Andrew Peters, Director of Markets and Applications
Pacific Netting Products
Kingston WA. USA 360-297-0858

Fish Passage and River Connectivity Barriers

- Anything that hinders any life stage of fish and other aquatic organisms, energy and inert matter from moving through a waterway.
  - Cultural
  - Physical barriers: dams and deteriorating culverts.
  - Environmental / biological barriers: water velocity, temperature, quality, predators, upstream habitat.
  - Technical barriers: materials, engineering and know-how
- Restoration of connectivity of freshwater habitats throughout the historic range of anadromous fish requires a coordinated approach.

Technical Developments in Materials and Designs for Improved River Connectivity

Guidance, Collection, Exclusion, Separation

of

Fish, Debris & Water Quality


River Connectivity: Technical, cultural and biological aspects of
fish passage and reintroduction

ULTRA-MODERN FISH FINDING ELECTRONICS

SALMON * TUNA * HALIBUT

SPEND A DAY TO REMEMBER

ON THE 50 FOOT

Riviera

CAPTAIN ANDREW PETERS

CACHALOT CHARTERS

P.O. BOX 348 WESTPORT, WASHINGTON 98595
FOR RESERVATIONS PHONE (206)268-6323
TOLL FREE DURING SEASON 1-800-562-0141

Man has been trapping fish throughout our recorded history.

Man has been trapping fish throughout our recorded history.

Man has been trapping fish throughout our recorded history.

Heart shape trap,
Marshal Islands
….(note the long “lead”)

Man has been trapping fish throughout our recorded history.

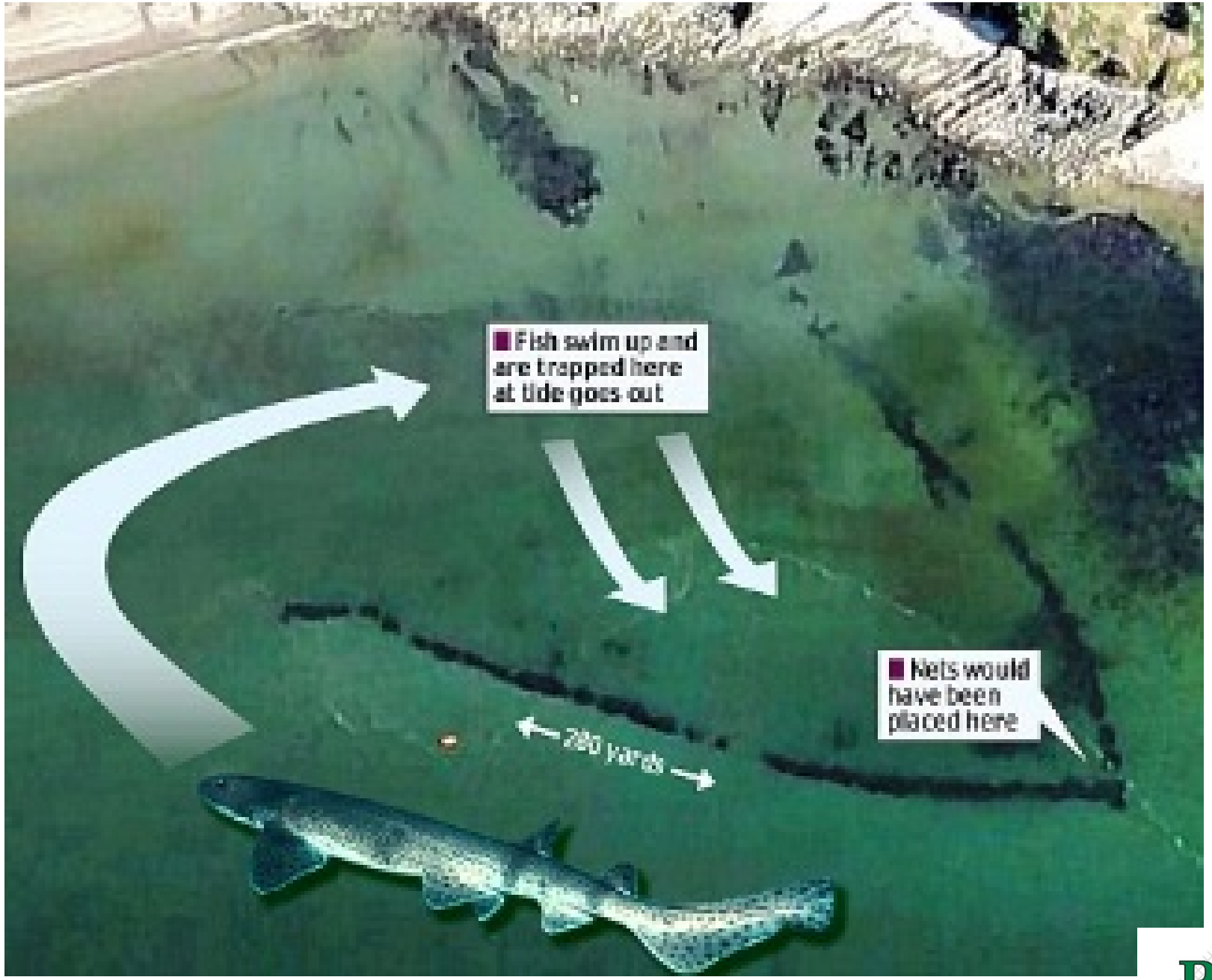
Double heart shape trap west of Taiwan

(note the lead and exclusion barrier)

Man has been trapping fish throughout our recorded history.

Ancient “V” shaped trap

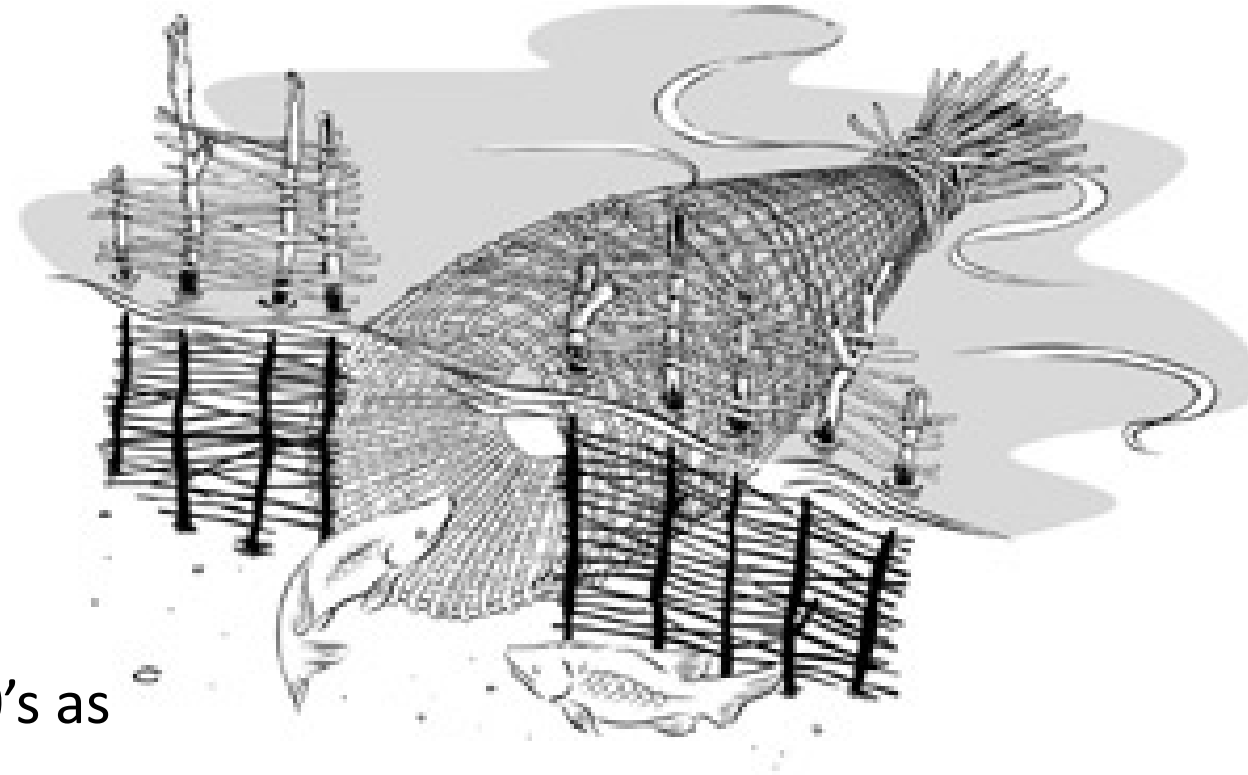
Teifi Estuary in Wales.



Over the years…

Wood Rocks

Hemp Jute



Source: National Science and Technology Centre, Australia

Romans made concrete by mixing lime and volcanic rock to form a mortar.
Synthetics Fiber: 1st invented in the mid 1800's as filament for a light bulb.
Nylon and Polyesters during the 2nd World War

Todays Materials

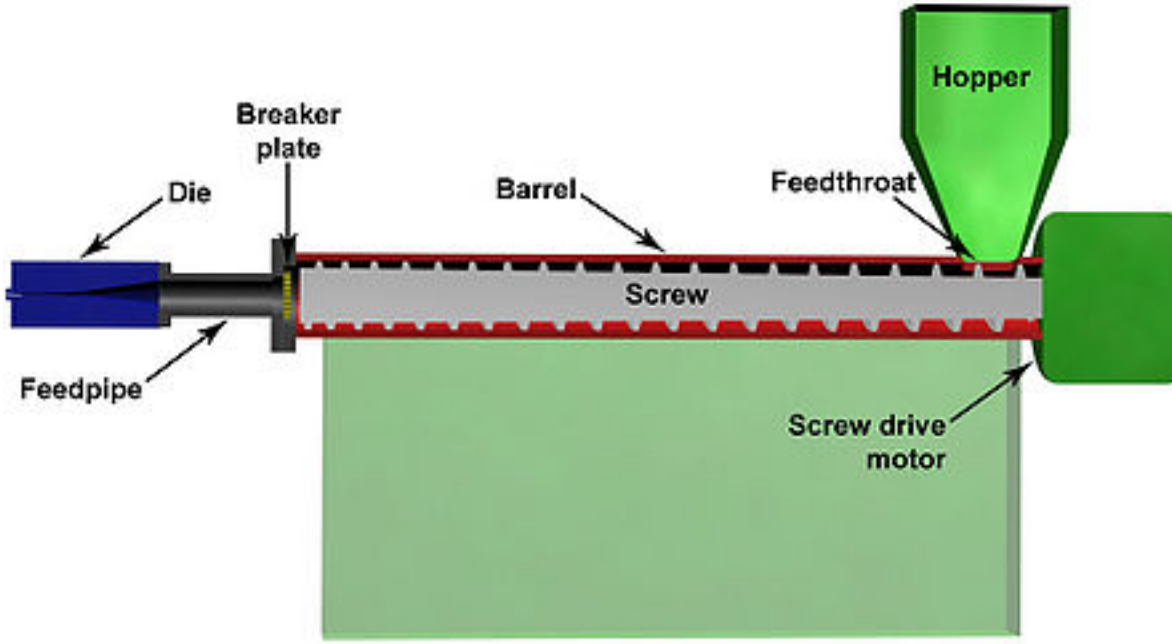
UHMWPE	Ultra-High Molecular Weight Polyethylene Invented in 1963 (Albert Pennings) Commercially available in 1990 (DSM). Brand Names: Dyneema, Spectra, Plasma *The* material for netting, ropes, anchor lines
HDPE	High Density Polyethylene Invented in 1953 (Karl Ziegler, Nobel Prize, Chemistry 1963) First commercial use in 1955 as pipe. *The* material for booms, flotation, docks.

