# LOWER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

**Water Body**: **North Fork Ninnescah River Watershed**
**Water Quality Impairment: pH**

## 1. INTRODUCTION AND PROBLEM IDENTIFICATION

**Subbasin:** North Fork Ninnescah **Counties:** Reno, Stafford, Pratt, and Kingman

**HUC 8:** 11030014

**HUC 11s** (HUC 14s): **010** (030, 040, 050, 060, 070, 080, 090)
**020** (010, 020, 030, 040, 050)
**030** (010, 020, 030, 040)

**Drainage Area:** 819.0 square miles.

**Main Stem Segments:** WQLS: 5 and 6; starting above Cheney Reservoir and ending in Stafford County near Stafford. **(Figure 1)**

**Tributary Segments:** WQLS:
Goose Creek (10)
Red Rock Creek (12)
Silver Creek (7)

Non-WQLS:
Crow Creek (*11*)
Dooleyville Creek (*8*)
Unnamed Stream (*289*)
Unnamed Stream (*999*)
Wolf Creek (*9*)

**Designated Uses:** Special Aquatic Life Support; Secondary Contact Recreation; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Main Stem Segments

Expected Aquatic Life Support and Food Procurement for Goose Creek

Special Aquatic Life Support and Food Procurement for Red Rock Creek and Silver Creek

**1998 303d Listing:** Table 3 - Predominantly Natural Conditions Impact

**Impaired Use:** Aquatic Life Support

**Water Quality Standard:** Artificial sources of pollution shall not cause the pH of any surface water outside of a zone of initial dilution to be below 6.5 and above 8.5 (KAR 28-16-28e(c)(2)(C))

