Paddle River Stewardship Group and West Central Forage Association

Paddle River Water Quality

In 2011, the Paddle River Stewardship group teamed up with the West Central Forage Association (WFCA) to gather water quality data on the Paddle River. Water quality data was collected due to a concern that agricultural activities were degrading water quality on Paddle River, upstream of the reservoir.

Possible *WCFA/Paddle River Stewardship Group* Objectives:

- Monitor baseline data on the Paddle River
- Improve the riparian area between agricultural activities and the river to improve water quality
- To see how WQ changes downstream between Paddle River headwaters and reservoir (near Mayerthorpe)

To address objectives, the WCFA will sample 1 x/year at three locations. Sample 1 was the furthest upstream (Range Road 113), Sample 3 was at the crossing of Highway 22 and Paddle River, while Sample 2 was in between (Range Road 102?). Samples will be taken at the same time of year (end of August) to monitor low flow water quality.

On August 24, 2011, three samples were taken along the Paddle River. Bacteria samples were re-sampled on September 13, 2011 at the same three locations and an additional station was added in between Stations 2 and 3 (Range Road 100?).

Thoughts on the 2011 data

With 3 samples from one day, we can't do much to evaluate watershed health. There is a water quality index that could rate water quality as excellent, good, fair, marginal, or poor, however, you need at least 4 samples (preferably on different dates) to make this assessment (http://www.ccme.ca/assets/pdf/wqi_techrprtfctsht_e.pdf). The index is based on the exceedence of Canadian Council of Ministers of the Environment (CCME) federal guidelines.

When I looked specifically at the guidelines and the data, I didn't see any points that exceeded CCME guidelines for protection of aquatic life or agricultural uses (CCME guideline summary table: http://st-ts.ccme.ca/). Alberta guidelines have been developed by Alberta Environment (http://environment.gov.ab.ca/info/library/5713.pdf). Using those, I could only see one exceedence which was with the total phosphorus concentrations in samples 2 and 3. The Alberta protection of aquatic life guideline recommends that total phosphorus concentrations do not exceed 0.05 mg/L. Samples 2 and 3 had total phosphorus concentrations of 0.13 and 0.10 mg/L. Note that with past monitoring of agriculturally dominated watersheds, Alberta Agriculture and Rural Development (ARD) has found that more often than not, total phosphorus concentrations exceed the 0.05 mg/L guideline.

Changes downstream:

- Chemical oxygen demand increases: COD is the amount of oxygen consumed by contaminants. In the three samples take, COD increases, suggesting there is more pollution downstream
- Total phosphorus concentrations increase from Samples 1 to 2: Phosphorus in agricultural areas is applied to fields in the form of manure and fertilizer. The increase in phosphorus could be related to agricultural activities but could also be the result of other land uses. Typically, with increased agriculture, we see an increase in the dissolved form of phosphorus; however, in this case, we are not sure what fraction of phosphorus is increasing (dissolved versus particulate) so it's difficult to say why P increased.
- Total and fecal coliforms concentrations decrease: a decrease in their concentrations could be related to die-off. Depending on the distance between samples, there may not always be an increase in concentrations. Keep in mind that total coliforms are mostly harmless bacteria that live in soil and water as well as in the gut of animals.
- Electrical conductivity increases: Electrical conductivity is a measure related to total dissolved solids (which also increases). The more ions that are present, the more conductive the water is. Conductivity is related to the rock composition and soil type of a basin, but can be altered by pollutant sources such as road salts and sewage. Lower flows often have higher conductivity because the ions in the water are more concentrated.
- Calcium/magnesium/potassium/chloride concentrations increase: Calcium, magnesium, and potassium have natural sources but are also found in manure.
- Nitrate-nitrogen concentrations increase: Often places of higher agricultural intensity have higher nitrate concentrations. The increase from Samples 1 through 3 could be related to agriculture but may also be related to other land use activities.
- Sulphate concentrations increase: Natural sources so increase may be related to natural variations

Suggestions

Parameters

If the main concern is cattle access and riparian issues, you may want to re-evaluate the current suite of parameters analyzed. Cattle access usually impacts erosion, sedimentation, runoff and parameters impacted may include those sediment bound, biological and soluble pollutants. When looking to see water quality changes as the result of changing agricultural practices, ARD typically looks at: total phosphorus, total dissolved phosphorus, total particulate phosphorus, total nitrogen, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, total suspended solids, fecal coliforms, and *Escherichia coli.*

To give you a bit of insight/background information into the parameters your group currently analyzes, I pulled together some notes that came from an Oldman Watershed Council report (see end of this document).

