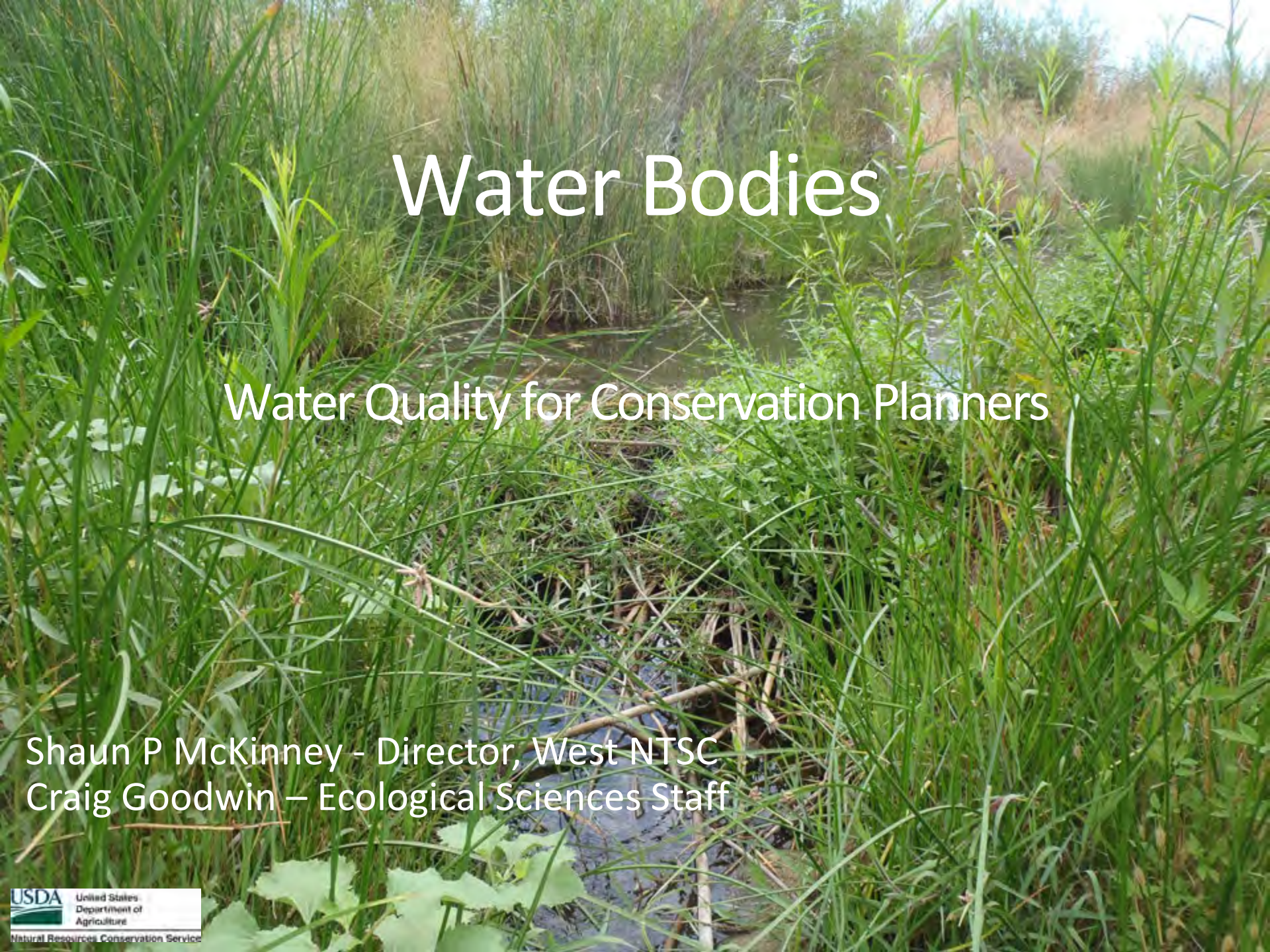

Water Bodies

Water Quality for Conservation Planners

Shaun P McKinney - Director, West NTSC
Craig Goodwin – Ecological Sciences Staff

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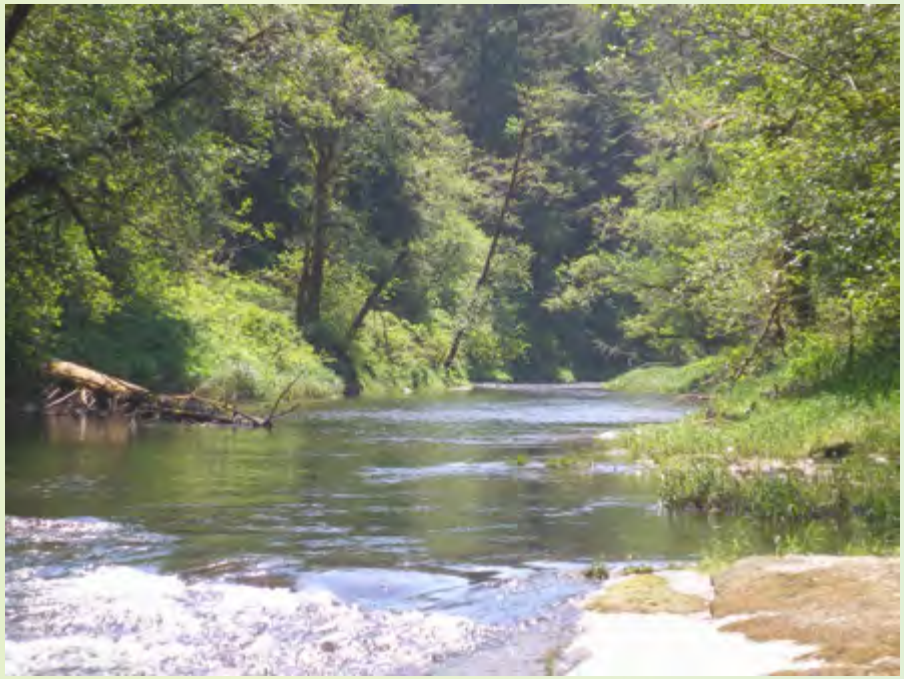
Natural Resources Conservation Service

Water Bodies are where we see Water Quality Resource Concerns show up on the farm, field and pasture.

As water flows downhill – the sum total of activities in a watershed show up in water bodies. - Pathways



Agricultural water bodies –
Often highly altered from their original state.
Part of a working lands environment
Highly valued – ecologically, ascetically, economically
Often the focal point of the Operation, Farm, Field

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Ponds and Lakes
Aquifers
Streams and Rivers

Water Bodies

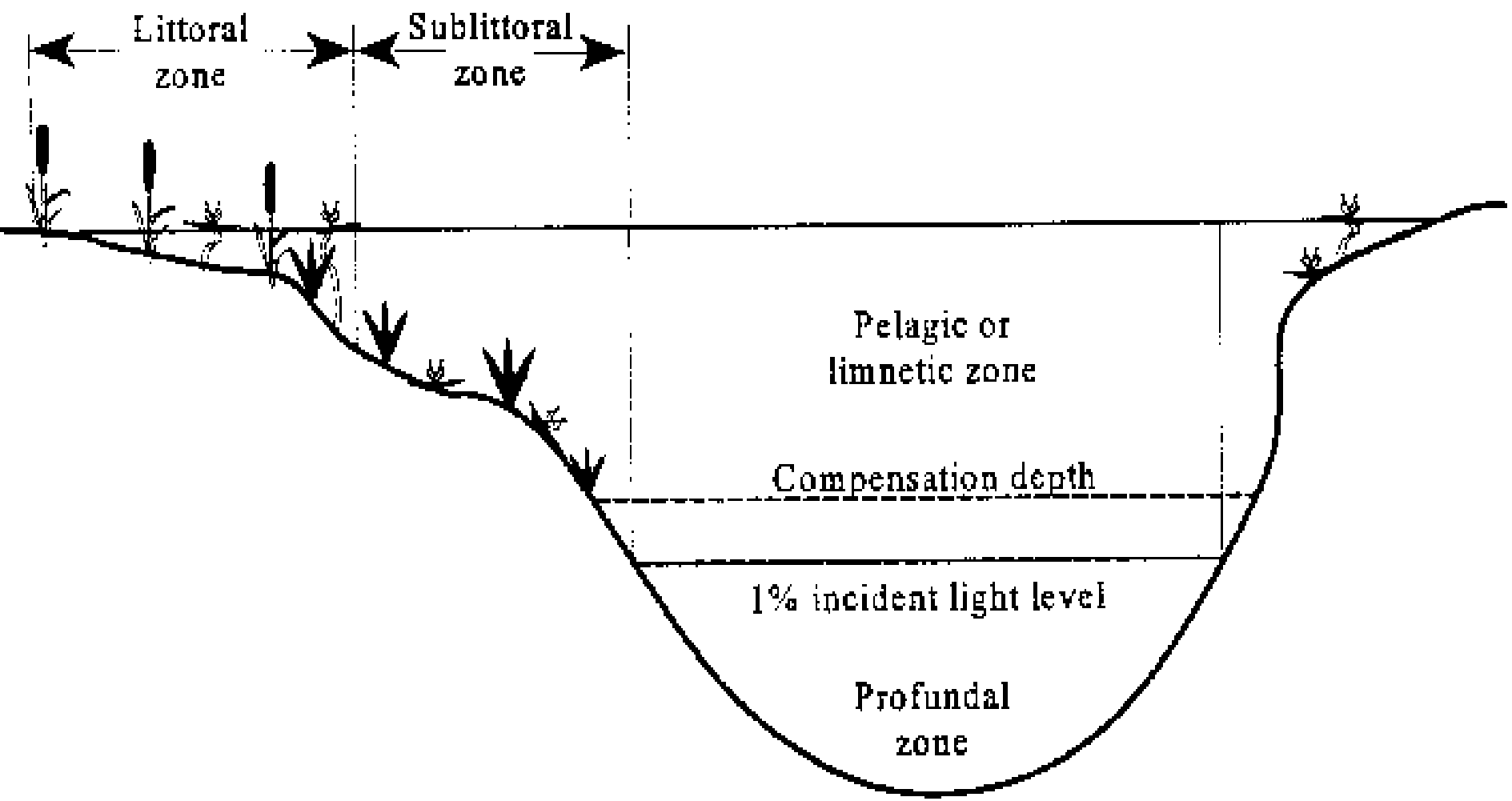
- Pond and Lakes
  - Natural lakes
  - Impoundments and reservoirs
- Aquifers
  - Underlie the landscape but unseen
  - Important sources for well and irrigation water
- Streams
  - Part of a larger network
  - Dynamic – always changing and always will
  - Resilient

Roadmap

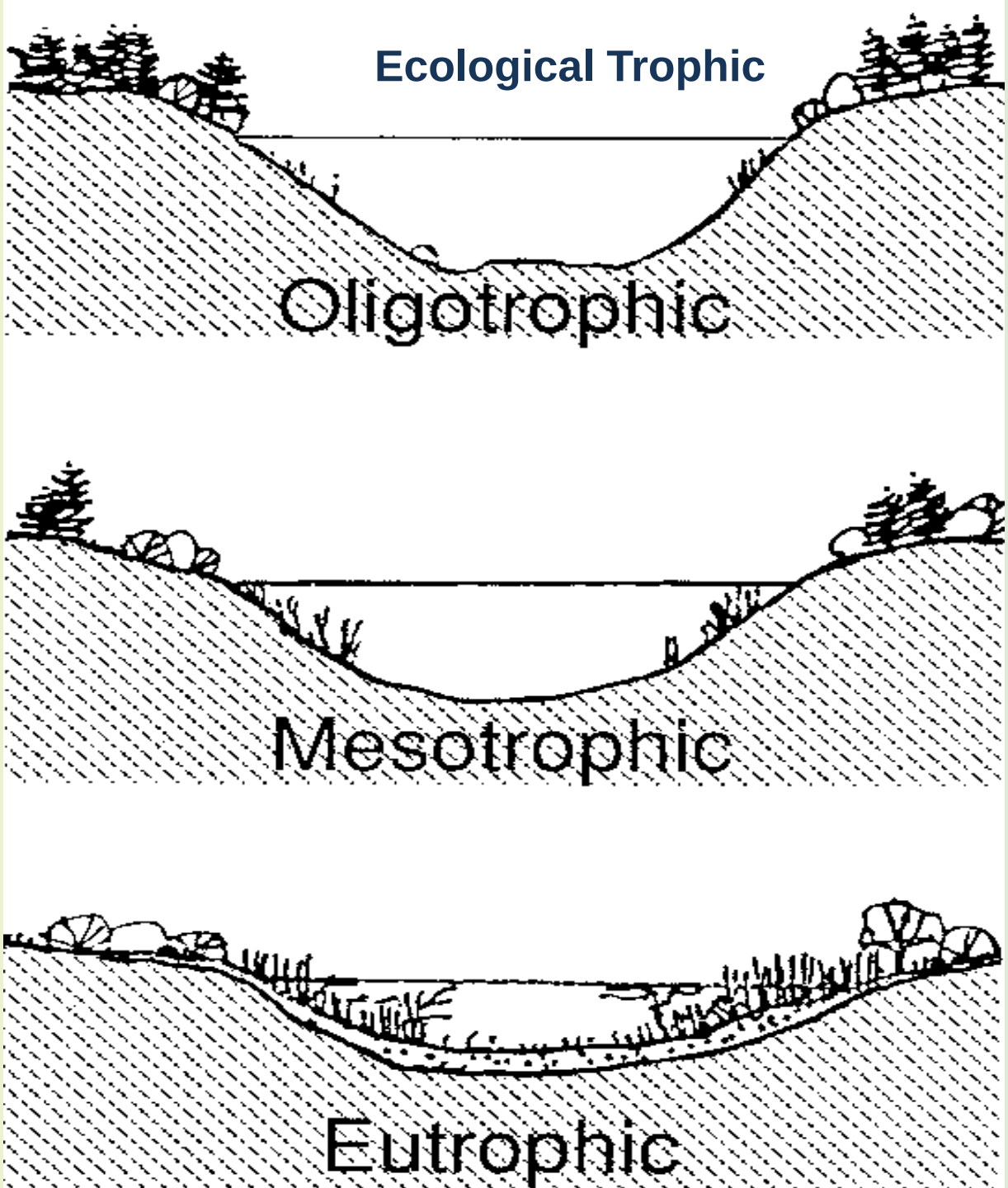
- Lakes and Ponds
- Aquifers and Groundwater
- Streams and Rivers
  - SVAP

Lakes and Ponds

Zonation of Lakes



Lake Types



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Lake Trophic State Characteristics

