Sediment Formation, Transport and Deposition

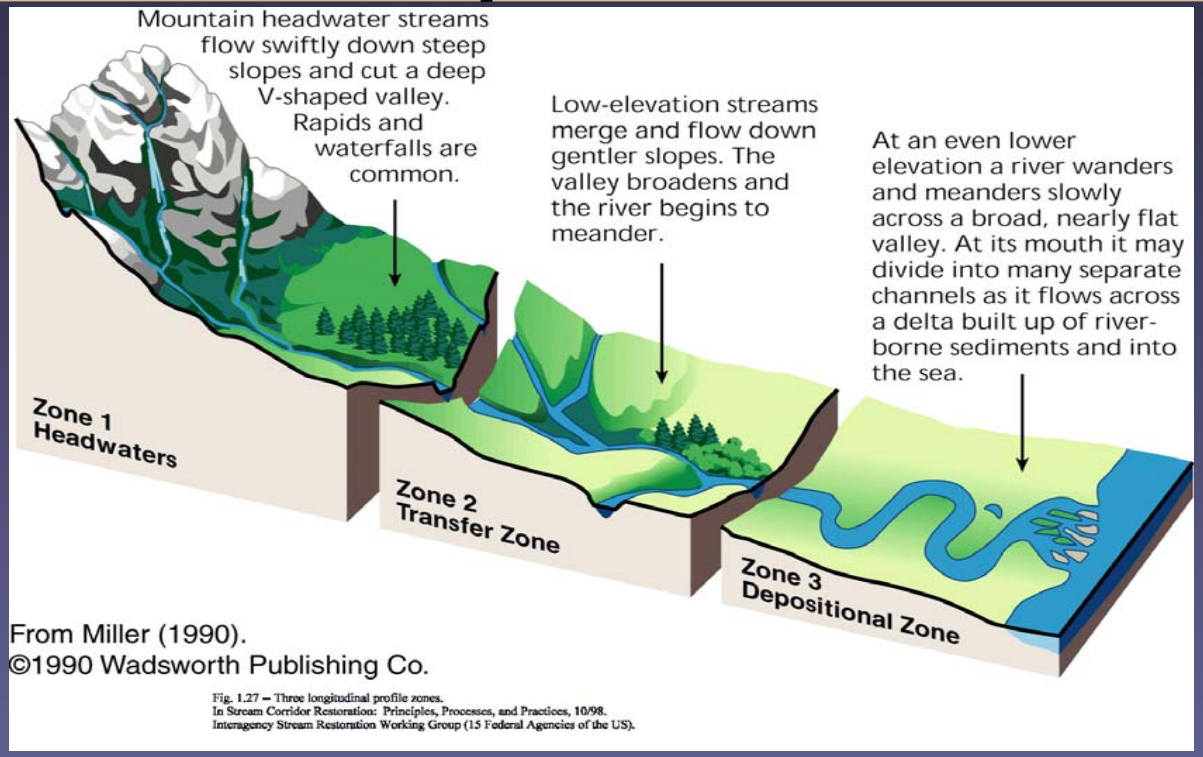


Fig. 1.27 – Three longitudinal profile zones.
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (15 Federal Agencies of the US).

Managing Sediments in the Watershed: Bringing Dredged Material and Watershed Managers Together

August 29-31, 2006

Portland, OR

Jeff Waters, Ph.D., USACE-ERDC

Sediment Formation, Transport and Deposition

- Sediment Formation – Weathering
- Soil Erosion
- Stream Flow and Sediment Transport
- Deltas - Where Rivers Meet the Sea
- Estuarine Sediment Transport & Deposition
- Coastal Processes and Inlets

Weathering

Breakdown of Rock to Form Sediment

Mechanical Weathering – Physical abrasion due to the action of:

- **Water (streams, rivers and surf)**
- **Ice (frost, snow and glaciers)**
- **Wind**

Chemical Weathering – Minerals formed deep in the earth's interior are not stable under surface conditions.

- **Stability is reverse of Bowen's reaction series**
- **The principle agent of chemical weathering is water**
  - ***Quartz: very stable***
  - ***Feldspars: form clay minerals***
  - ***Mafic minerals: alter to oxides***

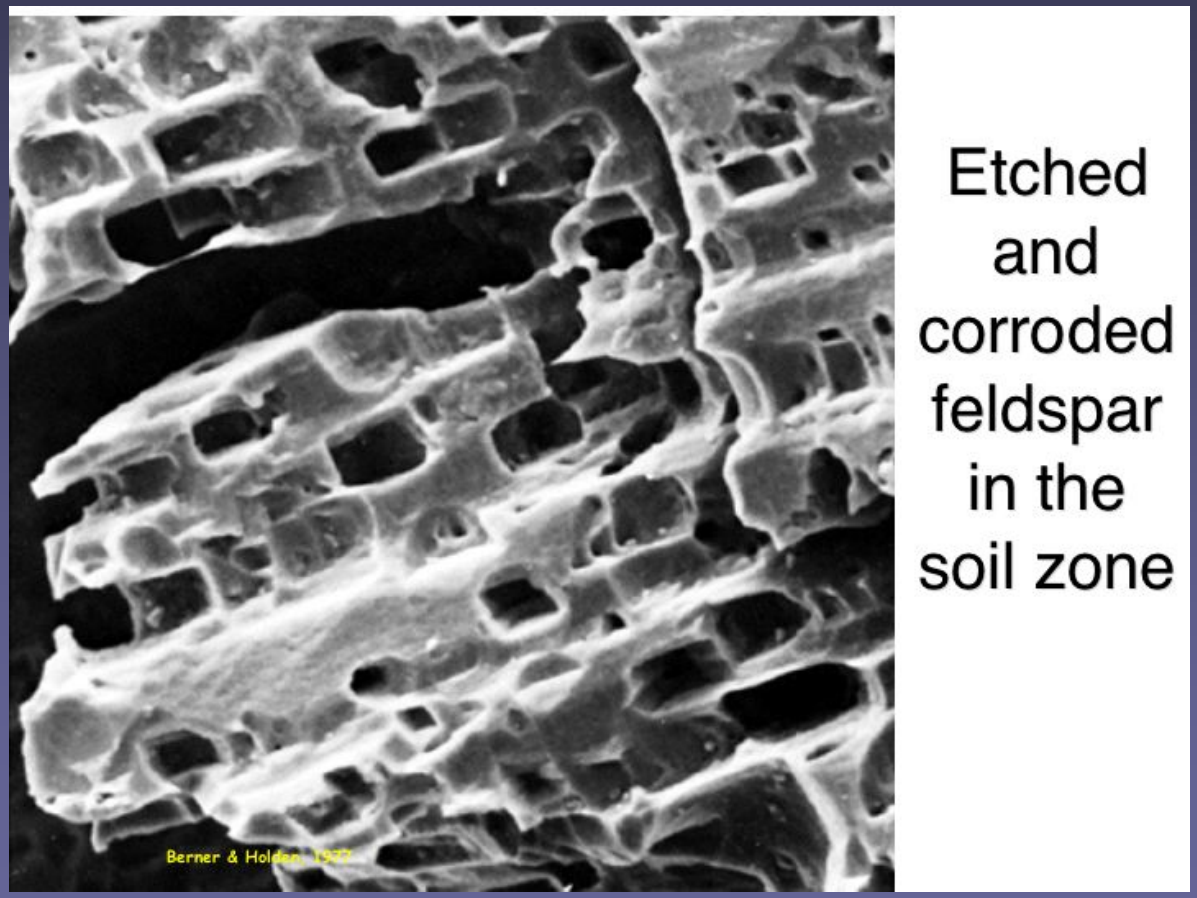
Boulders

Cobbles

Sand

Pebbles

Chemical Weathering



Etched and corroded feldspar in the soil zone

- Silicate minerals weather by hydrolysis to form clay
- Feldspars are stable at high temperatures and pressures (not at earth's surface)
- Clays are stable under conditions at the earth's surface

