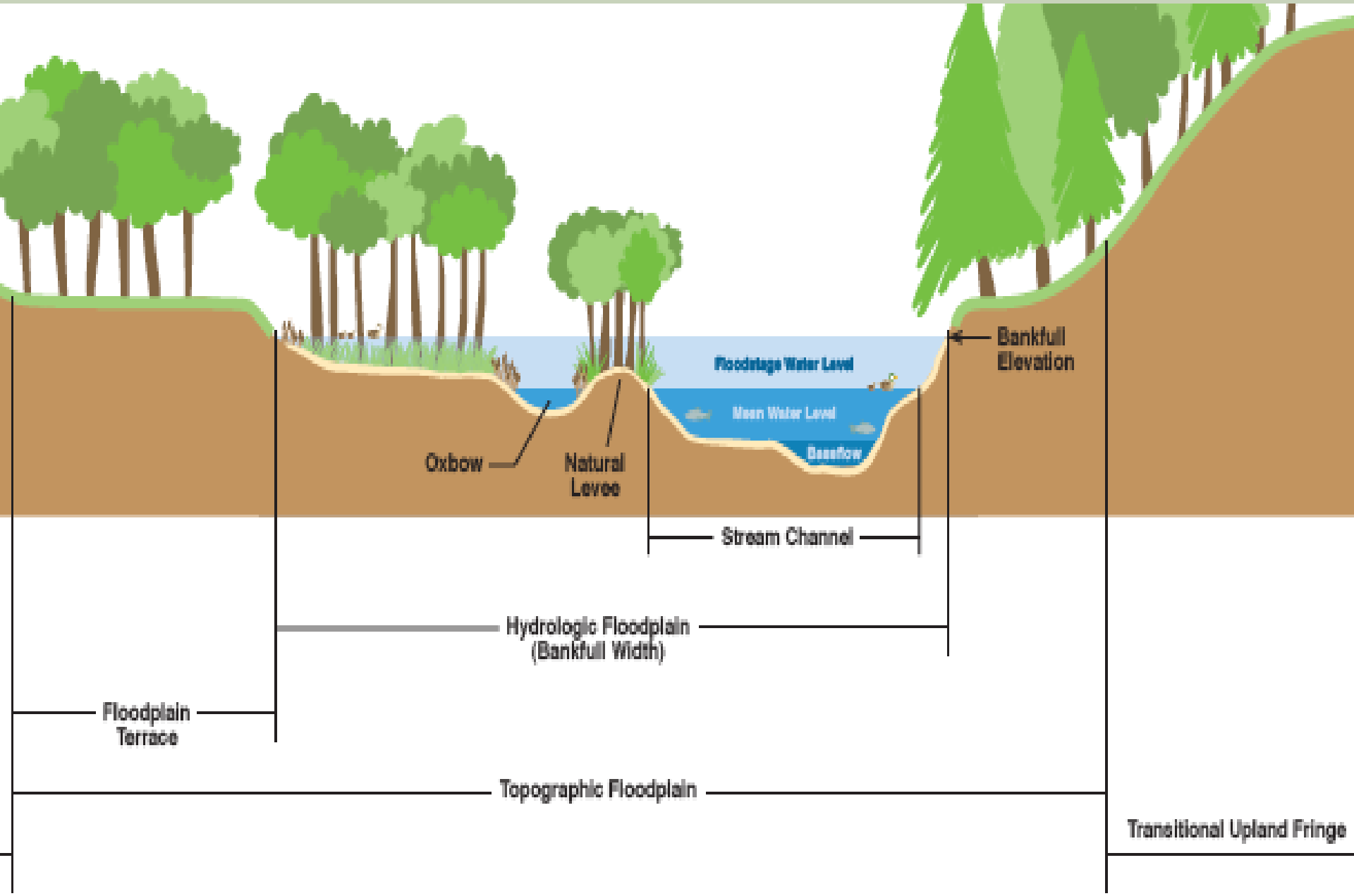
INTRO TO INLAND WATER ENVIRONMENTS

Geomorphological and riverine processes as applied to SCAT

What are we going to talk about?

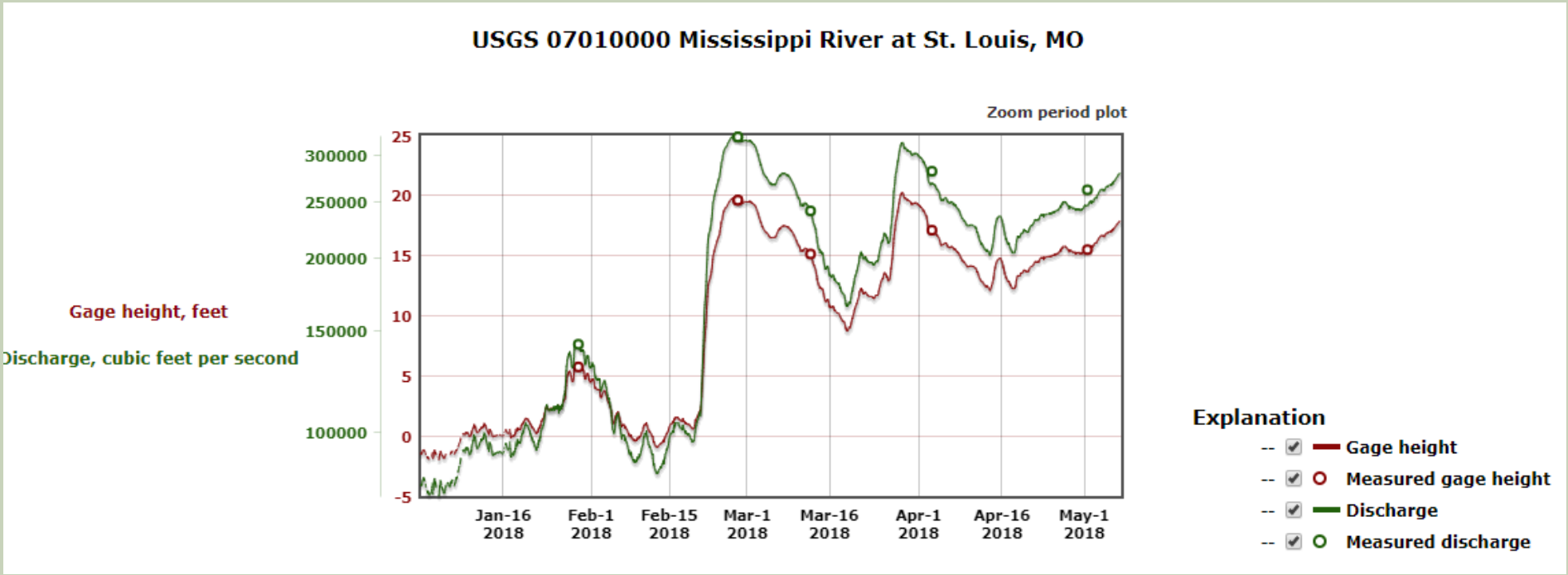
- Geomorphology of rivers/streams in terms of oil behavior and fate
- Riverine current flow patterns and how they affect oil behavior
- Importance of varying water levels in how oil strands, becomes submerged, and can be refloated
- Oil behavior and fate when rivers enter man-made impoundments
- Effects of suspended sediments and Oil-Mineral Aggregates

River Corridor



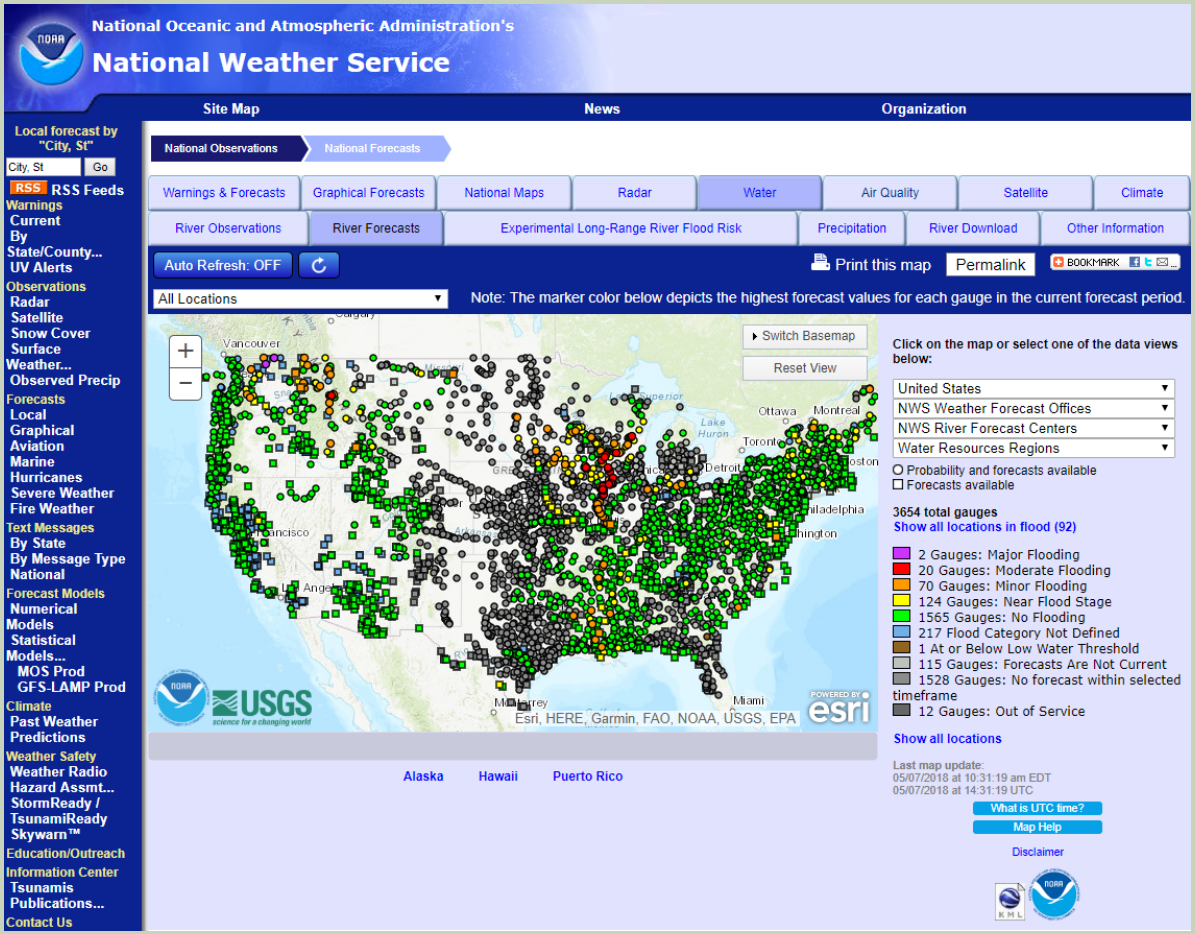
Hydrographs

- http://maps.waterdata.usgs.gov/mapper/index.html
- http://waterdata.usgs.gov/nwis/uv?site_no=02477500



Customized Hydrographs (Forecast)

- https://water.weather.gov/ahps/forecasts.php
- http://water.weather.gov/ahps2/hydrograph.php



ALERT!! A **Flood Warning** and **Flood Watch** are in effect for portions of the area.

