SOLOMON BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit: Lower S. Fk. Solomon River
Water Quality Impairment: E coli Bacteria

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower S. Fk. Solomon River **County:** Mitchell, Osborne and Rooks

HUC 8: 10260014
HUC 10 (HUC 12s)**:** **01** (01, 02, 03, 04, 05 and 06)
02 (01, 02, 03, 04, 05, 06 and 07)
03 (01, 02, 03, 04, 05, 06 and 07)
04 (01, 02, 03 and 06)

Ecoregion: Central Great Plains – Rolling Hills and Breaks (27b)

Drainage Area: 862 square miles

Main Stem Segment: WQLS: 1, 3 & 4 (South Fork Solomon River) lying between the confluence of Kill Creek and the headwaters of Waconda Lake (**Figure 1**)

Main Stem Segment	**Tributary (see Appendix B)**
1	Carr Crk (21) [joins SF Solomon within Waconda Lake]
	Twin Crk (20)
	East Twin Crk (29)
3	Covert Crk (19)
4	Kill Crk (18)
5	Medicine Crk (17)
6	Medicine Crk (16)
7	
8	Dibble Crk (363)
	Lost Crk (13)
10	

Designated Uses: All streams in Lower South Fork Solomon Sub-basin have secondary "b" contact recreation designation, except Segments 1 & 3 of the SF Solomon which have Primary "C" contact recreation designation, Segments 4 & 10 of the SF Solomon which have Primary "B" contact recreation designation and Segment 363, Dibble Creek which has a secondary "a" contact recreation designation. All streams have Expected Aquatic Life support as a designated use.

All segments of the Lower South Fork Solomon River have domestic water supply, food procurement, ground water recharge, irrigation, industrial and stock water supply as designated uses.

Carr Creek has domestic water supply and food procurement as designated uses. Covert, Kill and Twin Creeks have food procurement as a designated use.

303(d) Listings: The SF Solomon River monitored by Station SC543 cited as impaired by E coli bacteria in the 2008-303(d) list for the Solomon Basin.

Impaired Use: Primary Contact Recreation

Water Quality Criteria: K.A.R. 28-16-28d. Surface water classification and use designation. (a) Surface water classification. Surface waters shall be classified as follows:

(1) Classified stream segments shall be those stream segments defined in K.S.A. 82a- 2001(a), and amendments thereto. (K.S.A. 82a-2001(a) provided in **Appendix A**)

K.A.R. 28-16-28e(c)(7):
(D) Primary contact recreation for classified stream segments. At least five samples shall be collected during separate 24-hour periods within a 30-day period. A geometric mean analysis of these samples shall not exceed the criteria in table 1i, as adopted in subsection (d) of this regulation, beyond the mixing zone.

(E) Secondary contact recreation for classified stream segments. The following criteria shall be in effect from January 1 through December 31 of each year. At least five samples shall be collected during separate 24-hour periods within a 30-day period. A geometric mean analysis of these samples shall not exceed the criteria in table 1i, as adopted in subsection (d) of this regulation, beyond the mixing zone.

(F) Wastewater effluent shall be disinfected if it is determined by the department that the discharge of non-disinfected wastewater constitutes an actual or potential threat to public health. Situations that constitute an actual or potential threat to public health shall include instances in which there is a reasonable potential for the discharge to exceed the applicable criteria supporting the assigned recreational use designation or if a water body is known or likely to be used for either of the following:

(i) Primary or secondary contact recreation; or
(ii) any domestic water supply.

Table 1i. Escherichia coli Criteria For Classified Stream Segments.

USE	Colony Forming Units (CFUs)/100mL	
PRIMARY CONTACT RECREATION	Geometric Mean April 1 – Oct. 31	Geometric Mean Nov. 1 – March 31
Class A	160	2358
Class B	262	2358
Class C	427	3843
SECONDARY CONTACT RECREATION	Geometric Mean Jan. 1 – Dec. 31	
Class a	2358	
Class b	3843	

Note: The term "counts" in this TMDL will refer to the criteria parameter: CFUs / 100 ml

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2008- 303(d): Bacteria levels on the South Fork Solomon River at Osborne (SC543) exceeded the geometric mean criteria in 2006. Geometric mean based sampling on Carr Creek did not exceed the secondary contact recreation criterion. Sampling on Twin Creek did not produce any samples because of dry or pooled stream conditions.

Stream Monitoring Sites and Period of Record: KDHE permanent ambient Stream Chemistry sampling station SC543, located on the South Fork of the Solomon River on a county road bridge 1.5 miles east and 0.75 miles south of Osborne from 2003-2009 **(Figure 1)**. A permanent sampling station SC737, located on the South Fork Solomon River near Woodston similarly has E coli data from 2003-2009. Rotational stations on Kill Creek (SC665), Covert Creek (SC666) have data from 2003 and 2007, although zero flow occurred during many of those site visits. Twin Creek (SC668) and Carr Creek (SC669) have data from 2004 and 2008. A rotational sampling station, SC542, located above Osborne on the South Fork has no data since 1998.

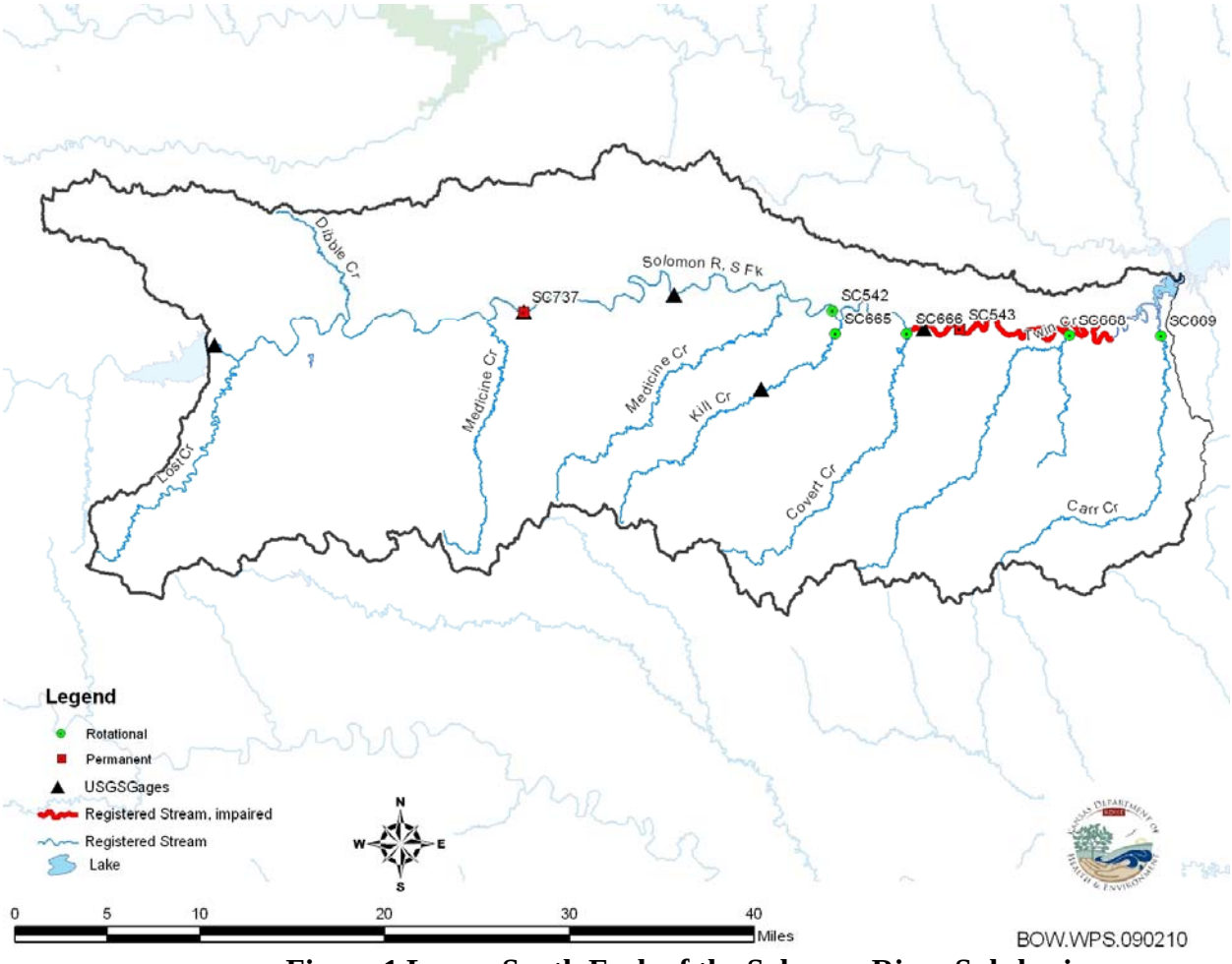

Figure 1 Lower South Fork of the Solomon River Sub-basin

Hydrology: The USGS has maintained gaging stations on the South Fork of the Solomon River below Webster Dam (06873200) from 1956-2002, at Woodston (06873460) from 1978-present and at Osborne (06874000) since 1946. Since 1990, there has been little discharge out the main river outlet at Webster dam, but substantial gains in flow are seen between Webster and Woodston and then at Osborne (**Figure 2**). Flow conditions at Woodston and Osborne dried somewhat during the 2003-2009 period, relative to flows seen over 1990 – 2002. Irrigation return flows and canal waste releases to the river likely comprise much of the increase in flow seen at Osborne. KDHE sampling for E coli bacteria since 2003 has been predominantly at the lower flow conditions **(Figure 3).** Sampling at higher flows occurred with the resumption of wet conditions in mid-2007 to present (**Figure 4**). Despite the lower flows over 2003-2006, elevated E coli bacteria was seen. The geometric mean violations occurred at low flows in April and June of 2006, averaging 6 and 0.65 cfs during each of the five sampling sets.

Over the past two decades, the high flow period occurs over May thru August, when irrigation flows move through the system (**Figure 5**). The more recent seven-year period when E coli sampling occurred had significantly lower flows, lower gains in flow between Woodston and Osborne and negligible monthly peaks during the traditional irrigation season.

Use attainability analysis surveys conducted by KDHE staff along the Lower South Fork between Webster Dam and Waconda Lake in 2005 showed good flow throughout the reaches but shallow depths. Stream depth was over two and a half feet in the pool below the Webster spillway, then shallowed to a half-foot as the stream coursed through Stockton to Osborne. Stream reaches from Osborne to Waconda Lake were a foot to a foot and a half in depth.

Bacteria Concentrations: E coli bacteria (ECB) were sampled at Osborne from July 2003 to December 2009 (**Figure 6**). Geometric mean of overall ECB data was 359 at Osborne (SC543) but isolating on the primary recreation season (April – October), the geometric ECB mean rose to 690 counts. Two sets of intensive sampling (five samples taken in a 30-day period) occurred in April and June of 2006. The geometric mean of the April samples was 528 counts and that for June was 1123 counts. These results were the justification for listing the stream as impaired.

High bacteria levels are seen during most primary contact recreation seasons, the off-season (November thru March) values are substantially lower. Five of the past seven recreation seasons have seen geometric means of samples taken in those months exceed the nominal criterion value for primary recreation (262 counts). These annual seasonal geometric means are not legal cause for citing impairment by bacteria, but give an indication of the persistence of high bacteria during April thru October in most years.

Plotting bacteria counts against the ambient flow at the time of sampling shows high bacteria become prevalent at flows below 10 cfs and over 100 cfs (**Figure 7**). Flows between 10 and 100 cfs do not automatically translate to high bacteria; the few samples taken in that flow range were at or below the 262 criterion value. While a few samples taken at flows below 10 cfs were below 262 counts, flows over 100 cfs would always have high bacteria. Off-season bacteria levels were mostly low at any flow condition.

If the flow-bacteria relation is viewed in the context of flow condition or flow duration (**Figure 8**), many high bacteria counts occur at flows exceeded more than 90% of the time. Most of the high bacteria levels are seen at relatively low flows (75-99%). Another set of high bacteria samples are seen at flow conditions where high flows are exceeded 20% of the time or less. Examining the bacteria levels against the gain in flow on the South Fork between Woodston and Osborne (**Figure 9**) shows large bacteria values under conditions of small contributions of flow from the watershed. When watershed-wide runoff does occur, bacteria counts increase as expected with the gain in flow, but during periods of little gain, similarly high bacteria levels are seen, especially when the gain in flow is less than one cfs. This implies that direct loading by adjacent sources into the stream above Osborne may be causing some of the high bacteria levels.

