

**City of St. Joseph, Missouri**  
**Facilities Plan**

**Technical Memorandum No. TM-CSO-3b**

**Phase IA CSO Control**  
**Water Quality Model**



**By**



Work Order No. 09-005  
B&V Project 165152

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## Phase IA CSO Control Water Quality Model

### 1.0 Executive Summary

The purpose of this technical memorandum is to predict the reduction in annual *Escherichia coli* (*E. coli*) loadings and concentrations in the river that are expected to be achieved by implementing the modified Phase IA combined sewer overflow (CSO) control improvements. The results of this evaluation will be used as the basis for measuring anticipated water quality benefits associated with the modified Phase IA CSO control improvements recommended in the Facilities Plan. In Technical Memorandum (TM) TM-CSO-3a – Phase IA CSO Control Recommended Improvements Model, the calibrated XP-SWMM model was used to determine the CSO volume from the existing combined sewer system (CSS) and the volume predicted with the proposed Phase IA CSO control improvements. The model indicated that the modified Phase IA improvements would reduce the overall CSO volume by 2.4 billion gallons annually from approximately 4.1 billion gallons to 1.7 billion gallons, a reduction in volume of approximately 60 percent.

Based on the hydrograph volumes developed in TM-CSO-3a, *E. coli* loadings were calculated for each of the design storm events A through H for each of the 14 CSO outfalls. The rainfall volume ranged from 0.29 inches for Event A to 2.88 inches for Event H.

The Phase IA improvements are expected to reduce the total annual *E. coli* loading for a typical year by approximately 70 percent as compared to the annual volumetric CSO reduction of 60 percent. The somewhat higher degree of loading reduction would be achieved because the *E. coli* concentrations associated with CSOs that were significantly volumetrically improved (e.g., Whitehead) were higher than the concentrations for CSOs receiving less CSO control improvement.

The QUAL2K water quality model was used to predict *E. coli* concentrations in the river for each of the design storm events A through H for the existing CSS and the modified Phase IA CSO control improvements. For each storm event, it was assumed that the flow in the river was at the navigation season 7-day low flow that occurs at a

frequency of once every 10 years (7Q10). The E. coli loading for each CSO outfall was calculated by multiplying the peak flow in the XP-SWMM event hydrograph by its event mean concentration.

The Event C existing condition CSOs resulted in the highest E. coli loading and resulting concentration of 72,000 colony forming units (cfu) per 100 mL in the Missouri River. This occurred in the vicinity of the Water Protection Facility (WPF), which is 5.6 km (3.5 miles) downstream of the most upstream CSO outfall, Roy's Branch. The Phase IA improvements were predicted to reduce the Event C concentration by 51 percent, which is a significant reduction even though the concentration exceeds the E. coli water quality criterion for the river of 206 cfu per 100 mL. The E. coli water quality criterion of 206 cfu per 100 mL is based on a monthly geometric mean. When the peak QUAL2K E. coli concentrations are averaged with the concentrations during the dry weather days, the monthly average concentrations will be much lower. To calculate the monthly geometric averages that include both the wet and dry weather days, a continuous simulation water quality model, such as WASP, would be required. A continuous simulation water quality model would generate a time series of average daily E. coli concentrations for a typical year, which could be used to calculate monthly geometric means for comparison to the criterion.

For events A through G, the modified Phase IA improvements would provide a significant reduction in E. coli concentrations in the river. Event A would provide the highest reduction in concentration, 77 percent, which is important because during a typical year there are 42 events which are equal to or smaller than Event A. The total number of events per typical year is 78. Events in the A, B, and C ranges, which have the highest percent reductions, occur more often than the other events, 66 out of 78 storm events. Events F, G, and H with the lowest percent reductions occur only once per year. Thus, the Phase IA improvements would result in the highest reductions in E. coli concentrations for the events that occur more frequently during a typical year.

QUAL2K used the peak flow in each of the event hydrographs, so the predicted E. coli concentrations are the maximum concentrations at any location in the river. As the hydrographs and associated loadings rise to the peak flow and fall from the peak

flow, the average concentrations at any location would be significantly lower than the maximum concentrations.

Upon completion of the Phase IA CSO control improvements, it is recommended the City develop a continuous simulation model of the Missouri River to demonstrate water quality. This model could be used to determine the monthly geometric mean concentration of E. coli in the Missouri River for the improved conditions. Furthermore, it would help demonstrate the significant E. coli peak concentration reductions documented herein for the Phase IA improvements with the monthly E. coli geometric mean concentration present in the Missouri River. Ultimately, this tool would further support the water quality benefits resulting from the City of St. Joseph, Missouri's significant investment in reducing the impact of their CSOs on Missouri River water quality.

## **2.0 Purpose of Technical Memorandum**

The purpose of this technical memorandum is to predict the reduction in annual E. coli loadings and concentrations in the Missouri River that are expected to be achieved by implementing the modified Phase IA CSO control improvements. The results of this evaluation will be used as the basis for measuring anticipated water quality benefits associated with modified Phase IA CSO control improvements recommended in the Facilities Plan.

## **3.0 Introduction**

The City of St. Joseph, Missouri (City) is developing a Facilities Plan for CSO control improvements that will be required by the United States Environmental Protection Agency (USEPA) and the Missouri Department of Natural Resources (MDNR) as part of the existing Long Term Control Plan (LTCP). Black & Veatch developed a hydrologic and hydraulic model of the CSS during development of the LTCP. The model was used for evaluating potential improvements to reduce the volume of CSOs. The model encompasses the area of the City that is serviced by combined sewers, which is approximately the western half of the City.

In TM-CSO-2 – CSS Model Calibration and Existing Conditions, additional model calibration was documented. The updated model was used to determine CSO volumes for the existing CSS. During recent discussions between the City, MDNR, and USEPA and based on the financial capability assessment, it was determined that the City can only implement a limited number of the CSO control improvements during the next 20 years to reduce CSO volume. TM-CSO-2 documented existing conditions CSO volume and recommended system improvements for a modified Phase IA that would provide the City the most cost effective CSO controls.

#### **4.0 Development of Annual E. coli Loadings**

As stated in TM-CSO-3a, the calibrated XP-SWMM model was used to determine the CSO volume from the existing CSS and the volume predicted with the proposed Phase IA CSO control improvements. It was determined that during a typical year, the proposed Blacksnake and Whitehead stormwater separation conduits will reduce the annual volume of combined sewage overflow by 1.35 billion gallons. Increasing the conveyance capacity at the Whitehead Pump Station, increasing the treatment capacity of the existing WPF headworks to 88 mgd, and providing high rate treatment and disinfection facilities will reduce CSO volume by an additional 0.85 billion gallons annually. Finally, completing the Roy's Branch partial sewer separation project (currently underway) will reduce CSO volume by an additional 0.23 billion gallons annually. The Phase IA CSS model results indicate that the overall CSO volume will be reduced by 2.4 billion gallons annually from approximately 4.1 billion gallons at existing conditions to 1.7 billion gallons at the completion of the Phase IA improvements. The existing CSS system is estimated to capture approximately 12 percent of the combined sewage volume. By implementing the modified Phase IA improvements, a combined sewage volumetric capture of approximately 60 percent is anticipated.

Annual E. coli CSO loadings to the Missouri River were calculated for a typical year, starting with the hydrograph volumes developed in TM-CSO-3a. Loadings were calculated for each of the design storm events A through H for each of the 14 CSO outfalls. To obtain the loadings for each event, the event volumes for each CSO outfall

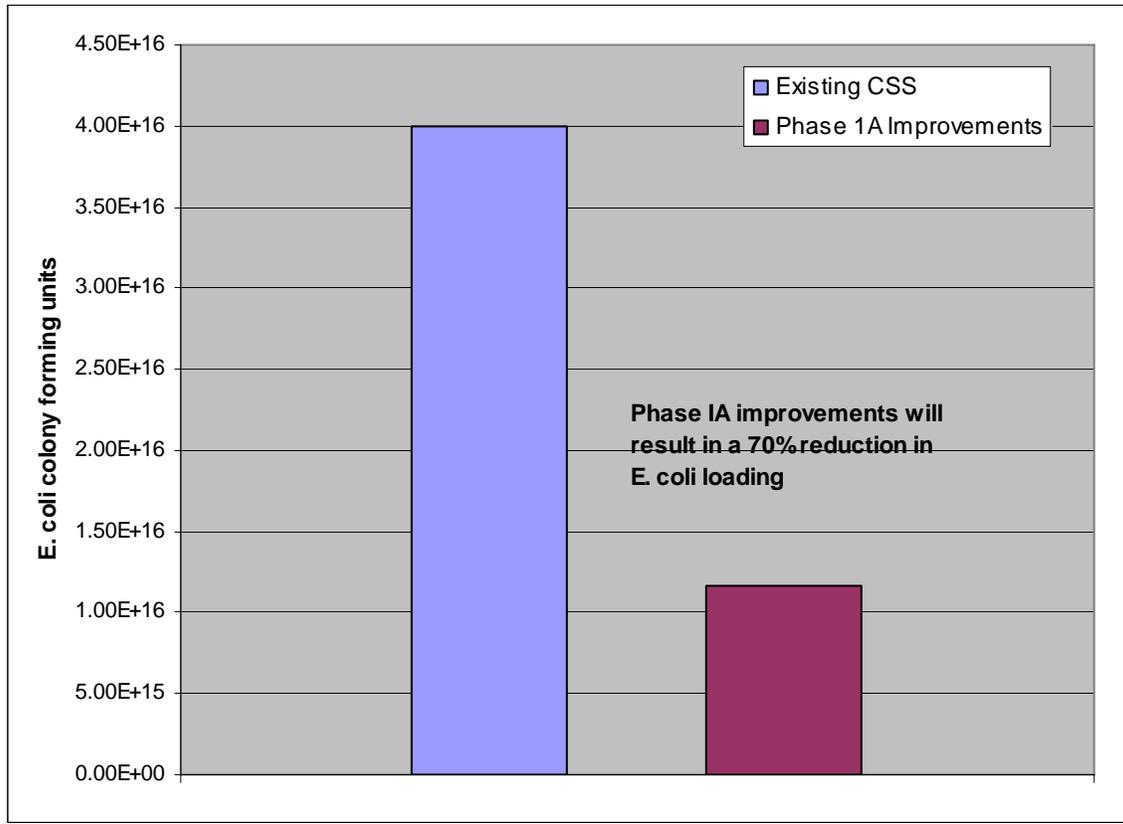
were multiplied by the E. coli event mean concentrations. Development of the event concentrations was documented in the Combined Sewer System Long Term Control Plan 2008 Update.

