

Bay-Delta Geometry and Salt Mixing: Modeling and Mechanisms

IEP Workshop
February 27, 2004

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Suisun Marsh Branch
DWR

with
Jon Burau, John DeGeorge and Curt Schmutte

Two topics:

- What we've learned from levee breach modeling
- Primer on hydrodynamics and transport processes

Take home's

- Modest geometry changes can influence tidal propagation and mixing estuary wide.
- Understanding processes provides the opportunity to use geometry changes to meet goals.
- Modeling is less about “what would happen if,” than, “why does it happen if.”

Franks Tract Modeling Team

- We have stakeholder and agency modeler participation.
- The emphasis is on physical process understanding.
- Differences in model results are instructive.
- Collaboration and buy-in among modelers.

Franks Tract Reclamation?

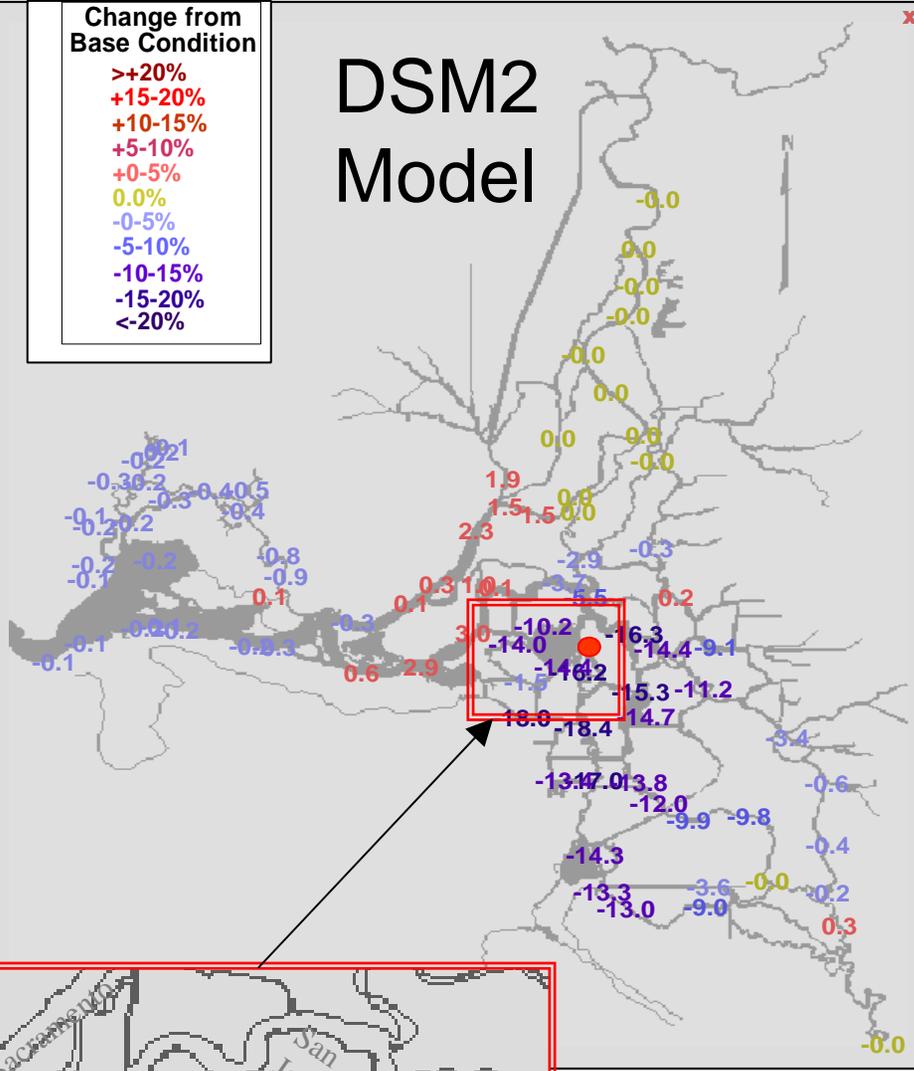
Curt Schmutte asked:

- Can we reduce tidal pumping and trapping of salt by reclaiming Franks Tract levees?

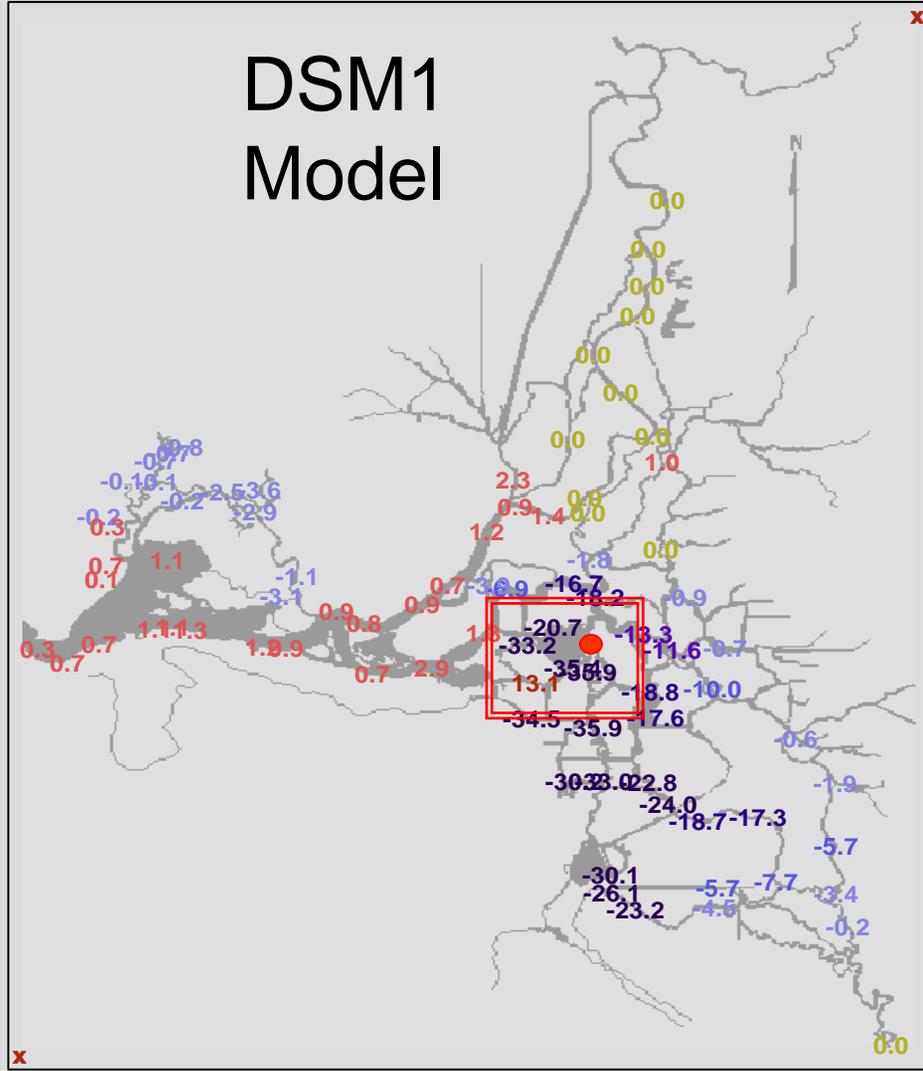
Change from Base Condition

- >+20%
- +15-20%
- +10-15%
- +5-10%
- +0-5%
- 0.0%
- 0-5%
- 5-10%
- 10-15%
- 15-20%
- <-20%

DSM2 Model



DSM1 Model



Franks Tract Reclamation with 100 Foot Levee Breach Historical Water Year 1992 Simulation

(July 29, 1992)

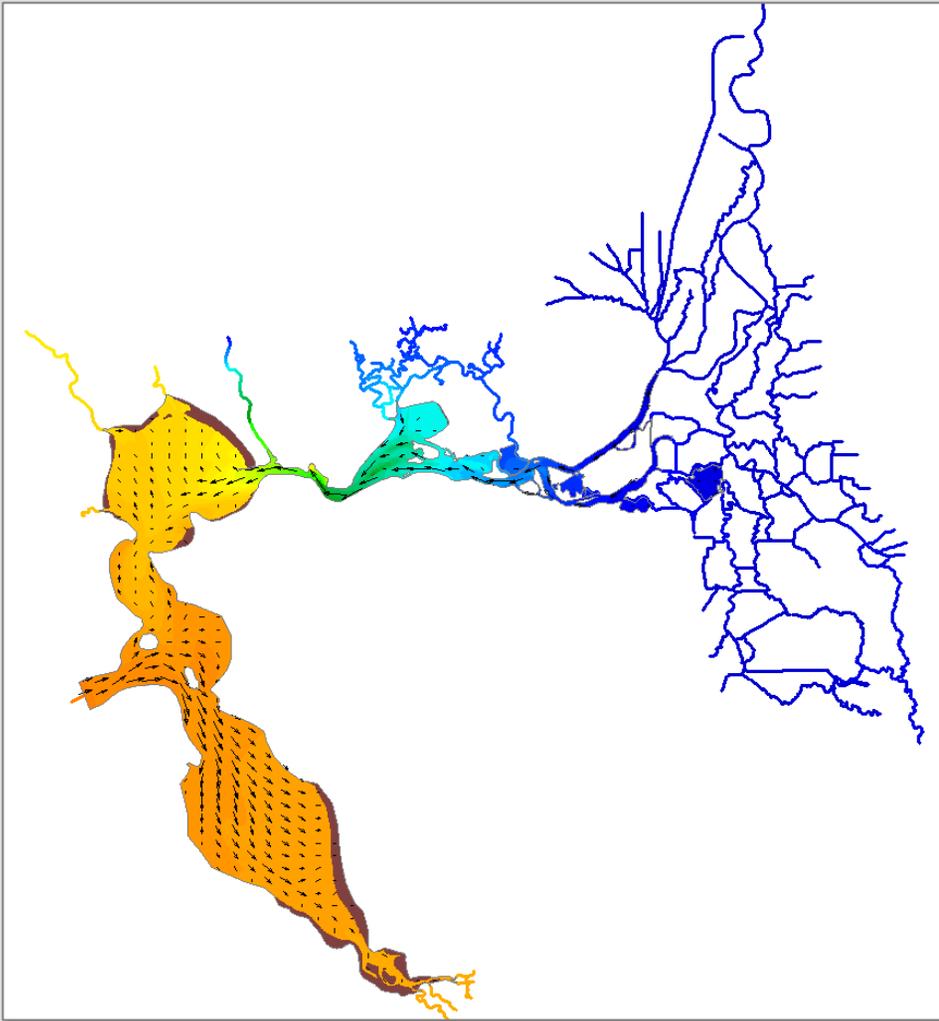
Concurrence of modeling results

- Contra Costa WD
- Resource Management Associates
- Metropolitan WD
- DWR Delta Modeling
- DWR Suisun Marsh Planning

Application of multiple models to the same problem is essential!

Flow Calibration of the RMA Bay-Delta Model

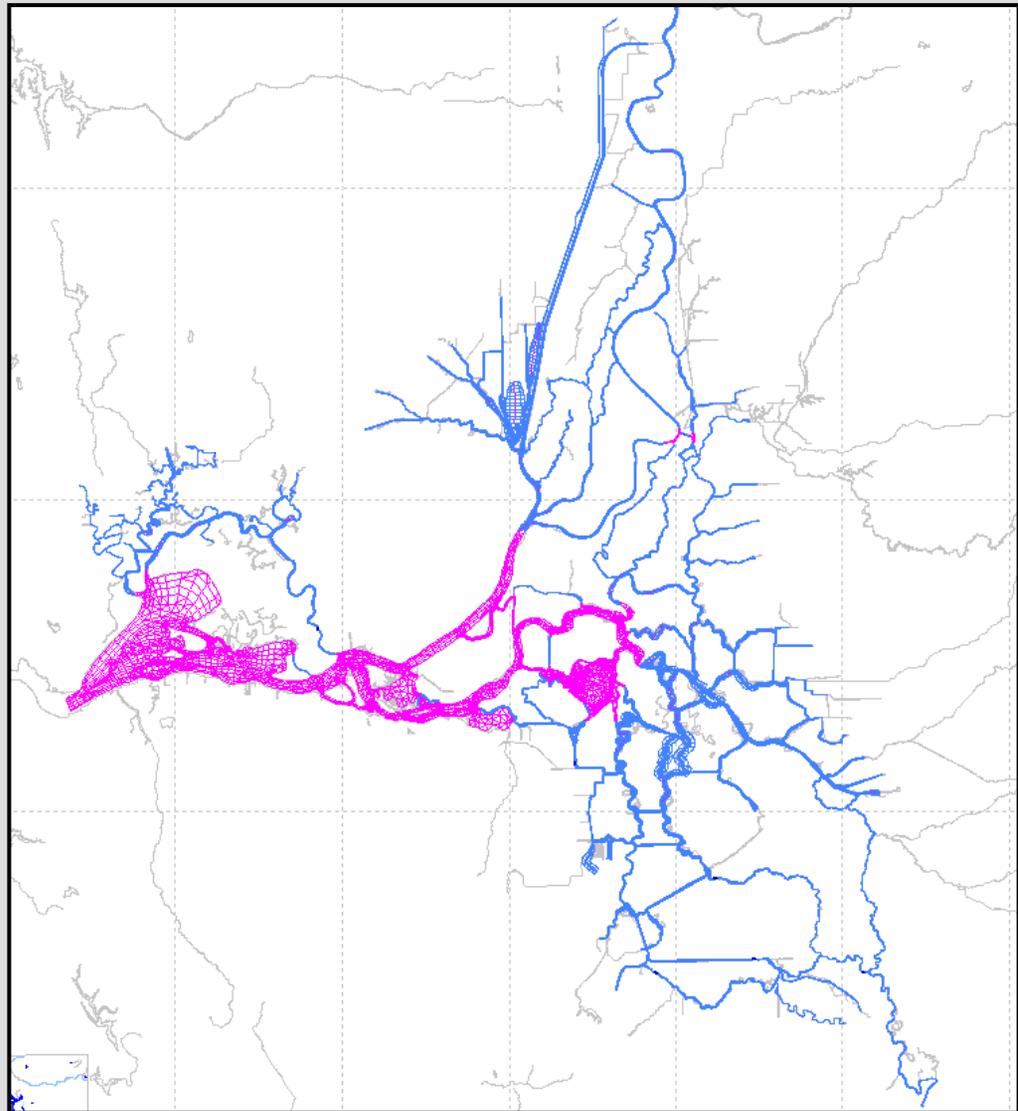
April 10 to August 27, 2002



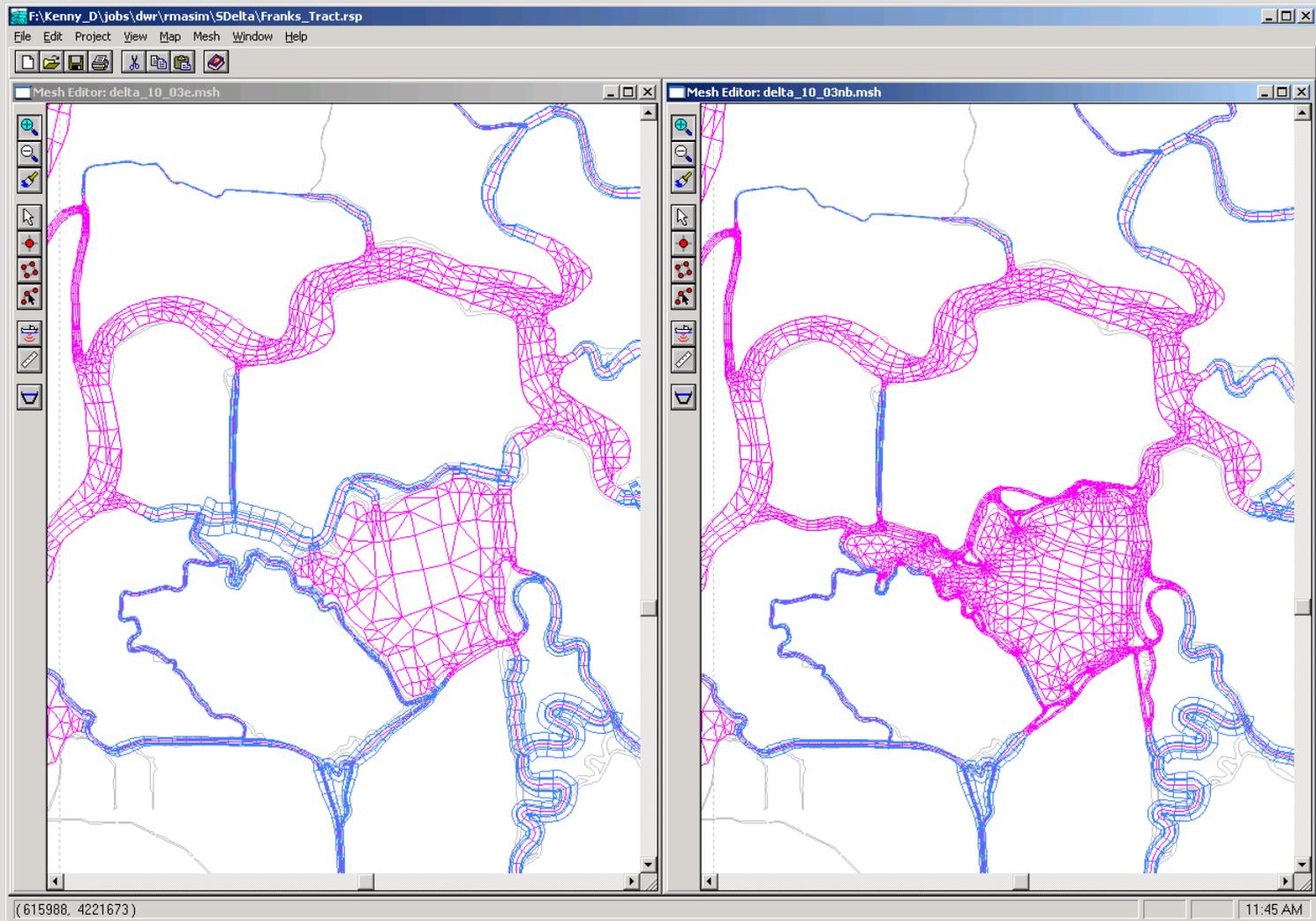
- RMA2 Hydrodynamics
- RMA11 Water Quality
- Bay and Delta
- Suisun Marsh Tide Gate
- Delta Cross Channel
- South Delta Barriers
- Clifton Court Gate
- Delta Island
- Consumptive Use

RMA Delta Network

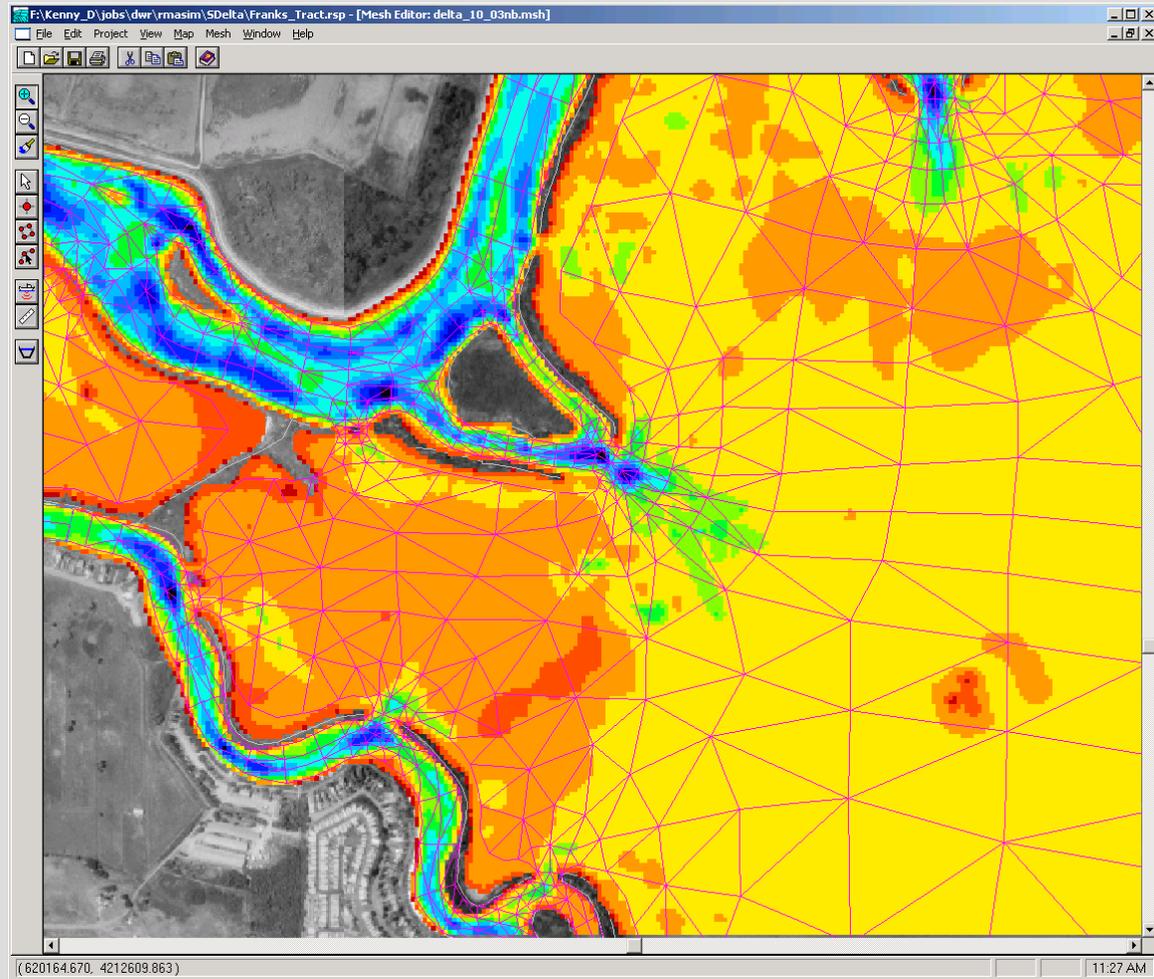
- Tidal BC at Martinez
- Combination of 2-D depth-averaged elements and 1-D channels elements



Franks Tract Finite Element Network Refinement

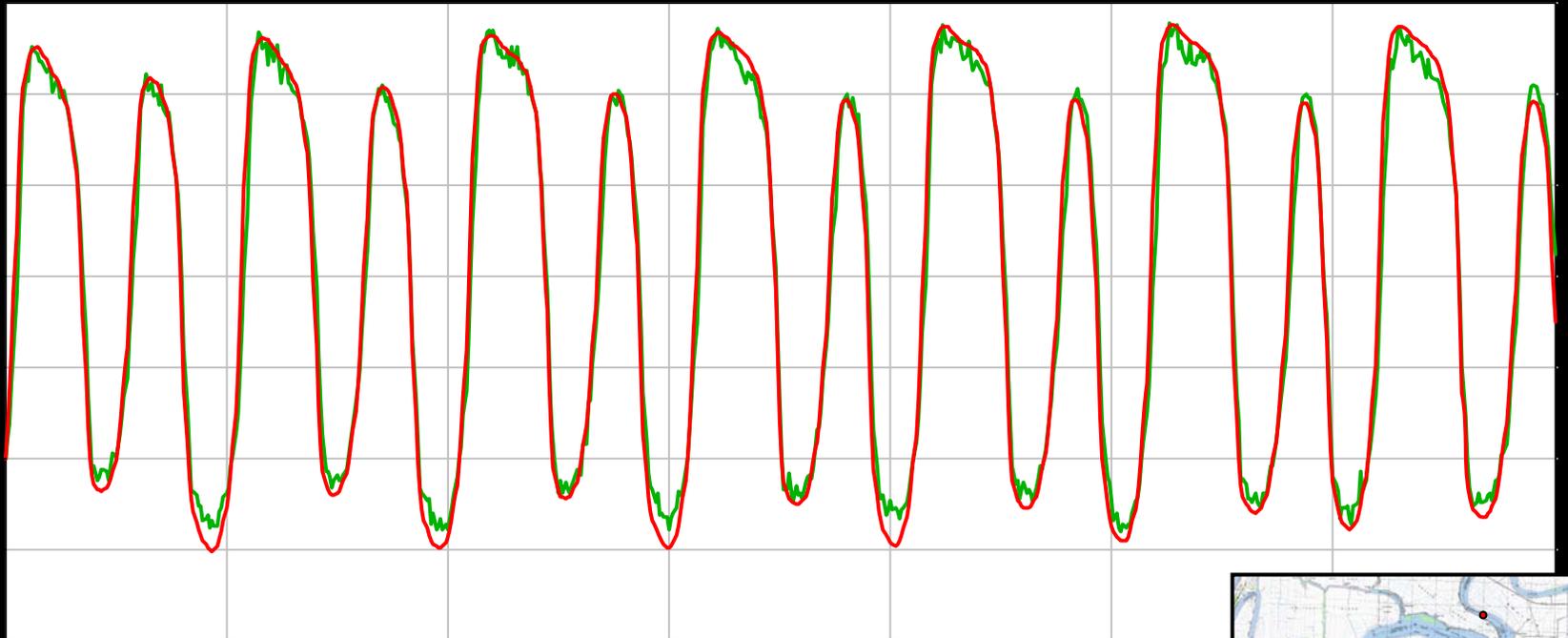


Franks Tract Network, Near NW Breach



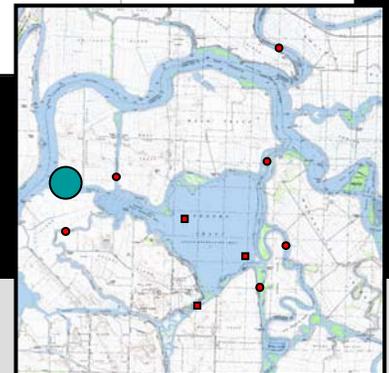
Franks Tract Flow Comparison, June 20-26, 2002