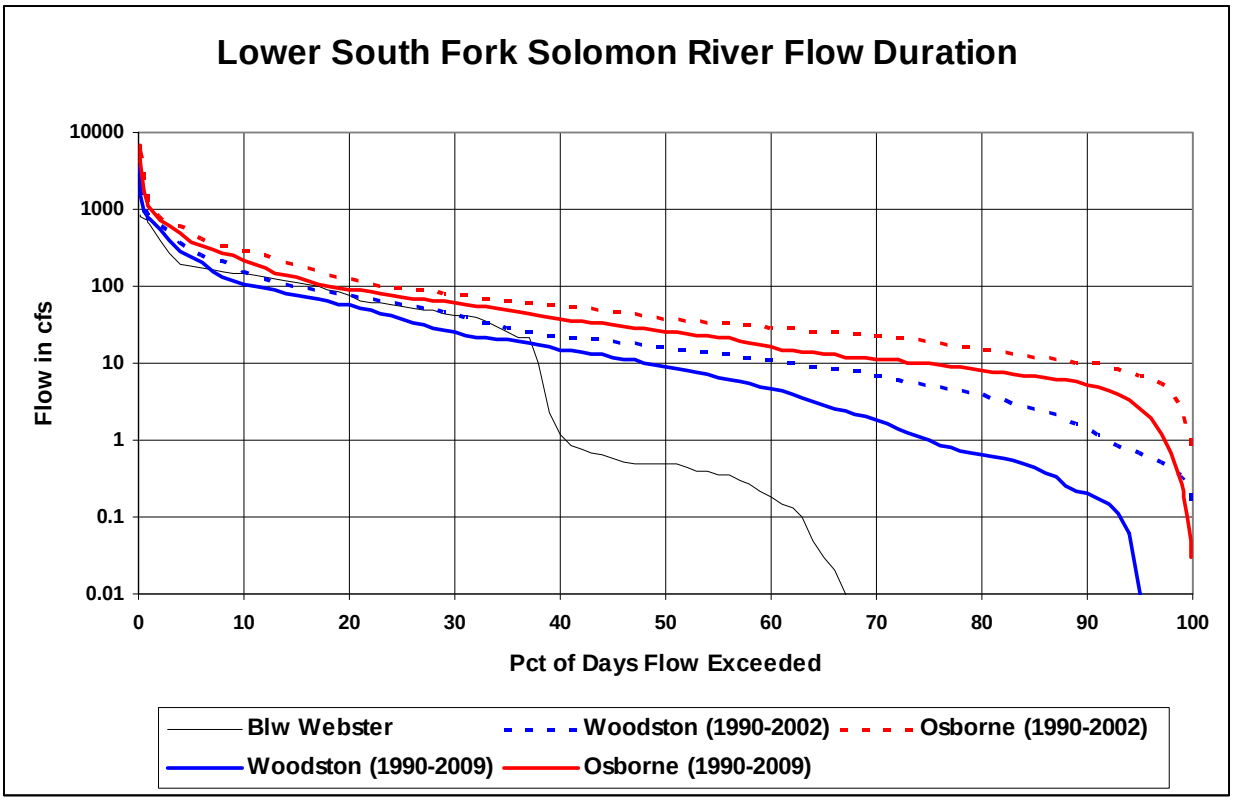

Figure 2. Flow Duration for Lower South Fork Solomon River

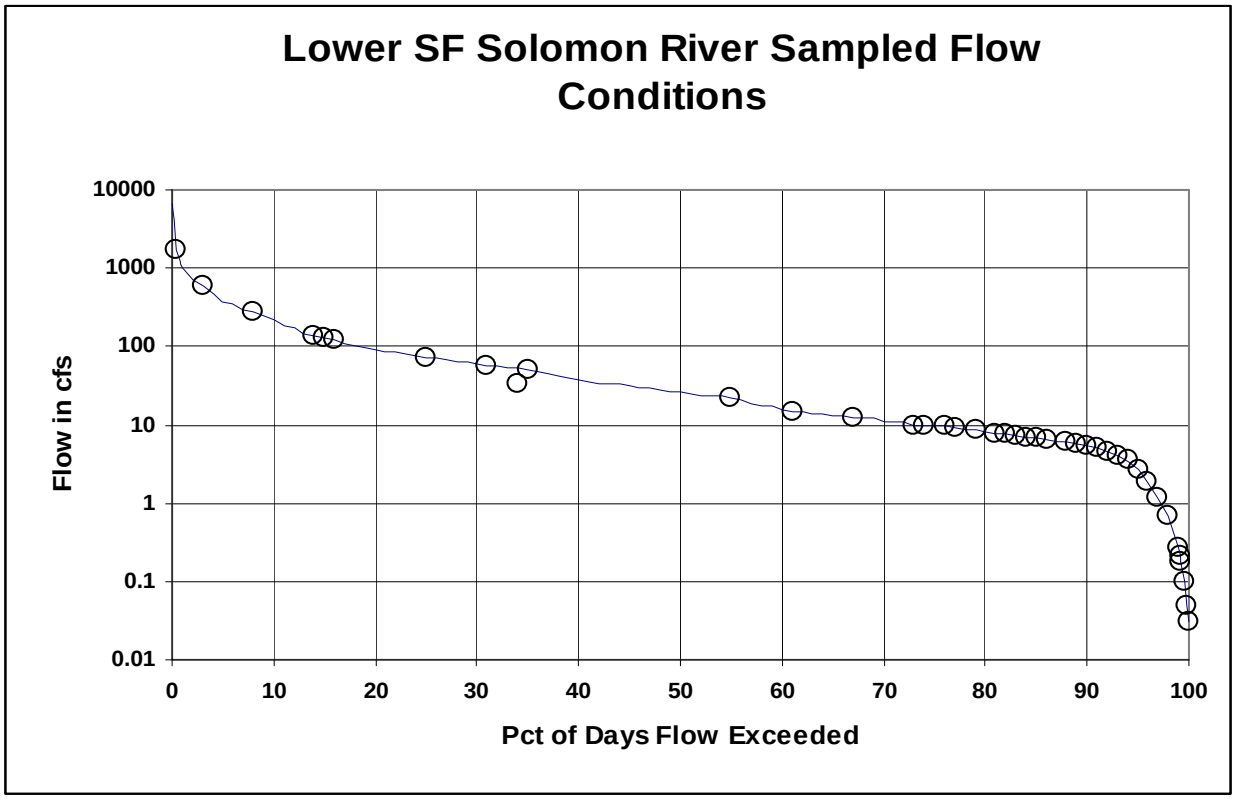

Figure 3. 2003-2009 E coli Bacteria Sampling Distribution along Flow Conditions

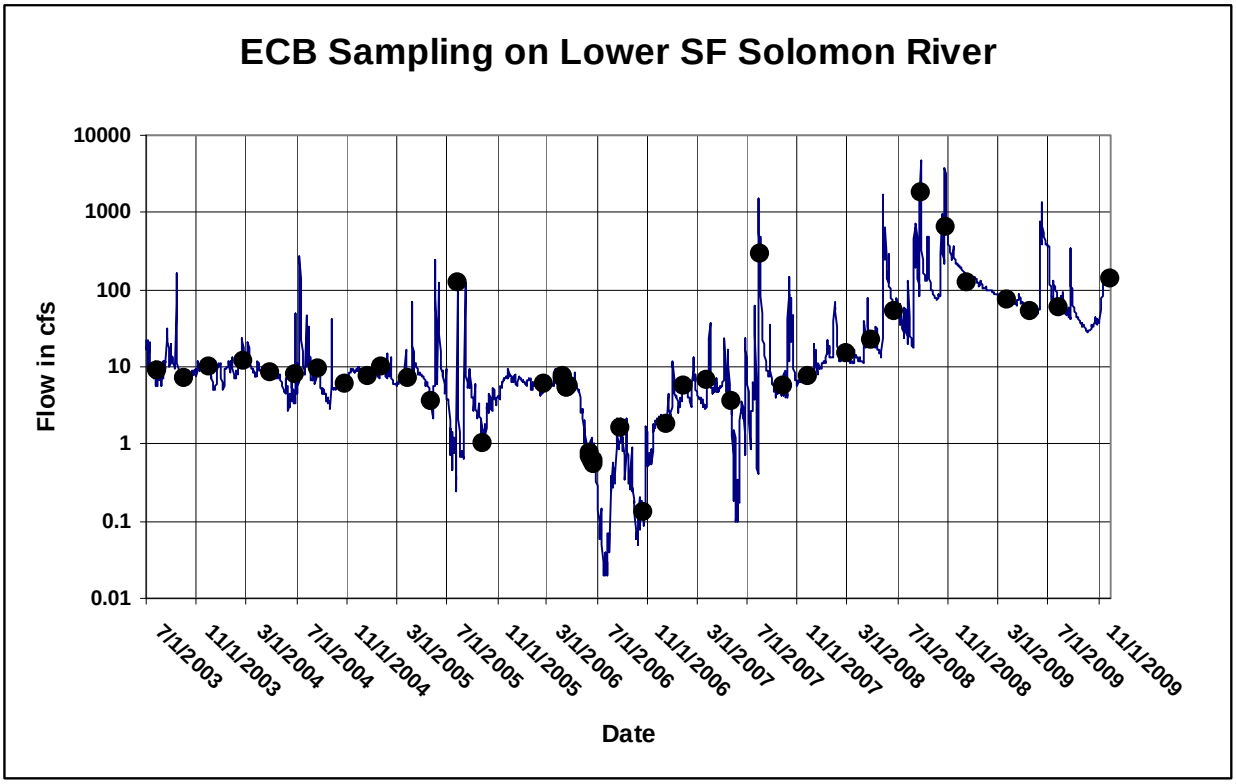

Figure 4. Daily Flows of South Fork Solomon River during 2003-2009 E coli Sampling