Key Features

Allows facilities a solution for fish guidance previously unachievable

- Does not decay or absorb water
- Excellent UV resistance
- Excellent fatigue and predator resistance
- Excellent material for lowest adhesion of zebra mussels and other marine growth
- Smooth to the touch
- Durable, Reliable
- High abrasion resistance
- Low drag
- Greatly reduce surface area
- Long lifespan

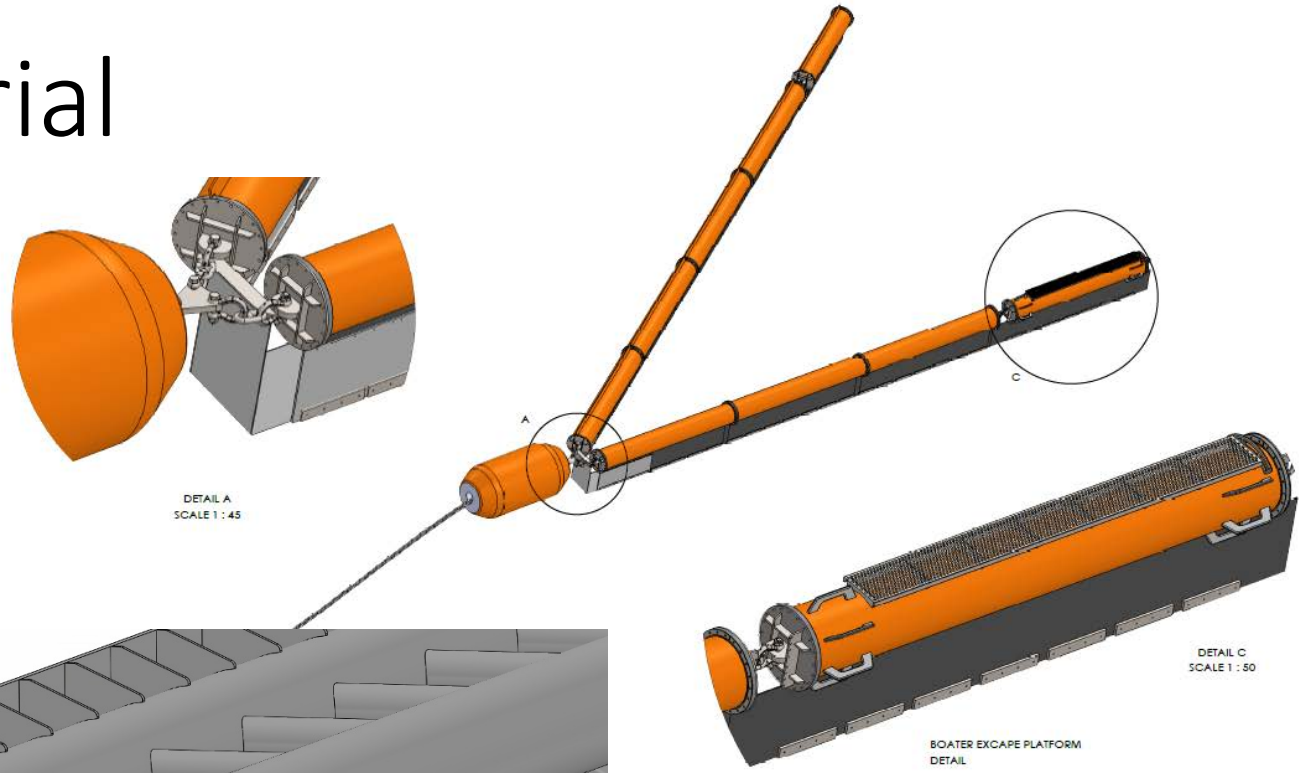
Custom Extruded HDPE

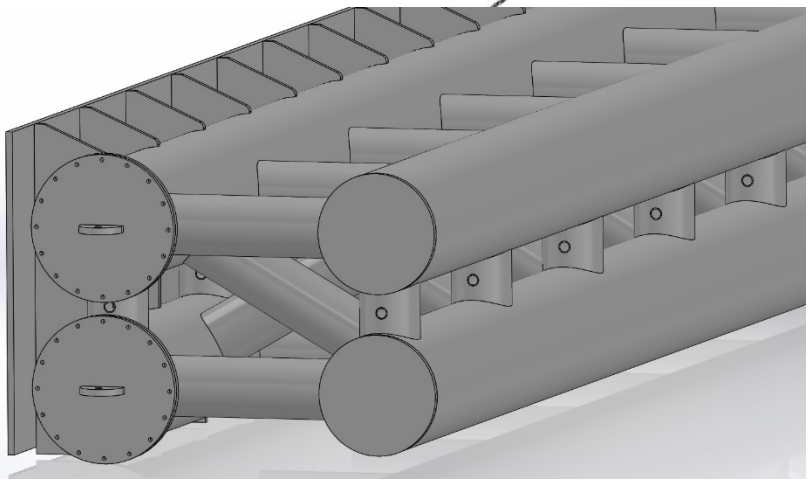


A different kind of material

Material Benefits

- ✓ Can be used to construct a variety of marine structures
- ✓ Capacity for high deformation without fracture (great for ice, or impacts)
- ✓ Long services life, low maintenance
- ✓ Very adaptable



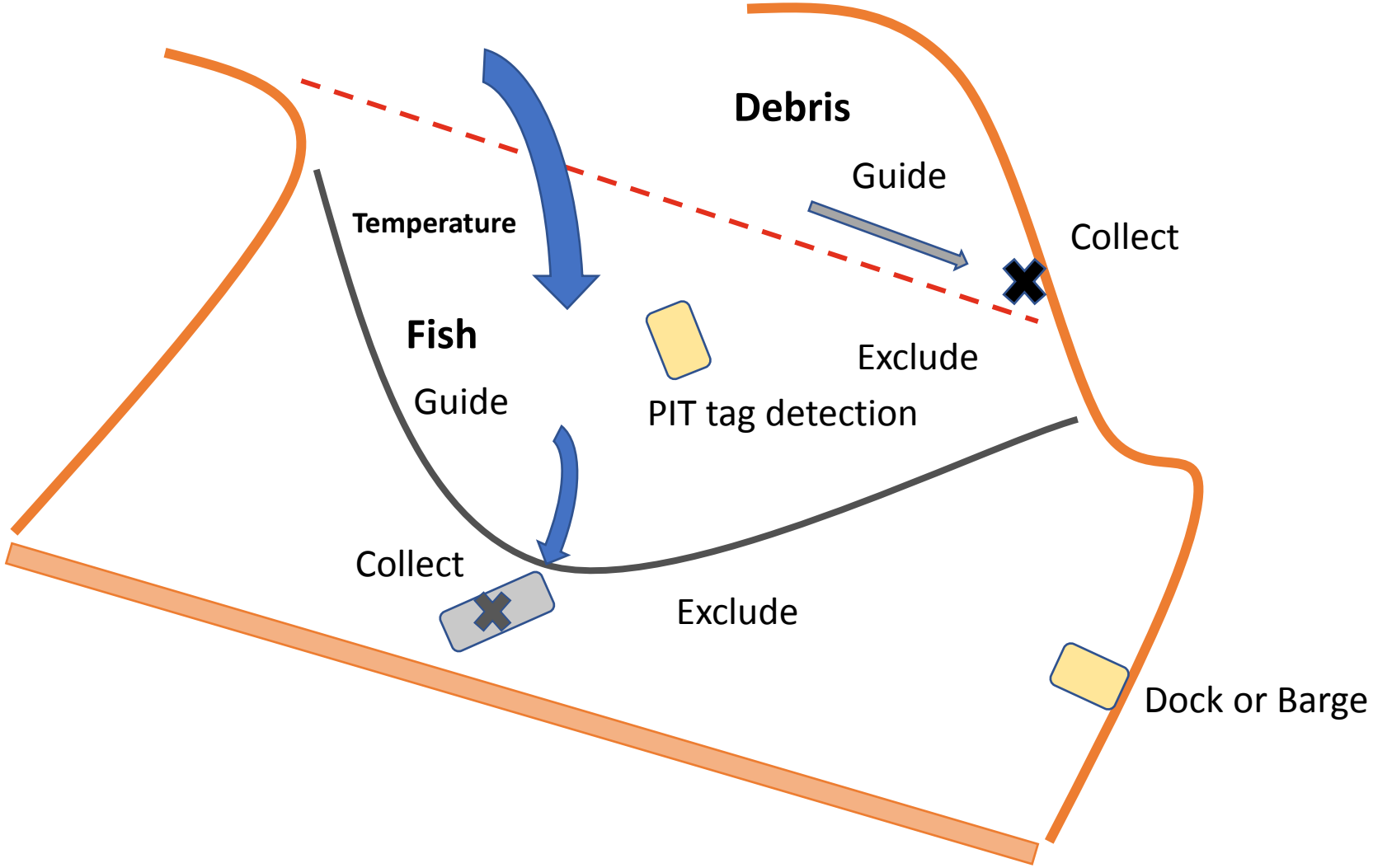


PNP
PACIFIC NETTING PRODUCTS

Benefits of both materials combined

In aquatic environments these materials used to:

- ✓ Guide
- ✓ Collect
- ✓ Exclude
- ✓ Transport
- ✓ Attenuate
- ✓ Separate
- ✓ Float



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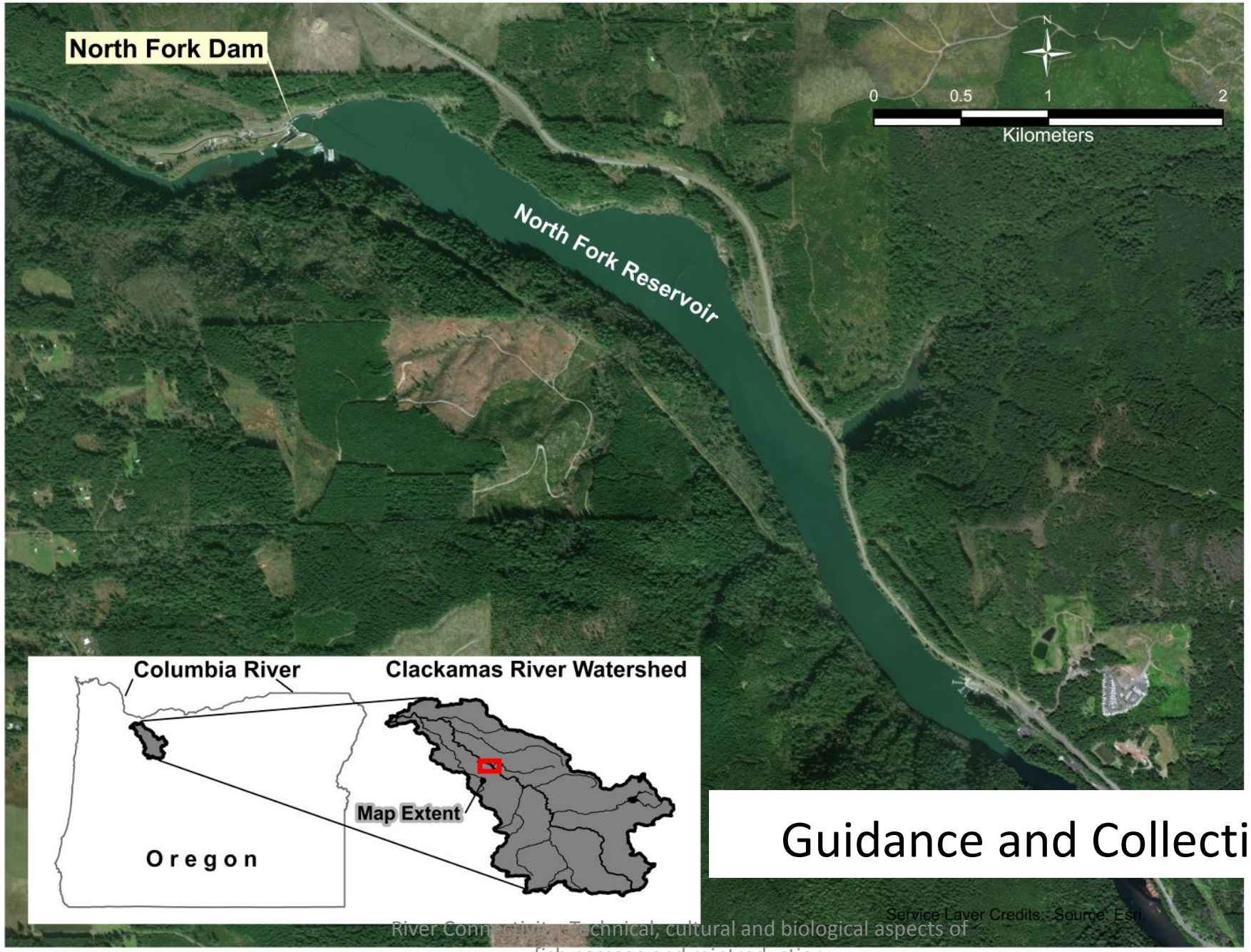
PNP PACIFIC NETTING PRODUCTS INCORPORATED

