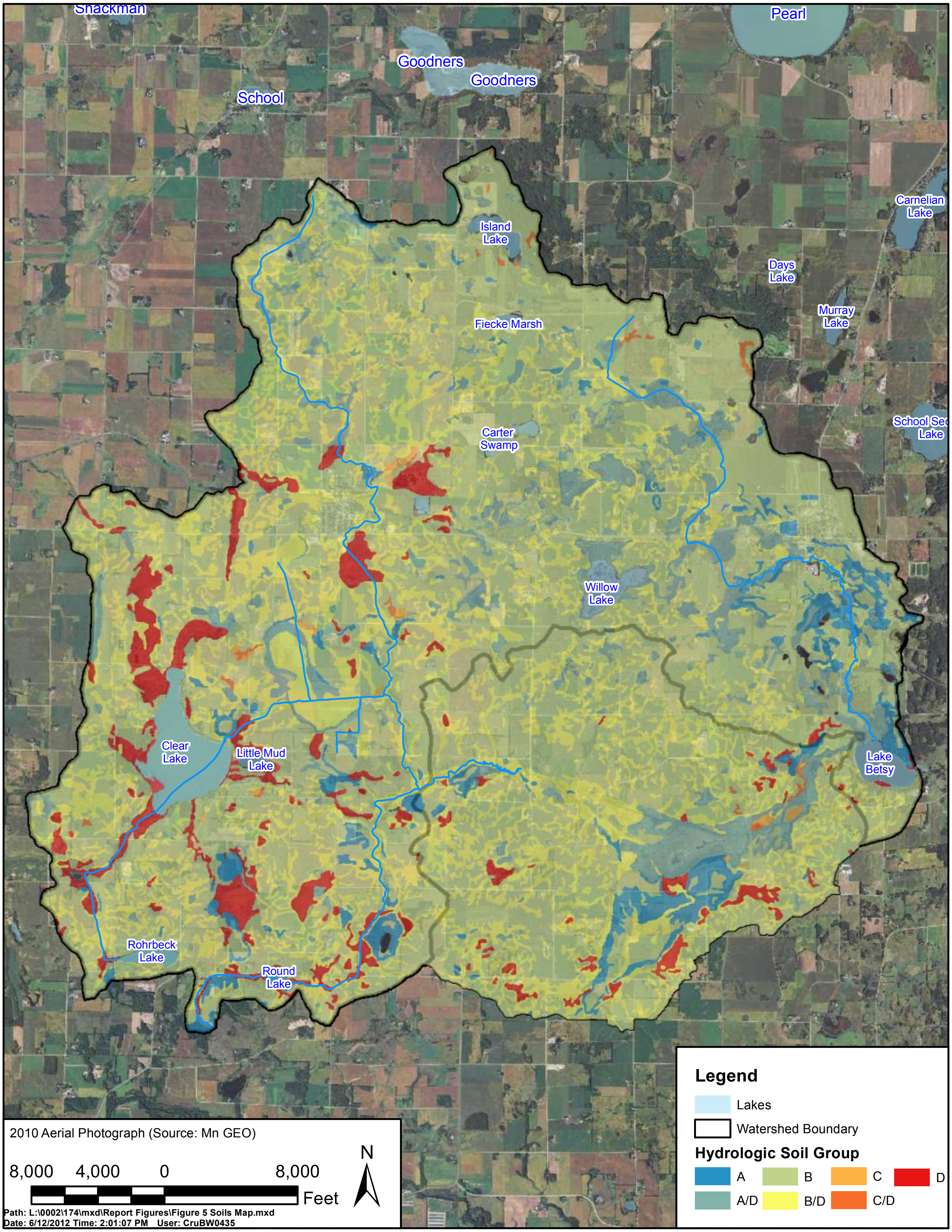
JUNE 2012

Figure A.4



CLEARWATER RIVER WATERSHED DISTRICT

Soils Map

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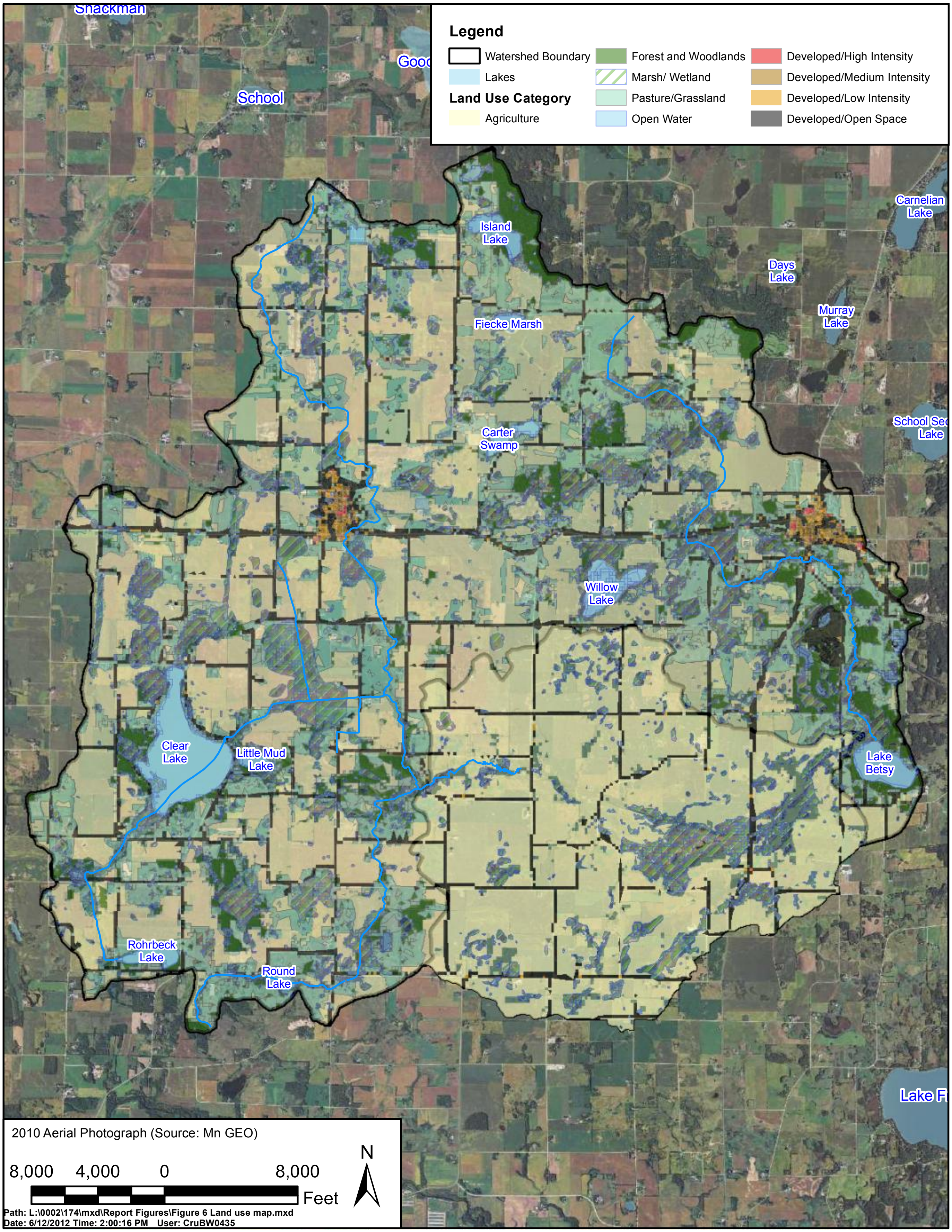
JUNE 2012

Figure A.5



CLEARWATER RIVER WATERSHED DISTRICT

Land Use Map

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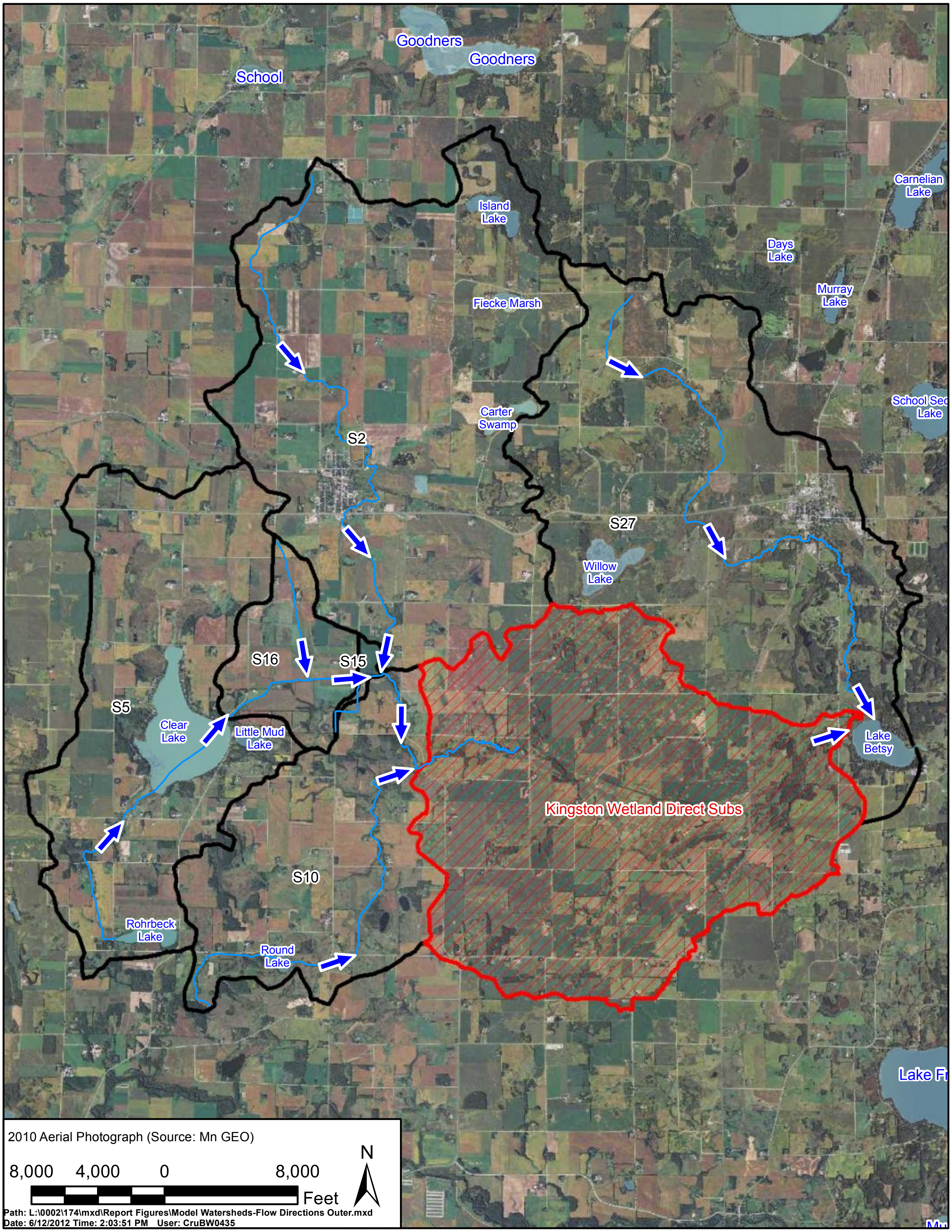
Figure A.6



CLEARWATER RIVER WATERSHED DISTRICT

Outer Subwatershed Delineation

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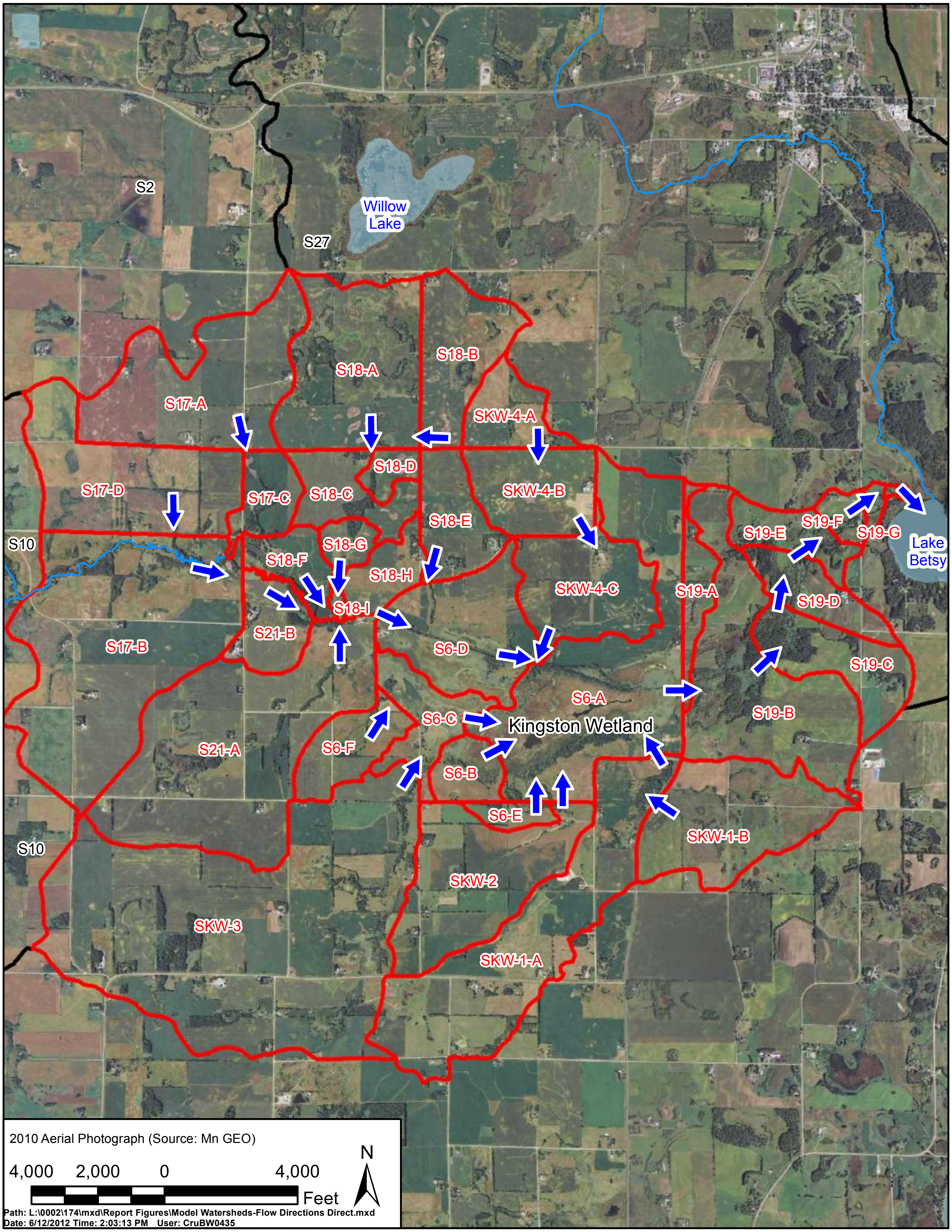
Figure A.7



CLEAR WATER RIVER WATERSHED DISTRICT

Direct Watershed Delineation

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Figure A.8

REV	REVISION DESCRIPTION	DWN	APP	REV DATE

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PROJECT TITLE
KINGSTON WETLAND RESTORATION

CLEARWATER RIVER WATERSHED DISTRICT

SHEET TITLE
PROPOSED PLAN CONCEPT

DWN BY	CHK'D	APP'D	DWG DATE	5/7/2012
BWC			SCALE	NTS

PROJECT NO.	SHEET NO.	REV NO.
0002-174	FIGURE A.9	

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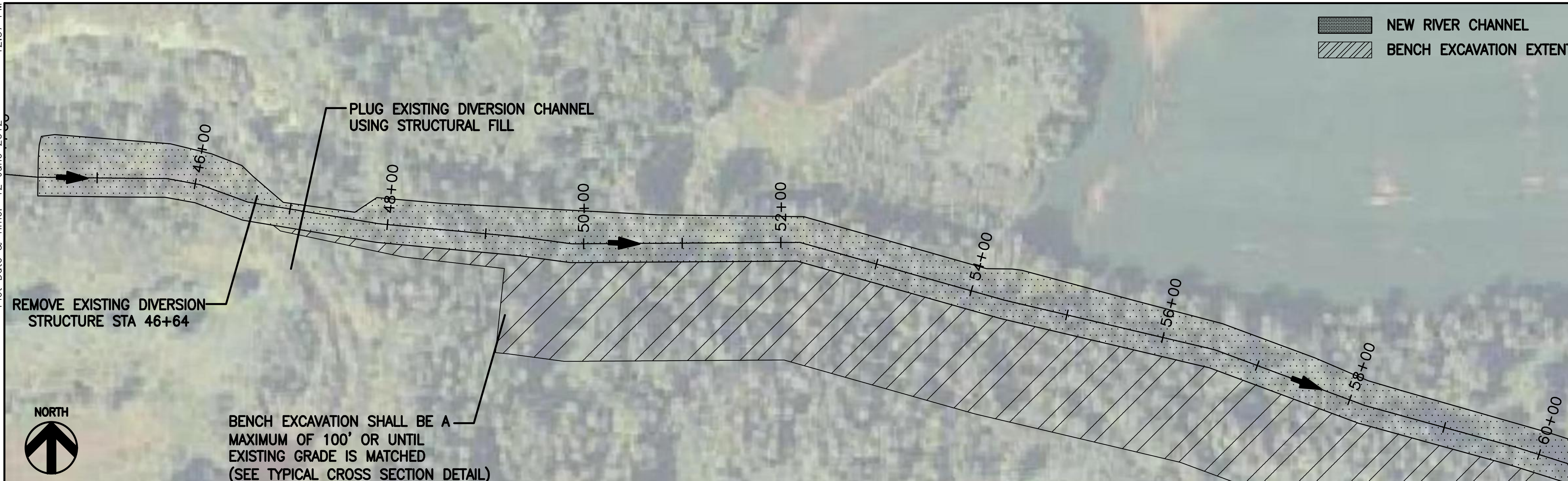

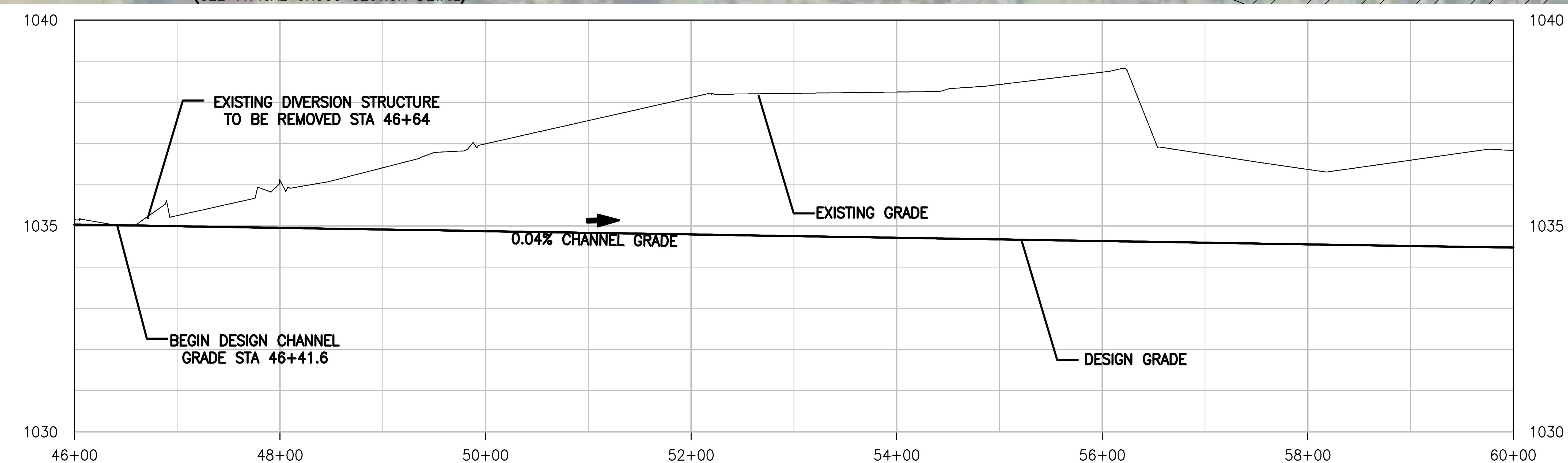

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DWG DATE: 5/7/2012		
SCALE: 1"=100'		