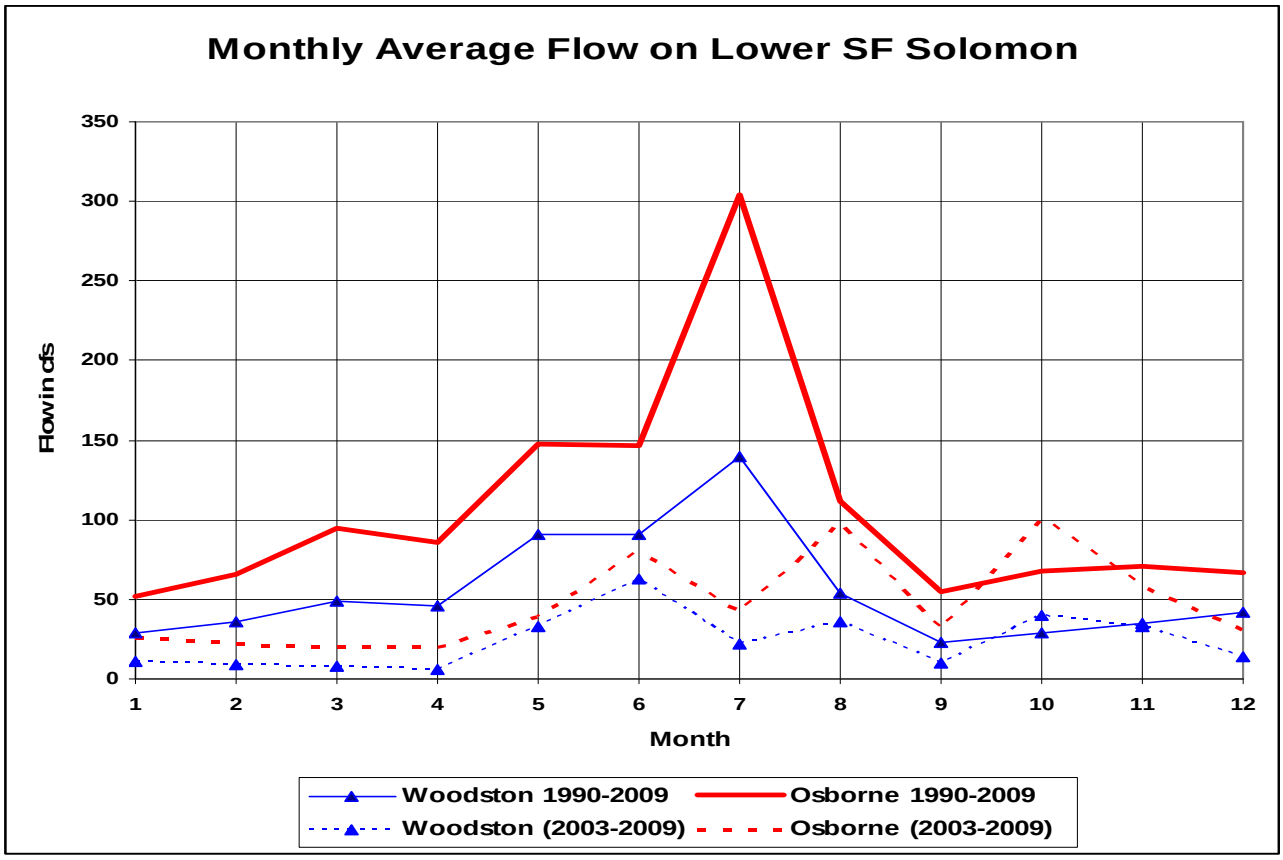

Figure 5. Monthly Average Flows on Lower South Fork of Solomon River

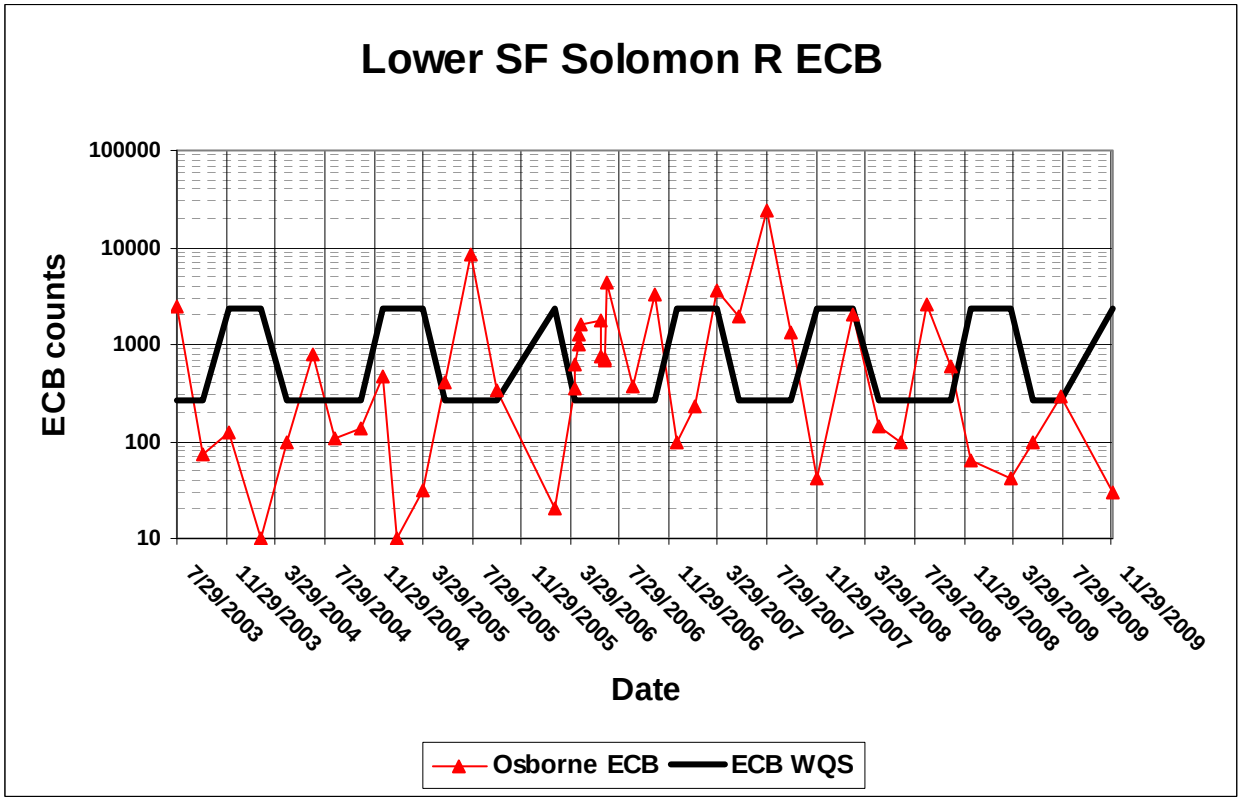

Figure 6. E coli Bacteria Counts on Lower South Fork of the Solomon River

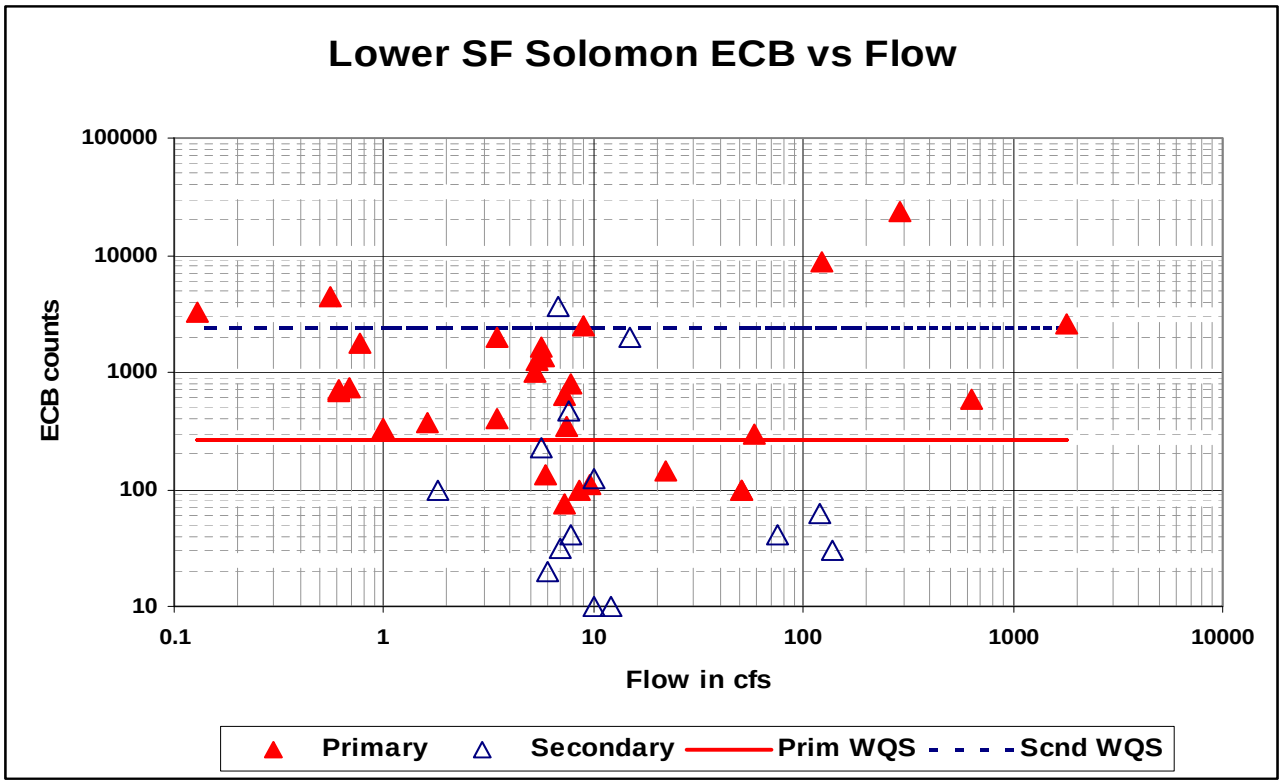

Figure 7. Bacteria and Flow on Lower South Fork of the Solomon River, 2003 – 2009

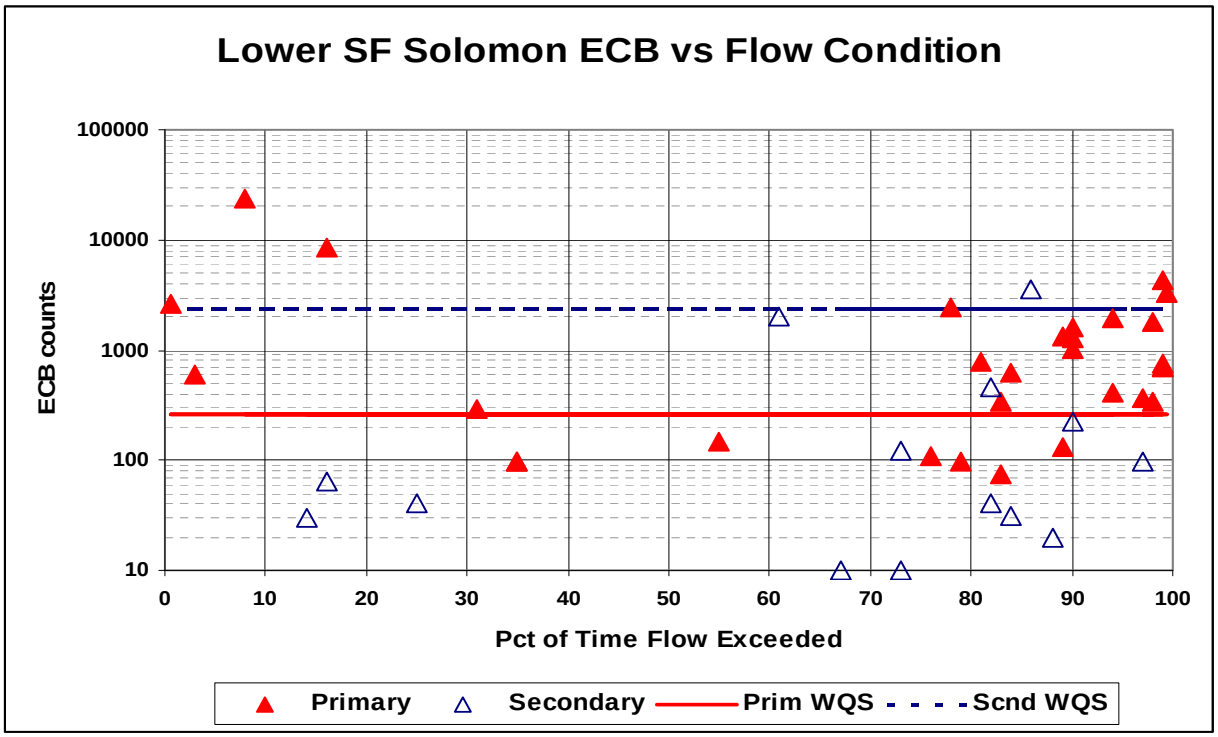

Figure 8. Bacteria at Varying Flow Condition on South Fork of the Solomon River.

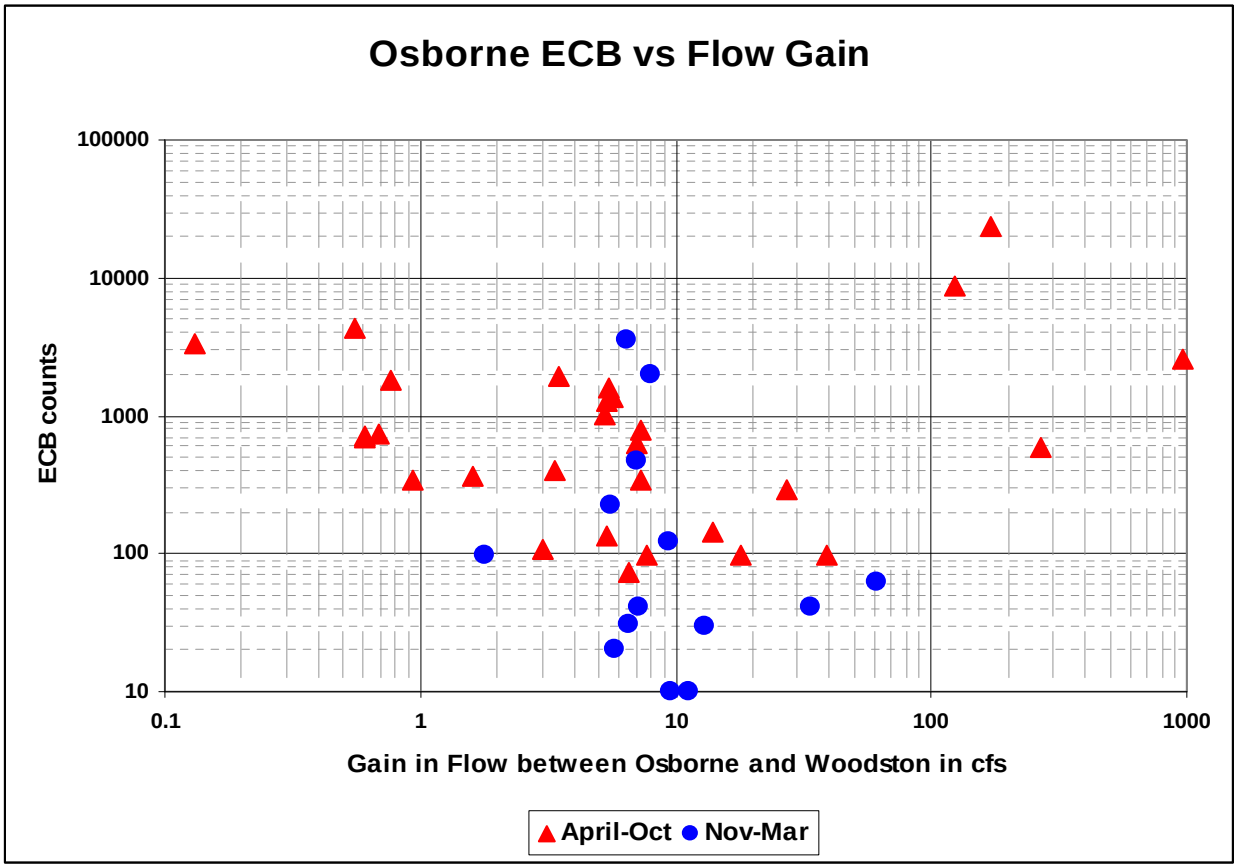

Figure 9. Bacteria on the South Fork under Varying Gains in Flow from Upstream

Bacteria levels on the South Fork at Osborne are substantially greater than those seen upstream at Woodston (**Figure 10).** Once flows exceed 20 cfs, the watershed begins to appear uniform in bacteria content, but at lower flows below 6 cfs, there is a marked increase in bacteria seen at Osborne than upstream or on tributaries. The tributaries do not sustain flow during dry weather, so their datasets are substantially smaller because of lack of flow. At higher flows, they begin to flow but still have generally lower bacteria levels than on the South Fork at Osborne.

There is some relationship between bacteria and suspended solids (**Figure 11**). A stronger relationship exists between bacteria and phosphorus (**Figure 12**). At Woodston, the bacteria – TSS relationship appears to be direct, but at Osborne, the relationship is almost flat for TSS values between 10 and 100 NTU. After TSS exceeds 100 NTU, a linear increase is seen with bacteria. With phosphorus, the relationship appears linear for both stations, albeit with substantial variability in the values of both parameters. The relationships imply that there is some near-field source of bacteria and phosphorus along the South Fork in Osborne County.

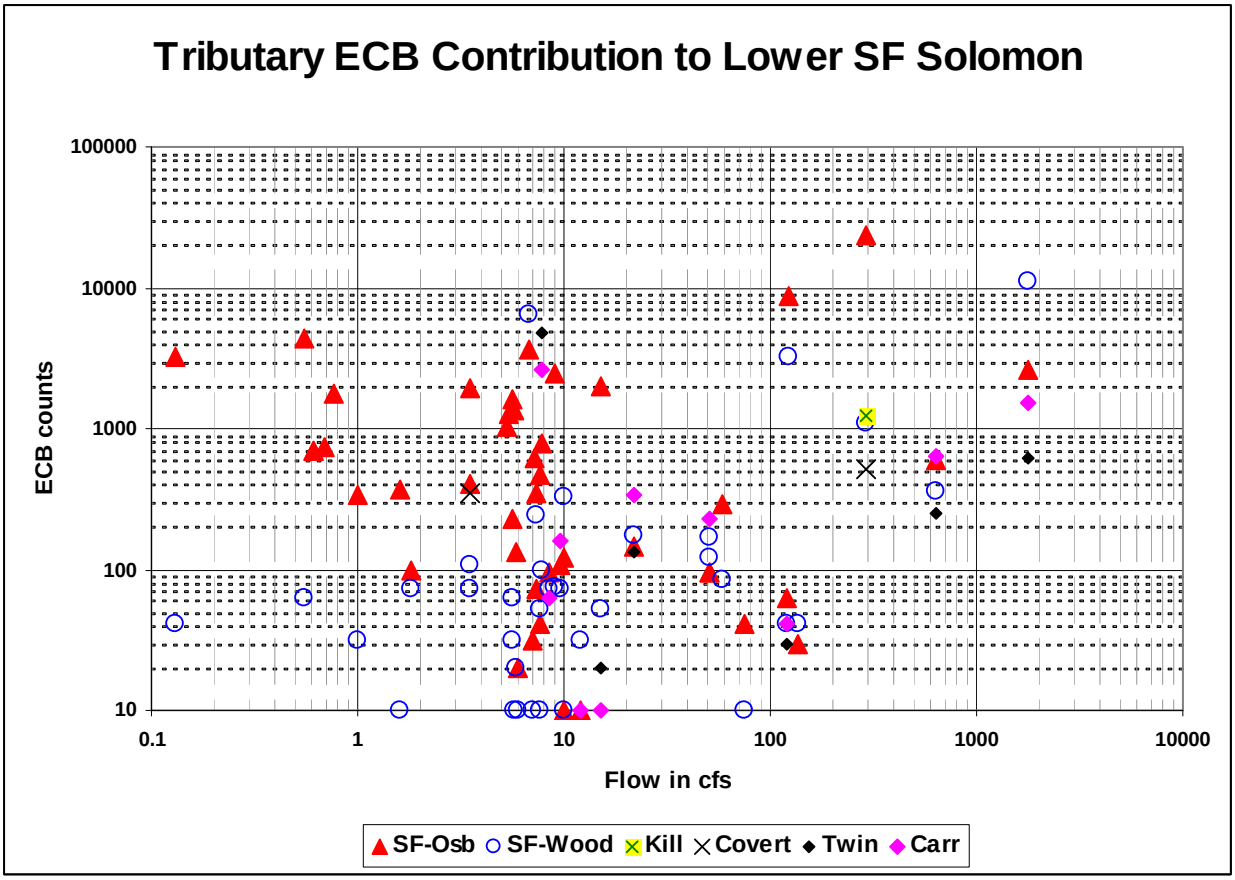

Figure 10. Tributary Contribution of E coli Bacteria to Lower South Fork Solomon River

