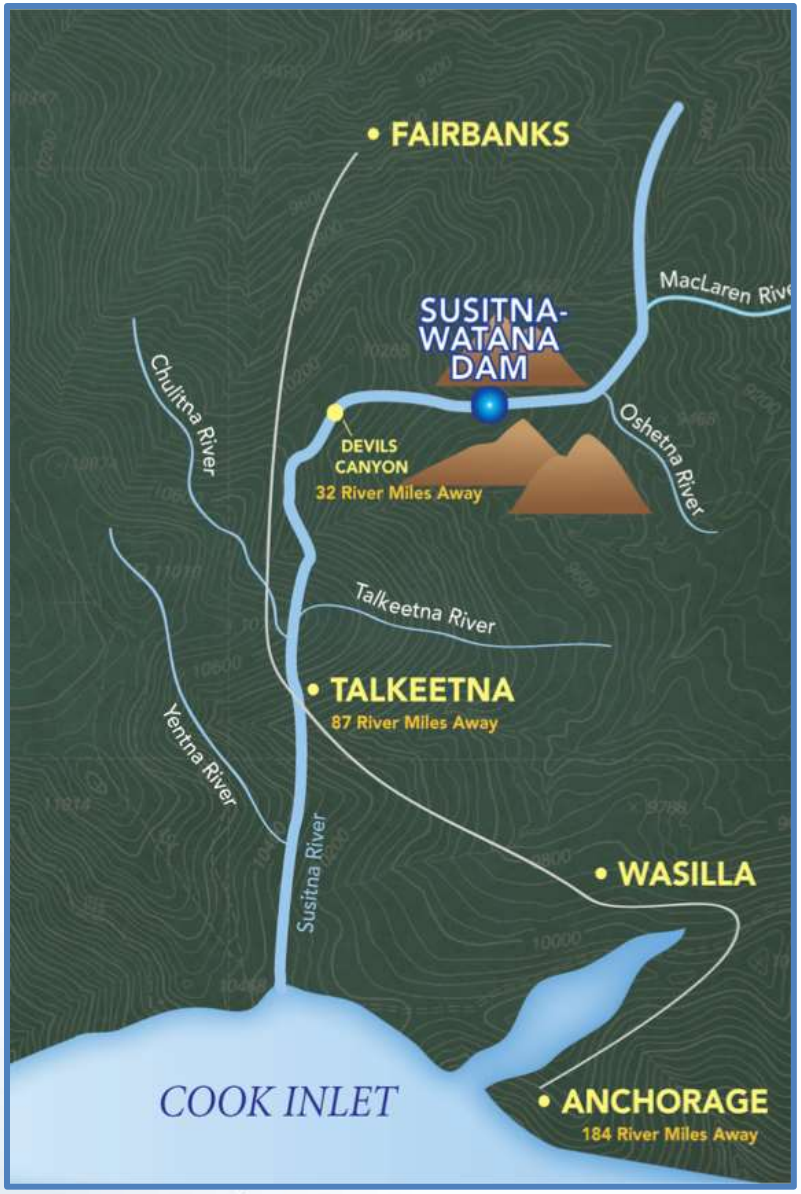

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IFS-TT: Riverine Modeling

Groundwater Study Modeling & Analysis Integration

November 13, 2013

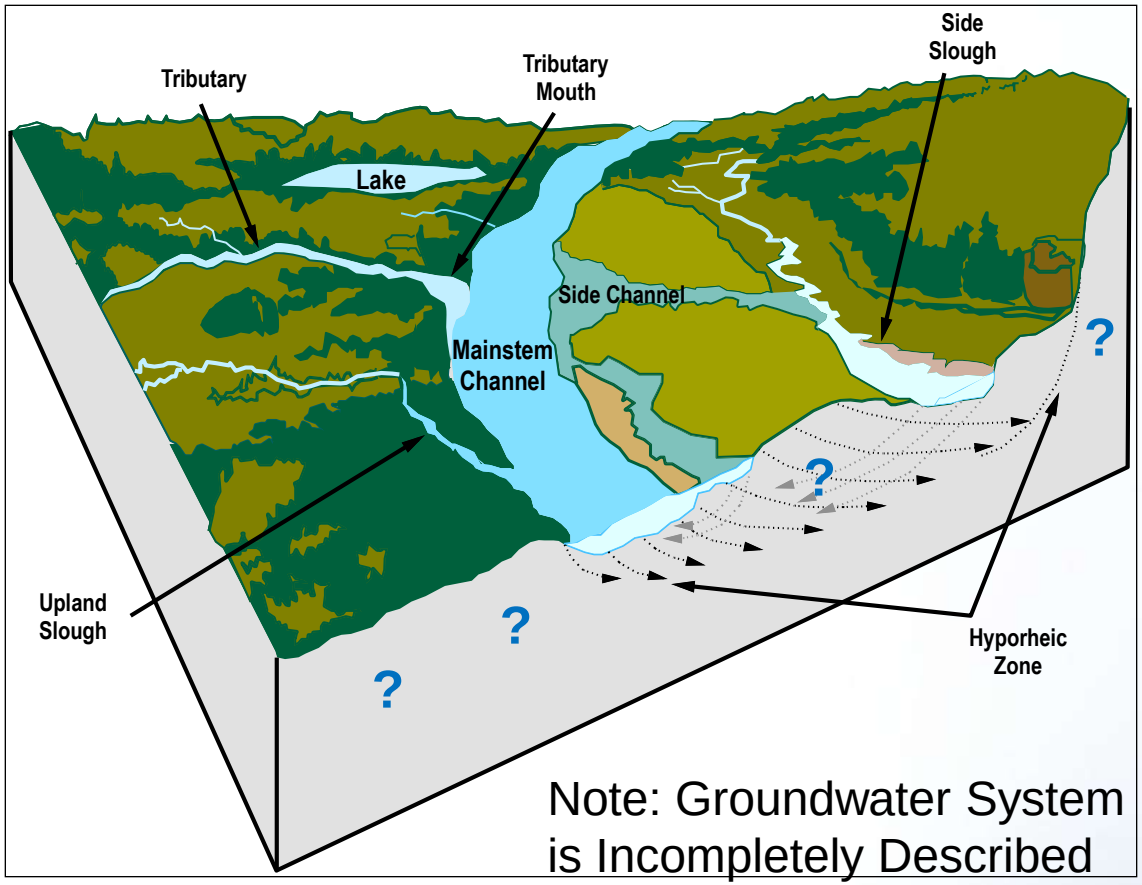
Prepared by
GW Scientific

Groundwater Study Modeling

- Why Model?
  - Understand processes we can not easily see place
  - Bracket the range of processes interactions
  - Use in combination of other data and studies to guide reasonable estimates of groundwater conditions and potential changes outside the range of natural variability
  - To address specific questions

Aquatic and Riparian Resources

- Inter-Related
- Impacts on Riparian = Impacts on Aquatic
- Groundwater Questions Have Many Overlaps



Habitat types identified in the middle reach of the Susitna River during the 1980s studies (adapted from ADF&G 1983; Trihey 1982).

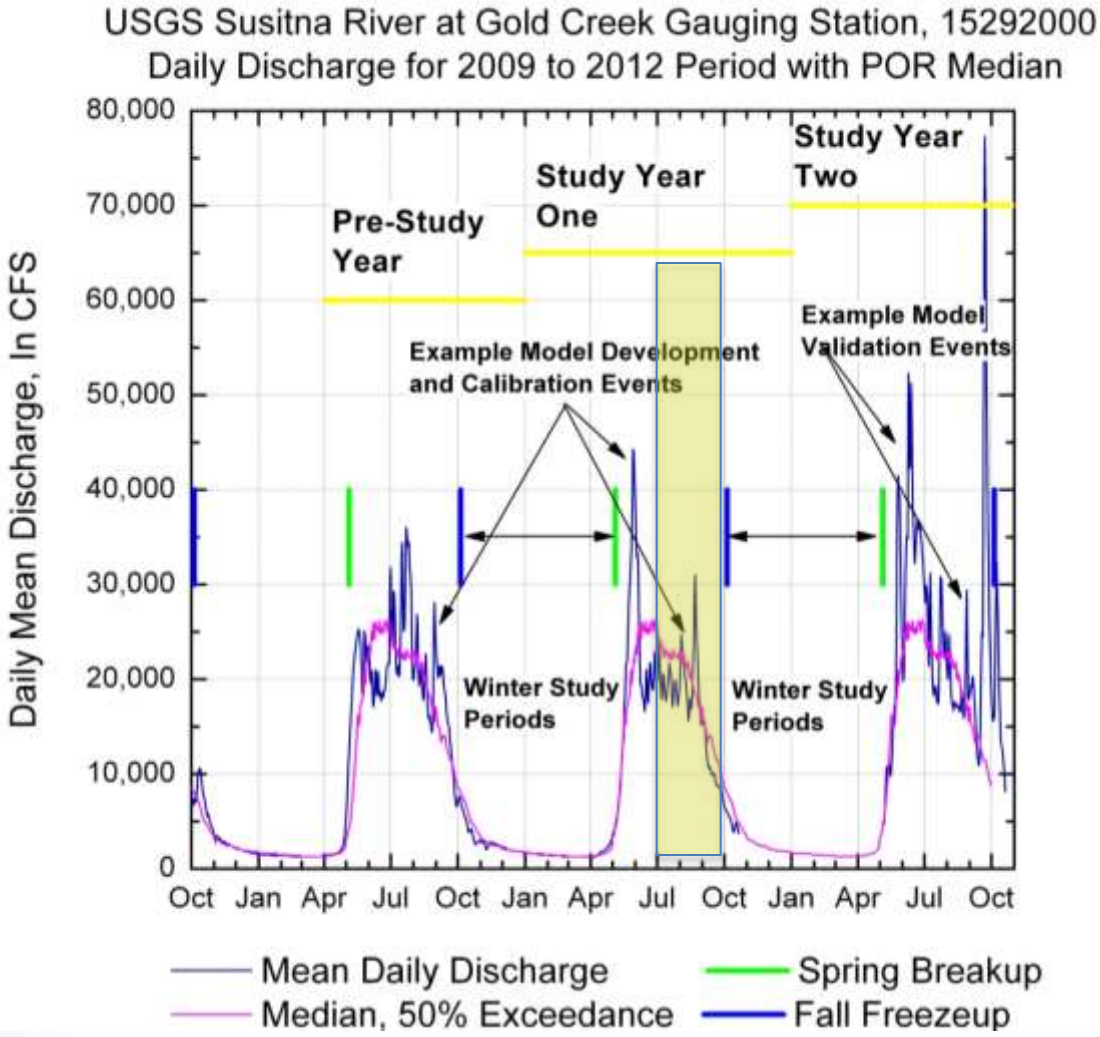
Groundwater Study Modeling & Analysis

- Key Questions:
  - Aquatic Questions
    - What groundwater processes (magnitude, duration, timing) are important for lateral habitats (side channels and sloughs)?
    - Under Project operational scenarios, how will lateral habitats be impacted by?
      - Higher water levels in winter?
      - Lower water levels in summer?
    - Will sources of groundwater change in lateral habitats, both in terms of quantity, level and quality?

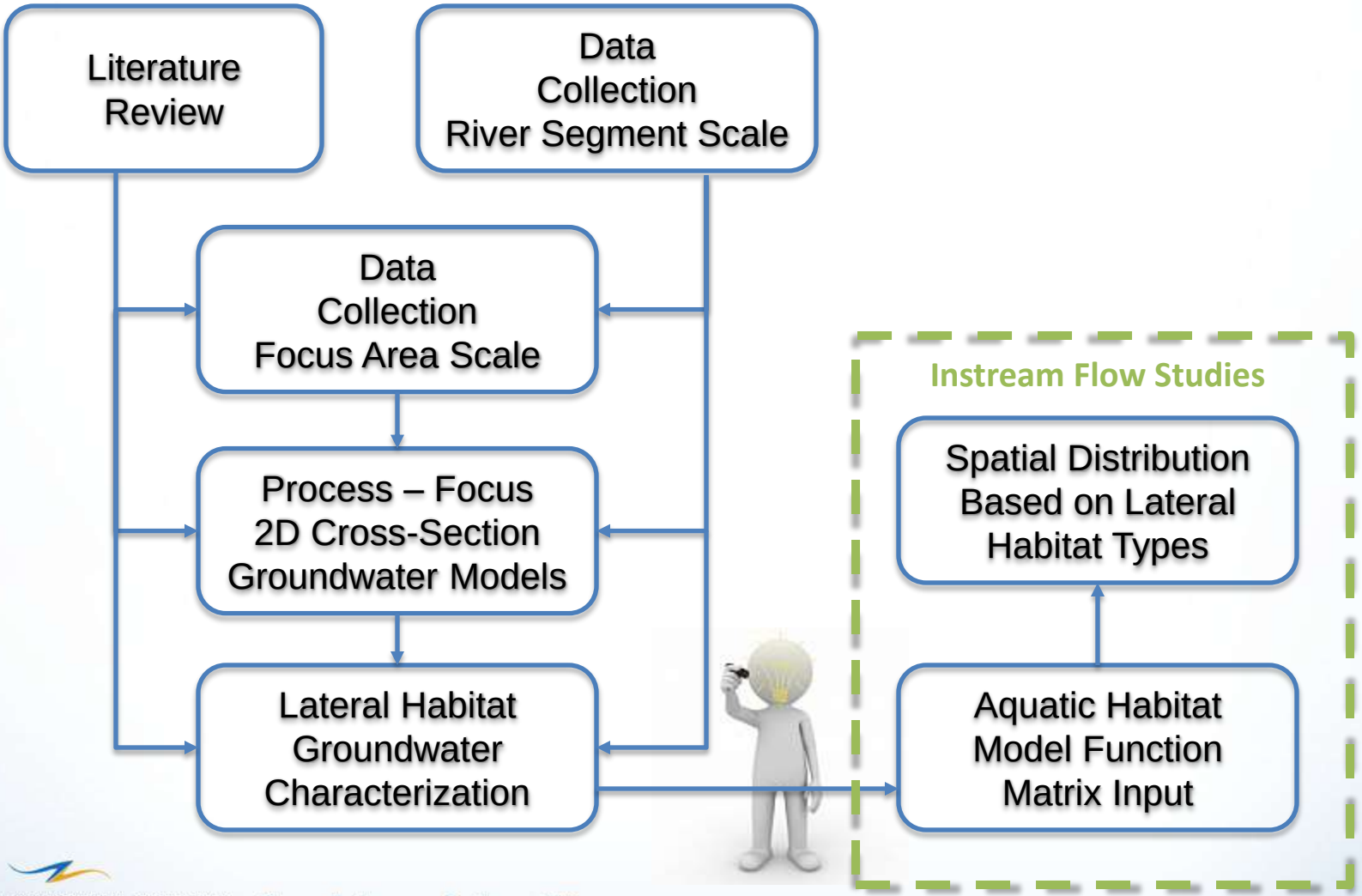
Groundwater Study Modeling & Analysis

- Key Questions:
  - Riparian Questions
    - Will Project operations result in lower groundwater levels in the floodplain during summer periods and to what extent?
    - To what extent are groundwater levels dependent on surface water levels in the main channel?
    - Will precipitation (snowmelt, rainfall) and groundwater inflow be sufficient for limiting Project influences on riparian vegetation?
    - To what extent do these differences vary in multiple geohydrologic and floodplain types?

