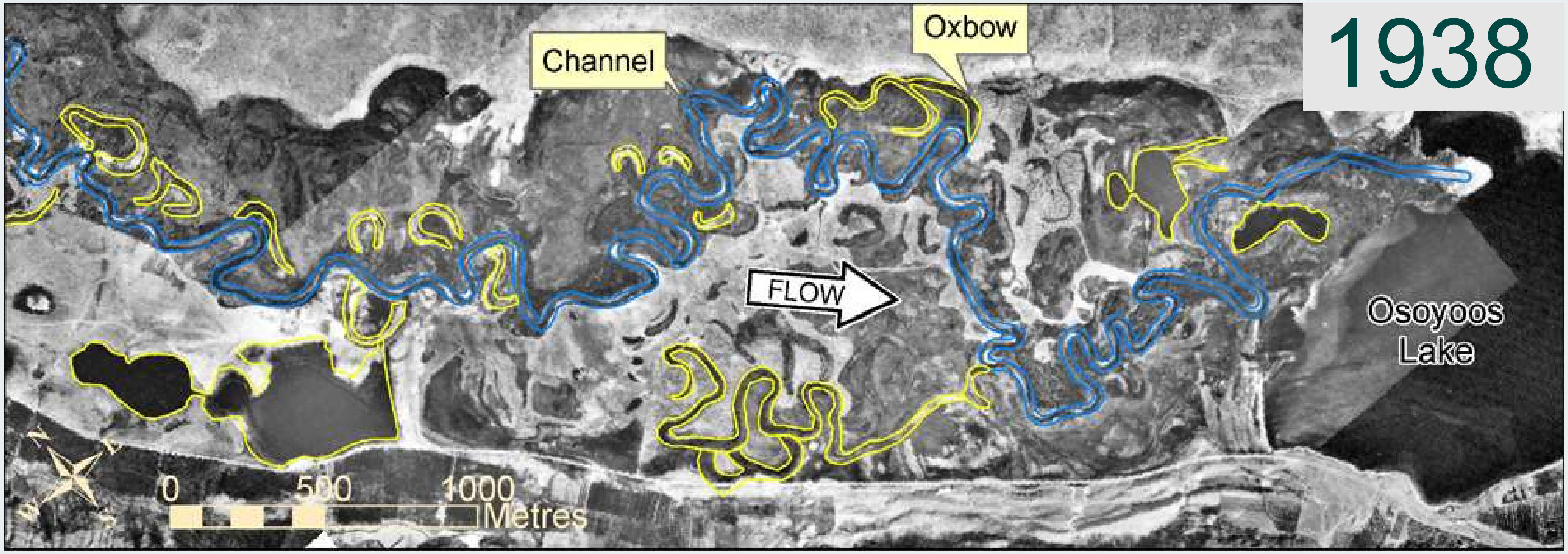
Integrating Biological Design Criteria into Channel Rehabilitation Projects

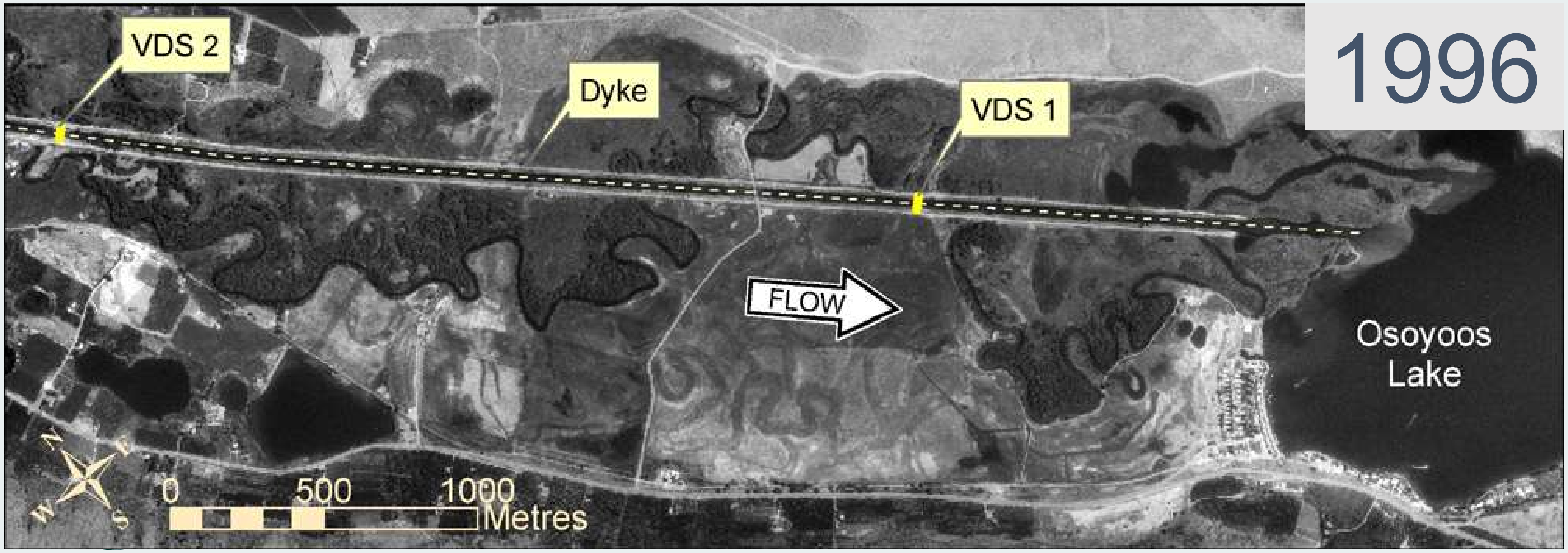
Marc Gaboury

LGL LIMITED
environmental research associates

NATURAL CHANNEL SYSTEMS
5th International Conference
September 26 & 27, 2016
Niagara Falls, Ontario



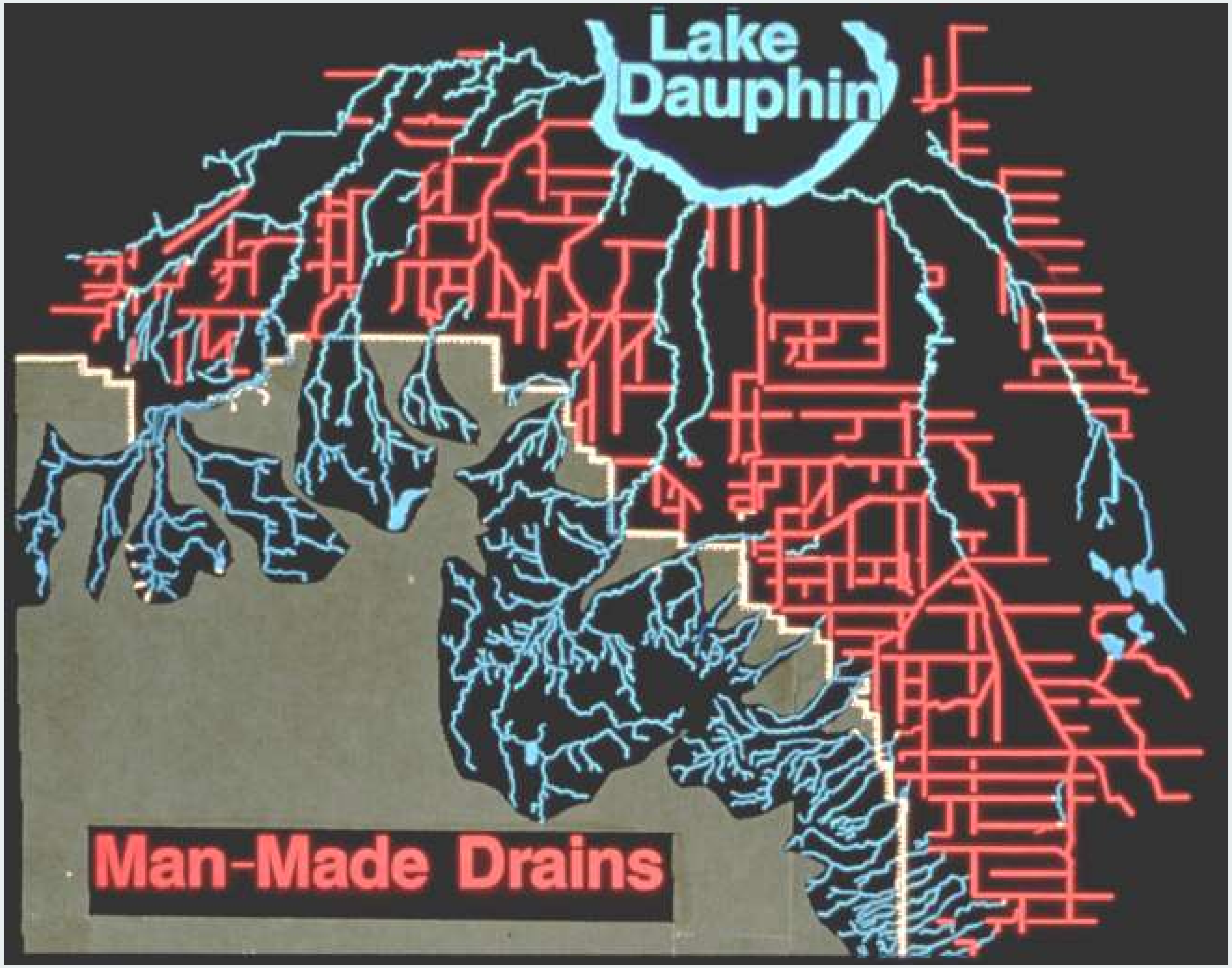
Okanagan River shortened from 54 km to 26 km



