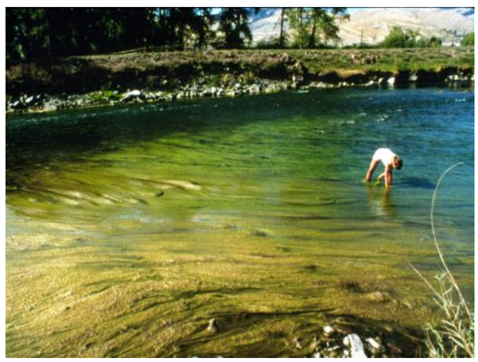
FINAL REPORT:

THE CLARK FORK RIVER
VOLUNTARY NUTRIENT REDUCTION PROGRAM
1998-2008

The Progress of a Voluntary Program in Reducing Nutrients and Noxious Algae in the Clark Fork River in Montana

August 21, 2009



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***Cover photo: courtesy of Dr. Vicki Watson, University of Montana**

I) Introduction:

A. Purpose of this Report

The purpose of this report is to review the progress during the 10-year Clark Fork Voluntary Nutrient Reduction Program (VNRP), a voluntary effort to control nutrient pollution and nuisance algae in the Montana portion of the Clark Fork River. The VNRP is a program of the Tri-State Water Quality Council (Council), a non-profit watershed organization working to improve water quality in the Clark Fork-Pend Oreille watershed through mutual respect, collaboration, science and education.

This report summarizes the results of the Council's collaborative effort with its members, including businesses, industries, state, local and tribal governments, Federal agencies and environmental groups, to reduce nutrient discharges, and improve water quality in the Clark Fork River. The VNRP effort focuses on the 200 miles of the Clark Fork River above its confluence with the Flathead River, a watershed of approximately 11,000 square miles which includes cities such as Butte and Missoula, small towns, agricultural valleys, national forests, and nationally-known trout fishing streams. The VNRP agreement was originally facilitated by the Council, which coordinated the VNRP's implementation as part of its larger effort to protect the Clark Fork, Lake Pend Oreille and the Pend Oreille River from the detrimental effects of nutrient pollution, and the threat of eutrophication (Tri-State Implementation Council, 1998).

In October, 1998, the VNRP participant organizations in Montana signed a formal agreement which committed them to specific measures each would take to reduce discharge of nitrogen and phosphorus to the Clark Fork, and to monitoring the effects of their work on water quality in the river. Part of the VNRP agreement specified that the group would formally evaluate its efforts every three years during the 10-year duration of the VNRP (from 1998 to 2008). Two tri-annual reports were prepared (TSWQC, 2002 and 2005) to this effect. This final report will do the following:

1) Review the specific commitments of each signatory in the VNRP agreement.
2) Review the progress each signatory has made in meeting its commitments, noting progress on point-source and non-point reductions since1987, and especially focusing on progress during the VNRP period from 1998 to 2008.
3) Examine whether the signatories met their goals in reducing nutrient concentrations and algal biomass in the river, as measured by the Council's monitoring program during 1998-2008, with reference to changes in overall water quality since 1988..
4) Identify the issues remaining as the signatories look beyond the VNRP to future nutrient management and water quality goals in 2009 and beyond.

B. Historical Retrospective on Development of the VNRP Agreement:

The Nutrient Pollution Problem: In 1988, a study commissioned by Governor Ted Schwinden of Montana identified excess nutrient loads and resulting high levels of attached algae growth as one of two major water quality issues in the Clark Fork basin (heavy metals pollution was the other issue). High levels of nitrogen and phosphorus in the Clark Fork result in summer blooms of dense mats of attached filamentous algae (*Cladophora* sp.) in the upper river, and heavy growths of diatom algae on the river bottom below Missoula. This benthic (stream bottom) algae, known locally as "moss" or "slime," can cause detrimental ecological effects on aquatic life, and is also a nuisance to irrigators, fishermen, and boaters and reduces the aesthetic value of the river. The downstream states, Idaho and Washington, also had nutrient pollution concerns around Lake Pend Oreille and the Pend Oreille River. Since the Clark Fork discharges its entire flow into Lake Pend Oreille, there was also concern about the possible effect of Montana's nutrient load on these downstream water bodies.

<u>The Ecological Effects of Excess Algae:</u> The documented negative ecological effects of excessive algae growth in rivers include: 1) degradation of aquatic habitats, 2) depletion of dissolved oxygen supplies, especially at night; 3) loss of diversity in aquatic invertebrate communities; and 4) stress on native fish populations (Carpenter, et.al., 1998). Low summertime oxygen levels and changes in invertebrate communities have been measured in the Clark Fork River where heavy algae growths occur. In lake ecosystems, like Lake Pend Oreille, excess nutrients and algae can lead to classic eutrophication problems: loss of water clarity, proliferation of noxious algae (phytoplankton) and weeds in open water and shoreline areas, and changes in lake ecology. Lake Pend Oreille is experiencing nutrient increases and weed problems along shorelines, but not yet in the open waters of the lake.

<u>Identification of the Problem and Sources</u>: Studies funded by the 1987 reauthorization of the Clean Water Act, quantified the nutrient pollution problems in the Clark Fork River. These studies--known as the section 525 studies for the pertinent section of the Clean Water Act--were completed in the Montana, Idaho, and Washington sections of the Clark Fork-Pend Oreille watershed in1992 (Coots, 1992; Helscher et.al., 1993, Ingman, 1992a). The Montana study identified the upper Clark Fork from Warm Springs downstream to near Clinton, Montana, as well as the area downstream of Missoula, as sites with high levels of instream nutrients, and correspondingly excessive growths of benthic algae. Key sources of nutrients identified in the Clark Fork included the larger municipal wastewater treatment plants, as well as septic systems, some industries, and agriculture. The 525 study identified specific point sources, primarily wastewater effluent from municipal and industrial plants, as the source of 49% of the soluble phosphorus and 28% of the soluble nitrogen in the Clark Fork (Ingman, 1992b). The proportion of basin non-point nutrient load from each major tributary was quantified, but the source of those nutrient loads, such as specific land uses in those tributaries, were not quantified.

<u>History of the Nutrient Pollution Clean-Up Effort:</u> In 1993, the Environmental Protection Agency published a combined Clark Fork-Pend Oreille Basin Water Quality Study based on the conclusions of the 525 studies in each state (EPA, 1993). This study included a Management Plan for nutrient pollution and associated problems in the Montana, Idaho, and Washington State portions of the Basin.

The Council was formed in 1993 to implement the Plan's recommendations. In 1994, the Council began to facilitate discussions among interested stakeholders, and to support scientific studies about possible voluntary nutrient pollution controls in the upper and middle Clark Fork. In 1998, these discussions among the municipalities, State, industry, and environmentalists culminated in the development of the Clark Fork VNRP.

The VNRP was a landmark agreement in Montana in 1998—it was one of the first approved Total Maximum Daily Load (TMDLs) in the state, it covers a huge watershed, it includes a detailed water quality restoration plan and monitoring plan, and it was developed through a collaborative process led by the stakeholders, not by state or federal government. The State of Montana agreed to let the stakeholders work for 10 years to achieve the VNRP's in-stream water quality targets without the regulatory pressure of constricting the nutrient limits in the signatories' Montana Pollution Discharge Elimination System (MPDES) permits.

C. Formalization of Nutrient/Algae Targets on the Clark Fork:

The VNRP specifies water quality targets for 200 miles of the Clark Fork river above the Flathead confluence, and allocates the necessary pollution reductions between the important dischargers. Signatories to the VNRP had until 2008 to meet their commitments, which are intended to meet the targets and eliminate the nuisance algae problems in the river.

The water quality targets in the VNRP were developed based on analysis of conditions in the Clark Fork river, and the work of third-party reviewers who looked at large data bases on nutrient-algae problems in a variety of geographic settings (Dodds, Smith, and Zander 1997). The targets finally arrived at by the VNRP Committee of the Council are expressed in Table 1:

Table 1: VNRP Targets for Clark Fork River above the Flathead

VNRP Algae Targets:
100 milligrams/meter2 chlorophyll a (summertime mean), and
150 milligrams/m2 (peak), chlorophyll a
VNRP Nutrient Targets:
20 micrograms/Liter of Total Phosphorus (upstream of Missoula)
39 micrograms/Liter of Total Phosphorus (downstream of Missoula)
300 micrograms/Liter of Total Nitrogen (anywhere in river)

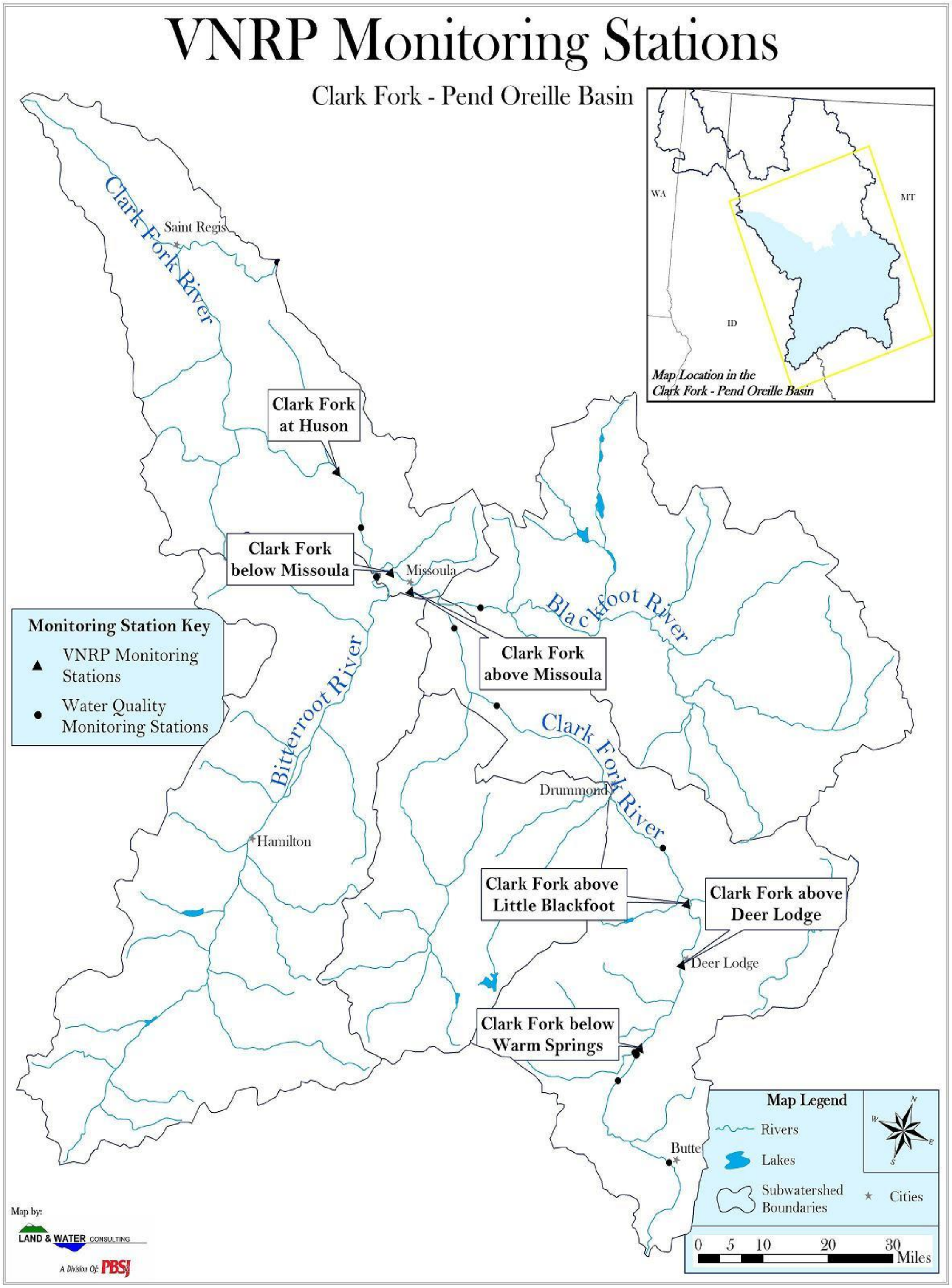
In 2001, the Montana Board of Environmental Review, in response to DEQ review of nutrient standards, approved new nutrient and algae standards for the Clark Fork. These standards are substantially identical to the original VNRP targets, and vary only in that the downstream phosphorus target is applied from the confluence of the Blackfoot and Clark Fork, downstream (rather than at Missoula).

In 2008, the DEQ published recommendations for nutrient and algae standards for the wadeable rivers of the entire state of Montana (Suplee et.al., 2008). These recommended standards, which would apply in the upper Clark Fork (above Rock Creek), have not yet been submitted to or approved by the Board of Environmental Review.

The VNRP was designed to achieve its targets by 2008, through the investments of the signatories in significant new nutrient pollution control. Once these targets are achieved it is believed that excess algae will be reduced to a point which no longer harms the aquatic habitat, the aquatic life, or the aesthetic quality of the river.

However, the VNRP signatories realize that nutrient levels are only one of several natural factors affecting algae growth. Sunlight, temperature, drought or flood patterns, browsers (insects or others) and other factors that are not under human control also affect algae growth. Therefore, the algae levels in the Clark Fork are not expected to respond in a simple linear fashion to nutrient reductions.

FIGURE 1: Clark Fork VNRP Project Area and Selected Monitoring Stations



II) Point Source Nutrient Reduction Measures and Their Effectiveness

The VNRP was signed by eight distinct entities—and each had specific commitments detailed within the document. The major signatories and their specific commitments are summarized in Table 2:

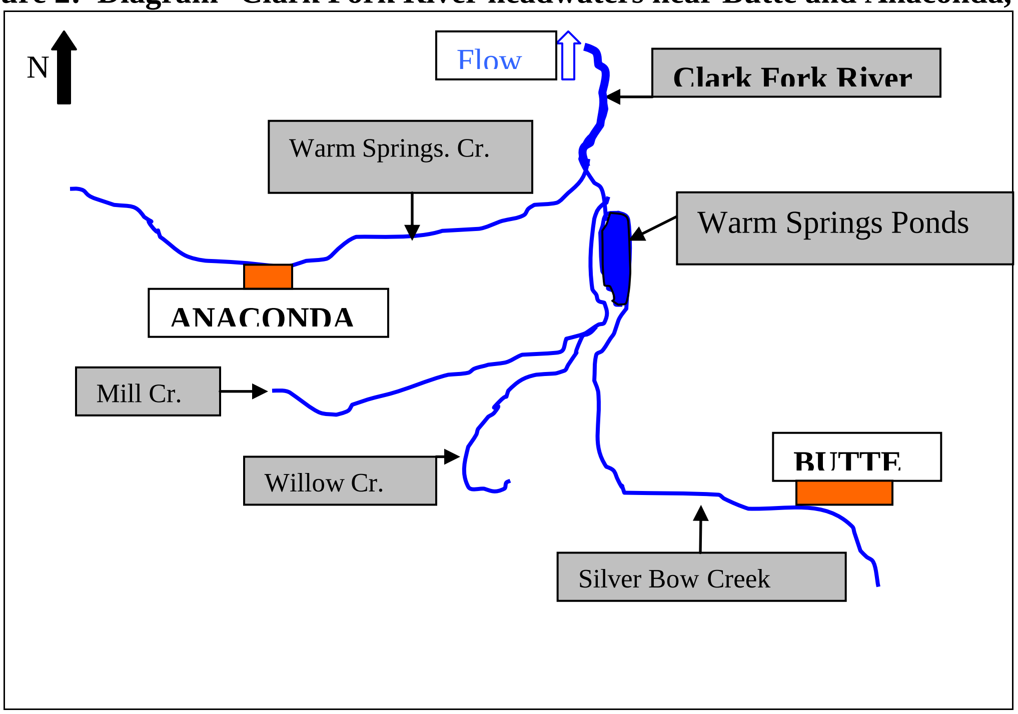
TABLE 2: VNRP Signatory Commitments:

Signatory to VNRP and Role:	Specific Commitments in VNRP
Butte-Silver Bow government/ (Butte Metro Sewer wastewater treatment plant)	*Reduce summer phosphorus and nitrogen discharge loads to 9% and 22% of 1991 levels. *To accomplish this, Butte will: --pump effluent to land application sites; --take other measures as necessary to meet target levels of nutrients in Clark Fork, such as flow augmentation below Warm Springs Creek.
City of Deer Lodge (wastewater treatment plant)	*Meet in-stream nutrient and algae targets by constructing a land application system for wastewater effluent. *Implementation of a phosphate laundry detergent ban.
Missoula County/ City-County Health Department (septic and subdivision policies).	*Address septic effluent impact on surface water pollution by: --offering incentives to connect to public sewer for existing facilities and new subdivisions. --Connecting 50% of the 6,780 existing septic systems in the Missoula urban area to sewer. --Continue to connect existing septic systems to sewers in the Missoula area to achieve no net growth of septic systems.
City of Missoula (Missoula wastewater treatment plant)	*Continue experimentation with biological nutrient removal using existing facility; *Reduce nutrient loading to the river through an upgrade and expansion of the existing wastewater treatment plant. *Collaborate with Missoula County on hooking up septic systems to sewer.
Smurfit-Stone Container Corporation	*Reduce nutrient loading to meet in-stream nutrient loading and algae targets by: --Use of color removal plant --No direct discharge to river during July-August; --Summer use of storage ponds remote from river; --Research on additional techniques. *Participate on VNRP committee to evaluate progress
Montana Department of Environmental Quality	*Address new and existing discharge permits. *Implement subdivision review procedures to reduce water quality impacts. *Work with Missoula agencies on septic issues. *Work with Council on a nonpoint prioritization and strategy. *Repository of the Clark Fork water quality model. *Coordinate with VNRP committee.
Tri-State Water Quality Council	*Provide coordination/administration of VNRP *Oversee implementation/evaluation of VNRP. *Coordinate in-stream data with monitoring subcommittee. *Hire a VNRP Coordinator to work with other parties in watershed. *Report to EPA and the public.
Clark Fork Coalition	*Continue participation on VNRP committee to monitor and evaluate program.

A. Activities and Impact in Butte-Silver Bow County: The Butte-Silver Bow County government (Butte) has applied diverse strategies for reducing the impact of its municipal wastewater treatment system on nutrient concentration in the Clark Fork. Butte has an MPDES permit to discharge treated wastewater from its wastewater treatment plant into Silver Bow Creek, a small tributary to the Clark Fork, which flows through Butte.

From the beginning of the VNRP process, Butte has focused on meeting nutrient concentration targets (20 micrograms/L total phosphorus, 300 microgram/L total nitrogen) in the Clark Fork river where it begins, at the confluence of Silver Bow Creek, Mill-Willow Creek and Warm Springs Creek, about 20 miles downstream of Butte. This location is the most upstream monitoring point on the Clark Fork itself, and is referred to as "Butte's point of compliance" with VNRP. This allows Butte to take advantage of the Warm Springs Ponds as a nutrient sink for Silver Bow Creek water and of Warm Springs Creek as a conduit for clean dilution water for the Clark Fork.