PROJECT: KINGSTON WETLAND RESTORATION
CLIENT: CLEARWATER RIVER WATERSHED DISTRICT
SHEET TITLE: DESIGN CHANNEL PROFILE
PROJECT NO.: 0002-174
SHEET NO.: FIGURE A.10
REV NO.:

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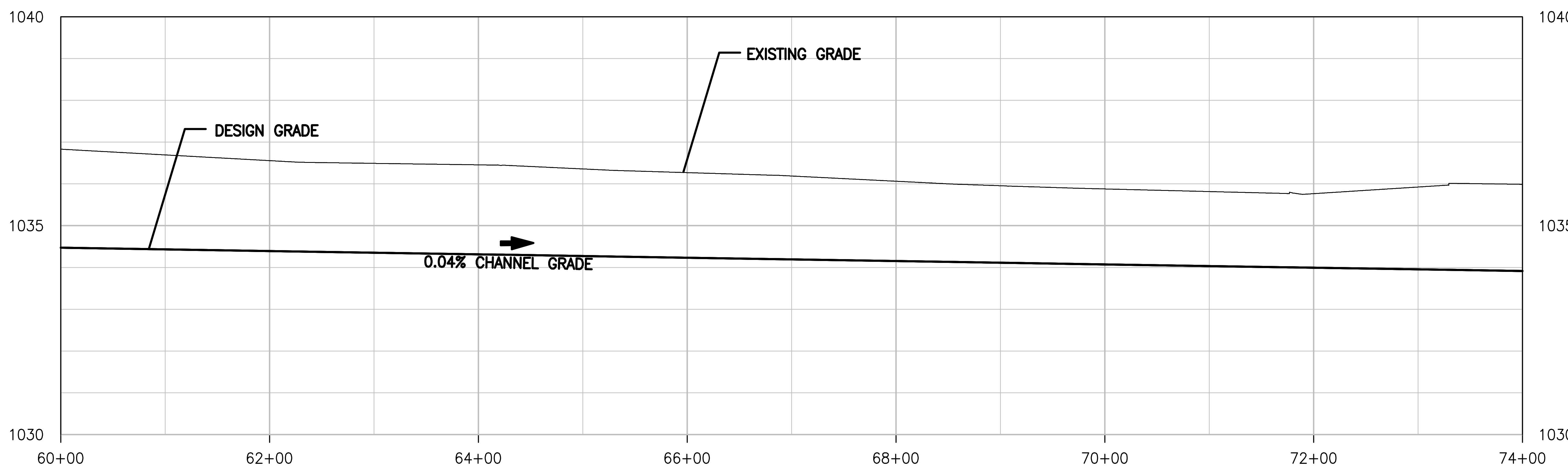

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PROJECT KINGSTON WETLAND RESTORATION

CLIENT CLEARWATER RIVER WATERSHED DISTRICT

SHEET TITLE DESIGN CHANNEL PROFILE

PROJECT NO. 0002-174

SHEET NO. FIGURE A.11

REV NO.

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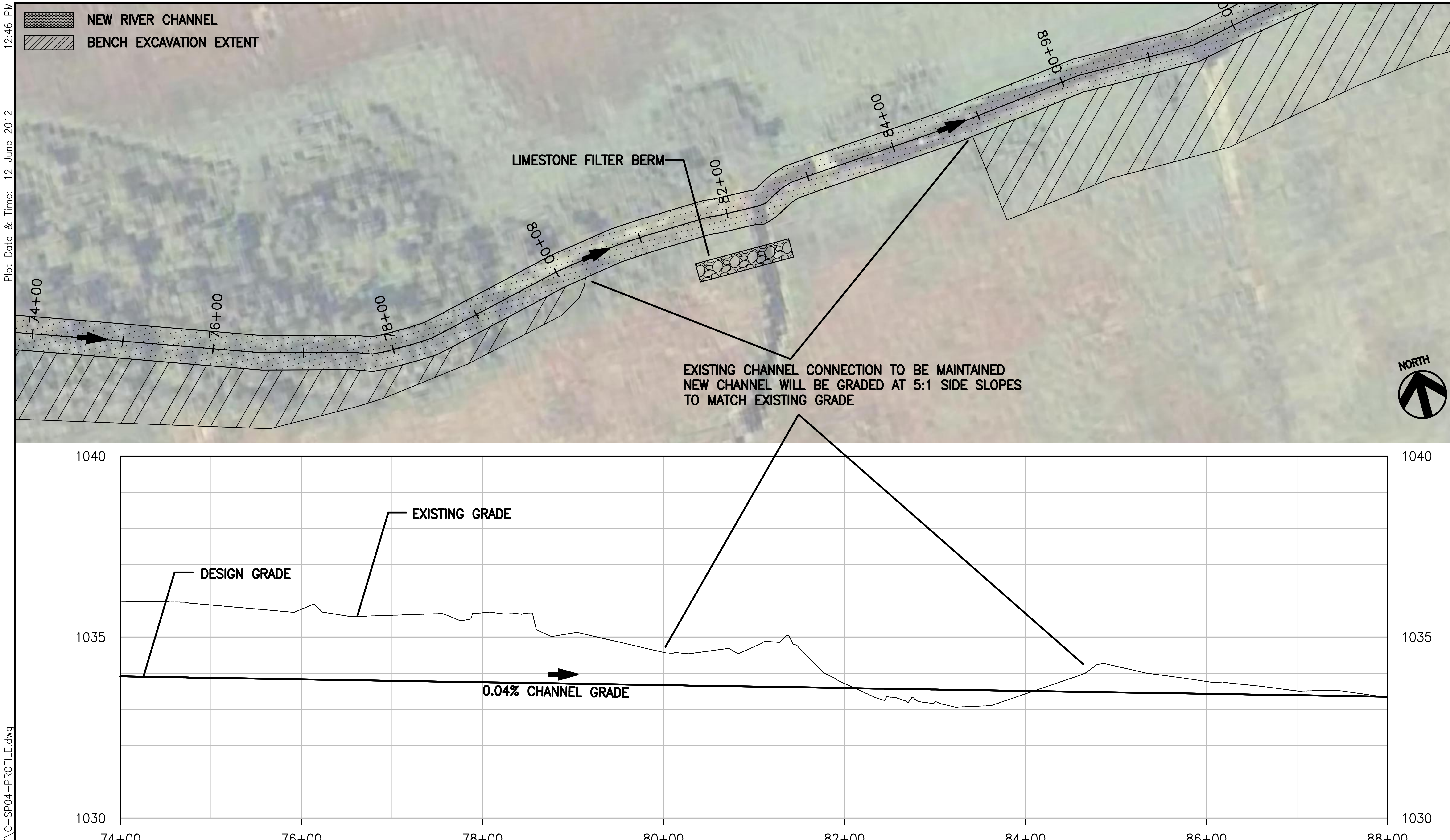

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PROJECT KINGSTON WETLAND RESTORATION

CLIENT CLEARWATER RIVER WATERSHED DISTRICT

SHEET TITLE DESIGN CHANNEL PROFILE

PROJECT NO.	SHEET NO.	REV NO.
0002-174	FIGURE A.12	

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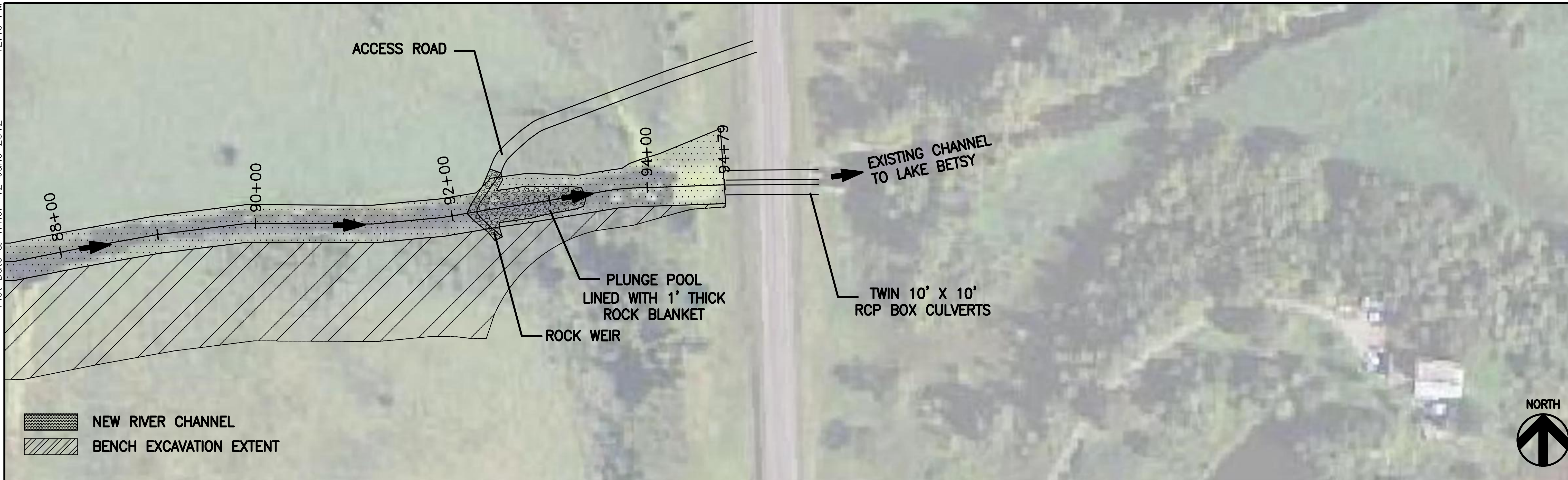

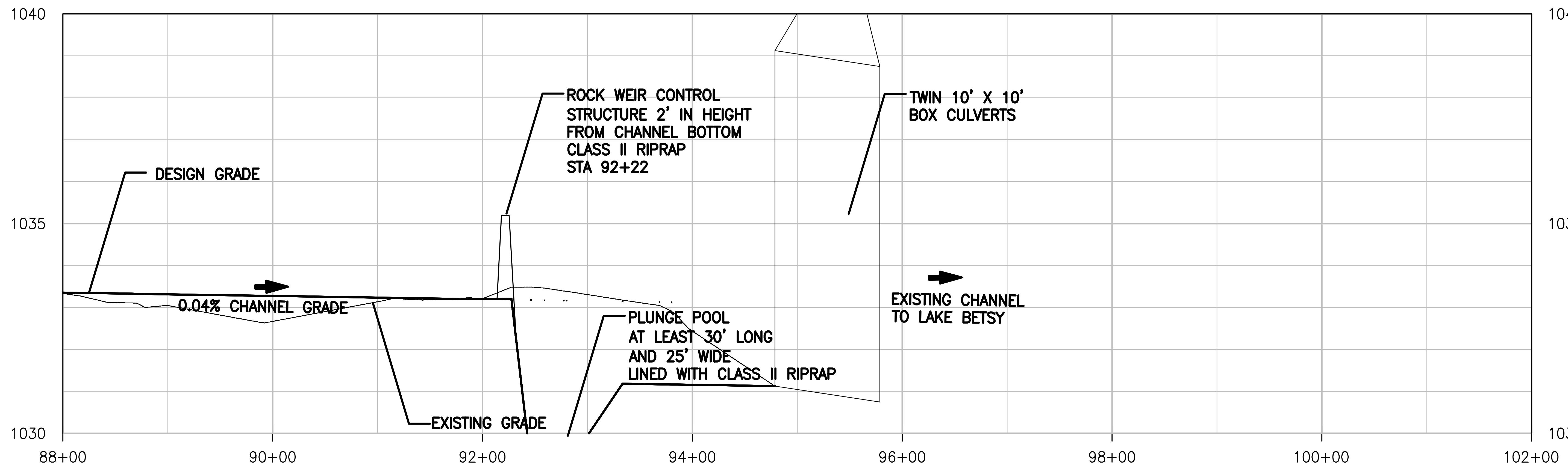

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APP'D	
DWG DATE	5/7/2012
SCALE	1"=100'
PROJECT	KINGSTON WETLAND RESTORATION
CLIENT	CLEARWATER RIVER WATERSHED DISTRICT
SHEET TITLE	DESIGN CHANNEL PROFILE
PROJECT NO.	0002-174
SHEET NO.	FIGURE A.13
REV NO.	

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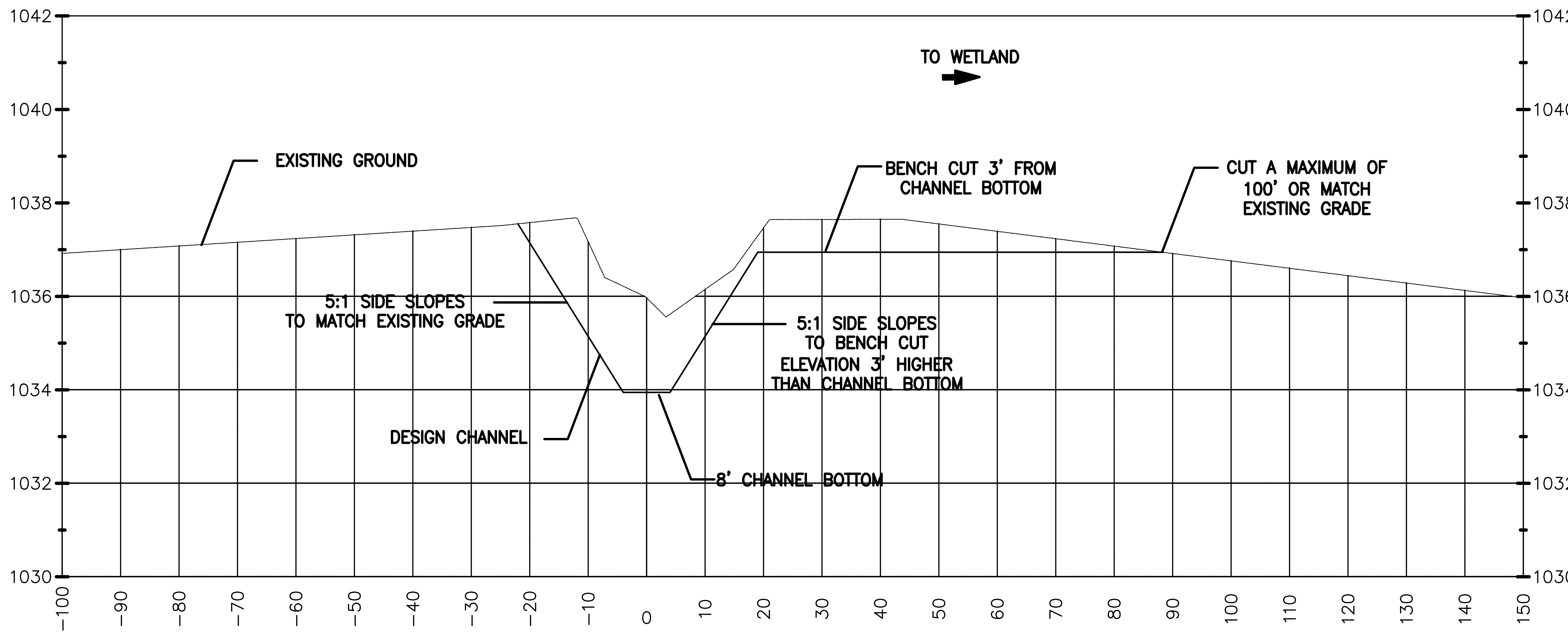

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PROJECT KINGSTON WETLAND RESTORATION

CLIENT CLEARWATER RIVER WATERSHED DISTRICT

SHEET TITLE TYPICAL DESIGN CHANNEL CROSS SECTION

PROJECT NO.	SHEET NO.	REV NO.
0002-174	FIGURE A.14	

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Appendix B

Kingston Wetland Feasibility Study and Restoration TMDL Project QAPP

Kingston Wetland Feasibility Study and Restoration TMDL Project Quality Assurance Project Plan

Prepared for:

Clearwater River Watershed District
P.O. Box 481
Annandale, Minnesota 55302

March 2011

Prepared by:

Roger Fisher
Water Quality QA/QC Coordinator
Performance Management & Quality Unit
Environmental Analysis & Outcomes Division
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, Minnesota 55155–4194

A. PROJECT MANAGEMENT

A1. APPROVAL SIGNATURE PAGE

By their signatures below the undersigned attest that they are familiar with the requirements of this document and agree to fulfill their responsibilities as specified herein.

Rebecca Kluckhohn, Project Manager, Wenck Assoc., Inc.	Date
Dennis Loewen, Assistant Administrator, CRWD	Date
Phil Votruba, Project Manager, MPCA	Date
Roger Fisher, WQ QA/QC Coordinator, MPCA	Date

A2. TABLE OF CONTENTS

GROUP A – PROJECT MANAGEMENT

GROUP B – MEASUREMENT/DATA ACQUISITION

GROUP C – ASSESSMENT/OVERSIGHT

GROUP D – DATA VALIDATION AND USABILITY

Tables

Standard Operating Procedures (SOPs)

Charts

Table 1. Acronyms and Abbreviations

ANC : Acid Neutralizing Capacity
CBOD : Carbonaceous Biochemical Oxygen Demand
CRWD : Clearwater River Watershed District
DQO : Data Quality Objective
DI : Deionized
DNR : [Minnesota] Department of Natural Resources
DO : Dissolved Oxygen
DOW : Division of Waters
eH : Oxidation–Reduction Potential
EPA : Environmental Protection Agency
EQuIS : Environmental Quality Information System
ERA : Environmental Resource Associates, Arvada, CO
EDI : Equal Depth Increment
EWI : Equal Width Increment
FD : Field Duplicate
GIS : Global Information System
H_2SO_4 : Sulfuric Acid
L : Liter
LGU : Local Government Unit
LIMS : Laboratory Information Management System
µ : Micron
µg : Microgram
µS : Microsiemen
mg : Milligram
MDA : Minnesota Department of Agriculture
MDH : Minnesota Department of Health Environmental Laboratory
MPCA : Minnesota Pollution Control Agency
MVTL : Minnesota Valley Testing Laboratories, Inc.
NIST : National Institute of Standards and Technology
PM : Project Manager
QA : Quality Assurance
QAC : Quality Assurance Coordinator
QAM : Quality Assurance Manual
QAPP : Quality Assurance Project Plan
QC : Quality Control
RPD : Relative Percent Difference
RSD : Relative Standard Deviation
SB : Sampler Blank
SM : *Standard Methods* (*for the Examination of Water and Wastewater*)
SOD : Sediment Oxygen Demand
SOP : Standard Operating Procedure
SWCD : Soil and Water Conservation District
SU : Standard Unit
TB : Trip Blank
TMDL : Total Maximum Daily Load
TP : Total Phosphorus
TSS : Total Suspended Solids
U of M : University of Minnesota
VOC : Volatile Organic Chemical
WLI : Water Laboratories, Inc.
WQ : Water Quality

DOCUMENT CONTROL

This document has been prepared according to the United States Environmental Protection Agency publication, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R5, March 2001). This QAPP will be reviewed annually and updated as needed. Updated versions of this QAPP will bear a new (x + 1) revision number. Phil Votruba will assume responsibility for archiving outdated versions of this QAPP which will be kept at Project headquarters. Archived versions of this QAPP will be retained for a minimum of ten years from the date of archival.

