Battelle

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Using Applied Environmental Sequence Stratigraphy to Predict TCE Contaminant Migration Pathways: Air Force Plant 42, Palmdale, California

Ryan Samuels

April 11, 2018

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- The importance of Understanding Subsurface Geology
  - Why do we need Environmental Sequence Stratigraphy?
  - What is Environmental Sequence Stratigraphy?

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  - Understanding the depositional environment
  - Regional-scale Sections
  - Plume-scale Sections

01

The Importance of Understanding Subsurface Geology

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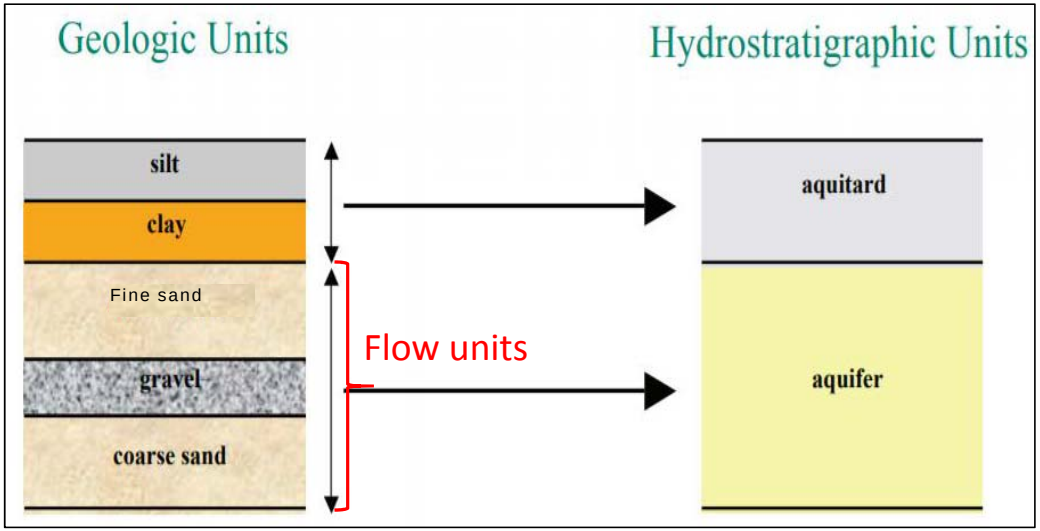
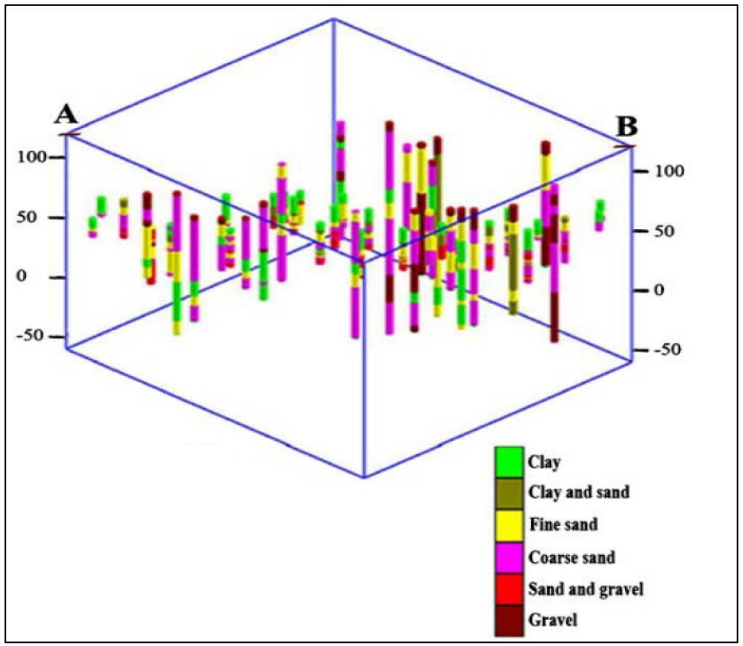
Where is the Water Flowing?

Water and contamination flow through porous sediments with high permeability.



How are the flow units distributed in the subsurface?

Drillers' logs



Spatial variability is limited.

Must understand the subsurface geology!

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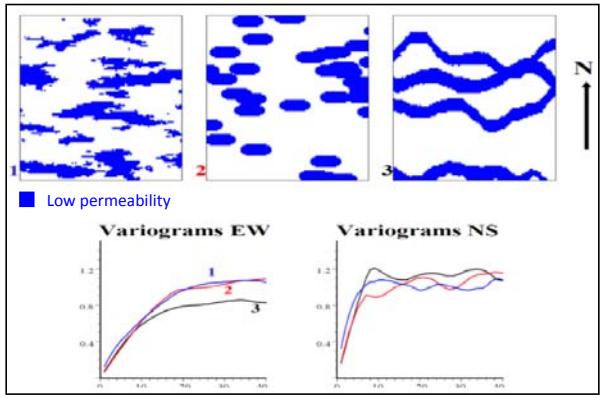
The problem with traditional correlation methods

