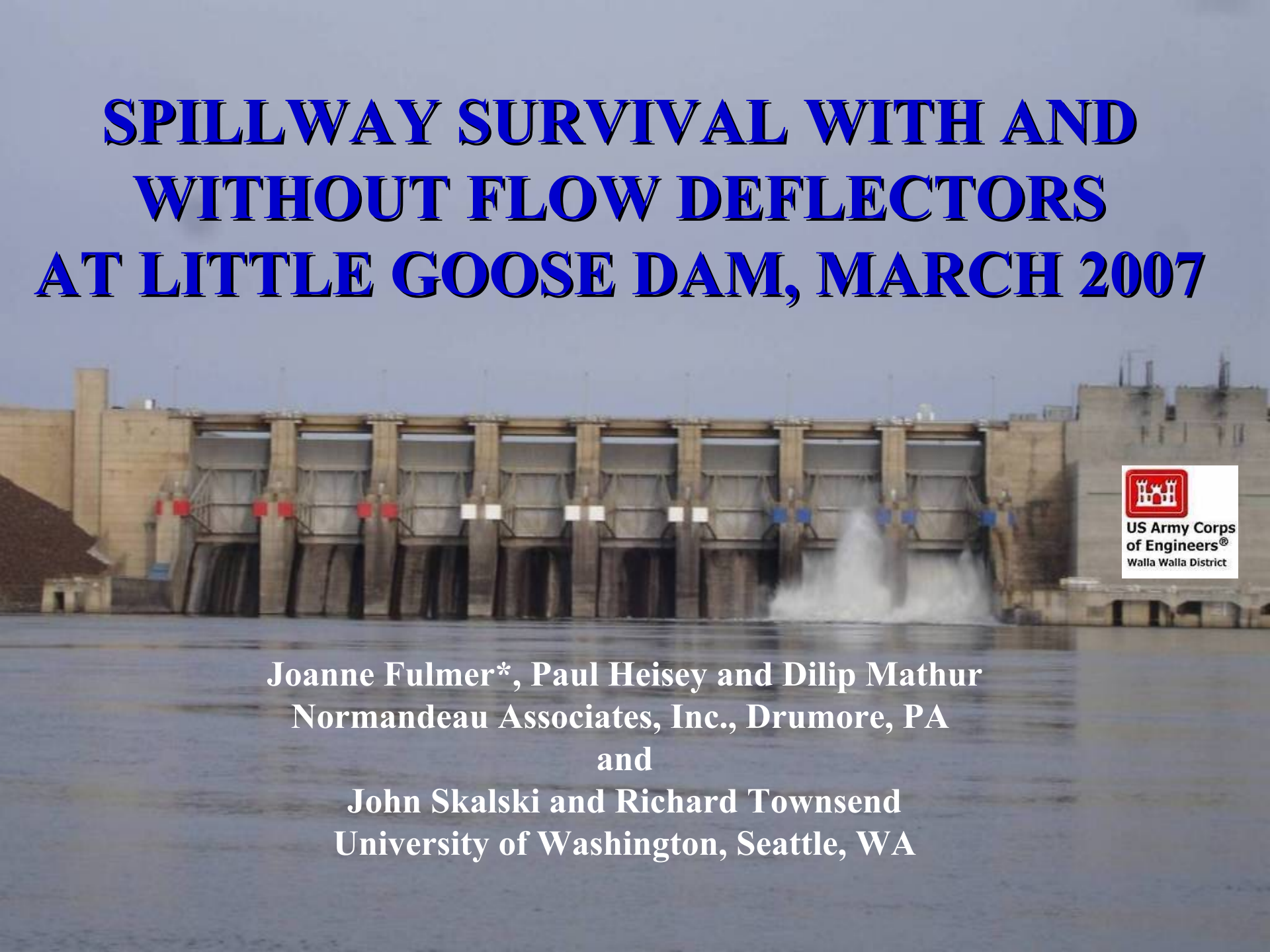
SPILLWAY SURVIVAL WITH AND WITHOUT FLOW DEFLECTORS AT LITTLE GOOSE DAM, MARCH 2007