Downstream Fish Passage

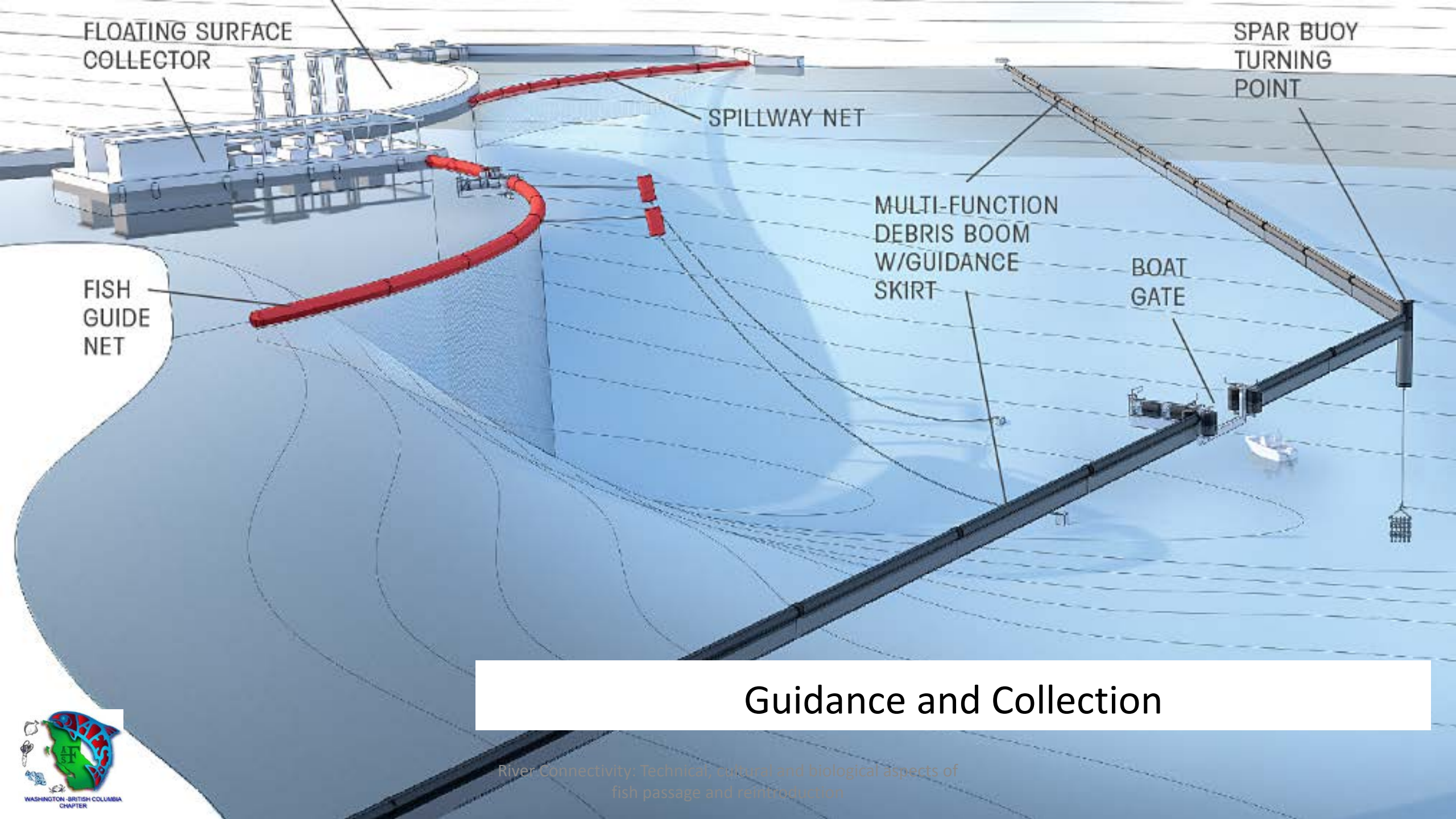
- Full exclusion guide net allows only one way out for downstream migrating fish
- Guide net acts “as an extension of the shoreline”..
- Currents guides fish to net transition structure (NTS) and floating surface collector (FSC) for site specific handling.
- Full exclusion net prevents entrainment and impingement
- Installation fits bathymetry of specific site

Guidance and Collection

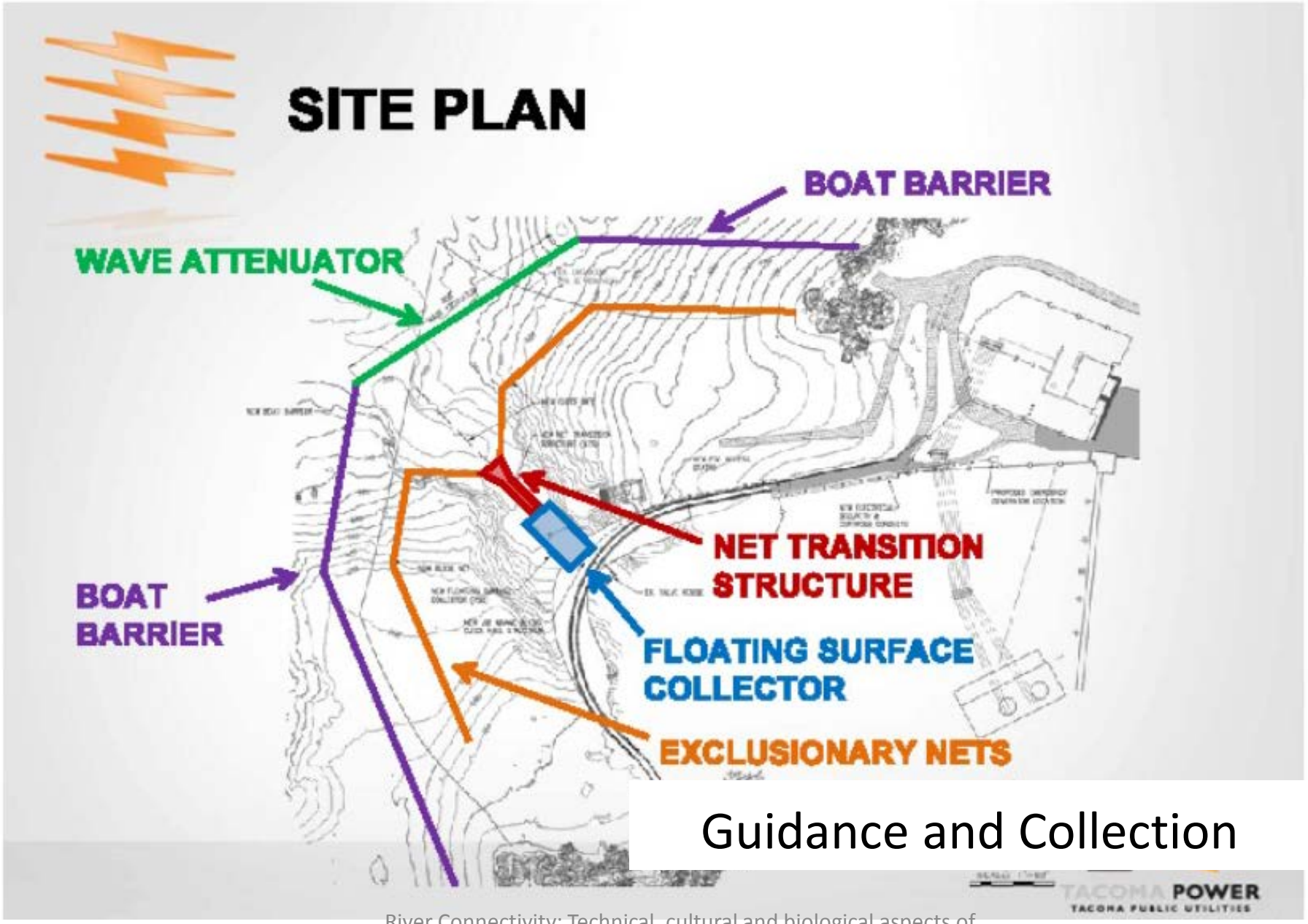


Guidance and Collection


FSC
1,000 cfs
Est. Fall 2015
Spillway exclusion net
Est. 2013
Migrant Collector
250 cfs
Est. 1958
Guidance and Collection



Guidance and Collection



Guidance and Collection

Not passage, but exclusion…

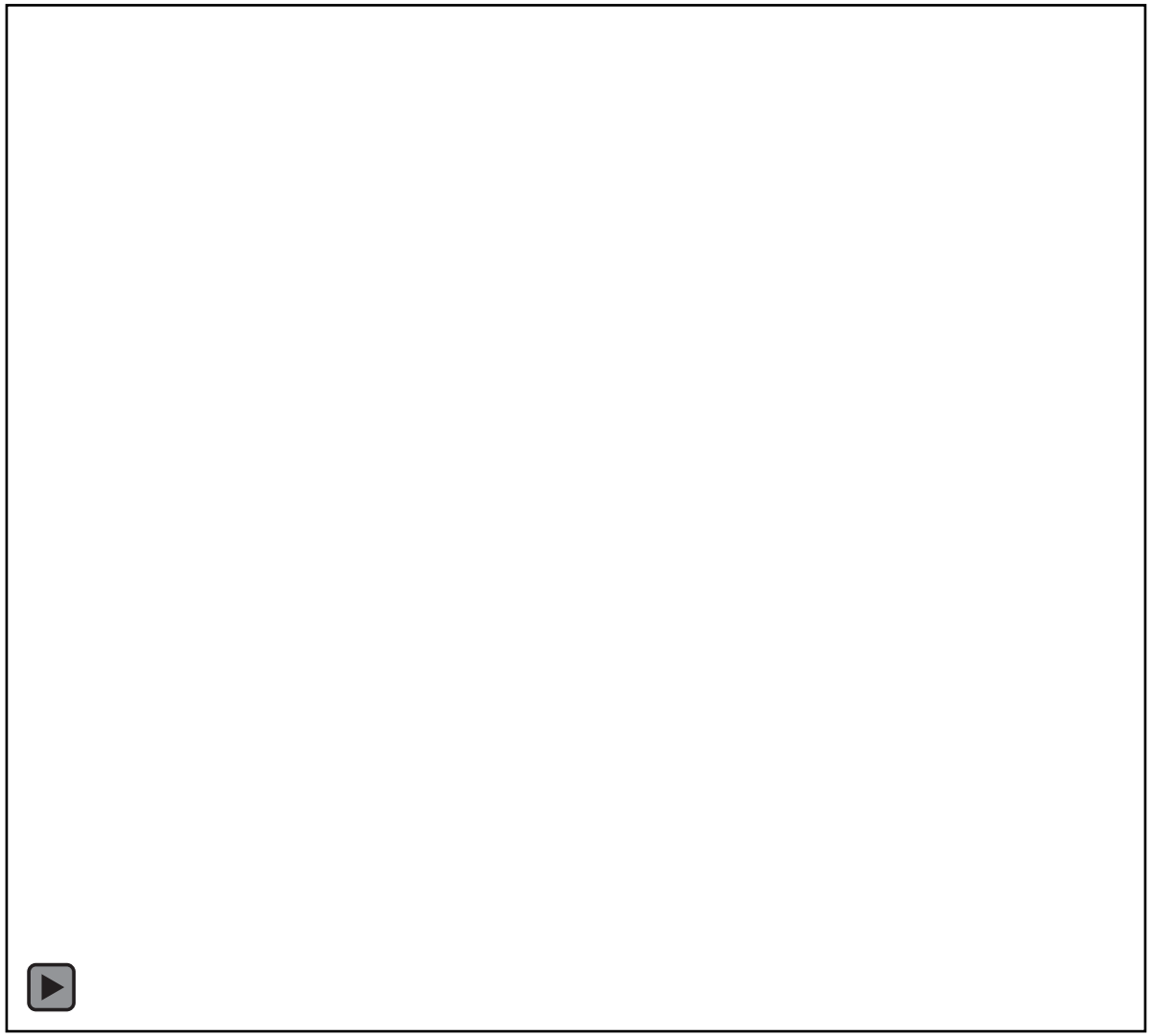
Consumer's Energy, Ludington Michigan

- Longest Full Exclusion Net in the world
- 2.5 mile long, 55 ft. average depth 650,000 sq. ft.
- 2 billion cubic ft. of water per hour flow through it during operation.
- Seasonally deployed, continuously cleaned during deployment, and 20% of net replaced annually to maintain effectiveness.

Exclusion

Designed for:

- Ocean-like conditions, rolling surf and winds and high water flow velocity
- bi-directional currents with water flow velocities up to 5.0 fps
- With net floats that reduce load while still maintaining shape, position and effectiveness.



Exclusion

Prevents entrainment and impingement

- Full Exclusion Net, Ameren UE Bagnell Dam
- Designed to protect adult paddlefish and other critical species from passing through facility turbines.
- Fail-safe deployment as close as 10 feet from the nearest turbine intake.
- 1,200 ft. long / 120 ft. deep
- Designed for periodic reverse directional currents
- Water flow velocities: 1.0 to 3.4 fps

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Exclusion

Invasive Species

Fish exclusion barrier to prevent downstream migration of non-native species
Consisting of both a MultiFunction Boom™ for protection from debris and ice boom and an exclusion net.

