NEOSHO BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Canville Creek
Water Quality Impairment: Dissolved Oxygen

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Middle Neosho River **County:** Allen and Neosho

HUC 8: 11070205

HUC 11 (HUC 14s)**:** **010** (020 and 030)

Drainage Area: 80.2 square miles

Main Stem Segment: WQLS: 16 (Canville Creek) starting at confluence with the Neosho River and traveling upstream to headwaters in southeast Allen County (**Figure 1**).

Tributary Segment: WQLS: Pecan Creek (45)

Designated Uses: Expected Aquatic Life Support, Secondary Contact Recreation and Food Procurement for Main Stem Segment.

Expected Aquatic Life Support and Secondary Contact Recreation on Pecan Creek.

1998 303(d) Listing: Table 1 - Predominant Non-point Source and Point Source Impacts

Impaired Use: Expected Aquatic Life Support

Water Quality Standard: Dissolved Oxygen (DO): 5 mg/L (KAR 28-16-28e(c)(2)(A))

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 612 near Shaw

Period of Record Used: 1992, 1996 and 2000 for Station 612; Some 2000 and all 2001 Kansas Biological Survey Data (**Figure 2**)

Flow Record: Marmaton River near Marmaton (USGS Station 06917380) matched to Canville

Creek watershed area via estimated runoff from Chetopa Creek watershed (USGS 07169550).