US Army Corps of Engineers®
Walla Walla District

Joanne Fulmer*, Paul Heisey and Dilip Mathur
Normandeau Associates, Inc., Drumore, PA
and
John Skalski and Richard Townsend
University of Washington, Seattle, WA

Contents

- Objectives
- Experimental Conditions
- Methods
- Results
- Conclusions

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Objectives

- Estimate direct survival and injury ($\leq \pm$ 0.03, 95% of the time) on yearling chinook salmon passed through spillbays with and without flow deflectors
- Resulting data to assist in bay selection for RSW installation as well as the design of a flow deflector for Spillbay 1 if it is selected for the RSW

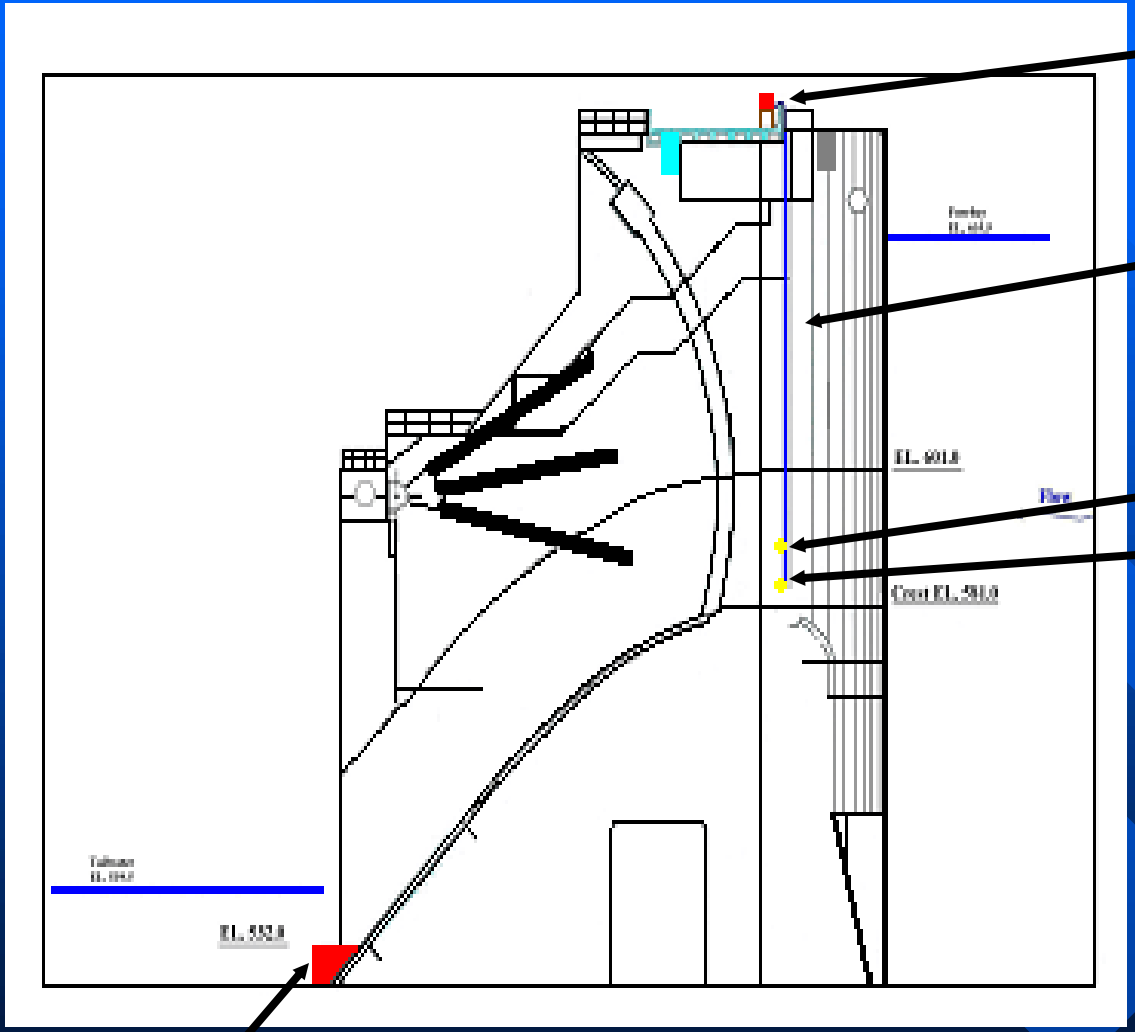
NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Experimental Conditions