Given that monitoring is planned for the next 2 to 3 years, there may not be enough time to see a change in the water quality. Depending on the amount of time and effort people have to dedicate to the project, there could be some monitoring of other changes such as area of wildlife habitat, plant diversity, re-emergence of willows, etc. Some of these factors may already be covered off if Cows and Fish plan to return and re-assess the area.

Sample timing- runoff vs. low flow

I generally believe that changes in agricultural activity (i.e. beneficial management practices) will be most effective when there is active runoff from the land. To cover this, ARD will sample during periods of runoff and low flow. If sampling only during low flow, when the land is not contributing, you may notice no difference in water quality or the differences found will be related to other factors (i.e. climate/precipitation/stream flow). On the other hand, if you are just looking for baseline data, the method you've selected may be what you want.

Sample frequency

Ideally, you'd want more samples taken throughout the year, however, I do understand that funding is a key factor to determining how many samples can be taken. If more samples were taken and parameters analyzed were modified, you could run data through the CCME water quality index. Note that ARD has a modified index used for watersheds we monitor- the parameters are slightly different than those listed in the CCME link above. I can send you more information if interested.

As a thought (and not knowing discussions that have occurred previously), could you take those 3 samples taken on one day and instead sample one location (i.e. at Highway 22 or Range Road

101) three times a year? The answer depends on the objectives and questions the group wants answered.

Historical Data

ARD has monitored Paddle River through the Alberta Environmentally Sustainable Agriculture (AESA) Stream Survey. Our outlet that we monitored was the intersection of Range Road 101 and Paddle River crossing- west of the reservoir. Data could overlap depending on where site 2 is located. The data could be very useful as it would provide a baseline for nutrient, bacteria, and pesticide parameters.

We monitored Paddle River from 1999 through 2006 with a flow biased sampling regime (sampled more frequently when flows were higher to capture peaks). We only sampled from March 1 through October 31. An additional bonus to this site is the Water Survey of Canada gauging station (Station 07BB011) (Water Survey of Canada). Knowing flows will help to understand and compare water quality results over the years.

The table below shows our summary statistics for some of the parameters that overlap with your analytical suite. We did analyze for more nutrient parameters- let me know if you are interested in seeing these data.

Summary statistics for AESA Paddle River Instream concentrations between 1999 and 2006 (n=156).

	Total Nitrogen (mg/L)	Nitrate + nitrite-Nitrogen (mg/L)	Ammonia-nitrogen (mg/L)	Total Phosphorus (mg/L)	Fecal coliforms (CFU/100 mL)	*E. coli* (CFU/100 mL)
Min	0.373	0.003	0.003	0.021		
Max	4.758	0.778	0.654	0.744	4000	1400
Median	0.846	0.005	0.027	0.073	40	20
Mean	1.046	0.048	0.053	0.13	123	82

Comparing the historical concentrations to Sample 2

Total phosphorus and fecal coliforms concentrations were very close to historical mean concentrations. Nitrate + nitrite concentrations were above the historical mean and median concentrations but well below the maximum. All ammonia-nitrogen concentrations were below the minimum detection limit and cannot be compared to historical data.

As a side note, between 1999 and 2006 there were pesticides that were detected at the outlet including: 2,4-D, MCPA, dicamba and triclopyr.

The last summary of Paddle River was done in 2005. It's attached to the email. It gives you an idea of the ratings given through the water quality index.