To obtain the annual loadings, each of the event loadings was multiplied by the number of times each event was expected to occur during the year. For example, events smaller or equal to Event A, which has a rainfall volume of 0.29 inches, are expected to occur 42 times per year, while events larger than Event A but equal to or less than Event B, with a rainfall total of 0.51 inches, are expected to occur 18 times per year. As the events become progressively larger, the number of occurrences per year decreases. Event H, with a volume of 2.88 inches, would occur only once during the year. The total annual E. coli loading for each CSO is the sum of the loading for each event times the number of times the event is expected to occur during the year. This process was conducted for both the existing CSS and the Phase IA improvements. Appendix A provides the calculation sheets that were used to approximate the annual loadings for the typical year.

The total annual E. coli loading for the existing CSS is approximately  $4.0E+16$  cfu. The Phase IA improvements are expected to reduce the total annual loading to approximately  $1.2E+16$  cfu or by approximately 70 percent as indicated in Figure 1.

CSO control improvements for the Whitehead and Mitchell CSOs will result in the largest reductions in loadings. Roy's Branch loadings will be completely eliminated because of the separation project, and there is no change in the Missouri Avenue and Brown's Branch CSOs because improvements in these areas are not planned during Phase IA.

As previously presented, the annual volumetric reduction expected from implementing the Phase IA improvements is approximately 60 percent, while the reduction in loadings is approximately 70 percent. The somewhat higher degree of loading reduction would be achieved because the E. coli concentrations associated with CSOs that were significantly volumetrically improved (e.g., Whitehead) were higher than the concentrations for CSOs receiving less CSO control improvement.



**Figure 1 –Annual E. coli Loading: Existing CSS versus Phase IA CSO Control**

### 5.0 Modeling of E. coli in Missouri River

This evaluation also included QUAL2K modeling of E. coli concentrations in the Missouri River for each of the storm events A through H. The original LTCP model development and calibration is documented in the Combined Sewer System Long Term Control Plan 2008 Update. The headwaters of the model were arbitrarily assumed at river kilometer 100, and the model was extended downstream 100 km in order to show the effect of natural decay of the bacteria.

The loading for the most upstream CSO, Roy’s Branch, was input to the model at river km 98.4. All of the CSO outfalls, except Missouri Avenue and Brown’s Branch, were input upstream of the WPF as shown in Table 1.

For each storm event, it was assumed that the flow in the river was at the navigation season 7-day low flow that occurs at a frequency of once every 10 years (7Q10). The 7Q10 is approximately 682 cms (24,000 cfs). It was assumed that the

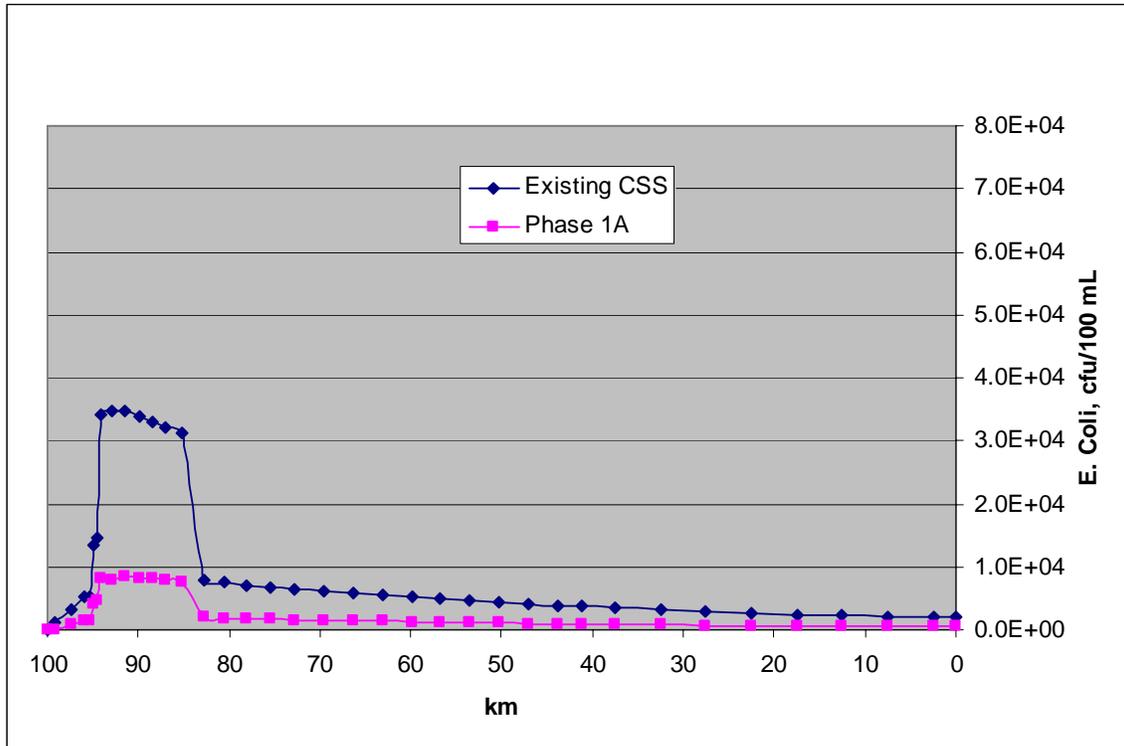
CSOs, which all discharge at the east bank of the Missouri River, would initially mix with only 25 percent of the river, and the remaining river flow would completely mix with the CSOs at km 84.2 as shown in Table 1.

<b>Table 1 CSO Input Location in QUAL2K Model</b>	
<b>CSO Outfall</b>	<b>River km</b>
Roy's Branch	98.4
Blacksnake	96.8
Francis	96.3
Charles	96.5
Messanie	96.1
Patee	96.0
Olive	95.7
Mitchell	95.3
Duncan	94.9
Maple	94.5
Hickory	94.2
Whitehead	93.9
Water Protection Facility	91.7
Missouri Avenue	91.7
Brown's Branch	91.6
Full Flow (completely mixed)	84.2

A separate model run was made for each storm event. The loading for each CSO was calculated by multiplying the peak flow in the event hydrograph by the event mean concentration. Each of the storm events was modeled for both the existing CSS and the Phase IA improvements. It was assumed that the peak flows for each CSO would enter the river at the same time. The sum of all the peak loadings would result in the maximum E. coli concentrations in the river at any location. The peak flows and E. coli concentrations for each storm event and each CSO are provided in Appendix A.

Figure 2 shows the E. coli model results in the river for storm event A. As the CSOs enter the river, the E. coli concentrations increase rapidly from the assumed headwaters background concentration of 206 cfu per 100 mL. At approximately km 92, which is the location of the WPF input, the peak concentration of approximately 35,000 cfu per 100 mL has occurred. However, Figure 2 indicates that the Phase IA

improvements would result in an approximately 80 percent reduction in E. coli concentrations. The rapid reduction in concentration at river km 84 was caused by the dilution from the remaining 75 percent of the river mixing with the river carrying the CSOs. Graphs representing the model results for the remaining storm events are provided in Appendix B.



**Figure 2 – E. coli Concentration in Missouri River for Storm Event A:  
 Existing CSS versus Phase IA CSO Control**

Table 2 summarizes the peak E. coli concentrations for each storm event. Event C, Existing CSS, results in the highest concentration, 72,000 cfu per 100 mL, while events D through G show a decreasing trend, from 52,000 cfu per 100 mL to 38,000 cfu per 100 mL. Table 2 also provides the percent reductions in concentrations resulting from the Phase IA improvements and the number of events per year for each storm.

<b>Storm Event</b>	<b>Existing, cfu/100 mL x 10,000</b>	<b>Phase IA, cfu/100 mL x 10,000</b>	<b>Reduction, %</b>	<b>Approx. Events per Year</b>
A	3.5	0.8	77	42
B	6.5	2.7	58	18
C	7.2	3.5	51	6
D	5.2	3.2	39	6
E	4.7	2.9	38	2
F	4.1	2.7	35	1
G	3.8	2.5	36	1
H	3.3	2.8	15	1

The existing CSS for Event H, the largest rainfall volume event, resulted in the lowest E. coli concentration of 33,000 cfu per 100 mL. Generally, the E. coli event concentrations are inversely related to the magnitude of the event due to dilution effects. Bacteria and other pollutants accumulate on the land surface during dry weather. The smallest storm events provide the least dilution of the pollutants as they are washed off, while the largest events provide the most dilution during wash-off. The Phase IA improvements were predicted to reduce the Event H concentration by 15 percent, which is the least reduction of all of the events. This is because the Phase IA improvements would result in the lowest reduction in loadings compared to the other events.

For all of the other events, the improvements would provide a significant reduction in E. coli concentrations, ranging from 78 percent for all events smaller than or equal to Design Event A to 36 percent for Event G. The resulting concentrations exceed the E. coli water quality criterion of 206 cfu per 100mL. The E. coli water quality criterion is based on a monthly geometric mean. When the peak QUAL2K E. coli concentrations are averaged with the concentrations during the dry weather days, the monthly average concentrations will be much lower. To calculate the monthly geometric averages that include both the wet and dry weather days, a continuous simulation water quality model, such as WASP, would be required. A continuous simulation water quality model would generate a time series of average daily E. coli concentrations for a typical

year, which could be used to calculate monthly geometric means for comparison to the criterion.

The high reduction for events equal to or less than Event A is important because during a typical year events of this magnitude occur much more frequently, 42 times, compared to the other events. Events in the range of A, B, and C, which have the highest percent reductions, occur more often during a typical year than the other events. Events in the range of F, G, and H with the lowest percent reductions occur only once per year. The total number of events per typical year is 78. Table 2 indicates that between 51 to 77 percent reduction in peak E. coli concentrations occurs in the smallest 66 out of 78 storm events (events in the A through C range). Thus, the Phase IA improvements would result in the highest reductions in E. coli concentrations for the events that occur more frequently during a typical year.