Long Term Flow Conditions: 10% Exceedance Flows = 104 cfs**,** 95% = 0 cfs

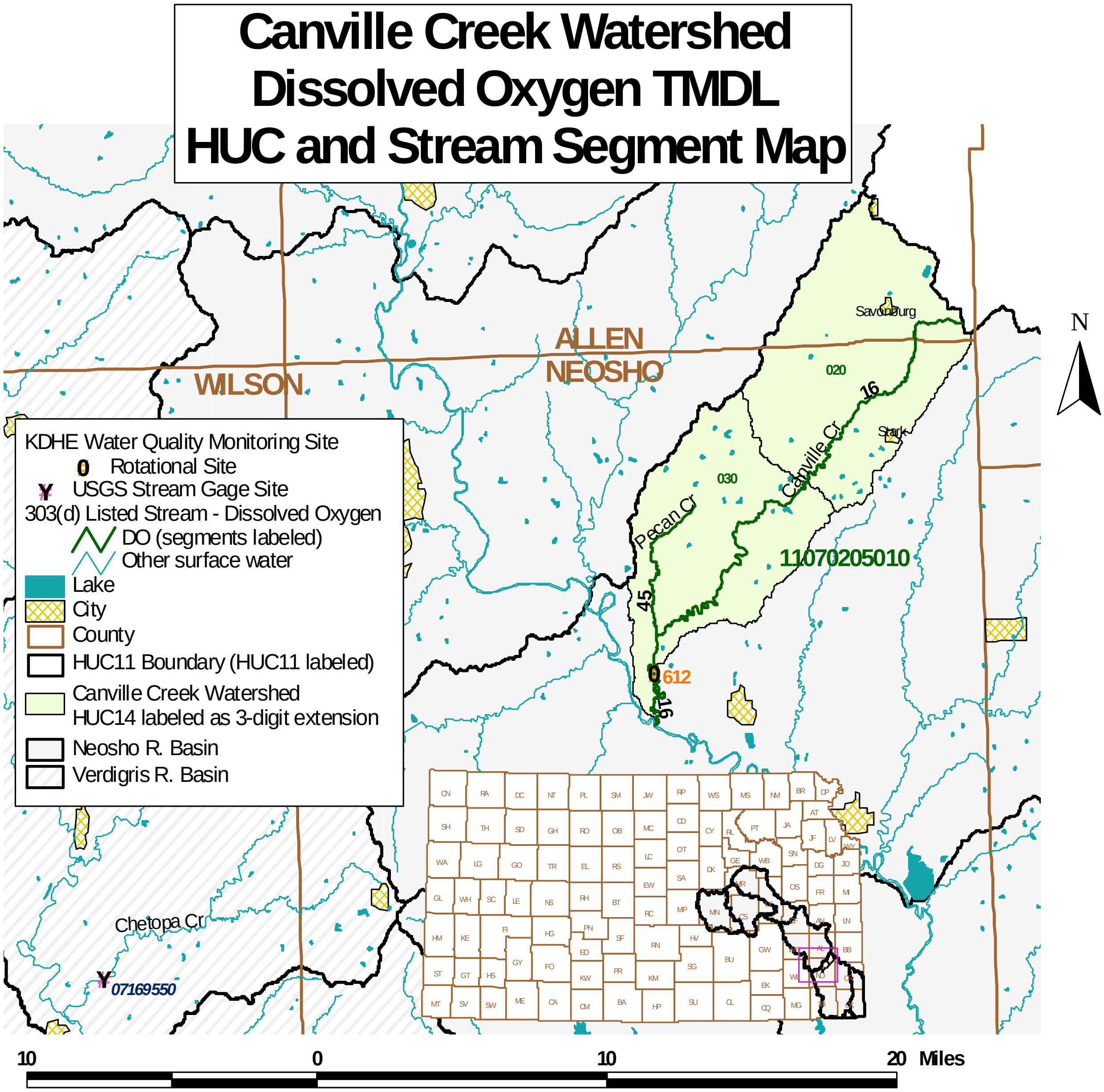

Figure 1

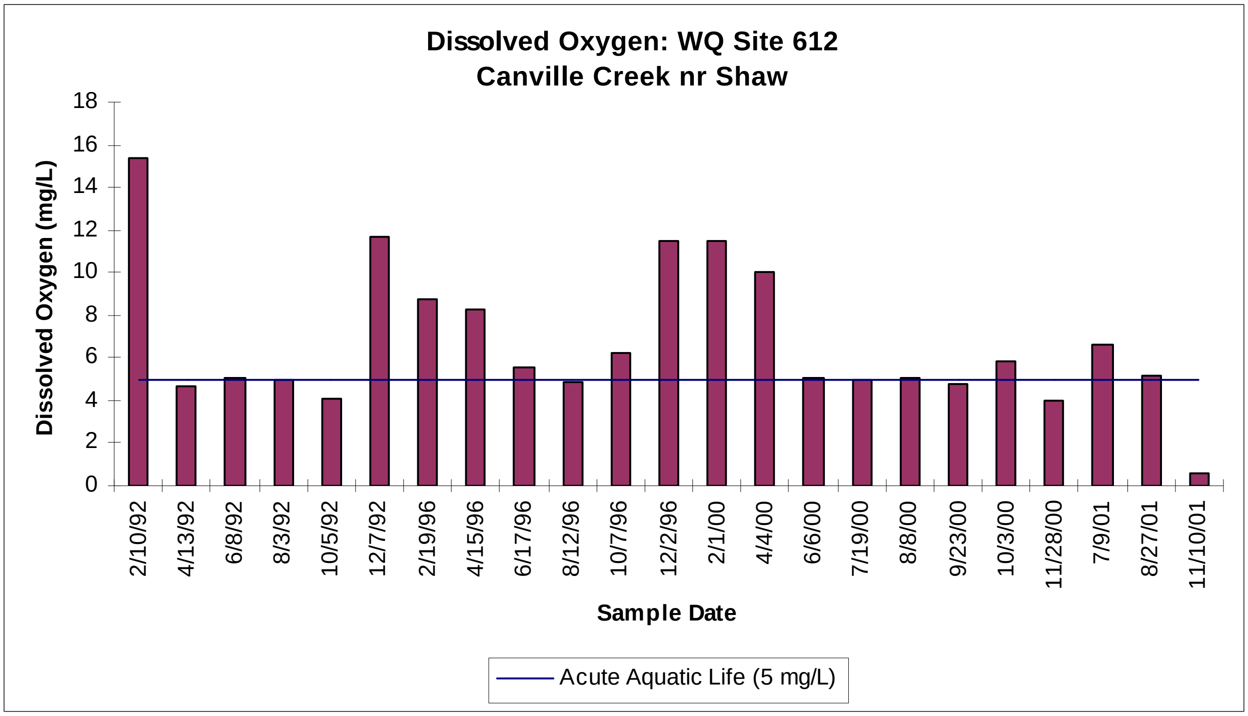

Figure 2

Current Conditions: Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. Sample data for the sampling site were categorized for each of the three defined seasons: Spring (Apr-Jul), Summer-Fall (Aug-Oct) and Winter (Nov-Mar). High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range. Load curves were established for the Aquatic Life criterion by multiplying the flow values for Canville Creek near Shaw along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of DO per day. This load curve graphically displays the TMDL since any point along the curve represents water quality at the standard at that flow. Historic excursions from water quality standards (WQS) are seen as plotted points *below* the load curves. Water quality standards are met for those points plotting *above* the applicable load duration curves (**Figure 3**).

Excursions were seen in all seasons and are outlined in Table 1. Thirty eight percent of the Summer-Fall samples and 13% of Spring samples were below the aquatic life criterion. Twenty nine percent of the Winter samples were under the aquatic life criterion. Overall, 26% of the samples were under the criterion. This would represent a baseline condition of non-support of the impaired designated use.