GW Hydrologic Study



Groundwater Study Analysis Process



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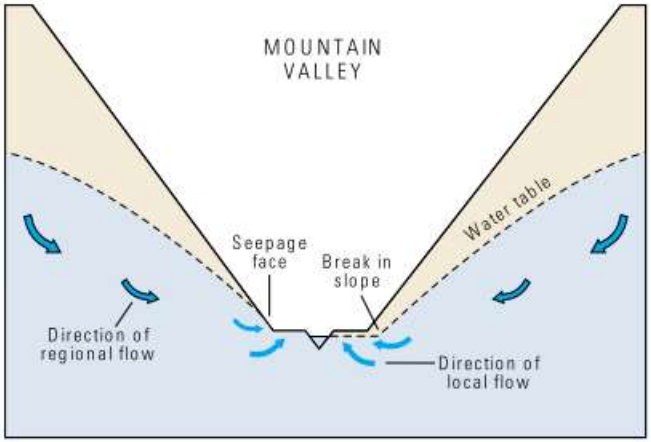
Groundwater System Examples



Upper Middle River - Mountainous Terrain:

- **Groundwater-supplied "baseflow"**
- **Hyporheic exchange: local-scale importance**

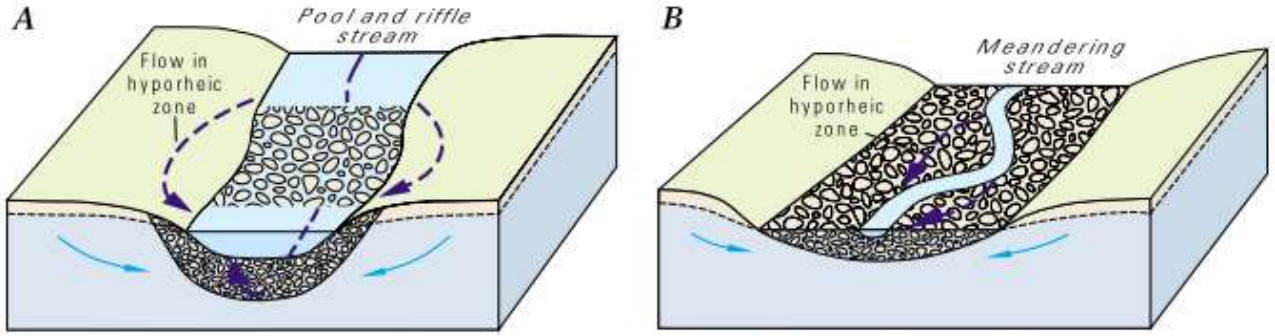
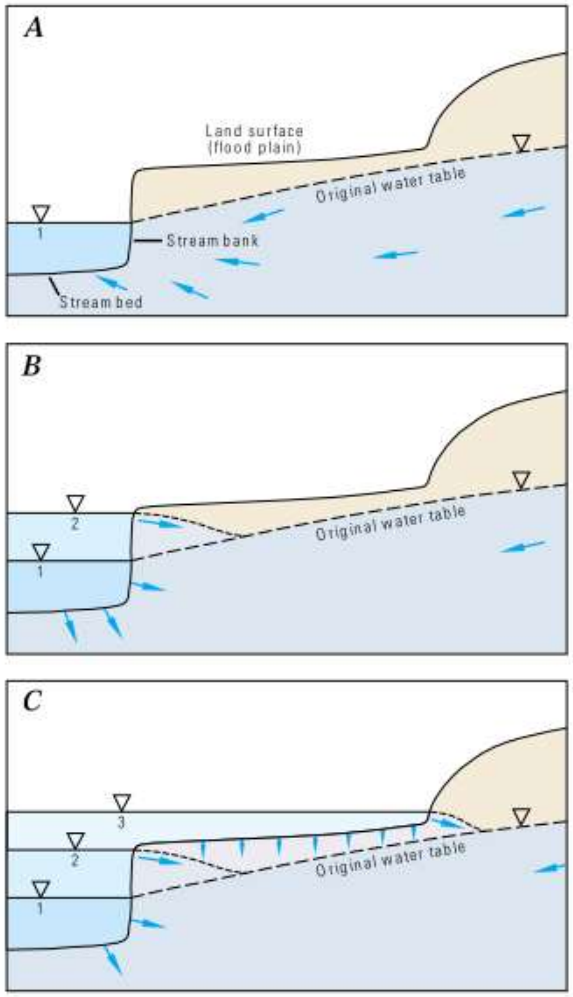


Figure 14. Surface-water exchange with ground water in the hyporheic zone is associated with abrupt changes in streambed slope (A) and with stream meanders (B).

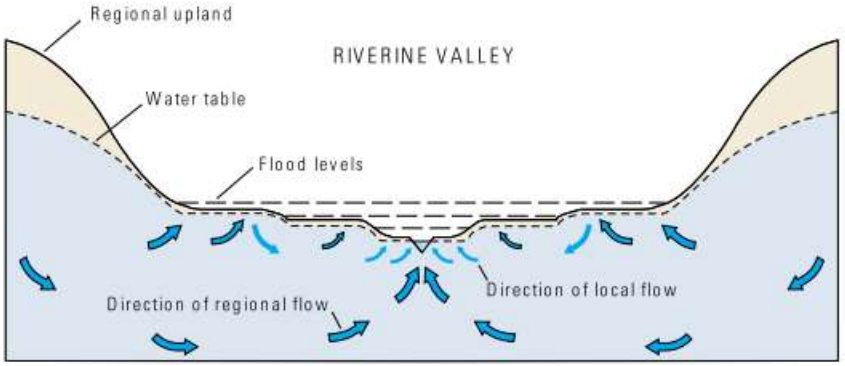
T.C. Winter, 1998

Groundwater System Examples



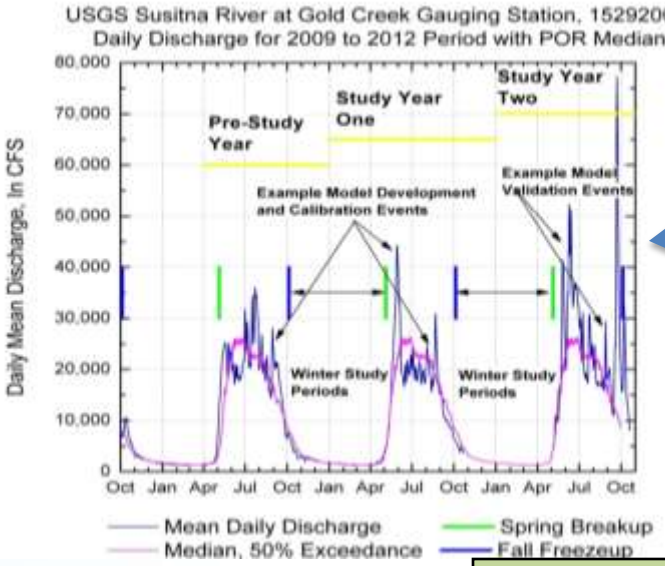
Lower Middle River - Riverine Terrain:

- **Regional vs. local scale flowpaths**
- **Flood waters → "Bank storage"**

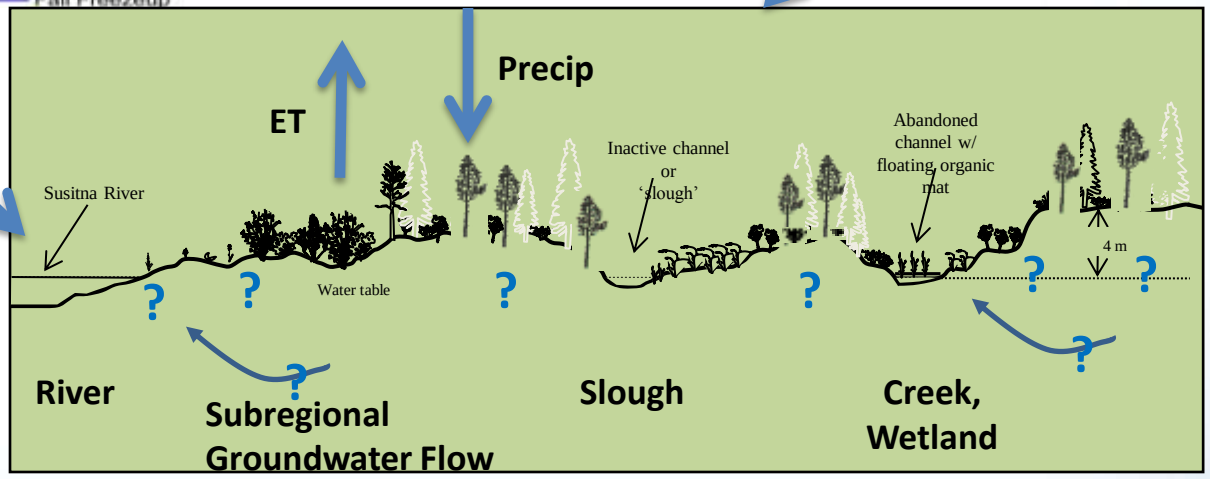


T.C. Winter, 1998

How Does The Natural System Work?



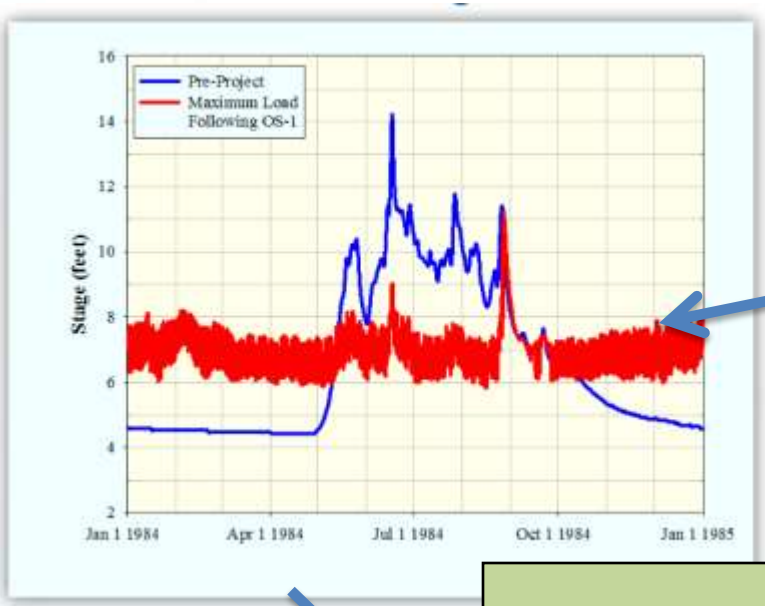
Consider These Surface Water Dynamics with the Below Environment: Taking into Account the Predominant Winter Period, Transition Periods and Summer Season



ET = Evapotranspiration

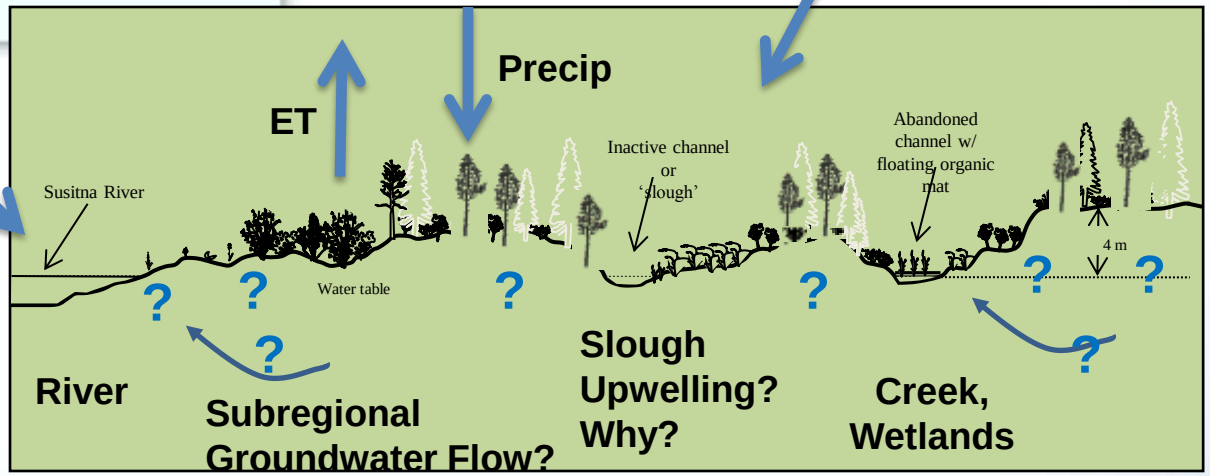
Looking Downstream, (note: groundwater flow is not 2D)

Would There Be Project Effects?



