2. Hydrocycling

2. Hydrocycling

Goal

- Determine if Project hydrocycling operations benefit or adversely affect the habitat used by interior least terns, piping plovers, and pallid sturgeon in the lower Platte River.

2. Hydrocycling

Objectives

1. To compare the sub-daily Project hydrocycling operation values (maximum and minimum flow and stage) to daily values (mean flow and stage). In addition to same-day comparisons, periods of weeks, months, and specific seasons of interest to protected species will be evaluated to characterize the relative degrees of variance between hydrocycling (current operations) and run-of-river operations in the study area.
2. To determine the potential for nest inundation due to both hydrocycling (current operations) and run-of-river operations.

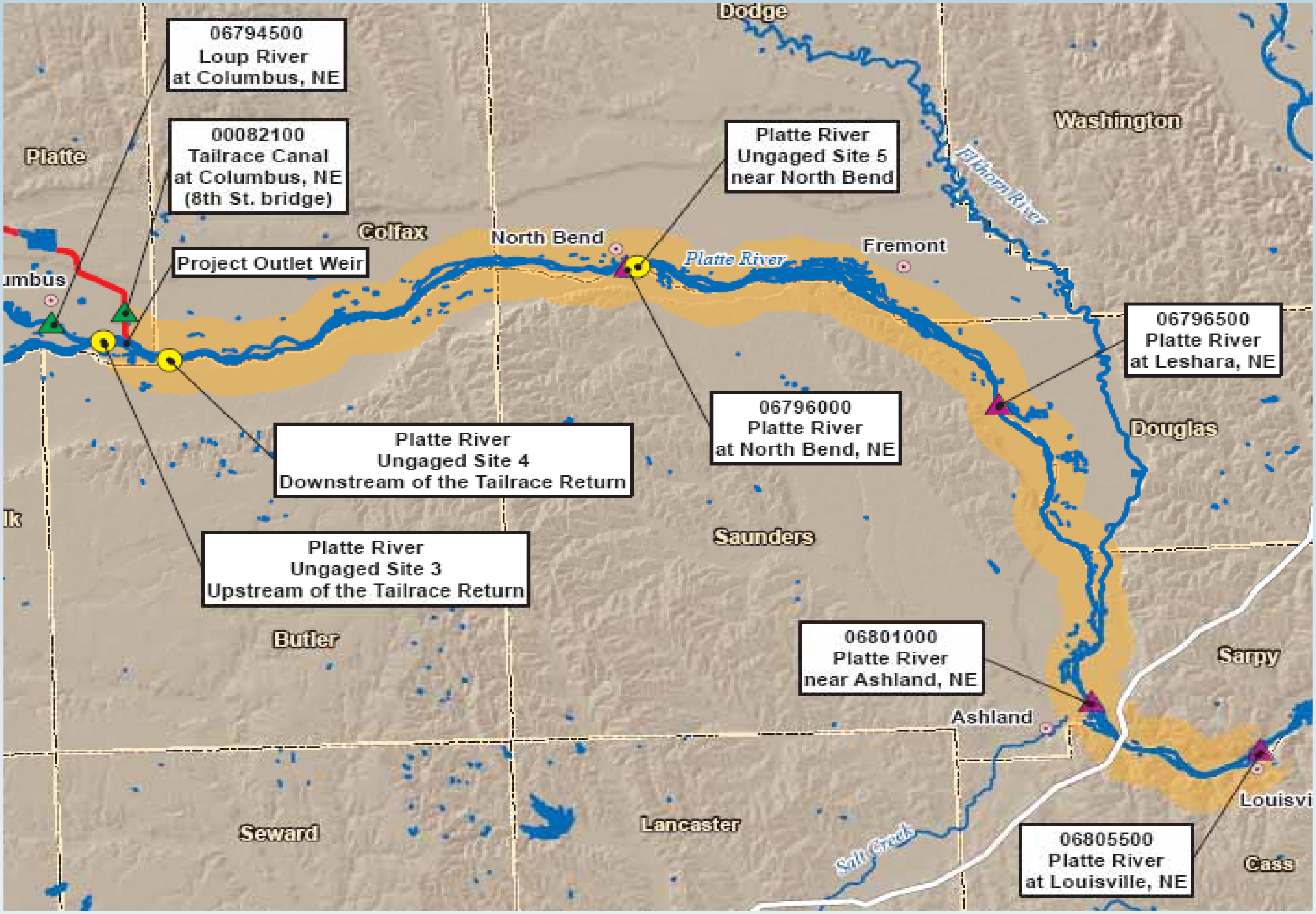
2. Hydrocycling

Objectives (continued)

3. To assess effects, if any, of hydrocycling (current operations) on sediment transport parameters
4. To identify material differences in potential effects on habitat of the interior least tern, piping plover, and pallid sturgeon.

2. Hydrocycling

Study Area



2. Hydrocycling

Objective 1

1. To compare the sub-daily Project hydrocycling operation values (maximum and minimum flow and stage) to daily values (mean flow and stage). In addition to same-day comparisons, periods of weeks, months, and specific seasons of interest to protected species will be evaluated to characterize the relative degrees of variance between hydrocycling (current operations) and run-of-river operations in the study area.

Associated Tasks:

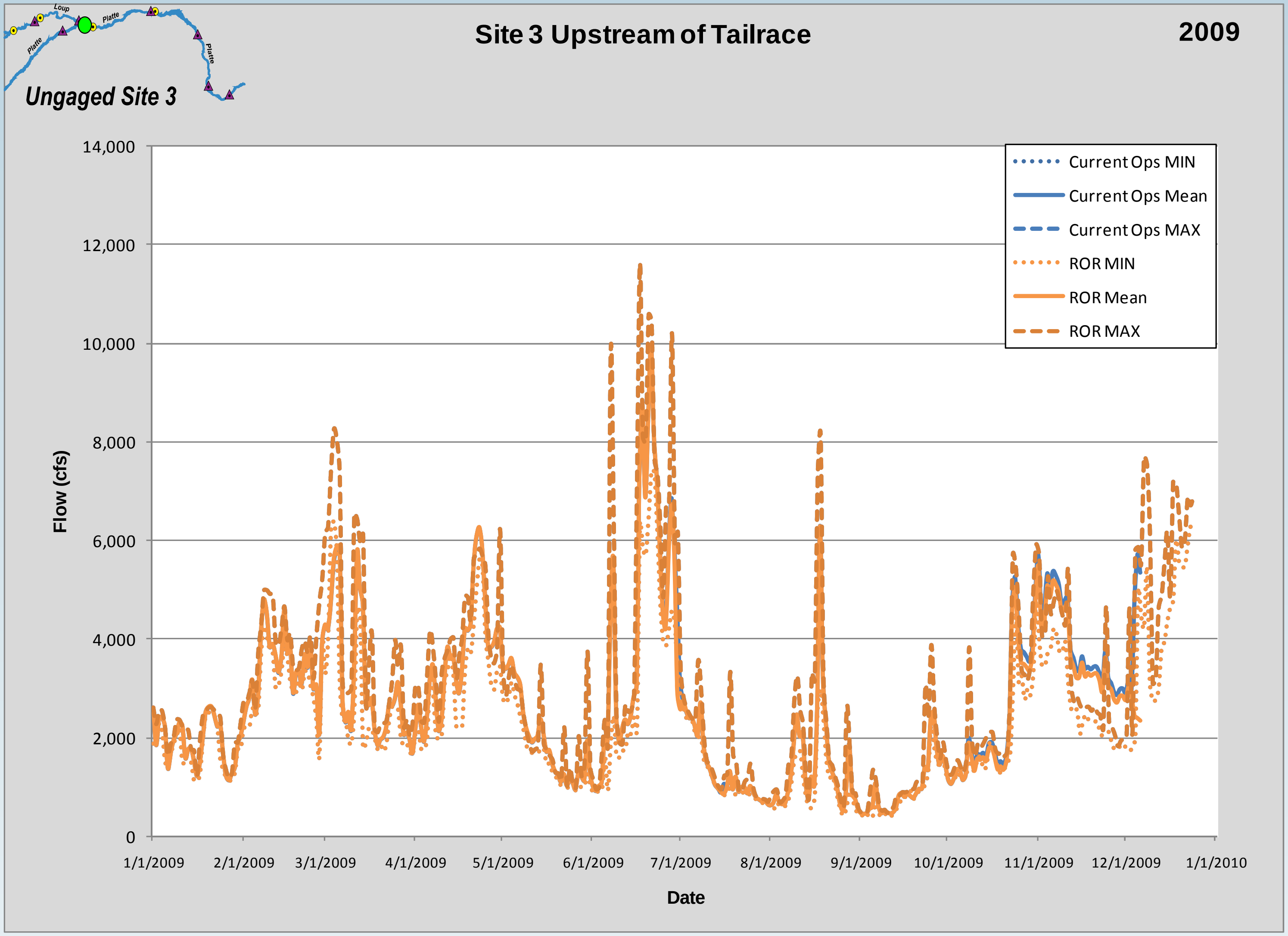
- Data Collection
- Gage Analysis
- Hydrographs for Current Operations vs. Run-of-River Operations

2. Hydrocycling

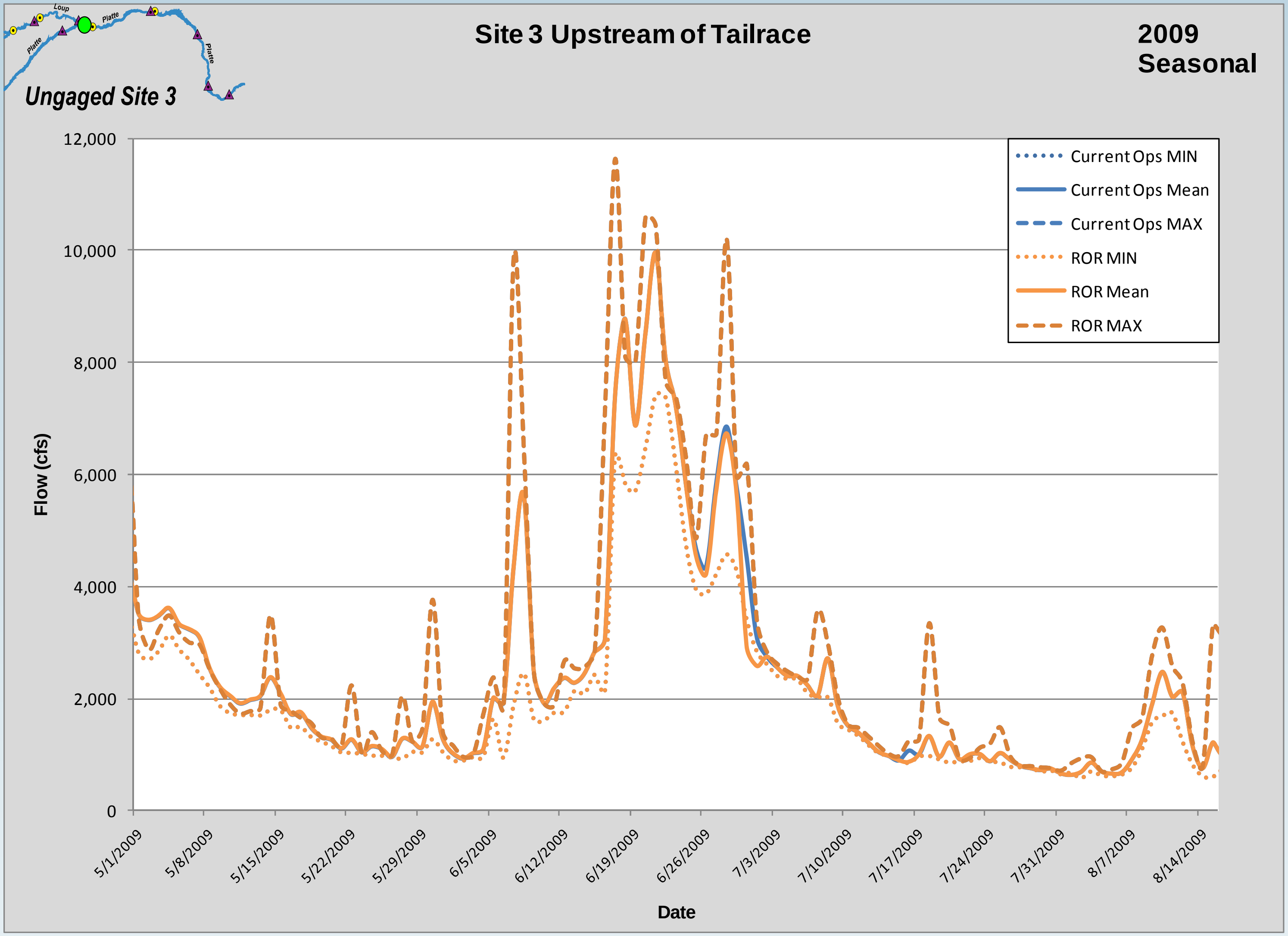
Methodology:

- Synthetic hydrographs plotted for current operations and run-of-river operations
- Maximum, minimum and mean flows were plotted for a wet, dry, and normal flow classification
  - Gaged locations
  - Ungaged locations
  - Annually
  - Seasonally

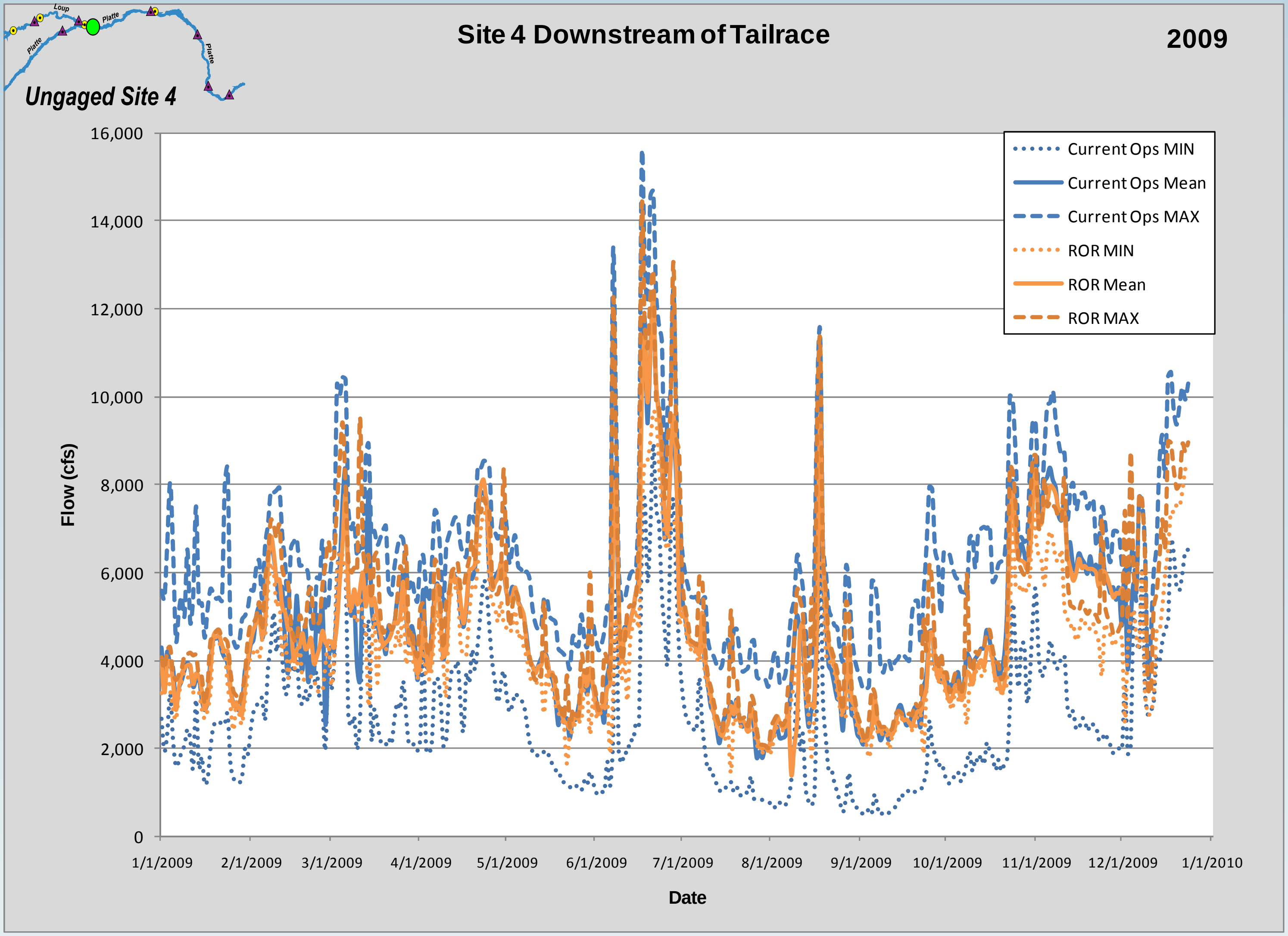
2. Hydrocycling



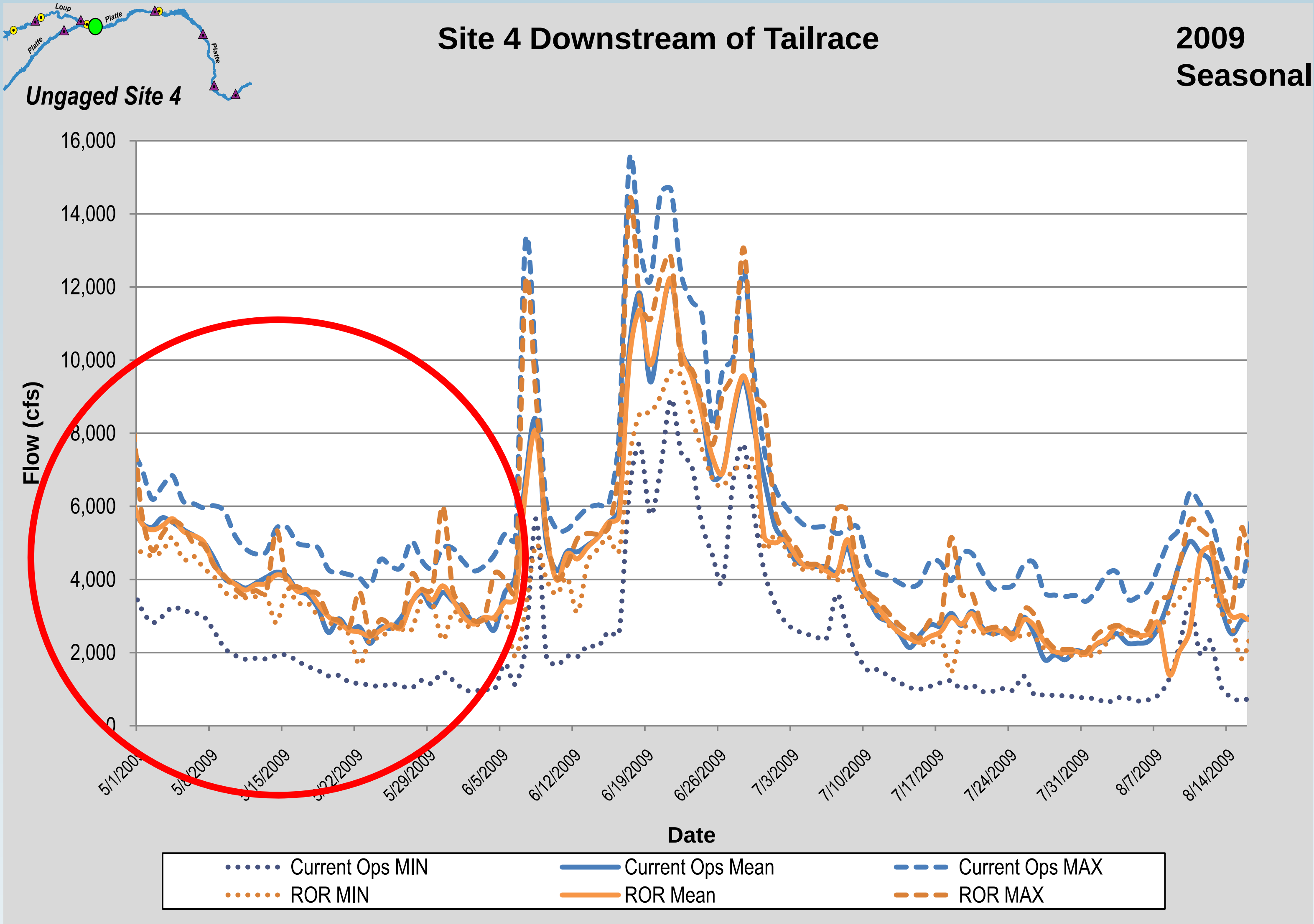
2. Hydrocycling



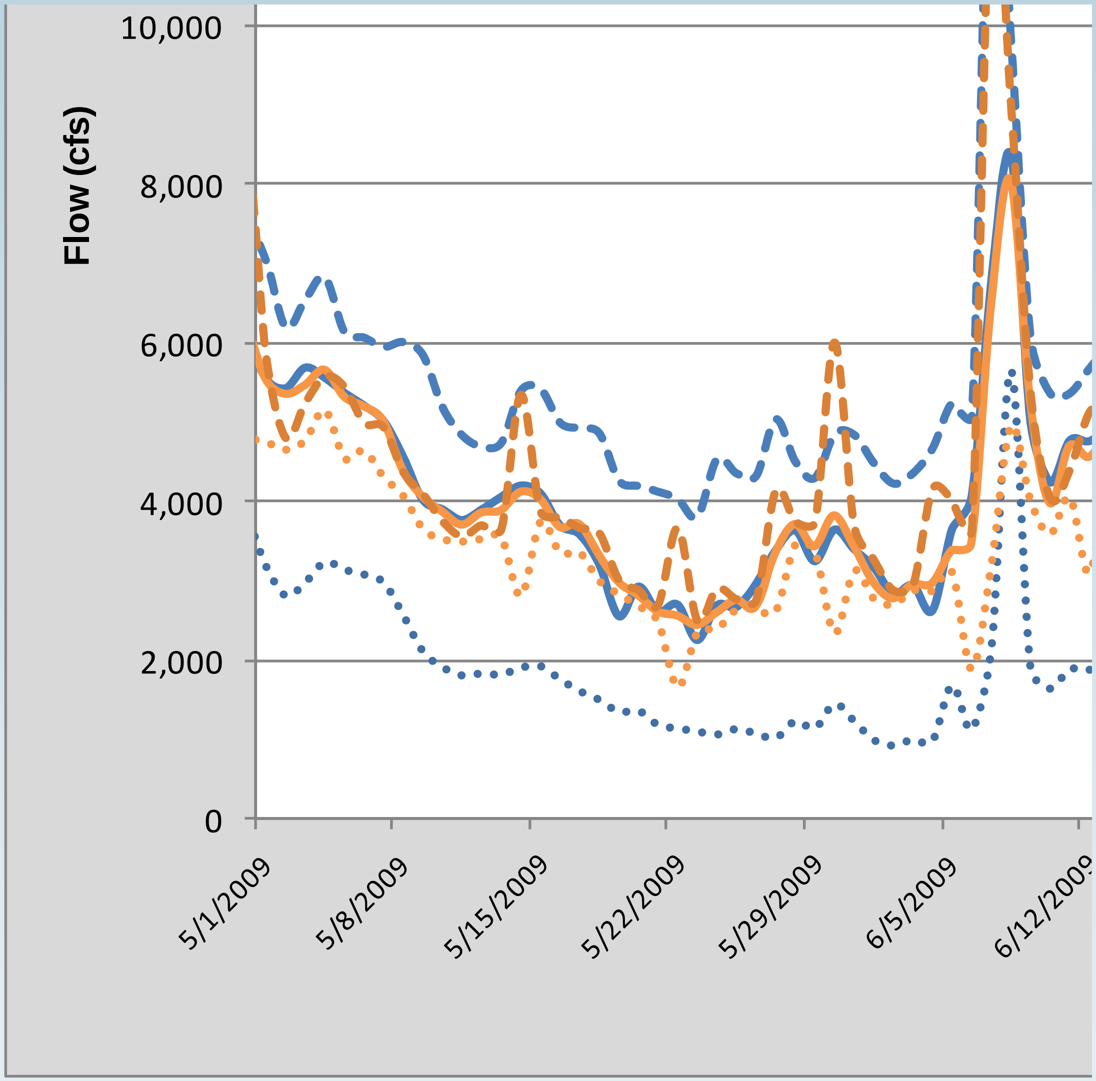
2. Hydrocycling



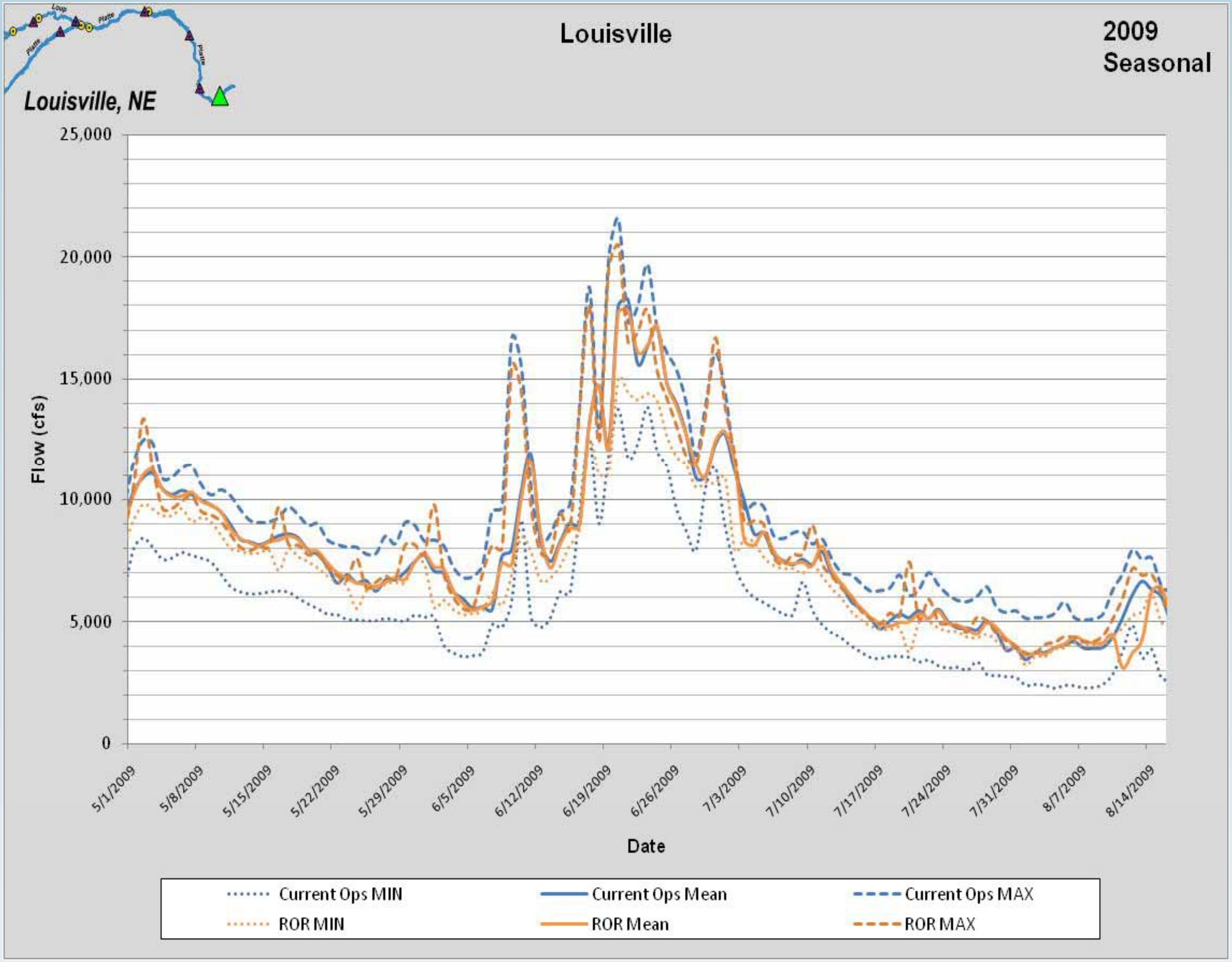
2. Hydrocycling



2. Hydrocycling



2. Hydrocycling

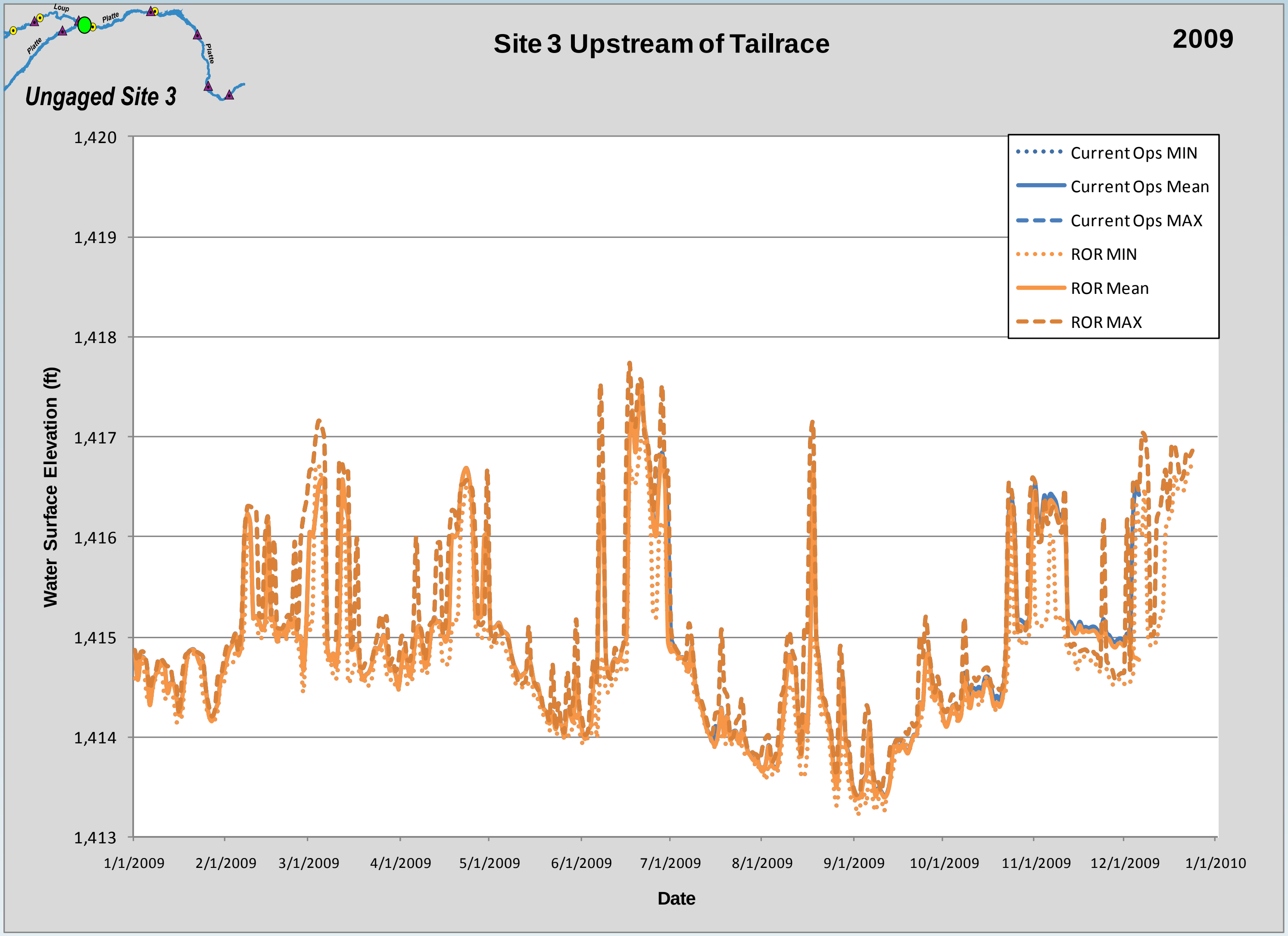


2. Hydrocycling

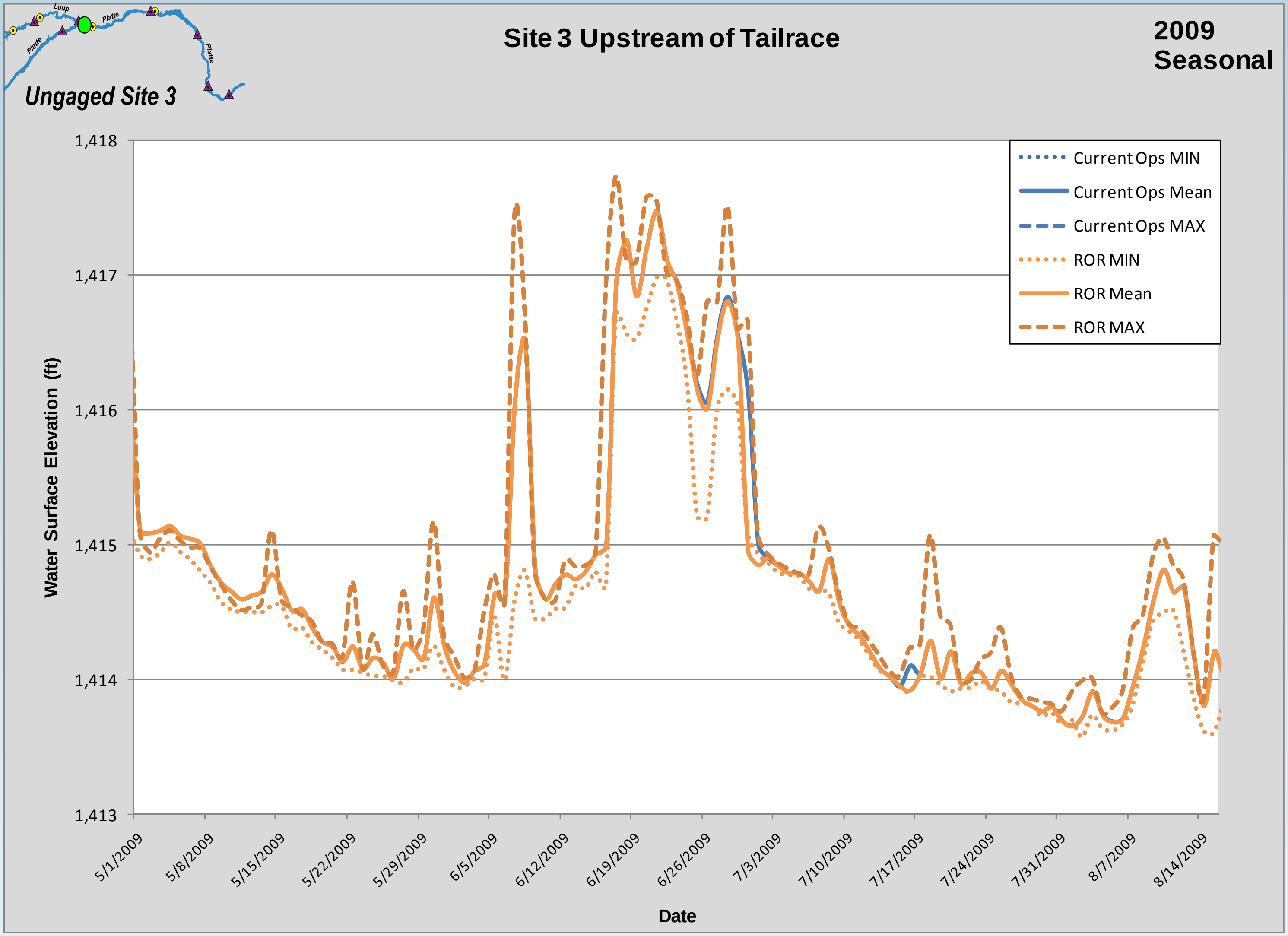
Methodology:

- Maximum, minimum and mean stage plotted for a wet, dry, and normal flow classification based on calibrated model results
  - Gaged locations
  - Ungaged locations
  - Annually
  - Seasonally