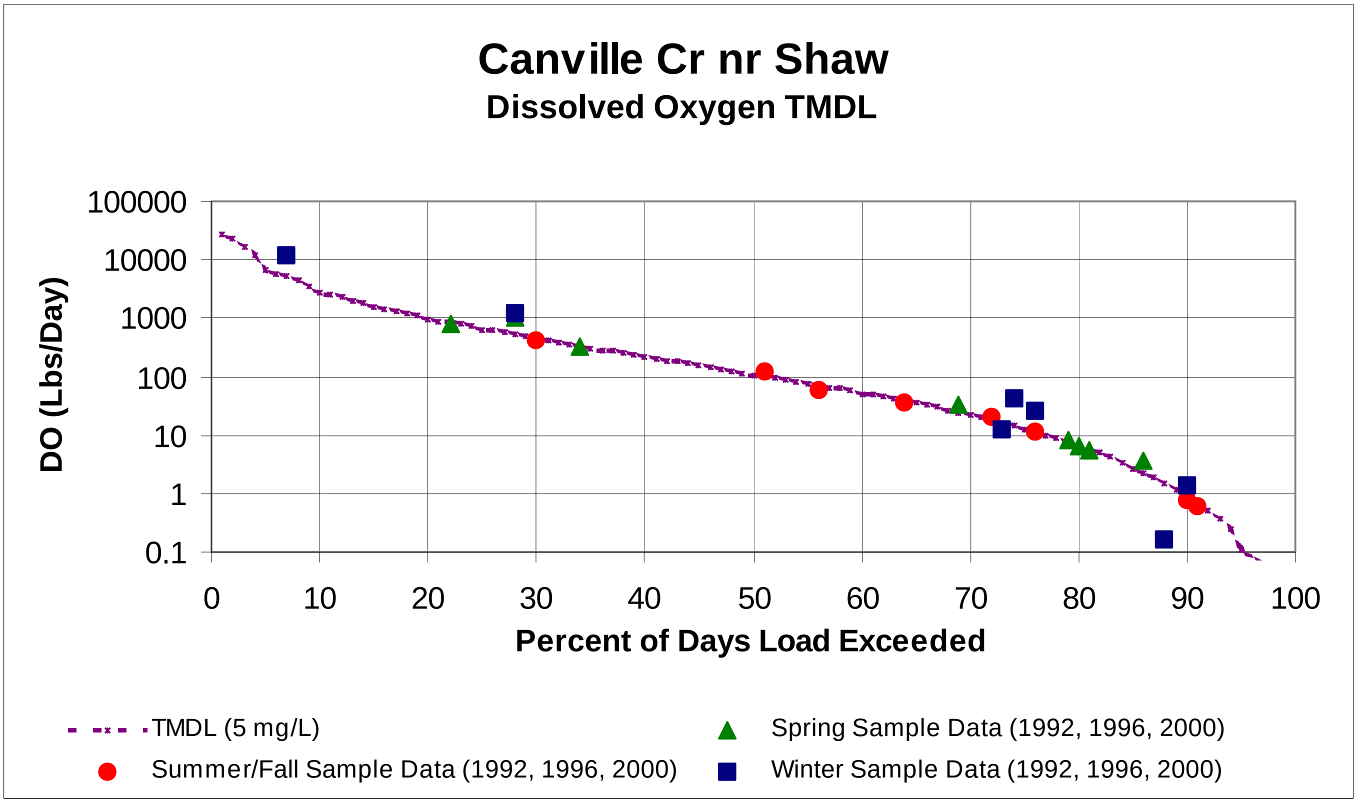

Figure 3

Most DO violations have been encountered at flows less than 2.8 cfs on Canville Creek near Shaw, therefore a critical low flow can be identified on Canville Creek as those flows of 2.8 cfs or less.

Table 1
NUMBER OF SAMPLES UNDER DISSOLVED OXYGEN STANDARD OF 5 mg/L BY FLOW

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Canville Creek near Shaw (612)	Spring	0	1	0	0	0	0	1/8 = 13%
	Summer	0	0	0	2	0	1	3/8 = 38%
	Winter	0	0	0	1	1	0	2/7 = 29%

A watershed comparison approach was taken in developing this TMDL. The Big Creek watershed (Water Quality Sampling Site 611 in the watershed was not impaired by low DO) and the Flat Rock Creek watershed (Water Quality Sampling Site 613 in the watershed was not impaired by low DO) have roughly similar land use characteristics (**see Table 2 in Appendix**) to the Canville Creek watershed, have comparable areas, and bracket the Canville Creek watershed to the north and south. The relationship of DO to ammonia, biochemical oxygen demand (BOD), fecal coliform bacteria (FCB), water temperature, turbidity, nitrate, phosphorus, pH and total suspended solids (TSS) were used in the comparisons
.

Table 3 in the Appendix outlines those water quality data for the samples taken on the same date for the three sites of interest. **Table 4 in the Appendix** summarizes those sample dates when DO was below the aquatic life criterion for sample site 612. At site 612 the average ammonia, BOD, FCB, water temperature, turbidity, nitrate, phosphorus, pH, and TSS were all less than the averages for the comparison watersheds. It appears the primary cause driving the occasional DO excursion can only be low flow in the stream.

The Canville Creek watershed has about 10 - 20% more grassland and 10 - 20% less cropland as percentage of total watershed area than the comparison watersheds. It has a slightly larger percentage of watershed lakes as a percentage of total watershed area too (**Table 2 in Appendix**). Runoff in the watershed is likely reduced because of the larger percentage of grassland (or smaller percentage of cropland) and a larger proportion of the runoff generated within the watershed is captured by the watershed ponds. These differences in land use features of the Canville Creek Watershed in comparison to the reference watersheds and its effect on flow in the creek are likely the primary cause in the difference in DO levels between the reference and comparison watersheds.

Desired Endpoints of Water Quality at Site 612 over 2007 - 2011

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standard of 5 mg/l to fully support Aquatic Life.

Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow conditions, usually occurring in the Summer and Fall seasons.

This endpoint will be reached as a result of expected, though unspecified, improvements in tributary buffer strip conditions which will filter sediment before reaching the stream and stream morphology assessments which will be used to determine if enhancement to reaeriation of flow within the stream is needed. Improvements to buffer strip conditions will result from implementation of corrective actions and Best Management Practices, as directed by this TMDL. Achievement of this endpoint will provide full support of the aquatic life function of the creek and attain the dissolved oxygen water quality standard.

Since BOD is not considered a factor in the occasional DO excursion at this site, the BOD target will be to maintain the historical average in stream BOD of 3.15 mg/L or less at the sampling site.

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: There are two NPDES permitted wastewater dischargers within the watershed (**Figure 4**). These systems are outlined below in **Table 5**. The Morning Glory Dairy facility has a non-discharging lagoon that may contribute an organic substance load to Segment 45 of Pecan Creek under extreme precipitation events (flow durations exceeded under 5 percent of the time). Such events are not even remotely related to the flow conditions associated with the DO violations in this watershed.

Table 5

DISCHARGING FACILITY	STREAM REACH	SEGMENT	DESIGN FLOW	TYPE
Savonburg MWTF	Canville Cr.	16	0.014 mgd	Lagoon
Stark MWTF	Canville Cr.	16	0.015 mgd	Mech.

The city of Savonburg relies on a four cell lagoon system with at least 120 day detention times for treatment of their wastewater. Kansas Implementation Procedures - Waste Water Permitting - indicates both of these lagoon system meet standard design criteria. The city of Stark has an extended aeration activated sludge facility.

The population projections for Savonburg and Stark to the year 2020 indicate little change. Projections of future water use and resulting wastewater appear to be within the design flows for of these current system's treatment capacity. Examination of 1998, 1999, 2000 and 2001 effluent monitoring of the cities of Savonburg and Stark indicate that BOD discharges are usually well within permit limits. In the case of each city, effluent monitoring indicates BOD discharges in excess of permit limits occurred only once during this time period.