Exclusion

Invasive Species

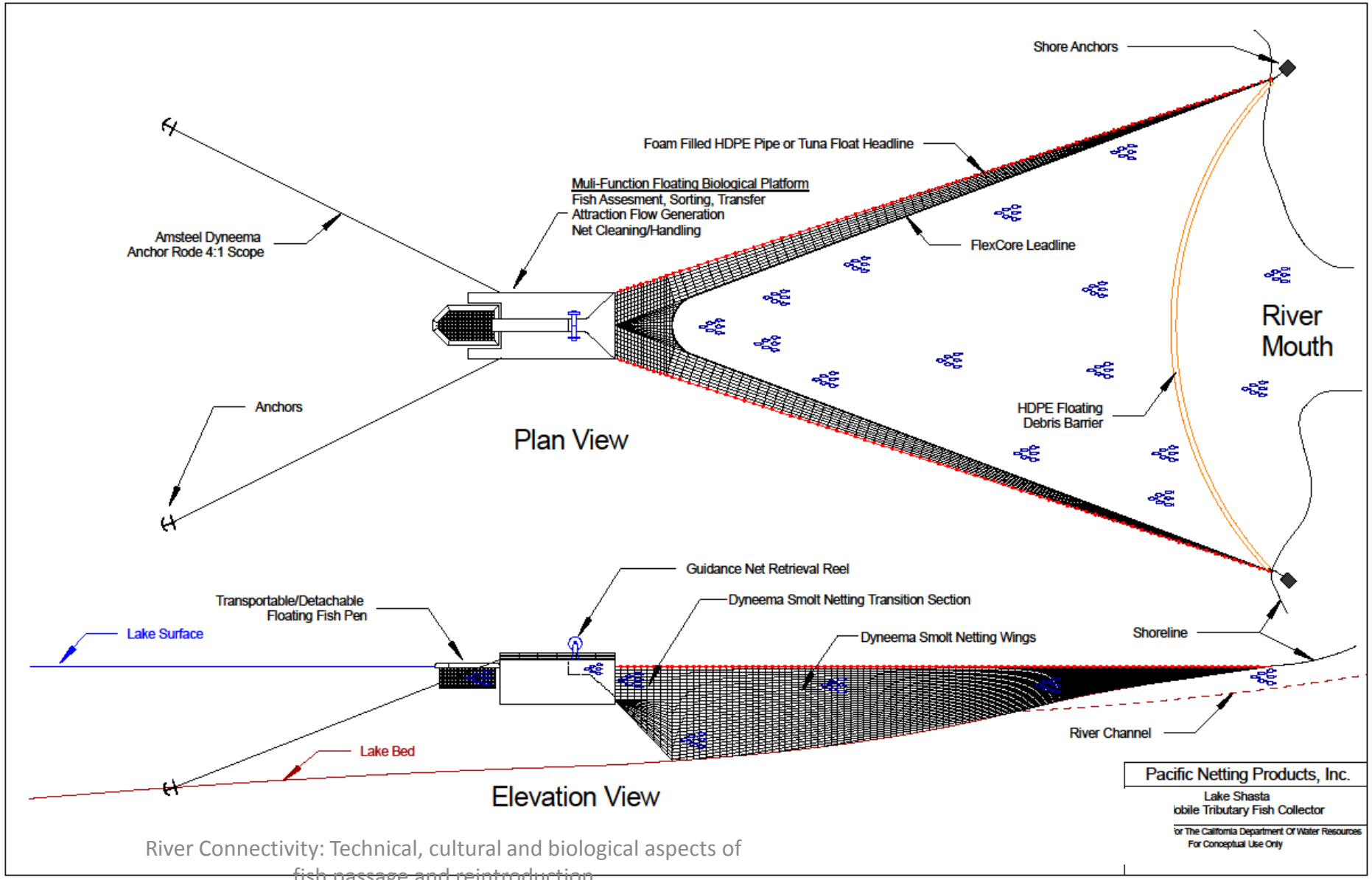
Elkhead Lake, Colorado.
Boom: 800 feet of 24inch Class 1 Material
Exclusion net: ¼ inch Dyneema fiber, 540 feet long, 31 feet deep

Exclusion

Head of Reservoir Fish Collection

Fish Collection doesn't have to be at the dam

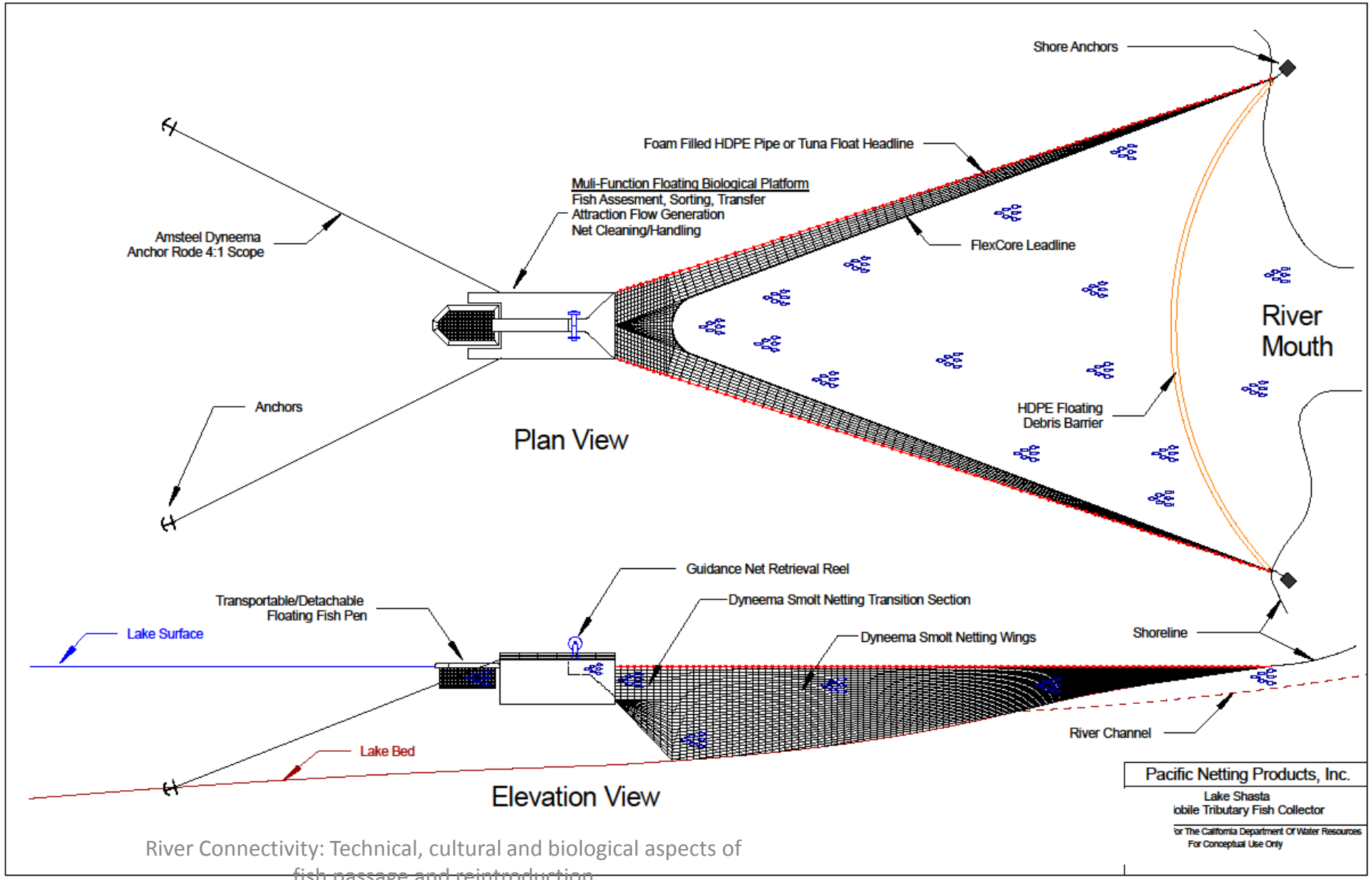
- ✓ Portable and seasonally deployable.
- ✓ Nets reels ease set and retrieval, cleaning and maintenance.
- ✓ Effective at different sites.
- ✓ Debris controlled by a boom incorporated in design or placed up river.



Head of Reservoir Fish Collection

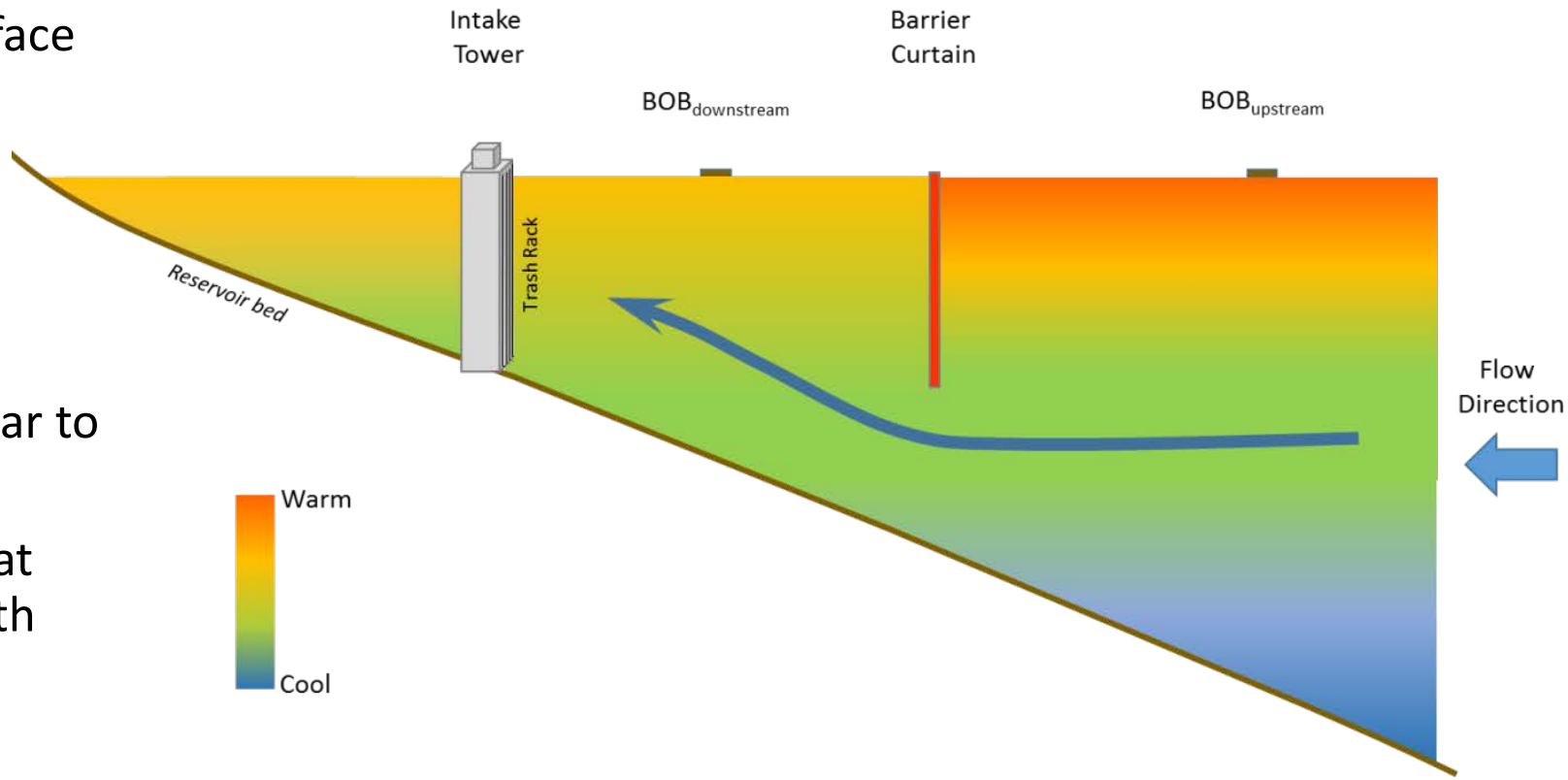
Fish Collection doesn't have to be at the dam

- ✓ Biological platform for fish assessment, agency or stakeholders needs.
- ✓ Attraction flow via river current.
- ✓ Transportable, floating fish pens, built of HDPE pipe and Dyneema netting.
- ✓ Cost effective, efficient and portable.

