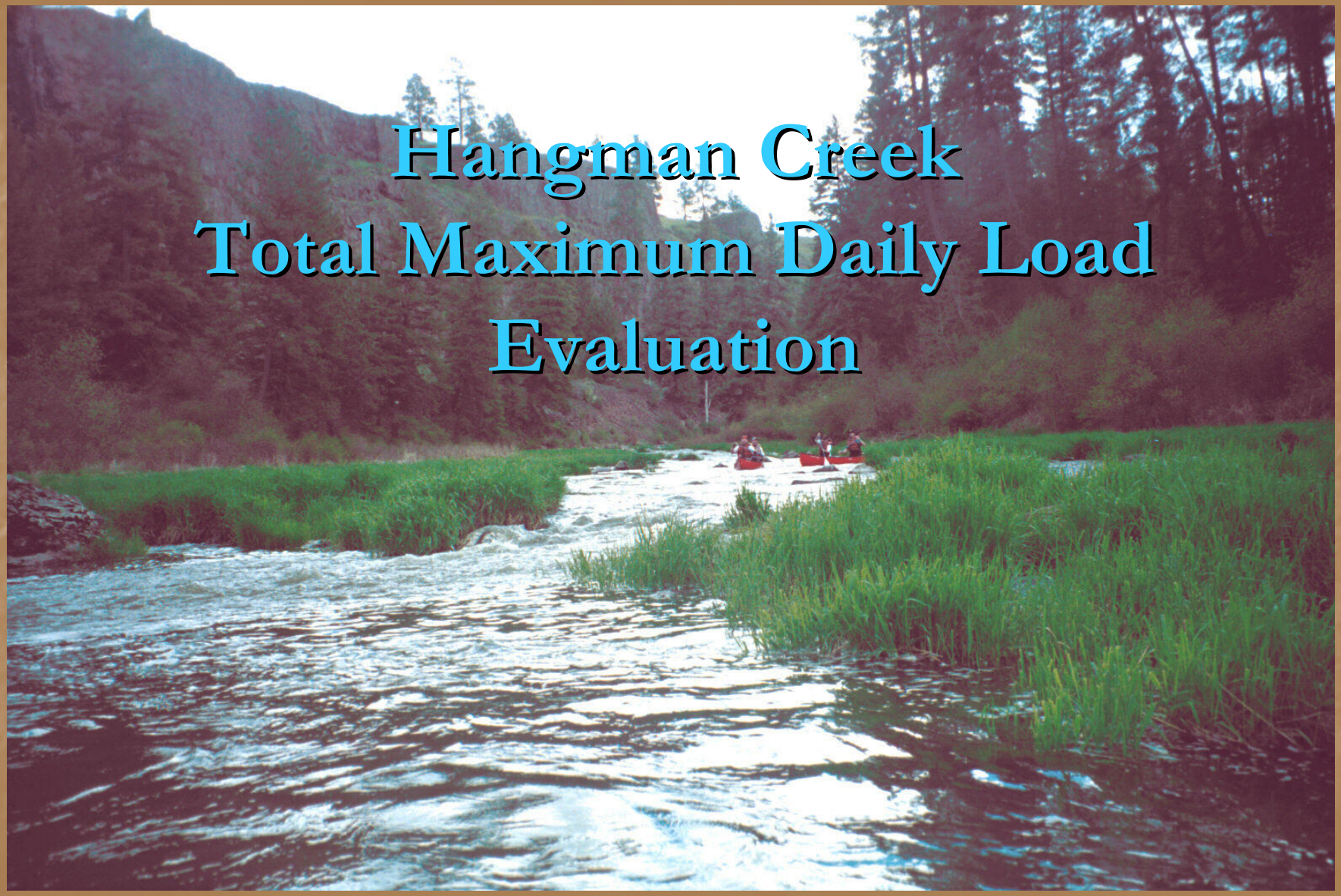
Hangman Creek Total Maximum Daily Load Evaluation



Hangman Creek TMDL

- Fecal coliform
  - Statistical roll-back method
  - Load curve analysis
  - Checking upstream mass balance
- Temperature
  - SNTEMP Model from Hardin-Davis (2003)
  - Shade Model analysis
  - Shade Curves for Tributary Reaches

Hangman Creek TMDL

- Phosphorus
  - Seasonal & Annual assessments
  - Spokane River TMDL Load Allocations
  - Multiple Regression & WARMF Models
- Turbidity
  - Seasonal & Annual assessments of TSS
  - Multiple Regression & WARMF Models
  - Setting Upstream and Downstream Boundaries