Canville Creek Watershed
NPDES Sites and Livestock Waste Management Facilities

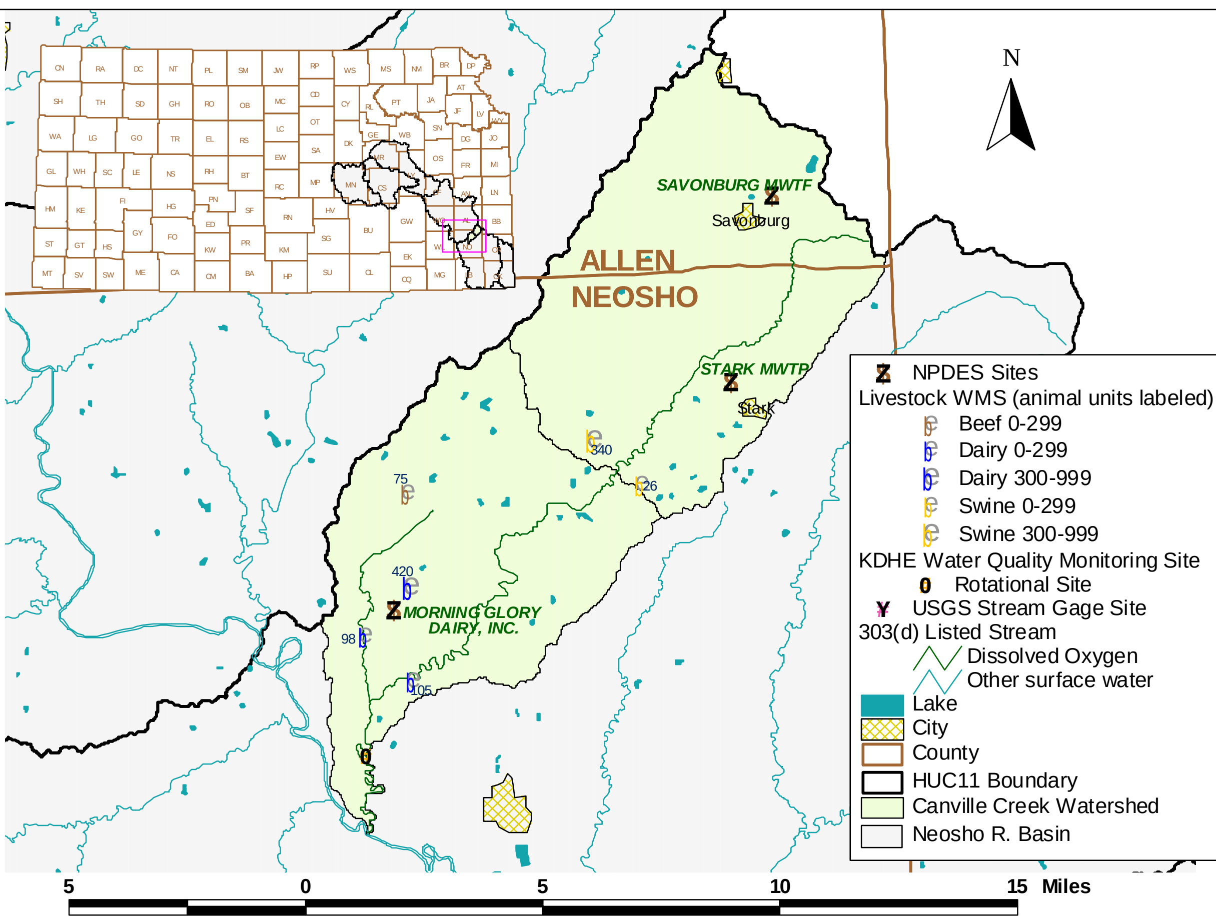

Figure 4

Canville Creek Watershed
Land Use, Population and Grazing Density

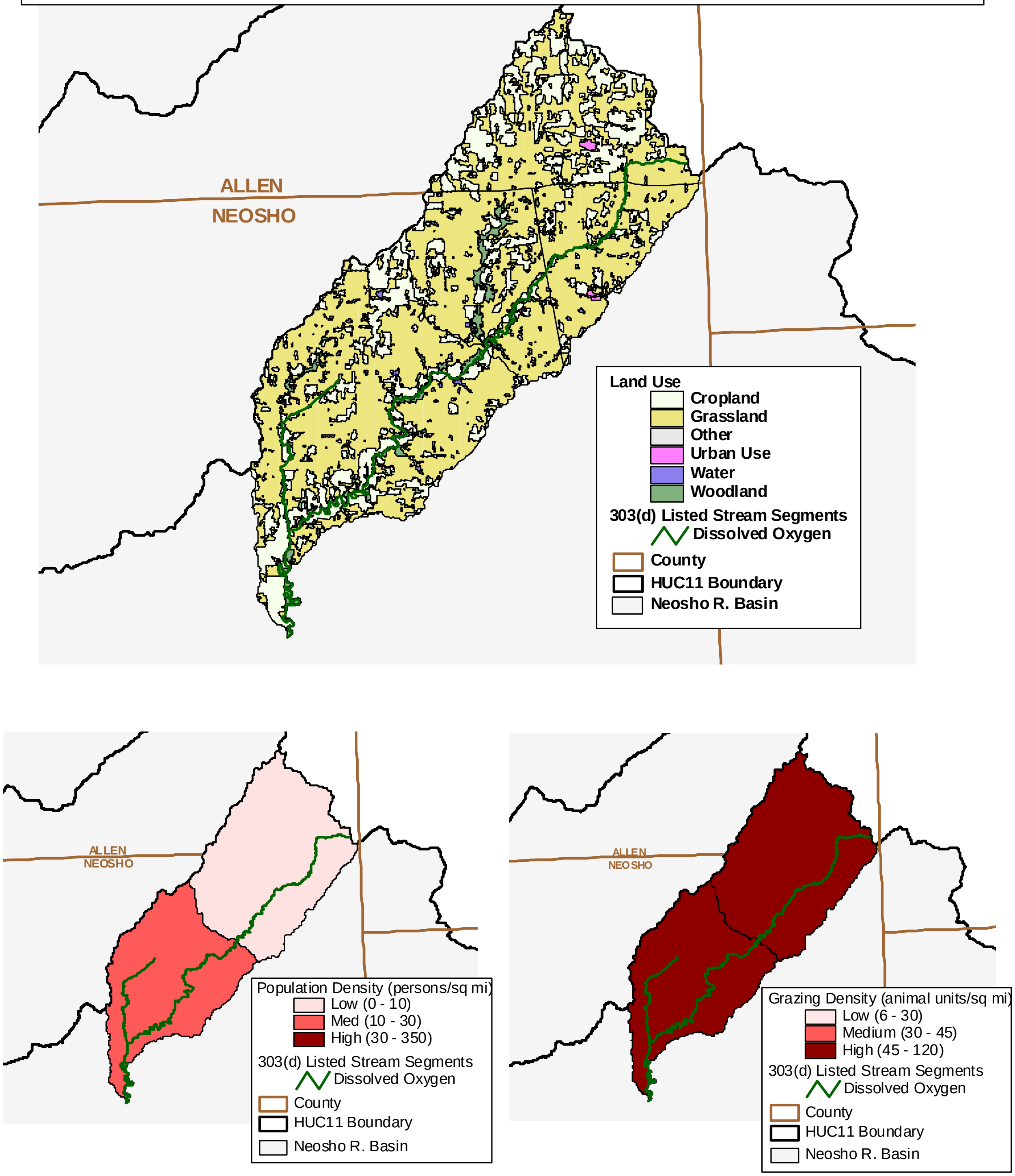

Figure 5

Livestock Waste Management Systems: Six operations are registered, certified or permitted within the watershed. The facility types are primarily dairy or swine. These facilities are mainly located toward the lower half of the watershed near the main stem or primary tributaries (**Figure 4**). All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25 year, 24 hour rainfall/runoff event, which typically coincide with stream flows exceeded less than 1 - 5 % of the time. NPDES permits, also non-discharging, are issued for facilities with more than 1,000 animal units. None of the facilities in the watershed are of this size. Total potential animal units for all facilities in the watershed total 1,064. The actual number of animal units on site is variable, but typically less than potential numbers.

Land Use: Most of the watershed is cropland (29% of the area), grassland (67%), or woodland (4%). Most of the cropland is located in either the upper or lower third of the watershed. The grazing density estimate is high when compared to densities elsewhere in the Neosho Basin (54-57 animal units/mi^2) (**Figure 5 and Table 2 in Appendix**).

On-Site Waste Systems: The watershed's population density is low to average (7-11 person/mi^2) when compared to densities elsewhere in the Neosho Basin (**Figure 5**). The rural population projections for Allen and Neosho County through 2020 show slight to modest growth (2-22% increase, respectively). While failing on-site waste systems can contribute oxygen demanding substance loadings, their impact on the impaired segments is generally limited, given the small size of the rural population and magnitude of other sources in the watershed.

Background Levels: Some organic enrichment may be associated with environmental background levels, including contributions from wildlife and stream side vegetation, but it is likely that the density of animals such as deer is fairly dispersed across the watershed and that the loading of oxygen demanding material is constant along the stream. In the case of wildlife, this loading should result in minimal loading to the streams below the levels necessary to violate the water quality standards. In the case of stream side vegetation, the loading should be greater toward the middle third of the watershed with its larger proportion of woodland near the stream.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

BOD is a measure of the amount of oxygen required to stabilize organic matter in a stream. As such, BOD is used as a benchmark measure to anticipate DO levels while it measures the total concentration of DO that will be demanded as organic matter degrades in a stream. It is presumed that the maintenance of historical BOD loads with improvements to tributary buffers and any stream restoration projects cited by local assessments will reduce DO excursions under certain critical flow conditions. Therefore, any allocation of wasteloads and loads will be made in terms of BOD.