Figure 2: Diagram--Clark Fork River headwaters near Butte and Anaconda, MT:



Butte-Silver Bow has been using the following initial strategies for nutrient concentration reduction in the Clark Fork at its "compliance point" below Warm Springs ponds:

- Starting in 1999, Butte-Silver Bow has allowed ARCO to divert up to 24 million gallons/day (37 cfs) of clean, low-nutrient water from Silver Lake into the Warm Springs Creek drainage. The purpose is to alleviate de-watering in lower Warm Springs Creek, and to improve water quality (for metals and nutrients) in the creek and Clark Fork river by dilution. The Silver Lake water significantly dilutes the nutrient content of the Clark Fork river below Warm Springs Creek. Silver

Lake water has a phosphorus content below detection and less than 0.1 mg/L total nitrogen, so it serves very well for dilution of nutrients.

- In 2000-2001 Butte-Silver Bow installed a center pivot irrigation system on city-county land west of Butte for the purpose of wastewater effluent irrigation. A pipeline carries treated effluent west from Butte WWTP to the site, where the center pivot irrigates approximately 100 acres. The wastewater treatment plant staff installed the system, and have been operating it each year from late April to early September. This system pumps approximately 0.4-0.6 cfs (0.25 to 0.4 mgd) of treated effluent during peak irrigation season, effectively removing this effluent from Silver Bow Creek.
- Storm water from urban Butte contains nutrients and metals, but much of this water is captured in the Butte hill stormwater retention basins, constructed over the last eight years. These basins result in approximately 60% of the stormwater and sediment from the urban area of Butte being captured. The basins were built primarily to capture metals and sediment. The amount of nutrients retained has not been calculated, but urban stormwater sediments generally include significant attached phosphorus.
- Butte maintains a voluntary laundry detergent phosphorus ban.

After 2002, Butte-Silver Bow took the following additional steps to reduce nutrient impacts on the Clark Fork:

- Beginning in 2004 up to 3 mg/d (4.6 cfs) of Silver Lake water has been discharged into the Metro storm drain, a tributary of Silver Bow Creek in downtown Butte. This provides dilution for nutrients in Silver Bow Creek.
- Plans call for treated water from the Berkeley Pit (treatment of Pit effluent will begin in about 2017) to be discharged into the re-naturalized stream channel of Metro storm drain. This water will come from the Horseshoe Bend Treatment facility and will be very low in nutrients. Approximately 7 mg/d (10.8 cfs) of this treated water will be discharged continuously into the Metro Storm drain; at that time, the importation of Silver Lake flow will be discontinued.
- Butte has 10” pipelines running from the municipal wastewater plant to the municipal golf course and Copper Mountain recreational park. These two facilities have a capacity to use 1.5 mg/d (2.3 cfs) of treated effluent in summer months. Use of these sites for wastewater effluent irrigation has not yet begun..
- In November, 2006, Montana DEQ issued a new MPDES Permit (No. MT-0022012) for Butte’s wastewater treatment plant (WWTP), including tough new requirements for nutrient management. In 2007, Butte completed a Facility Plan and Basis of Design report for WWTP upgrades in 2007 to respond to these new permit requirements. In May, 2008, Butte-Silver Bow (BSB) and the Montana Department of Environmental Quality (MDEQ) entered into an Administrative Order on Consent (AOC) regarding a compliance schedule for meeting the new effluent limits for nitrogen, phosphorus, and residual chlorine. Three phases have been established within the AOC that outline the necessary requirements and

compliance dates. In June 2008 BSB entered into an engineering agreement with Morrison-Maierle, Inc. to assist BSB with these AOC compliance efforts.

- Phase I of Butte's compliance schedule included elaboration of an *__Effluent Reuse Plan__*. This Plan found that partnering with a private entity in the mining industry (MRI) required taking on a level of risk and uncertainty that was not practical or cost effective for BSB's needs and planning horizon. Effluent reuse on agricultural lands west of Butte was found to offer a practical and potentially long-term solution, but required a capital investment that, in combination with WWTP upgrades necessary for winter operation, effluent storage (when effluent cannot be reused), and discharge did not make financial sense. Continued effluent irrigation at the existing Sod Farm, including some modest expansion, was recommended as part of the optimized long-term effluent management strategy. Finally, in-town reuse of effluent on larger tracts of cemeteries, park land and golf courses was found cost effective compared to other alternatives, and offered several additional benefits, including the ability to divert existing Silver Lake water to other uses, instead of using it as dilution water. This in-town reuse is the route that Butte-Silver Bow is now pursuing. However, development of these in-town effluent reuse sites requires further WWTP upgrades, planned for the Phase 2 upgrades.
- Phase 2 of Butte's schedule stipulates that by October 1, 2011 "BSB shall submit maps, plans, and specifications for the final design of the Technical Plan Phase II", that includes a Biological Nutrient Removal Expansion to the WWTP. By October 1, 2015 BSB shall certify that these Phase 2 nutrient removal improvements have been constructed in accordance with the plans and specifications. Finally, on and after October 1, 2017 any limits for nitrogen or phosphorus not meeting any amended or re-issued permit will be considered non-compliance and the agreement to not initiate enforcement proceedings expires. BSB has entered into discussions with the MDEQ that would create a Phase 2A and 2B project, resulting in interim nutrient reductions by 2012-2013, significantly before the 2017 deadline.
- It is Butte's intent to implement the recommended "in-town" effluent reuse projects in concert with the Phase 2 WWTP upgrades, well ahead of the 2017 deadline. Phase 3 would require further actions only if Butte's Phase 1 and Phase 2 improvements do not fully meet all nutrient discharge limits in their new MPDES permit.
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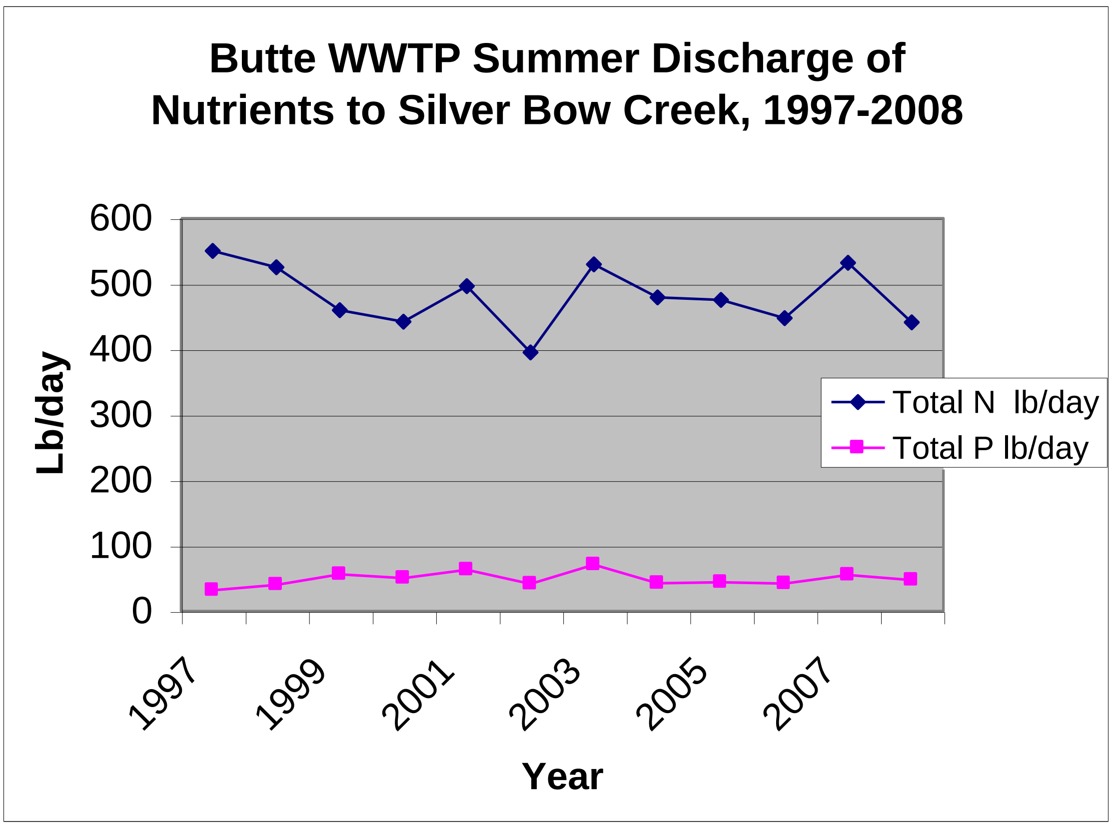
The land application work done up to 2008 directly diverts approximately 10% of the summer nutrients in municipal wastewater effluent from Silver Bow Creek to the "sod farm." Additional nutrients are removed from Silver Bow Creek by the Warm Springs Ponds before the ponds discharge to the Clark Fork river. Once the pond discharge enters the Clark Fork, it is diluted by Warms Springs Creek flows which have been augmented by "clean" low-nutrient water from Silver Lake. The Butte nutrient load is also affected by the town's long-term reduction in wastewater flow, from an average of 5.7 million gallons/day in summer 1991 to 3.4 million gallons/day in summer 2006-2008. This flow reduction is partly due to the capture of storm water flows in retention basins; formerly much of the urban storm water infiltrated into the sanitary sewer system.

Summary of Results, Butte: Butte reduced its summer total phosphorus discharge from 114 lb/day to 48 lb/day from 1991 (the VNRP baseline) to the period 2006-2008. Most of this improvement occurred before the VNRP agreement in 1998, probably due to reduction of phosphorus concentration from household laundry detergents and industrial sources in the 1990s. Total nitrogen discharged by Butte WWTP did not decline from 1991 to 2006-2008. Instead, total nitrogen discharge rose from 449 lb/day in the 1991 baseline to 473 lb/day. The VNRP projected nutrient reductions in Butte by 2008 to approximately 96.8 lb/day total N and 9.7 lb/day total P.

Figure 3: History of Butte's WWTP Summer Nutrient Discharge to Silver Bow Cr.



B. Activities and Impact in the City of Deer Lodge: During the VNRP period from 1998 to 2008, Deer Lodge focused its nutrient reduction strategy on a summer-season effluent irrigation project with Grant Kohrs Ranch, a National Park Service facility on the north end of the City. This system was designed to pump 1.1 million gallons/day of Deer Lodge wastewater effluent to pastures on the north end of the Grant Kohrs Ranch. This project was inaugurated in summer 2000, and has now functioned for eight (8) summers. Initially the Park Service operated the irrigation system and paid the pumping bills. After several years the City of Deer Lodge and the Park Service renegotiated their agreement, and the City assumed a greater portion of the operating costs. Eventually the Grant Kohrs

Ranch clearly expressed its intent to have the City of Deer Lodge find an alternative disposal site for its treated wastewater, although they facilitated the effluent irrigation project through summer of 2008.

Accomplishments and observations in Deer Lodge included the following.

- Constructed the stilling well, pump, and effluent pipeline to Grant-Kohrs ranch. The land application of irrigation effluent project began functioning in 2000 and has been running up to three to five months per year (May-September).
- The irrigation system was designed to use all the City's effluent in summer, but this has not occurred. In early summer--June and early July-- the high quantity of groundwater inflow into the City's wastewater collection system overwhelms the pumping capacity for the irrigation effluent project, and some dilute effluent continues to be discharged to the river.
- A phosphate laundry detergent ban continues to function in Deer Lodge.

Recent accomplishments in Deer Lodge include the following:

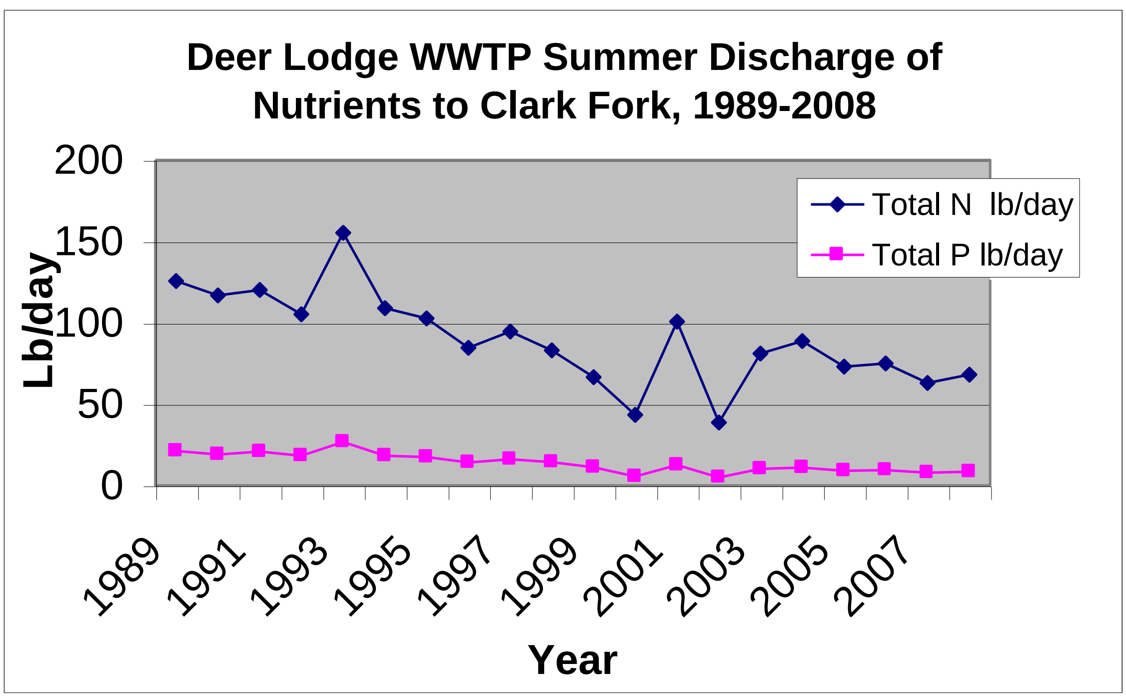
- In 2003, Deer Lodge replaced several sections of 40-year old sewer line, including one under the Clark Fork river, reducing groundwater infiltration into the system.
- In 2004, the City of Deer Lodge began to prepare a new facility plan for its wastewater, using City funds and grant funding from the Council and the State of Montana. The new facility plan was intended to: 1) identify the source of excess seepage inflow during high water in spring; 2) find options to the effluent land application system at Grant-Kohrs Ranch; 3) develop new approaches to meeting the VNRP targets of zero nutrient discharge during summer.
- The Facility Plan process was nearly complete in January, 2009. It has reached several preliminary conclusions: 1) much of the groundwater infiltration problem is within the sewer collection system in Deer Lodge. A video inspection in May 2006 identified specific locations of excessive groundwater infiltration, 2) the new MPDES permit for Deer Lodge, issued in 2006, incorporated tighter limits for organics, solids, and nutrients, including ammonia. It incorporated existing TMDLs for the Clark Fork effective in 2008 (after VNRP), which require zero nutrient discharge from 21 June to 21 September; 3) based on population, the City's wastewater flow should be 0.35 to 0.5 million gallons/day. But due to groundwater infiltration (and sump pumps discharging to the sewer system), the early summer flows go as high as 2-3 million gallons/day, causing significant effluent to be spilled into the river, because the effluent irrigation system only has actual capacity for 0.9 million gallons/day.
- If groundwater infiltration to the system can be reduced, the city's current aerated lagoon system can probably meet the future discharge limits for all constituents during winter, spring and fall. Meeting zero summer nutrient discharge, and meeting the ammonia limits in the Clark Fork, are current challenges.
- Preliminary estimates indicate that the City of Deer Lodge may need to replace (or slipline) 15,000 feet of 8-inch sewer main to reduce infiltration. However, certain residential parts of Deer Lodge experience high groundwater which is

partly alleviated by the sewer system. If the sewer no longer accepts groundwater inflow, then a supplementary drainage system will need to be constructed.

- An alternative effluent irrigation site was located, and in-depth discussions with the landowner were initiated. However this site requires a two-mile long effluent discharge pipeline and pumping capacity for 470 vertical feet of lift, which are expensive infrastructure components to devote to a site not owned by the City. Another recommended component for an alternative irrigation effluent project is to excavate and line with geo-membrane a 25-acre site of the former facultative lagoon to serve as a 60-million gallon storage pond for early season excess flows, and for periods when the irrigation system was shut down for maintenance or harvest.
- Deer Lodge is considering building a mechanical wastewater treatment plant which would upgrade treatment processes, and might include oxidation ditches, extended aeration, sequencing batch reactor, or Biolac process.
- Over $200,000 of City of Deer Lodge funds and $300,000 of grant funds have been invested in the sewer main replacements/river crossing, preliminary wastewater engineering report and other work since 2003, as well as the $500,000 invested in the late 1990s to install the wastewater effluent irrigation project.

Summary of Results, Deer Lodge: Although Deer Lodge's effluent irrigation system has not met its goal of removing all summer effluent discharge to the river, it has succeeded in dramatically reducing the average summer nutrient discharge. The VNRP summer baseline discharge in 1991 was 78 lbs/day of total nitrogen and 19 lbs/day of total phosphorus. By 2006-2008, the summer average nutrient load discharge had declined to 69 lb/day of total nitrogen and 9 lb/day of total phosphorus (see below).

Figure 4:



C. Activities and Impact at Missoula City-County Health Dept.:

The Missoula Environmental Health Division enforces the City-County Health code, which regulates septic systems and subdivisions in both the City of Missoula and Missoula County. The Missoula Valley Water Quality District does monitoring and research on surface and groundwater quality, and promotes clean up of hazardous threats to Missoula's shallow aquifer drinking water source. Together with the City of Missoula's Public Works Division, these agencies are implementing a program to transfer existing septic systems to sewer in the Missoula valley (the City and surrounding area), and to sewer new subdivisions and growth areas. Cumulative progress since 1998 includes:

- Newly sewered areas in the Missoula valley include East Reserve I and II, East Missoula, and Mullan Road areas. The East Reserve and East Missoula locations were neighborhoods with dense existing development on septic systems, while Mullan Road has several dense existing developments, and rapid subdivision and construction of residential housing. East Reserve I and II were connected to city sewer by 2002, while East Missoula and Mullan Road connections to the sewer system were completed by 2005.

- A total of 3,107 existing residential units had their septic systems connected to the City of Missoula sewer system and the Missoula wastewater treatment plant from 1998 to 2007. The goal was to connect approximately 3,390 existing septic systems to sewer by 2008, so the **Missoula City-County governments have accomplished 92% of their VNRP-related goal.**

- Meanwhile, a total of 5221 new residential units (homes, townhomes, apartment units) built in Missoula's projected sewer service area from 1998-2007 were connected to sanitary sewer. Only 403 new residential units were built in the same area with septic systems during that period.

- Therefore, there has been a net reduction of housing units on septic systems in the Missoula valley (WWTP planning area) since 1998, with 79% of homes and townhomes, and 92% of apartment units now connected to the sewer and wastewater treatment plant. This meets the policy goal to maintain no net growth in the number of septic systems in the Missoula valley for the long-term.

Other new sewer extension projects were proposed and planned in the Missoula valley during the last five years, but several remain controversial. Some neighborhoods are concerned that sewer extension will bring with it unwanted growth or city annexation. One neighborhood, southwest "Target Range" has responded by voluntarily zoning itself at a minimum of 1-acre lots in an attempt to avoid the push toward sewer extension.