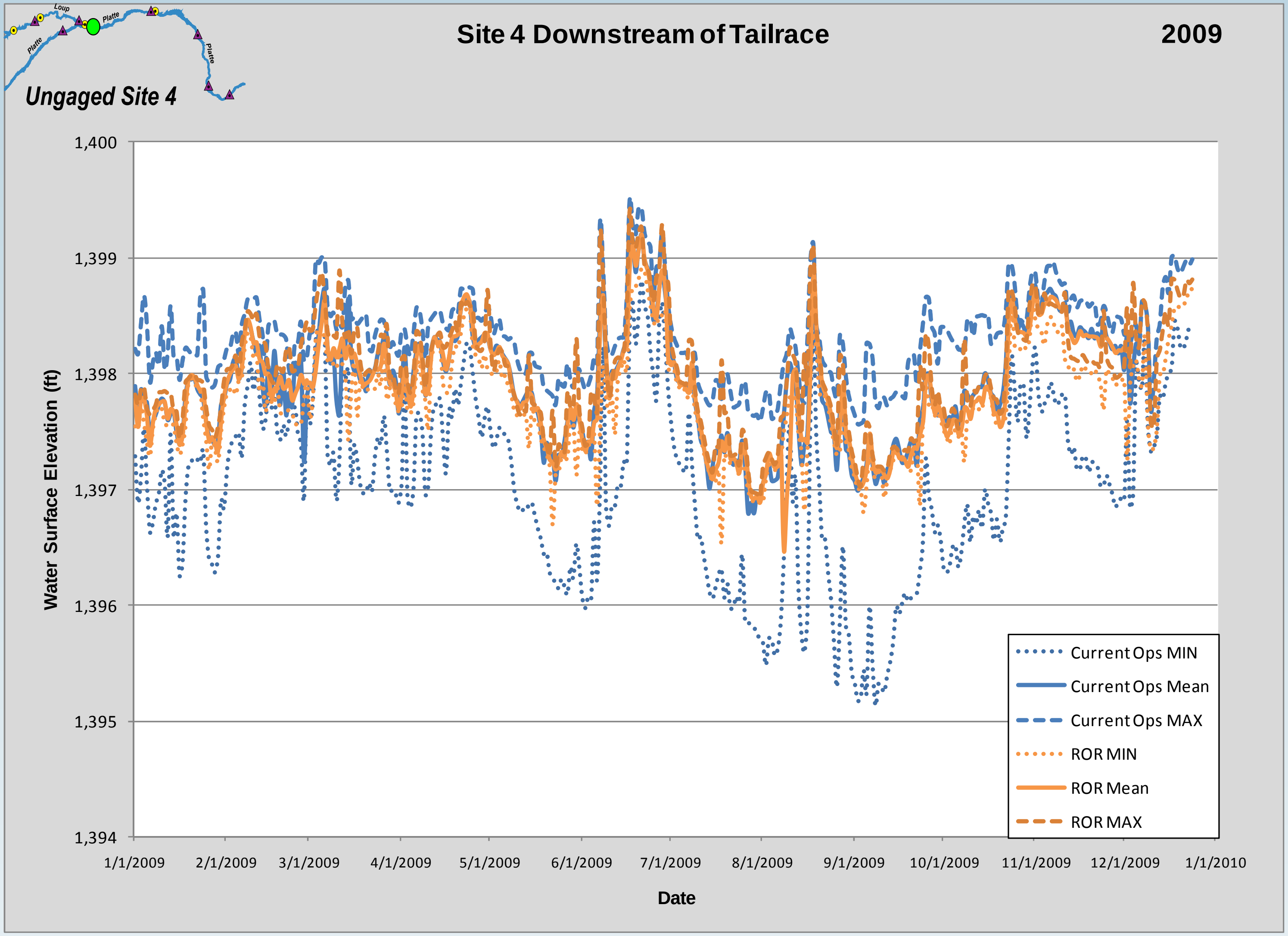
2. Hydrocycling



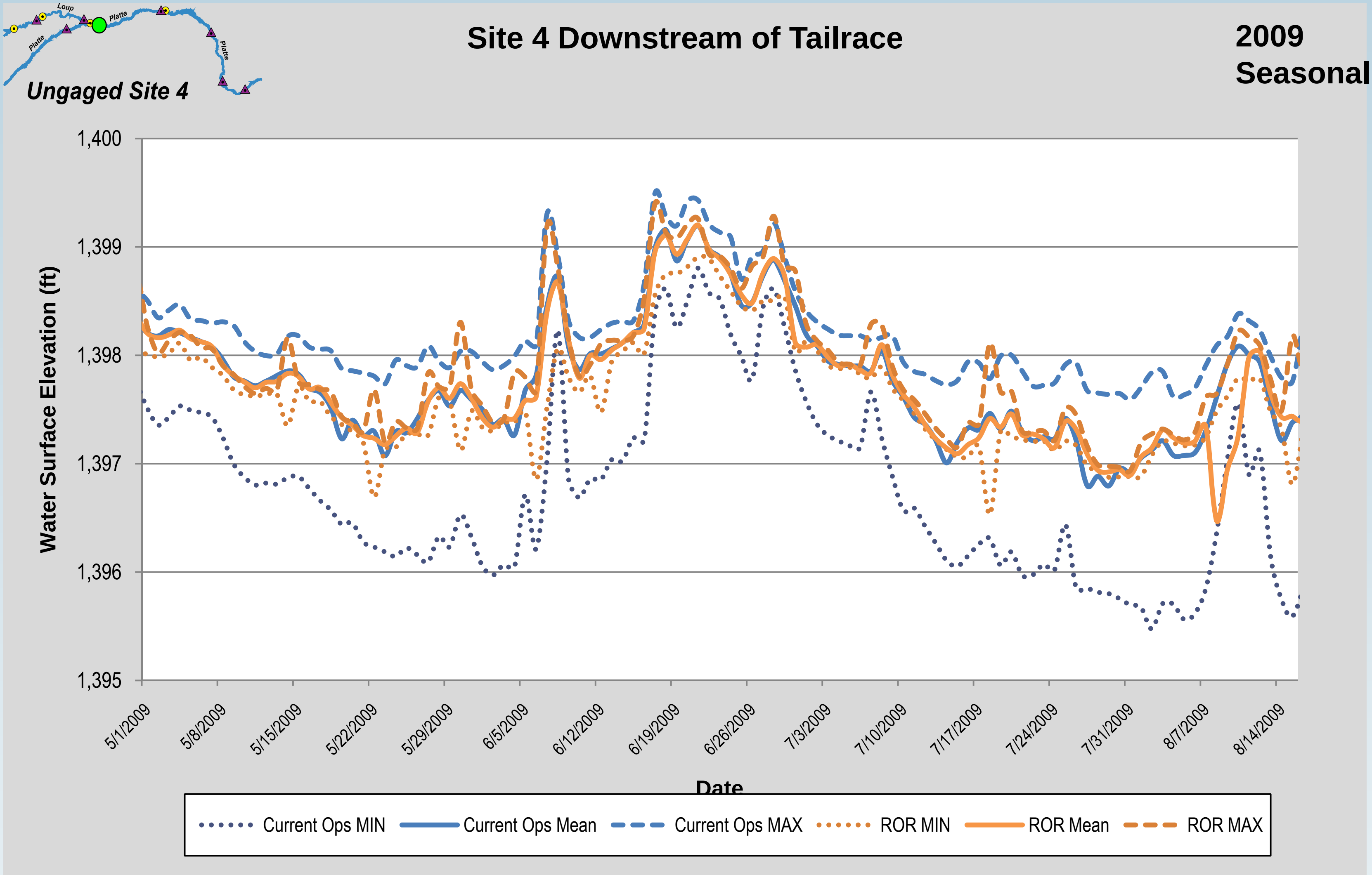
2. Hydrocycling



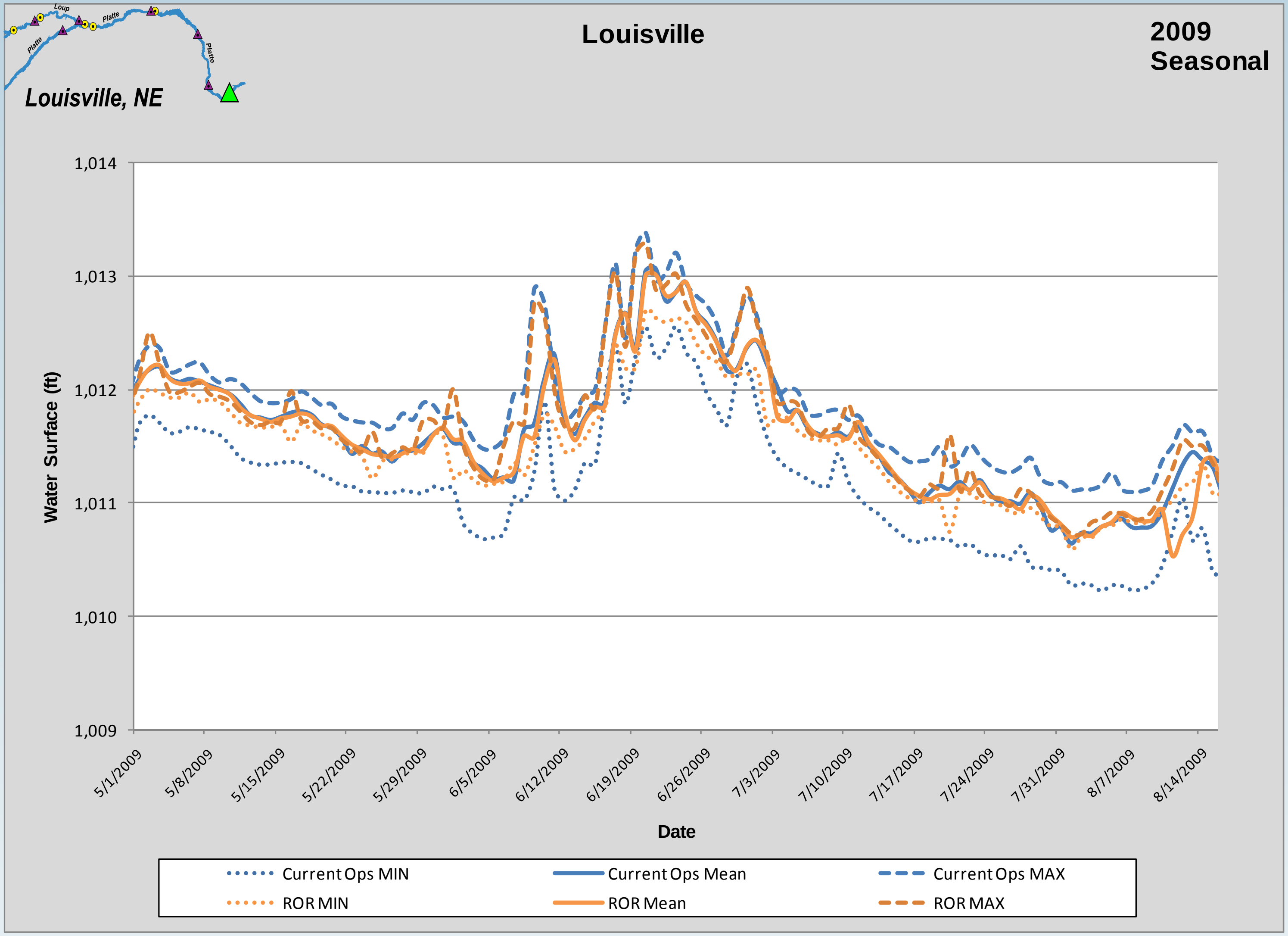
2. Hydrocycling



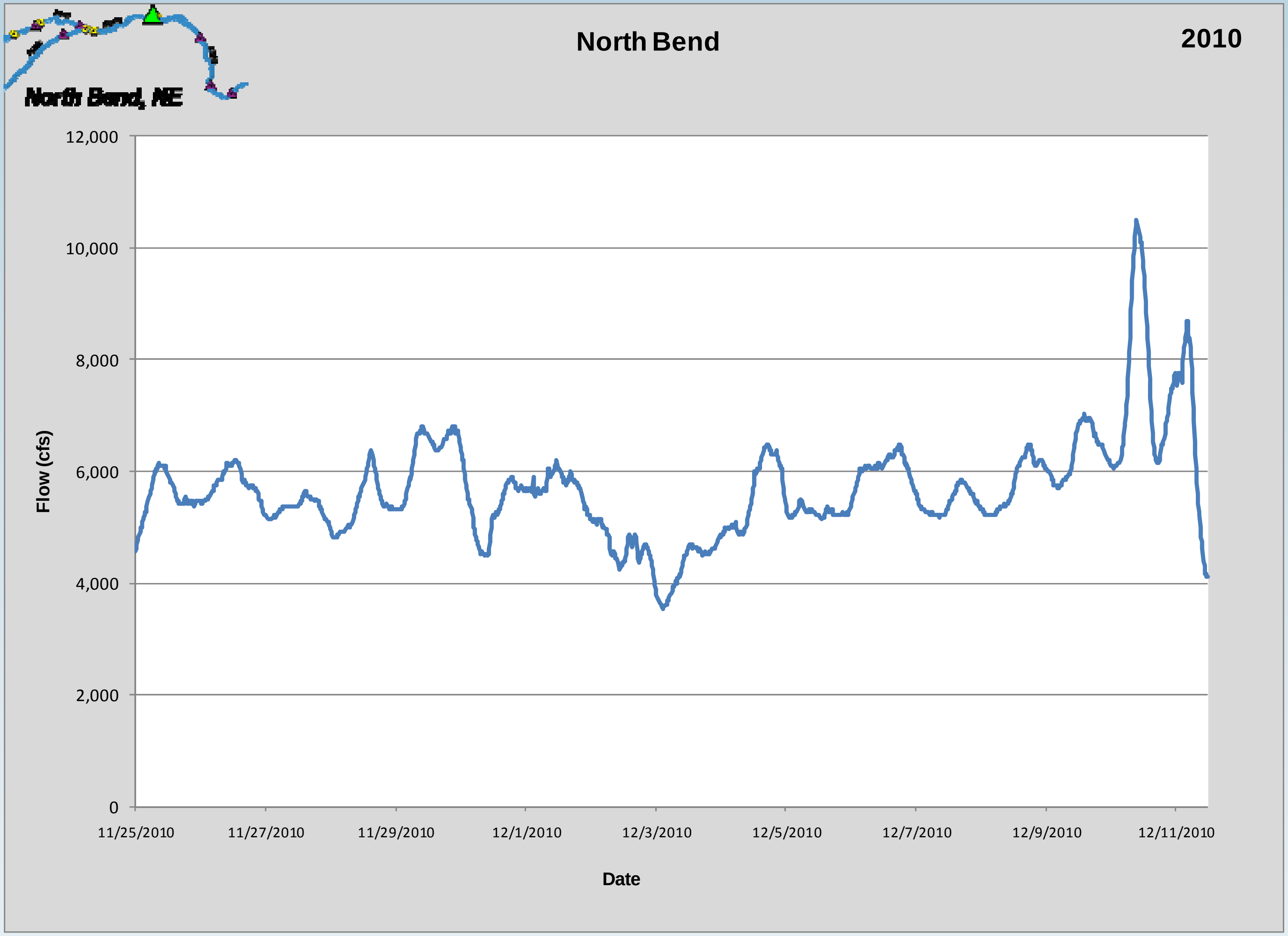
2. Hydrocycling



2. Hydrocycling



2. Hydrocycling



2. Hydrocycling

2009 Annual

Location	Flow Difference (cfs)			Water Surface Elevation Difference (feet)		
	Current Operations Max - Min Difference[1]	Run-of-River Operations Max - Min Difference[1]	Current Operations Max - Run-of-River Max Difference[2]	Current Operations Max - Min Difference[3]	Run-of-River Operations Max - Min Difference[3]	Current Operations Max - Run-of-River Max Difference[4]
Site 3 – Upstream of the Tailrace Return	840	840	0	0.41	0.41	0.00
Site 4 – Downstream of the Tailrace Return	3,750	1,020	1,210	1.30	0.26	0.30
Platte River at North Bend	3,760	1,020	1,090	0.94	0.21	0.23
Platte River at Leshara	3,490	1,040	1,030	0.87	0.21	0.21
Platte River near Ashland	3,610	1,150	1,080	0.83	0.21	0.21
Platte River at Louisville	3,540	1,130	1,010	0.69	0.19	0.18

2. Hydrocycling

2009 Seasonal

Location	Flow Difference (cfs)			Water Surface Elevation Difference (feet)		
	Current Operations Max - Min Difference[1]	Run-of-River Operations Max - Min Difference[1]	Current Operations Max - Run-of-River Max Difference[2]	Current Operations Max - Min Difference[3]	Run-of-River Operations Max - Min Difference[3]	Current Operations Max - Run-of-River Max Difference[4]
Site 3 – Upstream of the Tailrace Return	890	890	0	0.38	0.38	0.00
Site 4 – Downstream of the Tailrace Return	3,590	1,070	1,010	1.40	0.28	0.29
Platte River at North Bend	3,570	1,060	830	0.93	0.22	0.18
Platte River at Leshara	3,560	1,100	940	0.90	0.21	0.20
Platte River near Ashland	3,700	1,270	1,010	0.90	0.23	0.22
Platte River at Louisville	3,680	1,270	960	0.72	0.21	0.18

2. Hydrocycling

Results

- Objective 1
  - Difference between maximum and minimum daily WSEL larger under current operations than under run of river condition
  - Similar differences for run-of-river condition over several weeks
  - Largest difference occurs for a dry year
  - Downstream differences less than in the Project vicinity
  - Average annual difference in WSEL is typically less than 1 ft.

2. Hydrocycling

Objective 2

- To determine the potential for nest inundation due to both hydrocycling (current operations) and run-of-river operations

Associated Tasks

- Nesting Season Sandbar Inundation Heights

2. Hydrocycling

Methodology:

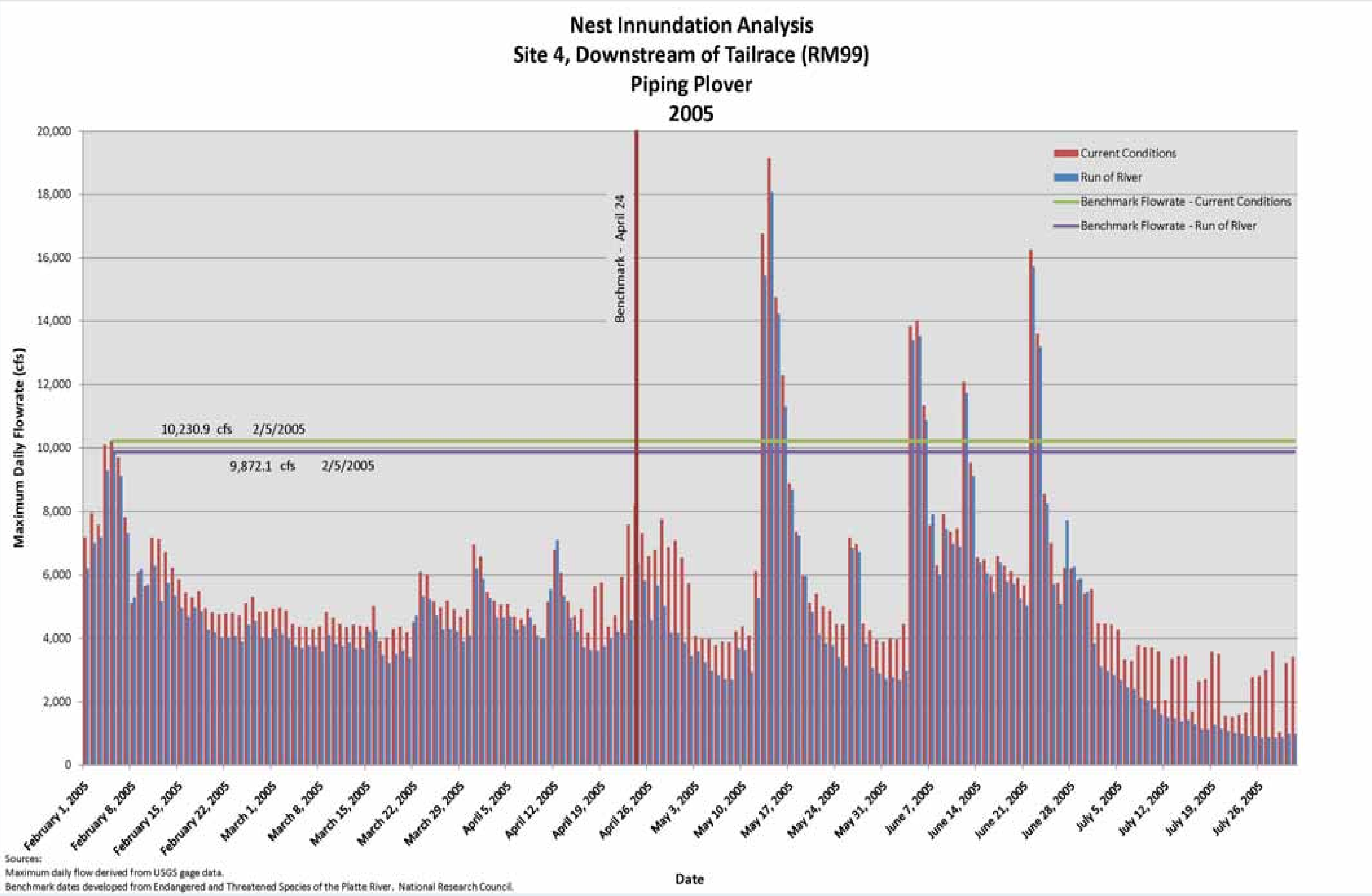
- Synthetic Hydrographs Used (2003 -2009)
- Site 4, Downstream of Tailrace was analyzed
- Current Operations vs. Run-of-River

2. Hydrocycling

Methodology (cont.):

- Benchmark flow – pre-nesting season, both species
  - Highest daily flow
  - Set between February 1 and April 25 (plovers) or May 15 (terns)
  - Theoretic elevation or surrogate for highest potential nesting elevation

2. Hydrocycling

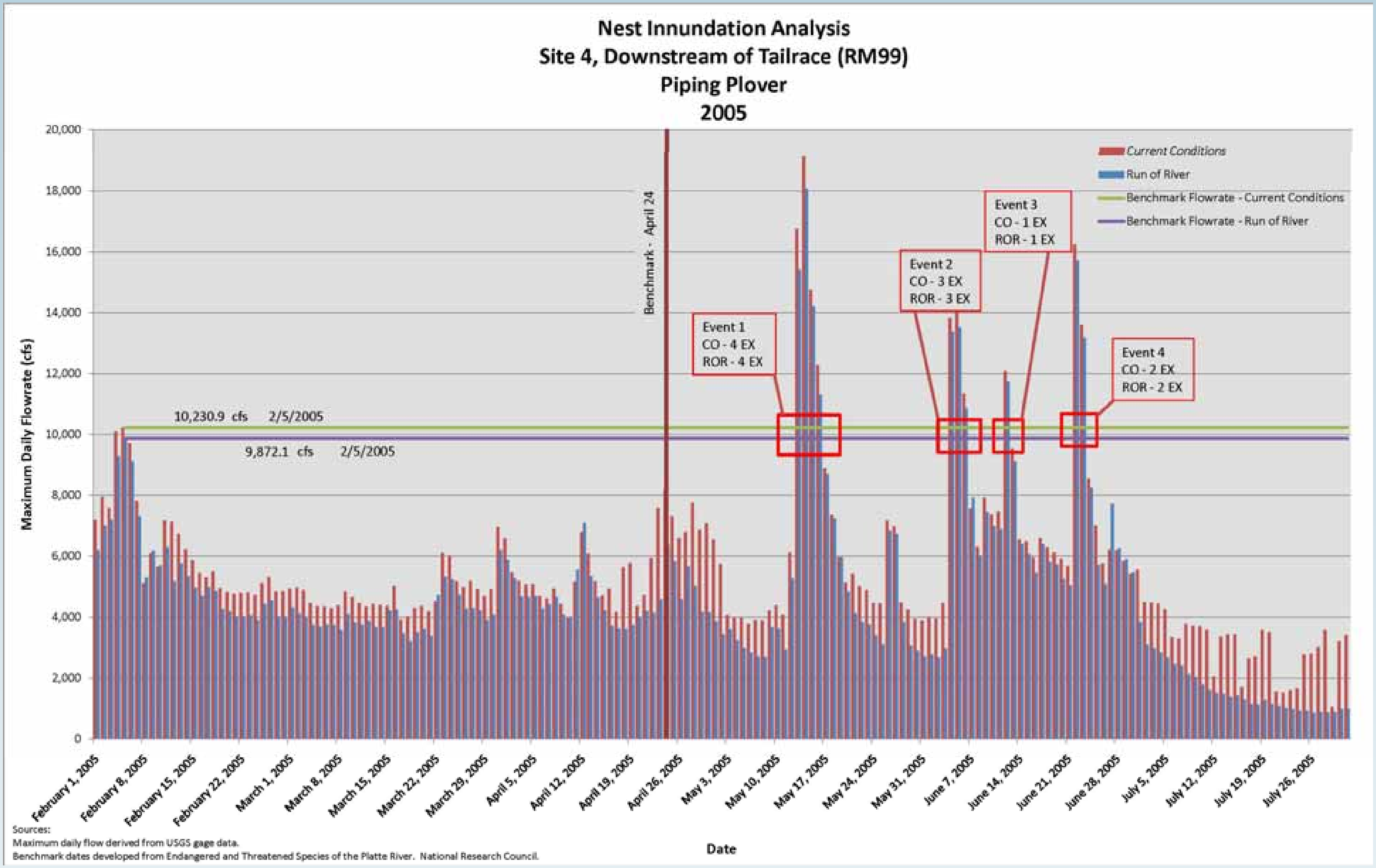


2. Hydrocycling

Methodology (cont.):

- Benchmark flow compared to subsequent sub-daily flows for each year from:
  - April 25 – July 31 (nesting season for piping plover)
  - May 15 to August 15 (nesting season for least tern)
- Determine number of times the benchmark was exceeded for both current operations and run-of-river condition
- Classification of exceedances into “events”

2. Hydrocycling



2. Hydrocycling

Assumptions:

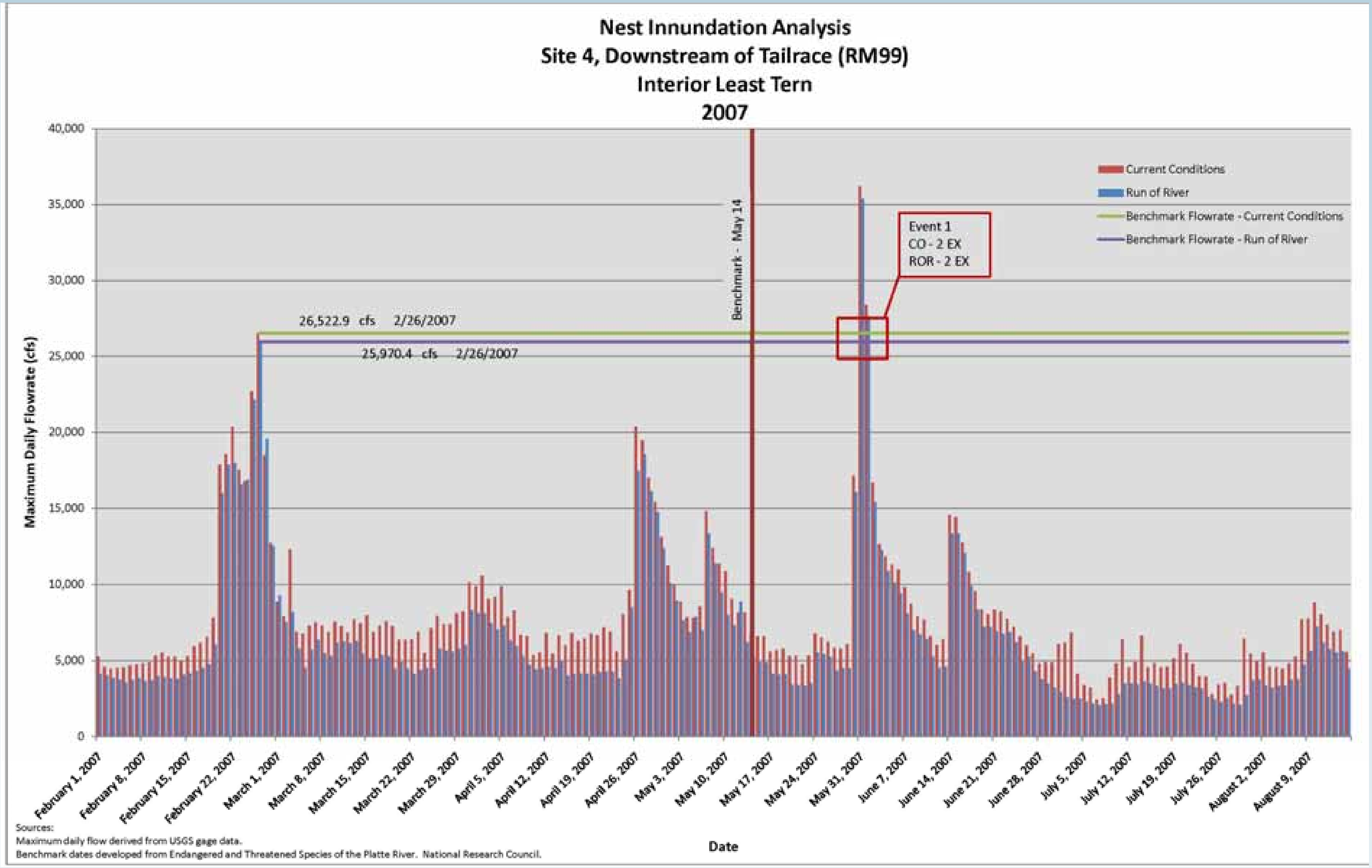
- Not an evaluation of habitat or actual nest inundation
- Habitat may be available above a benchmark or a benchmark exceedance flow
- Birds can and do nest below the highest elevation available
- Depending on timing of benchmark exceedance, re-nesting could be possible
- 60-day period assumed for a successful nesting attempt

2. Hydrocycling

Results:

- Generally, current operations have higher maximum daily flows than run-of-river
- Benchmarks not exceeded:
  - 2003 – 2006 for interior least terns
  - 2004 and 2006 for piping plover
- Identical benchmark exceedances for both conditions:
  - 2007 to 2009 for interior least terns
  - 2005 and 2007 to 2009 for piping plovers

2. Hydrocycling

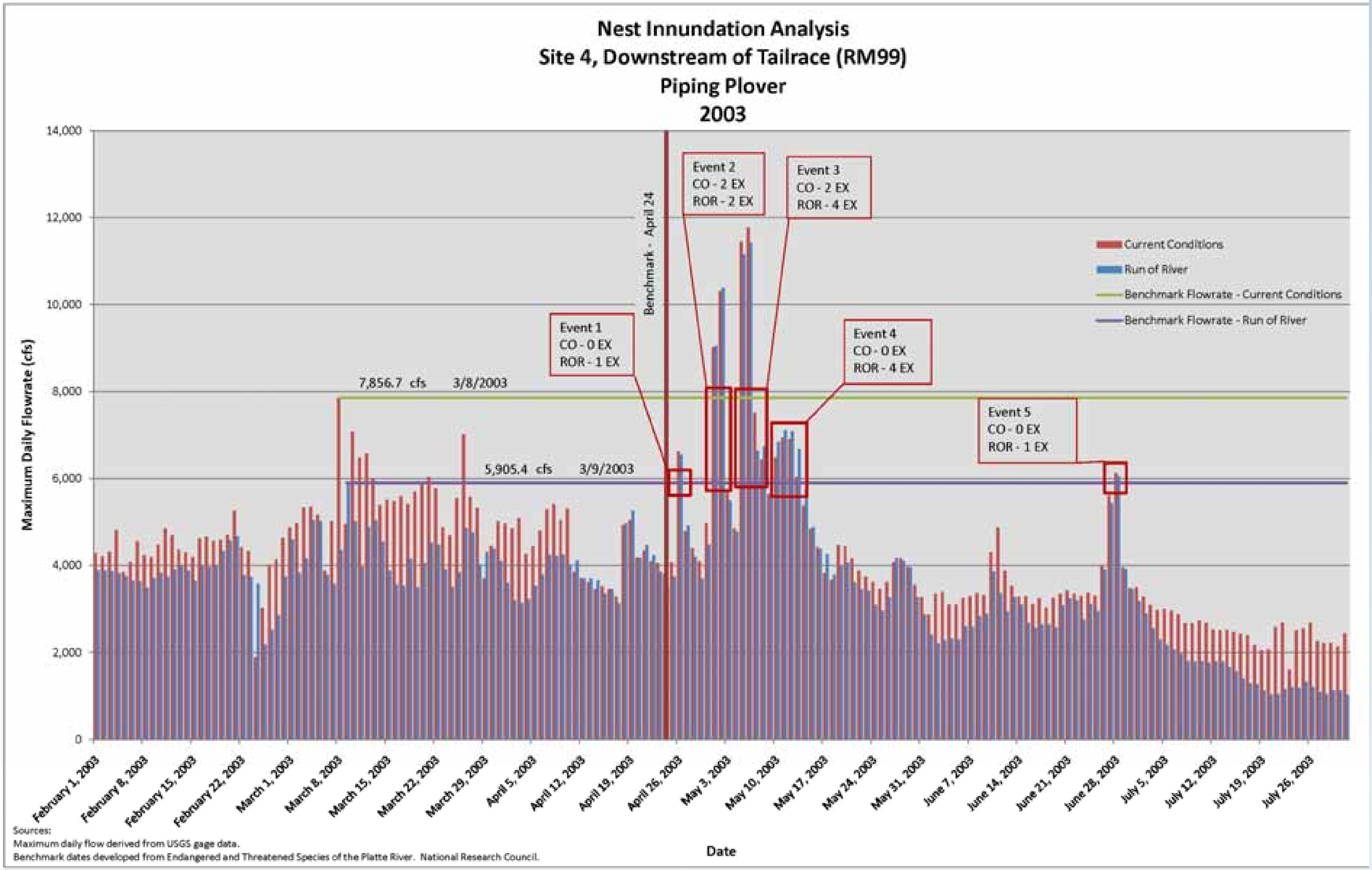


2. Hydrocycling

Results:

- One occurrence when run-of-river condition had more exceedances than current operations
  - Piping Plovers (2003) – 12 exceedances for run-of-river and 4 for Current Operations

2. Hydrocycling



2. Hydrocycling

Summary of Results:

- Objective 2

  In review of all years for both species:

  - No instances where a current operations exceedance could have been avoided under run-of-river operation
  - Normal seasonal flow events during the nesting season create conditions for potential nest inundation
  - Project operations did not cause any exceedances of benchmark flows

2. Hydrocycling

Objective 3

- To assess effects, if any, of hydrocycling (current operations) on sediment transport parameters

Associated Tasks

- Sediment Transport Calculations
- Sediment Transport Indicators
- Channel Characteristics
- Regime Analysis

2. Hydrocycling

Sediment Transport Indicators

Location on the Platte River	Current Operations						Run-of-River Operations (Sub-daily)		
	Daily			Sub-daily					
	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)
Site 3 – Upstream of the Tailrace Return	2,700	2,100	1,100	2,600	2,400	1,100	2,600	2,400	1,100
Site 4 – Downstream of the Tailrace Return	4,800	4,900	2,970	4,700	5,600	2,950	4,600	4,800	2,840
USGS gage at North Bend	4,400	3,900	2,050	4,700	4,500	2,200	4,700	4,500	2,210
Site 5 – Near North Bend	4,000	4,200	2,140	4,200	4,500	2,300	4,200	4,400	2,310

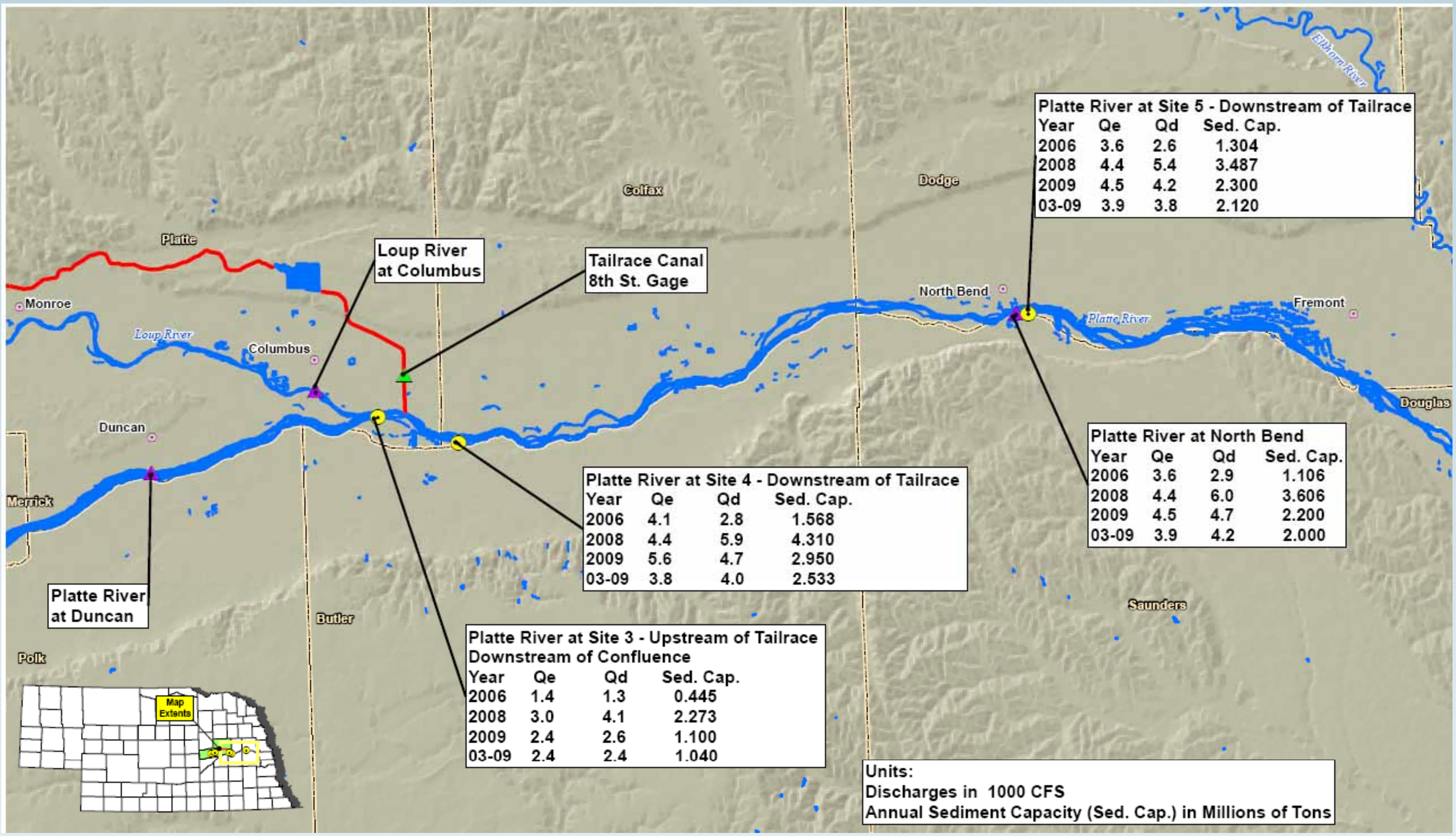
2. Hydrocycling

Sediment Transport Indicators

Location on the Platte River	Current Operations						Run-of-River Operations (Sub-daily)		
	Daily			Sub-daily					
	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)
Site 3 – Upstream of the Tailrace Return	2,400	2,100	1,040	2,400	2,400	1,040	2,400	2,400	1,040
Site 4 – Downstream of the Tailrace Return	3,900	3,600	2,440	4,000	3,800	2,530	3,900	3,400	2,440
USGS gage at North Bend[1]	5,300	5,600	2,890	--	--	--	--	--	--
USGS gage at North Bend	4,100	3,400	1,880	4,200	3,900	2,000	4,100	3,400	1,940
Site 5 – Near North Bend	3,600	3,200	2,030	3,800	3,900	2,120	3,700	3,400	2,080