## North Fork Ninnescah River TMDL Reference Map

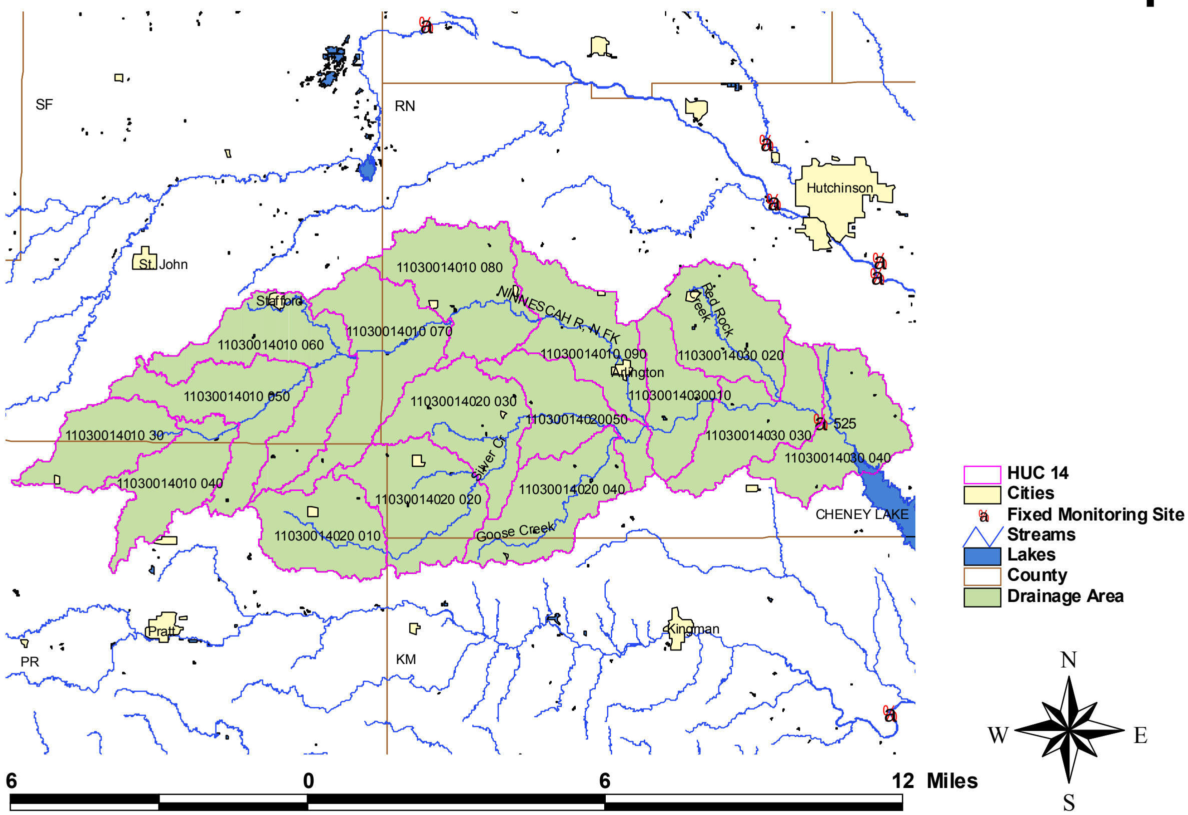



**Figure 1**

## 2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

**Level of Support for Designated Use under 1998 303(d):** Not Supporting Aquatic Life

**Monitoring Sites:** Station 525 near Castleton

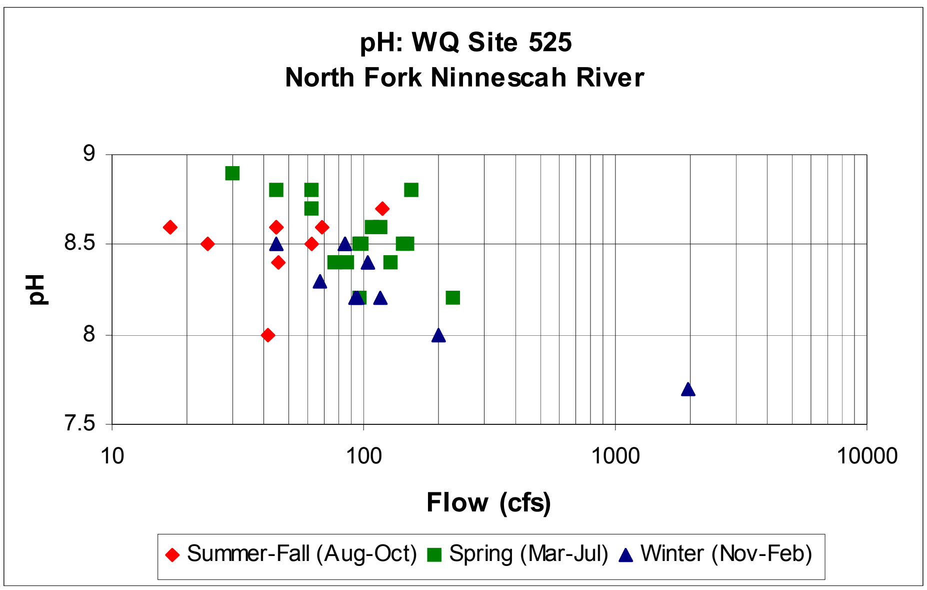
**Period of Record Used:** 1993 to 2000

**Flow Record:** North Fork Ninnescah River above Cheney Reservoir (USGS Station 07144780; 1993-2000).

**Long Term Flow Conditions:** Median Flow = 79 cfs; 7Q10 = 5.4 cfs

**Current Conditions:** Samples for each of the three defined seasons, Spring (Mar-Jul), Summer-Fall (Aug-Oct) and Winter (Nov-Feb), are plotted in **Figure 2** for the site 525. Excursions were seen in spring and summer-fall. Excursions occurred under flow conditions of less than 156 cfs at the North Fork Ninnescah River above Cheney Reservoir Gaging Station 07144780. Generally, trends for those samples exceeding 8.5 in pH show higher water temperatures, biochemical oxygen demand (BOD) and total suspended solids, yet lower nitrate concentrations. Of the thirteen excursions over pH of 8.5, 7 were in Spring and 6 were in Summer-Fall.