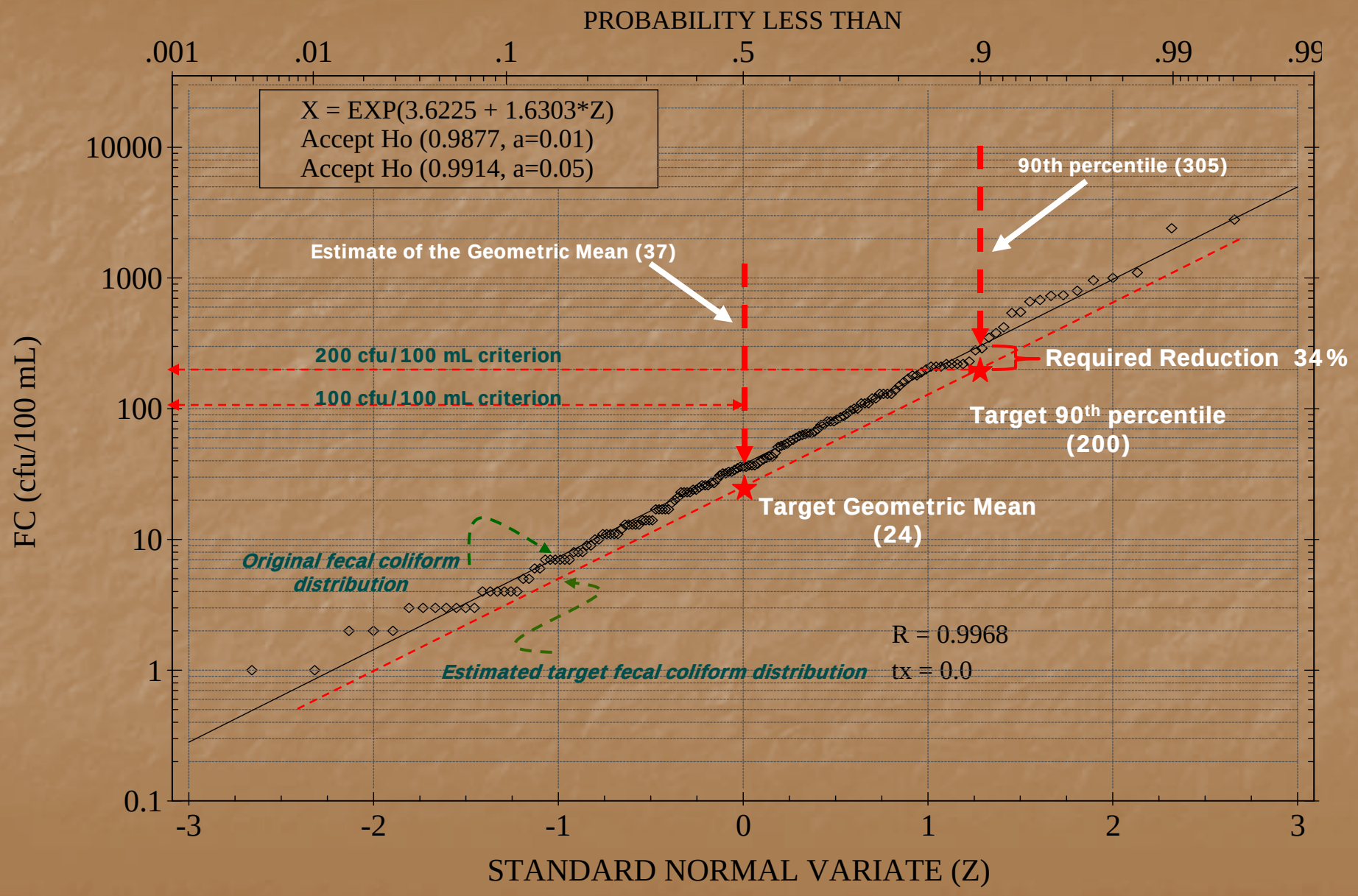
Hangman Creek TMDL

Fecal Coliform Evaluation

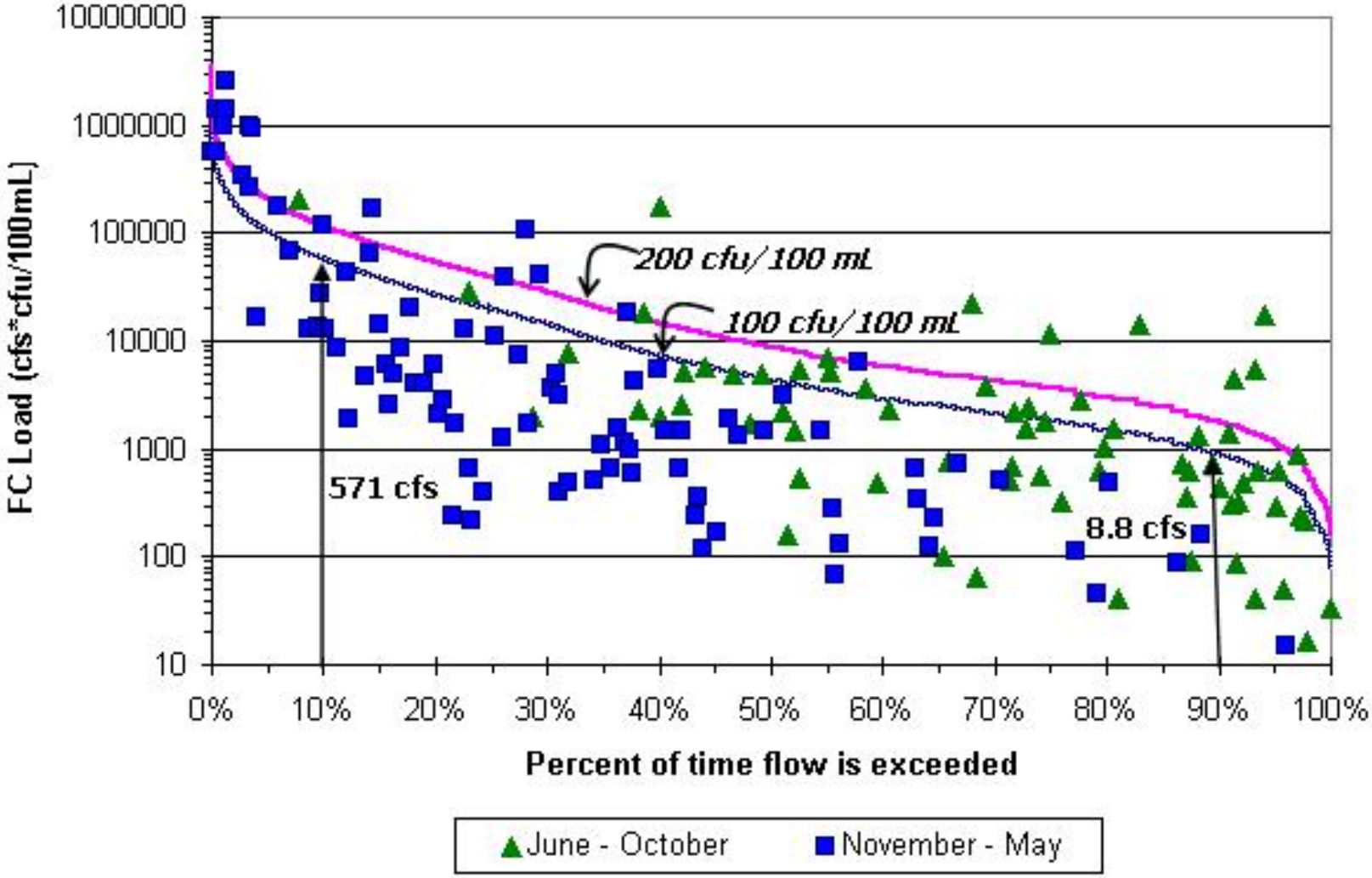
The two-level fecal coliform bacteria numeric criteria for recreational water contact

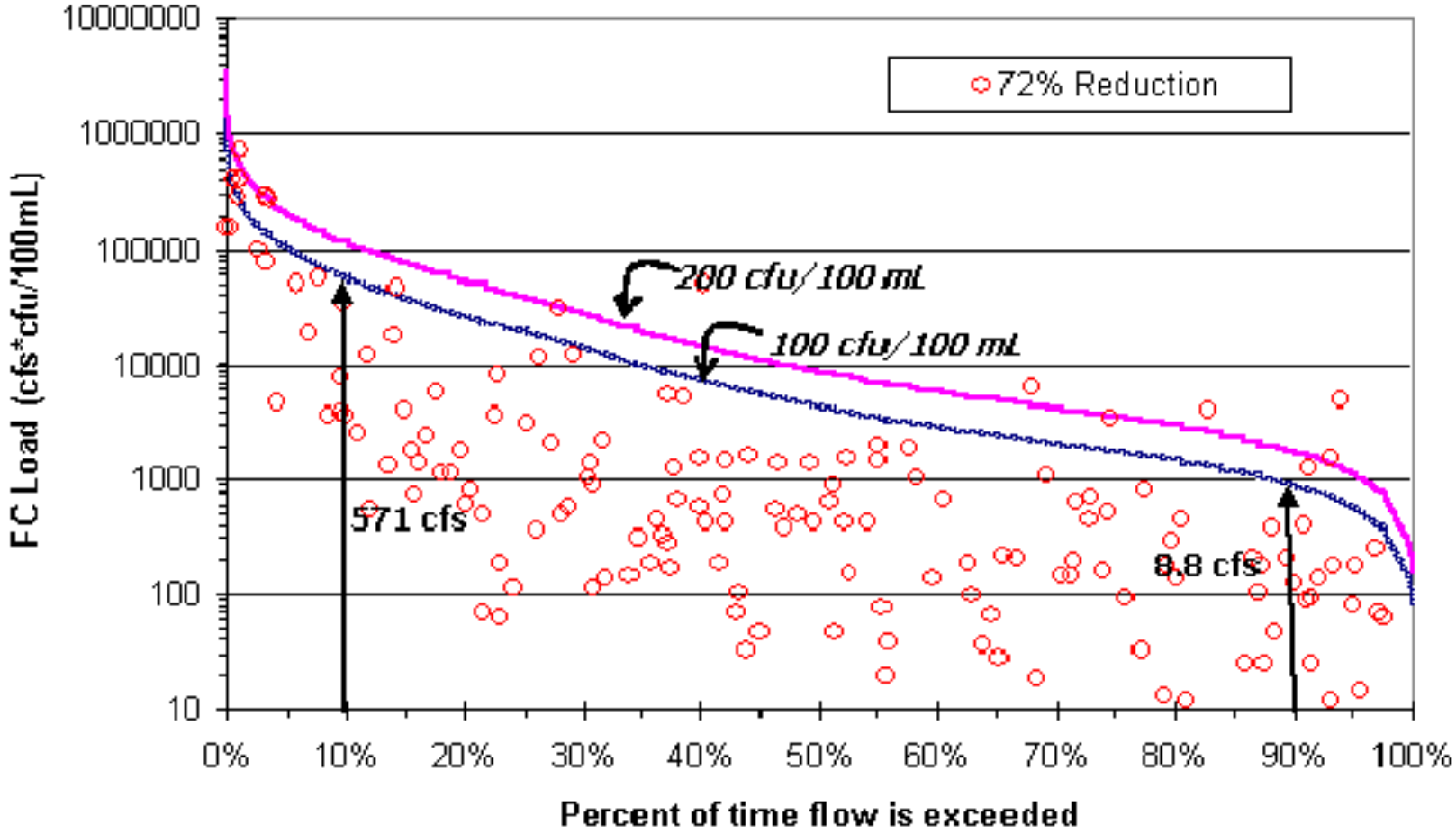
- Primary Contact (formerly Class A)
  - 100 cfu/100 mL geometric mean
  - not more than 10% >200 cfu/100 mL
  - TMDL uses 90th percentile ~ 10% criterion

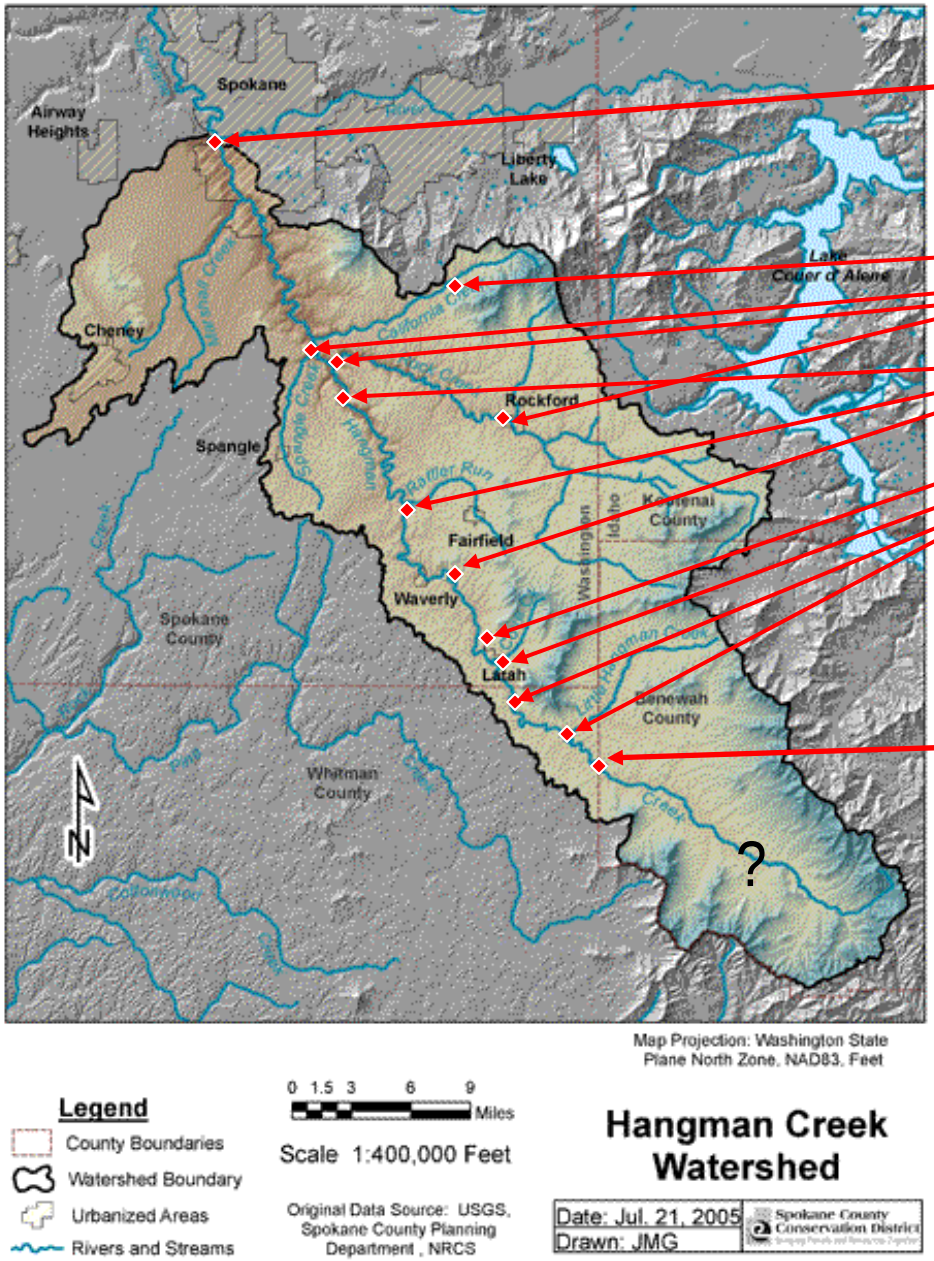
HANGMAN CREEK AT MOUTH



River Mile	Location	Critical Period*	No. Samples	FC Reduction	FC Target Capacity (cfu/100mL)	
					90th % tile	Geomean.
57.4	Hangman Creek at State Line	Aug - Jan	20	72%	200	36
	Hangman Creek at Fairbanks Road		7	56%	200	20
	Hangman Creek at South Valley Road		7	65%	200	24
47.3	Hangman Creek at Marsh Road		8	32%	200	24
41.5	Hangman Creek at Roberts Road		12	27%	200	36
32.9	Hangman Creek at Bradshaw Road		35	60%	200	30
29.2	Hangman Creek at Keevy Road		12	78%	200	11
	Hangman Creek at Kay Road		12	56%	200	20
18.6	Hangman Creek at Duncan Road		12	10%	200	27
0.8	Hangman Creek at Mouth	July - Sept	43	72%	200	40
	Little Hangman Creek		21	67%	200	31
	Cove Creek		12	79%	200	19
	Rattler Run		31	85%	200	12
	Rock Creek at Rockford		11	67%	200	12
	Rock Creek at Jackson Road		33	68%	200	16
	Rock Creek at Mouth		12	70%	200	34
	Spangle Creek		7	28%	200	18
	California Creek at Marsh Road		12	49%	200	14
	California Creek at Mouth		12	23%	200	15
	Marshall Creek at McKenzie Road		11		200	9
	Marshall Creek at the Mouth		12	54%	200	19