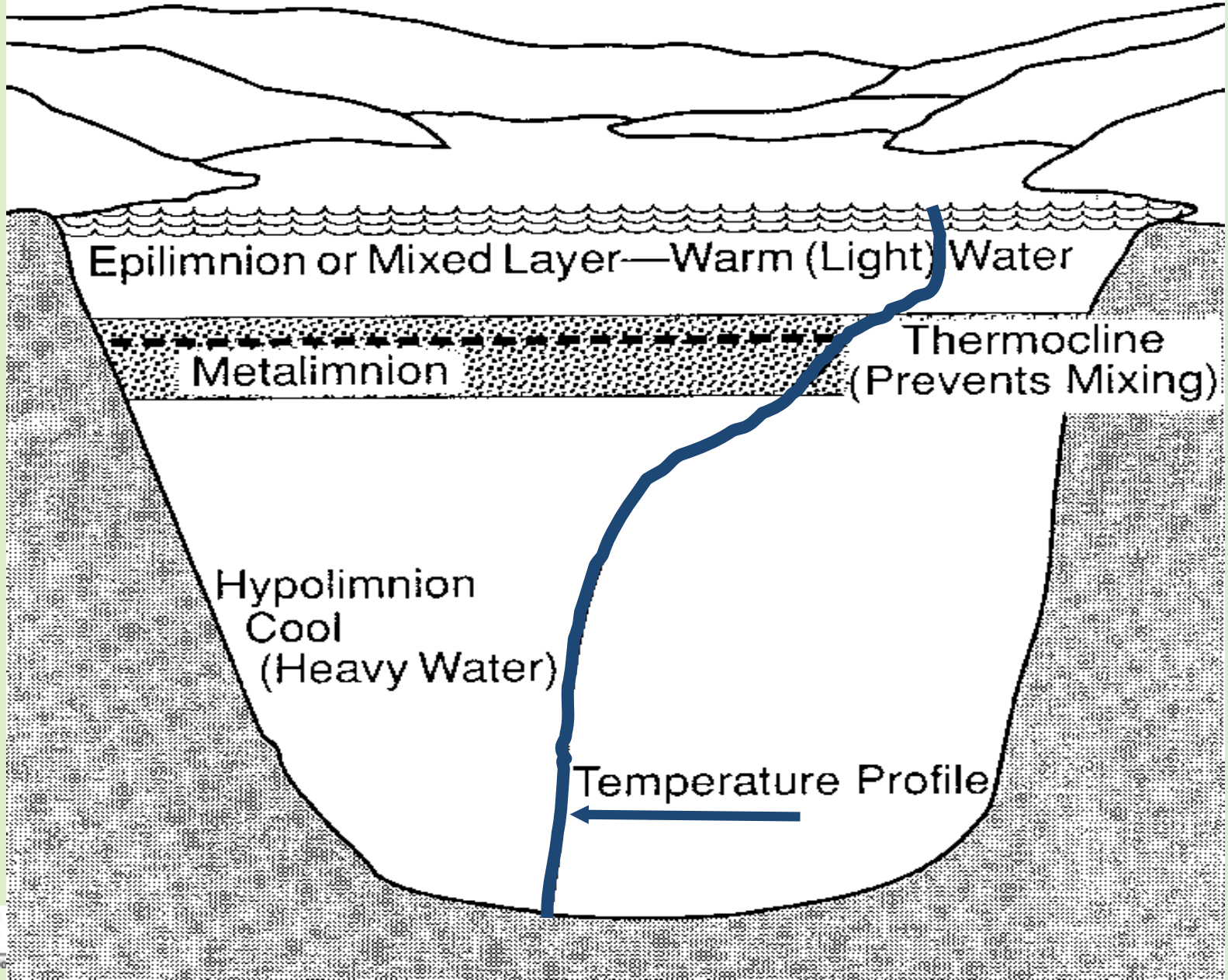
Trophic State	Total Nitrogen (ug/L)★	Total Phosphorus (ug/L)★	Chloro-phyll-a (ug/L)★	Secchi Depth (meters)
Oligotrophic	< 350	< 10	< 3.5	> 4
Mesotrophic	350 - 650	10-30	3.5 – 9	2 - 4
Eutrophic	650 - 1,200	30 - 100	9 – 25	1 - 2
Hypereutrophic	>1,200	> 100	> 25	< 1

★micrograms per liter or parts per billion

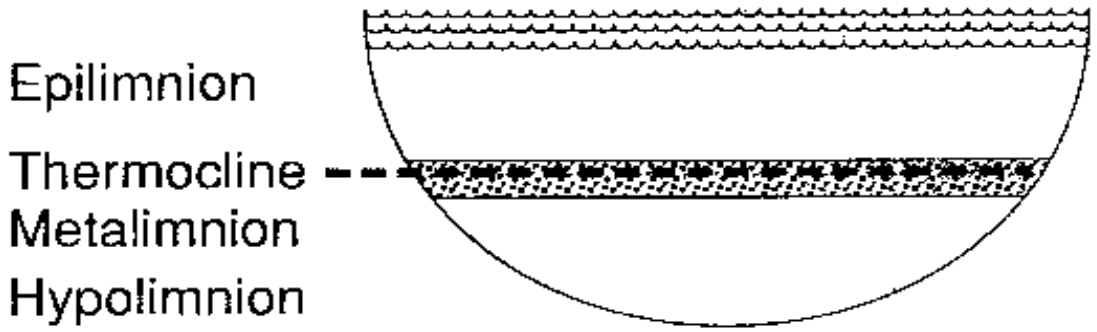
Artificial Eutrophication

1. An increase in nutrient levels (total phosphorus and total nitrogen).
2. An increase in suspended solids level (especially phytoplankton) & color (colorless to green, brown, etc.).
3. An increase in the mean epilimnetic temperature.
4. A decrease in Secchi depth.
5. An increase in the volume of the hypolimnion.

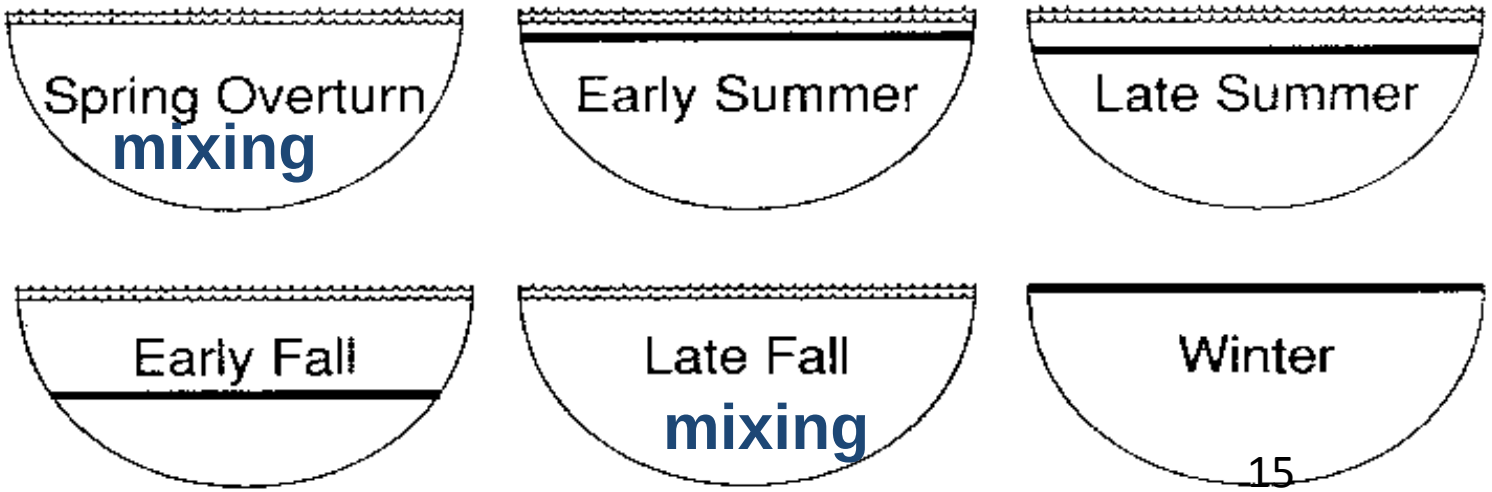
Thermal Profile



Summertime Thermal Stratification



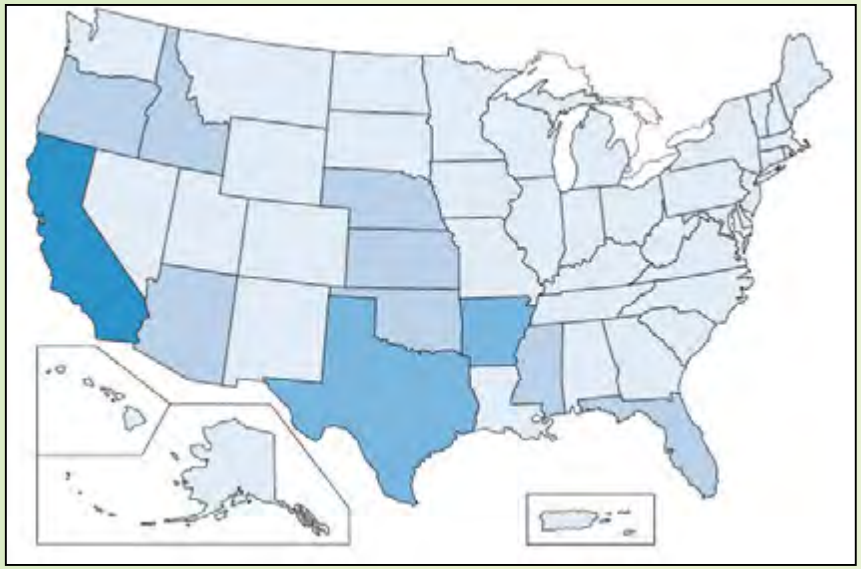
Annual Cycle of Thermal Stratification



Ground Water:
The Well-Used but Invisible Water Resource

- 22% of all fresh water occurs underground
- 79.3 billion gallons used per day in US
- 115 million Americans rely on groundwater for drinking water
- 43 million Americans rely on groundwater from private wells
- Irrigation is the major consumer of ground-water

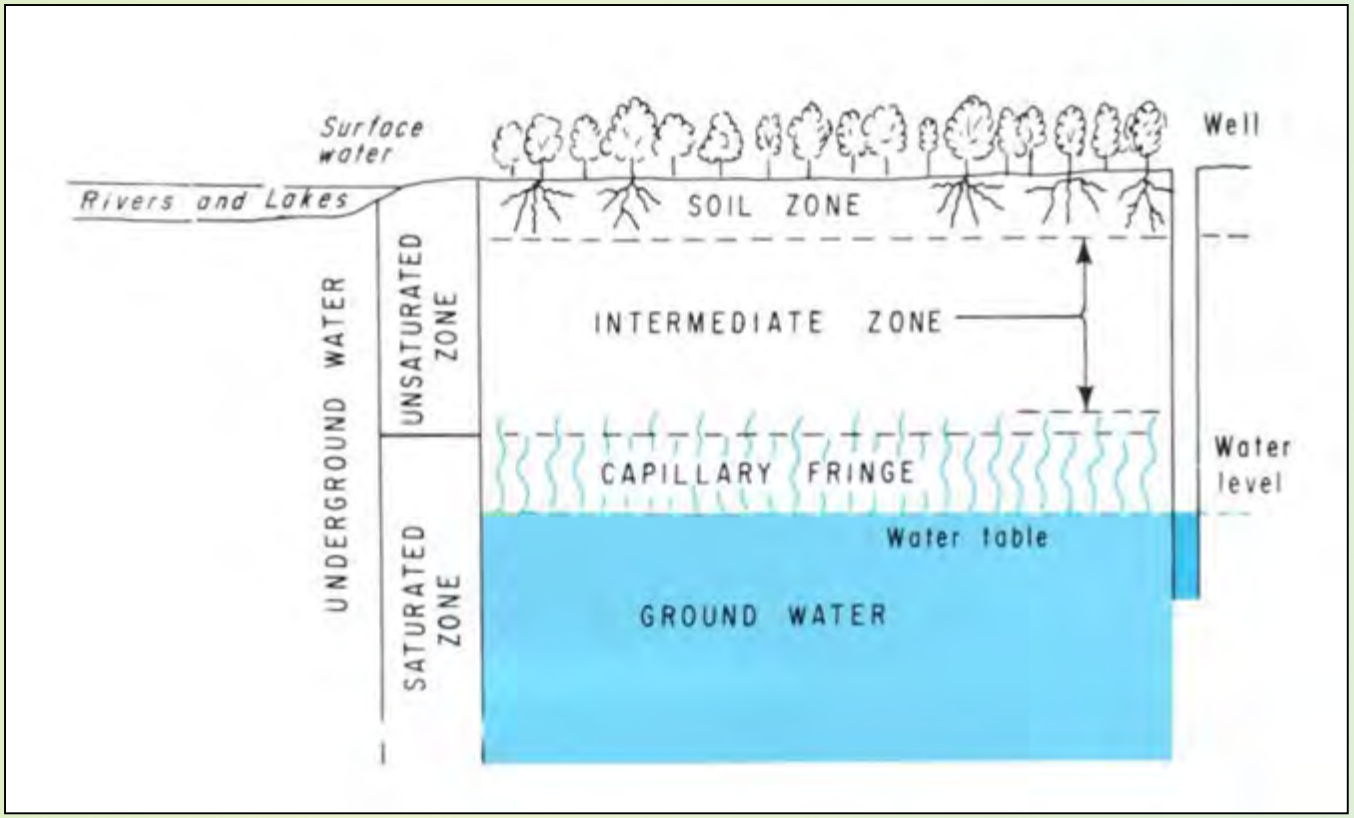
Ground-Water Withdrawals 2010



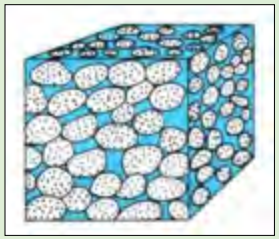
Use	MGD
Public supply	15,700
Self-supplied domestic	3,540
Irrigation	49,500
Livestock	1,200
Aquaculture	1,820
Self-supplied industrial	2,948
Mining	3,910
Thermoelectric power	721
Total	79,300

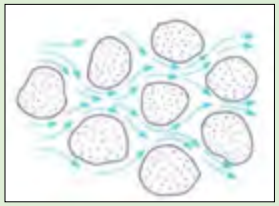
Source: Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p.