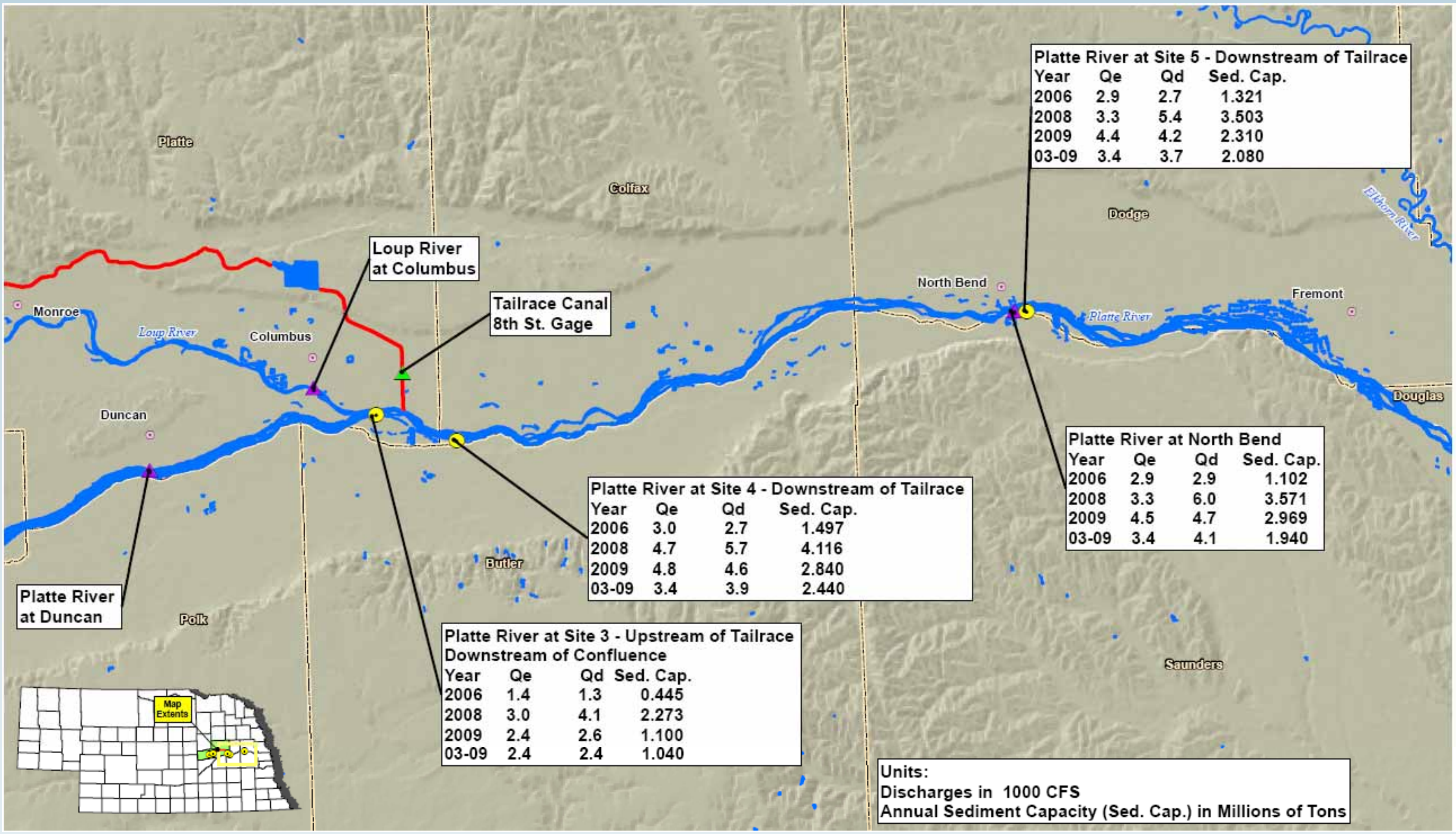
2. Hydrocycling

Sediment Transport Indicators – Current Operations



2. Hydrocycling

Sediment Transport Indicators – Run of River Condition



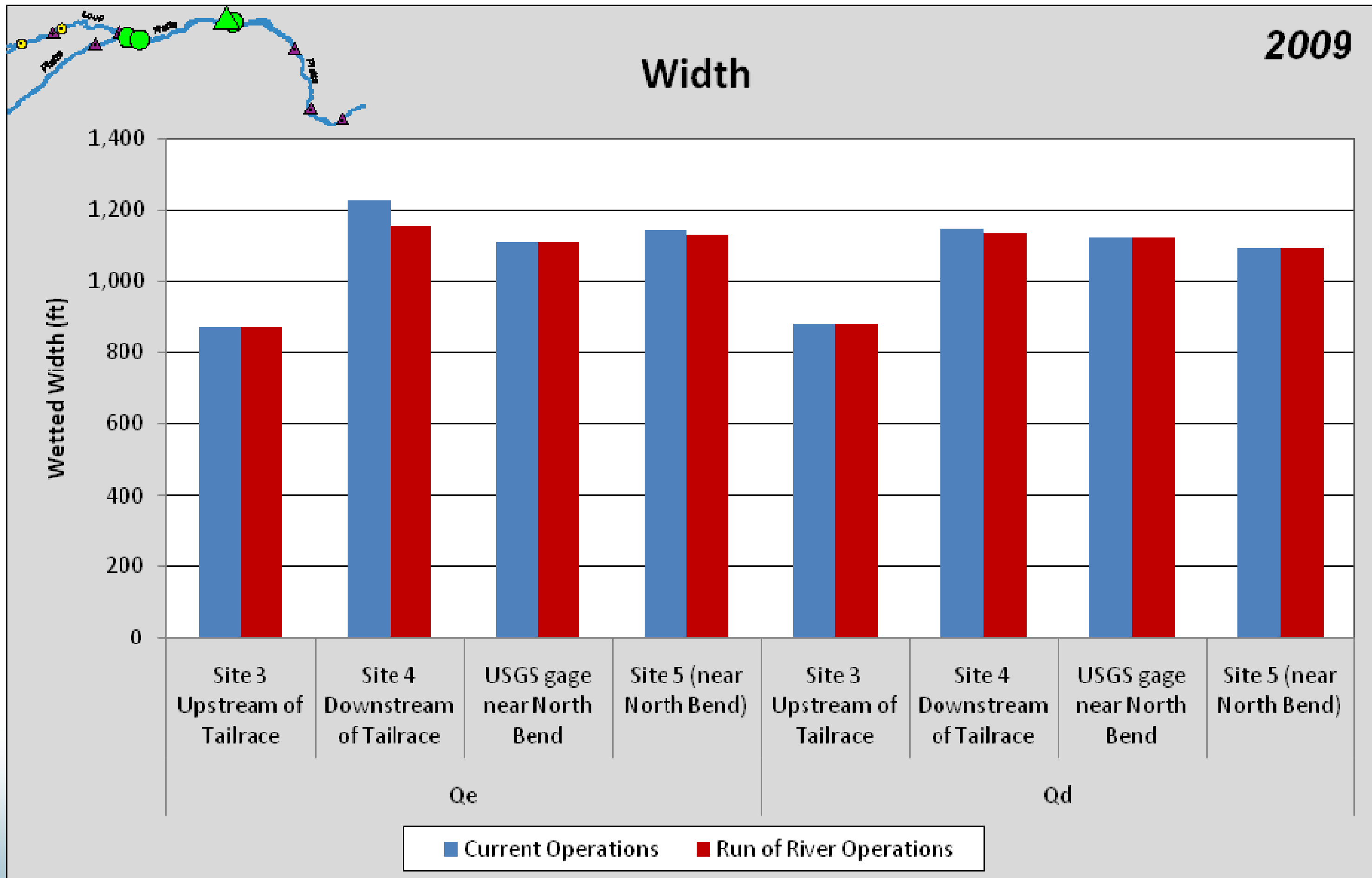
2. Hydrocycling

Results – Sediment Transport Indicators:

- Subdaily values slightly higher than daily values
- Short term values differ from long term values by up to 40 percent
- Total sediment transport at capacity slightly higher for current operations than run of river condition

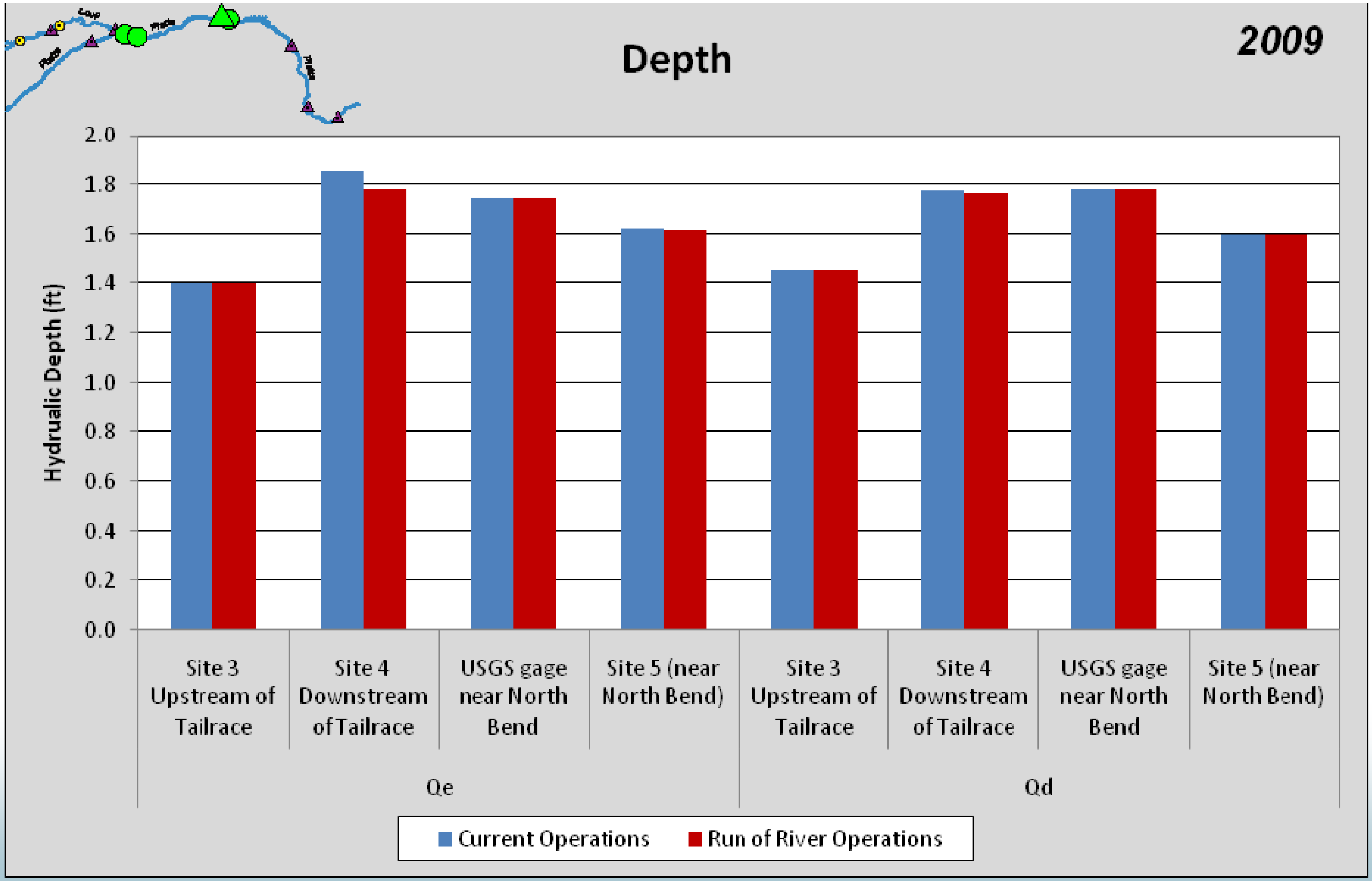
2. Hydrocycling

Channel Characteristics



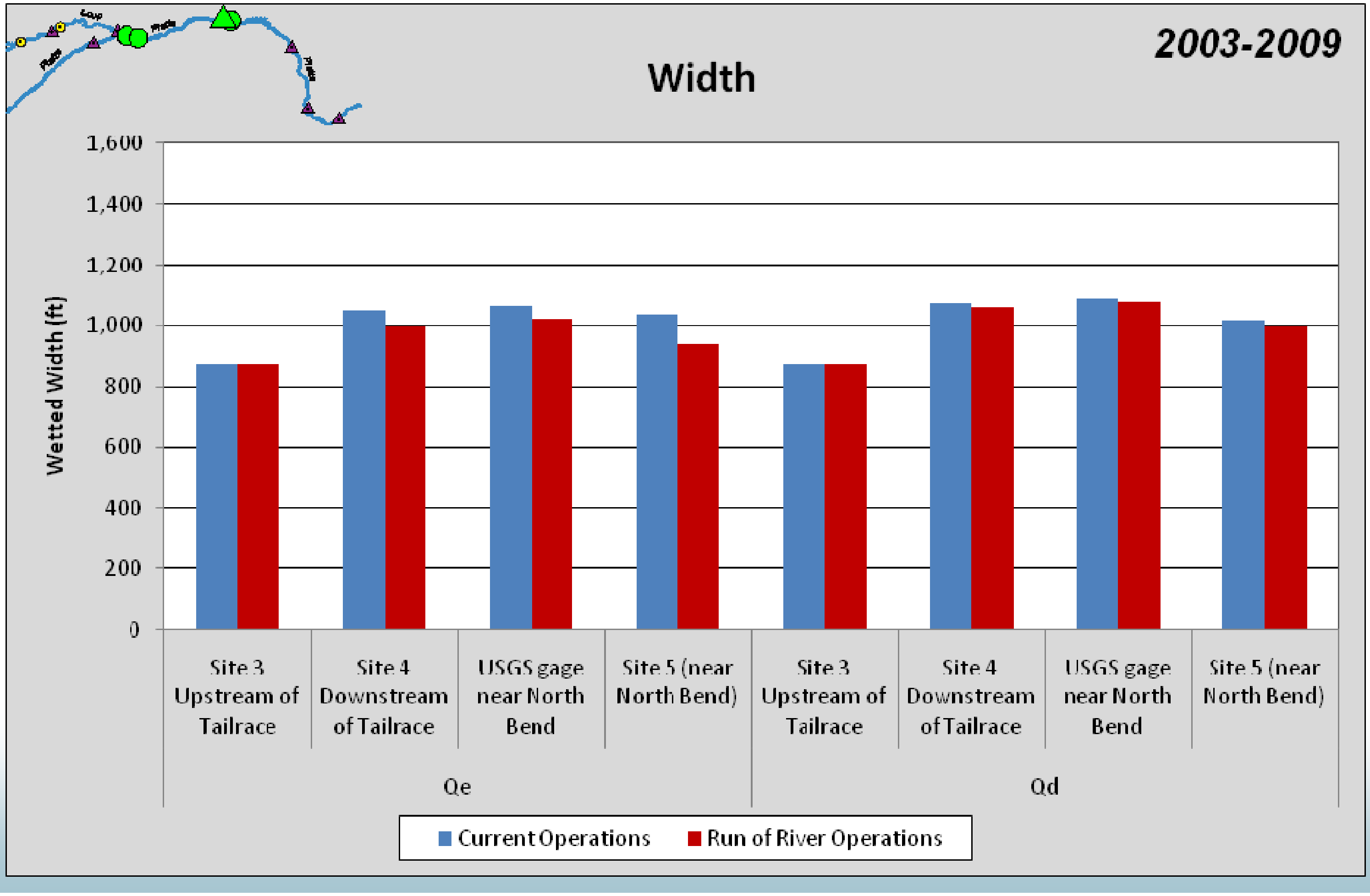
2. Hydrocycling

Channel Characteristics



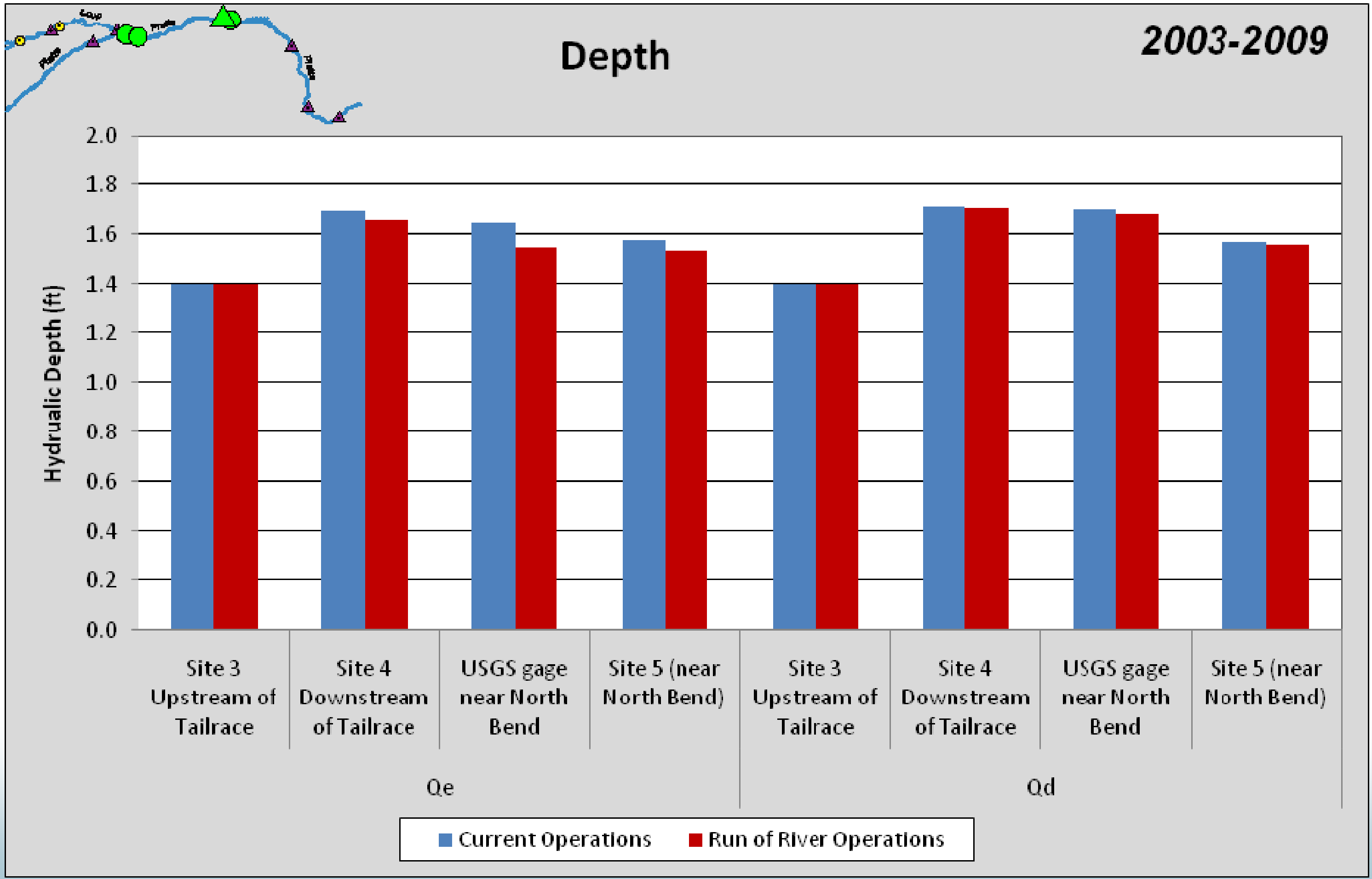
2. Hydrocycling

Channel Characteristics



2. Hydrocycling

Channel Characteristics



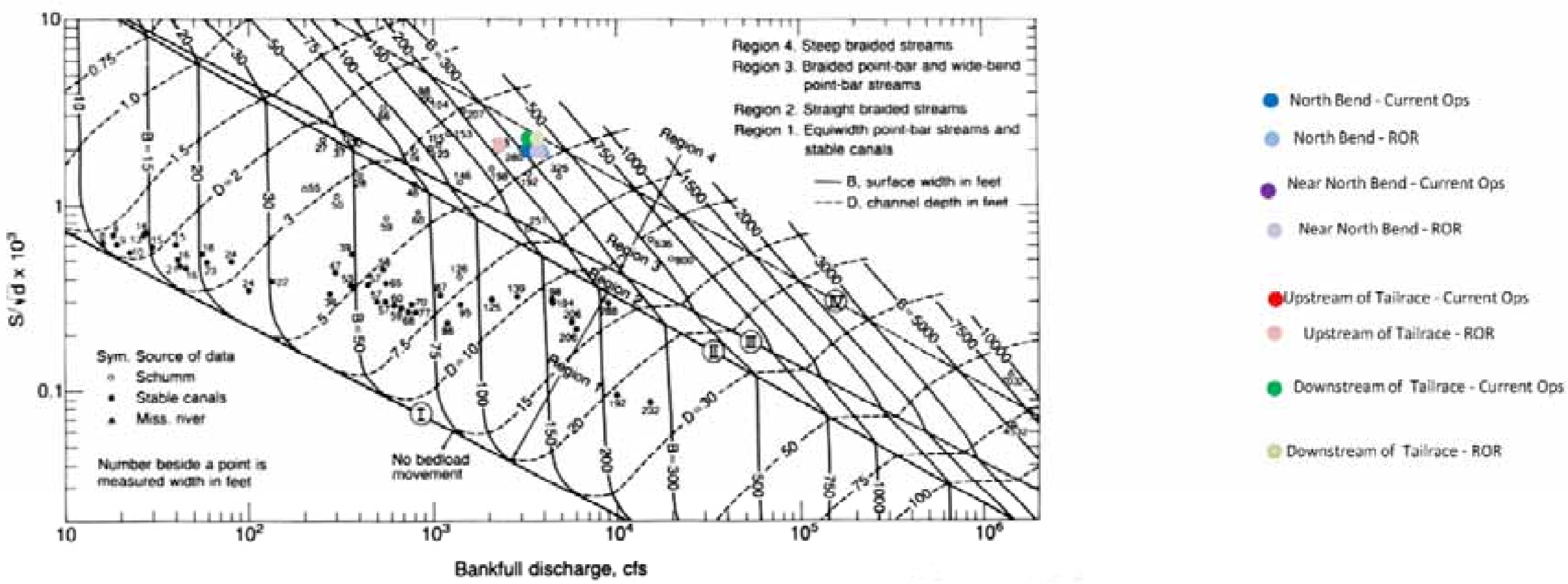
2. Hydrocycling

Results – Channel Characteristics:

- Channel widths and depths are slightly smaller for run of river operations than for current operations

2. Hydrocycling

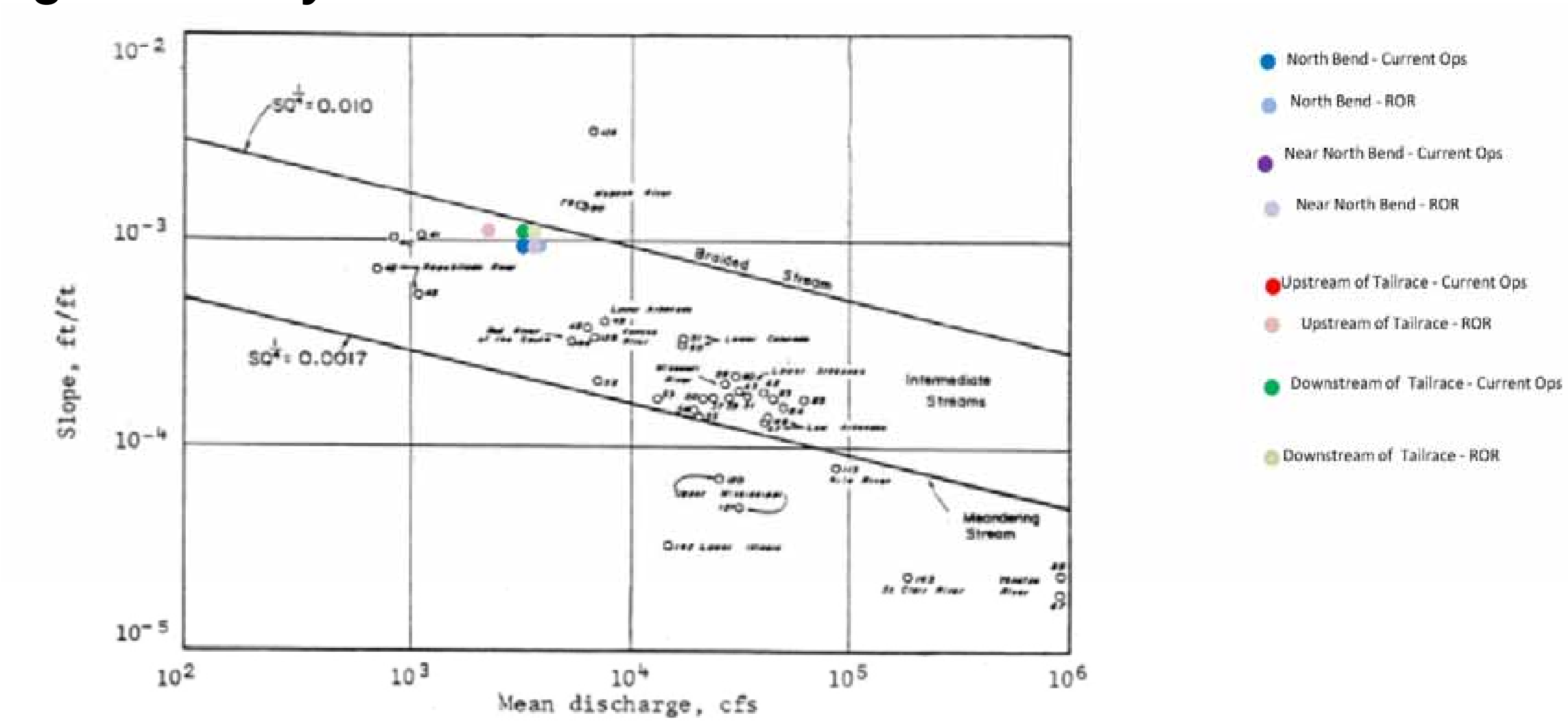
Regime Analysis



Regime channel bed geometry for sand bed rivers, from Chang (1985). For the historic Platte River channel (1900), the bankfull discharge was about 10,000 cfs, the median grain size was about 0.4 mm, and the slope was 0.00126. Therefore, the term $[(S/d^{0.5})1000]$ was equal to 2.0. For the present Platte River channel (2000), the bankfull discharge is about 4,000 cfs, the median grain size near Overton, Nebraska is about 1.5 mm, and the slope is still 0.00126. Therefore, the term $[(S/d^{0.5})1000]$ is now equal to 1.0. Based on the classification by Chang (1985), the Platte River evolved from a steep braided channel (Region 4) to a braided point-bar and wide bend point-bar channel (Region 3).

2. Hydrocycling

Regime Analysis



Lane's (1957) regime diagram for sandbed streams based on slope and mean discharge, taken from Richardson, et al. (1990). Red points shown are for the central Platte River with a slope of 0.0026 ft/ft and a mean discharge of 3,700 cfs for the year 1900, and a mean discharge of 2,100 cfs for the year 2000.

2. Hydrocycling

Results – Regime Analysis:

- Current operations and run-of-river operation are both well within braided river morphology, with neither being near to transitioning to another morphology.

2. Hydrocycling

Summary of Results

- Objective 3
  - Run of river operation would carry less sediment than current operations
  - Channel area would likely be smaller under run of river operations

2. Hydrocycling

Objective 4

- To identify material differences in potential effects on habitat of the interior least tern, piping plover, and pallid sturgeon

Associated Tasks

- Effects of hydrocycling on interior least tern, piping plover, pallid sturgeon, and isolation of backwaters and side channels

2. Hydrocycling

Methodology:

- Literature Review and Comparison to Other Rivers
- Peters and Parham’s Discharge vs. Habitat Relationship
- Lower Platte River Stage Change Study
- Cross-section Comparison
- Habitat Evaluation using HEC-RAS Model

2. Hydrocycling

Methodology – comparison to other rivers:

- Rivers were selected by:
  - Range-wide survey population counts
  - Rivers with flow alterations and structures
  - Rivers within interior of country
- What was compared?
  - Habitat characteristics
  - Manipulated flow operations to Project operations
  - Population counts from range-wide survey downstream of structures

2. Hydrocycling

Methodology – comparison to other rivers:

- Rivers Chosen for Comparison:
  - Interior Least Tern
    - Red River below Denison Dam
    - Arkansas River below Keystone Dam
    - Missouri River below Fort Randall Dam
    - Missouri River below Gavin's Point Dam
  - Piping Plover
    - Missouri River below Fort Randall Dam
    - Missouri River below Gavin's Point Dam
  - Pallid Sturgeon
    - Yellowstone River below Intake Montana
    - Missouri River below Fort Randall Dam
    - Missouri River below Gavin's Point Dam

2. Hydrocycling

Rivers Used for Comparison

2. Hydrocycling

- River Comparisons – Terns & Plovers
  - Red River below Denison Dam (terns only)
  - Arkansas River below Keystone Dam (terns only)
  - Missouri River below Fort Randall Dam
  - Missouri River below Gavin's Point Dam

2. Hydrocycling

River Characteristics – Results
(Interior Least Terns and Piping Plovers)

Missouri River – Below Fort Randall Dam	Missouri River – Below Gavins Point Dam	Red River – Below Denison Dam	Arkansas River – Below Keystone Dam	Platte River – Below Loup Tailrace
Remnant, unchannelized, braiding with wide meandering channel	Wide meandering system with man-made sandbars; downstream – single stabilized channel	Braided upstream of dam, moves to meandering system with sandy substrate downstream	Meandering system with very sandy substrate and changing geomorphology	Very sandy, braided system with several small channels and sandbars
Annual Mean Daily Flow: 26,100 cfs	Annual Mean Daily Flow: 28,900 cfs	Annual Mean Daily Flow: 4,800 cfs	Annual Mean Daily Flow: 8,900 cfs	Annual Mean Daily Flow: 4,500 cfs
2005 Interior Least Tern Count: 76 adults	2005 Interior Least Tern Count: 476 adults	2005 Interior Least Tern Count: 812 adults	2005 Interior Least Tern Count: 54 adults	2005 Interior Least Tern Count: 53 adults

2. Hydrocycling

Structure Characteristics – Results (Interior Least Terns and Piping Plovers)

Fort Randall Dam	Gavins Point Dam	Denison Dam	Keystone Dam	Loup Diversion
Dam & Reservoir built for hydropower, flood control, navigation support, irrigation, recreation, water supply	Dam & Reservoir built for navigation, flood control, hydropower, irrigation, recreation, water supply	Dam & Reservoir built for flood storage, power generation, fish and wildlife management	Dam & Reservoir built for flood storage and power generation	Diversion weir & power canal built for power generation
44,500 cfs max through units	36,000 cfs max through units	12,000+ cfs max through units	12,000+ cfs max through units	4,800 cfs max through units
Daily hydrocycling and during nesting season, flows increased to Every Third Day Cycling	Daily releases for navigation; prior to nesting – adjust releases for future flow needs; during Nesting – regulated flows	Large releases during flooding and daily hydrocycling	Large releases during flooding and daily hydrocycling	Daily hydrocycling

2. Hydrocycling

Results – River Comparison – Terns & Plovers

- Difficult to compare Project's operations and these larger structures on larger rivers
- Changes in Fort Randall operations have shown that flow releases at higher rates during early nesting has encouraged birds to nest higher

2. Hydrocycling

Results – River Comparison – Terns & Plovers

- Leslie et al. 2000 – daily hydropower operations not found to be effecting the birds, whereas subjecting habitat to periodic high flows prior to nesting was beneficial
- Because Project does not control large flood flows, Project's effects from daily hydrocycling on sandbar formation are minor compared to effects from large flood flows

2. Hydrocycling

- River Comparisons – Pallid Sturgeon
  - Intake Dam on Yellowstone River
  - Fort Randall Dam on Missouri River
  - Gavin's Point Dam on Missouri River

2. Hydrocycling

River Characteristics – Results (Pallid Sturgeon)

Missouri River	Yellowstone River	Platte River
Silt/sand substrate	Cobble/gravel substrate	Predominately sand substrate
Higher flows (average annual flow at Fort Randall = 26,100cfs)	Higher flows (average flow at lowest gage = 12,250cfs)	Lower flows (average flow below tailrace canal = 4,500 cfs)
Main stem river	Large tributary	Large tributary
0-500 NTU	86-418 NTU	50-500 NTU

2. Hydrocycling

Structure Characteristics – Results (Pallid Sturgeon)

Gavin's Point Dam	Fort Randall Dam	Intake Dam	Loup Diversion Weir
Hydropower facility and regulates downstream water levels for navigation	Hydropower facility	Diversion dam to store water for irrigation	Not a dam, but is a facility for power generation
Primarily seasonal water releases for navigation	Daily releases for power generation	No hydrocycling	Daily releases for power generation
Stores water in large reservoir and has hypolimnetic releases	Stores water in large reservoir and has hypolimnetic releases	Diverts water for irrigation	No long term water storage

2. Hydrocycling

Results – River Comparison – Pallid Sturgeon

- Utilize a range of habitat (Temperature, flow, turbidity)
  - Collected in nearly all channel types
  - Seem to prefer sand and fines, but have been collected over gravel and cobble areas, and seem to target revetment areas as well
  - Stream bottom velocities ranged from 0.0 to 4.25ft/s (average of 2ft/s)
  - Depths ranged from 1.9 to 45 ft (averaged 10.2 ft)
  - Water temperature ranged from 32 to 86 degrees F
  - Turbidity ranged between 12-6400 NTUs

2. Hydrocycling

Results – River Comparison – Pallid Sturgeon

- Recent spawning has been recorded for the reach below Gavin's Point Dam – 2007 (DeLonay, 2007)
- Pallid sturgeon spawning has not been observed in the Platte River.
  - but *Scaphirhynchus spp*. larvae have been collected
- Other evidence of spawning has been observed along revetments below Gavin's Point Dam.

2. Hydrocycling

Results – River Comparison – Pallid Sturgeon

- Pallid captures have been on the rise in all rivers; however increases also coincide with hatchery supplemented stocking
- Pallid sturgeon often are captured in areas with sandbars or sandy substrates along with shovelnose sturgeon
- No direct evidence providing a link between hydrocycling and reproductive behavior in pallid sturgeon.
  - Many theorize that indirect effects of altered flow regime (e.g. decreased temperature and turbidity in larger retention basins) may affect behavior; however DeLonay theorizes a combination of temperature rise and flow increases trigger spawning response

2. Hydrocycling

Methodology – Peters & Parham:

- Peters and Parham Chapter 10 methodology specifically identified in Study Plan Determination
- Published Peters and Parham equation was incorrect
  - Dr. Parham provided correction
  - Published results for pallid sturgeon were replicated
  - Published results for shovelnose sturgeon were still off by 2 to 3 percent

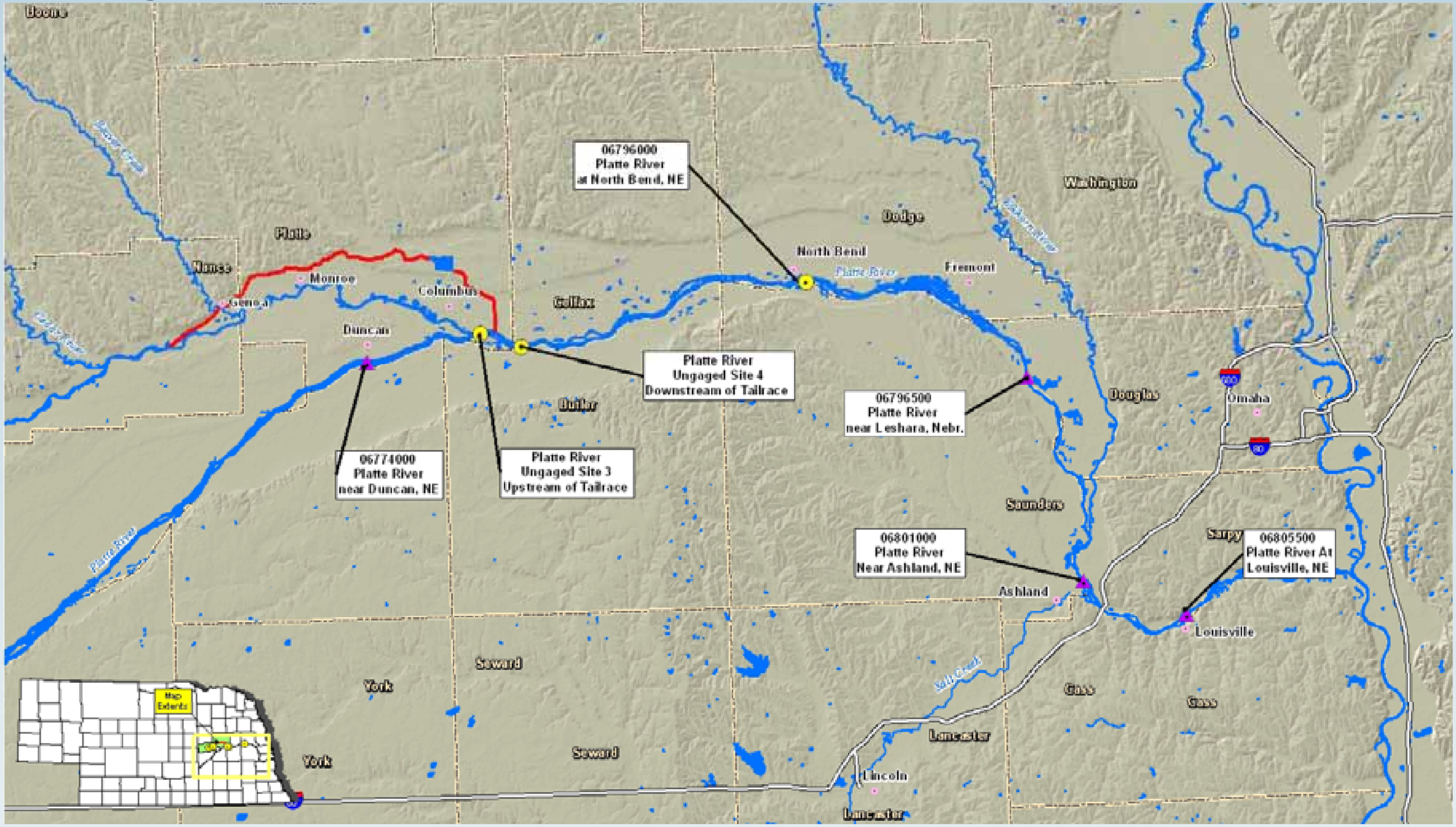
2. Hydrocycling

Methodology – Peters & Parham:

- Analyzed daily % suitable habitat for pallid sturgeon based on the minimum, maximum, & average discharges
- Evaluated for current and run-of-river operations
- Evaluated wet year (2008), dry year (2006), and normal year (2009)

2. Hydrocycling

Study Sites – Peters & Parham



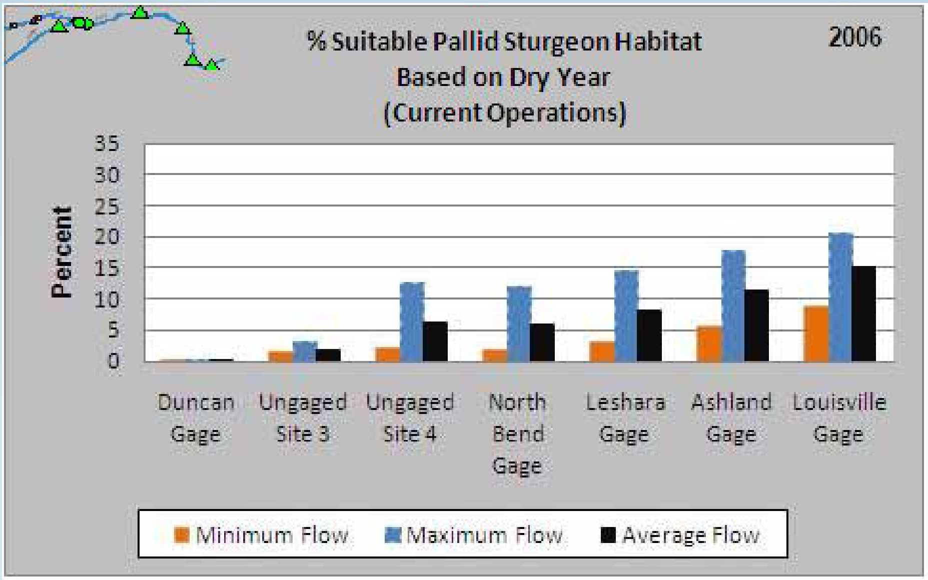
2. Hydrocycling

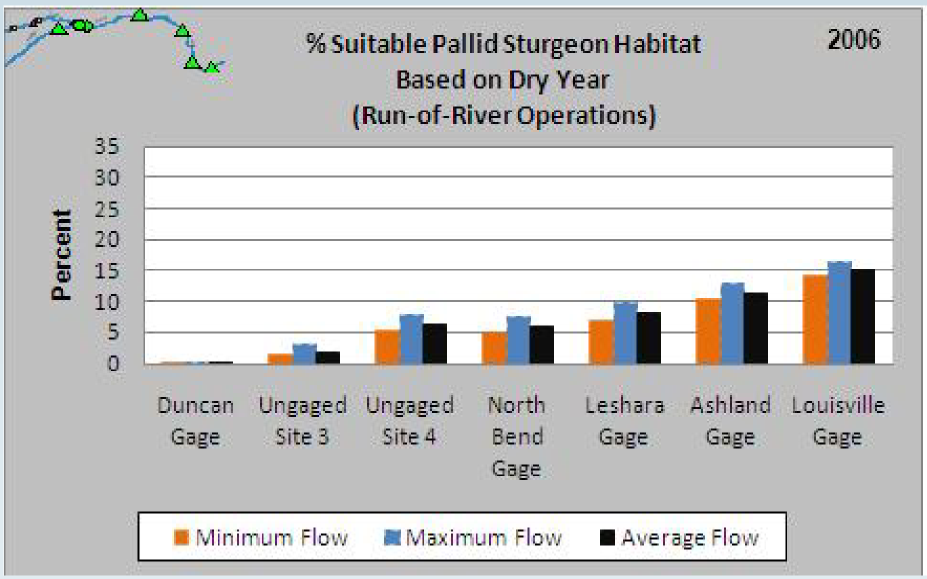
Results – Peters & Parham:

- Current Operations = higher max, lower min
- March - June = highest percentage of habitat available.
- July - October = lowest habitat percentages.
- Habitat increased as you move downstream for wet, dry, and normal years.