10000000
1000000
100000
10000
1000
100
10
FC Load (cfs*cfu/100mL)
200 cfu/100 mL
100 cfu/100 mL
571 cfs
8.8 cfs
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of time flow is exceeded
June - October
November - May


72% Reduction
200 cfu/100 mL
100 cfu/100 mL
571 cfs
8.8 cfs
FC Load (cfs*cfu/100mL)
10000000
1000000
100000
10000
1000
100
10
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of time flow is exceeded



Hangman Creek at Mouth

=

Fecal coliform target reductions at each upstream site must be adequate to support the downstream target reductions

+

Hangman Creek at State Line

Hangman Creek Reach, Point Source, or Tributary	WLA or Load Allocation (cfu/day)	Current Load (cfu/day)	Target Reduction (%)	Target Basis WLA/LA WQ criterion
Hangman Creek at State Line	5.6×10^{11}	2.0×10^{12}	72%	10% > 200
Little Hangman Creek	5.6×10^{10}	1.7×10^{11}	67%	10% > 200
Tekoa WWTP	1.2×10^{9}	3.9×10^{9}	70%	NPDES permit
Hangman Creek at Fairbanks Road	2.4×10^{11}	5.4×10^{11}	56%	10% > 200
Hangman Creek at South Valley Road	2.8×10^{11}	8.0×10^{11}	65%	10% > 200
Hangman Creek at Marsh Road	3.3×10^{11}	4.9×10^{11}	32%	10% > 200
Cove Creek	1.3×10^{9}	6.0×10^{9}	79%	10% > 200
Hangman Creek at Roberts Road	5.1×10^{11}	7.0×10^{11}	27%	10% > 200
Hangman Creek at Bradshaw Road	6.8×10^{11}	1.7×10^{12}	60%	10% > 200
Rattler Run at Mouth	2.3×10^{9}	1.5×10^{10}	85%	10% > 200
Rattler Run Nonpoint Sources	1.3×10^{9}	1.2×10^{10}	89%	10% > 200
Fairfield WWTP	9.6×10^{8}	3.0×10^{9}	68%	NPDES permit
Hangman Creek at Keevy Road	3.7×10^{11}	1.7×10^{12}	78%	10% > 200
Hangman Creek at Kay Road	2.9×10^{11}	6.7×10^{11}	56%	10% > 200
Rock Creek at Mouth	6.6×10^{10}	2.2×10^{11}	70%	10% > 200
Rock Creek at Jackson Road	2.4×10^{11}	7.5×10^{11}	68%	10% > 200
Rockford WWTP	2.8×10^{8}	2.9×10^{8}	3%	NPDES Permit
Freeman School District	1.3×10^{7}	2.0×10^{7}	15%	NPDES Permit
Rock Creek at Rockford	2.4×10^{10}	7.4×10^{10}	67%	10% > 200
Spangle Creek at Mouth	8.6×10^{8}	1.2×10^{9}	28%	10% > 200
Spangle Creek Nonpoint Sources	8.4×10^{8}	1.2×10^{9}	29%	10% > 200
Spangle WWTP	2.2×10^{7}	2.2×10^{7}	NPDES permit (no reduction)	
Hangman Creek at Duncan Road	7.0×10^{11}	7.8×10^{11}	10%	10% > 200
California Creek at Mouth	2.5×10^{9}	3.2×10^{9}	23%	10% > 200
California Creek at Marsh Road	7.1×10^{8}	1.4×10^{9}	49%	10% > 200
WA Dept. of Transportation stormwater	NC	NC	72%	10% > 200
Spokane County stormwater WLA	NC	NC	72%	10% > 200
Marshall Creek at the Mouth	8.3×10^{8}	1.8×10^{9}	54%	10% > 200
Marshall Creek at McKenzie Road	3.0×10^{9}	3.0×10^{9}	no reduction required	
Cheney WWTP*	1.6×10^{9}	1.6×10^{9}	NPDES permit (no reduction)*	
City of Spokane stormwater WLA	NC	NC	72%	10% > 200
Hangman Creek at Mouth	2.3×10^{10}	8.2×10^{10}	72%	10% > 200