False River



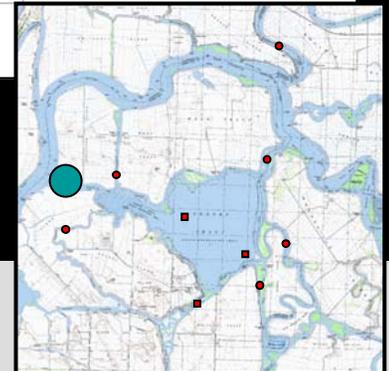
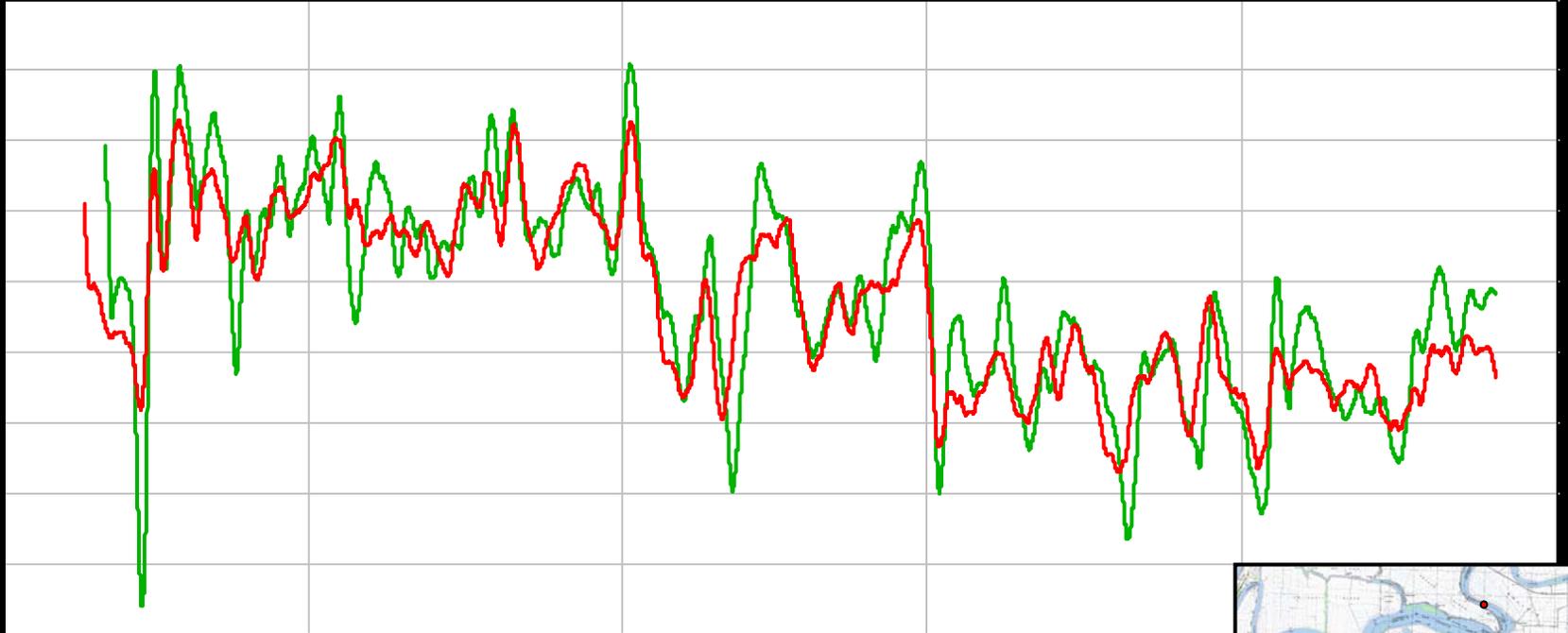
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Franks Tract Flow Comparison, Tidally Averaged

False River

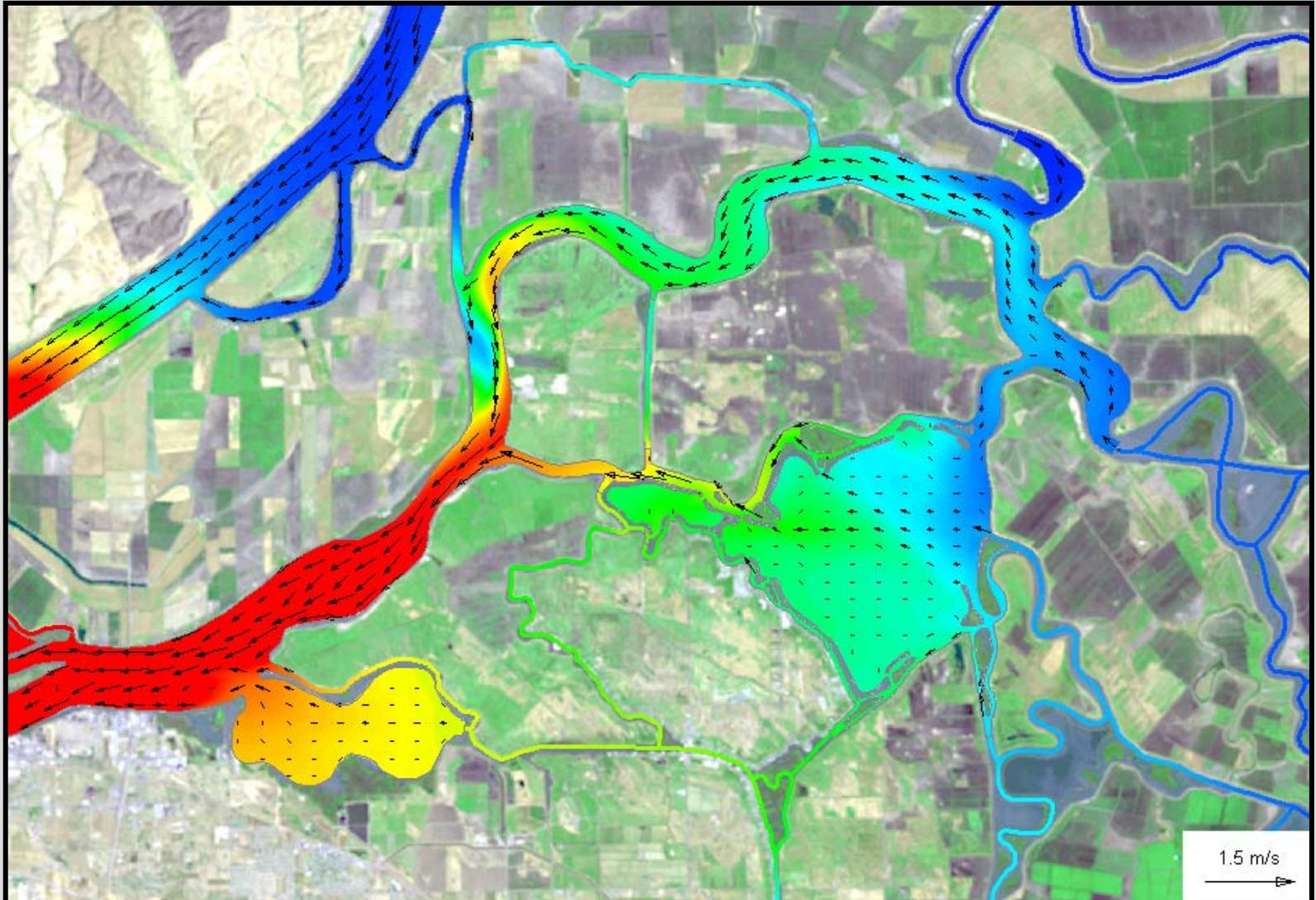


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EC near Franks Tract

$\mu\text{mhos/cm}$ (red >1500)



Hydrodynamics and Transport Process Primer

Hydrodynamic Processes

Hydrodynamic Processes

Tidal forcing and river flow (energy source)

Hydrodynamic Processes

Tidal forcing and river flow (energy source)

Friction from geometry (energy sink)

Hydrodynamic Processes

Tidal forcing and river flow (energy source)

- Water level (potential energy)
- Water velocity (kinetic energy)

Friction from geometry (energy sink)

*Mass and
Momentum
are
Conserved*

Transport processes

1. Advection
2. Dispersion

} Move and mix gradients of dissolved, particulate, and biotic material

Transport processes

1. Advection

2. Dispersion

} Move and mix gradients of dissolved, particulate, and biotic material

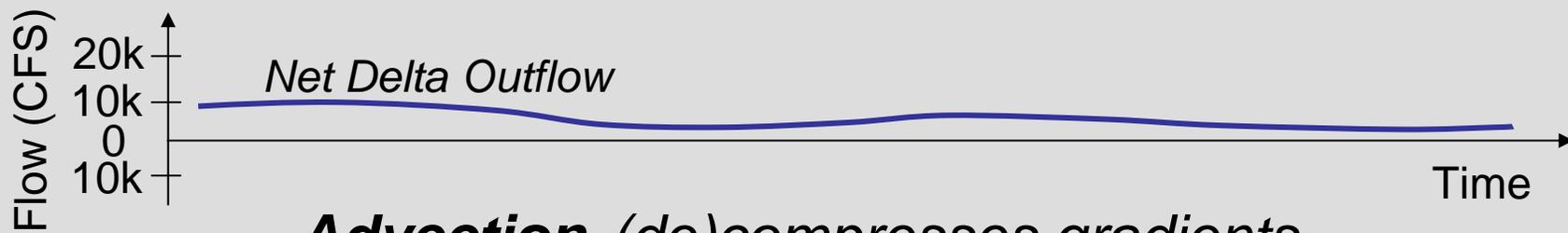
1. Advection

- Transport by the net current, e.g. river flow or “net Delta outflow”

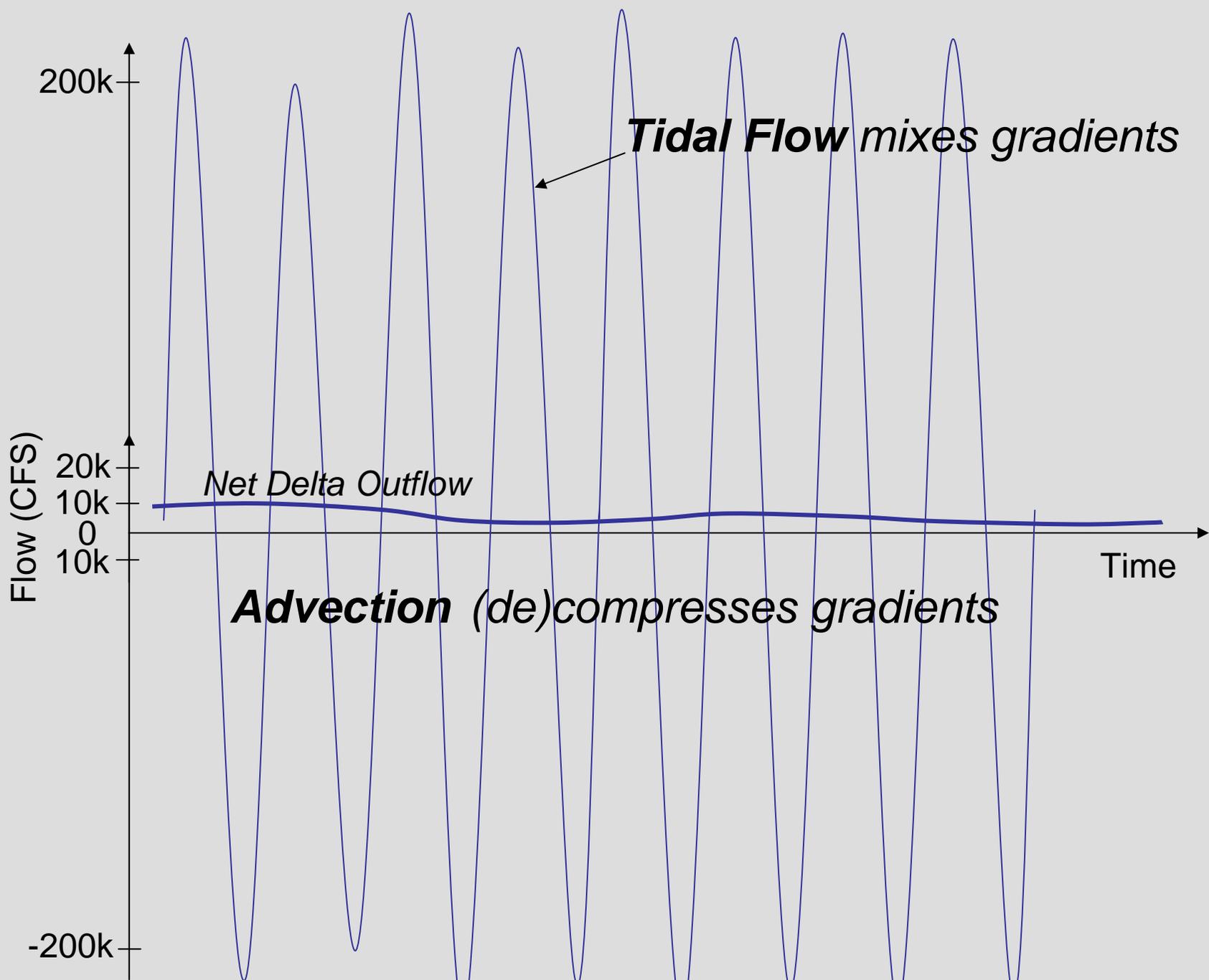
2. Dispersion

Transport by:

- “sheared” tidal currents and
- interaction with irregular estuary geometry



Advection (de)compresses gradients



Forces that cause mixing

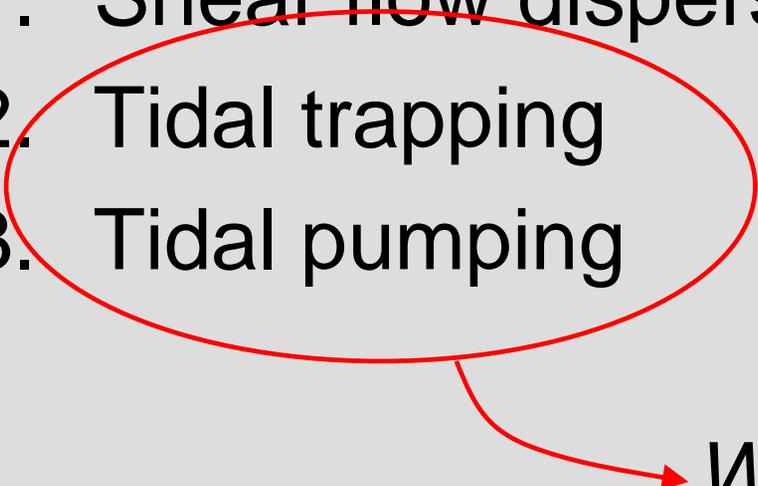
- **Tides (dispersion)**

- Meteorology
- Density gradients
- Earth rotation

Tide causes dispersive mixing by:

1. Shear flow dispersion
2. Tidal trapping
3. Tidal pumping

Tide causes dispersive mixing by:

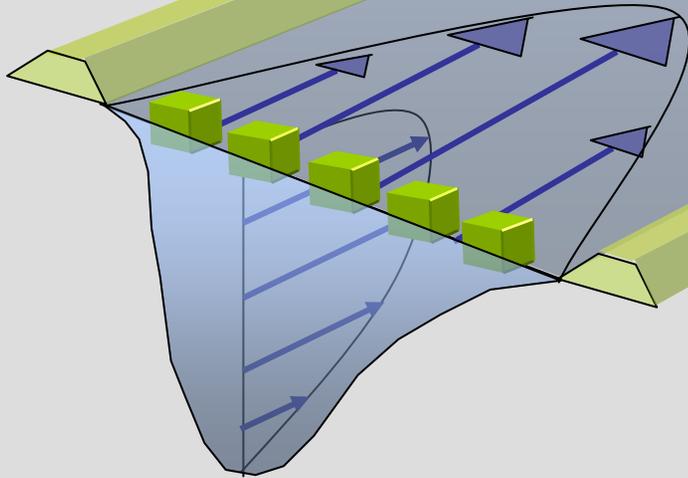
1. Shear flow dispersion
 2. Tidal trapping
 3. Tidal pumping
- 

*What we're influencing
At Franks Tract*

1. Shear Flow Dispersion

Shear

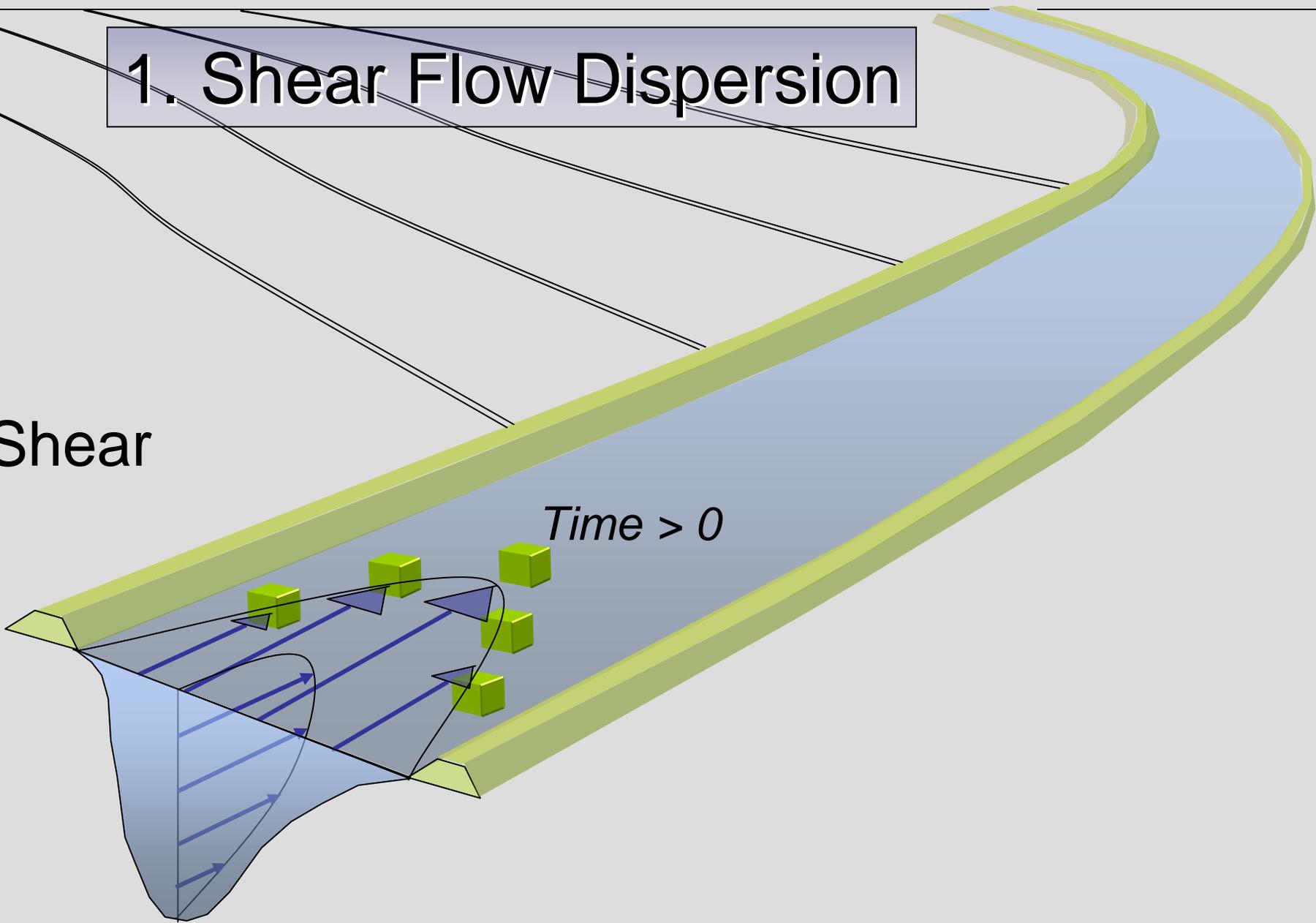
Time = 0



1. Shear Flow Dispersion

Shear

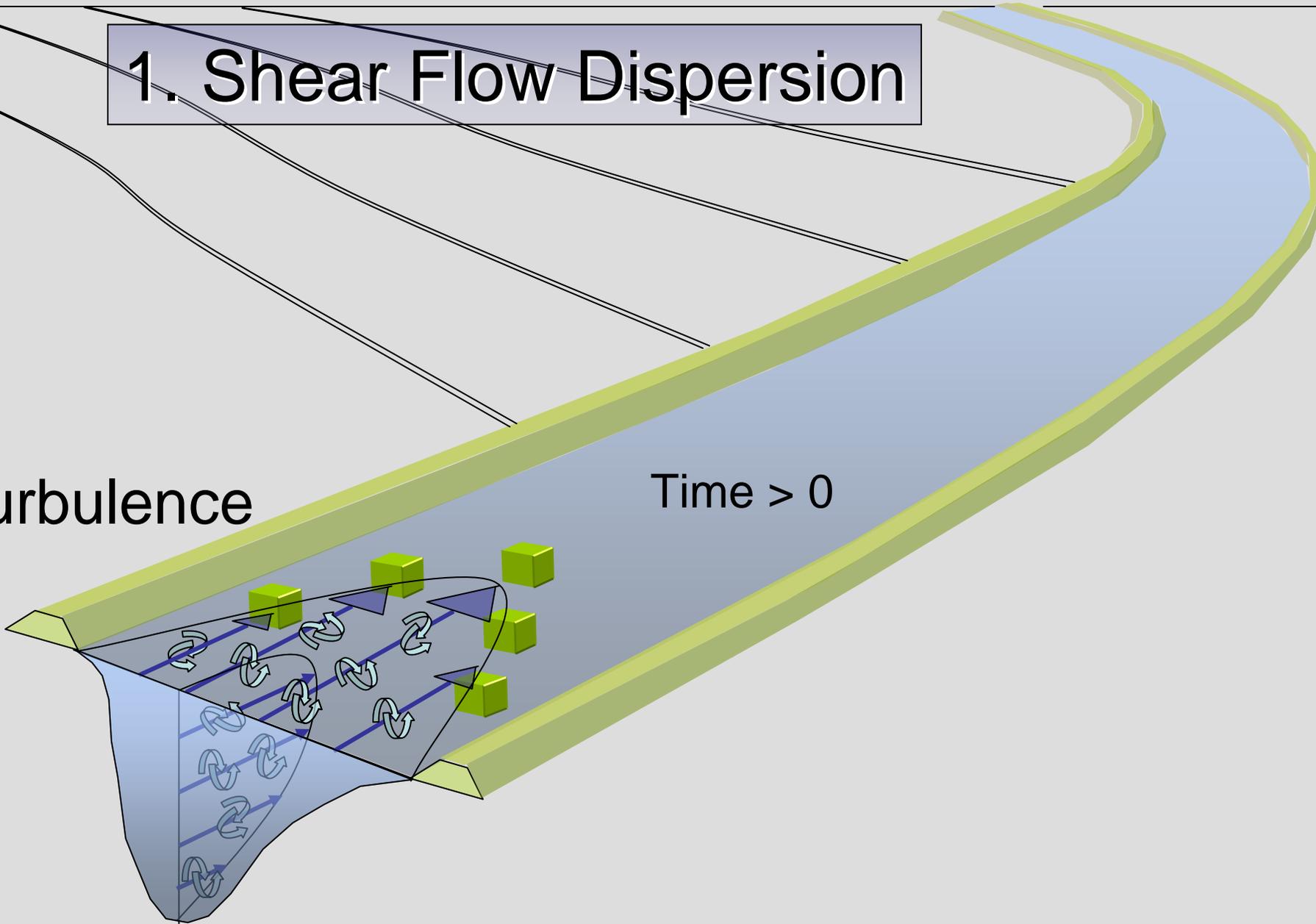
Time > 0



1. Shear Flow Dispersion

Turbulence

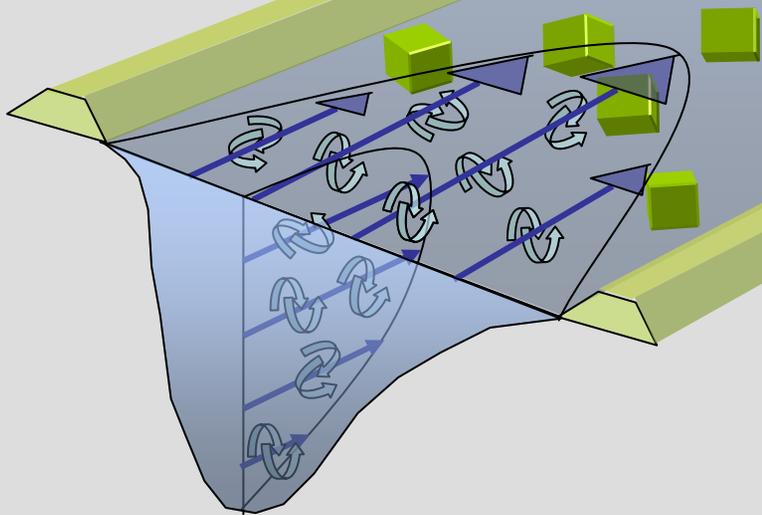
Time > 0



1. Shear Flow Dispersion

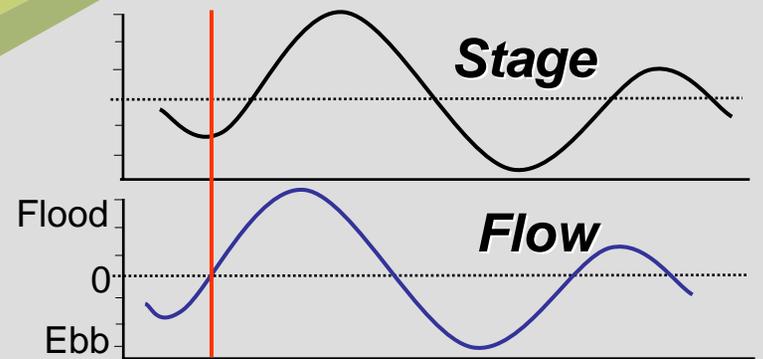
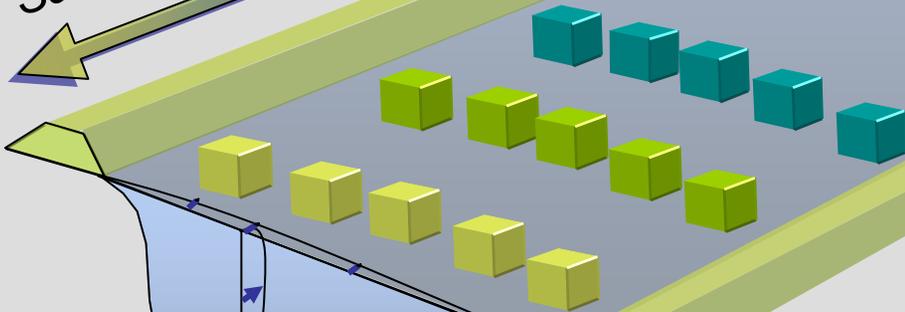
Shear +
Turbulence