2. Hydrocycling

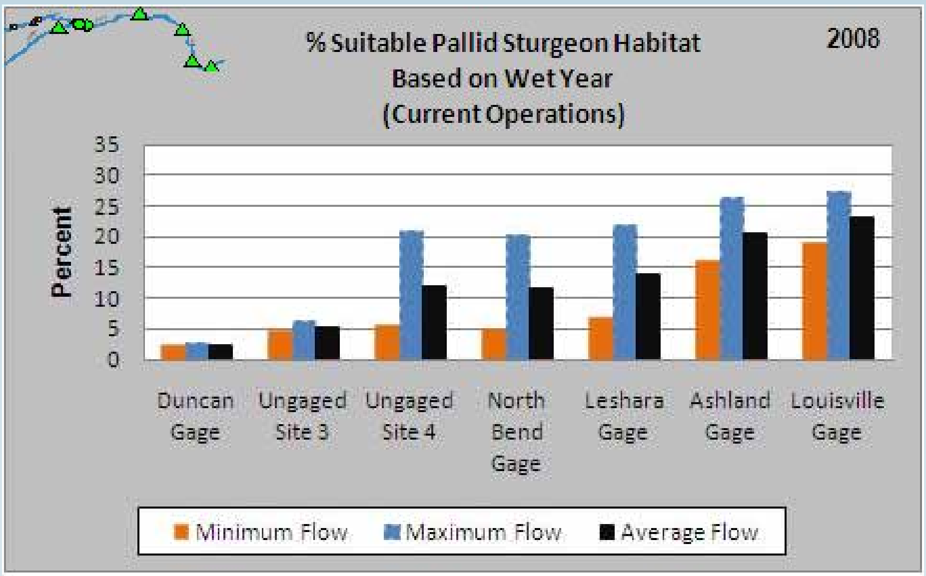
Yearly Summary

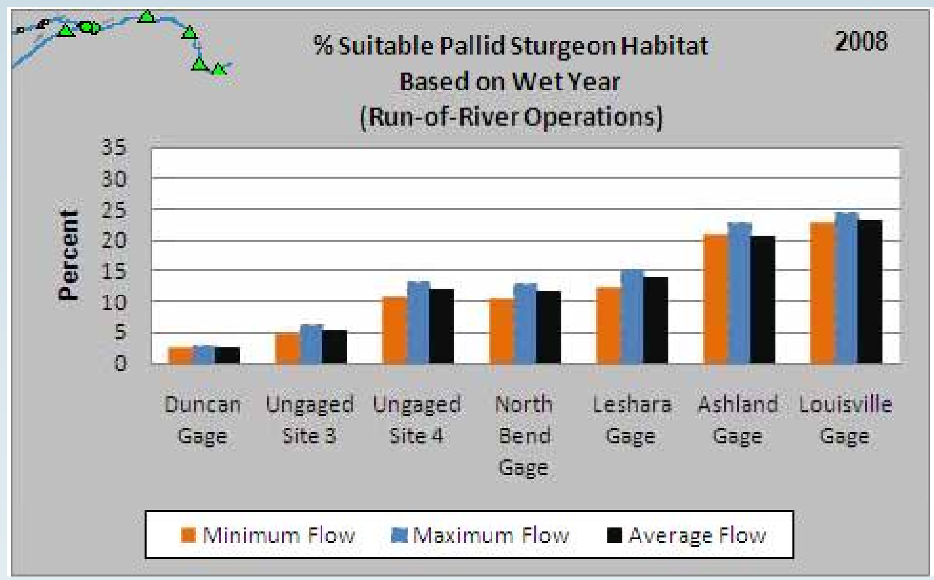




2. Hydrocycling

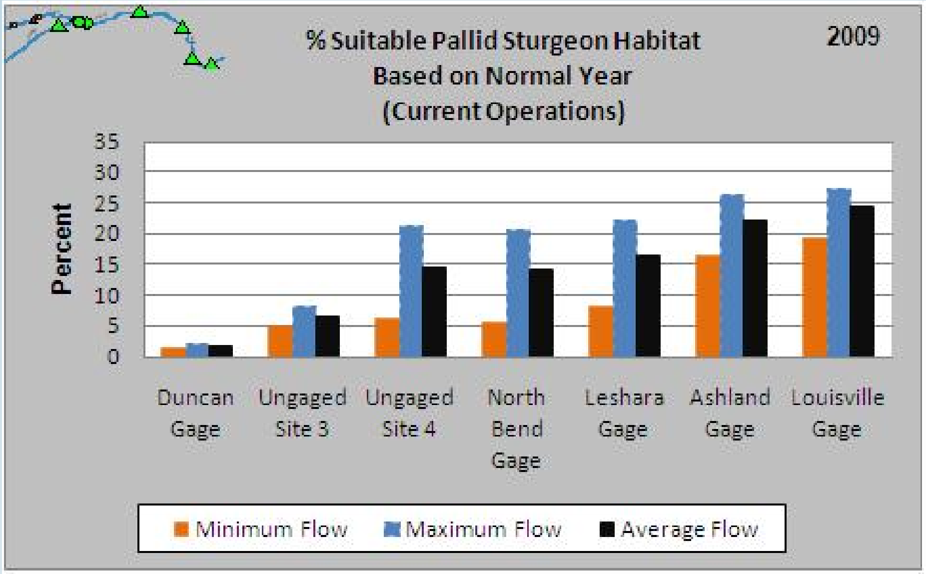
Yearly Summary

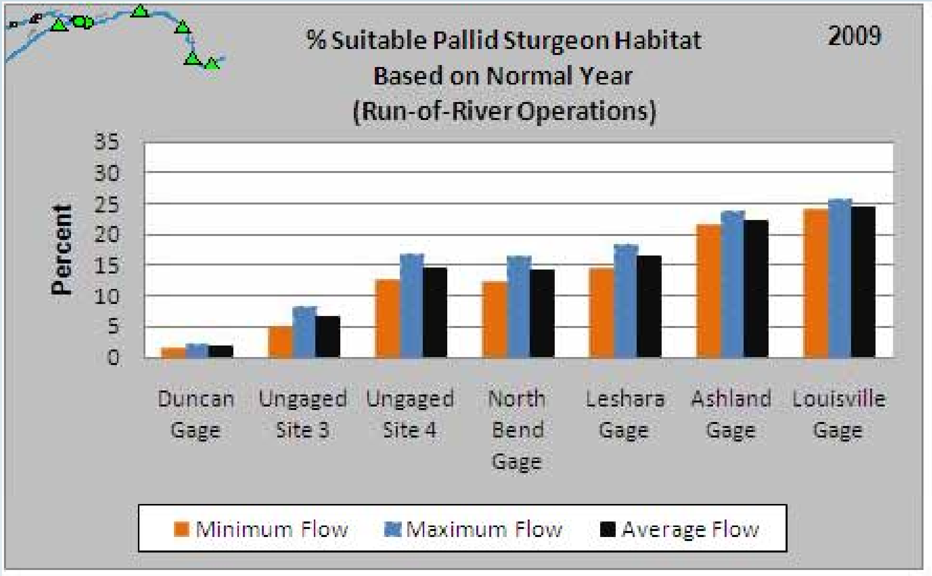




2. Hydrocycling

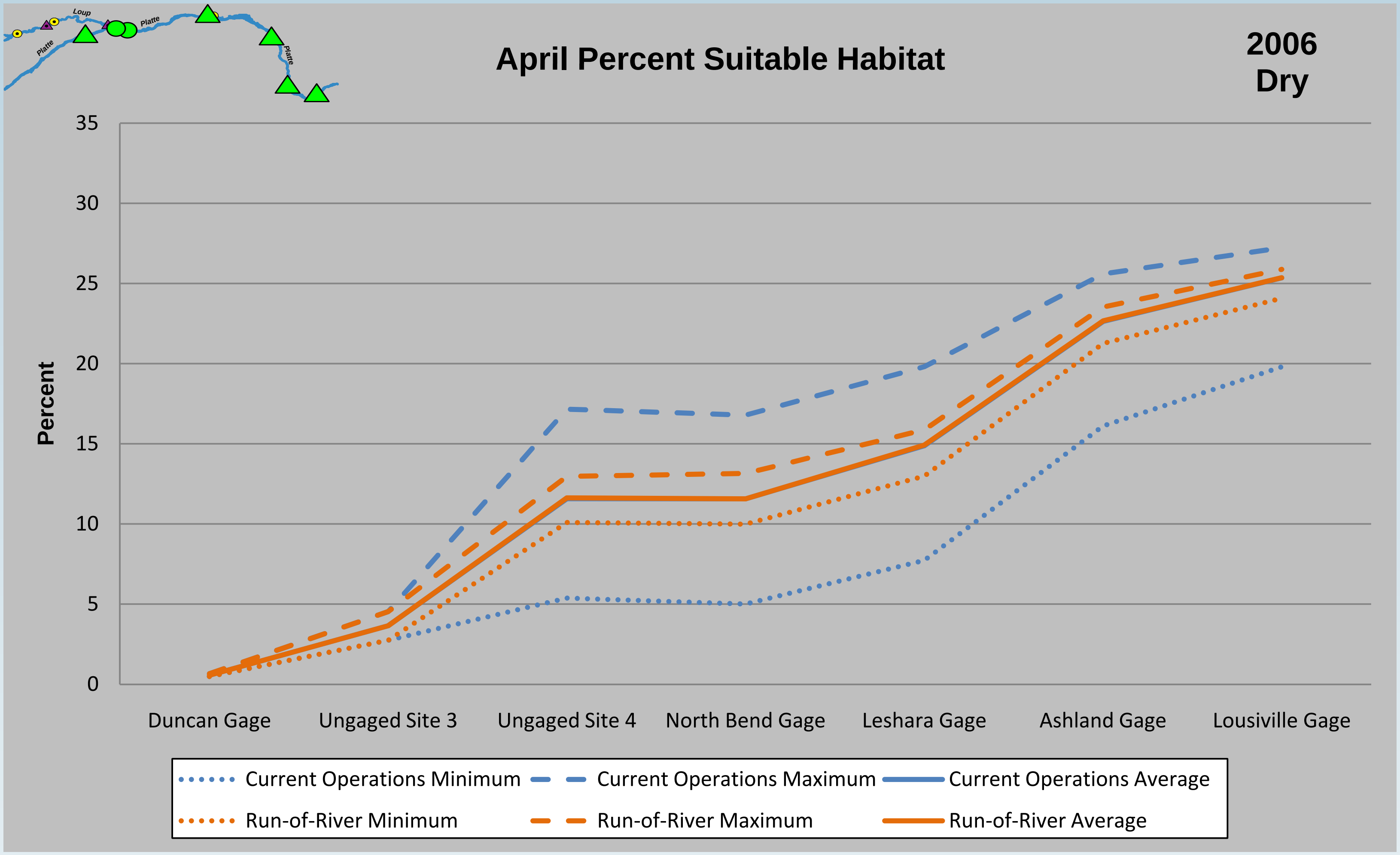
Yearly Summary





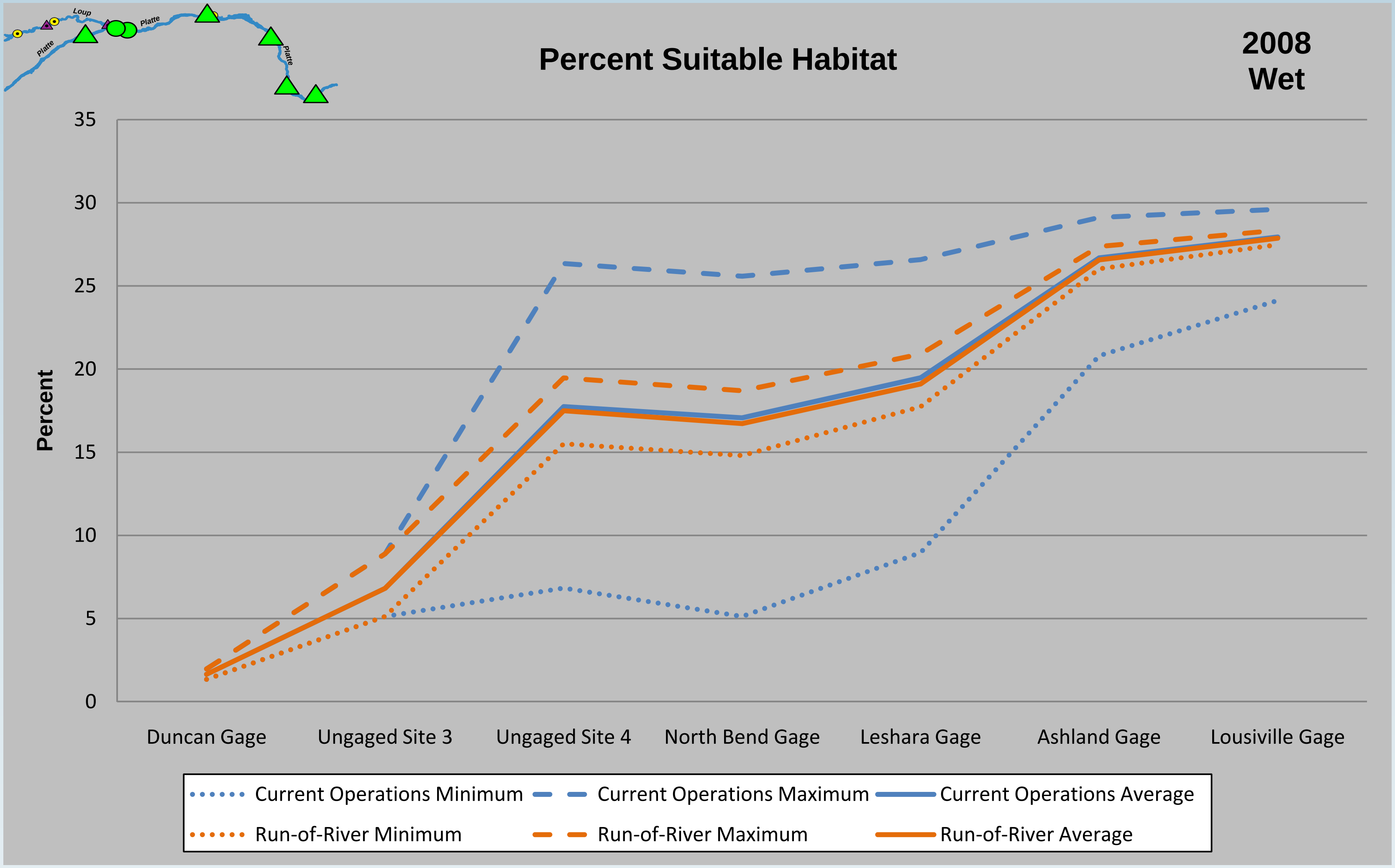
2. Hydrocycling

April – Dry Year



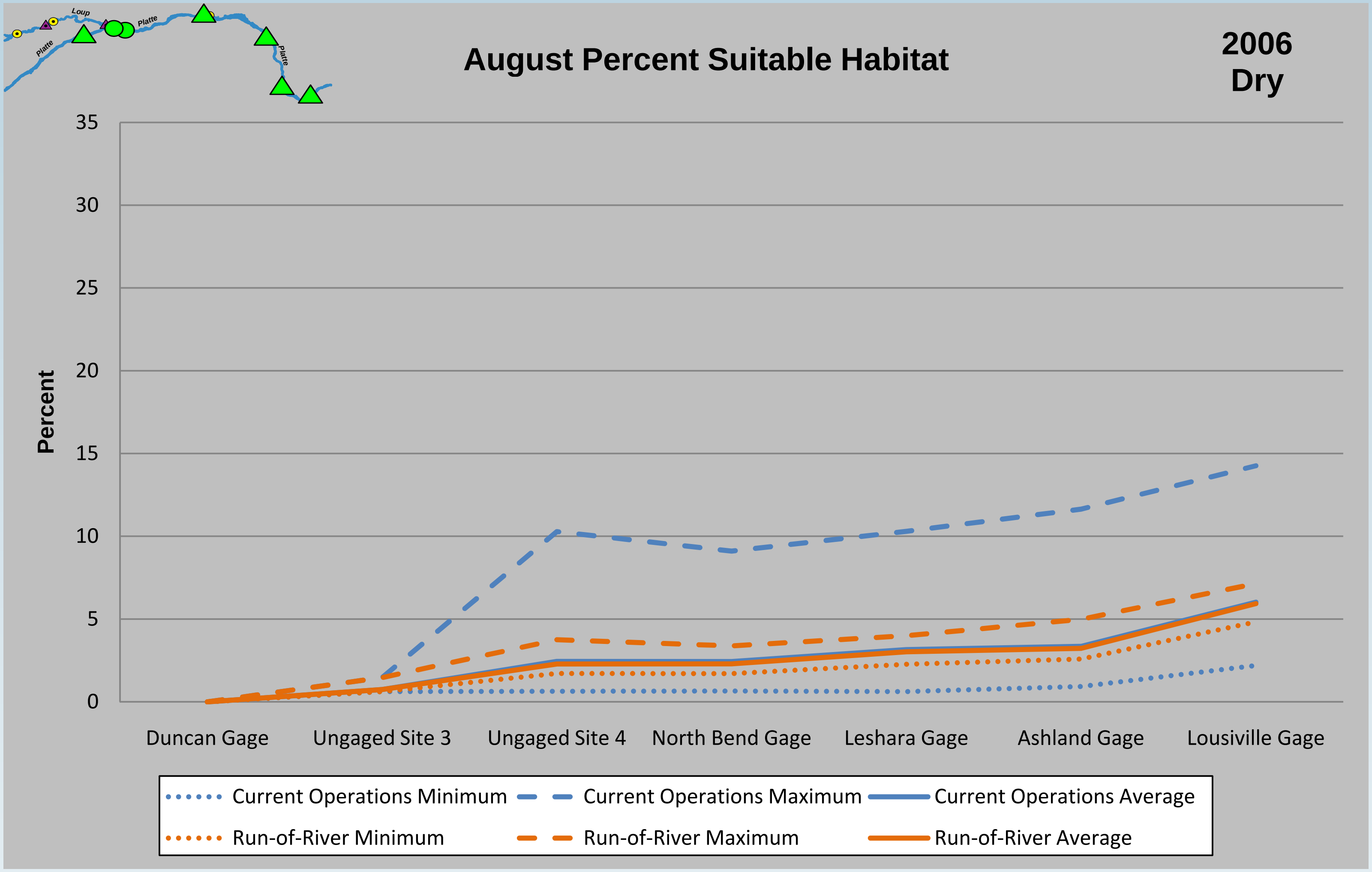
2. Hydrocycling

April – Wet Year



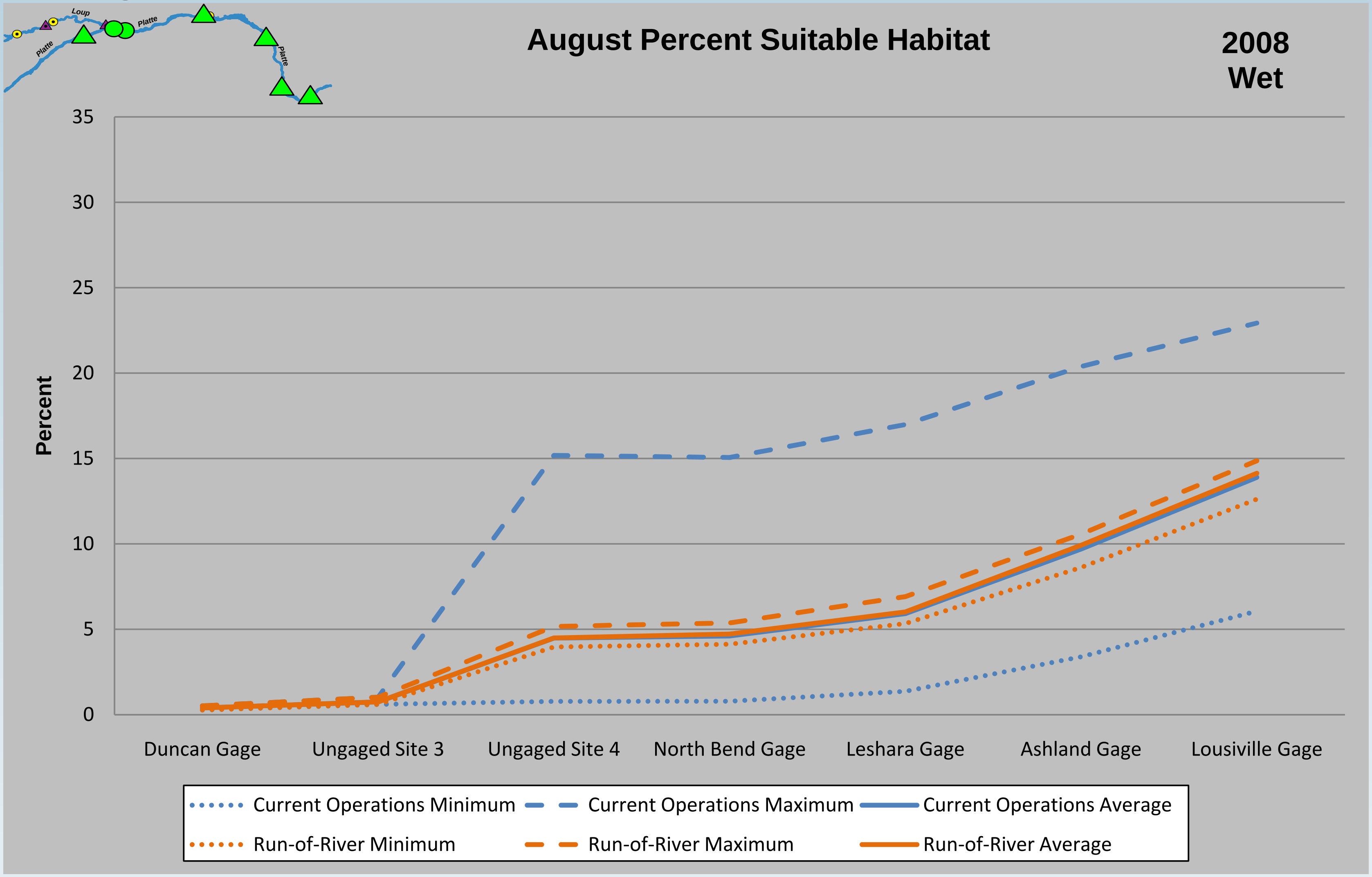
2. Hydrocycling

August – Dry Year



2. Hydrocycling

August – Wet Year



2. Hydrocycling

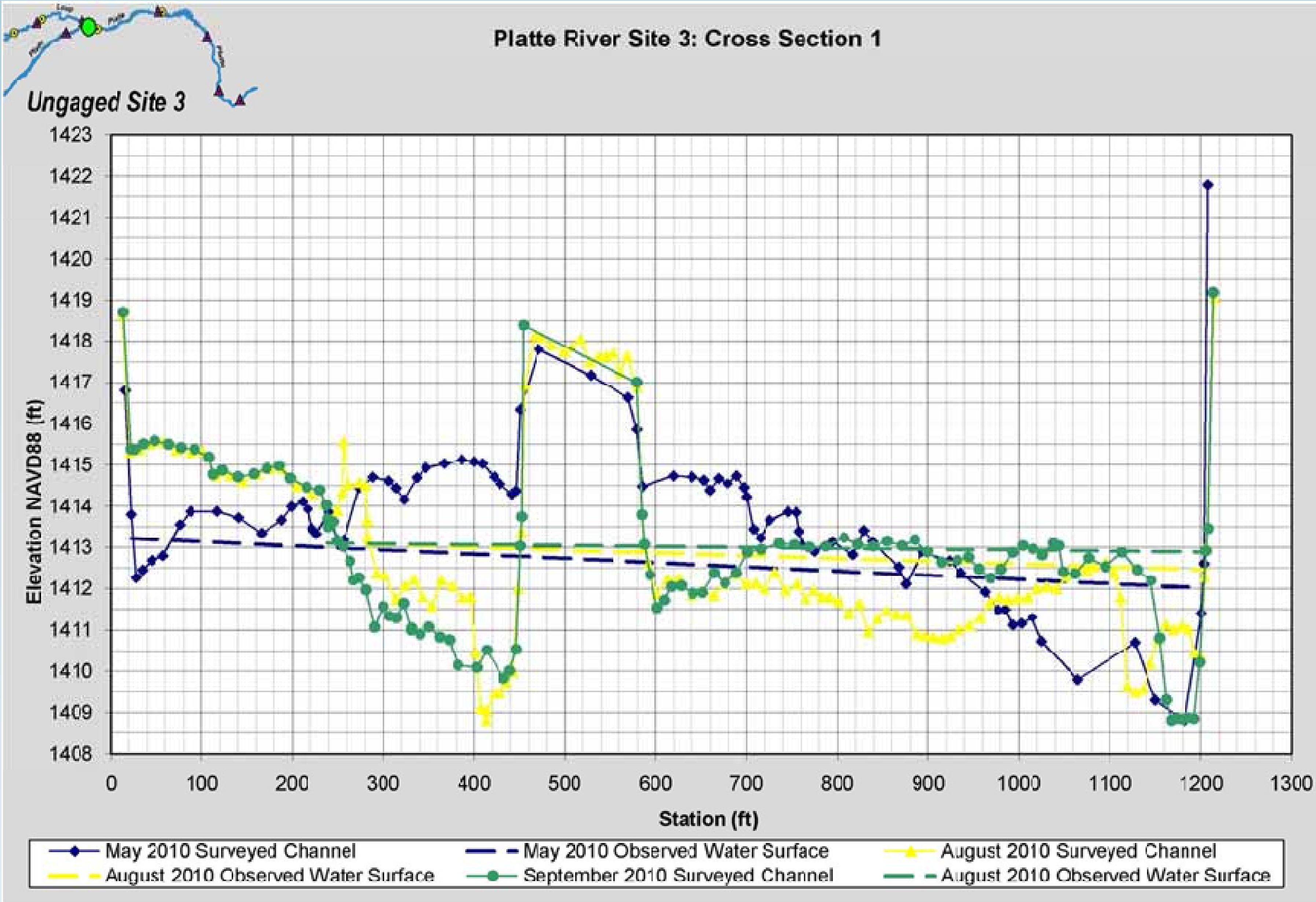
Results – Peters & Parham:

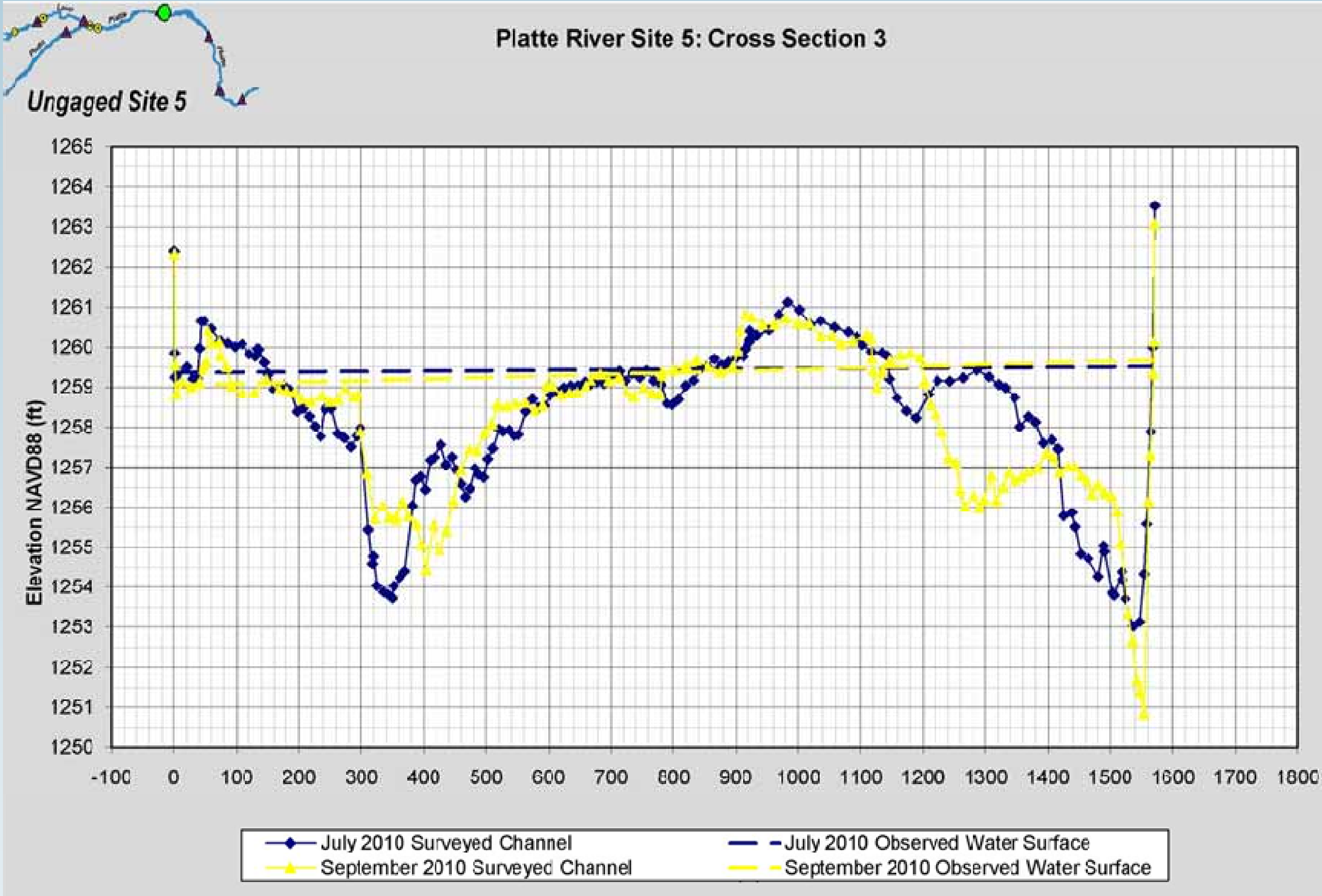
- Current operations exhibit higher % habitat during maximum flows and lower % habitat during minimum flow scenarios
- Under both run-of-river and current conditions, the habitat above Ashland would be considered marginal.
- Effect of hydrocycling appears to diminish as you move downstream.

2. Hydrocycling

Results – Peters & Parham:

- Even with large fluctuations of discharge, deeper plunge areas can be utilized for the short term for refuge.
- During drier months, pallid sturgeon naturally move out of the warmer, oxygen depleted portions of tributaries and move into larger rivers.
- When flows are available and conditions are conducive, pallid sturgeon will access the available habitat.
- Even with Run-of-river or with current operations, habitat is limited above the Elkhorn Confluence (above Ashland gage).


Platte River Site 3: Cross Section 1
Ungaged Site 3
Elevation NAVD88 (ft)
Station (ft)
1423
1422
1421
1420
1419
1418
1417
1416
1415
1414
1413
1412
1411
1410
1409
1408
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
May 2010 Surveyed Channel
May 2010 Observed Water Surface
August 2010 Surveyed Channel
August 2010 Observed Water Surface
September 2010 Surveyed Channel
August 2010 Observed Water Surface


Ungaged Site 5
Platte River Site 5: Cross Section 3
Elevation NAVD88 (ft)
1265
1264
1263
1262
1261
1260
1259
1258
1257
1256
1255
1254
1253
1252
1251
1250
-100
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
July 2010 Surveyed Channel
September 2010 Surveyed Channel
July 2010 Observed Water Surface
September 2010 Observed Water Surface

2. Hydrocycling

Results – Peters & Parham:

- Most habitat is found below Elkhorn confluence
- Greatest habitat in Spring
- UNL research provides evidence that pallid sturgeon prefer lower reaches, but utilize upper reaches.
- Primary spring utilization
  - Some fall utilization

2009 UNL Research

Season	Segment 1	Segment 2
Spring		
Trotlines	8	1
Trammel Nets	0	0
Summer		
Trotlines	10	0
Trammel Nets	6	1
Fall		
Trotlines	33	0
Trammel Nets	9	1

2010 UNL Research

Season	Segment 1	Segment 2
Spring		
Trotlines	21	3
Trammel Nets	0	0
Summer		
Trotlines	1	0
Trammel Nets	0	1
Fall		
Trotlines	11	0
Trammel Nets	1	0

2010, Hamel et al; 2011, Hamel and Pegg

2. Hydrocycling

Lower Platte River Stage Change Study

- Evaluated the potential effects of PRRIP water management activities on the lower Platte River
- Conclusions
  - Percent habitat has a relatively high rate of change for flows ranging between 4,000 cfs to 6,000 cfs.
  - Changes in habitat areas as a result of 100 or 500 cfs environmental releases would have a negligible influence on pallid sturgeon habitat in the lower Platte River.

2. Hydrocycling

Lower Platte River Stage Change Study

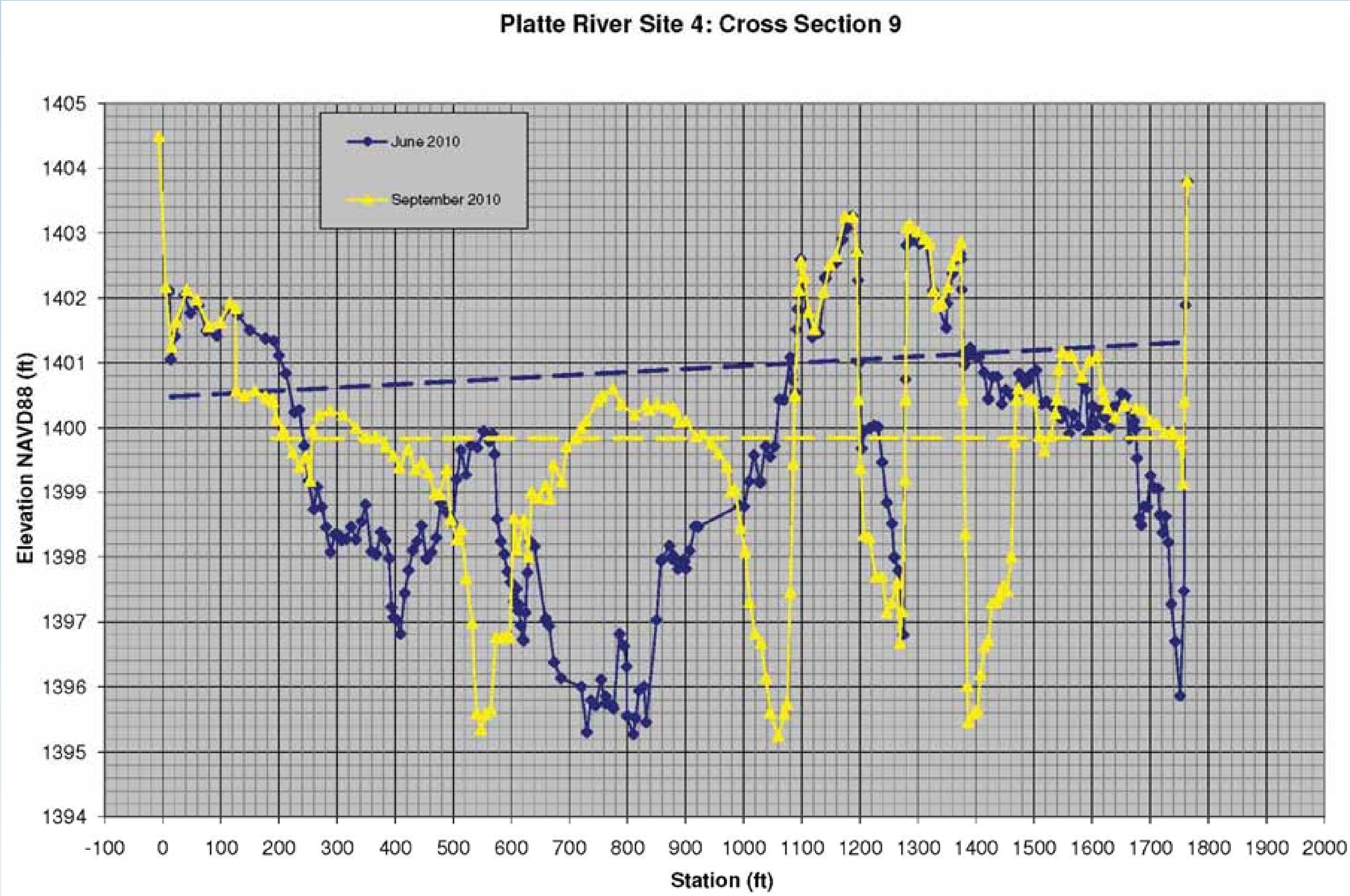
- Conclusions (cont.)
  - Increases in discharge do not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range selected by pallid sturgeon
  - Large changes in discharge may have the most effect on pallid sturgeon when flows are at about 4000-6000 cfs.