**Figure 2**



Overall 1993-2000 averages of BOD, TSS, nitrate and phosphorus were 3.6 mg/l, 45 mg/l, 1.08 mg/l and 0.16 mg/l, respectively.

**Figure 3** compares those pH samples equal to or less than 8.5 and those greater than 8.5 and the relationship between DO and BOD for each season. While average DO is not significantly different between these sample groups during spring and summer, as seen in **Table 1**, BOD is statistically almost double for samples with pH greater than 8.5 (average BOD = 5.2 mg/L) than those samples with pH less than or equal to 8.5 (average BOD = 3.2 mg/L)

**Figure 3**

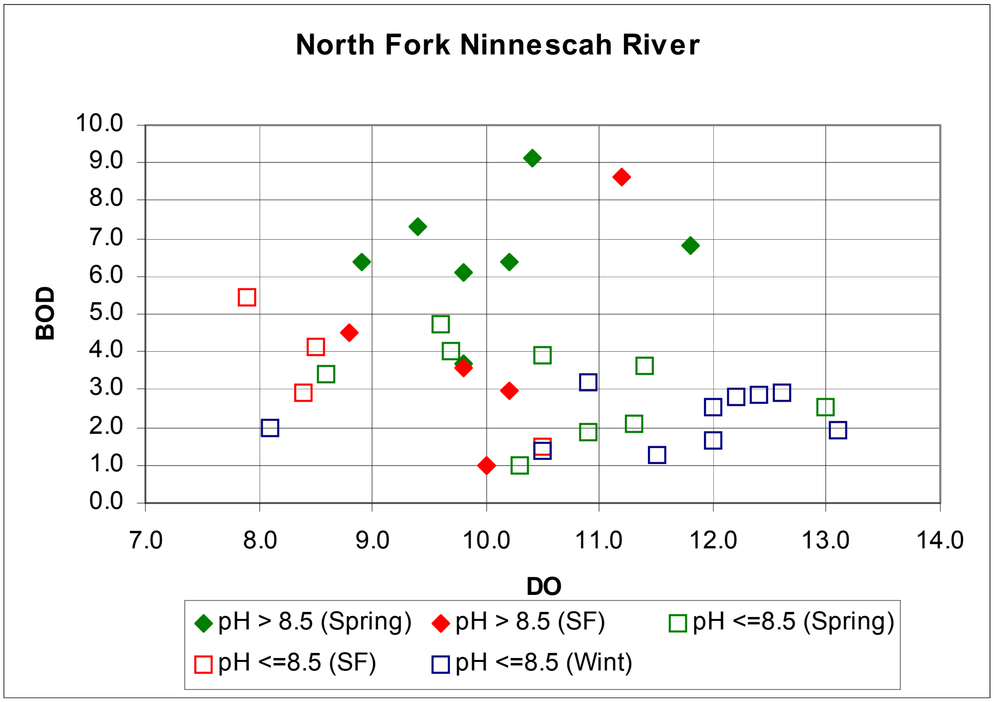



**Table 1**
Anova: Single Factor (Spring and Summer-Fall Seasons)

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| BOD <=8.5 | 13 | 41.11 | 3.16231 | 1.73199 |
| BOD > 8.5 | 13 | 67.43 | 5.18692 | 6.92139 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 26.643938 | 1 | 26.6439 | 6.15805 | 0.020477 | 4.259675 |
| Within Groups | 103.84051 | 24 | 4.32669 | | | |
| | | | | | | |
| Total | 130.48445 | 25 | | | | |

**Table 2**
Anova: Single Factor (Spring and Summer-Fall Seasons)

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| DISOXY <=8.5 | 13 | 130.6 | 10.0462 | 2.12103 |
| DISOXY > 8.5 | 13 | 130.3 | 10.0231 | 0.67026 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 0.0034615 | 1 | 0.00346 | 0.00248 | 0.960692 | 4.259675 |
| Within Groups | 33.495385 | 24 | 1.39564 | | | |
| | | | | | | |
| Total | 33.498846 | 25 | | | | |

**Figure 4** outlines the relationship between Total Suspended Solids (TSS) and average daily streamflow for flows less than 250 cfs for those samples whose pH was less or equal to 8.5 and those samples greater than or equal to 8.5. A comparison of these two sample means was performed and found that these means are significantly different (see **Table 3**), with greater TSS for the high pH samples.