Time > 0

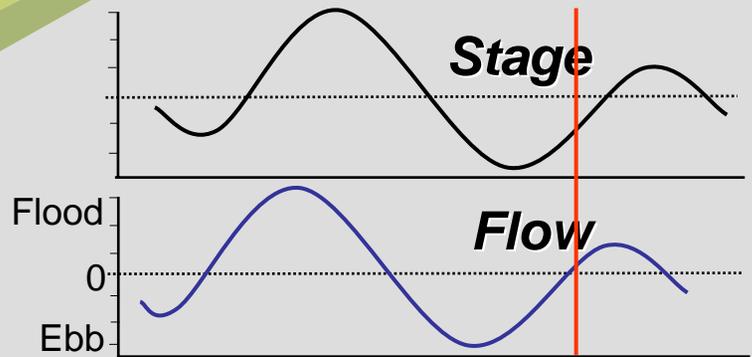
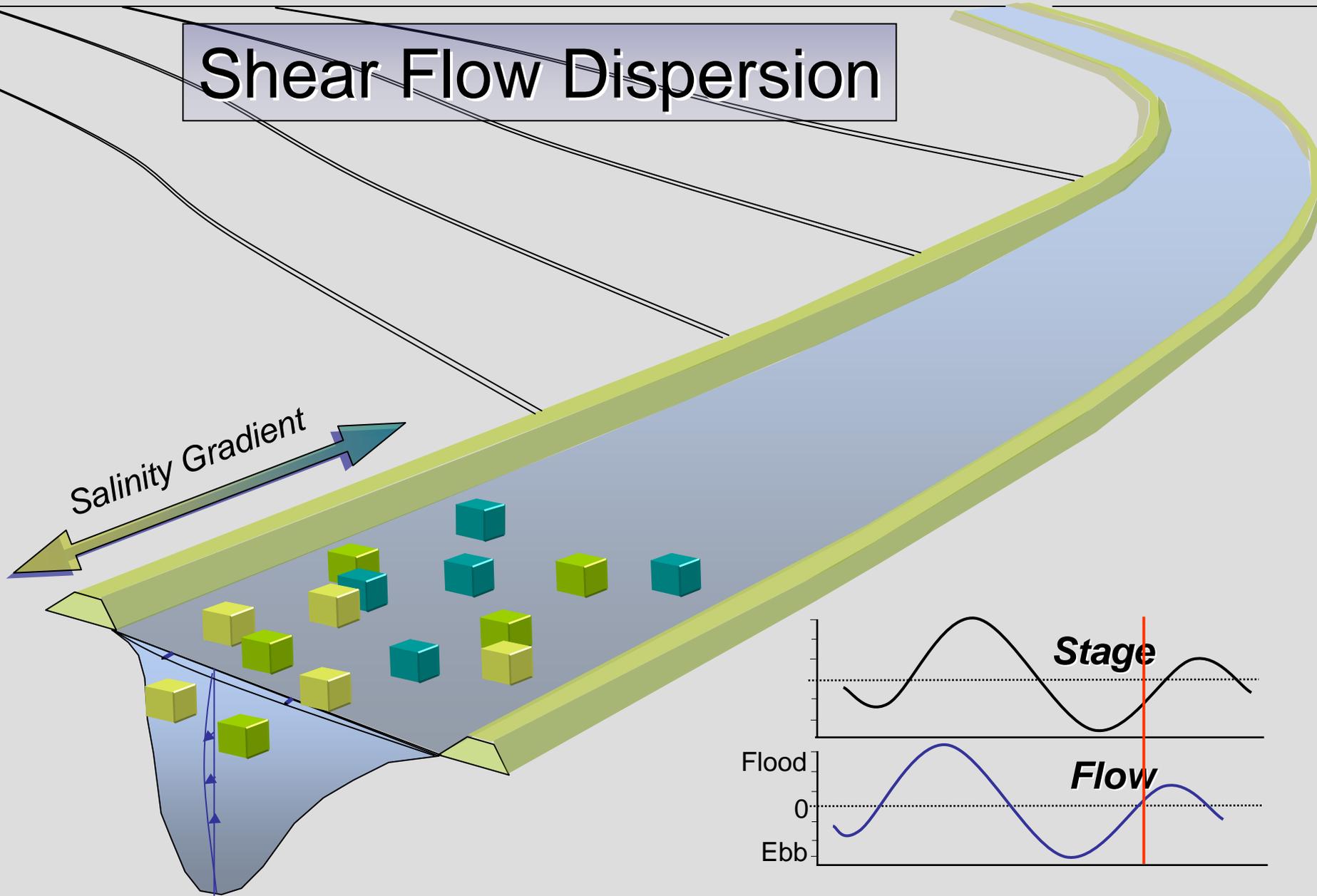


Shear Flow Dispersion

Salinity Gradient

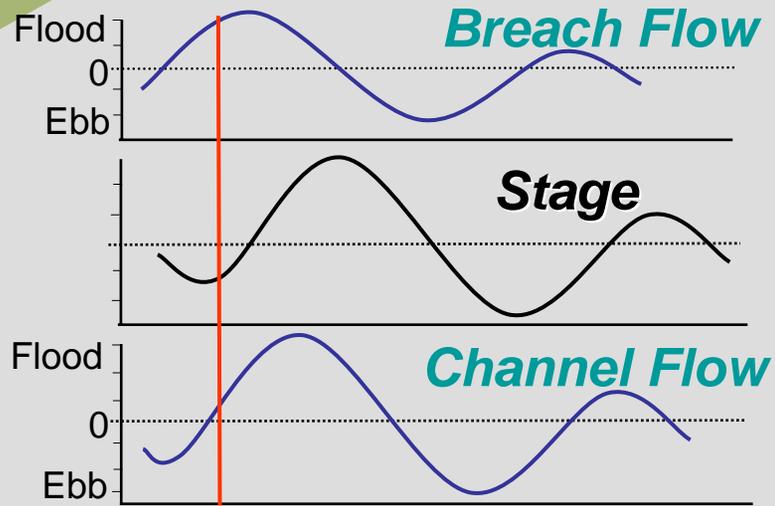
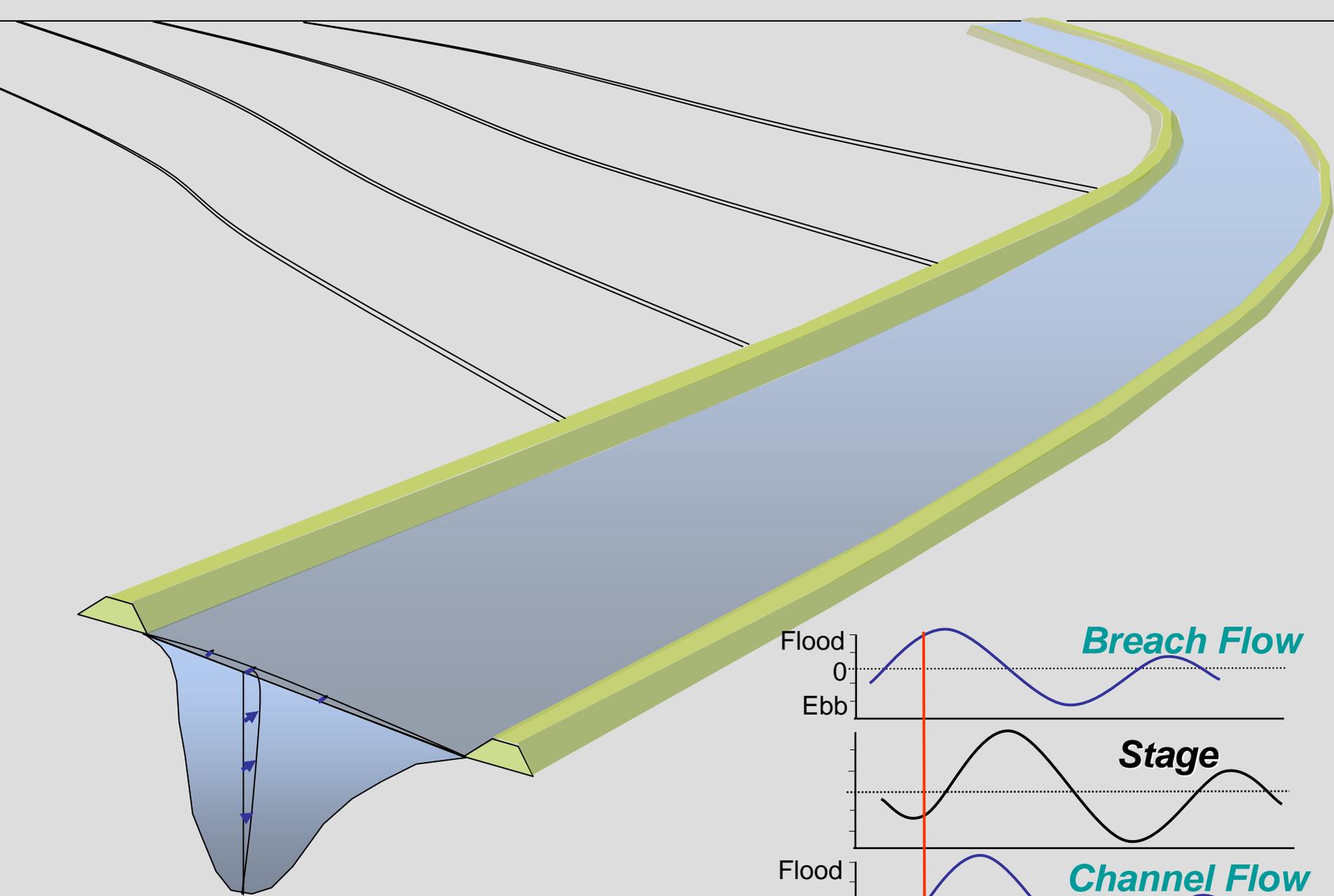


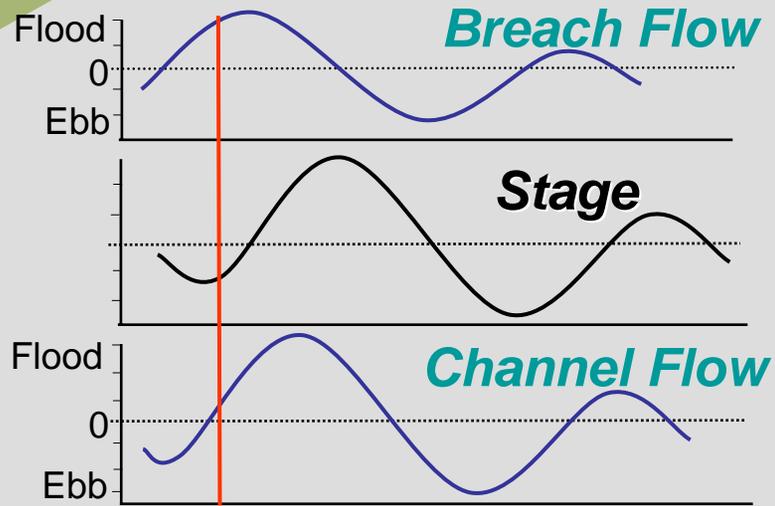
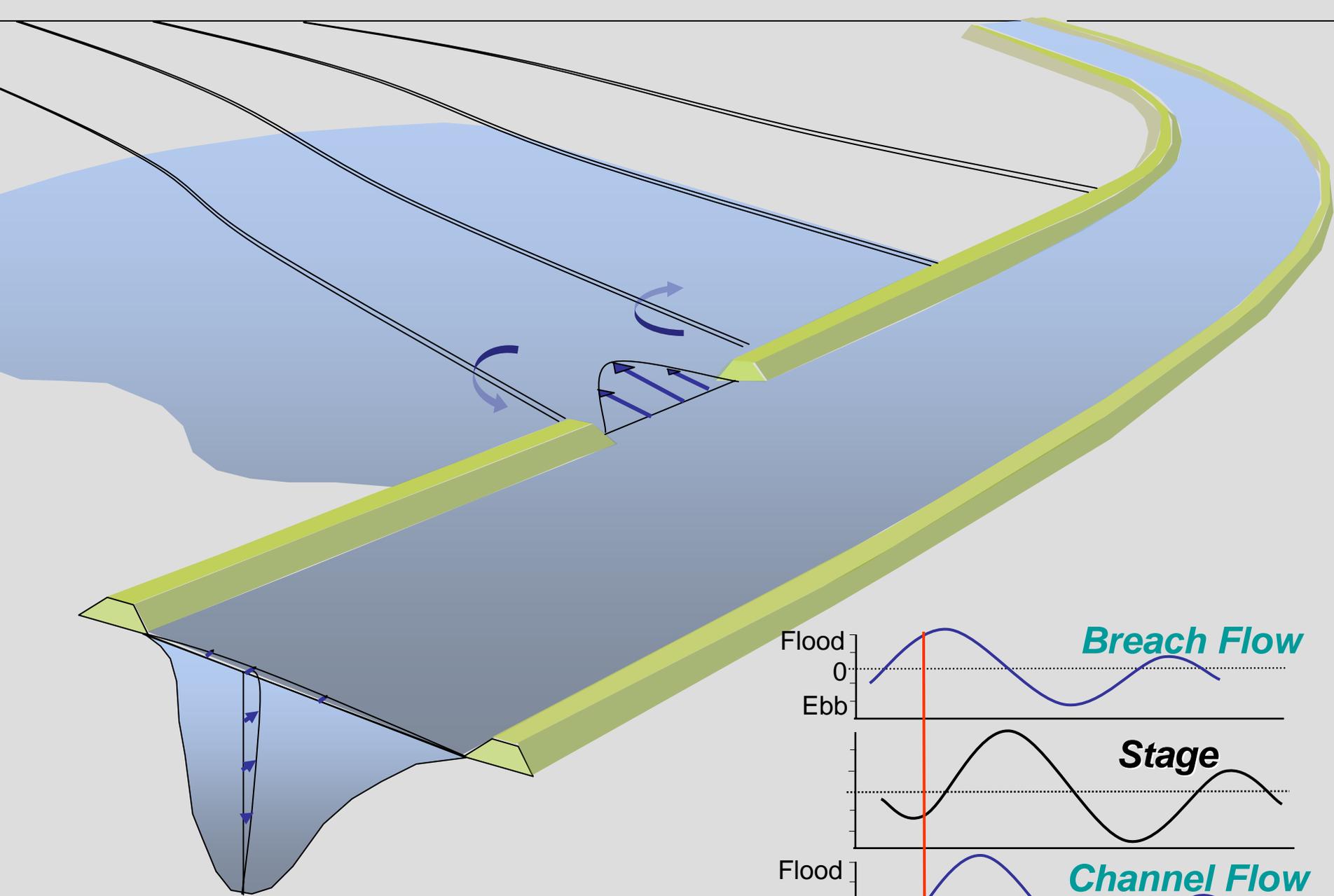
Shear Flow Dispersion

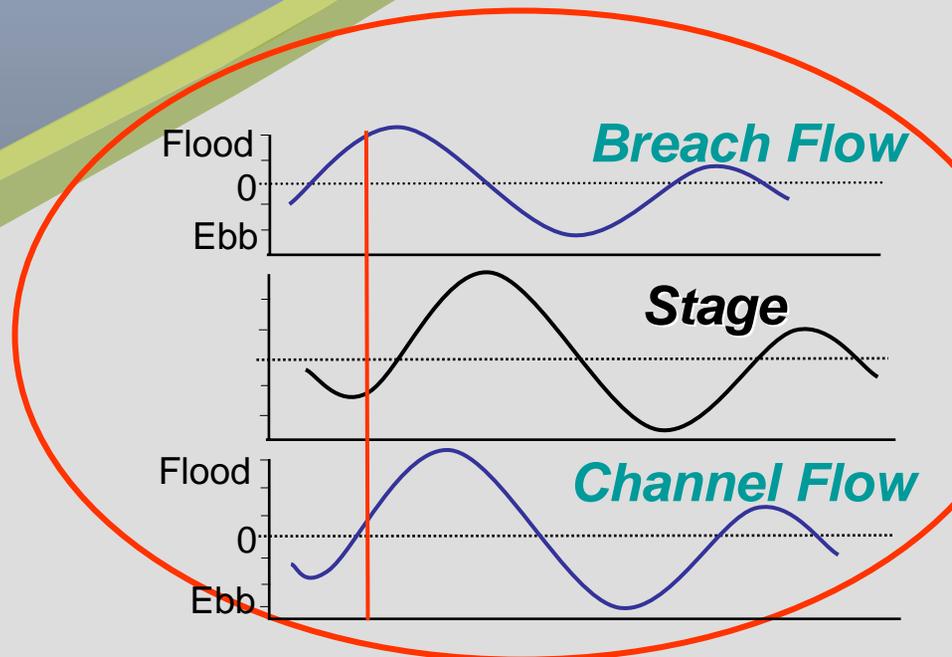
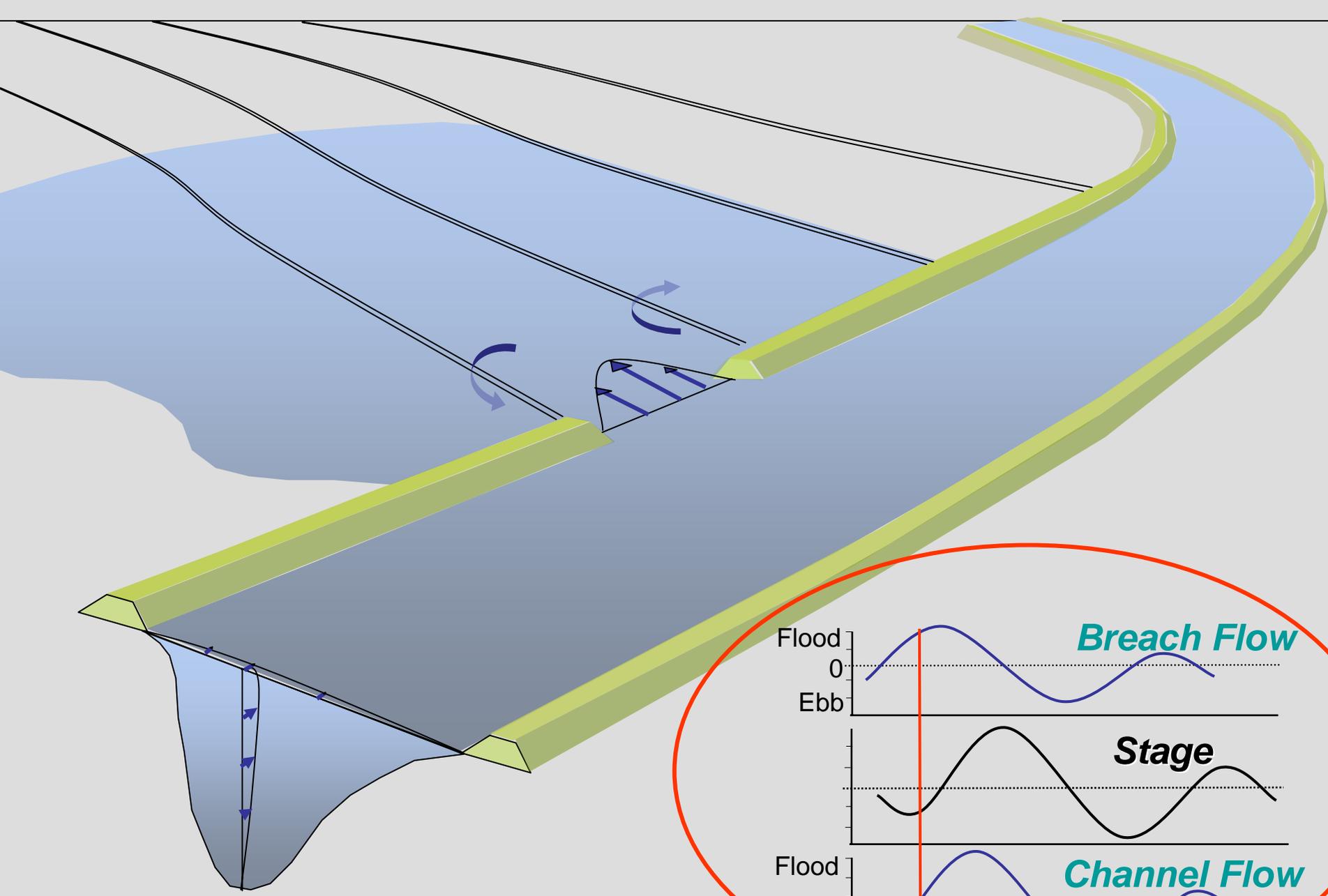


2. Tidal Trapping

- Differential tidal propagation in geometric irregularities

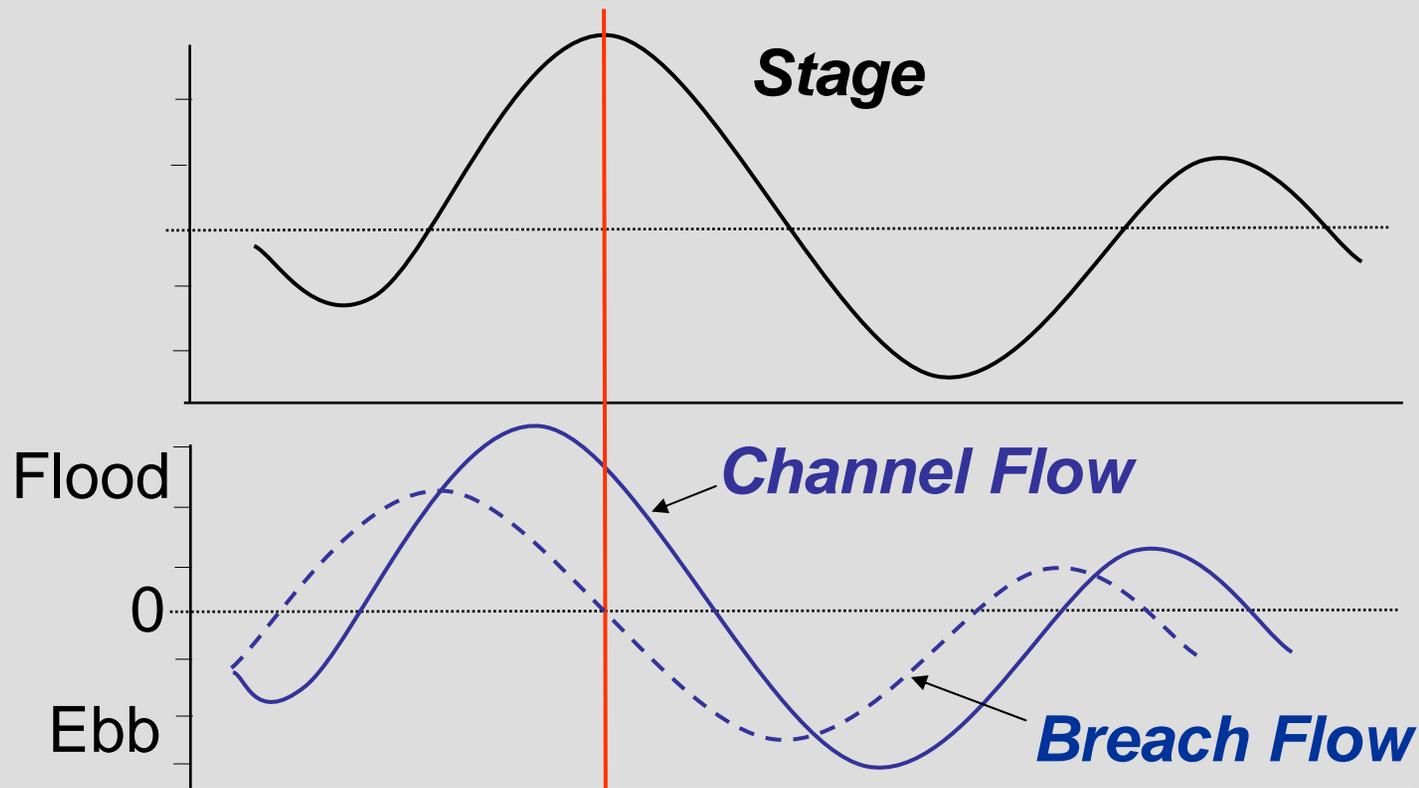






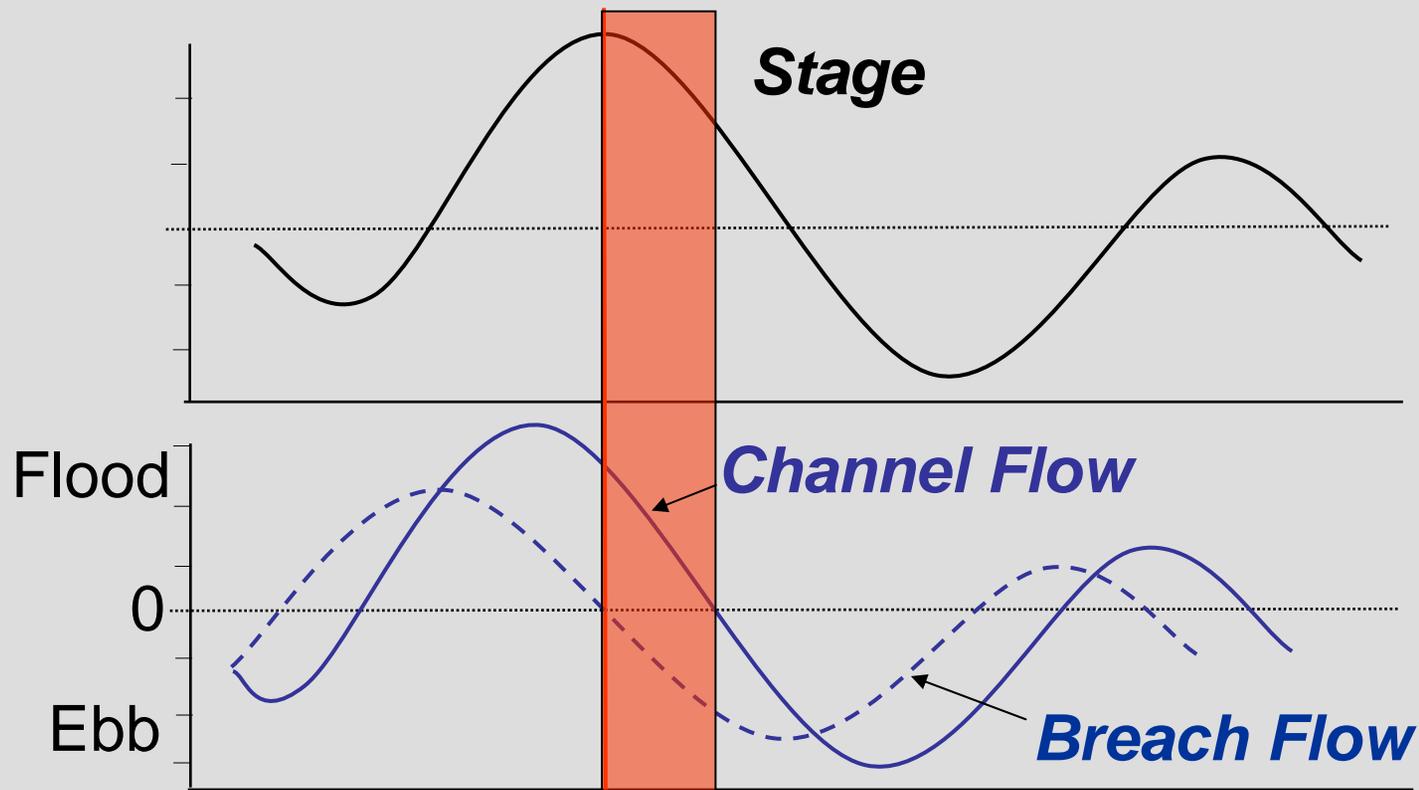
Tidal Trapping

- Timing of tidal stage and tidal flow:

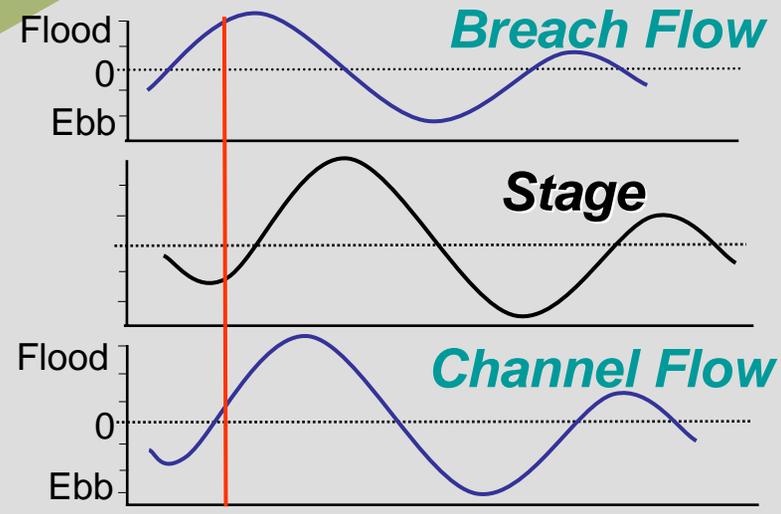
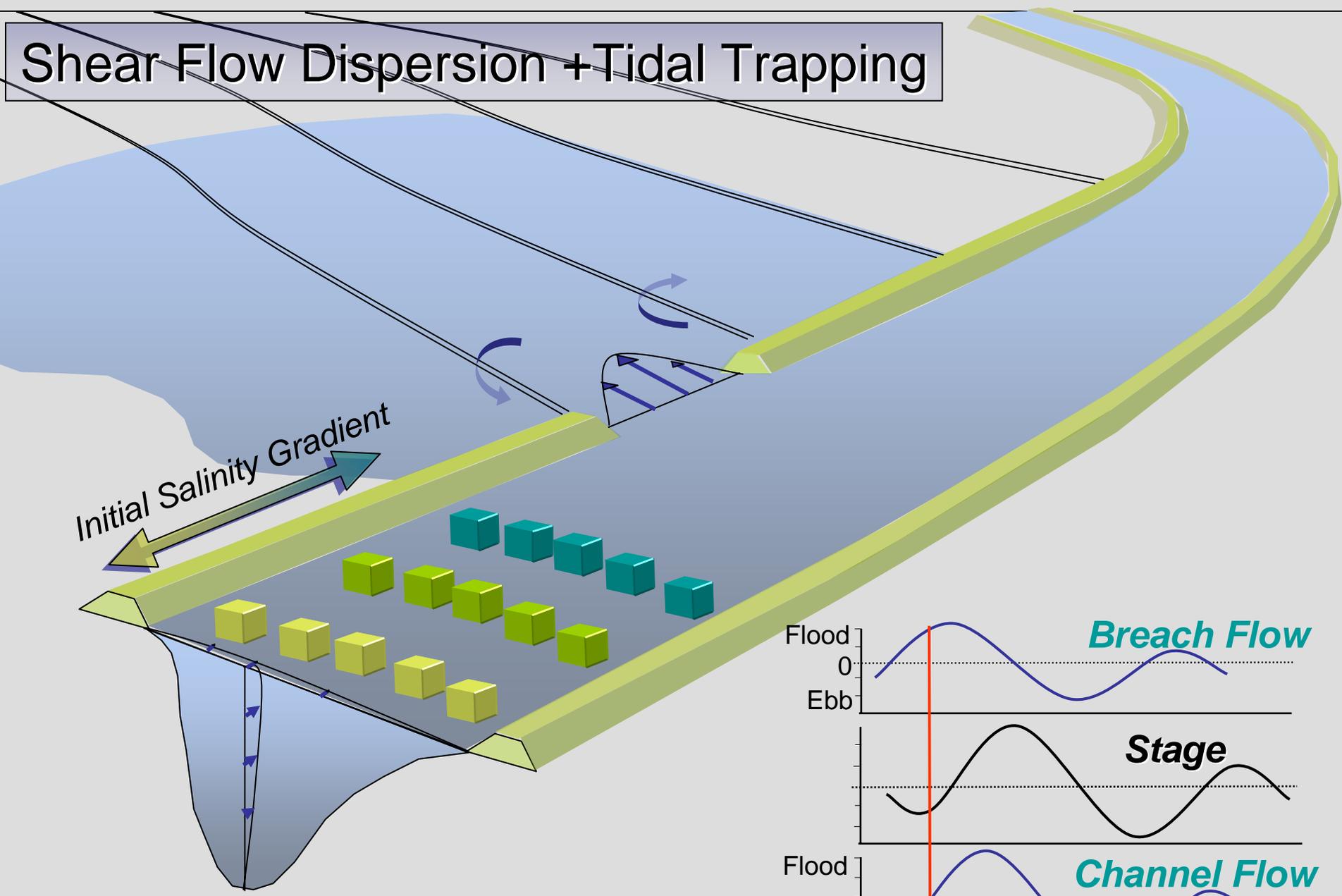


Tidal Trapping

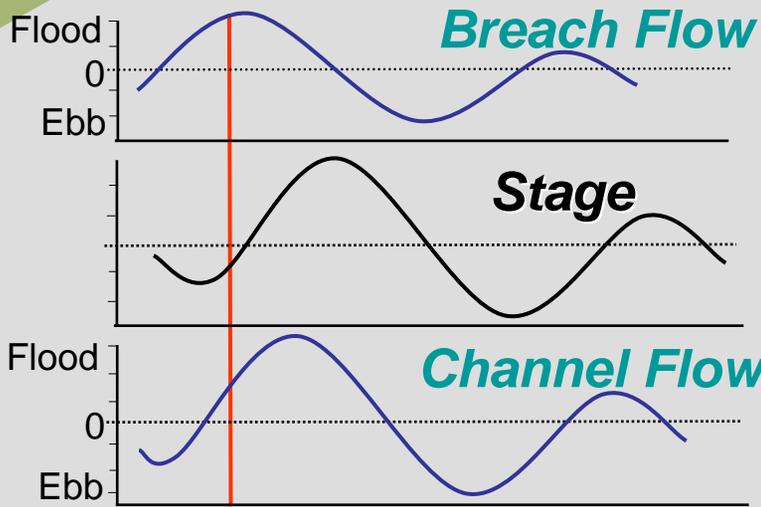
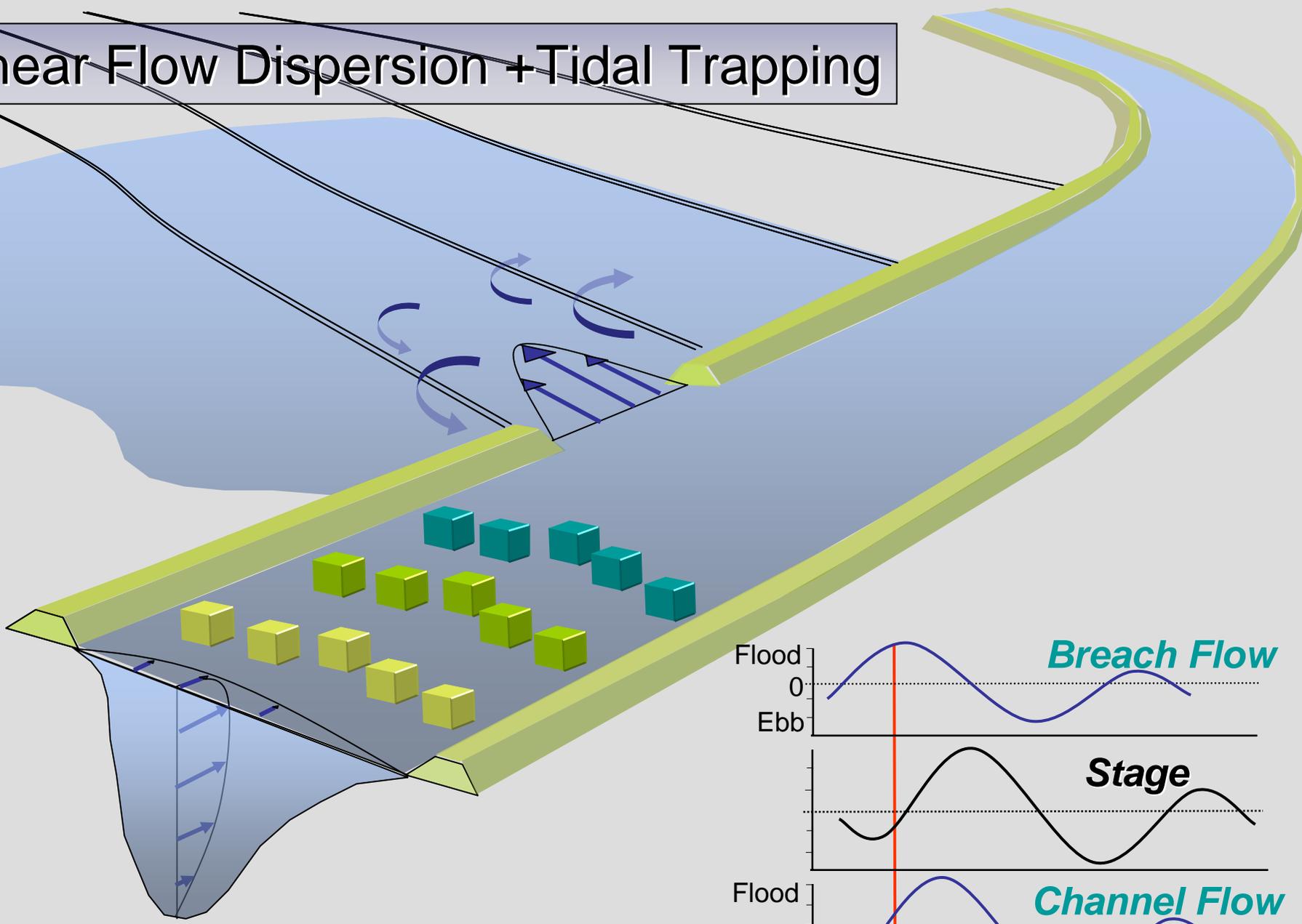
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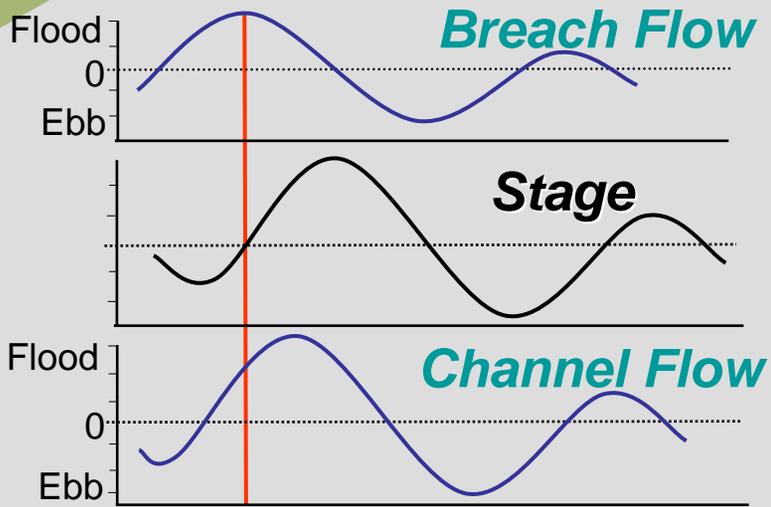
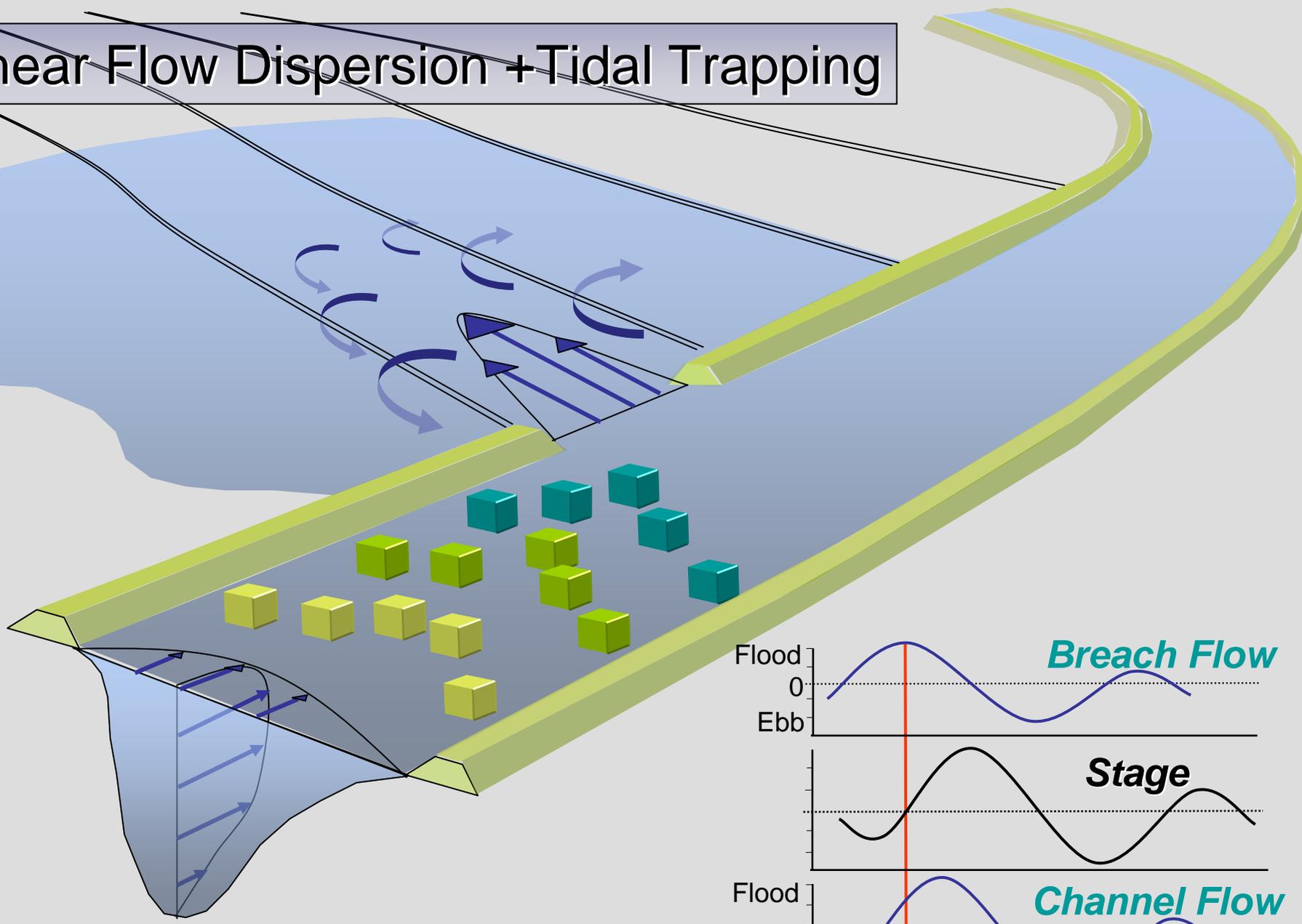
Shear Flow Dispersion + Tidal Trapping