Progress in connecting the Missoula valley to sewer is summarized in Table 3 below:

Table 3: Missoula WWTP Plan Area Residences on Sewer and Septic, 1998-2007

Unit type:	Number of pre-existing units connected to sewer 1998-2007	Number of new units connected to sewer 1998-2007	Number of units total in 1998	Percentage of units connected to sewer in 1998	Number of units total in 2007	Percentage of units connected to sewer in 2007
Homes	2167	3188	17,419	65%	20,904	79%
Apartment units	339	2033	7,321	86%	8,640	92%
Mobile homes	601*	--	3,352	28%	3,600	50%
Total:	3107	5221	**28,092**	**66%**	**33,144**	**80%**

*approximate pre-existing and new units combined due to type of statistics kept on mobile homes
Data source: Jon Harvala, Missoula Water Quality District, unpublished data, 2008

D) City of Missoula Wastewater Treatment Facility: The City of Missoula's Wastewater Division has been involved in nutrient reduction efforts since well before the VNRP agreement, and continues to make progress in this area. In 1989-1990, the City wastewater treatment plant staff documented a 30-40% decrease in the total phosphorus content of raw wastewater after laundry detergents with phosphates were banned. The annual average total phosphorus discharge from the plant dropped from 342 lbs/day in 1988 to 189 lb/day in 1990, due to that local government policy.

In 1995, the City's staff developed a method for further reducing phosphorus in their effluent by altering their treatment process using existing infrastructure. This "experiment" reduced effluent phosphorus concentrations from 4.3 mg/L in 1989 to between 1.5 and 2.1 mg/L, levels that were maintained until 2004. The City of Missoula wastewater treatment facility was rapidly approaching its design capacity by the end of the 1990's due to population growth and incorporation of new neighborhoods into the sewer service area. By 2002, a project to expand and upgrade the Missoula treatment facility was well underway, and in late 2004, the upgrade was complete and on-line. The City of Missoula has made the following progress:

- In the period 2002-2004 the City of Missoula constructed an $18 million biological nutrient removal (BNR) treatment system at the existing wastewater treatment plant. This project increased the wastewater treatment capacity from 9 million gallons/day to 12 million gallons/day (average daily flow), and reduced nutrient concentrations and loads in the treated effluent (phosphorus, nitrogen, and ammonia). The improvements were inaugurated in fall, 2004.

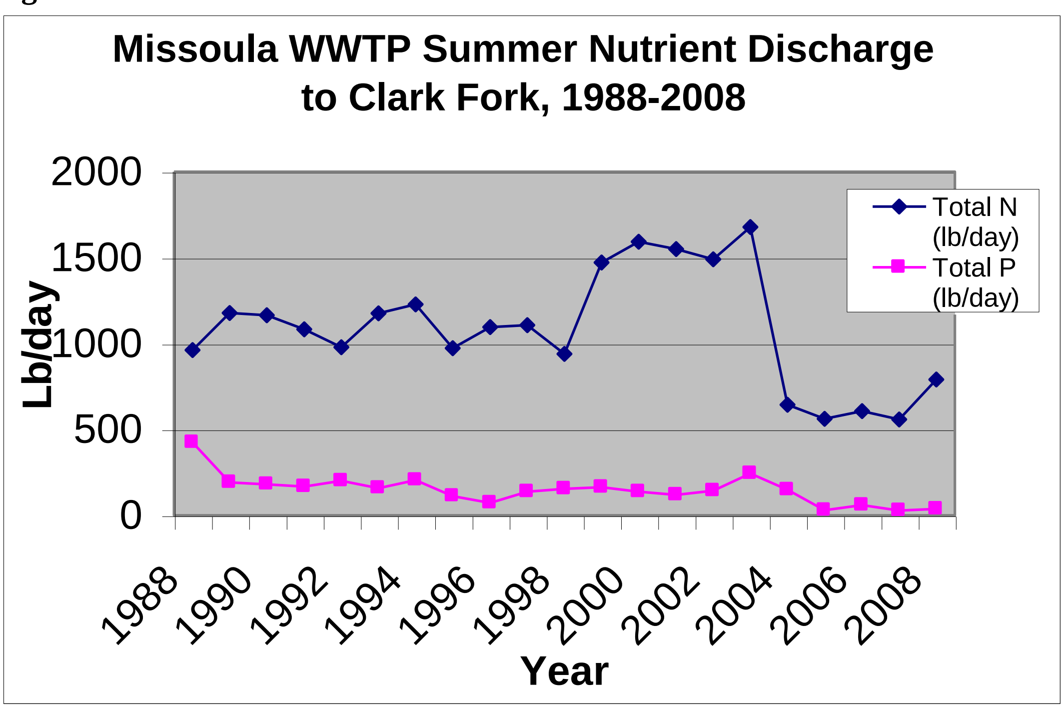
- Since the new biological nutrient removal system has been in full operation and stabilized total phosphorus load discharges have been reduced by more than 80%, total nitrogen load has been reduced more than 65%, and ammonia (toxic to some aquatic life) has been reduced by more than 95%. The performance of the new biological nutrient removal system has exceeded design criteria, and is expected to meet the city's VNRP commitments as well as all State and Federal regulatory requirements for many years. In the summers of 2006-2008, total N discharge was down to an average of 652 lbs/day, and total P discharge was down to an average of 42 lbs/day, down from a 1988-1990 summer average of 1100 lbs/day total N and 266 lbs/day of total P. The data can be seen in Figure 6 below.

- The City of Missoula funded a "mini-grant" program during 2002-2003 with $45,000 of City funds in order to find opportunities to reduce nutrient discharges from small point sources and non-point sources in the Clark Fork basin. Details of this program are described below under "VNRP Activities."

- The City of Missoula also provided $35,000 in funding for a nutrient modeling project in 2003 for the Bitterroot River watershed (see details below under "VNRP Activities.")

- In June, 2005, the City was presented with an opportunity to remove an MPDES-permitted point-source discharge to the Clark Fork. This MPDES permit was associated with an industrial food-processing facility, and was a significant source of phosphorus (estimated at 40 lbs. per day). The City wastewater treatment plant is now accepting this industrial wastewater and combining in with the municipal wastewater stream treatment process.

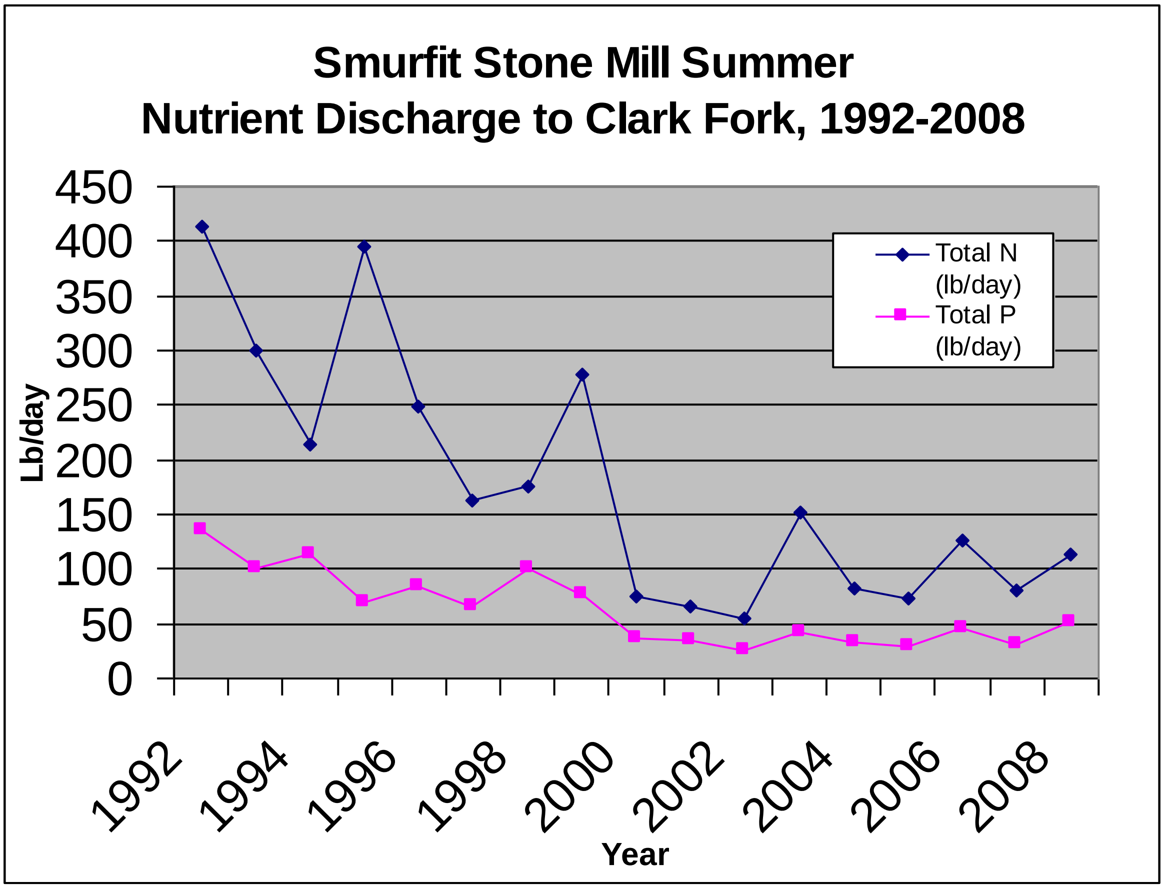
Figure 5:



D. Activities and Impact at Smurfit-Stone Container Corporation: The Smurfit-Stone Container Corporation linerboard mill (the Mill) near Frenchtown has been a participant in the Tri-State Water Quality Council since its inception, and an active member of the VNRP Committee since 1994. In the late 1980's and early 1990's the Mill dramatically reduced the amounts of supplemental nitrogen and phosphorus which were added to its wastewater stream, which has in turn reduced the nutrient load of its wastewater. For example, the Mill has accomplished a number of its specific objectives relative to VNRP since 1998, including the following:

- The Mill's bleach plant was shut down in February, 1999, reducing the volume and strength of process wastewater, including its nutrient content, thus eliminating the need for the operation of the Color Removal Plant.
- Long-term efforts were continued to optimize supplemental nutrients added to wastewater, a practice which was eventually discontinued. Research has been conducted on the possible use of artificial wetlands for nutrient removal.
- In-plant process controls further reduced mill process wastewater strength.
- The Mill does extensive in-stream monitoring above and below its Plant site, and has noted that its total nitrogen load to the river varied from about 1% to 3% of the total river load in summers of 1999-2001; while its contribution of total phosphorus to the river in those summers (mostly through seepage) varied from about 9% to 10% of the total river load just upstream at Harper's Bridge.
- The Mill has maintained fairly stable levels of total N and total P for the past five years. Since the Mill does not discharge directly to the Clark Fork at flow levels below 4,000 cfs, which are common in July and August, most summer nutrient discharge is indirect, through groundwater seepage into the river. The long-term changes in summer nutrient discharge from the Smurfit-Stone Mill (calculated as July, August and September flows) are shown in Figure 6 below.
- Annual nutrient discharge from the Mill is also down substantially. In 1988-1990, the Mill discharged an average of 556 lb/day of total N and 134 lb/day of total P. In 2005-2007, the average annual discharge was 182 lb/day total N and 45 lb/day total P.

Figure 6:



E. Other Point-Source Activities:

Tri-State Water Quality Council: The Council has been the entity responsible for coordination and facilitation of the VNRP since the early negotiations and studies in 1994. All the VNRP signatories are also members of the Council, and assist in its broader deliberations in addition to their specific responsibilities within the VNRP Committee. Since 1999, the Council has taken on a new role of outreach and project implementation through the VNRP Coordinator, who is a part-time consultant hired specifically to work with other parties in the watershed on nutrient control projects. Specific accomplishments of the Council on point source issues from 1998-2002 include:

- Implementing five mini-grants to small communities for nutrient pollution diagnostic studies, grant-writing, or wastewater project designs (Florence, Drummond, Rocker, Silver Bow County, Deer Lodge Valley Conservation District).
- Developing a new Clark Fork computer model (using QUAL2-E software) to predict nutrient concentrations in the river with the contractor HDR Engineering.
- Working with Montana Dept. of Environmental Quality on the process of developing nutrient standards for the Clark Fork river.

- Performing a case study of the impact of phosphorus in automatic dishwasher detergents on nutrient discharge from Lolo, Montana's wastewater treatment plant. This case study was completed in late 2001, reported in several conferences/newsletters in Montana, and posted on the Council's website. People interested in dishwasher detergent phosphorus bans nationwide have contacted the Council about this research.

In the period after 2002, the Council has continued to work on point-source issues in the Clark Fork. For example, the Council's VNRP Committee:

- Developed a second mini-grant program in 2002-2004, with money donated from the City of Missoula. This program awarded $45,000 in grants to five projects: 1) Gold Creek Water Quality Improvement Plan, a watershed assessment managed by the Watershed Restoration Coalition of the Upper Clark Fork; 2) Land Application Feasibility Study at Alberton, MT, with the City of Alberton; 3) City of Deer Lodge Wastewater Seepage Control project (folded into their on-going Facility Plan); 4) Conservation Easement Project with Five Valleys Land Trust; and 5) Assessment of Groundwater Nutrient Budget in Lost/Dutchman Creeks, with the University of Montana (later cancelled).
- Worked with Montana DEQ to evalate subdivision regulation changes which could reduce the impact of septic systems on water quality.
- Supported a bill in the 2009 Montana Senate (SB 200) which would prohibit the sale of automatic dishwasher detergents and other household cleaning products containing phosphorus in watersheds which violate Montana phosphorus standards.

F. Policy Affecting Nutrients/Algae in the Clark Fork

Montana Department of Environmental Quality Water Quality Standards: In 2000 the State of Montana's Department of Environmental Quality (MDEQ), reacting to concerns from the Council about possible increases in non-VNRP nutrient discharge to the Clark Fork, and to a recent national directive from the Environmental Protection Agency on nutrient standards, began the process of developing in-stream water quality standards for algae, nitrogen and phosphorus for the Clark Fork river. In preparation of the proposed standards, Dr. Mike Suplee of MDEQ made an independent review of the targets being used by the VNRP. The MDEQ initially recommended that soluble inorganic nitrogen and phosphorus concentrations would be more appropriate water quality standards.

However, after considerable debate with stakeholders about the advantages of soluble vs. total nutrient criteria, and possible variations in target levels, MDEQ made a decision to use the VNRP total nutrient criteria and "chlorophyll a" algae criteria as water quality standards for the upper and middle Clark Fork. The State did change the point of transition from an upper river total phosphorus target (20 micrograms/Liter) to a lower river target (39 micrograms/Liter) to the confluence of the Blackfoot and Clark Fork rivers. This change was based on Dr. Suplee's analysis of other factors controlling the type of algae in the river, such as water hardness. The Montana Board of Environmental

Review adopted the new nutrient and algae water quality standards for the Clark Fork in August, 2002.

Subsequently the MDEQ has continued to research appropriate nutrient and algae standards for the Clark Fork other regions of Montana. Suplee (2008a) noted that the nutrient and algae standards for the Clark Fork appear to be appropriate since three monitoring stations which do not exceed the algae standard during 1998-2006 have a nutrient exceedence rate which is approximately 8%, while three sites which frequently exceed the algae standard (Deer Lodge, above Little Blackfoot, below Missoula) have a nutrient exceedence rate of 58%. Later in 2008, Suplee et. al (2008b) published recommendations for nutrient standards for Montana's wadeable streams, which include distinct nitrogen and phosphorus standards for different ecoregions of the state, and promote an benthic algae chlorophyll a density standard of 150 mg/M2.

<u>DEQ Pollution Discharge Permits:</u>
During the VNRP, the MPDES permits for the Clark Fork dischargers did not increase constraints on nutrient discharge—that's why it was called a "voluntary" program. But as the VNRP period drew to a close, DEQ used permit renewals to require that the wastewater treatment facilities would have to meet the waste load allocations (WLAs) in the VNRP, shortly after the voluntary "grace period" expiration in fall, 2008. In 2006 the new MPDES permits for Butte and Deer Lodge incorporated precisely these requirements, which continue to be very challenging for those municipalities, due to the drastic reductions in nutrient discharge required.

Where it appears a facility's present discharge will not meet its WLA, Montana DEQ is imposing interim effluent limits and a compliance schedule requiring the facility to take action toward full compliance with the final limits. This is consistent with standard DEQ practice.

<u>The Clark Fork TMDLs:</u> The DEQ is in the process of developing basin-scale nutrient TMDLs for the entire Clark Fork/Bitterroot/ Blackfoot/ Flathead basin, including tributaries, with a current goal of completing the work by 2012. These TMDLs will consider all significant nutrient sources in the basin, both point and non-point, and will allocate loads to each source. These new TMDLs will re-examine the TMDLs, WLAs, and load allocations approved in 1998 (see Table 4). The DEQ is careful to note that the new WLA's for point sources will not necessarily be lower than the existing WLAs. What proportion of the tributaries within the basin will receive formal load allocations in the new TMDLs is unclear.

MDEQ is using a water quality model known as the Soil and Water Assessment Model (SWAT) to help in developing the new TMDLs. The SWAT model estimates non-point nutrient loads based factors including on land use, soils, climate, and topography. In the case of nutrient inputs from septic systems, applying the SWAT model will represent cutting-edge work done with input from Texas A&M and Temple Universities, which developed the model. MDEQ will use the VNRP's QUAL2E modeling work on the Bitterroot River system as input in developing the SWAT model for the Bitterroot basin.

Table 4: Summer Waste Load Allocations and Load Allocations Approved by EPA in the VNRP TMDL , October, 1998*:

Location:	WLA: (kg/day)	LA: (kg/day)	TMDL (kg/day):
Silver Bow Creek abv. Butte		75 TN, 2.7 TP	
Butte WWTP	44 TN, 4.4 TP		
Clark Fork abv. Deer Lodge		52 TN, 0.84 TP	
Deer Lodge WWTP	0 TN, 0 TP		
Clark Fork above Little Blackfoot			52 TN, 0.84 TP
Blackfoot River		184 TN, 7.9 TP	
Clark Fork abv. Missoula		285 TN, 19 TP	
Missoula WWTP	404 TN, 40 TP		
Clark Fork below Missoula			689 TN, 59 TP
Bitterroot River		414 TN, 28 TP	
Clark Fork abv. Smurfit Stone		771 TN, 54 TP	
Smurfit Stone mill: (seepage): (direct):	30 TN, 23 TP 0 TN, 0 TP		
Clark Fork below Smurfit Stone			801 TN, 77 TP

*Values of waste load allocation (WLA) and load allocations (LA) are 30-day averages based on a 30 Q10 low flow condition (drought). TN=Total Nitrogen, TP= Total Phosphorus.

Finally, DEQ notes that it is in the process of developing a rule setting forth numeric nutrient standards for *all* waters in Montana. DEQ expects this process to take one or more years.

G. Summary of Point-Source Impacts on the Clark Fork

The point-source and septic system nutrient impacts on the Clark Fork have been significantly reduced by the nutrient reduction measures of the signatories. A comparison of 1989-91 annual nutrient loads to the Clark Fork with 2005-2008 annual loads is shown in Table 5 below. The reduction in summer loads was shown in the graphs in each of the preceding sections for each discharger.