**Table 3**
Anova: Single Factor (Flow < 250 cfs)

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| TSS <= 8.5 | 22 | 731 | 33.22727273 | 562.0887446 |
| TSS >8.5 | 13 | 724 | 55.69230769 | 1224.230769 |

ANOVA

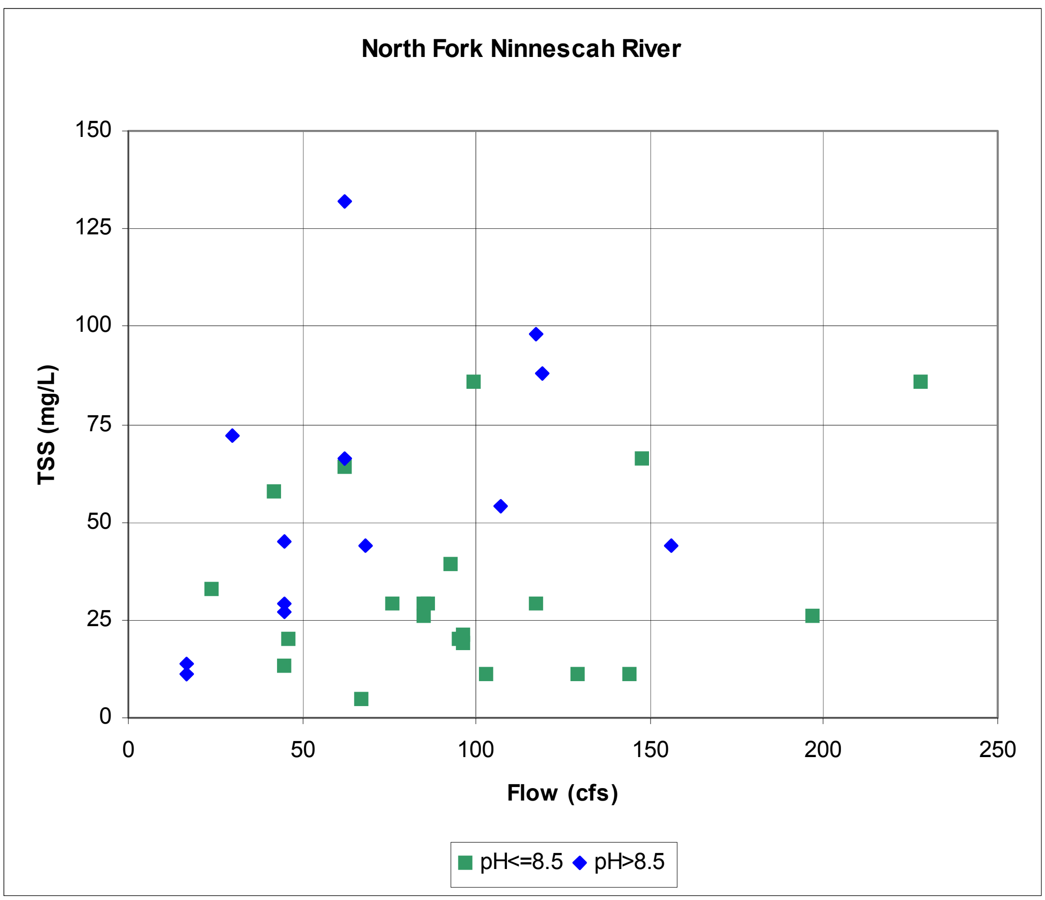
| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 4123.93856 | 1 | 4123.938561 | 5.136510976 | 0.030109571 | 4.13925 |
| Within Groups | 26494.6329 | 33 | 802.8676626 | | | |
| | | | | | | |
| Total | 30618.5714 | 34 | | | | |

This information hints that excessive algae growth among streamperiphyton is causing the pH excursions at Site 525. The North Fork of the Ninnescah is a clear, shallow, wide stream with a sandy substrate. The morphology of the North Fork Ninnescah River is conducive to the growth of phytoplankton. The river is clear, allowing light to penetrate and warm the water and reach the phytoplankton. Sufficient nutrients are apparently available to support growth. Because the river is wide and has a consistent low flow, the phytoplankton have a stable environment in which to grow.