View all valid statements/warnings or choose a specific point or river to get the details for that location.

Weather Forecast Office Quad Cities, IA

North Central River Forecast Center

River Observations | River Forecasts | Experimental Long-Range Flood Risk | Precipitation | Download

Auto Refresh: OFF

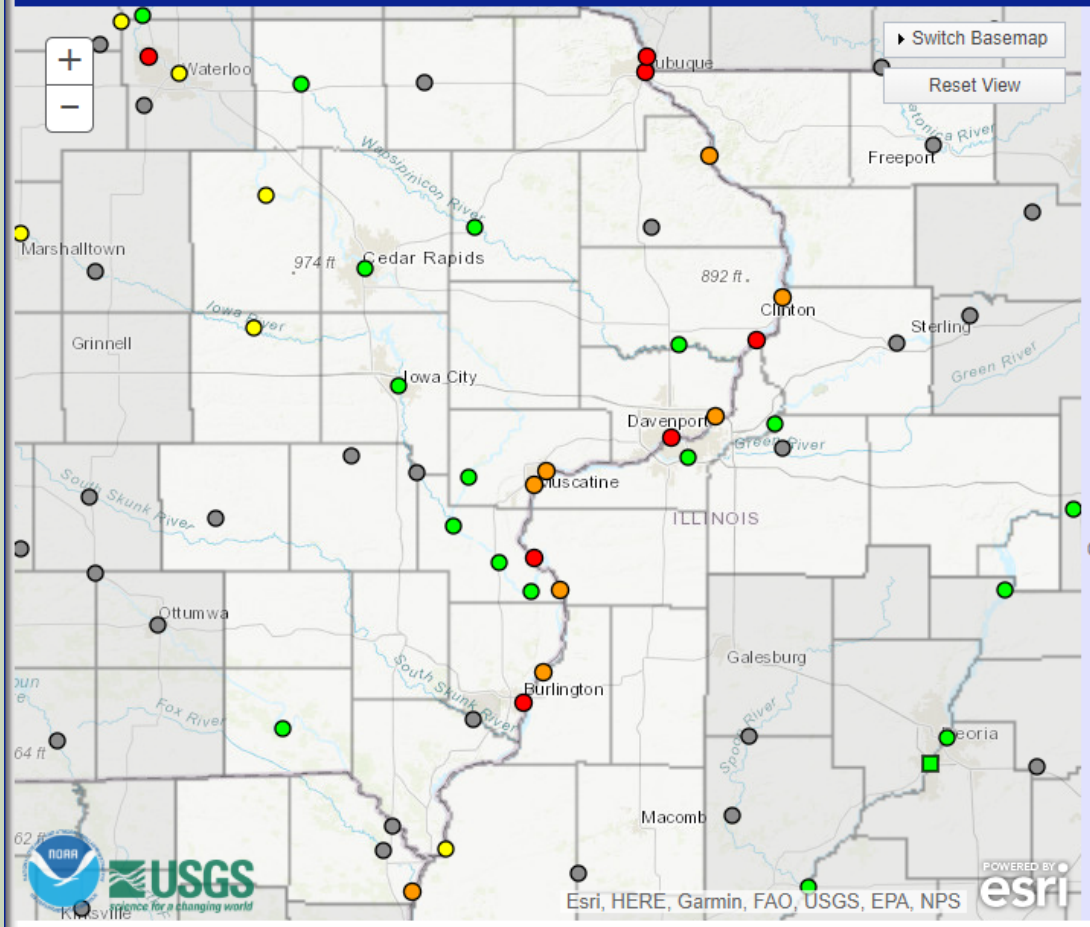
Print this map | Permalink | BOOKMARK

1-day Maximum Forecast Flood Category Through: 05/11/2018 14:50:57 UTC

Day 1 2 3 4 5 6

Entire Period

69 total gauges 20 gauges in flood



- Forecast available
- Probability and forecasts available
- Major Flooding
- Moderate Flooding
- Minor Flooding
- Near Flood Stage
- No Flooding
- Forecasts Are Not Current
- No Forecast Within Selected Timeframe
- Out of Service
- Flood Category Not Defined
- At or Below Low Water Threshold

Last map update:
05/07/2018 at 09:40:37 am CDT
05/07/2018 at 14:40:37 UTC

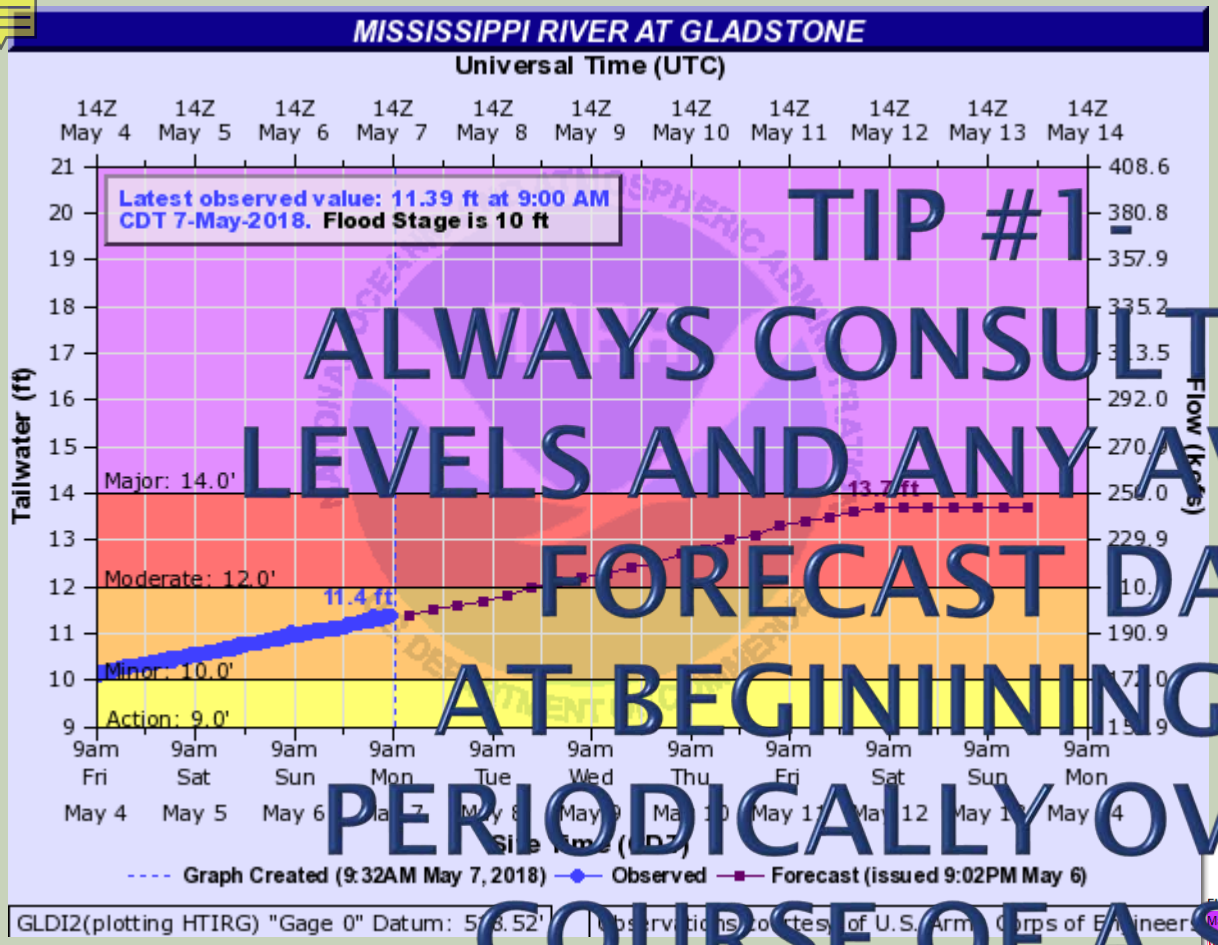
What is UTC time?

Map Help

Disclaimer

KML

Map Overlays



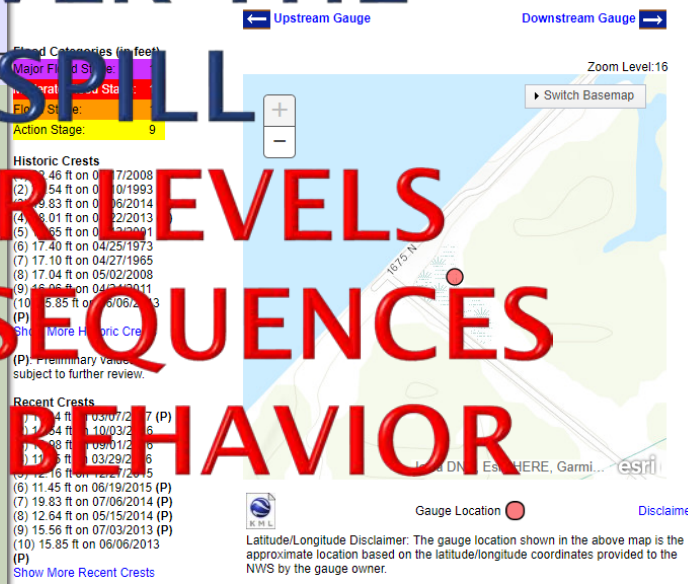
NOTE: River forecasts for this location take into account past precipitation and the precipitation amounts expected approximately 24 hours into the future from the forecast issuance time.

NOTE: Forecasts for the Mississippi River at Gladstone are issued routinely year-round.