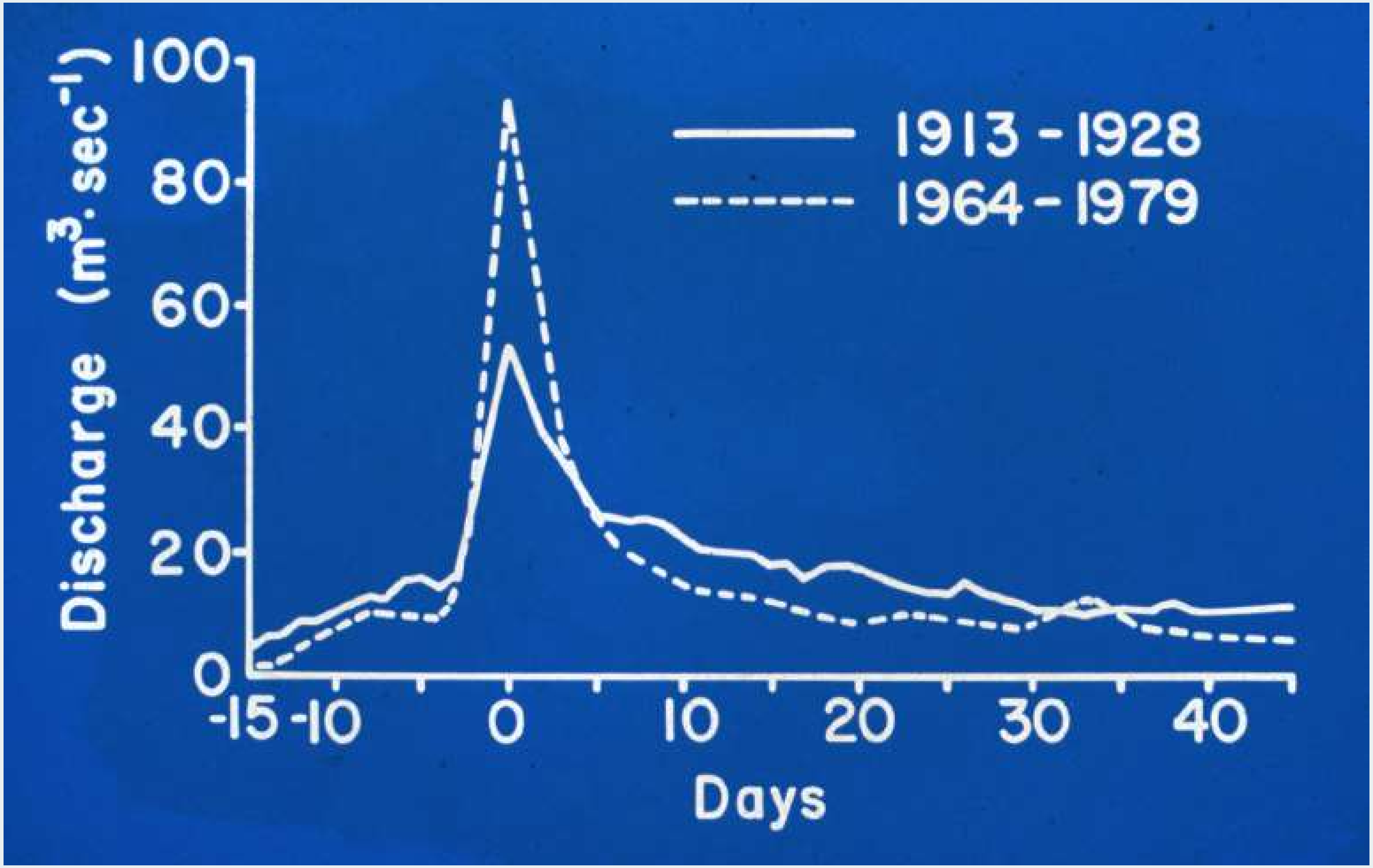
Wilson River Channelization

- 25 km of channel lost or 31% of 1949 length

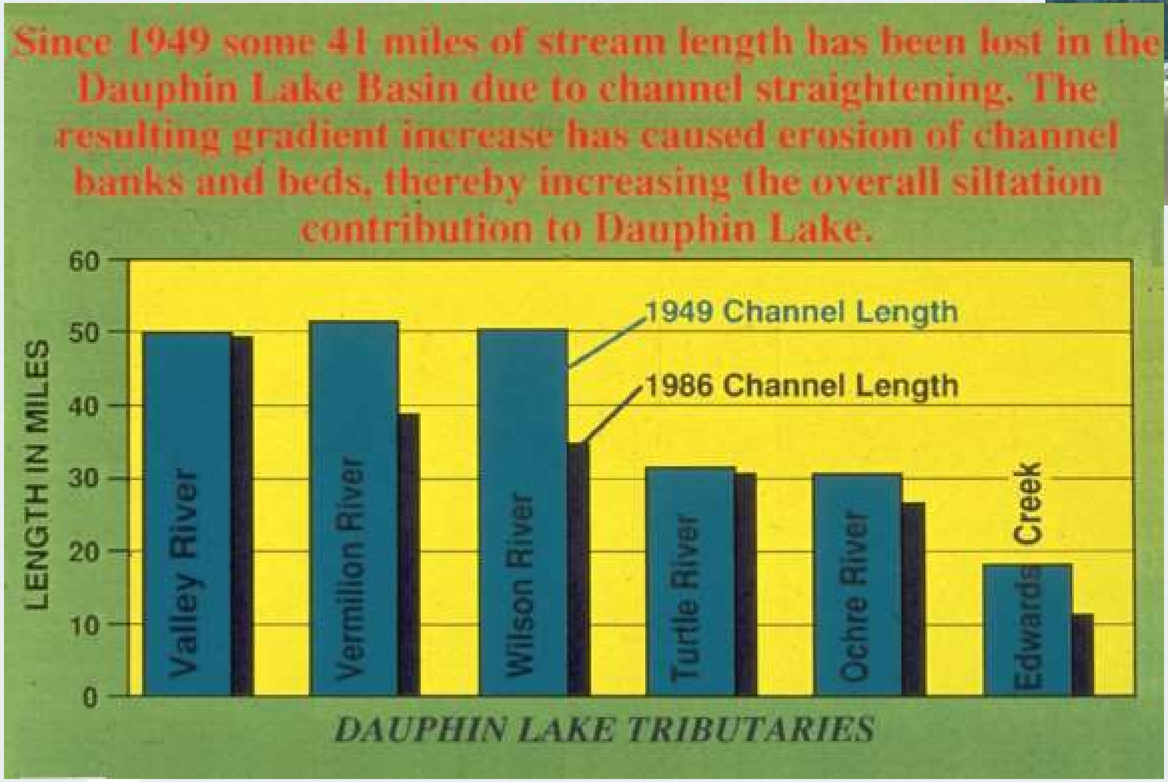
Land Drainage Improvements



Hydrological Effects



Channelization 1949-1986

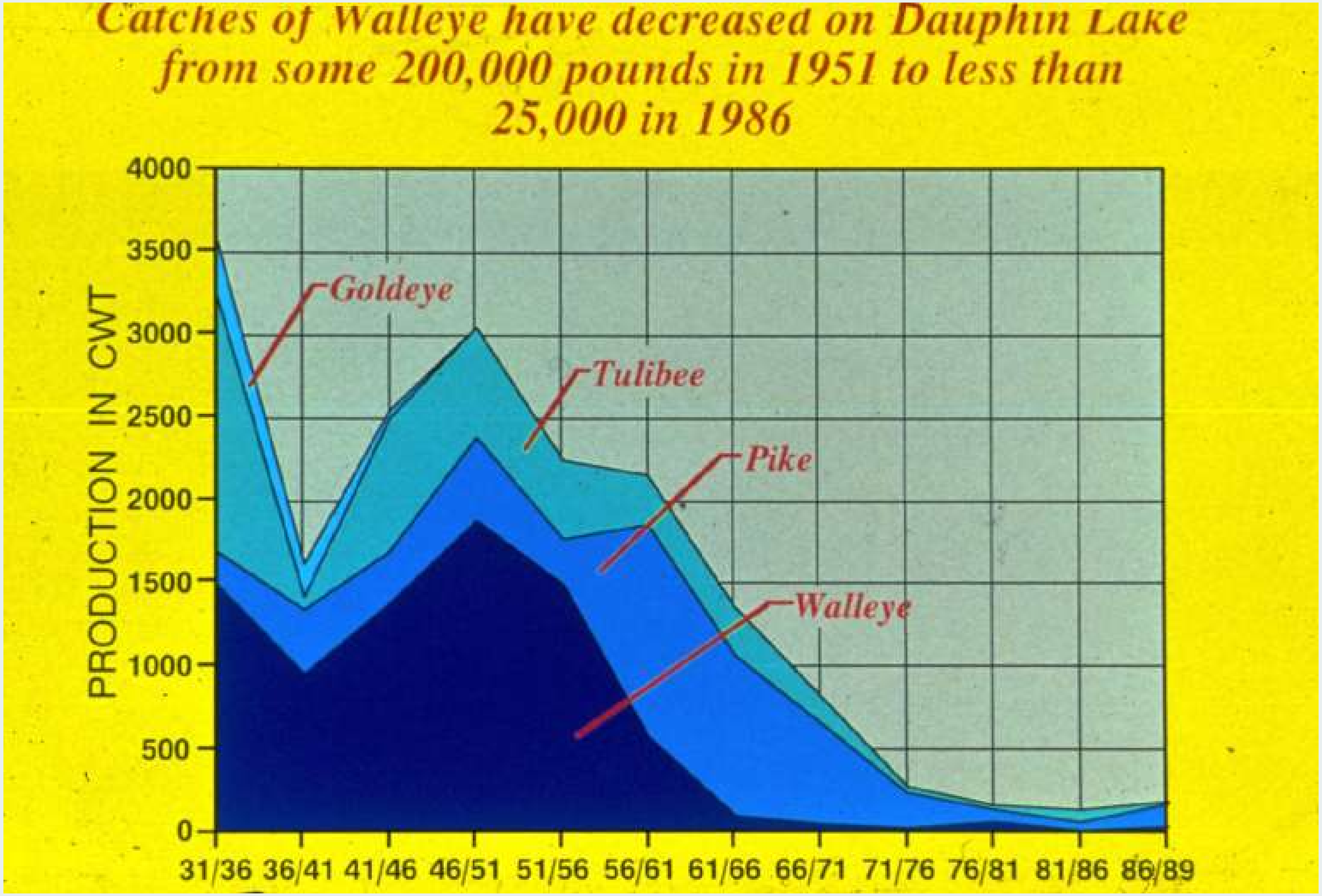


What Was the Impact of Physical Channel Changes on Fish?

Dauphin Lk Tributaries:

- Loss of channel meanders – pools & riffles used for walleye spawning and incubation
- Channel degradation (~1 m from 1950 to 1982) & high sedimentation affecting egg incubation success & early fry survival

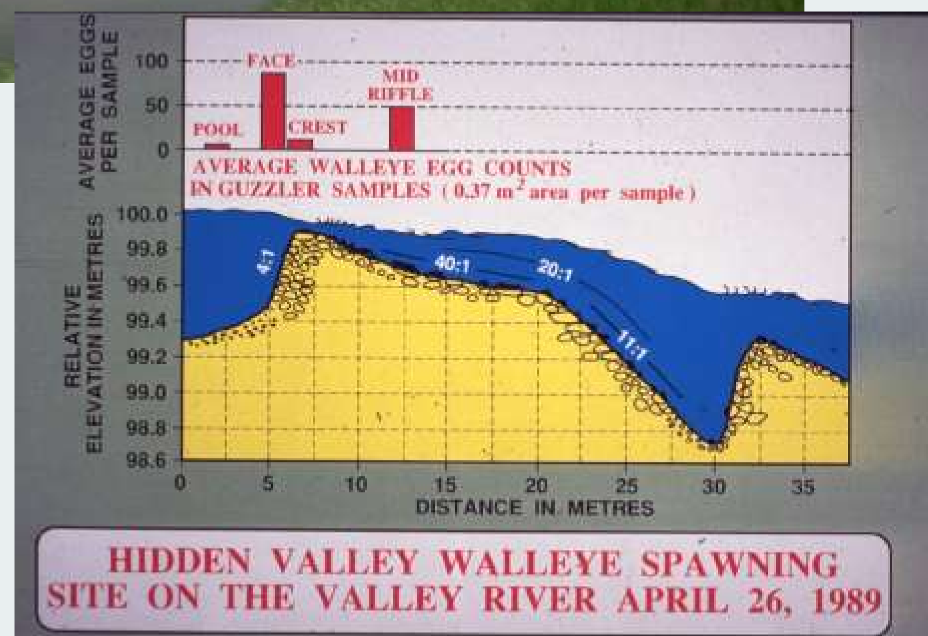