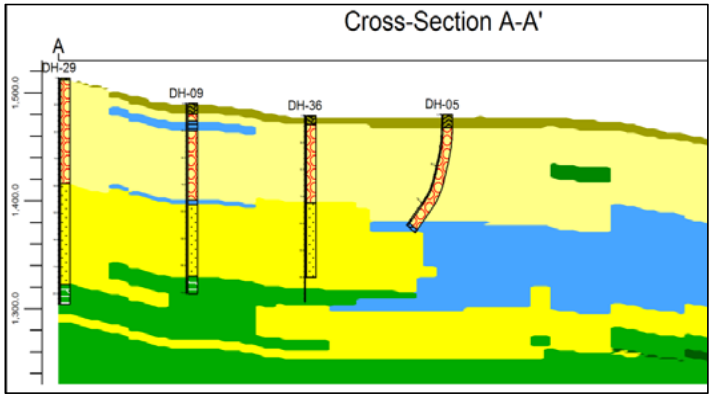
Traditionally, different geostatistical methods are applied (Kriging, Monte Carlo Simulation, etc.) in order to address the lateral variability.

- Does **NOT** represent real-world complexity
- Poor at making 'plume-scale' predictions of flow-path



Caers & Zhang, 2004

Slight parameter tweaks result in drastically different permeability projections!



Example from Rockware Blog.

- Very coarse approximation
- Does not accurately depict geology
- Where is the water flowing?

Must understand the subsurface geology!

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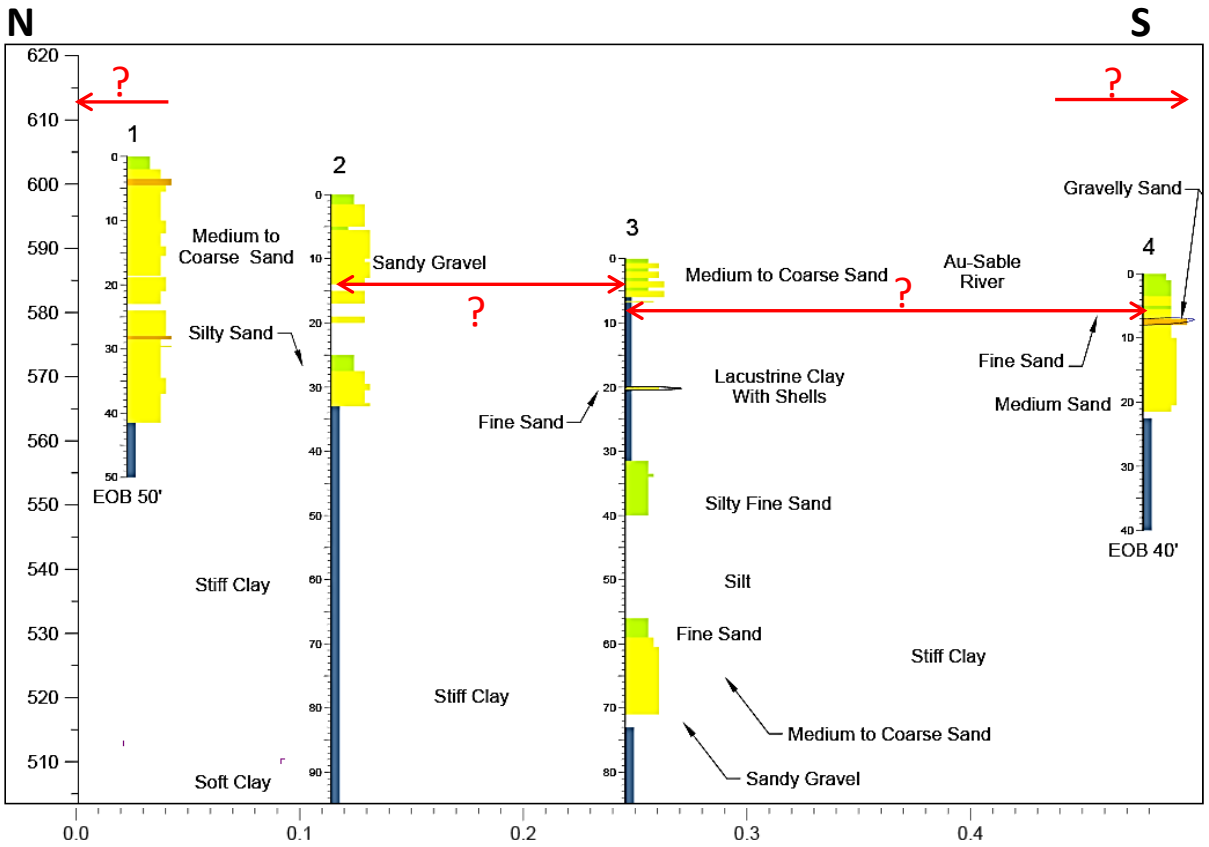
Why do we need Environmental Sequence Stratigraphy?



Challenges

- What do these rocks represent?
- Are these sandstones (yellow & green) continuous between the wells?
- What happens if we go farther in any direction outside data coverage?
- Zero predictive ability.