- **Date:** 3 - 12 March 2007
- **Spillbays:** Spillbay 1 (without flow deflector)
  Spillbay 2 (with flow deflector)
- **Release Location:** 3 and 8 ft above ogee
- **Water Temp:** 4.5°C
- **Specimens:** Yearling chinook salmon; (138 mm)

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Pipe Release Location



Induction System

Release Pipe

8’ Release Point

3’ Release Point

Flow Deflector

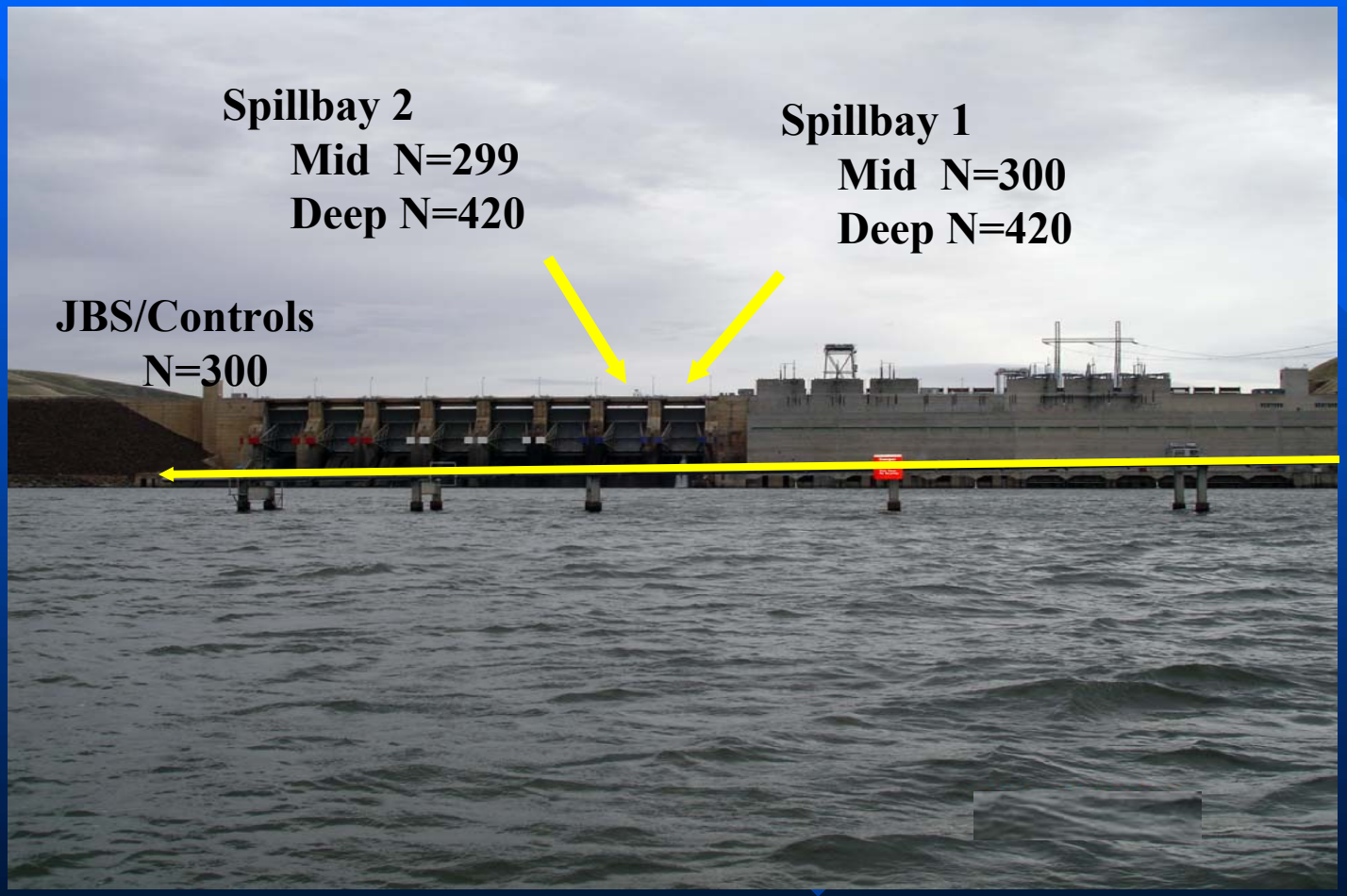
NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Pipe Release Location