Consider These Surface Water Dynamics with the Below Environment

Project Effects?



Looking Downstream, (note: groundwater flow is not 2D)

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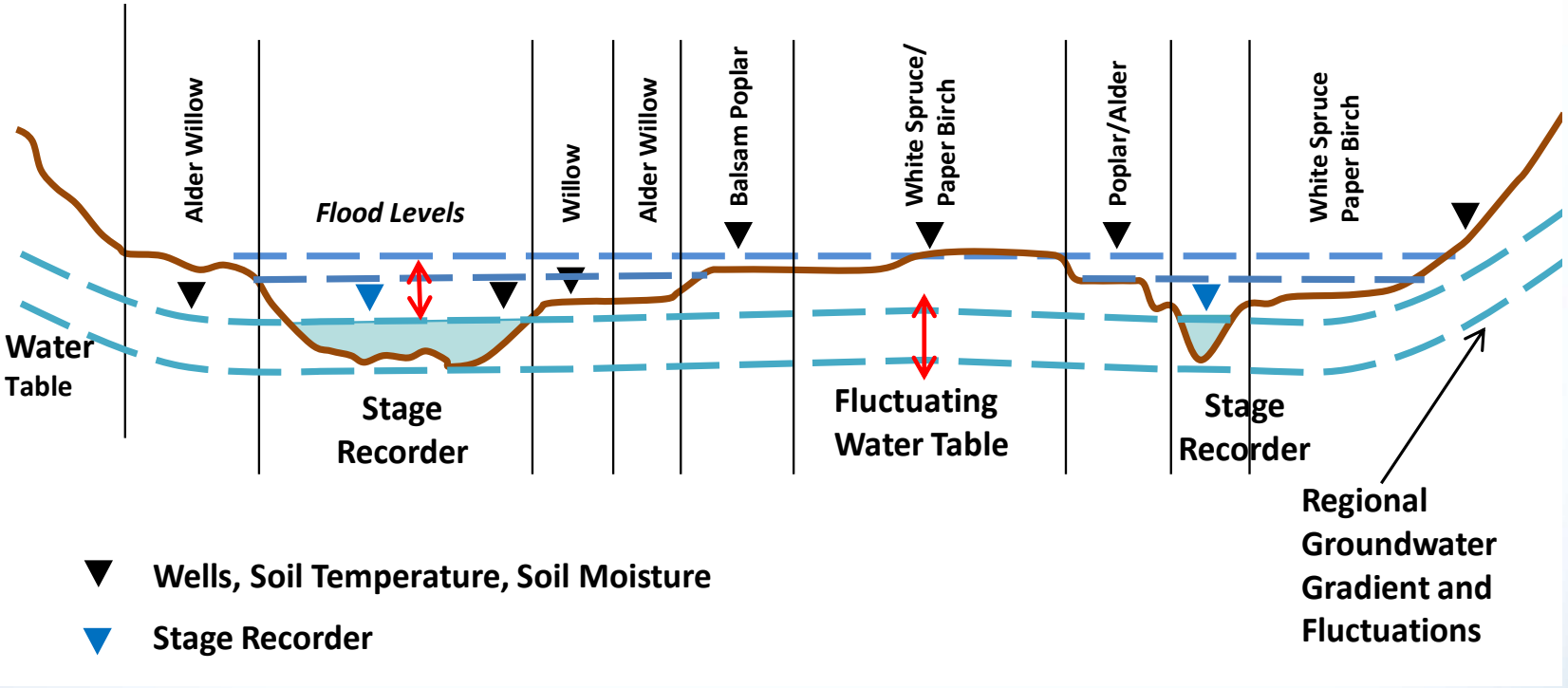
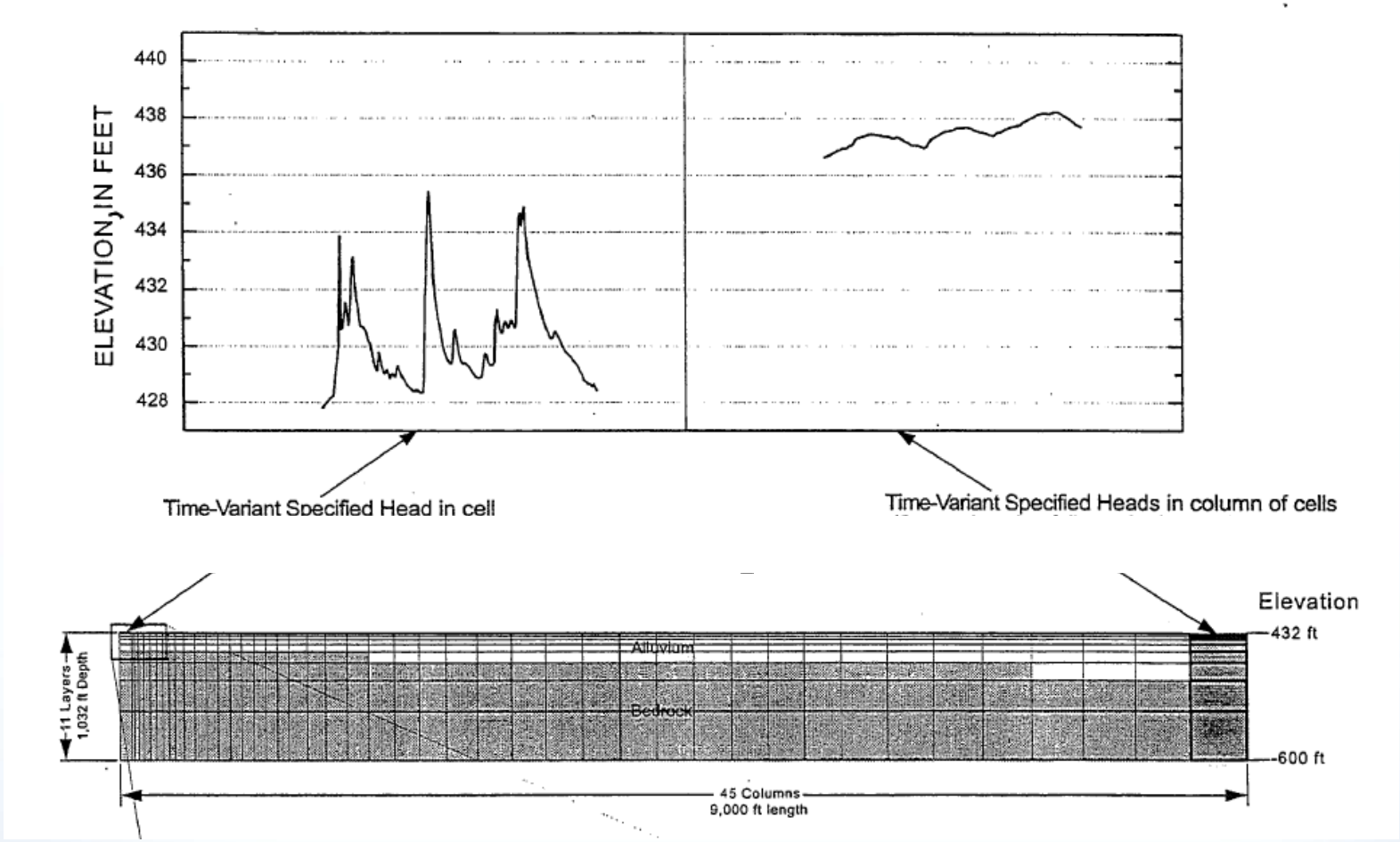
Groundwater/Surface-Water Interactions

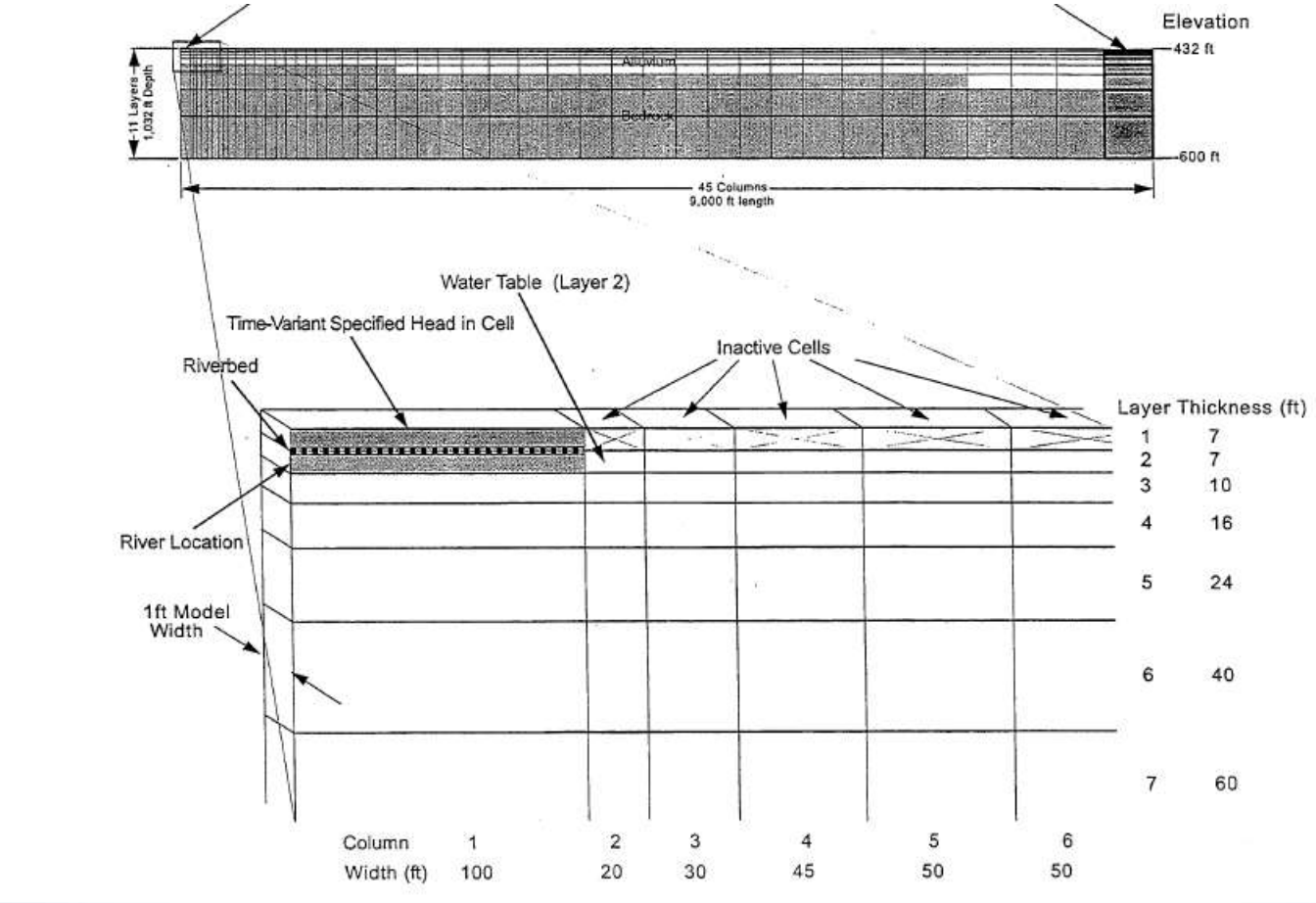
Data Collection + Modeling = Process Understanding