During photosynthesis, the phytoplankton up take carbon dioxide and give off oxygen. In this reaction, water molecules are cleaved. The organism takes up the hydrogen cation, and the remaining hydroxyl anion remains in solution. The pH value increases with the decrease in available hydrogen cations. Peaks in pH occur in the afternoon, when the greatest amount of radiant energy reaches the river. Because the algae are only active during the growing season, the pH excursions are a seasonal impairment.

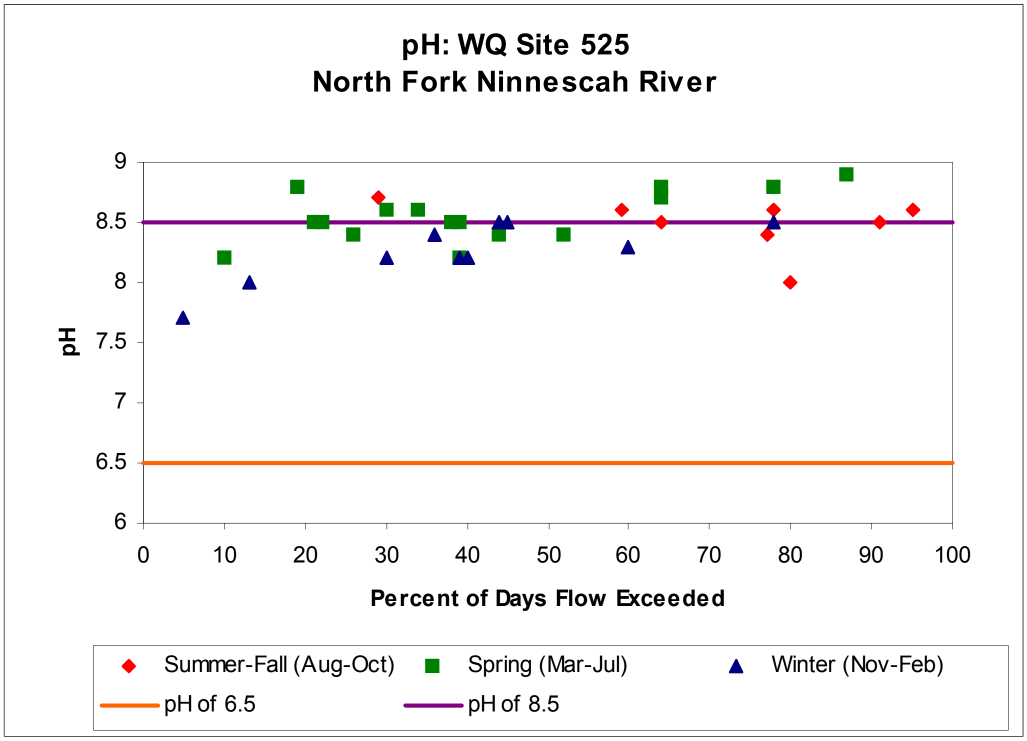
BOD sample levels (**Figure 2**) are also greater for those samples with pH greater than 8.5 possibly because of the greater presence of detached algae and periphyton in the stream under this condition. Despite the higher BOD, DO levels remain the same because of DO production from algae photosynthesis. It is believed that the nitrate concentration decreases in the water column under pH conditions greater than 8.5 because much of the available nitrate is being used by the algae in the river. There was no difference in phosphorus levels between the two situations.