- Positioned at release depths similar to the depths tested at Ice Harbor spillbays
- Fish released by pipes midbay in both spillbays and at two depths, 3 ft (deep) and 8 ft (mid) above the ogee.
- Mid release pipe positioned where most fish expected to pass
- Deep pipe added because of evidence of higher injuries to deeper passed fish at Ice Harbor spillbays

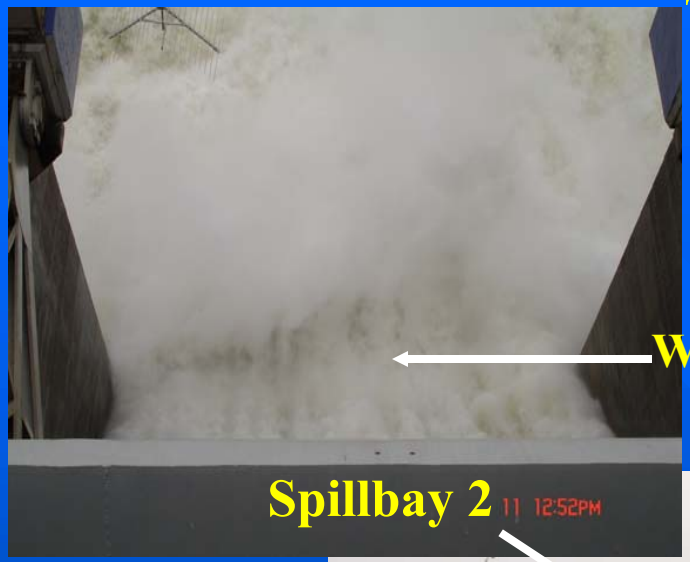
NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Treatment and Control Releases



NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Test flow 7 kcfs per spillbay



Water turned by deflector

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Analysis

- Statistical analyses were performed primarily by Drs. John Skalski and Richard Townsend, University of Washington, Seattle, Washington
- The analysis assessed the effect of Spillbay 1 (without) and Spillbay 2 (with) flow deflectors, at 2 depths (3 ft and 8 ft) above the ogee, and at one flow condition (7 kcfs) on survival and fish condition

Metrics Used

- *Direct Survival* (1 and 48 h)
- *Conditional probability* of fish being malady-free given alive at 48 h
- *Joint probability* of 48 h survival and being malady free
- *Malady* defined as a fish with a visible injury, >20% scale loss per side and/or loss of equilibrium

Release and Recapture

- Sample size higher for deep releases to account for potentially higher injury rates
- Physically recaptured ranged from 98.6% to 99.7% of treatment fish and all 300 control fish.

	Spillbay 1		Spiillbay 2 (deflector)	
	Mid (8')	Deep (3')	Mid (8')	Deep (3')
		Treatment		
No. Released	300	420	299	420
Recaptured	99.7%	99.3%	99.7%	98.6%
		Control		
		100%		

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Results-48 h Direct Survival Estimates

- Estimated survival for spillbays was highest for Spillbay 1 at mid (99.7%), followed by the Spillbay 1 at deep (98.8%), Spillbay 2 at mid and deep was 98.6% and 96.7%, respectively
- Precision (ε) was ≤ ±2%, 95% of time and met criteria (≤ ±3%, 95%)
- Spillbay 1 survival significantly higher (P≤ 0.01) than Spillbay 2
- Mid released survival significantly higher (P< 0.023) than deep released

	Spillbay 1		Spillbay 2 (deflector)	
	Mid (8')	Deep (3')	Mid (8')	Deep (3')
Survival	99.7%	98.8%	98.7%	96.7%
95% CI (±)	0.6%	1.0%	1.3%	1.7%