Subsurface Water



Porosity and Permeability

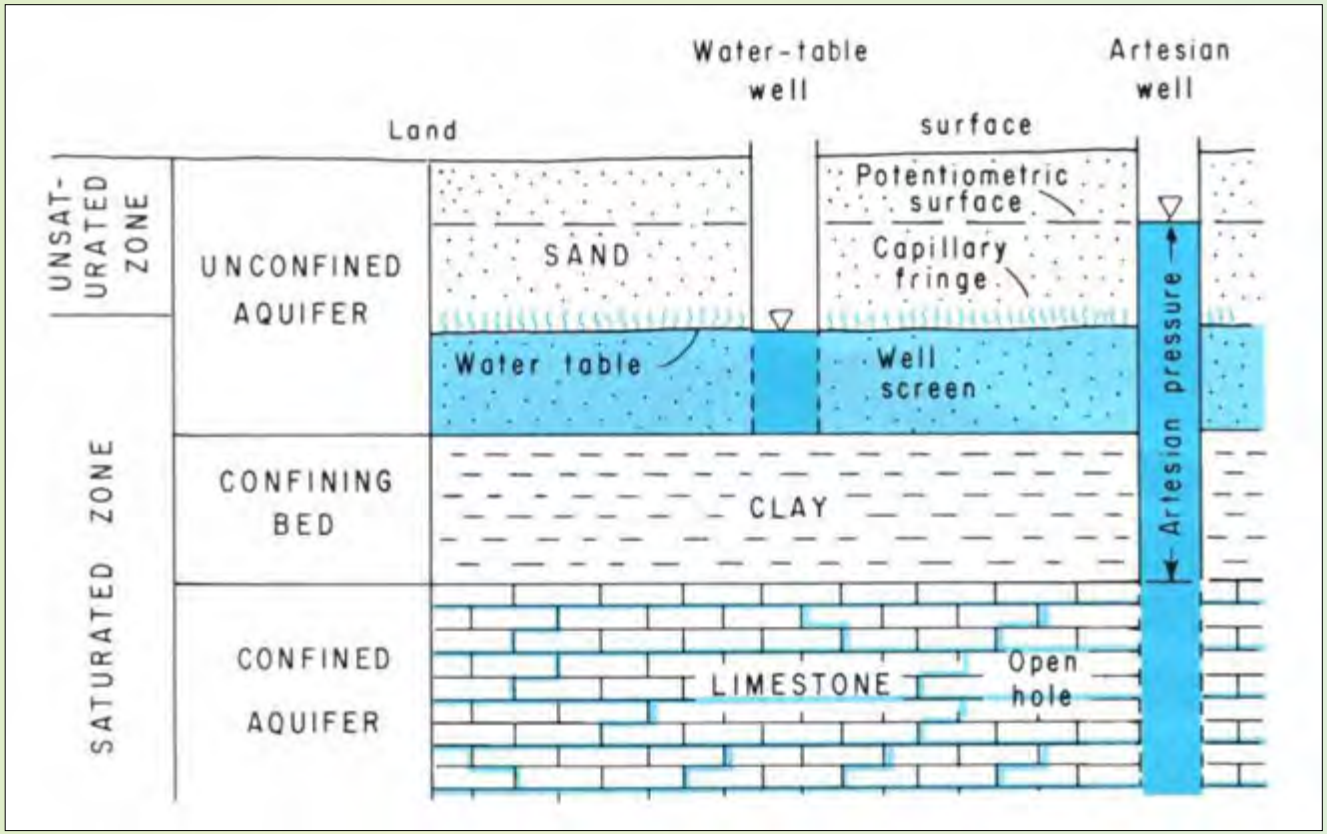




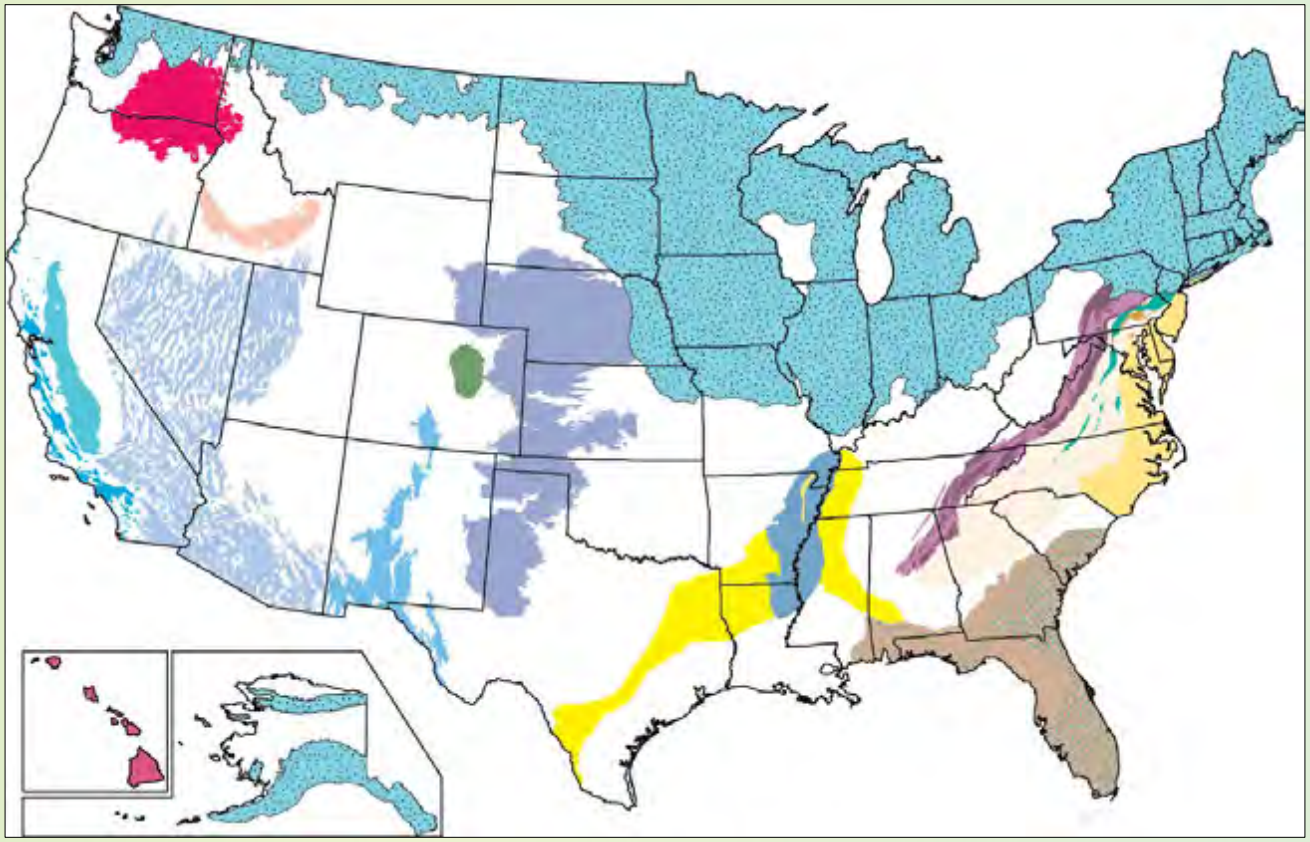
- **Porosity**: The ratio of openings (voids) to the total volume of a soil or rock. Porosity is expressed either as a decimal fraction or as a percentage.
- **Permeability**: The capacity of a soil or rock for transmitting water under pressure. Also known as ***hydraulic conductivity***, it is the rate at which soil or rock will transmit water through a given cross section under a given difference of pressure per unit of distance. Units are those of velocity, i.e., distance divided by time.

	Porosity	Hydraulic Conductivity
Clay	45-55%	<0.01 m/day
Sand	30-52%	0.01 – 10 m/day
Gravel	25-45%	1000 to 10,000 m/day

Aquifers: Confined and Unconfined

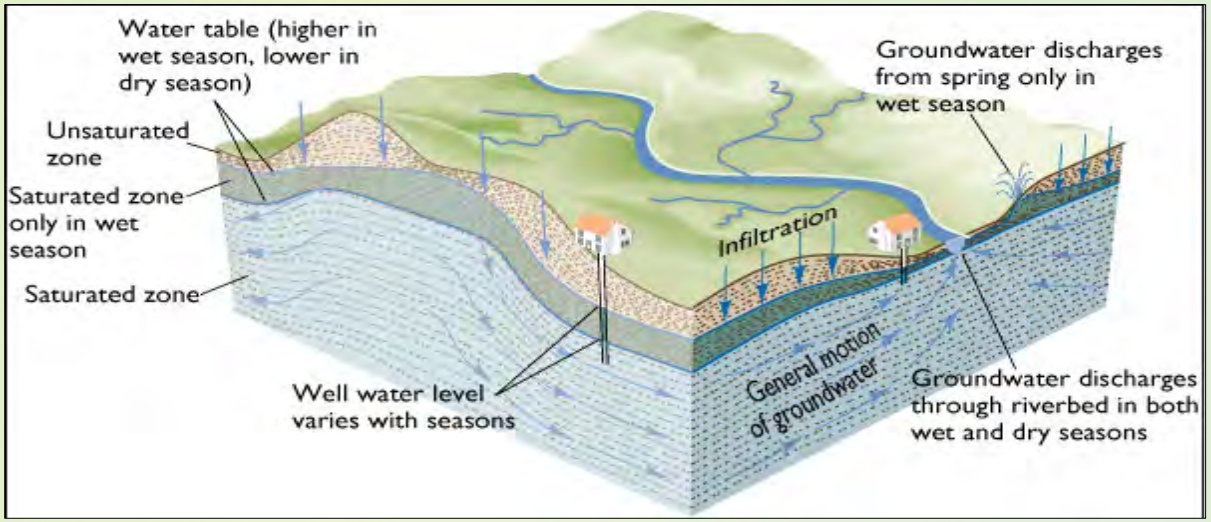


Principle Aquifers of the U.S.



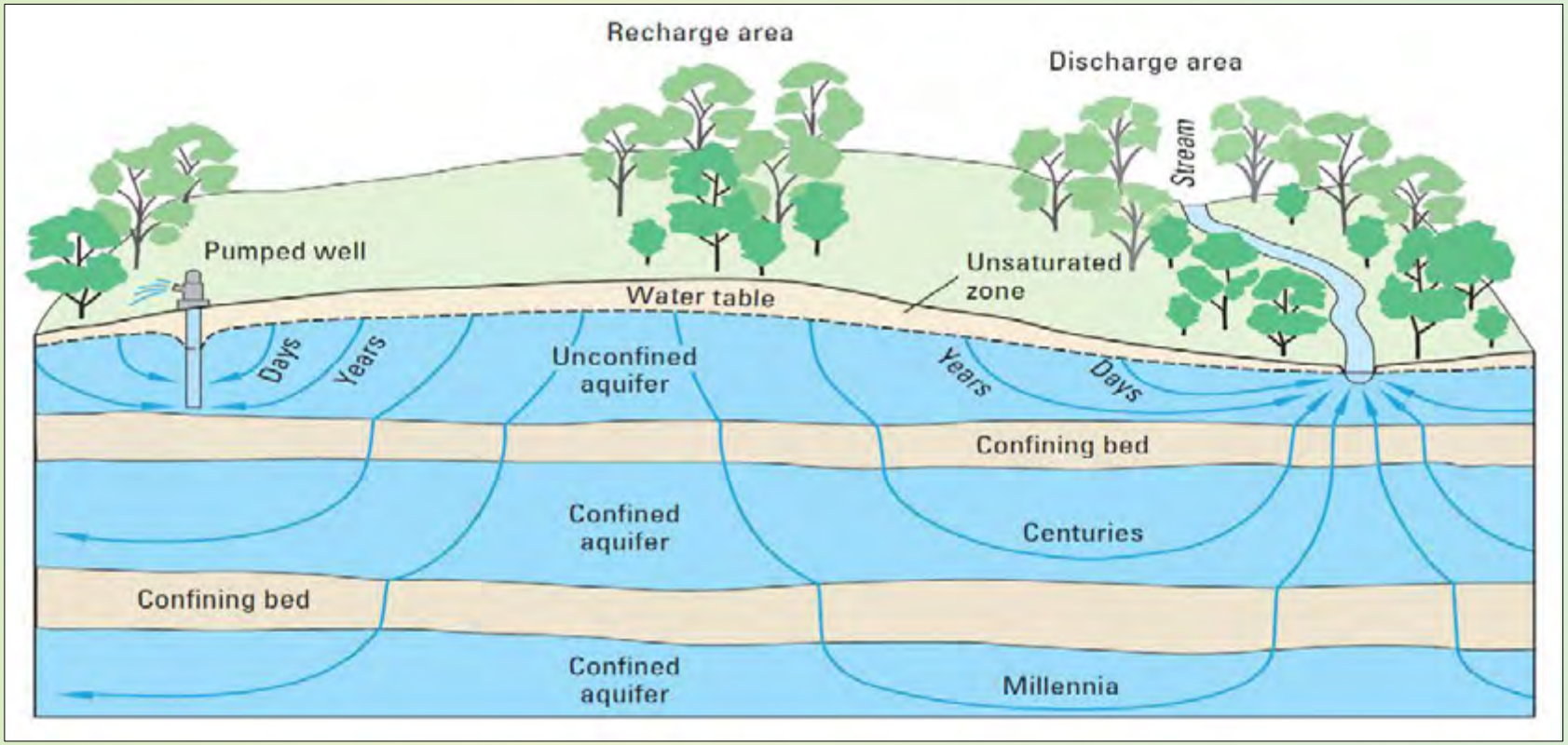
Source: US Geological Survey

Unconfined Aquifers

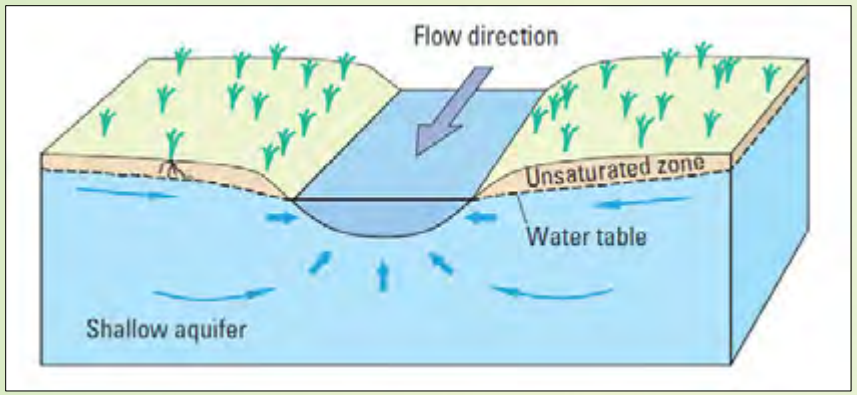


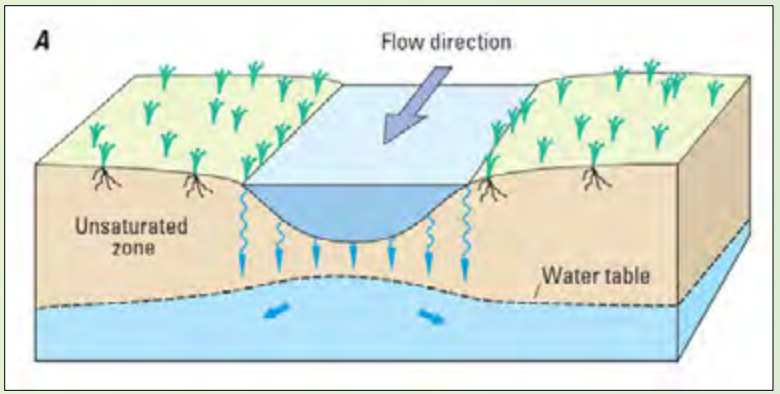
- Water table follows the topography but is more gentle
- Intersection of water table and ground surface produces lakes, streams, spring, wetlands…
- Ground water flows from higher elevation to lower, from areas of lower use to higher use, from wet areas to dry areas.