TIP #1

ALWAYS CONSULT WATER LEVELS AND ANY AVAILABLE FORECAST DATA AT BEGINIING AND PERIODICALLY OVER THE COURSE OF A SPILL

-CHANGING WATER LEVELS ALWAYS HAVE CONSEQUENCES FOR OIL FATE AND BEHAVIOR




7.02.2011


7.05.2011


7.27.2011


8.04.2011

Channel Forms: CASACDE

A short, steep drop in stream bed elevation often marked by boulders and agitated white water

Channel Forms: RAPIDS

A reach of stream that is characterized by small falls and turbulent high velocity water.

Channel Forms: POOL

A reach of stream that is characterized by deep low velocity water and a smooth surface.

Channel Forms: RIFFLE

A reach of stream that is characterized by shallow, fast moving water broken by the presence of rocks and boulders.

Channel Forms: GLIDE

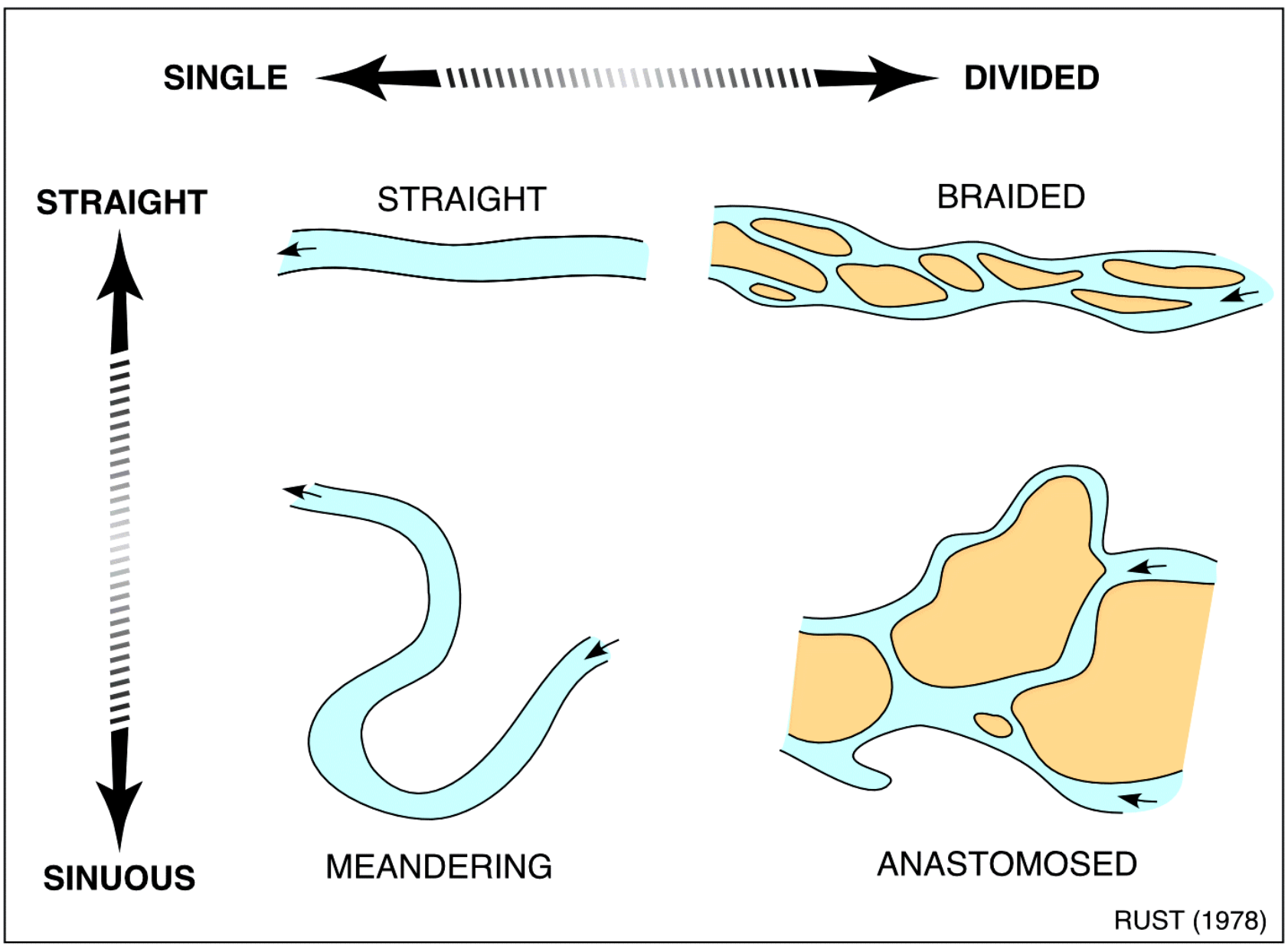
A section of stream that has little or no turbulence.

Channel Forms: JAM

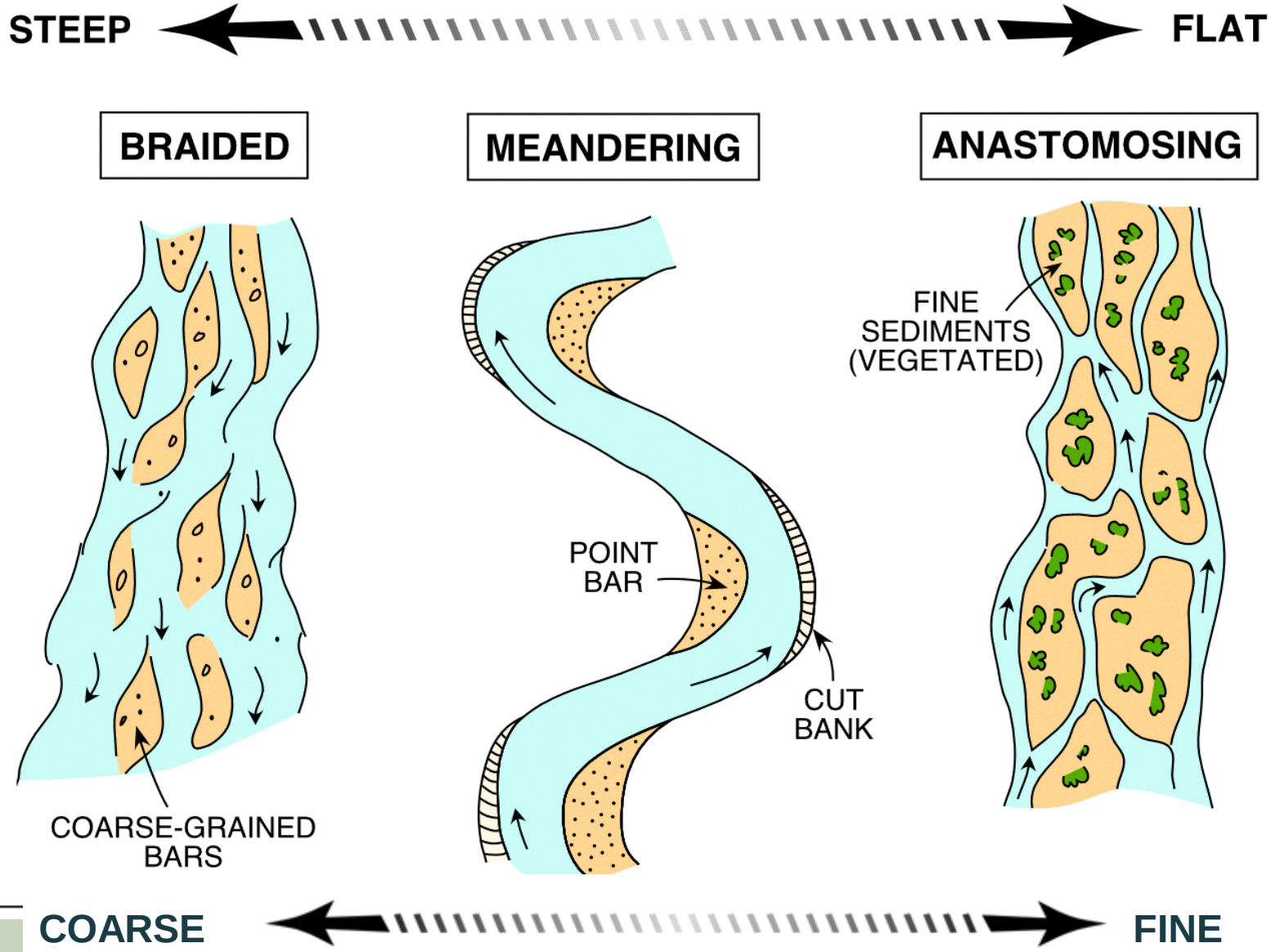
Large accumulations of woody debris (often logs) that block and re-route water flow in the channel

Types of Channels

(controlled by gradient [steep/flat], discharge [steady/flashy], Sediment bed load/grain size)



CHANNELS IN UNCONSOLIDATED SEDIMENTS



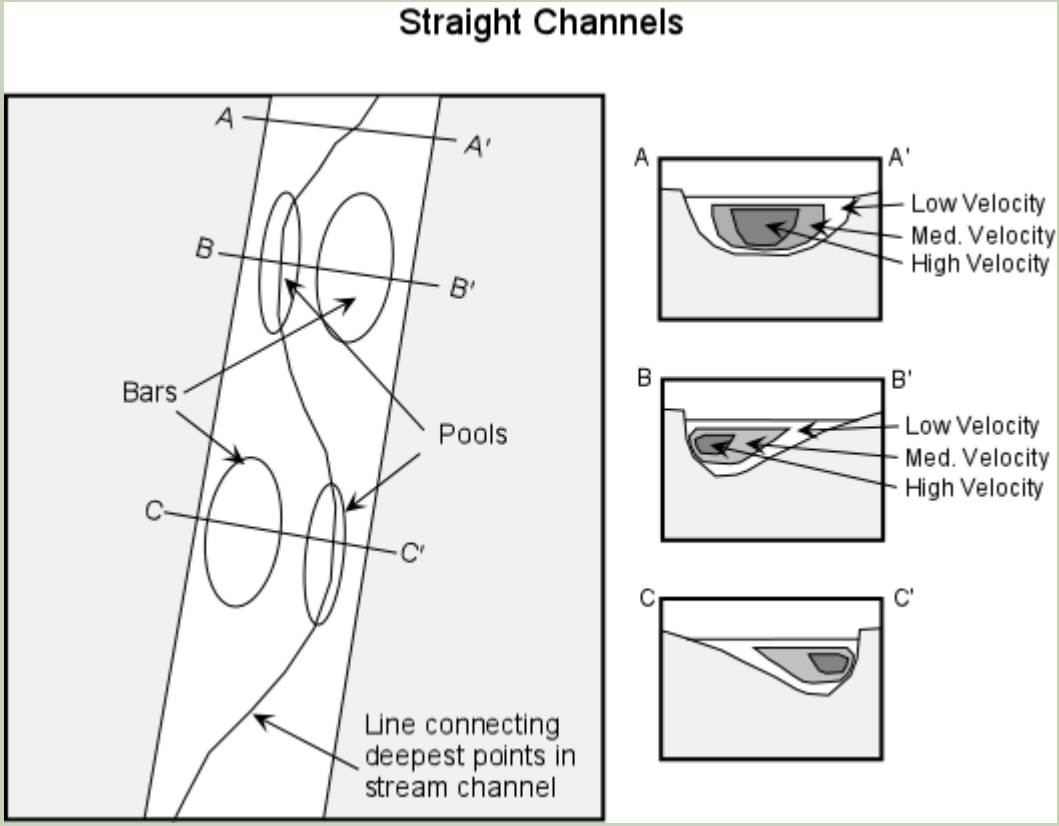
What factors affect stream morphology?