Clay Minerals

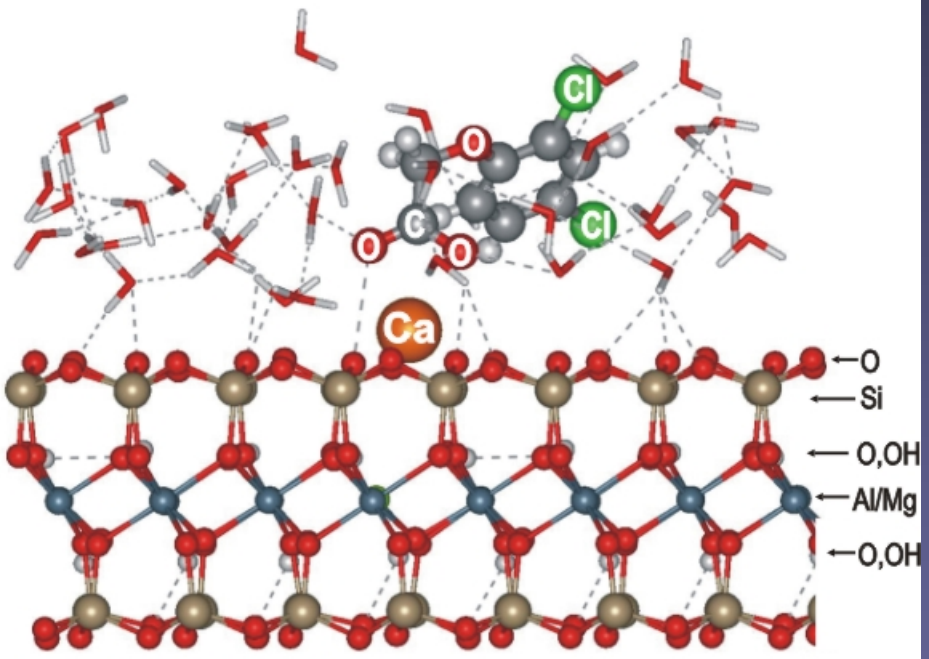


Fig.1 Hydrated pesticide 2,4-D, adsorbed on Montmorillonite surface *via* Ca^{2+} cation.

- Size (microns) and Shape (platelet) result in transport over great distances with minimal current velocity
- Cation Exchange Capacity (Surface Electrical Charge) results in contaminant transport potential and flocculation

Sediment and Soil Classifications

Table 6.9 Comparison of the Soil Classification Systems compiled from various sources

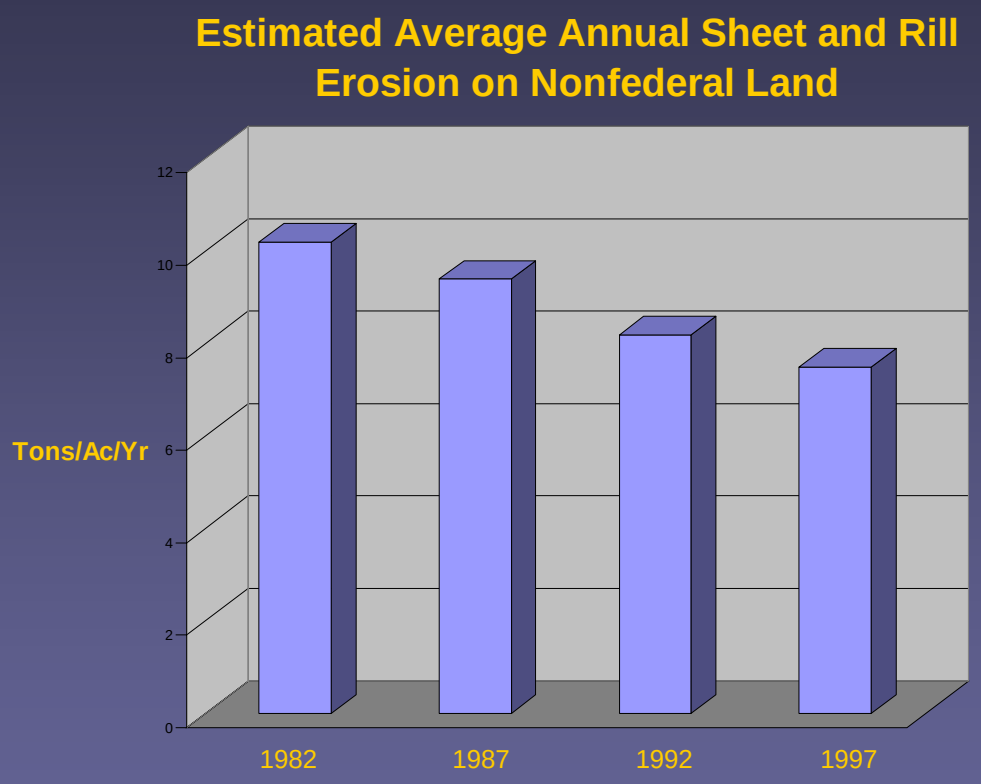
Wentworth	Burmister	USCS	USDA	mm	in	US Stan. Sieve Size
boulders		boulders	cobbles	4026		No. 5+
				2048		
				1024		
				512		
				256	10.08	
		cobbles		128	2.52	
cobbles				64		
	coarse gravel	coarse gravel	medium gravel	32	1.26	
v. coarse				16	0.63	
coarse pebble gravel	medium gravel		fine gravel			
medium fine		fine gravel		8	0.31	
	fine gravel			4	0.16	
gran. (vf) gravel		coarse sand		2	0.08	No. 5-10
v. coarse sand	coarse sand	medium sand	v. coarse sand	1	0.04	No. 10-18
coarse sand			coarse sand	0.5	0.02	No. 18-35
medium sand	medium sand	fine sand	medium sand	0.25	0.01	No. 5-60
fine sand	fine sand		fine sand	0.125	0.005	No. 60-20
v. fine sand			v. fine sand	0.031	0.002	No. 120-No. 230
	coarse silt	silts & clays	silt			
coarse silt	fine silt			0.0625		<No. 230
medium silt				0.0156		
fine silt				0.0078		
v. fine silt				0.0039	0.0002	
clay			clay	<0.0039	<0.0002	