THE GRADED APPROACH TO QUALITY ASSURANCE PROJECT PLANS

The Graded Approach to Quality Assurance Project Plans is defined as the process of basing the level of application of managerial controls applied to the Project to the intended use of the Project outcomes (e.g., data) and on the degree of confidence needed in the quality and validity of these outcomes. This approach enables the Project partners to adapt the quality assurance and quality control activities to meet the rigor required by the Project.

During Project development the Project partners should use the *Systematic Planning* process (explained below) to develop Project data performance criteria, i.e., to determine the data type, data quantity, and data quality required to achieve Project objectives. These data performance criteria, then, determine the level of oversight and quality control activities necessary to ensure the data performance criteria requirements are met.

As an example, projects that provide initial estimates of parameters or that are non–regulatory in nature would not require the same Project quality assurance and Project planning rigor as would those generating outcomes (e.g., data) that are to be used to determine regulatory requirements.

In applying the graded approach, two important aspects for defining the necessary Project quality assurance rigor are:

- The intended use of the Project outcomes (e.g., data)
- The Project scope and magnitude

The intended use of the Project outcomes (e.g., data) is a determining factor because it is based upon the evaluation of the possible adverse impacts that may occur due to wrong decisions made and inappropriate or ineffective actions taken that may occur due to inadequate or inaccurate Project outcomes (e.g., data).

Examples of uses for Project outcomes, e.g., data, in descending order of importance are:

- Congressional testimony
- Regulatory compliance
- Litigation
- Regulatory development
- Agency infrastructure development
- Trends monitoring (non–regulatory)
- Compliance reporting guidelines
- Technological assessment
- Hypothesis testing
- Data display

SYSTEMATIC PLANNING

EPA has developed a Systematic Planning process call the Data Quality Objectives (DQO) Process. This is based on the *EPA Guidance for the Data Quality Objectives Process (QA/G–4) (EPA 2000).* While not mandatory, the DQO Process is the recommended planning approach for many EPA and EPA–funded data collection activities.

The purpose for using the Systematic Planning process is to document how individual data operations will be planned within the organization to ensure that data or information collected are of the needed and expected quality for their desired use. Use of the Systematic Planning process involves describing or referencing management and staff roles, responsibilities, and authorities for planning environmental data operations using a systematic planning process.

The Systematic Planning process has the following attributes:

- Identification and involvement of the Project manager, sponsoring organizations, responsible officials, Project personnel, stakeholders, technical staff, suppliers, and Project customers including data end users.
- Description of the Project goals, objectives, questions, and issues to be addressed.
- Identification of Project schedules, resources, milestones, and regulatory and contractual requirements.
- Identification of the type and quantity of data needed and how it will be used to support Project objectives.

- Specification of performance criteria for measuring quality.
- Specification of the quality control and quality assurance activities needed to assess the quality performance criteria such as field and laboratory quality control samples, audits, technical assessments, and performance evaluations.
- Description of how, when, and where the data (including existing data) will be obtained and the identification of any constraints on data collection and use.
- Description of how the acquired field and/or laboratory data will be analyzed, reviewed, evaluated, verified, validated, and assessed to determine if they meet the quality performance criteria and are appropriate for their intended use.
- Development of a Quality Assurance Project Plan (QAPP) or similar planning document and reviewing, approving, implementing, and revising it, as needed, in conformance with *EPA Requirements for Quality Assurance Project Plans (QA/R–5) (EPA 2001).*
- Evaluation and qualification of secondary data from other sources, if used, including the application of statistical methods.

GROUP A. PROJECT MANAGEMENT

A3. QAPP DISTRIBUTION LIST

Each person listed on the Approval Signature Page and each person listed in Table 2 or his/her successor will receive a copy of the final approved version of this Quality Assurance Project Plan. A copy will also be made available to other persons taking part in the Project and to other interested parties.

Table 2. Kingston Wetland Feasibility Study and Restoration TMDL Project QAPP Distribution List

Name	Title/Affiliation	Address	Phone/e–mail
Dennis Loewen	Assistant Administrator, CRWD	P.O. Box 481, Annandale, MN 55302	320.274.3935; loewen.dennis@yahoo.com
Rebecca Kluckhohn., P.E.	Principal, Wenck Assoc,, Inc.	1800 Pioneer Creek Center, Maple Plain, MN 55359	612.479.4224; rkluckhohn@wenck.com
Joel Toso, Ph.D., P.E.	Wenck Assoc., Inc.	1800 Pioneer Creek Center, Maple Plain, MN 55359	1.800.472.2232; jtoso@wenck.com
Wes Boll	Wetland Biologist, Wenck Assoc., Inc.	1800 Pioneer Creek Center, Maple Plain, MN 55359	612.479.4284; wboll@wenck.com
Phil Votruba	Project Manager, MPCA	7678 College Road, Suite 105, Baxter, MN 56425	218.316.3901; phil.votruba@state.mn.us
Roger Fisher	WQ QA/QC Coordinator, MPCA	520 Lafayette Road North, St. Paul, MN 55155–4194	651.757.2360; roger.fisher@state.mn.us

A4. PROJECT/TASK ORGANIZATION

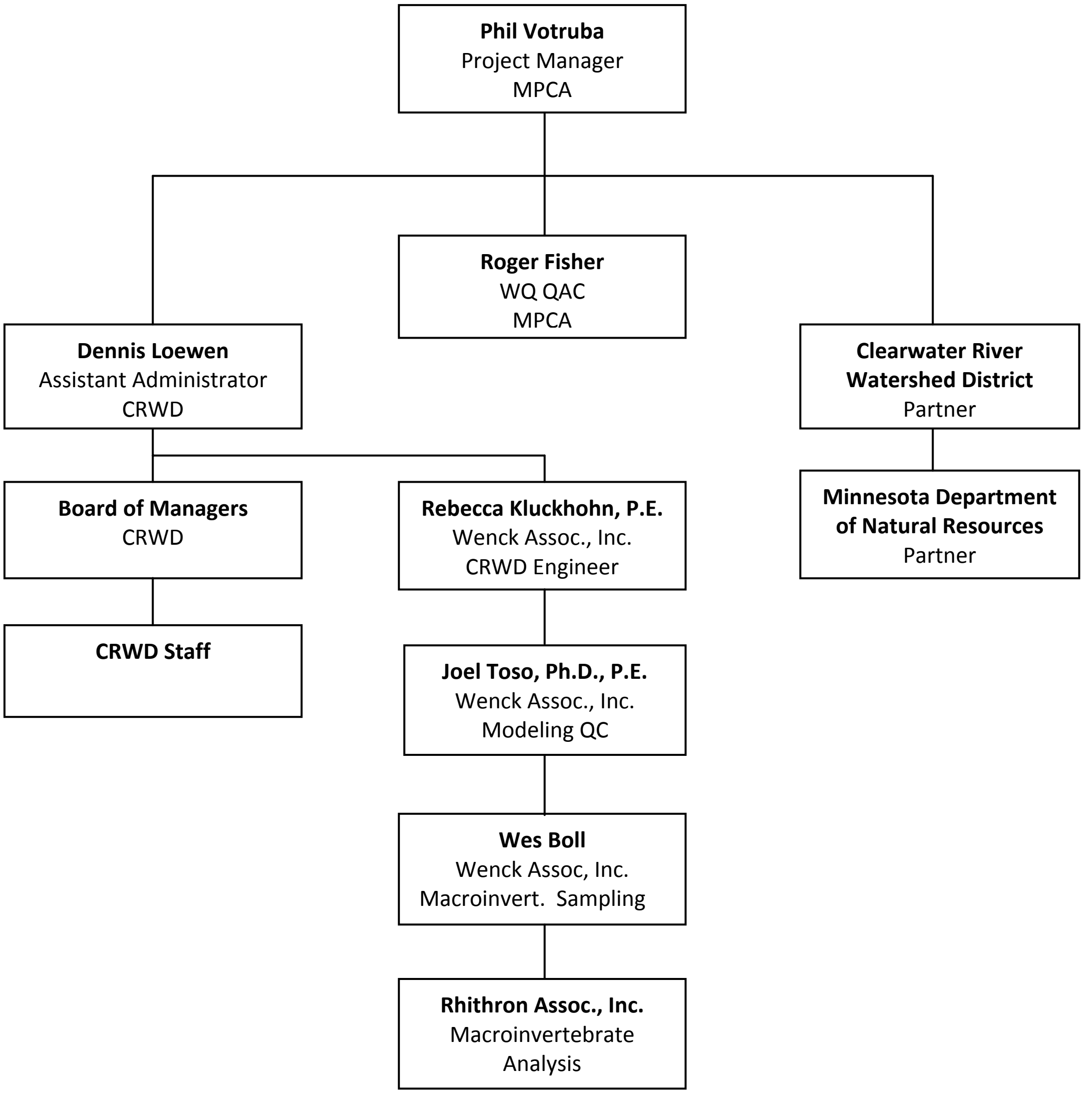
Table 3. Kingston Wetland Feasibility Study and Restoration TMDL Project Personnel

Name/Title	Project Responsibility
Dennis Loewen, Assistant Administrator, Clearwater River Watershed District	Project Oversight; Project Decisions; Data Review, Assessment, Verification and Validation; Project and Watershed Partners Liaison; Historical Data Integration and Analysis; Report Preparation
Rebecca Kluckhohn, P.E., Principal	Project Manager; Project Oversight; Project Decisions; Data Review, Assessment, Verification, and Validation; Modeling QC; Report Preparation
Joel Toso, Ph.D., P.E.	Modeling QC; Report Preparation Assistance
Wes Boll, Wetland Biologist	Macroinvertebrate Sampling; Report Preparation Assistance
Phil Votruba, Project Manager, MPCA	Project Oversight; Project Decisions; Data Review, Assessment, Verification and Validation; Project Partners Liaison; Project Report Submittals
Roger Fisher, WQ QA/QC Coordinator	Project QAPP Author; QA/QC Support

The MPCA QA/QC Coordinator (QAC) is independent from Project staff including those that generate data. The extent of the QAC role is to assist in the writing of this QAPP and to be available to address Project QA/QC problems and concerns. The QAC is not accountable to anyone directly or indirectly associated with this Project.

Dennis Loewen is responsible for maintaining the latest official approved version of this QAPP.

Chart 1. Kingston Wetland Feasibility Study and Restoration TMDL Project Organizational Chart



A5. PROBLEM DEFINITION/BACKGROUND

A5.1 Kingston Wetland Feasibility Study and Restoration TMDL Project Background

The Kingston Wetland Complex is a riparian wetland of the Clearwater River Chain of Lakes. The Minnesota Pollution Control Agency (MPCA) found that the Clearwater River between Clear Lake and Lake Betsy, reach ID 07010203–549 located in Meeker County, Minnesota, is impaired and does not meet Minnesota water quality standards for dissolved oxygen (DO). This reach was placed on the 303(d) impaired waters list in 2004 because monitoring data have revealed that DO concentrations sometimes fall below the state standard of 5 milligrams per liter (mg/L) which can impair aquatic habitat. The Total Maximum Daily Load (TMDL) Study completed for this reach in January 2009 showed that the sediment oxygen demand (SOD) and altered wetland hydrology in the Kingston Wetland were contributing to the DO impairment. The study further showed that a reduction in the Kingston Wetland SOD and possibly a change in hydrology would be needed to meet the state standard.

Historically, the Clearwater River was straightened and ditched through the Kingston Wetland to facilitate drainage of fields for agriculture, the dominant land use in the watershed. In the early 1980s the Clearwater River Watershed District (CRWD) undertook a Project in the Kingston Wetland Complex to restore the wetland's assimilative capacity for phosphorus and to improve water quality in downstream lakes. The Project was part of the CRWD's Clearwater Chain of Lakes Restoration Project through which Clearwater Lake water quality was improved from 400 µg/L to 40 µg/L average summer surface Total Phosphorus (TP).

The original Kingston Wetland Project included a dike constructed around the wetland's perimeter to route the Clearwater River to the edges of the wetland to allow it to filter through the wetland and back into the main channel. A perpetual easement was secured on the property through the Clearwater Chain of Lakes Restoration Project. The Project was designed to remove particulate phosphorus by restoring some hydrology to the wetland. The Project successfully improved water quality in all the downstream lakes over the past 30 years.

A5.2 Kingston Wetland Feasibility Study and Restoration TMDL Problem Definition

Although Clearwater Lake nutrient levels are at or below state nutrient standards the CRWD has expanded its water quality goals through the TMDL process. The CRWD has 7 approved TMDLs, one pending de–list, 6 lake nutrient TMDLs in the post–public comment stage, and an approved TMDL Implementation Plan. The *Clearwater River Watershed District Watershed Protection and Improvement Plan,* approved by MPCA in May 2010, serves as the TMDL Implementation plan for all CRWD impaired waters and identifies the need to implement additional phosphorus filtration in the Kingston Wetland to enable 6 impaired lakes to meet the state nutrient standard and to enable the Clearwater River to meet the state DO standard.

The wetland serves as a natural sink for particulate phosphorus and is somewhat protective of water quality in downstream lakes. However, nutrients imbedded in wetland sediments impose an oxygen demand that reduces DO levels in the main channel and at times contribute soluble phosphorus to downstream lakes.

A6. PROJECT/TASK DESCRIPTION

A6.1 Kingston Wetland Feasibility Study and Restoration TMDL Project Goals

The Kingston Wetland Feasibility Study and Restoration TMDL Project (hereinafter: Project) goal is to design and implement a Clearwater River and Kingston Wetland restoration plan to improve dissolved oxygen concentrations in the Clearwater River, reduce nutrient loads to impaired Lakes Betsy, Union, Louisa, Marie, and Caroline, connect a recreational corridor, and improve riverine and wetland habitat.

DO improvements are to be achieved by mitigating sediment oxygen demand in the wetland complex. Additional Project goals are to achieve a 60% wetland SOD reduction and a 1,970 lbs./yr. TP reduction to Lake Betsy and 5 other nutrient impaired lakes by preventing soluble phosphorus export from the riparian wetland. Improving the system will protect its existing phosphorus assimilative capacity and will help 6 nutrient–impaired lakes downstream meet their water quality standards while protecting two high value recreational waters: Clearwater and Grass Lakes,. The CRWD also seeks to improve the riparian wetland and main channel habitat by restoring the system to a pre–agrarian condition, re–establish a Clearwater River corridor to connect the upper agricultural watershed with the downstream recreational lakes area, and to engage local stakeholders by involving them in a technical advisory process. Further, the CRWD seeks to educate area residents through the distribution and posting of educational materials and by including Project activities and achievements in its annual watershed tour.

This Project will strive to restore the wetland and main channel to its pre–agrarian hydrology by redirecting the low flow channel through the wetland complex which will enable high flows to access the floodplain and reduce the main channel low flow exposure to sediment oxygen demand and soluble phosphorus export in the wetland while maintaining the assimilative capacity of particulate phosphorus in higher flows. The concept design will also result in a condition that is closer to native landscape providing wetland and riverine habitat to support a broader range of species. Further, by restoring the main channel and meander to a pre–agrarian condition the river goes from being a ditch through a wetland to a significant recreational resource.

A6.2 Kingston Wetland Feasibility Study and Restoration TMDL Project Summary

Significant data collection and modeling are required to optimize the design. The CRWD will administer the Project which involves collecting one year of monitoring data which will include wetland/main channel and groundwater hydrology and water quality. CRWD will also work with the District Engineer to construct a hydrologic and hydraulic model of the upper watershed and collect topographic data for the wetland. Hydrology and hydraulics model will be used in conjunction with the existing QUAL–2K model constructed to set the DO TMDL to optimize design. CRWD will design and construct the work. A contractor will be retained for construction through the CRWD's standard bidding process. The work will be done through a combination of in–kind staff labor and consultant/contractor time.

Following implementation of the Project the CRWD will monitor the results of the Project and collect inflow and outflow data. Flow, total and soluble phosphorus, suspended sediment, and dissolved oxygen will be monitored. CRWD will also conduct habitat evaluations of the system before and after the restoration to track effectiveness.

A6.3 Project Tasks

Objective 1: Identification and Selection of Restoration Approach

Task 1.1 Monitoring

Conduct field monitoring to assess conditions such as channel and wetland morphometry, water quality, flow regimes, groundwater interaction, and existing ecological conditions. These results will be used to design the restoration and to assess its success during the first several years following system construction. Monitoring data will be reported to the Minnesota Pollution Control Agency's (MPCAs) EQuIS (Environmental Quality Information System) by November 1st of the monitoring year.

For water quality analysis CRWD will use MVTL or WLI for this task. The budget for this task includes installation of up to 3 piezometers, two flow pressure transducers upstream and downstream of the wetland and discrete flow–gauging to develop inflow and outflow rating curves. Water quality samples will be collected at the inflows to the wetland and wetland outflow.

Task 1.2 Modeling

Water quality, hydrologic, and hydraulic modeling will be conducted to develop and evaluate the design options. Modeling will optimize channel re–meander design for optimal function and model DO response to design alternatives.

Task 1.3 Reporting

Design options will be summarized in the Engineers Report and presented to the Board and stakeholders for a final recommendation and selection.

Objective 2: Restoration Implementation

Task 2.1 Design

Prepare bid documents including plans and specifications for construction and bidding assistance.

Task 2.2 Construction

This task includes construction of the restoration (implementation), construction observation, preparation of record drawings and, processing of contractor change orders and pay requests.

Objective 3: Operation, Maintenance, and Follow–up Monitoring

Task 3.1 Operation and Maintenance

Annual activities include inspection and maintenance of restoration which may include vegetative maintenance, adjustment of operational components such as flows, and potentially improvements or adjustments.

Task 3.2 Follow–up Monitoring

The efficacy of the restoration will be evaluated annually by measuring flows, loads, and DO into and out of the systems. Ecological monitoring will also be conducted to assess Project impacts. Results will be reported annually for two years in the CRWD's Annual Monitoring Report. Analysis of follow–up water quality monitoring will be done by Water Laboratories Inc., Elk River. MVTL will perform any analyses Water Laboratories, Inc. is unable to do.

Objective 4: Technical and Stakeholder Information Program

Task 4.1 Information Program

Develop technical, educational, and outreach informational materials for stakeholders and conduct meetings and make direct contacts with stakeholders to facilitate Project. The stakeholders include land–owners, local school districts, cities, townships, lake associations, county and state officials, DNR, and other agencies.

Task 4.2 Permitting

Secure necessary Project permitting with appropriate agencies.

Objective 5: Fiscal Management and Administration

Task 5.1 Fiscal Management

Track, manage, and report Project financial status, as required.

Task 5.2 Administration

Track, manage, and report on Project administrative elements, as required.

A6.4 Quantifiable Outcomes

Following are the desired Project outcomes. Project success will be measured by the degree to which they are achieved.

1. Sixty percent reduction in wetland SOD.
2. Twenty percent annual nutrient load reduction to downstream lakes.
3. The degree to which the wetland and riverine habitats support a wider range of wildlife.
4. The degree to which Clearwater River recreational opportunities are enhanced.
5. The degree to which local partner Project participation increases.
6. The degree to which Project meeting public attendance increases.
7. Local school district environmental curriculum development.

A6.5 Kingston Wetland Feasibility Study and Restoration TMDL Project Milestone Schedule

Following are Project milestone tasks for 2010 – 2015. For task details refer to the Project Work Plan.