Cross-Section Model Examples



Cross-Section Model Examples



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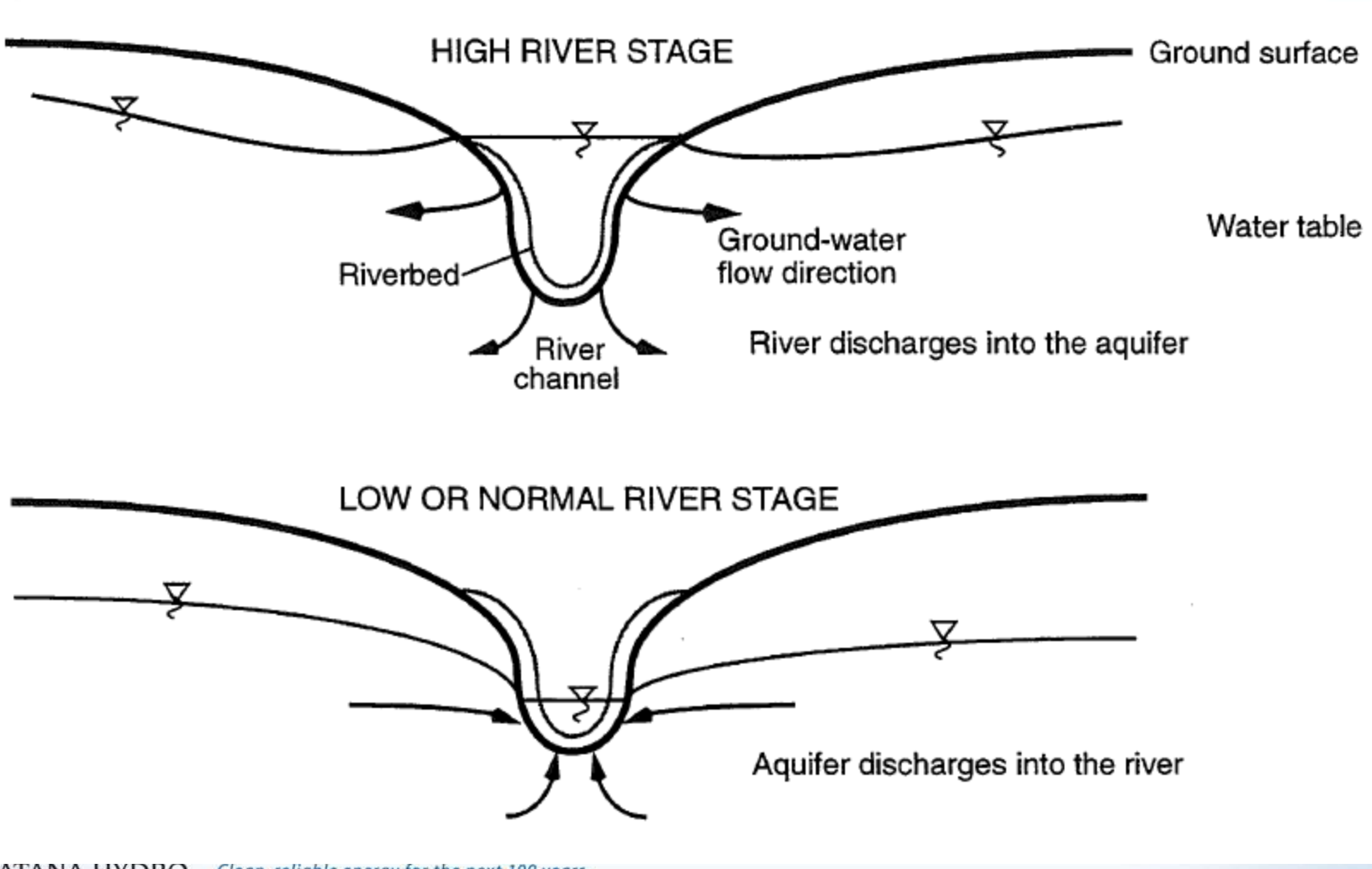
Groundwater System Examples



Groundwater Study Modeling

- Major Objective:
  - Improve Process Understanding of GW/SW Interactions
- Major Model Inputs:
  - Main Channel/Side Channel River Stage
  - Precipitation
  - Groundwater Boundary Conditions
  - Hydrogeologic Aquifer Properties
  - Topographic Surface and Surface-Water Features

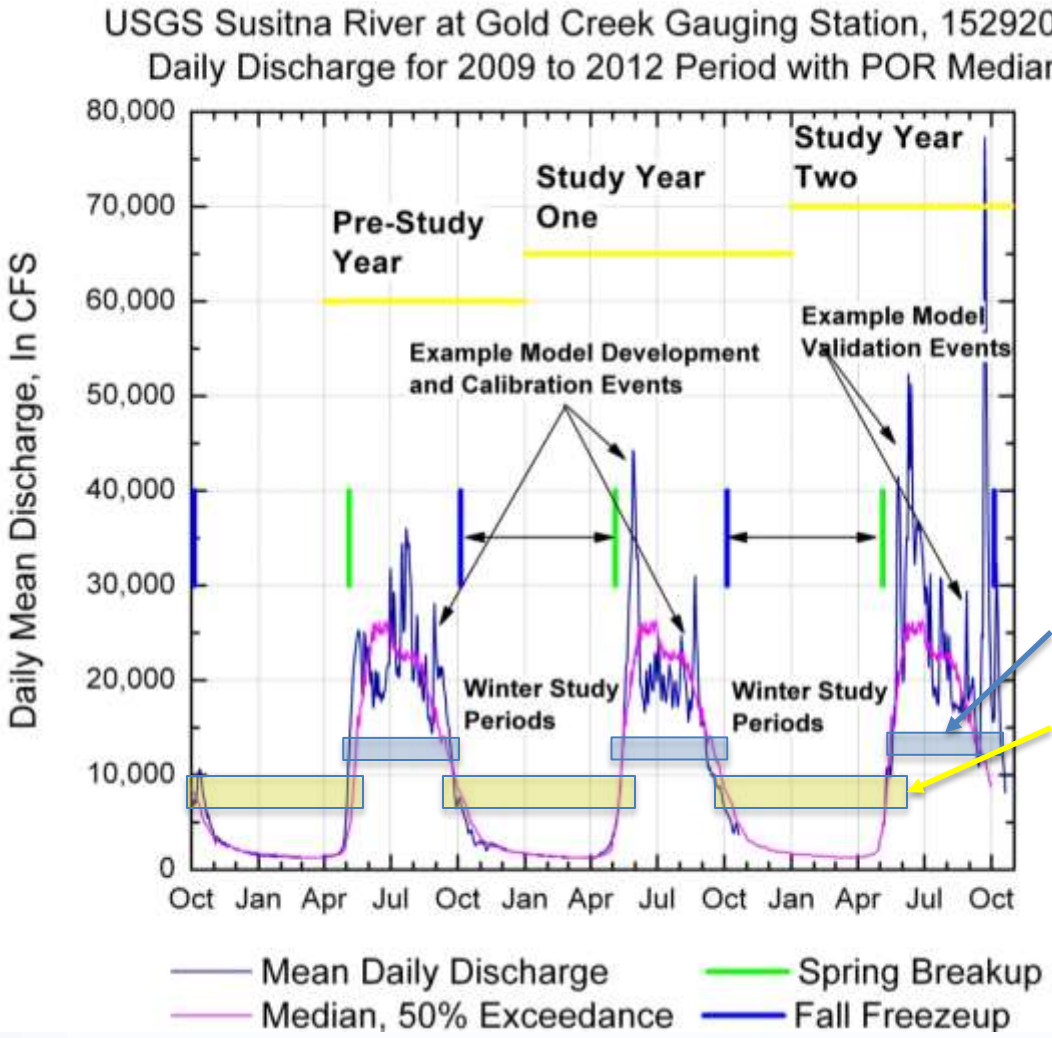
Groundwater Study Modeling

- Modeling Timescales:
  - Transient, Annual, Multi-Year
  - Major Hydrologic Periods
    - Spring Breakup
    - Summer
    - Fall Freeze-Up
    - Winter
  - Field Data Collection Design For These Periods

Groundwater Study Modeling

- Modeling Dependencies:
  - Summer and Winter Main Channel Stage Levels
    - Open Water Flow Routing Model
      - 15 minute to daily stage data at cross-section location, or close enough to apply shifts
    - Winter Ice Processes Model
      - 15 minute to daily stage data at cross-section location, or close enough to apply shifts

Major Groundwater Model Inputs



Open-Flow Routing Model Stage Input

Ice Routing Model Stage Input

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Groundwater Study Modeling

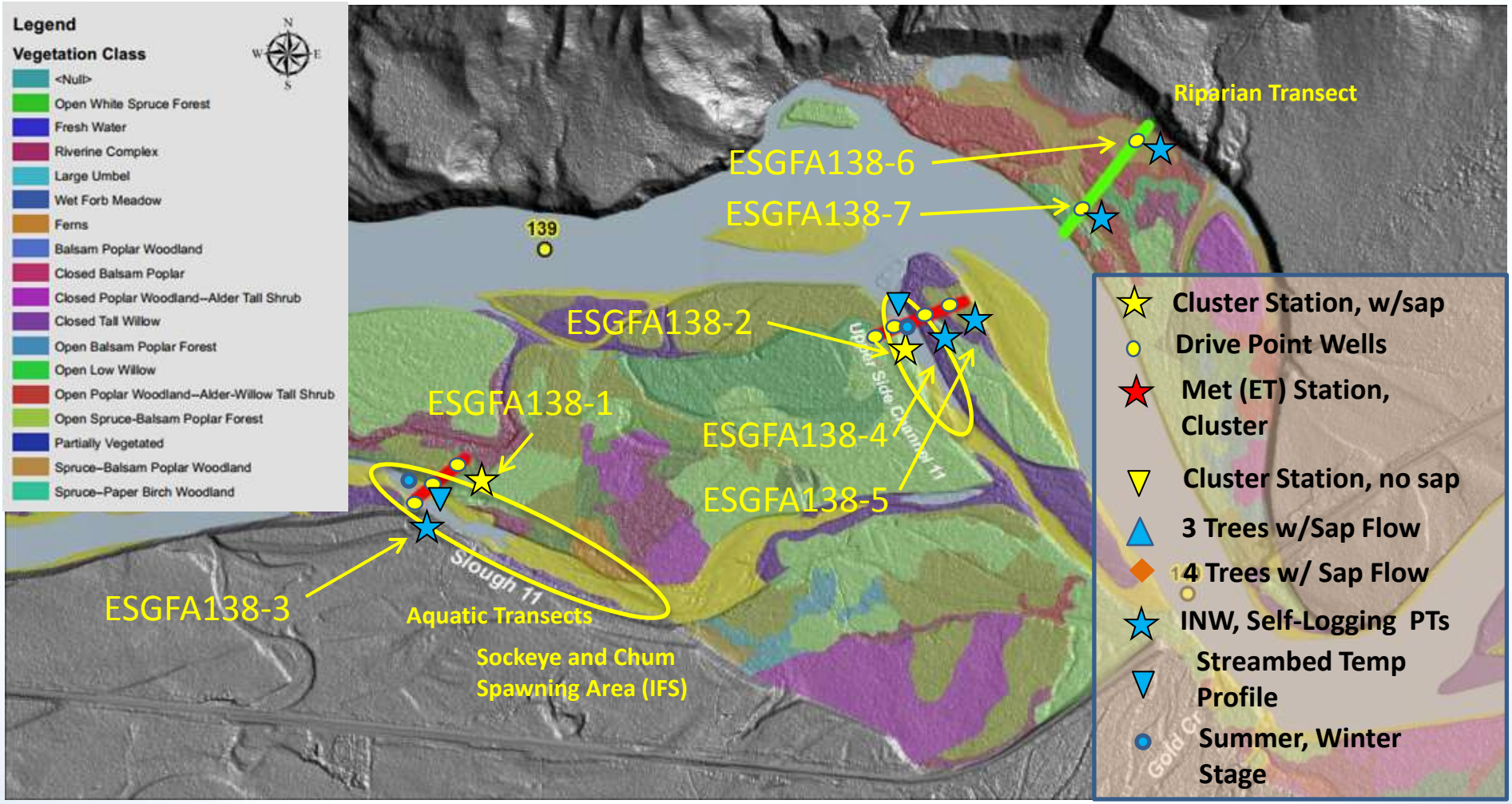
- Modeling Units:
  - Stage or Water Level = Feet Above Sea Level (Project Datum Standards)
  - Flux or Discharge = Cubic Feet per Second (cfs)
  - Horizontal Coordinates = State Plain to Project Datum

Groundwater Study Modeling

- Focus Areas with Groundwater Modeling:
  - FA104 – Whiskers Creek
    - (1) Riparian 2-D Transect Model
    - (2) Small Aquatic 2-D Transect Models
  - FA115 – Lane Creek – Slough 6A
    - (1) Riparian 2-D Transect Model

Groundwater Study Modeling

- Focus Areas with Groundwater Modeling:
  - FA128 – Skull Creek Complex – Slough 8A
    - (2) Riparian 2-D Transect Model
    - (2) Small Aquatic 2-D Transect Models
    - (1) Combined Aquatic/Riparian 3D Model
  - FA138 – Gold Creek
    - (2) Small Aquatic 2-D Transect Models