2. Hydrocycling

Methodology - Cross-Section Comparison

- Cross-sections taken pre-nesting and post-nesting
- Reviewed cross-sections to identify changes
  - Calculated in-channel cross-sectional area for each cross-section
  - Evaluated cross-section changes both above and below Tailrace
- Evaluated differences between sites affected by and unaffected by the Project (Site 3 vs. Site 4)

2. Hydrocycling

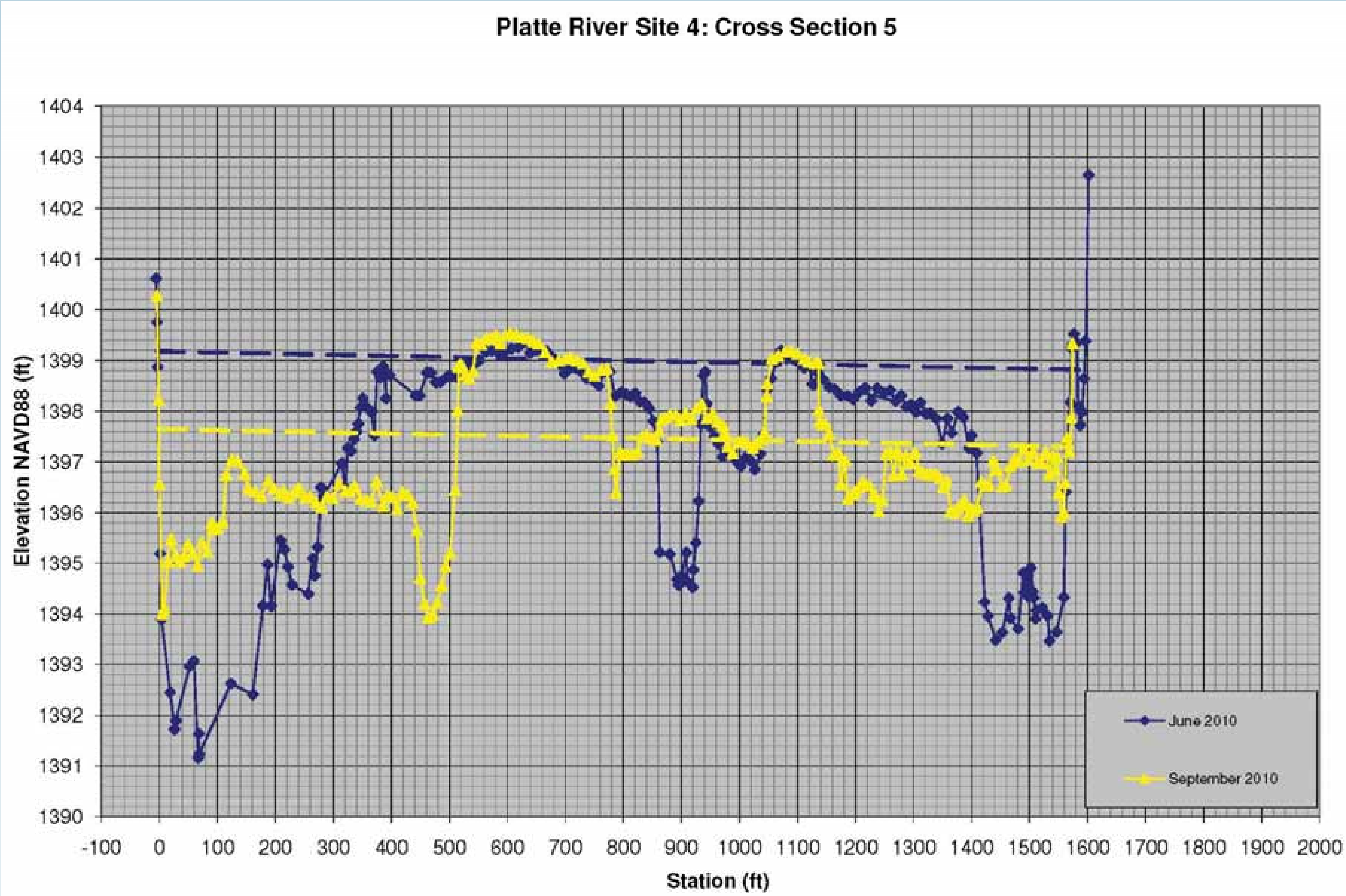


2. Hydrocycling

Results:

- At each site, average channel cross-section area decreased from the early to late nesting season survey
  - 6% decrease at Site 3
  - 4% decrease at Site 4
  - 3% decrease at Site 5
- Macroforms present in June were still there in September

2. Hydrocycling

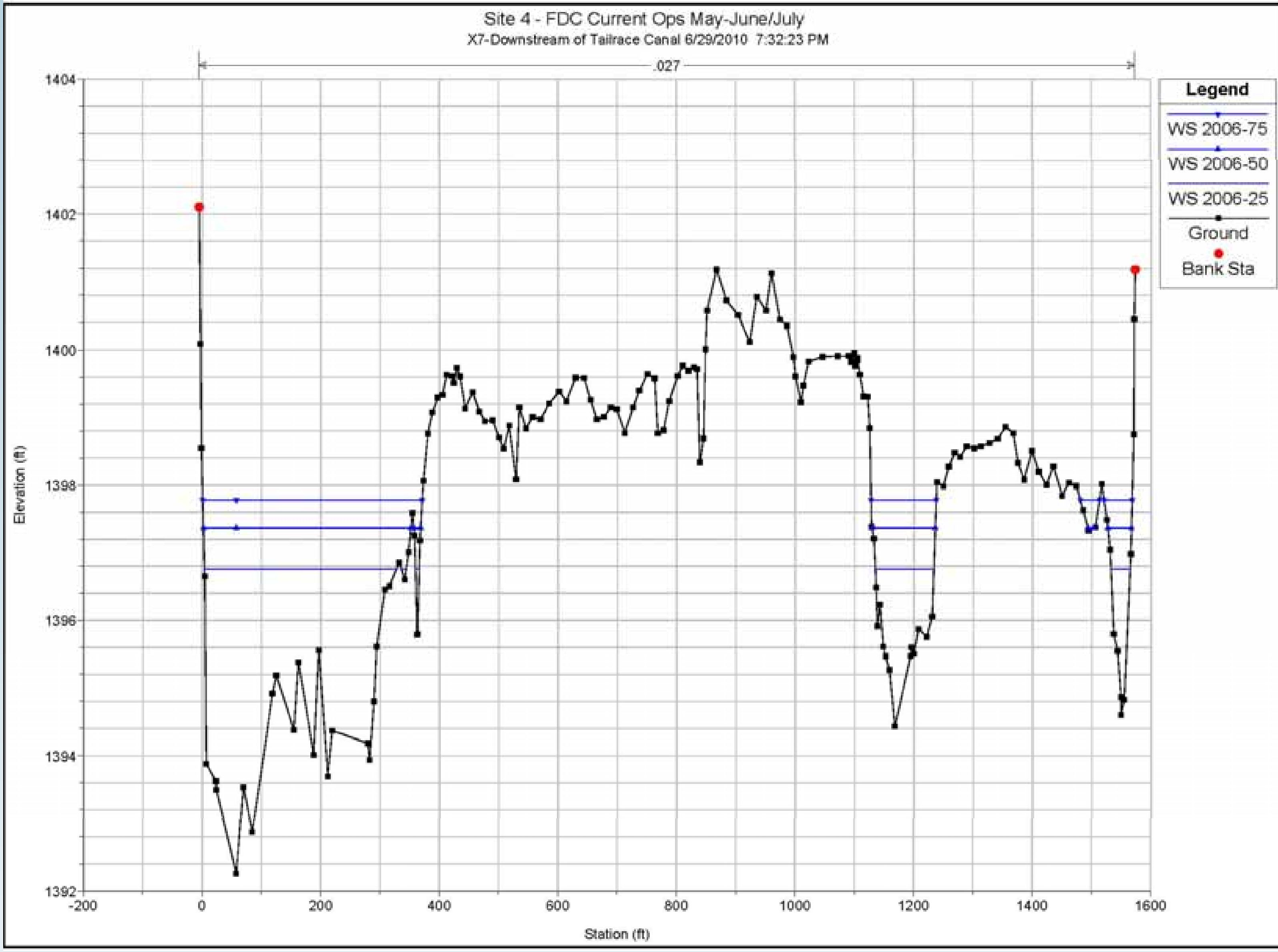


2. Hydrocycling

Methodology – Habitat Evaluation Using HEC-RAS Model

- Steady-state 1-D HEC-RAS Model Developed
  - Model capabilities
- Years evaluated based on wet/normal/dry analysis
- Flow conditions evaluated based on 25%, 50%, and 75% exceedance flows
- Percent Channel Width Exposed
- Current Operations vs. Run-of-River operation

2. Hydrocycling



2. Hydrocycling

Results – Comparison of Sites 3 and 4

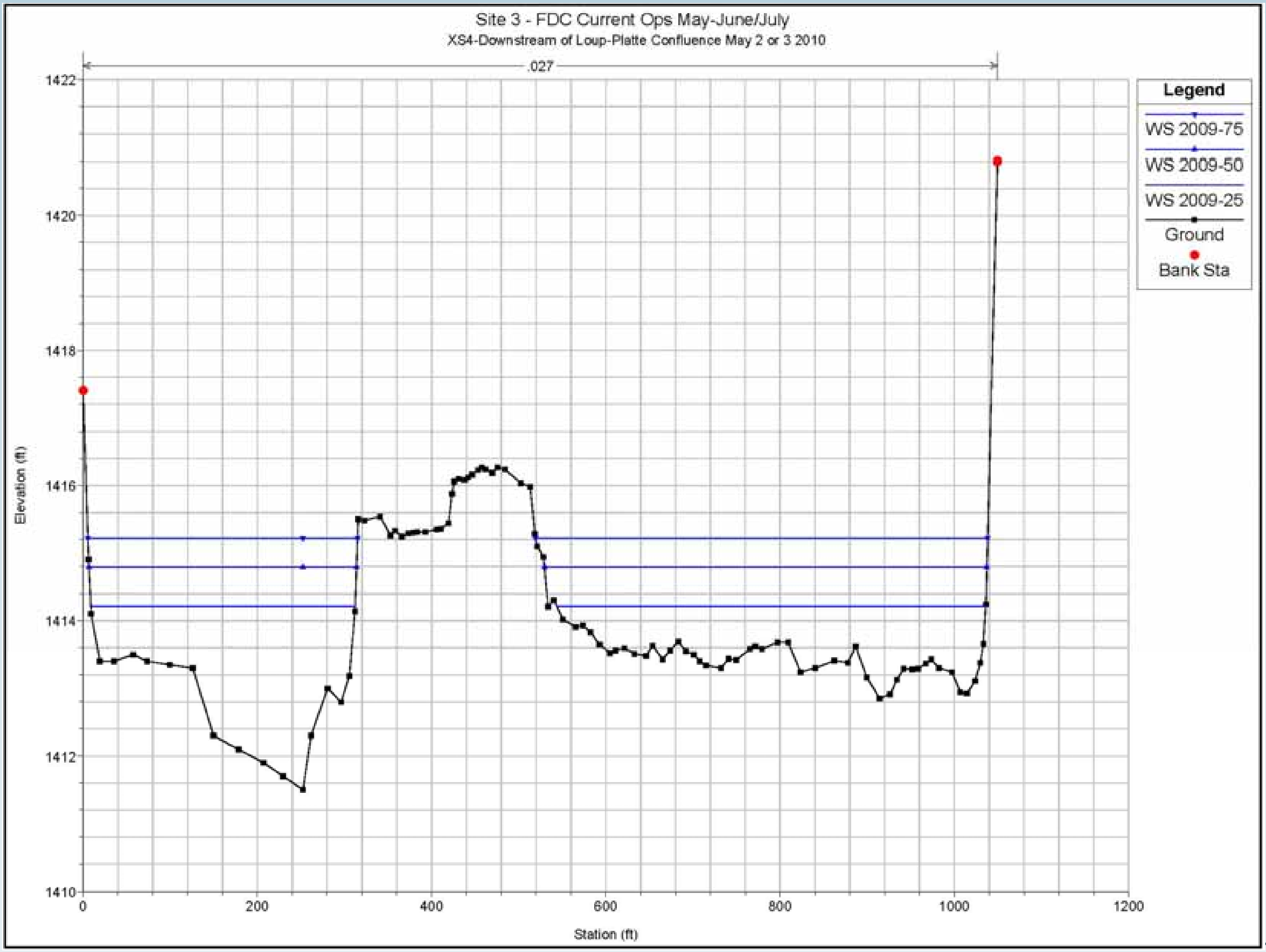
- Site 3 – percent of exposed channel width generally decreases as flow increases
  - From early to late summer, percent exposed channel width increases at Site 3 due to reduction in flow
  - Decreases at Site 4 during this same period
- Current operations
  - Site 3 has higher percent exposed channel width than Site 4 during a wet year
  - Opposite is true during normal and dry years

2. Hydrocycling

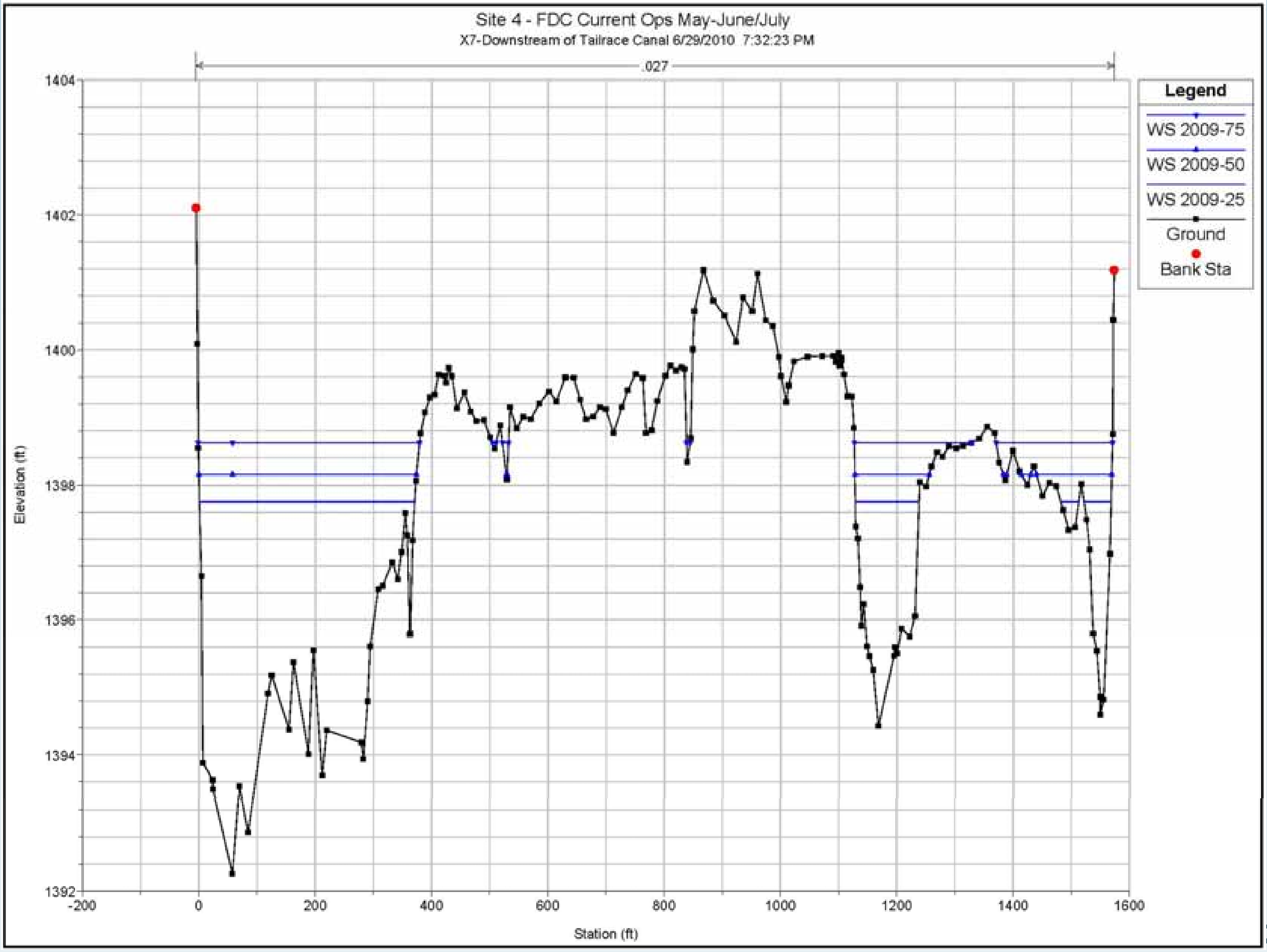
Results – Comparison of Sites 3 and 4 (Cont.):

- Potential reasons….
  - Channel width – as flow decreases, percent exposed channel width is a function of overall channel width
    - Site 3 width is 1,074 ft.
    - Site 4 width is 1,725 ft.
  - Under higher flows, at Site 3, water is out of the deeper channel and distributed over bars
  - Under increasing flows, wider distribution of water at Site 4 would cause less channel width exposed

Site 3 – 2009 – Current Operations



Site 4 – 2009 – Current Operations



2. Hydrocycling

Results – Comparison of Current Operations to ROR at Site 4:

- Normal Year
  - Early summer had greater percentages of exposed channel width than late summer
  - Current operations had lower percent exposed channel width than run-of-river (other than at 50% exceedance flow)
  - Little difference between operations in late summer conditions for medium and high flows

2. Hydrocycling

Results – Comparison of Current Operations to ROR at Site 5:

- Normal Year
  - Current operations had greater percent exposed channel width at 50% and 75% exceedance flows than did run-of-river for both early and late summer
  - 25% exceedance flow is opposite of above
  - 50% exceedance flow showed the greatest difference between early and late summer cross-sections

2. Hydrocycling

Results – Comparison of Current Operations to ROR:

- Sites 3 & 4 – All Flows
  - Late summer had larger difference between operations
  - Early summer did not show much difference between operations

2. Hydrocycling

Results Summary:

- Site 3 had greater percent exposed channel width than Site 4 during a wet year; opposite is true during a normal and dry years
- Current operations had lower percent exposed channel width than run-of-river
- Early summer had greater percent exposed channel width than late summer
- Site 4 had greater percent exposed channel width than Site 5

QUESTIONS?

5. Flow Depletion and Flow Diversion

5. Flow Depletion and Flow Diversion

Goals

- To determine if Project operations result in a flow depletion on the lower Platte River and to what extent the magnitude, frequency, duration, and timing of flows affect the Loup River bypass reach.
- Determine if Project operations (current operations) relative to flow depletion and flow diversion adversely affect the habitat used by interior least tern and piping plover populations, the fisheries, and the riverine habitat in the Loup River bypass reach and the lower Platte River compared to alternative condition (the no diversion condition).

5. Flow Depletion and Flow Diversion

Objectives

1. To determine the net consumptive losses associated with Project operations compared to the no diversion condition.
2. To use current and historic USGS gage rating curves to evaluate change in stage in the Loup River bypass reach during Project operations and compare against alternative hydrographs.
3. To evaluate historic flow trends on the Loup and Platte rivers since Project inception.
4. To determine the extent of interior least tern and piping plover nesting on the Loup River above and below the Diversion Weir.

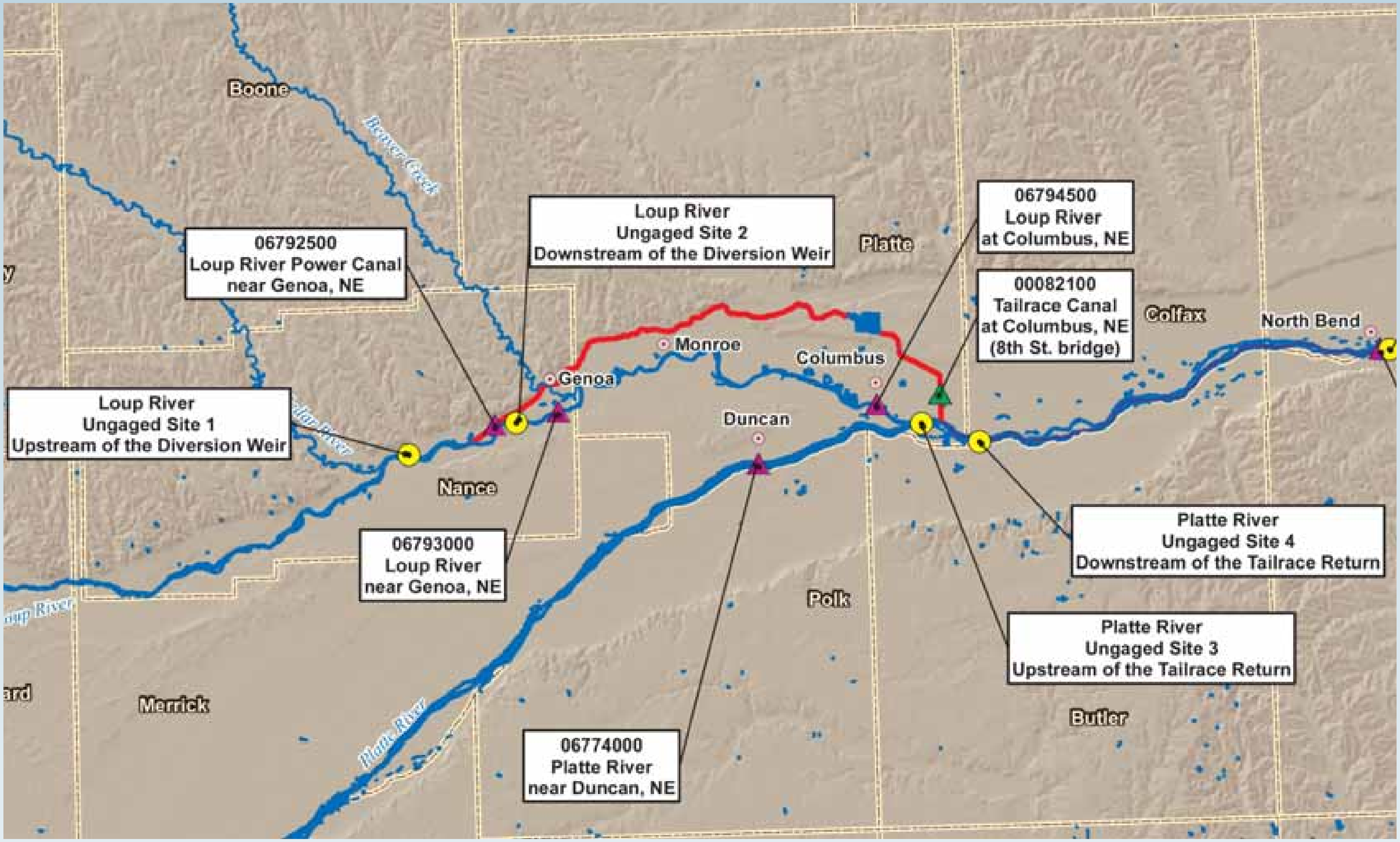
5. Flow Depletion and Flow Diversion

Objectives (continued)

5. To determine Project effects, if any, of consumptive use on fisheries and habitat on the lower Platte River downstream of the Tailrace Canal.
6. To determine the relative significance of the Loup River bypass reach to the overall fishery habitat for the Loup River.
7. To determine the availability of potential whooping crane roosting habitat above and below the Diversion Weir under Project operations compared to the no diversion condition.

5. Flow Depletion and Flow Diversion

Study Area



5. Flow Depletion and Flow Diversion

Objective

1. To determine the net consumptive losses associated with Project operations compared to the no diversion condition.

Associated Activities

- Determine Surface Area for Project and Bypass Reach for Current Operations and No Diversion Condition
- Apply evaporation and ET rates, based on USFWS methodology, to contributing areas
  - Performed for wet, dry, normal flow classifications

5. Flow Depletion and Flow Diversion

Associated Activities (cont.):

- Per SPD, evaluate consumptive use of irrigation water.
- Per SPD, evaluate consumptive use of Lost Creek

5. Flow Depletion and Flow Diversion

Methodology – Canal/Bypass Consumptive Use:

- Evaporation Surface Area - Project
  - Project Current Operations
    - Based on design drawings
    - Normal operating conditions
  - No Diversion Alternative
    - Assumed canal bottom width would still have a nominal depth based on recharge (<1 ft)
    - Evaluated both with and without regulating reservoirs

5. Flow Depletion and Flow Diversion

Methodology – Canal/Bypass Consumptive Use (cont.)

- Evaporation Surface Area - Bypass Reach
  - Project Current Operations and No Diversion Alternative
    - Computed daily surface area from USACE Loup River hydraulic model
- ET Contributing Area – Project and Bypass Reach
  - Area of riparian vegetation within 100 ft of source

5. Flow Depletion and Flow Diversion

Riparian Vegetation

5. Flow Depletion and Flow Diversion

Surface Area Summary

Water Surface Areas in Acres			
Year	2005	2006	2008
Current Operations			
Project - Canal	470	470	470
Project - Reservoirs	960	960	960
Project - Total	1,430	1,430	1,430
Bypass Reach	2,052	1,676	2,408
No Diversion Scenario			
Project - Canal	232	232	232
Project - Reservoirs	960	960	960
Project - Total with Reservoirs	1,192	1,192	1,192
Project - Total without Reservoirs	232	232	232
Bypass Reach	3,454	3,199	3,895

Evapotranspiration Areas	
Location	Area (acres)
Project – Canal	295
Project – Reservoirs	47
Bypass Reach	823

5. Flow Depletion and Flow Diversion

Methodology – Canal/Bypass Consumptive Use:

- Evaporation Rate
  - Project Canal and Regulating Reservoirs
    - Based on NWS daily pan evaporation rates
    - Applied lake coefficient of 0.7 to Canal and Lake North
    - Applied lake coefficient of 0.9 to Lake Babcock
  - Bypass Reach
    - Based on NWS daily pan evaporation rates
    - Applied lake coefficient of 0.9
- ET Rate
  - Based on NWS daily pan evaporation rates
  - Applied seasonal coefficient of 0.7 * 0.5 (winter) or 0.7 * 0.8 (growing)

5. Flow Depletion and Flow Diversion

Consumptive Use with Regulating Reservoirs

With Regulating Reservoirs		Current Operations	No Diversion Condition
Normal Year – 2005			
Loup Power Canal	Total Mean Open Water Evaporation (acre-feet [AF])	6,030	5,400
	Total Mean ET (AF)	870	870
	Subtotal Consumptive Use (AF)	6,900	6,270
Loup River Bypass Reach	Total Mean Open Water Evaporation (AF)	9,070	16,150
	Total Mean ET (AF)	2,110	2,110
	Subtotal Consumptive Use (AF)	11,180	18,260
	Total Consumptive Use	18,080	24,530

5. Flow Depletion and Flow Diversion

Consumptive Use without Regulating Reservoirs

Without Regulating Reservoirs		Current Operations	No Diversion Condition
Normal Year – 2005			
Loup Power Canal	Total Mean Open Water Evaporation (AF)	6,030	1,090
	Total Mean ET (AF)	870	870
	Subtotal Consumptive Use (AF)	6,900	1,960
Loup River Bypass Reach	Total Mean Open Water Evaporation (AF)	9,070	16,150
	Total Mean ET (AF)	2,110	2,110
	Subtotal Consumptive Use (AF)	11,180	18,260
	Total Consumptive Use	18,080	20,220

5. Flow Depletion and Flow Diversion

Results – Objective 1:

- Canal/Bypass Consumptive use
  - Flow depletions under current operations are less than would occur under the no diversion alternative

5. Flow Depletion and Flow Diversion

Methodology – Irrigation Consumptive Use:

- Determined crop irrigation requirement based on crop type, demand curve, and precipitation
- Based on irrigation records, determined amount of applied irrigation water consumed

5. Flow Depletion and Flow Diversion

Results – Objective 1

- Irrigation Consumptive Use:
  - On average, 71% of applied irrigation water is lost to consumptive use
  - For both Current Operations *and* the No Diversion Scenario

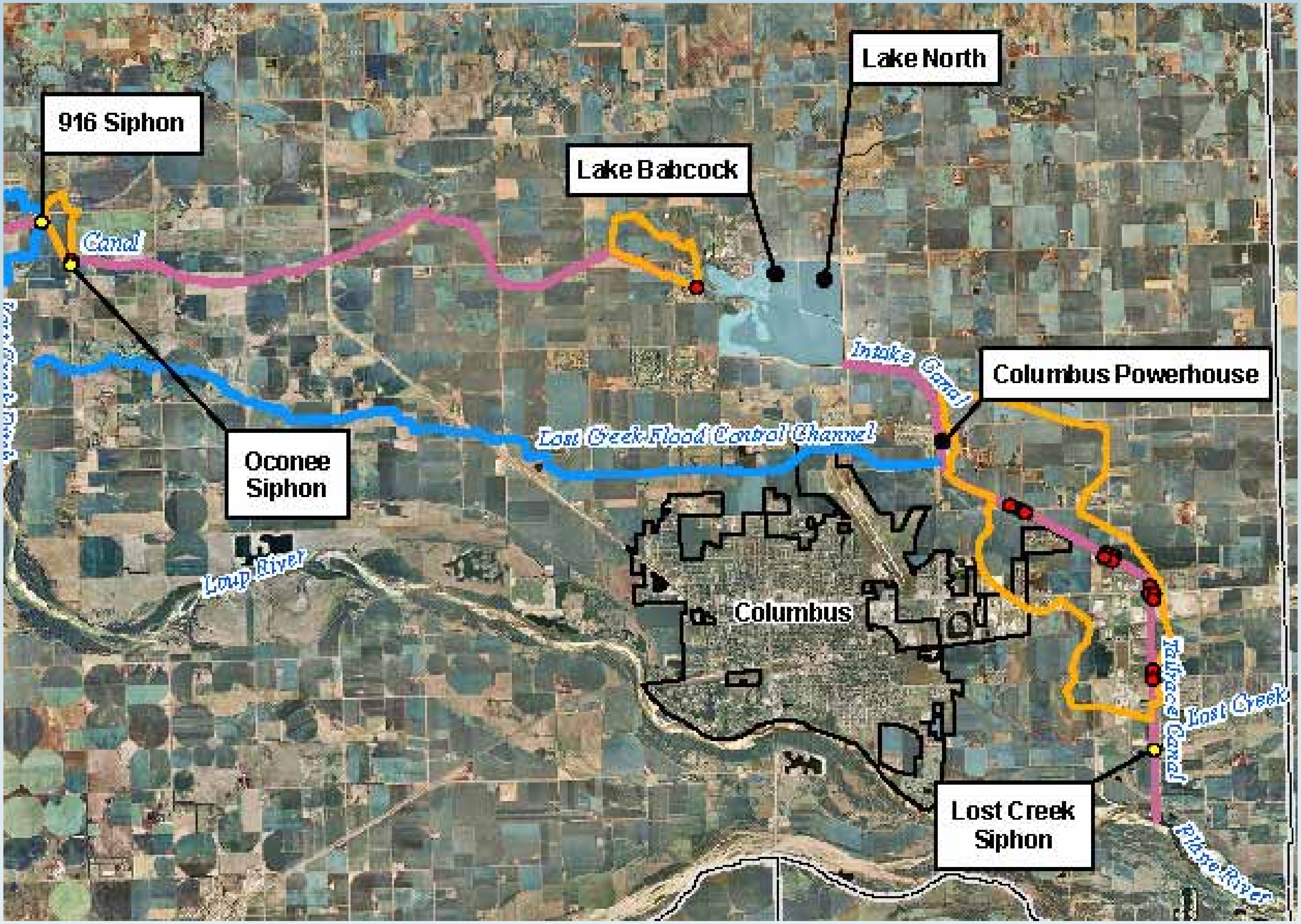
5. Flow Depletion and Flow Diversion

Lost Creek Consumptive Use

Background

- Lost Creek siphon was constructed with the Project to convey Lost Creek flood flows
- Gate was installed to discharge water from the canal to keep the siphon free of debris
- In 1980's, the Lost Creek Flood Control Project was constructed, which discharges Lost Creek flows into the Tailrace Canal just downstream of Columbus Power House

5. Flow Depletion and Flow Diversion



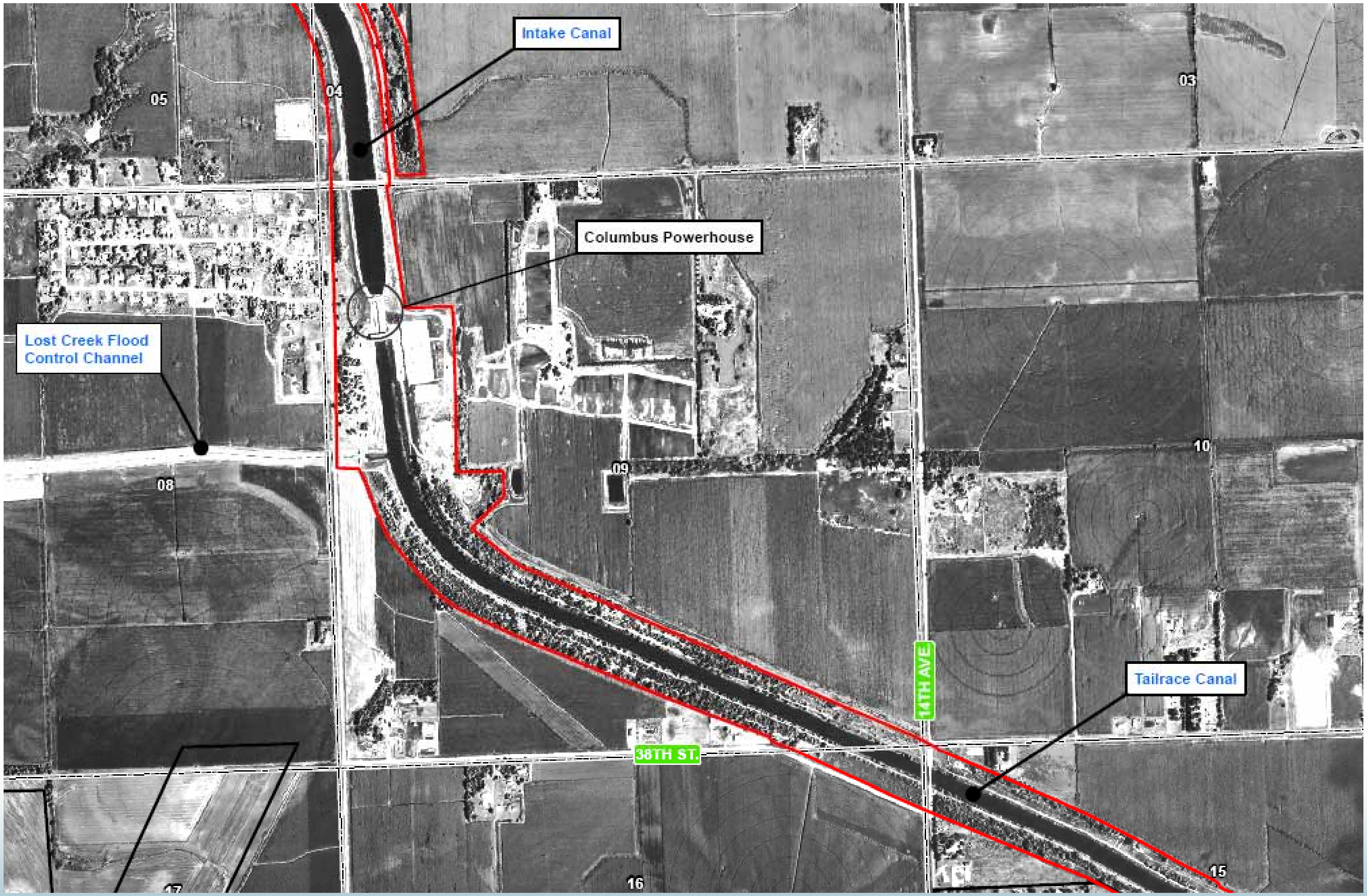
5. Flow Depletion and Flow Diversion

Methodology – Lost Creek Consumptive Use:

- Determined average annual amount of Lost Creek flows (base flow plus average annual runoff) entering the Tailrace Canal from the Lost Creek Flood Control Channel
  - Low flow channel water markings and weir equation
  - Average annual runoff curves
- Determined average annual amount of flows discharged from the Tailrace canal
  - Gate opening records
  - HY-8