The annual loads reflect the reduced load passed to downstream water bodies (lower Clark Fork, Lake Pend Oreille, etc.). Data for annual loads from wastewater plants in 1989-91 is taken from Ingman (1992, “Assessment of Phosphorus and Nitrogen Sources in the Clark Fork River Basin: Final Report, Section 525 of the 1987 Clean Water Act Amendments) based on monitoring done at each facility in 1989-1991. Data for 1990 for Smurfit-Stone Container Corporation is taken from Smurfit-Stone’s own records for 1990 (which record a substantially higher value than Ingman’s monitoring report—possibly because they include an estimate of the seepage component). The 2004/2005 loads are based on reports from each agency’s own monitoring system (Missoula reported daily average data to date for 2005, while Butte, Deer Lodge and Smurfit-Stone use 2004 data.

Table 5: Comparison of Summer Nutrient Loads Discharged by VNRP Signatories in 1988-90 and 2006/2008:

Discharger:	1988-90 TN, TP Load: (lbs/day)	2006/08 TN, TP Load (lbs/day):	Reduction N Load (%):	Reduction P Load (%):
Butte WWTP:	449 N 114 P	473 N 48 P	- 5%	58%
Deer Lodge WWTP:	78 N 19 P	69 N 9 P	11%	53%
Missoula WWTP:	841 N 173 P	652 N 42 P	22%	76%
Smurfit-Stone Mill*:	309 N 116 P	182 N 45 P	41%	61%
Total Point Source Load:	**1677 N 422 P**	**1376 N 144 P**	**18%**	**66%**

*Smurfit-Stone did not have summer discharge data before 1992. Therefore, this is July-September data for 1992-94, compared to mill discharge data for 2005-2007.

The data show that the VNRP signatory MPDES point sources have **reduced their annual load of total nitrogen to the river by 18% in the last 14-18 years, and reduced their total phosphorus load to the river by 66%.** The much greater reduction in phosphorus load is explained below.

The change in ratios between nitrogen and phosphorus since 1991 indicate that that Butte and Deer Lodge raw wastewater loads currently include far less phosphorus than in 1989-91. For Butte, this is probably due to a combination of stormwater detention basins reducing stormwater overflow to the sanitary sewers, the laundry detergent phosphate ban and reduction of industrial loads. In Deer Lodge, the laundry detergent ban is the main known effect before 2000. Since that time, Deer Lodge's land application system is removing a large part of the summer wastewater effluent and thus nutrient load (remobilization of soluble nitrogen in effluent to shallow groundwater and groundwater discharge to the river may occur to some extent, depending on the efficiency of irrigation; while phosphorus is expected to mostly be retained in irrigated soils).

The Missoula wastewater treatment plant's new biological nutrient removal system, which became fully effective in 2005, is more efficient at removing phosphorus than nitrogen, which partly explains why their phosphorus reduction is more dramatic than the nitrogen reduction. Also note that the 1988 phosphorus loads in Missoula were very high (prior to the phosphorus laundry detergent bans), causing the 1988-90 total P average to be high. Note that City of Missoula has decrease total nutrient loads discharged while adding several thousand new residential connections to sewer, and increasing their inflow from certain industrial clients.

A further reduction in total nitrogen load discharged in the Missoula valley is due to the connection of septic systems to sewer, and the associated net reduction in the number of septic systems. This load reduction is not shown in the table, and is not easy to measure directly, but is estimated at 0.08 lb/day total N per septic system, or about 250 lbs/day of total nitrogen (mostly nitrate) from the net reduction of over 3,000 septic systems.

Smurfit-Stone Container has dramatically reduced both nitrogen and phosphorus annual loads discharged to the river—note that their reductions in each nutrient are more proportional. Smurfit-Stone discharged more nutrient load to the river during high flow years in July and sometimes early August during the period prior to about 1996. Once the VNRP began to take shape, Smurfit-Stone voluntarily reduced surface water discharges in July and August, even if flow levels were sufficient to allow those discharges according to their MPDES permit.

III) Non-point Source Nutrient Reduction Measures

A. VNRP Non-point Source Priority Tributaries

Priority Tributaries: In 1999 the VNRP Coordinator proposed a strategy for reducing non-point nutrient loads which focused on priority tributaries in a paper called "VNRP Coordinator's Non-point Source Strategy and Goals." The priorities were set up based on the perceived feasibility of obtaining significant reductions in nutrient discharge from those streams. Assumptions included: a) streams with nutrient concentrations higher than the Clark Fork targets deserved most attention; b) high non-point nutrient concentrations were assumed to be due to land use practices which could be mitigated; c) smaller watersheds were assumed to present more opportunities for nutrient reduction than larger watersheds (where the problems are more difficult to locate or expensive to mitigate).

The criteria chosen for ranking tributaries were:

a) High concentrations of either total nitrogen or total phosphorus (>VNRP targets).
b) High concentrations of both nutrients.
c) Significant nutrient loads (arbitrarily defined as >10 kg/day total P or 40 kg/day total N).
d) Watershed size, assuming smaller watersheds would be easier places to have an impact.
e) Social factors, including the existence of stream restoration projects with other agencies, watershed groups working in area, or prior history with restoration.

The results were based heavily on data collected by Ingman (1992) during source monitoring of tributaries in the upper and middle Clark Fork in 1989-1991. The rankings were as follows (higher numbers indicate higher ranking):

Table 6: Ranking Clark Fork Tributaries for Nutrient Reduction Priority

Tributary:	Score (5 is max. -2 is min.)
Lost Creek	5
Little Blackfoot River	4
Gold Creek	4
Flint Creek	4
Warm Springs Cr.-Garrison	4
Mill-Willow Creeks	3
Dempsey Creek	3

Racetrack Creek	3
Cottonwood Creek	2
Warm Springs Creek-Anaconda	2
Bitterroot River	2
Ninemile Creek	1
Trout Creek	1
Rock Creek	0
Blackfoot River	0
Fish Creek	-1
St. Regis River	-1

Subsequent tributary nutrient sampling work done by the Council and by Dr. Vicki Watson of the University of Montana, resulted in general confirmation of this ranking system, with some modifications. For example, the Lost Creek, Little Blackfoot, Gold Creek, and Flint Creek have the largest effects on the Clark Fork due to their flows and relatively high nutrient loads. The Little Blackfoot can be either a positive or negative influence on nutrient concentrations in the Clark Fork, because its nutrient concentrations vary considerably above and below the VNRP targets. We also know that much of the Little Blackfoot, Gold Creek, and Warm Springs Creek-Garrison load is from naturally high phosphorus groundwater, particularly in Gold Creek, with no known point sources.

The Bitterroot River probably merited a higher ranking---it had a total nitrogen average concentration in the 1989-1991 data that was barely below the VNRP target, and it has by far the largest nutrient load of any tributary. More importantly perhaps, the human population in the Bitterroot is growing more rapidly than any other part of the upper/middle Clark Fork, with major land use changes tending toward suburbanization. Concerns about stormwater, additional sewer load, and the tremendous growth of septic system loads are acute in the Bitterroot. The State of Montana lists the Bitterroot River mainstem and eight of its tributaries—including Rye and North Rye, Threemile and Ambrose, Burnt Fork, Sweathouse and Sleeping Child, as nutrient-impaired.

The Blackfoot River system has a relatively high load of nutrients but only because of its high flow, while its nutrient concentrations tend to be well below VNRP targets. Two Blackfoot river reaches from Nevada Creek to Belmont Creek are nutrient-impaired, as are Nevada Creek, Union Creek, and Elk Creek, according to the DEQ 303(d) list.

B. Non-point Source Nutrient Reduction Activities and Impacts in the Upper and Middle Clark Fork Basin

In recent years a growing number of different organizations have worked to improve water quality and fisheries habitat in the upper and middle Clark Fork. The VNRP Coordinator has worked with a number of these groups since 1999 to specifically promote watershed conservation, water quality monitoring, planning, education or stream restoration activities which can improve the management of non-point source nutrient issues in the Clark Fork. Some projects identified by agencies and landowners as "fisheries improvement" or other types of conservation projects probably have, or will have, significant positive long-term effects on nutrient discharge from Clark Fork tributaries.

Starting in about 2006, the DEQ began the process of preparing TMDLs for sediments and metals in the upper Clark Fork (above Drummond). This process will ultimately result in a "water quality restoration plan," which may have important indirect effects on non-point nutrients, especially nutrients associated with sediment. A new TMDL for non-point nutrients has yet to be initiated by DEQ in either the upper or middle Clark Fork mainstem. But TMDLs have been developed for the upper Bitterroot, upper Lolo Creek, Ninemile Creek, St. Regis River and much of the Blackfoot during the VNRP period, and nutrient TMDLs are under development, as of 2008, in the middle and lower Bitterroot and Flint Creek basins.

Montana's major source of non-point source pollution abatement funding is the 319 Program, named after the non-point section of the Clean Water Act, which channels EPA funds to Montana DEQ each year. A review of Montana DEQ 319 funding from 1998 to 2008 in the upper and middle Clark Fork (above the Flathead confluence), including tributaries, reveals that Montana DEQ has provided at least $3.2 million in funding to organizations working in our part of the basin. A large portion of this money has gone into TMDL planning and implementation in the Big Blackfoot River basin, as well as TMDL-related work in the Bitterroot, upper Clark Fork, Little Blackfoot, Ninemile, and, recently, the Flint Creek basin. A list of those projects is included in Appendix 3.

C. Non-point Source Nutrient Reduction Actions in the Bitterroot

The VNRP Coordinator has worked extensively in the Bitterroot river valley since 1999 to educate the stakeholders about non-point nutrient issues in the drainage, and to initiate projects to address identified non-point nutrient sources. The VNRP Non-point Strategy highlighted Threemile Creek, Rye Creek, and Sweathouse Creek as Bitterroot River tributaries which were highly ranked as nutrient problem areas, using the same criteria as were applied to the upper Clark Fork. Several of the most important VNRP initiatives in the Bitterroot since 1998 include:

- Supporting the Bitterroot Water Forum, a citizen-based group doing education, fundraising, and project development around watershed and water quality issues in one of the fastest-growing counties in Montana. The VNRP Coordinator has written several successful grant proposals with the Forum, and works closely with several of their committees. In addition the Water Forum provided coordination and funding to three different tributary watershed projects—Mill Creek, Skalkaho Creek, and Threemile Creek-- in the valley, and is initiating activities in Rye Creek and the East Fork of the Bitterroot drainages.

- The VNRP Coordinator developed a comprehensive watershed assessment project for the Ambrose-Threemile drainage from 2002-2005. This 71-sq. mile drainage has by far the highest concentration of nutrients of any Bitterroot river tributary.

The assessment identified nutrient and sediment source areas (the problems are closely related), and developed specific priority work areas. The VNRP Coordinator developed partnerships which completed several major stream/riparian corridor projects in priority areas identified in the assessment, and several more are underway in priority reaches. These projects include a large conservation effort with Brown Valley Ranch, which owns more than five miles of the upper Threemile Creek—including new grazing systems, fencing, water gaps, off-stream water development, stream channel rehabilitation. Other projects include working with the USFS and MFWP on road rehabilitation planning, and with Montana DNRC and Wheelbarrow Creek Ranch on stream channel rehabilitation and off-stream water in both Wheelbarrow and Grayhorse Creeks (tributaries to Threemile).

- Since 2000, the VNRP Coordinator has been working with the Natural Resources Conservation Service and local dairymen to improve dairy manure management in the Bitterroot Valley. The six largest dairies in the County participated in a dairy waste management assessment project in 2001, and three of those dairies have gone on to invest in improved manure management systems. Two project dairies in the Bitterroot are now selling dairy manure compost, and irrigating using separated manure effluent, using infrastructure financed in part by Council projects, and one dairy is completing a methane digester project.

- Montana DEQ developed a Bitterroot Headwaters TMDL in 2001-2005, which addressed impairments on 14 upper watershed tributaries, primarily within the Bitterroot National Forest upstream of Darby, Montana. The Council participated as a Technical Advisory Committee member and coordinator. The Bitter Root Water Forum, with technical support from the Council, has recently begun field projects to implement the water quality restoration recommendations of this report.

- In 2004, DEQ began the process of preparing TMDLs for the Bitterroot mainstem (from Darby to Missoula) and numerous tributaries. The Council received several 319 grants to coordinate the mainstem and tributary monitoring program for sediment and nutrients in the basin from Darby to Missoula. The VNRP coordinator and Trout Unlimited did monthly water quality sampling for the nutrient-impaired mainstem, and quarterly sampling on eight nutrient-impaired tributaries (from 2005-2007). The Council is also developed a public participation strategy with Bitter Root Water Forum for that TMDL.

D. Non-point Source Nutrient Reduction Activities and Impacts in the Blackfoot

The Blackfoot Challenge, North Powell Conservation District and NRCS have been working for a number of years on water quality and fisheries projects in the Nevada Creek drainage, which is an important nutrient source for the Blackfoot. The Council is not directly involved in nutrient-reduction projects in the Blackfoot, but collaborated in obtaining and managing EPA (National Watershed Initiative) funding for several stream restoration/nutrient reduction projects managed by the Blackfoot Challenge in 2002-

2005, including projects in the Nevada Spring Creek, Ward Creek, Warren Creek and Wasson Creek drainages. Many other fisheries related projects coordinated by Blackfoot Challenge and Montana FWP in the last 10 years may also have secondary positive impacts on nutrients.

IV) In-Stream Impacts of Nutrient Reduction Work in the Clark Fork

A. Summary of Council Nutrient Monitoring Program

The Council has an extensive water quality monitoring program run in coordination with state and local governments and other stakeholders. The program began in 1998 with the signing of the VNRP and the need to monitor the effects of those efforts. The VNRP portion of the monitoring program has three major objectives: 1) detect trends in nutrients in the river; 2) detect trends in attached algae density; and 3) evaluate summer nutrient concentrations relative to the VNRP targets.

The monitoring program established 32 monitoring sites in 1998, including 15 Clark Fork river sites, 11 of them above the Flathead confluence, and 17 tributary sites. The mainstem stations were initially monitored 12 times per year, and the tributaries 4 times per year. Since that time the monitoring program has been modified several times by the Council's Monitoring Committee due to funding constraints and various scientific criteria

However, summer data for nutrients and algae in the upper and middle Clark Fork is consistently collected every summer. Most key sites have data collected 10-12 different times during the June-September period. This data, in combination with earlier intensive data collection by the State of Montana in 1989-91, and work done by the University of Montana and others, allows a good picture to emerge of changes in nutrients and algae since the late 1980s to the present.

B. Summary of Trend Analysis Published by the Council for 1984-2007

In 2008, the Council's contractor PBSJ of Helena, MT, produced an in-depth trend analysis of nutrient and algae data in the Clark Fork (PBSJ, 2008). This information is summarized in the report "Water Quality Status and Trends in the Clark Fork-Pend Oreille Watershed: Time Trends Analysis for the period 1984-2007," available from the Tri-State Council's office in Sandpoint, Idaho. A prior trend analysis was done in 2004 (Land & Water Consulting, 2004).

The trend analyses revealed the following:

- Total phosphorus concentrations show decreasing trends for 1984-2007 in a majority of sites in the upper and middle Clark Fork, although not all trends are significant. A few sites, such as Silver Bow Creek at Opportunity (the headwaters of the Clark Fork) and the Clark Fork above Missoula, show increasing trends.
- Total nitrogen shows decreasing trends in all upper and middle Clark Fork sites from 1984-2007, although not all trends were statistically significant.
- Total nitrogen was decreasing significantly at Clark Fork at Warm Springs and at Huson, while total phosphorus was decreasing significantly at Clark Fork above Little Blackfoot, Clark Fork below Missoula; all for data from 1984-2007.

- In 2004, the prior trend analysis (Land & Water Consulting, 2004) showed soluble inorganic nitrogen was increasing at 14 sites in the Clark Fork basin and only decreasing at two sites. The soluble nitrogen issue was not re-examined in the 2008 analysis.

C. Clark Fork Nutrient Concentrations from 1988-2007

In order to further elucidate the status of nutrient concentrations in the Clark Fork, this section of the report includes an "illustrative analysis" for river data from 1988 to 2007 to complement the published, statistically-rigorous trend analysis. This is simply an attempt to put the most recent monitoring data from the river into historical perspective. The objective is to help us understand how historical reductions in nutrient discharge by the VNRP signatories are reflected in the river's water quality. More detailed statistics and box-plots illustrating river nutrient concentrations, particularly the distribution of samples (medians, quartiles, maximums and minimums) at each site for each time period, are available in Appendix 3.

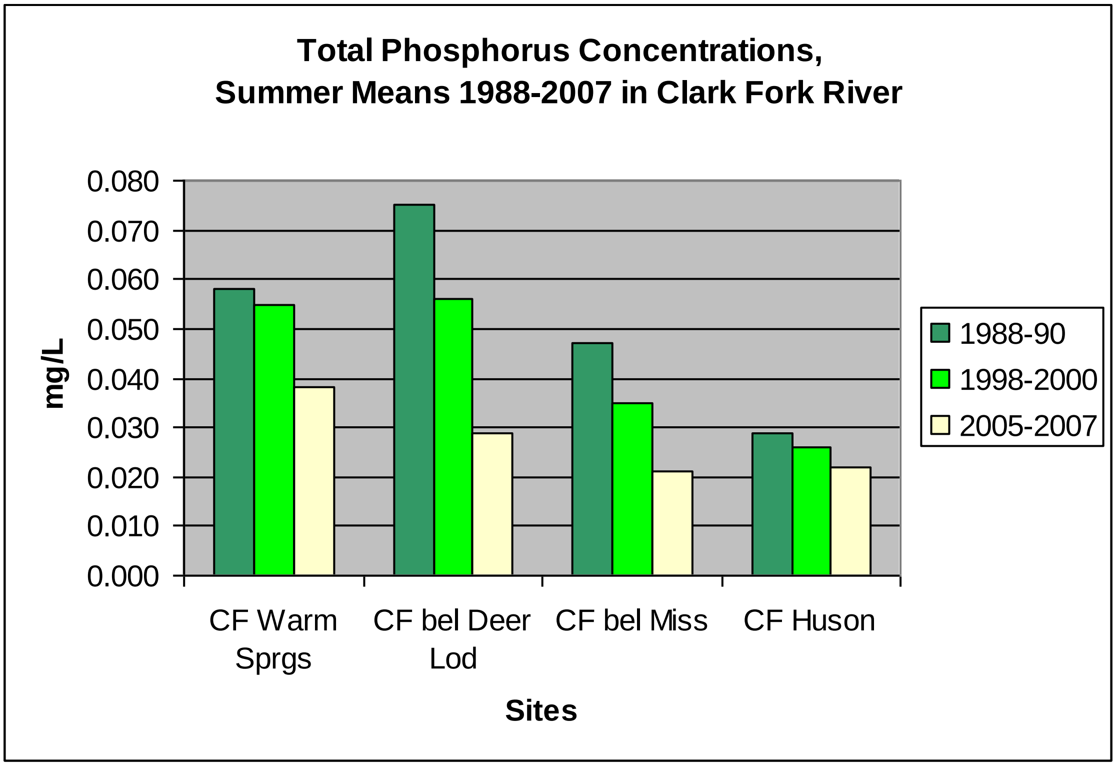
River nutrient data is notoriously variable from year-to-year, due to a variety of factors, including variations in flow and poorly understood non-point source loads. This report compares three-year sets of nutrient data from the Clark Fork from three distinct time periods: 1989-1991, 1998-2000, and 2005-2007. These three time periods roughly represent these historical situations:

- nutrient concentrations when problems in the river were first recognized (1988-90)
- nutrient concentrations once initial efforts to curb nutrients were underway, and the VNRP was recently signed (1998-2000)
- nutrient concentrations near the end of the VNRP implementation period (2005-07)

Each three-year combined data set has 10-25 data points. Comparing these multi-year data sets tends to minimize the effects of outlier data and annual flow-related fluctuations. All three data sets have mostly low-flow years, and no particularly high flow years (comparing mean annual flows), with mean flows below long-term averages at most points on the river. The general similarity in flow conditions in these three periods makes our comparison more credible. Nutrient data are averaged (arithmetic means) for the VNRP "summer" period, which is 21 June to 21 September.