Dauphin Lake Fish Production



NATURAL CHANNEL SYSTEMS
5th International Conference

Natural Walleye Spawning Area

- Reference reach topo survey of natural riffle
- Assessment to determine walleye spawning behaviour



Riffle Design Considerations

Geomorphic:

- Riffle spacing
- Siting of riffle structures in plan and profile

Engineering:

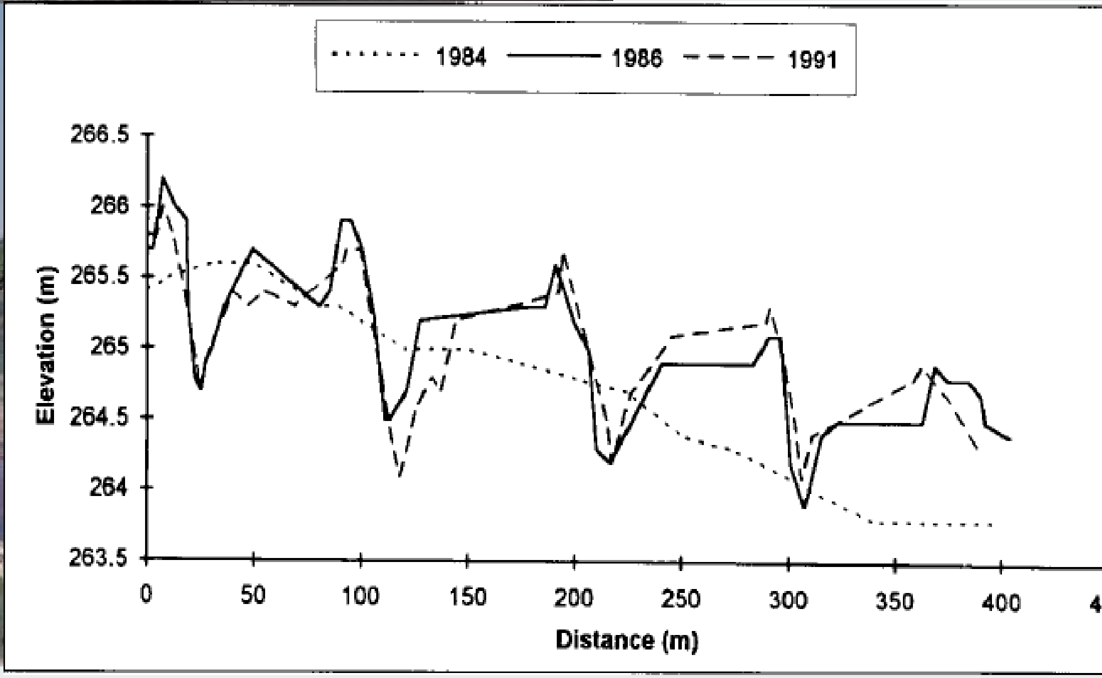
- Stable rock size
- Height of riffle crest
- Elevation drop between riffle crests
- Backwatering of riffle toe
- Slope & roughness of downstream riffle face
- Frequency of floodplain inundation

