Wetland Restoration Hydrology and Design Overview

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Objectives

- Understand Hydrologic Inputs and Outputs
- Understand Relationship Between Wetland Types and Hydrology
- Understand the Water Budget Components for Hydrogeomorphic (HGM) classes
- Gain Awareness of Hydrologic Data Sources
- Be Able to Select Practices and Structures Appropriate to HGM Classes

Hydroperiod

- The period of time (on an average basis) that a site has wetland hydrology

High Plains Playa
DEPRESSION – Early Summer Thunderstorm Runoff

Colorado Headwater
SLOPE – Spring Snowmelt

New York SLOPE -
Long Term Groundwater Discharge

Hydrologic Regime
- Regime is a Range in:

- The depth of ponding of surface water
- The depth to groundwater

Different plant communities and animals require different regimes

Hydrologic Diversity Means Variable Regimes and Hydroperiods

- General Rules:
  - Deep Water AND Shallow Water
  - Long Hydroperiod AND Short Hydroperiod
  - Keep Slopes FLAT (Flatter than 5:1)
  - Match vegetative establishment with hydroperiod and regime

Water Budget Parameters

- Precipitation – P
- Evaporation – E
- Transpiration – T
  - E and T MAY be considered together as ET
- Groundwater out – Go
- Groundwater in – Gi
- Surface Runoff in – Ri
- Surface Runoff out – Ro
- Storage - S

Three Factors that Define Wetland Classes in the Hydrogeomorphic (HGM) System

Hydrodynamics
(i.e. vertical lake Fluctuations)

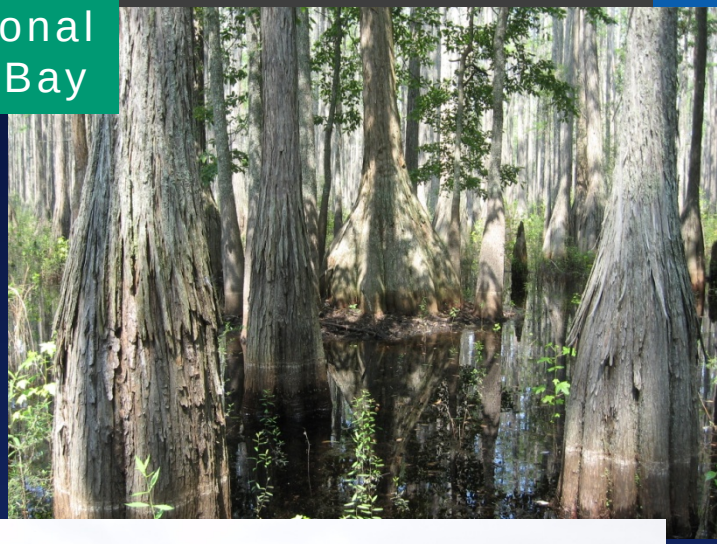
Landscape Position
(i.e. Headwaters)

Dominant Water Source
(i.e. Groundwater)

The Seven HGM Classes

- RIVERINE
- SLOPE
- MINERAL SOIL FLAT
- ORGANIC SOIL FLAT
- ESTUARINE FRINGE
- LACUSTRINE FRINGE
- DEPRESSION

Depressional
Carolina Bay



Estuarine Fringe
Oregon

Mineral Flats
Indiana Flatwoods

Slope
Puerto Rico

RIVERINE Wetlands

Landscape Position
Floodplains
Dominant Water Source
Stream Hydrographs (Surface and Groundwater)
Hydrodynamics
Horizontal, Bi-Directional

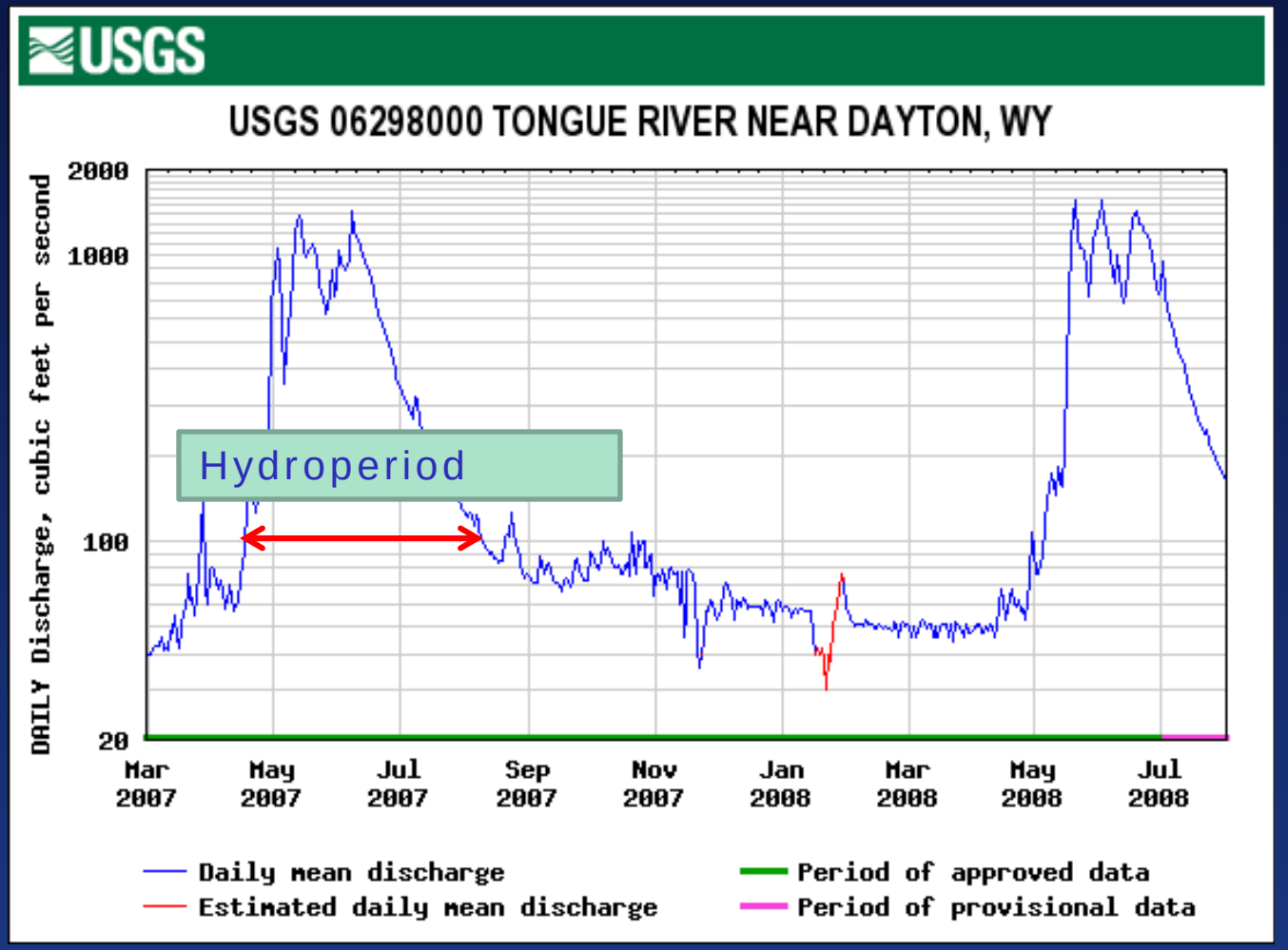
Floodplain Oxbow -Wyoming

Lateral Connectivity
Is the Key Consideration
In Riverine Wetlands

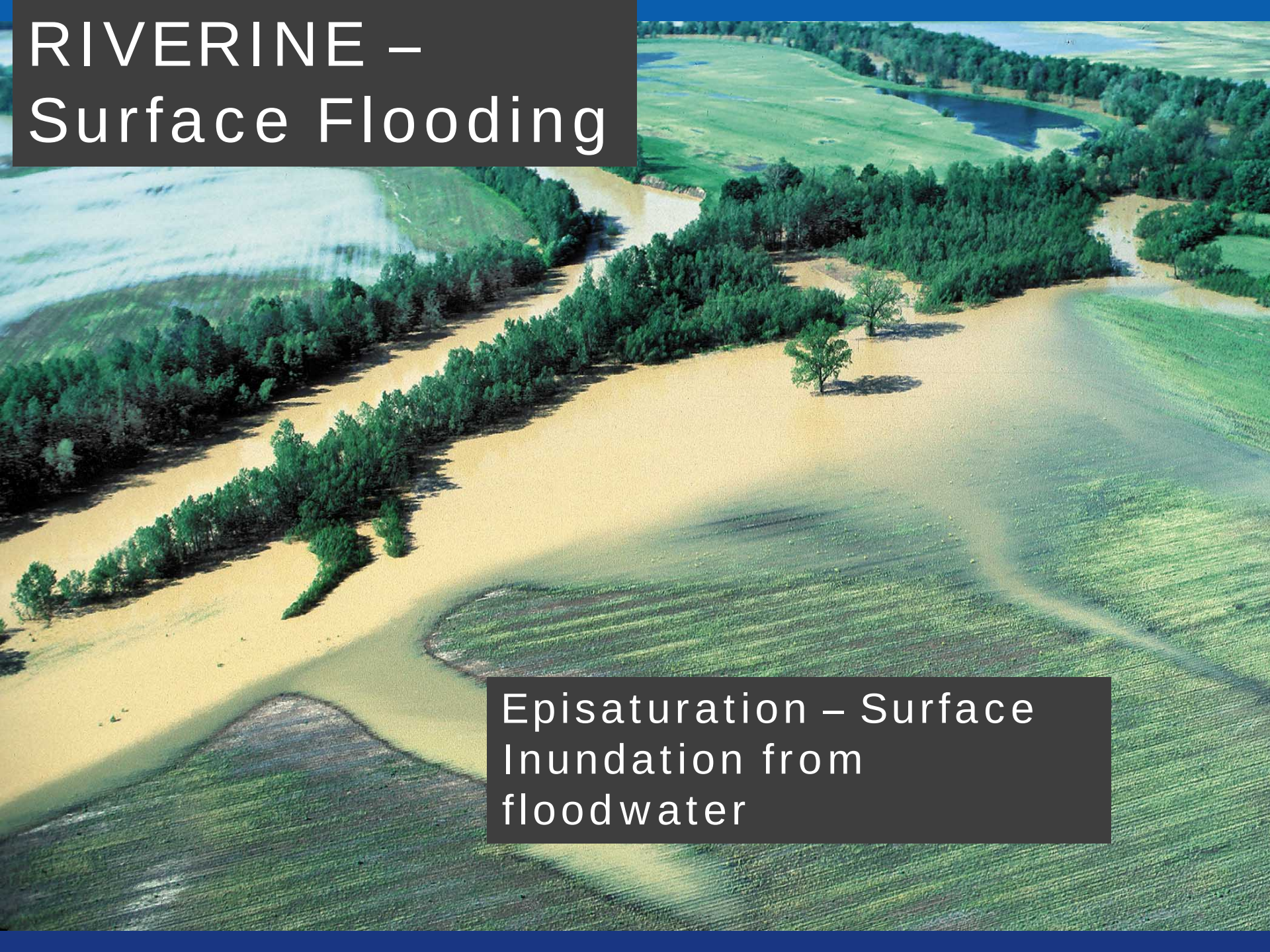
RIVERINE – Dominant Water Source – Stream Hydrograph