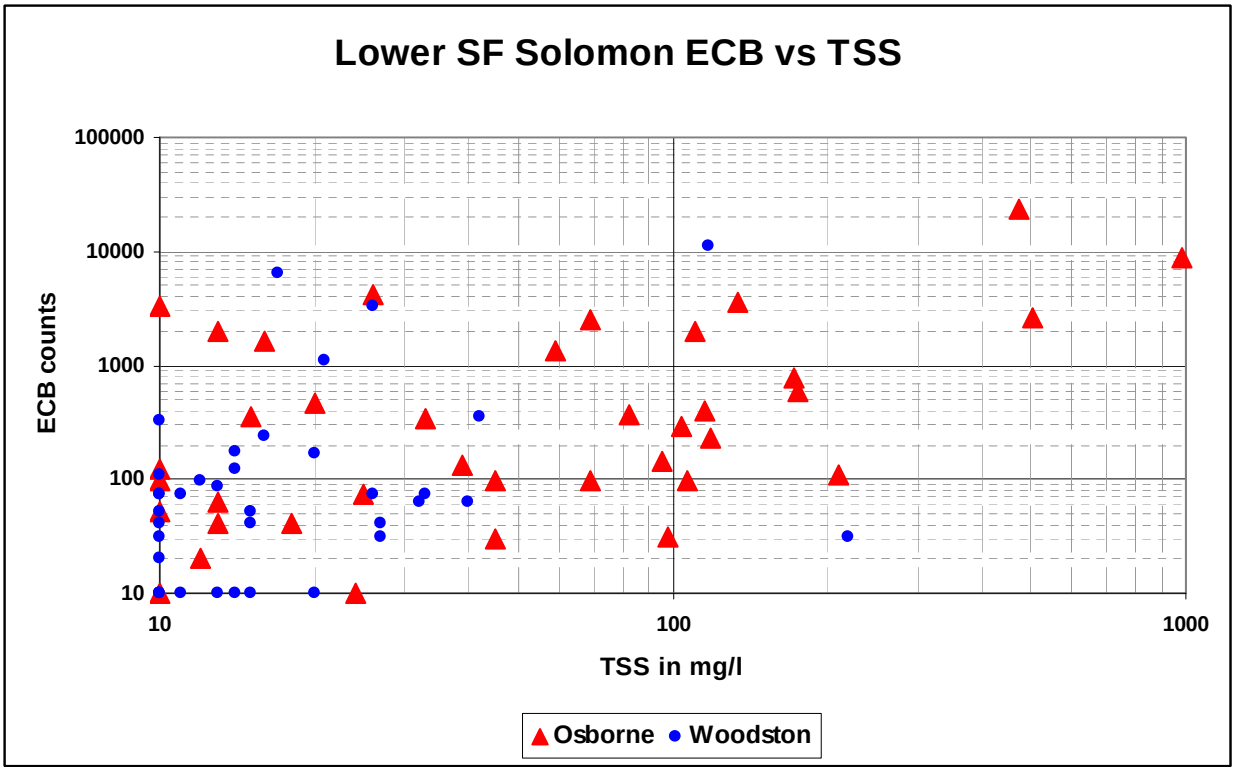

Figure 11. Bacteria – Suspended Solids Relationship in Lower South Fork Solomon River

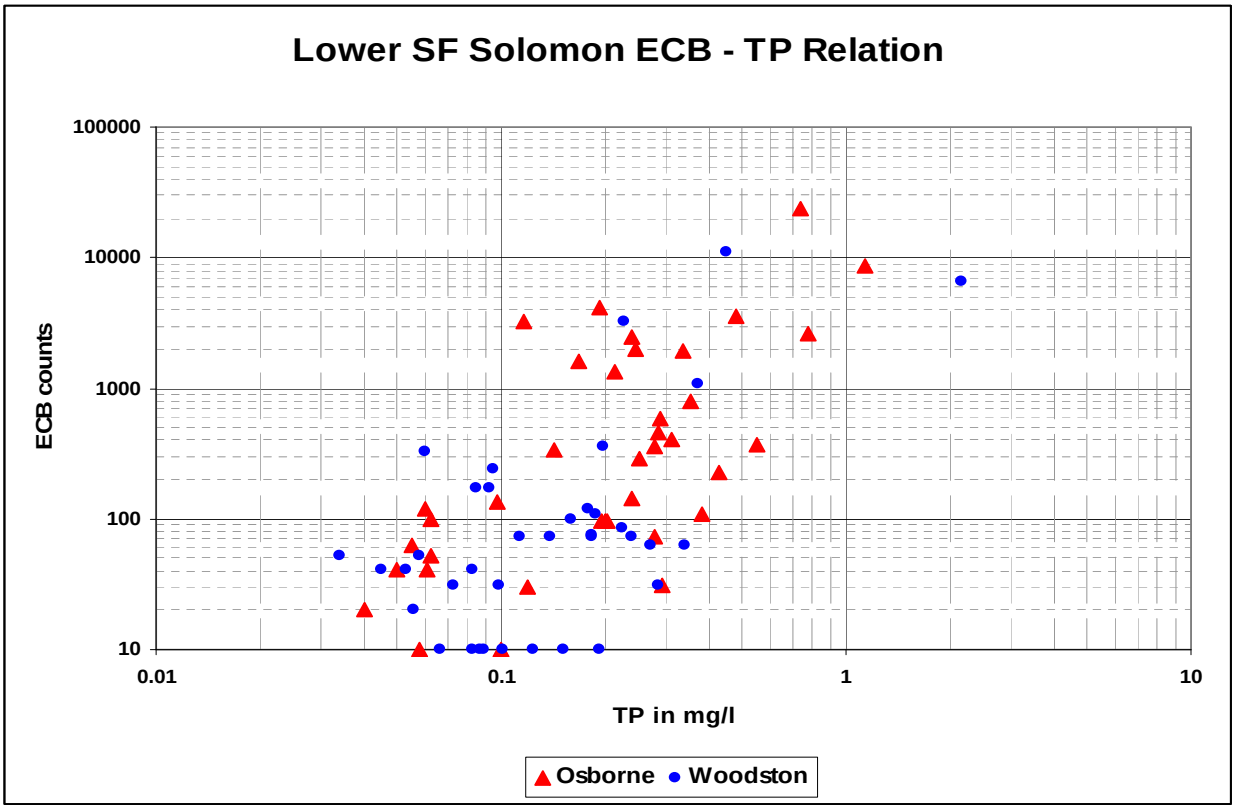

Figure 12. Bacteria – Phosphorus Relationship in Lower South Fork Solomon River

One way to look at the pattern of E coli presence along the South Fork of the Solomon River is to plot the respective ECB index profiles for stations at Osborne and Woodston **(Figure 13).** The index is computed for the samples taken during the primary (April – October) period by taking the natural log of each sample's bacteria count and divide by the natural log of the applicable criterion, in this case, 262 counts. The resulting values normalize each bacteria sample to the criterion and profiles can be derived by the cumulative frequency distribution of those index values.

In the case of the lower South Fork, the Osborne station displays a much more elevated profile than Woodston's. Ideally, at least 90% of the samples should be below the index value of 1 symbolizing the nominal 262 count criterion, as shown by the desired profile. There are still some digressions at Woodston, but they are dwarfed by the consistently high bacteria occurrence at Osborne. The profiles indicate that the likely sources of bacteria are occurring along the South Fork below Woodston. Implementation of controls and management practices should result in lowering the profile for Osborne in the future. This would indicate reductions in the magnitude, duration and frequency of bacteria levels in the lower reaches. The utility of the index profile is to use routine sample data to assess bacteria conditions until such time that low bacteria is regularly encountered, justifying use of the more intensive (five times in 30 days) sampling to assess compliance with water quality standards.

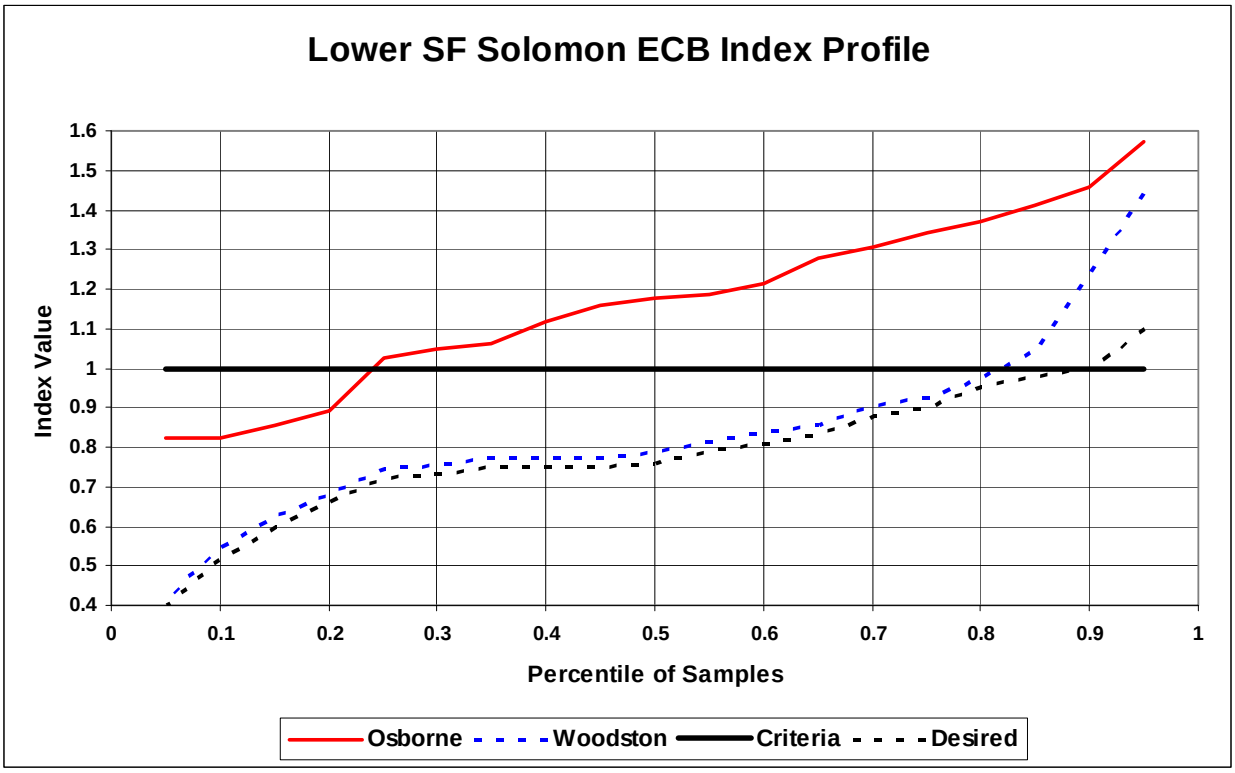

Figure 13. E coli Bacteria Index Profile for the South Fork Solomon River

Use Attainability: Use Attainability Analyses were conducted in 2005 in the Lower South Fork Solomon Sub basin. Four segments were found to support Primary recreation; 1, 3, 4 & 10. The first three segments run from Osborne to Waconda Lake and were found to have adequate depth to support primary recreation. Segment 10 is located immediately below the spillway at Webster Dam. Segment 4 runs through Osborne and is therefore accessible to the public, the downstream reaches are more limited in access, therefore, they are designated with the less stringent recreation status (Class "C" vs "B"). The remaining reaches of the South Fork and all the tributaries are too shallow to support primary contact recreation. Certain streams lost their status as classified streams because of their paltry hydrology and lack of a defined channel. As ephemeral streams, they would flow only with excessive rainfall and runoff.

Streamflow measurements at the USGS gage at Osborne (06874000) from 1987 – 2008 (and a few from 1946-49) were used to establish a dataset of flow, depth and velocities across a wide range of flow conditions. Regression equations were used to establish hydraulic geometry relations for depth (**Figure 14**) and velocity (**Figure 15**):

Depth = 0.284 * Flow^0.368 (R2 = 72%)
Velocity = 0.565 * Flow^0.178 (R2 = 56%)

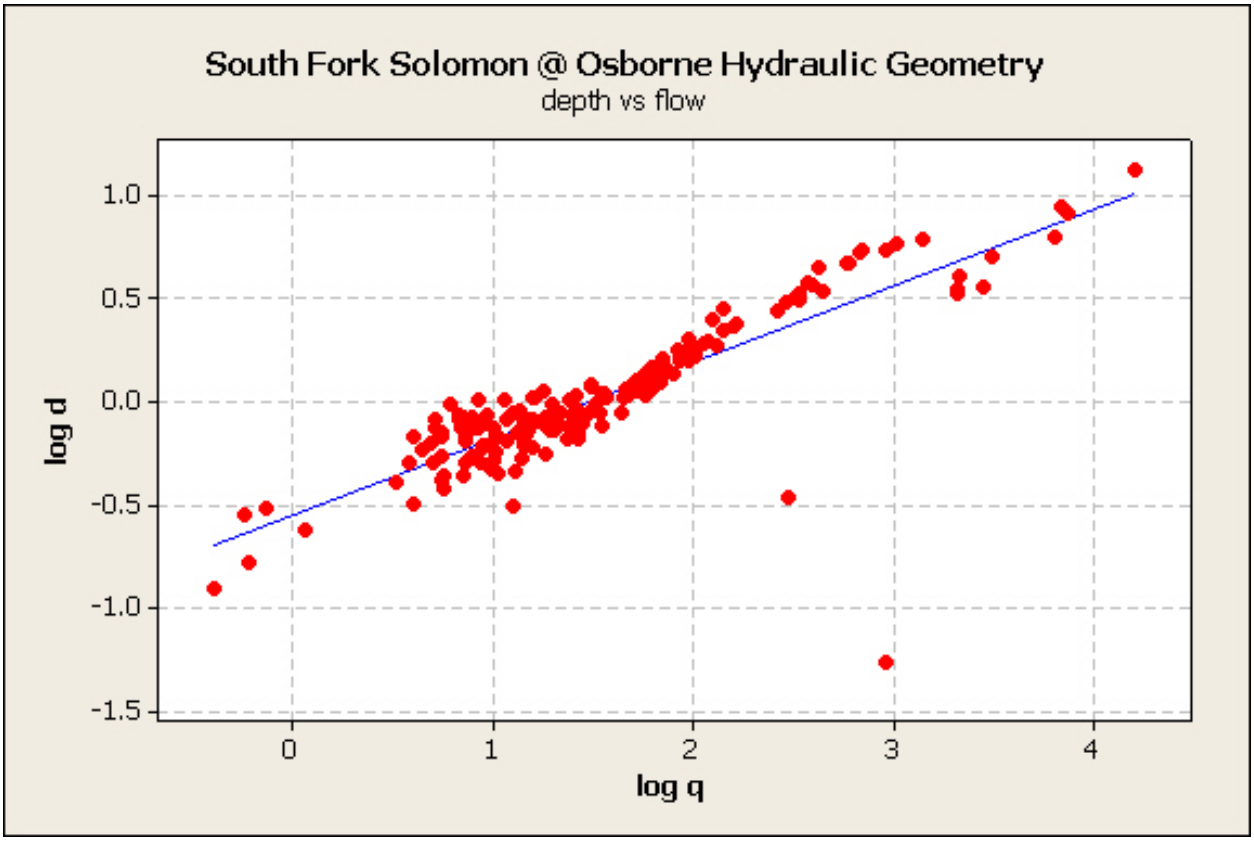

Figure 14. Log-normal relationship of depth & flow on South Fork Solomon at Osborne