Riffle Design Considerations

Biological – Spawning, Rearing & Migration

- ❖Emergent boulders on downstream face to capture & hold fertilized eggs
- ❖Backwatering to reduce streambed erosion & sediment transport
- ❖V-notched riffle to ensure adequate migration & incubation flows

Mink Creek – Before and After



Stream Analysis & Habitat Design

Multi-disciplinary Process

- Biology
- Geomorphology
- Hydrology
- Fluid Hydraulics

Stream Analysis & Design Process

(Newbury Hydraulics)

1) Drainage Basin	Trace watershed lines on topographical and geological maps to identify sample and rehabilitation basins.
2) Profiles	Sketch mainstem and tributary long profiles to identify discontinuities which may cause abrupt changes in stream characteristics (falls, former base levels, etc.).
3) Flow	Prepare flow summary for rehabilitation reach using existing or nearby records if available (flood frequency, minimum flows, historical mass curve).
4) Channel Geometry Surveys	Select and survey sample reaches to establish the relationship between the channel geometry, drainage area, and bankfull discharge.
5) Rehabilitation Reach Survey	Survey rehabilitation reaches in sufficient detail to prepare construction drawings and establish survey reference markers.
6) Preferred Habitats	Prepare a summary of habitat factors for biologically preferred reaches using regional references and surveys. Where possible, undertake reach surveys in reference streams with proven populations to identify local flow conditions, substrate, refugia, etc.
7) Selecting and Sizing Rehabilitation Works	Select potential schemes and structures that will be reinforced by the existing stream dynamics and geometry.
8) Instream Flow Requirements	Test designs for minimum and maximum flows, set target flows for critical periods derived from the historical mass curve.
9) Supervise Construction	Arrange for on-site location and elevation surveys and provide advice for finishing details in the stream.
10) Monitor and Adjust Design	Arrange for periodic surveys of the rehabilitated reach and reference reaches to improve the design as planting matures and the re-constructed channel ages.