Primary Data Source – Stream Gage

Soil Survey Water Features
- **Flooding**
- **Ponding**
- **Groundwater**



RIVERINE – Surface Flooding



Episaturation – Surface Inundation from floodwater

RIVERINE – Surface Ponding (Episaturation)

Episaturated RIVERINE Restoration Techniques

Macrotopography to Restore Hydrologic Diversity

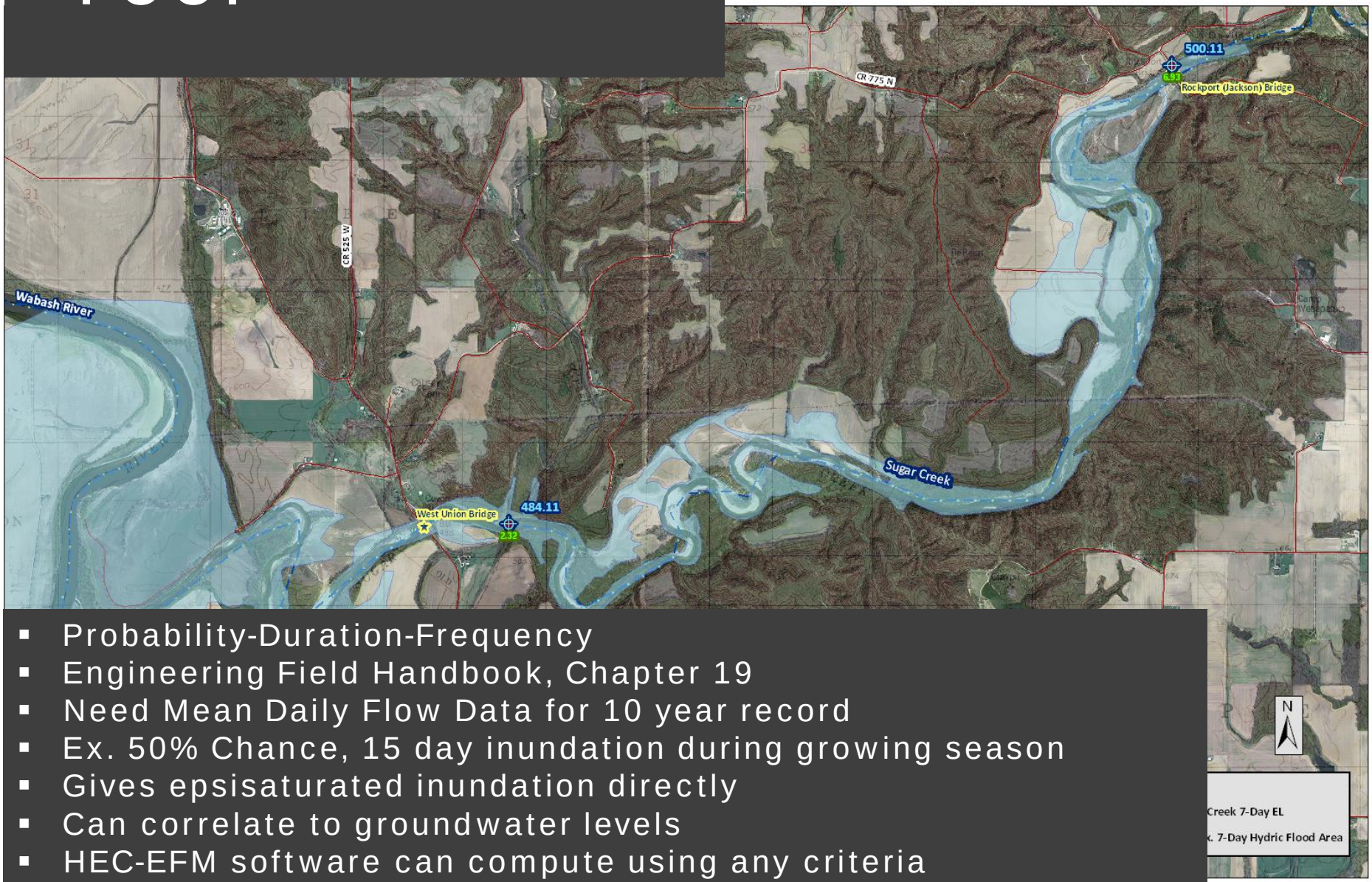
Levee Removal To Restore Lateral Connectivity


RIVERINE – Floodplain Groundwater
Endosaturation – Groundwater Fluctuations

Endosaturated Riverine Excavations

- Can Expose Groundwater Table
- Can Drain Site due to Flow Under Valley Gradient

Hydrology "Tool"



- Probability-Duration-Frequency
- Engineering Field Handbook, Chapter 19
- Need Mean Daily Flow Data for 10 year record
- Ex. 50% Chance, 15 day inundation during growing season
- Gives epsisaturated inundation directly
- Can correlate to groundwater levels
- HEC-EFM software can compute using any criteria

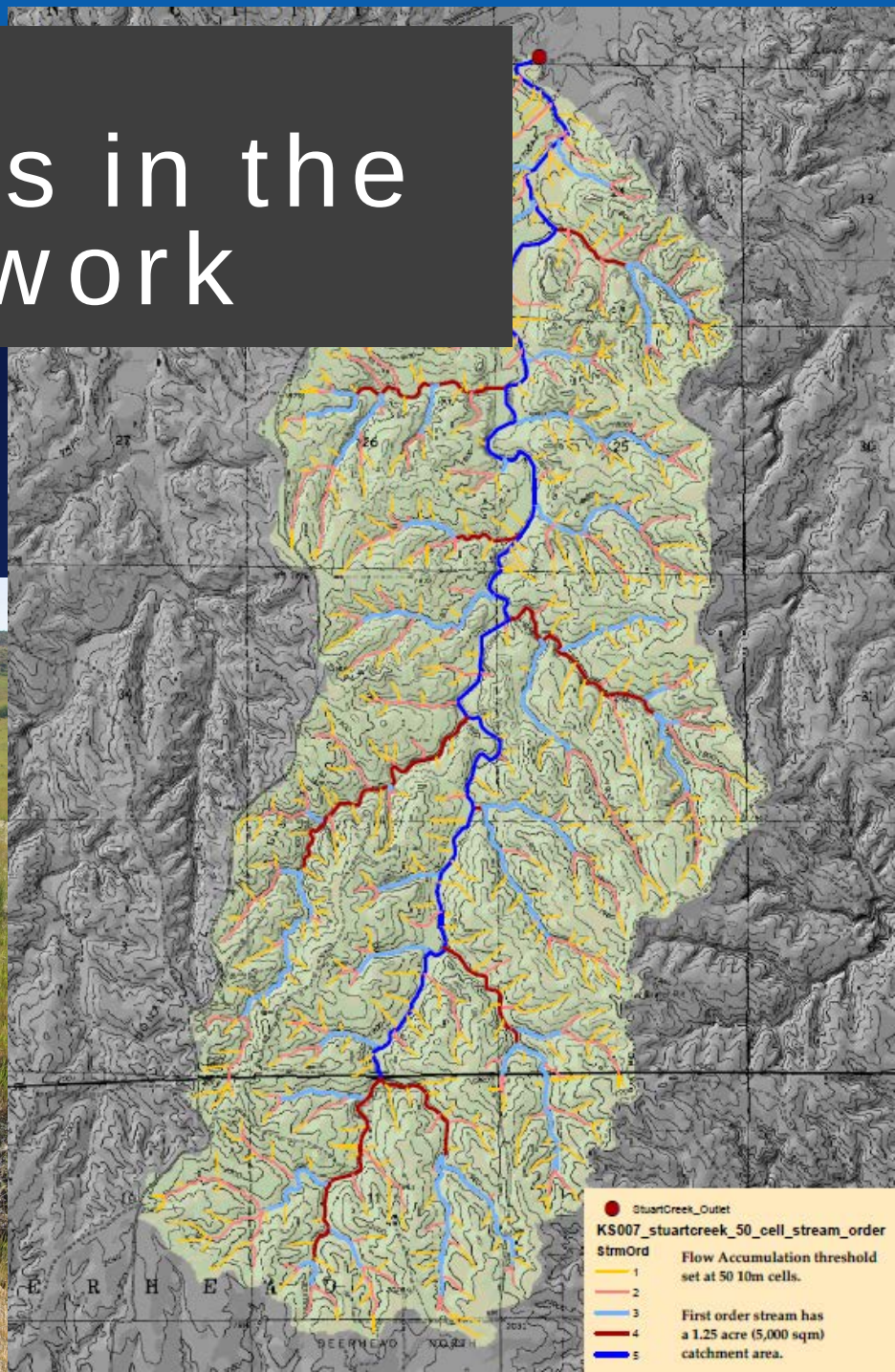
SLOPE

- Dominant Water Source – Groundwater
- Often Called “fens”
- Organic Soils or Histic Epipedons