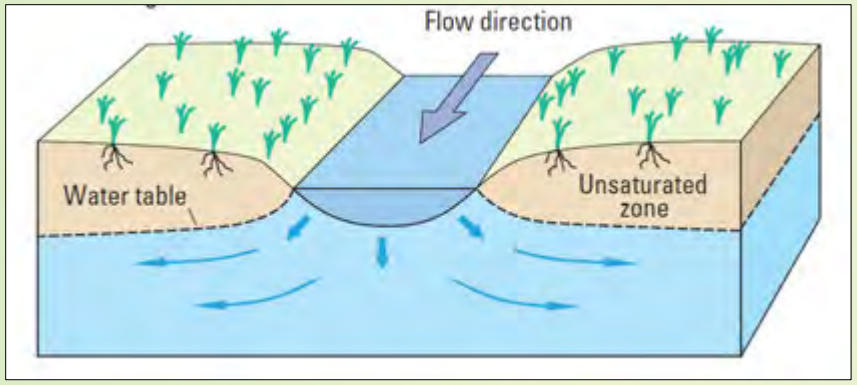
Groundwater Flow Rates

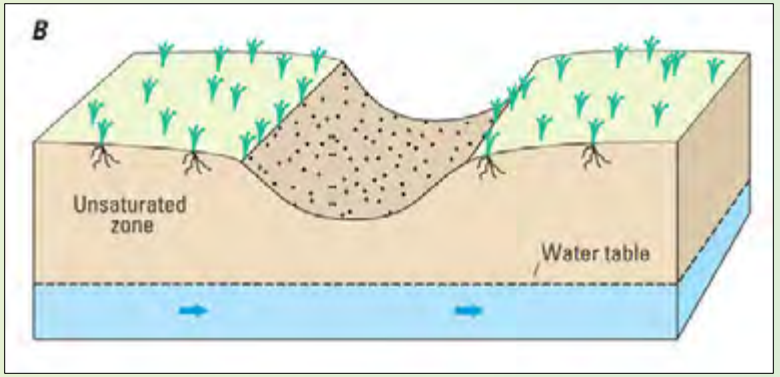


Surface-Water Ground-Water Interaction

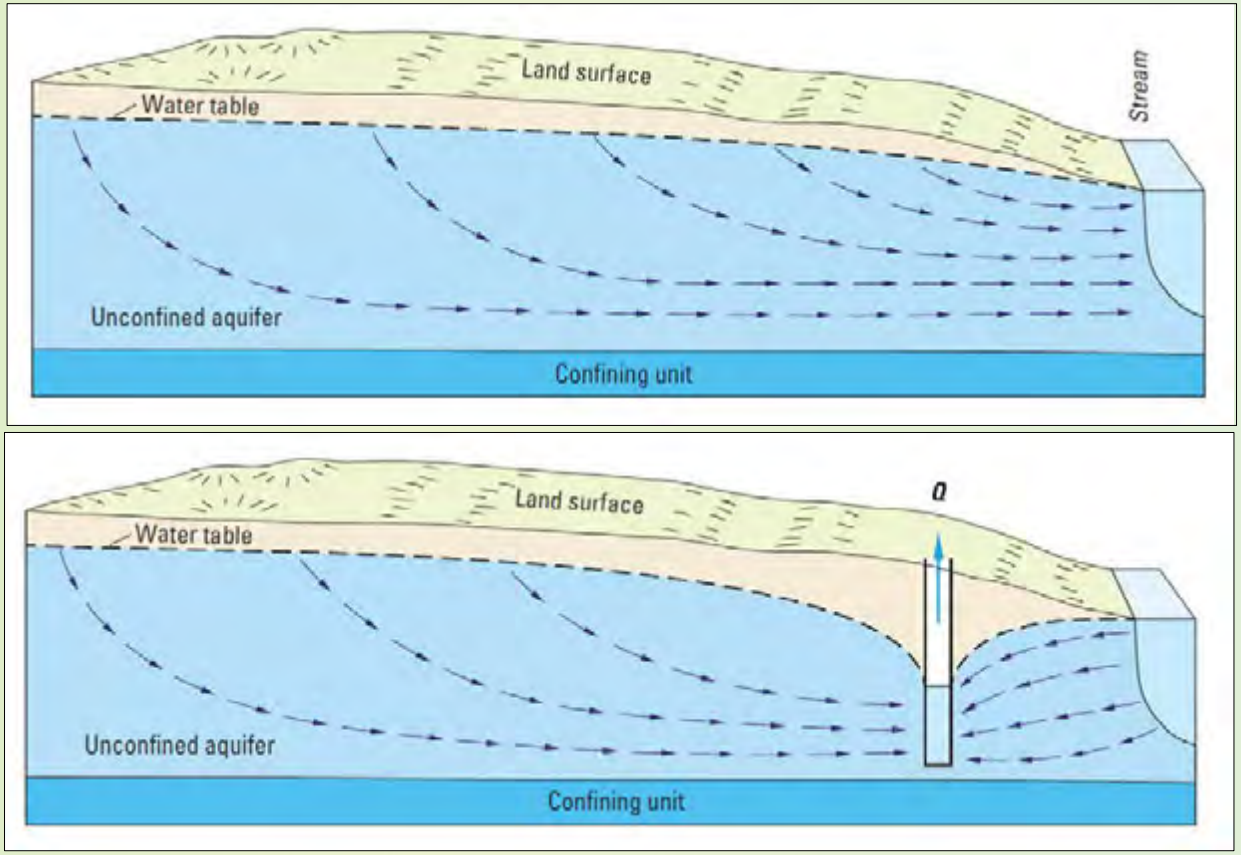




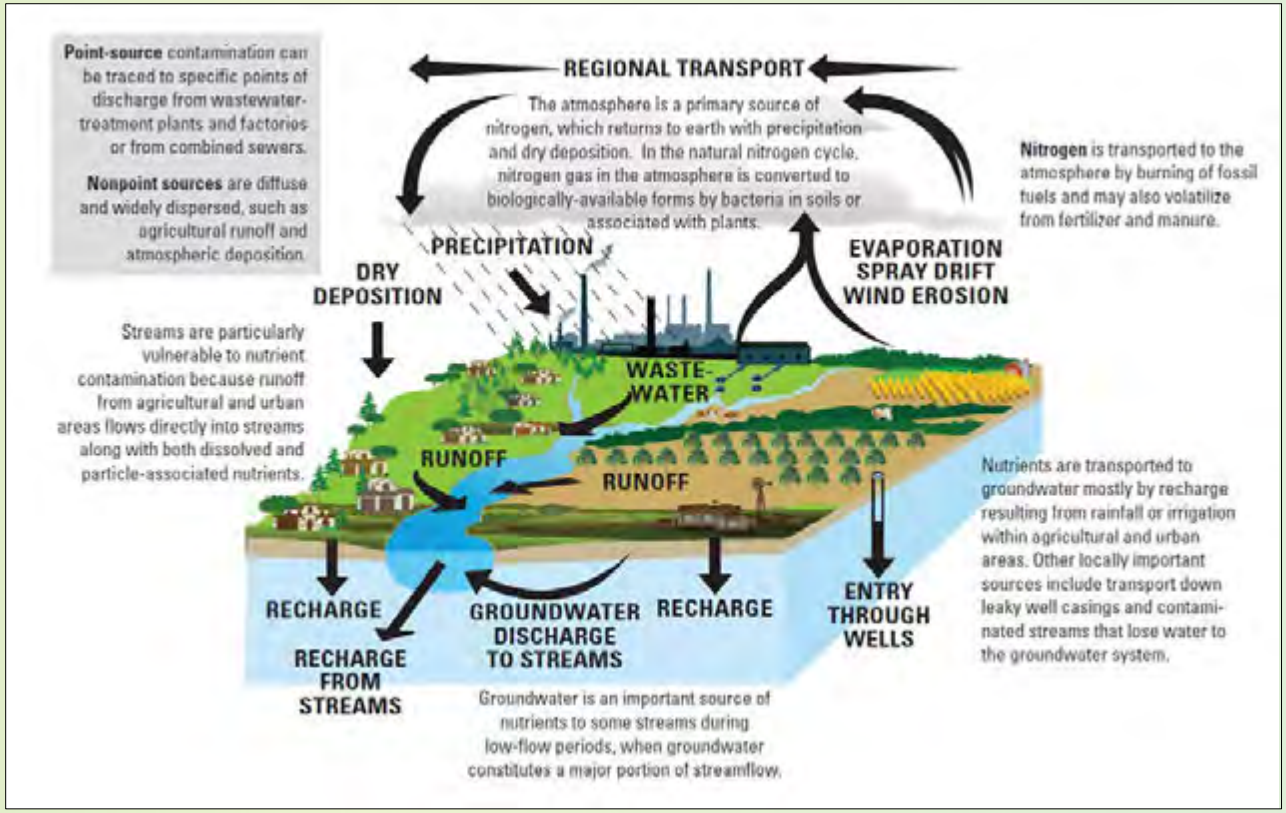




Ground-Water Withdrawal

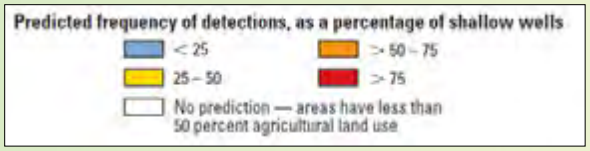


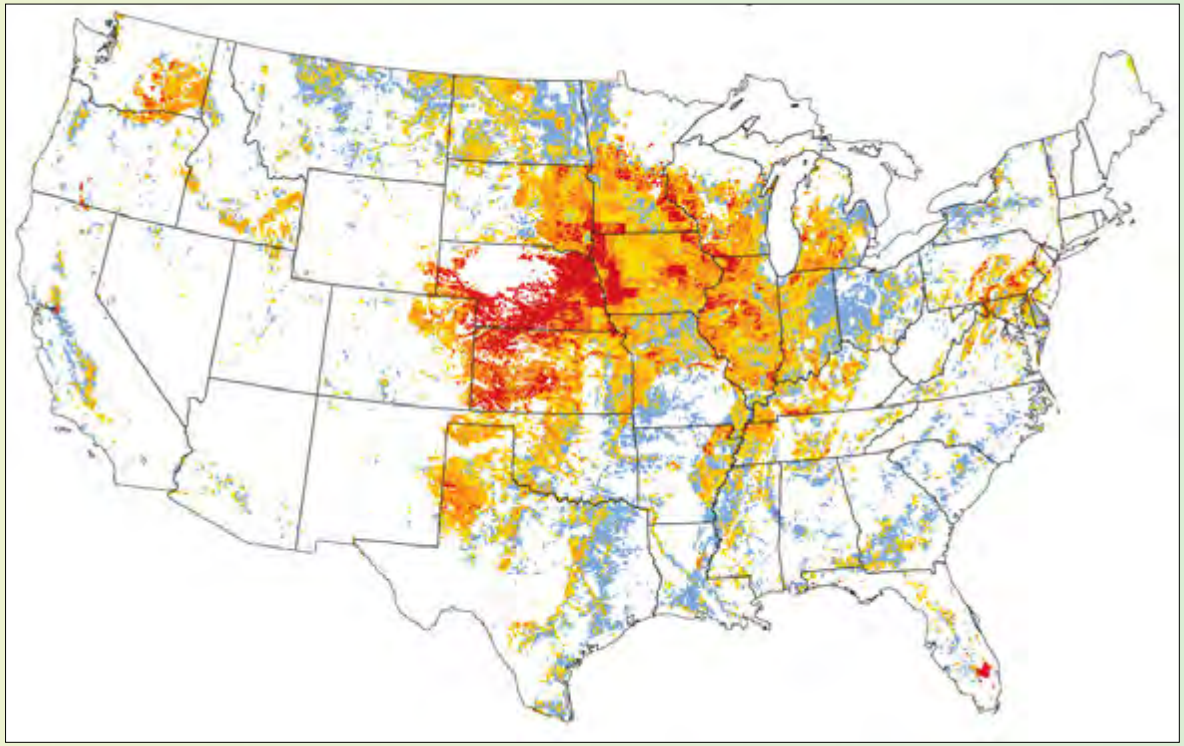
Contaminant Cycling through the Hydrologic System



Source: Dubrovsky, N.M., Burow, K.R., Clark, G.M., Gronberg, J.M., Hamilton P.A., Hitt, K.J., Mueller, D.K., Munn, M.D., Nolan, B.T., Puckett, L.J., Rupert, M.G., Short, T.M., Spahr, N.E., Sprague, L.A., and Wilber, W.G., 2010, The quality of our Nation's waters—Nutrients in the Nation's streams and groundwater, 1992–2004: U.S. Geological Survey Circular 1350, 174 p.