In the following data sets, the more upstream stations are to the left, and the stations proceed downstream. These four stations in particular were chosen because they are the first river stations downstream of each major point source discharger (Butte WWTP-Warm Springs, Deer Lodge WWTP-below Deer Lodge, Missoula WWTP-below Missoula, and Smurfit-Stone-Huson).

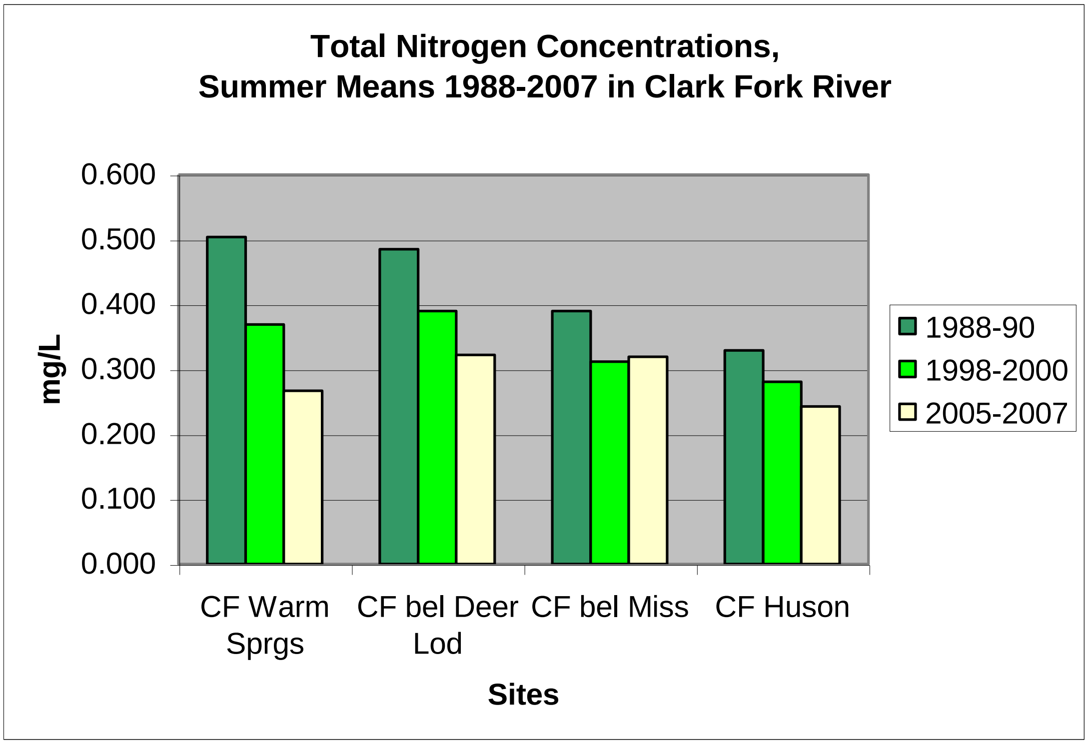
Figure 7: Summer Total Phosphorus Concentrations



This illustrative comparison indicates that total phosphorus concentrations decreased consistently in each summer time period, at each station. Relative declines in total phosphorus concentration were most significant at Clark Fork below Deer Lodge (station 10, also known as "above Little Blackfoot,**"** is located about 11 miles downstream of the town of Deer Lodge**).** Declines in total phosphorus below Missoula (station 18, known as "Shuffields") were also quite marked over the full time period. The long-term reductions in total phosphorus at Warm Springs and Huson do not appear as marked.

Long-term changes in total nitrogen concentrations in the Clark Fork can be visualized using the following data.

Figure 8: Summer Total Nitrogen Concentrations



Total nitrogen seems to be consistently decreasing at the upper Clark Fork sites below Warm Springs and below Deer Lodge, but not as drastically as phosphorus. In the middle river, there is some decline in total nitrogen below Missoula, but not during the most recent epoch (1998-2000 to 2005-2007). The trend analysis found the long-term trend for decline in total nitrogen below Missoula to be "not statistically significant." Declines in total nitrogen at Huson appear consistent, but are proportionally smaller than in the upper river. Note that the Clark Fork is a much larger river below Missoula, once the Blackfoot and Bitterroot tributaries enter, and the effects of upstream nutrient reductions are expected to be somewhat diluted, especially at Huson.

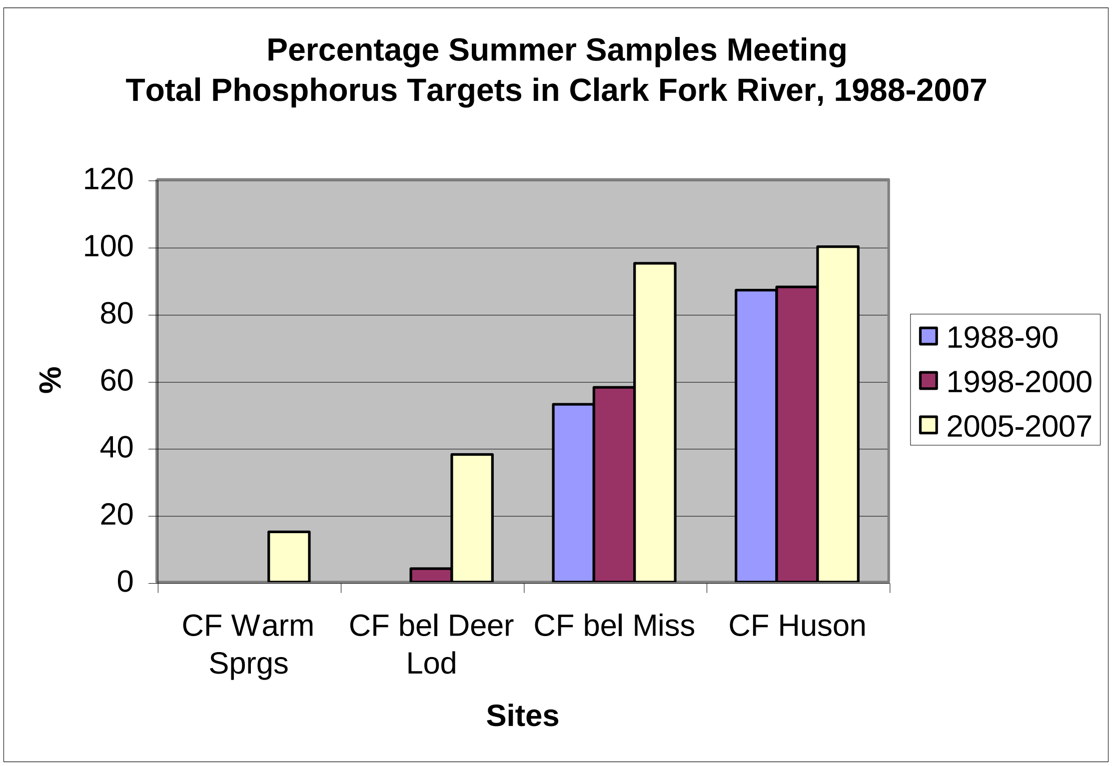
In general, the major decreases in total phosphorus and total nitrogen discharge by the VNRP signatories from 1989 to the present (66% decrease in annual total phosphorus load and 18% decrease in annual total nitrogen load) appear to be reflected in the consistently improving water quality of the river. This can be seen in the results of the Trend Analysis, and in this illustrative analysis of data from three periods between 1988 and 2007. These positive impacts appear to be greater in the upper river, and are not as notable below Missoula and in Huson. This may be because Missoula's WWTP has been absorbing an ever-greater wastewater load in recent years as new sewer districts hook up to the system. The major improvements in Missoula's wastewater effluent quality noted during 2005-2007 as the new biological nutrient removal system came on-line are captured by the river data, especially in regards to total phosphorus concentration in river.

Meanwhile, it is of concern that **the 2004 Trends Analysis found increasing trends for soluble inorganic nitrogen in many parts of the river, including the station at Huson**. This general increase in soluble nitrogen also may be affecting the relatively minor recent improvement in total nitrogen in the lower river. The source of additional soluble nitrogen is not known. It may be related to the drought, since low flows often reflect a higher relative hydrologic influence from ground water (high in nitrates) vs. surface water runoff as a source of river flow. Soluble inorganic nitrogen, distinct from the other nutrient species, is discharged to surface water quite readily through shallow ground water. The original source of soluble nitrogen may be septic systems (which have increased dramatically in the Bitterroot sub-basin), fertilizer or perhaps other sources.

D. Meeting the VNRP Nutrient Targets:

The following data expresses the frequency that water samples at various points in the river that meet the VNRP's total phosphorus targets (0.020 mg/L in the upper river, 0.039 mg/L in the lower river).

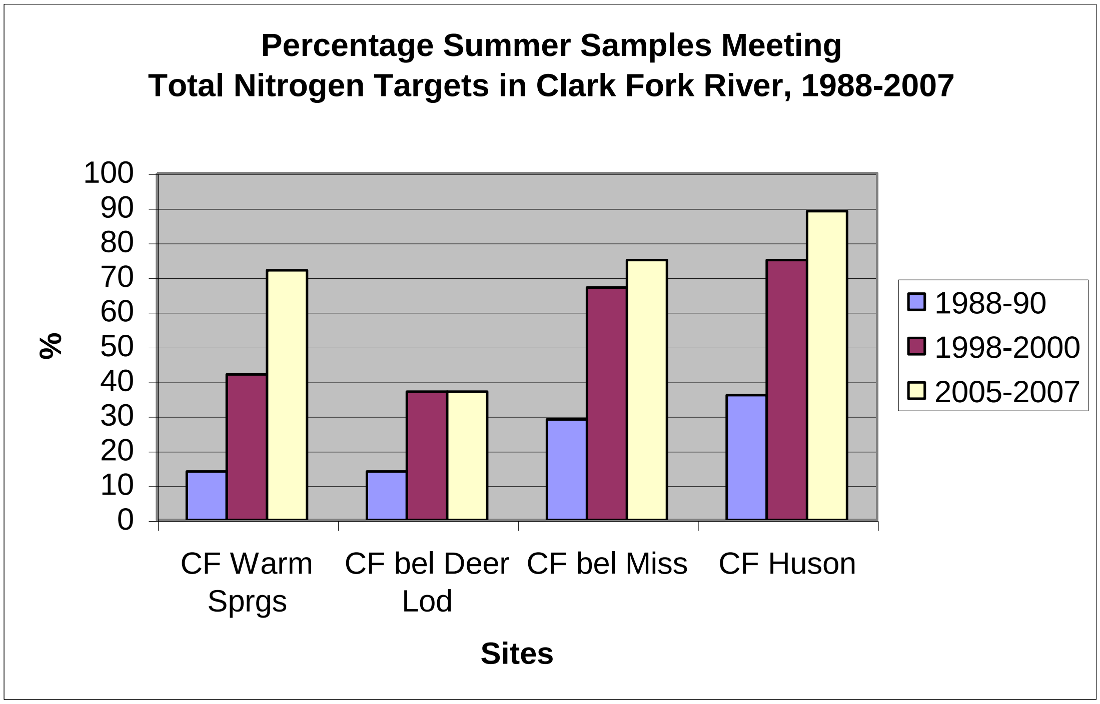
Figure 9:



Clearly, the last three years (2005-2007) have seen an improvement in the percentage of samples which meet the total phosphorus targets in the upper river stations (CF Warm Springs and CF below Deer Lodge). This is another indicator of the progress being made to reduce total P concentrations in the upper river. In the lower river the percentage of samples meeting targets appears to have increased markedly after Missoula WWTP installed its biological nutrient removal system in late 2004. Improvements continue downstream in Huson, where in 2005-2007 all samples met the phosphorus target.

The frequency of meeting total nitrogen targets at different periods since the late 1980s is expressed in the following graph:

Figure 10:

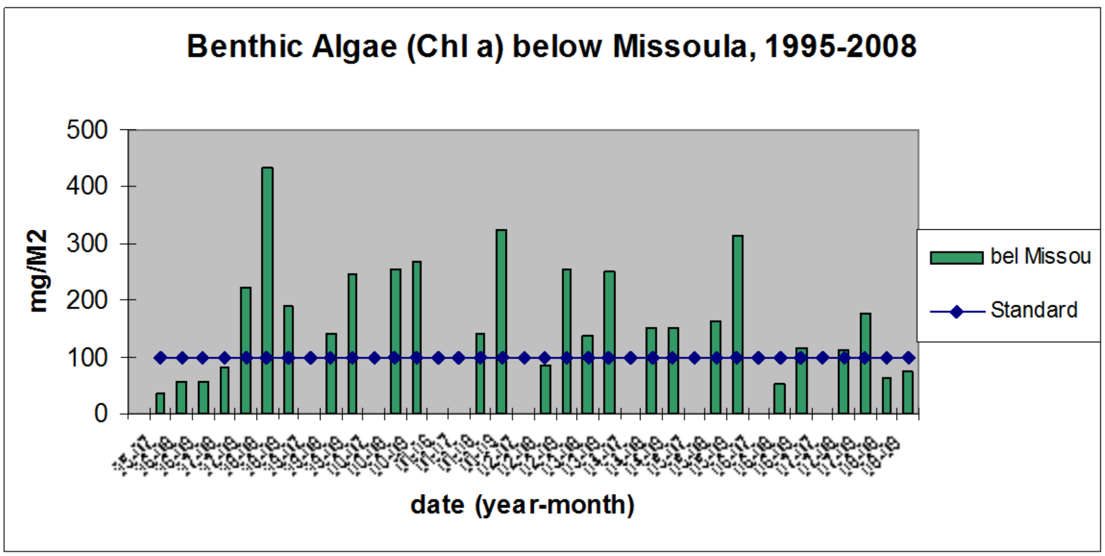


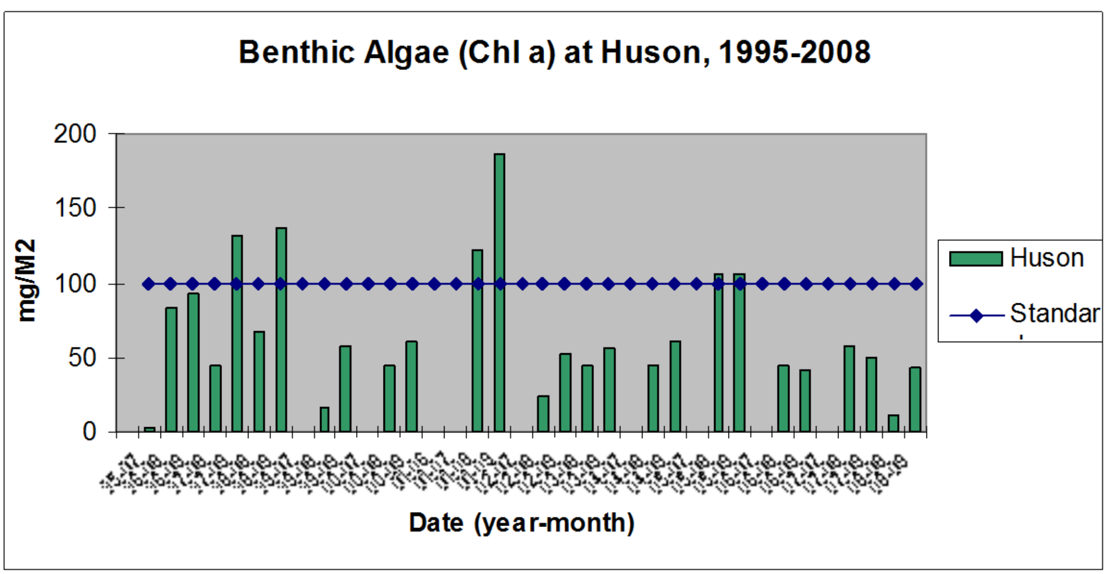
The improvements in meeting total nitrogen targets are quite marked in the upper river, especially at Warm Springs, where compliance increased to over 70% in 2005-2007. The relatively modest improvement since 2000 in meeting total nitrogen targets in the Clark Fork below Missoula comes as no real surprise. This is because data from the Missoula Wastewater Treatment Plant show that total nitrogen load discharge from the plant peaked in 2003. Although nitrogen load from the Missoula WWTP is lower than the 2001-2004 time period, the total N load now is somewhat comparable to the N load in the 1990s, due to increase in volume as new areas are hooked up to sewer, and population grows.

E. Benthic Algae Density in the Clark Fork:

There was relatively little benthic algae data available prior to the initiation of the VNRP monitoring program in 1998. The sporadic data from the 1980s indicates that benthic algae was more abundant at that time, but effective annual monitoring of algae levels has only been done consistently from 1998 to 2008. This algae data is displayed, as "chlorophyll a density" vs. the VNRP algae target, for three key stations in the following graphs (**Figure 11**):


Benthic Algae (Chl a) above Little Blackfoot, 1995-2008
mg/M2
Date (Year-month)
Ab L Blkft
Standard


Benthic Algae (Chl a) below Missoula, 1995-2008
mg/M2
0
100
200
300
400
500
date (year-month)
bel Missou
Standard


Benthic Algae (Chl a) at Huson, 1995-2008
mg/M2
0
50
100
150
200
Date (year-month)
Huson
Standar

The benthic algae data show considerable annual variation, and the trend analyses show variable trends for algae density depending on each site (PBSJ, 2008). It is clear that the monitoring sites below Deer Lodge (above Little Blackfoot) and below Missoula, show algae densities in excess of the targets most years (25/35 and 19/27 sampling events, respectively). Prior to 2005, below Missoula, the algae density was more than double the target in at least half the sampling events. In 2006-2008, the algae densities downstream of Missoula have been lower, and a decreasing algae density trend was noted in the trend analysis (PBSJ, 2008). This may indicate that the algae density below the City of Missoula will eventually respond to lower nutrient concentrations and consistently re-establish densities below the target.

Meanwhile, in the monitoring site immediately above Missoula (located near East Missoula), where nutrient concentrations are consistently lower, the algae density only exceeded targets in four events out of 14 (29%) from 1998-2004, and the trend remains static (PBSJ, 2008). This indicates that there are major changes in benthic algae flora above and below Missoula, and that the target of < 100 mg/M2 chlorophyll a for benthic algae is a feasible and realistic goal.