**Figure 4**



Additionally, the TSS is likely higher (**Figure 4**) for situations where the pH is greater than 8.5 because of phytoplankton suspended within the water column.
Flow duration data **(Figure 5)** were examined from the above Cheney Reservoir Gaging Station. High flows and runoff equate to lower flow durations. Baseflow and point source influences generally occur in the 75-99% range. The pH/flow exceedence curves were established for the criterion by plotting pH samples on flow exceedence for the flow on the sample date. The water quality standard(s) on the pH/flow exceedence curves represent the TMDL since the standard is dimensionless and no load can be calculated. Historic excursions from WQS are seen as plotted points outside the acceptable pH range. Water quality standards are met for those points plotting within the acceptable range.

**Figure 5**




As previously noted, excursions were seen over low and high flows in Spring and Summer-Fall for water quality sampling site 525 (**Table 4**). Forty-four percent of Spring samples and 60% of Summer-Fall samples were over the criterion. Overall, 36% of the samples were over the criterion. This would represent a baseline condition of non-support of the impaired designated use for this site.

**Table 4**

**NUMBER OF SAMPLES OUTSIDE OF pH STANDARD (6.5 - 8.5) BY FLOW AND SEASON**

| Station | Season | 0 to 10% | 10 to 25% | 25 to 50% | 50 to 75% | 75 to 90% | 90 to 100% | Cum Freq. |
|---|---|---|---|---|---|---|---|---|
| N. Fork Ninnescah River above Cheney Reservoir | Spring | 0 | 1 | 2 | 2 | 2 | 0 | 7/16 = 43.8% |
| | Summer | 0 | 0 | 2 | 1 | 1 | 2 | 6/10 = 60.0% |
| | Winter | 0 | 0 | 0 | 0 | 0 | 0 | 0/10 = 0.00% |

**Desired Endpoints of Water Quality (Implied Load Capacity) at Site 525 over 2005 - 2010:**
The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting aquatic life. The current standard of pH between 6.5 to 8.5 was used to establish the pH/flow exceedence TMDL curves. However, the morphology of the river tends to foster periphyton growth and activity which can naturally cause rises in pH over the 8.5 criterion. Because the water quality standard for pH is tied to artificial sources, which are currently indeterminent along the river, this TMDL will concern itself with reducing phosphorus and nitrate levels in the face of changing land use conditions in the watershed and evaluating future patterns of pH.

Achievement of the endpoints indicate loads are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored.

## 3. SOURCE INVENTORY AND ASSESSMENT

**NPDES:** Five NPDES permitted facilities are located within the watershed. Four (Stafford, Arlington, Partridge, and Turon MWTP) have discharging, waste stabilization ponds. Preston MWTP has a single stage, trickling filter system. According to projections of future water use and resulting wastewater, Stafford MWTP does not look to have sufficient treatment capacity available. The excursions from the water quality standards do appear to occur under the flow conditions associated with the Spring and Summer seasons. Effluent monitoring records submitted by the municipalities were checked for 1999-2000, and this monitoring indicates that only Partridge MWTP exceeded the permitted pH range of 6.0 to 9.0.

| Name | Stream | Design Flow (MGD) | Predicted Population Change in 2020 | Maximum pH over 1999-2000 |
|---|---|---|---|---|
| Arlington MWTP | Unnamed Stream | 0.081 | No Change | No Samples Taken |
| Partridge MWTP | Red Rock Creek | 0.025 | - 18.8% | 9.4 |
| Preston MWTP | Silver Creek | 0.05 | - 12.0% | 7.9 |
| Stafford MWTP | Doolyville Creek | 0.145 | - 10.7% | 7.9 |
| Turon MWTP | Unnamed Stream | 0.065 | 7.7% | 7.8 |

**Background:** The primary cause of the pH impairment of the North Fork Ninnescah River in Reno County is dependent on the relatively unique morphology of the stream in the watershed. The North Fork of the Ninnescah, like a few other streams in south central Kansas such as the South Fork of the Ninnescah and the Arkansas River between Great Bend and Hutchinson where pH is also issue, is a clear, shallow, wide stream with a sandy substrate. As a result, sunlight easily penetrates the river's entire water column. As temperatures increase and flows decline in the warmer months (spring and summer) the algae population within the stream can grow rapidly.