SLOPE Wetlands in the Watershed Network

Landscape Position –

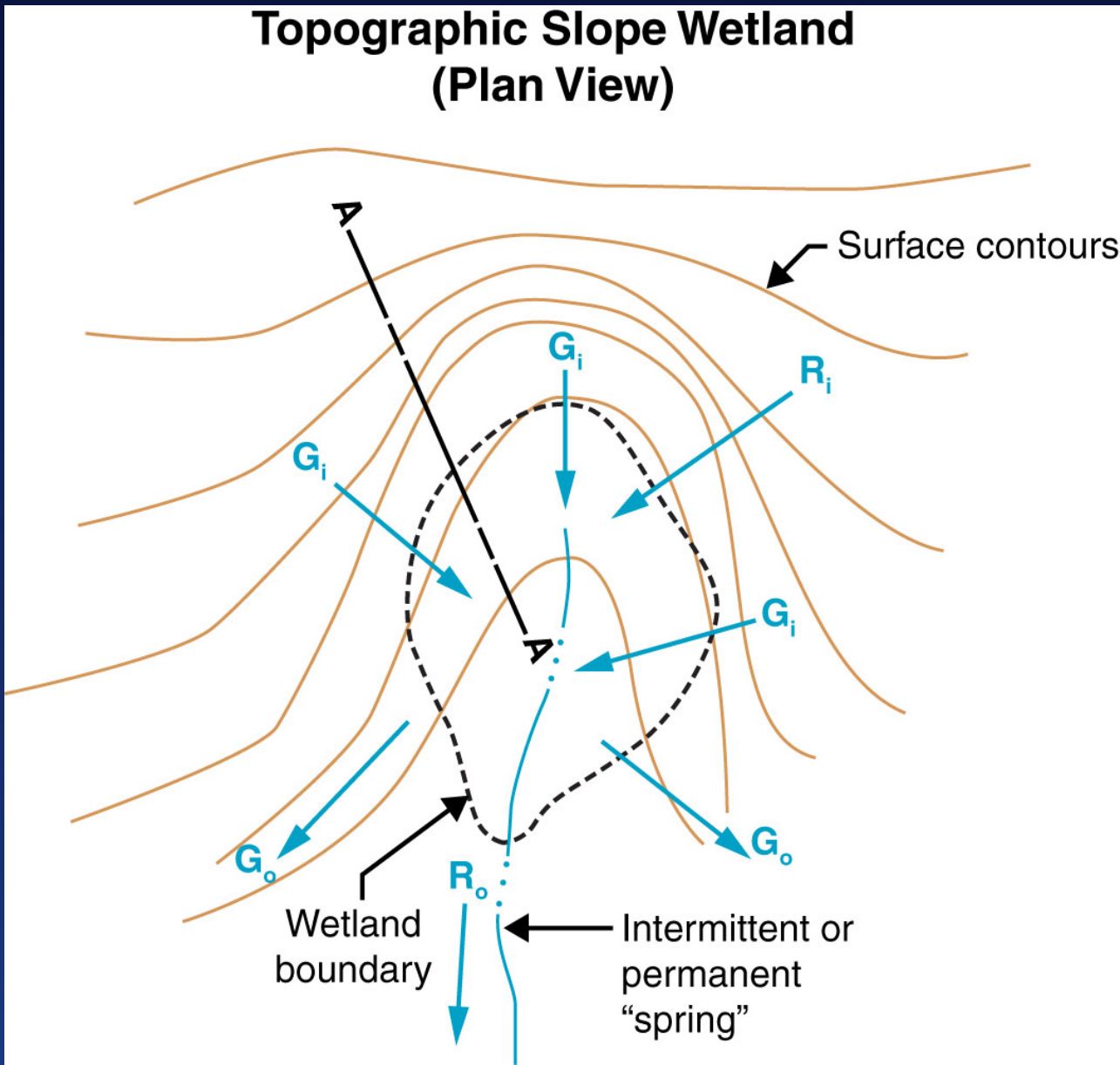
Concave Topographic positions, usually stream headwaters –



Topographic SLOPE Wetland Plan View

Concave Landscape Positions

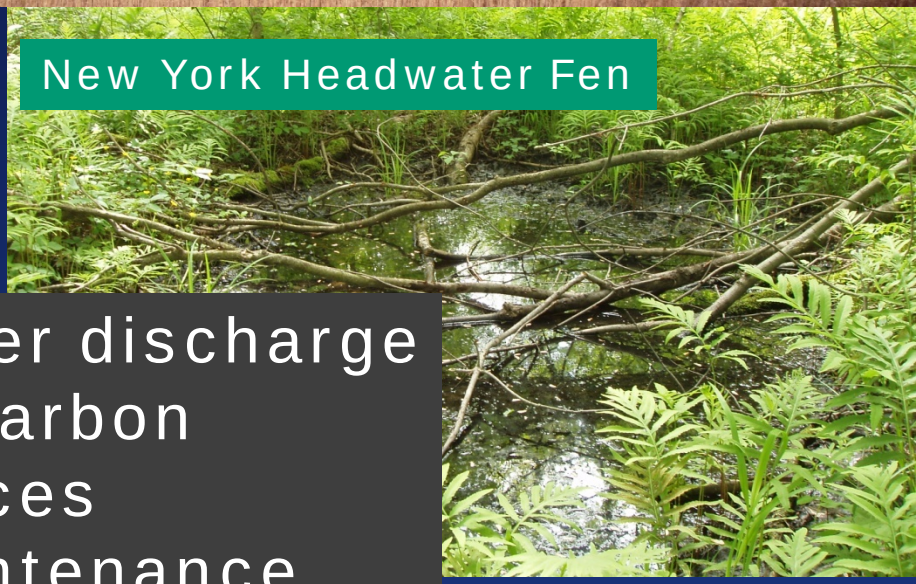
Typical of Stream Headwaters



SLOPE Wetlands – Unique Functions

Kansas Headwater

Idaho Headwater Fen



New York Headwater Fen

- Aquifer Storage/groundwater discharge
- Sequestration of Organic Carbon
- Critical Upland Water Sources
- Downstream Baseflow Maintenance
- Don't Typically Provide Waterfowl Habitat

SLOPE Wetland Degraded by Gully Advance

Upstream

- Stream Morphology Principles Don’t Apply
- No Channel/Floodplain Sequence
- Short Inundation Hydrographs
- Long Term Groundwater Discharge

Downstream

Don’t “Restore” SLOPE Wetland by Installing a Channel (Please)

- Large Headwater Site
- Organic Soils
- Strong Groundwater Source
- Channel Acts as Drainage Ditch

SLOPE Reaches Transition into RIVERINE Reaches

The Transition may be Temporal As Well as Spatial

SLOPE or Endosaturated RIVERINE Reach Restoration Techniques

- Incised Channel in “wet meadow”
- Rock Check Structures in Series

SLOPE or Endosaturated RIVERINE Restoration Techniques

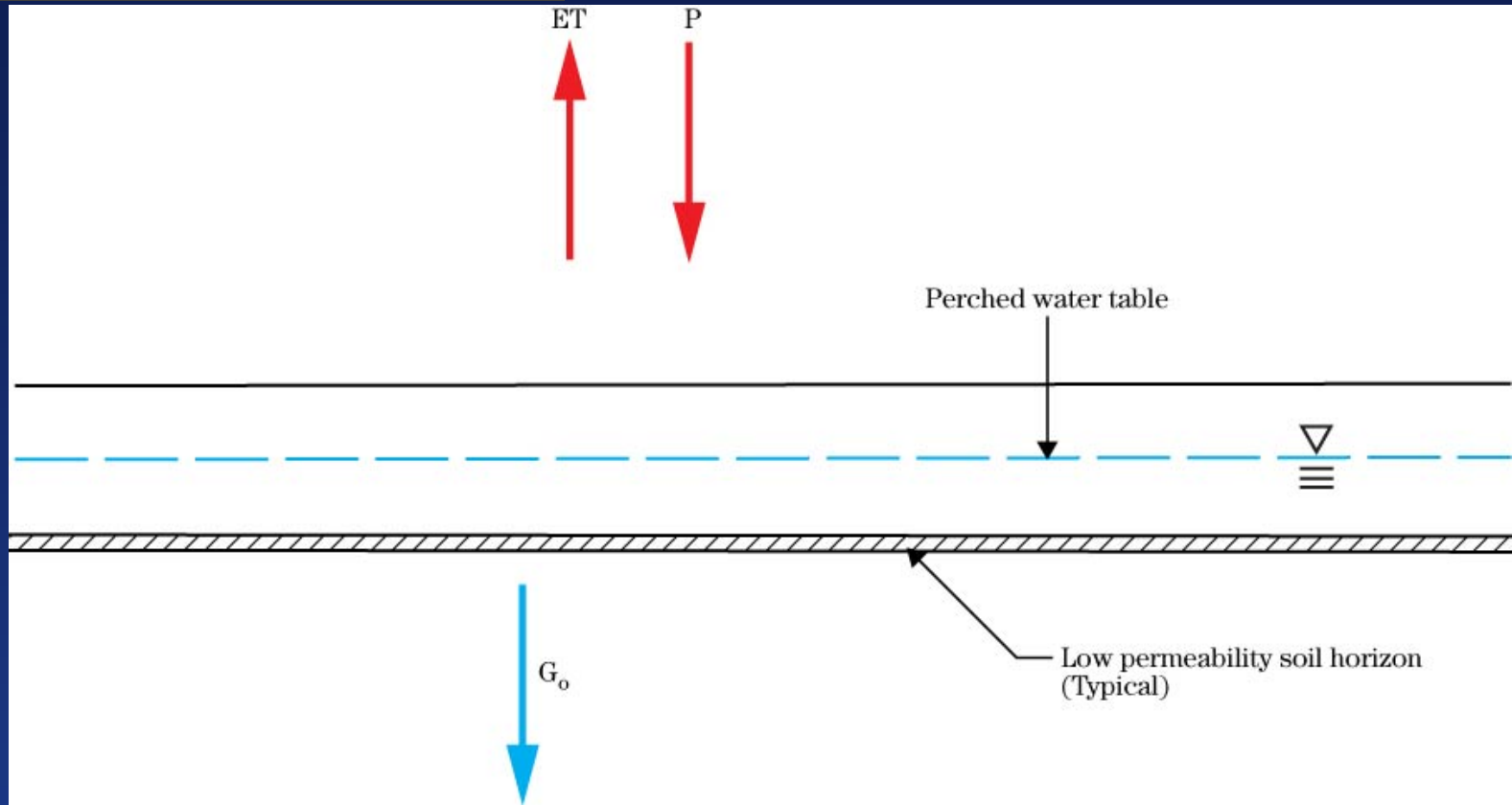
- On Channel Structures
- In Series
- Raise Floodplain Groundwater
- Restore Saturation Regime