Table 7: Frequency of Exceedance of Mean Algae Density Target, 1998-2008:

Site:	**Samples in compliance with the VNRP mean target (100 mg/M2):**	**Percent samples in compliance with the target (100 mg/M2) :**	**Percent samples exceeding the algae target:**	**Algae density trend (PBSJ, 2007):**
Clark Fork above Little Blackfoot	10/35	29%	71%	Increasing
Clark Fork below Missoula	8/27	30%	70%	Decreasing
Clark Fork at Huson	20/27	74%	26%	Static

Why trends from the upper river (above Little Blackfoot and Bonita) showed increases in algae density, despite declines in upper river nutrient concentrations, is not clear. A further analysis of algae limiting factors is warranted, especially given that the algacide copper sulfate is a relatively common chemical contaminant in waters of the upper Clark Fork (the river is a SuperFund site for metals contamination). The variable presence of this algacide, among other factors mentioned below, could complicate analysis of algal density in this setting, especially during SuperFund cleanups.

A trend analysis for attached algae was also conducted with data from 1987 to 2002 (Land and Water, 2004). The results showed no significant trends in chlorophyll “a” when each year’s replicates are averaged, but small sample size (only 6 or 7 years of data) limits the power of this analysis. Using raw data (over 150 data points per station) shows statistically significant decreasing trends for algae density at Clark Fork at Deer Lodge, Clark Fork above Little Blackfoot, Clark Fork at Bonita, and Clark Fork above the Flathead. However, all these analyses must be viewed with caution due to lack of independence of the data (i.e., algae growth one year affects the algae the next year) and other statistical limitations (Land and Water Consulting, 2004, p. 27-29).

Several problems limit our ability to link nutrient reductions with declines in algae. First, our algae data is much more limited than our nutrient data. Second, annual algae density is only loosely correlated to annual nutrient concentrations in river systems. Many other factors including timing and duration of streamflows, scouring flood flows, abundance of grazers, toxic metals (e.g. copper) concentrations, temperatures, etc. are involved in determining attached algae density in any given year. Among these factors, only nutrient concentrations can be controlled by society's decisions. It is expected that the major decreases in nutrient concentrations will have an impact on algae density in the medium-term. Further algae monitoring will be done by the Council in the coming years.

F. Achievement of Targets: Summary

The VNRP set very concrete targets for nutrient concentration and algae density in the upper and middle Clark Fork. Major investments were made in many urban and rural communities, including wastewater treatment plant upgrades, sewer connection extensions, and non-point best management practices. Total investments in water quality improvements by VNRP signatories in the Clark Fork basin total well over $50 million. These investments have proved effective in reducing phosphorus and nitrogen concentrations in the Clark Fork river in summertime in both the upper and middle river.

Achievement of nutrient targets in the last three full years of the program reached over 90% for total nitrogen targets in the middle river (Missoula and Huson), and over 70% of phosphorus targets in the middle river. Compliance with targets in the upper river was lower, partly because total phosphorus targets were set much stricter there. But major progress was made in lowering nutrient concentrations, and improving target compliance in the upper river.

Algae targets were met infrequently in the upper and lower river. Trend analysis showed improving or static conditions in the middle river, while the algae problem is more intractable in the upper river, partly because the species of algae involved there, *Cladophora glomerata*, is notoriously difficult to control (Dodds, 1991).

V. Challenges for Future Water Quality Improvements in the Clark Fork

Based on the trend analysis and recent data, it is clear that the VNRP set the basin on the right track to meet the current nutrient and algae standards in the Clark Fork, which are equivalent to the targets set by the VNRP. To make further improvements, it will be necessary for signatory agencies to put in place the remaining alternative effluent disposal systems now being planned. And it will require continuing dedicated efforts by DEQ in revising the Clark Fork nutrient TMDLs and the existing MPDES permits in the Clark Fork. Reaching the algae targets in the short term will be more challenging still, because algae respond to many different ecological cues besides nutrients.

The Montana DEQ has made substantial recent progress in establishing the scientific basis for new nutrient and algae standards in "wadeable" (i.e., shallow) rivers and streams in distinct ecoregions throughout the state (DEQ, 2008). These new standards are based on a variety of in-depth analyses which are now being published in peer-reviewed journals. These analyses suggest several changes to the approach currently being used:

First, the new DEQ work suggests a benthic algae standard of 150 mg/M2 chlorophyll "a" instead of the VNRP's target, and current state standard for the Clark Fork of 100 mg/M2. This new standard is based on a survey of river recreationists, and their perceived "aesthetic" concerns—people shown photos corresponding to algal levels above 150 mg/M2 objected to the condition of the river represented in the photos.

Second, the new DEQ work suggests nutrient standards which vary quite strongly by ecoregion, especially in the acceptable levels of total phosphorus. These standards are derived partly from statistical analysis of nutrient levels in "reference streams" in various ecoregions. The recommended new standards are shown below:

Table 8: New Recommended Nutrient Standards for Wadeable Streams in Montana (Suplee et.al., 2008)

Ecoregion:	Approx. Geographic area:	Total P standard (mg/L)	Total N standard mg/L)
Northern Rockies	Flathead, Kootenai, Lower Clark Fork	0.012	0.233
Canadian Rockies	Glacier, Bob Marshall, Missions	0.006	0.209
Middle Rockies	**Middle and upper Clark Fork, upper Missouri & upper Yellowstone**	**0.048**	**0.320**
Idaho Batholith	West and south Bitterroot only	0.011	0.130
NW Glaciated Plains	Highline-north of Missouri river	0.123	1.311
NW Great Plains	SE Montana-Yellowstone, Tongue, Powder, etc.	0.124	1.358

It is unclear if these recommended standards will actually be adopted by Montana. If they are adopted, the following may occur on the Clark Fork:

*Nitrogen management will vary little, as the proposed standards are very similar to the existing standards on the Clark Fork.

*Phosphorus standards would be substantially relaxed, especially on the upper river. In fact, these total P standards would result in the upper river actually meeting nutrient standards under current conditions. Given the fact that the algae density problem is still present in the upper Clark Fork, and shows no signs of abating, a relaxation of standards may imply simply accepting the status quo of noxious algae in that section of the river.

*Nitrogen and phosphorus standards on the middle Clark Fork (below Drummond) might remain as they are today (TP=0.039 mg/L and TN=0.3 mg/L below the Blackfoot confluence), because this section of the river is not "wadeable" by DEQ definitions.

A. General Challenges for Water Quality Improvement in the Clark Fork:

Many challenges still exist in the effort to control nutrient pollution and noxious algae in the Clark Fork. Some of the general basin-wide challenges are listed below:

1) Population growth continues to be strong in Ravalli, Missoula, and Mineral counties. Thousands of new septic permits have been granted in recent years in Ravalli county, and development there also may affect the integrity of some riparian areas and watersheds, both of which could affect nutrient levels in the Bitterroot River, a key tributary.

2) The increasing trend in soluble nitrogen concentrations in the basin, especially in the lower river, is of concern, especially if it reflects an actual nutrient load increase, rather than a shift towards proportionally more groundwater nitrates introduced to the river due to drought. It is still unclear if increased soluble nitrogen may be related to septic systems or other human-related sources in the basin at large. This problem requires more study and perhaps, a much greater effort on non-point soluble nitrogen sources. Policy-makers may have to consider more stringent methods to control nutrients from growth and urbanization.

3) New industries are locating in the upper basin, often in Clark Fork tributaries, and some of these industries can have have significant phosphorus discharges. For example, the Tax Increment Financing Industrial District (TIFID) near Butte is attracting new industries, and is considering various wastewater treatment options. It is unclear if TMDLs and MPDES permits on tributaries to an impaired water body like the Clark Fork will be sufficient to avoid increases in nutrient loads to the river. This is a challenge for the MDEQ permits division and the municipalities where these new industries locate.

4) Non-point pollution in general continues to contribute a large proportion of the total nutrient load to the Clark Fork. Important sources for these non-point loads are difficult to locate, and therefore to manage. Outreach to landowners in the vast rural areas of the basin is always challenging. Watershed groups in the Blackfoot, Upper Clark Fork, and Bitterroot are key partners for the Council in any non-point efforts. These groups sometimes struggle to find funding, and the funding environment for conservation and restoration is extremely competitive. Comprehensive planning for tributary watershed conservation is complex, and not usually attempted by smaller watershed groups. It may

be worthwhile for groups partnering with the Council to attempt a coordinated prioritization exercise for tributaries with different restoration goals.

5) Meeting the goals for expansion of sewer systems into the neighborhoods around Missoula continues to be a major political challenge for local government. Stronger efforts to assist these neighborhoods to do planning/zoning are required, because their concerns are usually not focused on water quality issues at all.
6) Finally, the municipal signatories have more large capital investments still ahead of them, and political issues about costs and revenue are a challenge for local government.

B. Clark Fork Tributaries: Non-point and Policy Issues

Upper Clark Fork:
The nutrient issues in the upper Clark Fork are imbedded in a complex array of other water quality issues related to SuperFund cleanups and sediment and metals impairments in the same area. Some particular concerns for nutrient management in the upper Clark Fork are:

- Solutions for metals contamination problems developed through the SuperFund (CERCLA) process should consider the impact of their activities on nutrient issues. Many times the solutions will be very compatible, such as any measures to minimize the sediment input to the system, and measures to increase flows to dilute contaminants.
- Silver Bow Creek's nutrient concentration is still extremely high, and includes many non-point source nutrients (N and P) from the urban area of Butte, even above the wastewater treatment plant. All efforts to improve Silver Bow creek biologically and aesthetically must consider the creek's potential to grow noxious algae. Continuing efforts to reduce non-point nutrient inputs are required.
- Mill-Willow Creek has had high nutrient concentrations in the past, and may still have these problems. The relationship of the creek to the diffuse septic system discharge from the town of Opportunity needs to be better understood.
- The impact of the Anaconda wastewater treatment system ponds on nitrate levels in Dutchman and Lost Creek is still unclear. A Council project to investigate the groundwater-surface water nutrient dynamics in this system was postponed because Anaconda did not give approval.
- In the Little Blackfoot, Warm Springs-Garrison, Brock and Gold Creek drainages, the potential for non-point source sediment/erosion control and fisheries habitat improvement projects could have major positive impacts on long-term nutrient loads.
- The Flint Creek drainage has potential nutrient issues related to development pressures in Georgetown Lake and Philipsburg areas, as well as historical land use.

Bitterroot River and Other Middle Clark Fork Tributary Drainages:
The nutrient issues in the Bitterroot river basin and adjacent areas of developed Missoula County are related to both historical land use and to current development pressures. Some of the most important problems and opportunities are:

- Land use planning decisions in the urbanizing areas of Ravalli County, and many parts of Missoula County, are very controversial. Sanitary sewer and stormwater issues need to be carefully planned to protect water quality in the areas around Missoula, Stevensville and Hamilton and the highway 93 /Bitterroot river corridor. But stakeholders in conflicts over growth tend to use water quality issues as a "weapon" to fight growth, rather than to face the need for land use planning.
- Rural land development continues to add septic system nutrient loads to the shallow groundwater throughout the Bitterroot Valley. Planning must take into account the capacity of the river to absorb the increased wasteloads. New septic systems with greater nutrient removal capacity may be needed in the future, especially in vulnerable groundwater areas where discharge to the river is rapid and unmitigated by nutrient uptake processes in healthy riparian areas.
- Tributary watersheds with nutrient issues—Threemile, Burnt Fork, Rye, Sweathouse, Bass, etc.-- need help developing watershed management and stream restoration plans to reduce their substantial sediment and nutrient loads, and obtaining funding to put these projects on the ground.
- Small-scale farms and ranches need to be educated about the water quality issues related to livestock and agriculture, and given incentives to adopt best management practices.
- Policies to support setbacks from streams in Missoula and Ravalli counties are needed to protect healthy riparian vegetation which can, in turn, protect water quality from contaminants in both surface runoff and groundwater.

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APPENDICES:

APPENDIX 1: Maps

Map 1: **Mean Long-term (1984-2002) Total Phosphorus Concentrations in the Clark Fork**

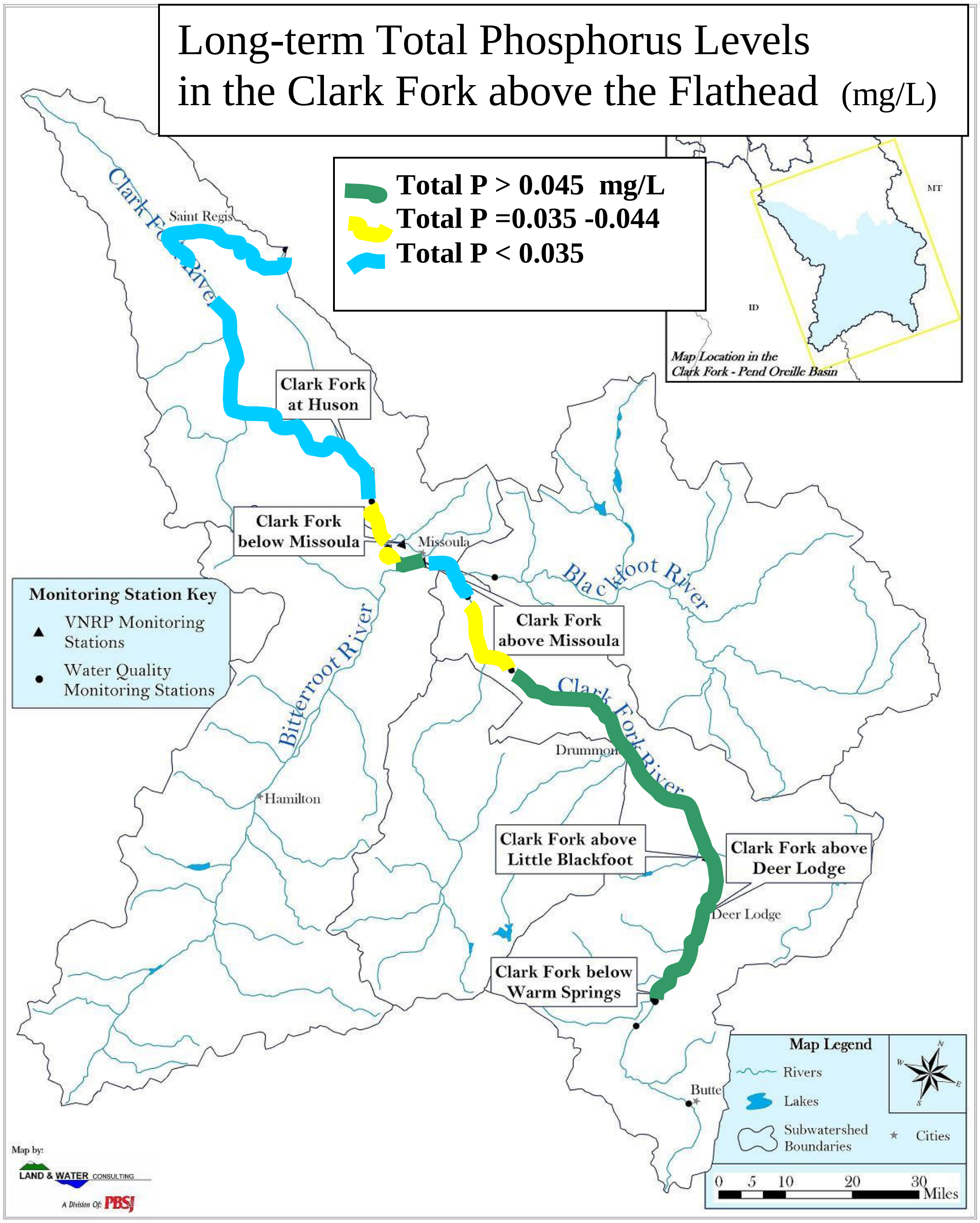
Map 2: **Mean Long-term (1984-2002) Total Nitrogen Concentrations in the Clark Fork**

APPENDIX 2: Tables: Mean Annual and Mean Summer Nutrient Discharge to the Clark Fork from Butte WWTP, Deer Lodge WWTP, Missoula WWTP, and Smurfit-Stone

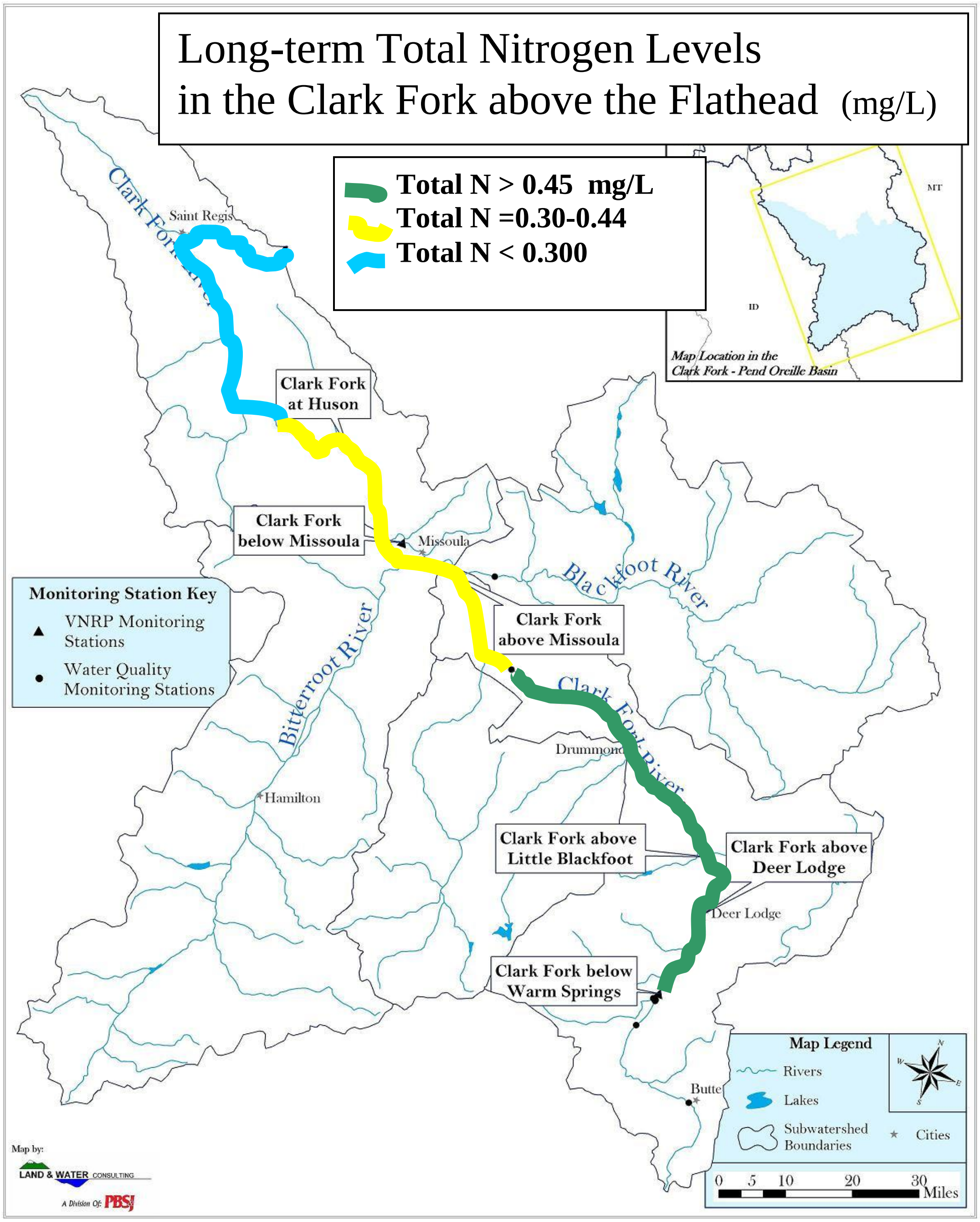
APPENDIX 3: Statistics and Boxplots for Total Phosphorus and Total Nitrogen Concentrations in the Summer Season at Four Sites on the Clark Fork River, Montana

APPENDIX 4: Non-point Source Projects funded by Montana's 319 Program from 1998 to 2008 in the upper and middle Clark Fork

MAP 1: Mean Long-term (1984-2002) Total Phosphorus Concentrations in the Clark Fork:



MAP 2: Mean Long-term (1984-2002) Total Nitrogen Concentrations in the Clark Fork:



Appendix 2: NUTRIENT DISCHARGE DATA FROM VNRP SIGNATORIES:

BUTTE SUMMER NUTRIENT LOADS DISCHARGED TO SILVER BOW CREEK (June-Sept, 1997-2008)

YEAR:	Total N lb/day	Total P lb/day	Flows mgd
1997	550	32	6.17
1998	525	40	6.12
1999	460	56	4.84
2000	442	51	4.05
2001	496	63	4.08
2002	395	42	3.54
2003	530	71	3.4
2004	479	43	3.11
2005	476	44	3.14
2006	447	42	3.43
2007	532	55	3.64
2008	441	47	3.3

DEER LODGE SUMMER NUTRIENT LOADS, FLOWS AND DISCHARGE TO CLARK FORK

	June- Sept	June-Sept		
	Discharge	Discharge	mgd	mgd*
	Total N lb/day	Total P lb/day	Flow total	Discharge to river
1989	126	21	2.18	2.18
1990	117	19	2.03	2.03
1991	120	21	2.09	2.09
1992	105	18	1.83	1.83
1993	155	27	2.71	2.71
1994	109	18	1.89	1.89
1995	103	17	1.78	1.78
1996	85	14	1.47	1.47
1997	95	16	1.64	1.64
1998	83	14	1.44	1.44
1999	67	11	1.16	1.16
2000	43	5	1.05	0.52
2001	101	13	1.79	1.21
2002	39	5	1.24	0.46
2003	81	10	1.65	0.97
2004	89	11	1.44	1.06
2005	73	9	1.55	0.88
2006	75	9	1.58	0.90
2007	63	8	1.43	0.76
2008	68	9	1.49	0.82

*Starting in 2000, a large part of the summer effluent was diverted to irrigation on Grant-Kohrs Ranch. The discharged N and P is calculated based on the proportion of total effluent flow which was discharged to river after irrigation.