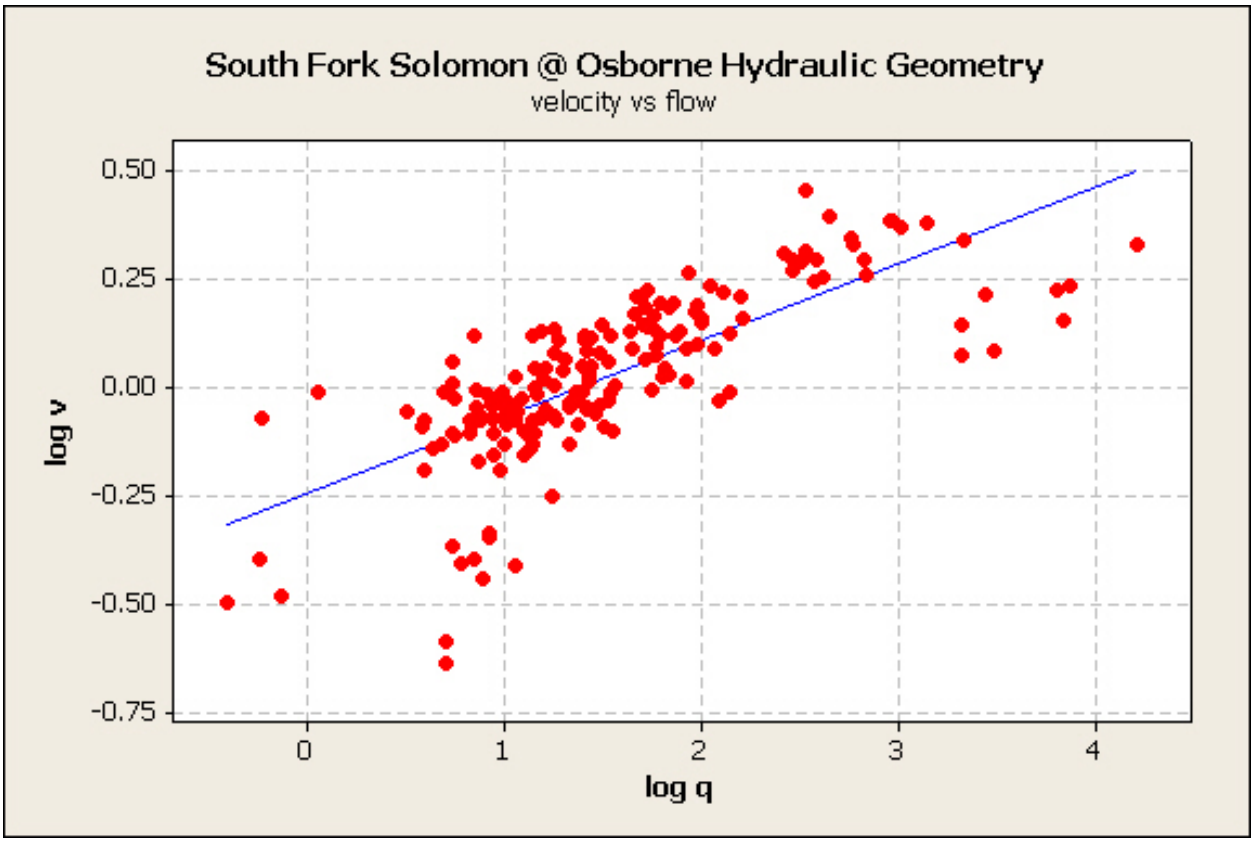

Figure 15. Log-normal relationship of velocity & flow on South Fork Solomon at Osborne

These relations were used to convert the flow duration curve into duration curves for specific depths and velocities. For this TMDL, although average depths over one and a half feet suggest primary contact recreation in Kansas, a depth of 1.25 feet was used to designate favorable primary recreation conditions. Average velocities over two feet per second constrain primary recreation because of safety concerns. Additionally, USGS protocols (Jim Putnam, USGS, pers comm., 2008) for stream wading suggest if the depth-velocity product (dxv) exceeds the wader's height, nominally, six feet, the stream is not safe to enter.

Figure 16 displays the estimated depth and velocity conditions seen over time on the South Fork. Because of its deeper runs along the channel at and below Osborne, optimal conditions for primary contact recreation occur once flows exceed the median flow. Unsafe conditions only occur for a very small percentage of time. Therefore, the primary recreation condition is conservatively suggested to be at flows exceeded 1-35% of the time. This relation tends to support the designation of the lower South Fork as supporting primary contact recreation.

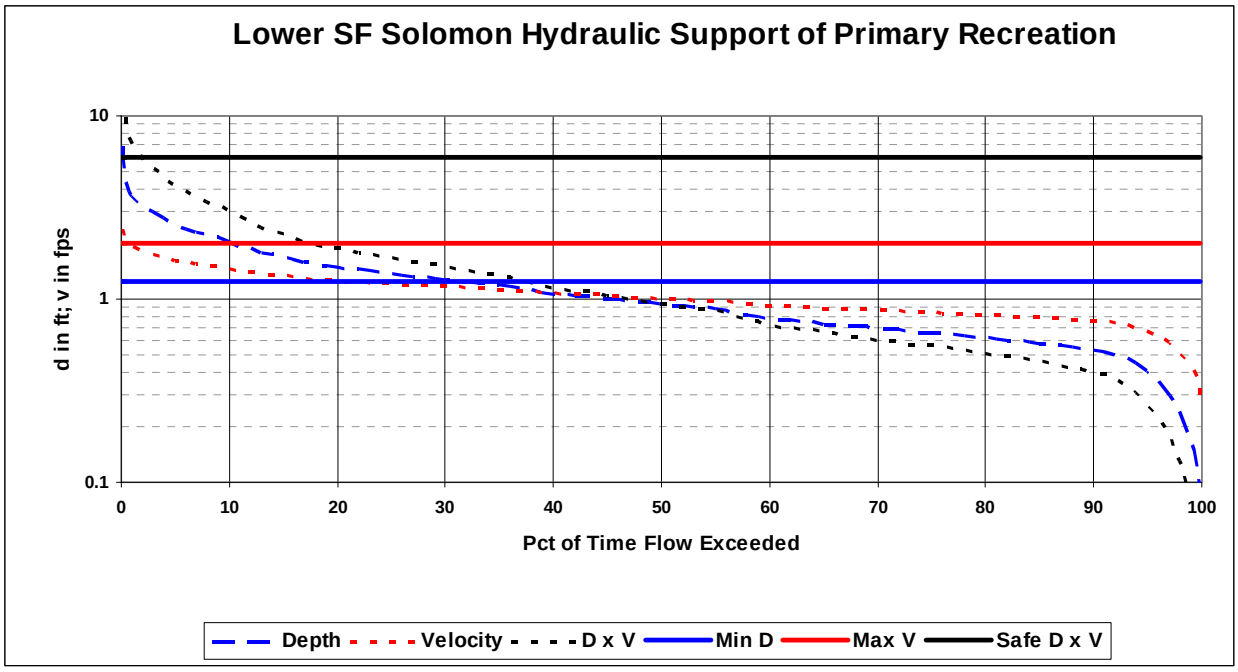

Figure 16. Hydraulic Geometry Supporting Primary Recreation on South Fork Solomon River

Desired Endpoint: The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards and support primary recreation on the Lower South Fork of the Solomon River. This requires geometric means of five samples taken within a 30-day period to be below the applicable criterion during April to October. For the purposes of this TMDL, the criterion will be 262 counts of E coli bacteria at Osborne. This reflects the recreation Class "B" designation for Segment 4, and would support the recreation Class "C" designations of the downstream segments heading toward Waconda Lake. Any reduction in bacteria loading along the tributaries of the South Fork will be conducted with the objective of reducing the ambient bacteria concentrations seen on the South Fork, but the data suggest the emphasis should be along the main stem of the South Fork. Because of the coincident elevation of sediment and nutrients during periods of high bacteria, implementation of this TMDL will effectively reduce all three pollutants on the South Fork above Waconda Lake.

Achievement of these endpoints indicate any loads of bacteria 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

Point Sources: There are a number of NPDES permitted facilities in the Lower South Fork Solomon Sub-basin (**Figure 17**), but only two potentially discharge to the surface waters of the South Fork above Station SC543 **(Table 3)**. The other facilities are industrial users, discharging process water, concrete plants and quarries and non-discharging municipalities and commercial entities; none who contribute bacteria from their wastewater. There are no MS4 stormwater permits.

The City of Stockton has a mechanical activated sludge plant that discharges to Dibble Creek, a tributary to the South Fork. The plant utilizes ultraviolet irradiation to disinfect its wastewater. Stockton monitors for bacteria weekly and since July 2008, has averaged 2830 counts of bacteria in its effluent, with numerous exceedances over its permit limit of 2358 counts (**Figure 18**). The episodes of high wastewater bacteria may be a factor in the elevation of bacteria downstream, but the Woodston station is below Stockton and typically does not see consistently high bacteria.

The City of Osborne uses a four-cell lagoon system to treat its wastewater. Disinfection occurs naturally with 120-days of retention before discharge to the South Fork. Reuse is allowed to irrigate surrounding croplands or grasslands. Among quarterly sampling periods, only three samples have been obtained, ranging in bacteria content from 219 counts in August 2008 to 1730 counts in September 2009. The last sample taken in December 2009 had only 9 counts of bacteria.

The City of Tipton discharges from a three-cell lagoon to Carr Creek which enters the South Fork below Station SC543. While it has a design flow of 0.0228 MGD, in practice, it has rarely discharged since 2004. The city has no limits for bacteria and monitors quarterly.

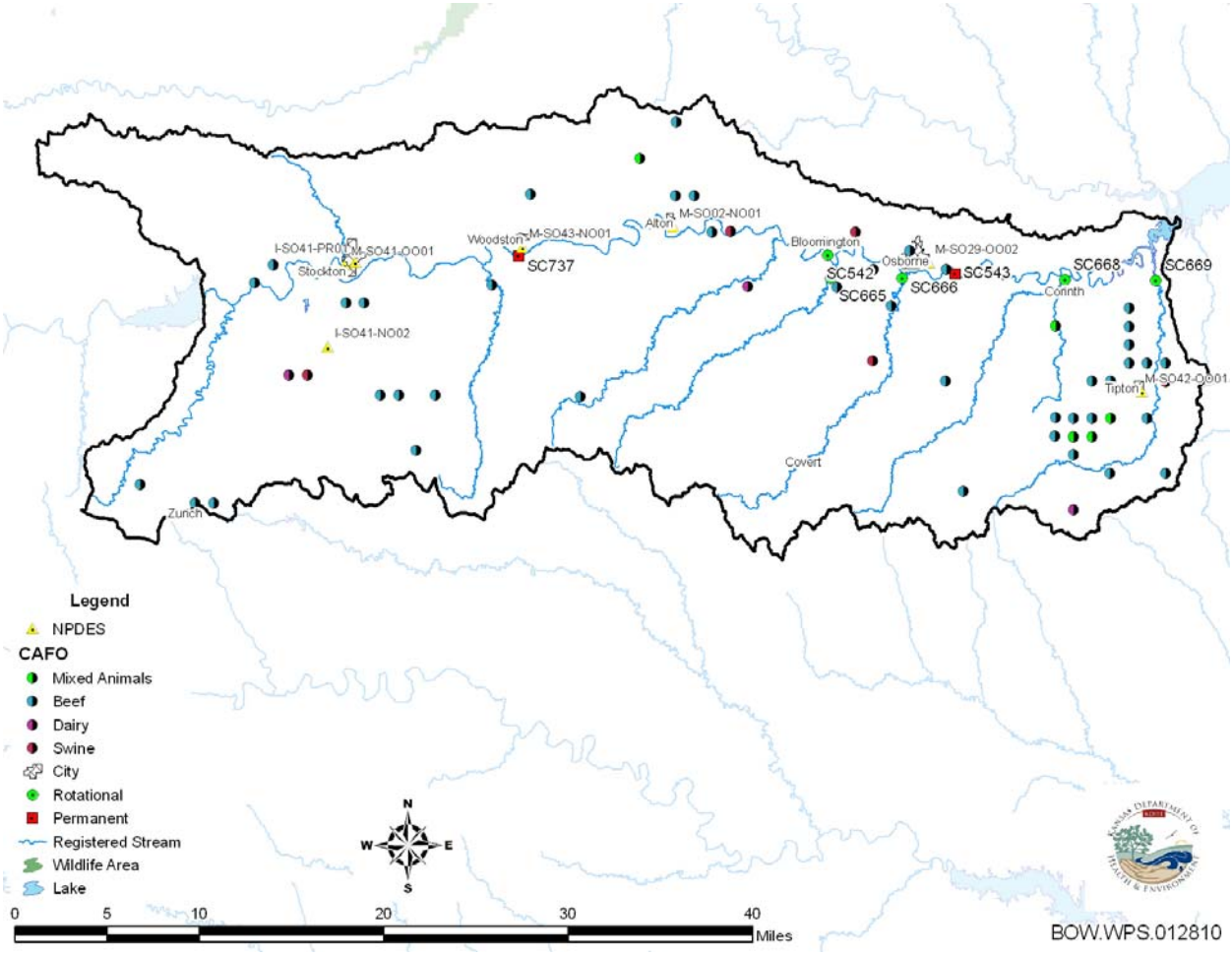

Figure 17. NPDES Facilities in the Lower South Fork Solomon Sub-basin

Table 3. NPDES Facilities in Lower South Fork Solomon Subbasin

Facility	NPDES#	KS Permit #	Type	Rec Stream	Design Q (MGD)	Permit Expires
City of Stockton WWTP	KS0117625	M-SO41-OO01	Activated Sludge	Dibble Creek to South Fork	0.275	5/31/2014
City of Osborne WWTP	KS0092398	M-SO29-OO02	4-Cell Lagoon	South Fork Solomon River	0.286	9/30/2014
City of Tipton WWTP	KS0085219	M-SO42-OO01	3-Cell Lagoon	Carr Creek to South Fork	0.0228	3/31/2014
B&B Redimix, Stockton	KSG110068	I-SO41-PR01	Concrete Batch Plant	Unnamed Trib to South Fork	0.0	9/30/2012
Stockton Industrial Park	KSJ000207	I-SO41-NO02	Non-Q	N/A	0.0	1/31/2015
City of Woodston	KSJ000286	I-SO43-NO01	Non-Q	N/A	0.0	3/31/2015
City of Alton	KSJ000301	I-SO02-NO01	Non-Q	N/A	0.0	11/30/2010
Shaw-Davis-Shaw (Osborne)	KSG110152	I-SO29-PR01	Concrete Batch Plant	Unnamed Trib to South Fork	0.0	9/30/2012