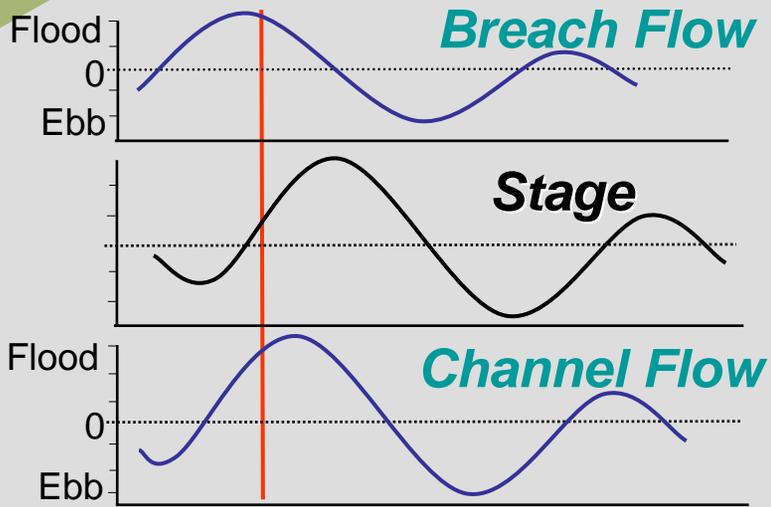
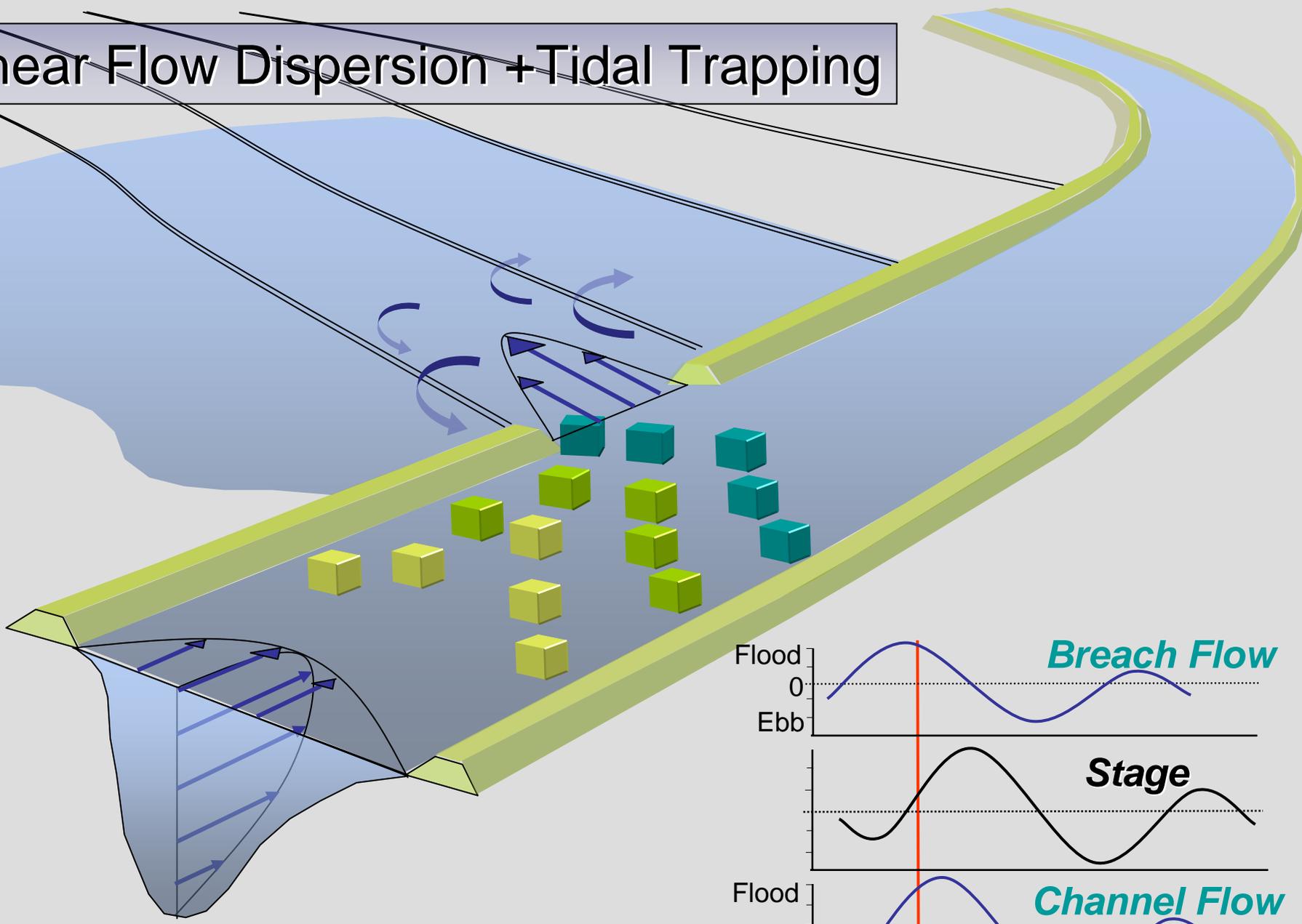
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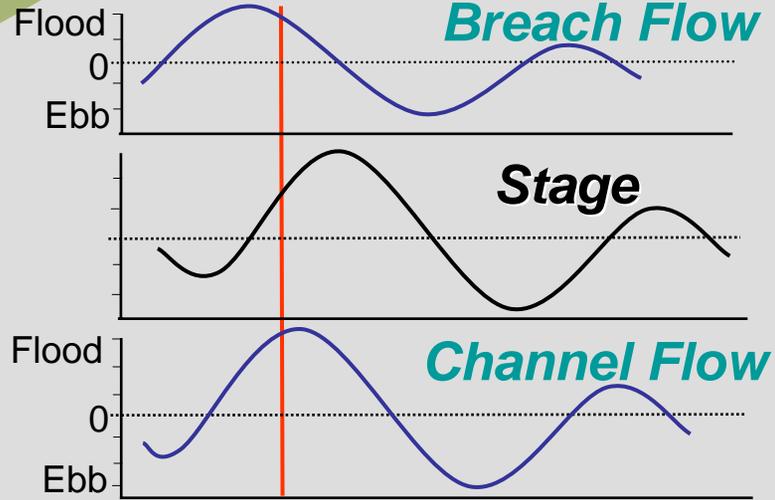
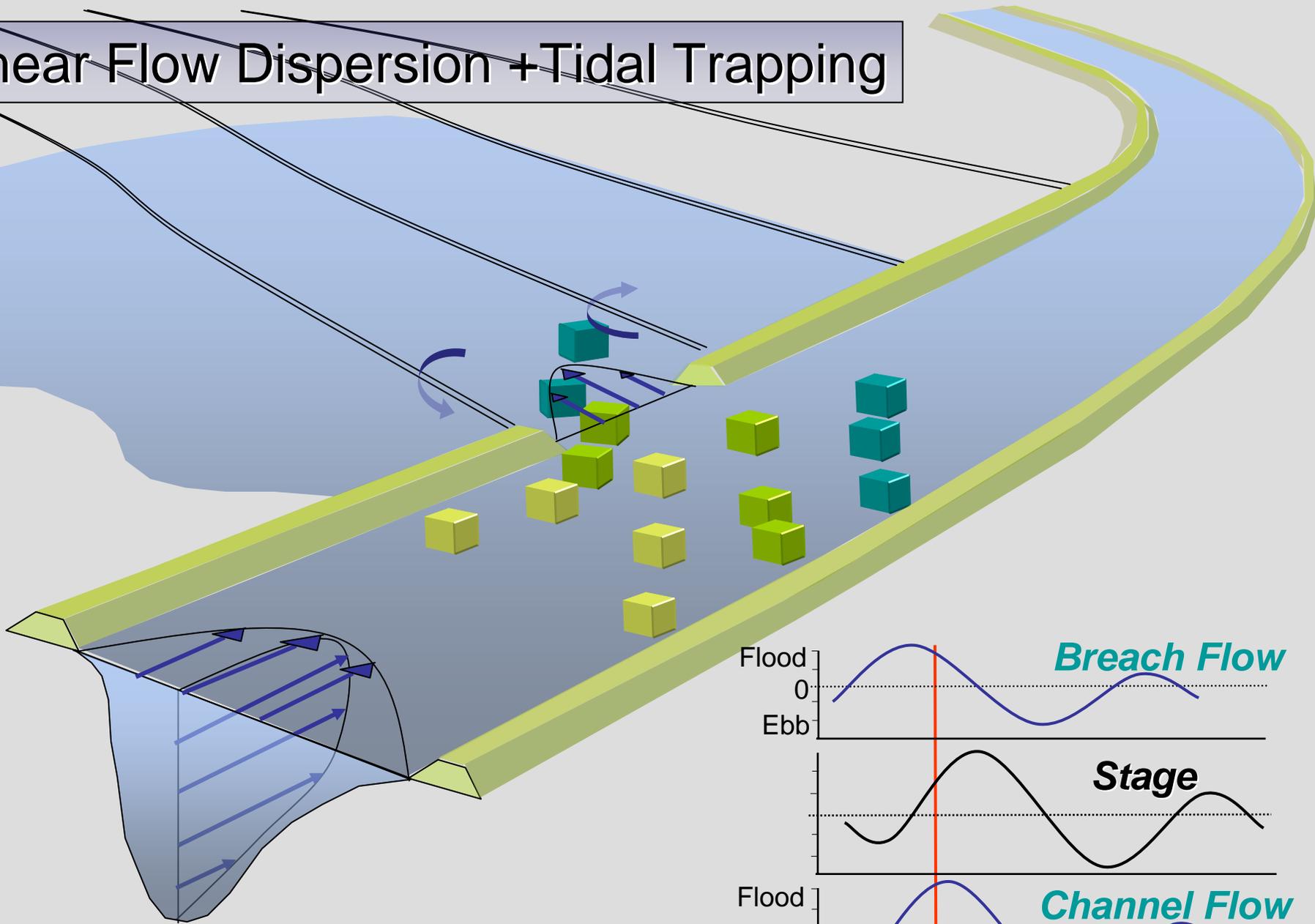
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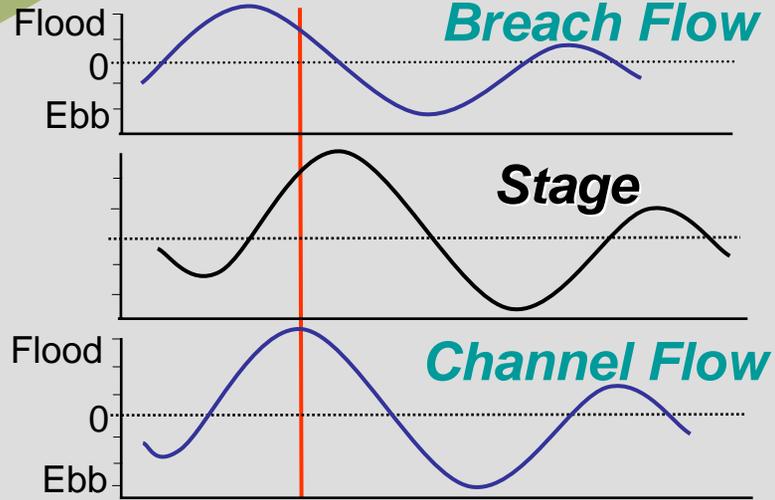
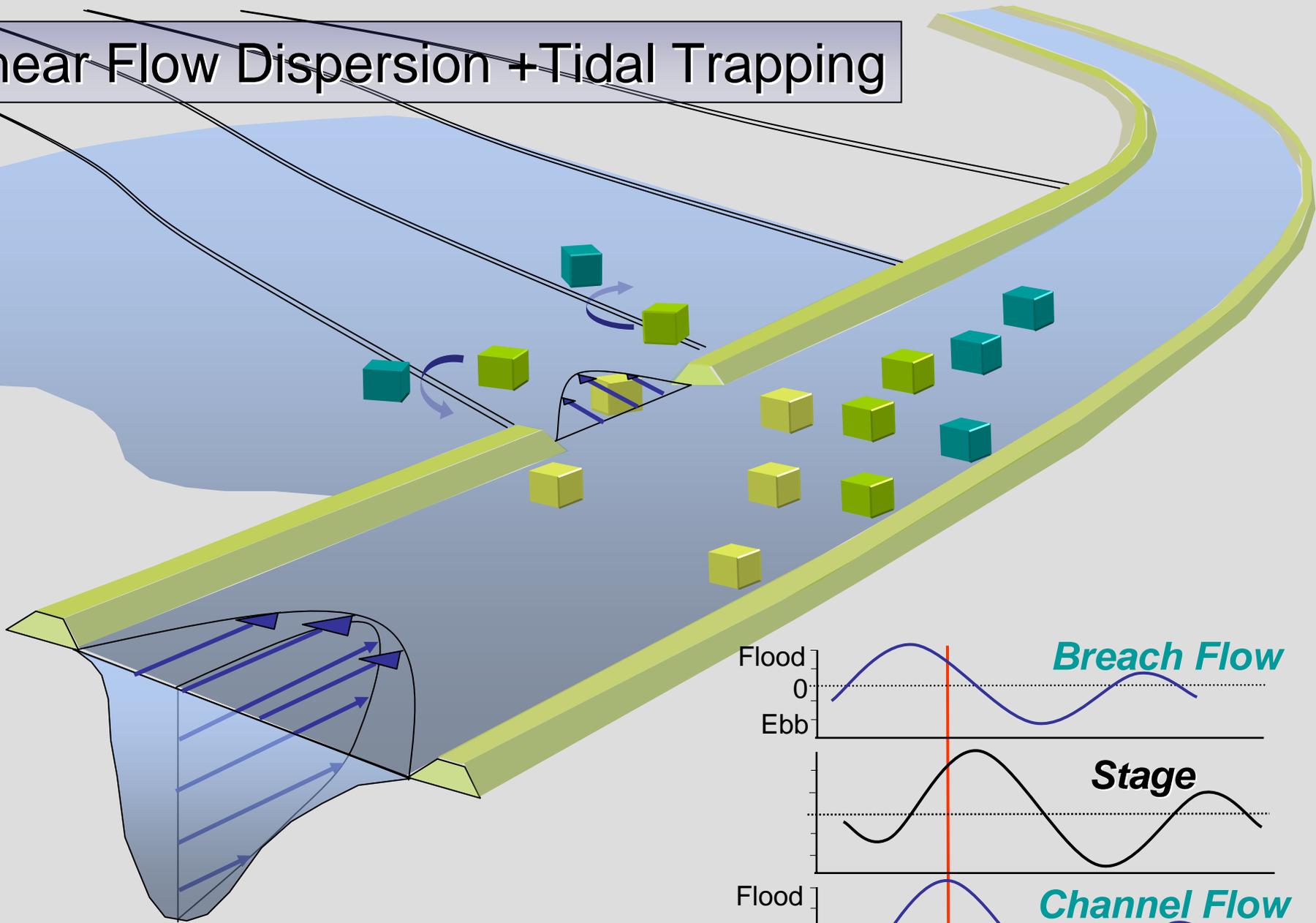
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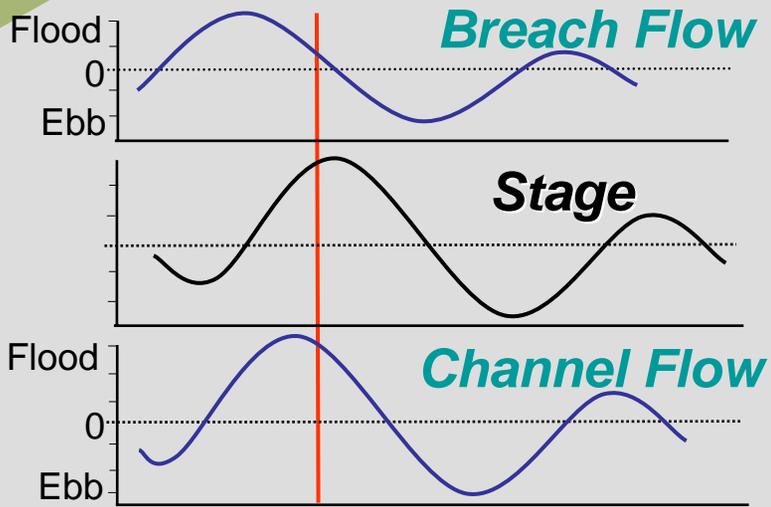
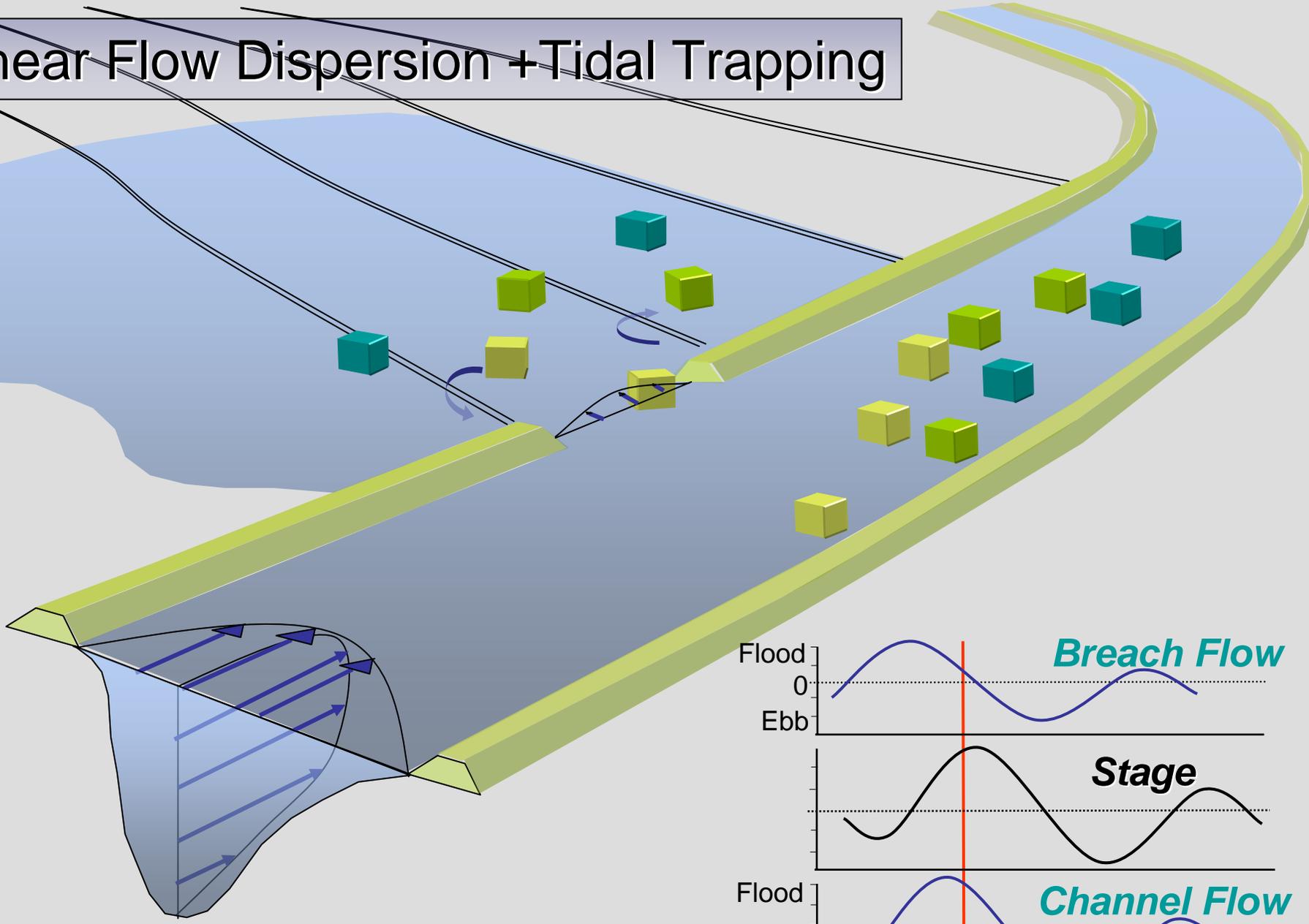
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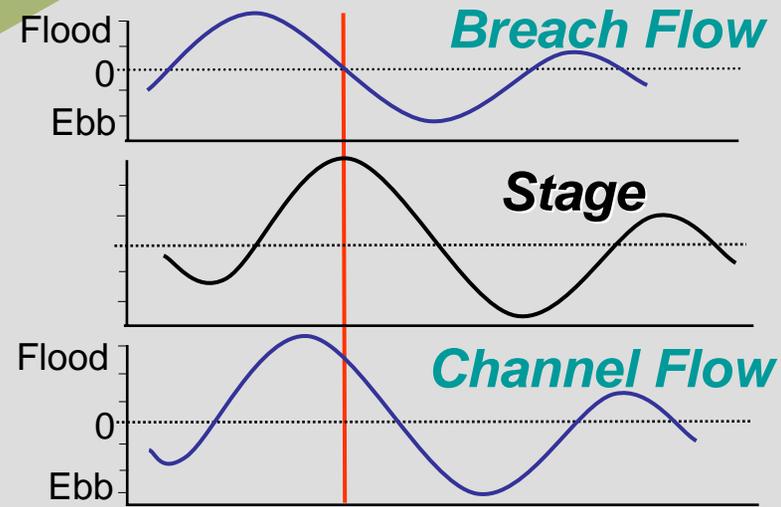
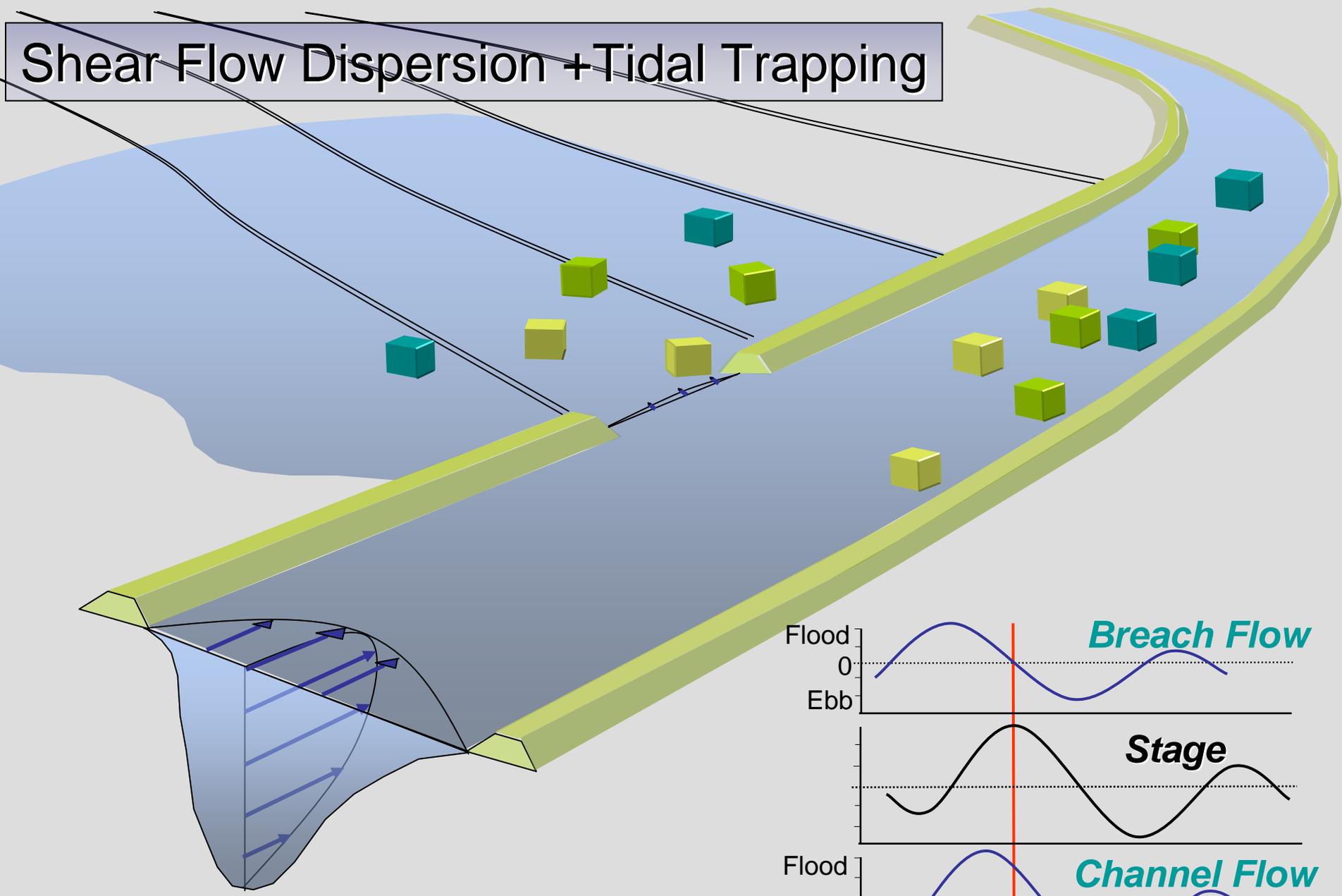
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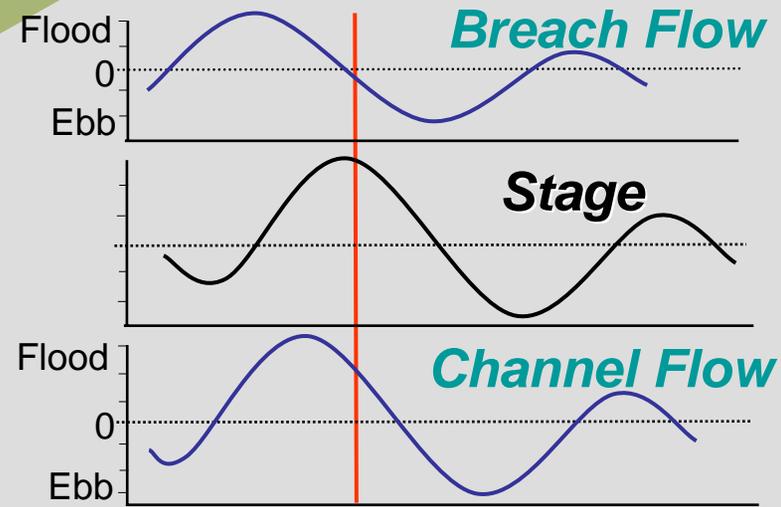
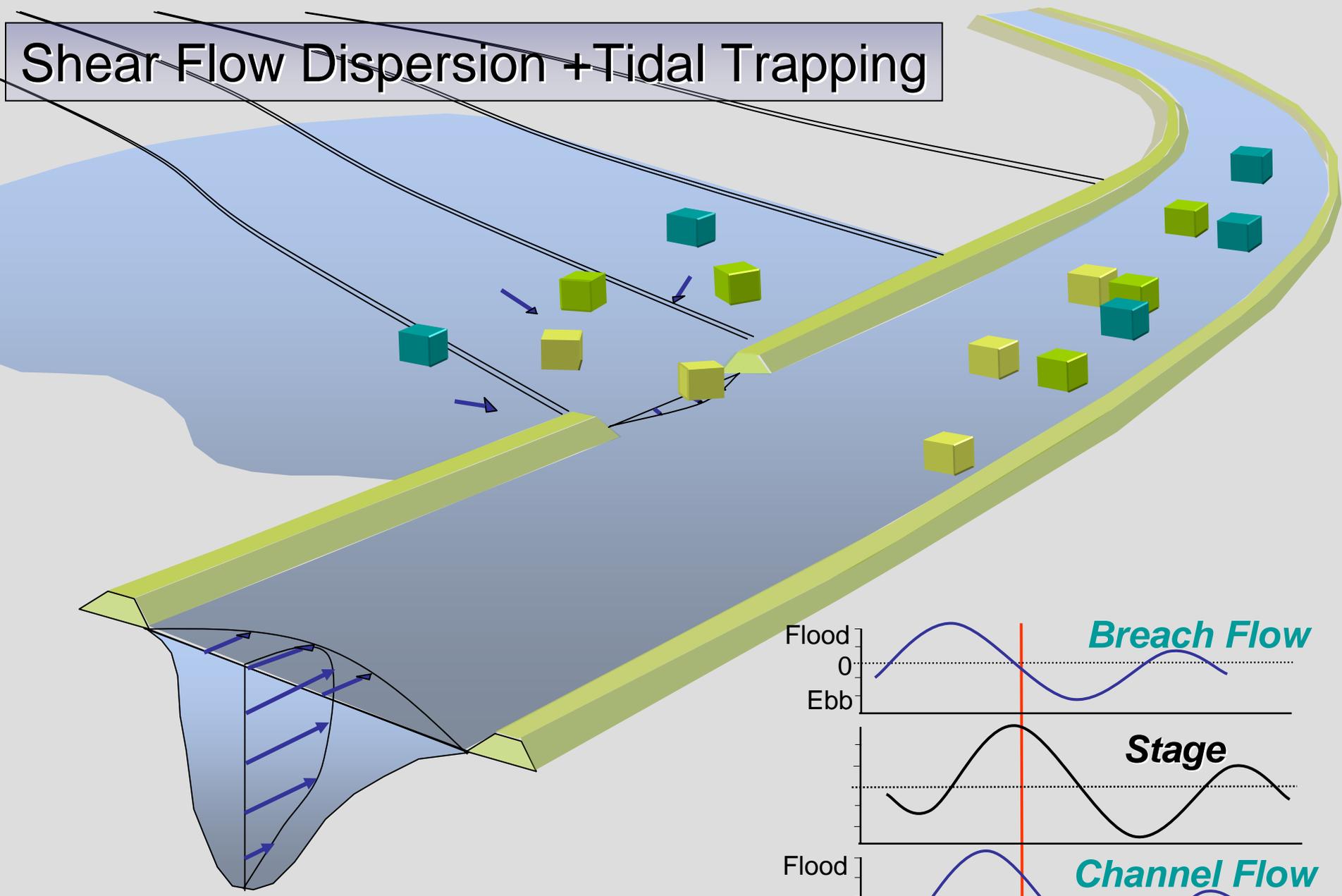
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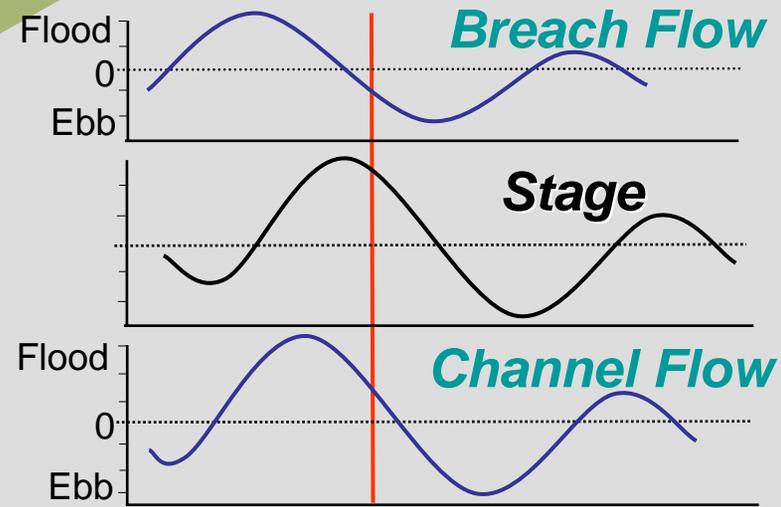