It should be noted that QUAL2K has used the peak flow in each of the event hydrographs, so the predicted E. coli concentrations are the maximum concentrations at any location in the river. As the hydrographs and associated loadings rise to the peak flow and fall from the peak flow, the average concentrations at any location would be significantly lower than the maximum concentrations.

## **6.0 Conclusions**

The modified Phase IA CSO control improvements are expected to result in a significant reduction in both typical annual E. coli CSO loadings and E. coli concentrations in the Missouri River. The modified Phase IA improvements are expected to reduce the annual Missouri River loadings from the existing CSS by approximately 70 percent.

The QUAL2K water quality model was used to predict E. coli concentrations in the river for each of the storm events A through H. The rainfall volumes range from 0.29 inches for Event A to 2.88 inches for Event H. The Phase IA improvements related to Event A will result in the highest reduction in E. coli concentration, approximately 77 percent, which is important because during a typical year this event occurs much more frequently than the other events. The improvements will result in a 51 to 77 percent

reduction in E. coli concentration for 66 out of the average 78 wet days per year in St. Joseph. Thus, the improvements would result in the highest reductions in E. coli concentrations in the river for the events that occur most frequently during a typical year.

The QUAL2K model used the peak flow in each of the event hydrographs, so the predicted E. coli concentrations are the maximum concentrations at any location in the river. As the hydrographs and associated loadings rise to the peak flow and fall from the peak flow, the average concentrations at any location would be significantly lower than the maximum concentrations.

Upon completion of the Phase IA CSO control improvements, it is recommended the City develop a continuous simulation model of the Missouri River to demonstrate water quality. This model could be used in determining the monthly geometric mean concentration of E. coli in the Missouri River for the improved conditions. Furthermore, it would help demonstrate the significant E. coli peak concentration reductions documented herein for the Phase IA improvements with the monthly E. coli geometric mean concentration present in the Missouri River. Ultimately, this tool would further support the water quality benefits resulting from the City's significant investment in reducing the impact of their CSOs on Missouri River water quality.

## 7.0 References

1. Black & Veatch Corporation, TM-CSO-2 – CSS Model Calibration and Existing Conditions, 2009.
2. Black & Veatch Corporation, TM-CSO-3a – Phase IA CSO Control Recommended Improvements Model, 2009.
3. Black & Veatch Corporation, Combined Sewer System Long Term Control Plan 2008 Update.

## **Appendix A**

### **CSO E. coli Mass Loading Calculations for Storm Events A through H**

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Roy's Branch

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		-						
A	8.17	0.64	550,000	352,000	42	0.32	13.44	176,000	7,392,000	2.79787E+14
B	17.4	1.55	500,000	775,000	18	1.095	19.71	563,500	10,143,000	3.83913E+14
C	31.45	3.34	300,000	1,002,000	6	2.445	14.67	888,500	5,331,000	2.01778E+14
D	69.37	9.45	150,000	1,417,500	6	6.395	38.37	1,209,750	7,258,500	2.74734E+14
E	109.05	16.49	100,000	1,649,000	2	12.97	25.94	1,533,250	3,066,500	1.16067E+14
F	136.69	20.24	100,000	2,024,000	1	18.365	18.365	1,836,500	1,836,500	6.95115E+13
G	195.91	28.68	100,000	2,868,000	1	24.46	24.46	2,446,000	2,446,000	9.25811E+13
H	327.44	41.76	100,000	4,176,000	1	35.22	35.22	3,522,000	3,522,000	1.33308E+14
					1	41.76	41.76	4,176,000	4,176,000	1.58062E+14
						<b>Total Annual Volume</b>	<b>231.935</b>	<b>Total Annual Load</b>	<b>45,171,500</b>	<b>1.71E+15</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

**Blacksnake**

<b>Event</b>	<b>Peak Flow (mgd)</b>	<b>Runoff Volume (MG)</b>	<b>CFU/100mL</b>	<b>Total Load for Event MGxCFU/100mL</b>	<b>Events in Range</b>	<b>Average Event Volume (MG)</b>	<b>Volume for Range (MG)</b>	<b>Average Load MGxCFU/100mL</b>	<b>Load for Range MGxCFU/100mL</b>	<b>Colony Forming Units</b>
None	0	0		-						
A	14.09	0.72	550,000	396,000	42	0.36	15.12	198,000	8,316,000	3.14761E+14
B	42.78	2.67	500,000	1,335,000	18	1.695	30.51	865,500	15,579,000	5.89665E+14
C	83	6.36	300,000	1,908,000	6	4.515	27.09	1,621,500	9,729,000	3.68243E+14
D	164.71	18.72	150,000	2,808,000	6	12.54	75.24	2,358,000	14,148,000	5.35502E+14
E	264.82	36.08	100,000	3,608,000	2	27.4	54.8	3,208,000	6,416,000	2.42846E+14
F	353.98	45.96	100,000	4,596,000	1	41.02	41.02	4,102,000	4,102,000	1.55261E+14
G	587.77	68.87	100,000	6,887,000	1	57.415	57.415	5,741,500	5,741,500	2.17316E+14
H	1051.64	105.67	100,000	10,567,000	1	87.27	87.27	8,727,000	8,727,000	3.30317E+14
					1	105.67	105.67	10,567,000	10,567,000	3.99961E+14
						<b>Total Annual Volume</b>	<b>494.135</b>	<b>Total Annual Load</b>	<b>83,325,500</b>	<b>3.15E+15</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

**Francis**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0	0	550,000	-	42	0	0	-	-	0
B	0.1	0	500,000	-	18	0	0	-	-	0
C	0.72	0.01	300,000	3,000	6	0.005	0.03	1,500	9,000	3.4065E+11
D	1.22	0.04	150,000	6,000	6	0.025	0.15	4,500	27,000	1.02195E+12
E	1.5	0.06	100,000	6,000	2	0.05	0.1	6,000	12,000	4.542E+11
F	1.71	0.07	100,000	7,000	1	0.065	0.065	6,500	6,500	2.46025E+11
G	1.96	0.08	100,000	8,000	1	0.075	0.075	7,500	7,500	2.83875E+11
H	2.42	0.11	100,000	11,000	1	0.095	0.095	9,500	9,500	3.59575E+11
					1	0.11	0.11	11,000	11,000	4.1635E+11
						<b>Total Annual Volume</b>	<b>0.625</b>	<b>Total Annual Load</b>	<b>82,500</b>	<b>3.12E+12</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Charles

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	9.01	0.34	550,000	187,000	42	0.17	7.14	93,500	3,927,000	1.48637E+14
B	18.45	0.97	500,000	485,000	18	0.655	11.79	336,000	6,048,000	2.28917E+14
C	39.6	2.08	300,000	624,000	6	1.525	9.15	554,500	3,327,000	1.25927E+14
D	65.02	4.48	150,000	672,000	6	3.28	19.68	648,000	3,888,000	1.47161E+14
E	78.96	7	100,000	700,000	2	5.74	11.48	686,000	1,372,000	5.19302E+13
F	108.87	8.39	100,000	839,000	1	7.695	7.695	769,500	769,500	2.91256E+13
G	136.13	11.31	100,000	1,131,000	1	9.85	9.85	985,000	985,000	3.72823E+13
H	204.86	15.75	100,000	1,575,000	1	13.53	13.53	1,353,000	1,353,000	5.12111E+13
					1	15.75	15.75	1,575,000	1,575,000	5.96138E+13
						<b>Total Annual Volume</b>	<b>106.065</b>	<b>Total Annual Load</b>	<b>23,244,500</b>	<b>8.80E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

**Messanie**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	3.05	0.2	600,000	120,000	42	0.1	4.2	60,000	2,520,000	9.5382E+13
B	7.57	0.51	500,000	255,000	18	0.355	6.39	187,500	3,375,000	1.27744E+14
C	15.83	1.02	500,000	510,000	6	0.765	4.59	382,500	2,295,000	8.68658E+13
D	23.42	1.98	300,000	594,000	6	1.5	9	552,000	3,312,000	1.25359E+14
E	30.14	2.77	150,000	415,500	2	2.375	4.75	504,750	1,009,500	3.82096E+13
F	32.5	3.07	80,000	245,600	1	2.92	2.92	330,550	330,550	1.25113E+13
G	36.77	3.76	75,000	282,000	1	3.415	3.415	263,800	263,800	9.98483E+12
H	45.32	4.71	50,000	235,500	1	4.235	4.235	258,750	258,750	9.79369E+12
					1	4.71	4.71	235,500	235,500	8.91368E+12
						<b>Total Annual Volume</b>	<b>44.21</b>	<b>Total Annual Load</b>	<b>13,600,100</b>	<b>5.15E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Patee

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	3.05	0.25	600,000	150,000	42	0.125	5.25	75,000	3,150,000	1.19228E+14
B	7.57	0.51	500,000	255,000	18	0.38	6.84	202,500	3,645,000	1.37963E+14
C	15.83	0.93	500,000	465,000	6	0.72	4.32	360,000	2,160,000	8.1756E+13
D	23.42	1.66	300,000	498,000	6	1.295	7.77	481,500	2,889,000	1.09349E+14
E	30.14	2.26	150,000	339,000	2	1.96	3.92	418,500	837,000	3.16805E+13
F	32.5	2.54	80,000	203,200	1	2.4	2.4	271,100	271,100	1.02611E+13
G	36.77	3.14	75,000	235,500	1	2.84	2.84	219,350	219,350	8.3024E+12
H	45.32	3.97	50,000	198,500	1	3.555	3.555	217,000	217,000	8.21345E+12
					1	3.97	3.97	198,500	198,500	7.51323E+12
						<b>Total Annual Volume</b>	<b>40.865</b>	<b>Total Annual Load</b>	<b>13,586,950</b>	<b>5.14E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Olive