FA-138, Gold Creek Focus Area, GW Task6 Aquatic, Task5 Riparian Stations

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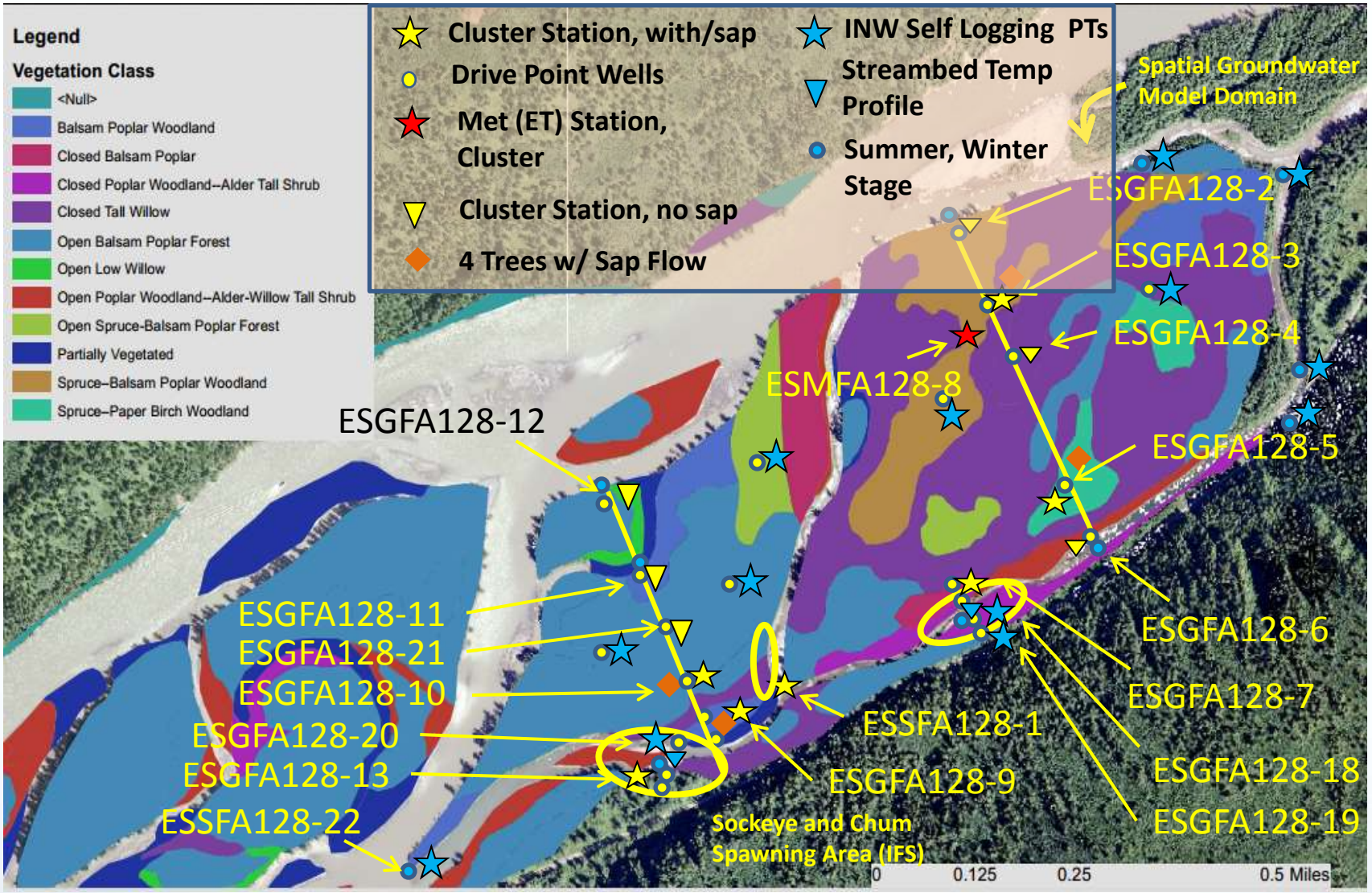
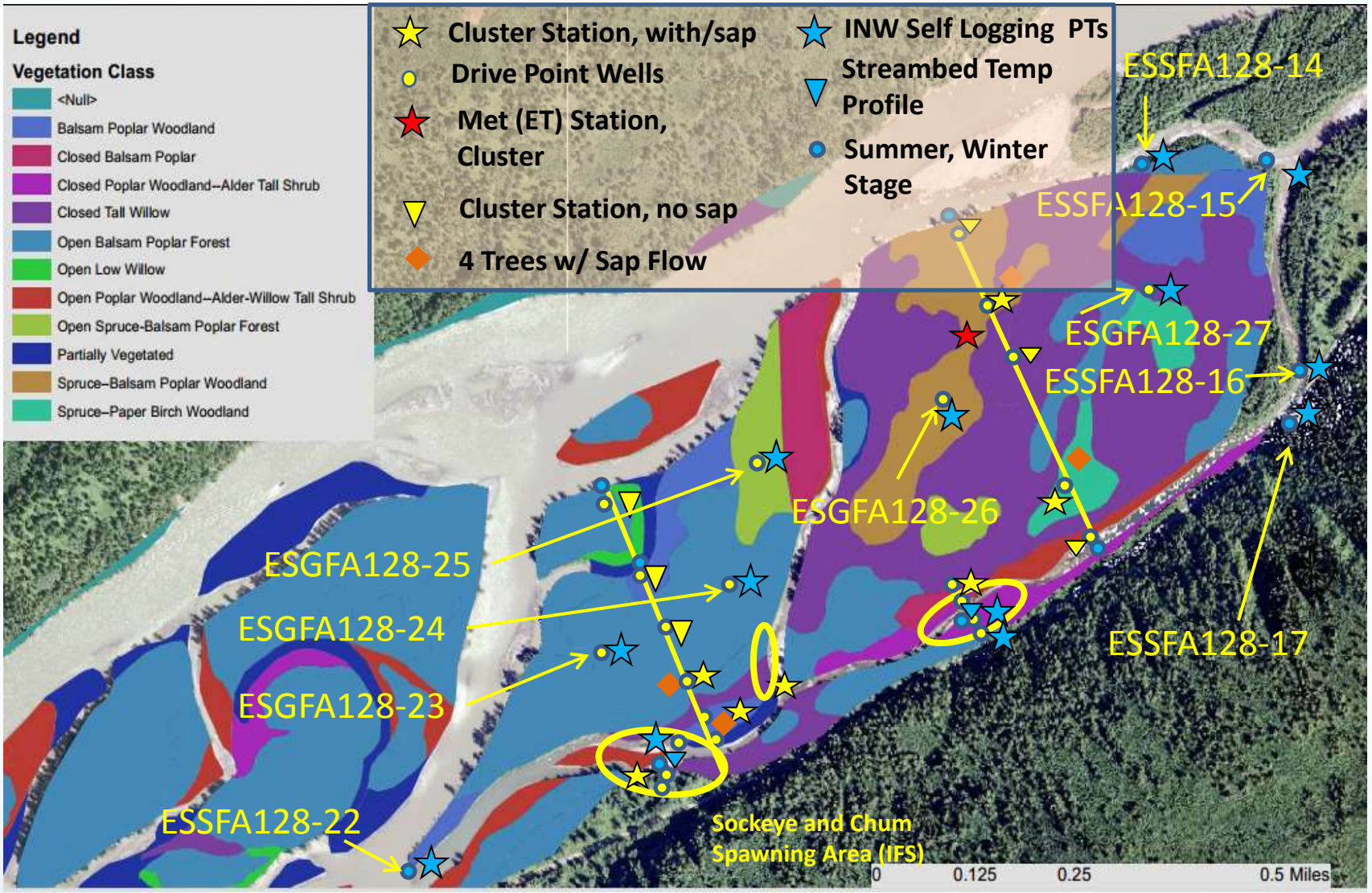


Skull Creek Complex FA (Slough 8A) Aquatic and Riparian Stations



Skull Creek Complex FA (Slough 8A) Aquatic and Riparian Stations

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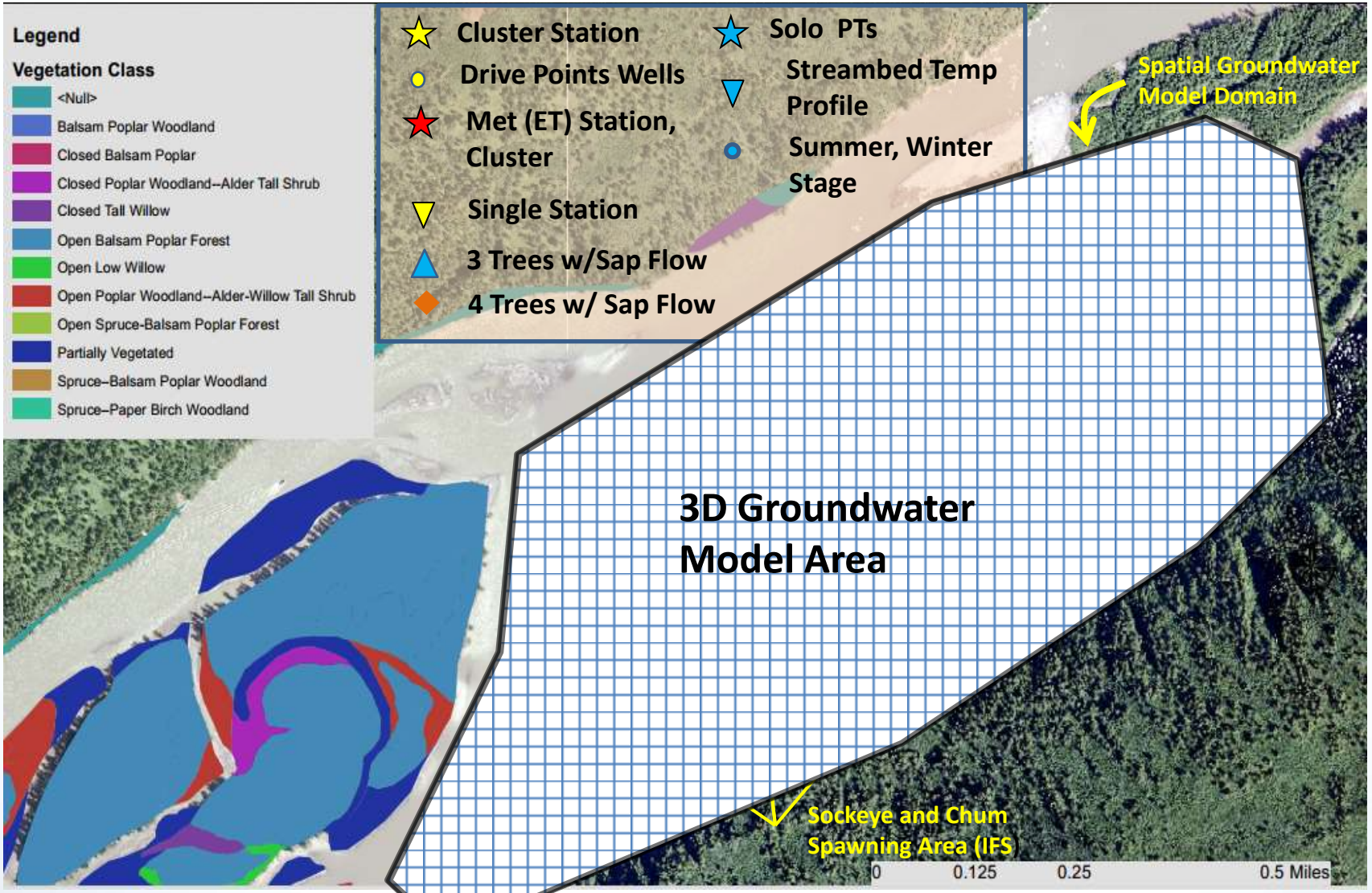