Table 4. Kingston Wetland Feasibility Study and Restoration TMDL Project Milestone Schedule

Tasks	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Water Quality Monitoring			●	●	●	●	●	●	●	●		
Water Quality Data Assessment						●	●	●	●	●	●	●
Modeling – Develop and Implement							●	●	●	●	●	●
Restoration Design	■	■	■	■	■	■						●
Restoration Construction Activities			■	■	■	■						
Operation and Maintenance Activities	♦▲¤	♦▲¤	♦▲¤									
Vegetative Maintenance				♦▲	♦▲	♦▲	♦▲	♦▲	♦▲			
Water Quality Effectiveness Monitoring				♦▲	♦▲	♦▲	♦▲	♦▲	♦▲			
Effectiveness Mon. Data Assessment						♦▲	♦▲	♦▲	♦▲	♦▲	♦▲	♦▲
Technical Information Program	♦▲¤	♦▲¤	♦▲¤	●♦▲	●♦▲	●♦▲	●♦▲	●♦▲	●♦▲	●♦▲	●♦▲	●♦▲
Model Development	■	■	■					●	●	●	●	●
Permitting Activities										●	●	●
Data Submittal to MPCA for EQuIS Entry											●■♦	
Project Progress Report to MPCA												●■♦ ▲
Final Project Report to MPCA								¤				

Legend: ● = 2011; ■ = 2012; ♦ = 2013; ▲ = 2014; ¤ = 2015

A6.5 Samples for Laboratory Analysis

Water quality samples are submitted to Minnesota Valley Testing Laboratories, Inc., (MVTL) New Ulm, or Water Laboratories, Inc., (WLI) Elk River and analyzed for the following parameters:

- Total Phosphorus
- Soluble Phosphorus
- Total Suspended Solids
- Total Suspended Volatile Solids
- Chlorophyll–a
- Alkalinity

A6.6 Samples for Field Measurement

The following parameters will be measured in the field through use of a multi–probe, meter, or other device:

- Dissolved Oxygen
- Specific Conductance
- pH
- Temperature

A6.7 Field Monitoring Activities

The following parameters will be monitored in the field through use of the appropriate instrumentation:

- Stream Flow
- Stream Stage
- Groundwater Elevation

A6.8 Biological Monitoring

Stream macroinvertebrate communities will be sampled and analyzed to assess Project impact on DO–sensitive species. Macroinvertebrate samples will be collected upstream and downstream of the Kingston Wetland per Protocol EMAP–SOP4, Rev. 0, the MPCA protocol for biotic sampling. Samples will be collected annually; once prior to restoration and twice during the first two full growing seasons following restoration. Samples will be collected by Wes Boll of Wenck Assoc., Inc., and analyzed by Rhithron Assoc., Inc., the laboratory used by MPCA for such analysis.

A7. MEASUREMENT DATA QUALITY OBJECTIVES AND CRITERIA

Table 5. Laboratory and Field Parameter Measurement Objectives

Parameter	Precision (% RPD)	Range	Reporting Limits	Units	Holding Times
Chlorophyll–a	30%	1.0 – ∞	‡	µg/L	¥
Total Phosphorus	30%	0.010 – 3	0.005	mg/L	28 D
Total Dissolved Phosphorus	30%	0.01 – 0.5	0.005	mg/L	28 D
Total Suspended Solids	30%	1 – 20,000	1.0	mg/L	7 D
Total Suspended Volatile Solids	30%	1 – 100	1.0	mg/L	7 D
Alkalinity	30%	10 – 200	4	mg/L	14 D
Dissolved Oxygen†	[0.1 mg/L]	0.5 – 14	—	mg/L	—
pH†	[0.3 Units]	6 – 9	—	Standard Units	—
Specific Conductance†	20%	100 – 2,000	0.2	µS/cm	—
Temperature†	[0.3°C]	0 – 25	—	°C	—

‡Depends upon the volume of sample filtered; ¥ Unfiltered samples may be stored on ice in the dark for up to 48 hours prior to analysis. Field filtered samples stored on ice and in the dark should be submitted for laboratory analysis within 7 days of sampling. The analyzing laboratory may freeze filtered samples at ≤ 20 °C for up to 30 days from date of sampling before analysis; †Field Measurement.

Virtually all environmental data are only approximations of the true values of the parameters measured. These estimates are affected by the variability of the medium being sampled and by random and systematic errors introduced during the sampling and analytical procedures.

Data Quality Objectives (DQOs) are qualitative or quantitative statements of:

- Precision (a measure of random error)
- Bias (a measure of systematic error)
- Accuracy
- Representativeness
- Completeness,
- Comparability, and
- Sensitivity

The DQOs must be defined in the context of Project requirements and objectives not the test method capabilities.

Precision – This quality element measures how much two or more data values are in agreement with each other. Precision is discussed in the introductory chapter of *Standard Methods for the Examination of Water and Wastewater,* 20th Edition, 1998. Field sampling precision is determined by using field split samples or field duplicate samples. Laboratory analytical precision is determined by comparing the results of split samples, duplicate samples, and duplicate spike samples.

Sampling and/or analytical precision may be determined from split or duplicate samples by calculating the Relative Percent Difference (RPD) as follows:

$$\mathbf{RPD = (A - B) \div ((A + B) / 2) \times 100}$$

where A is the larger of the two duplicate sample values and B is the smaller value.

When three or more replicate samples or measurements are taken, calculate the Relative Standard Deviation (RSD) instead of the RPD as follows:

$$\mathbf{RSD = (s/\sigma) \times 100}$$

Where **s** is the standard deviation of the replicate values and **σ** is the mean of the replicate values.

Bias – This expresses the degree to which a measured value agrees with or differs from an accepted reference (standard) value due to systematic errors. Field bias should be assessed by use of field blanks and trip blanks. Adherence to proper sample handling, preservation, and holding time protocols will help minimize field bias.

Since the sampling method for all sampling will be grab sampling, no field blanks (sampler blanks) will be taken. Trip blanks are taken only for VOC sampling which is not a parameter to be measured by this Project. Thus bias due to field activities will not be determined. However, laboratory bias will be determined as part of its internal quality control. Bias effects that fall outside the laboratory's acceptance limits will be flagged.

Accuracy – This expresses the degree to which an observed (measured) value agrees with an accepted reference standard (certified sample value) or differs from it due to systematic errors.

Completeness – Expressed as the number of valid (usable) data points made to the total number of measurements expected according to the original sampling plan. Percent completeness is determined separately for each parameter and is calculated as follows:

% Completeness = (number of usable data points ÷ number of planned data points) x 100

High or low water levels may reduce the number of samples that can be taken. This may be compensated for by scheduling additional sampling events or sampling as near to the original sampling site as possible. Any such variances to the established sampling protocol will be thoroughly documented. Resulting data will also be qualified to reflect this.

Representativeness – This expresses the degree to which data accurately and precisely represents parameter variations at a sampling point, or of a process or environmental condition. Representativeness of field data are dependent upon proper sampling program design and is maximized by following the sampling plan, using proper sampling protocols, and observing sample holding times.

Data will also be compared to historical Project data and to current and historical data generated by other organizations
Comparability – This represents the level of confidence with which the Project data set can be compared to other data. Indicate the steps to be taken to ensure the comparability of field measurements and laboratory analyses. Comparability is dependent upon establishing similar QA objectives for the sets being compared and is achieved by using similar sampling and analytical methods.

Sensitivity – For laboratory analyses this represents the lowest level of analyte that can be reliably detected by the laboratory analytical method. For field measurements this represents the lowest level of analyte the field analytical method or meter can reliably detect.

Table 6. Minnesota Valley Testing Laboratories, Inc. Analytical Parameters and Methods

Parameter	Sample Quantity	Sample Container	Preservative	Holding Times	Analytical Method
Chlorophyll–a	1 L	Amber Glass	Cool to 4°C	¥	SM* 10200 H
Total Phosphorus	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 365.1
Dissolved Phosphorus	500 mL	Plastic	Cool to 4°C	24 H	EPA 365.1
Total Suspended Solids	500 mL	Plastic	Cool to 4°C	7 D	USGS I–3765–85
Total Suspended Volatile Solids	500 mL	Plastic	Cool to 4°C	7 D	EPA 160.4
Alkalinity	500 mL	Plastic	Cool to 4°C	14 D	SM 2320 B–97

[¥]Unfiltered samples may be stored on ice in the dark for up to 48 hours prior to analysis. Field filtered samples stored on ice and in the dark should be submitted for laboratory analysis within 7 days of sampling. The analyzing laboratory may freeze filtered samples at ≤ 20 °C for up to 30 days from date of sampling before analysis,
**Standard Methods for the Examination of Water and Wastewater.*

Table 7. Water Laboratories, Inc. Analytical Parameters and Methods

Parameter	Sample Quantity	Sample Container	Preservative	Holding Times	Analytical Method
Chlorophyll–a	1 L	Amber Glass	Cool to 4°C	¥	SM* 10200 H
Total Phosphorus	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 365.4
Dissolved Phosphorus	500 mL	Plastic	Cool to 4°C	24 H	EPA 365.1
Total Suspended Solids	500 mL	Plastic	Cool to 4°C	7 D	USGS I–3765–85
Total Suspended Volatile Solids	500 mL	Plastic	Cool to 4°C	7 D	EPA 160.4
Alkalinity	500 mL	Plastic	Cool to 4°C	14 D	SM 2320 B–97

¥Unfiltered samples may be stored on ice in the dark for up to 48 hours prior to analysis. Field filtered samples stored on ice and in the dark should be submitted for laboratory analysis within 7 days of sampling. The analyzing laboratory may freeze filtered samples at ≤ 20 °C for up to 30 days from date of sampling before analysis,
**Standard Methods for the Examination of Water and Wastewater.*

A8. SPECIAL TRAINING REQUIREMENTS/CERTIFICATIONS

Training of Project staff, if needed, is done through assistance from knowledgeable CRWD staff and the MPCA Project Manager. Dennis Loewen is responsible for field sampling training and monitoring oversight.

Dennis Loewen is responsible for ensuring key Project staff have or receive adequate training to effectively and correctly perform their Project duties. Key staff include the Assistant Administrator, Project Manager, consultants, engineers, samplers, sample handlers, data reviewers, and data assessors. He is also responsible for documenting such training and maintaining the training records.

Wes Boll, macroinvertebrate sampler, has nine years experience as a wetland biologist with specific invertebrate sampling experience with several projects including the MPCA Shingle Creek Biotic TMDL Project. He appears on the Master Contract Watershed Protection and Restoration list for this type of work. His resume is on file and available for review upon request.

A8.2 Stakeholder Groups

Stakeholder groups have been well established and functioning in the CRWD. Numerous successes have been attributed to coordinated efforts in the CRWD including critical habitat protection, complex remedial actions, riparian enhancement, wetlands rehabilitation, and implementation of volunteer monitoring, stewardship and education programs. Project staff will partner with stakeholder group staff in a joint effort to achieve Project objectives.

A9. DOCUMENTATION AND RECORDS MAINTENANCE REQUIREMENTS

All versions of the QAPP are retained in the CRWD office. Data are entered into MPCA's Environmental Quality Information System (EQuIS) by MPCA staff. Field sampling sheets are completed on–site at the time of sampling.

Sampling collection records, field notebooks, and all records of field activity are retained by CRWD staff for five years following completion of the Project.

GROUP B. DATA GENERATION AND ACQUISITION

B1. SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN) REQUIREMENTS

CRWD staff and MPCA staff in consultation with Project partners developed the sampling plan.

Water chemistry and physical data are collected and used to monitor Project effectiveness. Samples taken during the Project are considered a snapshot of current water quality conditions. Long–term monitoring programs should be established to accurately measure water quality conditions.

B2. SAMPLING METHODS REQUIREMENTS

All field work for this Project, including water sample collection and delivery within the required time frame to MVTL or WLI, are conducted by Project staff. A certified laboratory analyzes the Project water samples for all Project analytes for which MPCA requires certification. This QAPP supports the laboratory's QAM and SOPs and is specific for Project.

Water chemistry field duplicates are collected 10% of the time for lake and stream samples. All samples are collected using approved methods and sampling devices. Samples are transferred from sample collection devices to pre–cleaned polyethylene or glass bottles. Project staff are responsible for collection and transport of the samples to MVTL or WLI which provides the pre–cleaned bottles and the sterile bacteriological bottles, if needed.

For detailed lake and stream sampling guidance information refer to Appendix C, *Lake and Stream Field Sampling Protocol*.

B3. SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Dennis Loewen is the field sample custodian and keeps records of all samples taken by field personnel. Sample bottles are labeled with bottle number, site identification, and date. They are sealed tightly and packed in a cooler on ice at the sampling location. The field record includes Project name, sampler's signature, unique station identification number, sample number, parameters for laboratory analysis, matrix, number and size of containers, and date and time. All laboratory samples are typically delivered to MVTL or WLI within 24 hours of collection. Coolers containing samples that require ice preservation are checked periodically to ensure samples remained adequately iced so sample temperatures do not exceed 6°C.

Information on field conditions, such as the weather, deviations from written procedures, operating condition of the equipment, and other unusual occurrences are also recorded for each sampling event.

B3.1 Laboratory Sample Handling

Sample containers are provided by the laboratory. Container cleanliness is verified by QA/QC procedures as specified in the laboratory's QAM and SOPs. The laboratory verifies sample bottle cleanliness by running a specified number of bottle blanks on each shipment received and on each batch of sample bottles following laboratory cleaning and sterilization, if reused. A preservative is added to specific bottles, as required, or accompanies the bottles in a separate container. Preservatives used and their volumes and concentrations are specified in the laboratory QAM.

Temperature blanks provided by the laboratory are included in the coolers to verify whether the appropriate sample temperature of ≤ 6°C has been maintained.

Upon arrival at the laboratory, the condition of the samples is determined. The samples are checked for leaks and appropriate preservation and the temperature taken. The information is recorded on the sample identification sheet. The sample identification sheet information is then compared to the information on the sample bottles and any discrepancies are noted. The samples are then logged into the Laboratory Information Management System (LIMS). They are assigned two identification numbers, a work order number and a unique laboratory number. The samples are then stored in the appropriate area as determined by required storage temperature, matrix, and analyses required. The laboratory sample storage areas are monitored daily.

Samples are tracked using LIMS. Any problems encountered are reported to the client. An analytical report is printed out. The samples are held until their holding time has expired or until 30 days after completion of the analysis. Samples are then disposed of in an environmentally acceptable manner. Samples are returned to the client if requested. Water samples that are environmentally safe are disposed into the local sanitation system. Samples that contain hazardous waste may be returned to the client for proper disposal.

Analytical Standard Operating Procedures (SOPs) are part of the laboratory QAM.

B3.2 Field Information Sheets

Field data sheets are the primary method for documenting most stream monitoring field activities. These sheets serve as an initial record of any field measurements and weather conditions at the time of sampling.

B3.3 Field Notes

Field notes are used to document important information during sampling events. They are entered into a bound notebook with waterproof pages. Entries are made using pens with indelible ink. The field notebook becomes part of the Project data and is retained with the analytical data hard copies and other Project documents.

B3.4 Sample Labeling

Each sample container has a label attached which is filled out in its entirety. Sample containers without labels or labels that are missing information are not, as per laboratory policy, accepted by the laboratory. The sample label includes the water body code or name, the site number, the date, and time of sample collection.

B3.5 Sample Shipping

All samples are packed in an ice–filled cooler for transport to the laboratory. Samples are typically transported within 24 hours of collection.

B3.6 Chain of Custody

A Chain of Custody (COC) form accompanies the samples when they are delivered to the laboratory by Project staff. At time of delivery the COC form is signed by the Project staff person as samples relinquisher and by the laboratory staff person as samples receiver. The COC form may be integrated into the sample field sheet. When not in the physical possession of the samplers, sample handlers, or laboratory staff, the samples are kept in a secure place with restricted accessibility.

When samples are shipped by common carrier a copy of the field sheet, a signed copy of the COC form, and the bill of lading accompany the samples to the laboratory. The field sheet and COC form are placed in the cooler with the samples in a water–tight zip–lock type bag. A copy of the bill of lading accompanies the sample package to the laboratory and a copy is retained by the Project staff person shipping the samples. The bill of lading becomes part of the Project record. Upon delivery of the sample package to the laboratory the COC form is signed by a laboratory staff person. A copy of the COC form bearing both signatures is returned to the Project leader and becomes part of the Project record. This copy may be in paper form or scanned and retained electronically.

B4. ANALYTICAL METHODS REQUIREMENTS

Analytical protocols are found in the MVTL or WLI QA/QC Manual and SOPs. Analytical accuracy is routinely checked by the laboratory's analysis of standard certified reference analytes.

All raw data generated in the laboratory are recorded in bound notebooks, on Project specific raw data sheets, MVTL or WLI custom logbooks, or as an instrument printout. This data includes sample numbers, calibration data, calculations, results, analyst notes and observations, quality control data, date of analysis, and initials of the analyst. Completed notebooks are returned to the Quality Assurance Unit where they are archived. Chromatograms, graphs, and strip charts, if part of the data package, are kept with the laboratory raw data. All items are labeled, dated and signed by the analyst. When completed, the data are integrated into a final report.

For out–of–control situations, a corrective action plan is in place. The initial action is to repeat the analyses of the samples bracketed by the unacceptable quality control sample. Replication of unacceptable results is investigated as a matrix effect by reviewing blank spikes or laboratory knowns. If the quality control samples are still unacceptable, the entire process is repeated. This includes sample preparation or extraction. If re–analysis is not possible due to the sample being past holding times or sample quantity is insufficient, documentation of the situation will be added to the raw data. In these cases, the client is notified and the report flagged.

B5. QUALITY CONTROL REQUIREMENTS

Where applicable, internal reference standards will be analyzed and recorded with each sample run. External certified reference standards obtained from an approved Proficiency Test (PT) sample provider will also be used. All stock standard solutions will be properly labeled, stored, and expiration dates visibly recorded on the label. The measured data for the certified standards must fall within the specified range as given by the provider or corrective action will be taken.

One field QC grab sample duplicate for laboratory analysis is collected at the sampling site for every ten like samples taken. The field duplicate for laboratory analysis is collected to determine sampling and laboratory analytical precision.

If QC samples reveal a sampling or analytical problem, field and laboratory personnel attempt to identify the cause. Upon working out a plausible solution, personnel take necessary steps to ensure that similar problems do not arise during future sampling events. If possible the sampling event is repeated. As per laboratory protocol, suspect data are flagged or qualified depending upon the nature and extent of the problem.

MVTL or WLI implements specific QA/QC methods and procedures for dealing with out–of–control situations. These are documented in MVTL's and WLI's QAM and SOPs, copies of which are maintained on file at MPCA and available for consultation and review upon request.

B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

All hand–held instruments, when used, are inspected and tested each sampling day prior to being used in the field. Steps are taken to fix any instrument problems noted during testing. If any problems cannot be resolved the instrument is taken out of service and a substitute instrument is used. pH buffer solutions are replaced with fresh solutions before the buffer solution expiration date. Batteries for all meters are routinely checked and replaced when meters showed power–related problems. Spare batteries for all instruments are taken on all sampling trips. All maintenance procedures are documented in the meter maintenance logs or the field notebook.

B7. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY REQUIREMENTS

Whenever possible, thermometers used during this Project are checked for accuracy with a NIST–certified thermometer or one that is traceable to a NIST–certified thermometer. The field thermometer must read within ± 0.1°C of the NIST–certified or NIST–traceable thermometer to be used. Thermometer accuracy is confirmed at the beginning of each sampling season and checked periodically throughout the sampling season. All field instruments are calibrated each sampling day before being taken into the field. Instrument calibration is checked periodically throughout the sampling day and recalibrated, if necessary. All instrument calibration checks and procedures are documented on the instrument maintenance log or in the field notebook.