Soil Erosion

	Erosion/Physical Process			
Erosion Type	Sheet	Concentrated Flow	Mass Wasting	Combination
Sheet and rill	x	x		
Interill	x			
Rill	x	x		
Wind	x	x		
Ephemeral gully		x		
Classic gully		x	x	
Floodplain scour		x		
Roadside				x
Streambank		x	x	
Streambed		x		
Landslide			x	
Wave/shoreline				x
Urban, construction				x
Surface mine				x
Ice gouging				x

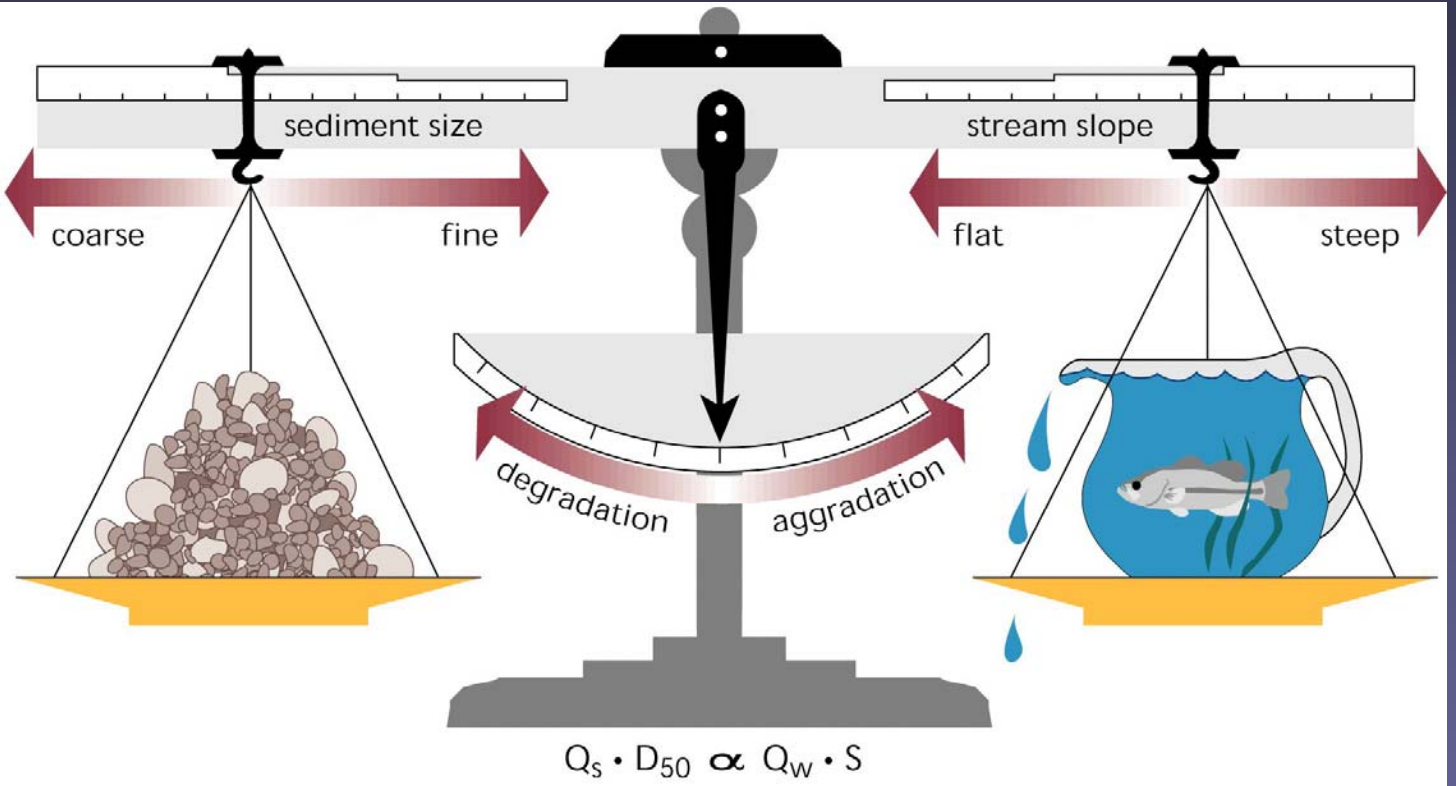
Table 2.3 -- Erosion types vs. physical processes.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98)
by the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

Soil Erosion



Source: NRCS

Stream Flow and Sediment Transport



From Rosgen (1996), from Lane, Proceedings, 1955.
Published with the permission of American Society of Civil Engineers.

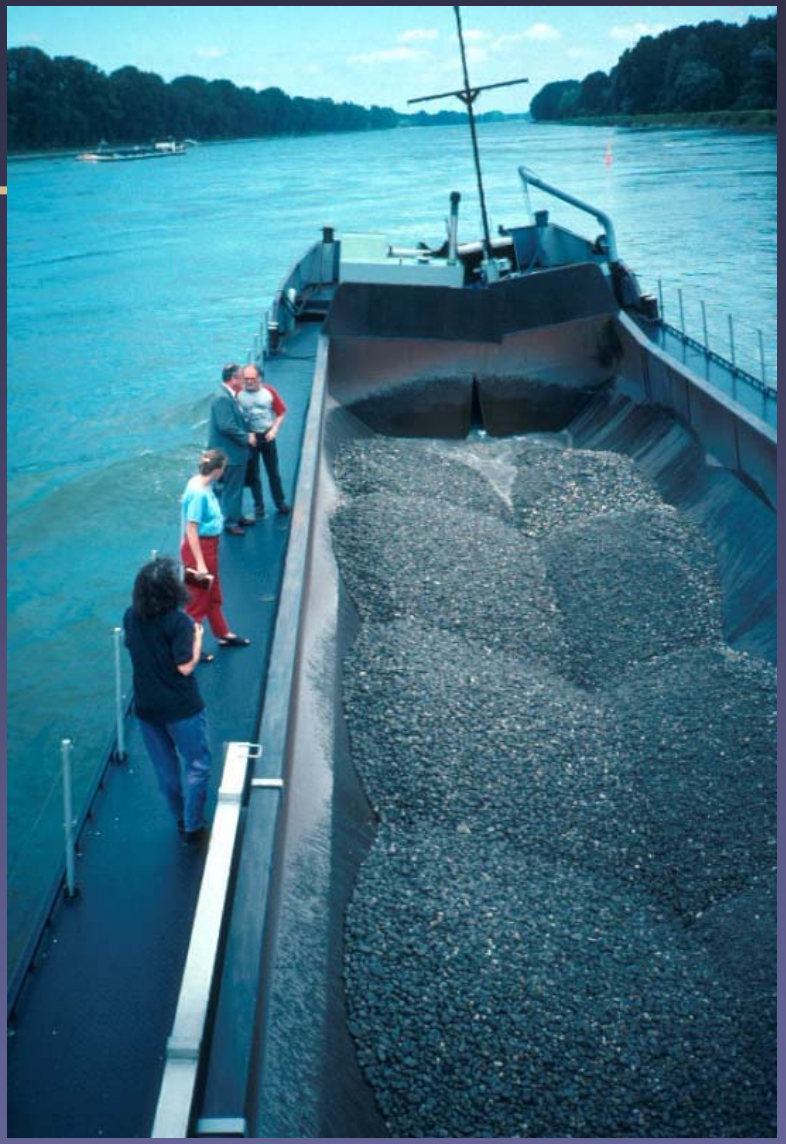
Fig. 1.13 – Factors affecting channel degradation and aggradation: Concept of "Stream Balance.".
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (15 Federal Agencies of the US).