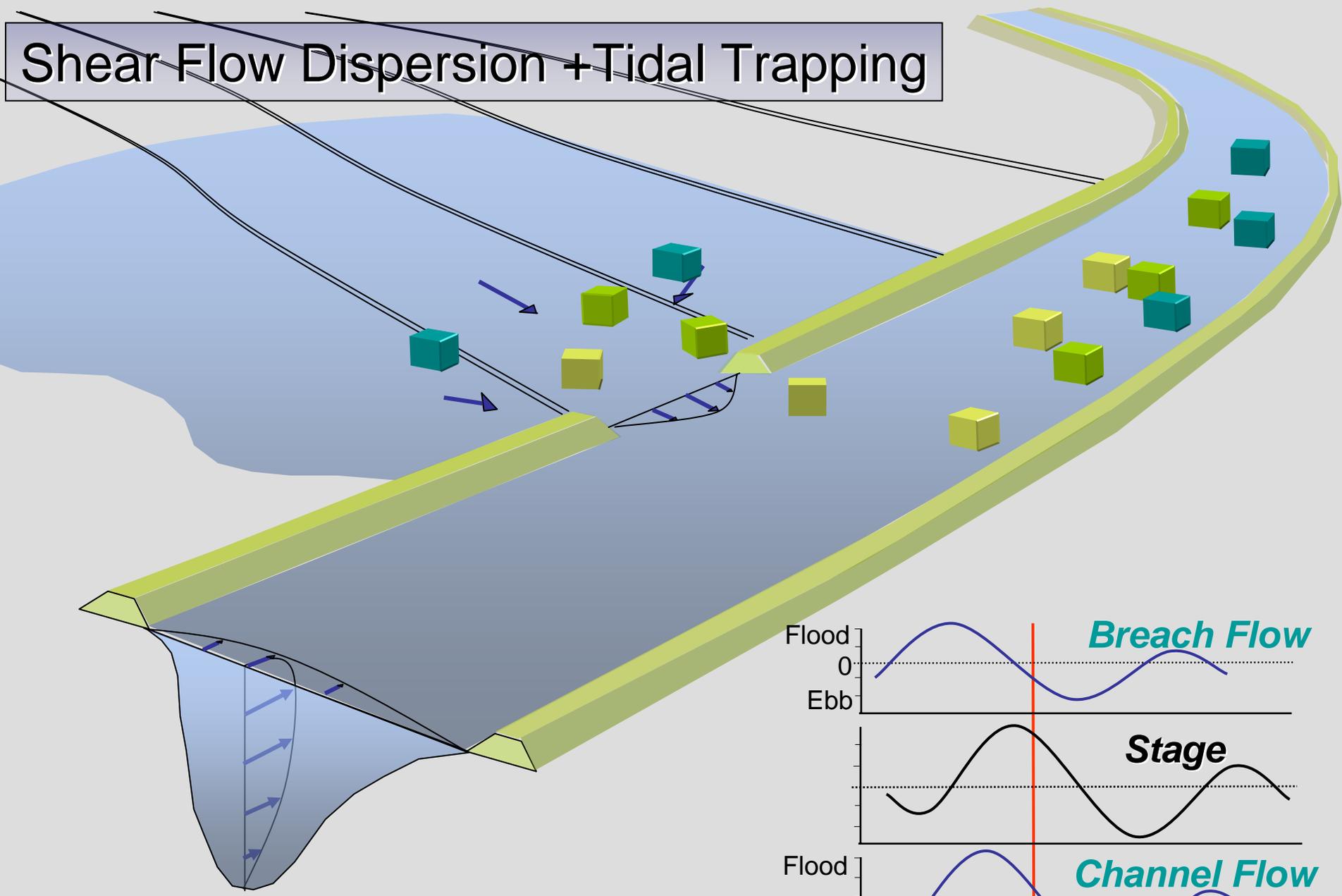
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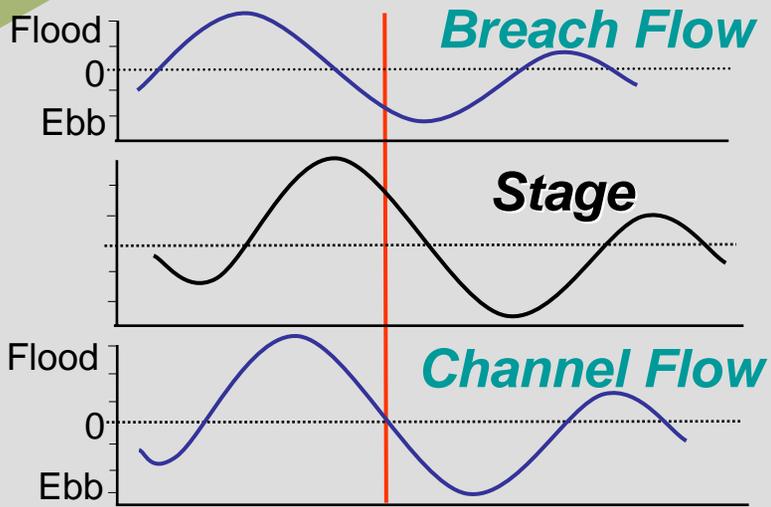
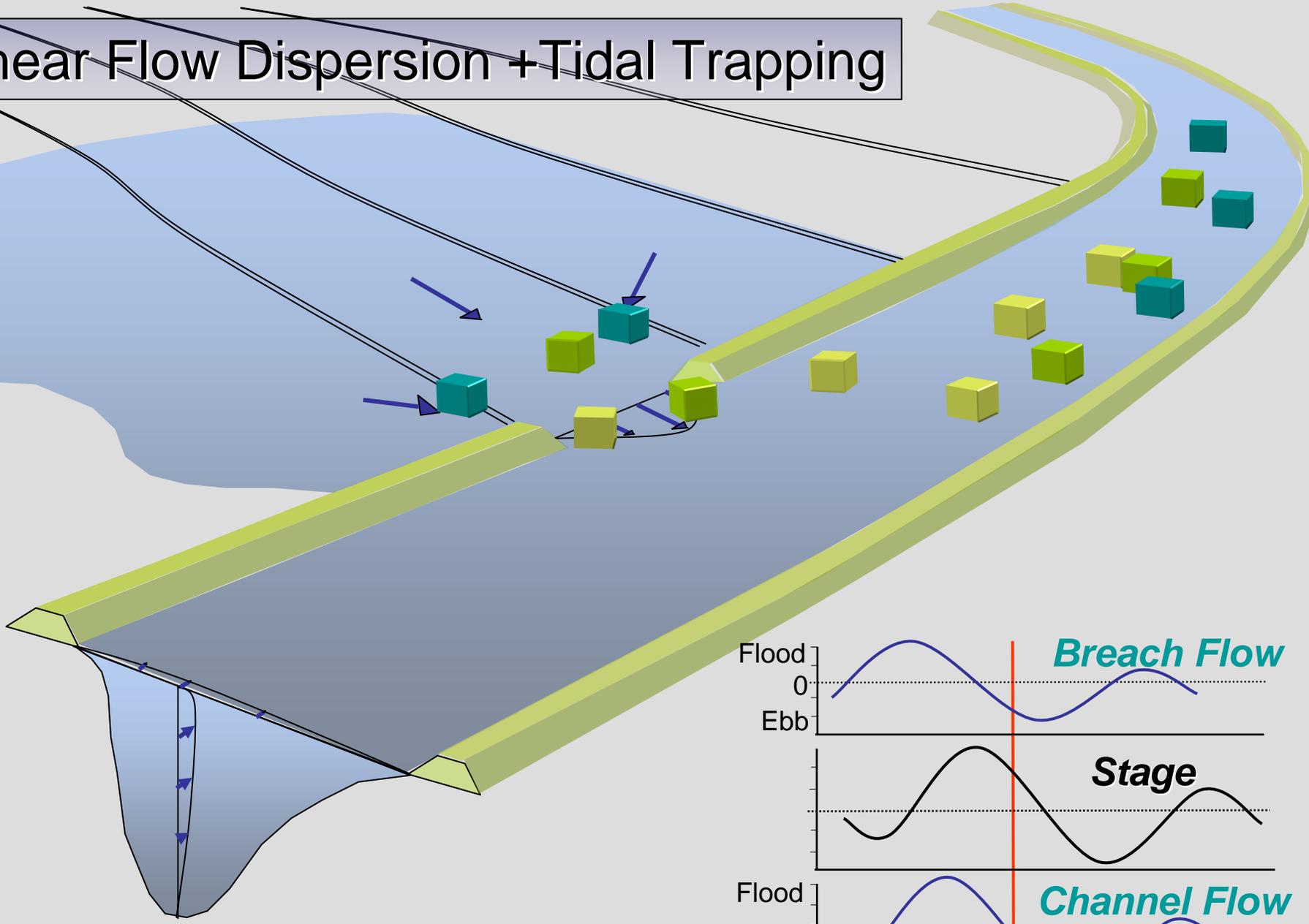
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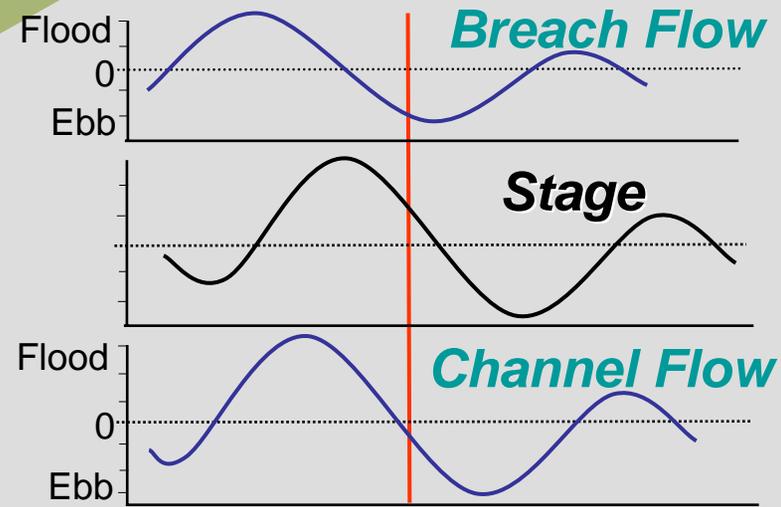
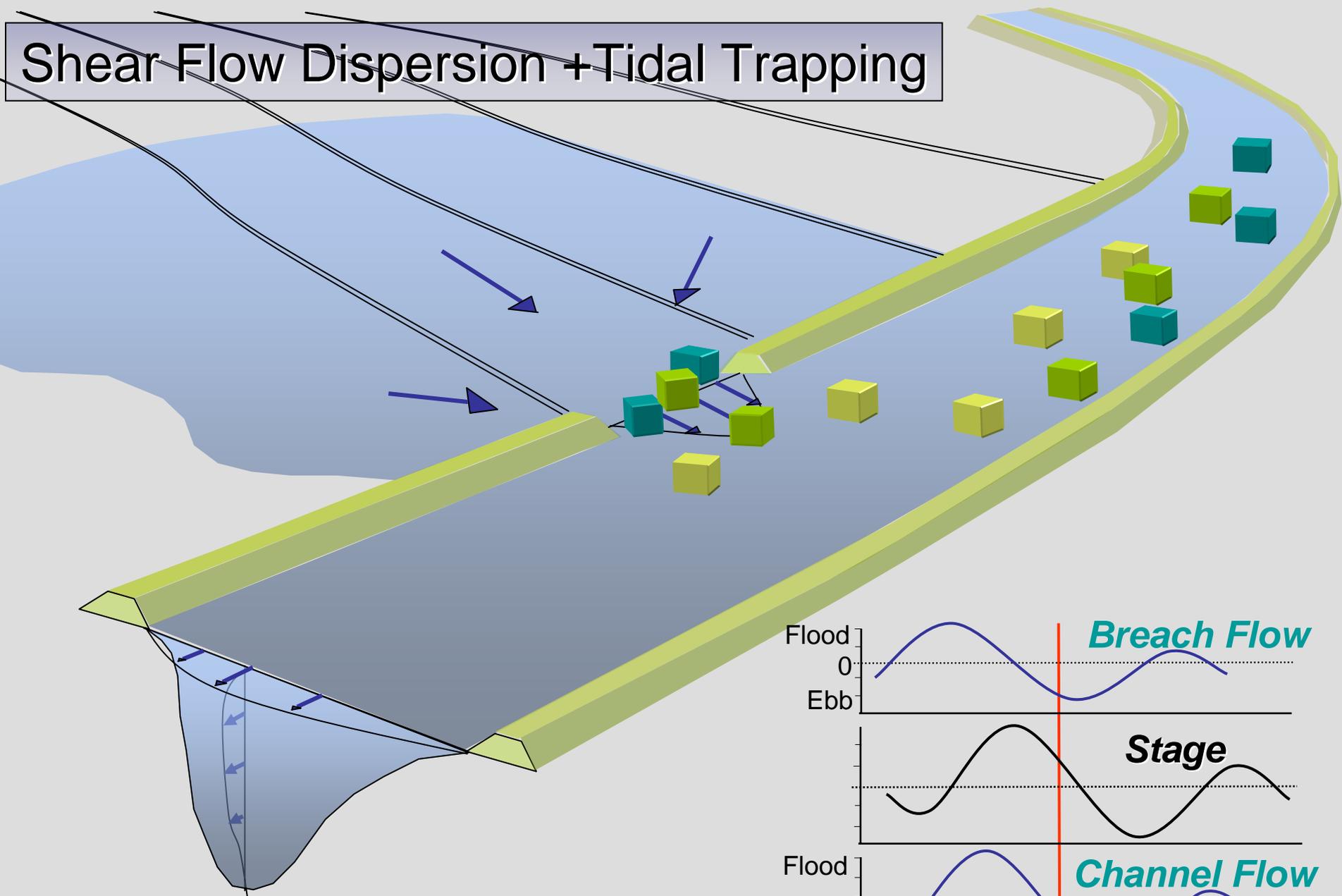
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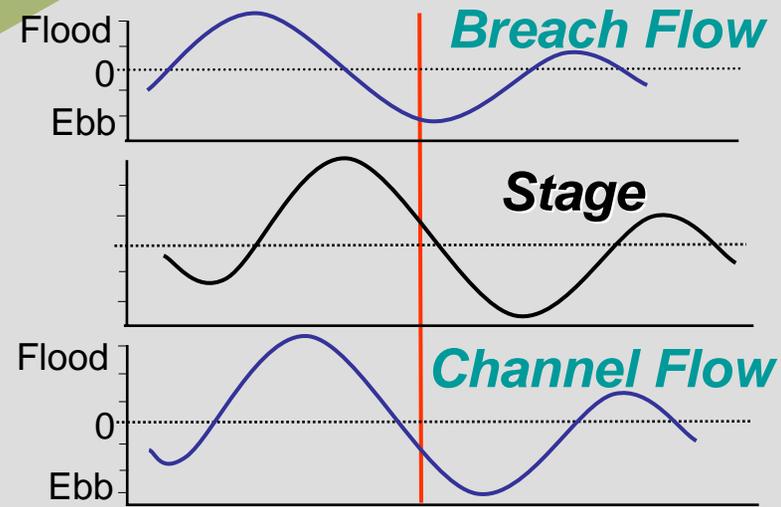
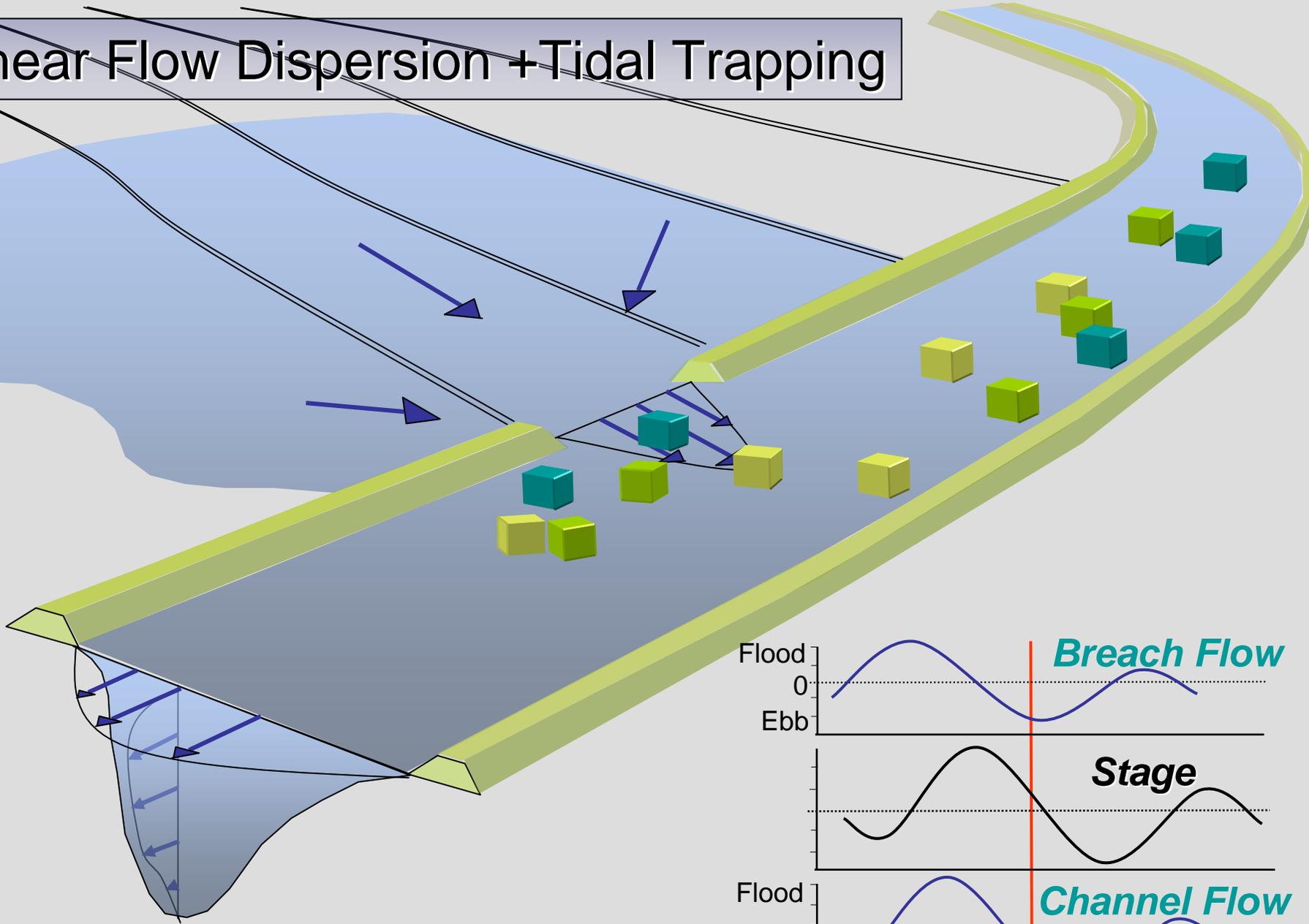
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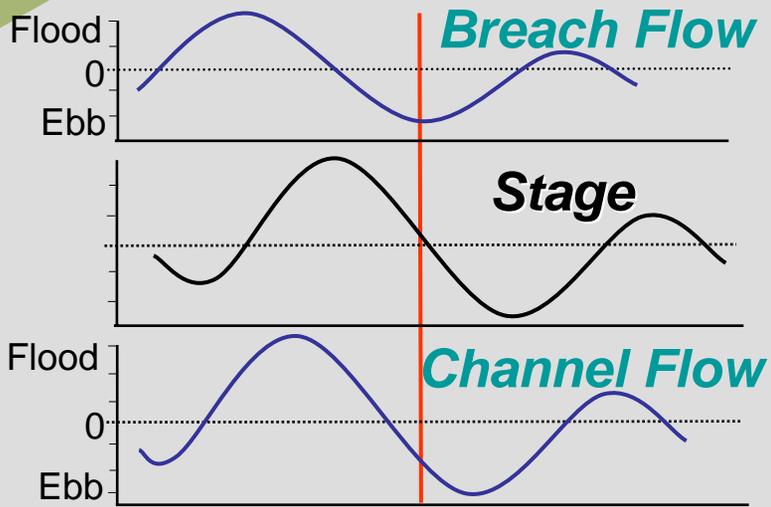
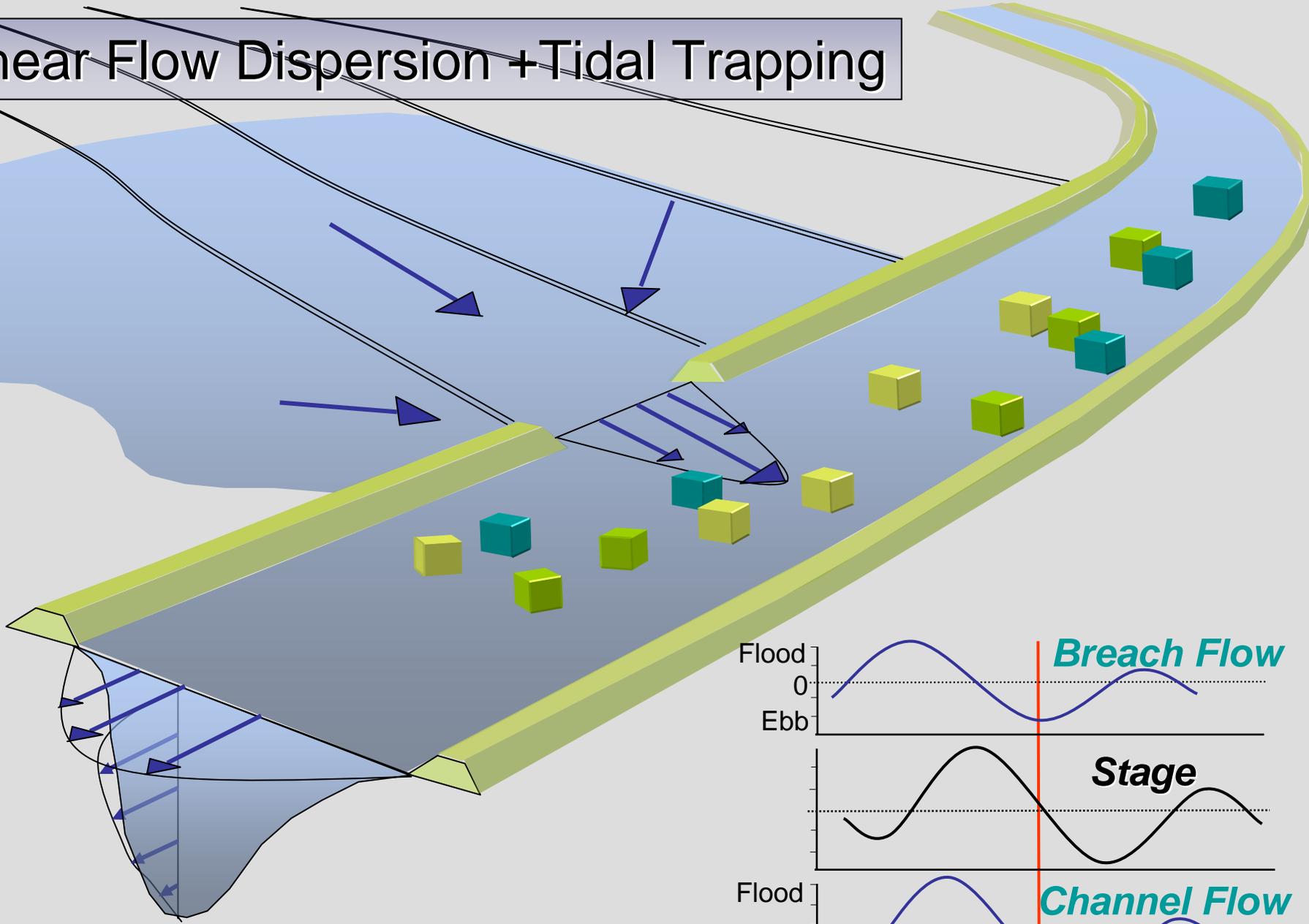
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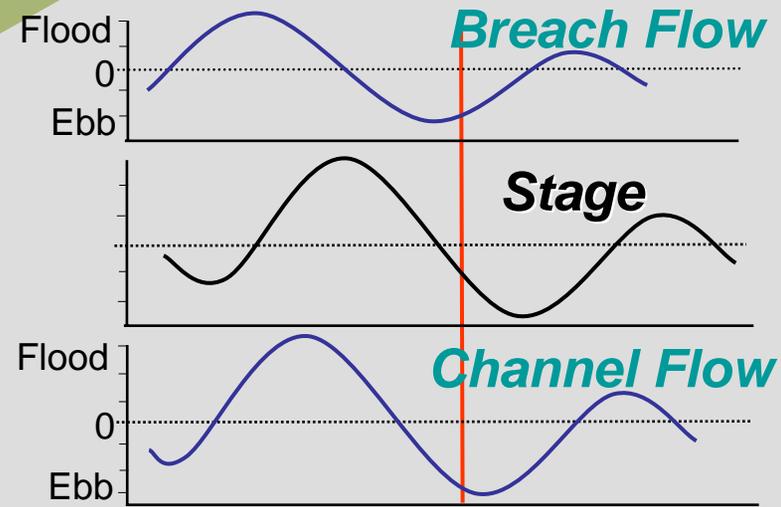
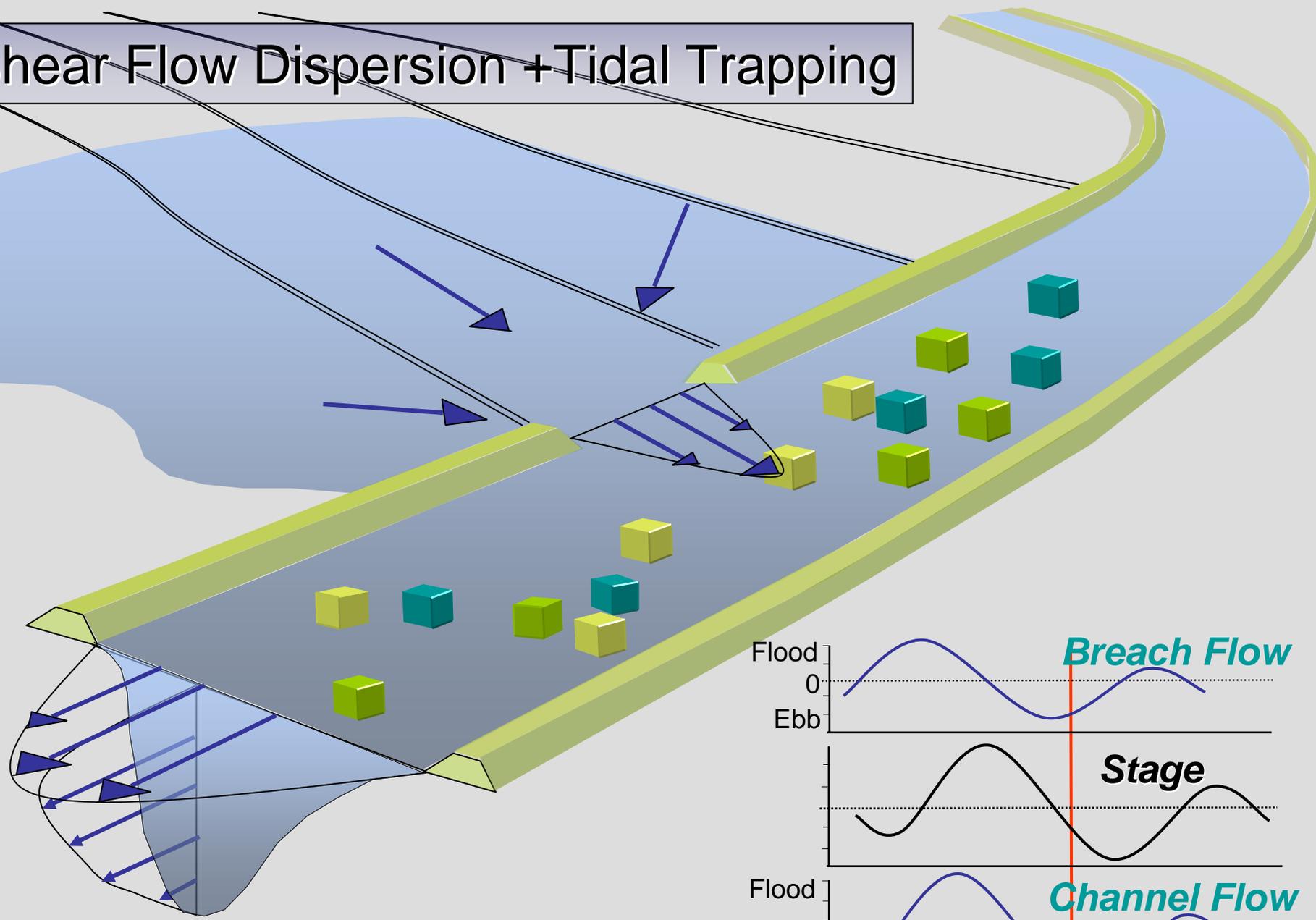
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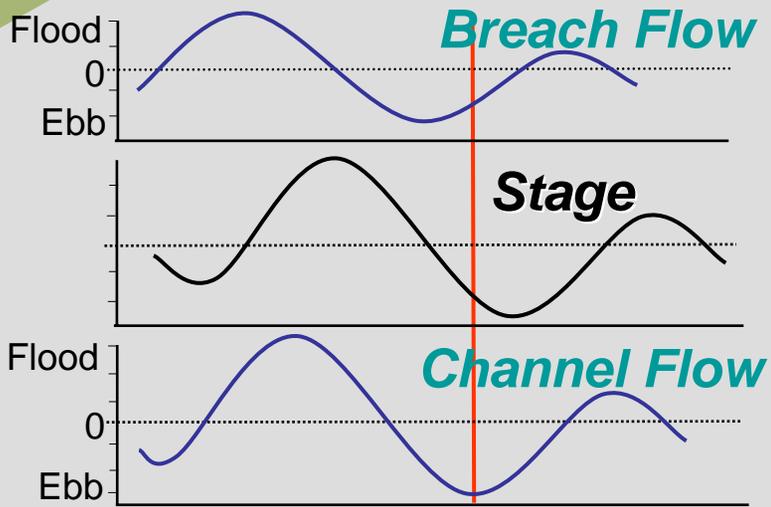
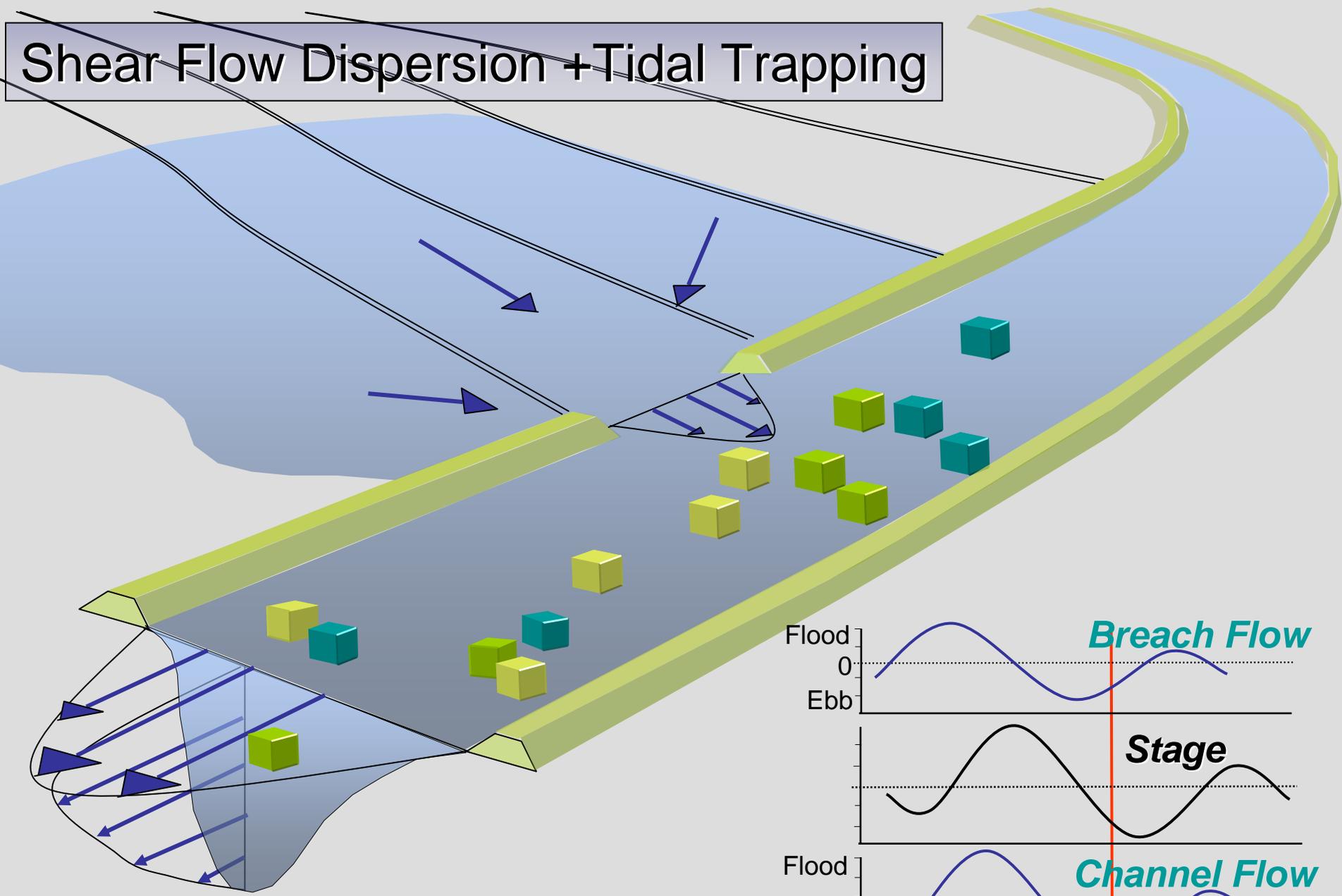