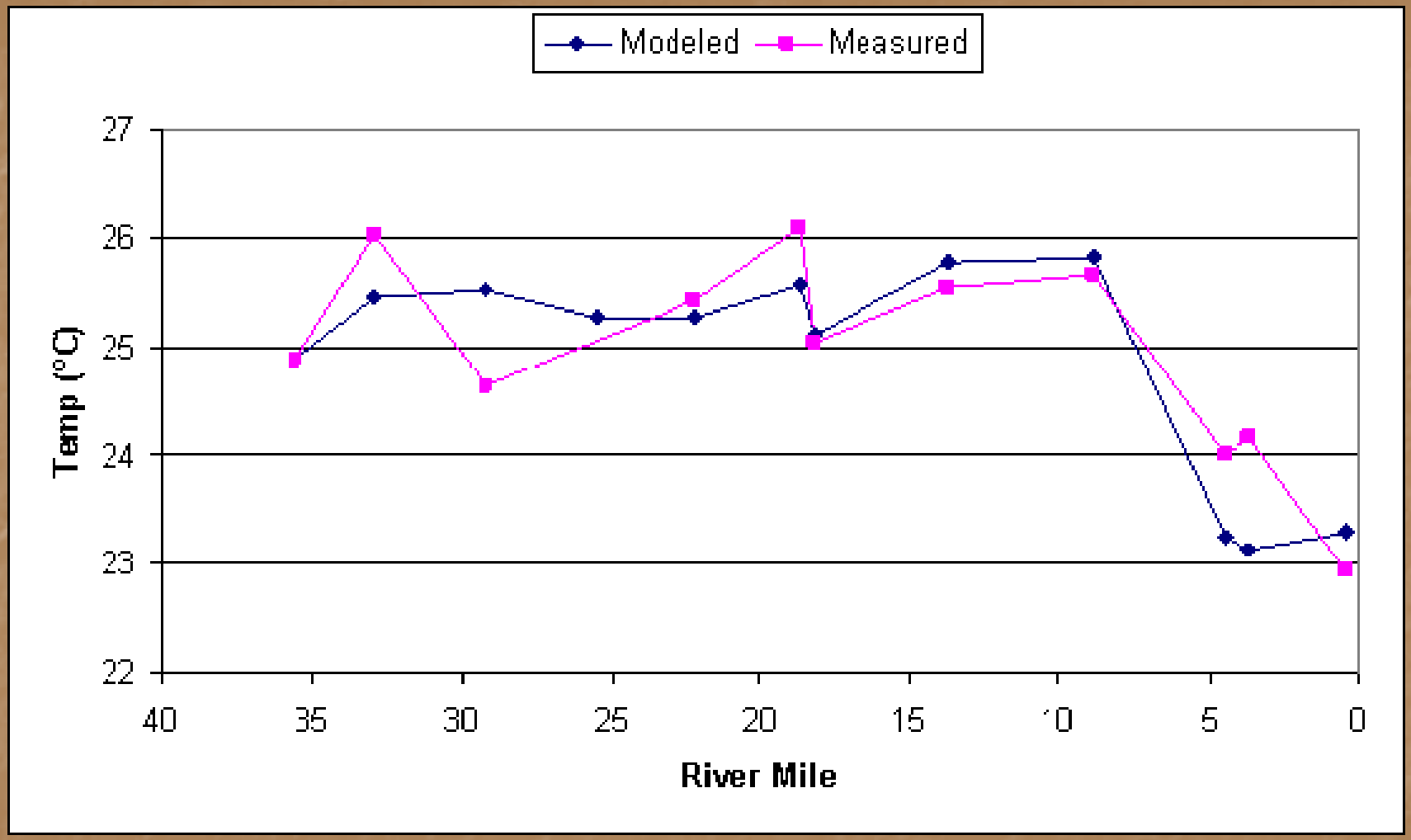
Hangman Creek TMDL

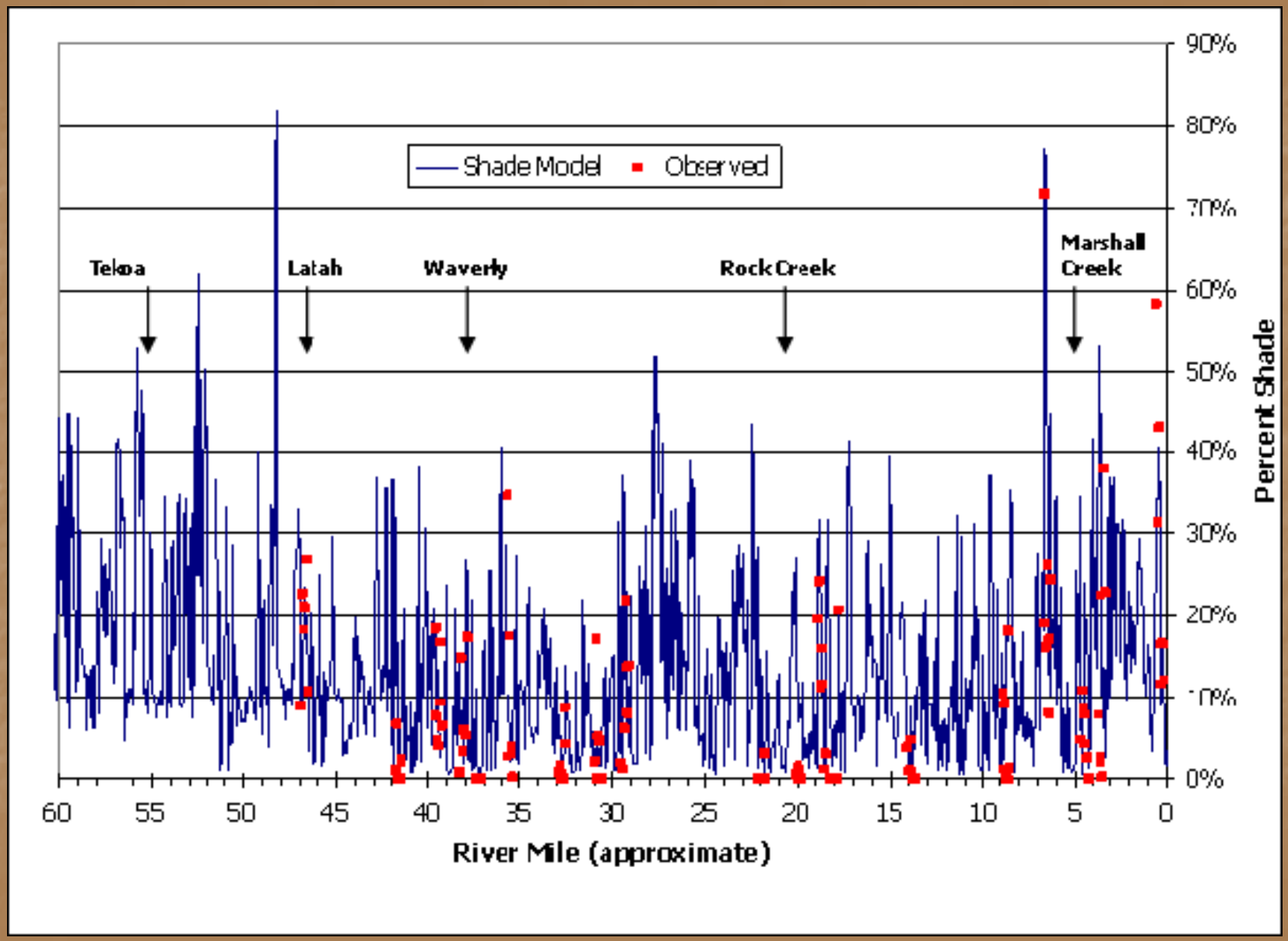
Temperature Evaluation

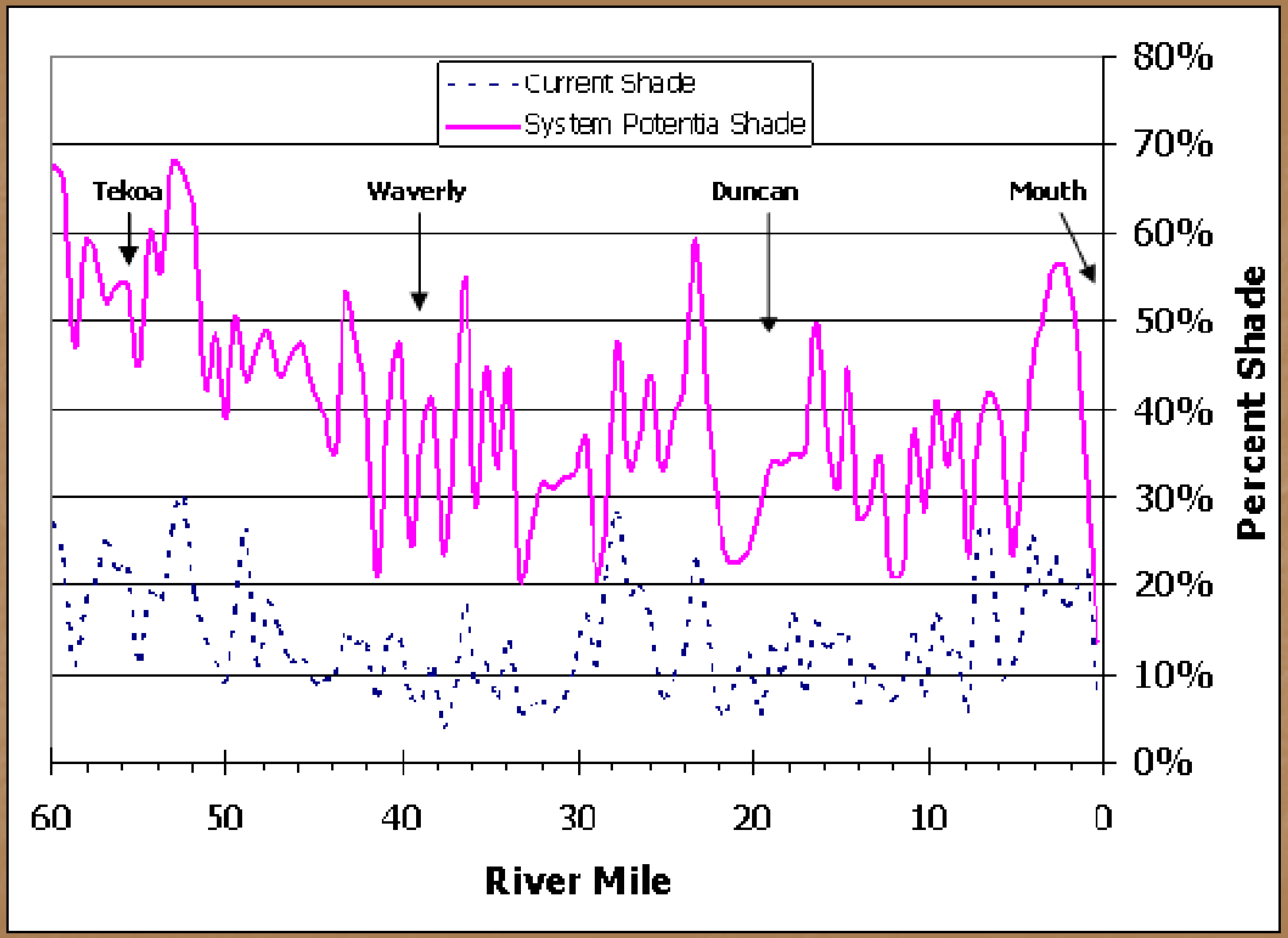
- *(1) All surface waters of the state not named in Table 602 are to be protected for the designated uses of: Salmon and trout spawning, rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values."*

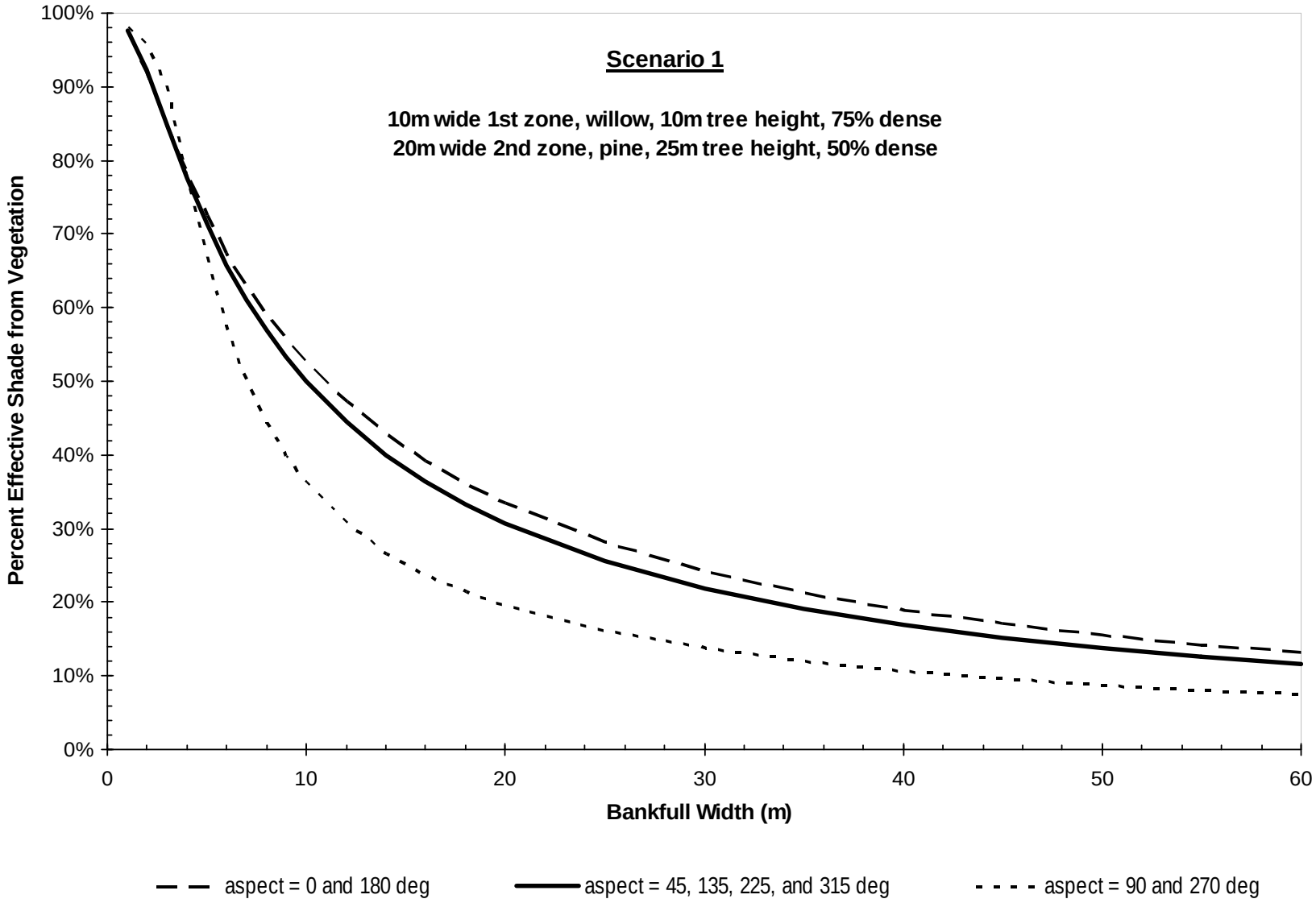
- *(3) To protect the designated aquatic life uses of "Salmon and Trout Spawning and Non-core Rearing" the highest 7-day average daily maximum (7-DADMax) temperature must not exceed 17.5°C (63.5°F) more than once every ten years on average.*