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0.64	0.01	600,000	6,000	42	0.005	0.21	3,000	126,000	4.7691E+12
B	1.78	0.07	500,000	35,000	18	0.04	0.72	20,500	369,000	1.39667E+13
C	4.25	0.17	500,000	85,000	6	0.12	0.72	60,000	360,000	1.3626E+13
D	7	0.35	300,000	105,000	6	0.26	1.56	95,000	570,000	2.15745E+13
E	8.69	0.5	150,000	75,000	2	0.425	0.85	90,000	180,000	6.813E+12
F	10.3	0.59	80,000	47,200	1	0.545	0.545	61,100	61,100	2.31264E+12
G	11.94	0.76	75,000	57,000	1	0.675	0.675	52,100	52,100	1.97199E+12
H	19	1	50,000	50,000	1	0.88	0.88	53,500	53,500	2.02498E+12
					1	1	1	50,000	50,000	1.8925E+12
						<b>Total Annual Volume</b>	<b>7.16</b>	<b>Total Annual Load</b>	<b>1,821,700</b>	<b>6.90E+13</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

**Mitchell**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	60.93	5.25	550,000	2,887,500	42	2.625	110.25	1,443,750	60,637,500	2.29513E+15
B	108.48	10.84	500,000	5,420,000	18	8.045	144.81	4,153,750	74,767,500	2.82995E+15
C	180.56	20.03	300,000	6,009,000	6	15.435	92.61	5,714,500	34,287,000	1.29776E+15
D	297.24	38.22	200,000	7,644,000	6	29.125	174.75	6,826,500	40,959,000	1.5503E+15
E	363.82	55.52	180,000	9,993,600	2	46.87	93.74	8,818,800	17,637,600	6.67583E+14
F	454.76	64.23	150,000	9,634,500	1	59.875	59.875	9,814,050	9,814,050	3.71462E+14
G	604.68	83.36	50,000	4,168,000	1	73.795	73.795	6,901,250	6,901,250	2.61212E+14
H	932.5	111.68	25,000	2,792,000	1	97.52	97.52	3,480,000	3,480,000	1.31718E+14
					1	111.68	111.68	2,792,000	2,792,000	1.05677E+14
						<b>Total Annual Volume</b>	<b>959.03</b>	<b>Total Annual Load</b>	<b>251,275,900</b>	<b>9.51E+15</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Duncan

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	1.1	0.05	550,000	27,500	42	0.025	1.05	13,750	577,500	2.18584E+13
B	3.19	0.18	500,000	90,000	18	0.115	2.07	58,750	1,057,500	4.00264E+13
C	6.61	0.37	300,000	111,000	6	0.275	1.65	100,500	603,000	2.28236E+13
D	9.91	0.72	200,000	144,000	6	0.545	3.27	127,500	765,000	2.89553E+13
E	11.63	1.05	180,000	189,000	2	0.885	1.77	166,500	333,000	1.26041E+13
F	13.2	1.19	150,000	178,500	1	1.12	1.12	183,750	183,750	6.95494E+12
G	14.85	1.47	50,000	73,500	1	1.33	1.33	126,000	126,000	4.7691E+12
H	18.26	1.86	25,000	46,500	1	1.665	1.665	60,000	60,000	2.271E+12
					1	1.86	1.86	46,500	46,500	1.76003E+12
						<b>Total Annual Volume</b>	<b>15.785</b>	<b>Total Annual Load</b>	<b>3,752,250</b>	<b>1.42E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Maple

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
					42	0.11	4.62	93,500	3,927,000	1.48637E+14
A	6.33	0.22	850,000	187,000	18	0.435	7.83	353,500	6,363,000	2.4084E+14
B	12.96	0.65	800,000	520,000	6	1.04	6.24	617,500	3,705,000	1.40234E+14
C	28.98	1.43	500,000	715,000	6	2.17	13.02	648,500	3,891,000	1.47274E+14
D	44.92	2.91	200,000	582,000	2	3.58	7.16	609,750	1,219,500	4.61581E+13
E	53.67	4.25	150,000	637,500	1	4.57	4.57	563,250	563,250	2.1319E+13
F	62.51	4.89	100,000	489,000	1	5.575	5.575	557,500	557,500	2.11014E+13
G	73.91	6.26	100,000	626,000	1	7.28	7.28	520,500	520,500	1.97009E+13
H	99.68	8.3	50,000	415,000	1	8.3	8.3	415,000	415,000	1.57078E+13
						<b>Total Annual Volume</b>	<b>64.595</b>	<b>Total Annual Load</b>	<b>21,161,750</b>	<b>8.01E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Hickory

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
					42	0.13	5.46	110,500	4,641,000	1.75662E+14
A	4.62	0.26	850,000	221,000	18	0.44	7.92	358,500	6,453,000	2.44246E+14
B	8.47	0.62	800,000	496,000	6	0.925	5.55	555,500	3,333,000	1.26154E+14
C	16.45	1.23	500,000	615,000	6	1.795	10.77	543,500	3,261,000	1.23429E+14
D	25.27	2.36	200,000	472,000	2	2.855	5.71	487,250	974,500	3.68848E+13
E	29.85	3.35	150,000	502,500	1	3.585	3.585	442,250	442,250	1.67392E+13
F	35.03	3.82	100,000	382,000	1	4.32	4.32	432,000	432,000	1.63512E+13
G	42.03	4.82	100,000	482,000	1	5.545	5.545	397,750	397,750	1.50548E+13
H	58.2	6.27	50,000	313,500	1	6.27	6.27	313,500	313,500	1.1866E+13
						<b>Total Annual Volume</b>	<b>55.13</b>	<b>Total Annual Load</b>	<b>20,248,000</b>	<b>7.66E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Whitehead

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
					42	2.87	120.54	2,439,500	102,459,000	3.87807E+15
A	91.35	5.74	850,000	4,879,000	18	11.27	202.86	9,159,500	164,871,000	6.24037E+15
B	209.86	16.8	800,000	13,440,000	6	26.435	158.61	15,737,500	94,425,000	3.57399E+15
C	408.75	36.07	500,000	18,035,000	6	55.535	333.21	16,517,500	99,105,000	3.75112E+15
D	743.96	75	200,000	15,000,000	2	95.135	190.27	16,145,250	32,290,500	1.2222E+15
E	975.46	115.27	150,000	17,290,500	1	125.465	125.465	15,428,250	15,428,250	5.83959E+14
F	1168.53	135.66	100,000	13,566,000	1	158.28	158.28	15,828,000	15,828,000	5.9909E+14
G	1462.24	180.9	100,000	18,090,000	1	215.54	215.54	15,299,500	15,299,500	5.79086E+14
H	2099.18	250.18	50,000	12,509,000	1	250.18	250.18	12,509,000	12,509,000	4.73466E+14
	7159.33					<b>Total Annual Volume</b>	<b>1754.955</b>	<b>Total Annual Load</b>	<b>552,215,250</b>	<b>2.09E+16</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

MOAV

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
					42	0.22	9.24	55000	2310000	8.74335E+13
A	14.22	0.44	250,000	110,000	18	1.03	18.54	217,000	3,906,000	1.47842E+14
B	33.75	1.62	200,000	324,000	6	2.645	15.87	437,250	2,623,500	9.92995E+13
C	72.81	3.67	150,000	550,500	6	5.49	32.94	640,750	3,844,500	1.45514E+14
D	117.32	7.31	100,000	731,000	2	8.9	17.8	627,750	1,255,500	4.75207E+13
E	139.98	10.49	50,000	524,500	1	11.31	11.31	504,850	504,850	1.91086E+13
F	161.3	12.13	40,000	485,200	1	13.82	13.82	475,250	475,250	1.79882E+13
G	187.13	15.51	30,000	465,300	1	17.97	17.97	436,950	436,950	1.65386E+13
H	242.22	20.43	20,000	408,600	1	20.43	20.43	408,600	408,600	1.54655E+13
						<b>Total Annual Volume</b>	<b>157.92</b>	<b>Total Annual Load</b>	<b>15,765,150</b>	<b>5.97E+14</b>

**St. Joseph, MO**  
**Existing Conditions Typical Year E. coli Loading**

Brown's Branch

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
					42	0	0	-	-	0
A	0	0	250,000	-	18	0.12	2.16	24,000	432,000	1.63512E+13
B	6.38	0.24	200,000	48,000	6	0.665	3.99	105,750	634,500	2.40158E+13
C	16.31	1.09	150,000	163,500	6	4.94	29.64	521,250	3,127,500	1.18376E+14
D	80.76	8.79	100,000	879,000	2	13.35	26.7	887,250	1,774,500	6.71648E+13
E	149.83	17.91	50,000	895,500	1	20.275	20.275	900,550	900,550	3.40858E+13
F	207.72	22.64	40,000	905,600	1	27.785	27.785	946,750	946,750	3.58345E+13
G	317.29	32.93	30,000	987,900	1	40.405	40.405	972,750	972,750	3.68186E+13
H	500.32	47.88	20,000	957,600	1	47.88	47.88	957,600	957,600	3.62452E+13
						<b>Total Annual Volume</b>	<b>198.835</b>	<b>Total Annual Load</b>	<b>9,746,150</b>	<b>3.69E+14</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Roy's Branch

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		-						
A	0	0	550,000	-	42	0	0	-	-	0
B	0	0	500,000	-	18	0	0	-	-	0
C	0	0	300,000	-	6	0	0	-	-	0
D	0	0	150,000	-	6	0	0	-	-	0
E	0	0	100,000	-	2	0	0	-	-	0
F	0	0	100,000	-	1	0	0	-	-	0
G	0	0	100,000	-	1	0	0	-	-	0
H	0	0	100,000	-	1	0	0	-	-	0
						<b>Total Annual Volume</b>	<b>0</b>	<b>Total Annual Load</b>	<b>-</b>	<b>-</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**Blacksnake**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		-						
A	5.65	0.12	550,000	66,000	42	0.06	2.52	33,000	1,386,000	5.24601E+13
B	19.04	0.74	500,000	370,000	18	0.43	7.74	218,000	3,924,000	1.48523E+14
C	44.18	1.98	300,000	594,000	6	1.36	8.16	482,000	2,892,000	1.09462E+14
D	82.68	5.46	150,000	819,000	6	3.72	22.32	706,500	4,239,000	1.60446E+14
E	105.62	11.23	100,000	1,123,000	2	8.345	16.69	971,000	1,942,000	7.35047E+13
F	181.01	16.37	100,000	1,637,000	1	13.8	13.8	1,380,000	1,380,000	5.2233E+13
G	389	30.06	100,000	3,006,000	1	23.215	23.215	2,321,500	2,321,500	8.78688E+13
H	879.81	54.6	100,000	5,460,000	1	42.33	42.33	4,233,000	4,233,000	1.60219E+14
					1	54.6	54.6	5,460,000	5,460,000	2.06661E+14
						<b>Total Annual Volume</b>	<b>191.375</b>	<b>Total Annual Load</b>	<b>27,777,500</b>	<b>1.05E+15</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**Francis**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0	0	550,000	-	42	0	0	-	-	0
B	0	0	500,000	-	18	0	0	-	-	0
C	0	0	300,000	-	6	0	0	-	-	0
D	0	0	150,000	-	6	0	0	-	-	0
E	0.11	0	100,000	-	2	0	0	-	-	0
F	0.27	0.01	100,000	1,000	1	0.005	0.005	500	500	18925000000
G	0.45	0.01	100,000	1,000	1	0.01	0.01	1,000	1,000	37850000000
H	0.83	0.03	100,000	3,000	1	0.02	0.02	2,000	2,000	75700000000
					1	0.03	0.03	3,000	3,000	1.1355E+11
						<b>Total Annual Volume</b>	<b>0.065</b>	<b>Total Annual Load</b>	<b>6,500</b>	<b>2.46E+11</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Charles