- Width
- Depth
- Slope
- Velocity
- Discharge
- Flow resistance
- Sediment size
- Sediment load

Leopold et al (1964)

SCAT Issues: Straight Channels

- Nature doesn't do straight lines- straight reaches are usually "engineered"
- Often they have structures to keep them straight, e.g. concrete or riprap sides
- Variable flows- sediment accumulates during low flow, high flow/floods scour sediments
- Usually oiling along high water line



SCAT Issues: Large Navigable Rivers

- Often highly variable seasonal flow patterns (high water in spring floods, ice in winter, low flow in summer)
- Control and navigational structures can be present and effect transport
- Containment in open water can be very challenging
- Shoreline cleanup typically on banks exposed to oil during falling water levels or lower energy, or vegetated banks


August 9, 2008 1:15 p.m.
August 9, 2008 6:45 p.m.


SCAT_2008_0803_Team4
N 29° 51.931' W 089° 54.502'
-9 ft
08/03/2008 10:48:00 AM


SCAT_2008_0803_Team4
N 29° 51.929' W 089° 54.510'
13 ft
08/03/2008 10:36:48 AM


08.01.2008 09:41
N 29° 34.276' W 089° 48.022'
37 ft
08/01/2008 9:41:48 AM

SCAT Issues: Braided Channels

- Steep gradient, high sediment bed load, coarser sediment
- Multiple banks can be oiled, typically high erodable bank

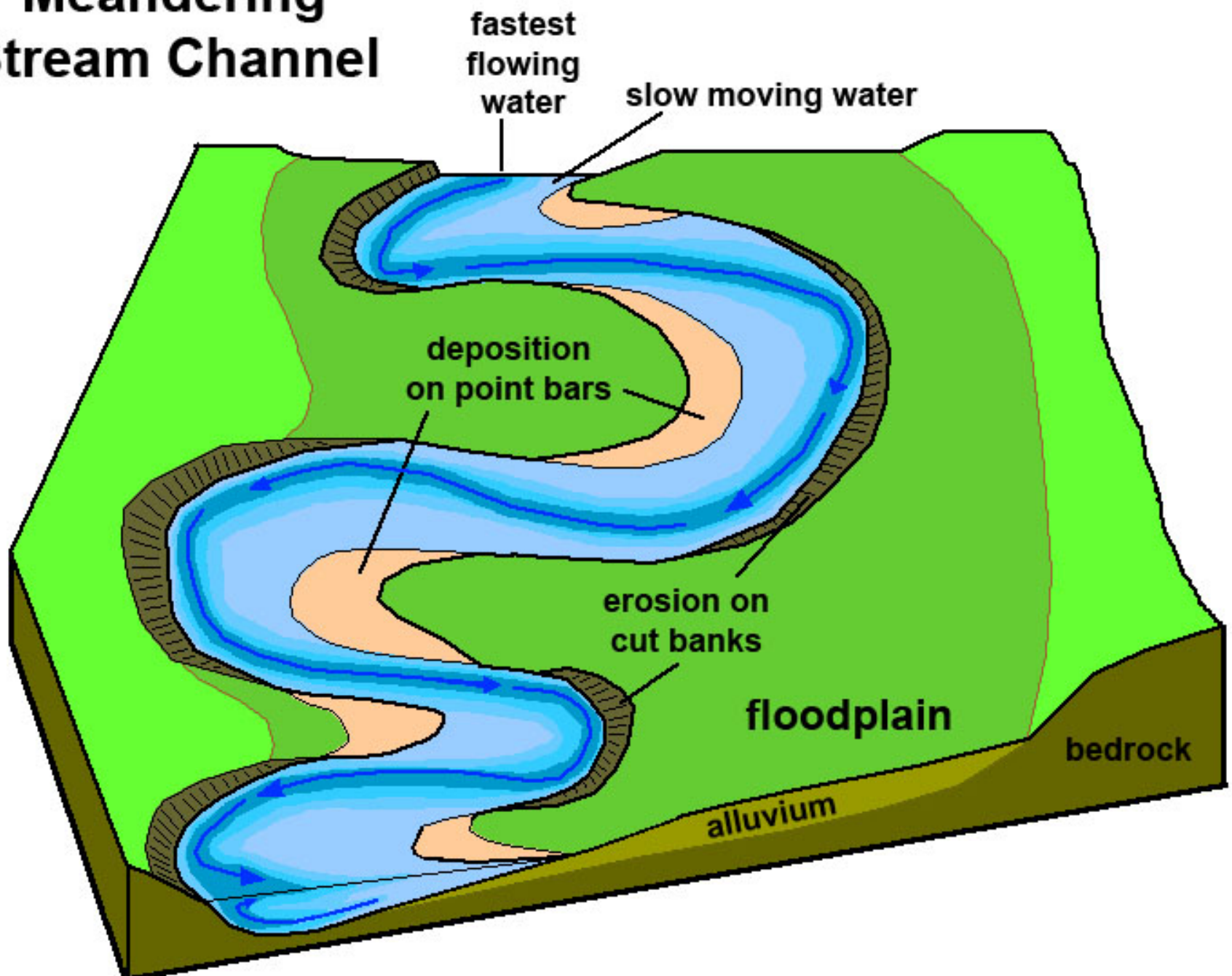
- Rapid and frequent variations in water flow=
- high potential for burial as river levels rise and fall

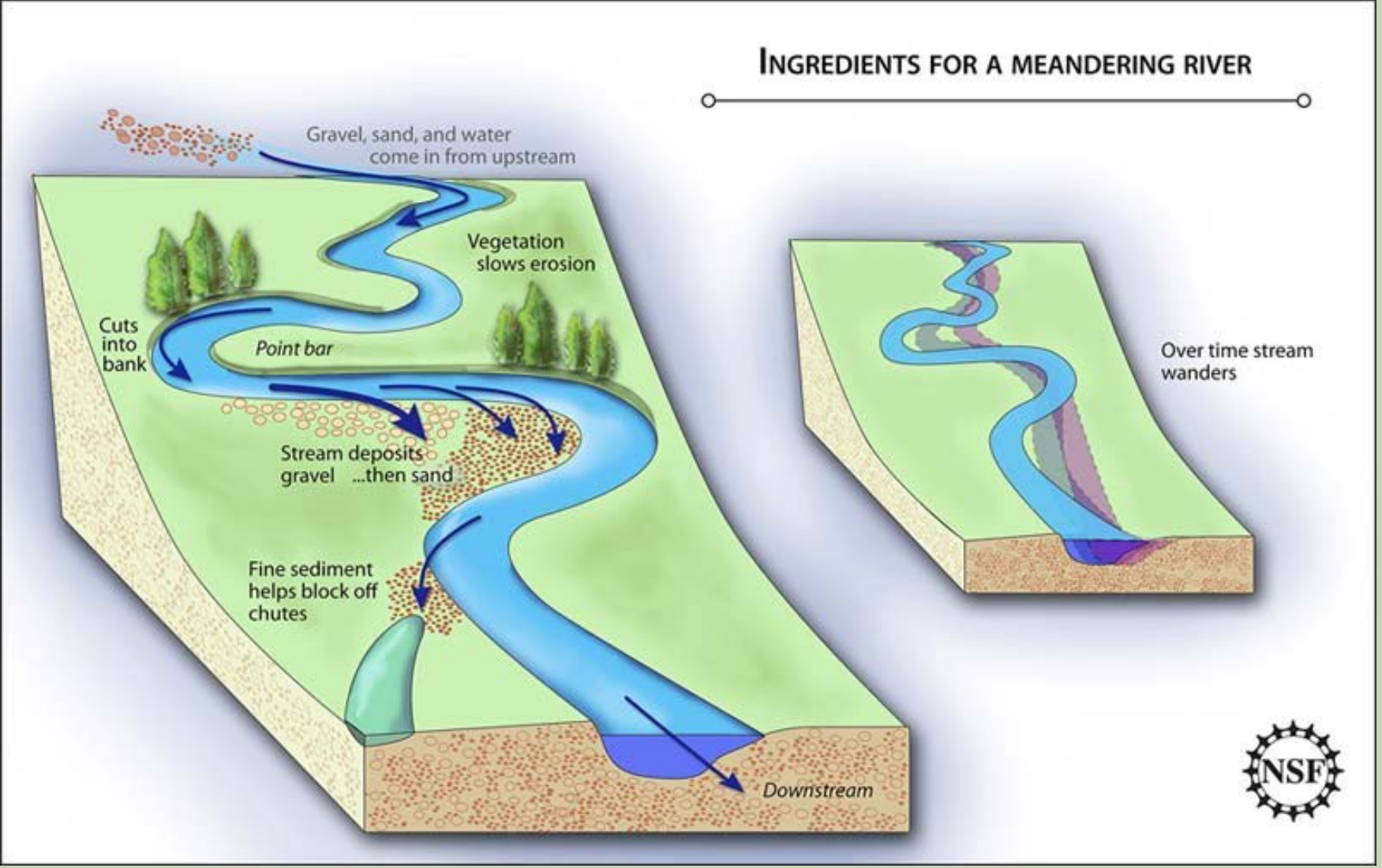
- Small changes in water level can result in multiple oil bands along the banks
- Some of the bars can be vegetated or have debris that can become oiled
- Access can be very difficult so surveys may be incomplete