5. Flow Depletion and Flow Diversion

Lost Creek – Into Canal



5. Flow Depletion and Flow Diversion

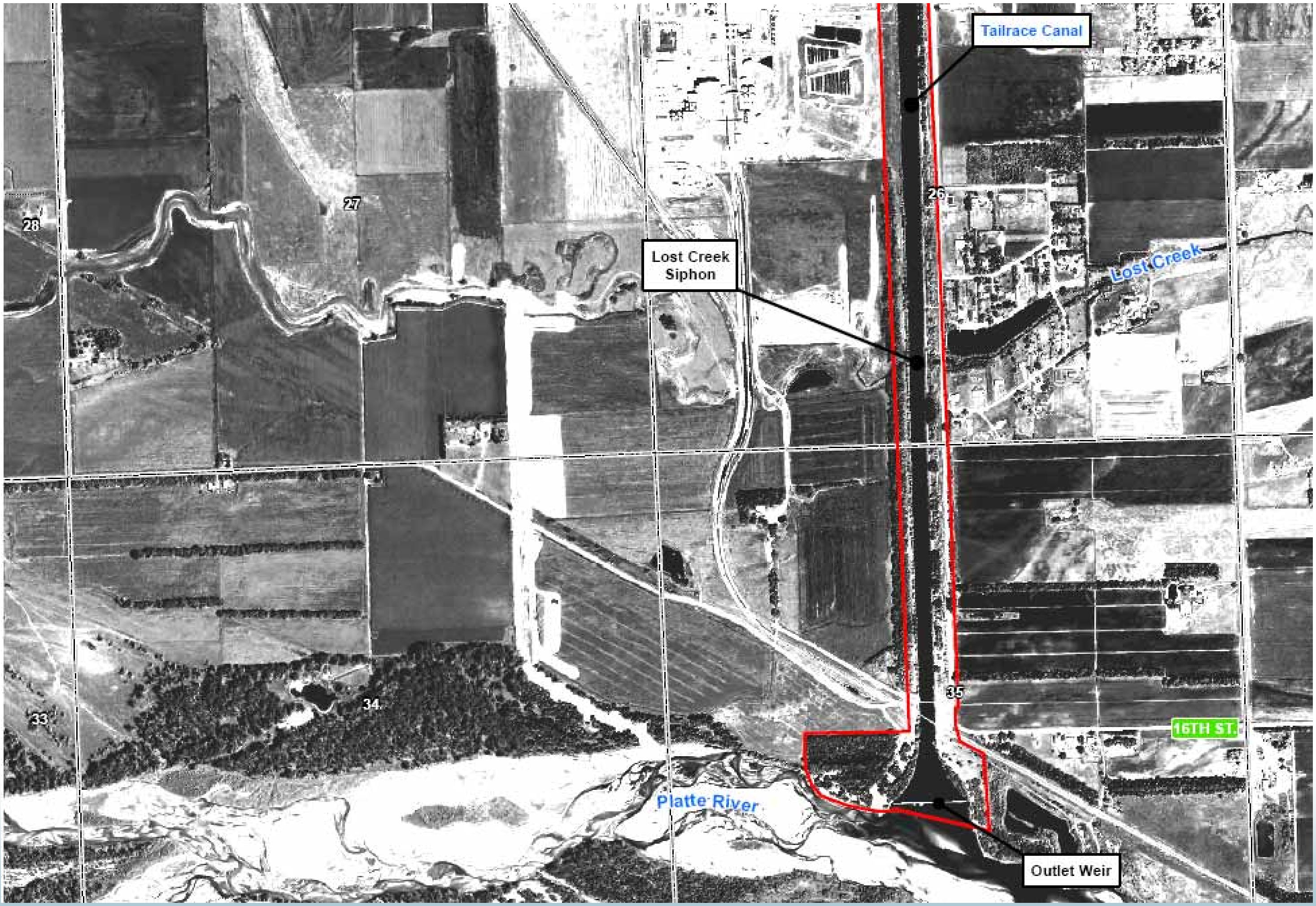
Lost Creek – Into Canal

5. Flow Depletion and Flow Diversion

Lost Creek – Into Canal

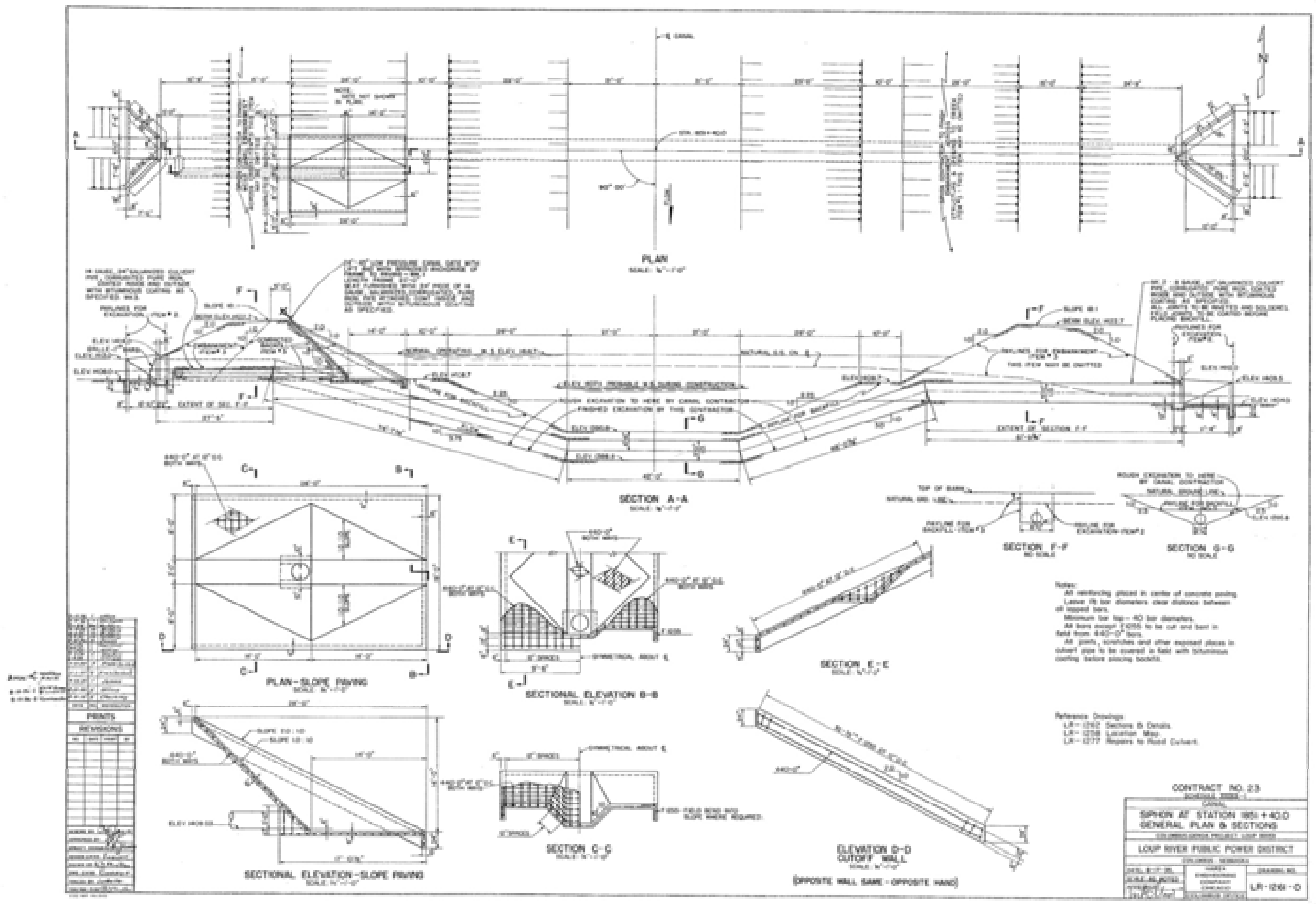
5. Flow Depletion and Flow Diversion

Lost Creek – Out of Canal



5. Flow Depletion and Flow Diversion

Lost Creek – Out of Canal



5. Flow Depletion and Flow Diversion

Lost Creek – Gate in the Canal

5. Flow Depletion and Flow Diversion

Lost Creek – Lost Creek Siphon Inlet

5. Flow Depletion and Flow Diversion

Results – Lost Creek Consumptive Use

- Average annual Lost Creek flow entering the Tailrace canal is 14 cfs
- Average annual flow discharged from the Tailrace Canal through the Lost Creek siphon is 12 cfs

5. Flow Depletion and Flow Diversion

Summary of Results

- Objective 1
  - Flow depletions under current operations are less than would occur under the no diversion alternative
  - On average, 71% of applied irrigation water is lost to consumptive use
  - Average annual Lost Creek flow entering the Tailrace canal is 14 cfs
  - Average annual flow discharged from the Tailrace Canal through the Lost Creek siphon is 12 cfs

5. Flow Depletion and Flow Diversion

Objective

2. To use current and historic USGS gage rating curves to evaluate change in stage in the Loup River bypass reach during Project operations and compare against alternative hydrographs.

Associated Tasks

- Evaluate stage using 25%, 50%, and 75% exceedance discharges from flow duration curves and USGS rating curves for wet, dry, and normal year
  - Current operations
  - No Diversion Condition

5. Flow Depletion and Flow Diversion

Results

Loup at Genoa

Year	Flow Classification	Operation	Percent Exceedance	Flow	Gage Height	Water Surface Elevation
2005	Normal	Current Operations	25	1,110	5.95	1,546.76
2005	Normal	Current Operations	50	570	5.42	1,546.23
2005	Normal	Current Operations	75	110	4.29	1,545.10
2005	Normal	No Diversion Condition	25	2,710	6.76	1,547.57
2005	Normal	No Diversion Condition	50	2,290	6.60	1,547.41
2005	Normal	No Diversion Condition	75	1,820	6.39	1,547.20

5. Flow Depletion and Flow Diversion

Results

Loup at Columbus

Year	Flow Classification	Operation	Percent Exceedance	Flow	Gage Height	Water Surface Elevation
2005	Normal	Current Operations	25	1,350	4.54	1,433.43
2005	**Normal**	**Current Operations**	**50**	**750**	**4.05**	**1,432.95**
2005	Normal	Current Operations	75	250	3.31	1,432.20
2005	Normal	No Diversion Condition	25	2,950	5.25	1,434.14
2005	**Normal**	**No Diversion Condition**	**50**	**2,460**	**5.07**	**1,433.96**
2005	Normal	No Diversion Condition	75	1,950	4.85	1,433.74

5. Flow Depletion and Flow Diversion

Summary of Results

- Objective 2
  - There is an increase in stage under the no diversion alternative.
  - The magnitude of the stage change decreases with increasing discharge
  - The increase is largest under dry flow conditions

5. Flow Depletion and Flow Diversion

Objective

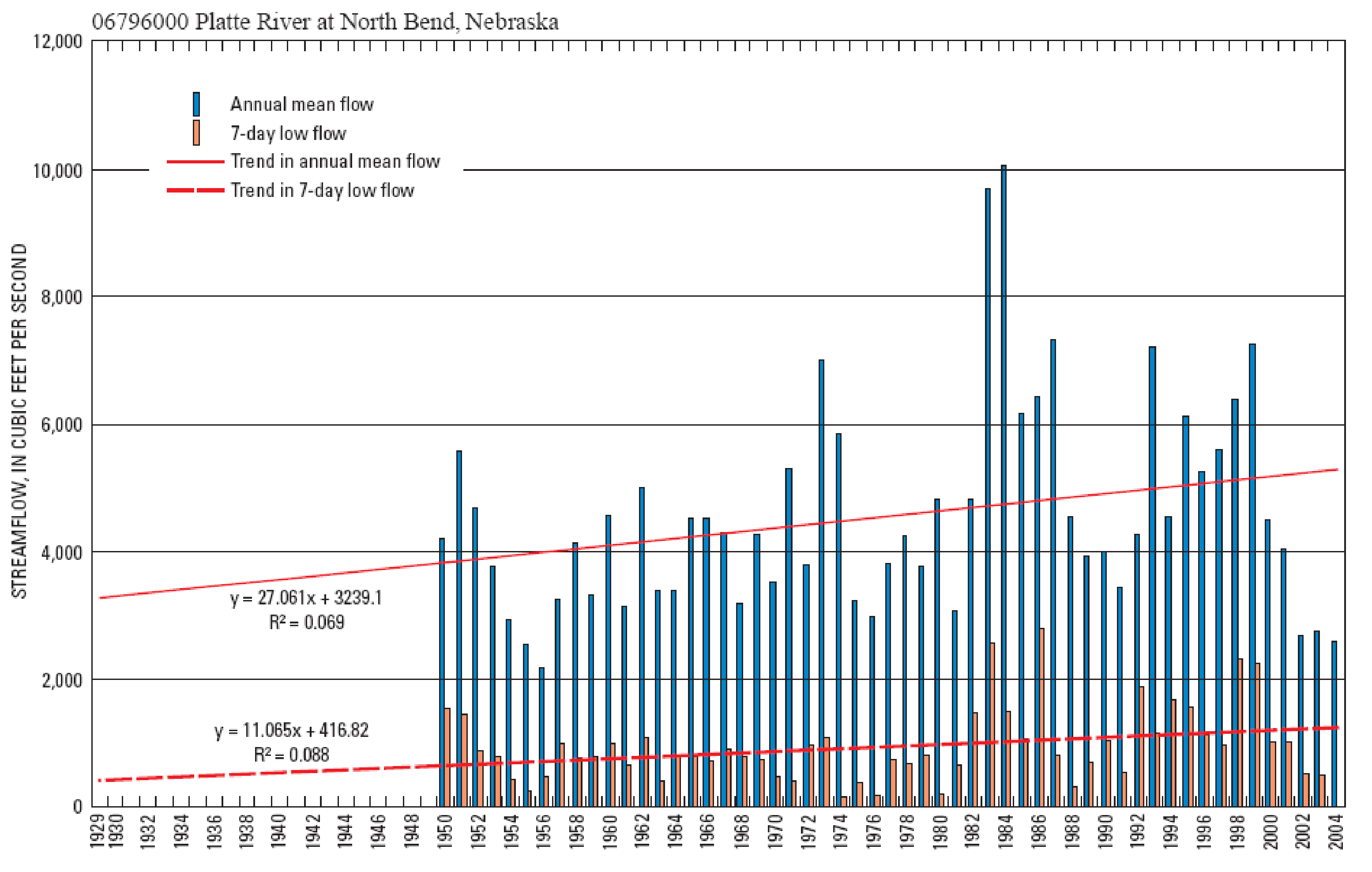
3. To evaluate historic flow trends on the Loup and Platte rivers since Project inception.

Associated Tasks

- Evaluate USGS gages
- Evaluate USGS reports
  - Temporal Differences in the Hydrologic Regime of the Lower Platte River, Nebraska, 1895-2006
  - Trends in Streamflow Characteristics of Selected Sites in the Elkhorn River, Salt Creek, and Lower Platte River Basins, Eastern Nebraska, 1928–2004
  - Evaluation of Streamflows in Relation to Instream-Flow Criteria, 1953–2004

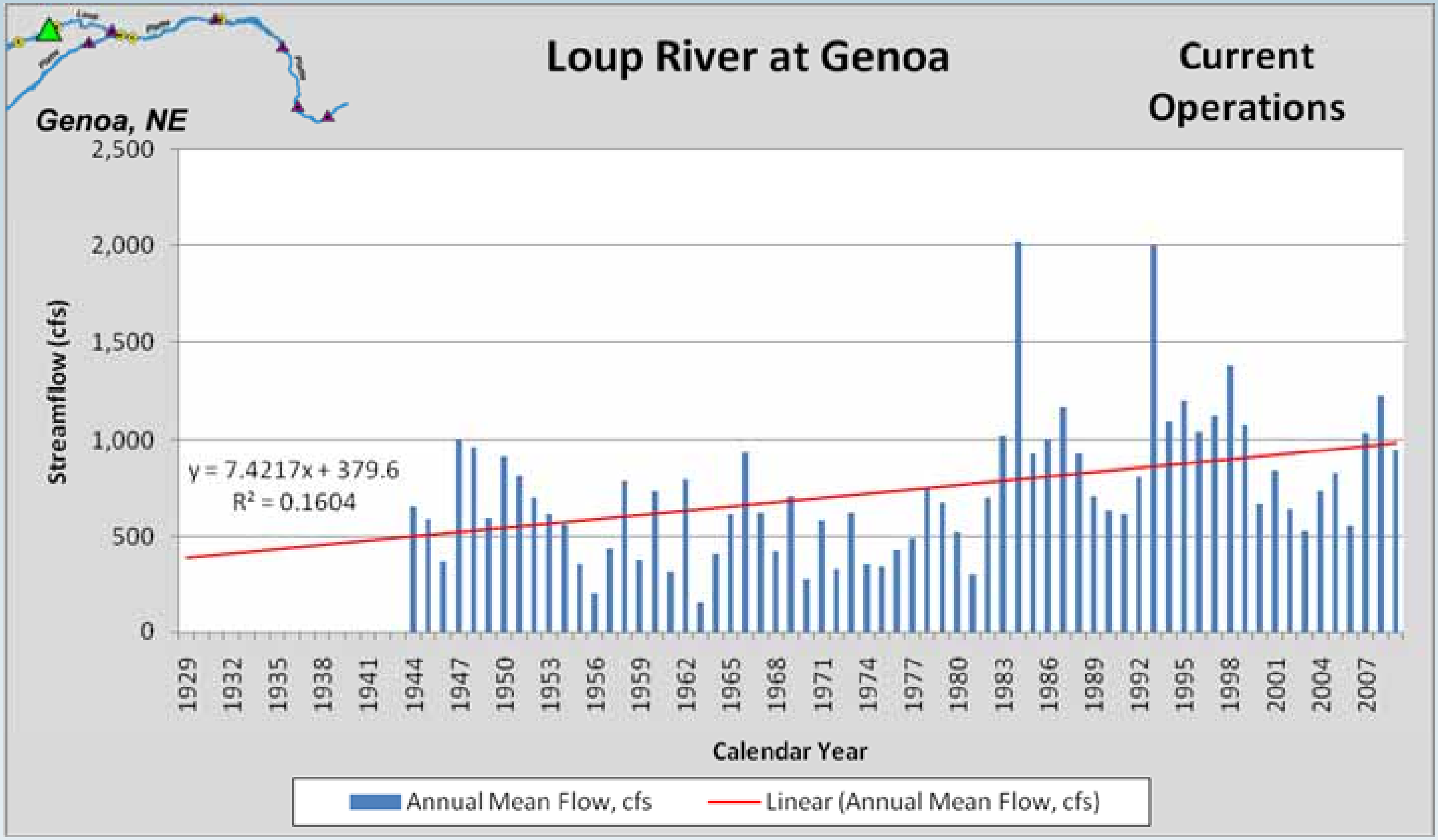
5. Flow Depletion and Flow Diversion

Historic Flow Trends – North Bend Gage



5. Flow Depletion and Flow Diversion

Historic Flow Trends – Loup River Genoa Gage



5. Flow Depletion and Flow Diversion

Results

- Objective 3
  - Long term positive flow trend
  - Same trends at downstream gages evident at Duncan
  - No Project Impact on long term historic trends

5. Flow Depletion and Flow Diversion

Objective

4. To determine the extent of interior least tern and piping plover nesting on the Loup River above and below the Diversion Weir

Associated Activities

- Interior Least Tern and Piping Plover Nesting on the Loup River Bypass Reach
- Sedimentation Analysis

5. Flow Depletion and Flow Diversion

Methodology – Nest Count Comparison

- Comparison of nest counts above and below the diversion weir
- Summary of nest counts
  - Limited years
  - Limited numbers
- Comparison inconclusive due to limited sample size

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Tern and Plover Habitat Characteristics

Habitat Parameter	Observed Measurements of Habitat Parameters	References
Channel width (bank to bank)	975 to 1,554 feet	Ziewitz et al., 1992; Kirsch, 1996; Brown and Jorgensen, 2009
Dry sand area	0.03 to 3.58 acres	Ziewitz et al., 1992; Kirsch, 1996; Brown and Jorgensen, 2009
Vegetation cover on dry sand area (percent)	0 to 25%	Ducey, 1988; Faanes, 1983; Ziewitz et al., 1992
Average location of sandbars (point or mid-channel)	Mid-channel	Kirsch, 1996
Valley width	0.68 to 4.72 miles	Elliott et al., 2009

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Parameters to be Evaluated

- Number of sandbars per river mile
- Average area of sandbars per river mile
- Average wetted width per river mile
- Average channel width per river mile
- Average valley width per river mile
- Percentage of vegetation on sandbars
- Percentage of mid-channel sandbars per river mile
- Percentage of point sandbars per river mile
- Percentage of bare sand per river mile
- Average area of bare sand per river mile
- Average area of shallow water/wet sand per river mile
- Percentage of shallow water/wet sand areas

5. Flow Depletion and Flow Diversion

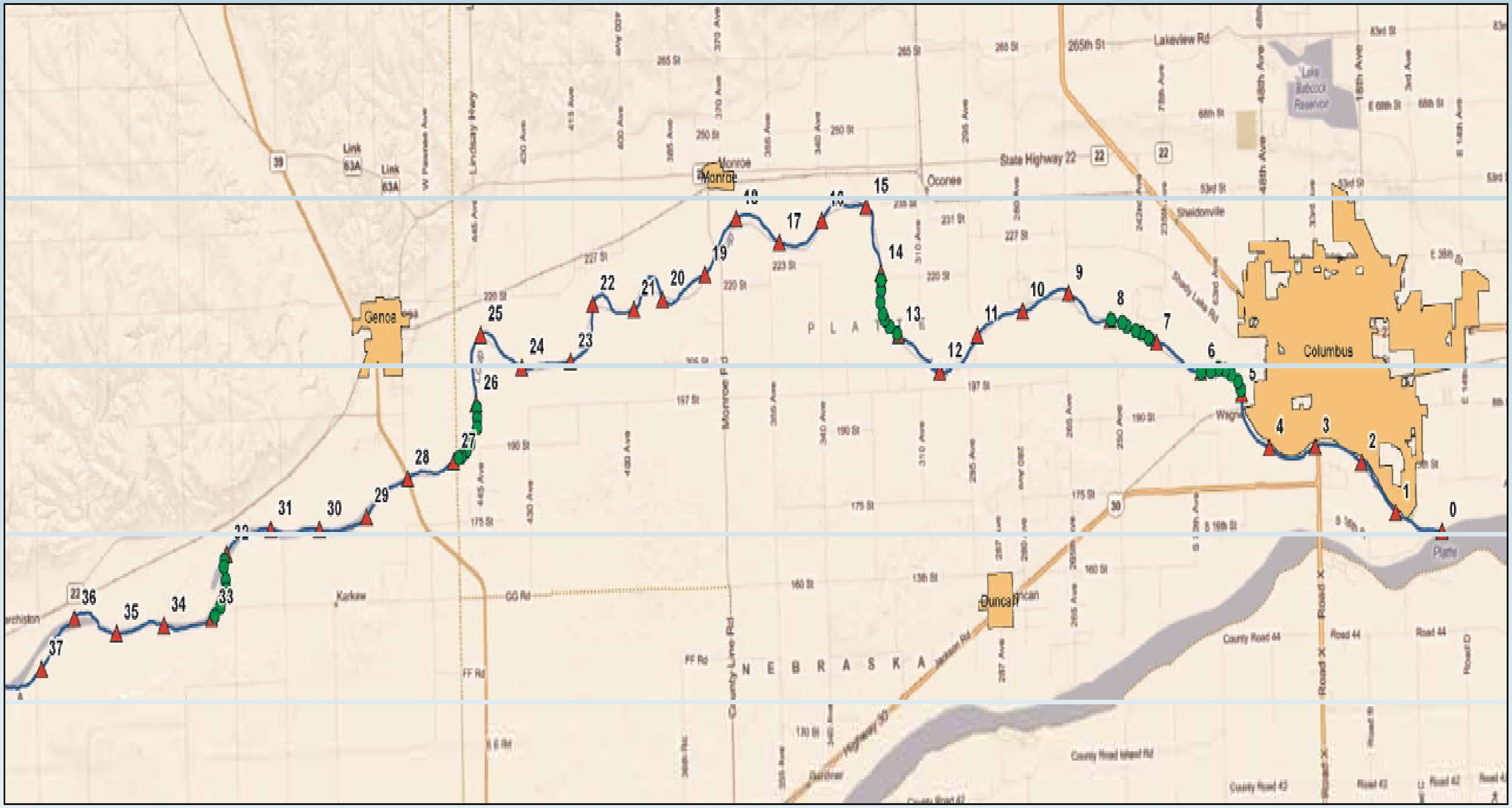
Methodology – Aerial Imagery Review

River Mile Selection

- 10 river miles (5 upstream and 5 downstream) were desired
- River Mile Range
  - 1-35 for downstream
  - 36-69 for upstream
  - One location within 5 miles upstream and 5 miles downstream
- Random number generator to select miles

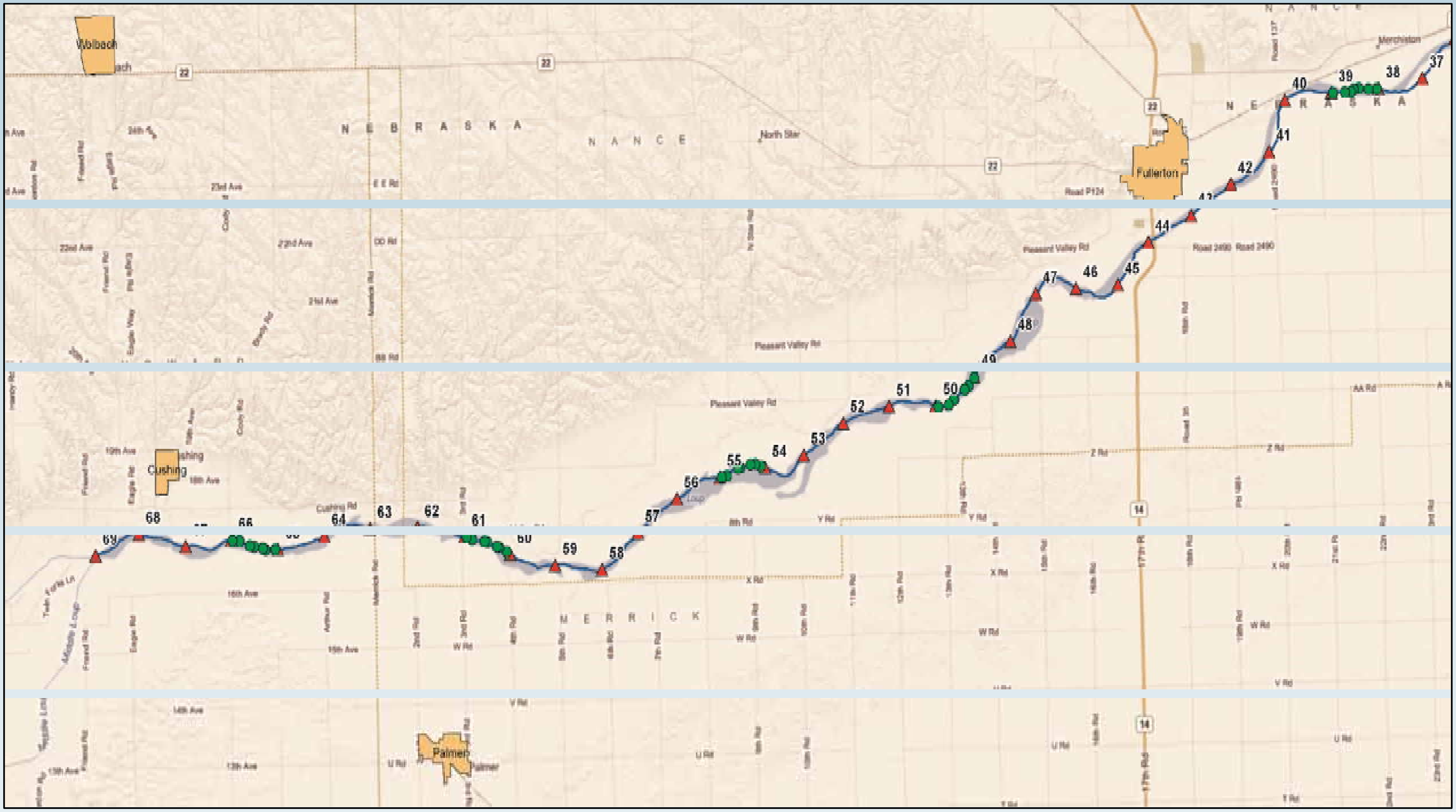
5. Flow Depletion and Flow Diversion

Loup River Miles - Downstream



5. Flow Depletion and Flow Diversion

Loup River Miles - Upstream



5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Years for Review

- Range of Years for Review – 2003 through 2009
- Selection of Wet, Dry, and Normal Years
  - Wet years – 2007, 2008, 2009 – Randomly selected 2009
  - Dry years – at Genoa alone, no dry year. 2003 and 2006, were two and three positions away from dry. 2003 selected
  - Normal – 2004, 2005, and 2006

5. Flow Depletion and Flow Diversion

Methodology - Aerial Imagery Review

Identifying Habitat Parameters

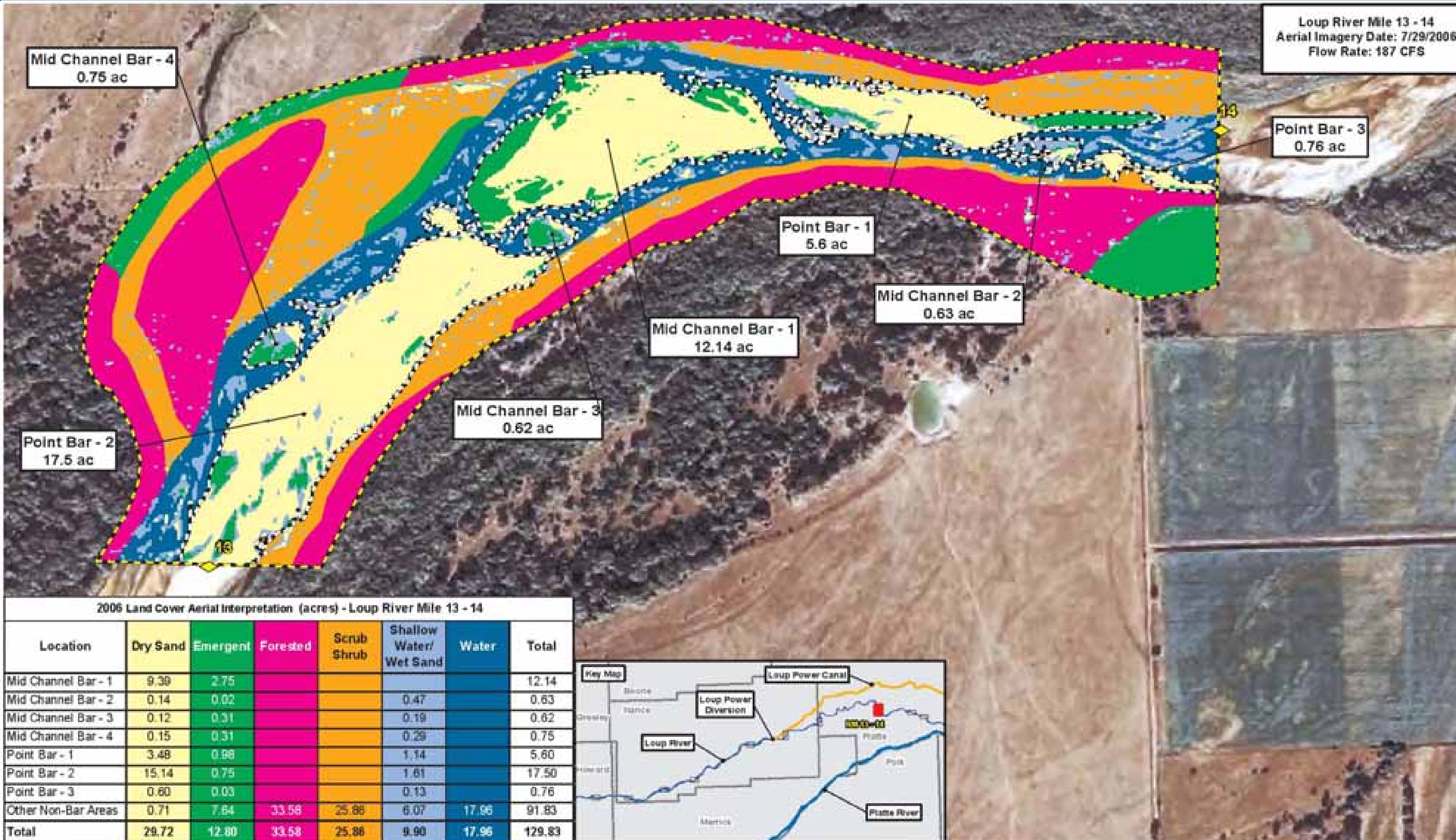
- Site visit for purpose of verification of aerial signatures exhibited on the 2009 aerials
- Unsupervised and visual interpretation methodologies

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Unsupervised Methodology

- ERDAS Imagine image classification based on pixel values
- Results of classification
  - flat and smooth features, such as bare sand, wet sand/shallow water were accurately defined based on cluster location and visual inspection of imagery
  - Rough features such as vegetation and choppy water were poorly defined



2006 Land Cover Aerial Interpretation (acres) - Loup River Mile 13 - 14							
Location	Dry Sand	Emergent	Forested	Scrub Shrub	Shallow Water/ Wet Sand	Water	Total
Mid Channel Bar - 1	9.39	2.75					12.14
Mid Channel Bar - 2	0.14	0.02			0.47		0.63
Mid Channel Bar - 3	0.12	0.31			0.19		0.62
Mid Channel Bar - 4	0.15	0.31			0.29		0.75
Point Bar - 1	3.48	0.98			1.14		5.60
Point Bar - 2	15.14	0.75			1.61		17.50
Point Bar - 3	0.60	0.03			0.13		0.76
Other Non-Bar Areas	0.71	7.64	33.58	25.86	6.07	17.96	91.83
Total	**29.72**	**12.80**	**33.58**	**25.86**	**9.90**	**17.96**	**129.83**

Legend

- Loup River Mile
- Study Area

Land Cover Types

- Dry Sand
- Emergent
- Forested
- Scrub Shrub
- Shallow Water / Wet Sand
- Water
- Bar Area

0 200 400
Feet

Land Cover Aerial Interpretation

Sheet 8 of 10

DATE February 2011

Loup River Hydroelectric Project
FERC Project No. 1256
Study 5.0 - Flow Depletion & Flow Diversion

FIGURE RM 13-14
2006

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Visual Interpretation Methods

- Photo Interpretation of emergent, scrub-shrub, and forested vegetation strata, and some water features.

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Parameter Classification

- Usable substrate (based on Ziewitz, et. al. 1992, and Kirsch, 1996) – bare sand vs. vegetated bars
- Macroform determination – sandbars
  - Size, area, number, position
  - Mid-channel bar – greater than 75% of exposed sand is surrounded by water
  - No attempt to define a sandbar for suitability of habitat was made
- Channel Width

5. Flow Depletion and Flow Diversion

Methodology Notes

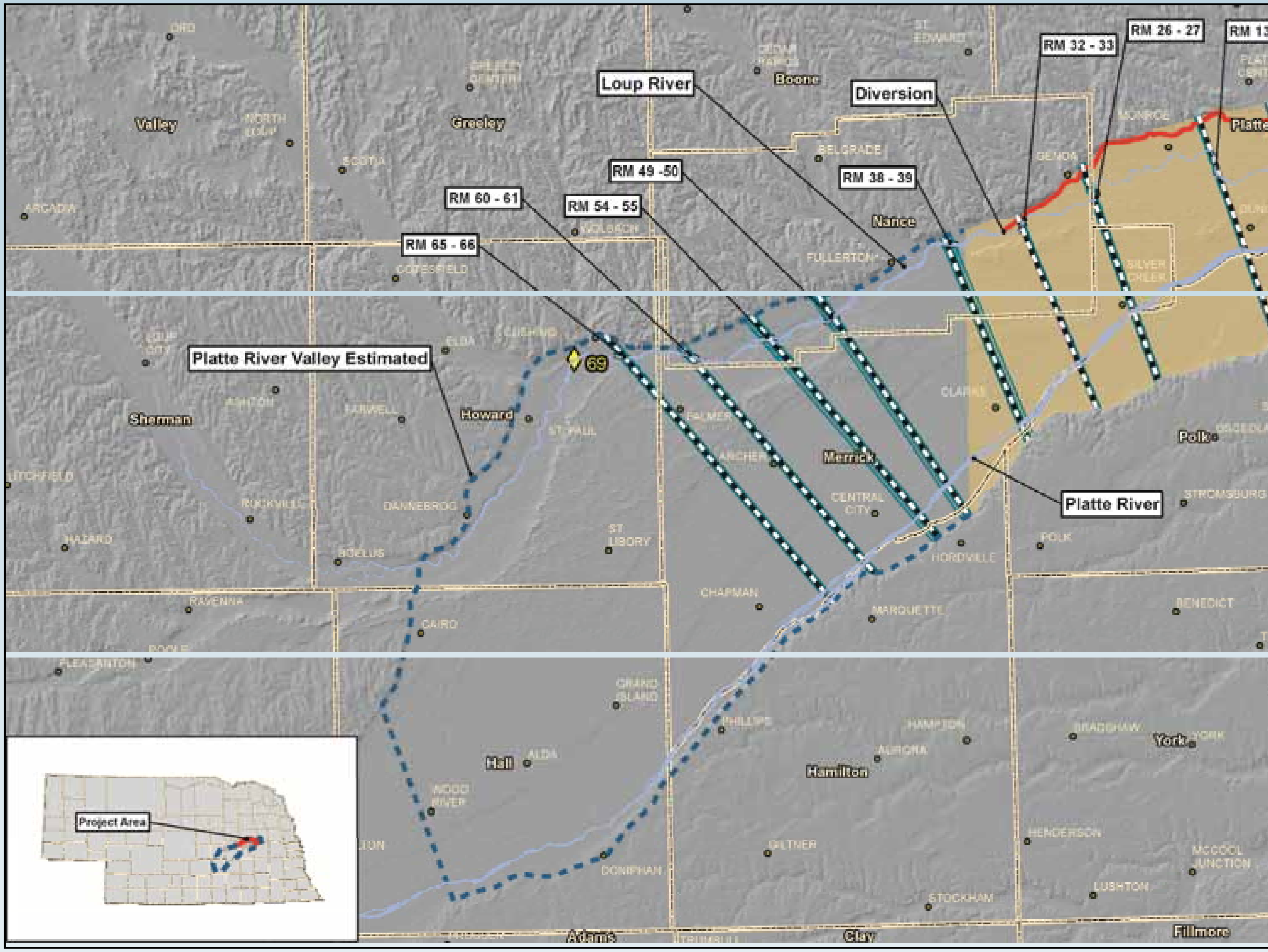
- Unsupervised portion is repeatable
- Visual inspection introduces human influence
- Flow on aerial date
- Quality of aerials
- Sandbar grouping

5. Flow Depletion and Flow Diversion

Parameter Classification

- Valley Width
  - USGS shapefiles used for Elliott et al, 2009 (through Platte RM 138.5)
  - Loup River from confluence with Platte to the Diversion Weir is within the Platte River valley.
  - Extended to Platte RM 187 based on regional geologic maps, digital elevation models, and 1:24,000 USGS topographic maps
  - Upstream of Diversion Weir to North Loup confluence, still within the Platte River valley
  - Transects established along the Platte River channel every 0.25 miles and compared to selected river miles to determine valley width

5. Flow Depletion and Flow Diversion



Loup River	Avg. Width (mile)
5-6	15.27
7-8	15.84
13-14	16.47
26-27	15.79
32-33	14.50
38-39	15.16
49-50	18.53
54-55	20.05
60-61	20.67
65-66	24.25

5. Flow Depletion and Flow Diversion

Results – Aerial Imagery Review

- Detectable Differences in measured parameters above and below the Diversion Weir (based on average of all years analyzed)
  - Greater number of sandbars per river mile above Diversion Weir (41 vs. 24)
  - Smaller sandbars above the diversion weir (4 ac vs. 10 ac)
  - Channel width is, on average, 400 ft wider above the Diversion Weir than below (1065 ft vs. 665 ft)
  - Lower percentage of vegetation on sandbars above the Diversion Weir (9% vs. 12%)

5. Flow Depletion and Flow Diversion

Results – Aerial Imagery Review (cont.)