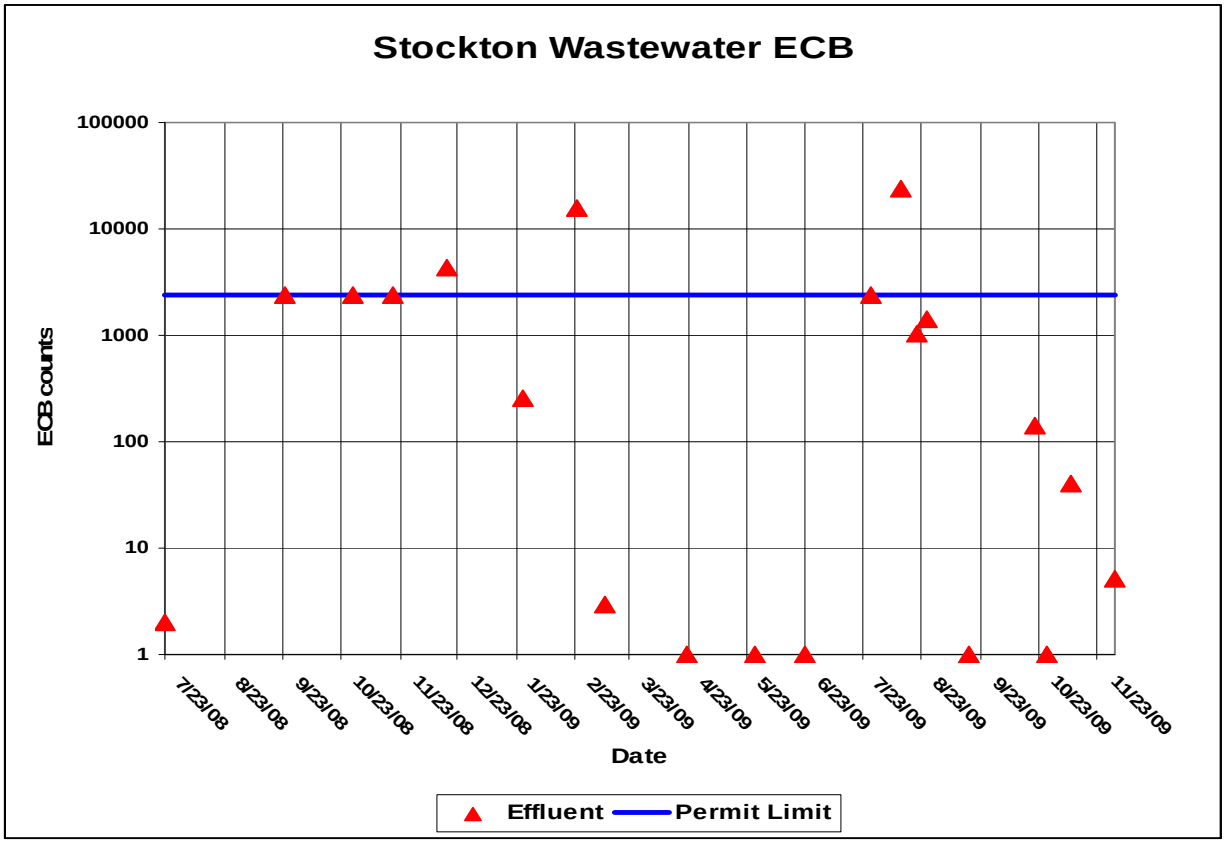

Figure 18. E coli Bacteria Content of Stockton Wastewater

Livestock Waste Management Systems: Twenty-eight operations are registered, certified, or permitted within the watershed above Station SC543 (**Figure 17**). There are 21 beef, 5 swine, and 2 dairy animal feeding operations in the watershed (**Table 4**). Three of these facilities are NPDES permitted, non-discharging facilities with 17,000 animal units. About 25,400 of the 27,700 animal units within state permitted facilities above SC543 are beef cows. Dairies comprise almost 200 animal units and swine facilities make up the remaining 2100 animal units.

Another 8656.5 animal units are permitted along the South Fork below Station SC543, 8130 animal units attributed to beef operations. Operations in Mitchell County make up 4755 of those animal units and include one NPDES facility of 1995 animal units (**Table 5**). Those facilities would not influence the bacteria levels found at SC543 that were the impetus for this TMDL, but they could impact recreation use on the lower reaches of the South Fork as it enters Waconda Lake. Actual number of animal units on site is variable, but is typically less than potential numbers.

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 to retain the 25 year, 24 hour rainfall/runoff event, as well as an anticipated two weeks of normal wastewater from their operations. Such a rainfall event typically coincides with stream flows which are exceeded 1-5 percent of the time. Therefore, events of this type, infrequent and of short duration, are not likely to add to chronic impairment of the designated uses of the waters in this watershed. Requirements for maintaining the water level of the waste lagoons at a certain distance below the lagoon berms ensure retention of the runoff from the intense, local storms events. In Rooks and Osborne counties, such events total 4.9 – 5.1 inches in 24 hours, generating 3.8 – 4 inches of runoff off low permeable surfaces.

Land Use: Most of the watershed is grassland (48.7%) or cropland (44.6% of the area). Developed land comprises 1.2% of the watershed. These proportions hold whether looking at the entire watershed between Waconda and Webster or just the subwatersheds above Station SC543 (**Figure 19**). Most of the cropland is located in the alluvial valleys of the South Fork or its tributaries or in irrigation district service areas and in proximity to the headwaters of Waconda Lake. Grassland is prevalent in the southern portions of the sub basin. The six sub-watersheds with greater than 60% grassland are the headwaters of Twin, Carr and Kill Creeks and upper and lower Covert Creek in Osborne County and Medicine Creek in Rooks County. The four subwatersheds with 60% cropland or greater are the South Fork valley below Osborne, the lower portions of Carr Creek and Medicine Creek in Osborne County. Livestock may be grazed on the grassland areas or on the harvested cropland areas.

On-site Waste Systems: Twenty-five to 30% of the population in Rooks and Osborne Counties use septic systems. The population density is low for Rooks and Osborne counties (5 – 6.4 people/mi^2). Estimated 2008 populations for the two counties indicate declines since 2000 of -9.7% (Rooks) and -14.6% (Osborne). All of the towns in the watershed saw declines between 2000 and 2008: -12.8% for Alton, -15.7% for Osborne, -10% for Stockton, and -8.6% for Woodston. The population of the unincorporated areas of the watershed will use on-site waste

Table 4 Permitted Livestock Operations in Lower South Fork Solomon River Subbasin

County	HUC10/12	KS Permit#	Permit Type	Fed AU	Type
Rooks	***0102***	A-SORO-BA01	Certification	500	Beef
		A-SORO-BA08	Certification	80	Beef
	0103	A-SORO-B011	Permit	800	Beef
	0104	A-SORO-C002	NPDES Permit*	6000	Beef
	0105	A-SORO-MA05	Certification	84	Dairy
		A-SORO-S003	Renewal	160	Swine
	0201	A-SORO-BA03	Certification	200	Beef
		A-SORO-B006	Permit	500	Beef
		A-SORO-BA04	Certification	300	Beef
	0203	A-SORO-B009	Renewal	200	Beef
		A-SORO-C001	NPDES Renewal**	8000	Beef
	0204	A-SORO-B012	Permit	900	Beef
	0206	A-SORO-B007	Permit	800	Beef
Osborne	***0301***	A-SOOB-BA15	Certification	60	Beef
		A-SOOB-S007	Permit	320	Swine, Beef
		A-SOOB-S004	Permit	32	Swine
		A-SOOB-BA17	Certification	250	Beef
		A-SOOB-B006	Permit	750	Beef
	0302	A-SOOB-M003	Permit	112	Dairy
		A-SOOB-BA09	Certification	900	Beef
	0304	A-SOOB-B003	Permit	700	Beef
	0306	A-SOOB-BA16	Certification	300	Beef
		A-SOOB-S011	Permit	831.2	Swine
	0307	A-SOOB-BA10	Certification	75	Beef
		A-SOOB-S001	Permit	768	Swine
	0401	A-SOOB-B002	Permit	980	Beef
		A-SOOB-C001	NPDES Permit***	3000	Beef
		A-SOOB-B012	Permit	102.2	Beef
	0403	A-SOOB-BA12	Certification	700	Beef, Swine
	0404	A-SOOB-BA04	Certification	300	Beef
		A-SOOB-BA08	Certification	290	Beef
		A-SOOB-M005	Permit	141.5	Dairy, Beef, Swine
		A-SOOB-M002	Permit	105	Dairy
		A-SOOB-B010	Permit	300	Beef
		A-SOOB-BA07	Certification	290	Beef
		A-SOOB-B007	Renewal	600	Beef
	0405	A-SOOB-B005	Permit	300	Beef
		A-SOOB-B008	Permit	426	Beef, Swine
		A-SOOB-B011	Renewal	250	Beef
		A-SOOB-BA14	Certification	199	Beef
NPDES #'s: *KS0097551 **KS0080888 ***KS0085847					

Table 5. Lower South Fork Solomon Livestock Operations in Mitchell County

County	HUC10/12	KS Permit#	Permit Type	Fed AU	Type
Mitchell	***0404***	A-SOMC-BA01	Certification	400	Beef
		A-SOMC-C004	NPDES Renewal*	1995	Beef
	0405	A-SOMC-B008	Renewal	400	Beef
		A-SOMC-BA25	Certification	300	Beef
		A-SOMC-BA10	Certification	500	Beef
		A-SOMC-BA31	Certification	100	Beef
		A-SOMC-B009	Permit	500	Beef
		A-SOMC-BA27	Certification	280	Beef
		A-SOMC-S013	Permit	280	Swine
*** NPDES # : KS0097420**					

systems, but is declining with time. Additionally, the number of failing systems will likely diminish through efforts of the Local Environmental Protection Program and by their low volume nature, only such failing systems close to the streams will likely have an impact on ambient stream water quality.

Contributing Runoff: The watershed's average soil permeability is 1.3 inches/hour according to NRCS STATSGO database. About 90.3% of the watershed produces runoff even under relatively low (1.5''/hr) potential runoff conditions. 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 4.5% of this watershed, chiefly along the stream channels.

Background Levels: Some contributions from wildlife, but it is likely that the density of animals such as deer is fairly dispersed across the watershed resulting in minimal loading to the streams below the levels necessary to violate the water quality standards.

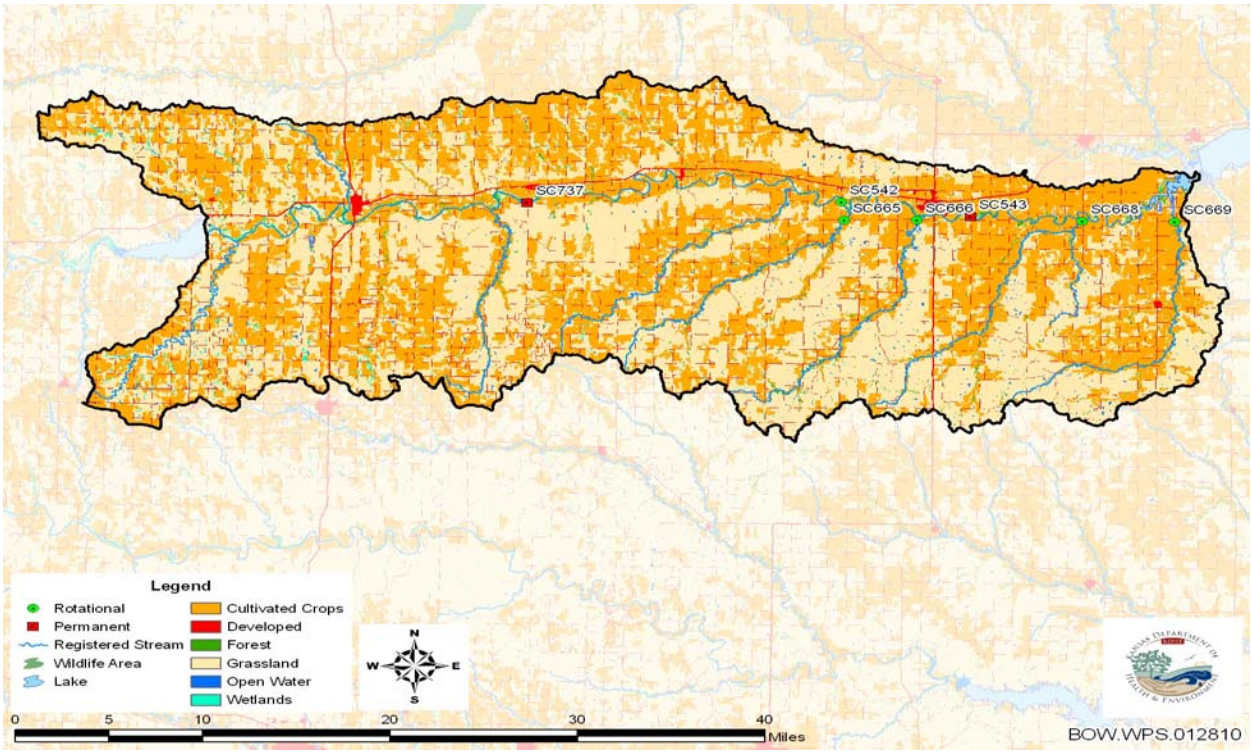

Figure 19. Land Use on the Lower South Fork Solomon River

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

This TMDL will be established to meet the primary recreation season geometric mean of bacteria counts for the South Fork Solomon River at Osborne. For Segment 4, as monitored by SC543, the geometric mean of five samples taken within 30 days should be below 262 counts during April through October. Adherence to the water quality standard in Segment 3 should beget attainment on downstream Segments 1 and 3 with their applicable geometric mean criterion of 427 counts.