MANNHEIM
HEIDELBERG
LUDWIGSHAFEN
Neckar
Rhine
1977
Iffezheim
1974
FRANCE
1970
1967
1963
GERMANY
1961
1959
1956
1952
1932
BASEL
SWITZERLAND

Rhine River

Iffezheim: the downstream-most dam

“Feeding” the Rhine

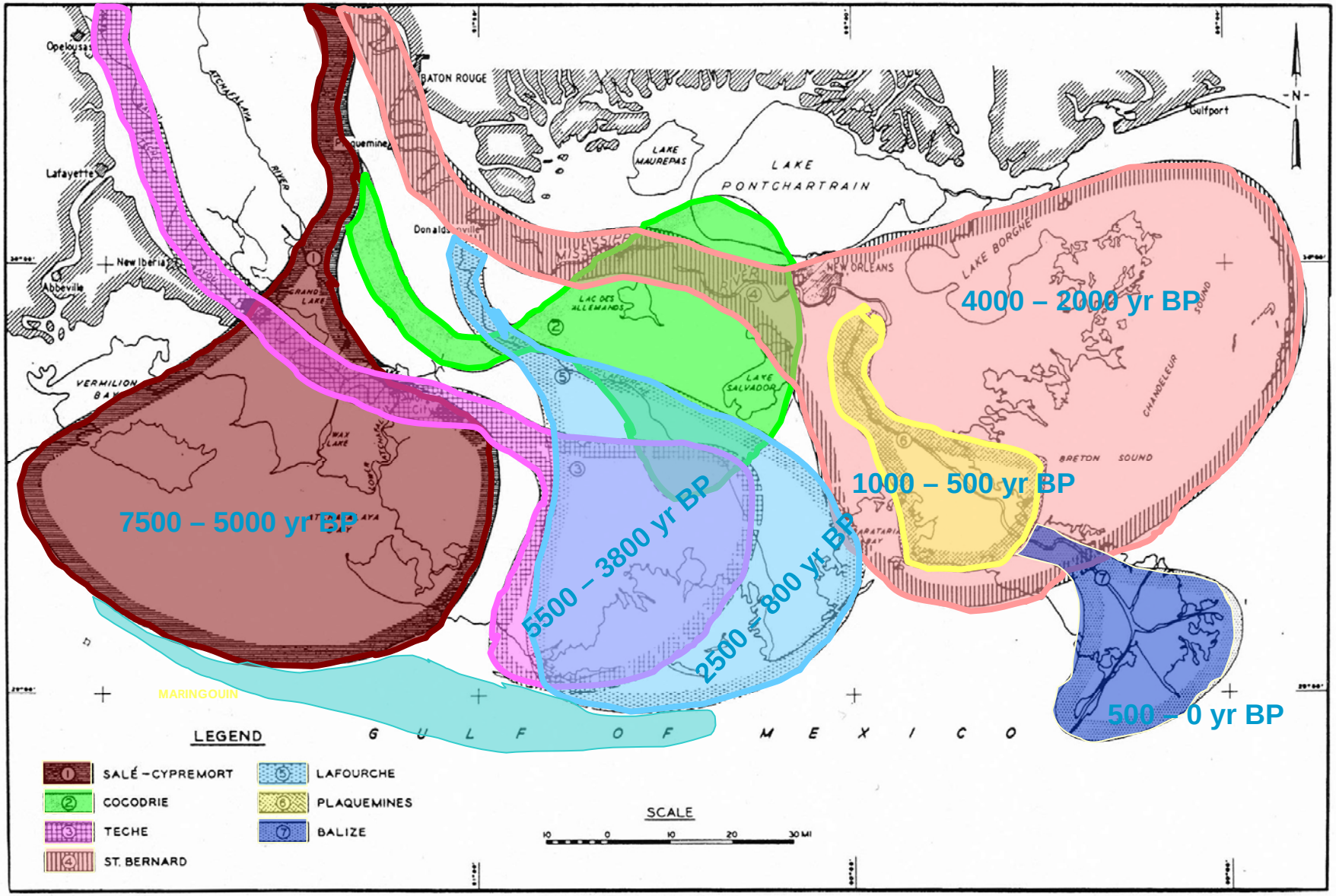


Deltas – Where Rivers Meet the Sea

Active Processes

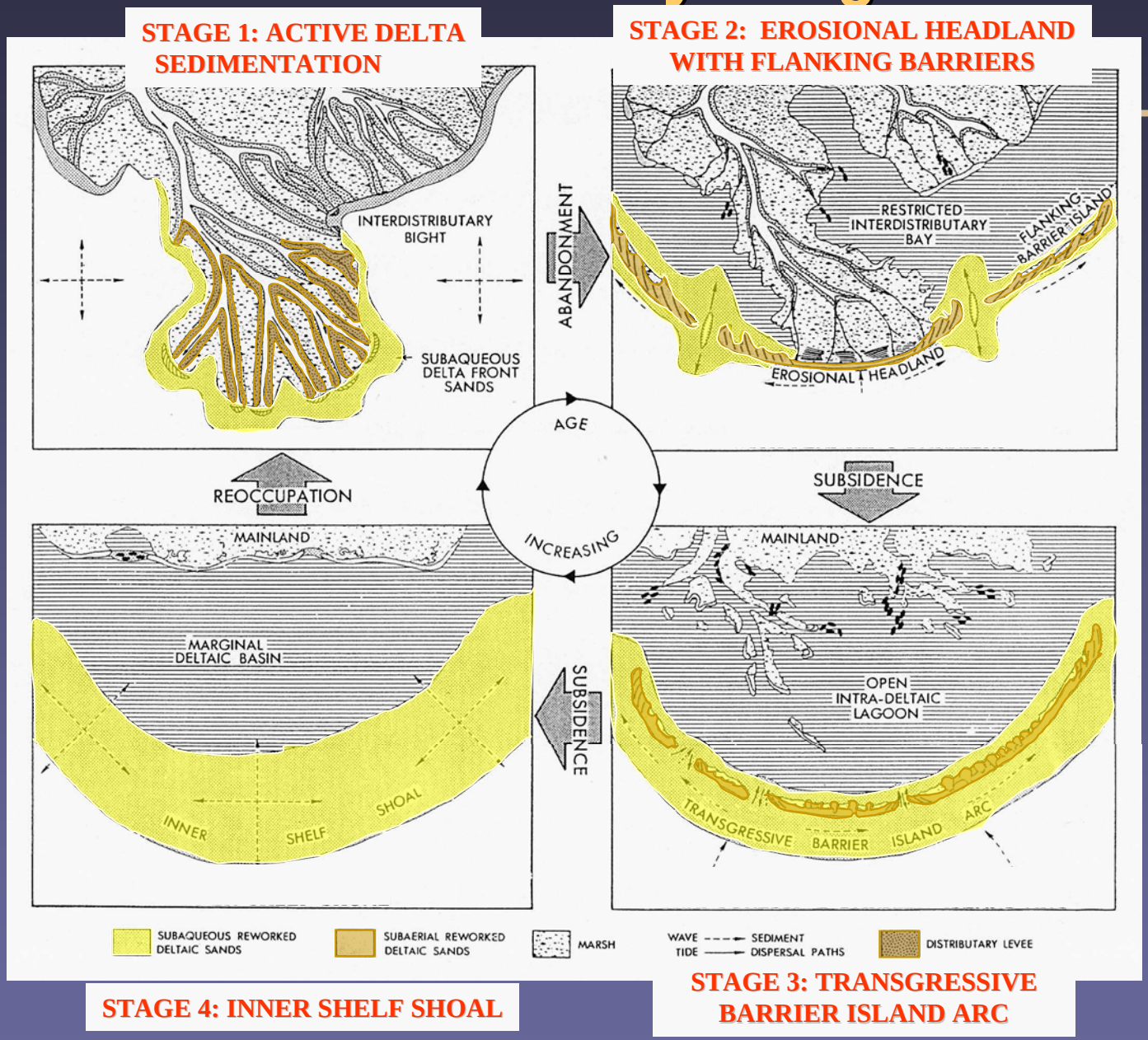
River Input vs.
Waves
Tides
Longshore drift
Geologic setting