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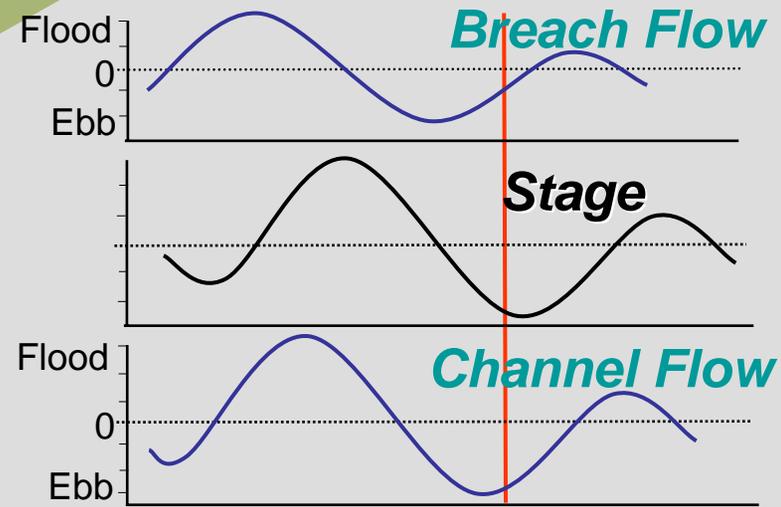
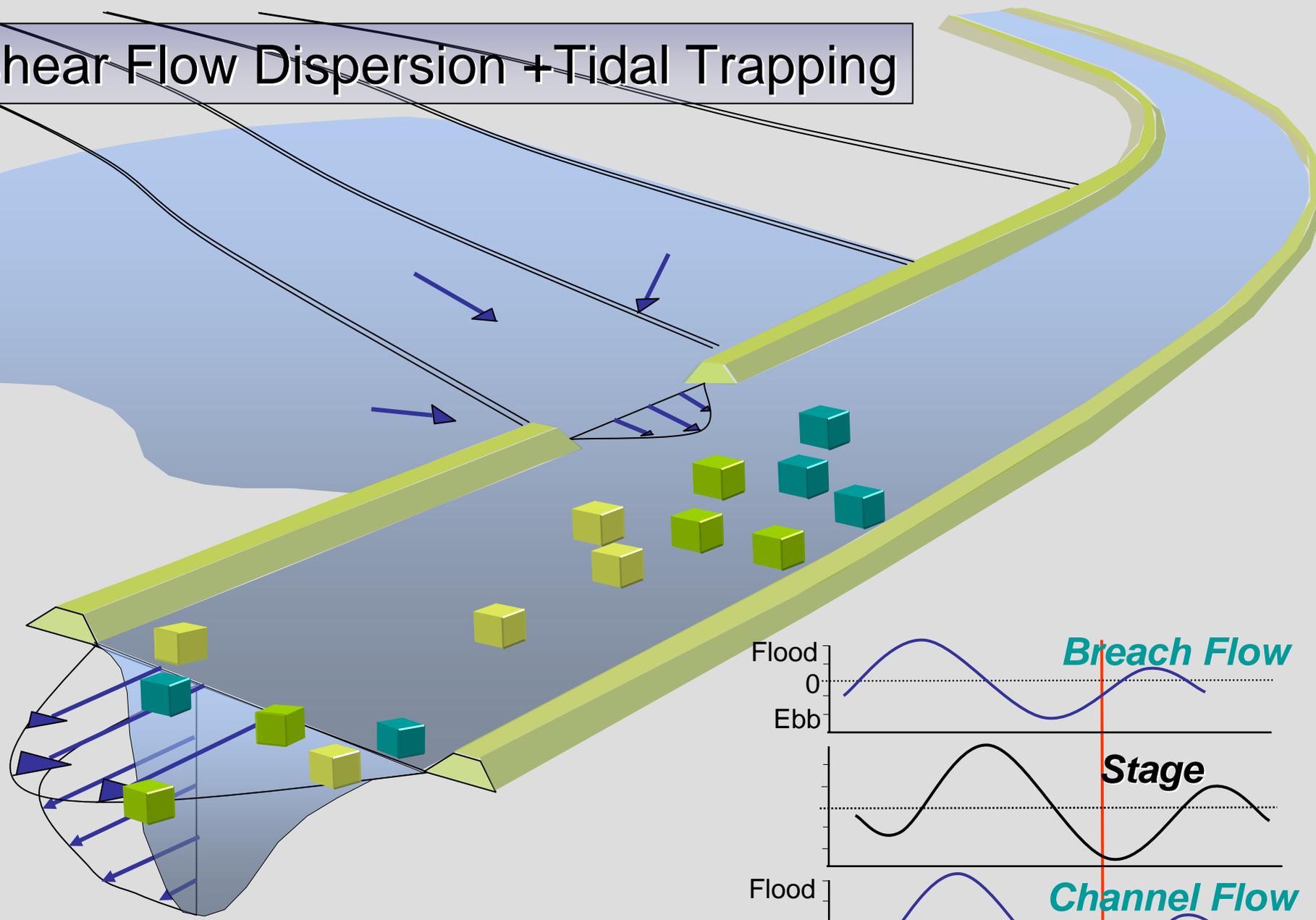
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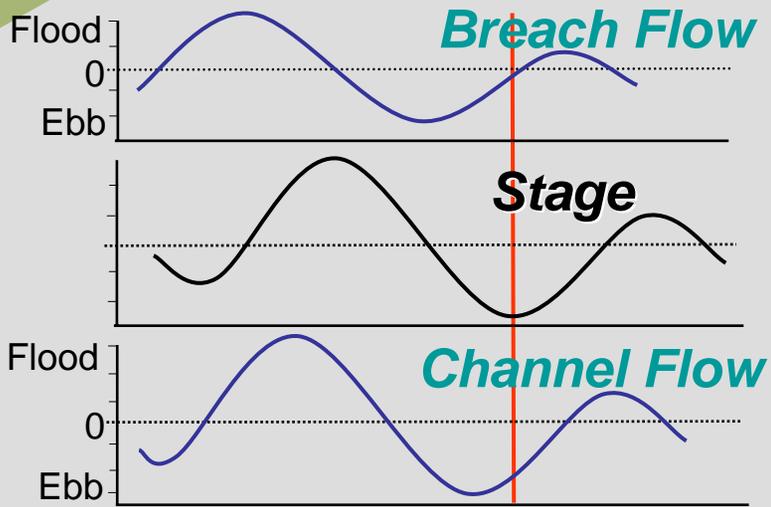
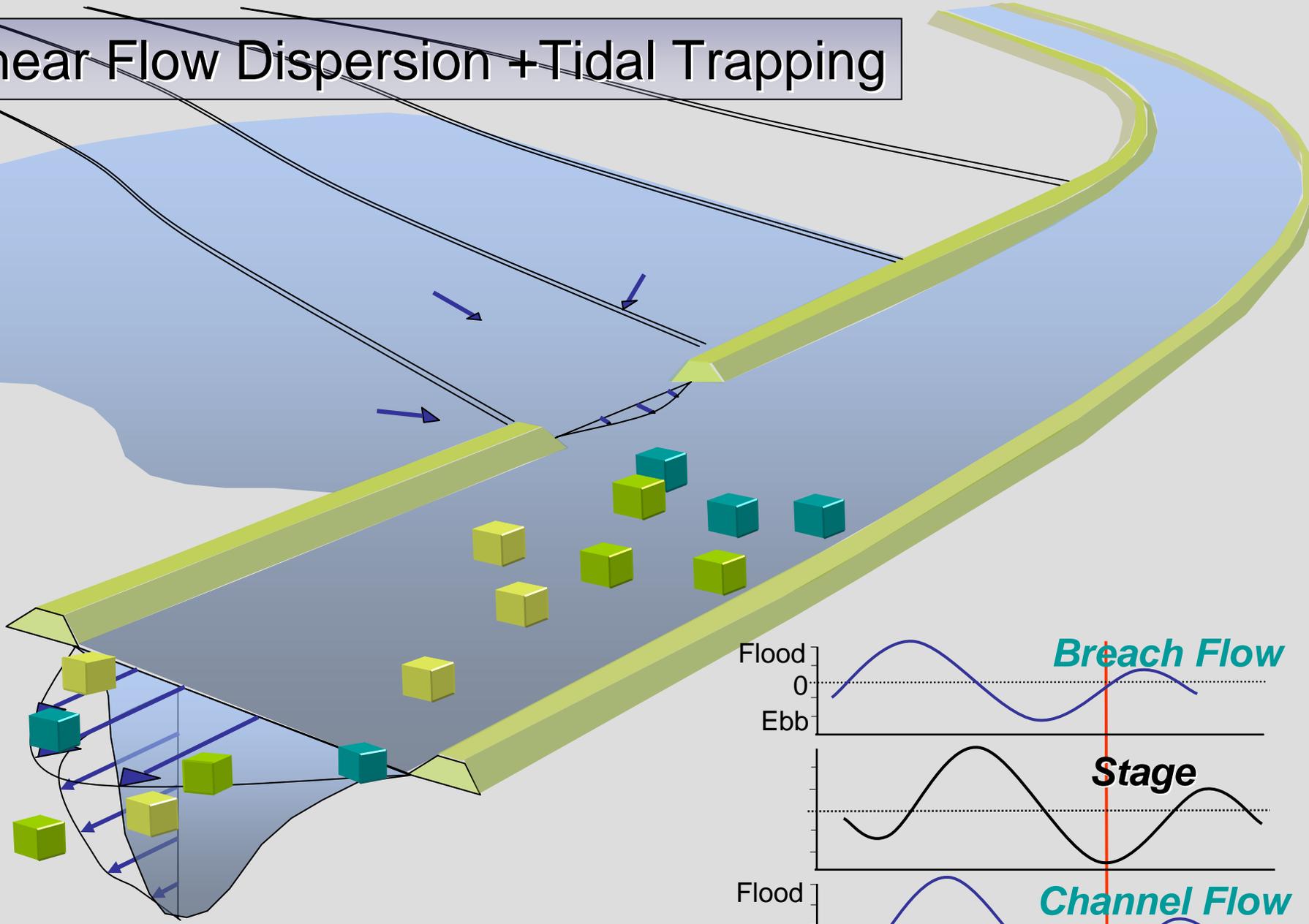
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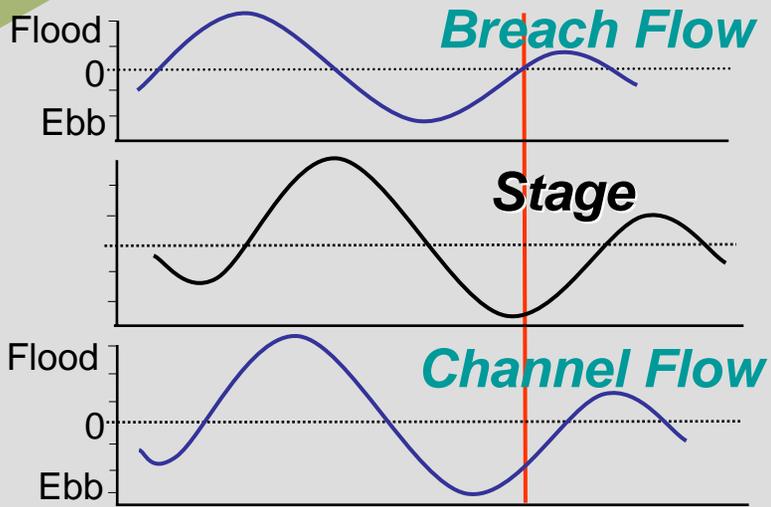
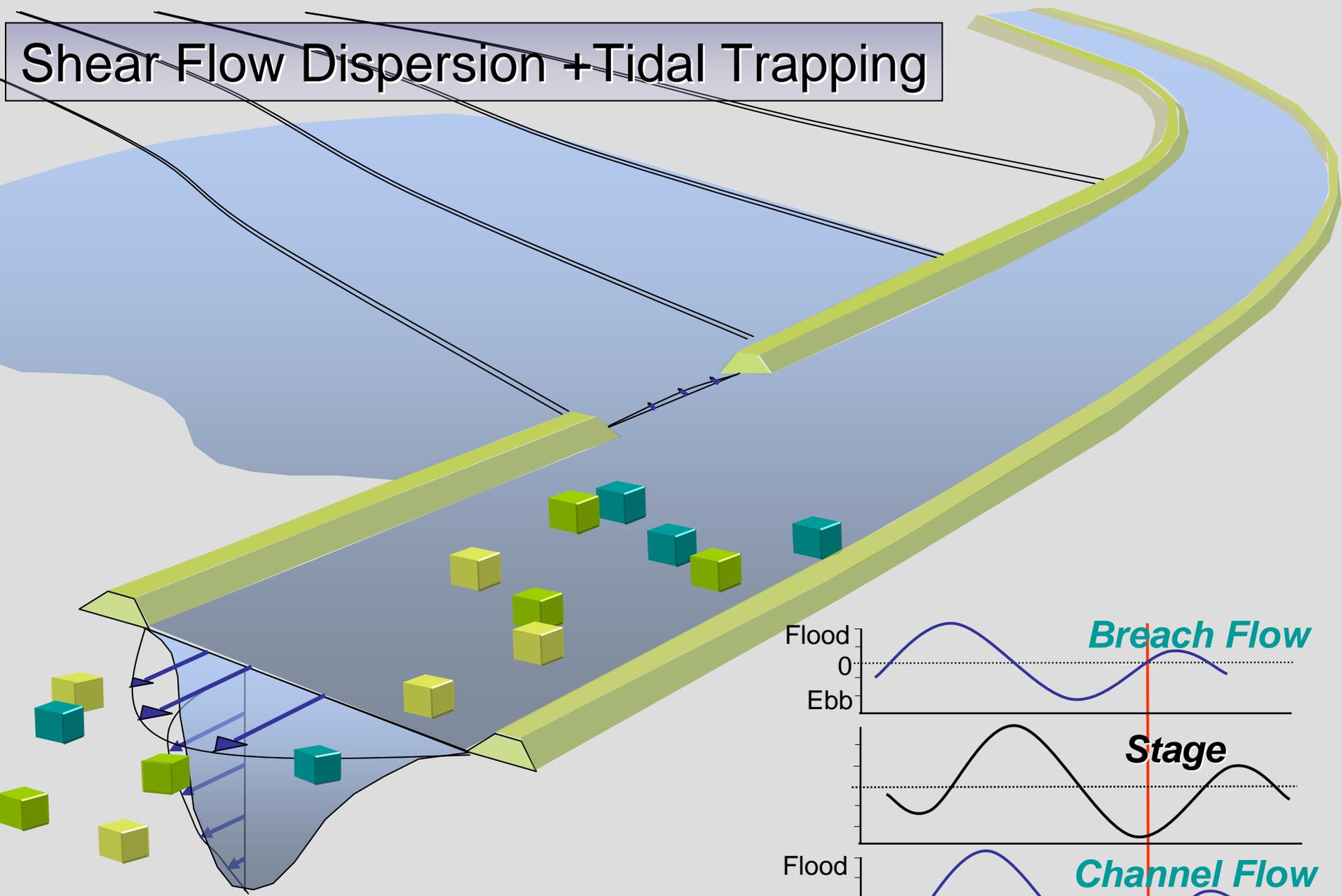
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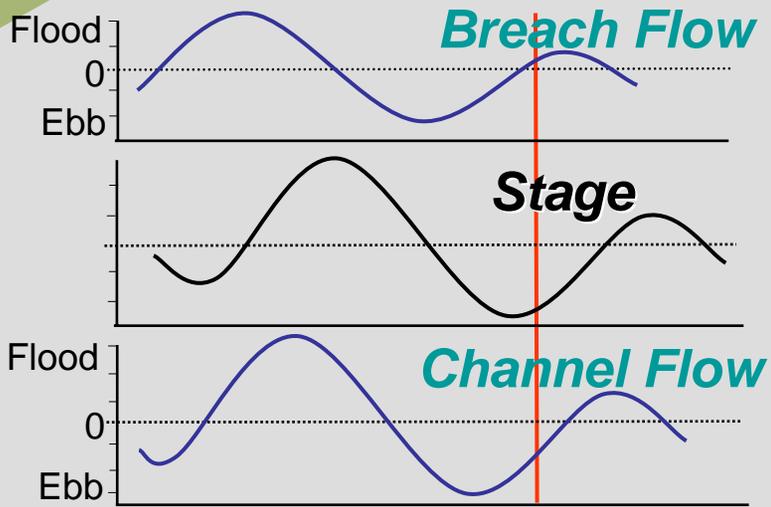
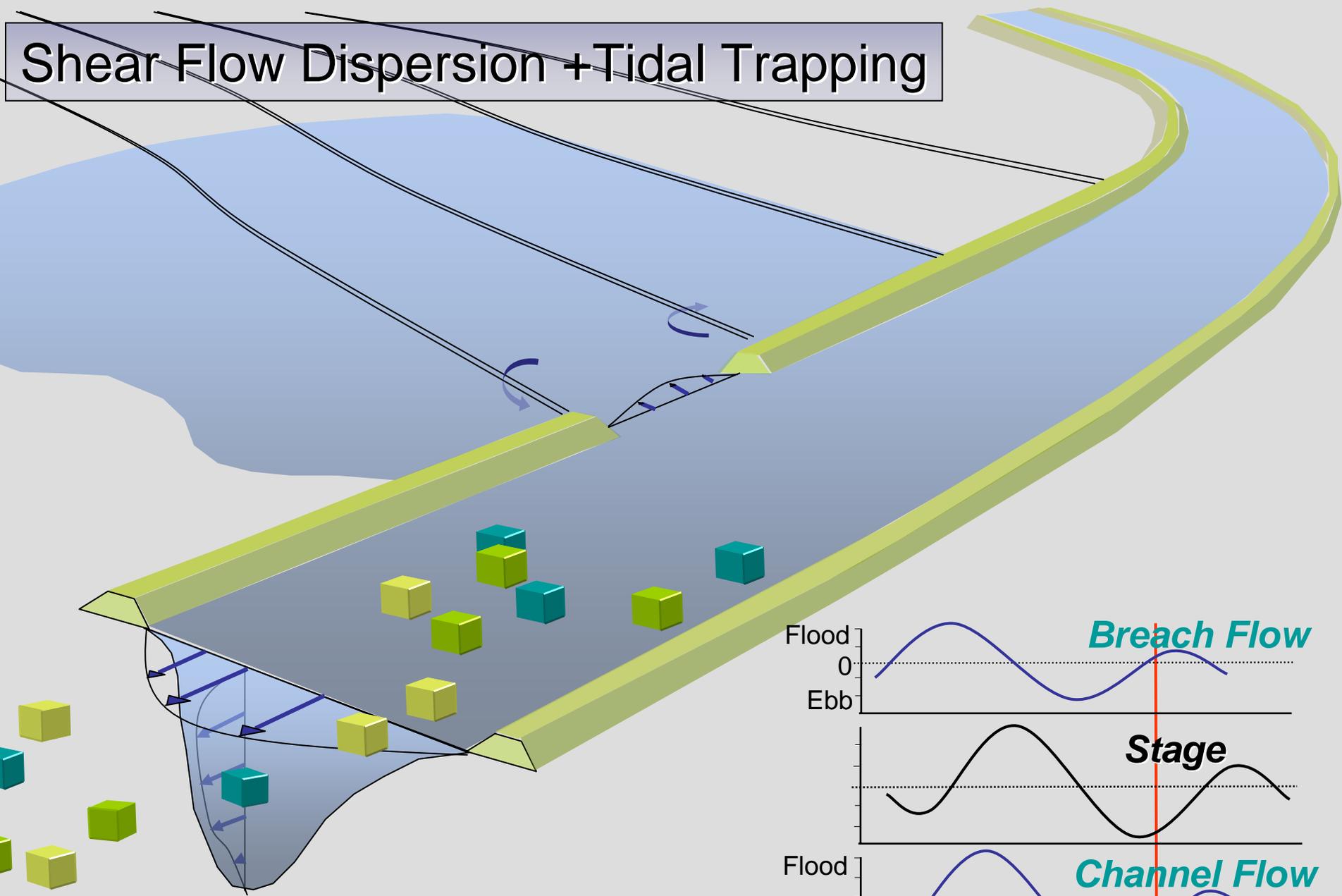
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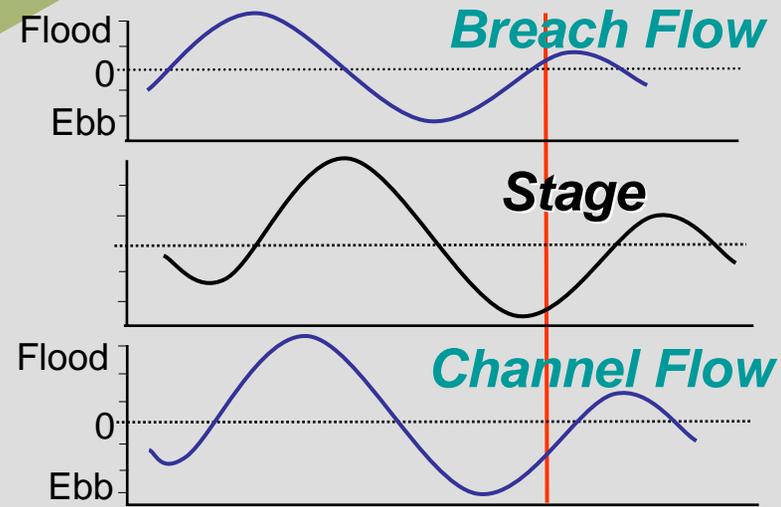
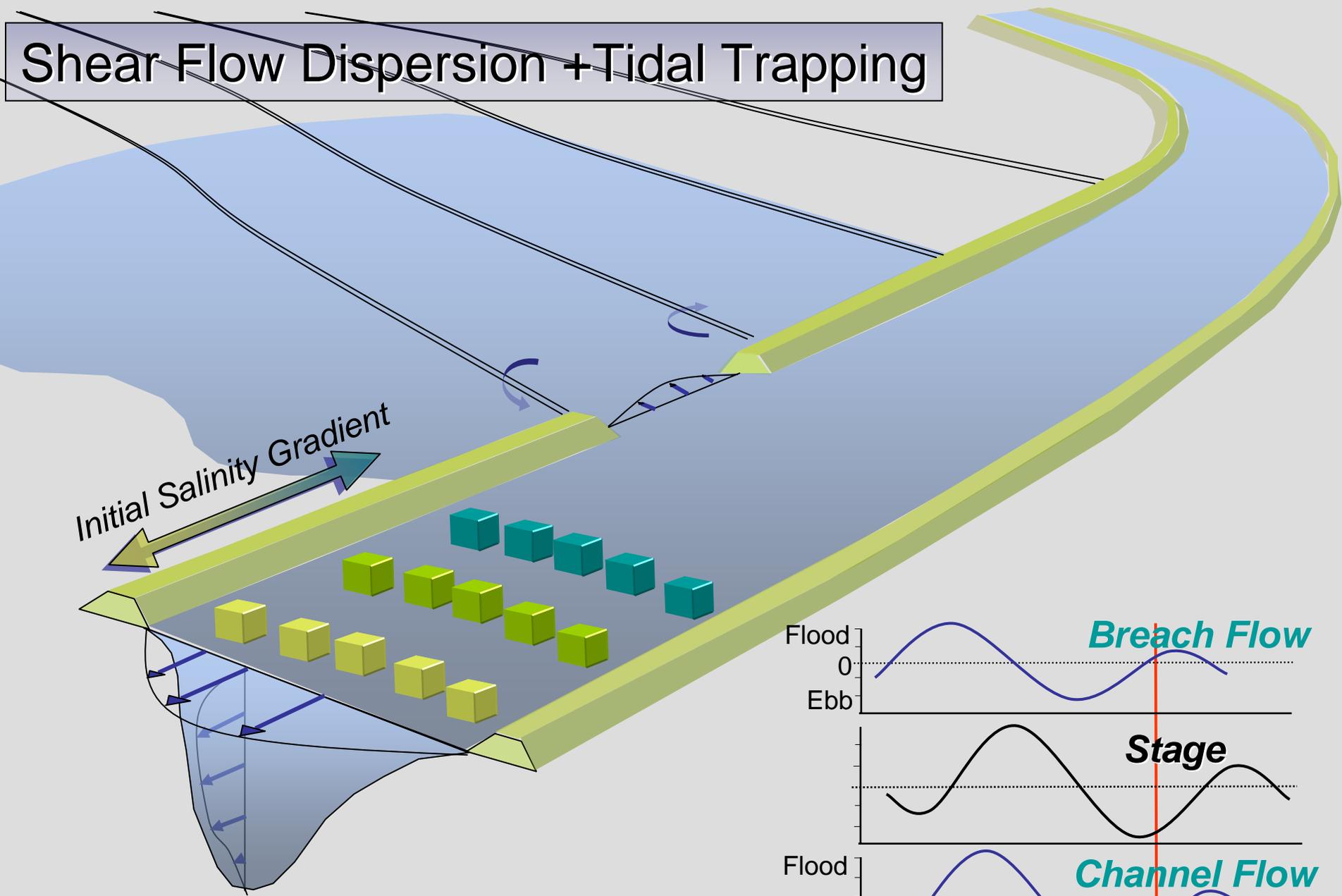
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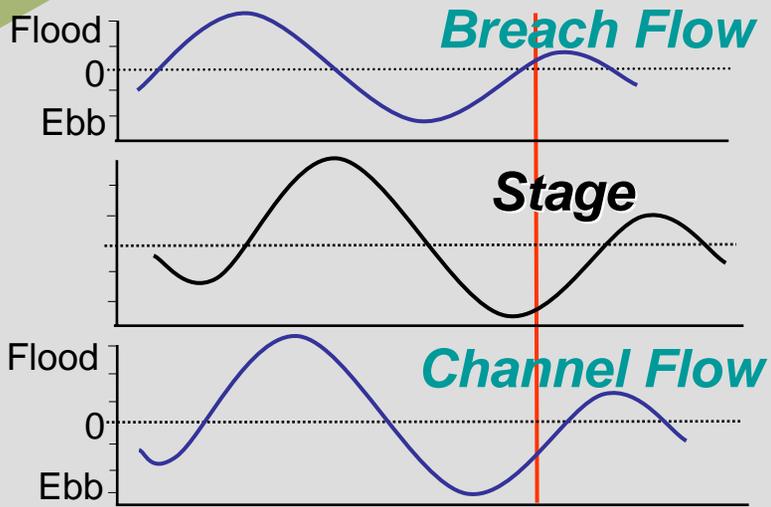
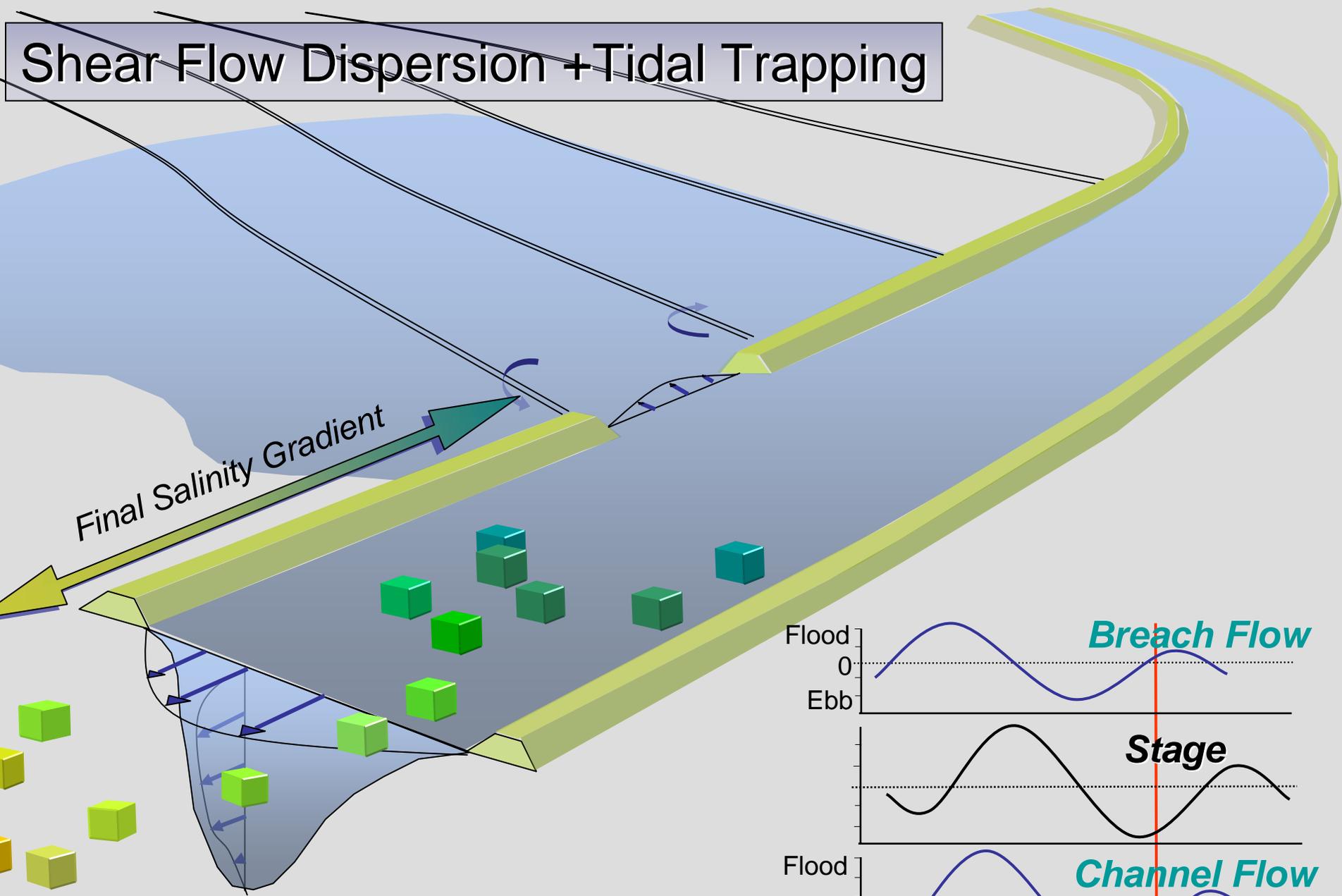
Shear Flow Dispersion + Tidal Trapping