MINERAL SOIL FLAT
Dominant Water Source- Direct Precipitation

- Usually contain shallow ephemeral depressions
- Areas between depressions have no surface hydroperiod
- Landscape is incapable of providing long term surface water
- Lateral Effects Equations and DRAINMOD “Tools” appropriate for modeling groundwater fluctuations

MINERAL FLAT Wetland Hydrodynamics and Water Budget

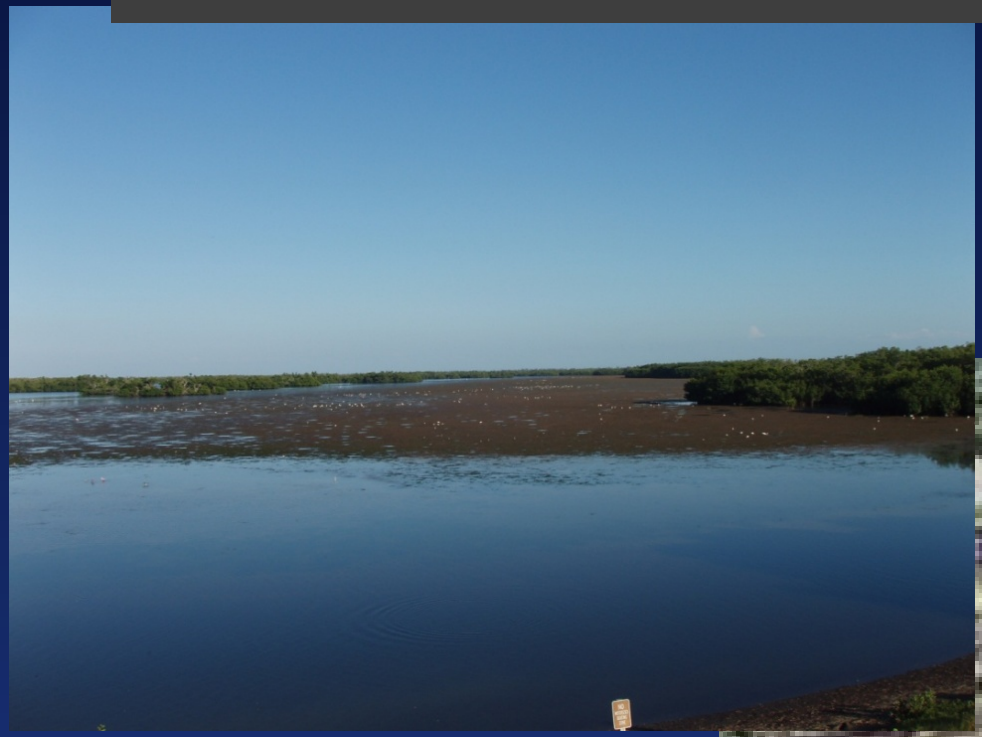
Deep Excavations will leave behind unsightly spoil piles and depressions with a few inches of rainwaterwater in the bottom



ORGANIC SOIL FLAT Dominant Water Source – Direct Precipitation

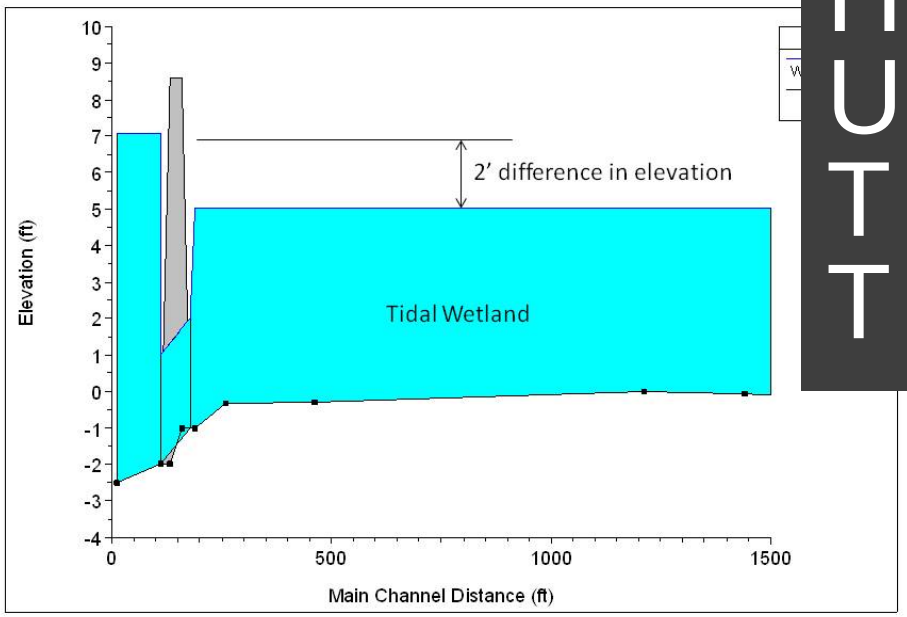
- Ombotrophic (Rainfed) Bogs
- Nutrient Poor
- High P-ET Balance Climates