Sequence of Holocene Mississippi Delta Lobes



Chronologic sequence of Holocene Mississippi Delta lobes (from Kolb and Van Lopik, 1966; Fraiser, 1967).

Deltaic Evolutionary Stages



Processes

A) Delta River Morphology Growth

↓

B) Eroding Delta Headland forms flanking Barrier Is. & Spits

↓

C) Transgressive Barrier Island Arc erosion

↓

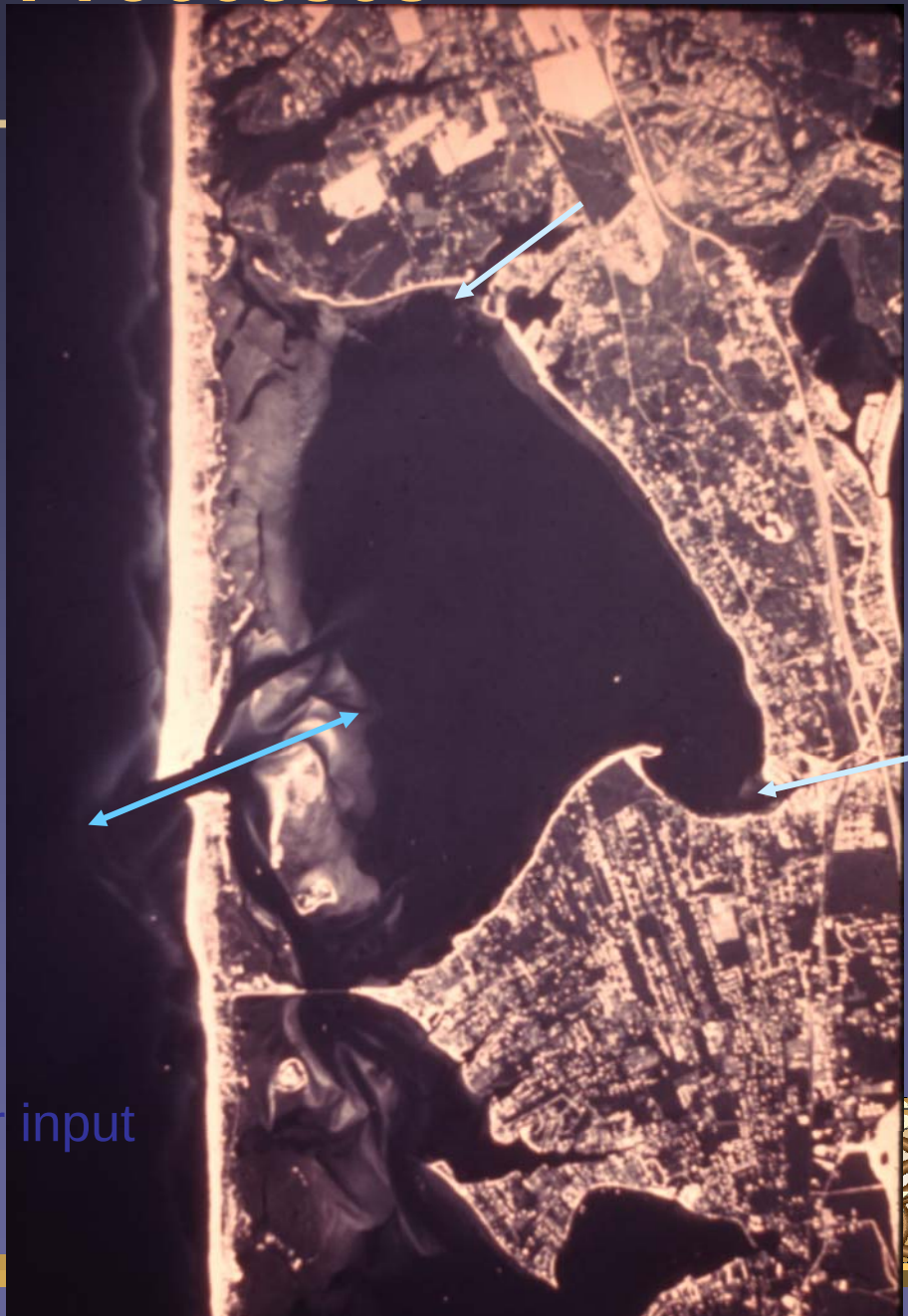
D) Loss of Barrier Island only Remnant Shoals left

(after Penland and Boyd, 1985)