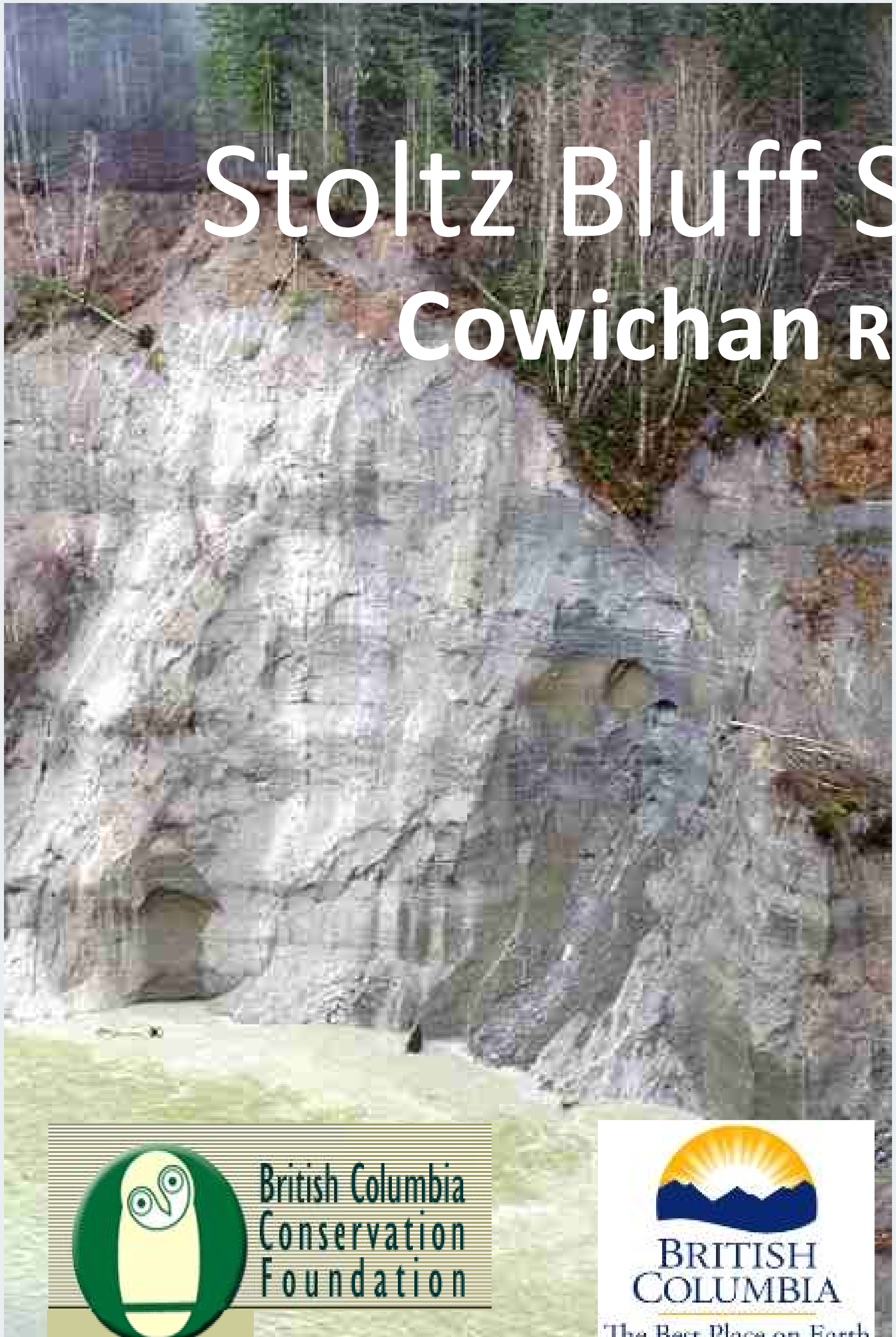
Biological Design Criteria - Fish

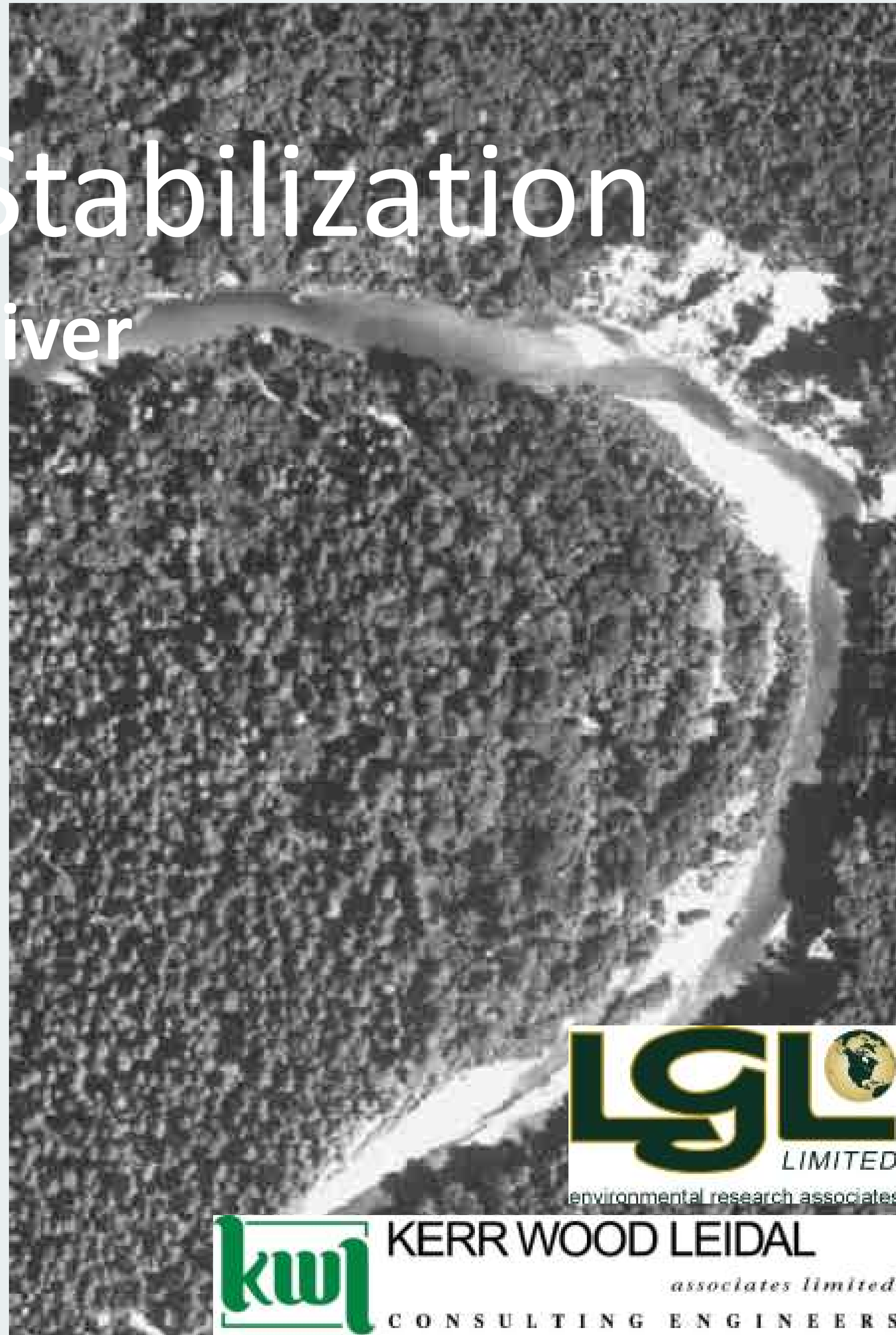
Criteria are Species & Life Stage Dependent:

- *Migration:* water velocity & depth, vertical drop, streambed slope
- *Spawning:* substrate size, sediment content, minimum water depths / flows
- *Rearing / Holding:* residual pool depth, riffle-pool-glide proportions, abundance & distribution of instream / over-stream cover

Stoltz Bluff Stabilization

Cowichan River





The Watershed

- Cowichan is a designated BC and Canadian Heritage River
- Annual economic value of fish resources est. $5-6M supporting FN, sport and commercial fisheries
- Principal species: fall chinook, coho and chum salmon, winter steelhead, resident rainbow and brown trout
- Winter steelhead sport fishery traditionally among top 3 on Vancouver Island

Stoltz Bluff is a deposit of glacial sediment (50 m high by 800 m long)

Biological Impacts

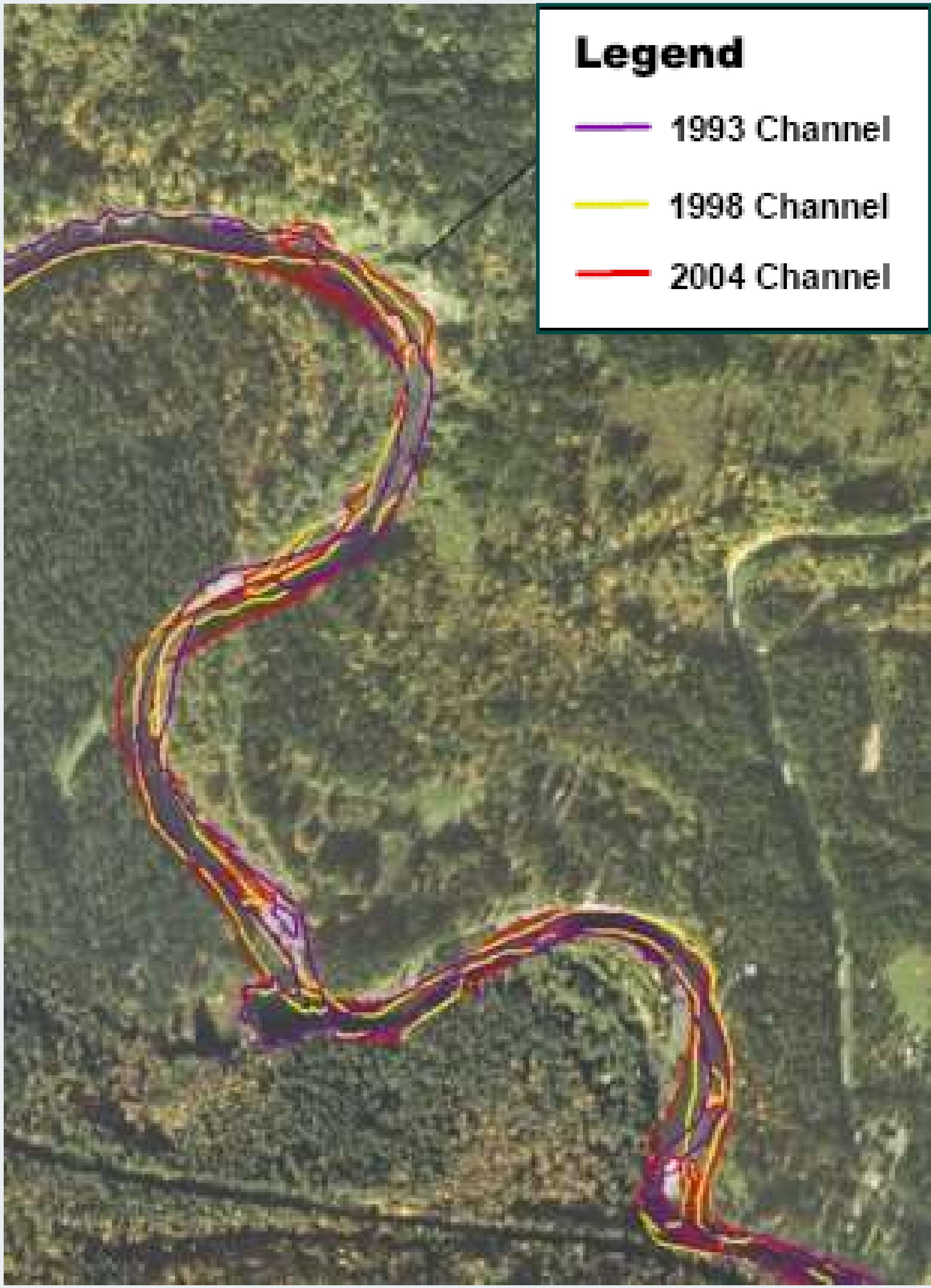
- "Paving effect" on stream substrates downstream of bluff
- Reduced salmon egg-fry survivals compared to upper river controls

- Sand infilling natural & enhanced side-channels
- Higher TSS/turbidity below Stoltz during winter months