- *combined effects of all human activities must also not cause more than a 0.3°C (0.54°F) increase above the naturally higher (inferior) temperature condition.*


Modeled
Measured
27
26
25
24
23
22
Temp (°C)
40
35
30
25
20
15
10
5
0
River Mile


Shade Model
Observed
Teloa
Latah
Waverly
Rock Creek
Marshall Creek
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Shade
60
55
50
45
40
35
30
25
20
15
10
5
0
River Mile (approximate)


Current Shade
System Potentia Shade
Tekoa
Waverly
Duncan
Mouth
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Shade
60
50
40
30
20
10
0
River Mile

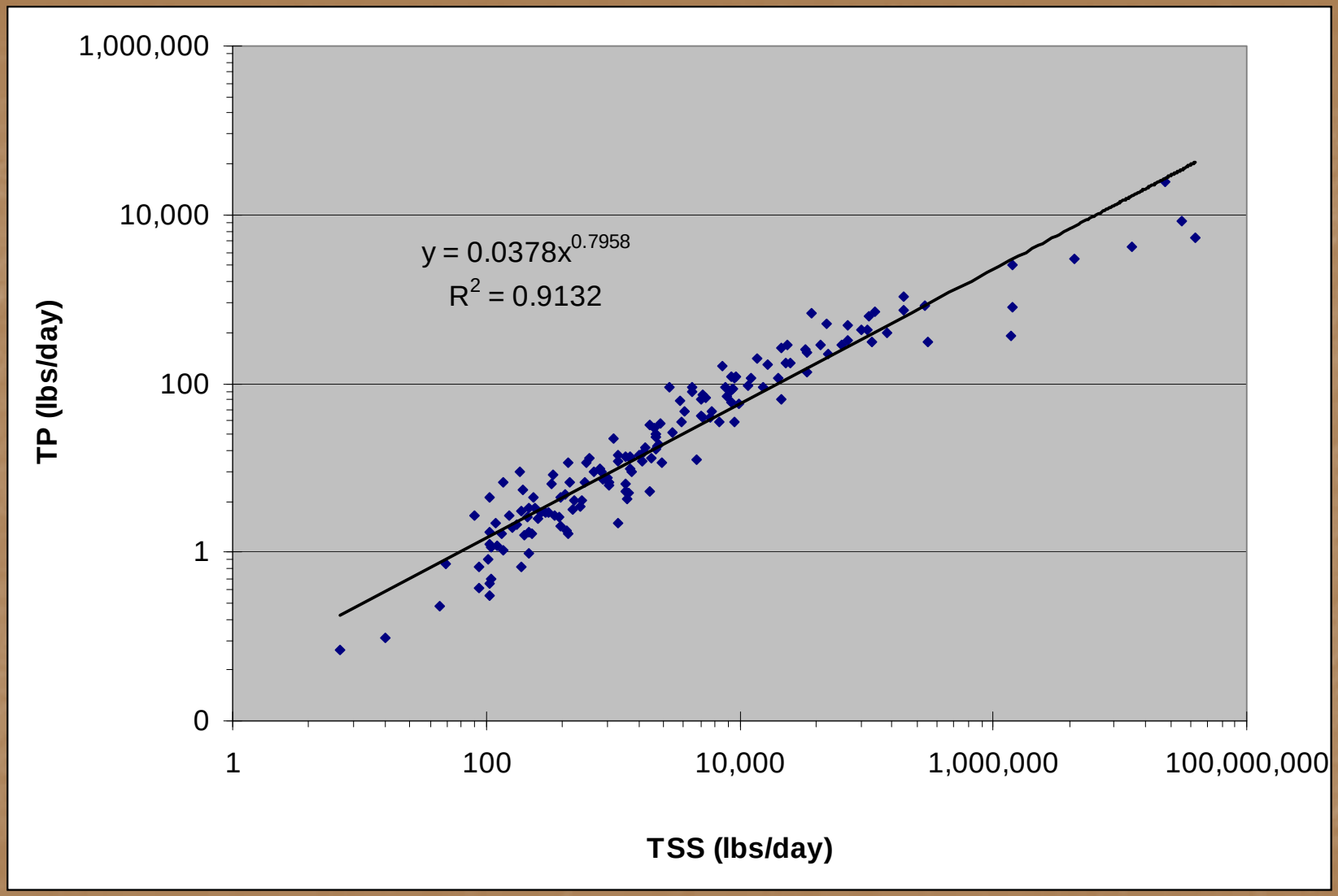

Scenario 1
10m wide 1st zone, willow, 10m tree height, 75% dense
20m wide 2nd zone, pine, 25m tree height, 50% dense
Percent Effective Shade from Vegetation
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
Bankfull Width (m)
aspect = 0 and 180 deg
aspect = 45, 135, 225, and 315 deg
aspect = 90 and 270 deg

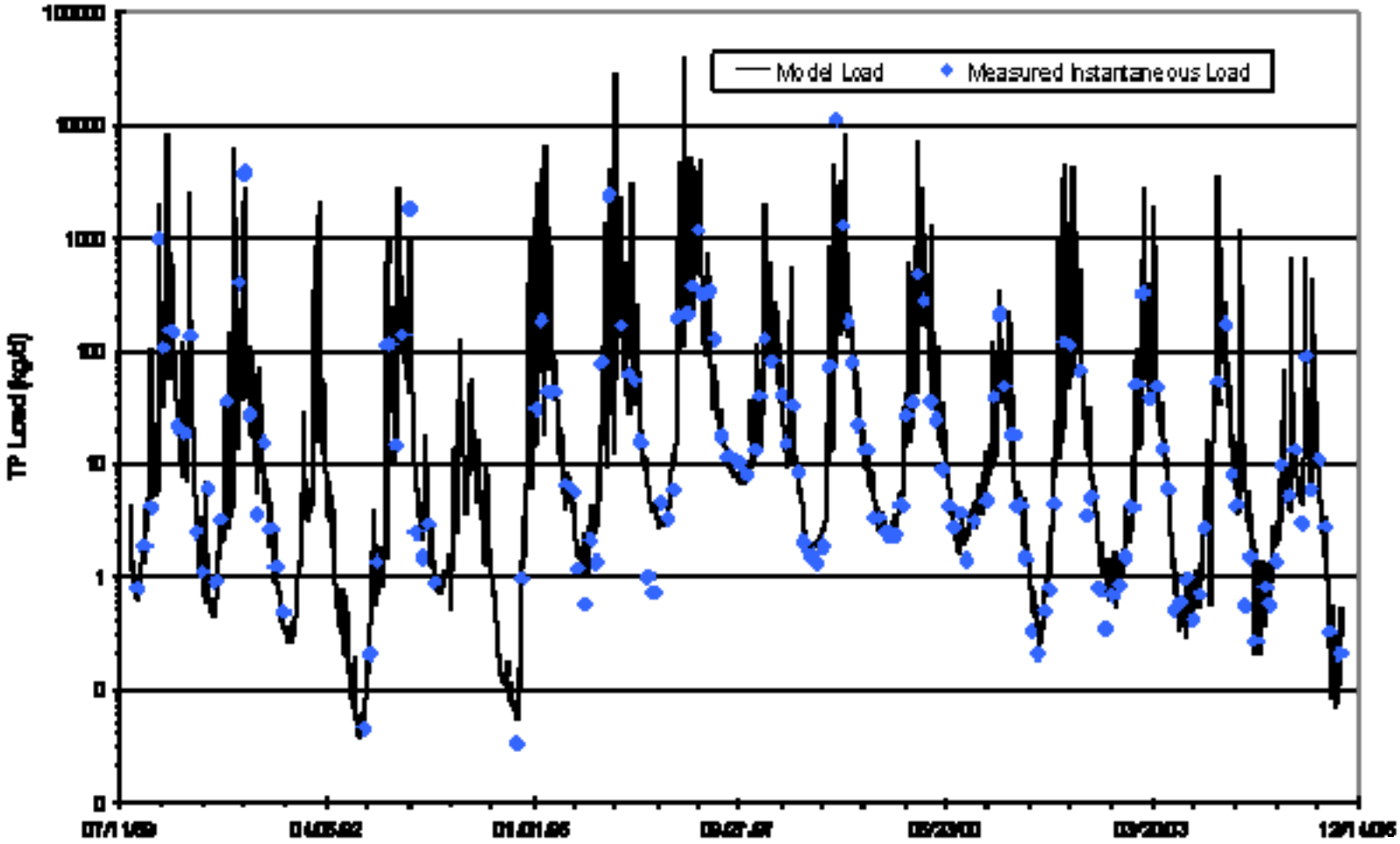
Distance from upstream segment boundary (Km)	Distance to downstream segment boundary (Km)	Current shade condition (%)	System potential shade	Increase in % shade needed	Landmark RM station	Load allocation for daily average shortwave solar radiation on August 1 (watts/m2)
1	2	21%	56%	**35%**	Idaho/Washington Border	137.5
2	3	27%	67%	**40%**		102.0
3	4	23%	66%	**43%**		106.3
4	5	11%	47%	**36%**		166.7
5	6	18%	59%	**41%**		128.9
6	7	20%	58%	**38%**		131.3
7	8	25%	52%	**27%**	Tekoa	149.6
8	9	22%	54%	**32%**		144.4
9	10	22%	54%	**32%**		143.6
10	11	11%	45%	**34%**		172.9
11	12	19%	60%	**41%**		125.8
12	13	18%	56%	**37%**		139.1
13	14	26%	68%	**42%**		100.3
14	15	30%	67%	**37%**		104.0
15	16	19%	62%	**43%**		119.8
16	17	14%	43%	**29%**		179.7
17	18	11%	48%	**37%**		162.0
18	19	9%	39%	**30%**		191.0
19	20	17%	50%	**33%**		155.3
20	21	27%	43%	**17%**		178.0
21	22	11%	47%	**36%**		167.0
22	23	18%	49%	**31%**		160.4
23	24	15%	44%	**29%**		176.5
24	25	11%	46%	**34%**		170.4
25	26	12%	47%	**35%**		165.5
26	27	9%	42%	**33%**		180.7
27	28	9%	39%	**30%**		189.9
28	29	10%	35%	**25%**		203.3
29	30	14%	53%	**39%**		147.8