SCAT Issues: **Meandering Channels**

- Occur where gradients are low
- Channels are very stable, within "SCAT" timeframes
- Flow usually steady and changes slowly
- Variable flow patterns along reaches, which affects shoreline oiling patterns
- Shorelines range from gravel or sand to vegetated
- May be deep enough for boat access (at least during high water or via airboat)

Meandering Stream Channel

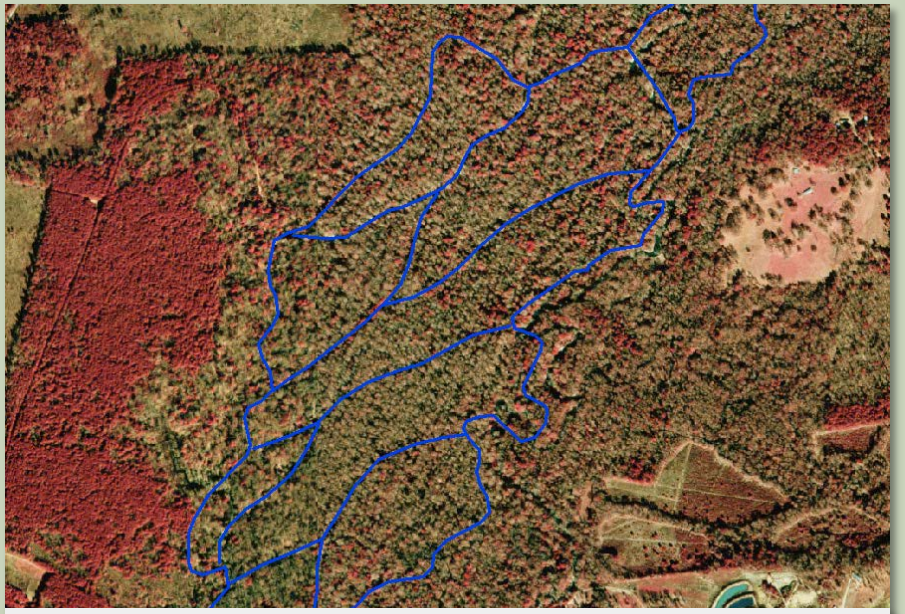


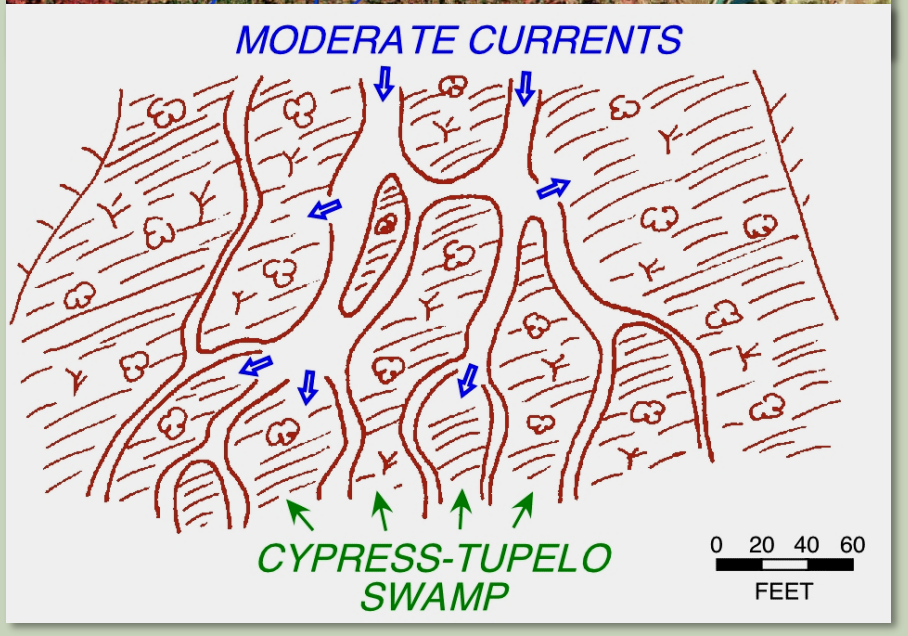


1. Vegetation to reinforce banks and prevent erosion, and
2. Sand to build point bars and block off cut-off channels and chutes. (Zina Deretsky, National Science Foundation)

SCAT Issues: Anastomosing Channels

- Occur in areas with very flat gradient and low sediment bed load
- Baseline flow usually steady and changes slowly
- Low banks, lots of debris
- Highly complex channels and flow patterns; during floods, water flows over the floodplain
- Potential for extensive oiling along multiple banks
- Too shallow for boat access; shoreline access very difficult





Which ones are YOU likely to encounter?

SCAT Issues: Anastomosing Channels

Complex channels

Lots of woody debris

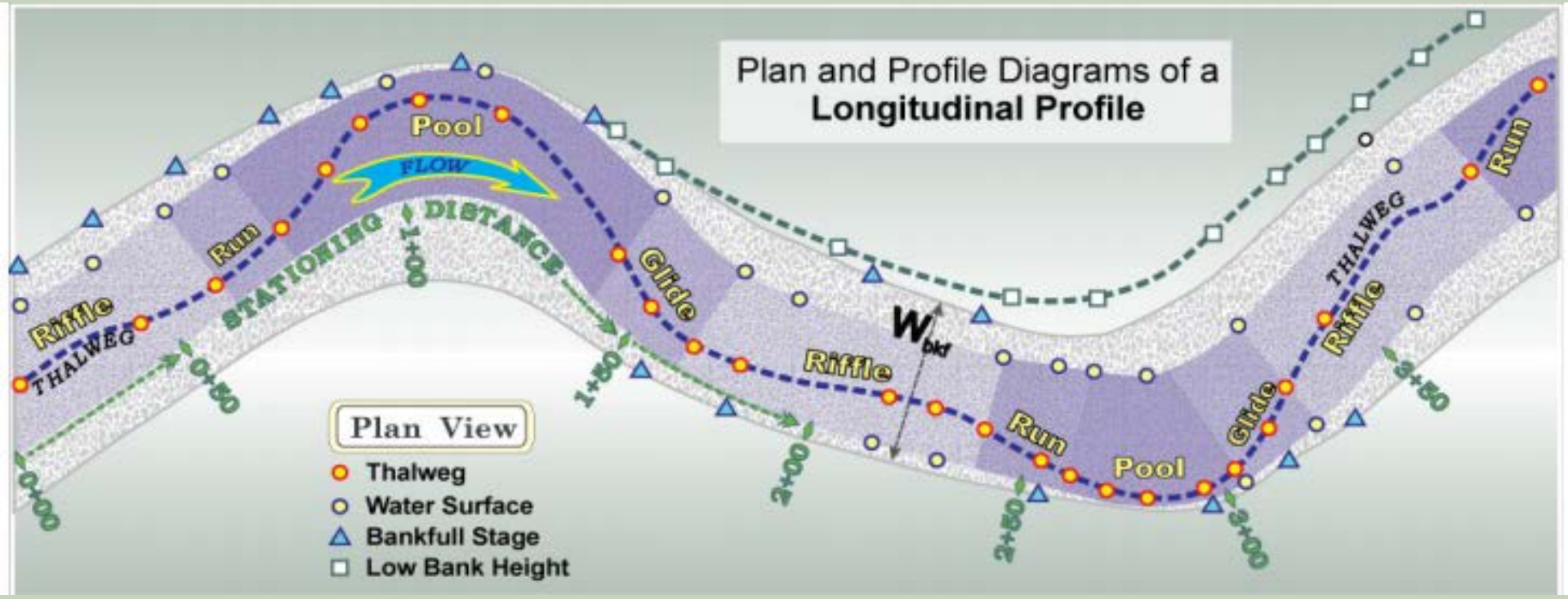
Long-term seepage from hotspots

Difficult to SCAT

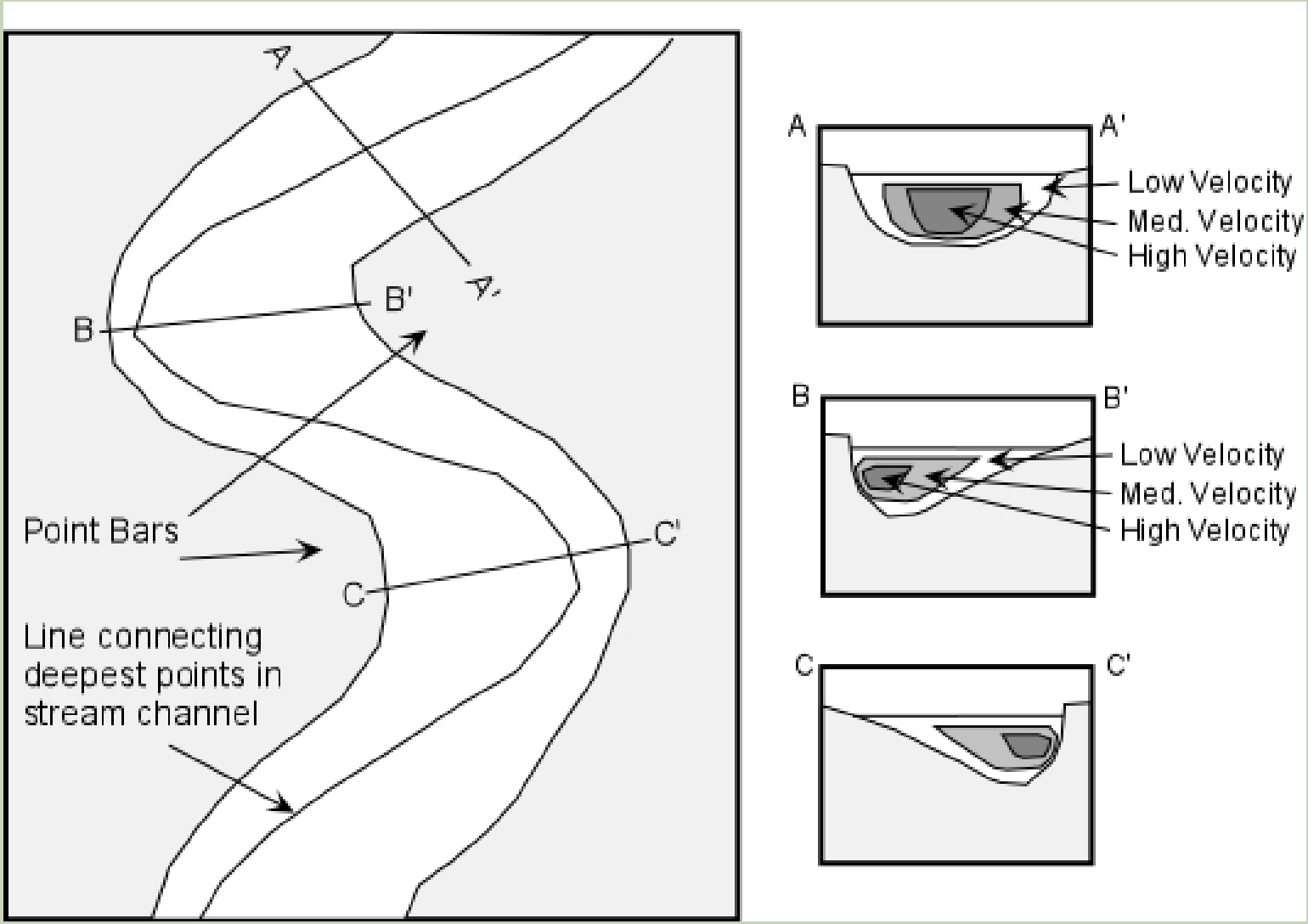
Flow Patterns

Flow Patterns in Meandering Channels

- In the straight riffle reach, max flow is mid-channel
- In the meander, the water piles up against the cut bank, flows both forward and downward, creating helical (twisty) flow patterns
- Low flows occur adjacent to the point bar or inner bank, where oil can strand and become buried over time