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	4.03	0.1	550,000	55,000	42	0.05	2.1	27,500	1,155,000	4.37168E+13
B	11.16	0.42	500,000	210,000	18	0.26	4.68	132,500	2,385,000	9.02723E+13
C	30.52	1.09	300,000	327,000	6	0.755	4.53	268,500	1,611,000	6.09764E+13
D	54.51	2.51	150,000	376,500	6	1.8	10.8	351,750	2,110,500	7.98824E+13
E	66.15	4.11	100,000	411,000	2	3.31	6.62	393,750	787,500	2.98069E+13
F	86.81	4.98	100,000	498,000	1	4.545	4.545	454,500	454,500	1.72028E+13
G	123.36	7.34	100,000	734,000	1	6.16	6.16	616,000	616,000	2.33156E+13
H	190.6	10.92	100,000	1,092,000	1	9.13	9.13	913,000	913,000	3.45571E+13
					1	10.92	10.92	1,092,000	1,092,000	4.13322E+13
						<b>Total Annual Volume</b>	<b>59.485</b>	<b>Total Annual Load</b>	<b>11,124,500</b>	<b>4.21E+14</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**Messanie**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0.06	0	600,000	-	42	0	0	-	-	0
B	1.83	0.04	500,000	20,000	18	0.02	0.36	10,000	180,000	6.813E+12
C	10.28	0.31	500,000	155,000	6	0.175	1.05	87,500	525,000	1.98713E+13
D	25.96	1.03	300,000	309,000	6	0.67	4.02	232,000	1,392,000	5.26872E+13
E	33.53	1.6	150,000	240,000	2	1.315	2.63	274,500	549,000	2.07797E+13
F	38.48	1.94	80,000	155,200	1	1.77	1.77	197,600	197,600	7.47916E+12
G	43.54	2.56	75,000	192,000	1	2.25	2.25	173,600	173,600	6.57076E+12
H	54.92	3.34	50,000	167,000	1	2.95	2.95	179,500	179,500	6.79408E+12
					1	3.34	3.34	167,000	167,000	6.32095E+12
						<b>Total Annual Volume</b>	<b>18.37</b>	<b>Total Annual Load</b>	<b>3,363,700</b>	<b>1.27E+14</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Patee

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0.36	0.01	600,000	6,000	42	0.005	0.21	3,000	126,000	4.7691E+12
B	9.57	0.39	500,000	195,000	18	0.2	3.6	100,500	1,809,000	6.84707E+13
C	14.8	0.88	500,000	440,000	6	0.635	3.81	317,500	1,905,000	7.21043E+13
D	21.45	1.54	300,000	462,000	6	1.21	7.26	451,000	2,706,000	1.02422E+14
E	24.7	2.47	150,000	370,500	2	2.005	4.01	416,250	832,500	3.15101E+13
F	28.04	2.89	80,000	231,200	1	2.68	2.68	300,850	300,850	1.13872E+13
G	31.79	3.81	75,000	285,750	1	3.35	3.35	258,475	258,475	9.78328E+12
H	40.84	5.18	50,000	259,000	1	4.495	4.495	272,375	272,375	1.03094E+13
					1	5.18	5.18	259,000	259,000	9.80315E+12
						<b>Total Annual Volume</b>	<b>34.595</b>	<b>Total Annual Load</b>	<b>8,469,200</b>	<b>3.21E+14</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Olive

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0	0	600,000	-	42	0	0	0	0	0
B	0	0	500,000	-	18	0	0	0	0	0
C	0.55	0.01	500,000	5,000	6	0.005	0.03	2,500	15,000	5.6775E+11
D	2.47	0.06	300,000	18,000	6	0.035	0.21	11,500	69,000	2.61165E+12
E	3.66	0.1	150,000	15,000	2	0.08	0.16	16,500	33,000	1.24905E+12
F	4.79	0.14	80,000	11,200	1	0.12	0.12	13,100	13,100	4.95835E+11
G	6	0.2	75,000	15,000	1	0.17	0.17	13,100	13,100	4.95835E+11
H	9	0.34	50,000	17,000	1	0.27	0.27	16,000	16,000	6.056E+11
					1	0.34	0.34	17,000	17,000	6.4345E+11
						<b>Total Annual Volume</b>	<b>1.3</b>	<b>Total Annual Load</b>	<b>176,200</b>	<b>6.67E+12</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**Mitchell**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	19.59	0.62	550,000	341,000	42	0.31	13.02	170,500	7,161,000	2.71044E+14
B	73.14	2.9	500,000	1,450,000	18	1.76	31.68	895,500	16,119,000	6.10104E+14
C	152.87	7.46	300,000	2,238,000	6	5.18	31.08	1,844,000	11,064,000	4.18772E+14
D	272.82	17.18	200,000	3,436,000	6	12.32	73.92	2,837,000	17,022,000	6.44283E+14
E	339.61	28.7	180,000	5,166,000	2	22.94	45.88	4,301,000	8,602,000	3.25586E+14
F	427.68	35.07	150,000	5,260,500	1	31.885	31.885	5,213,250	5,213,250	1.97322E+14
G	573.86	49.96	50,000	2,498,000	1	42.515	42.515	3,879,250	3,879,250	1.4683E+14
H	895.13	72.85	25,000	1,821,250	1	61.405	61.405	2,159,625	2,159,625	8.17418E+13
					1	72.85	72.85	1,821,250	1,821,250	6.89343E+13
						<b>Total Annual Volume</b>	<b>404.235</b>	<b>Total Annual Load</b>	<b>73,041,375</b>	<b>2.76E+15</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Duncan

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0	0	550,000	-	42	0	0	-	-	0
B	0.49	0.01	500,000	5,000	18	0.005	0.09	2,500	45,000	1.70325E+12
C	3.35	0.06	300,000	18,000	6	0.035	0.21	11,500	69,000	2.61165E+12
D	5.78	0.19	200,000	38,000	6	0.125	0.75	28,000	168,000	6.3588E+12
E	7.56	0.29	180,000	52,200	2	0.24	0.48	45,100	90,200	3.41407E+12
F	9.61	0.36	150,000	54,000	1	0.325	0.325	53,100	53,100	2.00984E+12
G	11.77	0.56	50,000	28,000	1	0.46	0.46	41,000	41,000	1.55185E+12
H	16.62	0.8	25,000	20,000	1	0.68	0.68	24,000	24,000	9.084E+11
					1	0.8	0.8	20,000	20,000	7.57E+11
						<b>Total Annual Volume</b>	<b>3.795</b>	<b>Total Annual Load</b>	<b>510,300</b>	<b>1.93E+13</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**Maple**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	2.82	0.06	850,000	51,000	42	0.03	1.26	25,500	1,071,000	4.05374E+13
B	7.94	0.28	800,000	224,000	18	0.17	3.06	137,500	2,475,000	9.36788E+13
C	22.46	0.74	500,000	370,000	6	0.51	3.06	297,000	1,782,000	6.74487E+13
D	36.63	1.57	200,000	314,000	6	1.155	6.93	342,000	2,052,000	7.76682E+13
E	44.4	2.32	150,000	348,000	2	1.945	3.89	331,000	662,000	2.50567E+13
F	51.96	2.74	100,000	274,000	1	2.53	2.53	311,000	311,000	1.17714E+13
G	63.29	3.65	100,000	365,000	1	3.195	3.195	319,500	319,500	1.20931E+13
H	84.72	5	50,000	250,000	1	4.325	4.325	307,500	307,500	1.16389E+13
					1	5	5	250,000	250,000	9.4625E+12
						<b>Total Annual Volume</b>	<b>33.25</b>	<b>Total Annual Load (lbs)</b>	<b>9,230,000</b>	<b>3.49E+14</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Hickory

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0.1	0	850,000	-	42	0	0	-	-	0
B	1.84	0.05	800,000	40,000	18	0.025	0.45	20,000	360,000	1.3626E+13
C	9.17	0.25	500,000	125,000	6	0.15	0.9	82,500	495,000	1.87358E+13
D	16.33	0.63	200,000	126,000	6	0.44	2.64	125,500	753,000	2.85011E+13
E	20.44	0.95	150,000	142,500	2	0.79	1.58	134,250	268,500	1.01627E+13
F	25.2	1.16	100,000	116,000	1	1.055	1.055	86,167	86,167	3.26141E+12
G	35.73	1.73	100,000	173,000	1	1.445	1.445	144,500	144,500	5.46933E+12
H	58.29	2.74	50,000	137,000	1	2.235	2.235	155,000	155,000	5.86675E+12
					1	2.74	2.74	137,000	137,000	5.18545E+12
						<b>Total Annual Volume</b>	<b>13.045</b>	<b>Total Annual Load</b>	<b>2,399,167</b>	<b>9.08E+13</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