This is a phased TMDL. Additional monitoring over time will be needed to further ascertain the relationship between enhancements through stream restoration and tributary buffer strip conditions which should filter sediment before reaching the stream, reduce sediment oxygen demand and consequently improve DO levels during the critical flow periods of concern. In Phase One of this TMDL the following allocations apply:

Point Sources: Point sources are responsible for maintaining their systems in proper working condition and appropriate capacity to handle anticipated wasteloads of their respective populations. The State and NPDES permits will continue to be issued on 5 year intervals, with inspection and monitoring requirements and conditional limits on the quality of effluent released from these facilities. Ongoing inspections and monitoring of the systems will be made to ensure that minimal contributions have been made by this source.

Based upon the preceding assessment, only the discharging point sources (Savonburg and Stark) contributing a BOD load in the Canville Creek watershed upstream of site 612 will be considered in this Wasteload Allocation. Because of the indications that low flow is the primary factor causing the occasional excursion from the water quality standard rather than BOD, these point sources are not seen as a significant source of DO excursions.

Streeter-Phelps analyses for both point sources indicate the present BOD permit limit (30 mg/L) for these point sources maintain DO levels above 5 mg/L in the stream when there is no flow upstream of the discharge point (see attached Streeter-Phelps analysis).

The sum of the design flows of the point sources (0.045 cfs) redefines the lowest flow seen at site 612 (89 - 99% exceedance), and the WLA equals the TMDL curve across this flow condition (**Figure 6**).

From this, the WLA for the city of Savonburg is 3.52 lbs/day BOD and 3.77 lbs/day BOD for Stark, which translates to an in stream WLA of 0.37 lbs/day BOD and 0.4 lbs/day at Site 290 for Savonburg and Stark, respectively (**Figure 6**).

Non-Point Sources: Again, because the indications that low flow is the driving factor causing the occasional excursion from the water quality standard rather than BOD, non-point sources are also not seen as a significant source of DO excursion in the watershed. The Load Allocation assigns responsibility for maintaining the historical average in-stream BOD levels at site 612 to 3.15 mg/L for flows greater than 0.045 cfs (0-88% exceedance). The LA equals zero for flows from 0 - 0.045 cfs (89 - 99 % exceedance), since the flow at this condition is entirely effluent created, and then increases to the TMDL curve with increasing flow beyond 0.045 cfs (**Figure 6**).

To address any artificial sources factoring into the DO violations outlined in **Table 4 of the Appendix** at water quality sampling site 612, buffer strips should be installed on directly contributing tributaries to filter sediment before reaching the stream.