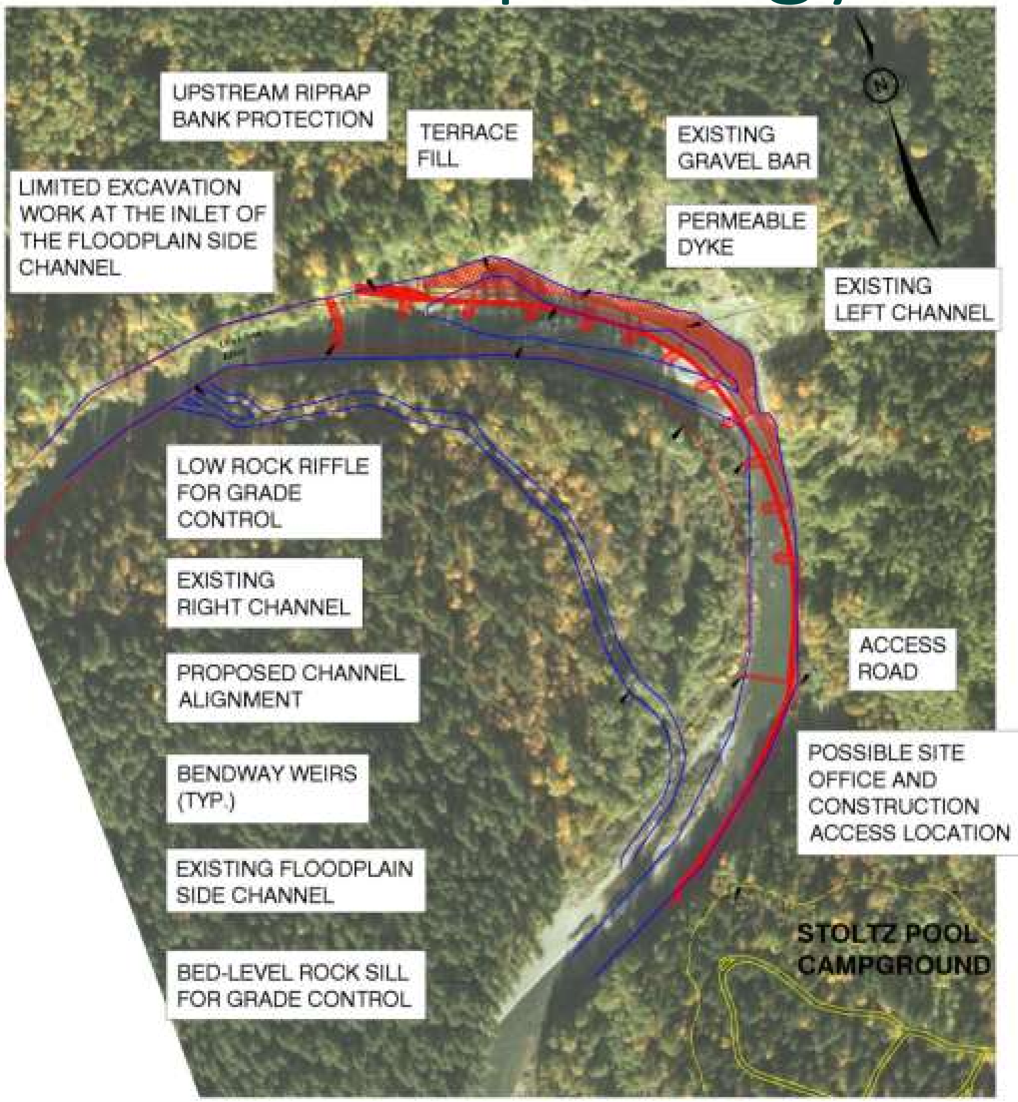
Geomorphic Assessment

- Determined erosion rates & annual sediment transport volumes
- Annual volumes ranged from 10,000 to 28,000 m^3/yr