- Lower percentage of bare sand on sandbars above the Diversion Weir (13% vs. 34%)
- More point bars below the Diversion Weir; more mid-channel above
- Valley Width
  - Wider valley widths above the Diversion Weir compared to below
  - Average valley width ranges from 15.2 to 24.3 miles wide.

5. Flow Depletion and Flow Diversion

Methodology – Habitat Evaluation Using HEC-RAS

Parameters Evaluated

- USFWS and NGPC coordination
  - Relationship among various discharge alternatives and the number, size, bar height, bar position (mid-channel or point), and channel depths which isolate these bars.
- Model Capabilities
  - Percent Exposed Channel Width

5. Flow Depletion and Flow Diversion

Methodology – Habitat Evaluation Using HEC-RAS

Conditions for Model Runs

- Flow Levels
  - 25% exceedance = high-flow
  - 50% exceedance = medium-flow
  - 75% exceedance = low-flow
- Wet, Dry, and Normal Years (2008, 2006, 2005)
- Pre-nesting and Post-nesting (survey dates)
- Study Sites 1 and 2
- Current Operations and No Diversion Condition (Study Site 2)

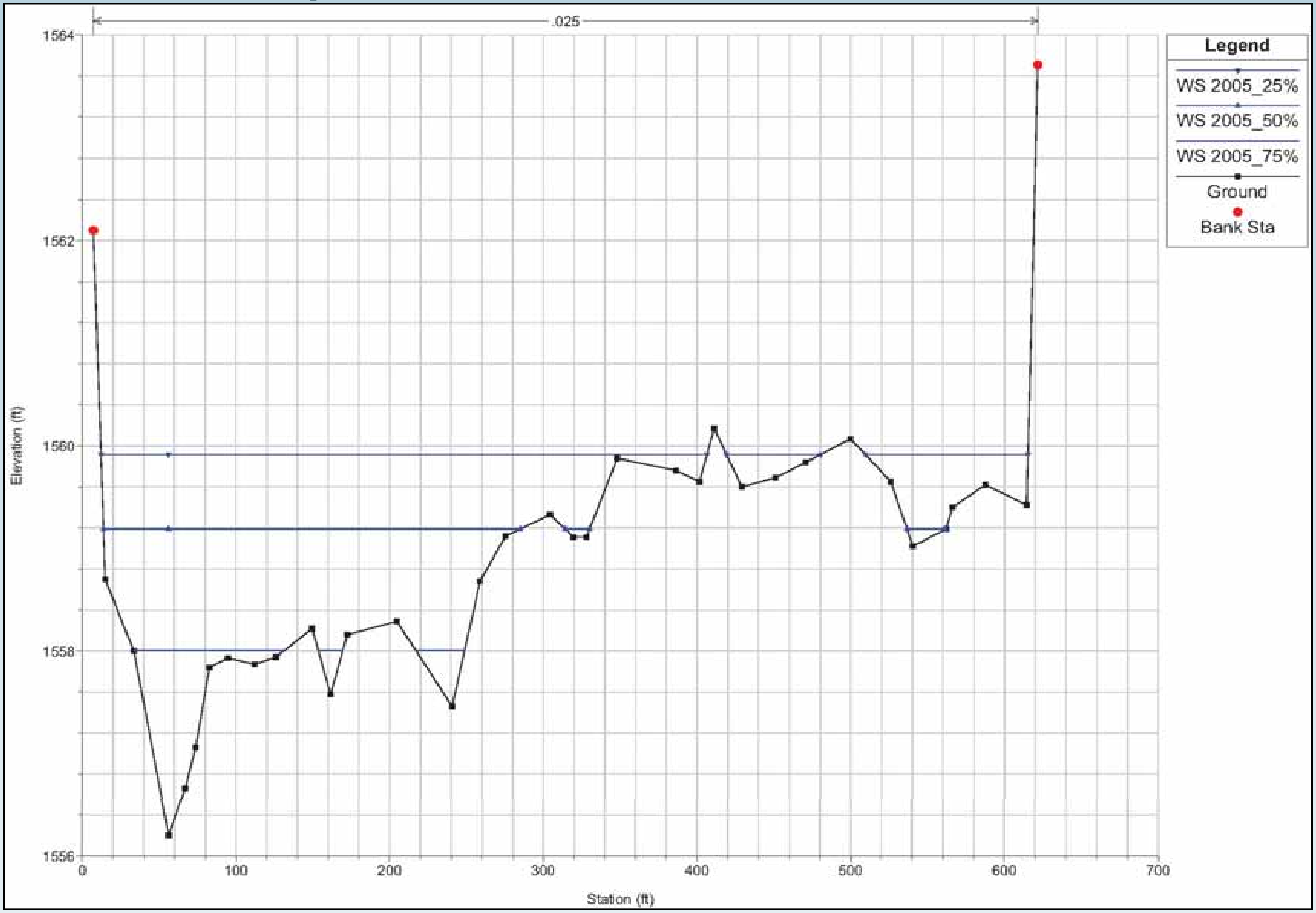
5. Flow Depletion and Flow Diversion

Methodology – Habitat Evaluation Using HEC-RAS

Percent Exposed Channel Width Calculations

- Area of exposed channel width for each cross-section
- Average for each study site

5. Flow Depletion and Flow Diversion



5. Flow Depletion and Flow Diversion

Methodology – Habitat Evaluation Using HEC-RAS

Percent Exposed Channel Width Calculations

- Exposed channel width is habitat, but no distinction as suitable.
- Cross-sections – flow on day or antecedent days may not coincide with the dry, normal, or wet year designation

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

Percent Exposed Channel Width Calculations:

- Decreased with wetter conditions at Site 1 and Site 2 (under both operation scenarios)
- At Site 2, current operations had greater percent exposed channel widths than under the no diversion condition
- Site 1 had similar percent exposed channel widths as Site 2 under the No Diversion condition (although slightly greater at Site 2)

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

Percent Exposed Channel Width Calculations:

Calendar Year of Analysis	Site 1	Site 2	
		Current Operations	No Diversion Condition
Channel width (linear feet)	825	640	640
2006 (Dry)	20%	63%	14%
2005 (Normal)	12%	46%	10%
2008 (Wet)	10%	41%	10%

5. Flow Depletion and Flow Diversion

Objective (cont.)

4. To determine the extent of interior least tern and piping plover nesting on the Loup River above and below the Diversion Weir.

Associated Tasks

- Sedimentation Analysis
  - Sediment Transport Calculations
  - Sediment Transport Indicators
  - Channel Characteristics
  - Regime Analysis

5. Flow Depletion and Flow Diversion

Sedimentation Analysis

2005 (Normal Flow Classification)

Location on the Loup or Platte River	Current Operations			No Diversion Condition		
	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)
Site 1 – Loup River Upstream of the Diversion Weir	2,300	2,500	2,240	2,300	2,500	2,240
Site 2 – Loup River Downstream of the Diversion Weir	1,000	2,900	890	2,400	2,500	2,370
Loup River near Genoa gage	1,100	3,000	1,260	2,600	2,500	3,410
Loup River at Columbus gage	1,200	1,400	950	2,700	2,400	2,290
Site 3 – Platte River Upstream of the Tailrace Return	1,200	1,400	950	3,400	3,600	1,760

5. Flow Depletion and Flow Diversion

Sedimentation Analysis

2003 – 2009

Location on the Loup or Platte River	Current Operations			No Diversion Condition		
	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)	Q_d (cfs)	Q_e (cfs)	Sediment Capacity (1,000 tons)
Site 1 – Loup River Upstream of the Diversion Weir	2,500	2,300	2,585	2,500	2,300	2,585
Site 2 – Loup River Downstream of the Diversion Weir	1,100	1,700	996	2,600	2,300	2,570
Loup River near Genoa gage	1,200	1,700	1,400	2,700	2,300	3,670
Loup River at Columbus gage	1,300	1,800	1,030	2,900	2,700	2,500
Site 3 – Platte River Upstream of the Tailrace Return	2,400	2,100	1,040	3,900	3,300	2,110

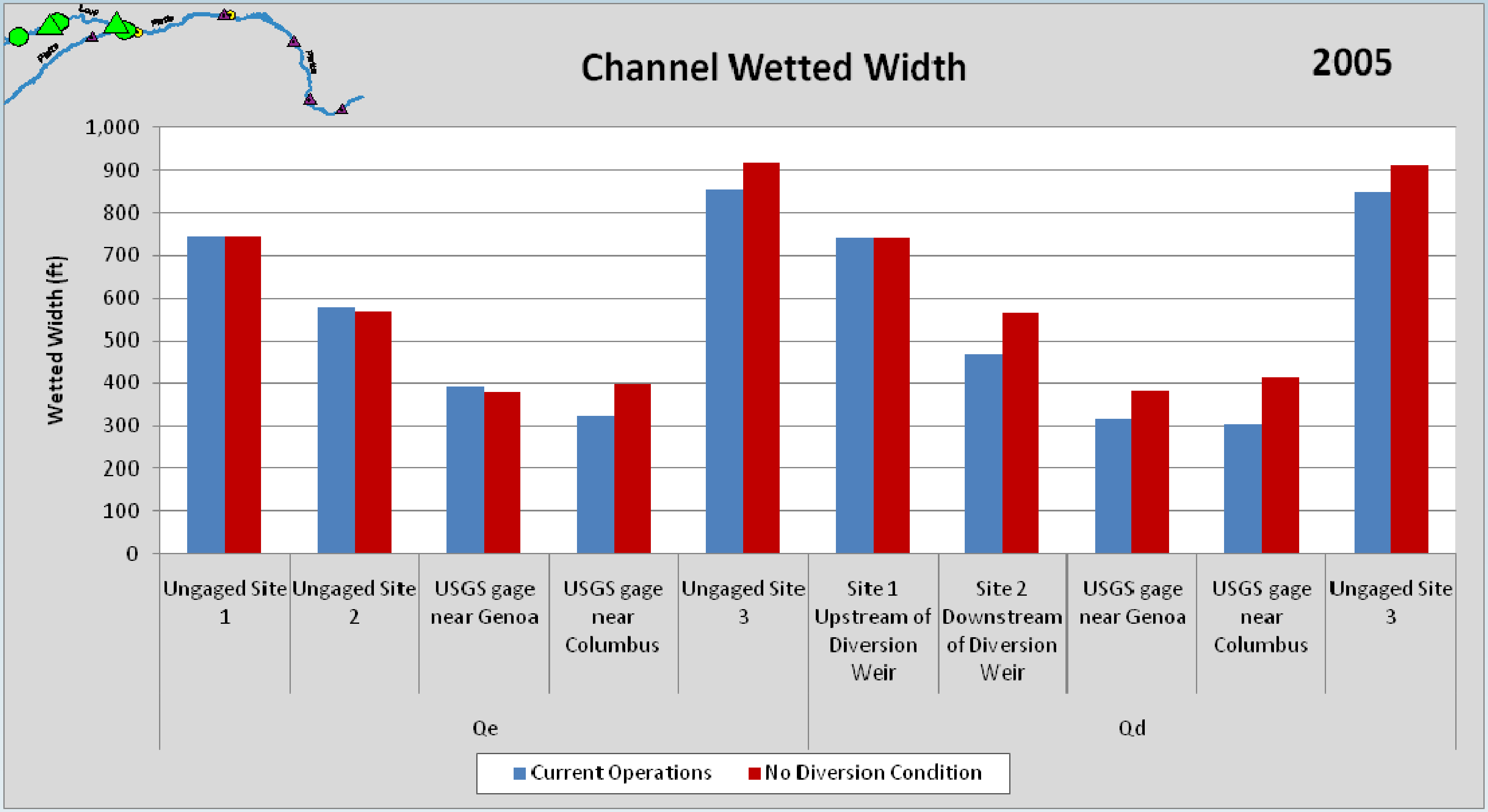
5. Flow Depletion and Flow Diversion

Results – Sedimentation Analysis:

- Total sediment transport, effective discharge, and dominant discharge higher for no diversion condition than current operations

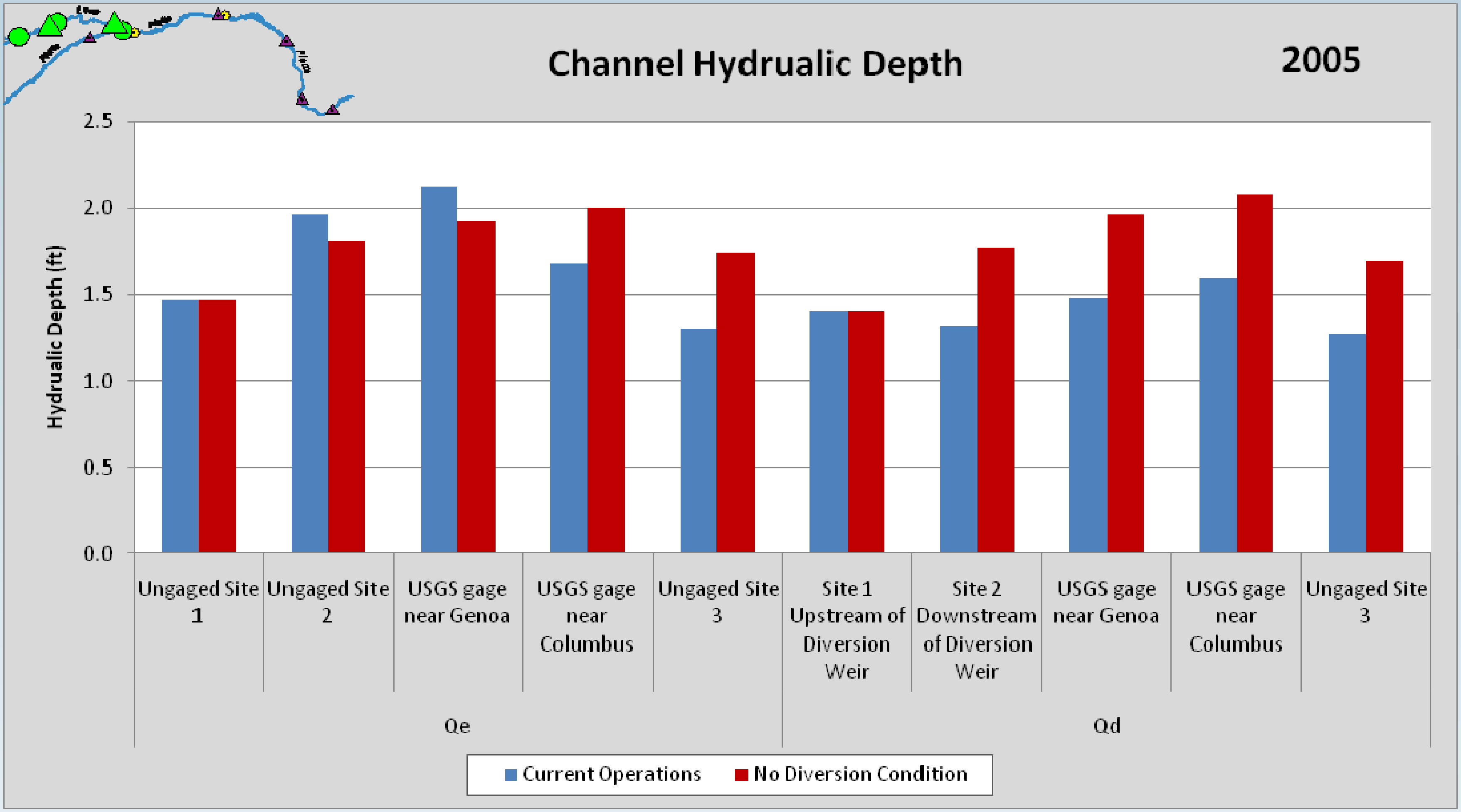
5. Flow Depletion and Flow Diversion

Channel Characteristics



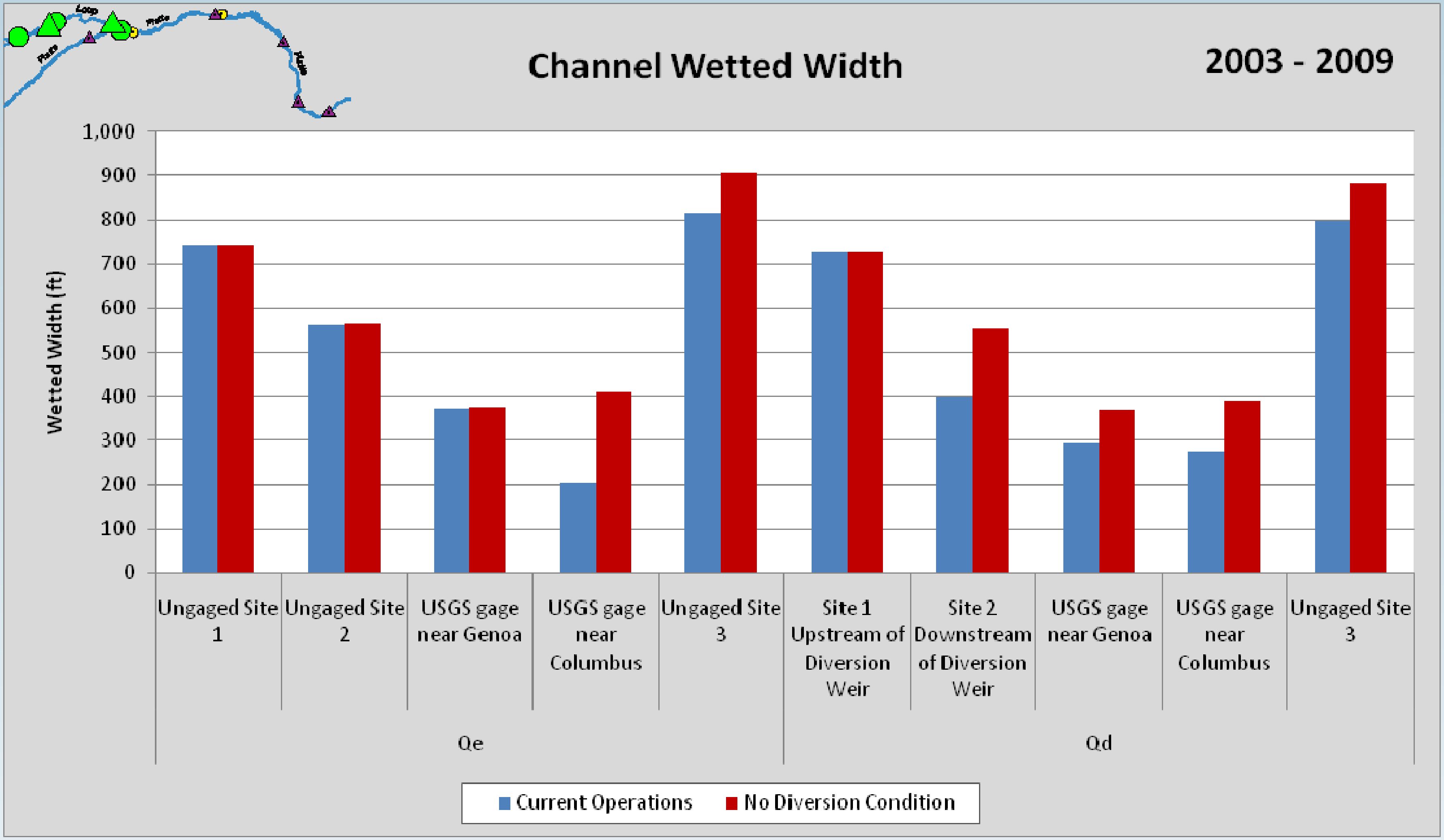
5. Flow Depletion and Flow Diversion

Channel Characteristics



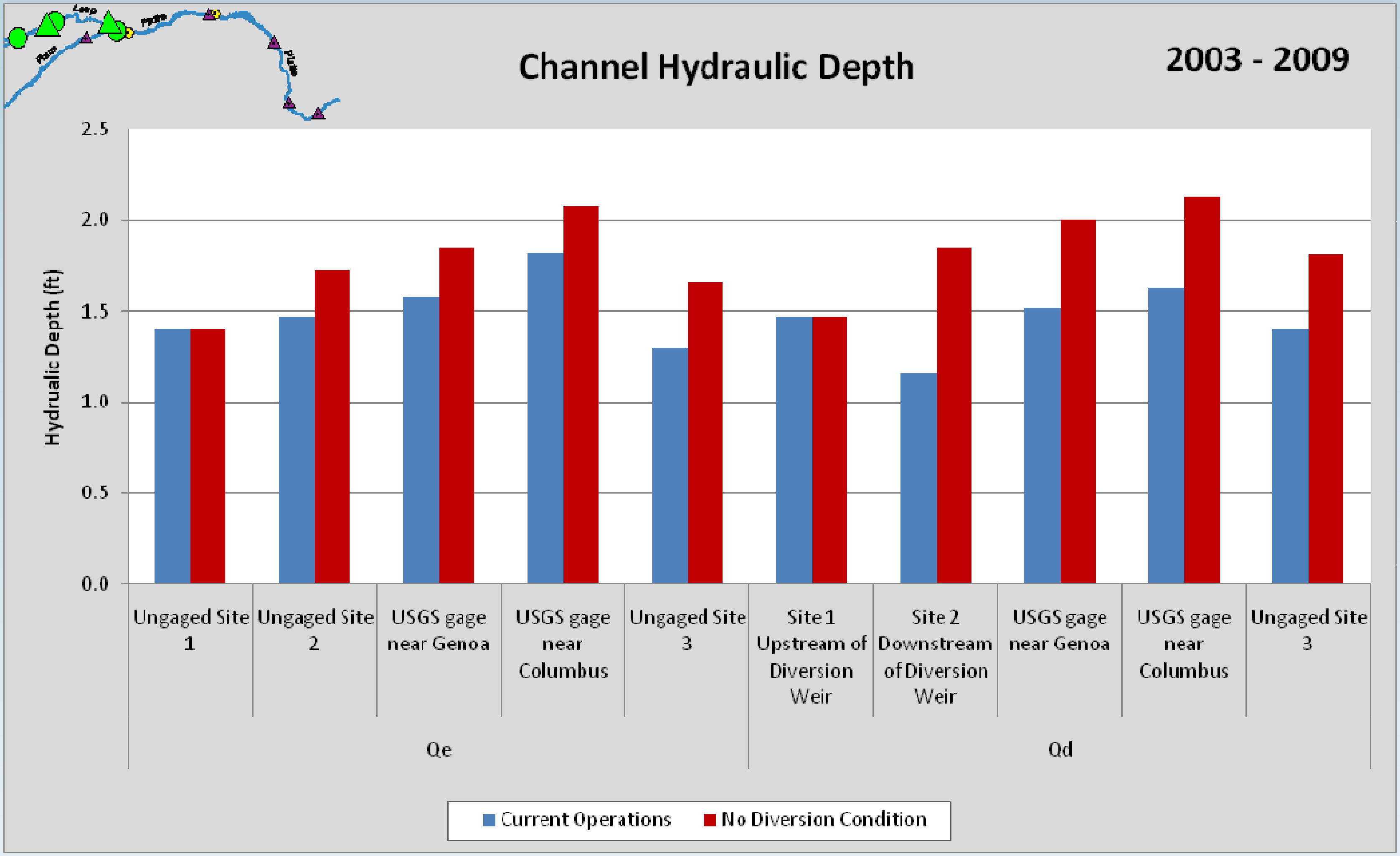
5. Flow Depletion and Flow Diversion

Channel Characteristics



5. Flow Depletion and Flow Diversion

Channel Characteristics



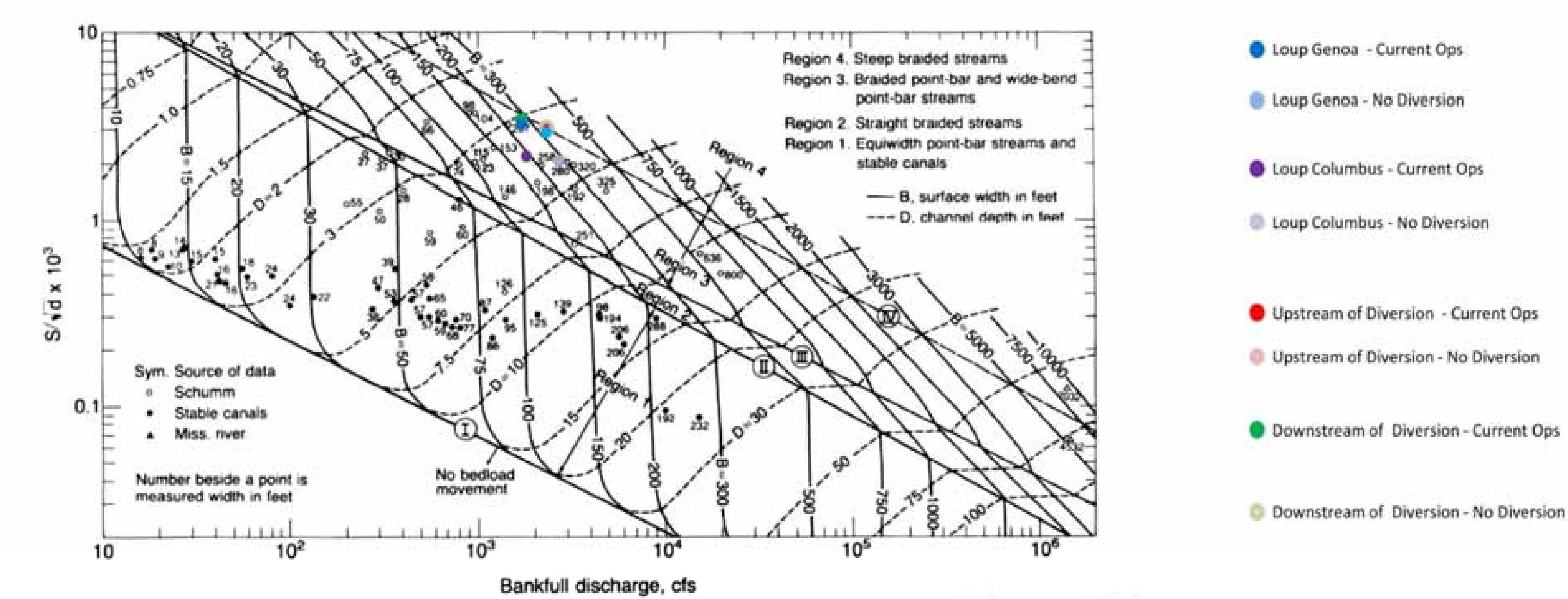
5. Flow Depletion and Flow Diversion

Results – Sedimentation Analysis:

- Channel widths and depths are greater for no diversion condition than current operations

5. Flow Depletion and Flow Diversion

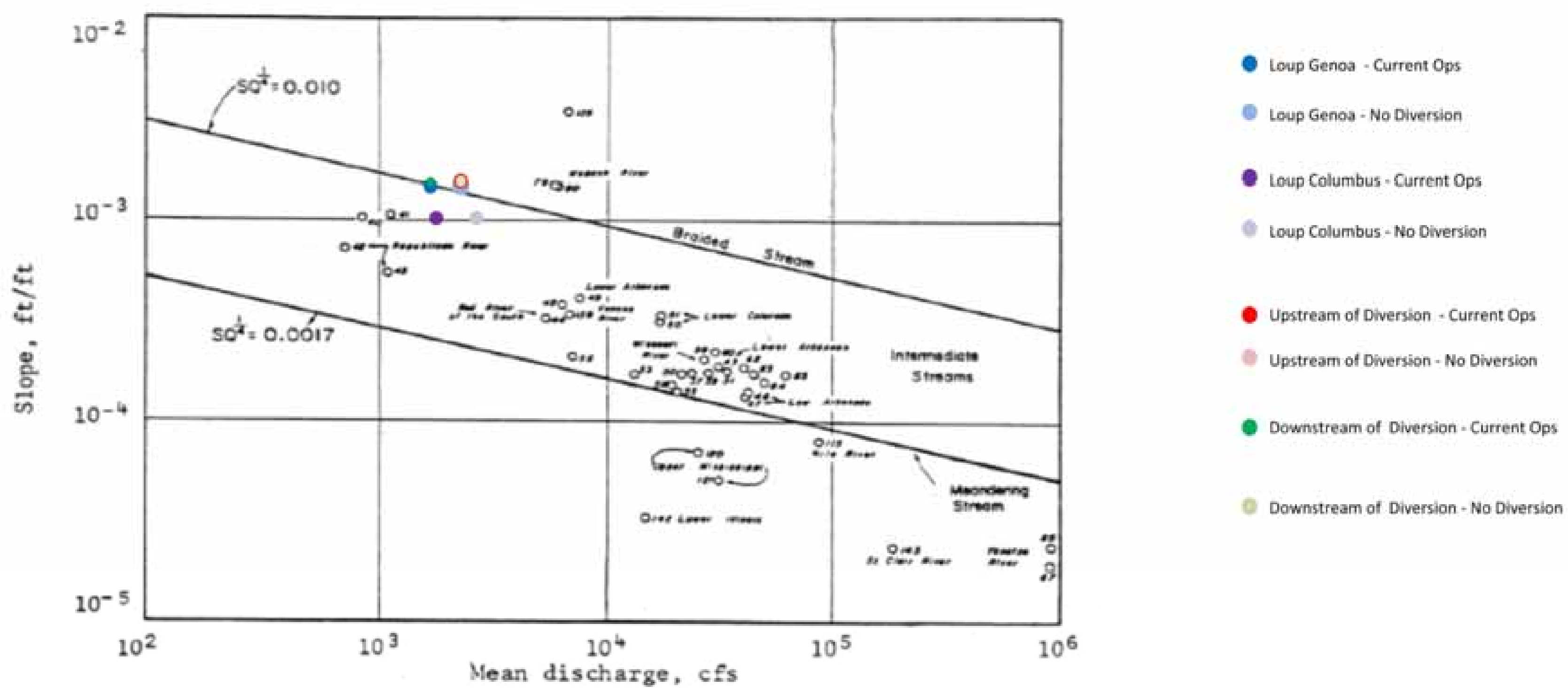
Regime Analysis



Regime channel bed geometry for sand bed rivers, from Chang (1985). For the historic Platte River channel (1900), the bankfull discharge was about 10,000 cfs, the median grain size was about 0.4 mm, and the slope was 0.00126. Therefore, the term $[(S/d^{0.5})1000]$ was equal to 2.0. For the present Platte River channel (2000), the bankfull discharge is about 4,000 cfs, the median grain size near Overton, Nebraska is about 1.5 mm, and the slope is still 0.00126. Therefore, the term $[(S/d^{0.5})1000]$ is now equal to 1.0. Based on the classification by Chang (1985), the Platte River evolved from a steep braided channel (Region 4) to a braided point-bar and wide bend point-bar channel (Region 3).

5. Flow Depletion and Flow Diversion

Regime Analysis



Lane's (1957) regime diagram for sandbed streams based on slope and mean discharge, taken from Richardson, et al. (1990). Red points shown are for the central Platte River with a slope of 0.0026 ft/ft and a mean discharge of 3,700 cfs for the year 1900, and a mean discharge of 2,100 cfs for the year 2000.

5. Flow Depletion and Flow Diversion

Results – Regime Analysis:

- Current operations and no diversion condition are both well within braided river morphology, with neither being near to transitioning to another morphology.

5. Flow Depletion and Flow Diversion

Objective

5. To determine Project effects, if any, of consumptive use on fisheries and habitat on the lower Platte River downstream of the Tailrace Canal

Associated Tasks

- Consumptive Use Analysis for Objective 1

Results

- No measurable depletions to the lower Platte River; therefore, fisheries and habitat are not adversely impacted to a greater extent under current operations than they would be under the no diversion condition

5. Flow Depletion and Flow Diversion

Objective

6. To determine the relative significance of the Loup River bypass reach to the overall fishery habitat for the Loup River.

Associated Tasks

- Fishery Populations Above and Below the Diversion Weir
- Montana Method

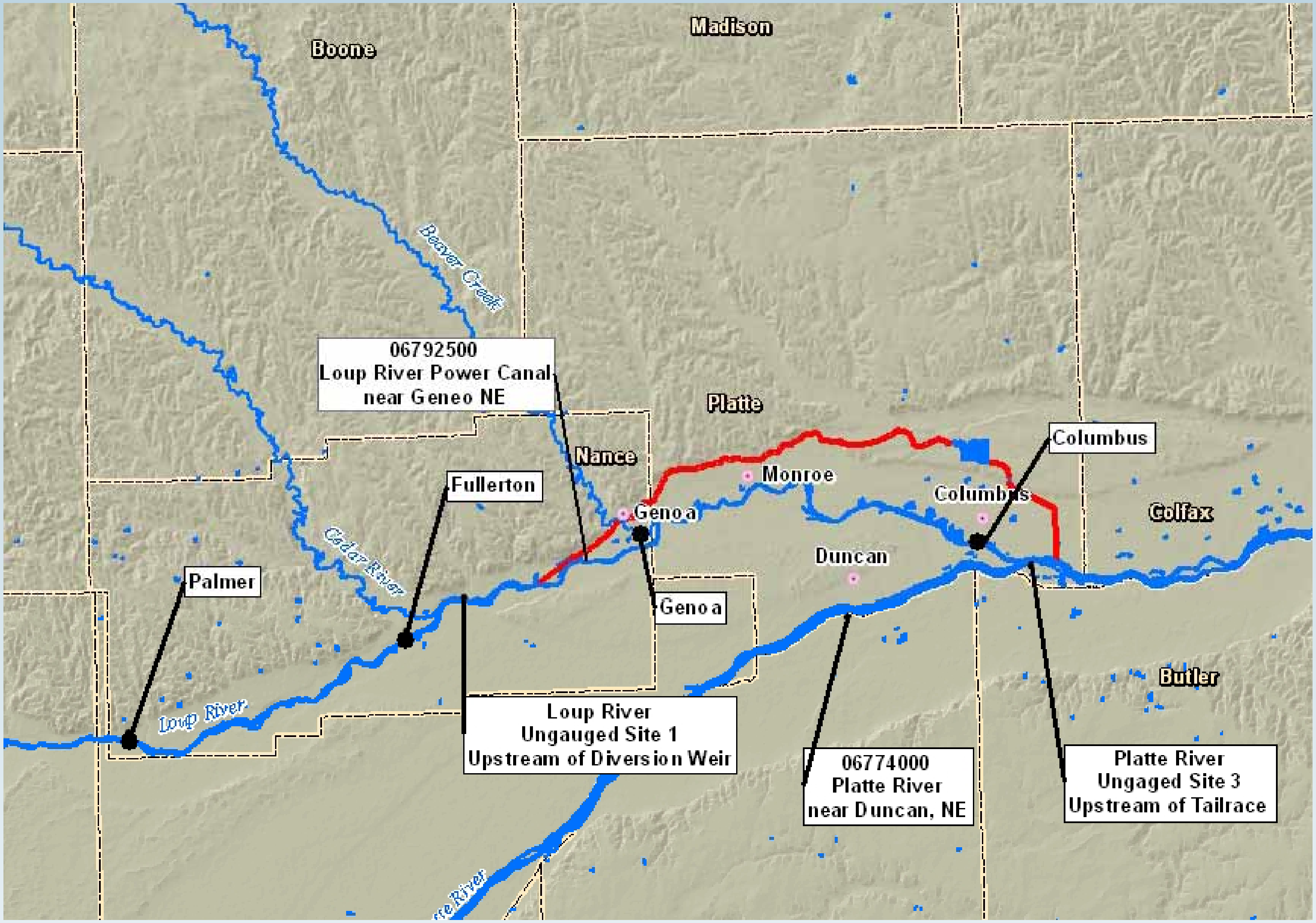
5. Flow Depletion and Flow Diversion

Methodology – Fishery Population Above and Below

- NGPC collected fish data in 1996 and 1997
- Many reaches on the Loup were evaluated
  - Used 2 reaches above and 2 reaches below for this study.
- NGPC study was used to help determine effects of the diversion on fisheries in the Loup.