Estuarine Sediment Processes

River forces vs.
Tidal Forces
with
- Waves
- Wind

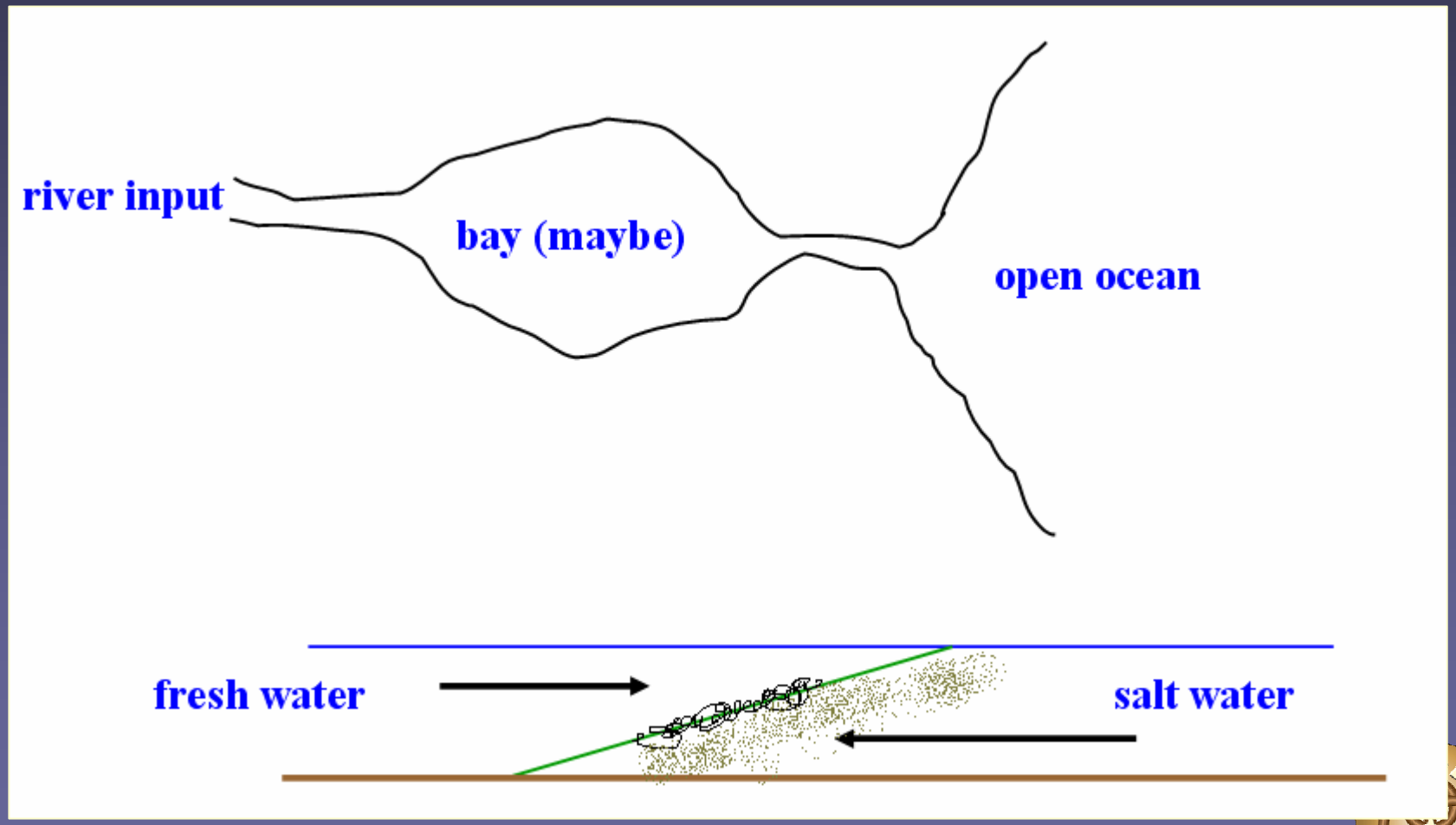
Geologic setting

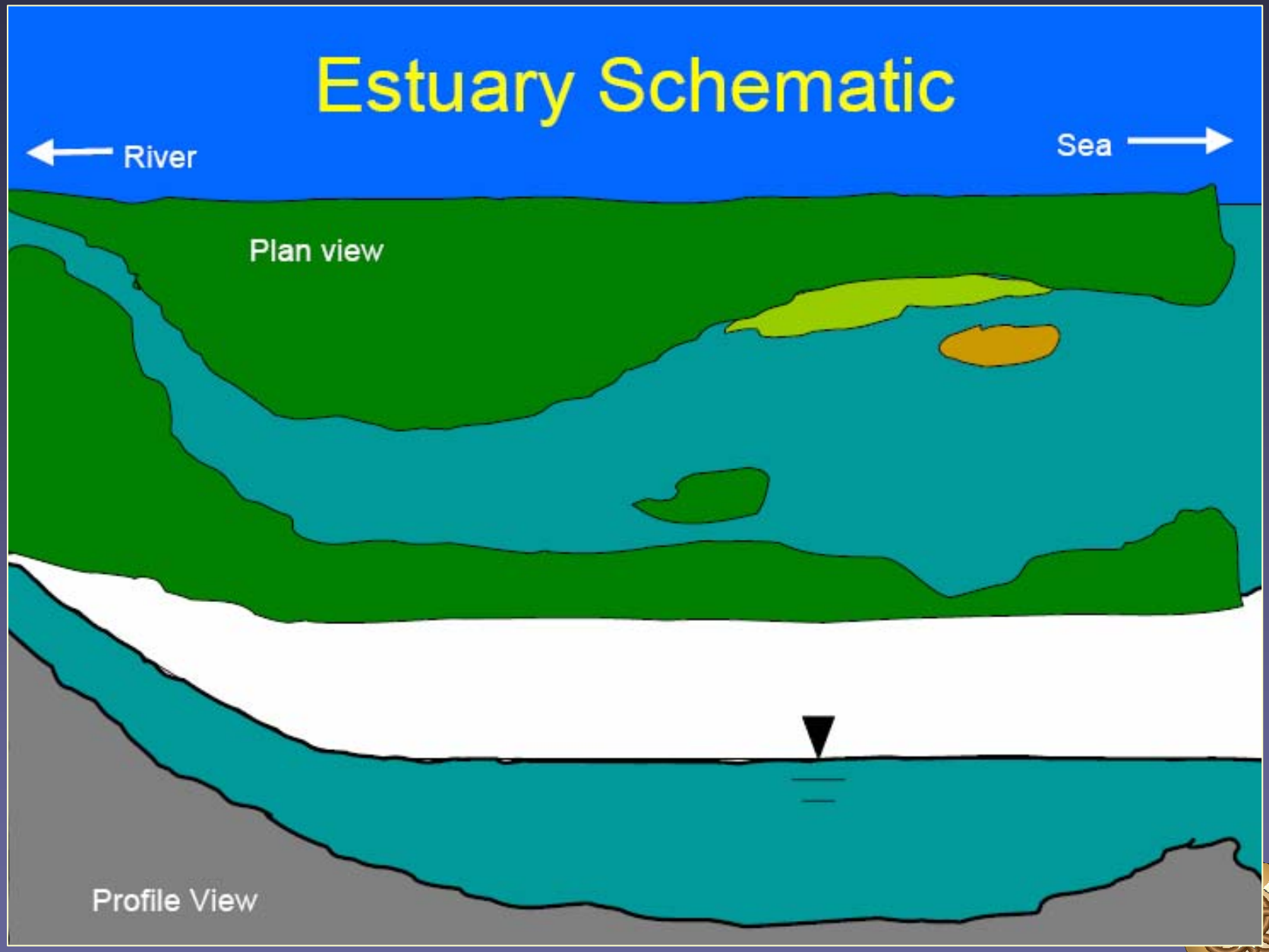


Estuary – semi-enclosed body of water having a opening to the open ocean and within which sea water is measurably Diluted with fresh water from river input