Let me know if there is an interest in getting more information about our monitoring on Paddle River. Our technical report is online, however, I will pre-warn you that it's long and thorough! (AESA WQ Report)

Information

A source of information that may be useful is on the ARD Ropin' the Web website. It's an introductory guide to water quality monitoring:
Introductory guide

Details on parameters currently analyzed

Chemical Oxygen Demand

The impact of an effluent or waste water discharge on the receiving water is predicted by its oxygen demand. This is because the removal of oxygen from the natural water reduces its ability to sustain aquatic life. The COD test is therefore performed as routine in laboratories of water utilities and industrial companies. The result of a chemical oxygen demand test indicates the amount of water-dissolved oxygen (expressed as parts per million or milligrams per liter of water) consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample. For the contaminants that can be oxidized biologically, the biological oxygen demand (BOD) method is used.

Ammonia-N

Ammonia, another inorganic form of nitrogen, is relatively instable. In water, total ammonia consists of ammonium ion (NH4+) and unionized ammonia gas (NH3), the relative proportions of which depend on pH and temperature. The CWQG for ammonia (as nitrogen, in mg/L) is therefore also dependent on temperature and pH. Nitrate, nitrite, and ammonia are all products of the decomposition of human and animal wastes; nitrate and ammonia are also key components of commercial fertilizers. Atmospheric deposition is another source of nitrogen.

Total Phosphorus

Total phosphorus (TP) can be divided into inorganic and organic fractions, or into dissolved and particulate fractions. Most phosphorus is in organic form, but the portion used by plants is in the soluble inorganic form of orthophosphate (PO43-).

pH

The pH scale measures how acidic or basic a substance is. The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic. A pH greater than 7 is basic.

Electrical conductivity

Specific conductance (electrical conductivity) is a measure related to TDS. The more ions that are present, the more conductive the water is, measured as microSiemens per centimetre (µS/cm). Conductivity is related to the rock composition and soil type of a basin, but can be altered by pollutant sources such as road salts and sewage. Lower flows often have higher conductivity because the ions in the water are more concentrated. There are no guidelines for specific conductance.

Calcium, Magnesium, Sodium, Potassium

The major cations (positively charged ions) found in surface water are calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^{+}) and potassium (K^{+}). Cations are all necessary for various biological processes, but human activities, such as industrial processes and the application of fertilizer, can increase their concentrations in surface waters. The only cation for which there is a CWQG is calcium; a level of 1000 mg/L has been set to protect drinking water for livestock. Sodium is of particular concern to irrigators because it can become attached to soil particles, altering soil structure and creating hard, compact conditions. Rather than examine sodium concentrations themselves as an indication of potential harm to plants and to soil permeability, the sodium adsorption ratio (SAR) is calculated. This ratio relates sodium concentration to calcium and magnesium levels, which help to counter the effects of sodium. In this report, results will be compared to a SAR of 3, which is the point at which use for irrigation for certain sensitive crops begins to be restricted (CCME 1999)

Iron and Manganese

Metals and other trace elements are commonly found in surface waters. Because of their natural origin in geological materials, levels are often positively associated with suspended solid concentrations. Anthropogenic sources include effluent discharge, atmospheric deposition of emissions, and runoff. While necessary in very small amounts, higher concentrations of many of these elements can be toxic to aquatic life, humans, livestock, and crops. The only metals tested regularly as part of the ORBWQI were iron and manganese. These metals are part of the routine water testing package offered by many laboratories because they can have aesthetic implications for drinking water.