Hangman Creek TMDL

Total Phosphorus Evaluation

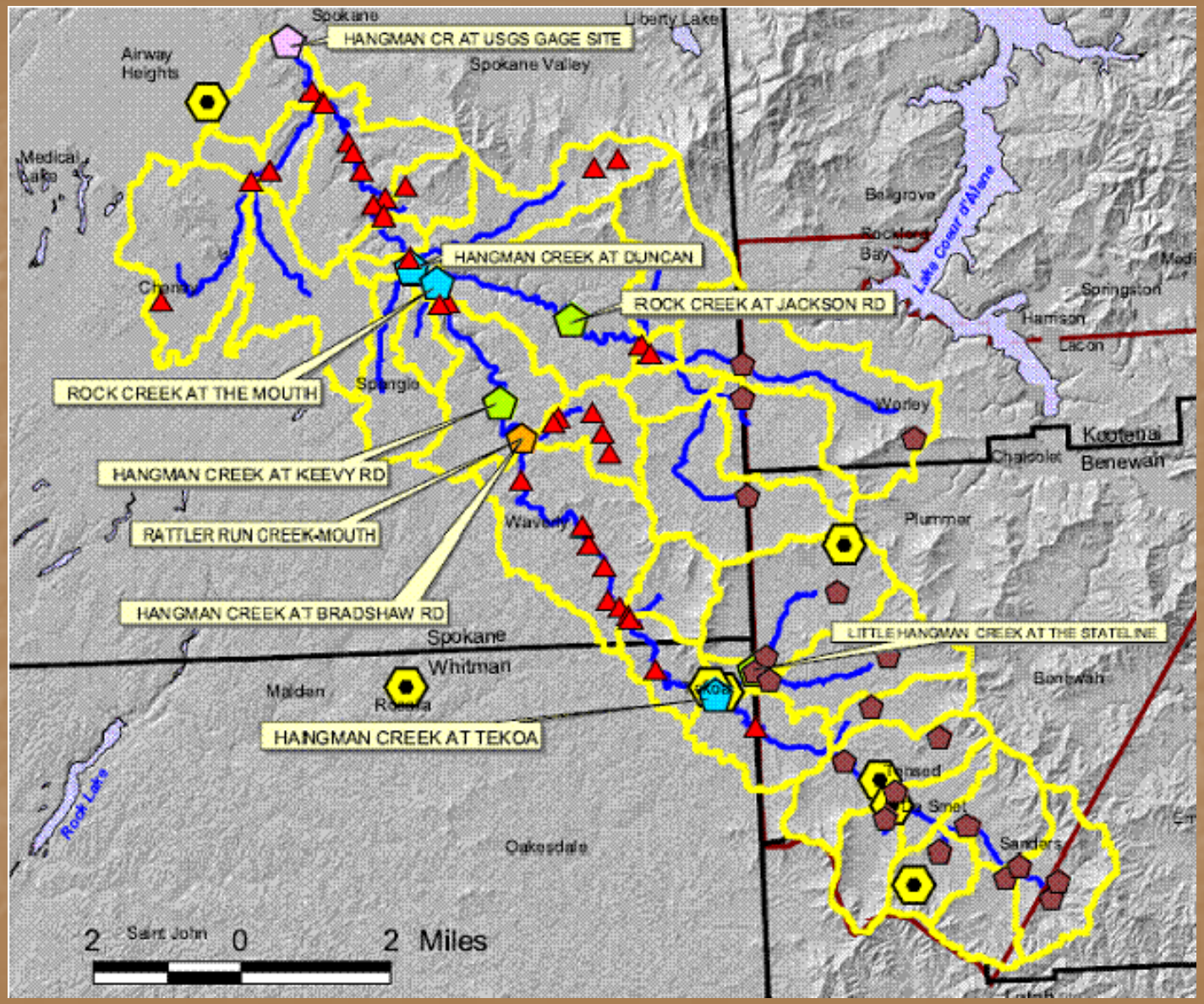
- Mouth of Hangman to meet the Spokane River Dissolved Oxygen TMDL recommended TP Load Allocations:
  - April – May = 50.6 lbs/day
  - June – October = 3.3 lbs/day

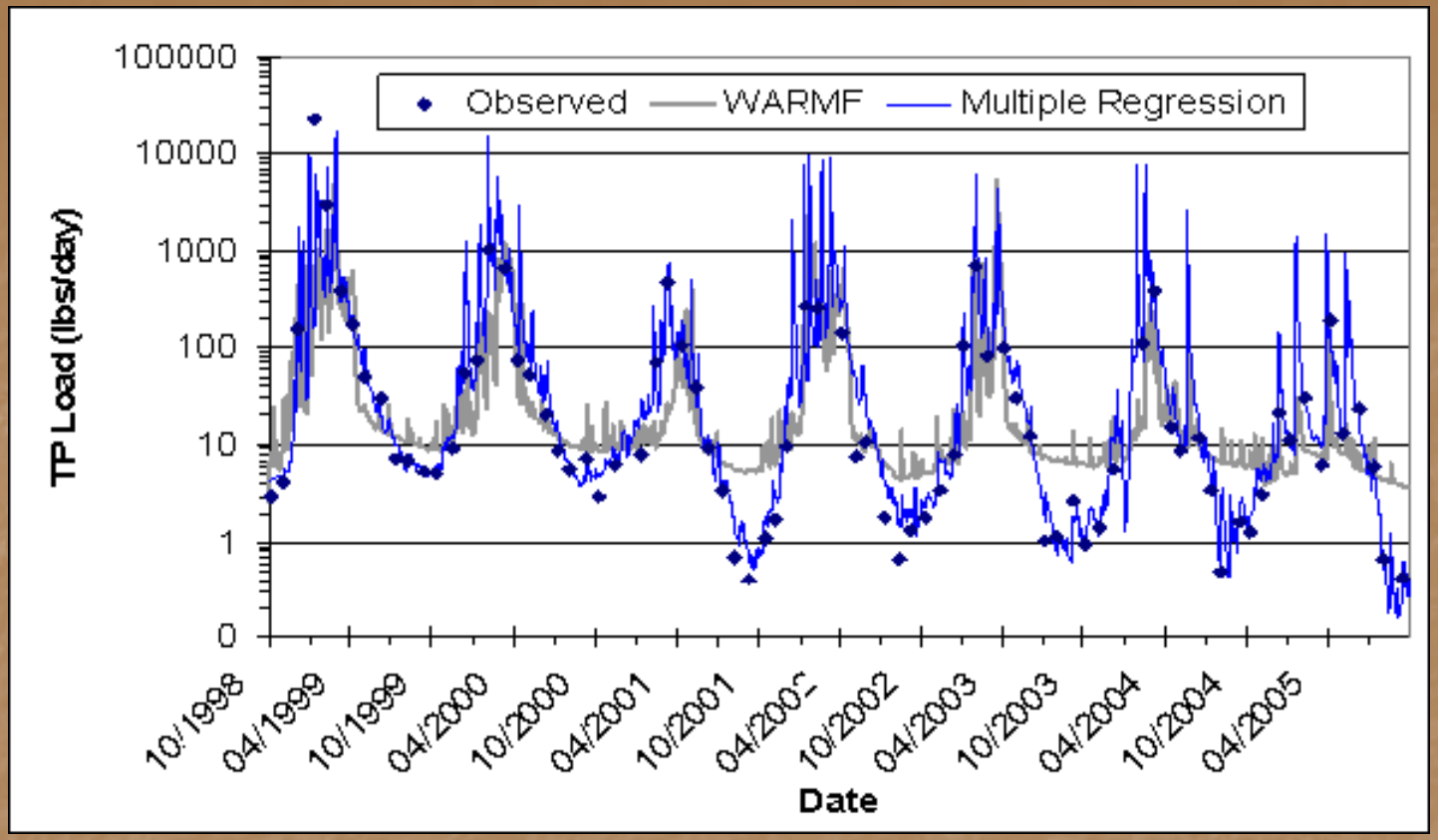

1,000,000
10,000
100
1
0
TP (lbs/day)
y = 0.0378x^0.7958
R^2 = 0.9132
1
100
10,000
1,000,000
100,000,000
TSS (lbs/day)


Model Load
Measured Instantaneous Load
TP Load (kg/d)
100000
10000
1000
100
10
1
0
0

Estimated daily average total phosphorus loads from Hangman Creek compared to the Spokane River DO TMDL recommended load allocations

Year	April	May	June	July	August	September	October	April-May	June – October
1996	661	168	31	13	7.1	6.4	13	410	14
1997	529	234	71	36	21	17	15	379	32
1998	75	145	39	11	4.5	3.9	4.6	107	13
1999	138	47	19	10	6.6	5.4	6.5	105	9.5
2000	364	81	35	11	4.8	4.9	5.6	219	12
2001	98	71	**8.3**	4.2	1.4	**0.7**	**1.6**	87	**3.2**
2002	260	42	14	4.2	2.0	2.1	3.0	146	5.0
2003	92	**37**	**8.0**	**1.7**	**0.9**	1.4	**1.6**	67	**2.7**
2004	**31**	167	22	5.1	1.5	1.8	3.0	73	6.5
2005	72	115	13	**3.7**	**0.4**	**0.4**	**1.4**	158	3.7
Load Allocation	60.6	40.6	8.3	3.8	1.3	1.0	2.1	50.6	3.3