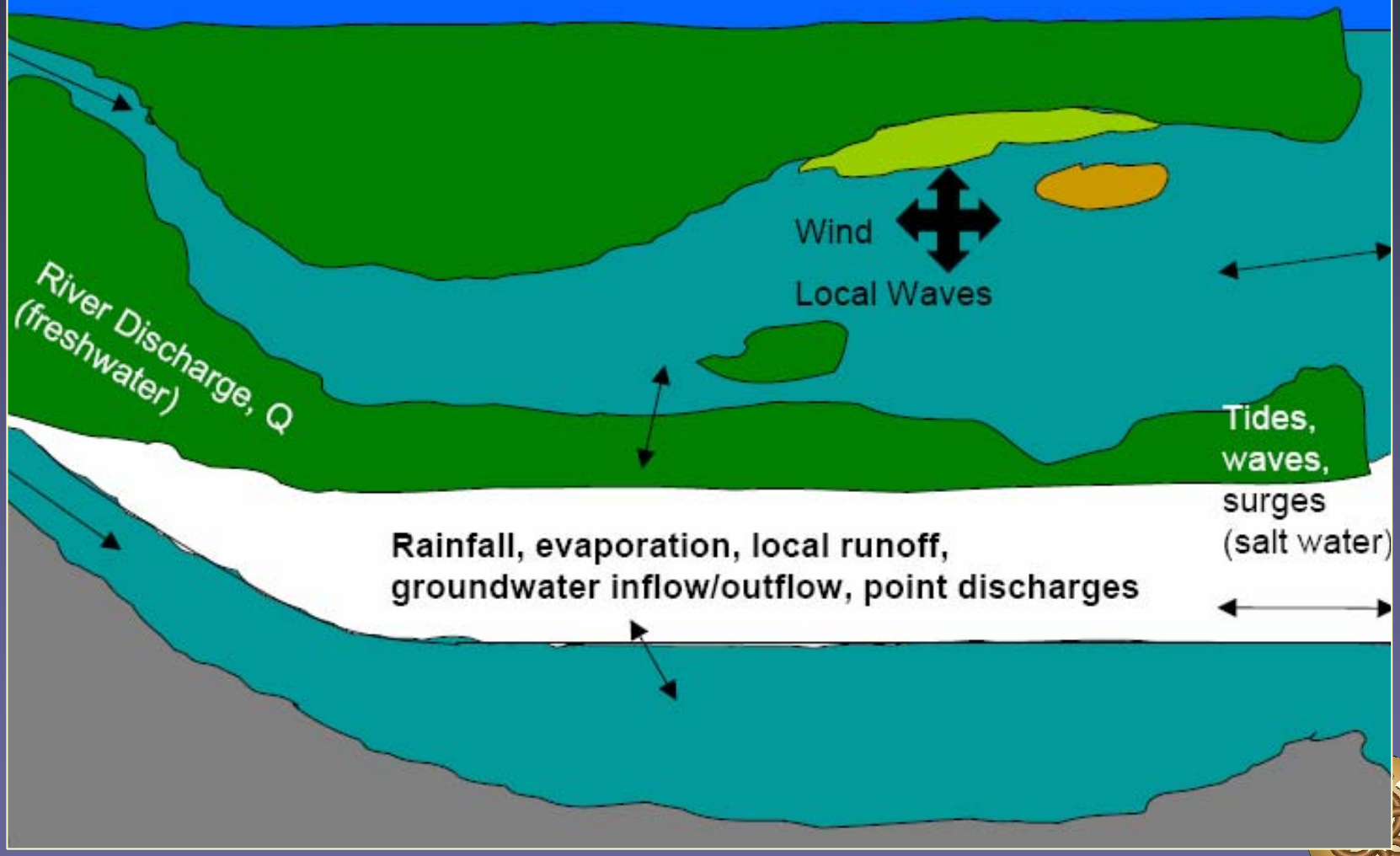
Salt Water and Fresh Water

(salt wedge and estuaries)