FA128 - Skull Creek Complex FA (Slough 8A) Riparian Transects

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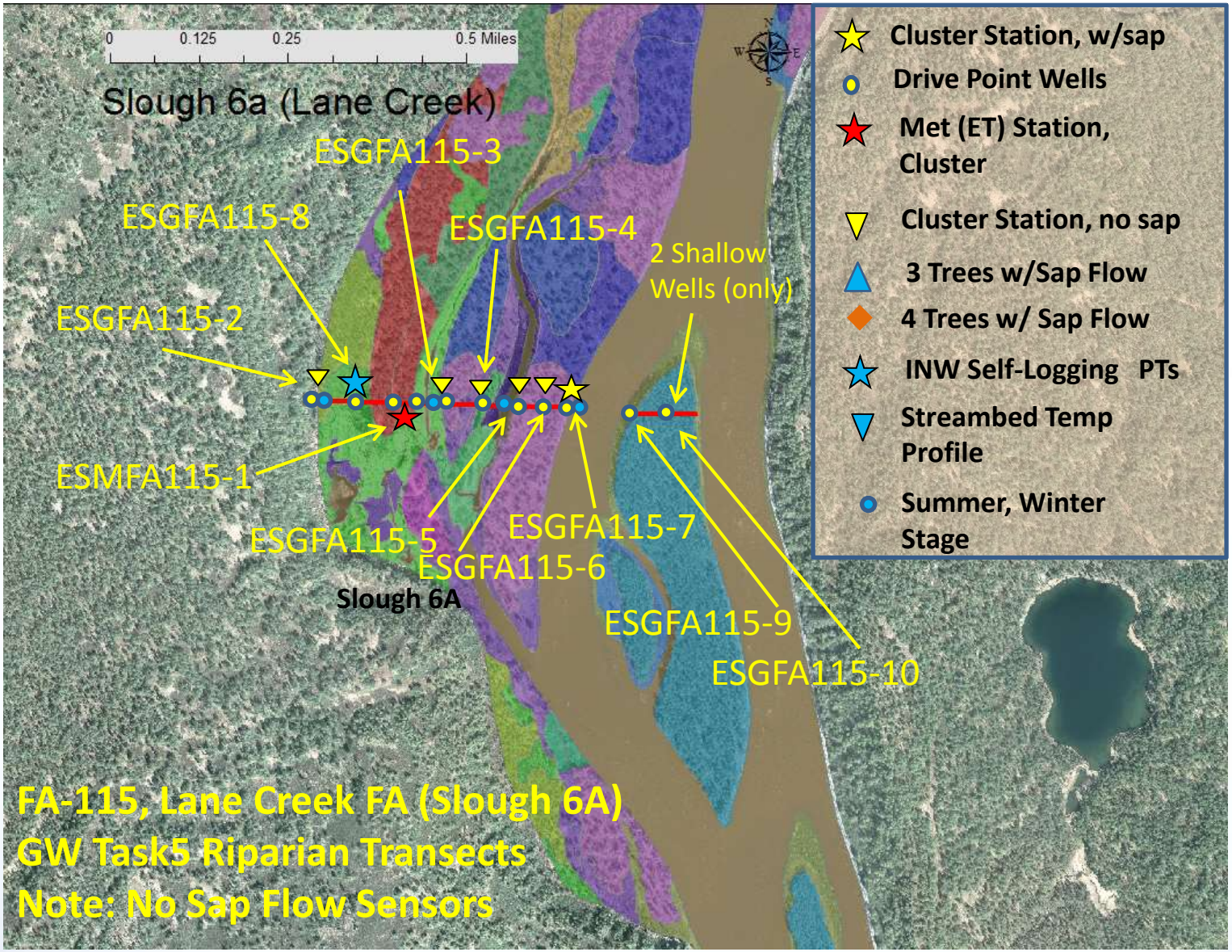
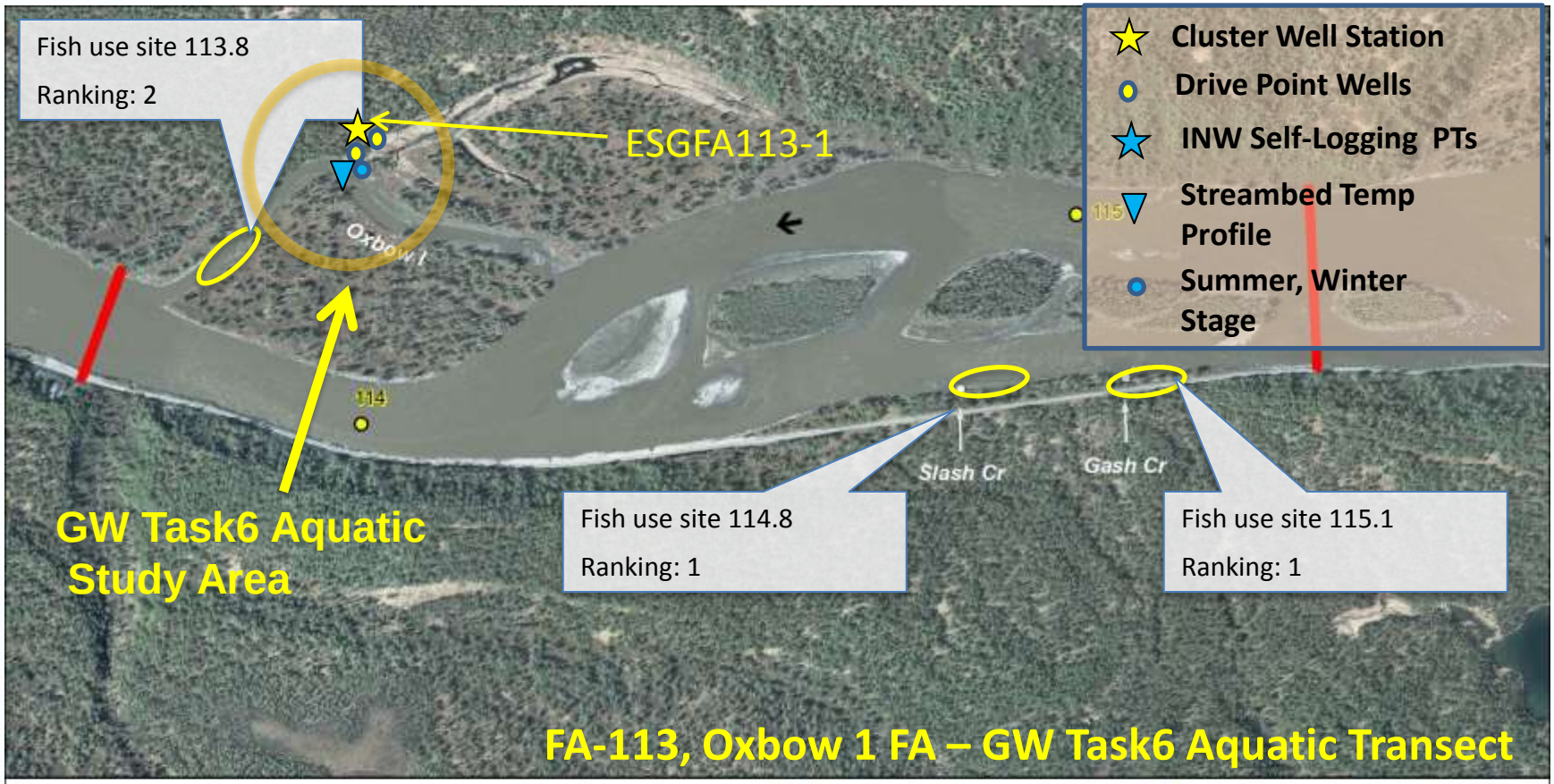
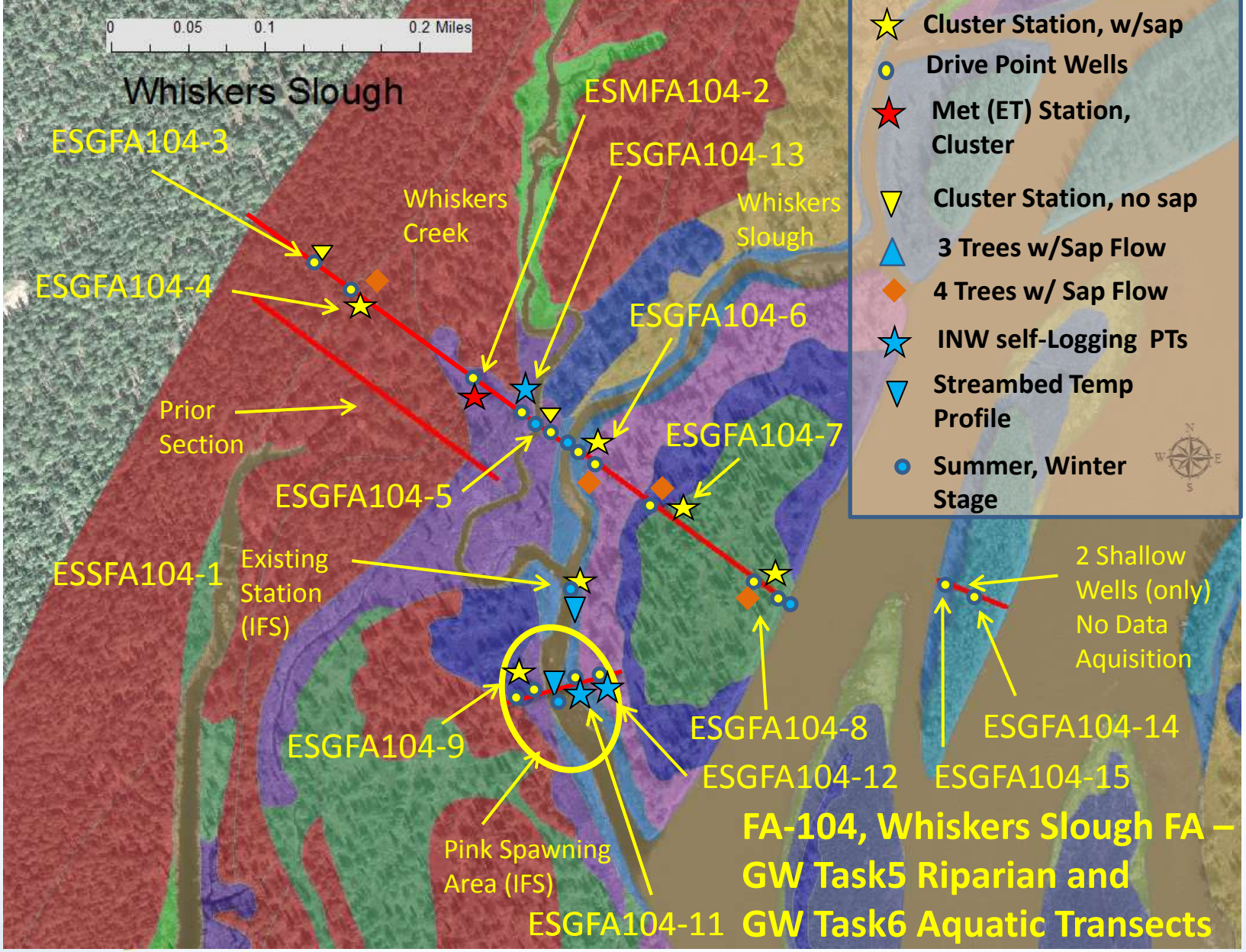
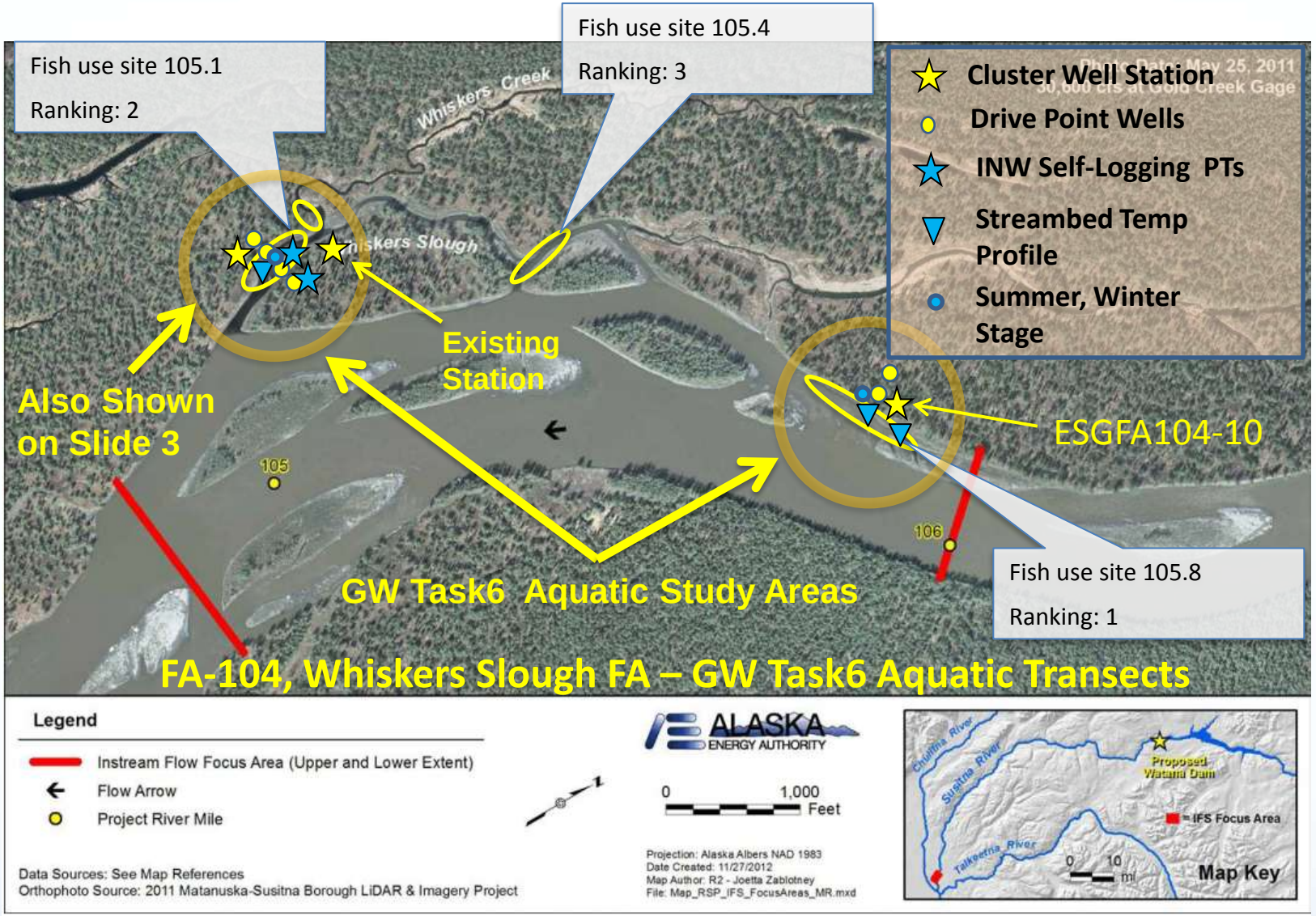

0
0.125
0.25
0.5 Miles
Slough 6a (Lane Creek)
ESGFA115-3
ESGFA115-8
ESGFA115-4
2 Shallow Wells (only)
ESGFA115-2
ESMFA115-1
ESGFA115-5
ESGFA115-7
ESGFA115-6
Slough 6A
ESGFA115-9
ESGFA115-10
Cluster Station, w/sap
Drive Point Wells
Met (ET) Station, Cluster
Cluster Station, no sap
3 Trees w/Sap Flow
4 Trees w/ Sap Flow
INW Self-Logging PTs
Streambed Temp Profile
Summer, Winter Stage
FA-115, Lane Creek FA (Slough 6A)
GW Task5 Riparian Transects
Note: No Sap Flow Sensors



SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*


0 0.05 0.1 0.2 Miles
Whiskers Slough
ESGFA104-3
ESMFA104-2
ESGFA104-13
Whiskers Creek
Whiskers Slough
ESGFA104-4
ESGFA104-6
Prior Section
ESGFA104-7
ESGFA104-5
ESSFA104-1
Existing Station (IFS)
2 Shallow Wells (only) No Data Aquisition
ESGFA104-9
ESGFA104-8
ESGFA104-14
ESGFA104-12
ESGFA104-15
Pink Spawning Area (IFS)
ESGFA104-11
FA-104, Whiskers Slough FA – GW Task5 Riparian and GW Task6 Aquatic Transects
Cluster Station, w/sap
Drive Point Wells
Met (ET) Station, Cluster
Cluster Station, no sap
3 Trees w/Sap Flow
4 Trees w/ Sap Flow
INW self-Logging PTs
Streambed Temp Profile
Summer, Winter Stage