Whitehead

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	16.12	1.11	850,000	943,500	42	0.555	23.31	471,750	19,813,500	7.49941E+14
B	59.89	4.36	800,000	3,488,000	18	2.735	49.23	2,215,750	39,883,500	1.50959E+15
C	116.42	10.22	500,000	5,110,000	6	7.29	43.74	4,299,000	25,794,000	9.76303E+14
D	225.02	22.35	200,000	4,470,000	6	16.285	97.71	4,790,000	28,740,000	1.08781E+15
E	306.18	35.2	150,000	5,280,000	2	28.775	57.55	4,875,000	9,750,000	3.69038E+14
F	387.26	42.13	100,000	4,213,000	1	38.665	38.665	4,746,500	4,746,500	1.79655E+14
G	520.96	64.37	100,000	6,437,000	1	53.25	53.25	5,325,000	5,325,000	2.01551E+14
H	1927.2	123.3	50,000	6,165,000	1	93.835	93.835	6,301,000	6,301,000	2.38493E+14
	3559.05					123.3	123.3	6,165,000	6,165,000	2.33345E+14
						<b>Total Annual Volume</b>	<b>580.59</b>	<b>Total Annual Load</b>	<b>146,518,500</b>	<b>5.55E+15</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**MOAV**

Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	14.34	0.42	250,000	105,000	42	0.21	8.82	52500	2205000	8.34593E+13
B	33.74	1.6	200,000	320,000	18	1.01	18.18	212,500	3,825,000	1.44776E+14
C	71.84	3.62	150,000	543,000	6	2.61	15.66	431,500	2,589,000	9.79937E+13
D	117.28	7.27	100,000	727,000	6	5.445	32.67	635,000	3,810,000	1.44209E+14
E	140	10.53	50,000	526,500	2	8.9	17.8	626,750	1,253,500	4.7445E+13
F	161.2	12.11	40,000	484,400	1	11.32	11.32	505,450	505,450	1.91313E+13
G	187.28	15.54	30,000	466,200	1	13.825	13.825	475,300	475,300	1.79901E+13
H	242.22	20.43	20,000	408,600	1	17.985	17.985	437,400	437,400	1.65556E+13
					1	20.43	20.43	408,600	408,600	1.54655E+13
						<b>Total Annual Volume</b>	<b>156.69</b>	<b>Total Annual Load</b>	<b>15,509,250</b>	<b>5.87E+14</b>

**St. Joseph, MO**  
**Phase IA Conditions Typical Year E. coli Loading**

**Brown's Branch**

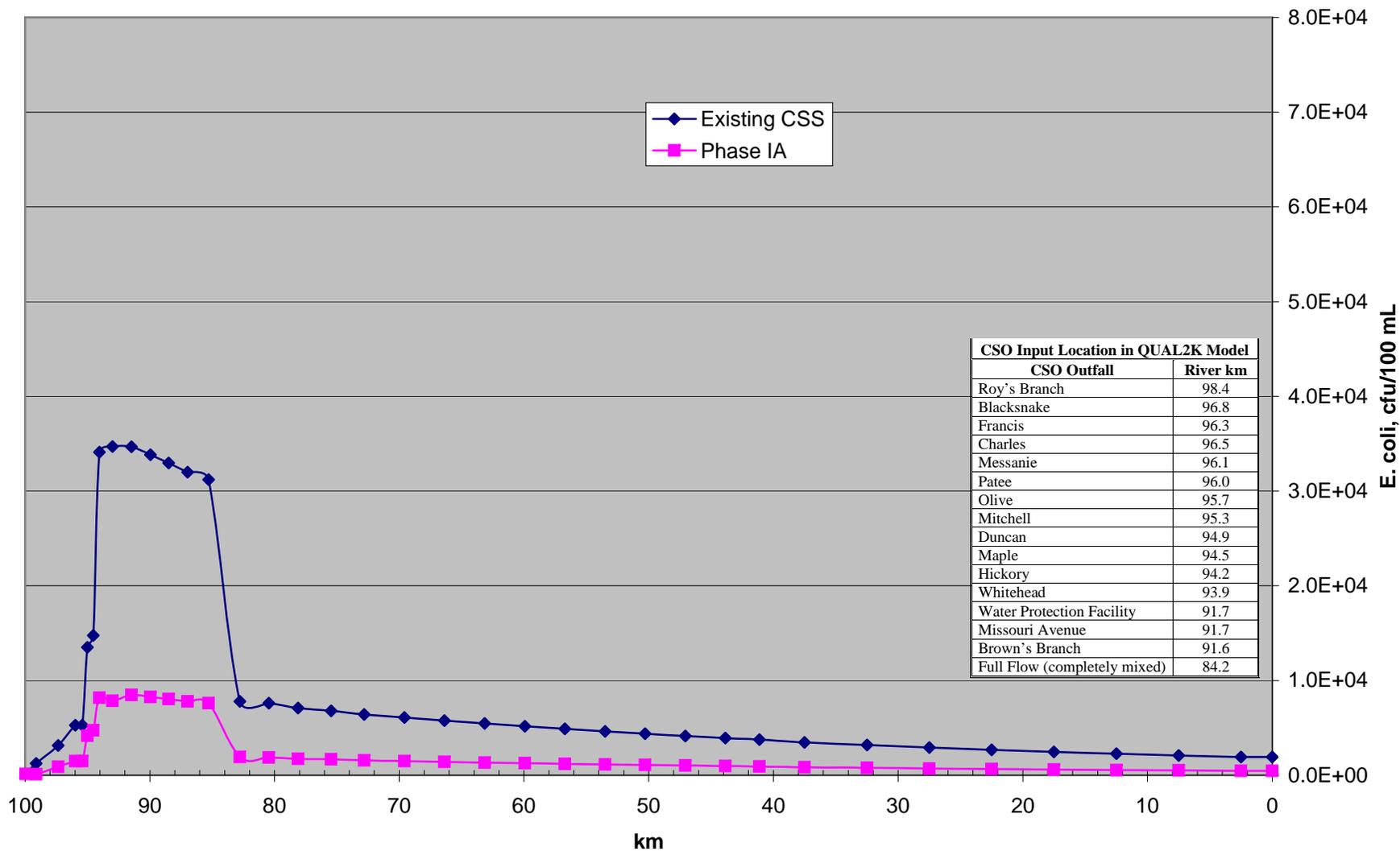
Event	Peak Flow (mgd)	Runoff Volume (MG)	CFU/100mL	Total Load for Event MGxCFU/100mL	Events in Range	Average Event Volume (MG)	Volume for Range (MG)	Average Load MGxCFU/100mL	Load for Range MGxCFU/100mL	Colony Forming Units
None	0	0		0						
A	0	0	250,000	-	42	0	0	-	-	0
B	6.38	0.24	200,000	48,000	18	0.12	2.16	24,000	432,000	1.63512E+13
C	16.32	1.08	150,000	162,000	6	0.66	3.96	105,000	630,000	2.38455E+13
D	80.78	8.79	100,000	879,000	6	4.935	29.61	520,500	3,123,000	1.18206E+14
E	149.83	17.9	50,000	895,000	2	13.345	26.69	887,000	1,774,000	6.71459E+13
F	207.66	22.63	40,000	905,200	1	20.265	20.265	900,100	900,100	3.40688E+13
G	317.41	32.94	30,000	988,200	1	27.785	27.785	946,700	946,700	3.58326E+13
H	500.31	47.88	20,000	957,600	1	40.41	40.41	972,900	972,900	3.68243E+13
					1	47.88	47.88	957,600	957,600	3.62452E+13
						<b>Total Annual Volume</b>	<b>198.76</b>	<b>Total Annual Load</b>	<b>9,736,300</b>	<b>3.69E+14</b>

## **Appendix B**

### **E. coli River Modeling Results for Storm Events A through H**

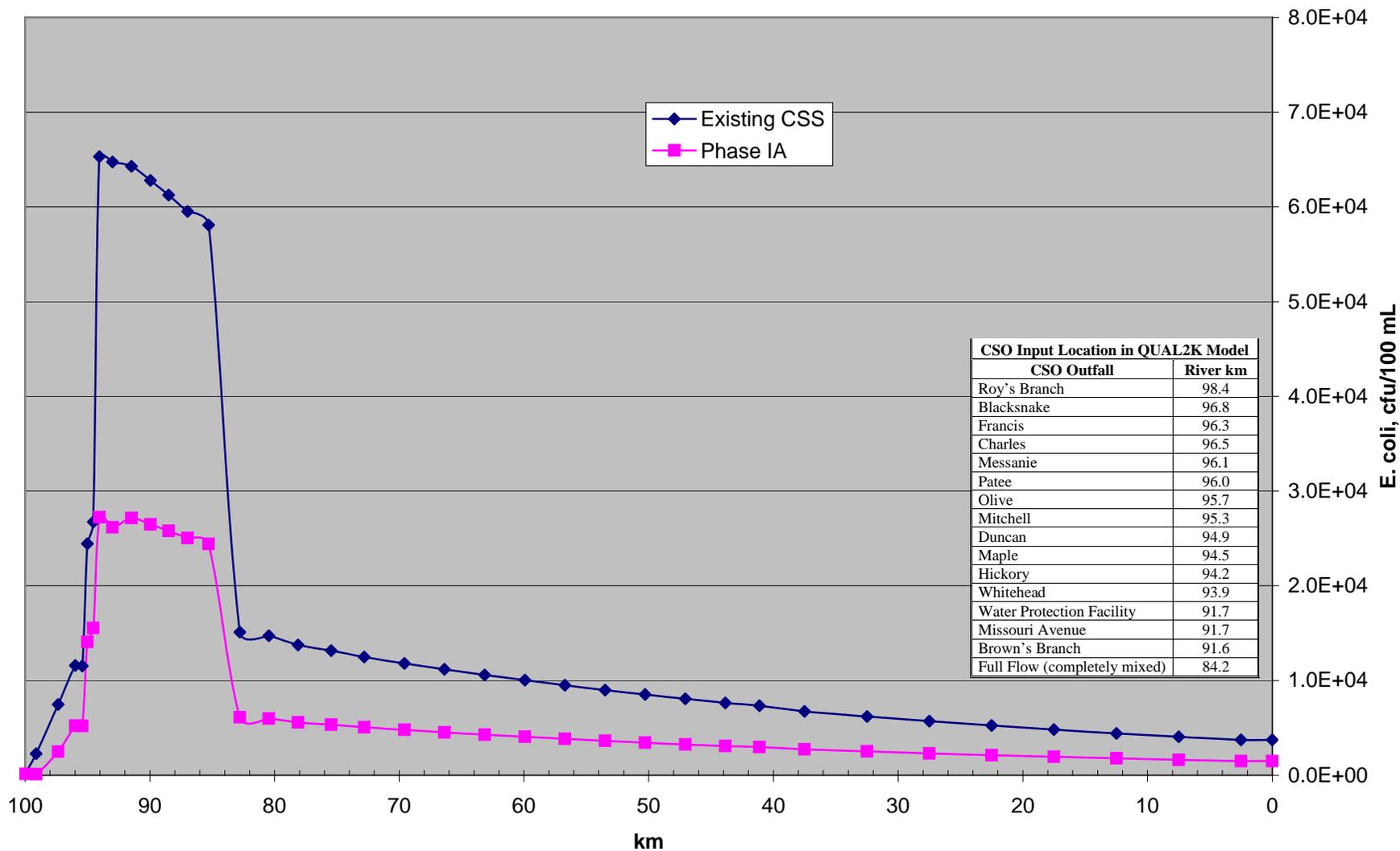
St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event A