Predicted Occurrence of Atrazine in Ground Water



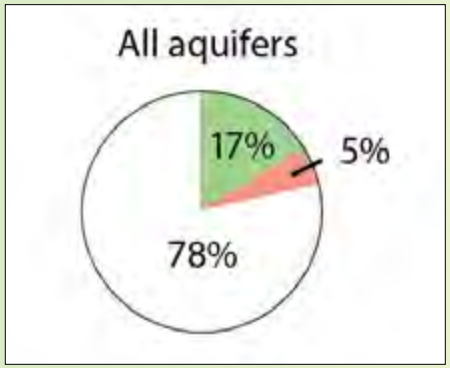


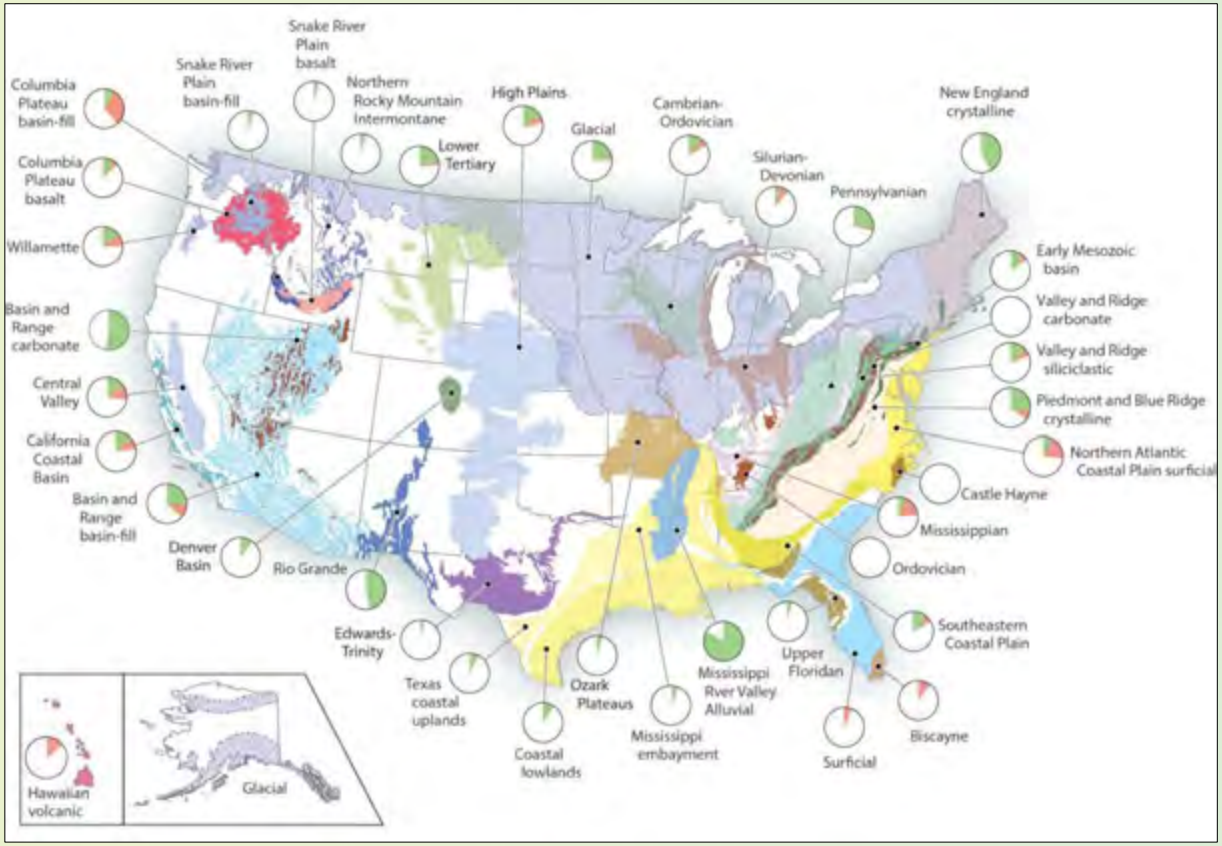
Source: Gilliom and others, 2006, The Quality of Our Nation's Waters—Pesticides in the Nation's Streams and Ground Water, 1992–2001: U.S. Geological Survey Circular 1291,172 p.

Ground-Water Quality: Exceedances of Human Health Benchmarks by One or More Contaminants

Exceedances of human-health benchmarks by one-or more contaminants

- None
- From geologic sources
- From human sources



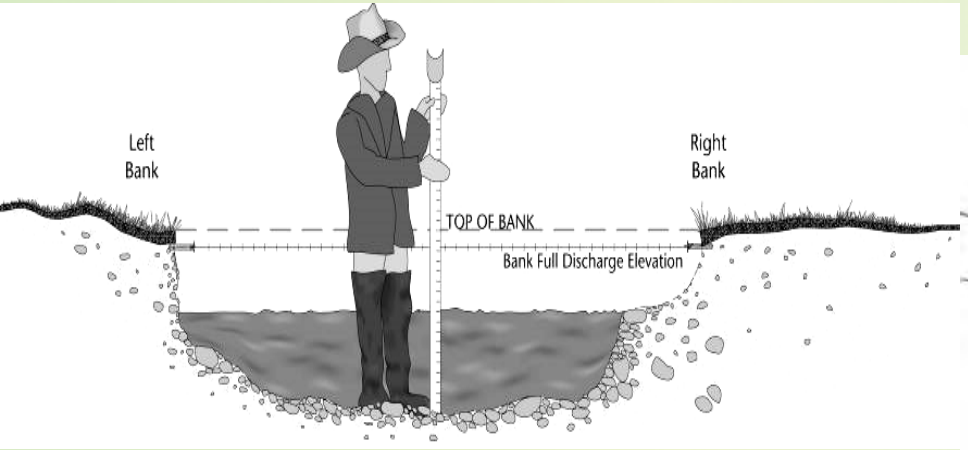


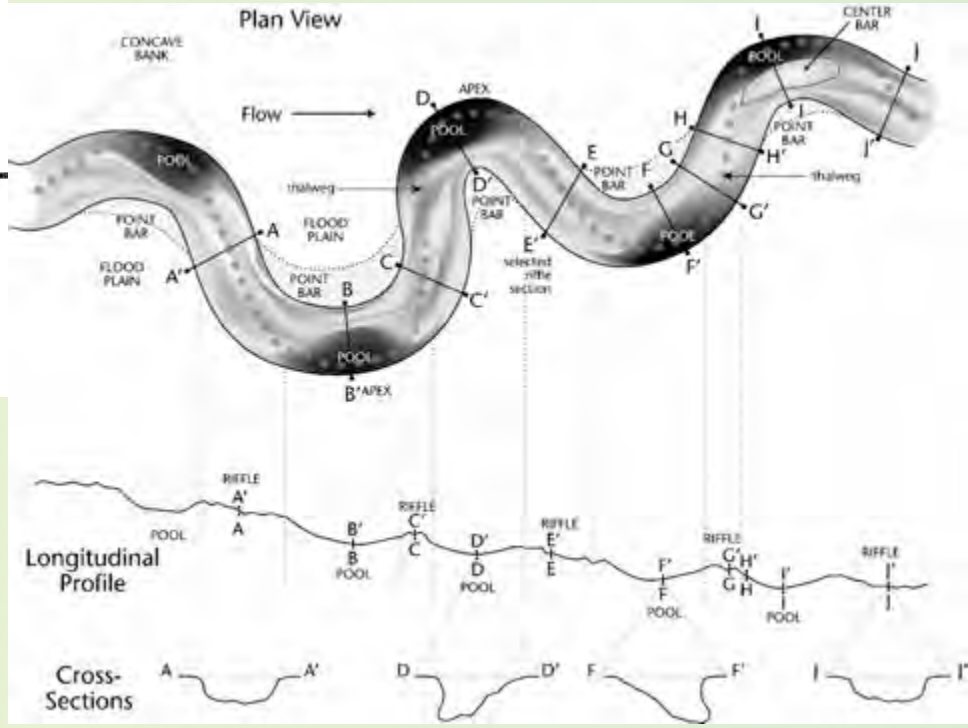
Source: U.S. Geological Survey

Streams and Rivers
Lotic Systems

Streams & Rivers

What to look for…





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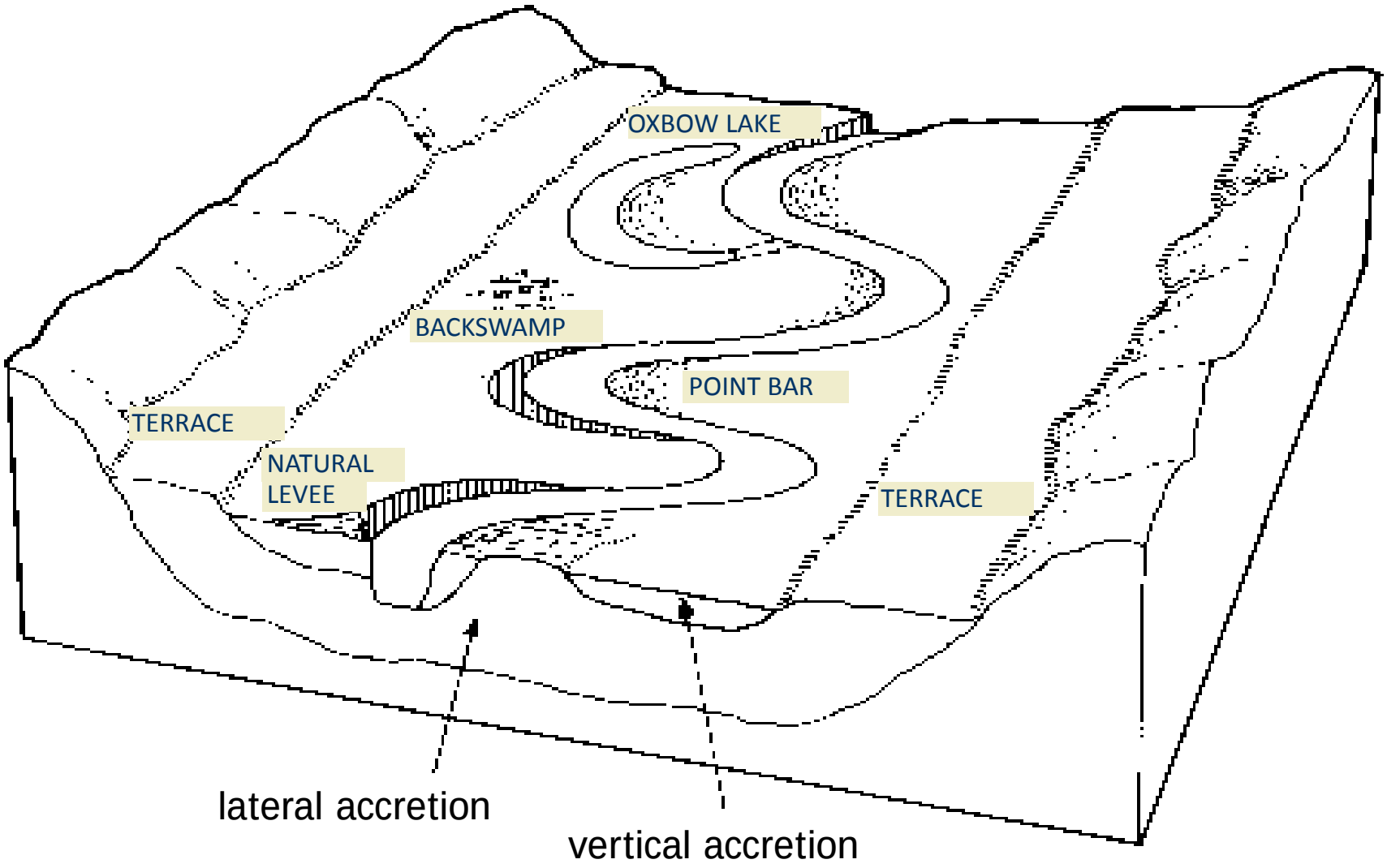
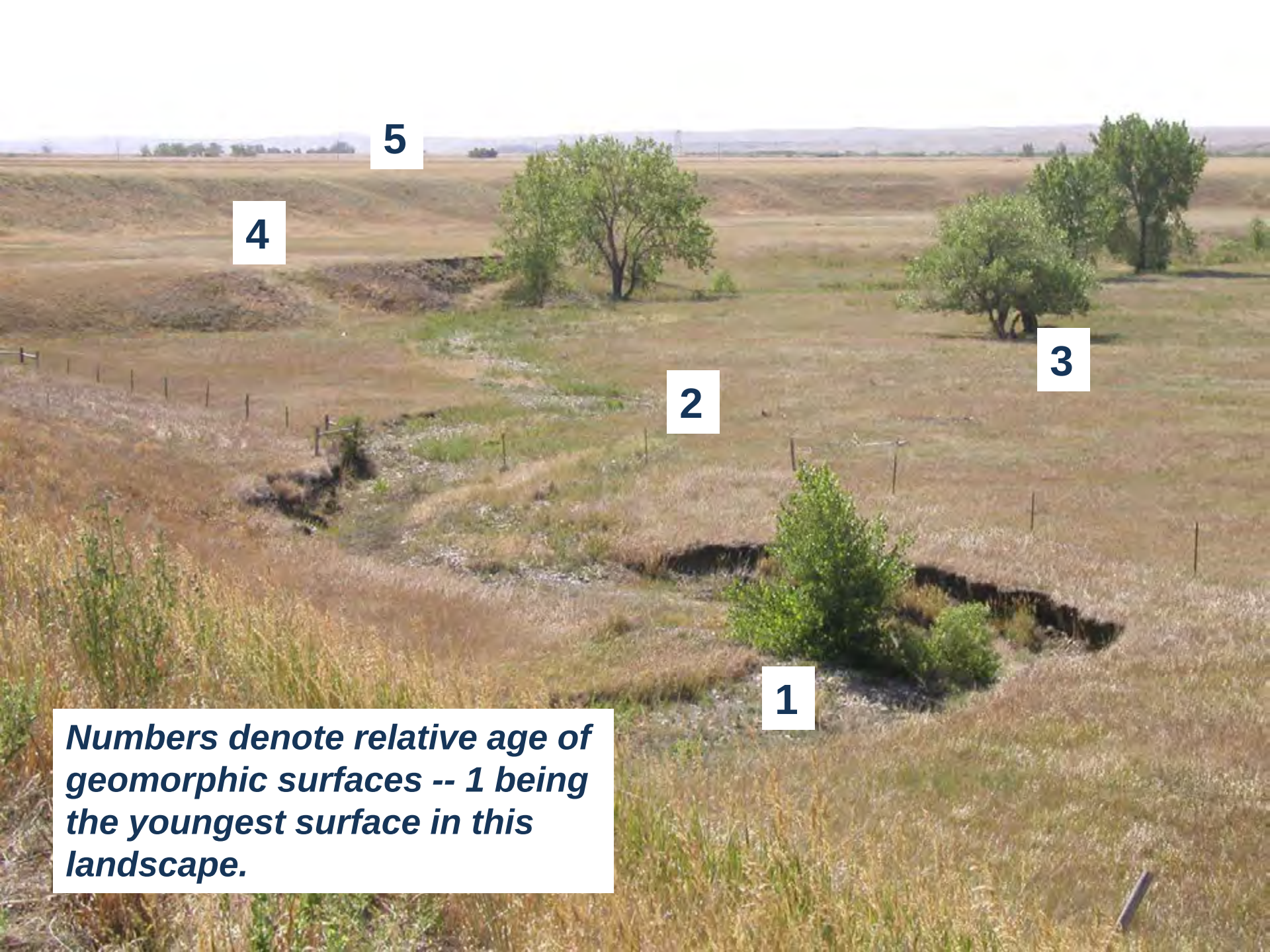
Stream, Floodplain, and Terrace Features