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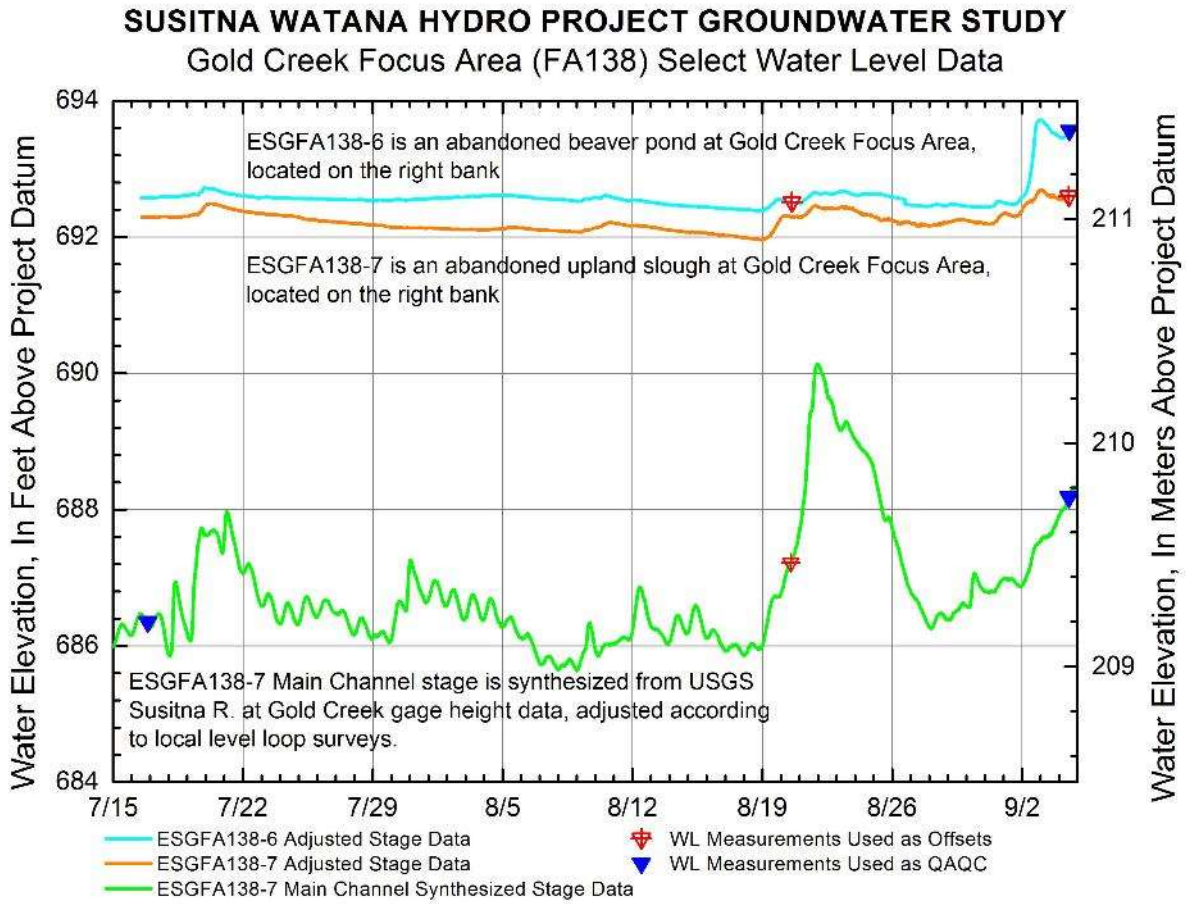
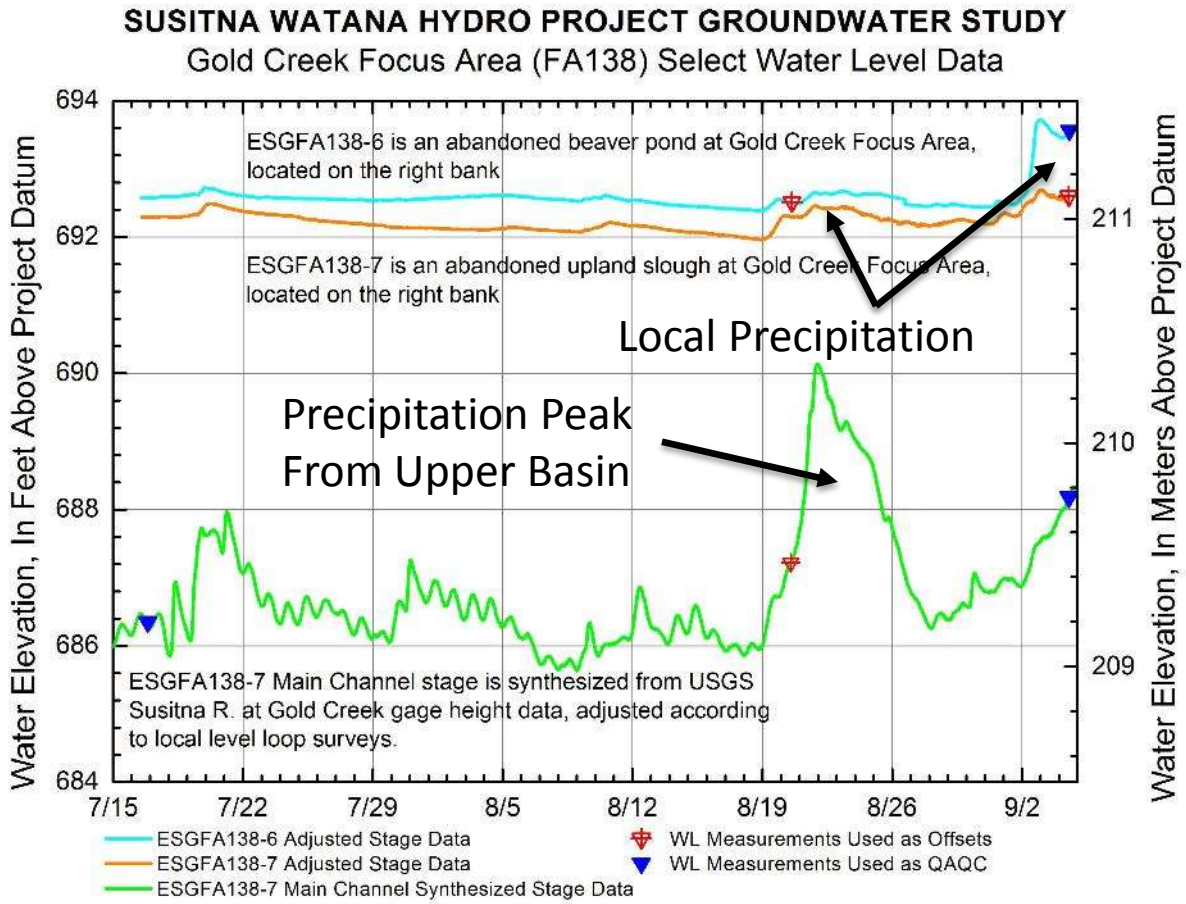
FA-138, Gold Creek Focus Area Example Data and Observations



FA-138, Gold Creek Focus Area Example Data and Observations



Groundwater Metrics

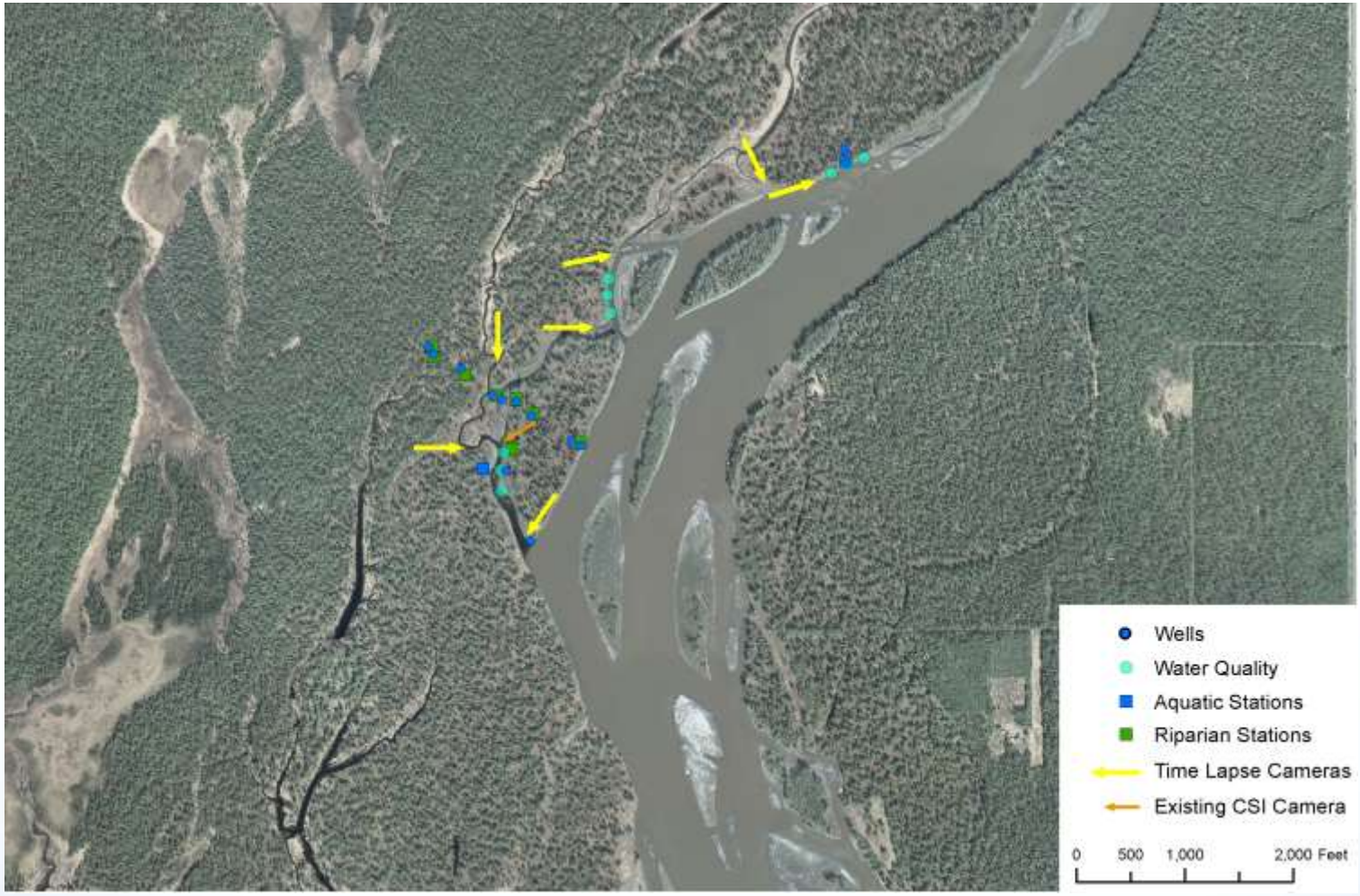
- Upwelling, downwelling changes
- Groundwater stage, temperature
- Range of variation in GW/SW processes, change in this variability
- Support process understanding to improve professional judgment

Focus Area Example: FA-104 – Whisker Slough

- (2) Aquatic Sections
- (1) Riparian Section
- Focus Area Scale Manual Observations

Lower FA-104 – Whiskers Slough, location of aquatic transect, October 29, 2013

Focus Area Example: FA-104 – Whisker Slough



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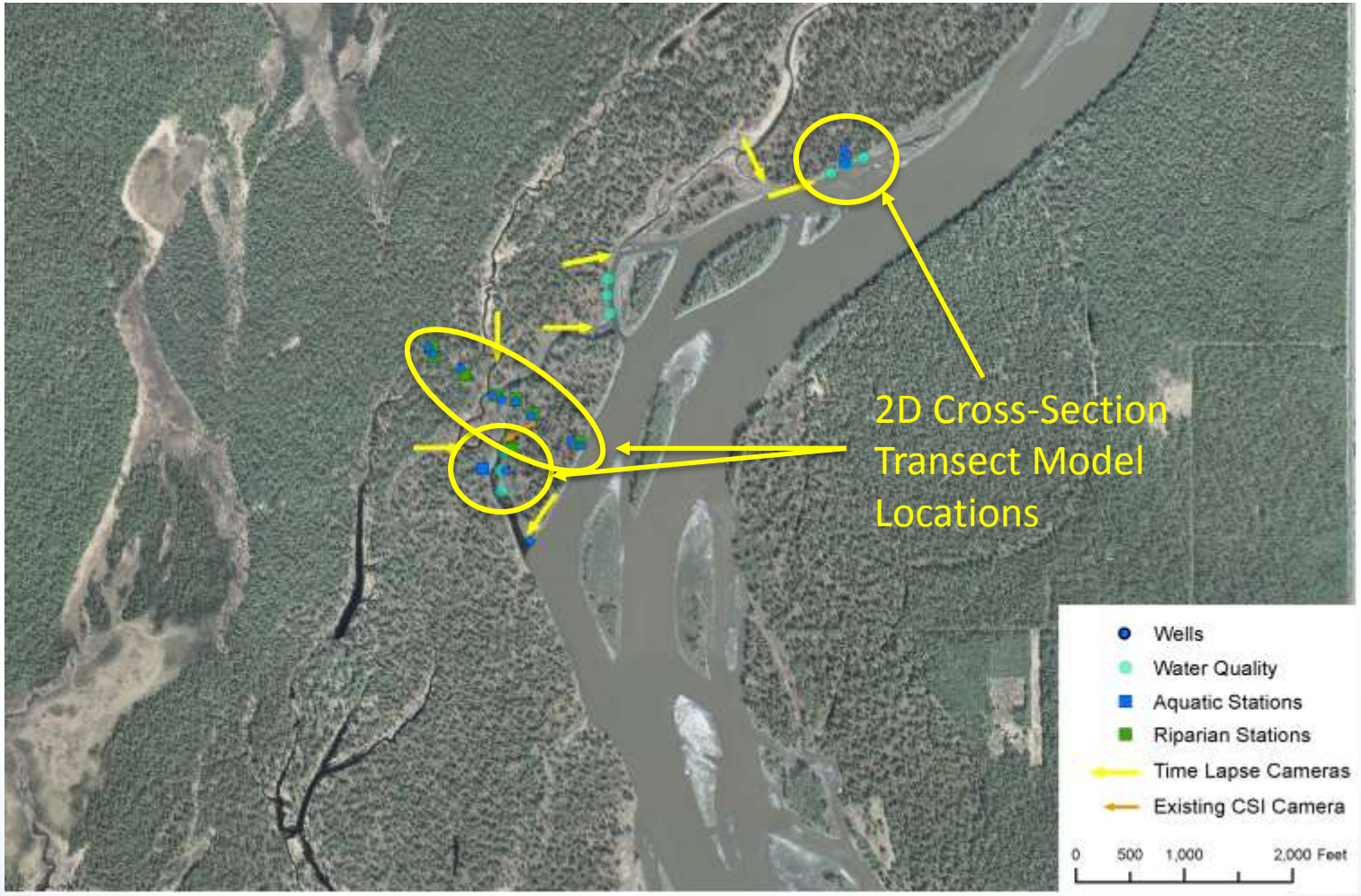
Focus Area Example: FA-104 – Whisker Slough