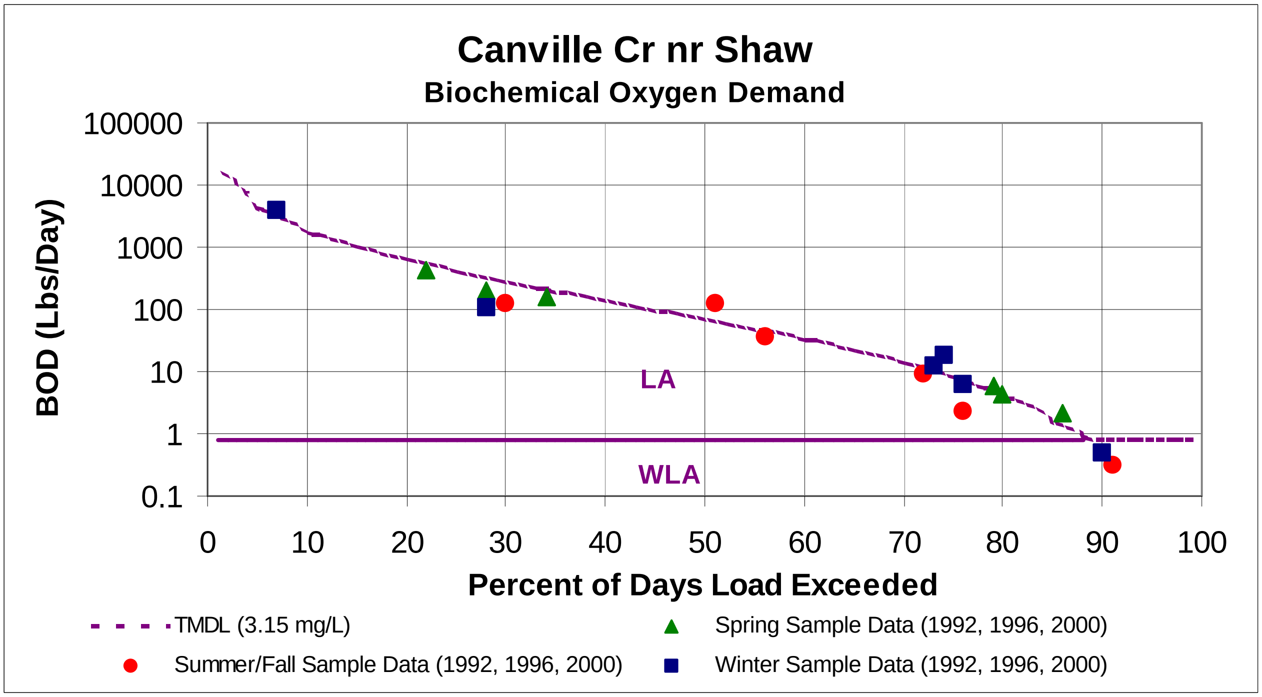

Figure 6

Defined Margin of Safety: The Margin of Safety will be implied based on conservative assumptions used in the permitting of the point source discharges including coincidence of low flow with maximum discharge from the treatment plant, associated CBOD content, temperature of the effluent, higher than expected stream velocity and the better than permitted performance of the treatment plant in producing effluent with BOD well below permit limits under critical seasonal conditions.

State Water Plan Implementation Priority: Because this watershed has indicated some problem with dissolved oxygen which has short term and immediate consequences for aquatic life, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Middle Neosho Basin (HUC 8: 11070205) with a priority ranking of 24 (Medium Priority for restoration work).

Priority HUC 11s and Stream Segments: Priority should be directed toward baseflow gaining stream segments along the main stem of Canville Creek (16), including Pecan Creek (45).

5. IMPLEMENTATION

Desired Implementation Activities

1. Conduct stream morphology review
2. Where needed, create/restore buffer strips along contributing tributaries.

Implementation Programs Guidance

Stream Restoration Program - SCC

a. Conduct a stream morphology evaluation along the stream reaches in the vicinity of the monitoring station.
b. Assess the degree to which sediment is altering stream flow patterns in the channel, including reducing slopes and aeration capability along the stream bed.
c. Ascertain probable sources of sediment deposition in stream, should it be a primary factor in influencing stream aeration or exerting oxygen demand.
d. Plan, design and install stream restoration measures which will restore stream flow conveyance and sediment transport capability to the target stream reaches.

Buffer Initiative Program - SCC

a. Install grass buffer strips near streams.

Timeframe for Implementation: Stream morphology assessments/restoration measures and buffer strips should be installed on main steam and directly contributing tributaries over the years 2003-2007.

Targeted Participants: Primary participants for implementation will be landowners immediately adjacent to the listed stream segments. Implemented activities should be targeted to those stream segments with greatest potential contribution to baseflow. Nominally, this would be most likely be :

1. Unbuffered cropland adjacent to contributing tributaries.
2. Unstable stream banks and modified channels.

Some inventory of local needs should be conducted in 2003 to identify such activities. Such an inventory would be done by local program managers with appropriate assistance by commodity representatives and state program staff in order to direct state assistance programs to the principal activities influencing the quality of the streams in the watershed during the implementation period of this TMDL.

Milestone for 2007: The year 2007 marks the mid-point of the ten year implementation window for the watershed. At that point in time, milestones should be reached which will have at least two-thirds of the landowners responsible for buffer strip restoration or stream restoration measures, cited in the local assessment, participating in the implementation programs provided by the state.

Delivery Agents: The primary delivery agents for program participation will be the conservation districts for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State County staff managing.

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.A.R. 28-16-69 to -71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

4. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including areas where buffer strips may be needed.

5. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control non-point source pollution.

6. 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.

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

8. The *Kansas Water Plan* and the Neosho 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 pollution 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 TMDL is a High Priority consideration.

Effectiveness: Buffer strips are touted as a means to filter sediment before it reaches a stream and riparian restoration projects have been acclaimed as a significant means of stream bank stabilization. The key to effectiveness is participation within a finite subwatershed to direct resources to the activities influencing water quality. The milestones established under this

TMDL are intended to gauge the level of participation in those programs implementing this TMDL.

Should participation significantly lag below expectations over the next five years or monitoring indicates lack of progress in improving water quality conditions from those seen over 1992, 1996 and 2000 the state may employ more stringent conditions on agricultural producers and urban runoff in the watershed in order to meet the desired endpoints expressed in this TMDL. The state has the authority to impose conditions on activities with a significant potential to pollute the waters of the state under K.S.A. 65-171. If overall water quality conditions in the watershed deteriorate, a Critical Water Quality Management Area may be proposed for the watershed, in response.