During photosynthesis, the phytoplankton up take carbon dioxide and give off oxygen. In this reaction, water molecules are cleaved. The organism takes up the hydrogen cation, and the remaining hydroxyl anion remains in solution. The pH value increases with the decrease in available hydrogen cations.

Peaks in pH occur in the afternoon, when the greatest amount of radiant energy reaches the river. Because the algae are only active during the growing season, the pH excursions are generally a seasonal impairment.

**Contributing Runoff**: The watershed's average soil permeability is 5.1 inches/hour according to NRCS STATSGO data base. About 24.1% of the watershed produces runoff even under relative low (1.5"/hr) potential runoff conditions. Under very low (<1"/hr) potential conditions, this potential contributing area is almost halved (13.2%). Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from only 3.7% of this watershed, chiefly along the stream channels.

## 4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

It is believed that warmer water temperatures and adequate nutrient availability, coupled with the natural morphology of the North Fork Ninnescah River (consistent base flow conditions, low turbidity, sandy substrate and shallow depth) are conducive to growth in algae population within the stream and the corresponding photosynthesis activity, causing pH to rise above the water quality standard of 8.5. Thus, these pH excursions from the water quality standard at water quality monitoring site 525 are seen as a natural consequence of the availability of current nutrient levels in this stream environment. This TMDL represents the "Best Professional Judgment" as to the indeterminent relationship between physical/biologic factors, stream morphology and pH.

As an interim management goal in this phase of the TMDL, nitrate and phosphorus averages should be reduced from 1.0 mg/l and 0.16g/l to 1.0 mg/l and 0.14 mg/l, respectively.

**Point Sources:** The currently existing facilities discharging to the stream are relatively small and distant from the monitoring site, totaling 0.6 cfs in design flows. Presuming an interim management goal of reducing average in-stream nitrate to 1.0 mg/l and average in-stream phosphorus to 0.14 mg/l, the Wasteload Allocation represent that portion of instream load tied to the point sources. This would yield 3.2 pounds per day of nitrate and 0.45 pounds of phosphorus in the stream at the monitoring site.

**Nonpoint Sources:** Maintaining a reduced average concentration of nitrate (1.0 mg/l) and phosphorus (0.14 mg/l) at flows ranging from 5 - 80 cfs, the resulting Load Allocation would be 27-432 pounds per day for nitrate and 3.8 - 60 pounds per day for phosphorus.

**Defined Margin of Safety:** The Margin of Safety will be implicit based on the conservative assumption that design flows will be discharged simultaneously and influence water quality at the downstream monitoring site. Furthermore, overall average nitrate and phosphorus conditions are expected to be reduced below current averages, despite the majority of samples taken represent conditions of no pH excursions. Should future study of point and nonpoint source activities within the watershed determine an impact on loading, the margin of safety will be crafted to reduce the available allocations available to those sources.

**State Water Plan Implementation Priority:** Because it appears this watershed's pH condition is predominately a natural response to the physical and chemical environment fostering photosynthesis , this TMDL will be a Low Priority for implementation.

**Unified Watershed Assessment Priority Ranking:** This watershed lies within the North Fork Ninnescah (HUC 8: 11030014) with a priority ranking of 7 ( High Priority for restoration).

**Priority HUC 11s:** The watershed is within HUC 11s (010, 020, 030).

## 5. IMPLEMENTATION

### Desired Implementation Activities

1. Evaluate and minimize artificial influences on stream pH.
2. Evaluate future trends in stream pH and nutrient levels.

**Implementation Programs Guidance**

**NPDES - KDHE**

a. Condition future permits of new facilities to maintain pH below 8.5 for the watershed.
b. Incorporate nutrient limits on permitted facilities in future after development of nutrient criteria
c. Monitor nutrient content of wastewater effluent from permitted facilities

**Non-Point Source Pollution - KDHE**

a. Monitor changes in land use activities in the watershed for potential impacts to stream water quality, particularly as implementation of Cheney Lake Watershed BMPs continues.
b. Evaluate any potential anthropogenic activities which might contribute nutrients to the river as part of an overall Watershed Restoration and Protection Strategy.