NATURAL CHANNEL SYSTEMS
5th International Conference



Geomorphology



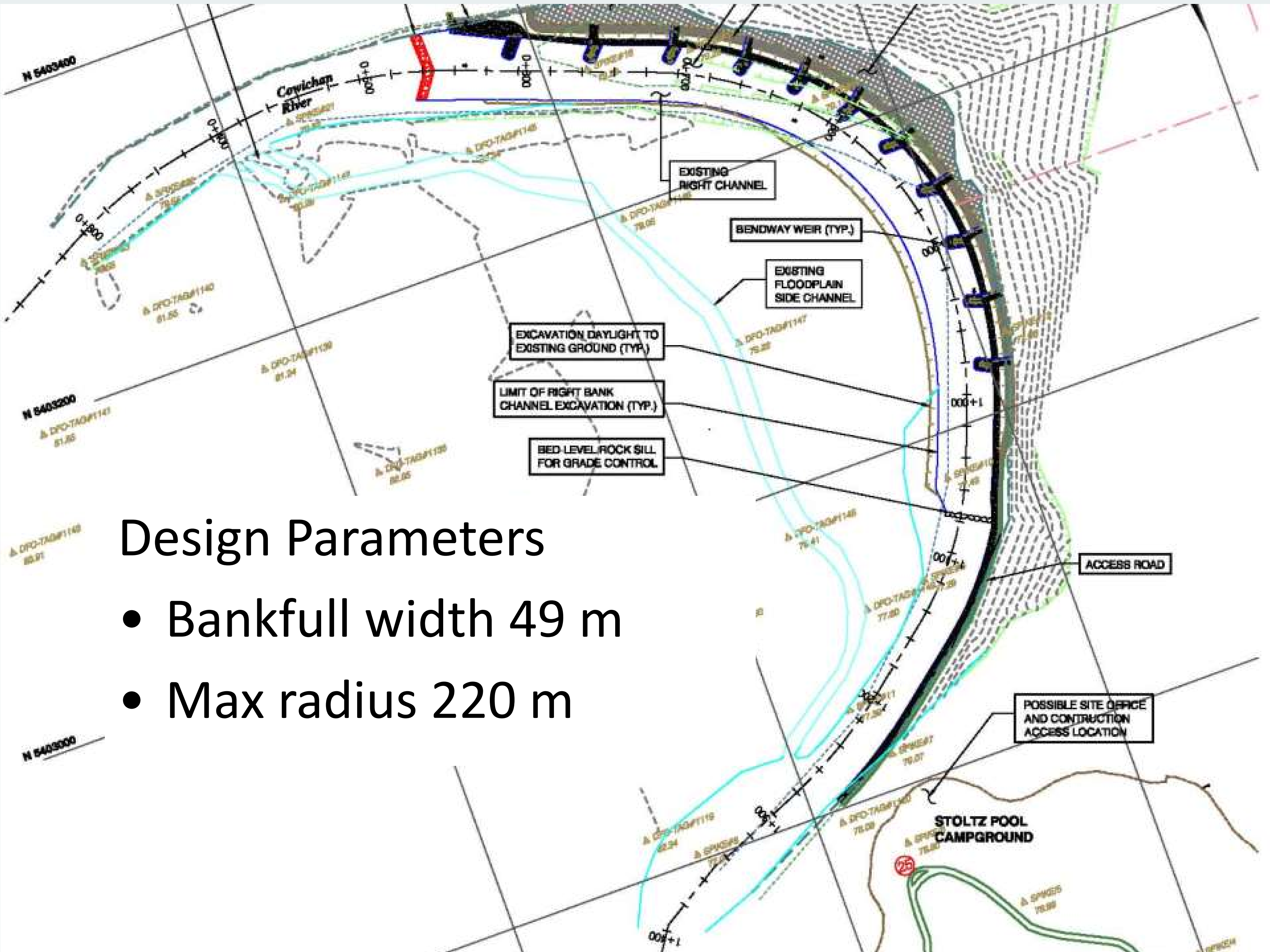
SITE PLAN

Design Criteria

- Reference meanders
- Maximum radius
- Bankfull width
- Gradient
- Roughness

Potential Impacts

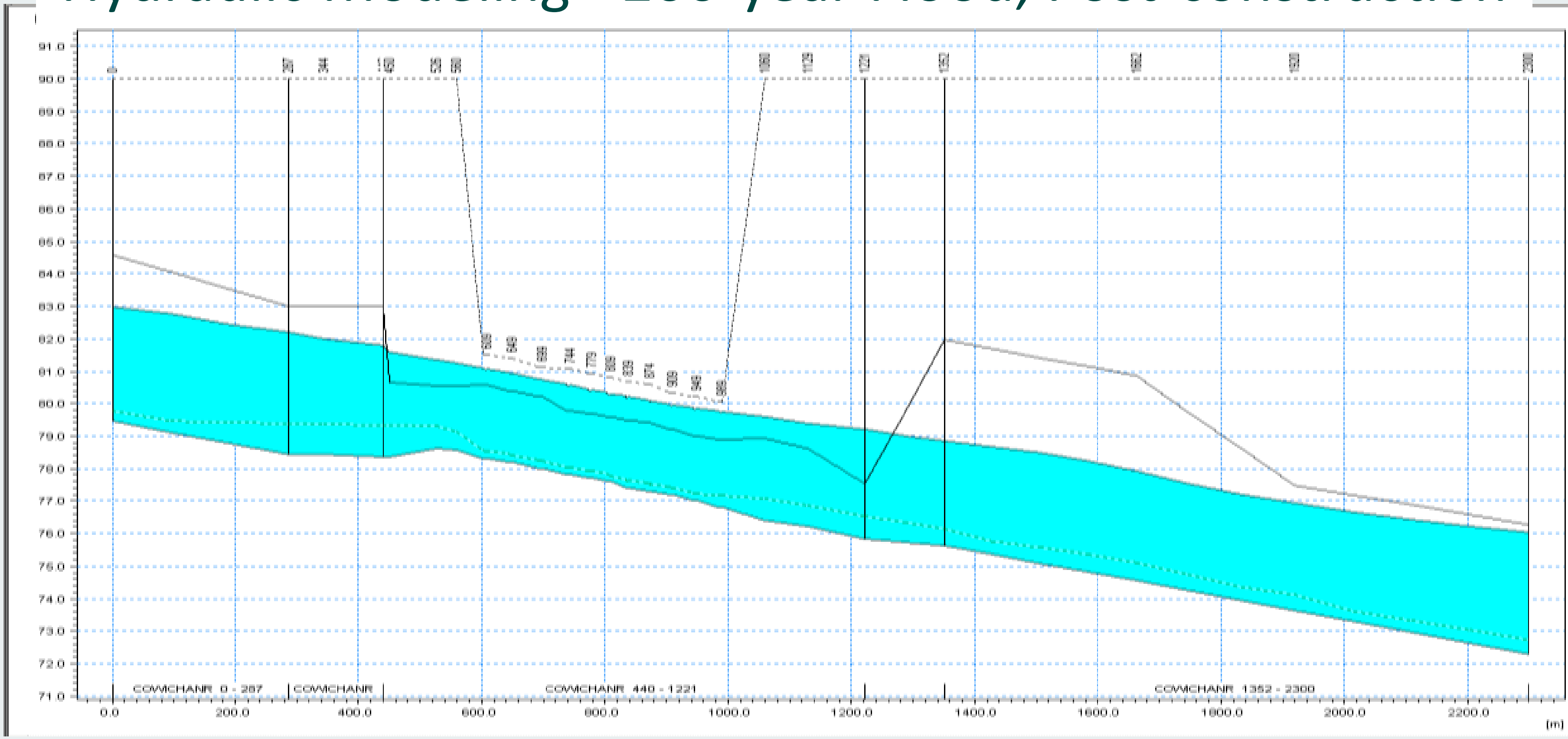
- Widening
- Decreased sediment
- Downstream bank & bed erosion

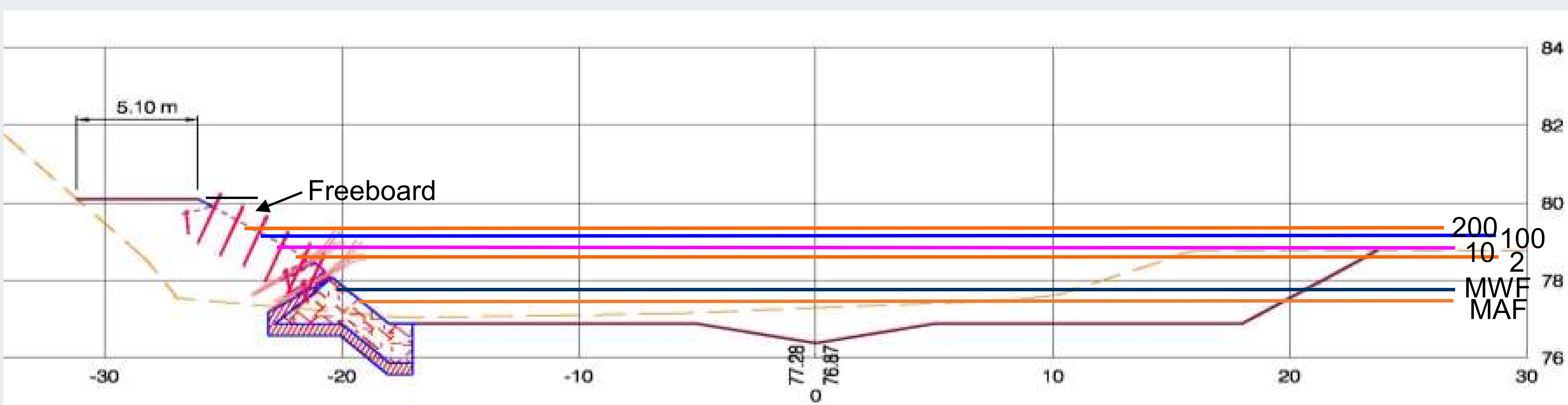


Design Parameters

- Bankfull width 49 m
- Max radius 220 m

Hydraulic Modeling - 200-year Flood, Post-construction





Excavation begins

Finished Bendway Weirs

NATURAL CHANNEL SYSTEMS
5th International Conference

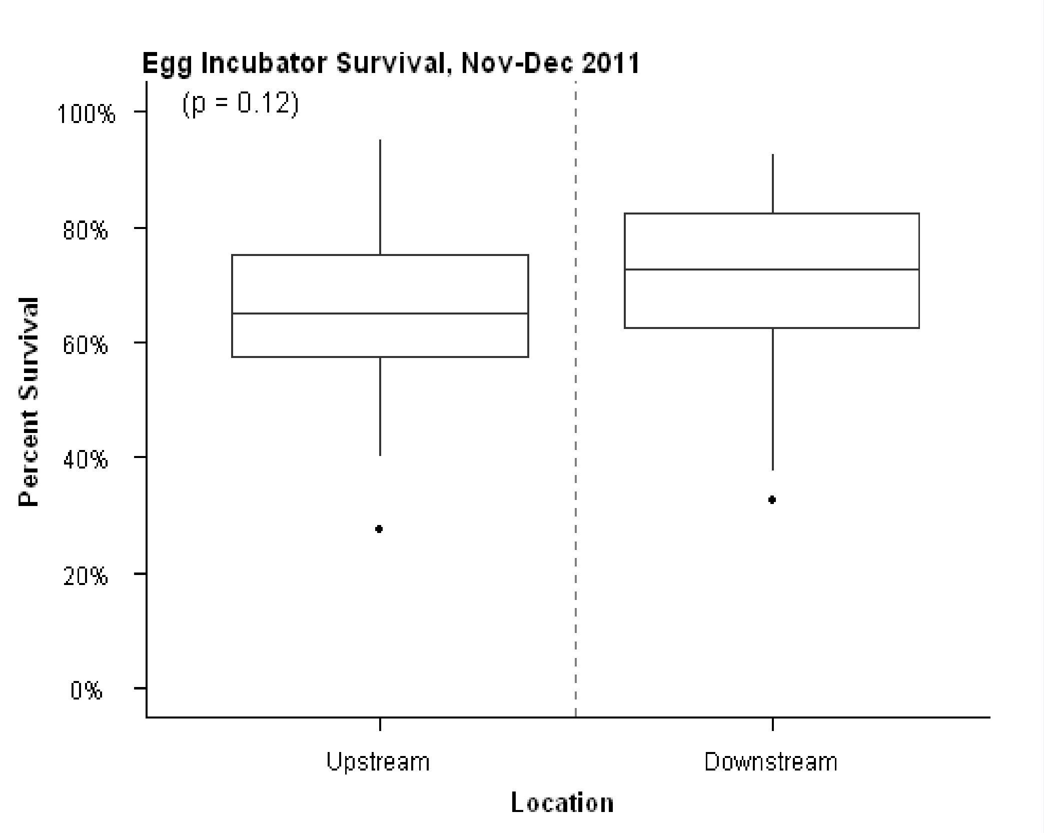
Stabilization Project Completed

Flow in new channel

Monitoring in 2010-2012 found contributions from Stoltz Bluff were reduced from ~15,000-22,000 tonnes/yr to ~1,000 tonnes/yr