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Malady/Injury Rate Cause and Severity

- 1,428 of the 1,439 (99.2%) released treatment fish examined for maladies
- All control fish recaptured and examined, all malady free
- 72 of 1,428 (5.0%) of the recaptured treatment fish had a malady
- Maladies consisted primarily of visible injuries, 70 of 72 incidences

Malady/Injury Rate Cause and Severity - continued

- Injury types consisted primarily of hemorrhaged or bulged eye(s), bruises or scrapes on the head or body, and damage to the opercula or gills
- Only 2 fish with exclusively loss of equilibrium, and no fish with only scale loss
- Most (51 of 72) maladies attributed to shear forces; 12 of 72 attributed solely to mechanical forces

Incidence of Common Injuries

- Injury rates for mid release for both *Spillbays 1* (1.0%) and 2 (2.3%) were lower than for deep releases of 4.3% and 10.1%, respectively
- *Spillbay 2* deep release had the highest incidence of injuries (10.1%) and was significantly higher than the other three tests conditions
- Common injuries for the four treatment conditions were: eye damage (3.4%), cuts/scrapes (1.6%), bruises (0.5%), and gill/operculum damage (0.1%)
- Some fish had multiple injury types

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Incidence of Common Injuries

- Eye damage was most prevalent (7.7%) for Spillbay 2 deep release
- Eye damage ≤1% for mid release at both spillbays

	Spillbay 1		Spillbay 2 (deflector)		
	Mid (8')	Deep (3')	Mid (8')	Deep (3')	Combined
Eye Damage	2(0.7%)	12(2.9%)	3(1.0%)	32 (7.7%)	49 (3.4%)
Bruise/Scrape	1(0.3%)	6(1.5%)	3(1.0%)	13(3.1%)	23 (1.6%)
Gill/Operculum	0	3(0.7%)	2(0.7%)	2(0.5%)	7 (0.5%)
Internal	0	1(0.2%)	1(0.3%)	0	2 (0.1%)

1,428

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Examples of Injuries

Spillbay 2 Deep

Spillbay 1 Deep

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Results: *Conditional Probability*

- The *Conditional probabilities* of being malady free given alive at 48 h ranged from 0.911 (Spillbay 2 deep) to 0.986 (Spillbay 1 mid)
- Spillbay 1 was significantly (P< 0.01) higher than Spillbay 2 and mid release was significantly (P< 0.01) higher than deep release
- Spillbay 2 deep release was significantly lower (P< 0.01) than the other three treatments

	Spillbay 1		Spillbay 2 (deflector)	
	Mid (8')	Deep (3')	Mid (8')	Deep (3')
Survival	0.986	0.961	0.983	0.911
95% CI (±)	.013	.018	.015	.027

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Results: *Joint Probability*

- Estimated *Joint probability* of 48 h survival and being malady free for the four treatment conditions ranged from 0.881 (Spillbay 2 deep) to 0.983 (Spillbay 1 mid)
- Spillbay 1 was significantly (P<0.01) higher than Spillbay 2 and mid release was significantly (P<0.01) higher than deep release
- Spillbay 1 mid release was significantly (P<0.01) higher than the other three test conditions

	Spillbay 1		Spillbay 2 (deflector)	
	Mid (8')	Deep (3')	Mid (8')	Deep (3')
Survival	0. 983	0.950	0.969	0.881
95% CI (±)	.015	.021	.019	.031

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Conclusions

- High recapture rates of fish (98.6-99.7%)
- All metrics used in data analysis pointed to Spillbay 2 deep (equipped with flow deflector) as the least benign passage route
- Precision (ε) was $\leq \pm 2\%$; 95% of the time for all survival and malady estimates and met criteria ($\leq \pm 3\%$; 95% of the time)
- Most common injury was eye damage

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

Conclusions
continued

- Sensor fish were not utilized in this study, but could help delineate the hydraulic conditions, additional deflector design/modifications may be needed before an RSW and a deflector are installed in Spillbay 1

Questions and Comments

US Army Corps of Engineers®
Walla Walla District

Baseline Industrial

Mid Columbia Consulting, Inc

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

John Skalski
and
Richard Townsend