B8. SUPPLIES AND CONSUMABLES INSPECTION/ACCEPTANCE REQUIREMENTS

Supplies and consumables included instrument calibration standards, buffer solutions, multi–probe sensor membranes, cleaning solutions, paper products, gloves, deionized water, and batteries. Supplies and consumables are purchased only from reputable and reliable suppliers and inspected for usability upon receipt.

B9. NON–DIRECT MEASUREMENTS DATA ACQUISITION REQUIREMENTS

B9.1 Modeling

Rebecca Kluckhohn, P.E. and Joel Toso, Ph.D., P.E., will assume responsibility for modeling QC activities. Both are approved by appearing on the Master Contract Watershed Protection and Restoration list for this type of work. Their resumes are on file and available for review upon request.

Water quality and hydrologic and hydraulic modeling will be conducted to develop and evaluate the habitat restoration design options. The selected model will optimize channel re–meander design for optimal function and model DO response to design alternatives.

Significant data collection and modeling are required to optimize design. The CRWD will administer the project which involves collecting one year of monitoring data which will include wetland, main channel, and groundwater hydrology and water quality. CRWD will also work with the district engineer to construct a hydrologic and hydraulic model of the upper watershed and collect topographic data for the wetland. A hydrology and hydraulics model will be used in conjunction with the existing QUAL2K model and constructed to optimize the DO TMDL design. CRWD will design and construct the work. A contractor will be retained for construction through the CRWD's standard bidding process. The work will be done through a combination of in–kind staff labor, and consultant/ contractor time, and grant dollars.

QUAL2K model information may be found in Appendix G.

B9.2 Basic Acceptance Criteria for Secondary Environmental Data

Rebecca Kluckhohn P.E., Principal, Wenck Assoc., Inc. will evaluate the quality of all data used for this Project. Secondary data to be used for this Project have been processed for MPCA's Hydstra, Environmental Data Access, and STORET data repositories or have been subjected to the rigorous USGS data validation process. All secondary data to be used is published USGS, MPCA, DNR, and CRWD data.

Environmental data includes any measurement or information that describe environmental processes, location, or conditions; ecological or health effects and consequences; or the performance of environmental technology. Environmental data includes information collected directly from measurements, produced from models, and compiled from other sources such as databases or the literature.

All secondary monitoring data if used as part of this Project must be of known quality and must be obtained as part of an environmental Project with an approved QAPP or equivalent documentation and result from samples taken using approved sampling and analytical methods. The analytical methods used to generate such data must have identifiable method and instrument detection and reporting limits, if applicable, and include uncertainty estimates such as precision and bias.

All secondary data used during this Project are assessed by the Assistant Administrator, MPCA Project Manager, other knowledgeable Project staff, sponsoring organizations, stakeholders, and Project consultants, if used, to ensure they are relevant to Project goals and meet Project data quality requirements. They establish acceptance/rejection criteria for all secondary data under consideration for use during this Project and define the decisions to be made as a result of the usage of such data.

The reason(s) for accepting and/or rejecting secondary data under consideration for use in this Project are thoroughly documented. Such documentation becomes part of the Project final report.

B9.2 Sources of Secondary Data

Possible *sources* of secondary data that may be used during this Project include:

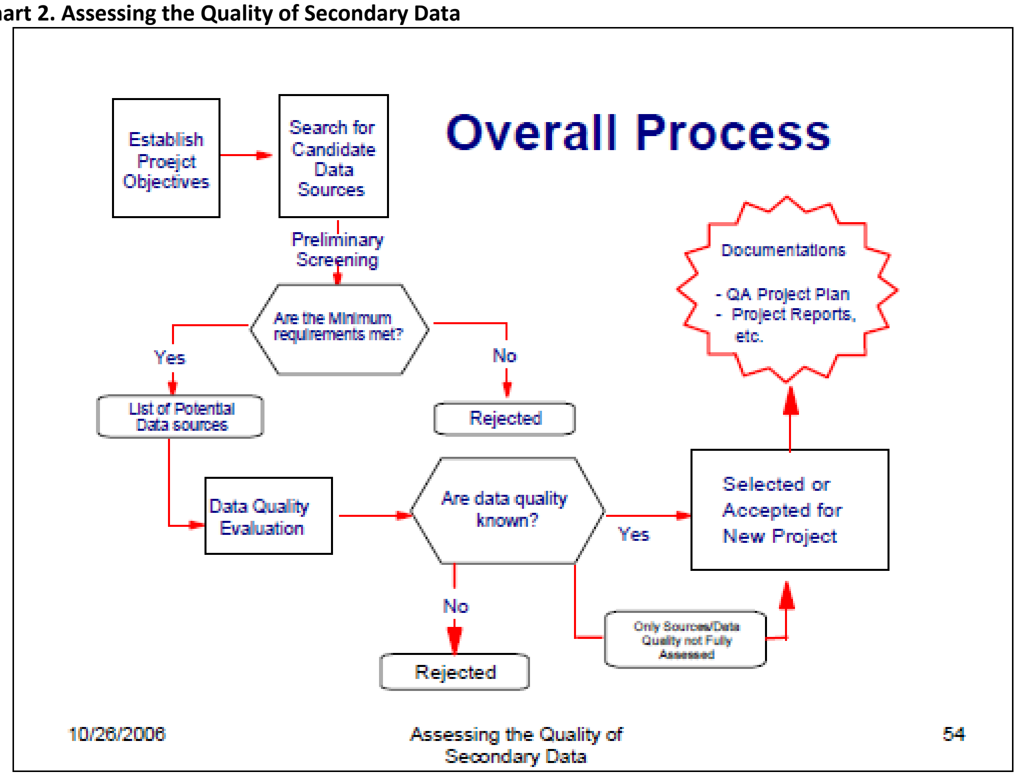
- Publicly available databases
- Published literature, reports, and handbooks
- State and local monitoring programs
- Unpublished research data
- Model–generated data
- Pilot studies

B9.3 Types of Secondary Data

Possible *types* of secondary data that may be used during this Project include:

- Computer databases and spreadsheets
- Laboratory analyses
- Field analyses and measurements
- Biological or ecological samples or analyses
- Peer review information
- Research data, e.g., data generated by universities or private industry
- Maps, plots, photographs, GIS data, or land surveys
- Historical data from previous relevant projects conducted in the same general geographical area
- Data generated through federally funded grants
- Volunteer monitoring data

Chart 2. Assessing the Quality of Secondary Data



Assessing the Quality of Secondary Data for New Applications;
.ppt; Arthur Lubin, Ph.D., Cheng–Wen Tsai, Ph.D; EPA; October 26, 2006

B9.4 Examples of Secondary Data

Examples of secondary data that may be used during this Project include:

- Maps
- Plots
- Photographs
- Geographic Information System (GIS) data
- Land Surveys
- Historical data (EPA, industry, other agencies)

- Volunteer monitoring data
- Federally–funded grants data

B9.5 Use of Secondary Data – Project Planning and Documentation

When using secondary data, Project staff will address the following to ensure the data are appropriate and of sufficient quality to help meet Project objectives:

1. Identify the Project objectives or the decisions to be made
2. Identify the data and information from outside sources proposed for use in this Project
3. Determine whether the data have any constraints affecting their use in this Project
4. Determine if the acquired data will be used in the decision making process
5. Scrutinize the data for quality concerns pertaining to the intended use of the data
6. Document the Project analysis plan in a QAPP, if applicable
7. Execute the analyses and document the outcomes, if applicable

B10. DATA MANAGEMENT REQUIREMENTS

Project staff are responsible for completing the field data sheets. This information is entered into a spreadsheet or database and archived. Laboratory results are entered into a computer database and/or spreadsheet which is maintained by the Project Manager who also assists with data maintenance, reduction, and transmittal. The MPCA Project Manager also reviews all data prior to its approved entry into EQuIS. [Note: Effective May 1, 2010, data is no longer being entered into STORET, however, data already in STORET remains retrievable].

Quality assurance data sheet checks include scanning for apparent entry errors, measurement errors, and omissions. Suspect data are flagged and/or excluded from use. Data may be presented in table, graph, and chart format. Unusual data are rechecked to verify their accuracy. The data are then entered into EQuIS by MPCA data entry personnel.

Modeling based on water chemistry data is typically done by a sub–contracted consultant. In addition, SWAT modeling is often used by the Minnesota Department of Agriculture (MDA) and the University of Minnesota (U of M). All data are collected and analyzed in accordance with this QAPP. CRWD staff provide the data and modeling results to Project partners and makes it available to the public.

GROUP C: ASSESSMENT AND OVERSIGHT

C1. ASSESSMENT AND RESPONSE ACTIONS

Dennis Loewen as Assistant Administrator is responsible for all field activities, data review, reporting to the group on findings, and forwarding all data to the appropriate state regulatory agency for inspection and input into EQuIS. He oversees and assesses all field sampling and data collection. The MPCA Project Manager and QA staff are also authorized to oversee field activities during this Project. The MPCA Project Manager and WQ QA/QC Coordinator are also authorized to follow up on sampling activities during the Project.

C2. REPORTS TO MANAGEMENT

A draft report of the Project findings will be prepared for the MPCA by Project staff or a sub–contracted consultant and shared with all involved local Government units (LGUs), local resource managers, and other involved parties.

Problems that arise during the Project are corrected and reported to all parties involved in the Project. CRWD staff are responsible for the reporting, tracking, and overall management of the Project. All data are recorded and tracked through use of the Microsoft Excel database management system. The data compiled during this Project is incorporated into spreadsheets and sent to the MPCA for storage in EQuIS, the MPCA environmental water quality database.

GROUP D: DATA VALIDATION AND USABILITY

D1. DATA REVIEW METHODS REQUIREMENTS

All raw data are transcribed to the data transmittal form and stored in a binder–type notebook. Where applicable, the data are organized electronically and filed in the MPCA EquIS database. Statistical analyses on replicate samples are recorded so that the degree of certainty can be estimated.

All data are reviewed by the Assistant Administrator and signed by the analyst. Copies of the data transmittal form and all pertinent records of calibration, standardization, and maintenance become part of the project data set and are archived.

All laboratory analytical results are cross–checked against the field notebook and sample tags to ensure that the raw, computer–generated summary of the laboratory analyses are assigned to the correct sampling stations. All analytical results are compared to the field sheets to ensure that the data are complete.

Field data and field QC sample sets are reviewed by Dennis Loewen to determine if the data meets the DQO and QAPP objectives. In addition, Phil Votruba**,** MPCA Project Manager, assists in the data review. Data are examined and outliers identified through statistical analysis. Decisions to qualify or reject data are made by Phil Votruba and Dennis Loewen and may also include Project partners, stakeholders, and consultants, if used, that are knowledgeable about data assessment.

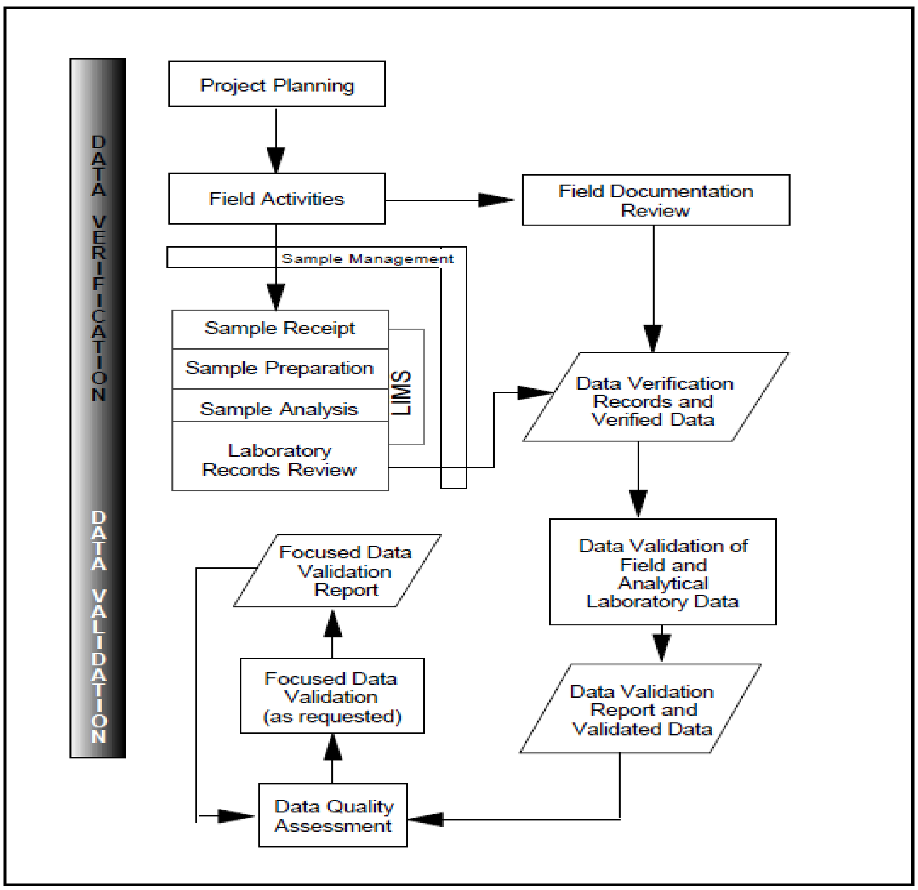
Data generated through laboratory analysis undergoes data reduction by the laboratory QA Officer prior to the reporting of the final results. If analytical data fail to meet the laboratory's acceptance criteria the corresponding samples are reanalyzed or flagged. If reanalysis gives the same result, data are qualified as being estimated. All flagged data are evaluated to determine their suitability for use in the Project decision making process.

Dennis Loewen compares the field notebook and laboratory report data with the draft final report data to ensure accuracy. He also reviews field notebook information to determine if any problems or unusual events occurred that may justify flagging and/or disqualifying specific data.

The formal data set is reviewed by the MPCA Project Manager for errors, omissions, qualified data, and data outliers.

Laboratory analytical reports are made available to the Assistant Administrator, MPCA Project Manager, and other Project partners in .pdf, .mdb, .xls, hard–copy, or other suitable format upon request. The Assistant Administrator submits the final approved data report to the MPCA Project Manager electronically and in hard–copy, .xls spreadsheet, or similar format with hard–copy or electronic–format laboratory analytical reports included.

Chart 3. Data Quality Assessment, Verification, and Validation in the Project Life Cycle



Source: EPA QA/G–8; EPA/240/R–02/004; November 2002

D2. DATA VERIFICATION AND VALIDATION METHODS REQUIREMENTS

Project staff follow the EPA *Guidance on Environmental Verification and Validation* (EPA QA/G–8) whereby the data are reviewed and accepted or qualified by Project and/or MPCA staff.

D3. DATA RECONCILIATION WITH DATA USER REQUIREMENTS

Within 48 hours of receipt of results of each sampling event, calculations and determinations of precision, completeness, and accuracy are made and corrective action implemented, if needed. If data quality does not meet Project specifications, the deficient data are flagged or discarded and the cause of failure evaluated. Any limitations on data use are detailed in the Project reports and other documentation.

Project data are compared to historical data, when available, and may also be used as complementary data for other monitoring efforts within the watershed.

For the data to be considered valid, data collection procedures, the handling of samples, and data analysis must be monitored for compliance with all the requirements described in this QAPP. Data are flagged and qualified if there is evidence of habitual violations of the procedures described in this QAPP. Any limitations placed on the data are reported to the data end user in narrative form.

References

A. Project History

Upper Watershed TMDL Studies for the Clearwater River Watershed District (EPA Approved May 2010)
Dissolved Oxygen TMDL for the Clearwater River: Clear Lake to Lake Betsy (May 2010)
Five Lakes Nutrient TMDL for Lake Caroline, Lake Augusta, Albion Lake, Henshaw Lake, and Swartout Lake (May 2010)
Clearwater River Watershed District Watershed Protection and Improvement Plan (TMDL Implementation Plan) (May 2010)

B. QAPP Development

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Appendix A

The Graded Approach to Quality Assurance Project Plans (QAPPs)

The Graded Approach to Quality Assurance Project Plans is defined as the process of basing the level of application of managerial controls applied to the Project to the intended use of the Project outcomes (e.g., data) and on the degree of confidence needed in the quality and validity of these outcomes. This approach enables the Project partners to adapt the quality assurance and quality control activities to meet the rigor required by the Project.

For example, projects that provide initial estimates of parameters or that are non–regulatory in nature would not require the same Project quality assurance and Project planning rigor as would those generating outcomes (e.g., data) that is to be used to determine regulatory requirements.

In applying the graded approach, two important aspects for defining the necessary Project quality assurance rigor are:

- The intended use of the Project outcomes (e.g., data)
- The Project scope and magnitude

The intended use of the Project outcomes (e.g., data) is a determining factor because it is based upon the evaluation of the possible adverse impacts that may occur due to decisions made and actions taken that may occur due to inadequate or inaccurate Project outcomes (e.g., data).

An example of a Project outcomes (e.g., data) hierarchy in descending order of importance is:

- congressional testimony
- regulatory rules, statutes, or laws development
- testimony in a civil or criminal court action
- technological assessment
- routine investigative monitoring

By analyzing the intended Project outcomes (e.g., data) end–uses, appropriate quality assurance criteria can be established to guide the Project. This is to say, the degree of rigor needed for a specific Project is to be determined based upon an evaluation of the Project needs, resources, and goals.

Appendix B

Data Quality Assessment, Verification, and Validation

11.1 Introduction

The primary goal of data quality assessment and validation is to determine if the data is usable for its intended purpose and can be made with desired confidence, given the quality of the data set. The DQA process is conducted upon completion of the data validation process. The EPA's Guidance for Data Quality Assessment: Practical Methods for Data Analysis (QA/G–9) (EPA, 2000b) may be used as a guide to the DQA process and provide a method for assessing data quality. This level of assessment is also equivalent to EPA's Tier 4 (Quality of Science Review. It is advisable that the specific data quality assessment procedure be specified in Project work plans and/or monitoring plans. At a minimum, individual data elements required for the data quality assessment are listed in Section 10.0 – Data Management.

11.2 Responsibilities

Data generators, i.e., the participating field and laboratory groups, are responsible for performing data verification. Data validation personnel, who could be designated Project team participants, agency data validators, or consultants, are responsible for validating data according to Project DQOs and contract requirements. A more detailed discussion on data verification and validation are included in Section 5.0 of this document. The Project or agency QA Officer is responsible for ensuring that data verification and validation are done according to EPA requirements.

Data quality assessments may be done by Project or agency–designated personnel or consultants who are knowledgeable of the Project DQOs, sampling design, and familiar with the data. Generally, data validations should not be completed unless all DQAs are approved. Statistical data evaluation must be done by qualified personnel with demonstrable knowledge and have documented experience in statistics.

Throughout the data life cycle there must be close communication with these key players to ensure that every participant is in the loop regarding DQOs and Project expectations, that anomalies are resolved, and that any further loss of data is minimized or prevented.

11.3 Skills and Training Requirements

Individuals involved in data quality evaluation and assessments must have the necessary education, skills, and training to perform the job. Those involved in monitoring and assessment must have relevant science background, demonstrable knowledge, and experience in these areas. Those involved in statistical data analyses must have demonstrable knowledge of statistics, statistical design, and statistical software.

11.4 The Five Steps of the DQA Process

The DQA process is a critical part of data life cycle that involves Planning, Implementation and Assessment.

- Planning is when Project DQOs are formulated, the monitoring plan is laid out, and the quality assurance Project plan is developed.
- Implementation is the comprehensive set of field, laboratory, and QA/QC activities that produced the data set.
- Assessment involves the processes of data verification, validation, and data quality assessment.