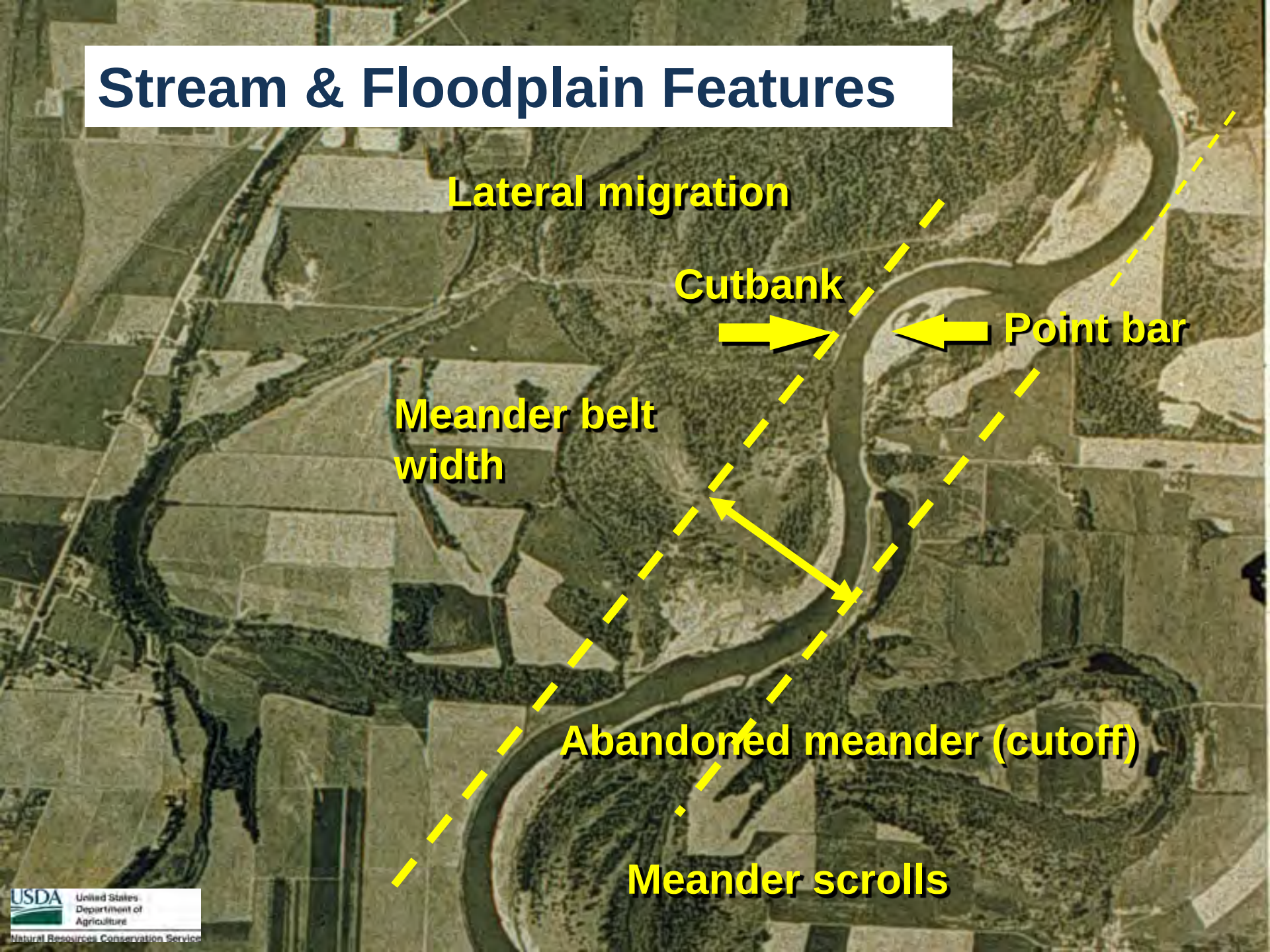


(modified from Vanoni 1971 and Gregory & Walling 1973)



Numbers denote relative age of geomorphic surfaces -- 1 being the youngest surface in this landscape.

Stream & Floodplain Features



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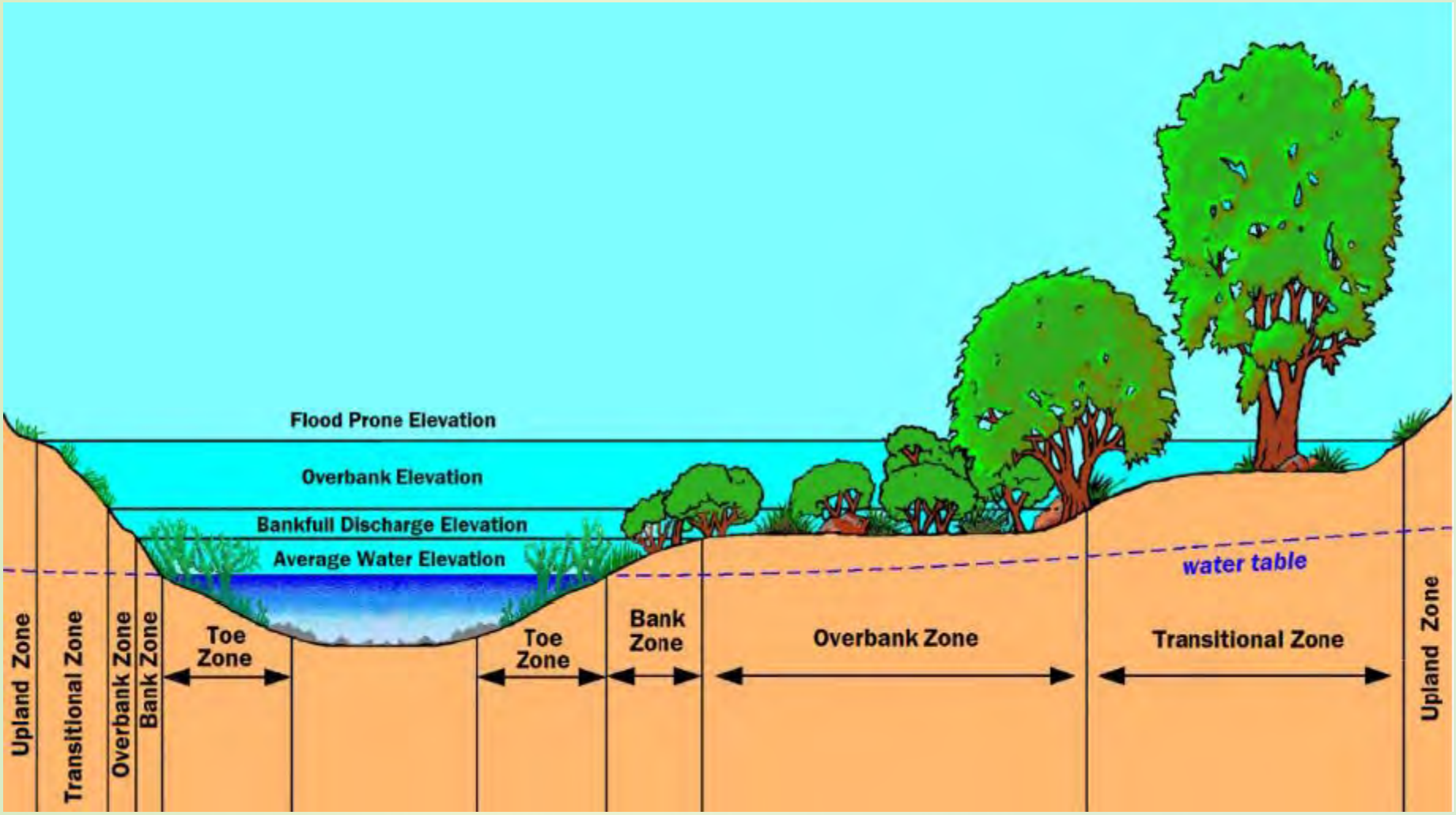
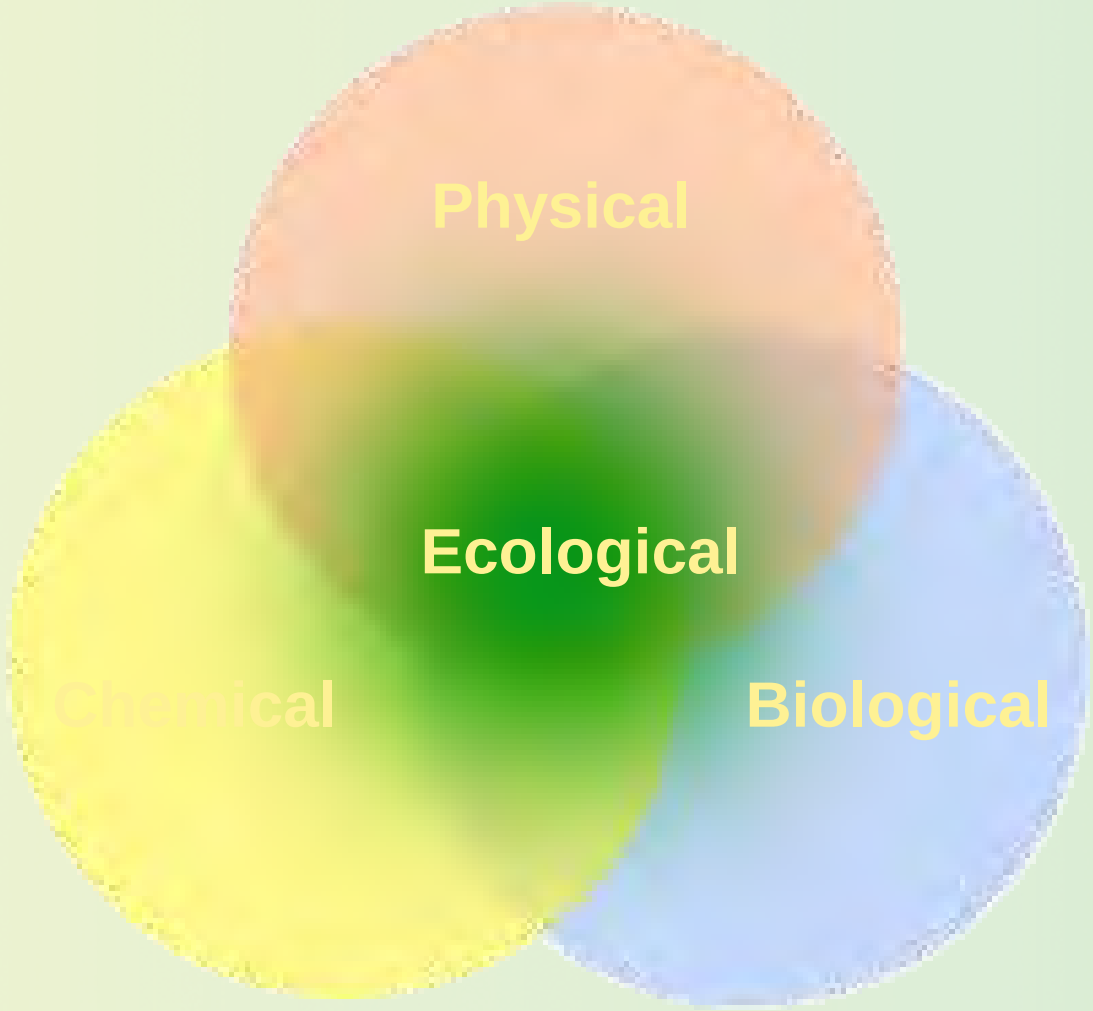
A cross-sectional look at a stream with an effective floodplain



Ecological Integrity

Ecological integrity is attainable when chemical, physical, and biological integrity occur simultaneously.

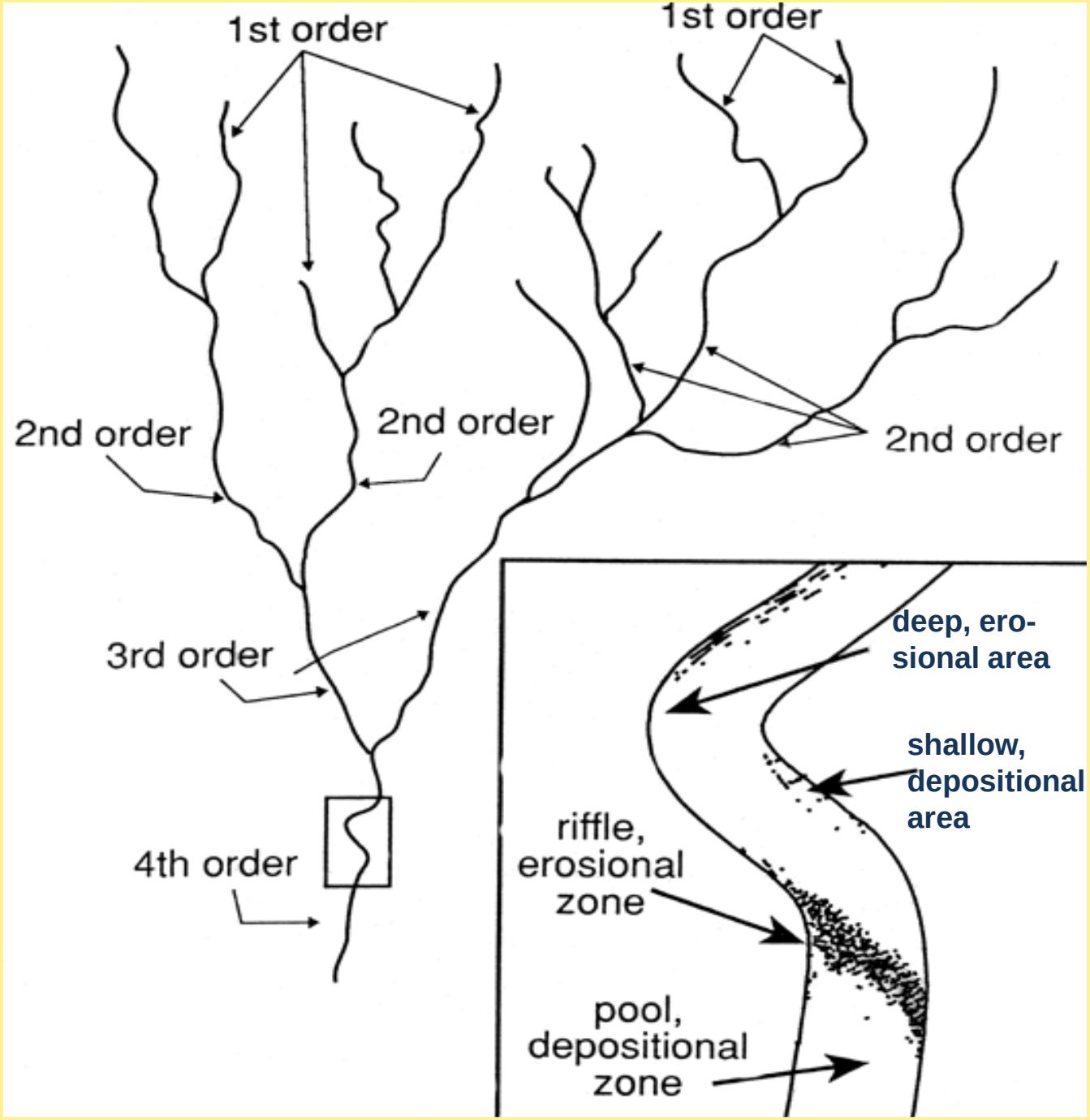
(EPA, 1990)



Overview

- Stream Orders
  - Velocity effects on biota
  - Temperature effect
  - O_2 ranges
  - Nutrients
    - Riparian types
    - Heterotrophic energy
    - Sources
    - Periphyton

Lotic System



Number & Lengths of Different Stream Orders in USA

Order	Number	Average length (km)	Total Length (km)	Mean Drainage area (km_2)
1	1,570,000	1.6	2,510,000	2.6
2	350,000	3.7	1,300,000	12.2
3	80,000	8.8	670,000	67
4	18,000	19	350,000	282
5	4,200	45	190,000	1,340
6	950	102	98,000	6,370
7	200	235	48,000	30,300
8	41	540	22,000	144,000
9	8	1,240	9,900	684,000
10	1	2,880	2,880	3,240,000

- Total length of all US rivers = 5,200,000 km.
- 50% are 1st Order; 1st-3rd Order combined is approximately 85% of total length.