5. Flow Depletion and Flow Diversion

NGPC Fish Sampling Locations



5. Flow Depletion and Flow Diversion

Results - Fishery Population Above and Below

- NGPC 1996 and 1997
  - Two sampling reaches above and below the Diversion Weir

1996

	Above the Diversion Weir		Below the Diversion Weir	
	Palmer	Fullerton	Genoa	Columbus
Total Fish Collected	4,059	1,673	4,564	11,433

1997

	Above the Diversion Weir		Below the Diversion Weir	
	Palmer	Fullerton	Genoa	Columbus
Total Fish Collected	3,386	1,552	4,737	4,804

5. Flow Depletion and Flow Diversion

Results – Fishery Population Above and Below

Percentages of Most Common Fish

1996	Above the Diversion Weir		Below the Diversion Weir	
	Palmer	Fullerton	Genoa	Columbus
Red Shiner	55%	75%	62%	23%
Sand Shiner	14%	3%	14%	17%
Western Silvery Minnow	0%	0%	6%	33%
Brassy Minnow	16%	7%	1%	4%
Flathead Chub	1%	5%	1%	1%
River Carpsucker	5%	3%	2%	7%

1997	Above the Diversion Weir		Below the Diversion Weir	
	Palmer	Fullerton	Genoa	Columbus
Red Shiner	54%	45%	20%	35%
Sand Shiner	5%	12%	15%	9%
Western Silvery Minnow	0%	<1%	34%	25%
Channel Catfish	6%	7%	3%	9%
Emerald Shiner	<1%	1%	5%	7%
River Shiner	<1%	<1%	6%	5%

5. Flow Depletion and Flow Diversion

Results – Fishery Population Above and Below

Numbers of Popular Sport Fishes

	Above the Diversion Weir				Below the Diversion Weir			
	Palmer		Fullerton		Genoa		Columbus	
	1996	1997	1996	1997	1996	1997	1996	1997
Channel Catfish	49	189	8	110	77	151	134	14
Bluegill	0	3	1	16	4	11	12	3
Largemouth Bass	16	42	18	94	8	47	4	14
White Crappie	0	4	0	0	2	2	0	2
Walleye	6	2	1	2	3	0	0	1
Freshwater Drum	4	6	0	1	4	12	0	2

5. Flow Depletion and Flow Diversion

Results – Fishery Populations Above and Below

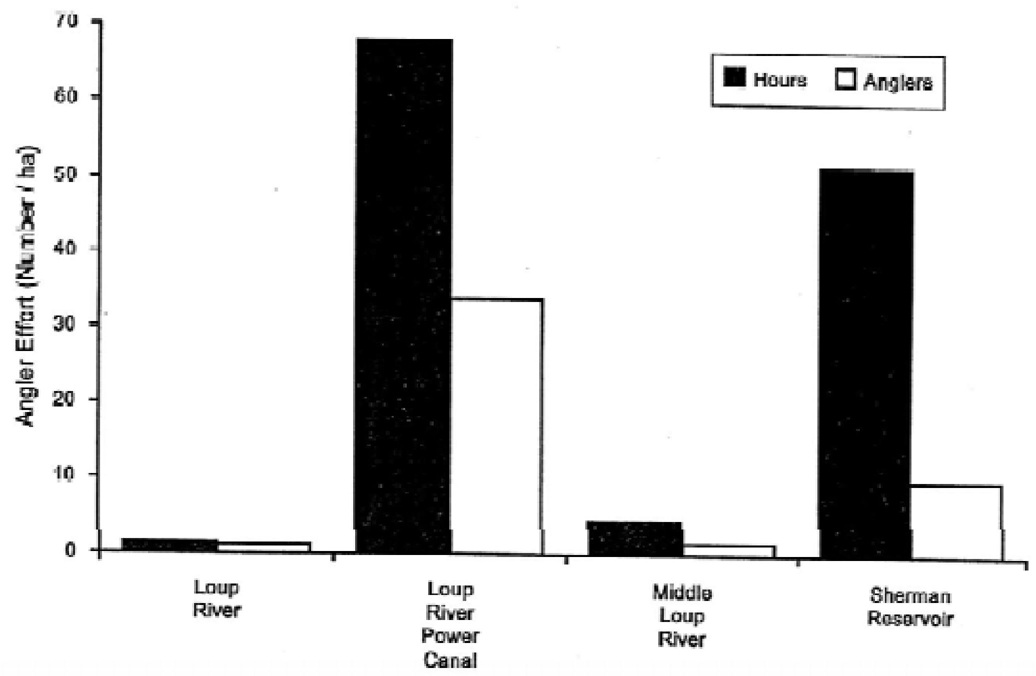
- NGPC study suggests that diversion is not negatively affecting fisheries.
- Fish populations and habitat collected in the NGPC Studies indicative of typical rivers found in the region.

Tailrace Canal

5. Flow Depletion and Flow Diversion

Results – Fishery Populations Above and Below

- Sports fisheries similar in both reaches.
- Power canal and Lake Babcock preferred by anglers



Total estimated angler effort based on surface area in the Loup Basin during 1996 (NGPC).

5. Flow Depletion and Flow Diversion

Results – Fishery Populations Above and Below

Fish Passage Summary

- When Sluice Gates are open, velocity under normal Headworks operations are usually too great to allow fish passage of the analyzed fish species
- May be situations where fish pathways exist not considered in model
  - Rest in hydraulic shadow and burst through in lower velocity areas
  - Debris or Ice build up
  - High tailwaters

5. Flow Depletion and Flow Diversion

Methodology – Montana Method

- Method required by FERC
  - Uses flow data to determine habitat condition
- Used to determine fisheries habitat in the Loup and Platte River
  - Loup River
    - Ungaged Site 1: above the Diversion Weir
    - Genoa Gage: below the Diversion Weir
  - Platte River
    - Duncan Gage: above Loup River confluence
    - Ungaged Site 3: below Loup River confluence

5. Flow Depletion and Flow Diversion

Methodology – Montana Method

Advantages

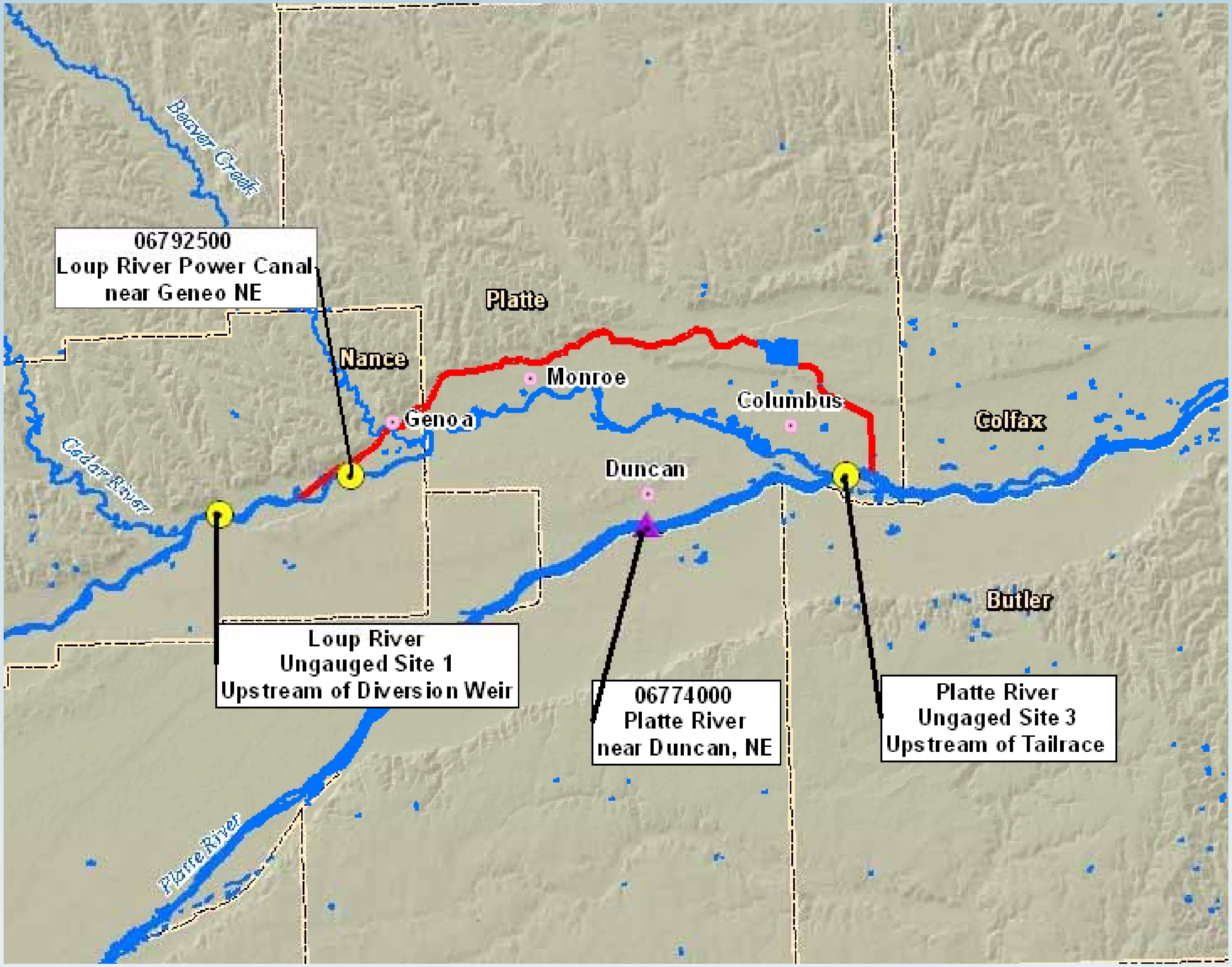
- Quick and easy
- Does not require extensive field work
- Easy to apply to nearly any situation
- Commonly adopted

Disadvantages

- Applies single criterion to all circumstances
- Does not incorporate intra-month variation
- Does not model the true complexity of a system

5. Flow Depletion and Flow Diversion

Study Sites – Montana Method



5. Flow Depletion and Flow Diversion

Methodology – Montana Method

Category	April to September	October to March
Optimum	60 to 100% of annual mean	60 to 100% of annual mean
Outstanding	60% of annual mean	40 to 59% of annual mean
Excellent	50 to 59% of annual mean	30 to 39% of annual mean
Good	40 to 49% of annual mean	20 to 29% of annual mean
Fair	30 to 39% of annual mean	10 to 19% of annual mean
Poor	10 to 29% of annual mean	10% of annual mean
Severe Degradation	Less than 10% of annual mean	Less than 10% of annual mean

Category	April to September	October to March
Satisfactory	>40% of annual mean	>20% of annual mean
Fair	30 to 39% of annual mean	10 to 19% of annual mean
Poor	10 to 29% of annual mean	10% of annual mean
Severe Degradation	Less than 10% of annual mean	Less than 10% of annual mean

5. Flow Depletion and Flow Diversion

Methodology – Montana Method

Minimum stream flow requirements for each condition category
April - September

Reach	Average Annual Flow (cfs)	Satisfactory 40% (cfs)	Fair 30% (cfs)	Poor 10% (cfs)[1]
Site 1 – Upstream of the Diversion Weir (Loup River)	2,379	952	714	238
Loup River near Genoa gage	743	297	223	75
Platte River near Duncan gage	1,821	728	546	182
Site 3 – Downstream of the Tailrace Return	2,828	1,131	848	283

Period of record = 1954-2009

Analysis
– Montana Method

MONTANA METHOD (Tennant, 1976)

Platte River Mean Monthly Flow (cfs)

Ungaged Site 3 (Downstream of Loup Confluence)

Satisfactory	>40% Mean Annual Flow for Period of Record
Fair	30-39% Mean Annual Flow for Period of Record
Poor	10-29% Mean Annual Flow for Period of Record
Degraded	<10% Mean Annual Flow for Period of Record

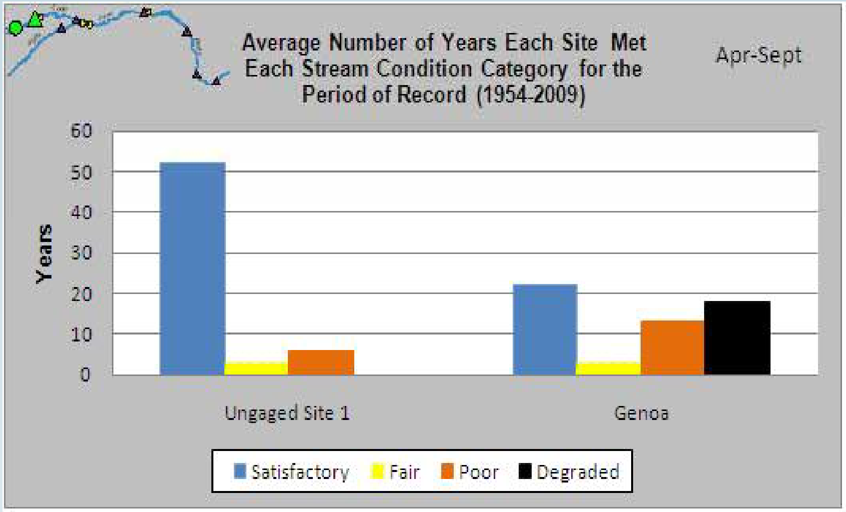
Calendar Year	Mean Annual Flow	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1954	1527	1705	1833	1431	247	245	191	350	1205	2536	1753	4228	2813
1955	1108	1626	569	1261	306	101	110	167	1397	954	1891	1036	3874
1956	818	1276	766	486	204	123	94	138	585	490	1052	1641	2986
1957	1578	1415	3892	4693	679	105	572	1022	1440	1681	619	1345	1505
1958	2343	5134	2926	2298	3253	420	249	480	1291	1446	2231	3872	4648
1959	1594	2780	2174	700	739	197	160	1090	2312	2182	1040	1868	3899
1960	2444	5023	4068	3150	866	208	193	538	1069	2457	2000	2318	7421
1961	1549	1732	2534	2650	294	277	165	1062	1891	1118	1795	2926	2287
1962	2593	2483	1980	5778	2451	1251	500	1355	1801	2032	1206	3444	6926
1963	1347	1893	982	878	159	174	888	1035	1158	1146	1330	3310	3388
1964	1446	3037	2168	1282	475	241	514	781	1351	1029	1336	2163	3035
1965	2745	2409	3241	3714	3134	361	2725	3512	2593	3667	1232	2106	4197
1966	2408	3155	1323	1191	352	4966	570	1192	1600	2306	3204	3984	5102
1967	2624	914	908	13184	3429	653	611	1381	1900	2650	1478	2311	2230
1968	1821	2039	1407	2689	580	540	845	1981	1979	2671	1727	2551	2896
1969	2774	3116	2021	2630	2619	548	1471	2094	2574	3452	1805	2412	8462
1970	2182	3541	2389	2063	1493	292	796	1909	2209	2074	2607	3832	3131
1971	3659	2844	7628	10012	2536	315	419	1514	2326	3333	2048	5117	5987
1972	2280	2374	4042	1147	885	810	724	1644	2333	2122	3174	3971	4158
1973	5535	4507	10286	11696	2327	1025	4553	7274	5226	4867	4005	4998	5724
1974	3039	7448	2776	1883	173	186	342	917	1173	2731	4903	7769	6581
1975	1709	2311	1358	3178	988	309	468	706	1367	3064	2169	1819	2801
1976	1544	2292	1965	776	228	79	295	661	1540	2640	1885	3666	2597
1977	1898	4015	3410	1834	293	589	1587	1224	1730	1312	1797	2293	2781
1978	2076	4306	1709	840	254	422	166	599	1403	2246	875	1062	10878
1979	2279	2758	2325	2270	2270	519	338	501	1692	4246	1112	1194	7948
1980	3506	5940	8987	7003	526	380	383	625	854	2706	4070	4606	6072
1981	1531	1403	1288	598	548	2352	445	895	1369	1992	2245	2901	2396
1982	2467	1740	3910	3246	1879	901	865	1525	2477	3097	1395	4696	4036
1983	7591	7964	9806	20152	13423	6388	6908	3210	2241	5169	4088	5982	5830
1984	9545	17761	21001	17237	4583	814	3538	4685	6253	7116	7042	12517	12404
1985	3851	4120	5322	2068	1202	1296	3196	3577	2836	2614	5898	6894	7386
1986	4761	6053	4568	3454	2297	2930	5747	6100	4885	5657	4474	5995	5119
1987	4448	8523	6189	5529	1523	958	2062	2017	3000	4134	5428	4553	9513
1988	2949	2976	3516	947	1425	814	988	1941	1218	2597	4360	8825	5973
1989	2157	1775	805	1309	2008	545	2244	823	1570	1540	3475	3625	6248
1990	2148	2745	2834	3292	564	866	302	536	1222	1547	4672	4378	2999
1991	1916	1534	2904	3833	601	495	255	471	2760	2859	1307	4134	2076
1992	2486	2258	1234	1753	1985	2696	1342	2130	2248	3394	3320	3060	4369
1993	5188	4199	2777	4699	12502	3389	3577	3164	2667	4967	2776	4898	12431
1994	2948	2910	1693	1665	2728	1676	2077	1493	1538	3567	3629	4861	7603
1995	4700	3939	6761	13802	7358	1785	1458	2771	3227	3685	3261	4921	3576
1996	3819	3153	3760	4793	1866	2942	3578	3657	4958	4594	3557	4624	4435
1997	4525	4253	2755	5191	2205	2553	3266	4478	5134	6740	4147	9069	4937
1998	4842	3168	5157	6197	2225	2315	3826	3567	4069	3050	5444	6266	7082
1999	4972	5566	7113	9981	4526	3845	3485	3386	3203	4284	3893	6010	4553
2000	2758	3176	2267	1714	1401	678	568	1272	3636	3239	5296	5432	4531
2001	2620	5800	4346	1302	800	892	1452	1397	1139	2345	2235	2761	6955
2002	1499	2025	1218	655	260	215	229	542	719	2567	3156	2913	3544
2003	1189	1345	2360	904	293	138	215	189	856	1978	2025	1842	2138
2004	1360	1352	1056	755	828	186	619	979	1286	2376	2189	2093	2602
2005[D]	1775	1855	2738	3805	524	271	1215	458	857	2050	2513	3201	1970
2006[D]	1158	1873	553	447	244	648	701	458	625	2506	1831	1960	2096
2007	2829	4279	4551	5611	1377	2123	719	1532	1003	2296	2044	5674	3027
2008[W]	3296	2758	6403	9627	2385	1031	750	3483	3213	2766	2207	2468	2506
2009	2628	3682	1993	4408	1420	1444	973	2327	3958	4148	1935	3428	3205
Mean (POR)	**2828**	**3612**	**3581**	**4102**	**1906**	**1116**	**1367**	**1765**	**2182**	**2893**	**2753**	**3961**	**4819**

D Dry, W Wet, N Normal

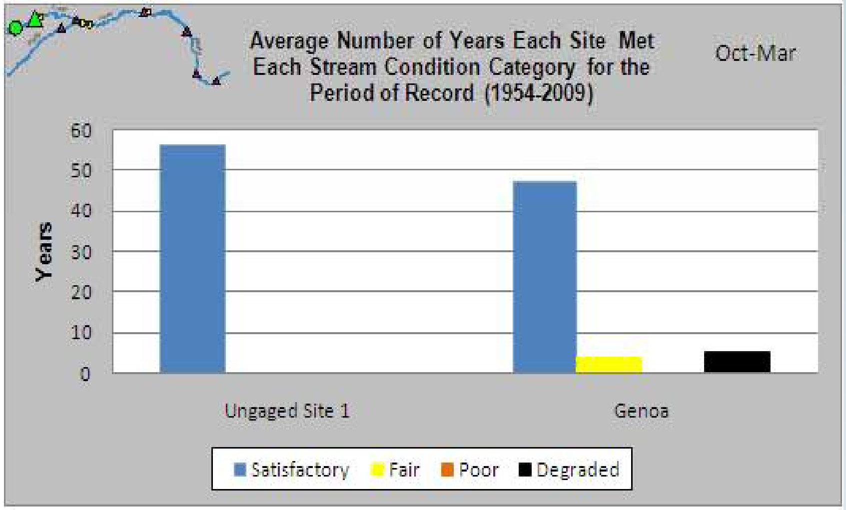
5. Flow Depletion and Flow Diversion

Results – Montana Method – Loup River

Stream Condition – Yearly Summary
April – September



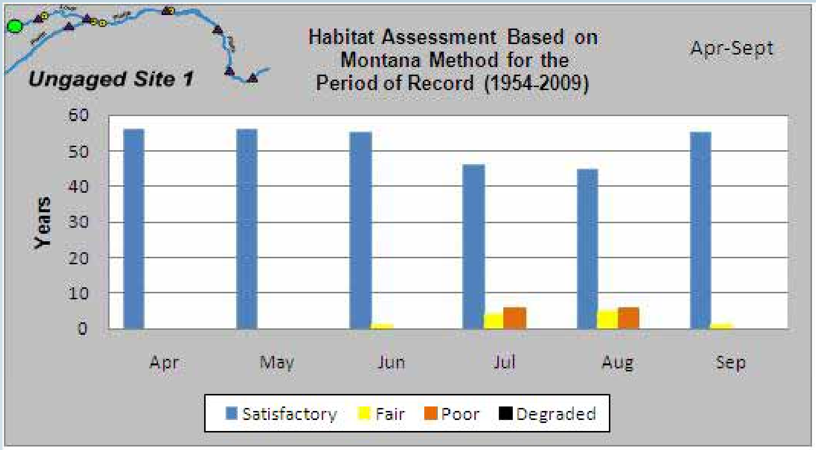
Stream Condition – Yearly Summary
October – March

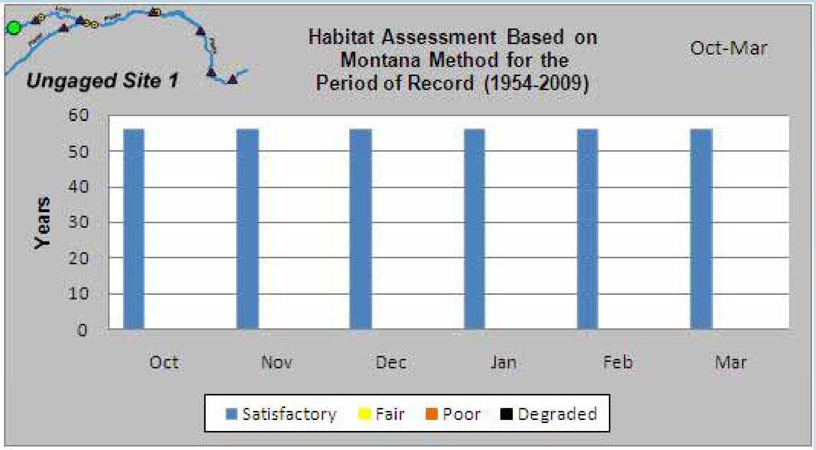


5. Flow Depletion and Flow Diversion

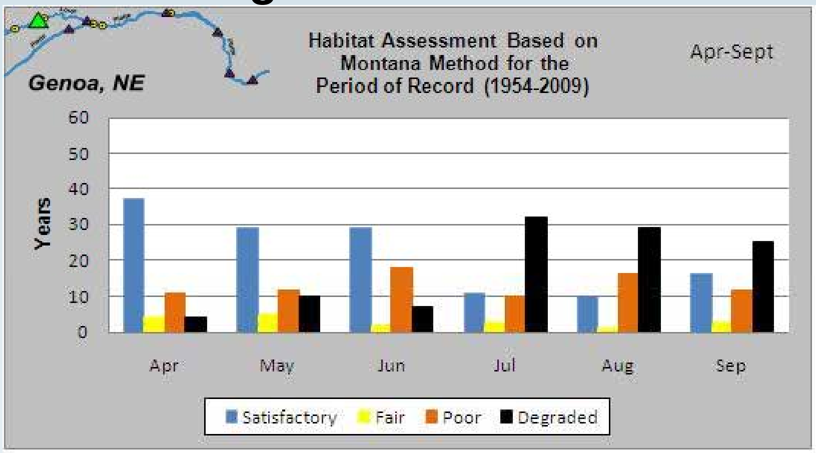
Results – Montana Method – Loup River

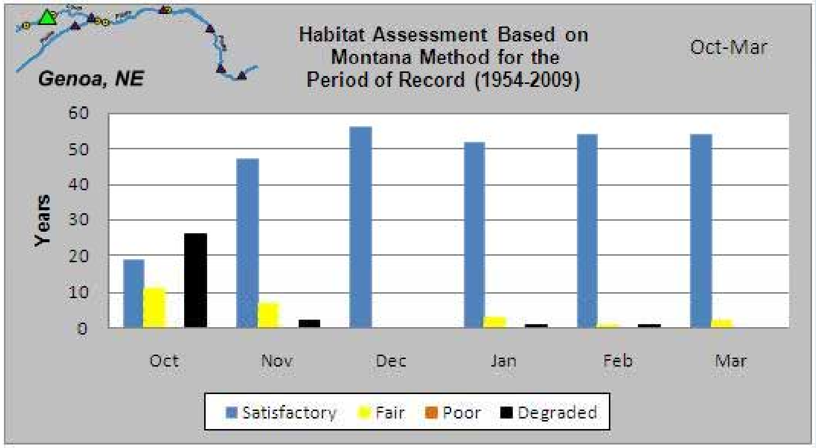
Ungaged Site 1 – Above Diversion Weir





Genoa Gage – Below Diversion Weir





5. Flow Depletion and Flow Diversion

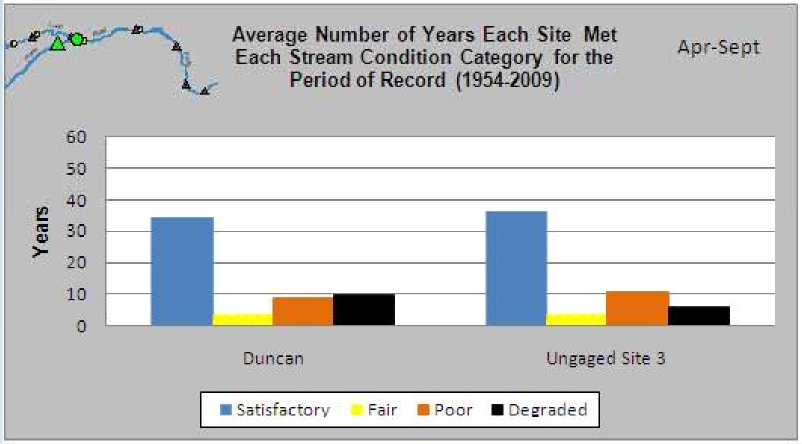
Results – Montana Method

- NGPC Studies found similar fish communities above and below diversion.
- Montana method may not take into consideration intra-month variation that may help maintain deeper channels pool areas that are part of the system.
- Power canal provides habitat and public access opportunity that the Loup River diversion may not provide.

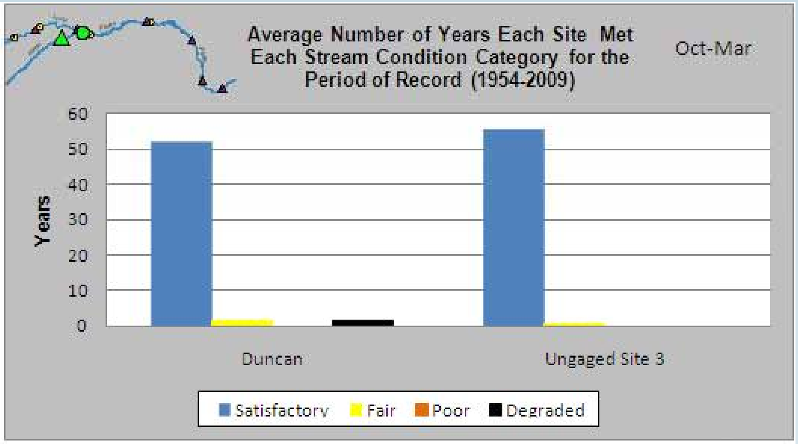
5. Flow Depletion and Flow Diversion

Results – Montana Method – Platte River

Stream Condition – Yearly Summary
April – September



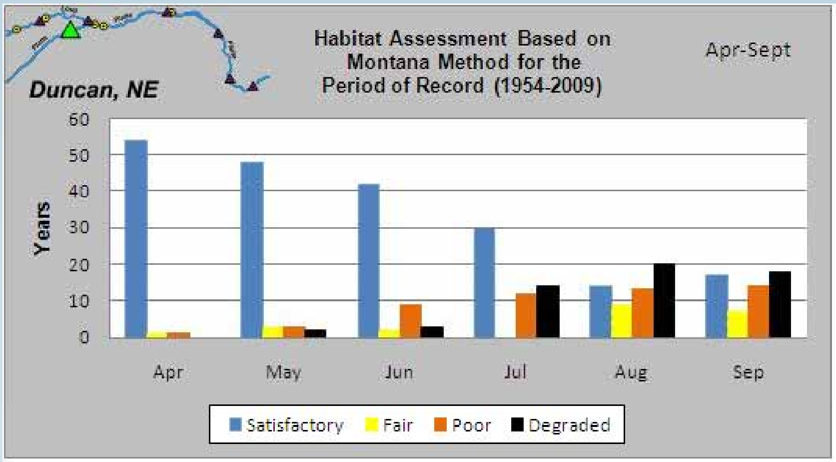
Stream Condition – Yearly Summary
October – March

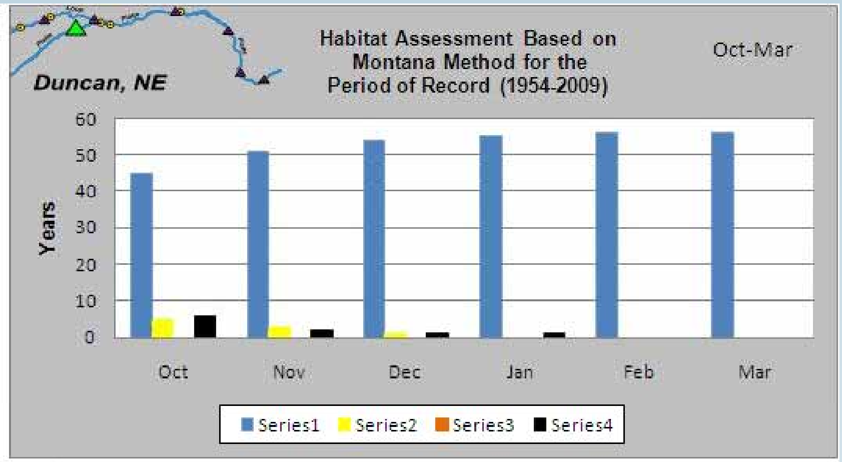


5. Flow Depletion and Flow Diversion

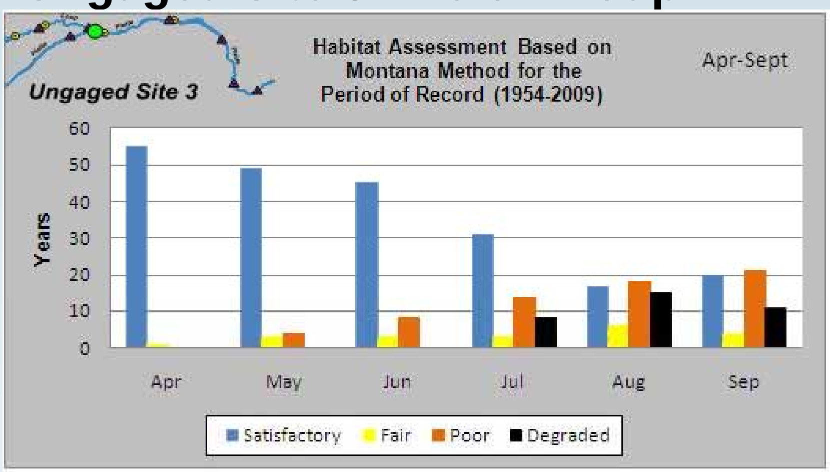
Results – Montana Method – Platte River

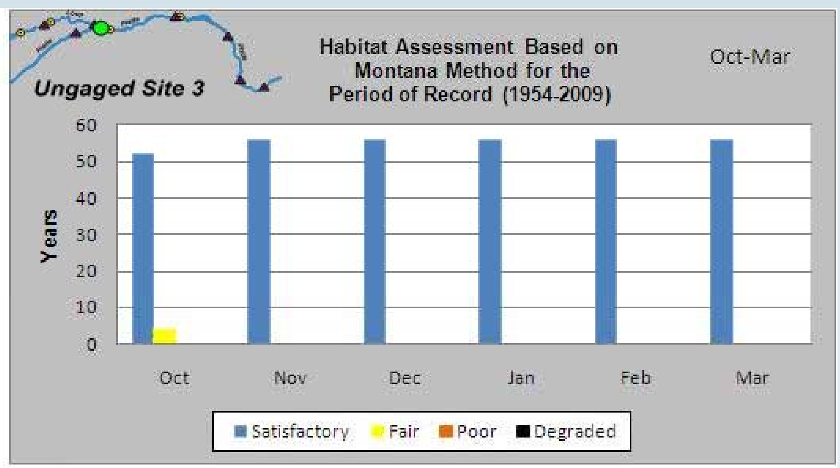
Duncan Gage – Above Loup Confluence





Ungaged Site 3– Below Loup





5. Flow Depletion and Flow Diversion

Summary of Results

- Objective 6 – Loup River Conclusions
  - NGPC Studies show fish use the lower reaches as much as the upper reaches, suggesting that habitat is not limiting
  - Sport fisheries are similar upstream and downstream
  - Montana Method analysis suggests shows degraded flows for the Loup but fisheries studies do not support this
  - Power canal is an important sport fishery resource

5. Flow Depletion and Flow Diversion

Summary of Results

- Objective 6 – Platte River
  - Exhibits degraded flows upstream and downstream of confluence
  - Suggests fisheries habitat in Platte River not affected by Loup River diversion

5. Flow Depletion and Flow Diversion

Objective

7. To determine the availability of potential whooping crane roosting habitat above and below the Diversion Weir under Project operations compared to the no diversion condition.

Associated Tasks

- Aerial Imagery Review
- Habitat Evaluation Using HEC-RAS

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

Whooping Crane roosting habitat parameters

Habitat Parameter	Observed Measurements of Habitat Parameters[1]	References
Channel width (bank to bank)	≥180 feet, usually >508 feet; average 764±276 feet	Johnson, 1982; Austin and Richert, 2001
Channel inundated (percent)	>80%	Faanes et al., 1992
Unobstructed channel width (feet)	≥1,165 feet, <2,625 feet	Faanes, 1992; Austin and Richert, 2001
Depth of water for roosting	0 to 0.82 foot, approximately 40% of channel area <0.7 foot	Johnson, 1982; Faanes, 1992; Farmer et al., 2005; Austin and Richert, 2001; PRRIP Land Plan, 2006

5. Flow Depletion and Flow Diversion

Methodology – Aerial Imagery Review

- Used results of Objective 4, Task 6
- Whooping Crane parameters
  - Channel Width
  - Average area of shallow water/wet sand per river mile
  - Percentage of water/wet sand areas
  - Unobstructed Width

5. Flow Depletion and Flow Diversion

Results – Aerial Imagery Review

- Channel Width
  - Consistently wider above the diversion than below (1077 ft. vs. 652 ft.)
  - Nebraska range for roosting habitat: 764±276 ft.
- Area of Shallow Water/Wet Sand
  - Upstream – 11% to 24%
  - Downstream – 10% to 16%.

5. Flow Depletion and Flow Diversion

Results – Aerial Imagery Review

- Unobstructed Width
  - Equal to active channel width due to forested areas directly adjacent to typical high bank as well as banks typically higher than 3 feet
  - Active channel width is consistently wider above the diversion weir than below (1077 ft. vs. 652 ft.)

5. Flow Depletion and Flow Diversion

Methodology – Habitat Evaluation Using HEC-RAS

- Whooping Crane parameters
  - Depth = 0.8 feet or less (Austin and Richert, 2001)
  - Channel Width = high bank to high bank

5. Flow Depletion and Flow Diversion

Methodology – Habitat Evaluation Using HEC-RAS

- Flow Levels
  - 25% exceedance = high-flow
  - 50% exceedance = medium-flow
  - 75% exceedance = low-flow
- Wet, Dry, and Normal Years (2008, 2006, 2005)
- Early summer cross-section
- Study Sites 1 and 2
- Current Operations and No Diversion Condition (Study Site 2)

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

- Upstream of Diversion Weir
  - Generally, as flows increased, the percentage of channel width with water depths of 0.8 feet or less decreased
  - On average, little difference between the dry, normal, and wet years

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

- Downstream of Diversion Weir (Current Operations)
  - Generally, as flows increased, the percentage of channel width with water depths of 0.8 feet or less increased
  - On average, very little difference between the dry, normal, and wet years

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

- Downstream of Diversion Weir (No Diversion Condition)
  - Generally, as flows increased, the percentage of channel width with water depths of 0.8 feet or less decreased

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

Upstream vs. Downstream – Current Operations

- Difference between Sites 1 and 2 diminishes as flow increases
- At higher flows (high flow, normal and wet years), downstream has higher percentage of channel width with water depths of 0.8 feet or less than upstream

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

Upstream vs. Downstream – No Diversion Condition

- Generally smaller percentage of channel widths with water depths of 0.8 feet or less downstream than upstream for all flows
- Difference increases as flow increases

5. Flow Depletion and Flow Diversion

Results – Habitat Evaluation Using HEC-RAS

Site 2 – Current Operations vs. No Diversion Condition

- Current Operations = Smaller percentage of channel widths with water depths of 0.8 feet or less during all low to medium flow conditions
- Current Operations = Greater percentage of channel widths with water depths of 0.8 feet or less during all higher flow conditions
- Percentage differences are greatest during lower flow conditions

5. Flow Depletion and Flow Diversion

Summary of Results

Objective 7

- Unobstructed widths above and below are outside WC parameters
- Channel widths above and below are within WC parameters
- Area of Shallow Water/Wet Sand is greater upstream (11% to 24% vs. 10% to 16%)
- Current Operations
  - Smaller percentage of channel widths with water depths of 0.8 feet or less during all low to medium flow conditions
  - Greater percentage of channel widths with water depths of 0.8 feet or less during all higher flow conditions

QUESTIONS?

Next Steps

18CFR5.15

- March 11, 2011
  - District submits meeting summary
- April 11, 2011
  - Agencies file meeting summary disagreements and submit requests for modification to on-going studies
- May 12, 2011
  - District responds to summary comments and study modification requests
- June 12, 2011
  - FERC resolves comments and study modification requests

Next Steps

18CFR5.15

- August 26, 2011
  - District submits Updated Initial Study Report to FERC
- September 9, 2011
  - Updated Study Report Agency Meeting (Location TBD)
- November 18, 2011
  - District files Draft License Application

Thank You for Your Attendance

Loup Power District
Hydro Project