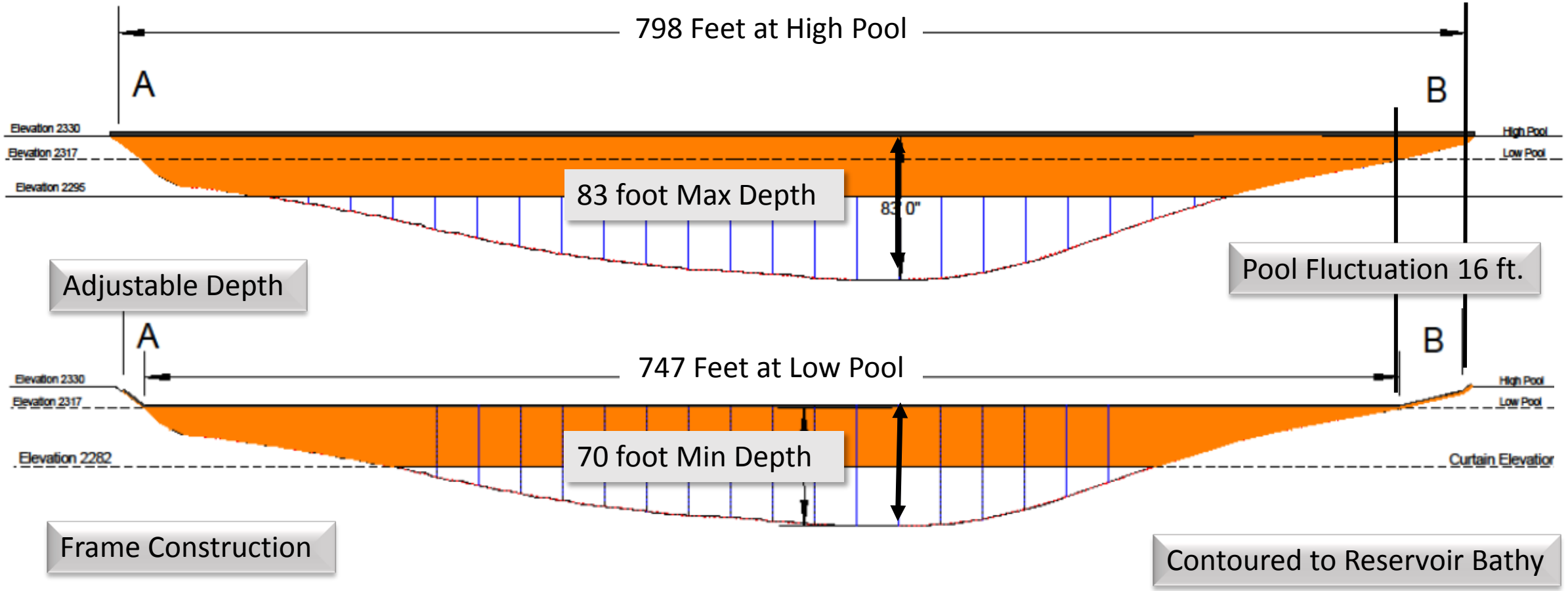


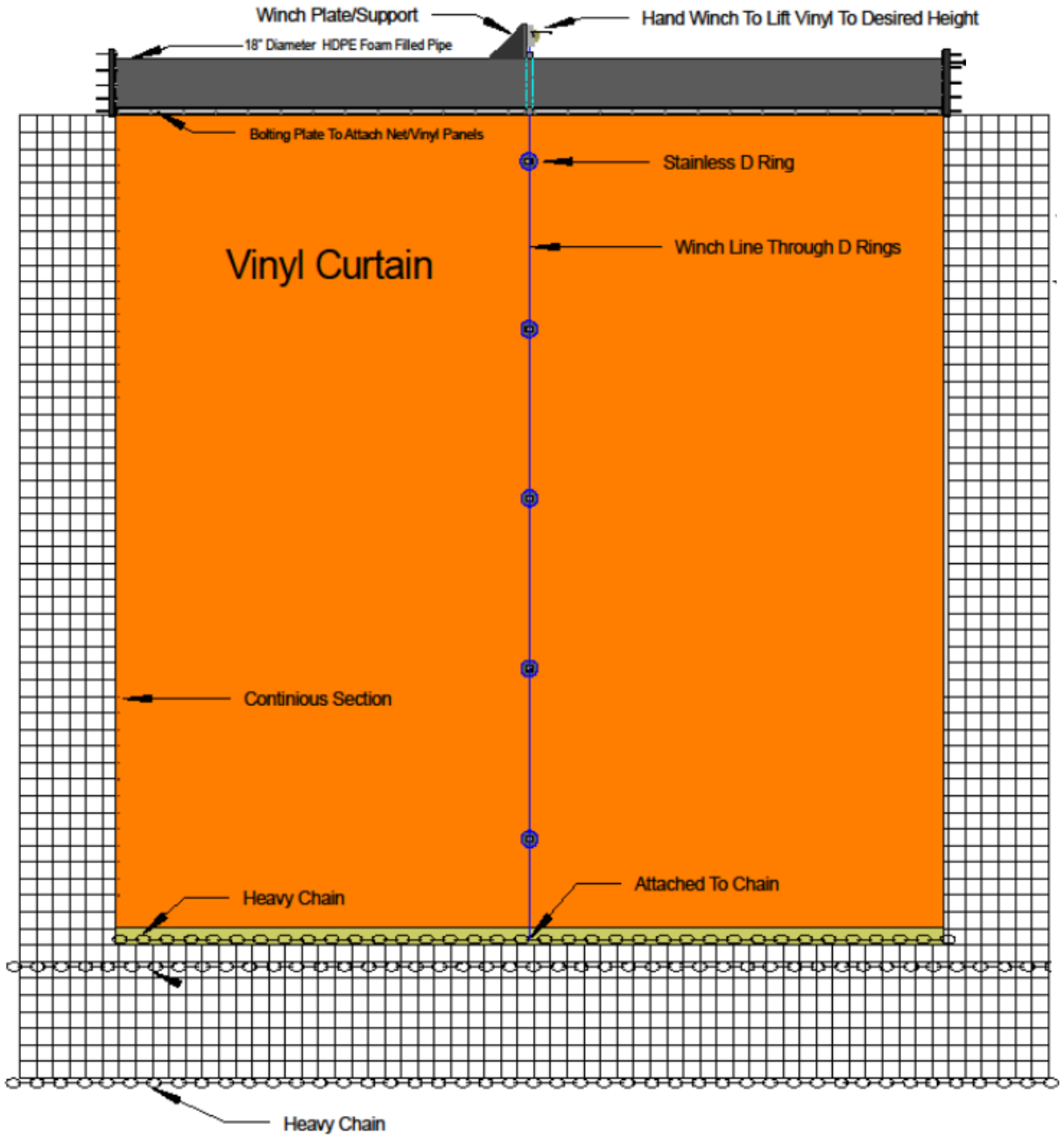
Control Temperature, Algae, Silt

- When stratification results in isolated, warmer, less dense surface waters
- A barrier curtain can effectively isolate and segregate the near-surface waters from the deeper waters.
- Downstream waters can be similar to deeper water upstream
- Demonstrated in an installation at the Iron Gate dam on the Klamath River



Curtain Design





Typical Barrier layout

Date: 1/15/2015	drwg# PC-IGD-004 Rev-0	Scale: None	Not For Constructio

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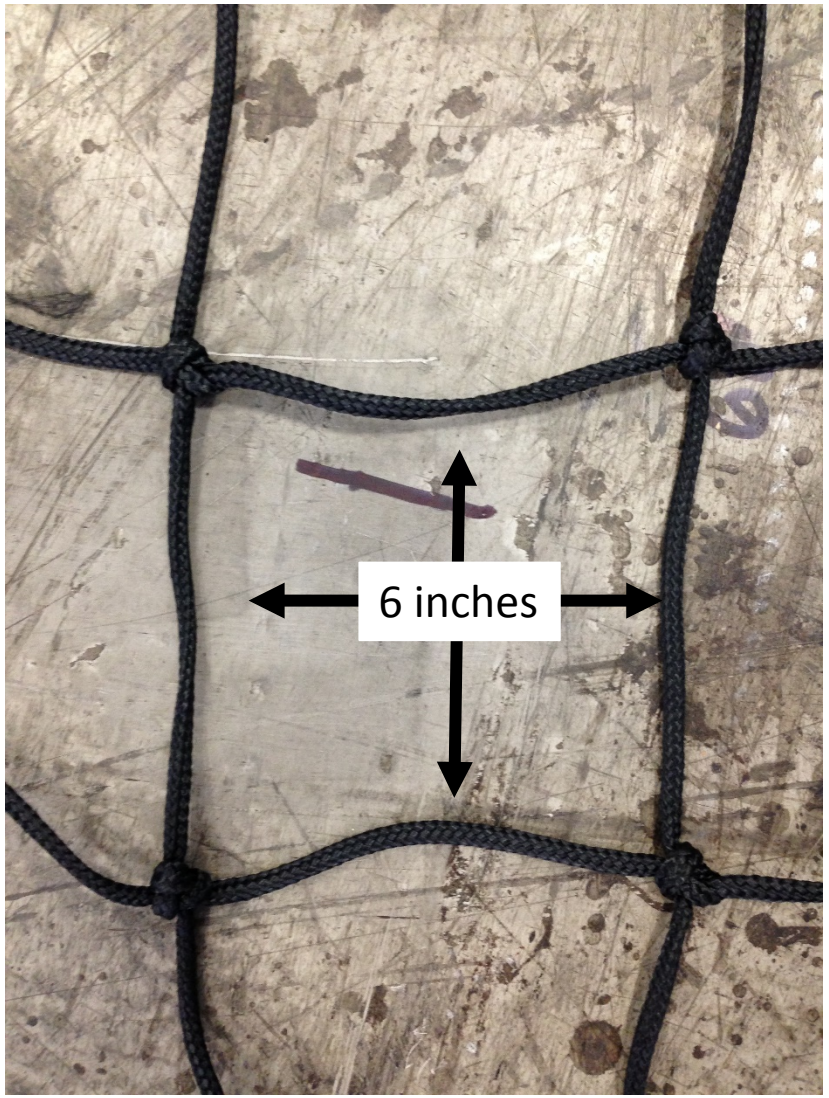
Strength and Shape:
Polyester Net, 6 Inch mesh



Impervious Surface

Seaman Corp. XR-5

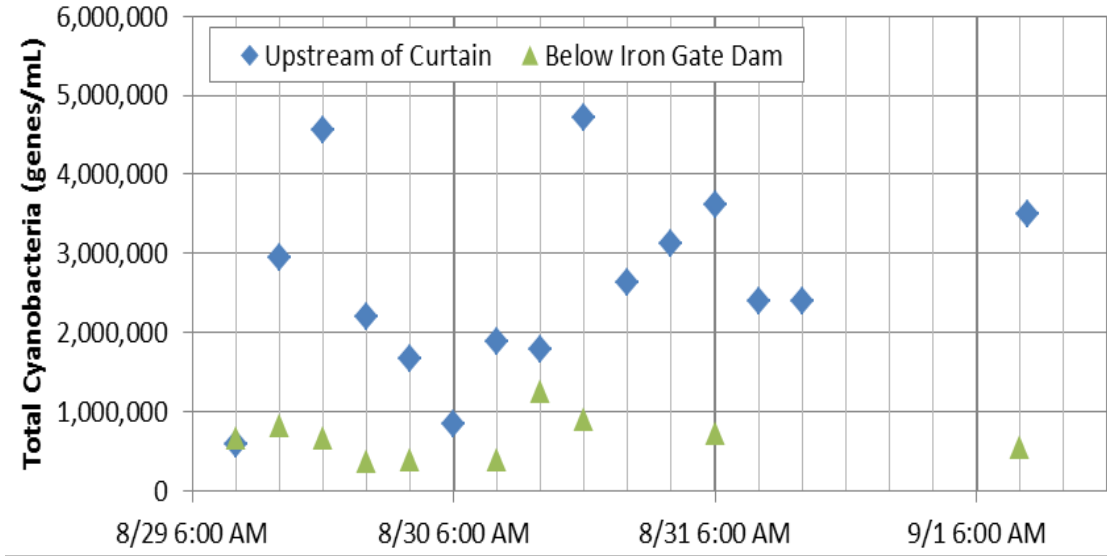
- Synthetic reinforced geomembrane
- High Puncture Resistance: 30 mil thick 868lbs
- Fabric inhibits damage spread if torn or punctured
- Flexible, prefabricated panels (15,000+ square feet) practical.
- Material is not subject to environmental stress cracking

Flotation and Anchoring

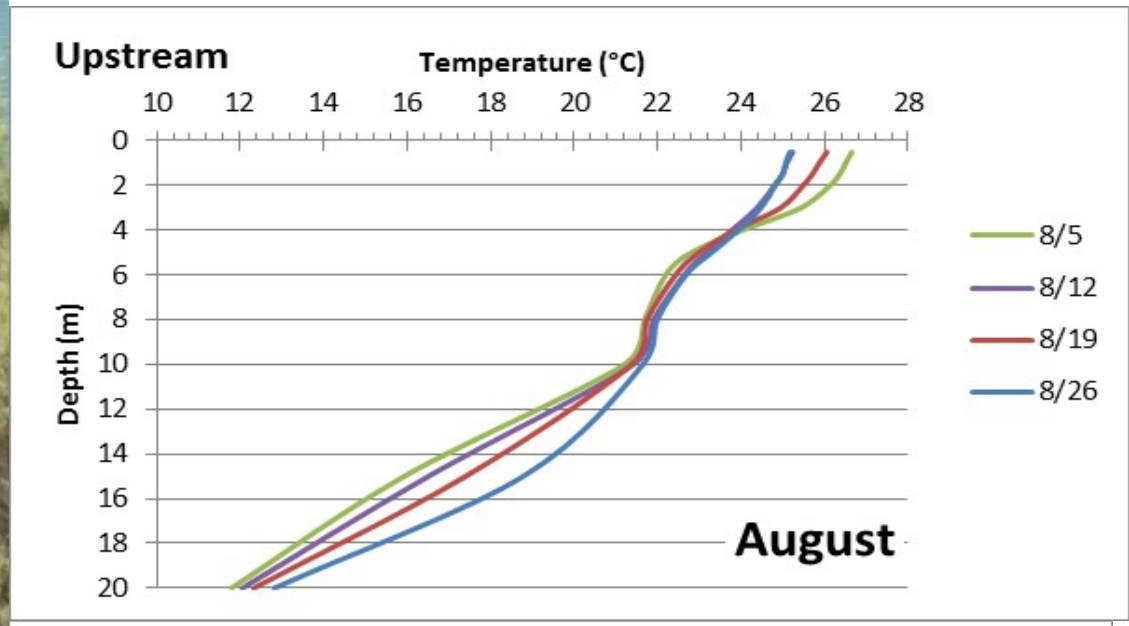
- Rigid float system.
- Each section flange bolted to the next to form a continuous boom
- Securely anchored in place.