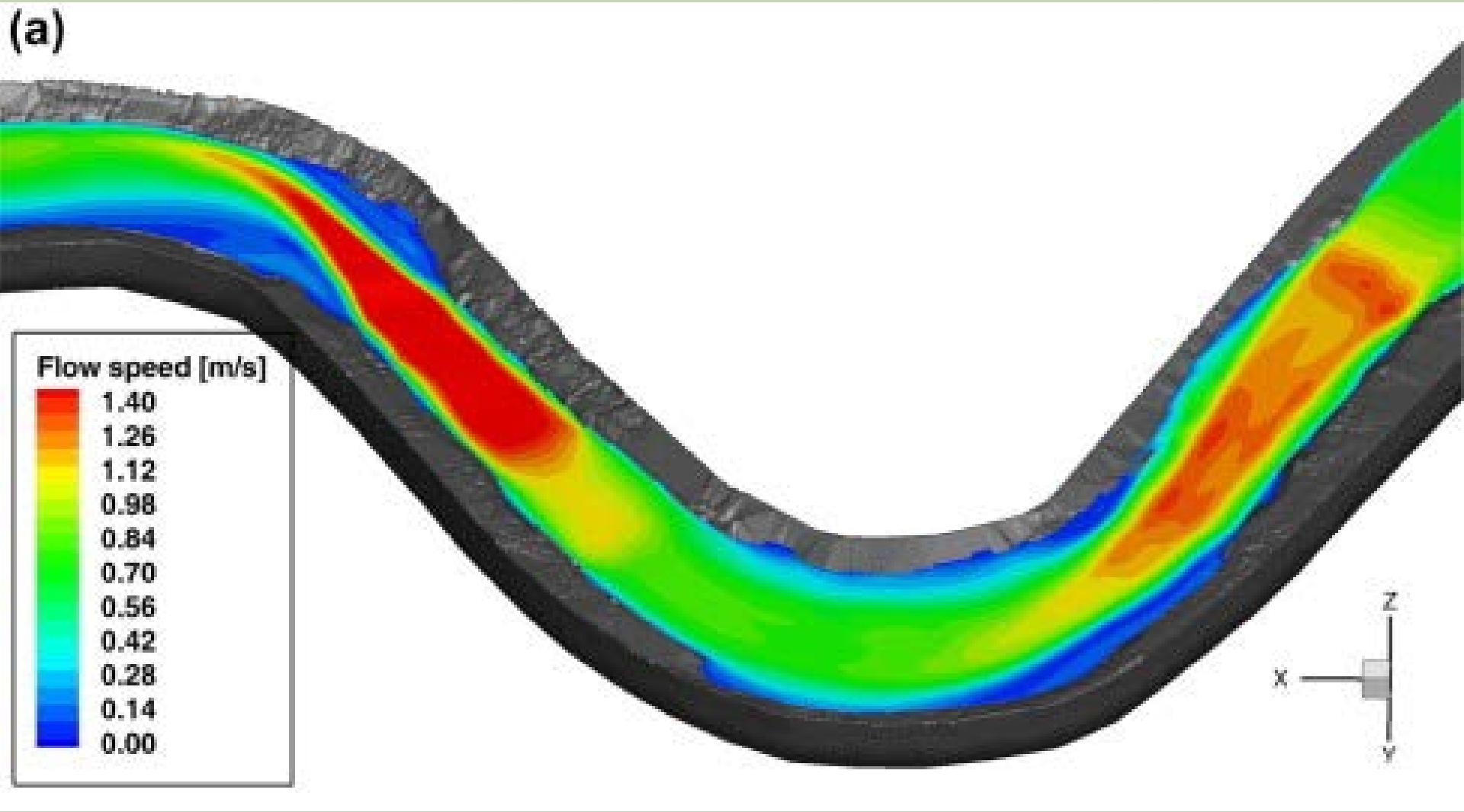


Flow Patterns in Meandering Channels



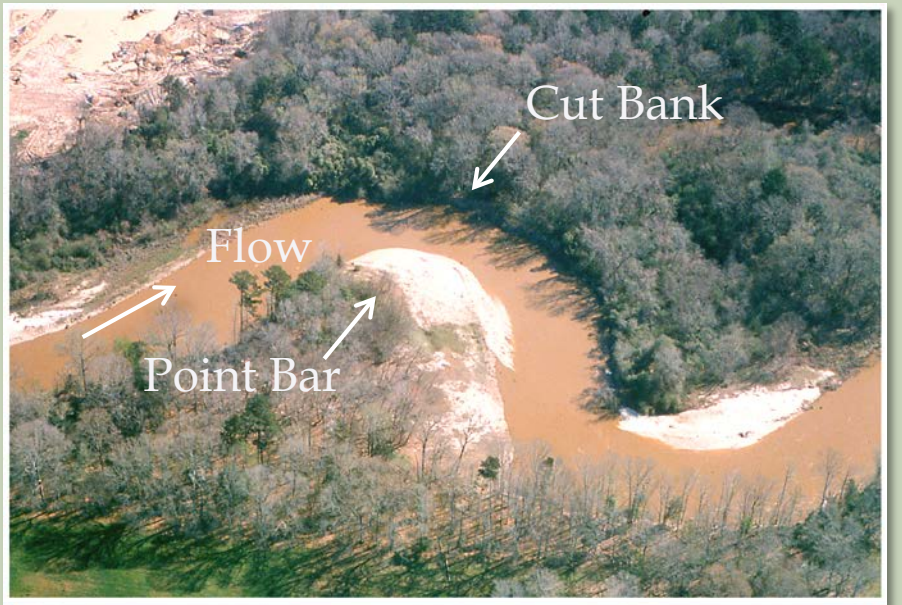
- Oil accumulates on the points bars and in eddies downstream of the bars

Meandering Channel Flow Speeds



Meander Bends, Cut Banks, and Point Bars

- Point bars have bedforms (ripples and dunes) created during high water levels and flows
  - They can be composed of sand to gravel, so have high potential for oil penetration
  - Often used for river access by the public
- Cut banks are steep and erosional; with the strongest currents
  - Can have a lot of deadfall trees that can trap oil and become coated

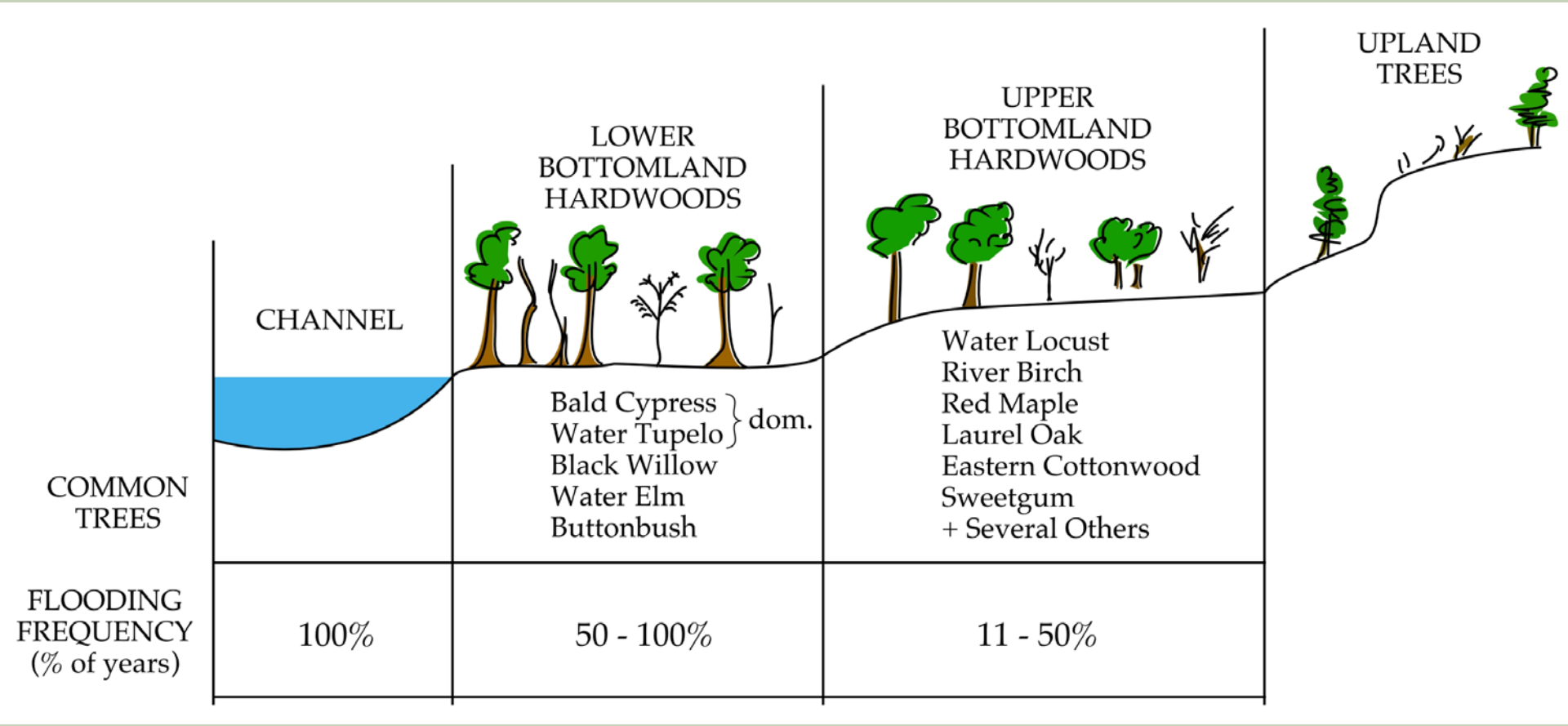



2012.09.19

Highly Meandering Rivers and Oxbow Lakes

- Meander cuts (oxbow lakes) usually are low flow with limited connection to the main flow
- During floods, river flows into oxbow, but can't flow out
- These "leakage" points at high water should be closed off with boom if possible