HANGMAN CR AT USGS GAGE SITE
HANGMAN CREEK AT DUNCAN
ROCK CREEK AT JACKSON RD
ROCK CREEK AT THE MOUTH
HANGMAN CREEK AT KEEVY RD
RATTLER RUN CREEK-MOUTH
HANGMAN CREEK AT BRADSHAW RD
LITTLE HANGMAN CREEK AT THE STATELINE
HANGMAN CREEK AT TEKOA
Spokane
Liberty Lake
Airway Heights
Spokane Valley
Medical Lake
Belgrove
Lake Coeur d'Alene
Springston
Harrison
Lacon
Worley
Kootenai
Benewah
Chatcolet
Plummer
Spangle
Waverly
Spokane
Whitman
Malden
Rosalia
Benewah
Tensed
Le Smet
Sanders
Oakesdale
Rock Lake
Saint John
2 0 2 Miles

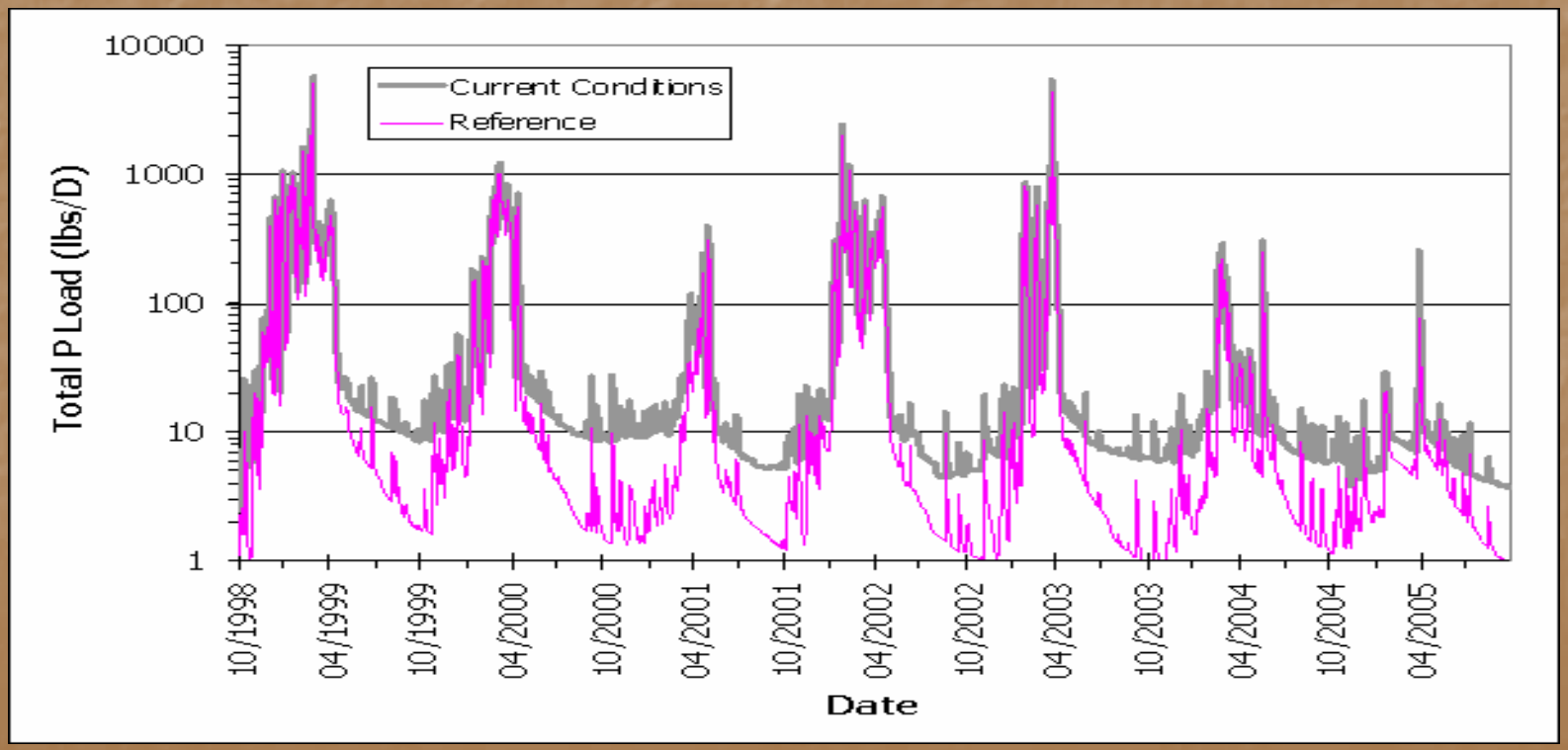


	2001		2002		2003	
Month	Multiple Regression	WARMF Model	Multiple Regression	WARMF Model	Multiple Regression	WARMF Model
April	98	67	260	270	92	80
May	71	50	42	12	37	12
June	8.3	9.1	14	10	8.0	8.6
July	4.2	6.5	4.2	6.3	1.7	7.3
August	1.4	5.4	2	5.1	0.9	6.8
September	0.7	5.3	2.1	5.1	1.4	7.1
October	1.6	8.0	2.6	5.2	1.6	6.8
Seasonal						
April - May	84	59	149	139	64	46
June - October	3.2	6.8	5.0	6.3	2.7	7.3

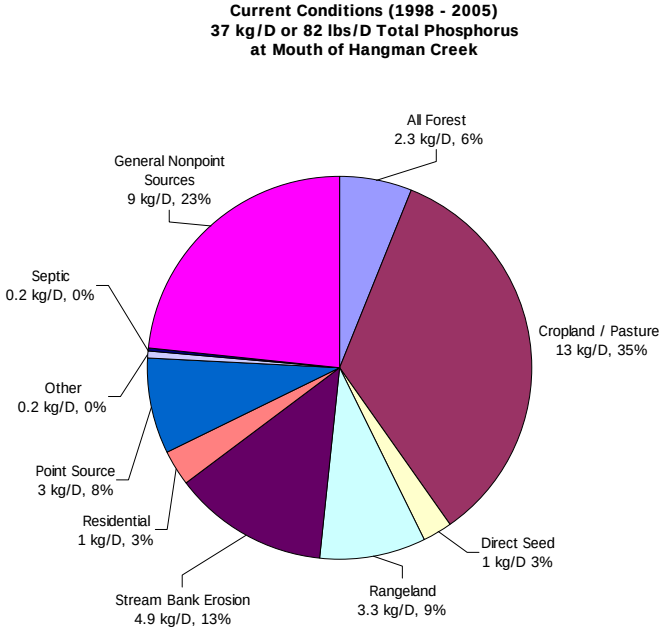
"What is the best possible set of actions that could be implemented in the Hangman Creek watershed to achieve phosphorus reductions?"

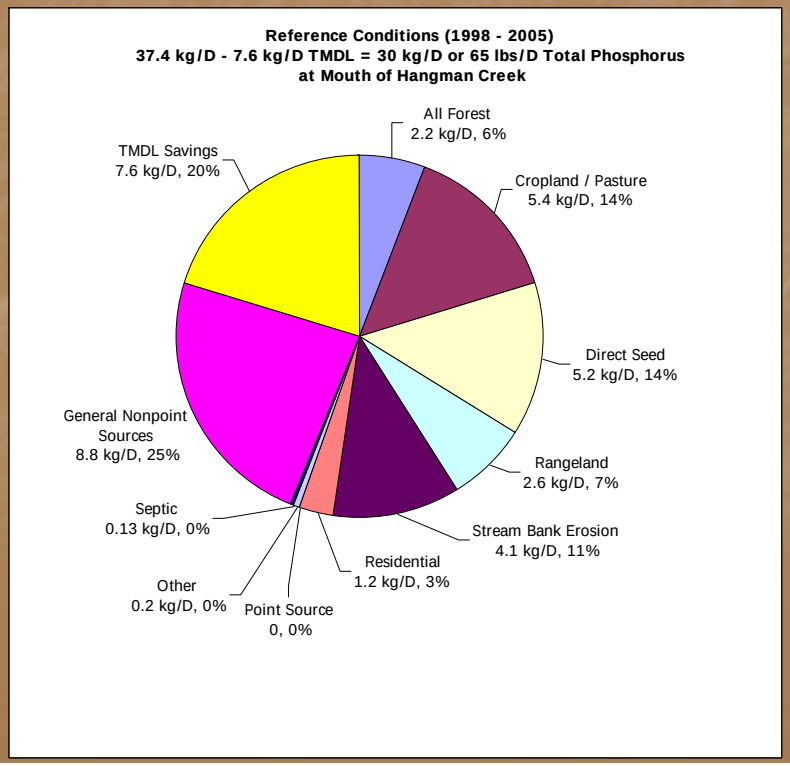
- Convert 60% of the agriculture in the watershed to direct seed or conservation practices.
- Have 10 foot riparian buffers established all along the mainstream channels and tributaries.
- Reduce the streambank erosion in the upper watershed (above Fairfield) by 50% and erosion in the lower watershed with Lake Missoula flood sediments by 10%.
- Increase forest cover in catchments above Rockford and Tensed by 50%.
- Limit residential growth to levels below 10% in lower catchments 3, 4, 7, 9 and 10.
- Eliminate point source discharges to surface water.
- Repair failing residential on-site septic systems.