6. MONITORING

KDHE should collect bimonthly samples at rotational Station 612 in 2004 and 2008 including dissolved oxygen samples, in order to assess progress and success in implementing this TMDL toward reaching its endpoint. Should impaired status remain, the desired endpoints under this TMDL may be refined and more intensive sampling may need to be conducted under specified seasonal flow conditions over the period 2007-2011. Use of the real time flow data available at the Marmaton River near Marmaton stream gaging station can help direct these sampling efforts.

A stream restoration review will be conducted in 2004 by the State Conservation Commission to evaluate Canville Creek in terms of morphology and sediment impacts on stream flow patterns and its effect on aeration within the stream as outlined in the implementation guidance.

Local program management needs to identify its targeted participants of state assistance programs for implementing this TMDL. This information should be collected in 2003 in order to support appropriate implementation projects.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Neosho Basin were held January 9, 2002 in Burlington and March 4, 2002 in Council Grove. 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 Neosho Basin.

Public Hearing: Public Hearings on the TMDLs of the Neosho Basin were held in Burlington and Parsons on June 3, 2002.

Basin Advisory Committee: The Neosho Basin Advisory Committee met to discuss the TMDLs in the basin on October 2, 2001, January 9 and March 4, 2002.

Milestone Evaluation: In 2007, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of Canville Creek. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The creek will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2007-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

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 2003 which will emphasize implementation of TMDLs. 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 for Fiscal Years 2003-2007.

Appendix (Canville Creek DO TMDL)

Table 2

Canville Cr Wtrshd (612)			Big Cr Wtrshd (613)			Flat Rock Cr Wtrshd (611)		
Land Use	Acres	% of Total	Land Use	Acres	% of Total	Land Use	Acres	% of Total
Cropland	14675	28.6	Cropland	27906	39.4	Cropland	45131	46.9
Grassland	34196	66.6	Grassland	40415	57.1	Grassland	45788	47.6
Urban Use	118	0.2	Urban Use	105	0.1	Urban Use	386	0.4
Water	294	0.6	Water	245	0.3	Water	528	0.5
Woodland	2051	4.0	Woodland	2068	2.9	Woodland	4419	4.6
Total	51335	100	Total	70739	100	Total	96252	100

Table 3

COL_DATE	DISOXY			AMMONIA			BOD			FECCOLI			NITRATE		
	612	613	611	612	613	611	612	613	611	612	613	611	612	613	611
2/10/92	15.4	8.9	13.6	0.000	0.060	0.000	6.70	8.10	5.10	10	20	10	0.46	0.05	0.03
4/13/92	**4.7**	7.6	9.4	0.050	0.110	0.050	2.50	5.60	4.00	1000	4000	130	0.09	1.48	0.07
6/8/92	5.1	7.1	7.1	0.060	0.050	0.050	2.50	2.30	2.80	100	100	400	1.62	2.58	3.05
8/3/92	5.0	5.2	5.2	0.100	0.080	0.050	1.40	2.20	2.00	600	800	400	0.53	0.43	0.73
10/5/92	**4.1**	8.0	8.5	0.050	0.050	0.050	2.50	3.40	2.50	10	900	200	0.07	0.16	0.48
12/7/92	11.7	11.6	11.0	0.050	0.050	0.080	1.00	1.00	1.20	10	10	100	0.78	0.89	1.11
2/19/96	8.8	9.1	10.6	0.037	0.016	0.010	3.30	2.60	2.90	1	1	1	0.03	0.03	0.01
4/15/96	8.3	11.4	6.9	0.089	0.078	0.114	4.70	8.70	5.00	14	18	22	0.03	0.03	0.03
6/17/96	5.5	6.5	6.8	0.084	0.081	0.136	3.90	3.10	6.40	200	60	90	0.08	0.05	0.04
8/12/96	**4.9**	6.0	5.0	0.119	0.128	0.048	2.60	2.70	3.20	30	210	1200	0.16	0.28	0.15
10/7/96	6.2	8.8	7.7	0.070	0.154	0.167	6.00	6.90	7.60	70	900	200	0.15	0.17	0.07
12/2/96	11.5	12.4	12.3	0.020	0.020	0.020	3.90	4.60	4.10	600	1000	800	0.76	0.43	0.70
2/1/00	11.5	11.4	10.7	0.030	0.050	0.020	2.85	3.51	2.28	10	150	20	0.01	0.01	0.01
4/4/00	10.0	9.7	10.4	0.020	0.020	0.020	1.95	2.22	3.06	60	200	100	0.08	0.19	0.34
6/6/00	5.1	7.0	6.0	0.030	0.020	0.020	3.30	4.35	4.65	370	130	100	0.29	0.07	0.11
8/8/00	5.1	7.9	8.0	0.020	0.020	0.020	1.08	1.89	2.73	100	130	240	0.20	0.07	0.14
10/3/00	5.8	8.7	**4.5**	0.020	0.020	0.020	2.55	1.32	1.83	10	50	20	0.04	0.04	0.03
11/28/00	**4.0**	9.8	**4.4**	0.020	0.020	0.040	4.05	4.92	4.95	20	180	40	0.01	0.01	0.01
Avg	7.4	8.7	8.2	0.048	0.057	0.051	**3.15**	3.86	3.68	179	492	226	0.30	0.39	0.40