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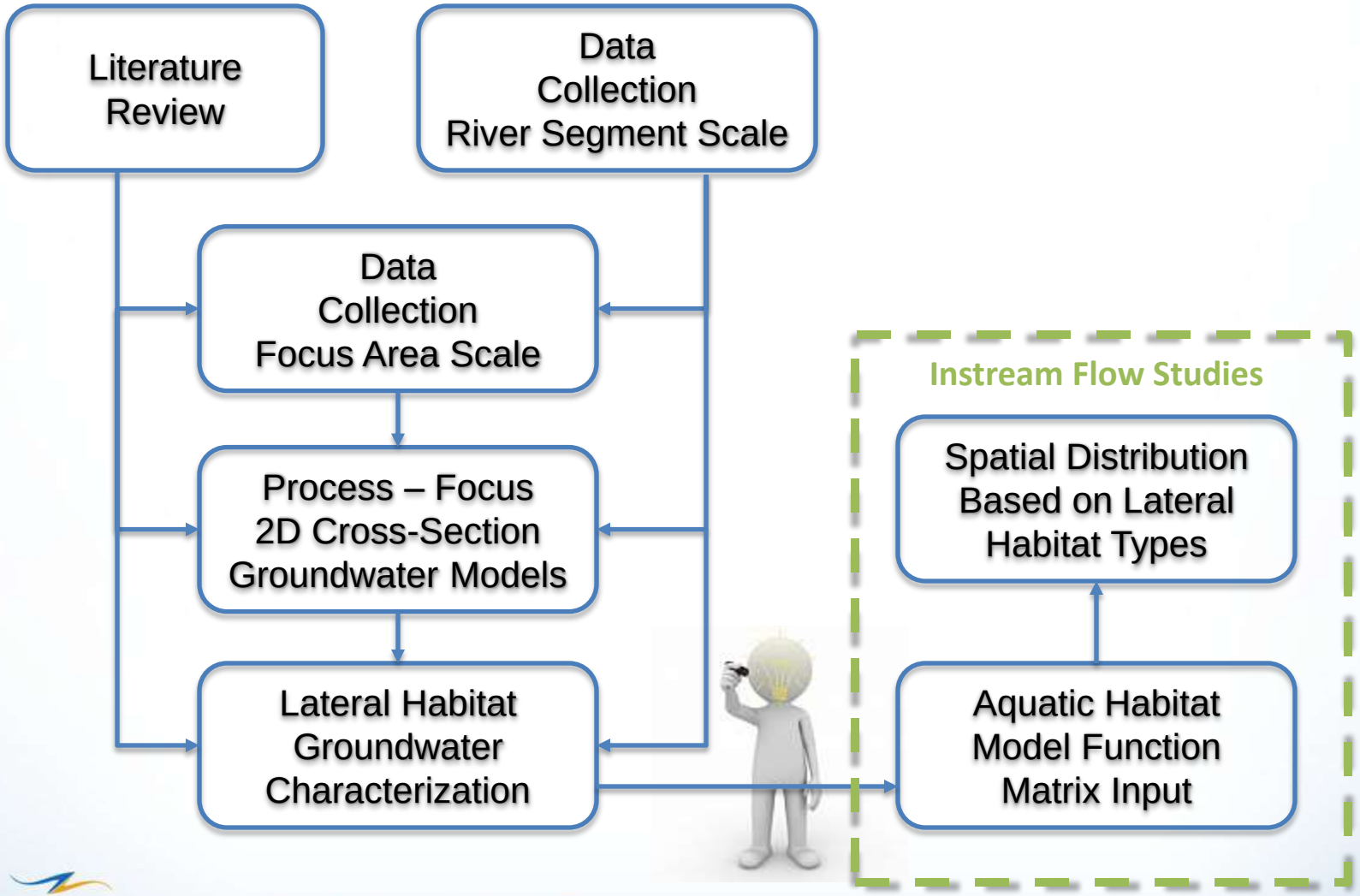
Focus Area Example: FA-104 – Whisker Slough



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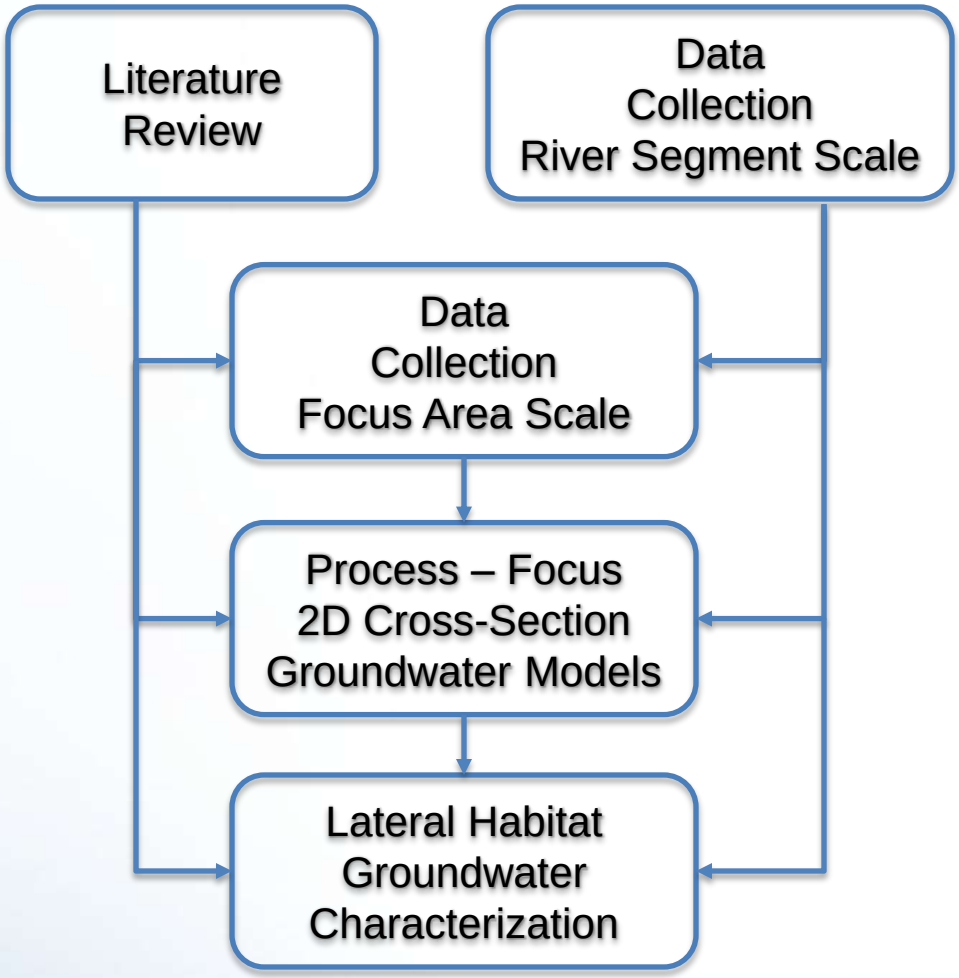
Focus Area Example: FA-104 – Whisker Slough



Data Collection on Annual Basis

- Winter and Summer
- Time-Series Information on Transects
- Additional Manual Measurements
- Spatial Data Sets – Thermal Imaging, Aerial Images (Winter, Summer)

Conceptual Models

- Helps Define the Hydrologic System – Groundwater, Surface Water, Atmospheric

Numerical Models

- Provide Process Understanding and Cause/Effect Analysis, Transient Analysis

Focus Area Example: FA-104 – Whisker Slough

- Aquatic Section FA104-2DM1 – Whiskers Slough
  - Drains Whiskers Creek, Groundwater Inflow, Warm
- Aquatic Section FA104-2DM2 – Right Bank Side Channel
  - Both lateral groundwater inflow (warm) and mainstem (cold – winter; warm – summer)

FA-104 – Whiskers Slough, Right bank side channel, location of aquatic transect, October 29, 2013

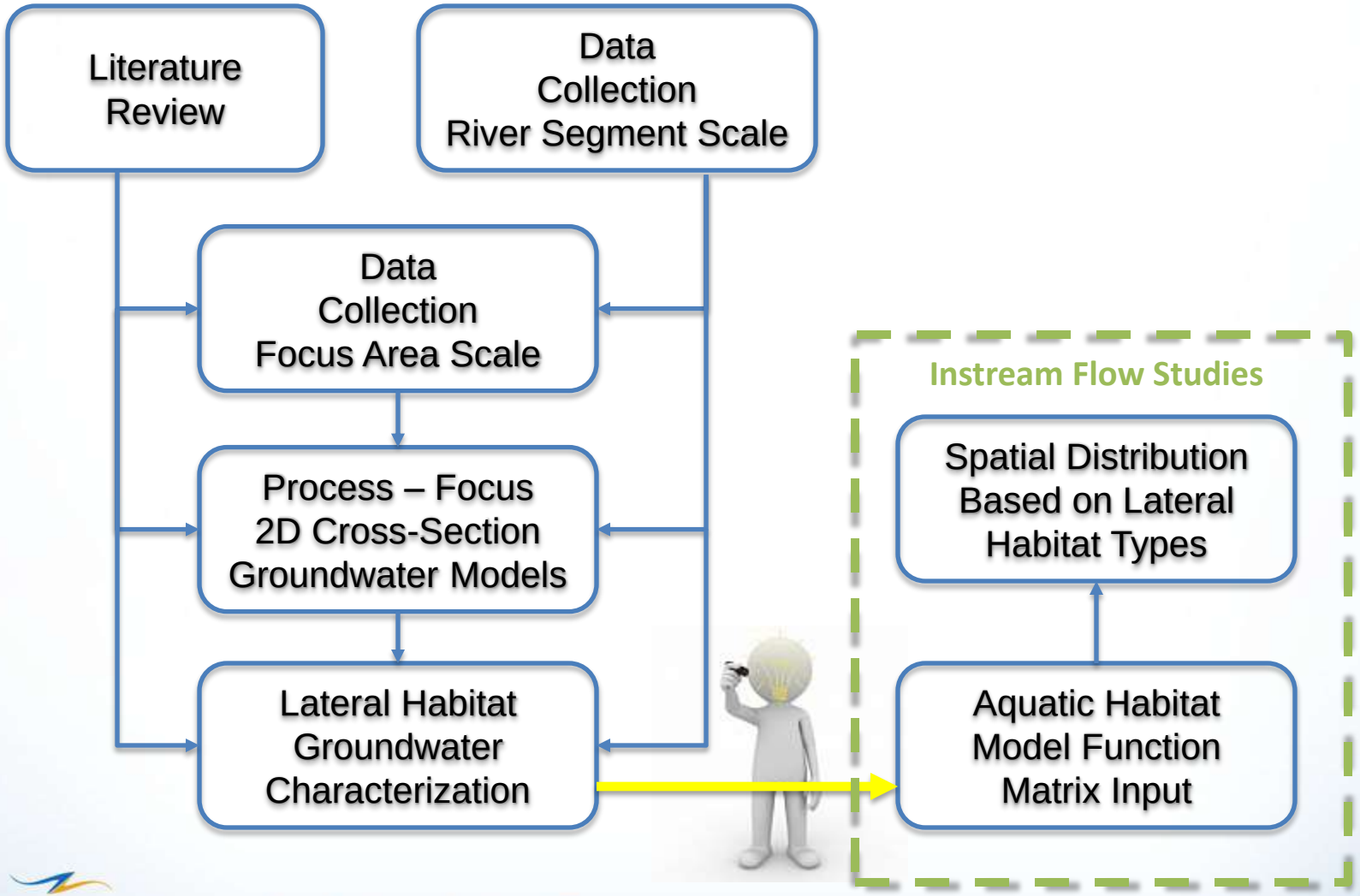
Focus Area Example: FA-104 – Whisker Slough

- Aquatic Section FA104-2DM1 – Whiskers Slough
  - Drains Whiskers Creek, Groundwater Inflow, Warm
- Aquatic Section FA104-2DM2 – Right Bank Side Channel
  - Both lateral groundwater inflow (warm) and mainstem (cold – winter; warm – summer)

Groundwater Upwelling Trends Matrix Input Table – Example Only

Month	Slough Lateral Habitat	Side Channel Lateral Habitat
Oct	Up, Increasing	Up, Increasing
Nov	Up, Increasing	Up, Increasing
Dec	Up, Increasing	Up, Increasing
Jan	Up, Increasing	Up, Increasing
Feb	Up, Increasing	Up, Increasing
Mar	Up, Stable	Up, Stable
Apr	Up, Stable	Up, Stable
May	Up, Stable	Up, Stable
June	Down, Increasing	Down, Increasing
Jul	Down, Increasing	Up, Increasing
Aug	Down, Stable	Up, Stable
Sept	Reversing	Up, Decreasing

Focus Area Example: FA-104 – Whisker Slough



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Groundwater Study

- Thank You!
- Questions?
- More information at:

  www.susitna-watanahydro.org

FA-104 – Whiskers Slough, Left bank side channel, water levels maintained in channel through groundwater seepage, primary source estimated to be mainstem during observed conditions October 29, 2013