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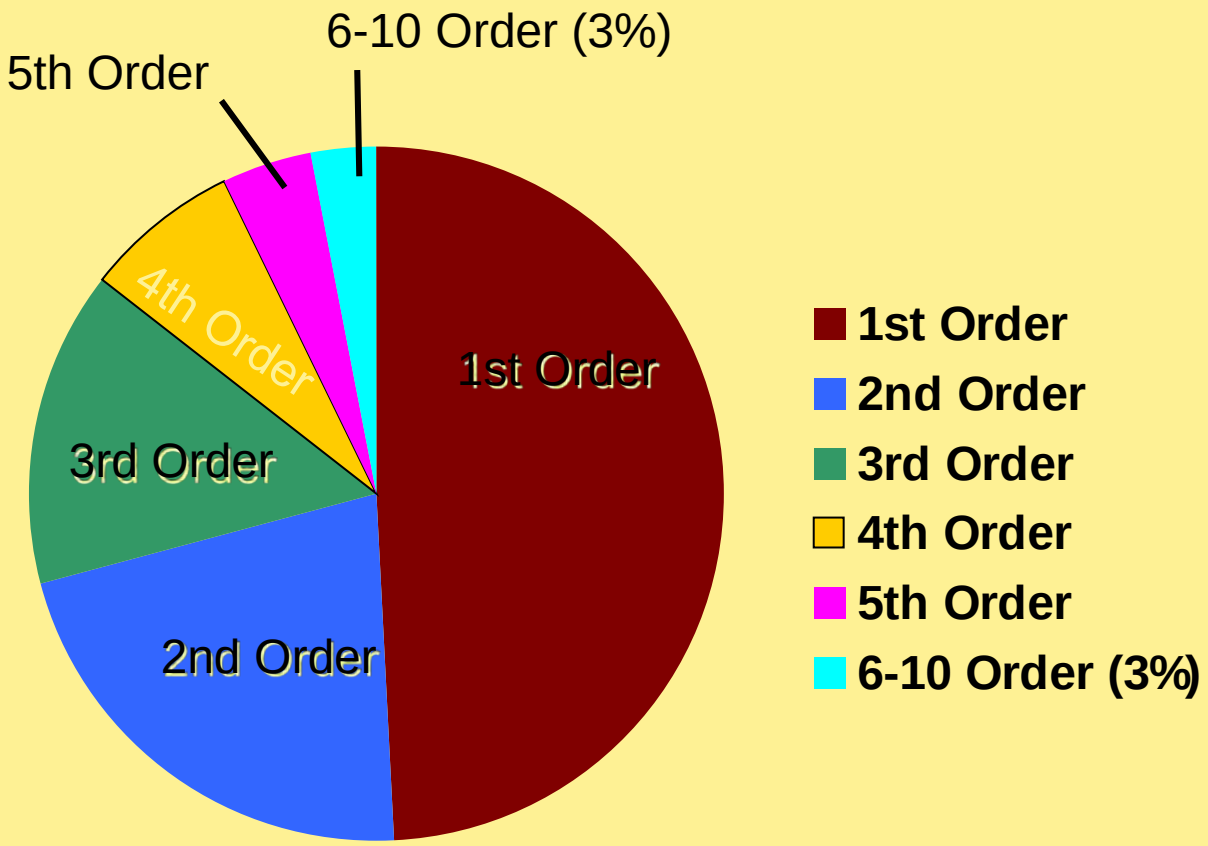
(Table 1.1, from Leopold *et al.* 1964)

Stream Order Relative to Cumulative Length



Small Order Streams / Relation to Total Stream Miles in U.S.

- 1st + 2nd order steams constitute approx. 95%
- Account for 3/4 of the collective length of more than 3.2 million miles
- Degradation of smaller streams: has a cumulative effect on larger order rivers

Dissolved Oxygen (DO)

as temperature ↑ O_2 dissolved in H_2O ↓

	O_2
0^0C	14.6 mg/L
10^0C	11.3 mg/L
15^0C	10.1 mg/L
20^0C	9.1 mg/L
25^0C	8.3 mg/L

DO:

O_2 produced by photosynthesis & aeration of H_2O by turbu-lence (O_2 from atmosphere)

Dissolved Oxygen (DO)

DO used by:

Respiration (algae, higher plants, animals, bacteria, & fungi) & Bio-degradation of organic matter (e.g. sewage, dead plant material)

Low DO caused by:

- **Increases in H_2O temp.**
- **Algal blooms**
- **Human waste**
- **Animal waste**
- **Nutrients - nitrogen, phosphorus**

Acceptable O_2 Ranges

Salmonid Waters: Embryo & Larval Stages

- No production impairment 11 mg/L
- Slight production impairment 9 mg/L
- Severe production impairment 7 mg/L

Non-Salmonid Waters: Early Life Stages

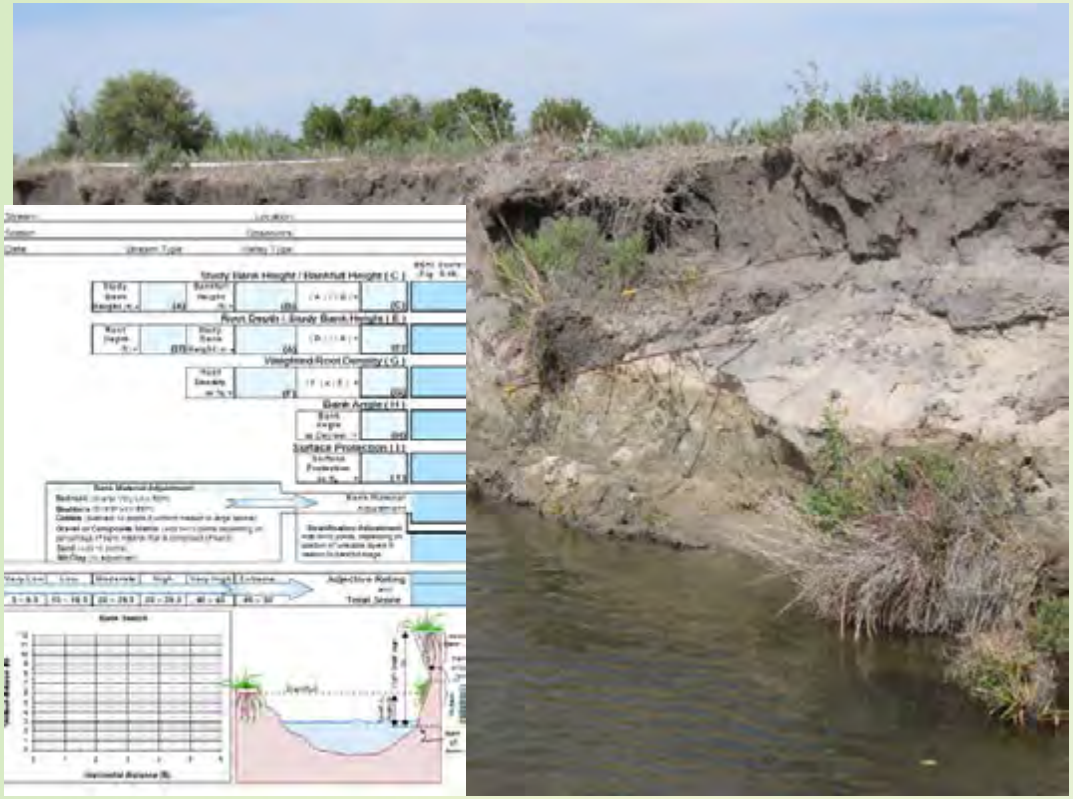
- No production impairment 6.5 mg/L
- Slight production impairment 5.5 mg/L
- Severe production impairment 4.5 mg/L

Invertebrates

- No production impairment 8 mg/L
- Some production impairment 5 mg/L
- Limit 4 mg/L

Streambank Erosion

- Today in many watersheds across the US streambank erosion can be as high as 70% of the total sediment load. Several decades ago streambank contributions were considerably less.



Erosion Pins on the East Fork of the Ninnescah, Kansas
After one average runoff season.

Direct Field measurement calibrating
Bank Erodibility Hazard Index Field Tool.

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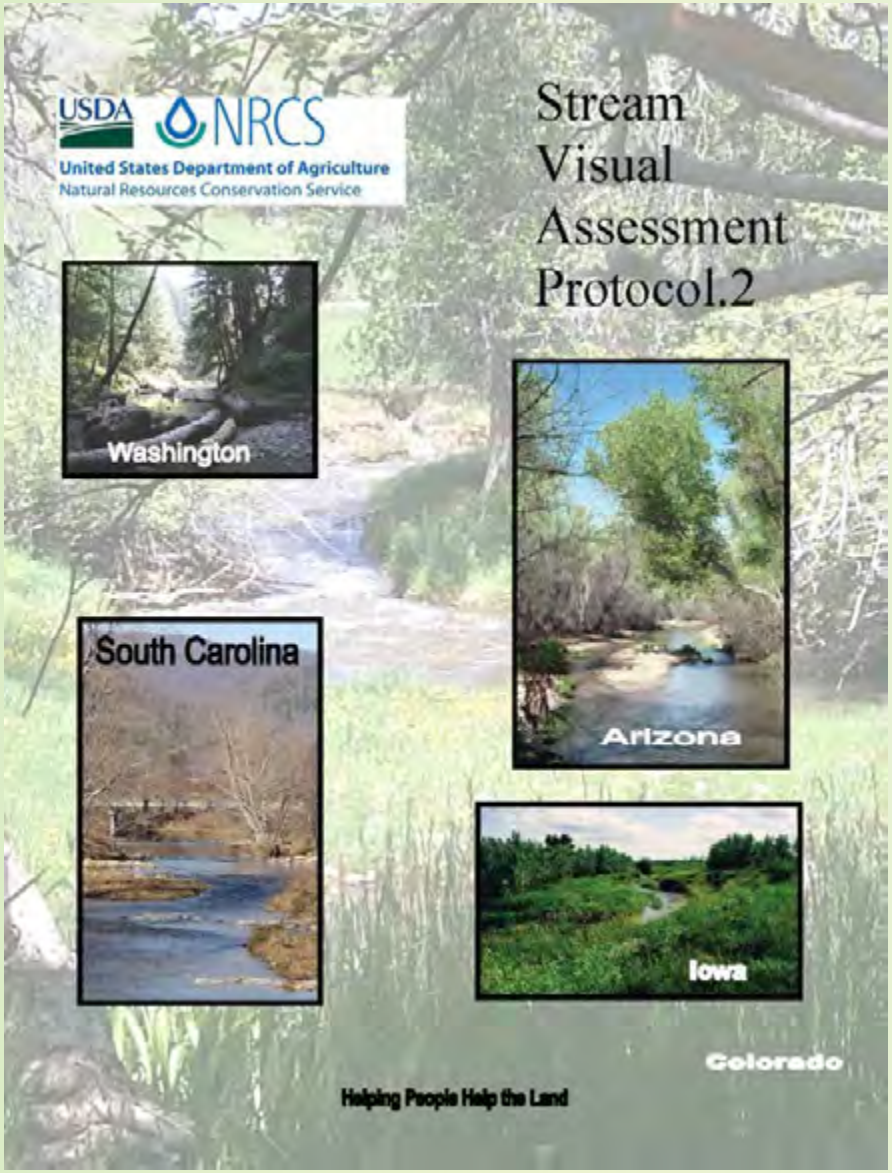
Natural Resources Conservation Service



2007: Why a Version 2?

1) Increased need for more detail: critical elements are channel condition, stream and riparian habitat features, and hydrological alteration. *

2) Determine eligibility for fish and wildlife resource conservation in Farm Bill programs.

3) Determine quality criteria: the level at which aquatic habitat is being achieved in in RMS.

4) Requirement for preliminary evaluation of streams where restoration actions are being considered using Code 395.

Who is the target user?