The following are the five steps that EPA had identified as components of the DQA process

11.4.1 Review the DQOs and Sampling Design.

Review the DQO outputs to assure that they are still applicable. If DQOs have not been developed, specify DQOs before evaluating the data, e.g., for environmental decisions, define the statistical hypothesis and specify tolerable limits on decision errors for estimation problems, define an acceptable confidence or probability interval width. Review the sampling design and data collection documentation for consistency with the DQOs.

11.4.2 Conduct a Preliminary Data Review.

Review data validation reports, calculate basic statistics, and examine data graphically. These types of reviews are done either by the Project manager, the task manager, or a consultant.

- **Review data validation reports.** The individual or group performing data evaluation and assessment should start by examining data validation reports, if available. If not, data must be validated following the procedures and guidance provided in **Section 5.0** of this manual. The assessment personnel or group must take note of any qualifiers applied on the data, the underlying reasons for those qualifiers, any confirmation results, and determine usability of data based on Project DQOs. This individual will have to communicate with data validators to verify or confirm any anomalies in the data set.
- **Historical outlier review.** Investigate and take necessary action (rework or qualify) for samples that appear to be historical outliers.
- **Data anomalies check.** Note any data anomalies that may be site, season, or Project specific. For example, a surge in total phosphorus concentration may result due to hydrological factors. In this case, the Project manager should make a decision on whether or not the data should be accepted as is or qualified.

• **Standards and compliance check.** Check data against applicable state/federal criteria (e.g., surface water, groundwater or drinking water standards) or action levels for compliance. Confirm any exceedances of criteria or action levels that may be suspect or challenged, providing appropriate comments in the final report.

• **Field notes.** Examine field notes for conditions that may affect data quality.

• **Qualifier codes.** Verify that suitable qualifiers and comments are applied to all qualified results, ensuring that qualifier codes from Chapter 62–160, FAC are used, where relevant.

• **Check data completeness levels.** Ensure that the Project will meet necessary data requirements. If not, adjust parameters to increase amount of usable data.

• **MDL suitability.** Some programs have varying DQOs that may require reliable measurements be made at very low concentrations. Others compare measurements to established criteria. A comparison of program action levels or Project criteria with method detection limits will provide information on whether field and laboratory methodologies are adequately sensitive to meet Project requirements.

• **Graph data.** Graph the data to identify patterns and trends, relationships, or potential anomalies that might go unnoticed by just looking at tables of data. Graphs can quickly disprove or confirm hypotheses.

• **Calculate basic statistical quantities.** This is done to summarize some basic quantitative characteristics of the data set using common statistical quantities. Some statistical quantities that are useful are: a) number of observations; b) measures of central tendency such as mean, median, or mode; c) measures of dispersion, such as range, variance, standard deviation, coefficient of variation, or inter–quartile range; d) measures of relative standing, such as percentiles; e) measures of distribution symmetry or shape; and f) measures of association between two or more variables, such as correlation.

11.4.3
Select the Statistical Test.

Select the most appropriate procedure for summarizing and analyzing the data, based on the review of the DQOs, the sampling design, and the preliminary data review. Identify the key underlying assumptions that must hold for the statistical procedures to be valid. To properly perform the right statistical test, it is important that the hypotheses are clear and address the questions that the Project is trying to answer. The analyst must know when to use parametric versus non–parametric statistics. While examining the data, the analyst should always list the underlying assumptions of the statistical hypothesis test and of the data set, such as distribution (normal vs. skewed) and dispersion. Select a statistical test that is robust, or not seriously affected by moderate deviations from its underlying assumptions. The analyst should note any sensitive assumptions where relatively small deviations could jeopardize the validity of the test results. EPA QA/G–9 document discusses in detail some of the most common statistical tests that could be used in assessing the quality of environmental data.

11.4.4
Verify the Assumption of the Statistical Test.

Evaluate whether the underlying assumptions hold, or whether departures are acceptable, given the actual data and other information about the study.

11.4.5
Draw Conclusion from the Data.

Perform the calculations required for the statistical test and document the interferences drawn as a result of these calculations. If the design is to be used again, evaluate the performances of the sampling design.

11.5 Peer Review

It is important that any data quality assessment and evaluation be peer–reviewed by others with similar background and knowledge, prior to release or adoption. The peer reviewers must validate and confirm the findings of the assessment and evaluation of the data.

11.6 Documentation and Recordkeeping

Data assessment and evaluation activities must be documented. Any assumptions, troubleshooting, communications, and other relevant documents and records must be maintained with the Project. These records must be organized and allow reconstruction of the process. The identity of the individual(s) and company performing the assessment must be clearly noted on the documents.

The procedure used for analyzing and assessing the data must be documented. Entities performing this for CERP must have this in a form of standard operating procedure or discussed in detail in the Project plan. There must be a version control with effective dates to clearly identify what version was used at any given time.

Appendix C

Lake and Stream Field Sampling Protocol

Water samples are often obtained by filling a container held just beneath the surface of the water and are commonly referred to as a dip or grab sample. Through the use of special depth samplers (such as a Van Dorn sampler) a grab sample may also be obtained from deep water. This is important as distinct thermal and chemical differences can occur throughout the vertical water column. A composite sample is obtained by mixing equal volumes of multiple discrete grab samples, e.g., samples collected at one point at regular time intervals. A composite sample provides an estimate of average water quality conditions.

Sample bottles are either new (disposable, one–use) or laboratory–cleaned and should **not** be rinsed prior to sampling.

Lake Sampling Protocol

Sample stations may be located either near the shore or in deep water. A lake sample is often taken at the deepest point of the lake. In general, the near–shore sites detect those effects that are associated with influences such as groundwater and run–off. Deep water stations provide information about the water column such as conditions associated with stratification (depth profiles). Additionally, near–shore site sampling tends to provide information for a relatively short time frame, e.g., days or weeks, whereas deep site sampling tends to provide information for a seasonal or longer time frame.

Shore Sampling Protocol

Sample collection at a near–shore station generally consists of taking a grab samples at a specified location. It is important that the sample be taken from the same location unless adverse site conditions (severe weather, site physical changes) pose a threat to sampler safety. If safety is an issue, select an alternate location nearby or simply bypass this sampling site. If an alternative location is used, details about the new site and the reason for using it should be recorded in the field log book.

To avoid suspended sediments contamination of the sample the sampler should preferably sample from a boat or dock or should wade out to a point where wave action doesn't affect the lake bottom. In most instances this distance isn't far from shore. If wading, the sampler must not exceed a depth where water may enter the boot or hip wader. This is particularly important during colder times of the year when getting wet poses a hypothermia risk.

- With a labeled bottle wade into the lake at the most accessible point.
- Once you reach a sufficient depth where bottom material will not interfere with the sample, stop and orient yourself toward the center of the lake.
- Remove the cap and grasp the bottle well below the neck.
- Lean out towards the center of the lake and, in one continuous motion, plunge the bottle beneath the surface and slowly draw it through the water until it is full.
- Replace the cap immediately.
- Return to shore and place the sample(s) in an iced cooler.

Boat Sampling Protocol

Collection of deep water samples using a boat requires that at least one member of the sampling crew be familiar with boat operation and safety. If a boat is used, the weather forecast should be obtained before beginning the sampling excursion. If weather conditions may become unsafe the sampling trip should be rescheduled.

Site Identification

Deep water sampling sites are found by selecting at least two easily identifiable features on shore. Reference points should be described in writing and, if possible, with photographs in the site identification log book. Use a global positioning system (GPS) device, if available. This will enable site identification with great accuracy. Once at the sampling site lower the anchor to maintain a stationary position. If the water is too deep to deploy the anchor one person must maintain the stationary location either with the motor or with paddles while the other person collects the samples and takes the field measurements.

Lake Surface Water Sampling Protocol

- The person at the bow (front) of the boat should always collect the samples because with the anchor deployed the bow is the stationary point. In quiescent water the samples should be collected before anchoring while the boat is slowly moving forward. This reduces the potential for contamination from the boat or motor. The person in the stern (rear) of the boat can then hold the boat's position (when not anchored) and take the field measurements and field notes

- Obtain a labeled sample bottle and remove the cap without touching the inside of the cap or bottle. Reach arm's length from the boat to take the sample. Ensure that the person in the stern is providing counterbalance so the boat doesn't tip
- Plunge the bottle about 0.5 meters (18") beneath the lake surface and move it slowly towards the current (the direction the boat is facing)
- Recap the bottle immediately and proceed with the next sample
- Sample filtration and/or preservation should be done as soon as possible after returning to shore

Lake Deep Water Sampling Protocol

Lake water samples may be collected from any desired depth by using a Van Dorn or similar type sampler. The Van Dorn sampler is designed for sampling at a depth of 2 meters (6') or more. It is equipped with a drain valve for sample removal. The Van Dorn sampler is available in both horizontal and vertical configurations. The advantage of the vertical configuration is that the water within the open bottle is flushed out as the bottle is lowered, so one can be guaranteed the water collected was collected from the desired depth. The advantage of the horizontal Van Dorn configuration is that a very narrow depth range is sampled. However, the vertical configuration is most commonly used. The horizontal configuration should be used when samples are taken near the bottom at the sediment–water interface or when samples are taken from a narrow segment of the depth profile such as the chemocline or thermocline.

The field measurements should be taken first which will enable the sampler to locate the depth from which the water samples should be taken, e.g., if multiple deep samples are to be taken it may be beneficial to know the depths of the major stratified zones, i.e., the epilimnion, the thermocline, or the hypolimnion.

- Ensure the Van Dorn sampler bottle is clean
- Open the sampler by raising the end seals
- Set the trip mechanism
- Lower the sampler to the desired depth
- Send the messenger down the rope to trip the mechanism that closes the end seals
- Raise the sampler to the surface
- Transfer the water sample from the Van Dorn sampler into the sample bottles via the sampler drain valve. Avoid contact with the drain spout which may contaminate the sample
- If necessary, filter and/or preserve the samples on shore

Winter Lake Sampling

Sampling in winter presents extra elements of danger. Always proceed with caution over ice and do not jeopardize your safety. Check the ice for thickness with a rod or ice chisel every few steps (ice should be a minimum of 3 – 4 inches thick). Ice over moving water can be of varying thickness, and the strength of the ice cannot be estimated from its apparent thickness near the shore. Always have someone accompany (follow) you, wear a life jacket, and carry a length of rope (tied around your waist) to use as a life line. If the ice is unsafe, do not take a sample. Never take unnecessary risks.

Note: Ice near the outlet of a lake is often thin, therefore, caution should be used when sampling this area of a lake. Additionally, ice thickness on reservoirs, where water levels fluctuate, can be variable.

In springtime, ice can be thick, but not strong enough to walk on (often called "Frazzle" or "corded" ice).

Sampling through the Ice

- With safety considerations in mind, winter sampling locations should be as close as possible to the summer locations. The sites should be chosen where the water is known to be deep enough to avoid stirring up bottom sediments and to ensure that there is water movement under the ice at your selected spot. It is preferable to select a site where the ice is sagging rather than bulging.
- Clear loose ice and snow from the sampling location, and drill through the ice with a hand or motorized auger. Keep the area around the hole clear of potential contamination (e.g., dirt, fuel, oil, and such). At least one member of the sampling team should be familiar with the operation and safety of both motorized and hand operated augers.
- Remove all ice chips and slush from the hole, using a plastic sieve.
- Use a Van Dorn (or similar) sampler to collect the sample.
- Do not allow samples to freeze.

River/Stream Sampling

The majority of samples collected from rivers and streams are grab samples taken near the surface at one point in the cross section of the flow. On rare occasions more sophisticated multi–point sampling techniques known as equal–depth–increment (EDI) or equal–width–increment (EWI) methods are used. Since these techniques are infrequently used they will not be discussed here.

Access from the Stream Bank

Wherever practical, samples should be collected at mid–stream rather than near the shore. Samples collected from mid–stream reduce the possibilities of contamination from shore effects such as back eddies, seepage from near–shore soils, and atmospheric components such as pollen concentrated in slow moving water. Samples should not be taken in back eddies or brackish waters unless required by the monitoring program objectives. The most important issue to consider when deciding where the sample should be collected from is **SAFETY**. If the flow is sufficiently slow that the collector can wade into the stream without risk, then the sample may be collected at a depth that does not pose a safety threat to the sampler. Never wade into water that appears deep or is fast–flowing. When conditions dictate that the sample be taken from the stream bank, deviations from the standard protocol should be accurately documented in the field log book and transferred to the database as soon as possible. Samplers must be wary of a non–visible bottom under turbid conditions.

Sampling While Wading Protocol

1. Obtain labeled bottles and wade into the river downstream from the point at which you will collect the samples, then wade upstream to the sample site. This ensures that you will not disturb sediments upstream of the sample point. Attach safety line if conditions have any significant risk
2. Stand perpendicular to the flow and face upstream
3. Remove the lid and hold it aside without touching the inner surface. If rinsing is required for the type of bottle, fill and rinse three times
4. With your other hand, grasp the bottle well below the neck. Plunge it beneath the surface in front of you with the opening facing directly down, then immediately orient the bottle into the current. Avoid collecting surface scum and film
5. Once the bottle is full, remove it from the water by forcing it forward (into the current) and upwards
6. Replace the cap immediately

Sampling from the Stream Bank Protocol

This method is to be used when the current is too strong, the water too deep, or the ice too thin.

1. Secure yourself to a solid object on shore (with a safety harness and line, if necessary). As a safety precaution, the second person must remain nearby while the first is collecting the samples
2. Remove the cap from a labeled bottle
3. Hold the bottle well below the neck or secure it to a pole sampler
4. Reach out (arm length only) and plunge the bottle beneath the water surface with the opening facing directly down, then immediately orient it upstream into the current
5. When the bottle is full, pull it up through the water while forcing it into the current
6. Immediately recap the bottle

Sampling from a Bridge Protocol

Some sample stations are designed to be sampled from a bridge. This enables sample collection from the central flow of the river or stream where wading is not feasible. The samples are typically collected using a bucket and rope that is lowered over the side of the bridge. The precise location at which the sampling device is lowered from the bridge should be marked to ensure that the same section of the river is sampled each time.

1. Whenever possible, lower the bucket over the upstream side of the bridge being careful not to disturb the bridge surface with the rope. This avoids sample contamination from bridge debris falling into the water.
2. Allow the bucket to submerge to the point that enables collection of sufficient sample to fill all sample bottles.
3. Recap each sample bottle.
4. Discard any excess water from the bucket back into the river.

Stream Sampling from a Boat Protocol

Due to the fact that fast–flowing waters pose a serious safety threat, it is essential that the person operating the boat be experienced with river boating. Ideally, there should be three persons along on the sampling trip when it involves sampling from a boat. Two persons are responsible for collecting the samples, taking field measurements, and recording field notes. The third person is responsible for boat operation **only**.

Sampling trips should begin at the sampling site that is most downstream and work your way upstream. This way, if mechanical problems should arise the current will work to your advantage and assist you in your return to the vehicle and trailer.

- When a sample site is reached the boat operator idles into the current to keep the boat stationary. Use a reference point on shore to determine this.

- The sampling person in the bow is responsible for collecting the water samples.
- The other sampling person is responsible for taking the field measurements.

Winter Stream Sampling Protocol

Due to the fact that the flow pattern in a river or stream is generally more complex than in lakes, additional safety factors must be considered. Honeycombed ice and areas over rapids should always be avoided. Be aware that ice downstream from bridge supports may be thin as a result of modified flow patterns and de–icing agents. At least two persons must proceed onto the ice, one ahead of the other. Each person must wear a life jacket. The following person should carry a rope.

- Clear loose ice and snow from the sampling location. Drill through the ice with a hand or motorized auger. Keep the area around the hole clear of potential contamination.
- Using a plastic sieve, remove all ice chips and slush from the hole.
- Load a pre–labeled bottle into the bottle holder.
- Remove the bottle cap and insert stopper (with attached cord) into the bottle opening.
- Lower the sampler and bottle through the hole until it is clear of the bottom of the ice surface and into freely moving water.
- Remove the stopper by pulling the cord, and allow the bottle to fill. For the bottle to fill in fast–flowing water the sampler may have to be held at an angle.
- Retrieve the bottle and decant the water into the appropriate sample bottles.
- There are a variety of unusual conditions that may be encountered during sampling through ice such as melt water beneath the snow on the ice surface or a slushy stratum within the ice itself. If these or other adverse conditions are present they should be noted in the field book.
- Use your judgment as to whether the sample is worth taking.
- In a stream where the ice is not too thick (20 – 50 cm) it may be possible to sample with shoulder–length gloves and reach below the ice into the flowing water.

Appendix D

QA Field Sampling Procedures

Sampler Blanks

A sampler blank (also commonly referred to as a rinsate blank or an equipment blank) is a sample of deionized water that is rinsed through the sampling device and collected for analysis. The first step in collecting a sampler blank is to decontaminate the sampling device in the same manner that is used to collect your regular samples. For example, if you clean the sampling device with detergent and rinse with DI water, then conduct this same procedure before you collect the blank. **If you normally rinse your sampling device with sample water before collecting your sample, then conduct this rinse with DI water instead of sample water** – this will prevent any residual sample water from being detected in your results. Try to eliminate as much of the rinse water from the sampling device as possible before you collect the blank.

To collect the blank, fill the sampling device with deionized water and transfer the water to the appropriate collection bottles. Handle the device as close to your normal sampling procedure as possible: agitate the sampling device in the same manner, try to leave the water in the sampling device for the same amount of time, and collect the same volume of water.

Trip Blanks

Trip Blanks are sample bottles of deionized water that are filled before going out into the field and are carried along the entire sampling trip in the cooler. They are typically obtained ahead of time from the laboratory and are preserved in the same manner as the regular sample. Trip blanks are generally only used when collecting samples for volatile organic compounds.

Field Duplicates

A field duplicate is a second sample taken right after an initial sample in the exact same location. Field duplicates assess the sampler's precision, laboratory precision, and possible temporal variability. The duplicate sample should be collected in the exact same manner as the first sample, including the normal sampling equipment cleaning procedures.

Lab Sheets

A column labeled "QA Type" has been added to the lab sheets. If you are collecting a QA sample, fill in the type of QA sample in this column. Leave the column blank if it is a normal sample. The abbreviations for the QA samples are as follows:

SB = sampler blank   FD = field duplicate   TB = trip blank

The sampler blanks and field duplicate samples will have the exact same station, date, time, depth, and substation as the samples with which they are associated. The only thing distinguishing the samples apart will be the specified sample type in the "QA Type" column. So please remember to fill in this column with the QA sample type (SB or FD).

Appendix E

Chain of Custody Procedures

MPCA policy mandates that a chain of custody form be used whenever environmental samples are taken and submitted to a laboratory for analysis. Chain of custody procedures must be used to document sample possession from the time the sample is collected until it arrives at the analyzing laboratory. Chain of custody procedures may vary somewhat from Project to Project, however, these procedures are fairly standard and those outlined in this SOP are typical. If you have any questions concerning the chain of custody procedure for your specific Project consult your Project manager.

Typically, each laboratory has its own lab sheets that it provides to its clients. If you do not have a lab sheet from the analyzing laboratory, request one when you order your sample bottles which the analyzing laboratory also provides. Often the chain of custody form is integrated into the lab sheet and is not a separate form.

If you have physical possession of a sample, have it in view, or have physically secured it to prevent tampering then it is defined as "being in custody." A chain of custody record, therefore, begins when the environmental sample is taken in the field. From this point on, a chain of custody record must accompany the sample containers.

Handle the environmental samples as little as possible in the field. Each environmental sample custody transfer requires a chain of custody record and may require a seal. If you do not seal individual samples, then seal the containers in which the samples are shipped.