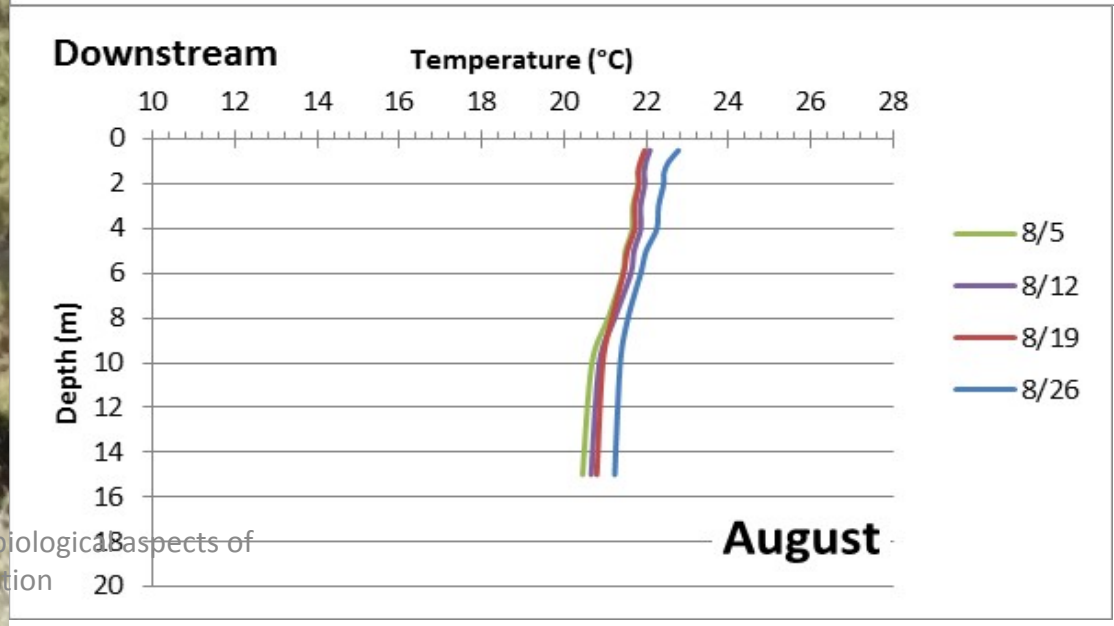
Flotation and Anchoring

Cyanobacteria & Microcystin consistently higher upstream of the curtain than those downstream of the curtain.

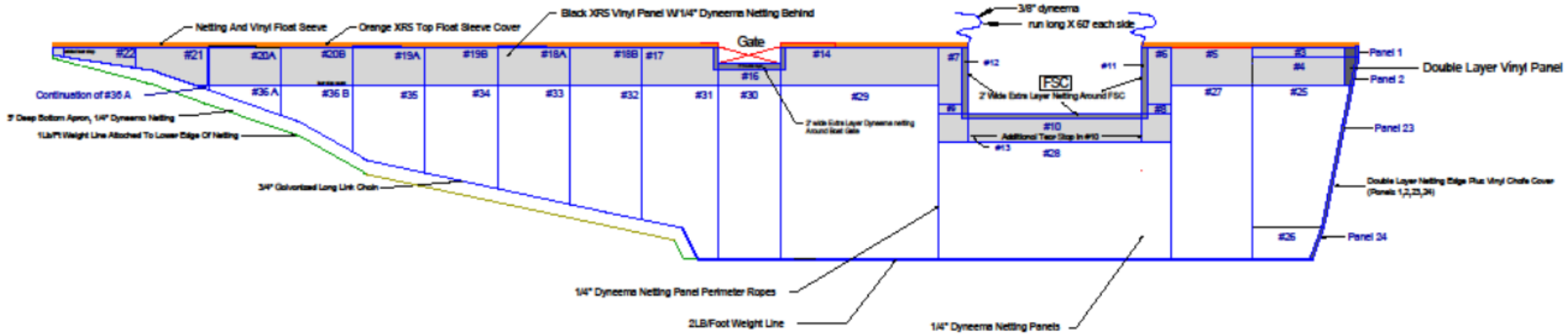


Thermograph shows less stratification downstream of the curtain.





Design and Construction

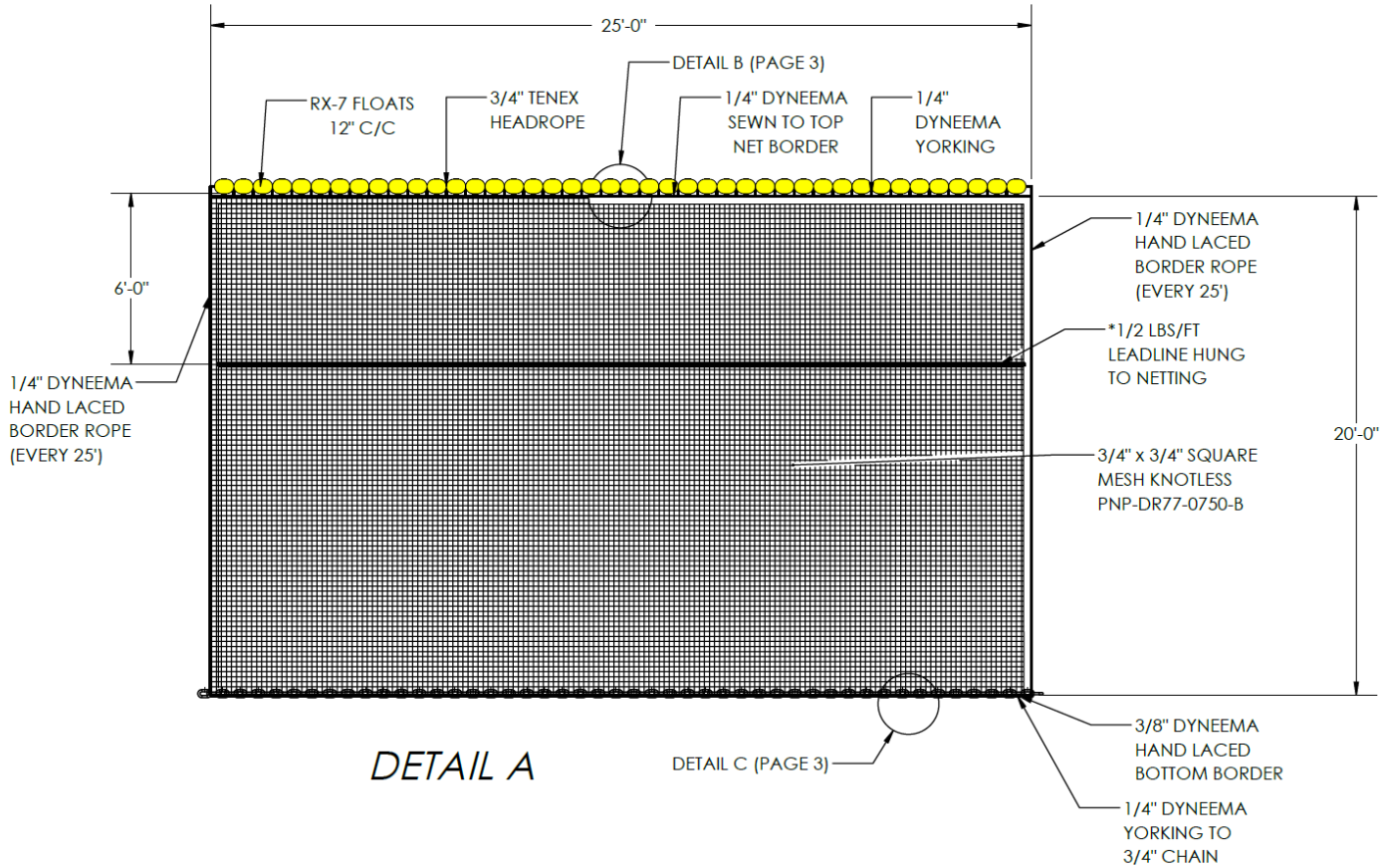


Typical Frame Section of a guidance structure

UHMWPE Fiber Mesh	Boat Gate
Square Orientation	Collection Gate
Standard Openings as small as 3.175 Mm	Pool Fluctuation
Vertical & Horizontal Frame Lines	Strength & Effectiveness
Lighter Weight Materials	Reduced Operations / Maintenance Costs