ESTUARINE FRINGE
Dominant Water Source - Tides



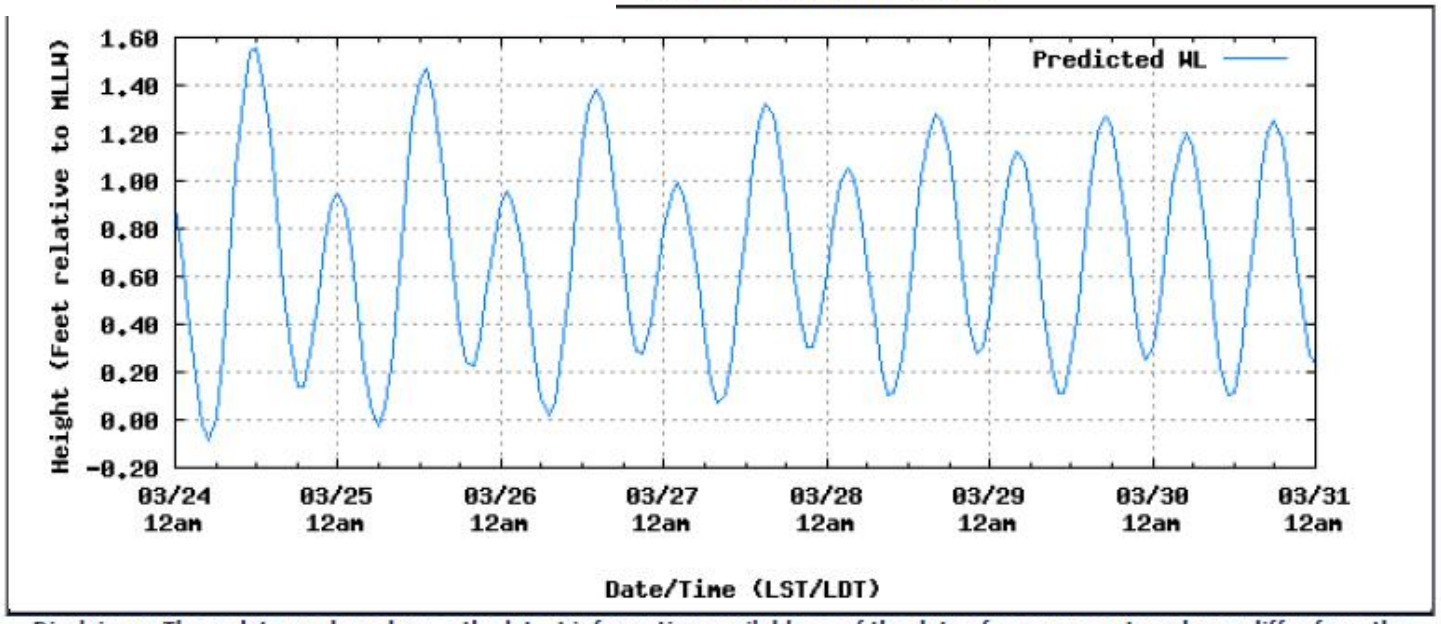
Pause for Questions

HEC-RAS Unsteady Flow Technique with Tide Data



Help Print

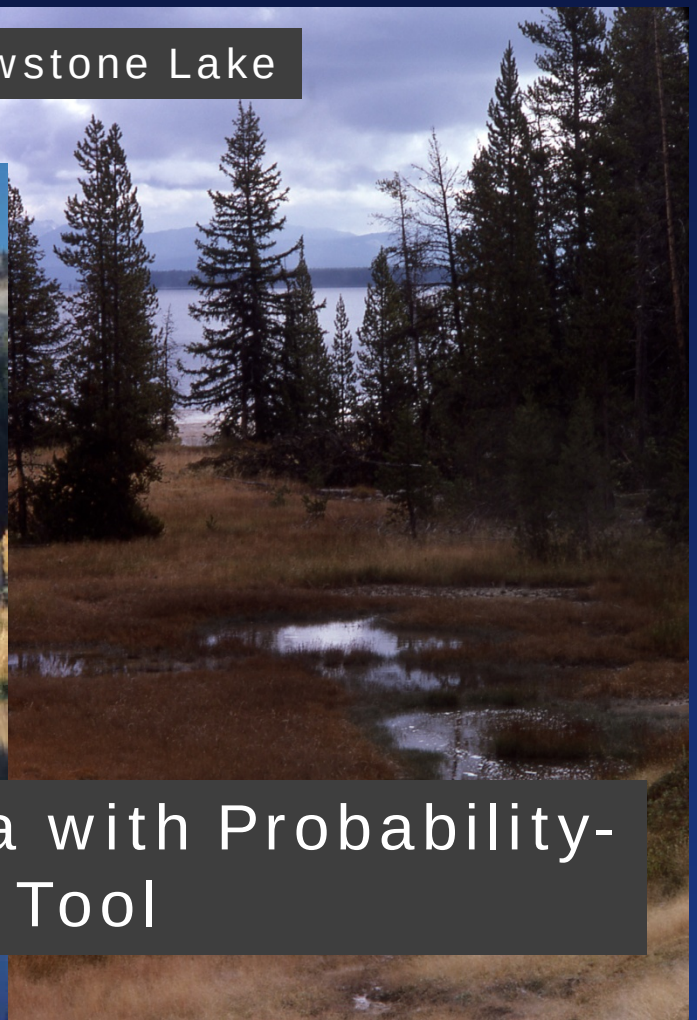
OS/CO-OPS
or TOLCHESTER BEACH,MD
d 8573364
/24 - 2011/03/30
: LST/LDT Datum: MLLW



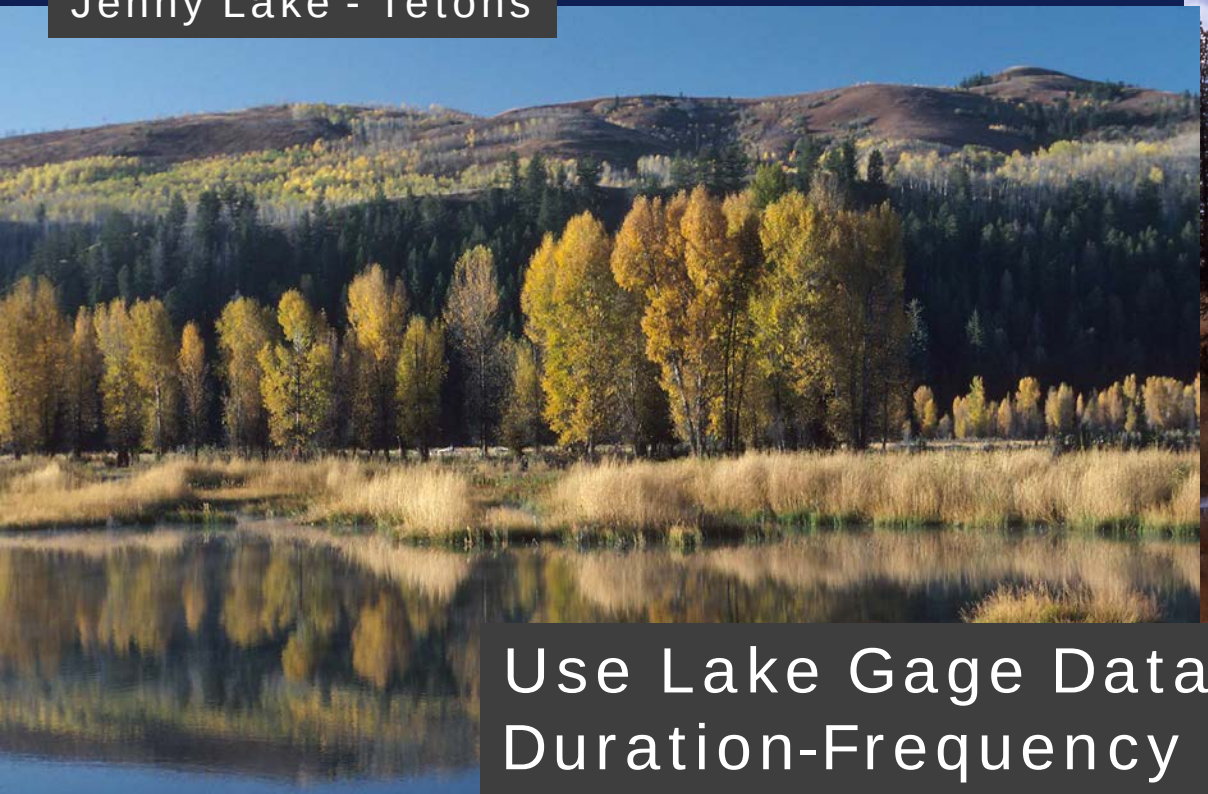
Disclaimer: These data are based upon the latest information available as of the date of your request, and may differ from the published tide tables.

LACUSTRINE FRINGE Dominant Water Source- Lake Fluctuations

Yellowstone Lake



Jenny Lake - Tetons



Use Lake Gage Data with Probability-Duration-Frequency Tool

DEPRESSIONAL

Nebraska Rainwater Basin – Recharge Depression

Wyoming – Recharge Depression, Gillette

South Carolina – Carolina Bay

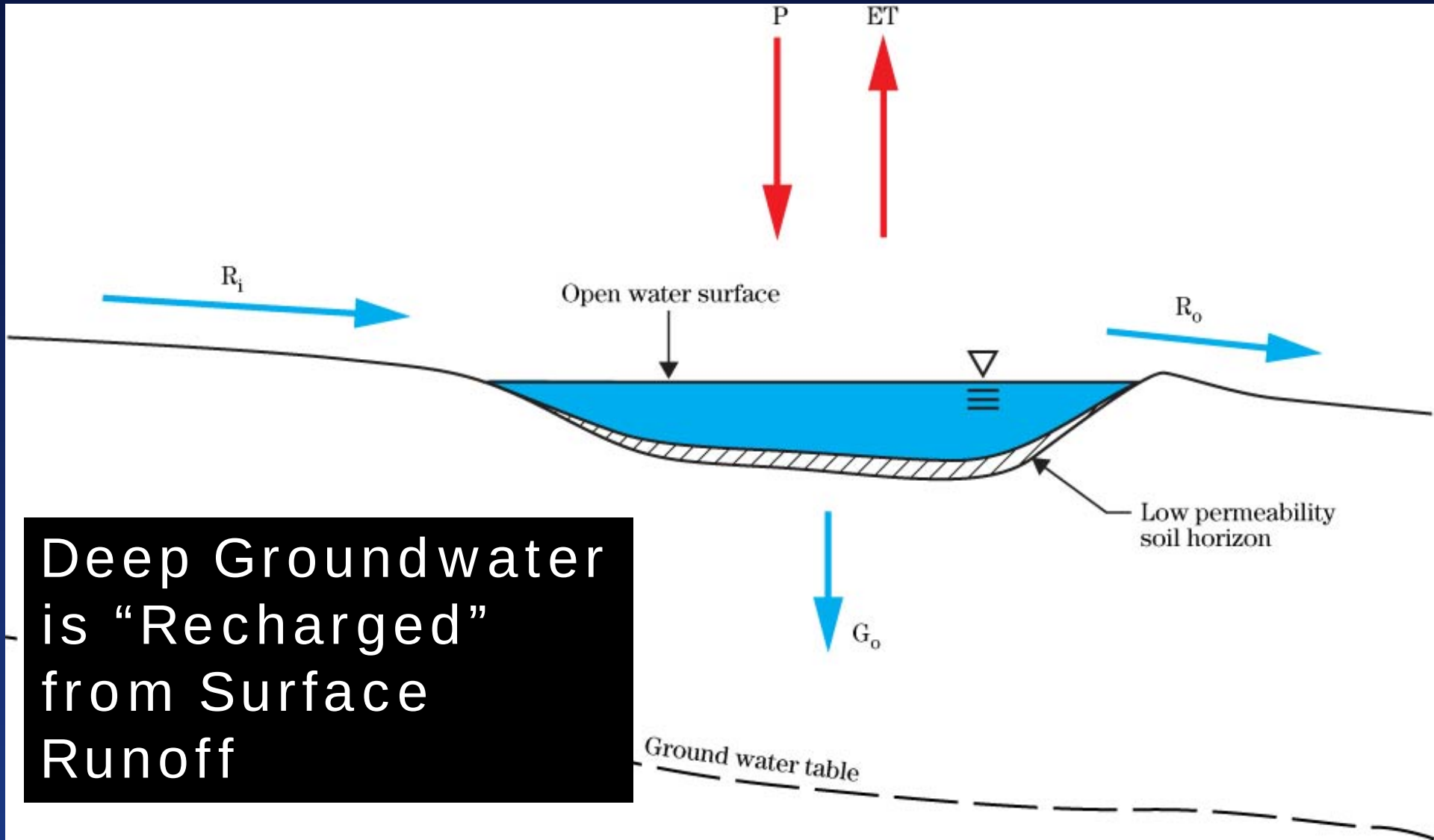
South Dakota Prairie Pothole

DEPRESSIONAL

Dominant Water Source – Surface Runoff and/or Groundwater

- Defined Catchment Area (Surface and/or Groundwater)
- Shallow, Ephemeral Depressions With Undefined Catchments are Elements in Mineral Flats