Shear Flow Dispersion + Tidal Trapping



Shear Flow Dispersion + Tidal Trapping

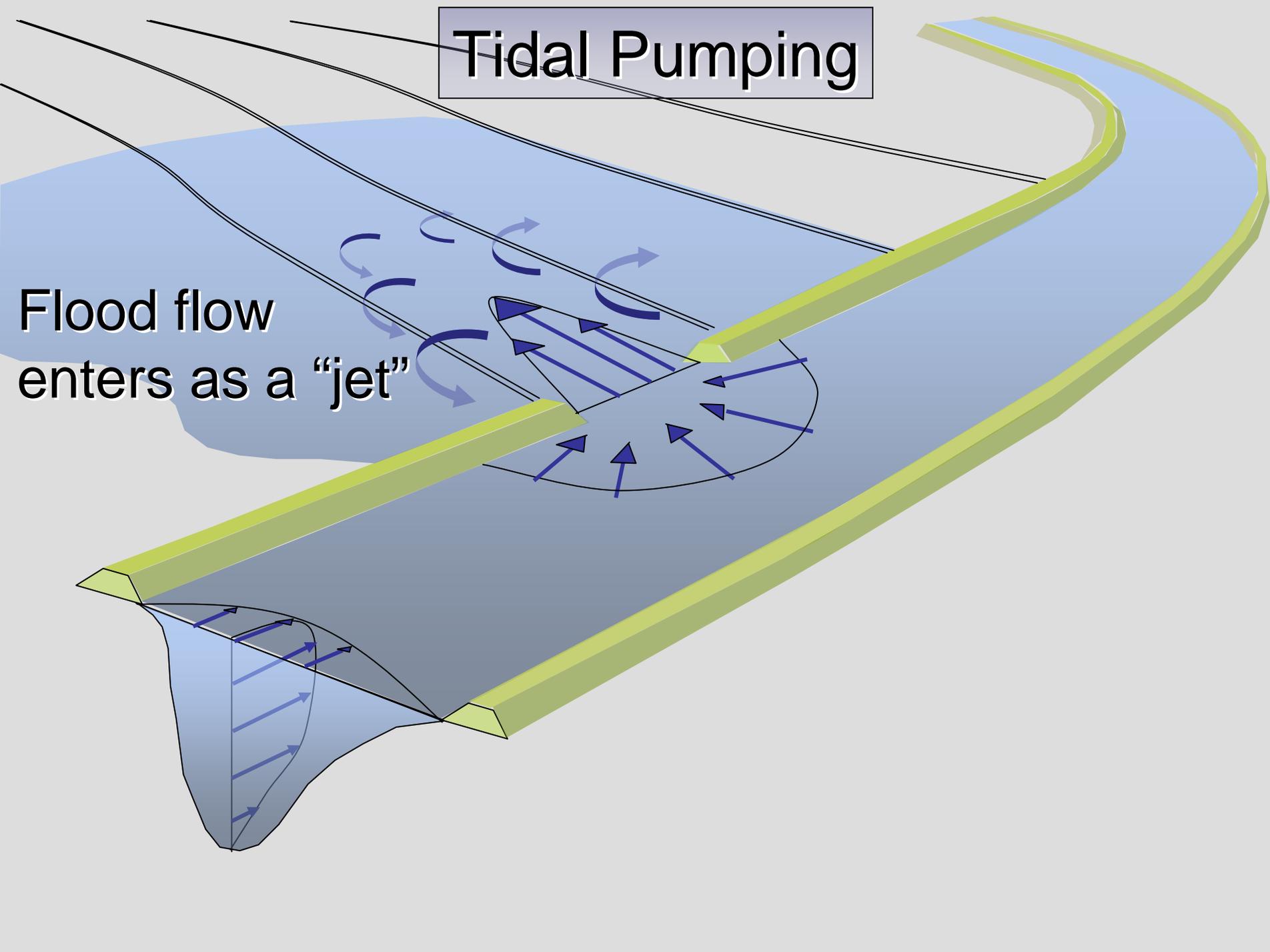


3. Tidal Pumping

- “Net” flow caused by tidal flow asynchrony

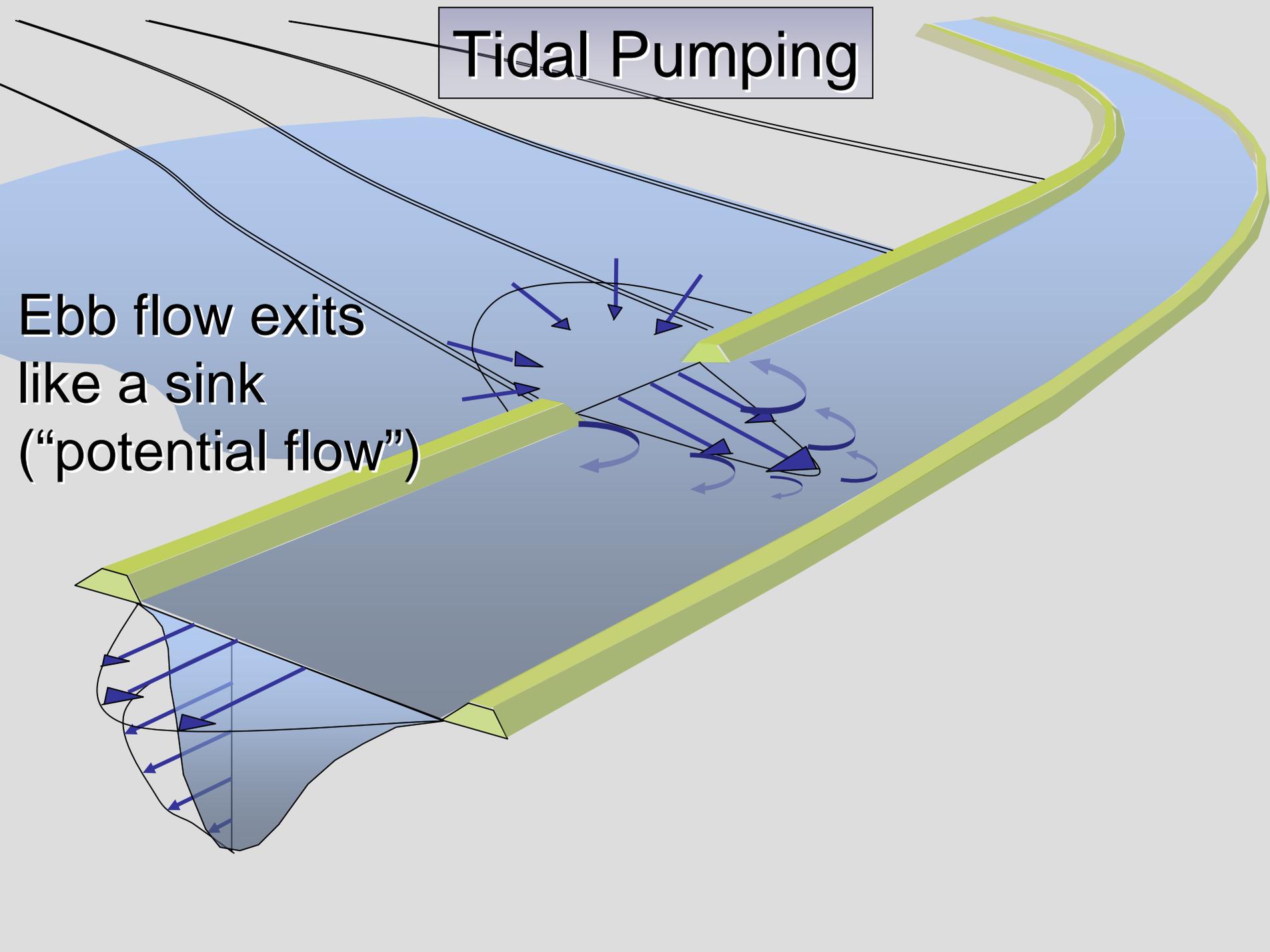
Tidal Pumping

Flood flow enters as a "jet"

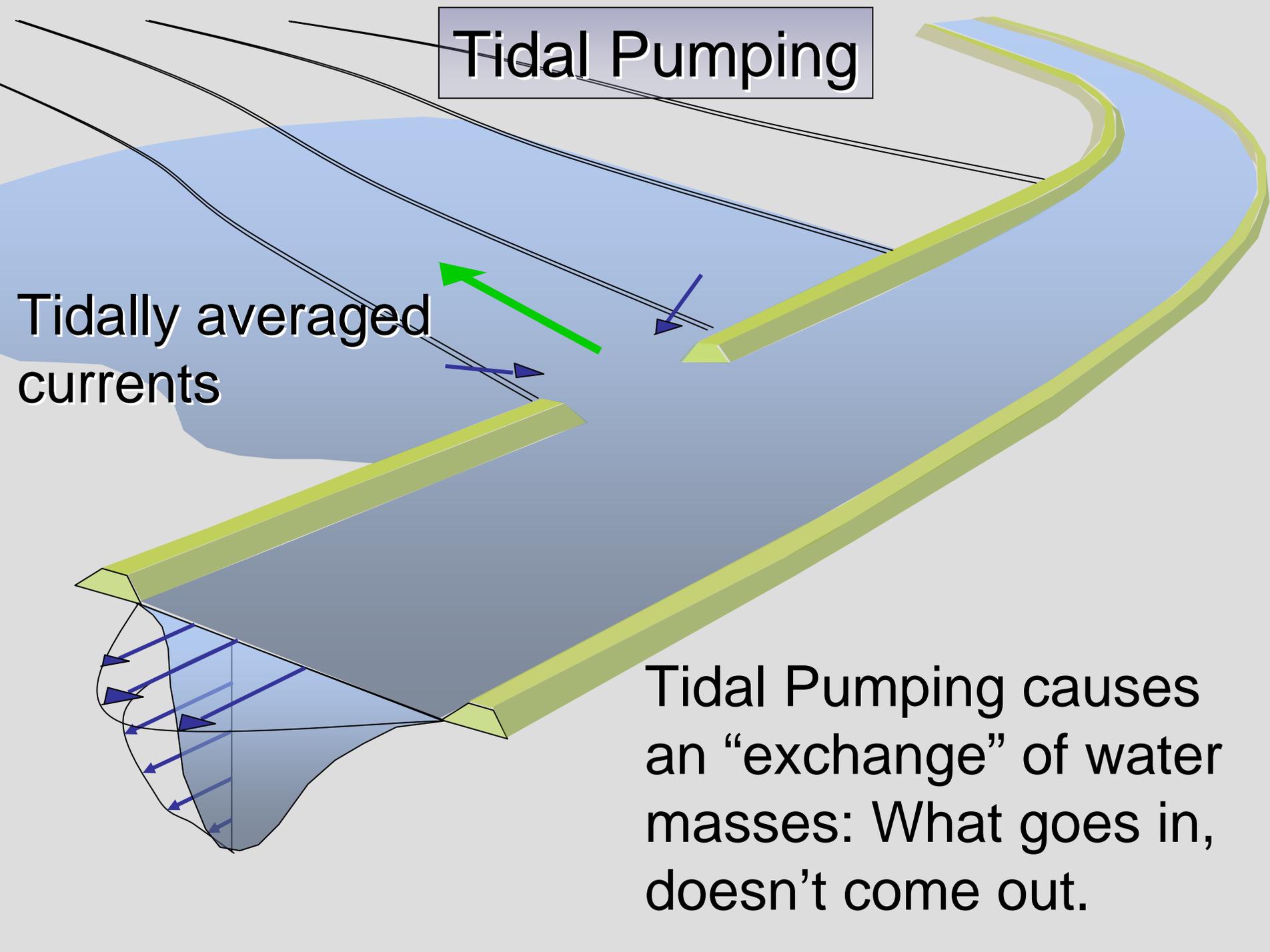


Tidal Pumping

Ebb flow exits
like a sink
("potential flow")



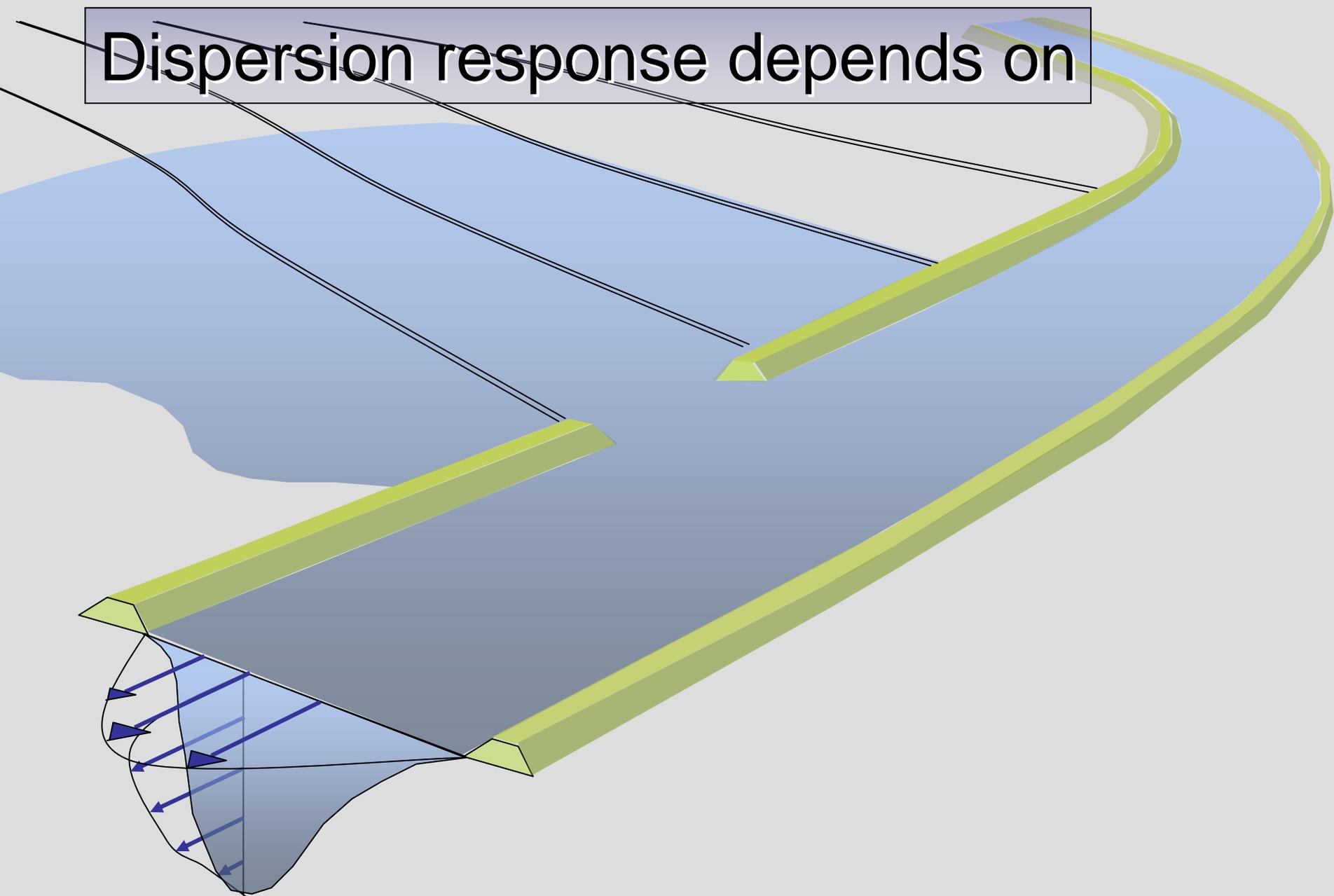
Tidal Pumping



Tidally averaged currents

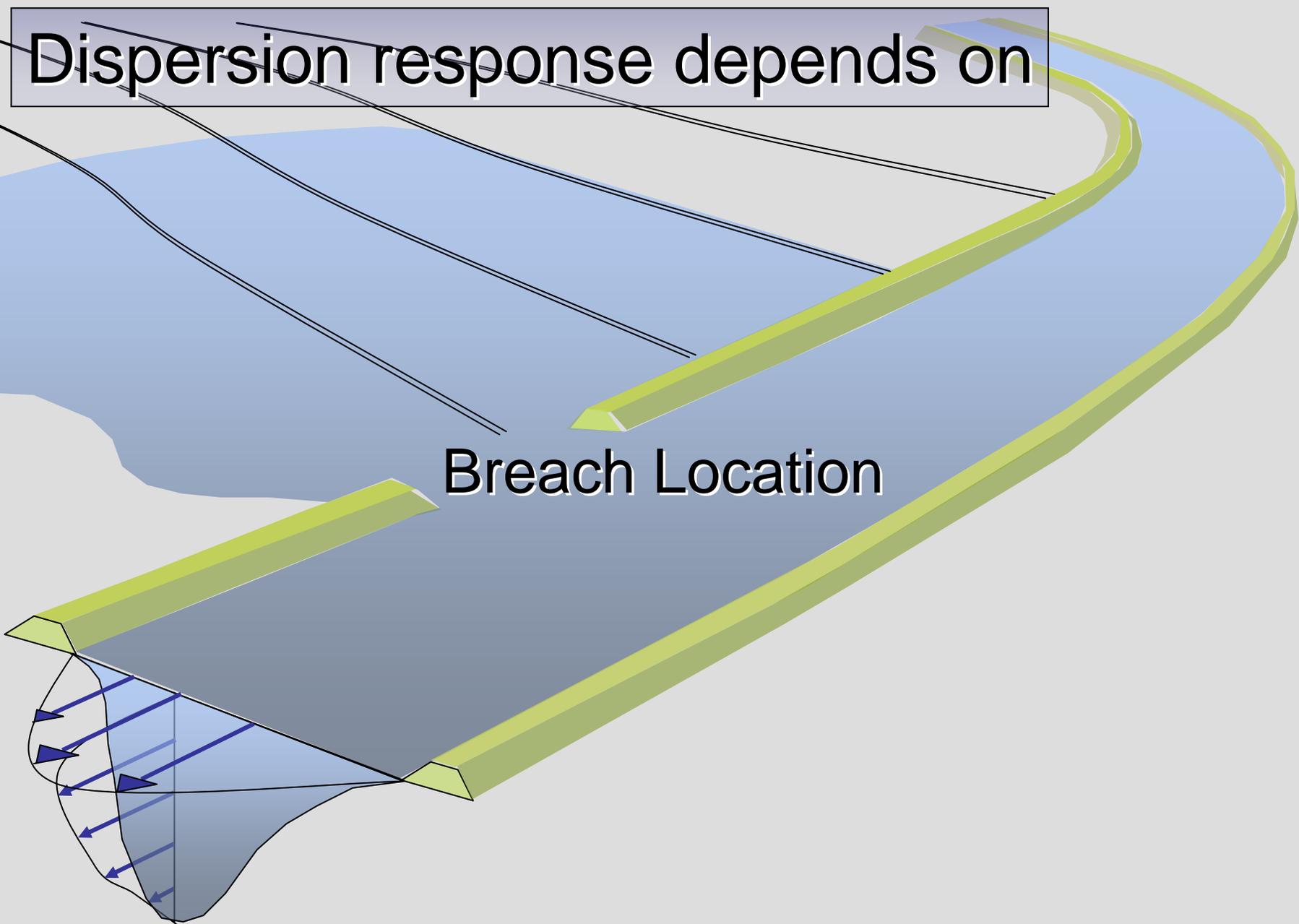
Tidal Pumping causes an “exchange” of water masses: What goes in, doesn’t come out.

Dispersion response depends on



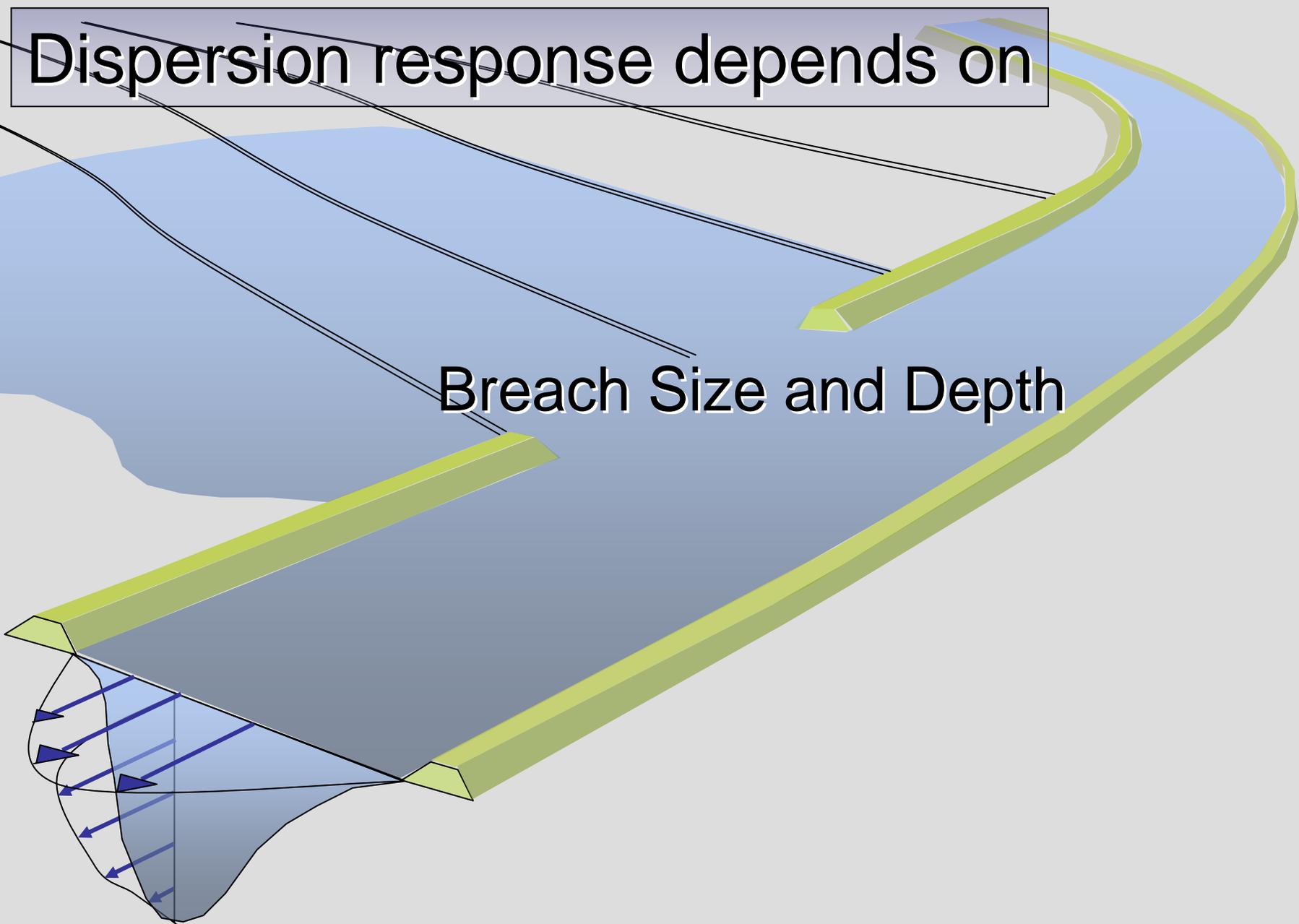
Dispersion response depends on

Breach Location



Dispersion response depends on

Breach Size and Depth



Key Ideas

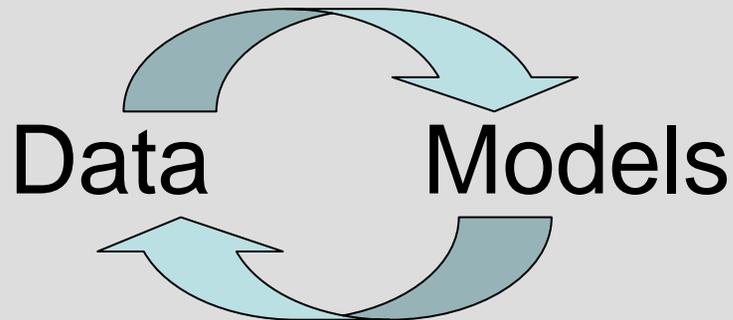
- Changing estuary geometry changes the way the estuary dissipates tidal energy through dispersive mixing.
- Understanding physical processes provides the opportunity to use geometry changes to meet goals.

Some Implications

- Projects that change geometry will interact and should be analyzed together.
- Need full Bay-Delta models with *demonstrated* tidal propagation accuracy.

Some Implications

- Projects that change geometry will interact and should be analyzed together.
- Need full Bay-Delta models with *demonstrated* tidal propagation accuracy.
- Process hydrodynamics/transport field studies are essential:



Thank You

- Jon Bureau
- Steve Culberson
- John DeGeorge
- Callie Harrison
- Aaron Miller
- Richard Richele
- Curt Schmutte