Freshwater Hardwood Wetland Types



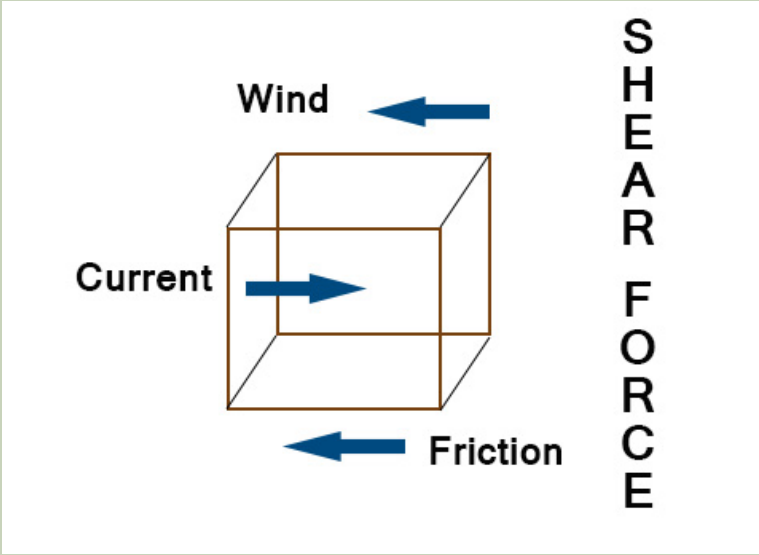
Lower Bottomland Hardwoods

- **Often flooded during wet season**
- **Large amounts of debris**
- **Oil penetration into soils- function of primary (size of soil granules) and secondary (root cavities, burrows) permeability and water level**
- **Oiling can be 3 dimensional and spatially variable, so difficult to survey and describe**

Bayou Sorell, LA (Jan 2013)

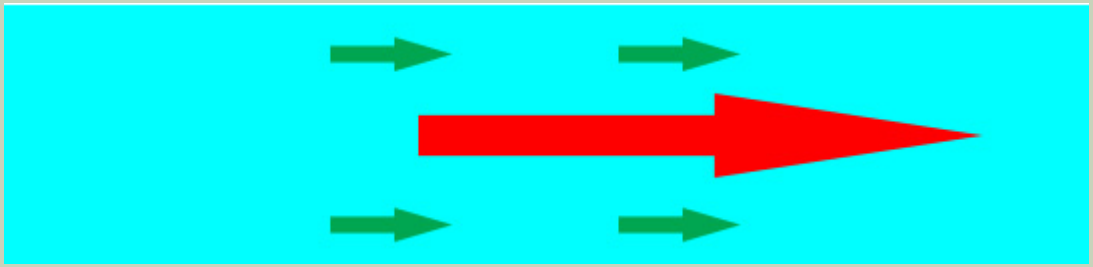
Oil Transport/Behavior in Rivers

- Currents and shear dominate vertical and cross-river distribution
- Wind determines which bank of the river the spill will trend
- Turbulence and shear forces created by currents interacting with the river bottom and banks can move significant amounts of oil below the surface (difficult to observe…)



Oil Transport/Behavior in Rivers

- Lower speeds along banks and bottom = surface and center move downstream faster than the flow along its boundaries
- Flow differential causes increased exchange of water and pollutants between the slower near-bank and the faster center
- Results in the smearing of a pollutant plume, particularly along the axis of the flow



Oil Transport/Behavior in Rivers

- Consequence of shear-dominated flow: leading edge of the pollutant distribution may move as a sharp front (at the current speed in the middle of the channel), but tail end of distribution is continually mixed and smeared

- Actual pollutant distribution over the first few hours will resemble a comet

Oil Behavior and Fate When Rivers Enter Man-made Impoundments

- Impoundments are characterized by very low flow velocities
- Wind, rather than currents, will primarily move oil
- Oil entering the impoundment will tend to slow down and spread out
- Good place to deploy boom and skimmer

Oil Behavior and Fate When Rivers Empty into Man-made Impoundments

- The exit of an impoundment is through a dam or lock-and-dam system

- Dams with greater flow control (such as hydroelectric dams) often pass the flow through gates that draw water from the bottom

- An underflow dam will serve as a very reliable boom: the oil on the surface gets trapped behind the dam, and little oil will flow through

Oil Behavior and Fate When Rivers Empty into Man-made Impoundments

- Overflow dams or weirs pass water over the top of the dam
- Floating oil will be drawn into the over-dam flow
- The discharge over the dam is usually highly turbulent, resulting in a well-mixed distribution
- Poses the greatest threat to water intakes and bottom-dwelling biota

Centralia Dam, Nisqually River

Oil Behavior and Fate When Rivers Empty into Man-made Impoundments

- Depending on the type and amount of oil, some oil may rise to the surface and create new sheens downstream when in calmer water

- The speed with which the oil refloats depends on the droplet size and density of the oil
  - Diesel spills would take several miles to resurface, mostly as sheens
  - Heavier oils resurface more quickly and slowly reform slicks

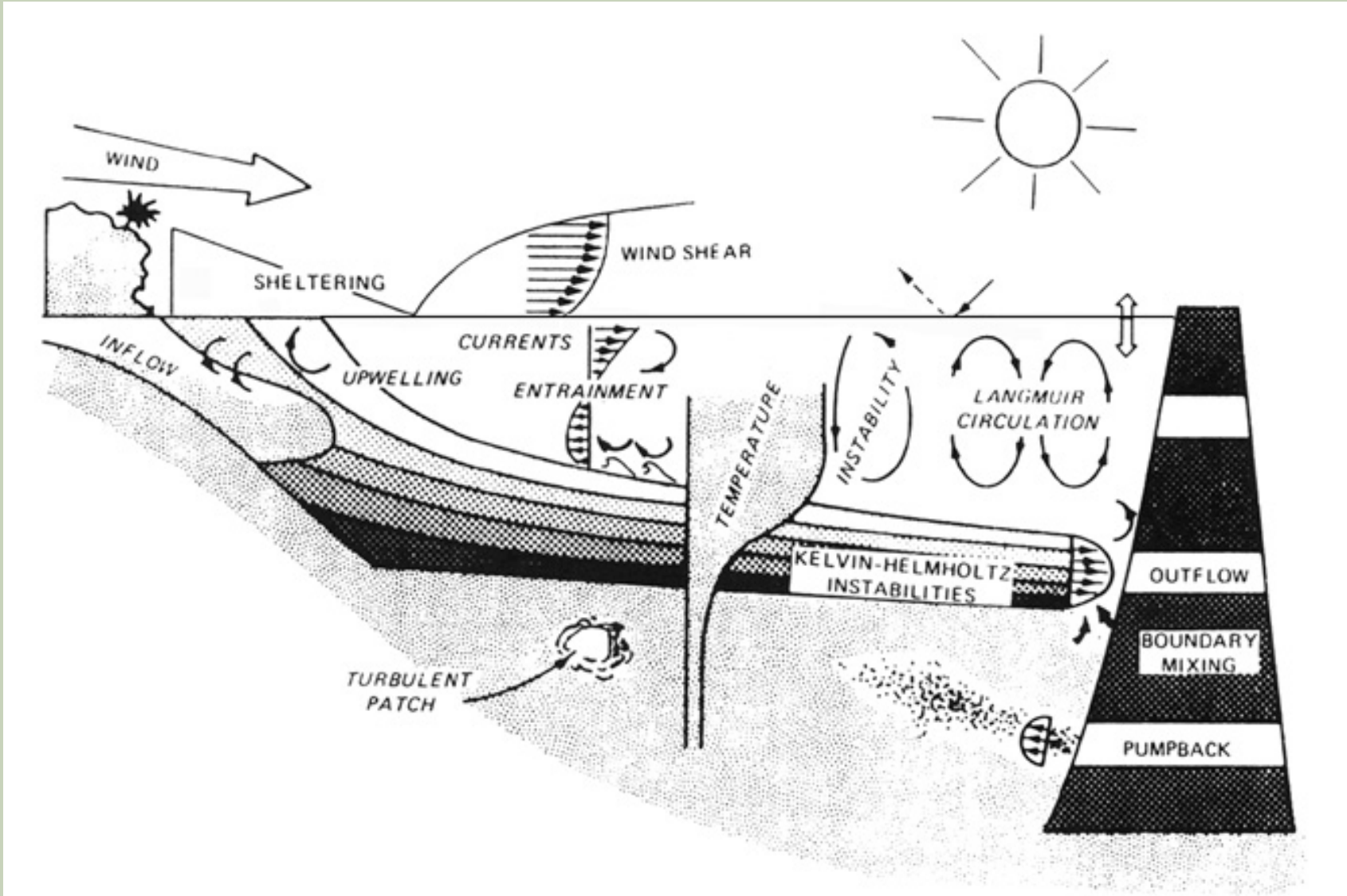
- TSS also impacts refloat potential

Reservoirs (lakes resulting from man made impoundments)

- Many lakes are the result of man-made impoundments for flood control, recreational, hydroelectric or drinking water sources

- Physical processes and hydrologic regime in the lakes are consequence of the dynamics of the watershed (inflow) and control structures (outflow), depth, and other factors such as vegetation as well as the local climatic conditions.

Physical Processes in Reservoirs?