When possible, notify the analyzing laboratory in advance of the day and approximate time the samples will arrive.

When possession of the environmental samples is transferred, both parties involved in the transfer must sign, date, and note the time on the chain of custody record. If the environmental samples are shipped and the carrier declines to sign the chain of custody form, sign the form, place it in a waterproof Zip–Lock bag along with the laboratory's copy of the lab sheet, and seal the cooler with tape. Attach the shipping invoice showing the transfer date and time to your copy of the lab sheet. The laboratory staff who accepts the sealed cooler from the carrier will sign the chain of custody form and provide you with a copy of the form bearing the signatures of all who had physical possession of the samples. If the samples are delivered after hours they should be placed in a secured container or room. Make note of this on the chain of custody record.

Appendix F

The Field Notebook

This section summarizes information, guidelines, and minimum requirements that apply generally to field measurements for all studies of water quality and the collection of basic data. Other terms commonly used for field measurements are field parameters and field analyses. Before proceeding with field work, check each field–measurement section for recommended methods and equipment, detailed descriptions of measurement and quality–control procedures, and guidelines for troubleshooting and data reporting.

Field Measurements—determinations of physical or chemical properties that are measured on–site as close as possible in time and space to the media being sampled.

Records, Field Instruments, and Quality Assurance

Field–measurement data and other field information must be recorded, either on paper or electronically, while in the field. *Reported* field measurements are defined as those data that are entered into EQuIS. The conventions used for reporting field measurement data are described at the end of each field measurement section.

Record field–measurement data, methods and equipment selected, and calibration information on field forms and in instrument log books.

Field forms include national or study–customized field forms and analytical services request forms; other forms and records (for example, chain–of–custody records) may be required for the study.

Instrument log books for each field instrument are required to document calibrations and maintenance.

Electronic records are maintained for each uniquely identified sampling location.

Field personnel must be familiar with the instructions provided by equipment manufacturers. This manual provides only generic guidelines for equipment use and maintenance or focuses on a particular instrument or instruments that currently are in common use. There is a large variety of available field instruments and field instruments are being continuously updated or replaced using newer technology. Field personnel are encouraged to contact equipment manufacturers for answers to technical questions.

Data Quality Objective (DQO) – Representativeness

Field measurements should represent, as closely as possible, the natural condition of the surface water or ground water system at the time of sampling.

Field teams must determine if the instruments and method to be used will produce data of the type and quality required to fulfill study needs. Experience and knowledge of field conditions often are indispensable for determining the most accurate field–measurement value. To ensure the quality of the data collected:

- Calibration is required at the field site for most instruments. Make field measurements only with calibrated instruments.
- Each field instrument must have a permanent log book for recording calibrations and repairs. Review the log book before leaving for the field.
- Test each instrument (meters and sensors) before leaving for the field. Practice your measurement technique if the instrument or measurement is new to you.
- Have back–up instruments readily available and in good working condition.

Data Quality Objective (DQO) – Precision

Precision is determined by taking duplicate samples. The closer the two values the better the precision. It is usually expressed as Relative Percent Difference (RPD). Duplicate samples can measure:

- Laboratory analytical proficiency
- Sampling proficiency
- Analyte variability occurring at the sampling point

Data Quality Objective (DQO) – Accuracy

The closer the sample value is to the true sample value, the better the accuracy. What is the *true* value of the sample?

Quality assurance protocols are mandatory for every data collection effort and include practicing good field procedures and implementing quality control checks. Make field measurements in a manner that minimizes artifacts that can bias the result. Check field measurement variability (precision) and bias (accuracy plus variability).

Requirement: Use reference samples to document your ability to make an accurate field measurement. Field teams also are encouraged to verify accuracy of their measurements at least quarterly against reference samples.

For measurements such as alkalinity made on a sub–sample, check precision in the field every tenth sample by repeating the measurement three times using separate sample aliquots from the same sample volume.

Before making field measurements, allow sensor to equilibrate to the temperature of the water being monitored. Before recording field measurements, allow the measurement readings to stabilize. The natural variability inherent in surface water or ground water at the time of sampling generally falls within these stability criteria and reflects the accuracy that should be attainable with a calibrated instrument.

For surface water: Allow at least 60 seconds (or follow the manufacturer's guidelines) for sensors to equilibrate with sample water. Take instrument readings until the stabilization criteria are met. Record the median of the final three or more readings as the value to be reported for that measurement point.

For sites at which variability exceeds the criteria: Allow the instrument a longer equilibration time and record more measurements. To determine the value to be reported for that measurement point or well, either use the median of the final five or more measurements recorded, or apply knowledge of the site and professional judgment to select the most representative of the final readings.

Table 8. Stabilization Criteria for Recording Field Measurements

Standard Direct Field Measurement	Stabilization Criteria for Measurements
Temperature	± 0.2°C
Specific Conductance ≤ 100 µS/cm[†] → > 100 µS/cm →	 ± 5 % ± 3 %
pH (meter displays to 0.01)	± 0.1 SU[‡]
Dissolved Oxygen (Amperometric method)	± 0.3 mg/L
Turbidity (Turbidimetric method)	± 10 %

[†]Microsiemens per centimeter, [‡]Standard Unit

Surface Water

Field measurements must accurately represent the body of surface water or that part of the water body being studied. Field teams need to select a method to locate the point(s) of measurement and the method(s) to be used to make the field measurements.

Normally, the point(s) at which field measurements are made correspond to the location(s) at which samples are collected. Standard procedures for locating points of sample collection for surface water sampling are detailed in Chapter A4 of the USGS National Field Manual.

Properties such as temperature, dissolved oxygen concentration, and Eh (oxidation–reduction potential) must be measured directly in the water body (*in situ*). Properties such as pH, specific conductance, and turbidity are best measured *in situ*, but also may be measured in a sub–sample of a composited sample. Because determinations of alkalinity or acid–neutralizing capacity (alkalinity/ANC) cannot be made *in situ*, a discrete sample must be collected or sub–sampled from a composite.

The method selected to locate the point(s) of measurement usually differs for still water and flowing water. If the water system is well–mixed and its chemistry is relatively uniform, a single sample could be sufficient to represent the water body. Often, however, multiple points of measurement are needed to determine a representative set of field measurement values.

Still Water

Still water conditions are found in storage pools, lakes, and reservoirs. Field measurements usually are made *in situ* at multiple locations and depths. Alternatively, pH, specific conductance, and turbidity can be measured in a discrete sample or sub–sample. Measurement of alkalinity/ ANC must be in a discrete sample. The location, number, and distribution of measurement points are selected according to study objectives.

Flowing Water

Flowing water conditions are found in perennial (water always present) and ephemeral (water intermittently present) streams. The location and the number of field measurements depend on study objectives. Different study objectives could dictate different methods for locating the measurement point(s). For example, field measurements designed to correlate water chemistry with benthic invertebrates may require measurements on one or more grab samples that represent populated sections of the stream channel. Generally, a single set of field measurement data is used to represent an entire stream cross section at a sampling site and can be useful when calculating chemical loads.

Locating Point(s) of Measurement

To locate measurement points:

- USGS EWI (Equal Width Increment) and EDI (Equal Depth Increment) methods are beyond the scope of our surface water sampling programs.
- Most sampling is single–point grab sampling.
- Knowledge and experience must often be applied to sampling site selection in that a single sample will represent the entire stream width.
- The sampling site must be well–mixed.
- Backwaters, pools, and eddies must be avoided.
- For safety purposes, the sample may have to be taken within arm's length or remote–sampling–pole length of the bank.
- As a rule, if stream flow feet per second • stream depth (in feet) > sampler's height (in feet), Do Not Wade!

***In Situ* and Sub–Sample Measurement Procedures**

***In situ* Measurement**

In–situ measurement, made by immersing a field measurement sensor directly into the water may be used to determine parameter variability at a single stream point. *In situ* measurement can be repeated at a variety of points if stream discharge is highly variable and a single measurement point may not be as representative as the average of multiple measurement point values.

Measurements made directly in the surface water body (*in situ*) are preferable to avoid changes that result from removing a water sample from its source. *In situ* measurement is necessary to avoid changes in chemical properties of anoxic (devoid of oxygen) water.

In situ measurement is **mandatory** for determination of:

- Temperature
- Dissolved Oxygen
- Eh

In situ measurement *may* also be used for pH, specific conductance, and turbidity, but not for alkalinity.

Sub–Sample Measurement

Depth– and width–integrated sampling methods can be used to collect and composite samples that can be sub–sampled for some field measurements. Again, these sampling methods are generally beyond the scope of our ambient surface water quality sampling programs. However, the same field measurements can be performed on discrete samples collected with a thief, a bailer, or a grab sampler. Sub–samples or discrete samples that have been withdrawn from a sample–compositing device or point sampler can yield good data for conductivity, pH, turbidity, and alkalinity as long as correct procedures are followed and the water is not anoxic.

Sub–samples are necessary for Alkalinity determinations.

Before using a sample compositing/splitting device, pre–clean and field–rinse the device in accordance with approved procedures.

When compositing and splitting a sample, follow manufacturer's instructions for the device being used.

Again, do not measure Temperature, Dissolved Oxygen, or Eh on sub–samples.

Appendix G

The QAAL2K Stream Water Quality Model

Description:
QUAL2K simulates flow and water quality in simple rivers and streams. It is typically used to assess the environmental impact of multiple pollution discharges along rivers. Pollutants can come from point sources such as industrial wastewater, municipal sewers and stormwater. Pollutants can also come from non–point sources such as agricultural or urban runoff, and commercial activity such as forestry, mining and construction. The model is commonly applied to support NPDES wastewater discharge permit applications, TMDL studies on riverine systems, and environmental impact statements for proposed development.

Capabilities:
A wide range of chemical and biological **pollutants** within a river can be modeled, including carbonaceous biochemical oxygen demand (CBOD), nitrogen and phosphorus species, suspended solids, algae, pathogens, phytoplankton and detritus. **Physical–chemical processes** simulated by the model include water quality kinetics, chemical equilibrium, advection, dispersion, settling, and interactions with the atmosphere (reaeration) and riverbed (sediment oxygen demand). **Water quality parameters** predicted throughout the modeled river domain include dissolved oxygen concentration, pH, salinity and temperature, in addition to the various pollutant quantities.

Limitations:
• *One–dimensional*: The river is assumed to be fully–mixed in the vertical and lateral directions.
• *Steady–state*: Pollutant inputs and predicted water quality parameters cannot evolve over time (i.e., days or weeks), although they can vary on a diurnal cycle (i.e., hourly variations repeated every day).

Basic Inputs:
• *River hydraulics*: Channel length, elevation, widths, slopes, roughness, for a series of discrete segments along river domain. Flow rates for the river entering the model, and for each pollution source.
• *Rates and constants*: For processes to be simulated, e.g., CBOD decay coefficients, reaeration rate, algal growth rate, turbulent eddy diffusivity, settling velocity.
• *Pollutant source quality*: Dissolved oxygen, CBOD, nitrogen and phosphorus species, alkalinity, pH, etc.

Basic Output:
A series of graphs showing river profiles of water quality parameter values along each modeled segment. Each water quality parameter is shown on a separate graph.

How to Run the Model:
The model is written in MS Windows Visual Basic, and Excel is used as the graphical user interface. All input and outputs are organized in a series of worksheet tabs, and it is very simple to use.

1) Enter input data into the various light blue tabs. If available, enter observed data (e.g., for model calibration) into the various yellow tabs.
2) In the first light blue "QUAL2K" tab, enter a filename and directory path for saving your input data.
3) Click on the "Run" button located within any input tab. This saves the input data, runs the model, and generates the steady–state output profiles in tabular format (green tabs) and graphical format (pink tabs). Output diurnal cycles are contained in the dark blue tabs.

Developer: QUAL2K was developed by the United States Environmental Protection Agency (USEPA), which maintains a model website and publishes a Fact Sheet and Users Manual.

Appendix H

EMAP–SOP4 Invertebrate Sampling Procedures

I. PURPOSE

To describe methods used in the collection of stream invertebrates for the purpose of developing biological criteria used in assessing water quality.

II. REFERENCES

A. Source Documents

U.S. Environmental Protection Agency (USEPA). 1994. Environmental Monitoring and Assessment Program – Surface Waters and Region 3 Regional Environmental Monitoring and Assessment Program: 1994 pilot field operations and methods manual for streams.
U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory. Cincinnati, OH. EPA/620/5–94/004.
Barbour, M. T., J. Gerritsen, and J. S. White. 1996. Development of the Stream Condition Index (SCI) for Florida. Florida Department of Environmental Protection, Tallahassee, Florida. 105 pp.

B. Other References

U.S. Environmental Protection Agency (USEPA). 1996. Biological Criteria: Technical Guidance for Streams and Small Rivers. Revised Edition. Office of Water, Washington DC. EPA/822/B–96/001.
U.S. Environmental Protection Agency (USEPA). 1997. Revision to Rapid Bioassessment Protocols for Use in Streams and Rivers (Draft). Office of Water, Washington D.C. EPA/841/D– 97/002.

III. SCOPE/LIMITATIONS

This procedure applies to all site visits in which stream invertebrates are to be collected for the development of biological criteria and/or the assessment of water quality.

IV. DEFINITIONS

Integrated monitoring. A stream monitoring technique to assess water quality using chemical, biological and physical indicators.

Environmental Monitoring and Assessment Program (EMAP): U.S. Environmental Protection Agency program designed to determine the status, extent, changes, and trends in the condition of our national ecological resources on regional and national scales.

Biological Criteria: Narrative expressions or numerical values that describe the reference biological integrity of a specified habitat. Biological criteria are the benchmarks for judging the condition of aquatic communities.

Qualitative Multihabitat Sample (QMH): A method of sampling invertebrates which involves sampling a variety of invertebrate habitats, including the following substrata: rocky substrates, vegetation, undercut banks, snags, leafpacks, and soft sediment.

V. GENERAL INFORMATION

The methods described herein are to be applied to all wadeable streams included in the MPCA's integrated stream condition monitoring program. This document is not meant to be used by itself, consult one of the documents indicated in the box below if any of the described situations apply. For most efficient use of time and resources, crew leaders must be in constant communication with crews sampling for fish, preventing duplication of effort. It must be understood that this method is not to be applied to streams sampled for fish that are not wadeable. Data generated from samples collected using the described method can be used for any of the following reasons: 1) Development of regional biological criteria, 2) Calibration of biological criteria, 3) Ambient water quality assessment, 4) Water quality assessment of sites suspected of a having a problematic source of pollution.

VI. REQUIREMENTS

NOTE

SOP1 – Site Reconnaissance: A site reconnaissance should be done by the first crew to visit a site. After the initial recon has been done, no more are required. One must be done before any sampling can take place.
SOP2 – Chemical Assessment: A chemical assessment should be done by the first crew to visit a site following a site reconnaissance. These procedures can be completed during a single site visit.

SOP3 – Habitat Assessment: A habitat assessment should be done during the same visit as the chemical assessment. If a habitat assessment is to be done during the same visit as an invertebrate collection, the invertebrate collection should be done first.

A. Qualifications of Crew Leaders

A crew leader must be a professional aquatic biologist with a minimum of a Bachelor of Science degree in biology with an aquatic entomology, invertebrate, zoology, fisheries, or closely related specialization. Additionally, they must have at least 6 months experience working under a macroinvertebrate biologist in the areas of invertebrate sampling methodology and taxonomy.

B. Qualifications of field technicians/interns

A field technician/intern must have at least one year of college education and had coursework in environmental and/or biological science.

C. General Qualifications

All personnel conducting this procedure must have excellent map reading skills and a demonstrated proficiency in the use of a GPS receiver and an orienteering compass. Because sites may be located miles from the nearest vehicle assessable road, it is often necessary to wade through streams and/or wetlands, canoe, or hike for long distances to reach a site. Personnel conducting this procedure must have the physical ability to accomplish this.

VII. RESPONSIBILITIES

A. Field Crew Leader

Ensures that data generated using this procedure meet the standards and objectives of the integrated condition monitoring program. Carries out the procedures outlined in the action steps.

B. Technical personnel

Carries out the procedures outlined in the action steps, including maintenance and stocking of equipment, date collection and recording.

VII. QUALITY ASSURANCE AND QUALITY CONTROL

Compliance with this procedure will be maintained through annual internal reviews. Technical personnel will conduct periodic self–checks by comparing their results with other trained personnel. Calibration and maintenance of equipment will be conducted according to the guidelines specified in the manufacturer manuals.

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific procedures, the QA/QC requirements for this protocol are as follows:

A. Control of Deviations

Deviations from the procedure shall be sufficiently documented to allow repetition of the activity as actually performed.

B. QC Samples

Ten percent of all sites sampled on any given year are resampled as a means of determining sampling error.

C. Verification

The field crew leader will conduct periodic reviews of field personnel to ensure that technical personnel are following the procedures according to this SOP.

IX. TRAINING

A. All personnel will receive training annually from a trainer designated by the program manager. Major revisions in this procedure will require that all personnel be retrained in the revised procedure by an authorized trainer.

B. Training activities will include instruction in the field as well as a field test to ensure that personnel can implement this procedure.

X. ACTION STEPS

A. Equipment List

Ensure that all of the following items are presents before implementing this procedure:
Two D–frame dipnets with 500 micron mesh nets, preferably Wildco, turtox design
Two sieve buckets with 500 micron sieves
Stream Invertebrate Visit Form
Stream verification form, previously completed with attached copies of 1:24,000 USGS topographical map
Minnesota Atlas and Gazateer (Delorme)
Pencils
Permanent/Alcohol proof markers
Labeling tape
Invertebrate sample identification labels
100% reagent alcohol, enough to preserve one days worth of samples, ca. 1 gallon/site
Waterproof notebook
Chest–high waders
Rain–gear
Jars or bottles in which sample is to be preserved; preferably non–breakable synthetic,
minimum 1 litre capacity
Box or crate to store sample bottles
Canoe
Backpack

B. Method

The multihabitat method entails collecting a composite sample from up to five different habitat types. The goal of this method is to get a sample representative of the invertebrate community of a particular sampling reach, it is also to collect and process that sample in a time and cost effective manner. For that reason the habitats described below are relatively non–specific, being chosen to represent broad categories rather than microhabitats. Every broad category includes numerous microhabitats, some of which will not be sampled. It is to the discretion of the sampler which microhabitats are to be sampled. As a general rule, sample in manner that reflects the most common microhabitat of any given broad habitat category.

The habitats to be sampled include:

Hard bottom (riffle/cobble/boulder)

This category is intended to cover all hard, rocky substrates, not just riffles. Runs and wadeable pools often have suitable "hard" substrates, and should not be excluded from sampling. The surfaces of large boulders and areas of flat, exposed bedrock are generally quite unproductive, avoid including these habitats in the sampling area if possible. This is a general rule, if a particular stream has productive exposed bedrock, or boulder surfaces, those habitats should be considered sampleable.

Aquatic Macrophytes (submerged/emergent vegetation)

Any vegetation found at or below the water surface should be considered in this category. Emergent vegetation is included because all emergent plants have stems that extend below the water surface, serving as suitable substrate for macroinvertebrates. Do not sample the emergent portion of any plant.

Undercut Banks (undercut banks/overhanging veg)

This category is meant to cover in–bank or near–bank habitats, shaded areas away from the main channel that typically are buffered from high water velocities.

Snags (snags/rootwads)

Snags include any piece of large woody debris found in the stream channel. Logs, tree trunks, entire trees, tree branches, large pieces of bark, and dense accumulations of twigs should all be considered snags. Rootwads are masses of roots extending from the stream bank.