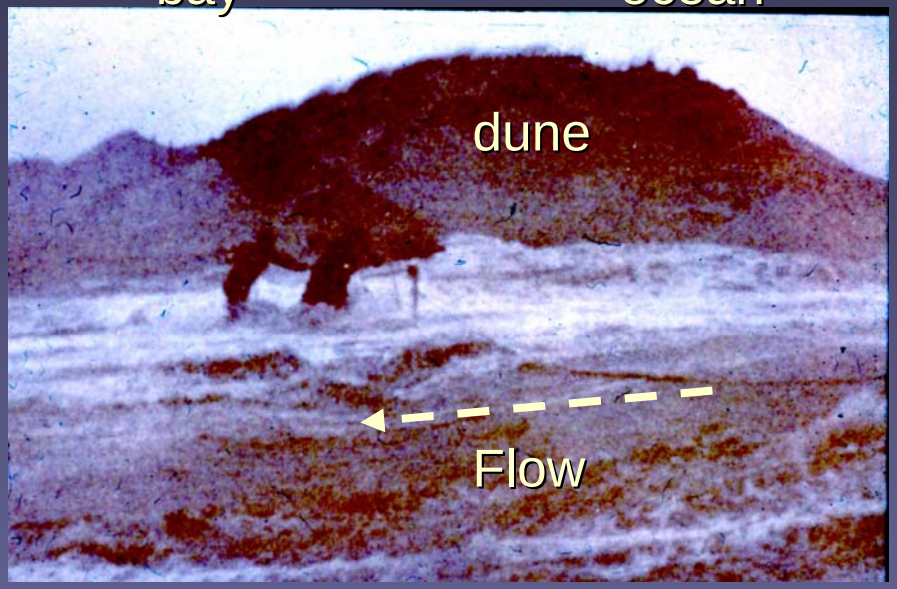

Estuary Schematic
River
Sea
Plan view
Profile View

Estuarine Hydro Forcing



Coastal Processes – Longshore Transport

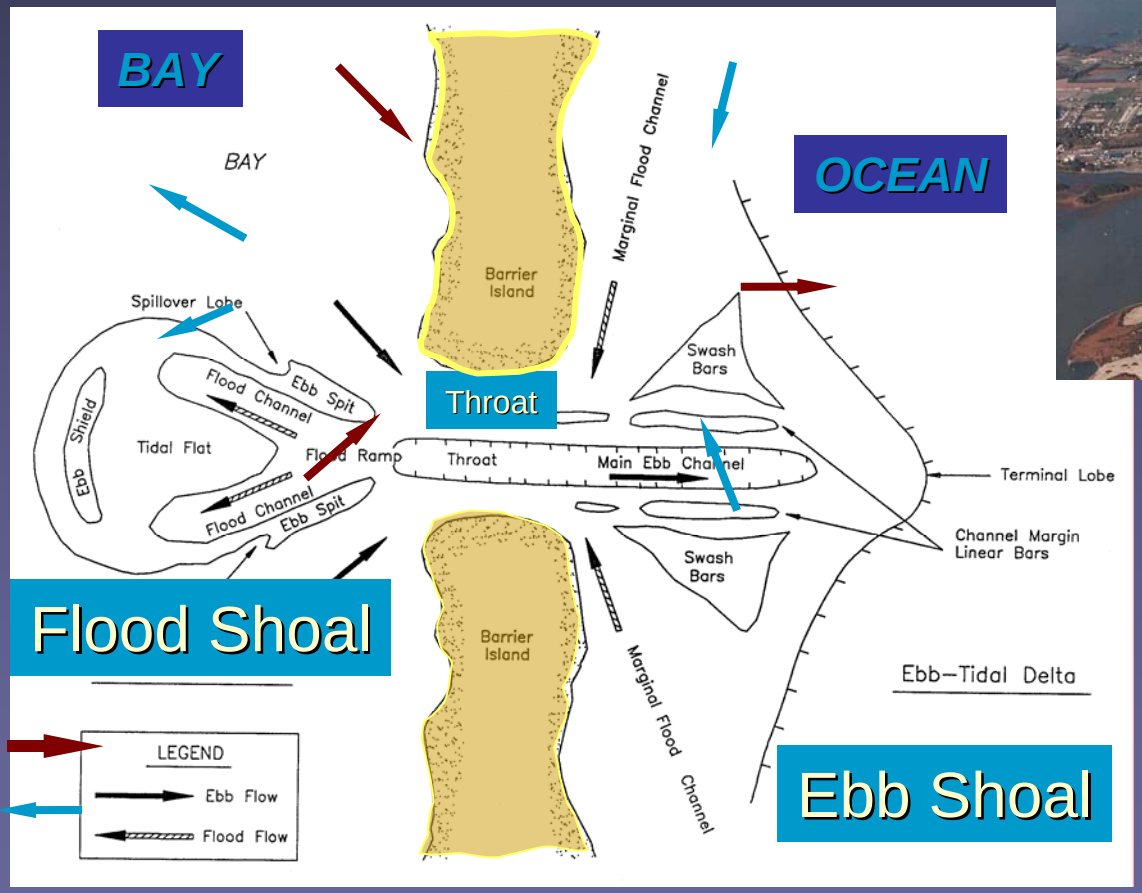
Coastal Processes
Overwash



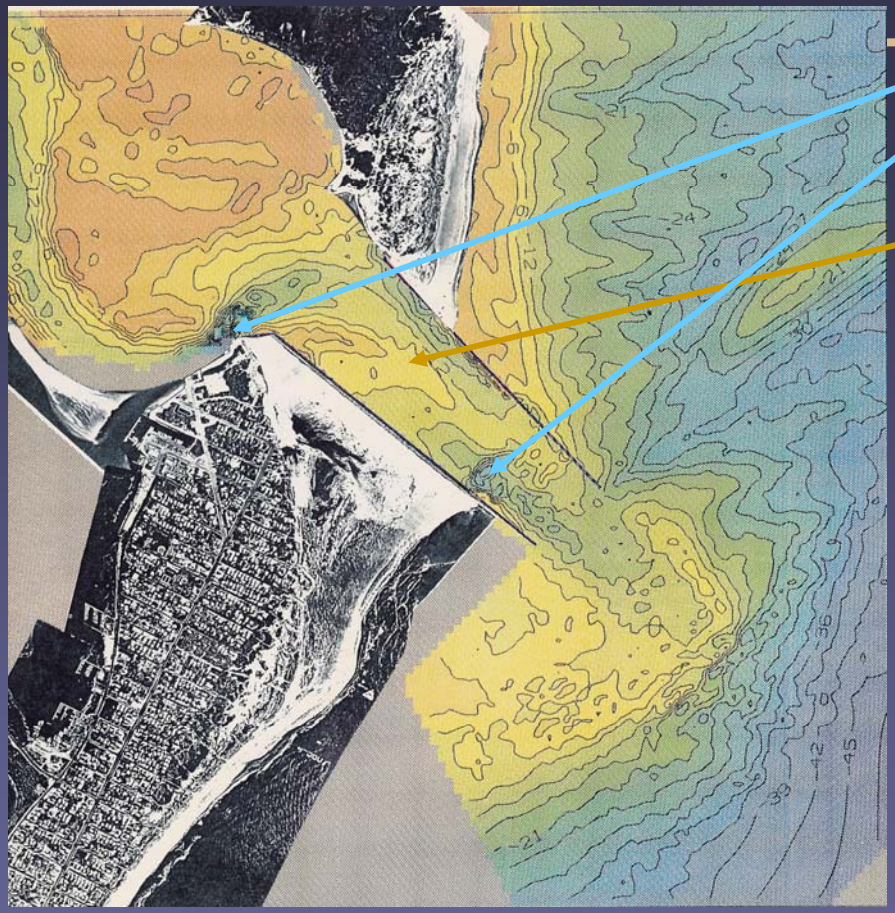
Measuring overwash velocity
In throat during
Hurricane Bell 1976

Overwash deposit in bay –
flow across entire island

Inlet Morphology



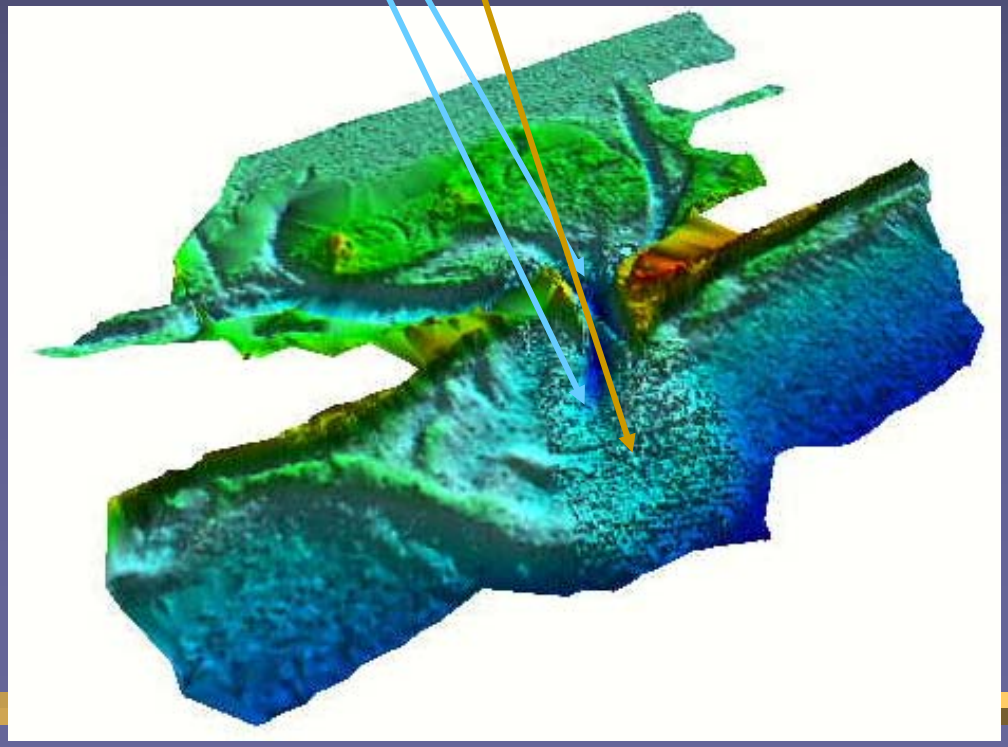
Scour and Shoaling at Inlets



Scour

Shoaling

Shinnecock Inlet, N.Y.



Barnegat Inlet, N.J.

Take Home

- Not all sediments are likely to be contaminated.
- Natural sediment systems are highly dynamic.
- Sound sediment management practices require an understanding of these dynamic sediment transport processes.