**Deer Lodge nutrient load averages are estimates based on measured flows and extrapolated 1994-1995 and 2007 nutrient data.

MISSOULA WWTP NUTRIENT LOADING TO CLARK FORK RIVER, 1986-2008				
	Annual Average		Summer Average (June-September)	
YEAR:	Total N	Total P	Total N	Total P
	(lb/day)	(lb/day)	(lb/day)	(lb/day)
1986	NA	299	NA	279
1987	NA	297	NA	304*
1988	1121**	342**	961	425
1989	1386	228	1177	192
1990	1335	189	1164	180
1991	1200	183	1083	167
1992	1230	198	979	201
1993	1177	180	1176	159
1994	1283	186	1227	204
1995	1025	91	973	112
1996	1144	95	1095	73
1997	1207	119	1107	137
1998	1218	143	940	155
1999	1482	134	1471	164
2000	1679	144	1593	137
2001	1862	146	1549	119
2002	1860	165	1491	144
2003	1745	214	1678	243
2004	799	163	644	148
2005	668	59	562	29
2006			606	60
2007			559	28
2008			790	37

*1987-Summer average total phosphorus for does not include June.

**1988- Annual and summer average total nitrogen includes only July-Dec.

SMURFIT-STONE NUTRIENT LOADING TO CLARK FORK, 1986-2008

	Annual Average		Summer Average (July-September)	
YEAR:	Total N	Total P	Total N	Total P
	(lb/day)	(lb/day)	(lb/day)	(lb/day)
1986	702	195	nd	nd
1987	646	217	nd	nd
1988	562	136	nd	nd
1989	552	125	nd	nd
1990	553	142	nd	nd
1991	487	107	nd	nd
1992	378	129	414	136
1993	387	102	300	100
1994	416	109	214	113
1995	405	98	395	69
1996	314	78	249	84
1997	272	113	163	66
1998	291	96	176	101
1999	232	58	278	76
2000	232	58	75	37
2001	131	57	65	35
2002	157	44	54	25
2003	259	53	151	42
2004	184	55	82	33
2005	158	42	74	30
2006	188	49	126	46
2007	201	45	81	31
2008	nd	nd	113	51

APPENDIX 4:

Statistics and Boxplots for Total Phosphorus and Total Nitrogen Concentrations in the Summer Season at Four Sites on the Clark Fork River, Montana

In this report, nutrient data from the Clark Fork sampling program was grouped into three data sets representing time periods important in the history of the Voluntary Nutrient Reduction Program. The data of interest were those collected in the VNRP "summer" time period, or between 21 June and 21 September each year. The three summer time periods analyzed in this report are:

*1988-1990: Time period of original DEQ studies, representing the first consistent long-term records of nutrient concentrations at various points in the Clark Fork.

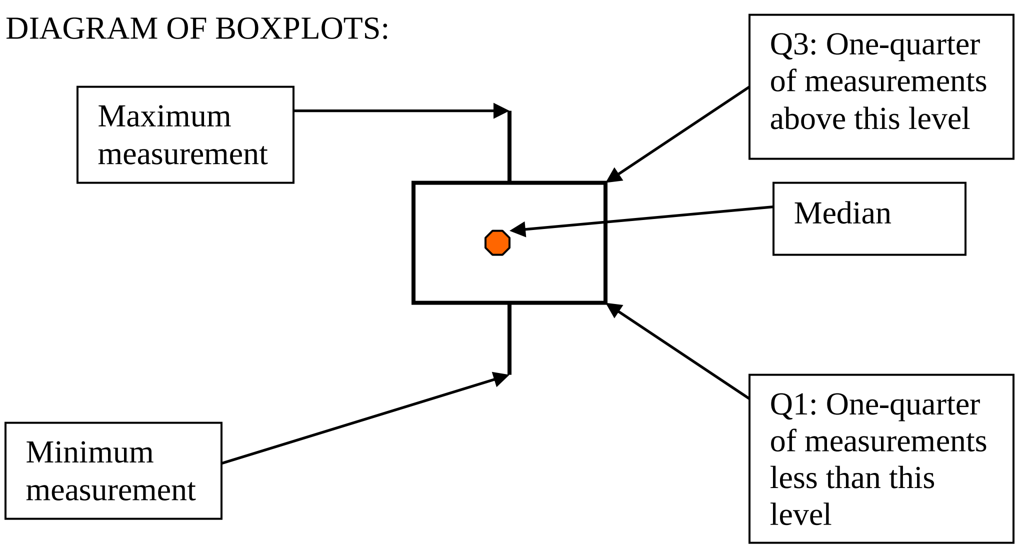
*1998-2000: The first three years of the official Clark Fork VNRP. Some nutrient reduction activities had already begun.

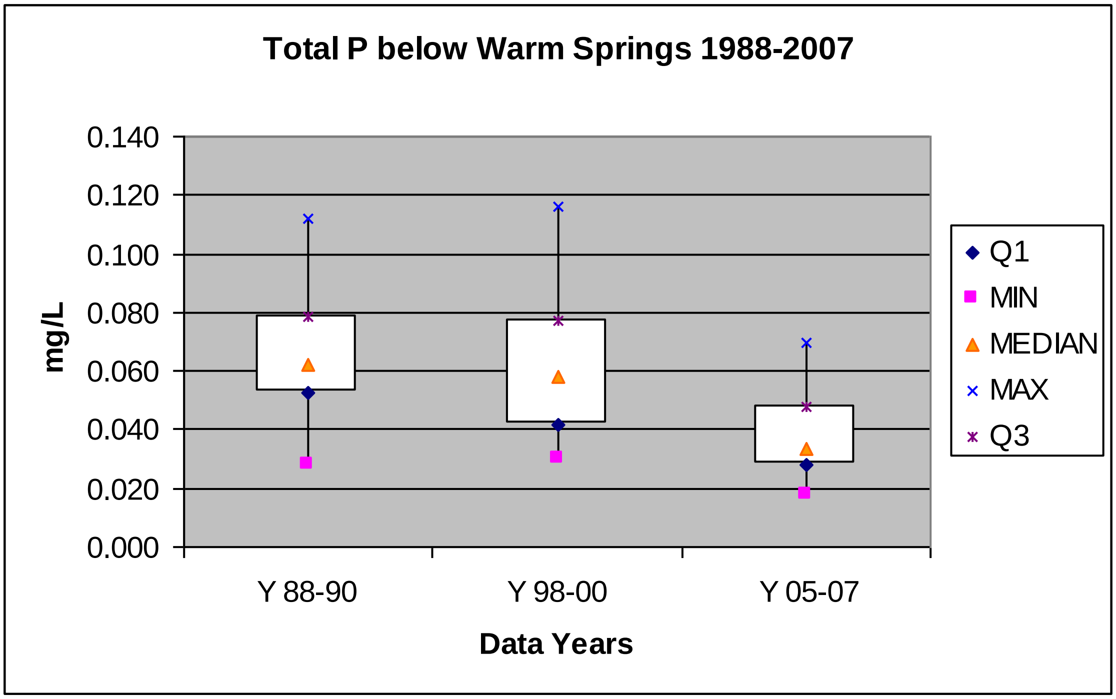
*2005-2007: The last three full years of the VNRP, representing the end-point conditions of the program.

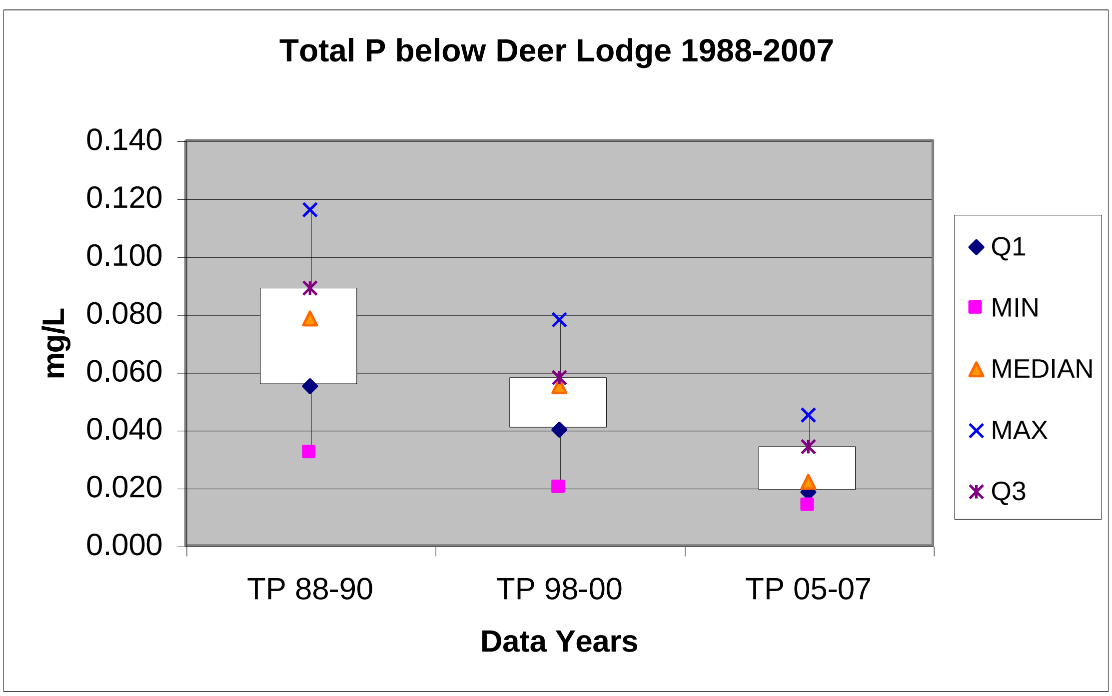
Each three-year time period has a sample size of approximately 10-25 data points for each parameter at each site. The graphs and data tables in the following pages provide the reader more detail on the statistics supporting the general conclusions of the report regarding changes in nutrient concentrations over time in-stream.

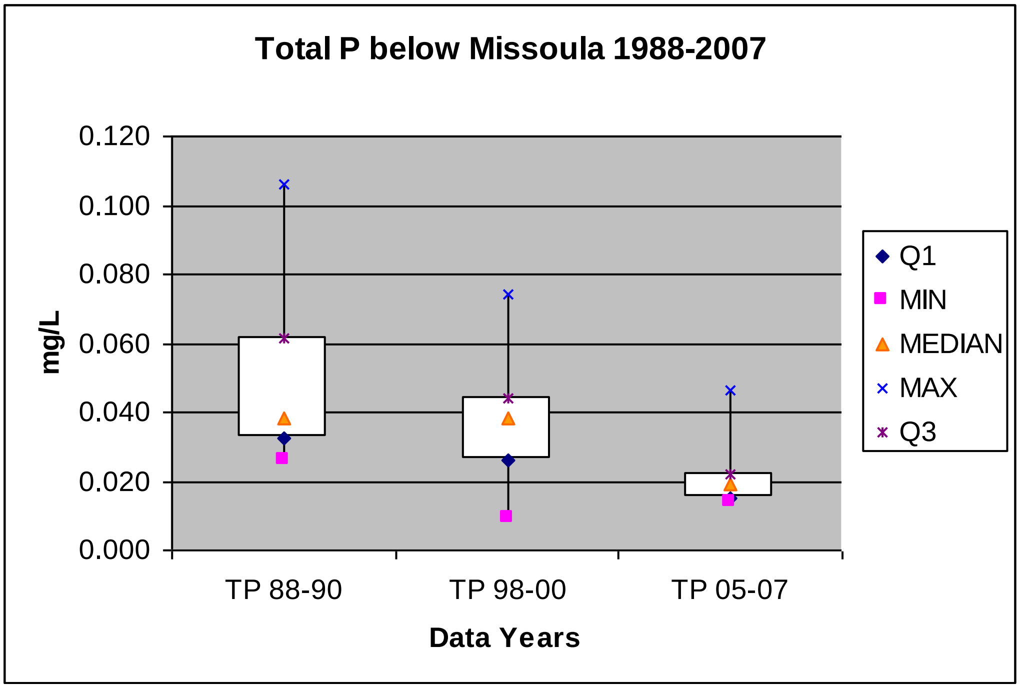
These statistics include first and third quartiles (representing the middle 50% of the samples), the median (50% of total samples less than this value), the minimum and maximum values measured during that three-year summer data set, and the arithmetic mean.

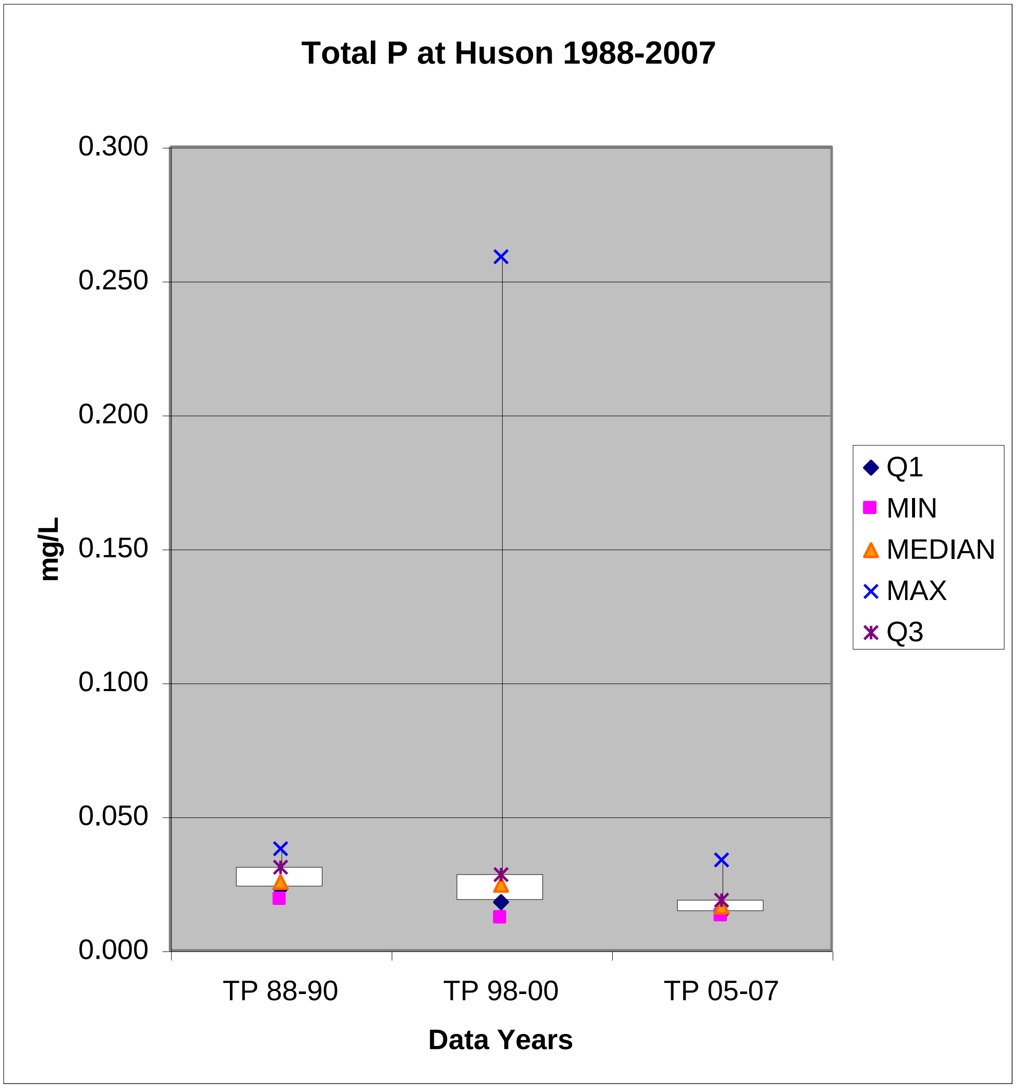
DIAGRAM OF BOXPLOTS:



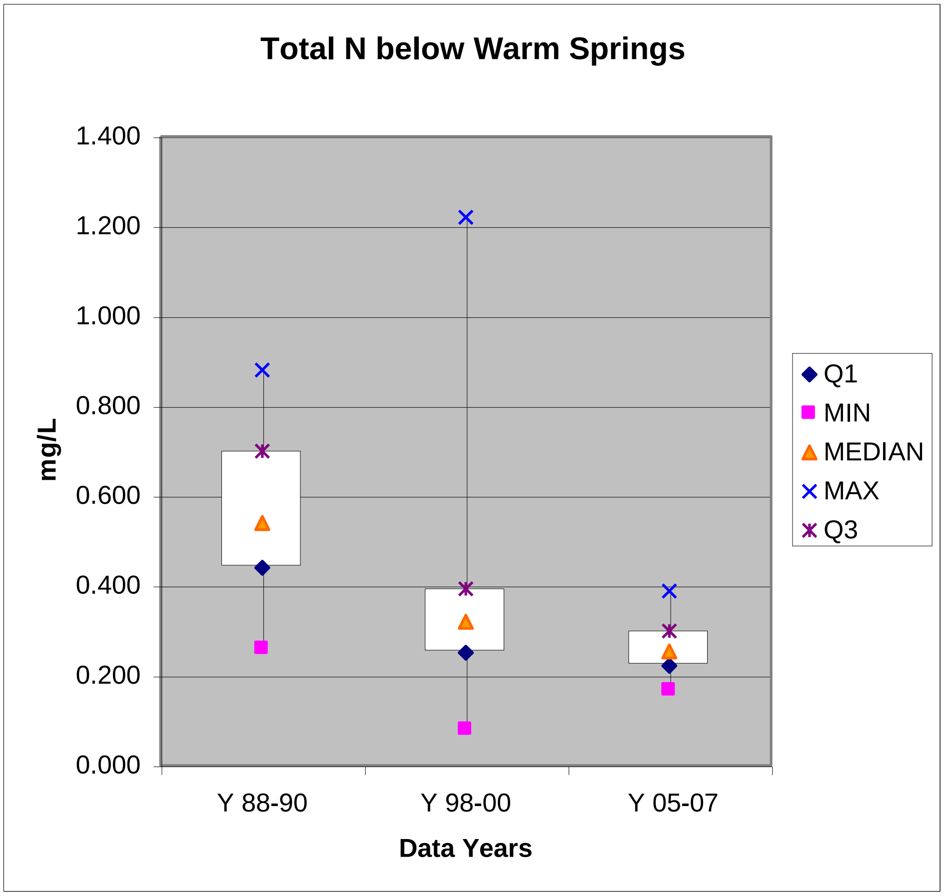

Total P below Warm Springs 1988-2007
mg/L
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Y 88-90
Y 98-00
Y 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3

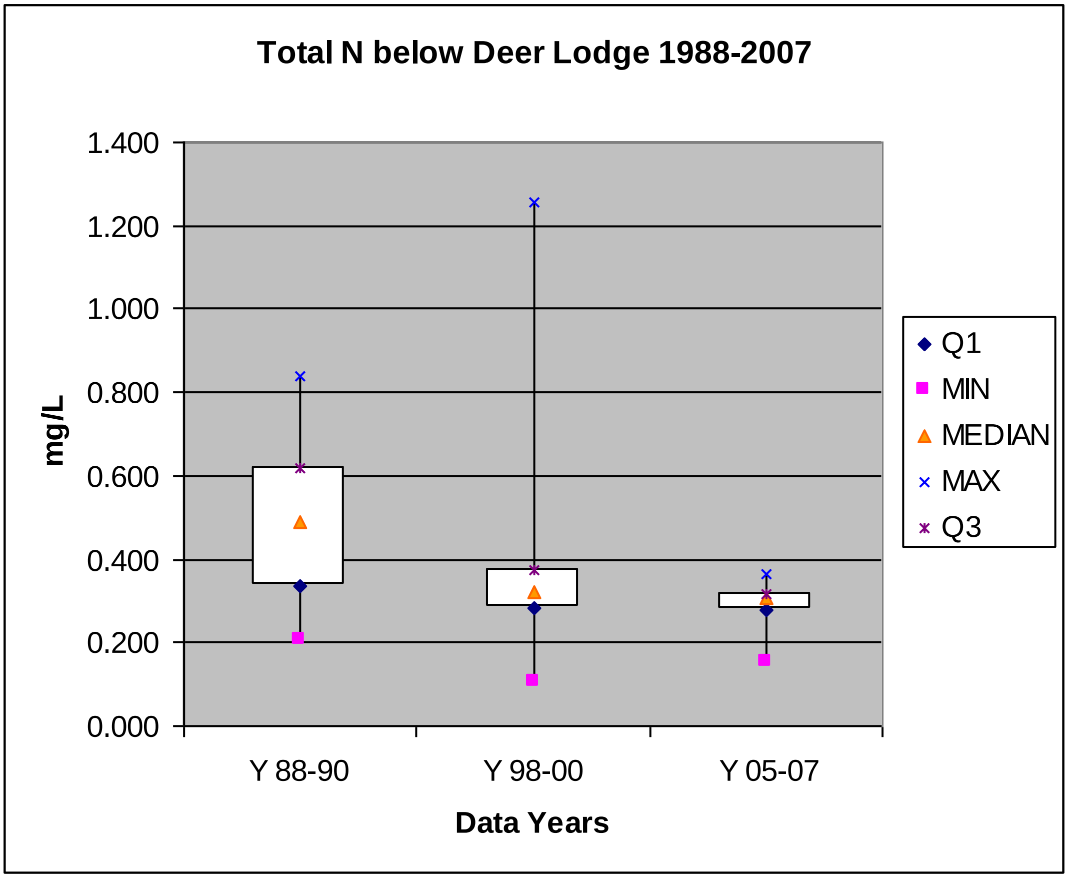

Total P below Deer Lodge 1988-2007
mg/L
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
TP 88-90
TP 98-00
TP 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3


Total P below Missoula 1988-2007
0.120
0.100
0.080
0.060
0.040
0.020
0.000
mg/L
TP 88-90
TP 98-00
TP 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3

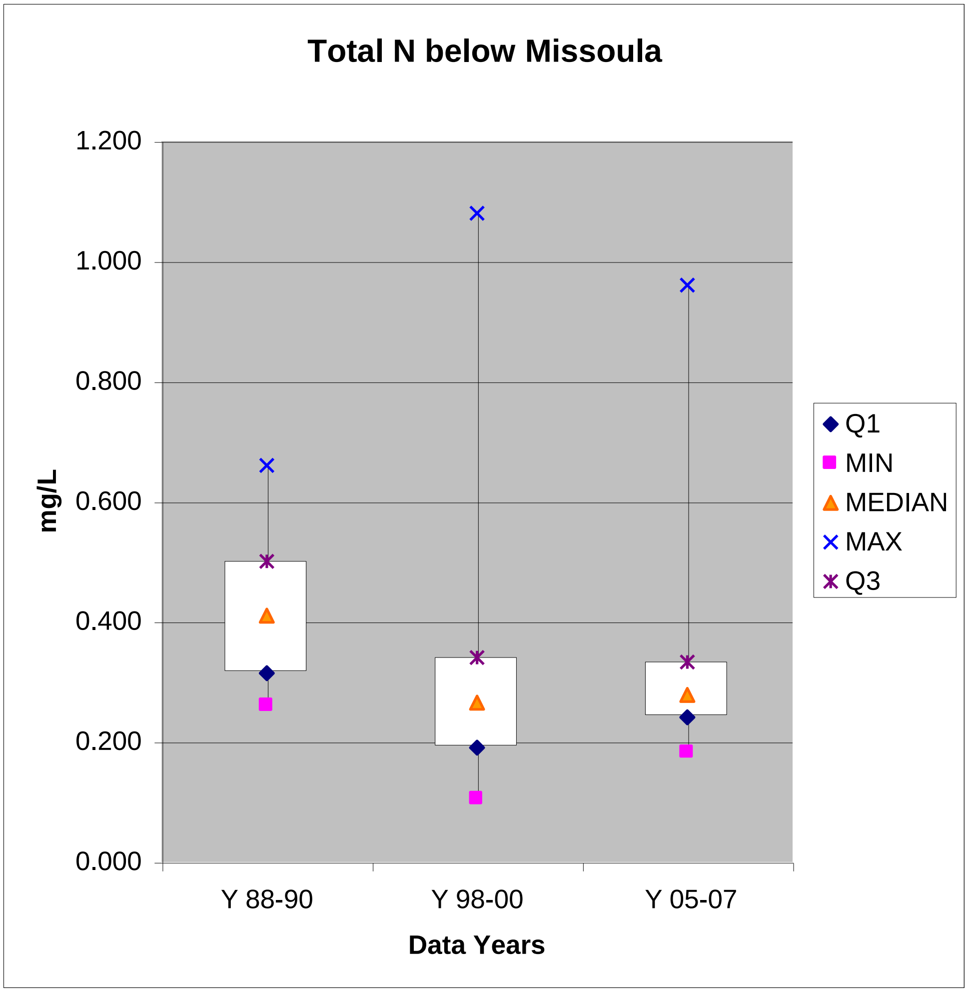


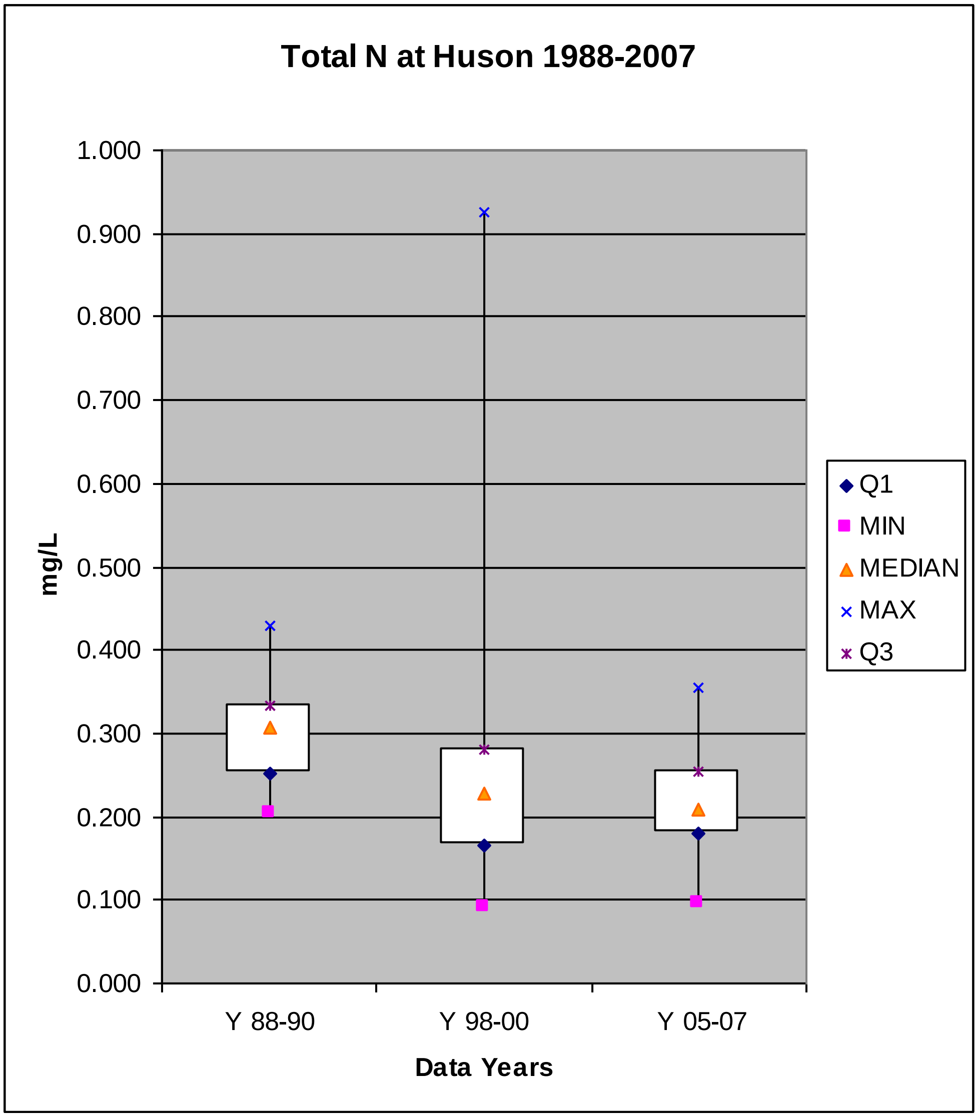
Total P at Huson 1988-2007
0.300
0.250
0.200
0.150
0.100
0.050
0.000
mg/L
TP 88-90
TP 98-00
TP 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3


Total N below Warm Springs
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
mg/L
Y 88-90
Y 98-00
Y 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3



Total N below Deer Lodge 1988-2007
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
mg/L
Y 88-90
Y 98-00
Y 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3


Total N below Missoula
1.200
1.000
0.800
0.600
0.400
0.200
0.000
mg/L
Y 88-90
Y 98-00
Y 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3



Total N at Huson 1988-2007
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
mg/L
Y 88-90
Y 98-00
Y 05-07
Data Years
Q1
MIN
MEDIAN
MAX
Q3

Statistics for Total P and Total N Data for Four Sites on the Clark Fork:

Based on Three-year Summer data sets 1988-1990, 1998-2000, 2005-2007

Summer: June 21 to September 21

Stat. 7 = Below Warm Springs Stat. 10= below Deer Lodge
Stat. 18= Below Missoula Stat. 22= Huson

n= 10 for 1988-1990, n=18-21 for 1998-2000, n=15-17 for 2005-2007

Total Phosphorus **Total Nitrogen**

Stat. 7	**TP 88-90**	**TP 98-00**	**TP 05-07**	**Stat. 7**	**TN 88-90**	**TN 98-00**	**TN 05-07**
Q1	0.022	0.020	0.014	Q1	0.440	0.251	0.222
MIN	0.028	0.030	0.018	MIN	0.260	0.080	0.168
MEDIAN	0.024	0.033	0.017	MEDIAN	0.540	0.320	0.254
MAX	0.112	0.116	0.070	MAX	0.880	1.220	0.388
Q3	0.026	0.040	0.018	Q3	0.700	0.393	0.300
MEAN	0.065	0.063	0.038	MEAN	0.544	0.408	0.262
Stat. 10	**TP 88-90**	**TP 98-00**	**TP 05-07**	**Stat. 10**	**TN 88-90**	**TN 98-00**	**TN 05-07**
Q1	0.026	0.029	0.017	Q1	0.336	0.285	0.276
MIN	0.026	0.020	0.014	MIN	0.205	0.105	0.153
MEDIAN	0.028	0.035	0.018	MEDIAN	0.488	0.320	0.307
MAX	0.038	0.259	0.070	MAX	0.840	1.255	0.366
Q3	0.035	0.063	0.026	Q3	0.620	0.372	0.316
Mean	0.072	0.052	0.026	MEAN	0.488	0.396	0.290
Stat. 18	**TP 88-90**	**TP 98-00**	**TP 05-07**	**Stat. 18**	**TN 88-90**	**TN 98-00**	**TN 05-07**
Q1	0.023	0.030	0.017	Q1	0.314	0.190	0.240
MIN	0.022	0.020	0.014	MIN	0.260	0.105	0.182
MEDIAN	0.024	0.037	0.018	MEDIAN	0.410	0.265	0.278
MAX	0.028	0.259	0.070	MAX	0.660	1.080	0.960
Q3	0.026	0.063	0.018	Q3	0.500	0.340	0.333
Mean	0.0502	0.036952	0.021345	MEAN	0.410	0.330	0.321
Stat. 22	**TP 88-90**	**TP 98-00**	**TP 05-07**	**Stat. 22**	**TN 88-90**	**TN 98-00**	**TN 05-07**
Q1	0.025	0.029	0.017	Q1	0.253	0.165	0.179
MIN	0.022	0.020	0.014	MIN	0.205	0.090	0.097
MEDIAN	0.026	0.036	0.018	MEDIAN	0.308	0.229	0.209
MAX	0.112	0.259	0.070	MAX	0.430	0.925	0.354
Q3	0.037	0.063	0.026	Q3	0.333	0.280	0.253
Mean	0.026	0.037	0.018	MEAN	0.306	0.282	0.220

APPENDIX 4:

Non-point Source Projects funded by Montana DEQ 319 Program From 1998-2008 in middle and upper Clark Fork and tributaries:

Year:	Title:	Recipient:	Amount:
1998	Little Blackfoot Streamflow and Thermal Assessment	Deer Lodge Valley Conservation District	$10,000.00
1999	Nevada Creek II	North Powell Conservation District	$206,600.00
1999	Denitrifying Septic Tank Demonstration Project	Missoula County Water Qaulity Protection District	$30,777.00
2000	Lost Creek Watershed Project	Montana Department of Fish, Wildlife & Parks	$277,330.00*
2000	Bitterroot Habitat TMDL Project	Ravalli County Land Services	$96,250.00
2000	Little Blackfoot TMDL	Deer Lodge Valley Conservation District	$37,250.00
2001	Bitterroot Headwaters TMDL Planning	Tri-State Water Quality Council	$23,500.00
2001	Ninemile TMDL	Missoula County Conservation District	$155,000.00
2002	Middle Blackfoot Watershed Habitat and Water Quality Restoration Plan	Blackfoot Challenge, Inc.	$274,280.00
2002	St Regis Wateshed TMDL	Mineral County Conservation District	$66,500.00
2002	Ambrose-Three Mile Project	Tri-State Water Quality Council	$38,500.00
2002	East Deer Lodge Valley Watershed Project	Deer Lodge Valley Conservation District	$87,000.00
2003	Upper Willow Creek Restoration Project	Montana Department of Fish, Wildlife & Parks	$84,000.00
2003	Blackfoot Combined TMDL	Blackfoot Challenge, Inc	$246,990.00
2003	Gold Creek Watershed Project	Deer Lodge Valley Conservation District	$15,115.00
2004	Nevada / Lower Blackfoot TMDL	Blackfoot Challenge, Inc	$115,500.00

2004	Bitterroot Mainstem TMDL Planning	Tri-State Water Quality Council	$39,878.00
2004	Lolo Watershed TMDL Phase I	Montana Trout	$30,001.00
2005	Upper, Middle Blackfoot / Nevada Creek TMDL Implementation Project	Blackfoot Challenge	$125,960.00
2005	Bitterroot Lolo	Montana Trout	$20,000.00
2005	Middle Blackfoot / Nevada Creek & Lower Blackfoot TMDL Planning	Blackfoot Challenge	$209,243.00
2006	Blackfoot Restoration Monitoring & Stewardship Support	Blackfoot Challenge, Inc.	$37,200.00
2006	Upper Lolo Creek TMDL - Granite Creek Culverts	Montana Trout	$25,000.00
2006	Lower Blackfoot TMDL	Blackfoot Challenge, Inc.	$100,000.00
2006	Upper Clark Fork (Tribs) TMDL Phase I	East Deer Lodge Valley Conservation District	$220,000.00
2006	Bitterroot (upper implement)	Bitterroot Water Forum	$60,000.00
2006	Bitterroot River monitoring	Tri-State Water Quality Council	$24,970.00
2007	Ninemile Watershed TMDL Implementation	Trout Unlimited (Missoula)	$35,000
2007	Blackfoot TMDL Implementation & Project Design	Blackfoot Challenge	$64,400
2007	Upper Lolo TMDL - Top Four Culverts Replacement	Montana Trout	$30,000
2007	Bitterroot TPA	Tri-State Water Quality Council	$75,754
2007	Upper Clark Fork TPA	Deer Lodge Valley Conservation District	$150,000
2008	Bitterroot Headwaters TMDL Implementation	Bitterroot Water Forum	$30,000
2008	Blackfoot Watershed Water Quality Restoration	Blackfoot Challenge	$50,000
2008	Ninemile Restoration Phase II	Trout Unlimited	$25,000
2008	Flint Creek TMDL	Granite Conservation District	$160,000
TOTAL:			**$3,276,998.00**

*Projects with highlighting were developed and/or executed with support of TSWQC's VNRP Committee (=$500,000).