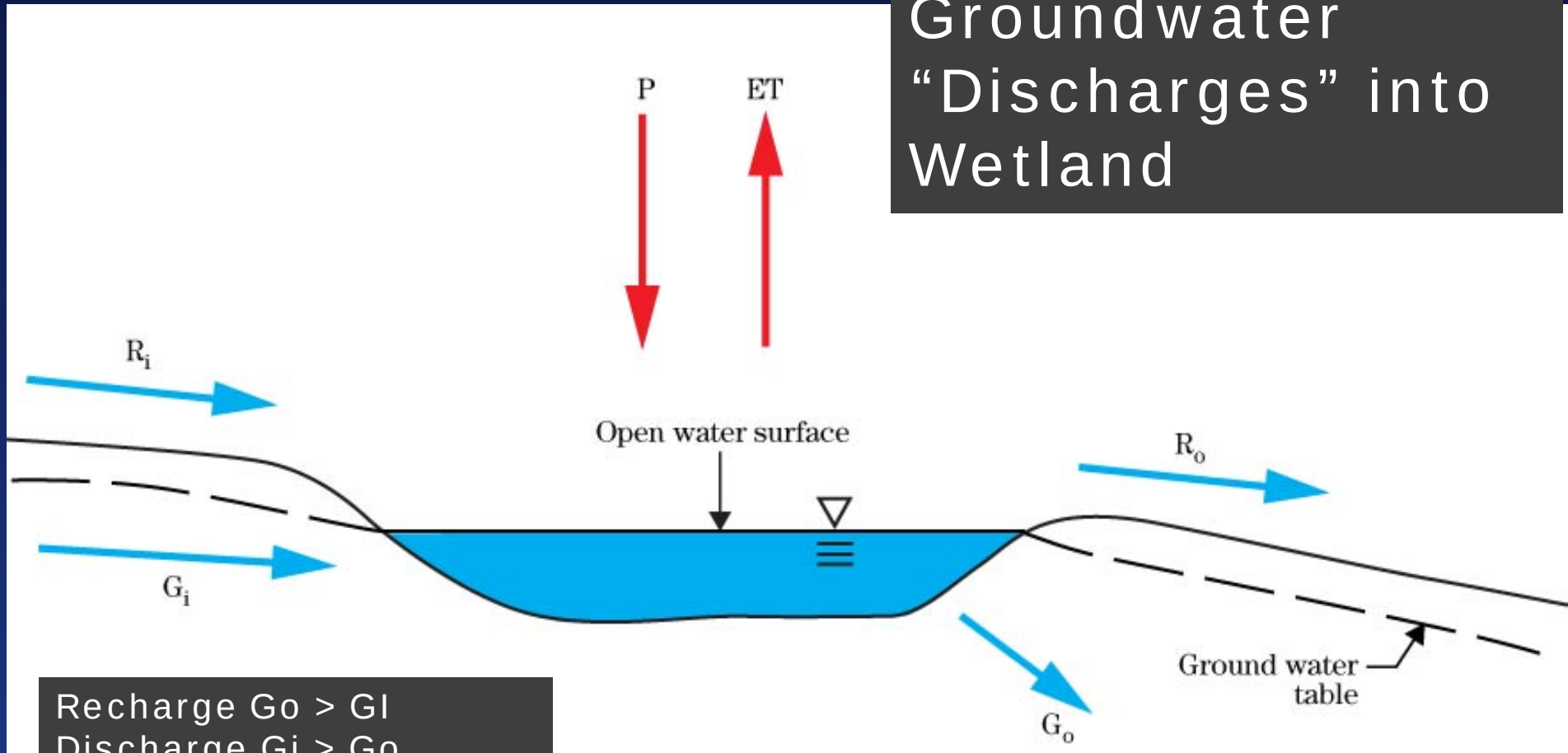
Depressional - Recharge



Deep Groundwater is “Recharged” from Surface Runoff

Depressional – Discharge or Flow Through

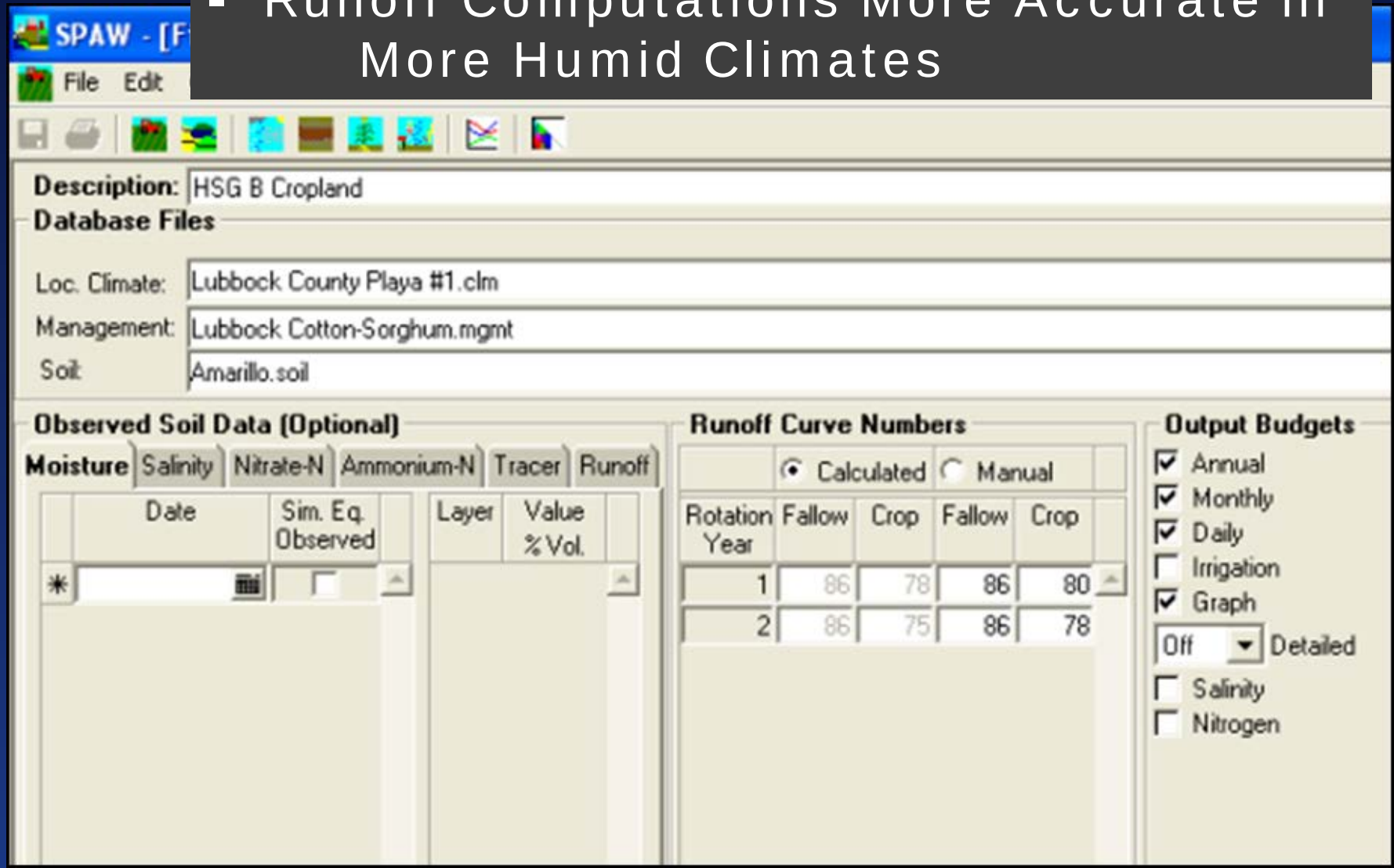
Shallow Groundwater “Discharges” into Wetland



Recharge Go > GI
Discharge Gi > Go
Flow Through Gi = Go

SPAW Model

- Works Well for Recharge Depressions
- Runoff Computations More Accurate in More Humid Climates



Simplified Water Budgeting with Spreadsheets

- Monthly Rainfall from WETS
- Monthly ET from Local Sources or AWM
- G_o From Web Soil Survey

Wetland Water Budget Spreadsheet

y: Adams Cont. DA CN_1 = 85 CN_{30} = 67

ted Max. Deep Percolation= 0.5 Inches/Month Overflow Height = 24 Inches

d Water Holding Capacity= 6.93 Inches

Drainage Area:Basin Area= 10 (runoff multiplied by this ratio to obtain runoff, surface inches)