**Water Quality Monitoring - KDHE**

a. Monitor future levels of pH and in-stream nutrients and evaluate for trends.

**Time Frame for Implementation:** Evaluation of trends and activities should be accomplished over 2001-2005.

**Targeted Participants:** Primary participants for implementation will be KDHE.

**Milestone for 2006**: The year 2006 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, additional monitoring data from the North Fork Ninnescah River will be reexamined to confirm the condition of the river relative to the current condition documented by this TMDL. Should the case of impairment remain, source assessment, allocation and implementation activities will ensue.

**Delivery Agents:** The primary delivery agents for program participation will be the Kansas Department of Health and Environment.

**Reasonable Assurances**

**Authorities:** The following authorities may be used to direct activities in the watershed to reduce pollution.

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

3. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

4. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*.

5. The *Kansas Water Plan* and the Lower Arkansas Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

**Funding:** The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration and should not receive funding.

**Effectiveness:** Minimal control can be exerted on natural contributions to loading. Best Management Practices are effective in reducing nutrient loadings to streams if installed at a sufficiently high density and in proximity to streams.

## 6. MONITORING

KDHE will continue to collect bimonthly samples at Station 525, including pH and nutrients over each of the three defined seasons over 2001-2010. Based on that sampling, trends will be evaluated in 2006 and the status of 303(d) listing will be evaluated in 2010.

Monitoring of nutrient levels in effluent will be a condition of NPDES and state permits for facilities discharging to the river or tributaries leading to the mainstem of the river.

## 7. FEEDBACK

**Public Meetings:** Public meetings to discuss TMDLs in the Lower Arkansas River Basin were held March 9, 2000 and April 26-27, in Hutchinson, Wichita, Arkansas City and Medicine Lodge. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Lower Arkansas River Basin. A draft of this TMDL has been maintained on the website since June 1, 2000 and modifications to the original draft have been available to the public for viewing and review up to the date of submitting this TMDL to EPA.

**Public Hearing:** A Public Hearing on the original draft of these TMDLs of the Lower Arkansas River Basin was held in Wichita on June 1, 2000.

**Basin Advisory Committee:** The Lower Arkansas River Basin Advisory Committee met to discuss the TMDLs in the basin on September 27, and November 8, 1999; January 13 and March 9, 2000. The Committee recommended approval of the Basin Plan which set high priority TMDLs in the basin, thereby, delegating medium and low priority status to this and subsequent TMDLs for the basin. The Kansas Water Authority approved the Basin Plan on July 11, 2000.

**Discussion with Interest Groups:** Meetings to discuss TMDLs with interest groups include:

Agriculture: January 12, February 2 and 29, 2000
Environmental: March 9, 2000
Conservation Districts: November 22, 1999
Industry: December 15, 1999, January 13, February 9 and 22, 2000
Local Environmental Protection Groups: September 30, November 2, December 16, 1999

**Milestone Evaluation:** In 2006, evaluation will be made as to the degree of impairment which has occurred within the drainage and current condition of North Fork Ninnescah River. Subsequent decisions will be made regarding implementation approach and follow up of additional implementation.

**Consideration for 303(d) Delisting:** North Fork Ninnescah River will be evaluated for trends based on the monitoring data over the period 2001-2005. Should modifications be made to the applicable criterion during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL, and implementation activities may be adjusted accordingly. The decision for delisting will come about in the preparation of the 2010 303(d) list, using monitoring data from 2005-2009.

**Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process:** Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2002 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in Kansas Water Plan implementation decisions under the State Water Planning Process after Fiscal Year 2005.

Approved July 27, 2001.