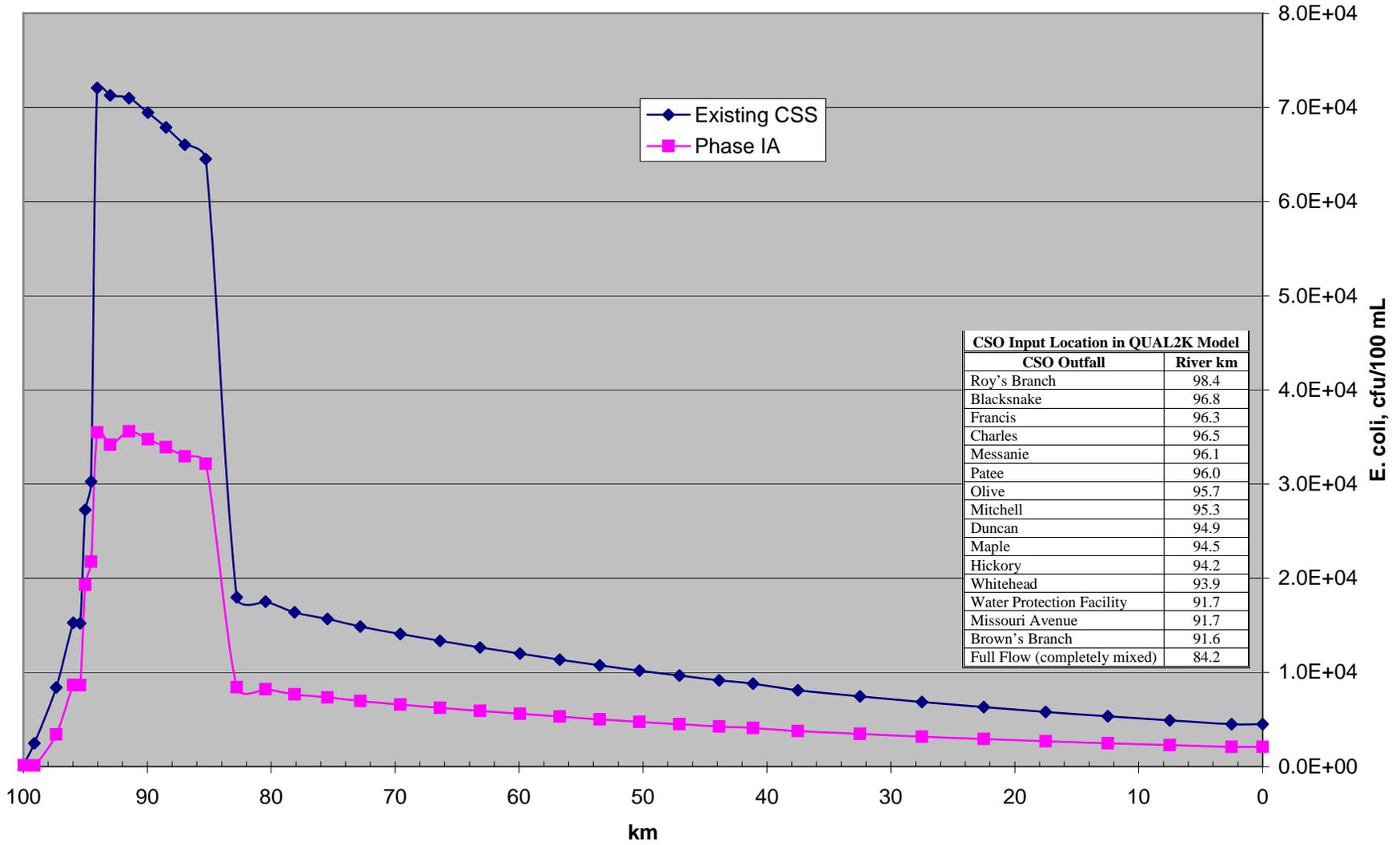
St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event B



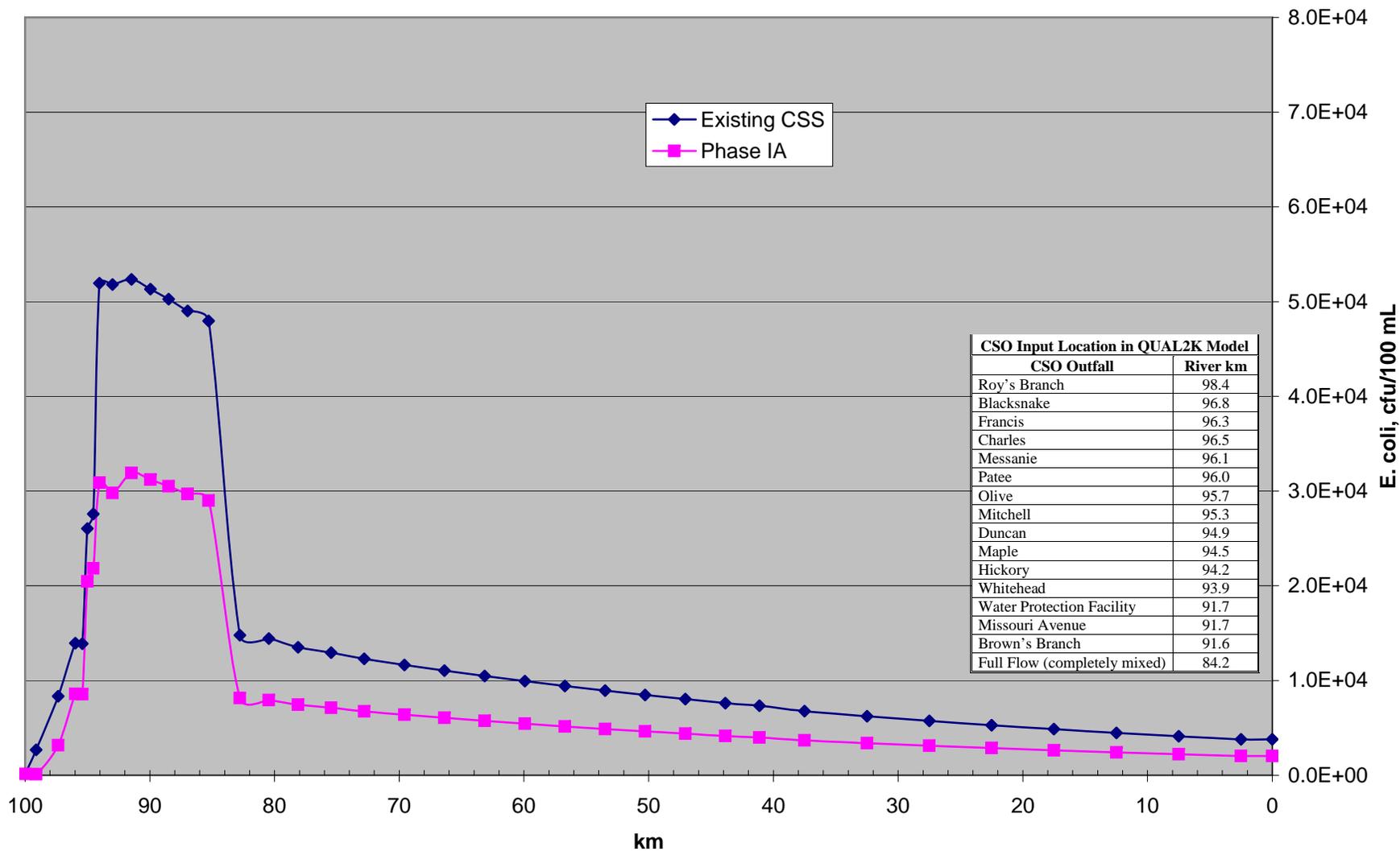
St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event C