While the legal determination of attainment is geometric means below the criterion, this TMDL will look to reduce the duration, frequency and magnitude of individual E coli samples taken during the primary recreation season such that a majority will be below the nominal value of the criterion. **Figure 20** displays the distribution of KDHE samples taken since 2003 over flow conditions at SC543 and SC737. Lower flows dominate the periods of KDHE sampling, so the current condition lacks definition in the mid-range flows. However, the hydraulic geometry of South Fork is favorable to support primary recreation during flows greater than median flow. While the Woodston station exhibits high bacteria during high flows, levels remain below the criterion value for the majority of flow conditions sampled. Conversely, Osborne displays consistently high bacteria levels at both high and low flows.

Table 6 displays the total flows, Load Capacity, Wasteload Allocations and Load Allocations for the Lower South Fork Solomon River at Osborne and in Segment 1 entering Waconda Lake. **Appendix C** provides the calculations for these daily loads of bacteria.

Table 6. Total Flows, Load Capacity, Wasteload Allocations & Load Allocations for Lower South Fork ECB

Flow Percentile	Osborne Flow	Osborne LC	Osborne WLA	Osborne LA	Seg 1/3 LC	Seg 1/3 WLA	Seg 1/3 LA	Flow @ Seg 1
90%	5.3 cfs	36.8 Gc/d	27.4 Gc/d	9.4 Gc/d	65.6 Gc/d	30.7 Gc/d	34.9 Gc/d	6.3 cfs
75%	9.8 cfs	65.6 Gc/d	27.4 Gc/d	38.2 Gc/d	113.6 Gc/d	30.7 Gc/d	82.9 Gc/d	10.9 cfs
50%	26 cfs	169.4 Gc/d	27.4 Gc/d	142.0 Gc/d	297.4 Gc/d	30.7 Gc/d	266.7 Gc/d	28.5 cfs
25%	73 cfs	470.5 Gc/d	27.4 Gc/d	443.1 Gc/d	850.7 Gc/d	30.7 Gc/d	820.0 Gc/d	81.5 cfs
10%	215 cfs	1380 Gc/d	27.4 Gc/d	1353 Gc/d	2584 Gc/d	30.7 Gc/d	2553 Gc/d	247.5 cfs

Point Sources: In accordance with The Surface Water Quality Standards at K.A.R.28-16-28e(c)(7)(F), "Wastewater effluent shall be disinfected if it is determined by the department that the discharge of non-disinfected wastewater constitutes an actual or potential threat to public health". Therefore, wastewater discharged by Stockton will be disinfected, while the two lagoon systems at Osborne and Tipton should have sufficient retention time prior to discharge to ensure bacteria die-off.

The Wasteload Allocations will reflect either applicable permit limits of counts (CFUs per 100 ml) of bacteria or expected levels of bacteria discharged by lagoons (**Table 7**). For Stockton, its current limit of 2358 counts would apply. While lagoon systems such as Osborne and Tipton have no permit limits for E coli bacteria, their Wasteload allocation will assume they need to have monthly geometric means of 262 counts and 3843 counts, respectively, reflecting the recreation designation of the stream segments to which they discharge. Non-discharging facilities such as Alton and Woodston will have Wasteload allocations of zero as will the other industrial dischargers who do not have bacteria in their wastewater. The confined animal feeding operations will have Wasteload allocations of zero, as well, because all of these facilities should not discharge to South Fork.

Both Stockton and Osborne have sporadic discharges of high E coli bacteria that may need to be reduced to achieve the goals and endpoints of this TMDL. Therefore, Wasteload Allocations for these dischargers would be based initially on adherence to their existing permit limits or expected performance (**Table 7**). If any discharger is shown to be causing the high bacteria levels at Osborne, subsequent adjustment and more stringent permit requirements will be made to their NPDES permit.

Table 7. Wastewater Permits and E coli Bacteria WLAs for South Fork Solomon River

Facility	Design Q	E coli Bacteria Existing or Expected Limit	Wasteload Allocation (giga-colonies/day)
Stockton	0.275 MGD (0.43 cfs)	2358 col/100ml	24.5
Osborne	0.286 MGD (0.44 cfs)	262 col/100 ml	2.8
Tipton	0.0228 MGD (0.04 cfs)	3843 col/100 ml	3.3
Total	0.584 MGD (0.91 cfs)		30.7

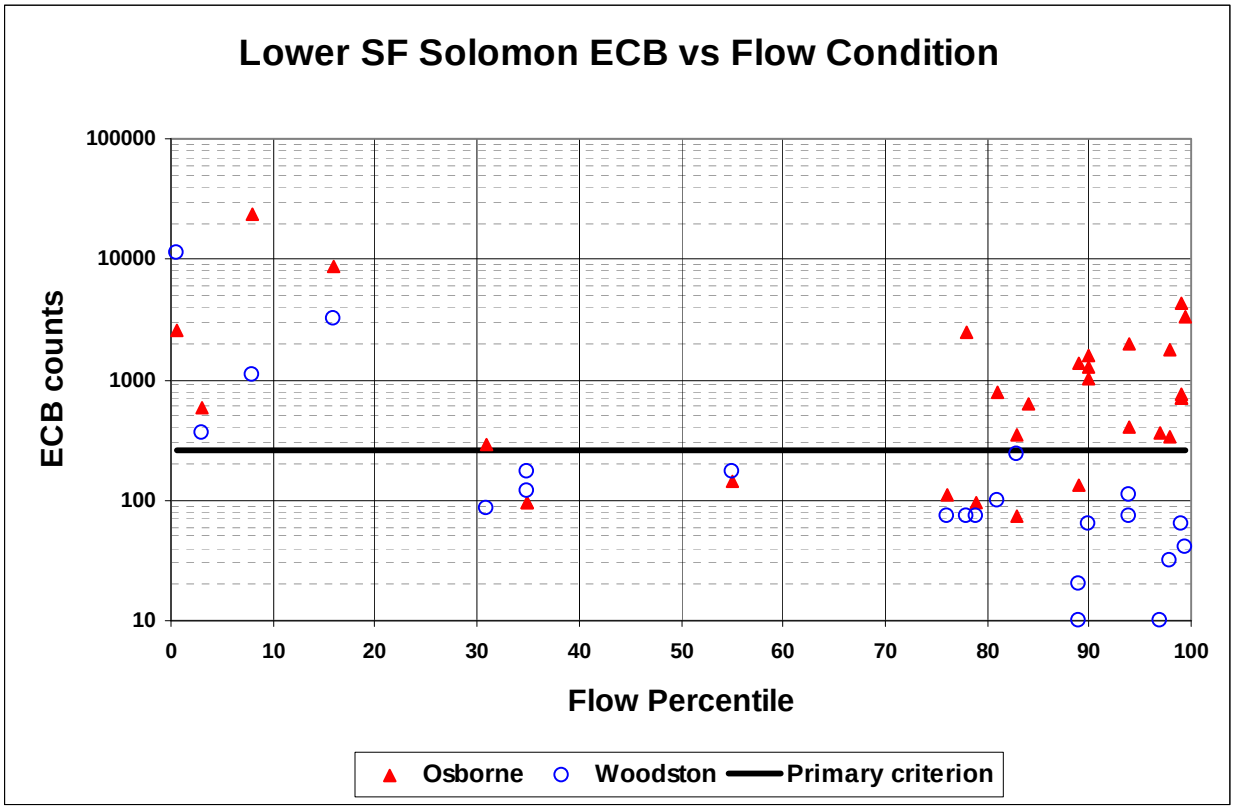

Figure 20. E coli Bacteria Distribution for Lower South Fork Solomon River

Nonpoint Sources: The Load Allocation (LA) assigns responsibility for nonpoint source contributors for the bacteria input into the South Fork, particularly from the tributaries. The Load Allocation for the South Fork in **Appendix C** would be determined from the remaining load from the total load capacity after accounting for the Wasteload Allocations. At low flow, either a point source is contributing bacteria or there are non-point activities (grazing livestock, leaking septic systems) in the immediate vicinity of the main stem of the South Fork below Woodston.

Progress will be determined by reduction in the Osborne ECB index profile, first approaching the Woodston profile and then the desired TMDL milestone indicated in **Figure 13.** Once the profiles decline, intensive sampling during the primary contact recreation season should ensue to assess whether the water quality standards are now being achieved.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty in bacteria loading into the South Fork, predominantly from point sources in the watershed. This TMDL uses an implicit margin of safety, relying on conservative assumptions tied to assuming Stockton and Osborne will discharge at design flows, even though demographic trends imply less loading in the future. Progress in reducing bacteria will be monitored through individual samples taken during primary recreation season, such that cumulative frequency, duration and

magnitude of individual digressions is reduced. Relying on individual samples is more stringent than assessing geometric means of multiple samples.
Finally, even though portions of the primary recreation season has hydrologic conditions that do not provide enough depth to support primary recreation, the primary criteria for the lower reaches will be applied as endpoints for this TMDL at any flow conditions throughout April to October.

State Water Plan Implementation Priority: Due to the concurrent mechanisms of loading bacteria into South Fork along with phosphorus and sediment during wet weather and the pervasively high bacteria levels seen at the lowest flows on the South Fork, this TMDL will be designated as a **High Priority** for implementation to direct point source compliance and non-point source management to abate such pollutant loads above Waconda Lake.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Lower South Fork Solomon Basin (HUC 8: 10260014) with a priority ranking of 34 (Medium Priority for restoration work).

Priority HUC 10s and Stream Segments: Priority focus of implementation should concentrate on the reaches of the South Fork Solomon between Woodston and Osborne and associated supporting tributaries and riparian areas in 1026001403. Additional controlling practices should be applied to 1026001402 & 06 along the South Fork below Osborne for the purposes of nutrient reduction to Waconda Lake.

5. IMPLEMENTATION

Desired Implementation Activities

1. Maintain disinfection operations under state and federal permits, inspect permitted facilities, continue monitoring requirements and evaluate compliance with permit limits, including adhering to non-discharge requirements.
2. Improve riparian conditions along stream systems by limiting overuse from grazing livestock along the stream.
3. Provide alternative water supplies for livestock to limit their use of streams as water sources.
4. Ensure land applied manure is being properly managed and is not susceptible to runoff into nearby streams.
5. Install pasture management practices, including proper stock density to reduce soil erosion and storm runoff.
6. Ensure proper on-site waste system operations in proximity to the main stream segments.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Monitor effluent from the discharging permitted wastewater treatment facilities, continue to encourage wastewater reuse and ensure compliance and proper operation to control bacteria in wastewater discharges.

b. Inspect and verify that non-discharging facilities at Alton and Woodston do not contribute wastewater to the South Fork of the Solomon.
c. Maintain permit limits after 2014 and operation of disinfection techniques.
d. Inspect permitted livestock facilities to ensure compliance.
e. New Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
f. New Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
g. Manure management plans will be implemented, to include proper land application rates and practices that will prevent runoff of applied manure.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 demonstration projects for reduction of bacteria loading from agricultural lands though livestock management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on bacteria management for livestock facilities in the watershed and practices geared toward small livestock operations which minimize impacts to stream resources.
d. Support Watershed Restoration and Protection Strategy (WRAPS) efforts for the Waconda Lake and incorporate long term objectives of this TMDL into their 9-element watershed plan

Water Resource Cost Share and Nonpoint Source Pollution Control Program – SCC

a. Install livestock waste management systems for manure storage.
b. Implement manure management plans.
c. Support terracing, grass waterways and buffers along cropland
d. Repair or replace failing septic systems which are located within 100 feet of the Lower South Fork or its tributaries.

Riparian Protection Program – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and stream bank vegetation.
b. Develop riparian restoration projects along targeted stream segments, particularly lower South Fork Solomon River.

Buffer Initiative Program – SCC

a. Install grass buffer strips near South Fork and tributary streams.
b. Mitigate removal of riparian lands from Conservation Reserve Program to hold streamside land out of production.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, bacteria and pasture management.
b. Educate livestock producers on livestock waste management and land applied manure applications.
c. Provide technical assistance on livestock waste management systems.

d. Provide technical assistance on buffer strip design and minimizing rural runoff.
e. Educate residents, landowners, and watershed stakeholders about homestead waste management.
f. Promote and utilize Waconda Lake WRAPS efforts at pollution prevention, runoff control and resource management.

Timeframe for Implementation: Inspection of point sources and rural runoff management should commence in 2010 on the lower reaches of the South Fork. Implementation of abatement practices should commence within 1026001403 in 2011, with subsequent efforts downstream in 102600140402 & 06. Implementation should continue through 2019.

Targeted Participants: The primary participants for implementation will be the agricultural and livestock operations immediately adjacent to the lower portions of South Fork Solomon River below Woodston. All will be encouraged to implement appropriate practices. Watershed coordinators and technical staff of the WRAPS, along with Conservation District personnel and county extension agents should assess possible sources adjacent to the streams over 2010 - 2011. Non-point source implementation activities should focus on those areas with the greatest potential to impact bacteria concentrations along the South Fork.