	Precip (Inches)	Runoff (Inches)	Runoff (Sur. In.)	Other Inflow (Sur. In.)	ET Potential (Inches)	Sum (Inches)	Deep Perc (Inches)	Sum (Inches)	Outflow (Inches)	Balance (Inches)
									Starting= →	-6.93
September	3.02	0.60	5.99		5.17	-3.09	0.00	-3.09	0.00	-3.09
October	1.67	0.08	0.85		3.76	-4.33	0.00	-4.33	0.00	-4.33
November	0.98	0.00	0.00		1.88	-5.23	0.00	-5.23	0.00	-5.23
December	0.85	0.00	0.00		0.94	-5.32	0.00	-5.32	0.00	-5.32
January	0.51	0.00	0.00		0.94	-5.75	0.00	-5.75	0.00	-5.75
February	0.70	0.00	0.00		1.41	-6.46	0.00	-6.46	0.00	-6.46
March	2.08	0.20	2.01		2.35	-4.72	0.00	-4.72	0.00	-4.72
April	2.54	0.38	3.76		4.70	-3.12	0.00	-3.12	0.00	-3.12
May	4.77	1.65	16.51		5.64	12.52	0.50	12.02	0.00	12.02
June	3.94	1.11	11.13		6.58	20.52	0.50	20.02	0.00	20.02
July	3.43	0.82	8.16		7.05	24.55	0.50	24.05	0.05	24.00
August	3.32	0.76	7.55		6.58	28.29	0.50	27.79	3.79	24.00
Total	27.8	5.6	55.96	0.00	47.00	47.8	2.00	45.8	3.84	

Soils Info:	Depth	AWC	Description
Fillmore, Clay County NE	0 - 19 in.	3.99	hydric
	19 - 33 in.	2.94	hydric
	33 - 45 in.	1.8	hydric

Design Info:
Precipitation and Runoff are monthly 50 percent chance events.
Et ~ 1.0 pan evaporation initial conditions, may be modified depending on location

Created by Geoff Cerrelli, Civil Engineer USDA/NRCS Harrisburg, PA (717) 237-2215
Modified by Jacob Robison, Civil Engineer USDA/NRCS Grand Island, NE

Additional weather data at www.wcc.nrcs.usda.gov/cgibin/getwetco.pl?state=ne

Recharge DEPRESSION Sediment Removal

- Surface Runoff “perched”
- Sediment Removal Restores depth
- Do not remove topsoil layer
- Do not remove perching layer

Precipitation, “P” WETS Tables

Average Monthly Precipitation

Monthly Time Step -

Use with hand calculations or simplified spreadsheets

The WETS table is located at eFOTG – State – County – Section III – Climate Data – AgCIS

WETS Station : DUBOIS S IND FORAGE FRM, IN2309 Creation Date: 01/22/2003
Latitude: 3827 Longitude: 08642 Elevation: 00690
State FIPS/County(FIPS): 18037 County Name: Dubois
Start yr. - 1971 End yr. - 2000

Month	Temperature (Degrees F.) avg daily max	avg daily min	avg	Precipitation (Inches) avg	30% chance will have less than	more than	avg # of days w/.1 or more	avg total snow fall
January	37.9	20.3	29.1	3.10	1.90	3.79	6	2.3
February	43.4	23.4	33.4	2.81	1.76	3.44	6	2.5
March	53.8	32.9	43.3	4.08	2.91	4.74	7	1.3
April	64.5	43.0	53.8	4.65	3.07	5.45	8	0.0
May	73.9	52.4	63.2	5.29	3.41	6.09	8	0.0
June	82.2	61.4	71.8	4.68	3.19	5.95	7	0.0
July	86.0	65.5	75.8	4.38	3.02	5.09	6	0.0
August	83.[illegible]	63.5	74.2	4.04	2.78	4.94	6	0.0
September	78.5	[illegible]	67.3	3.55	2.10	4.05	6	0.0
October	67.4	[illegible]	55.7	3.15	2.15	4.02	6	0.2
November	54.5	35.2	[illegible]	4.27	2.87	5.18	7	0.0
December	42.7	25.0	[illegible]	3.45	2.54	4.44	6	1.2
Annual	-----	-----	-----	------	[illegible]1.49	51.98	--	----
Average	64.1	43.6	53.9	------	------	------	--	----
Total	-----	-----	-----	47.45	------	------	74	7.6

GROWING SEASON DATES

Probability	Temperature: 24 F or higher	28 F or higher	32 F or higher
	Beginning and Ending Dates Growing Season Length		
50 percent *	3/27 to 11/ 8 226 days	4/ 5 to 10/27 204 days	4/21 to 10/16 178 days
70 percent *	3/23 to 11/13 236 days	4/ 1 to 10/31 213 days	4/17 to 10/20 186 days

* Percent chance of the growing season occurring between the Beginning and Ending dates.