COL_DATE	TEMP_CENT			PHFIELD			PHOSPHU			TSS			TURBIDITY		
	612	613	611	612	613	611	612	613	611	612	613	611	612	613	611
2/10/92	4	4	3	8.4	7.8	8.1	----	0.200	----	11	28	10	4.7	33.6	5.5
4/13/92	14	13	14	7.7	7.6	8.2	0.060	0.260	0.060	29	140	35	14.4	92.0	11.2
6/8/92	18		19	7.5	----	7.7	0.090	0.110	0.100	28	42	31	18.8	26.6	21.5
8/3/92	20	21	20	7.5	7.5	7.5	0.100	0.150	0.160	38	37	63	21.5	32.0	38.0
10/5/92	15	17	16	7.4	7.6	7.7	0.060	0.210	0.090	14	47	27	8.0	56.5	14.4
12/7/92	1	0	1	7.9	7.9	7.9	0.050	0.050	0.050	5	5	3	6.0	12.6	6.2
2/19/96	----	----	----	----	----	----	0.090	0.056	0.050	9	11	10	3.1	4.4	3.8
4/15/96	11	10	12	8.1	8.2	8.0	0.090	0.552	0.112	22	324	37	9.0	101.0	15.0
6/17/96	25	25	25	7.3	7.5	7.4	0.087	0.090	0.149	18	23	31	7.0	12.0	11.0
8/12/96	21	23	22	7.4	7.6	7.6	0.122	0.143	0.125	17	34	21	7.0	26.0	10.0
10/7/96	15	16	15	7.6	8.0	7.8	0.078	0.142	0.078	13	58	20	5.0	25.0	6.0
12/2/96	5	5	5	7.6	7.4	7.5	0.096	0.189	0.183	17	45	24	19.0	48.0	46.0
2/1/00	3	5	4	7.8	7.8	7.7	0.070	0.100	0.070	12	20	3	2.0	10.0	3.0
4/4/00	13	12	12	8.0	8.0	8.0	0.060	0.090	0.060	25	33	15	9.5	19.0	6.5
6/6/00	22	24	27	7.8	8.1	8.1	0.100	0.130	0.120	22	44	25	22.0	14.0	5.4
8/8/00	28	32	28	7.5	8.0	7.9	0.090	0.080	0.070	14	20	10	8.0	11.0	5.0
10/3/00	20	27	20	7.7	7.9	7.7	0.080	0.030	0.090	9	9	14	3.4	3.8	5.8
11/28/00	6	8	6	7.3	7.5	7.4	0.090	0.230	0.180	6	19	13	1.5	6.3	3.3
Avg	14.18	15.13	14.65	7.68	7.78	7.78	0.083	0.156	0.103	17.2	52.2	21.8	9.4	29.7	12.1

Table 4

COL_DATE	DISOXY			AMMONIA			**BOD**			FECCOLI			NITRATE		
	612	613	611	612	613	611	612	613	611	612	613	611	612	613	611
4/13/92	**4.7**	7.6	9.4	0.050	0.110	0.050	2.50	5.60	4.00	1000	4000	130	0.09	1.48	0.07
10/5/92	**4.1**	8.0	8.5	0.050	0.050	0.050	2.50	3.40	2.50	10	900	200	0.07	0.16	0.48
8/12/96	**4.9**	6.0	5.0	0.119	0.128	0.048	2.60	2.70	3.20	30	210	1200	0.16	0.28	0.15
11/28/00	**4.0**	9.8	**4.4**	0.020	0.020	0.040	4.05	4.92	4.95	20	180	40	0.01	0.01	0.01
Avg	4.4	7.9	6.8	0.060	0.077	0.047	2.91	4.16	3.66	265	1323	393	0.08	0.48	0.18

COL_DATE	TEMP_CENT			PHFIELD			PHOSPHU			TSS			TURBIDITY		
	612	613	611	612	613	611	612	613	611	612	613	611	612	613	611
4/13/92	14	13	14	7.7	7.6	8.2	0.060	0.260	0.060	29	140	35	14.4	92.0	11.2
10/5/92	15	17	16	7.4	7.6	7.7	0.060	0.210	0.090	14	47	27	8.0	56.5	14.4
8/12/96	21	23	22	7.4	7.6	7.6	0.122	0.143	0.125	17	34	21	7.0	26.0	10.0
11/28/00	6	8	6	7.3	7.5	7.4	0.090	0.230	0.180	6	19	13	1.5	6.3	3.3
Avg	14	15.25	14.5	7.45	7.58	7.73	0.083	0.211	0.114	16.5	60	24	7.7	45.2	9.7

Streeter-Phelps DO Sag Model - Stream - CanvilleCrDO_Stark_Savonburg
Single Reach - Single Load

1 cfs = .0283 m^3/s
0.25 mph =0 .11176 m/s

		Elev (ft)	Dist to 612	Min DO	Crit Dist DO
0.0006141	Design Flow (Savonburg)	1040	37.75	6.46	3.10
0.0006580	Design Flow (Stark)	1030	30.71	6.28	0.00

Elevation Correction (DO)

Elevation	**1040**	ft
Correctn Factor (DO_{sat})	0.96672	mg/L

Distance (km)
Flow (m3/s)
Concentration (mg/L)
Temp (C)
Vel (m/s)

Unless modified by upstream pt. source, upstream BOD set as target for basin

Upstream DO (where appropriate) elevation corrected and set at 90% sat.

Velocity	0.11176		
BOD coef	0.23	Theta	1.056
O2 coef	*see below*	Theta	1.024

		Flow	BOD	DO	T	Dist	Slope (ft.m	Calc K_r	
1	**Savonburg**	0.000614	29	6.59	21.6	16.35	11.8	3.14	
	Upstream	0	0	0	0	-----			
	Result at Dist	0.000614	18.96	6.94	21.6				
2	**Stark**	0.000658	29	6.59	21.6	9.31	19.01	5.23	
	Upsteam	0.000614	18.96	6.94	21.6	-----			
	Result at Dist	0.001272	22.77	6.9	21.6				
3	**Savonburg Result**	0.000614	18.96	6.94	21.6	21.4	3.6	1.00	Elev = 920
	Upstream (Stark Result)	0.001272	22.77	6.9	21.6	-----			
	Result at Dist (612)	0.001886	12	5.2	23.3				Elev= 872

Kr Values (Foree 1977) using for q < 0.05 where q = cfs/mi^2 and	0.42 (0.63 + 0.4S^1.15) S (ft/mile)
Min Flow Savonburg	0.0335689
Min Flow Stark	0.0353357