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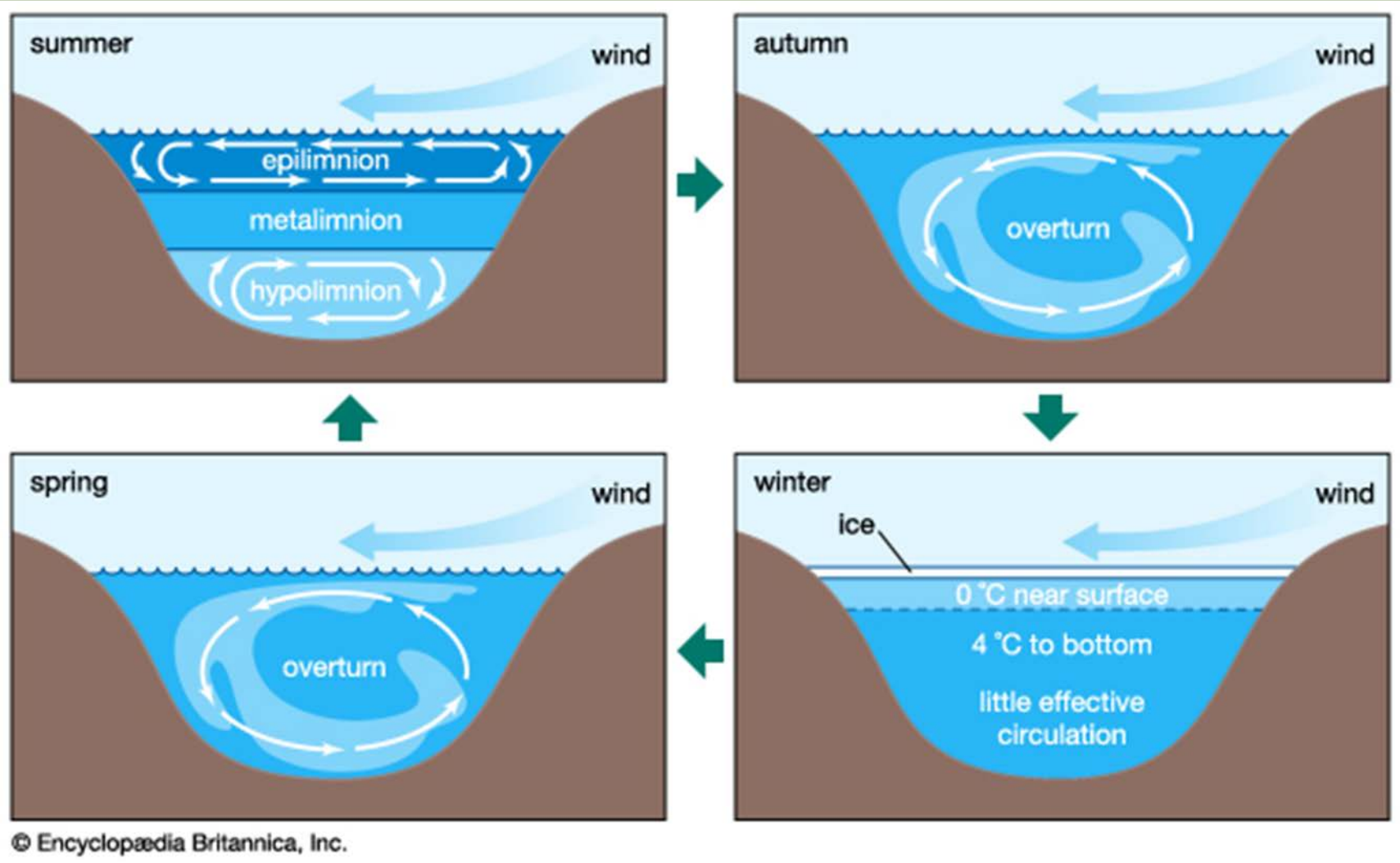
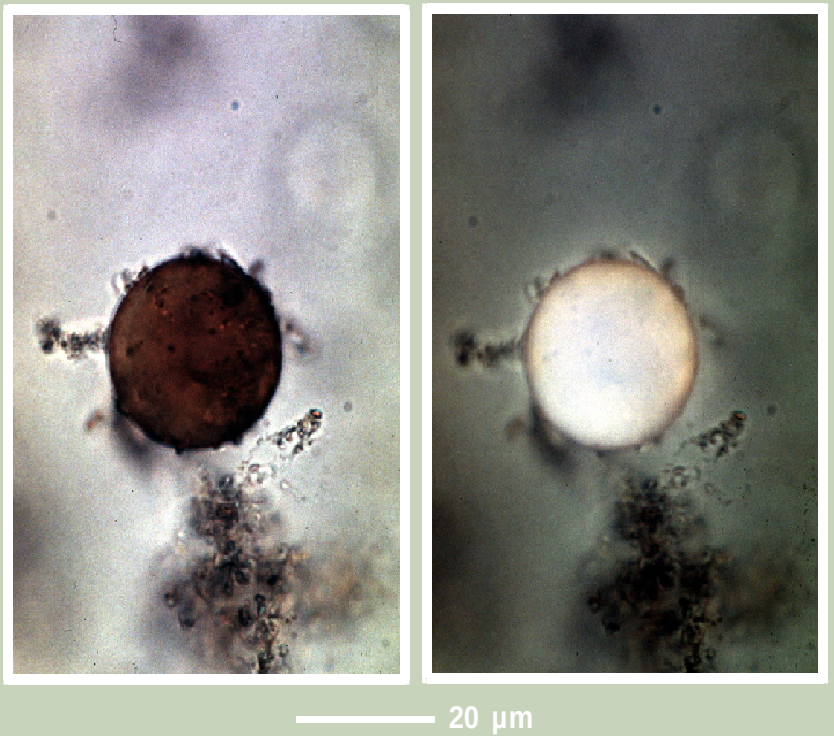
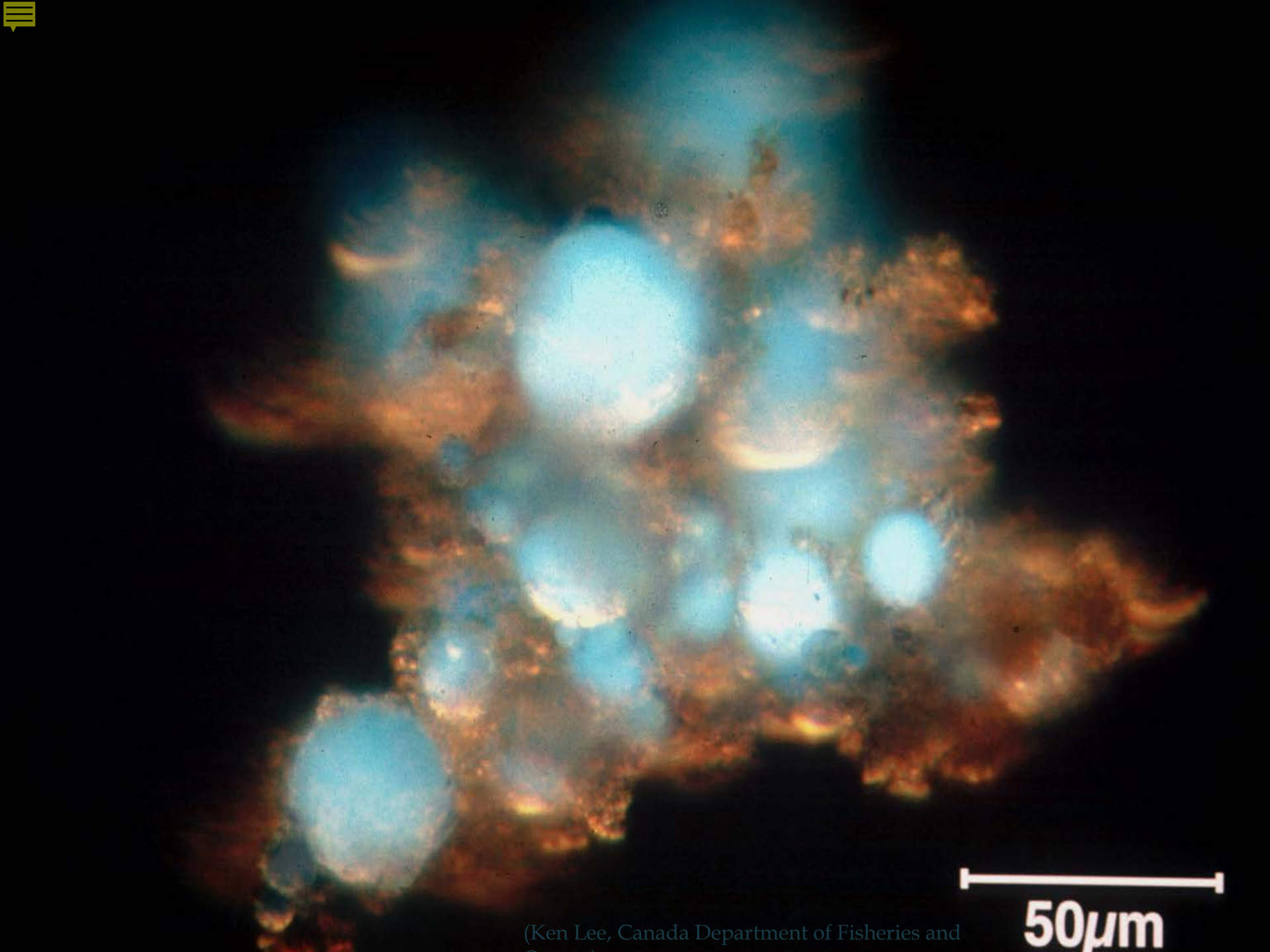


Oil Interaction with Suspended Sediments

- Turbulence disperses surface oil in the form of small droplets
  - Low suspended sediments: droplets may resurface in lower turbulence
  - Mod-high suspended sediments: oil droplets may become coated with heavier solid particles and stay suspended and eventually sink in depositional areas



Oil-mineral aggregates (OMA): oil droplets stabilized by fine mineral particles



(Ken Lee, Canada Department of Fisheries and

Oil Interaction with Suspended Sediments

- OMAs will stay suspended under even moderate flows; however, they will settle out in low flow areas
  - This is different than the sinking of an oil that is heavier than the receiving water (e.g., Enbridge pipeline spill of the tar sand oil/diluent mixture in the Kalamazoo River);
- In large, muddy rivers, such as the Mississippi River, this process can remove a large % of the oil from the surface

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Wait, what did we just talk about?

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Questions?