Leaf Packs

Leaf packs are dense accumulations of leaves typically present in the early spring and late fall They are found in deposition zones, generally near stream banks, around logjams, or in current breaks behind large boulders. Sampling consists of dividing 20 sampling efforts equally among the dominant, productive habitats present in the reach. If 2 habitats are present, each habitat should receive 10 sampling efforts. If 3 habitats are present, the two most dominant habitats should receive 7 jabs, the third should receive 6 jabs. If a productive habitat is present in a reach but not in great enough abundance to receive an equal proportion of sampling efforts, it should be thoroughly sampled and the remaining samples should be divided among the remaining habitat types present. A sample effort is defined as taking a single dip or sweep in a common habitat. A sweep is taken by placing the D–net on the substrate and disturbing the area directly in front of the net opening equal to the net width, ca. $1ft^2$. The net should be swept several times over the same area to ensure that an adequate sample is collected. Each effort should cover approximately $.09m^2$ of substrate. Total area sampled is ca. $1.8m^2$. Once a site reach has been found or newly established, invertebrate sampling should follow. If a habitat assessment and chemical analysis is to be done it should follow invertebrate sampling.

NOTE

Before leaving the vehicle be sure that the following equipment is brought to the site: two d–frame dipnets, one (or two) sieve buckets, habitat partition form, site file, compass, GPS receiver, backpack filled with sample bottles (optional), alcohol (optional).

Before sampling can begin, the Crew Leader and field tech must determine which habitats are present in the reach. This should be a cooperative effort. This is done by walking the length of the stream and determining which productive habitats dominate the stream reach. A site visit form should be filled out during this process. Ideally the stream should be viewed from the top of the stream bank, but this is generally the exception rather than the rule. For this reason, great care must be taken to walk gingerly along the stream edge, or any streamside exposed areas. If this is not possible, stay to one side of the stream so as to disturb as little substrate as possible. It is difficult to estimate total stream coverage of certain habitats due to their linear or three dimensional natures. Undercut banks and overhanging vegetation appear linear, snags are three dimensional, as are vegetation mats, and emergent vegetation. For these reasons best professional judgment must be used to determine what level of effort is adequate to equal one "sample effort" for any given substrate. Keep in mind that this method is considered semiquantitative, rulers and grids are not necessary to effectively implement this procedure. Following are some suggestions as to how approach each habitat for the perspective of

Hard bottom: Riffles are basically two dimensional areas, and should be thought of as such when trying to determine how dominant the riffle habitat is in a stream. It must be kept in mind that the riffle is likely to be the most productive and diverse habitat in the reach, relatively speaking. The field personnel must not get overzealous, the purpose of this method is to get a representative sample. The temptation will undoubtedly exist to spend all day in the riffle areas, this must be avoided.

NOTE

Since sampling should be conducted in a downstream to upstream fashion, it will save time to start the initial visual inspection of the stream from the upstream end of the sampling reach, and walk downstream. This will allow you to start sampling at the downstream end of the reach as soon the inspection is completed. Sampling in this habitat type is relatively simple. The D–net should be place firmly, and squarely on the substrate downstream of the area to be sampled. If the water is shallow enough, the area directly in front of the net should be disturbed with the hands, taking care to wash large rock off directly into the net. If the water is too deep for this, kicking the substrate in front of the net is adequate. Watch for stoneflies trying to crawl out of the net!

Vegetation: Aquatic vegetation is either completely submerged, mostly submerged and partially floating on the water's surface, or partially submerged and mostly extended above the water's surface. Things like Potamageton sp., coontail, and milfoil tend to clump and float at the water's surface. These types of plants should be sampled with an upward sweep of the net. If the net fills with weeds, the weeds should be hand washed vigorously or jostled in the net for a few moments and then discarded. Emergent plants such as reed canary grass and various plants in the rush family, should be sampled with horizontal and vertical sweeps of the net until it is felt that the area being swept has been adequately sampled. Plants like floating bur reed, and water celery tend to float in long strands with the current. They can be floating on the surface of completely submerged. These plants should be sample as emergent plants with horizontal and vertical sweeps in a downstream to upstream motion.

Undercut banks/ Overhanging Vegetation: Undercut banks and overhanging vegetation follow the line of the stream bank. Undercut banks can vary in how undercut they are. An additional problem is that many banks appear undercut, but when investigated prove not to be. For these reasons banks should be prodded to determine how deeply they are undercut. Overhanging vegetation should be treated the same way. Sampling should consist of upward thrusts of the net, beating the undercut portion of the bank or the overhanging vegetation, so as to dislodge any clinging organisms.

Snags: Snags and rootwads can be large or small, long or wide, simple or twisted masses of logs or twigs that don't have any consistent shape. Best professional judgment must be used to determine what a "sampling effort" is. Approximating the amount of sampleable surface area is a sensible method with larger tree trunks or branches. Whereas masses of smaller branches and twigs must be given a best guess. Given their variable nature, there is not one best method for sampling snags. Using something like a toilet brush works well for large pieces of wood, whereas kicking and beating with the net works best for masses of smaller branches. The person taking the sample must determine the best method for each particular situation.

Leaf packs: Leaf packs are simple, but messy to sample. One square foot of leaf pack surface area that has two cubic feet of leaf underneath should be sampled near the surface. Whereas a shallow leafpack can be sampled in its entirety. Sweeping to the bottom of every leafpack could create a disproportionately large amount of sample volume being collected for relatively small sample area. In most situations leaf packs will not be dominant enough to be included in a sample. If leaf packs are sampled, it is suggested that time be spent streamside washing invertebrates off of leaves and discarding the leaves, as a leaf pack sample can easily become overwhelmingly large.

After the number of productive, sampleable habitats have been determined, the sampling team should proceed in a downstream to upstream manner, sampling the various habitats present.

NOTE

In order to get complete samples, the contents of the D–net should be emptied into a sieve bucket frequently. This prevents the back flow of water resulting from a clogged net. In larger streams it is convenient for each sampler to have a sieve bucket. This allows samplers to sample independent of each other, avoiding frequent stream crossings which can alter the stream bed.

NOTE

While sampling it may become necessary to clean the sample of muddy, fine sediment. This can be done by filling the sieve bucket with clean water and allowing the resulting mucky water to drain. Care must be taken not twist and turn the bucket too much, this creates a washing machine action which separates insects from their delicate parts quite effectively.

Once sampling is complete the sample material should be preserved as quickly as possible. Transfer the sample material from the sieve bucket to the sample containers. Fill sample containers to the top with 100% reagent alcohol. Be sure to thoroughly clean the bucket as well as sampling nets of all invertebrates. The use of forceps might be necessary to dislodge some of the smaller organisms.

With labeling tape, label the outside of the container with field number, date, site name, initials of those who collected samples, and number of containers, e.g., 1 of 3, and place a properly filled out sample label in each sample container.

XI. REQUIRED RECORDS

Stream Invertebrate Visit Form

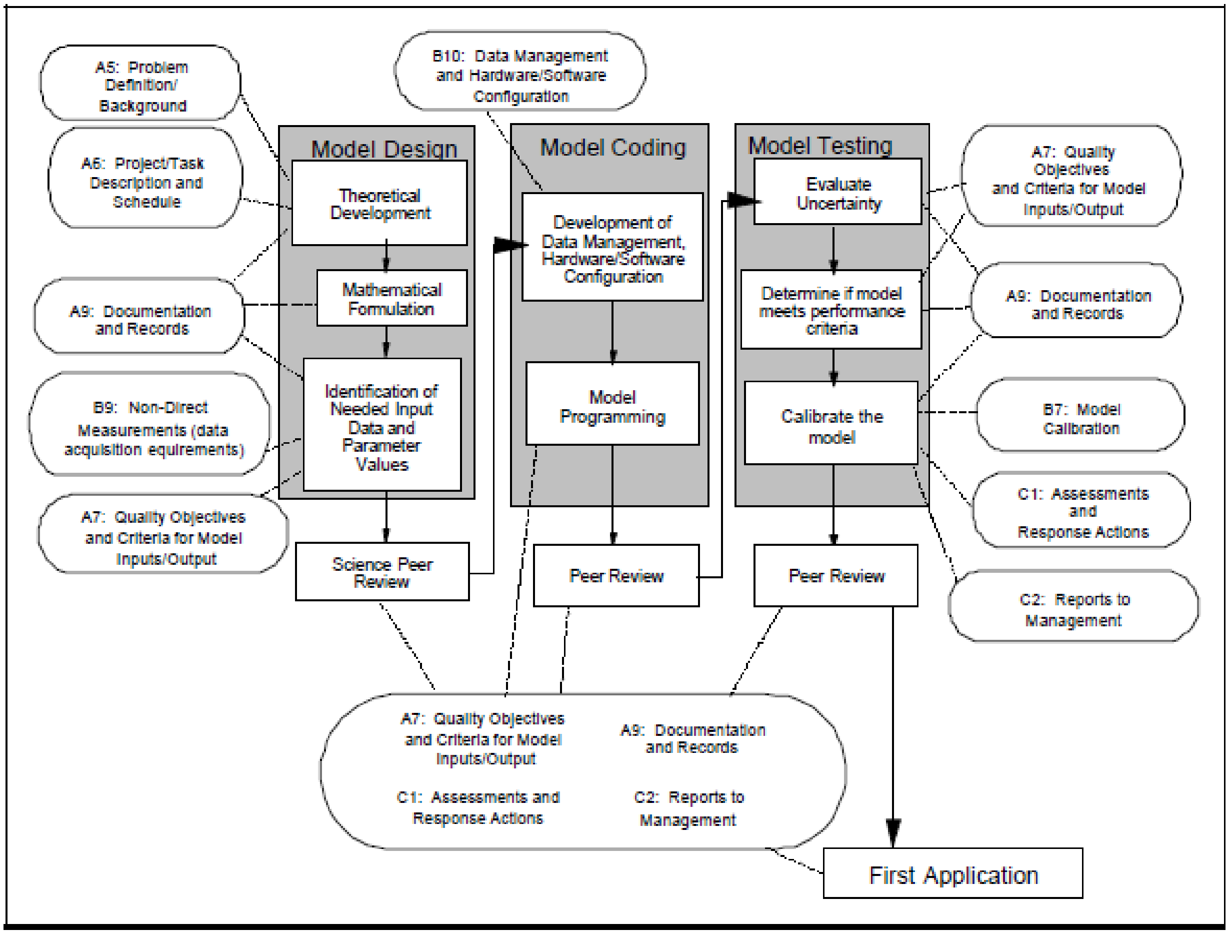
The Stream Invertebrate Visit Form should be filled out during the streamside survey, or notes should be taken on field note books and transferred to visit form. This information will be placed in the biological database.

Quantitative Riffle Sample (optional):

These samples are being taken by the MPCA as a means to determining the best method for sampling streams with dominant riffle/run features.
If a riffle is present in the sampling reach, or in close proximity to the reach, a riffle sample should be taken. This should be a “quality” riffle, that is, a riffle that consists of gravel and/or cobble of varying sizes, and has adequate flow for sampling. The flow should be fast enough to wash dislodged organisms into the sampling net. Three quantitative riffle samples should be taken. They do not need to be side by side. They should be spread throughout the riffle area.

Appendix I

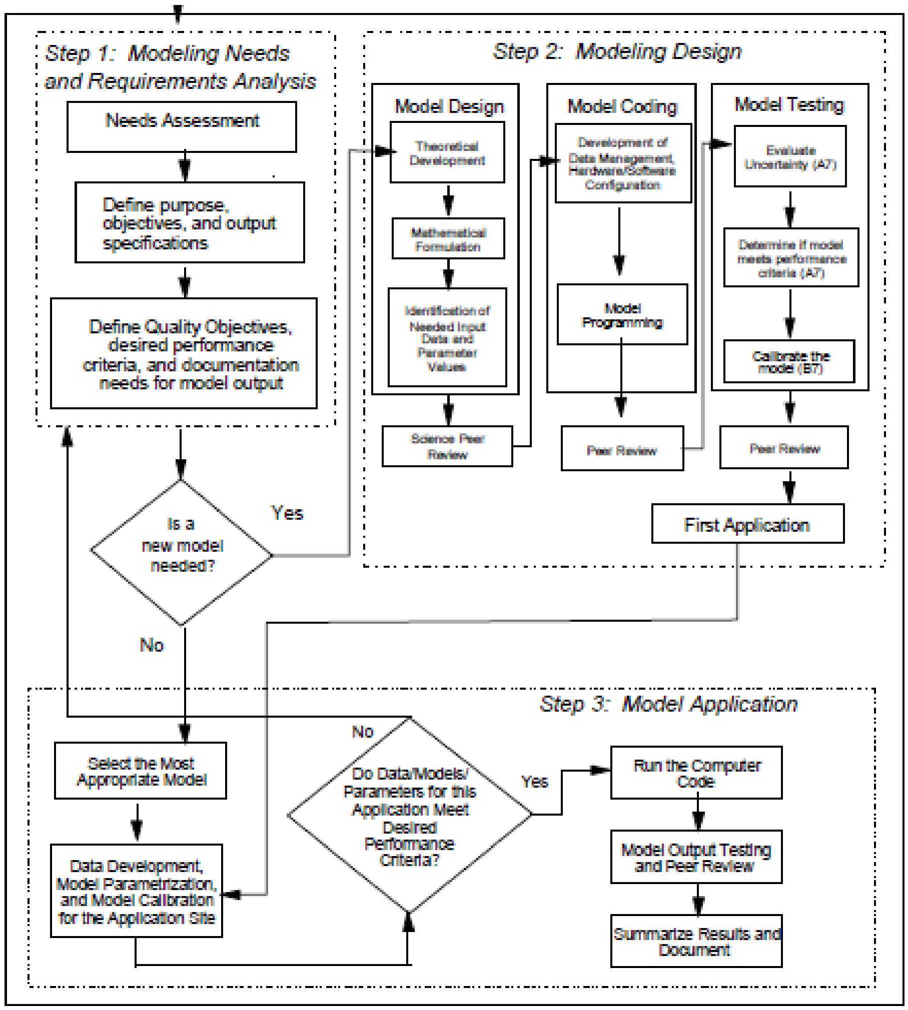
QAPP QA Elements Relevant to the Indicated Model Design and Development Tasks Flow Diagram



Source: EPA QA/G–5M; EPA/240/R–02/007, December 2002

Appendix J

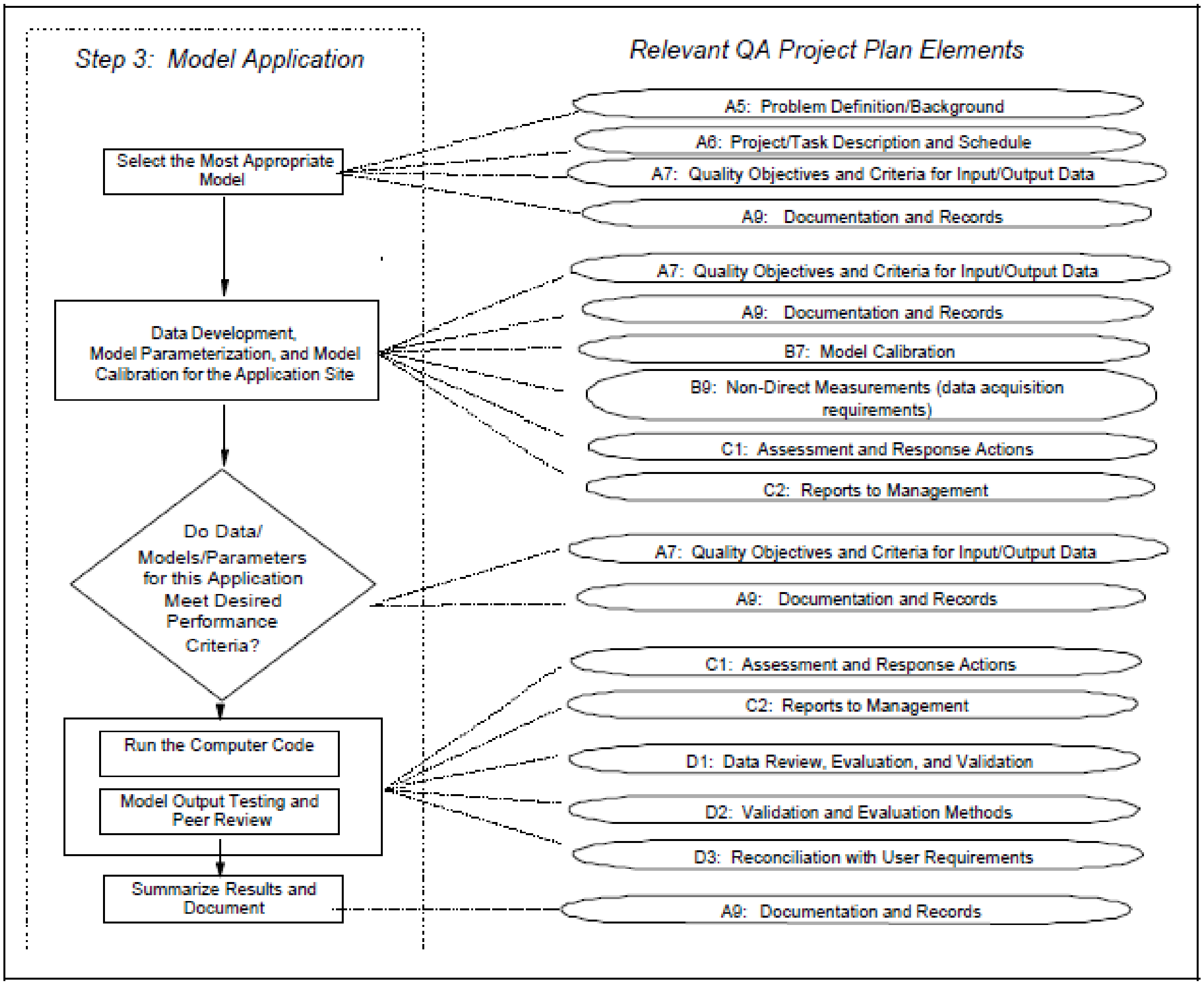
Water Quality Modeling Project Design and Application Flow Diagram



Source: EPA QA/G–5M; EPA/240/R–02/007, December 2002

Appendix K

Modeling Tasks and Corresponding QA Elements Flow Diagram



Source: EPA QA/G–5M; EPA/240/R–02/007, December 2002

Appendix L

Modeling Project QA Activities and Documentation for the Hardware/Software Configuration

Life Cycle Stage	Typical Activities	Documentation
Needs Assessment and General Requirements	• Assessment of needs and requirements interactions in systematic planning with users and other experts	• Needs assessment documentation (e.g., QA Project Plan) • Requirements document
Detailed Requirements Analysis	• Listing of all inputs, outputs, actions, computations, etc., that the modeling framework is to perform • Listing of ancillary needs such as security and user interface requirements • Design team meetings	• Detailed requirements document, including performance, security, user interface requirements, etc. • System development standards
Framework Design	• Translation of requirements into a design to be implemented	• Design document(s) including technical framework design, software design (algorithms, etc.)
Implementation Controls	• Coding and configuration control • Design/implementation team meetings	• In-line comments • Change control documentation
Testing, Verification, and Evaluation	• Verification that the modeling code, including algorithms and supporting information system, meets requirements • Verification that the design has been correctly implemented • Beta testing (users outside team) • Acceptance testing (for final acceptance of a contracted product) • Implement necessary corrective actions	• Test plan • Test result documentation • Corrective action documentation • Beta test comments Acceptance test results
Installation and Training	• Installation of data management system and training of users	• Installation documentation • User's guide
Operations, Maintenance, and User Support	• Usage instruction and maintenance resources for model framework and data bases	• User's guide • Maintenance manual or programmer's manual

Source: EPA QA/G–5M; EPA/240/R–02/007, December 2002