Nitrate-N and Nitrite-N

Nitrate (NO_3^-) is the most soluble and stable inorganic form of nitrogen in surface water and is the most readily available source of nitrogen to algae and aquatic plants. Nitrite (NO_2^-) is found less commonly in surface water because it is quickly converted (oxidized) to nitrate by bacteria. The two ions are reported in mg/L as nitrogen and are sometimes reported together as (NO2-+NO3-)-N. At the start of the ORBWQI, the only guideline available for nitrate (as nitrogen) was the Canadian Drinking Water Guideline of 10 mg/L, but recently a value of 3.0 mg/L has been set by the CCME for the protection of aquatic life. The CWQG for nitrite (as nitrogen) for the protection of aquatic life is 0.06 mg/L

Sulfate, Bicarbonate, Carbonate, Chloride

The major anions (negatively charged ions) found in surface waters are bicarbonate (HCO3-), carbonate (CO3-), sulphate (SO42-), and chloride (Cl-). Human activities can also increase the concentrations of anions in surface waters, while natural levels are determined by basin geology. Carbonate/bicarbonate concentrations are also influenced by biological processes (photosynthesis and respiration) and carbon dioxide exchange with the atmosphere. There are no guidelines for these two ions. For sulphate, a maximum concentration of 1000 mg/L is recommended for livestock drinking water (CCME). The maximum acceptable level of chloride in irrigation water ranges from 100 to 700 mg/L or higher, depending on the crop (CCME 1999).

Alkalinity

Total alkalinity, expressed as mg/L of calcium carbonate (mg CaCO3/L), measures the ability of water to neutralize acid. Alkalinity is an important attribute of surface water. The United States Environmental Protection Agency (USEPA 2002) recommends that 3-5 alkalinity of surface waters be at least 20 mg/L of calcium carbonate unless natural conditions are less. Alberta waters are generally high in alkalinity due to the presence of limestone parent material. Carbonate (CO3-), bicarbonate (HCO3-), and **hydroxide** (OH-), all measured in mg/L, are key components of alkalinity. The relative contribution of these ions to alkalinity is determined by comparing total alkalinity to another measurement called phenolphthalein alkalinity. These measurements are part of standard water quality testing and do not have to be examined closely unless alkalinity issues are present

P-Alkalinity

P-alkalinity determines all hydroxyl and half of the carbonate alkalinity
P alkalinity exists when the pH is greater than 8.3

T-Alkalinity

T alkalinity exists when the pH is greater than 4.3

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of the ions (salts) dissolved in water (mg/L). These ions come from both natural and anthropogenic sources and are transported into surface water through runoff and wind. The concentration of total dissolved solids (sometimes referred to as salinity) is either estimated by adding up all the dissolved constituents measured in the water, or is obtained by filtering and evaporating a water sample and weighing the dried residue (known as filterable residue or FR). Filterable residue measurements are often slightly higher than TDS but will be considered equivalent for the purposes of this report. The irrigation CWQG for TDS is between 500 and 3500 mg/L, depending on the crop. The upper limit for TDS in water for livestock is 3000 mg/L (CCME 1999).

Hardness

The hardness of water is a measure of ions present with a charge greater than +1. Hardness values (in mg $CaCO_3$/L) can be calculated from measurements of calcium (Ca^{+2}) and magnesium (Mg^{+2}) which are usually the most common of these ions in water. While hard water is a nuisance for homeowners, harder water actually decreases the amounts of heavy metals that fish can absorb through their gills. Municipal and industrial waste can influence hardness, but it is primarily determined by geology. No environmental guidelines for hardness exist; however, hardness is required for determining the guidelines for some metals.

Ionic Balance

Ionic balance refers to the ratio between cations and anions which should be around 1. This value is used as a check of analytical methods and may also suggest the presence of organic acids or bases in some systems. Further examination of this variable is not required for this report. The amount of hydrogen ion (H^+) in a solution is measured by pH. Water with a pH of 7 is considered neutral. A pH greater than 7 means that there are fewer free hydrogen ions available, and the water is basic. A pH less than 7 indicates that more free hydrogen ions are available, and the water is acidic. Basin geology, biological processes, and human activity all affect surface water pH. The solubility and biological availability of many substances are influenced by pH, and aquatic organisms differ in their tolerance for ranges of pH. In this report, the CWQG for the protection of freshwater life of 6.5 – 9.0 pH units will be used to evaluate conditions in the Oldman River Basin.

Information from:

Oldman River Basin Water Quality Initiative
Surface Water Quality Summary Report
April 1998 – March 2003
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January 2005