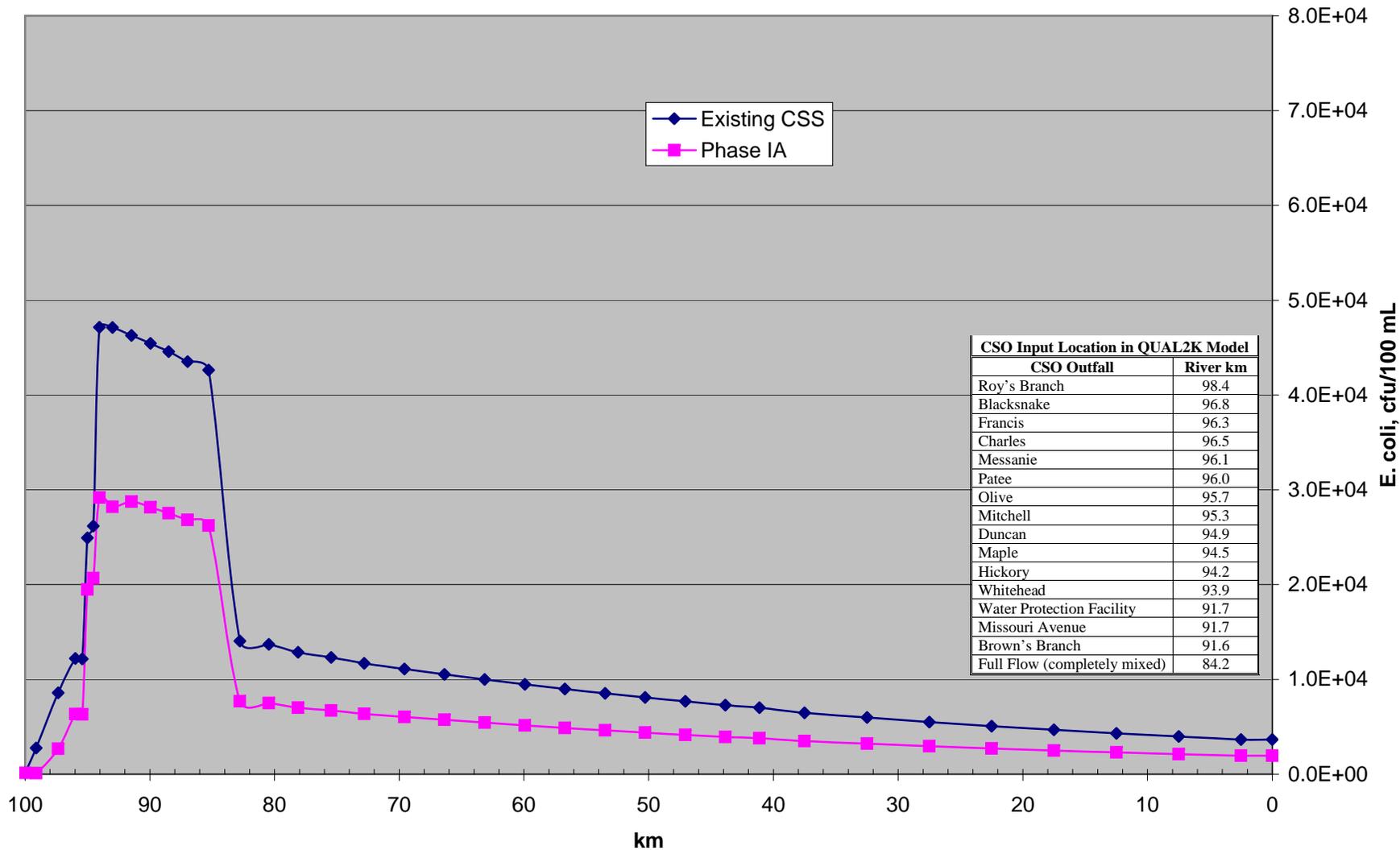
St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event D



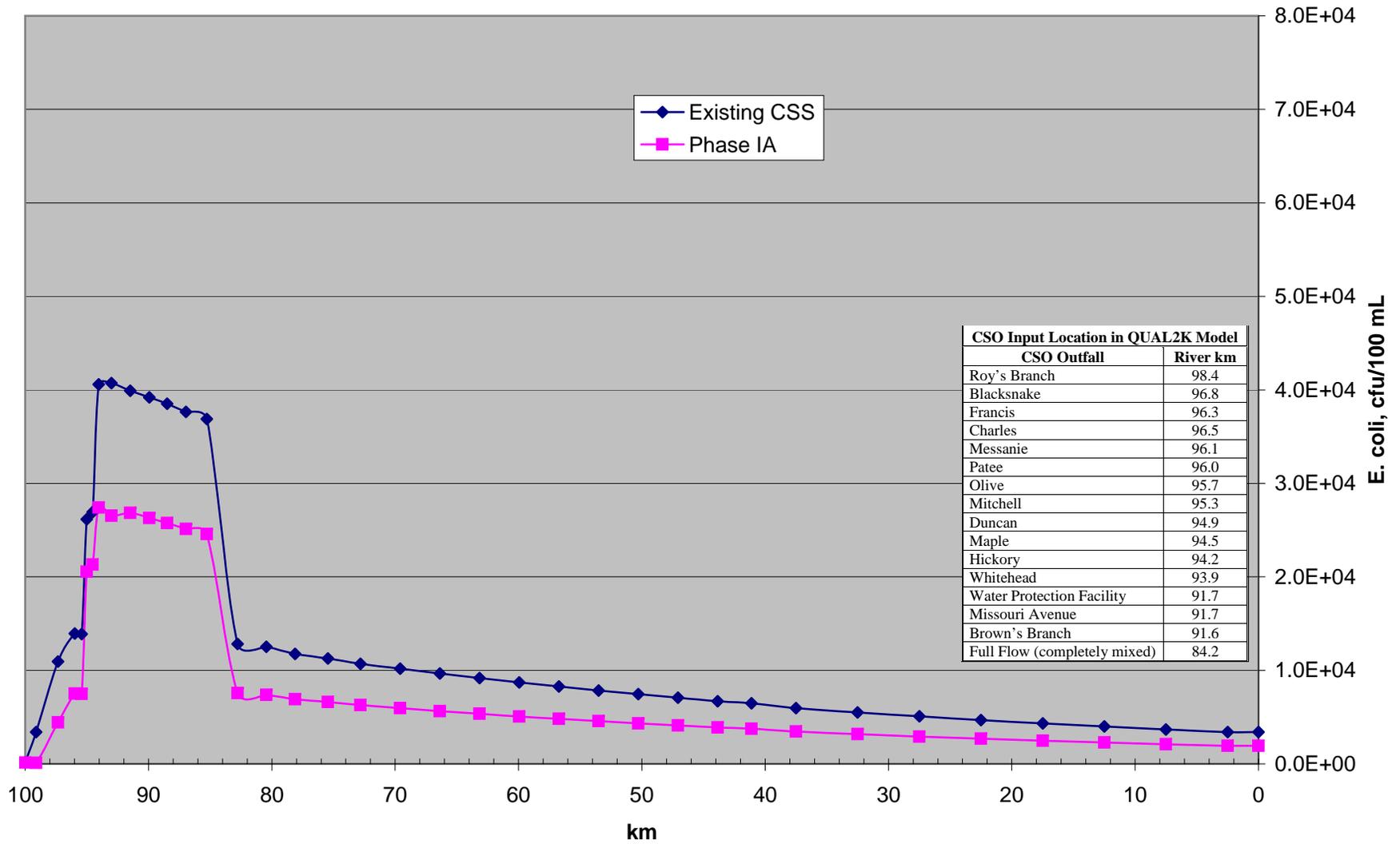
St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event E



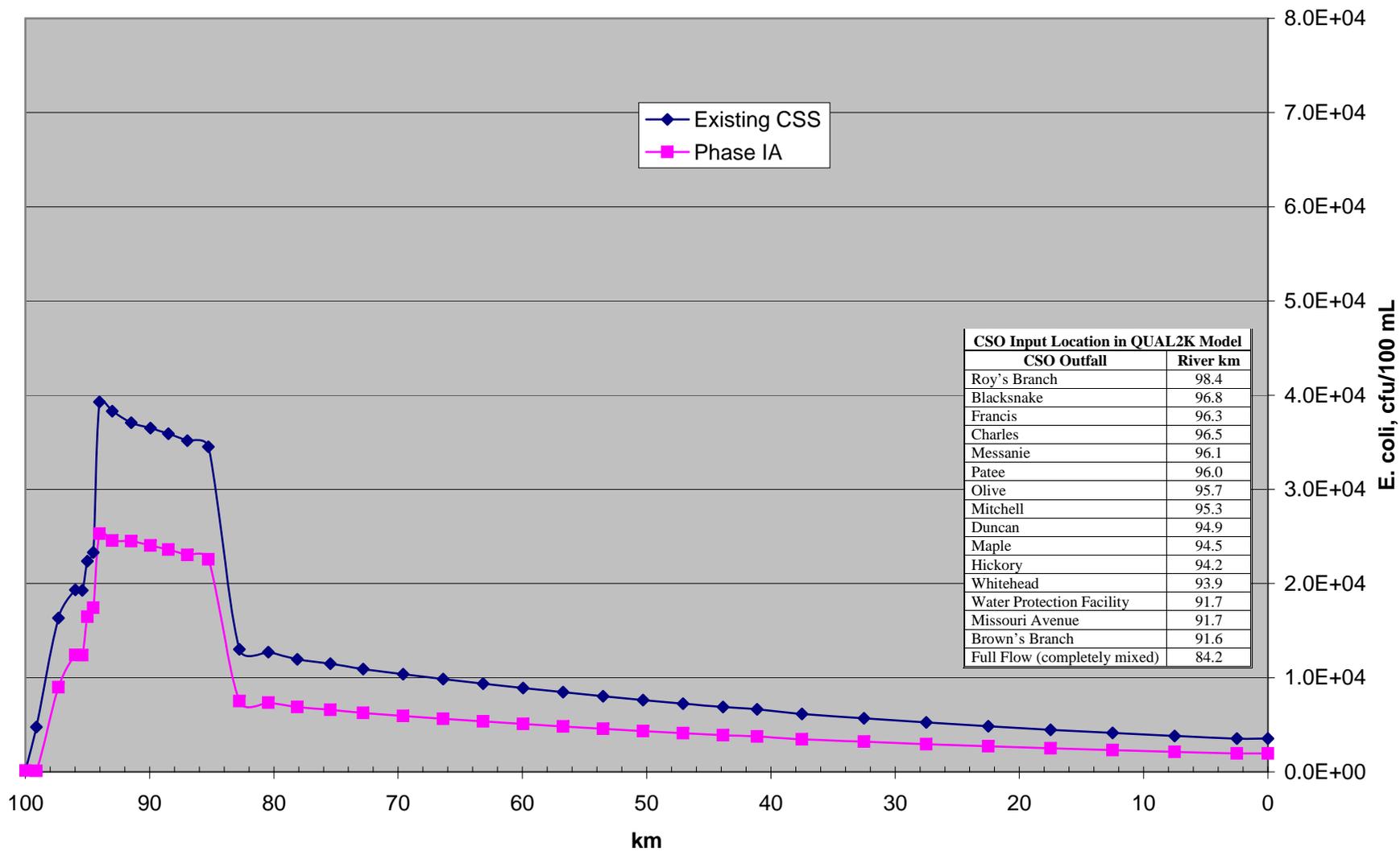
St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event F



St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event G



St. Joseph, Missouri  
 Peak Concentration of E. coli in Missouri River Resulting from Design Storm

Event H