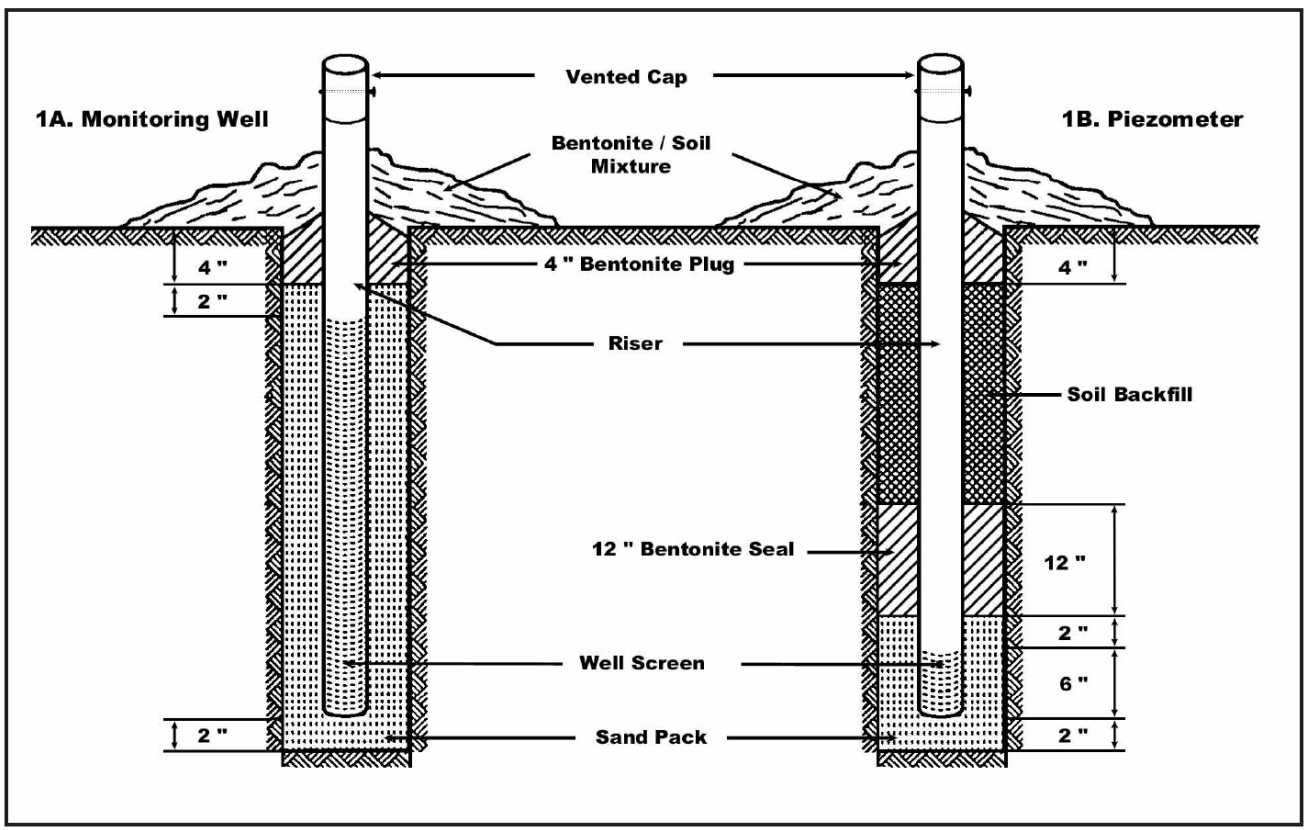
total 1955-2002 prcp

Station : IN2309, DUBOIS S IND FORAGE FRM

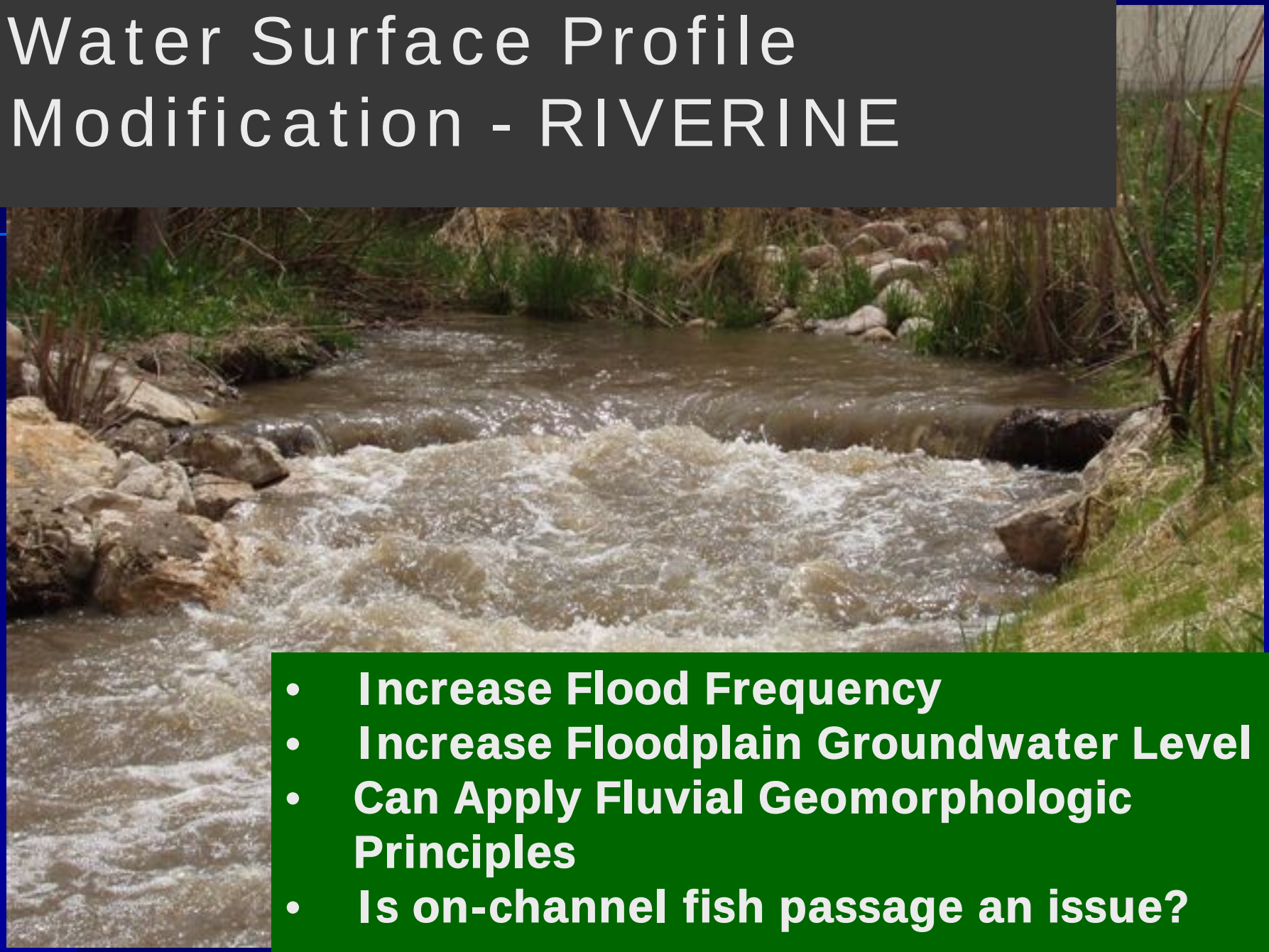
Groundwater – Gi and Go Monitoring Wells/Piezometers

SLOPE and Discharge DEPRESSION
Inflows have Vertical Upward movement

- Inexpensive
- Easy to Install
- Monitoring wells provide water table information only
- Wells WITH piezometers can detect direction of movement and can provide estimates of RATE of water movement.



Water Surface Profile Modification - RIVERINE



- **Increase Flood Frequency**
- **Increase Floodplain Groundwater Level**
- **Can Apply Fluvial Geomorphologic Principles**
- **Is on-channel fish passage an issue?**

Water Surface Profile Restoration –

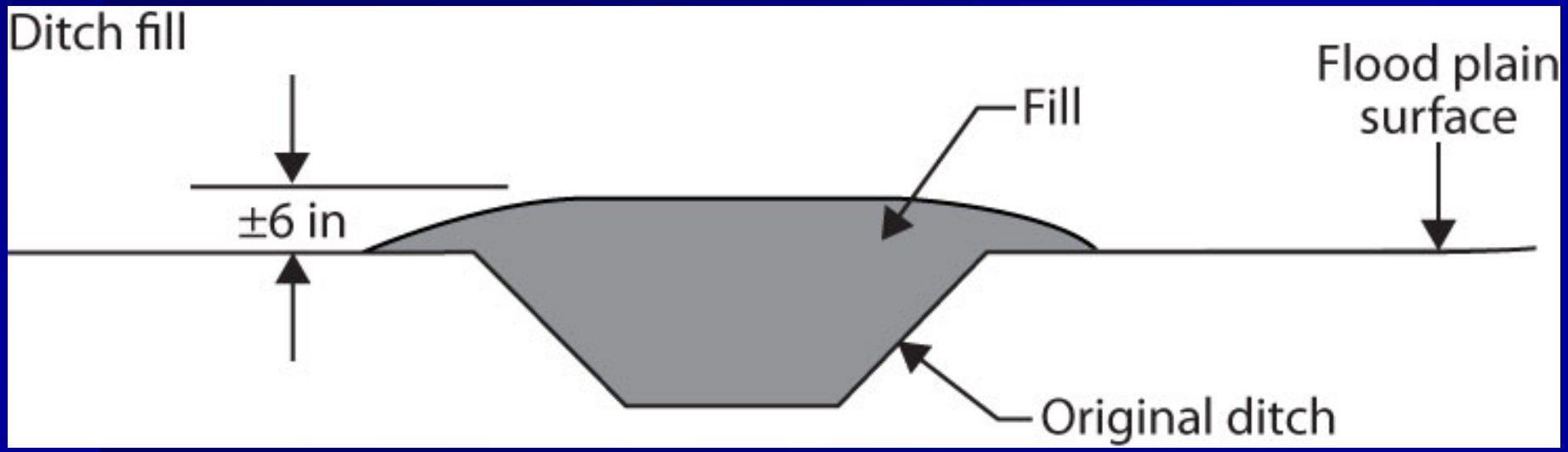
- RIVERINE, on incised channel
- SLOPE, drained by gully
- Reduces G_o

- Install in Series!
- Increases Lateral Connectivity
  - Surface Flooding
  - Groundwater

Ditch Plugs - Off channel RIVERINE, and all other HGM Classes

- Spread surface water
- Raise groundwater
- Reduces G_o, R_o
- Increases S

- No defined watershed
- Fill Higher than wetland surface
- Length based on soil types
- Fill constructed ditch



Sharp Crested Weir

- Degraded SLOPE
- Ditch Plug Alternative in sandy soils
- Can be installed thru shallow organic layers
- Not for on-channel RIVERINE
- Reduces G_o, R_o, Increases S

Pros-

High capacity at low heads.

Easy to clean, maintain

Cons-

Expensive- May require specialized equipment

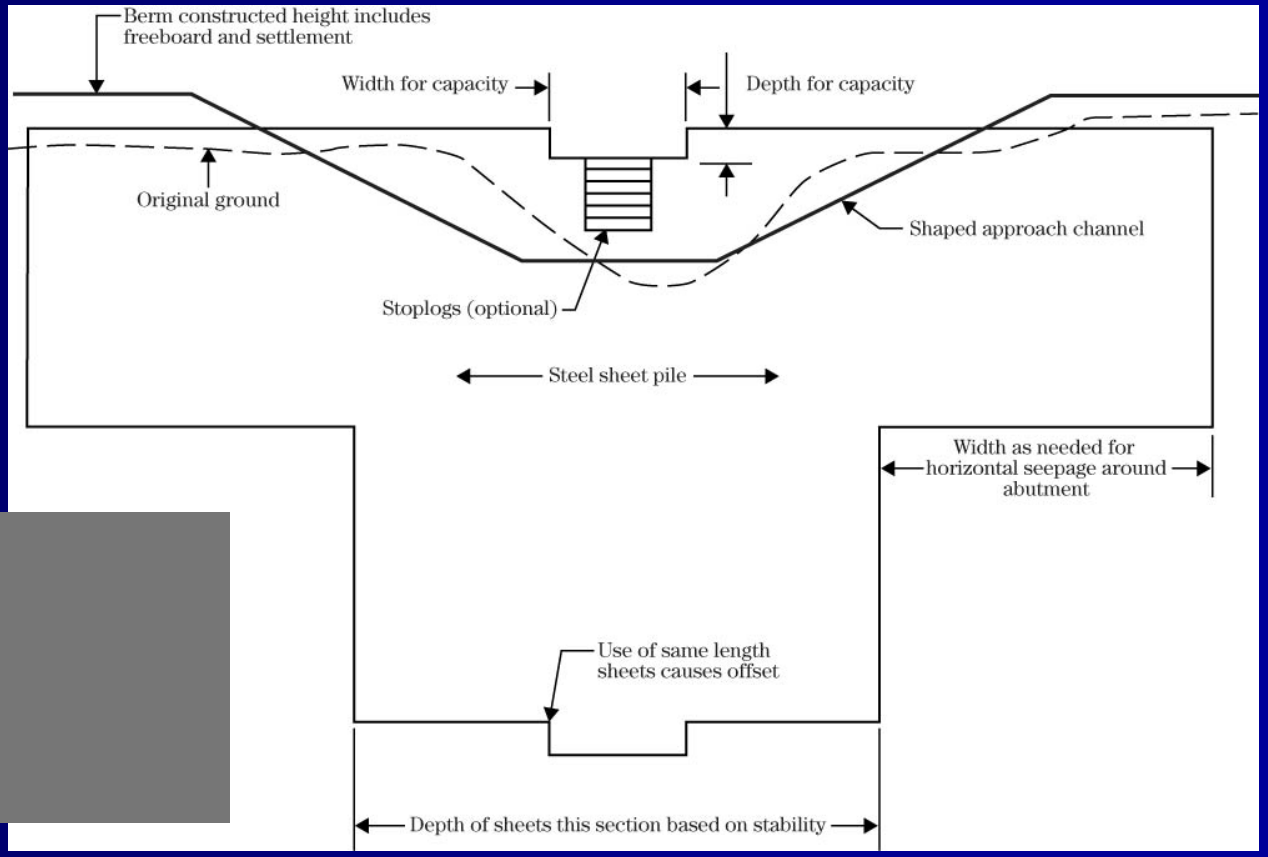
Aquatic Organism Passage Issue

Steel Sheet Pile Weir

Good option for peat and muck soils IF mineral layer exists within a few feet of the surface

Just like an iceberg, most of it is below the surface!

Weirs need:
- Bed and bank keys
- Control Section
- Scour protection (or tailwater)



Considerations: Hydraulic Structures are Bouyant!

Considerations: Hydraulic Structures can Be Heavy, too.

Questions?

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