Egg Incubation Survival

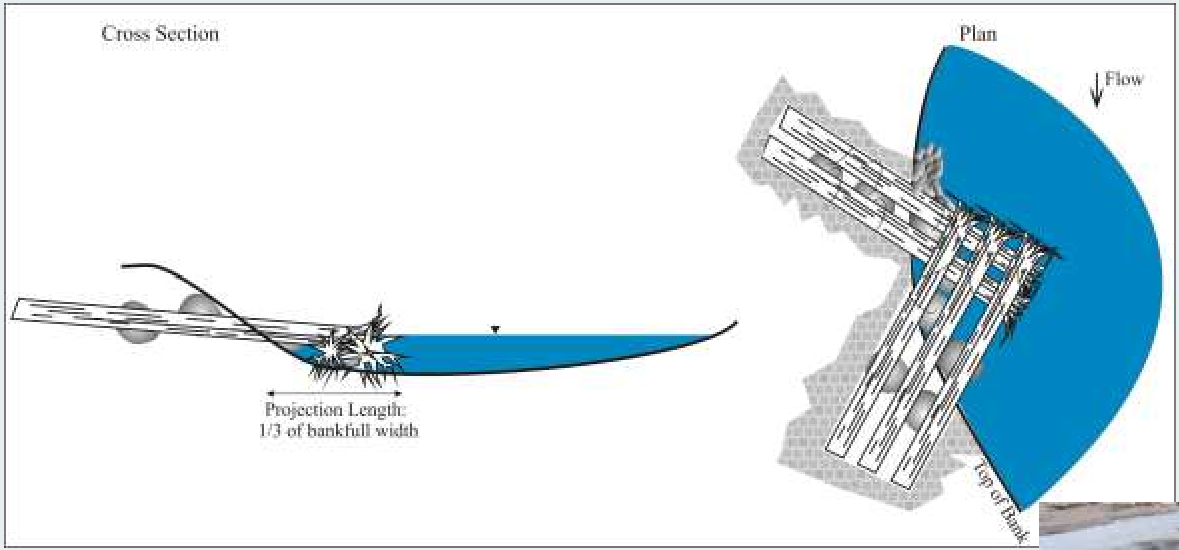
- For 2011 & 2012 Chinook egg incubation periods, egg survival did not differ significantly upstream versus downstream of Stoltz Bluff



Riparian Loss Affecting Channel Morphology and Aquatic Habitats

- Riparian trees and shrubs eliminated
- Accelerated bank erosion rates
- Increased sediment transport contributing to aggradation, braiding, over-widening, pool in-filling & sedimentation of spawning gravels, decreased diversity of mesohabitats
- Lack of LWD recruitment

Embedded Log Cover Structure



Biological Objectives:

- Increased cover in pools
- Pool scour & >1 m residual pool depth
- High quality spawning gravel in pool tail-outs

Series of Deflectors Along Bank

LWD structure spacing of ~4 times projection length offers some bank protection

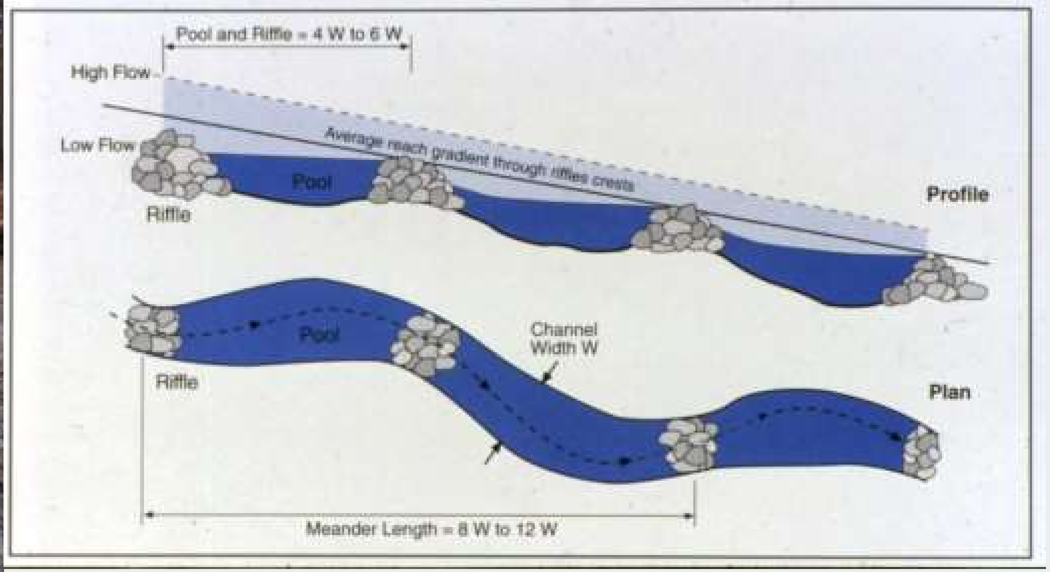
LWD Structures - Nicola River

Current Challenges:
Tailings Dam Breach Impacts Creek Corridor

Channel & Riparian Impacts

- Flood wave from breach scoured the creek channel changing its planform and proportions of riffle, pool and glide habitats
- All of the riparian vegetation was removed

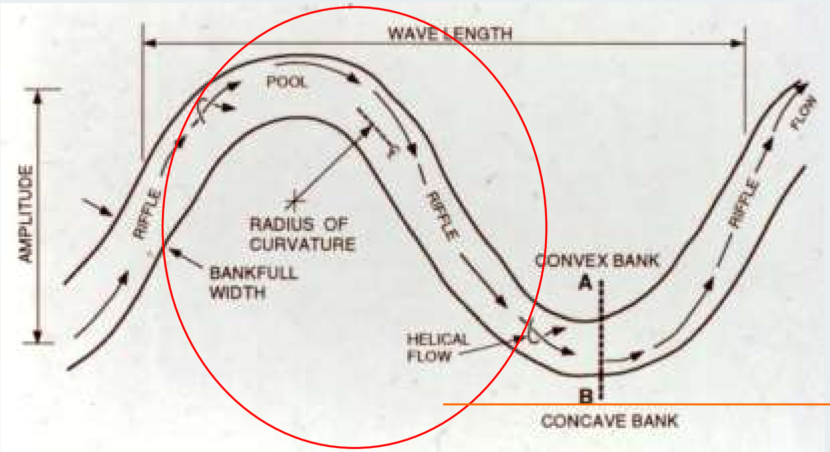
Rehabilitation Design Fundamentals

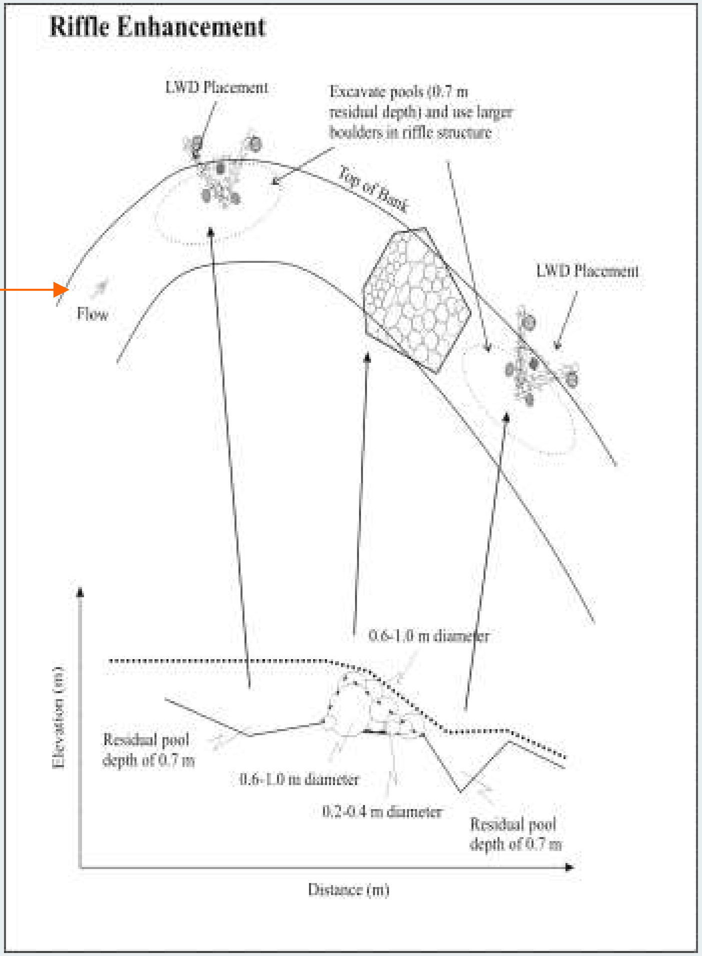


- Channel Planform & Streambed Profile to establish Riffle-Pool-Glide proportions
- Instream cover - design and siting of structures in appropriate mesohabitats

Rehabilitation Design Fundamentals

Riffle Siting





Rehabilitation Design Fundamentals

- Instream cover - design and siting of structures in appropriate mesohabitats

Rehabilitation Design Fundamentals

- Channel & Floodplain connectivity & flood capacities
- Substrate sizing to ensure stability during floods

Stages of Creek Rehabilitation


9 August 2016


8 September 2016


8 September 2016


11 August 2016


Wandse Creek, Germany
Channelized Streams – The Oxbows of Tomorrow