Net design and construction

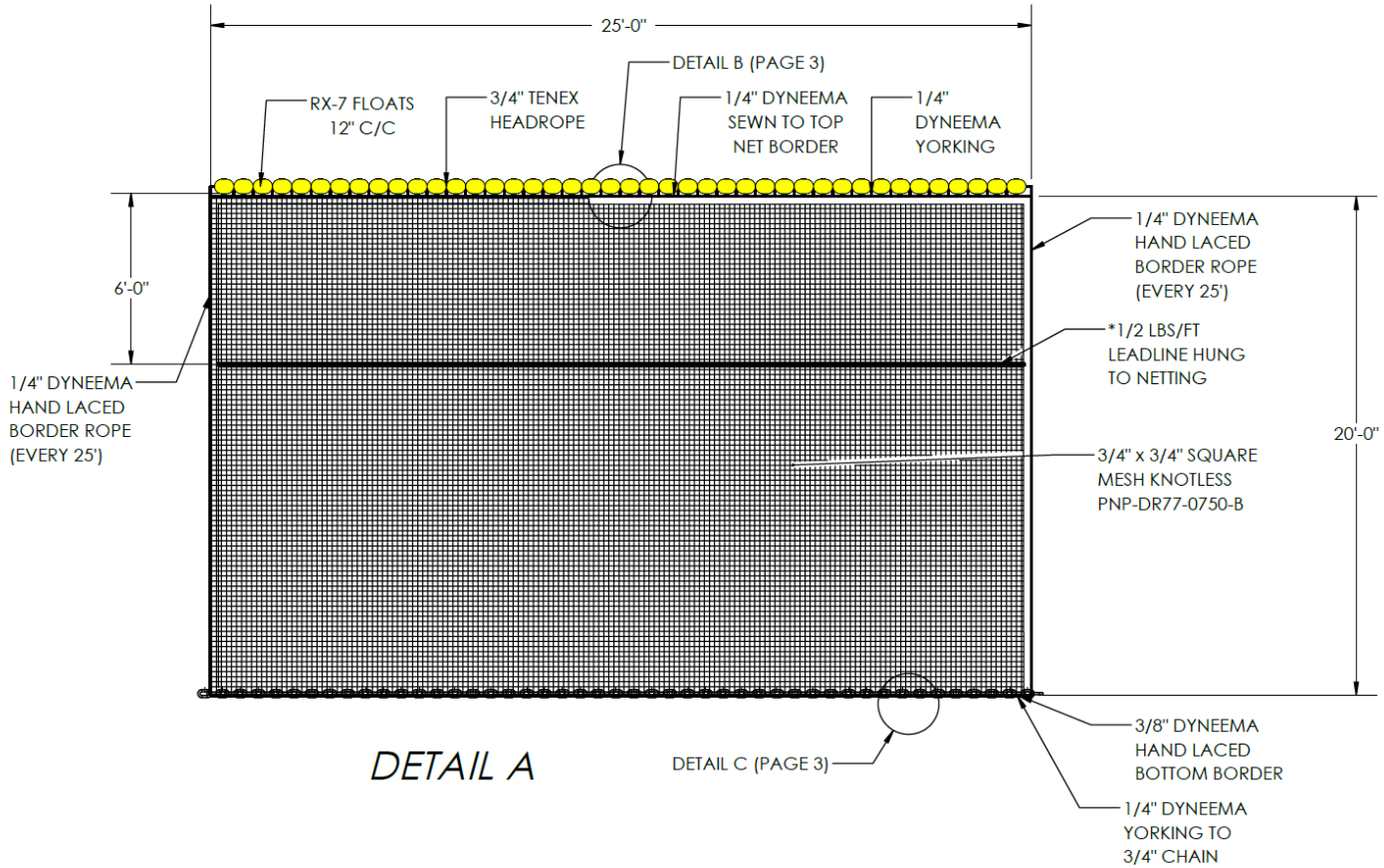
Regulatory
Environmental
Operational



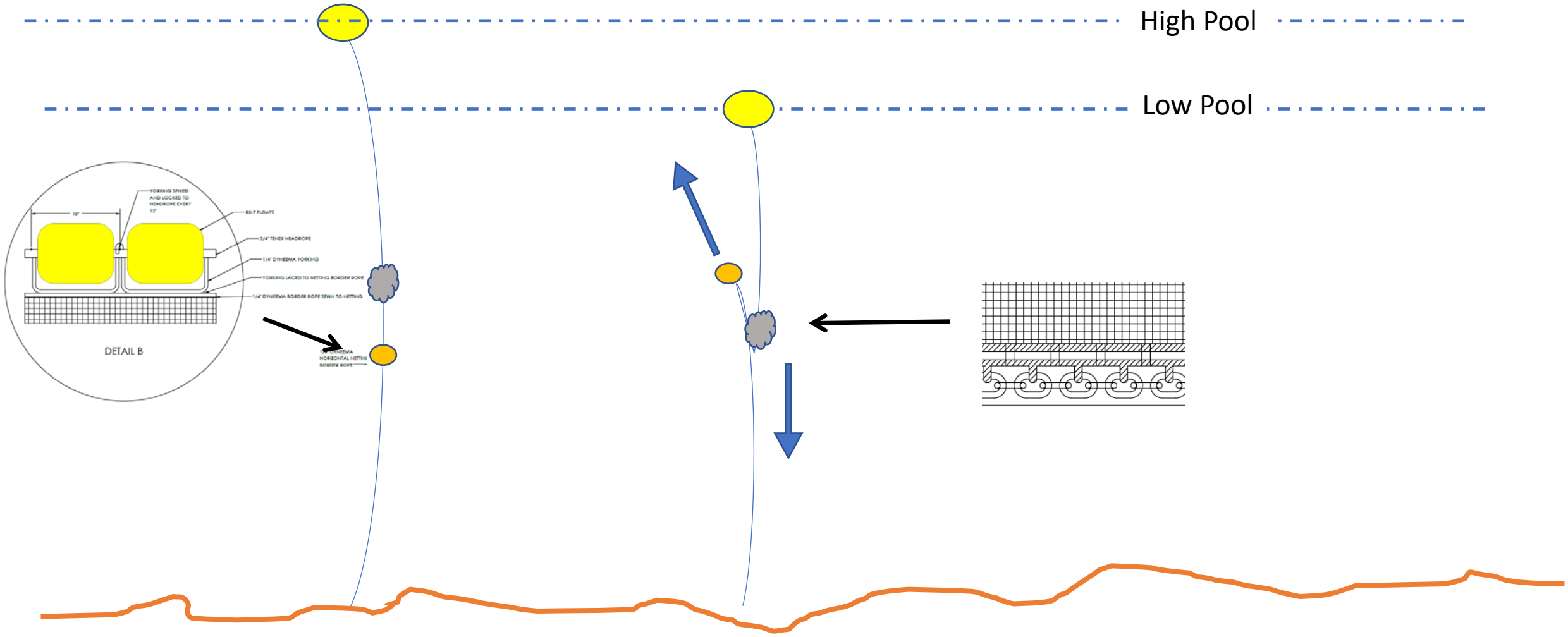
Net design and construction

Design and engineering

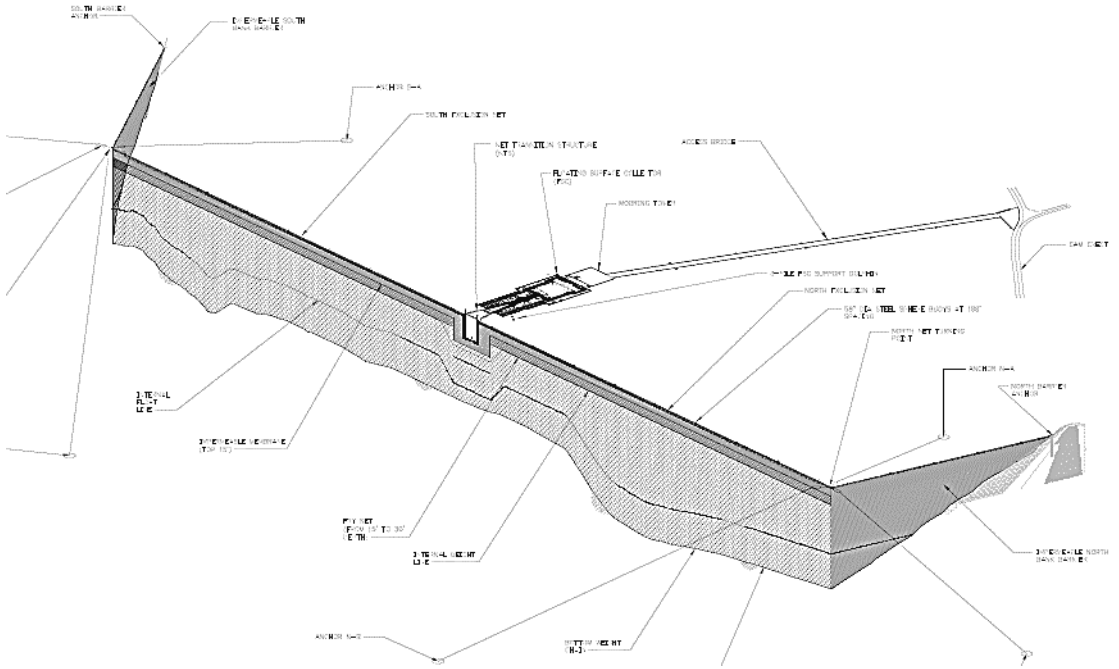
- ✓ Flow and velocity of water
- ✓ Debris; type, size, management
- ✓ Type of fish
- ✓ Guidance, collection or exclusion objectives
- ✓ Types of aquatic growth and maintenance procedures
- ✓ Weather, environment, ice, wind, waves
- ✓ Dam & Public Safety



Pool Fluctuation



Shape of Forebay and Net



Net Orientation

Rigid but flexible wall:

- To maintain mesh opening size
- To provide strength for anticipated loads
- To allow for changes in pool level

Square Mesh

Debris Control

- Exclusion
- Collection
- Guidance

Reducing Debris Loading Fish Collection Facilities

Reducing Debris Loading Fish Collection Facilities


River Connectivity: Technical, cultural and ecological aspects of
fish passage and reintroduction

River Connectivity: Technical, cultural and biological aspects of fish passage and reintroduction


River Connectivity: Technical, cultural and biological aspects of
fish passage and reintroduction

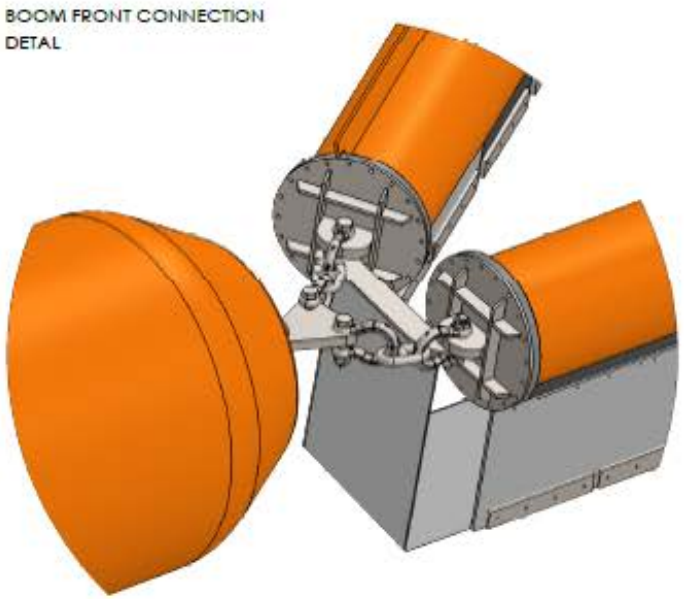

30
28


River Connectivity: Technical, cultural and biological aspects of
fish passage and reintroduction

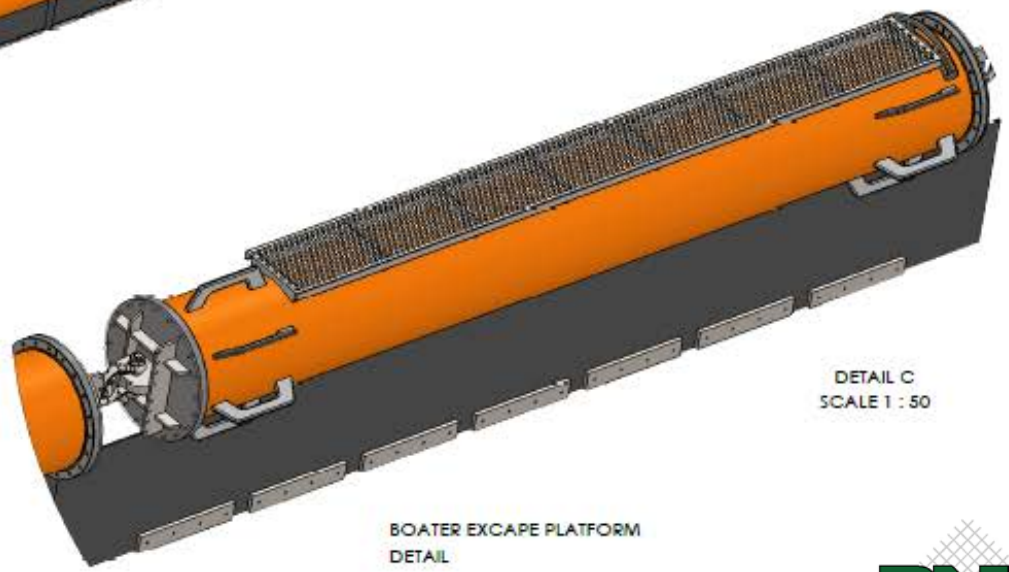
MultiFunction **Boom**™

DEBRIS | DEMARCATION | DAM SAFETY | FISH PASSAGE | ICE | SECURITY | ENVIRONMENTAL

Custom Designs



DETAIL A
SCALE 1 : 45



DETAIL C
SCALE 1 : 50

BOATER EXCAPE PLATFORM
DETAIL

Custom Boom to Protect Fish Screens

Alameda Creek Watershed

- 121 feet length.
- Depth 4 foot under floatation
- 6 debris barrier panels
- Floated by 30 in class 3/ MultiFunction Booms™
- Galvanized steel frame
- HDPE Pile Sliders to reduce friction and moving parts
- Anchored by wall beam slider and piles sliders

Custom Boom to Protect Fish Screens

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Custom Boom to Protect Fish Screens

Alameda Creek Watershed

Custom boom to prevent plant shutdown during debris and ice events

Brookfield, Lower Saint Anthony's Falls

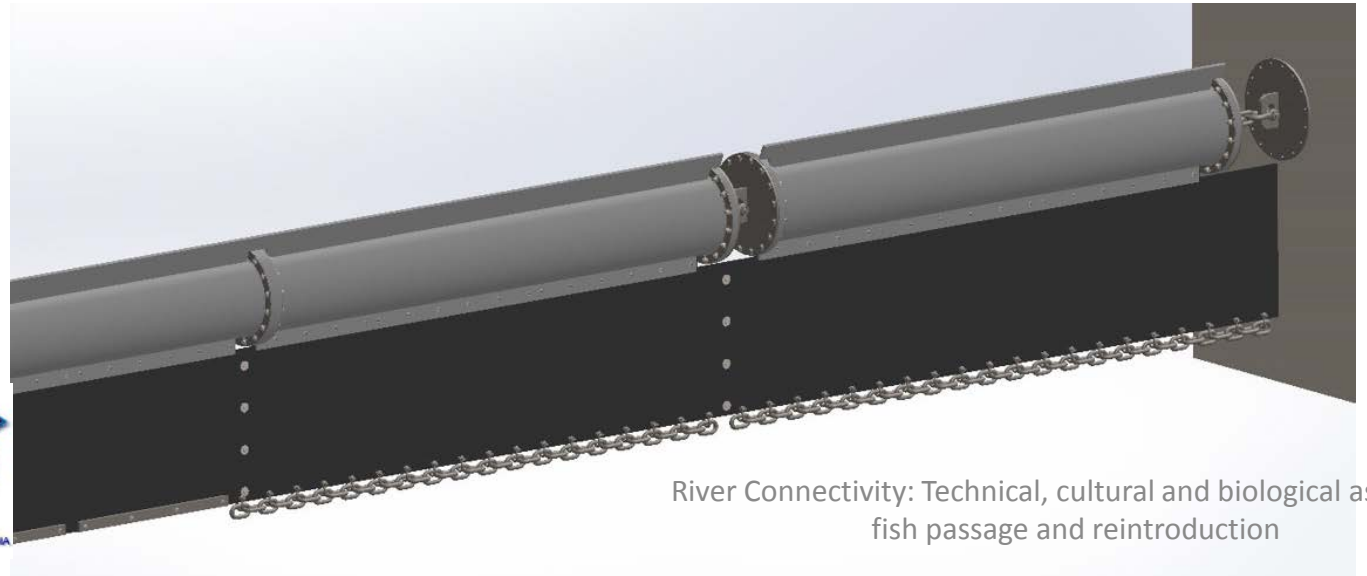
- 225 feet length overall
- 36 inch Class 1 Boom
- 9 sections, "V" Shape
- Main sections flange bolted with articulated sections on dam end
- Debris skirt / splashguard
- Swimmer ladder / emergency exit
- Walkway grate
- Designed for 10 feet sec flow
- Anchored by in river cored concrete pile, flush to river bed, connected by chain to 8ftx16ft anchor buoy