Year	April	May	June	July	August	September	October	April - May	June – October
1998	-	-	-	-	-	-	**1.5**	-	-
1999	107	**26**	9	**3.4**	1.9	1.1	**1.8**	70	**3.1**
2000	284	41	14	**3.7**	**1.0**	1.2	**1.2**	162	3.5
2001	66	51	**3.6**	**1.5**	**0.4**	**0.2**	**0.6**	58	**1.1**
2002	216	**25**	**5.5**	**1.5**	**0.8**	**0.6**	**0.6**	122	**1.7**
2003	71	**18**	**3.1**	**0.4**	**0.2**	**0.3**	**0.3**	**47**	**0.7**
2004	**22**	114	11	**1.7**	**0.5**	**0.5**	**0.8**	69	**2.3**
2005	**53**	75	**6.4**	**1.6**	**0.1**	**0.11**	-	66	-
Load Allocation	60.6	40.6	8.3	3.8	1.3	1.0	2.1	50.6	3.3

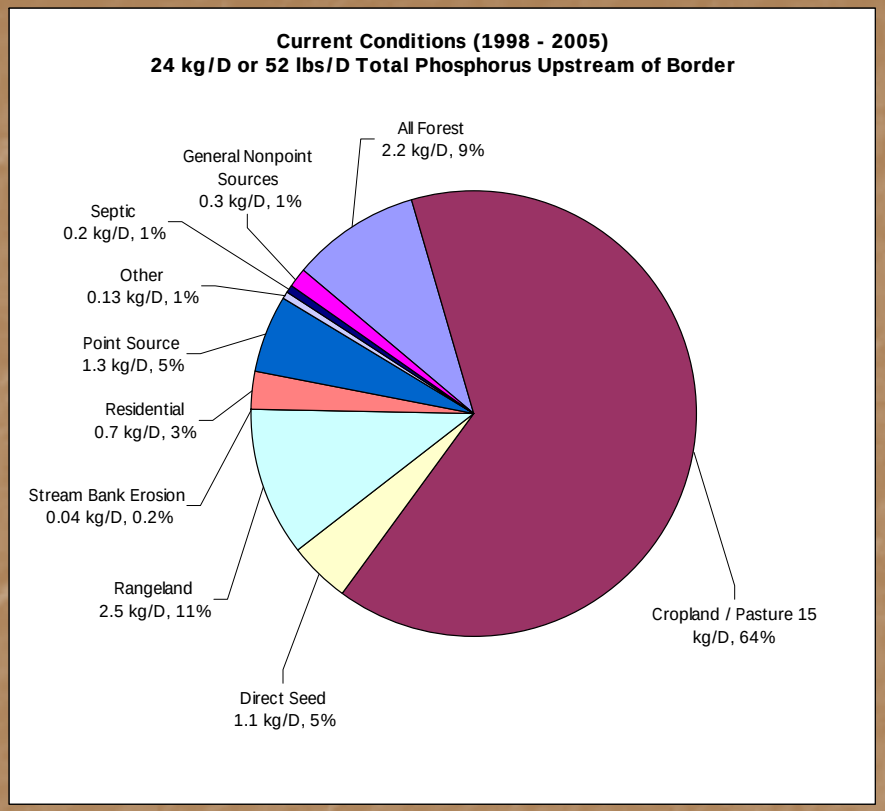


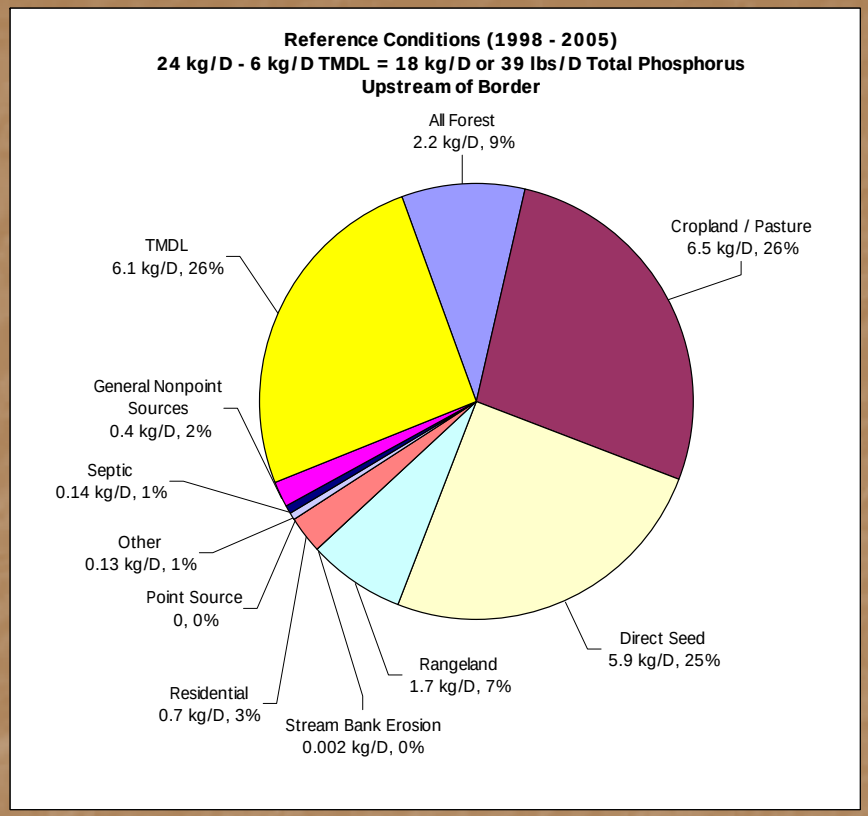
Source	Current TP Load kg/day	Reference TP Load kg/day	Percent TP Load Reduction
All Forest	6.9	7.5	-7%
Cropland / Pasture	59	25	24%
Direct Seed	3.8	22	
Rangeland	12	8.8	2%
Stream Bank Erosion	5.6	4.8	16%
Residential	3.4	3.6	-4%
Point Source	5.0	0	100%
Other	0.5	0.5	1%
Septic	0.3	0.3	7%
Total	**96**	**72**	**25%**





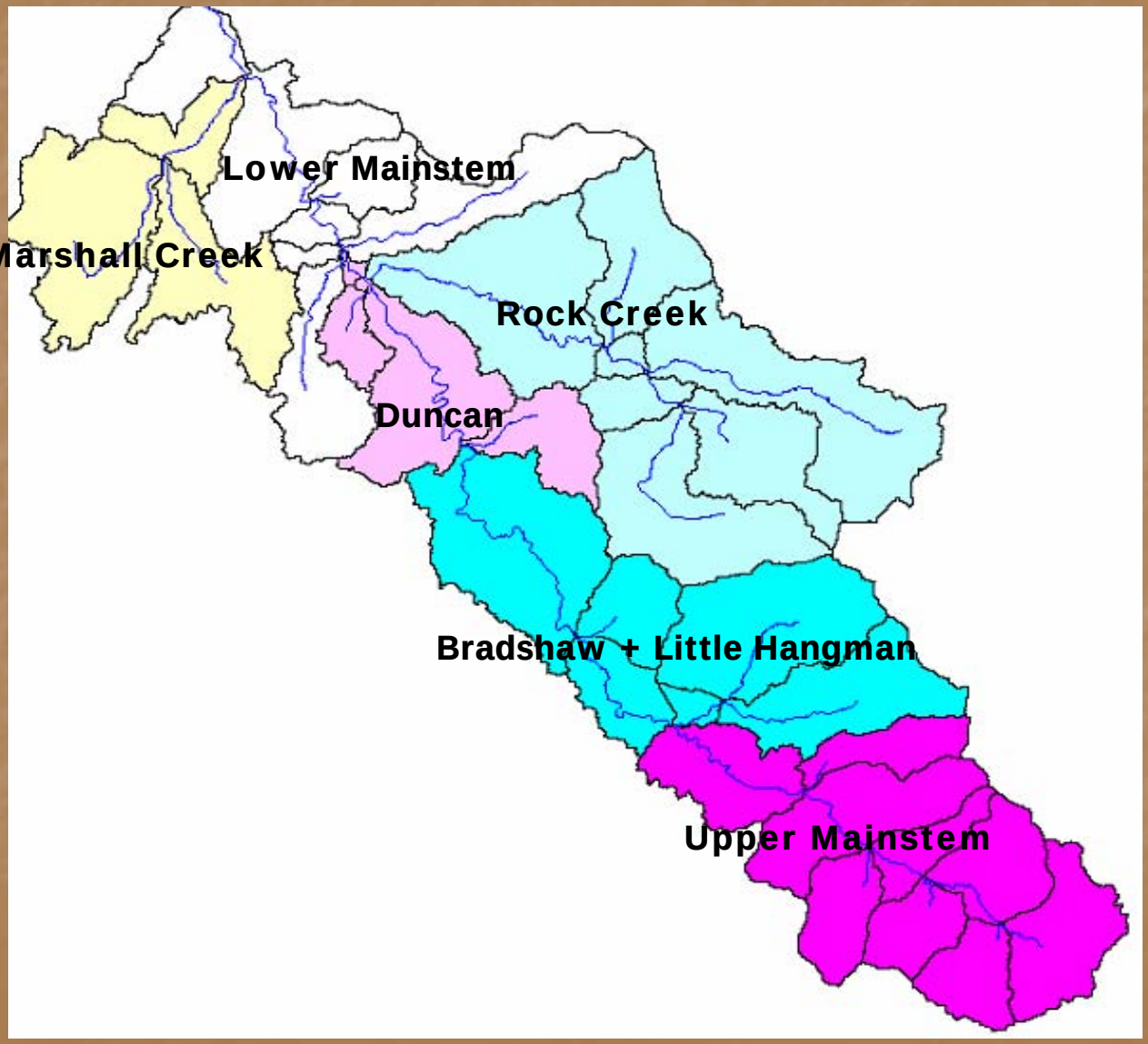
Hangman Creek Total Phosphorus Loads Associated with Coeur d'Alene Reservation and Idaho





13 catchments in Rock Creek, Little Hangman Creek, and the upper mainstem of Hangman Creek

Sub-watershed Analysis Areas



Most Significant Sub-watershed Sources

	Current	Reference	Land Area
Upper Hangman	13%	10%	20%
Bradshaw	12%	12%	19%
Duncan	1%	1%	8%
Rock Creek	60%	61%	27%
Marshall Creek	2%	2%	11%
Lower Hangman	12%	13%	15%

	Upper	Bradshaw	Duncan	Rock	Marshall	Lower
All Forest	17%	11%	0.2%	4%	22%	6%
Conven. Crop/Pasture	45%	57%	31%	75%	28%	19%
Direct Seed Crop	3%	4%	4%	5%	0%	1%
Rangeland	17%	9%	1%	11%	34%	17%
Stream Bank Erosion	0.4%	1%	0.0002%	0.02%	0.3%	48%
Residential	4%	1%	1%	3%	14%	7%
Point Source	11%	13%	62%	1%	0.3%	3%
Other	1%	1%	1%	0.4%	1%	0.4%
Septic	1%	1%	1%	0.02%	1%	0.3%

Hangman Creek TMDL
Total Phosphorus Allocation Options

- Provide TP allocations by source watershed-wide or on sub-watershed
  - Involves an agreement with Coeur d'Alene Tribe, Idaho, and EPA
  - Recognizes generated TP transport is variable and knows no boundaries
- Only deal with TP allocations in Washington
  - Set border loads as 'background' (~ 60%)
  - Work with Spokane DO TMDL process to provide a new load allocation target for Hangman Creek
- Other?

Hangman Creek TMDL