Targeted activities to focus attention toward include:

1. Overused grazing land adjacent to the stream.
2. Sites where drainage runs through or adjacent to livestock areas.
3. Sites where livestock have full access to the stream and it is their primary water supply.
4. Poor riparian area and denuded riparian vegetation along the stream.

Municipal wastewater systems will also be expected to comply with permit conditions and operate such that no bacteria impairment is contributed to the South Fork.

Milestone for 2014: In accordance with the TMDL development schedule for the State of Kansas, the year 2014 marks the next cycle of 303(d) activities in the Solomon Basin. Because bacteria loads are nonsensical, at that point in time, bacteria profiles from site SC543 should approach those of the upstream station SC737 (**Figure 13**). Such declines indicate reductions in the duration, frequency and magnitude of future E coli bacteria samples such that a majority will be below the nominal criterion value applied at Osborne. As the profiles approach the desired distribution expected by the TMDL, intensive sampling during the primary recreation season can be done to ascertain whether the primary season geometric means are in compliance with the bacteria criterion.

Delivery Agents: The primary deliver agents for program participation will be KDHE, the Waconda Lake WRAPS, the Osborne County Conservation District for programs of the State Conservation Commission and the cities of Osborne, Alton, Woodston and Stockton.

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. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. K.A.R. 28-16-69 through 071 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

5. 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 riparian areas.

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

7. 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.

8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected Watershed Restoration and Protection Strategies.

9. The Kansas Water Plan and the Solomon River Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic area of the state for high priority in implementation.

Funding: The State Water Plan 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 watershed 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 located within a **High Priority** WRAPS area and should receive support for pollution abatement practices that lower the loading of bacteria and associated pollutants of sediment and nutrients to the South Fork Solomon River and its tributaries.

Effectiveness: Use of retention and buffers that isolate streams from nearby uses and potential loadings has been effective in reducing the bacteria levels in streams, including under wet

weather conditions. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing runoff associated with livestock facilities.

6. MONITORING

KDHE will continue to collect quarterly to bimonthly samples in every year at Stations SC543 and SC737. Sampling can be expected at the rotational tributary stations between 2011 – 2020. Based on the sampling data, the priority status of the 303(d) listing will be evaluated in 2014. The stream will be evaluated for possible delisting in 2020. If necessary, supplemental intra-watershed monitoring for bacteria may occur between Stockton and Osborne to isolate possible sources of bacteria seen at Osborne. Additional monitoring of the lower reaches below Osborne may be necessary to ascertain support status for recreation above Waconda Lake.

7. FEEDBACK

Public Notice: An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Solomon Basin.

Public Hearing: A Public Hearing on this TMDL was held on February 10, 2010 in Phillipsburg to receive comments on this TMDL.

Basin Advisory Committee: The Solomon River Basin Advisory Committee met to discuss the TMDLs in the basin on July 7, 2009 in Stockton and September 30, 2009 in Stockton and again on March 2, 2010 in Beloit.

Watershed Restoration and Protection Strategy Group: This TMDL has been reviewed in February, 2010 by the Waconda Lake WRAPS group.

Milestone Evaluation: In 2014, evaluation will be made as the degree of implementation which has occurred within the watershed. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2014 with consultation from local stakeholders and WRAPS teams.

Consideration for 303(d) Delisting: The South Fork Solomon River will be evaluated for delisting under section 303(d), based on the monitoring data over 2010-2019. Therefore, the decision for delisting will come about in the preparation of the 2020-303(d) list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities might 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 would come in 2010, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made

into the WRAPS. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2010-2019.

Revised September 2, 2010

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Perry, C.A., D.M. Wolock and J.C. Artman, 2004. Estimates of Flow Duration , Mean Flow and Peak-Discharge Frequency Values for Kansas Stream Locations, USGS Scientific Investigation Report 2004-5033.

Stiles, T.C. & M.B.Tate, 2008. Managing bacteria TMDLs by overlaying water quality, hydrology and corrective measures on stream recreation. Water Practice 2: 1-13.

Appendix A. K.S.A. 82a-2001, et seq: Classified stream segments defined; other definitions. As used in this act:

(7) (A) "Recreational use" means:

(i) Primary contact recreational use is use of a classified stream segment for recreation during the period from April 1 through October 31 of each year, provided such classified stream segment is capable of supporting the recreational activities of swimming, skin diving, water skiing, wind surfing, kayaking or mussel harvesting where the body is intended to be immersed in surface water to the extent that some inadvertent ingestion of water is probable.

(a) Primary contact recreational use-Class A: Use of a classified stream segment for recreation during the period from April 1 through October 31 of each year, and the classified stream segment is a designated public swimming area. Water quality criterion for bacterial indicator organisms applied to Class A waters shall be set at an illness rate of eight or more per 1000 swimmers. The classified stream segment shall only be considered impaired for primary contact recreational use-Class A if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion. The water quality criterion for primary contact recreational use-Class A waters during the period November 1 through March 31 of each year shall be equal to the criterion applied to secondary contact recreational use-Class A waters.

(b) Primary contact recreational use-Class B: Use of a classified stream segment for recreation, where moderate full body contact recreation is expected, during the period from April 1 through October 31 of each year, and the classified stream segment is by law or written permission of the landowner open to and accessible by the public. Water quality criterion for bacterial indicator organisms applied to Class B waters shall be set at an illness rate of 10 or more per 1000 swimmers. The classified stream segment shall only be considered impaired for primary contact recreational use-Class B if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion. The water quality criterion for primary contact recreational use-Class B waters during the period November 1 through March 31 of each year shall be equal to the criterion applied to secondary contact recreational use-Class A waters.

(c) Primary contact recreational use-Class C: Use of a classified stream segment for recreation, where full body contact recreation is infrequent during the period from April 1 through October 31 of each year, and is not open to and accessible by the public under Kansas law and is capable of supporting the recreational activities of swimming, skin diving, water-skiing, wind surfing, boating, mussel harvesting, wading or fishing. Water quality criterion for bacterial indicator organisms applied to Class C waters shall be set at an illness rate of 12 or more per 1000 swimmers. The classified stream segment shall only be considered impaired for primary contact recreational use-Class C if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion. The water quality criterion for primary contact recreational use-Class C waters during the period November 1 through March 31 of each year shall be equal to the criterion applied to secondary contact recreational use-Class B waters.

(ii) Secondary contact recreational use is use of a classified stream segment for recreation, provided such classified stream segment is capable of supporting the recreational activities of wading, fishing, canoeing, motor boating, rafting or other types of boating where the body is not intended to be immersed and where ingestion of surface water is not probable.

(a) Secondary contact recreational use-Class A: Use of a classified stream segment for recreation capable of supporting the recreational activities of wading or fishing and the classified stream segment is by law or written permission of the landowner open to and accessible by the public. Water quality criterion for bacterial indicator organisms applied to secondary contact recreational use-Class A waters shall be nine times the criterion applied to primary contact recreational use-Class B waters. The classified stream segment shall only be considered impaired for secondary contact recreational use-Class A if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion.

(b) Secondary contact recreational use-Class B: Use of a classified stream segment for recreation capable of supporting the recreational activities of wading or fishing and the classified stream segment is not open to and accessible by the public under Kansas law. Water quality criterion for bacterial indicator organisms applied to secondary contact recreational use- Class B waters shall be nine times the criterion applied to primary contact recreational-Class C use waters. The classified stream segment shall only be considered impaired for secondary contact recreational use-Class B if the calculated geometric mean of at least five samples collected in separate 24-hour periods within a 30-day period exceeds the corresponding water quality criterion.

(B) If opposite sides of a classified stream segment would have different designated recreational uses due to differences in public access, the designated use of the entire classified stream segment may be the higher attainable use, notwithstanding that such designation does not grant the public access to both sides of such segment.

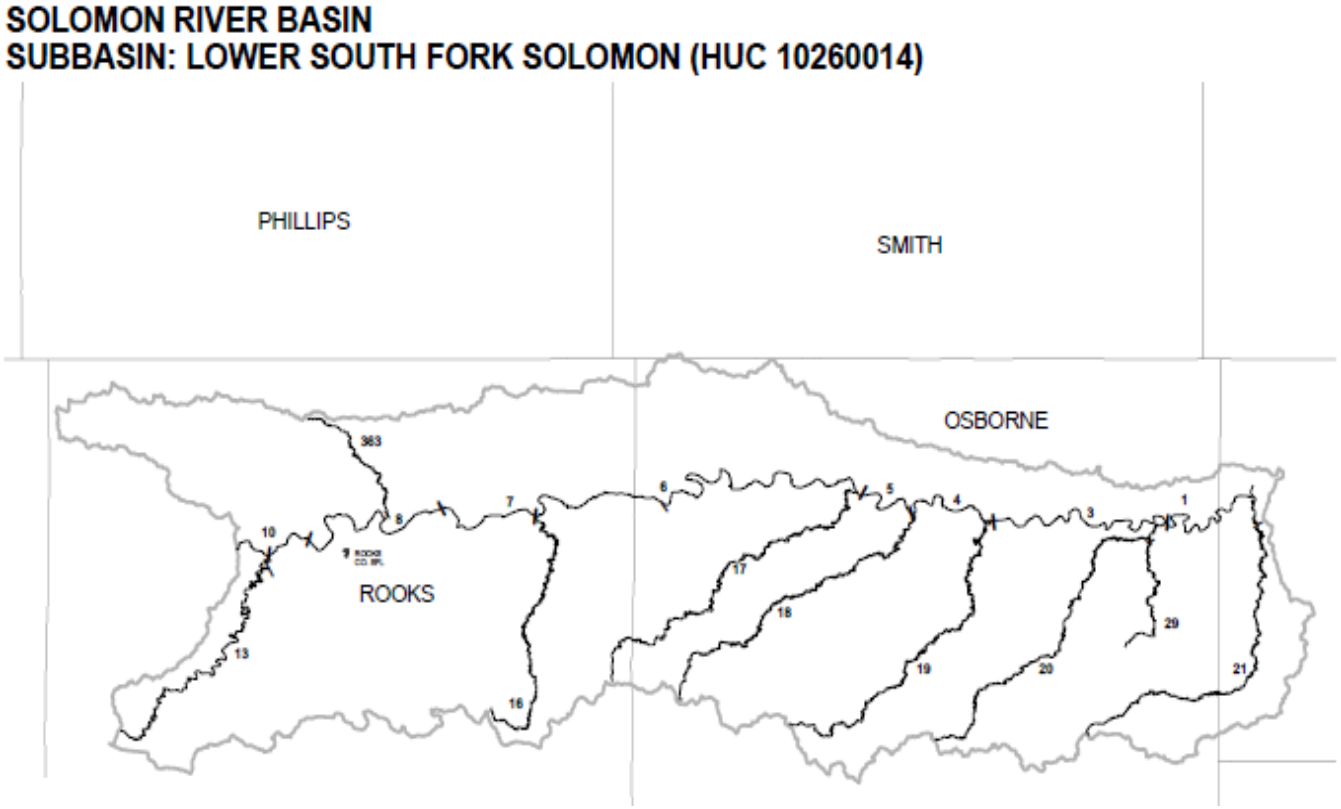
(C) Recreational use designations shall not apply to stream segments where the natural, ephemeral, intermittent or low flow conditions or water levels prevent recreational activities.

(d) "Ephemeral stream" means streams that flow only in response to precipitation and whose channel is at all times above the water table.

(e) "Secretary" means the secretary of health and environment.

History: L. 2001, ch. 100, § 1; L. 2003, ch. 105, § 1; May 1.

Appendix B. Classified Streams of the Lower South Fork Solomon River Basin



Appendix C. Calculation of Load Capacity and Allocations for Bacteria on South Fork Solomon

1. For each representative flow condition, the flow at the Woodston (0683460) and Osborne gages (06874000) were used to establish the base flow condition; since Woodston flows comprise a small portion of Osborne flows until flows exceed median flow, the Osborne flows were used as the base.

2. The design flow of Osborne WWTP was added to the Osborne gaged flow

3. The combined flow was multiplied by 262 counts(CFUs)/100 ml and the multiplier (0.0244512) to derive the Load Capacity (giga-colonies per day)

4. Wasteload Allocations were the sum of the Stockton and Osborne WWTP WLAs

5. The Load Allocation was the difference between LC and WLA

FLOW Percentile	stockton ww flow	woodston flow	Osborne flow	Osborne ww flow	**Osborne LC**	**Osborne WLA**	**Osborne LA**
90th	0.43	0.2	5.3	0.44	**36.8**	**27.4**	**9.4**
75th	0.43	0.98	9.8	0.44	**65.6**	**27.4**	**38.2**
50th	0.43	8.8	26	0.44	**169.4**	**27.4**	**142.0**
25th	0.43	37	73	0.44	**470.5**	**27.4**	**443.1**
10th	0.43	108	215	0.44	**1380.2**	**27.4**	**1352.8**

Below Osborne, the added flow was determined from Perry, 2006 as the difference in estimated flow between the reach below Osborne and the reach entering Waconda Lake. The Waconda flow was the sum of the added flow, the flow below Osborne and Tipton's design flow (0.04 cfs)

The Load Capacity at Waconda was determined as the converted product of the total flow at Waconda and 427 counts(CFUs)/100 ml, the criterion for the reaches between Osborne and Waconda

The Total WLA was the sum of the individual WLA for Stockton, Osborne and Tipton (**Table 7)** and the Total LA was the difference between Waconda LC and Total WLA

FLOW Percentile	Flow below Osborne	**Osborne LC**	**Osborne WLA**	**Osborne LA**	added flow blw Osborne	Waconda flow	**Waconda LC**	**Total WLA**	**Total LA**
90th	5.74	**36.8**	**27.4**	**9.4**	0.5	6.3	**65.6**	**30.7**	**34.9**
75th	10.24	**65.6**	**27.4**	**38.2**	0.6	10.9	**113.6**	**30.7**	**82.9**
50th	26.4	**169.4**	**27.4**	**142.0**	2.0	28.5	**297.4**	**30.7**	**266.7**
25th	73.4	**470.5**	**27.4**	**443.1**	8.0	81.5	**850.7**	**30.7**	**820.0**
10th	215.4	**1380.2**	**27.4**	**1352.8**	32.0	247.5	**2583.9**	**30.7**	**2553.2**