Custom boom to prevent plant shutdown during debris and ice events

Brookfield, Lower Saint Anthony's Falls

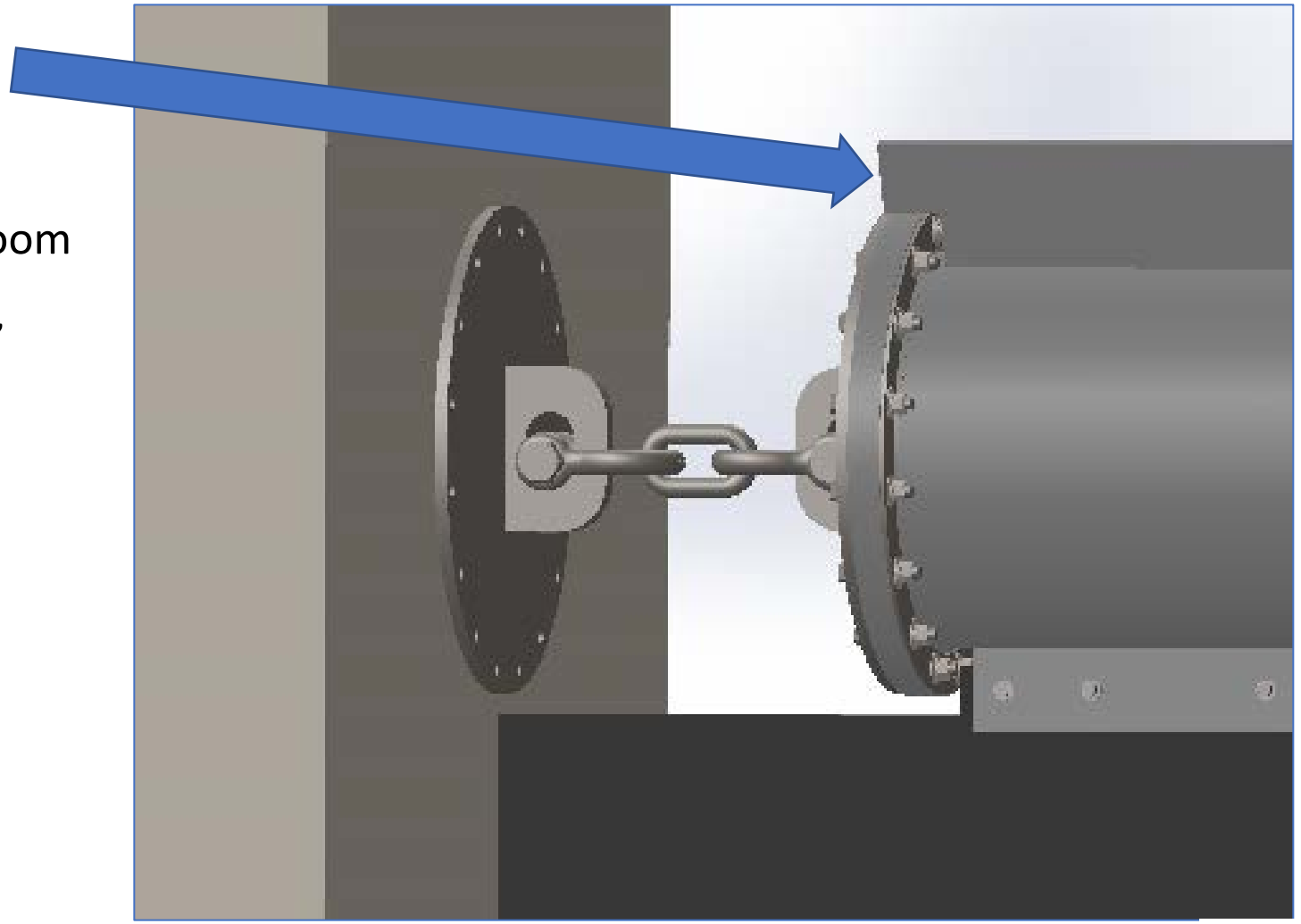
Material Features

- ✓ Not vulnerable to biological attack
- ✓ Exceptional resistance to fouling
- ✓ Smooth, non-stick surface
- ✓ Excellent Bending Radius
- ✓ 2% carbon black and/or ultraviolet stabilizer for UV

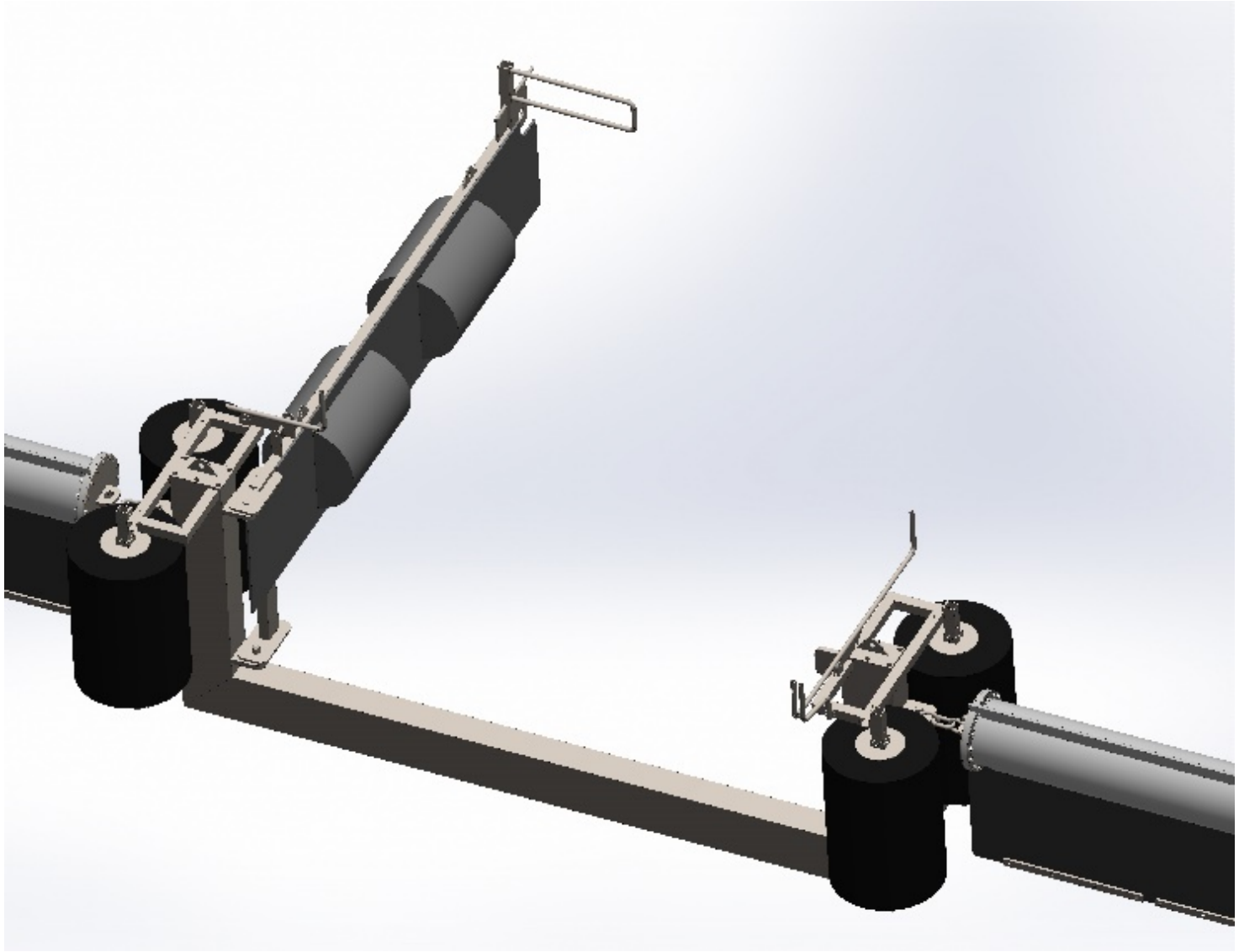


Debris Overtopping Guard (DoG)

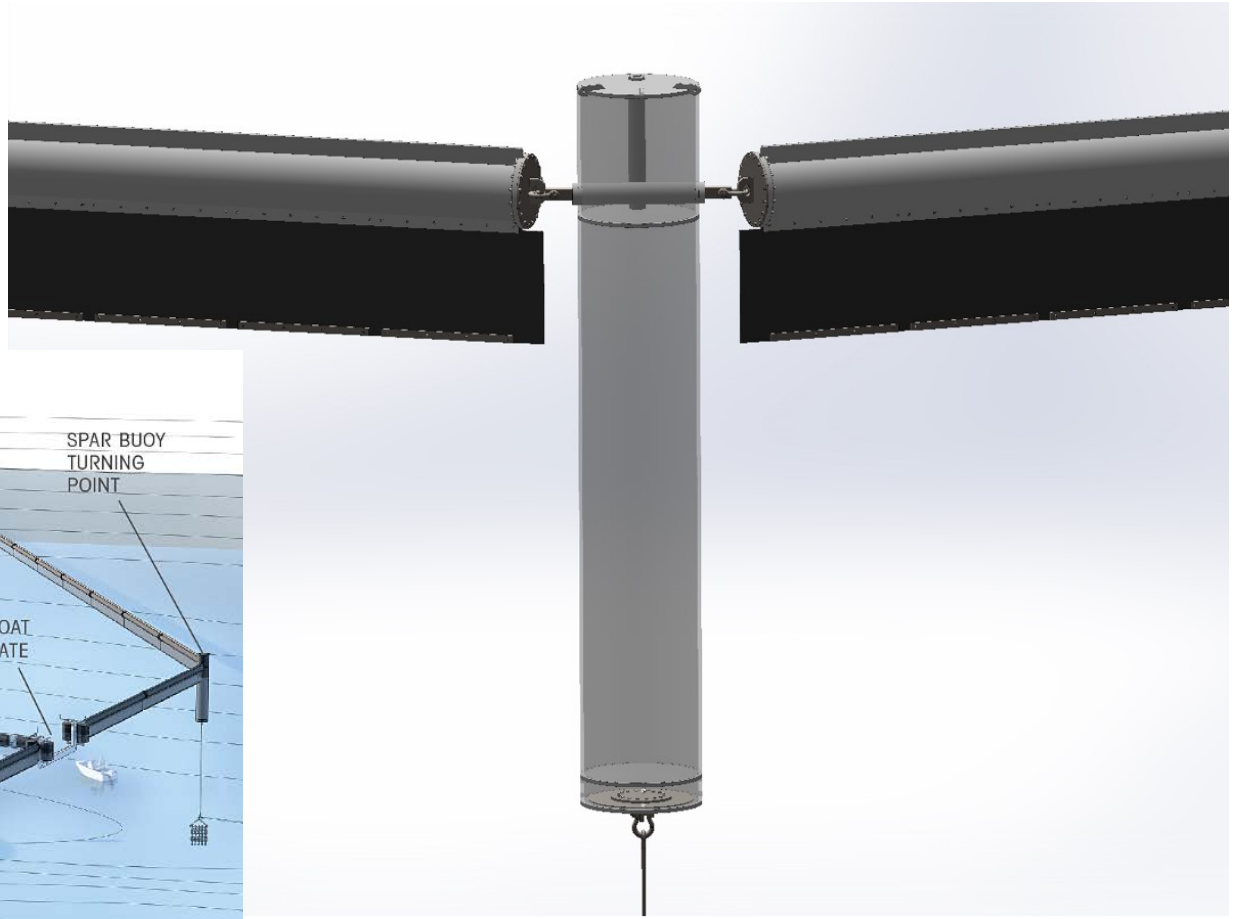
- Prevents debris overtopping boom
- On upstream side of the boom, works like the bow of a boat

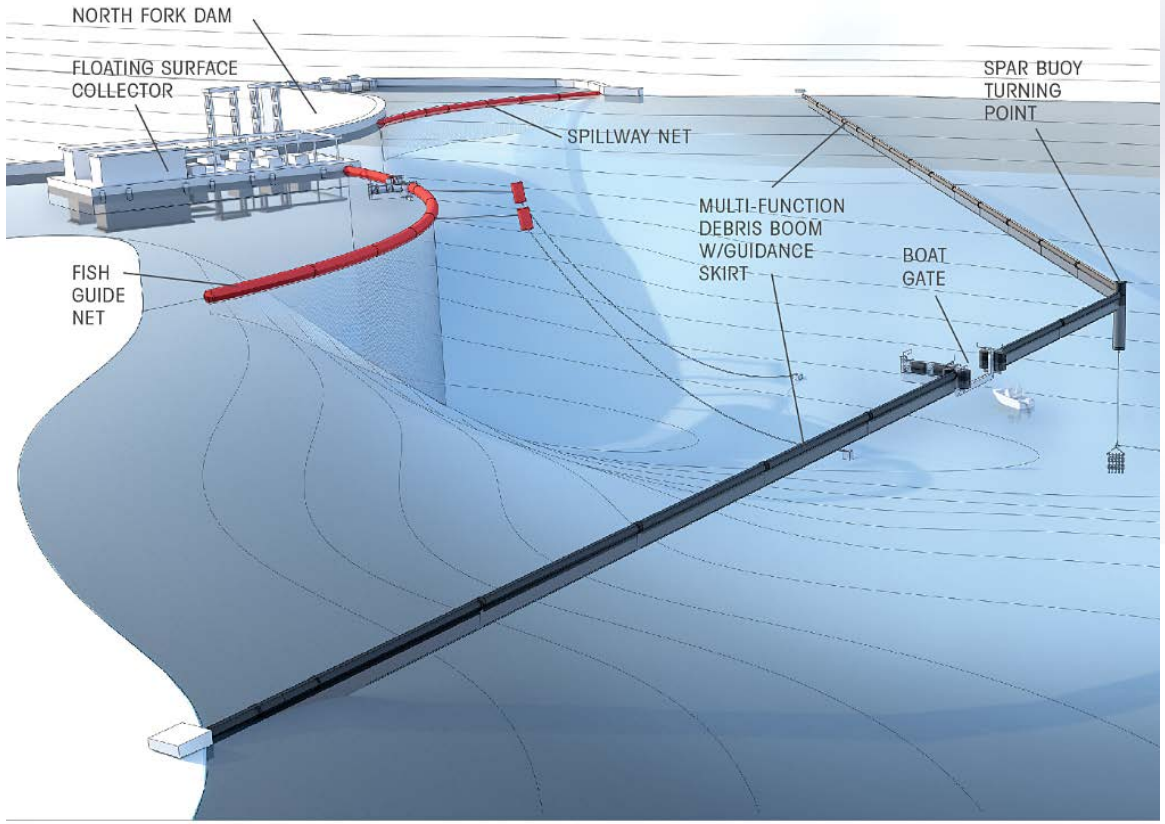


Boat Gates



Turning Points





Security

Conclusions

Barriers to river connectivity:

- Physical
- Environmental
- Political
- Technical
- Social

….are complex and interdependent

We humans have been building things for a long time to collect or guide or exclude fish from moving through a waterway.

Conclusions

Modern materials, UHMWPE and HDPE, engineering and design have opened new opportunities that benefit efforts for collection, exclusion and guidance of fish and debris and the restoration of freshwater habitats connectivity throughout the historic ranges of anadromous fish.

So my question to you is “Now which barriers do we need to overcome?”