- Field Conservationists
- Planners
- Engineering Techs
- Area Biologists

SVAP2 Basics:

- 3-page assessment sheet
- match descriptions of element conditions to what is seen throughout a specified reach
- average the scores (Sum of score of each element / no. of elements scored)
- overall rating compares reach to a “typical” reach of streams in the area, or reference reaches of the associated MLRA.
- Score of 7.0 or better meets Quality Criteria in Washington State

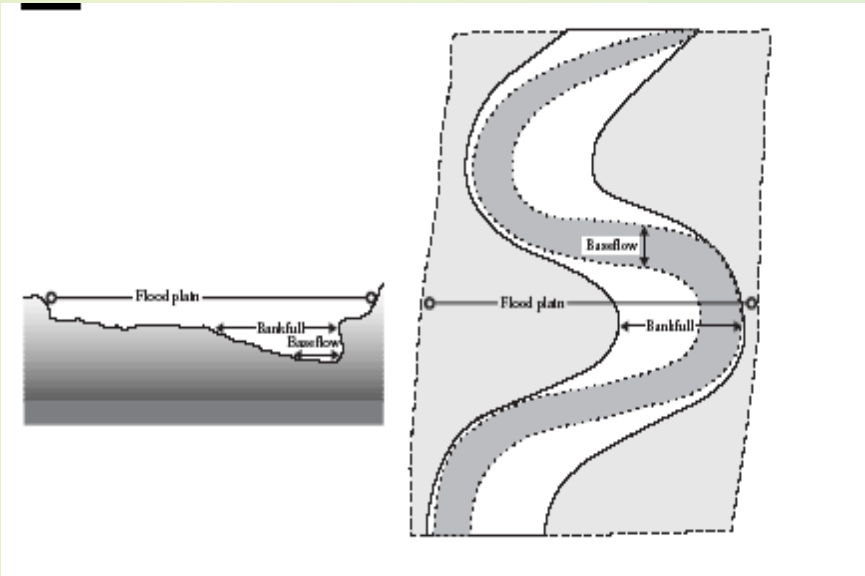
Preliminary Assessment

- Basic information:
  - ownerships, land uses
  - ecoregion and/or MLRA
  - watershed features such as diversions
  - flow regime
  - species of concern
  - reference stream id, for comparison and scoring accuracy

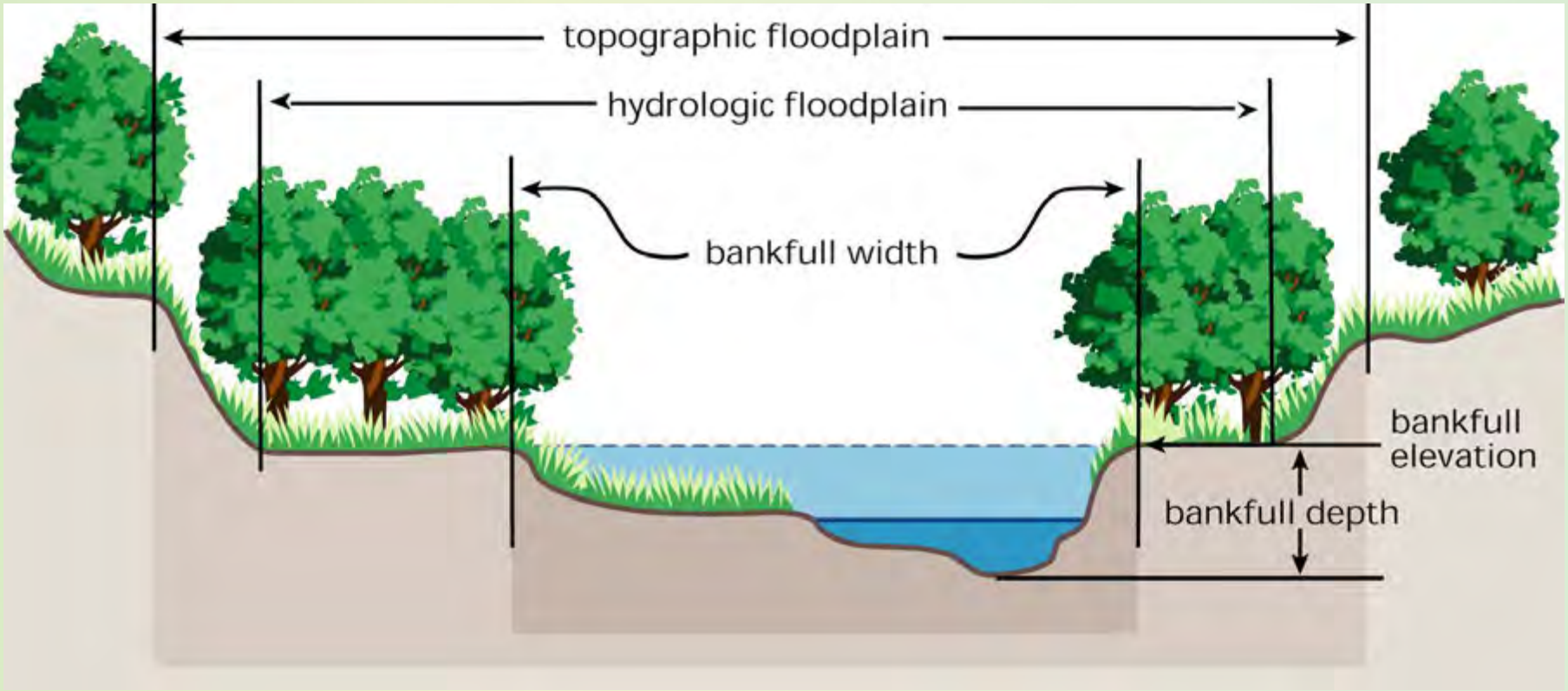
Assessment Reach

- Score one reach per assessment, but multiple reaches may be warranted. Choose a reach based on channel type.

- reach = at least *12X* width of stream channel at bankfull stage; some elements are scored based on conditions on entire property.



Identifying bankfull width:



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Stream Visual Assessment Protocol
Summary Sheet

Owner's name _____ Evaluator's name _____

Stream name _____ Tributary to _____ HUC: ____

1. Preliminary Assessment

A. Watershed Description:

Ecoregion or MLRA _____ Watershed Drainage area (acres or sq miles) _____

Watershed management structures: (no.): dams ___ water controls ____ irrigation diversions ___

No. of miles of contiguous riparian cover/mile of entire stream in watershed (estimated) _____

Land use within watershed (%): cropland ____ hayland ____ grazing/pasture ____ forest ____

urban ____ industrial ____ other (specify) ____

Agronomic practices in uplands include: _____

Confined animal feeding operations (no.) ____ Conservation (acres) ____ industrial(acres) ____

Number of stream miles on property _____ Number of total stream miles _____

Stream hydrology ____ intermittent; months of year wetted _____

____ perennial; months of year at base flow _____

B. Stream/Reach Description

Stream Gage Location/Discharge: _____/_____cfs

Applicable Reference Stream _____ Reference Stream Location: ____/____

Information Sources

What is the best we can expect for a given stream?

Add here: aquatic species known to occur or expected to occur in the drainage

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SVAP2 - Scoring

- maximum 16 stream elements to score
- range of scores: 10 (best conditions) to 0 (worst conditions)
- score only elements that are appropriate
- *Modify national protocol's elements to reflect local conditions, where needed*

B. SVAP2 Scores

Element	Score
1. Channel Condition	
2. Hydrologic Alteration	
3. Bank Condition	
4. Riparian Area Quantity	
5. Riparian Area Quality	
6. Canopy Cover	
7. Water Appearance	
8. Nutrient Enrichment	
9. Manure or Human Waste	
10. Pools	
11. Barriers to Movement	
12. Fish Habitat Complexity	
13. Aquatic Invertebrate Habitat	

Element	Score
14. Aquatic Invertebrate Community	
15. Riffle Embeddedness	
16. Salinity	

A. Sum of all elements scored

B. Number of elements scored

Overall score: A/B _____

1 to 2.9	Severely Degraded
3 to 4.9	Poor
5 to 6.9	Fair
7 to 8.9	Good
9 to 10	Excellent

Suspected causes of SVAP scores less than 5 (5.0 and greater meets Quality Criteria)

_____

_____

_____

Recommendations for further assessment or actions:

_____

_____

_____

Overall assessment calculations and interpretations

- Narratives for each element describe key features that are used to rank its condition; scores range from excellent to poor.
- Individual element scores can help identify potential stressors to the system
- Final SVAP2 score indicates the condition of the reach assessed, and whether quality criteria has been met (> 7.0)
- Site specific index

Channel Condition

Photo 4: CEM stage V channel with developing floodplain (left) and "abandoned floodplain," now a terrace, behind trees on right side of stream

10 Flooding every 1.5 to 2 years. No dams, no water withdrawals, no dikes or other structures limiting the stream's access to the flood plain.

Hydrologic Alteration

3 Flooding occurs only once every 6 to 10 years; channel deeply incised, *or* withdrawals significantly affect available low flow habitat for biota.

10 Banks are stable; protected by roots of natural vegetation, wood or rock; no man-made structures present on bank; no recreational or livestock access

Bank Condition

0-2 Banks are unstable; numerous bank failures, unrestricted use by recreational traffic or animals is contributing to long-term bank instability.

Riparian Zone Quality

1 Little or no natural vegetation, concentrated flows in are, invasive species widespread

10. Natural, diverse vegetation with composition, density, and age structure appropriate for the site.
No invasive species or concentrated flows through area.

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1 Natural vegetation less than a third of the active channel width on each side, or little or no regeneration.

Riparian Zone Quantity

10 Natural vegetation extends at least two bankfull widths or over the entire active floodplain

Canopy Cover

1 < 20% water surface shaded in reach.

Planning for coldwater species or warmwater species? Must specify!

10 > 75% of water surface shaded within the length of the stream in landowner's property

Water Appearance

7 Occasionally cloudy, especially after storm event, but clears rapidly; objects visible at depth 1.5 to 3 ft; may have slightly green color; no oil sheen on water surface.

Nutrient Enrichment

Fairly clear or slightly greenish water along entire reach; moderate algal growth on stream substrates? 10- 9

Or

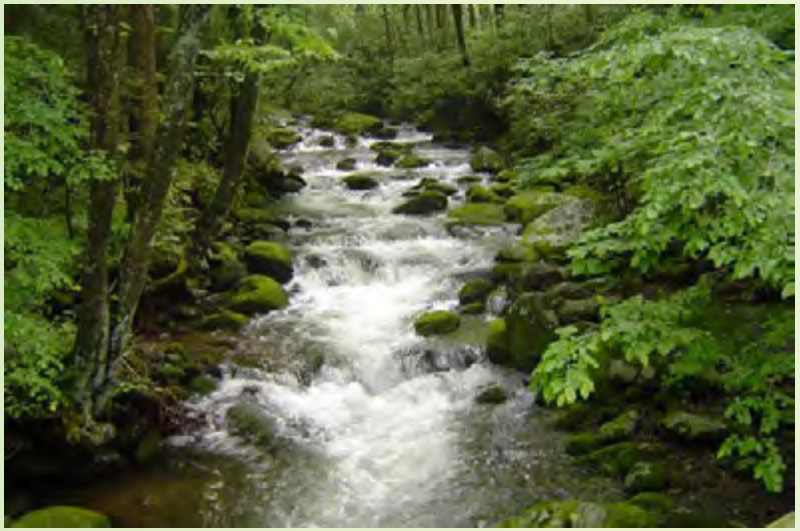
thick algal mats dominating stream? 2- 0

Pools

Is the stream reach low gradient <2%?

OR is the stream reach high gradient >2%?

High Gradient Pools



10 More than 3 deep pools separated by boulders or wood, each with > than 30% of bottom obscured to view.

Low Gradient Pools

10 More than 2 deep pools separated by boulders or wood, each with > than 30% of bottom obscured to view.

Element 11: Barriers to Fish Movement

Background information needed: which fish species are present in the stream, what is their life history? How high can they jump? Can they tolerate high water temperatures?

Element 12: Fish Habitat Complexity

10 or more habitat features available, at least one of which is considered optimal in reference sites (e.g., large wood in forested streams.)	8 to 9 habitat features available.	6 to 7 habitat features available.	4 to 5 habitat features available.	<4 habitat features available.
10 9	**8 7**	**6 5**	**4 3**	**2 1 0**

Habitat features include

- ✓ Logs, large wood, small wood
- ✓ Deep pools, shallow pools, glides, pockets
- ✓ Boulders, cobbles
- ✓ Overhanging vegetation
- ✓ Undercut banks
- ✓ Riffles
- ✓ Root mats, emergent vegetation
- ✓ Backwaters, oxbows, side-channels, wetlands

Macroinvertebrates :

Indicators of water quality conditions

Invertebrate community is diverse and well represented by Group I or intolerant species; One or two species do not dominate.	Invertebrate community is well represented by Group II or facultative species, and Group I species are also present; one or two species do not dominate.	Invertebrate community is composed mainly of Groups II and III, and/or 1 or 2 species of any group may dominate.	Invertebrate community composition is predominantly Group III species and/or only 1 or 2 species of any group is present and abundance is low.
10 9 8	7 6 5	4 3 2	1 0

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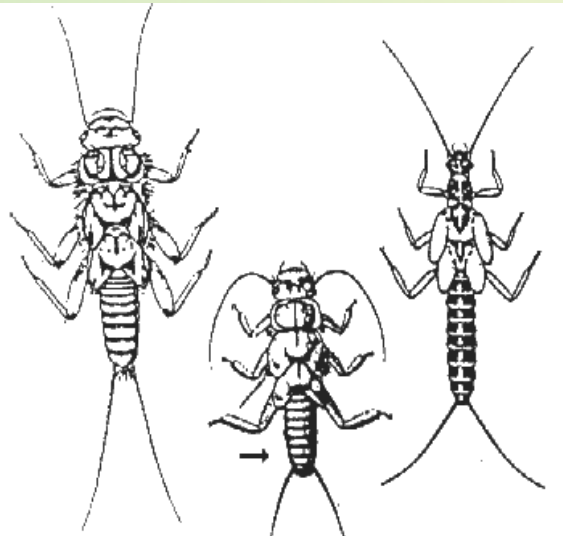
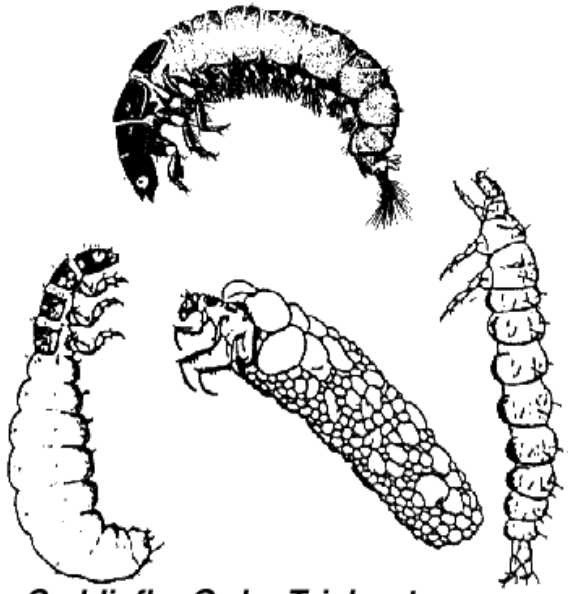
Group One Taxa: Pollution-sensitive species found in good quality water.



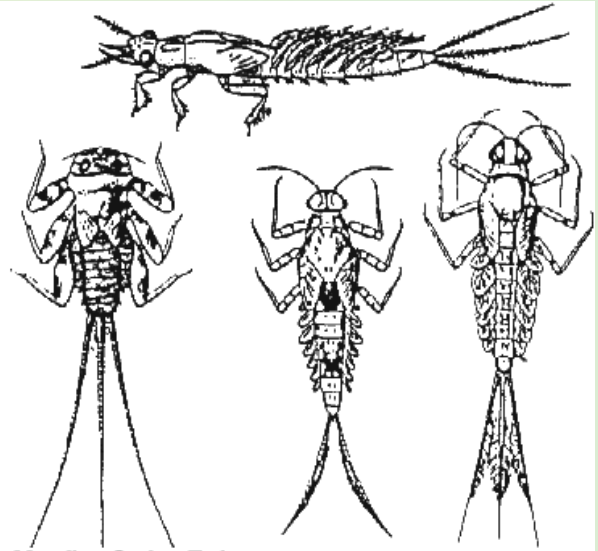
Stonefly: Order Plecoptera.

1/2" -1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow)



Caddisfly: Order Trichoptera.

Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on lower half.



Mayfly: Order Ephemeroptera.

1/4" -1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

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SVAP 2

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Streams, Lakes and Groundwater

- Water Bodies are important elements of the Agricultural Landscape
- For conservation planning to work we need to understand them
- THEY ARE ALL CONNECTED

Sediment Ripples – Gordon Creek Nebraska