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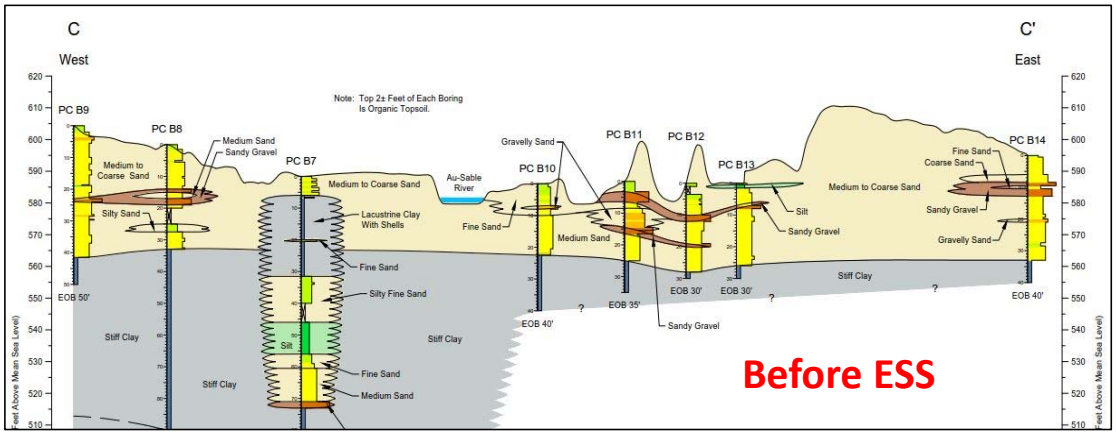
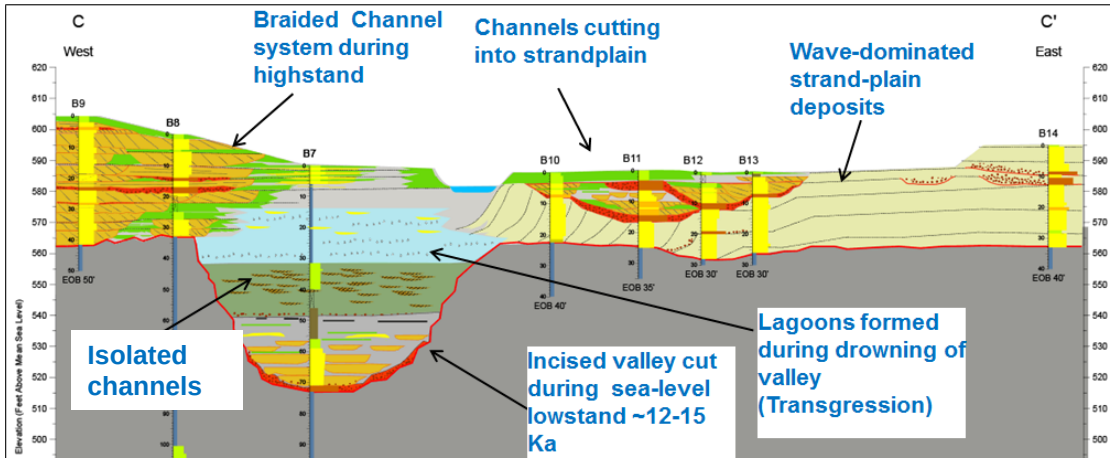
Why do we need Environmental Sequence Stratigraphy?





Environmental Sequence Stratigraphy (ESS) reduces uncertainty between wells/data points and adequately addresses internal heterogeneity.

After ESS

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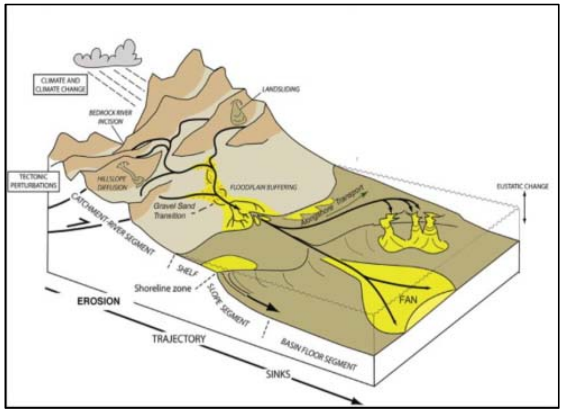
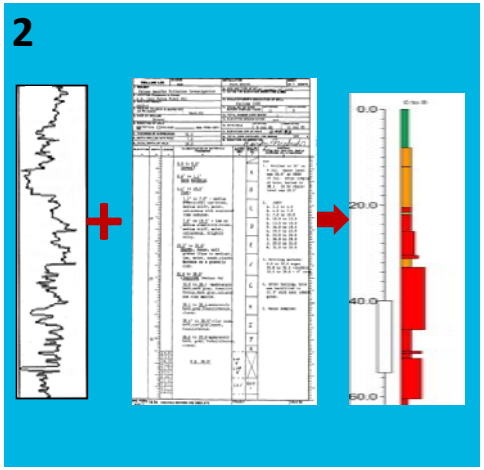
What is Environmental Sequence Stratigraphy (ESS)?

1



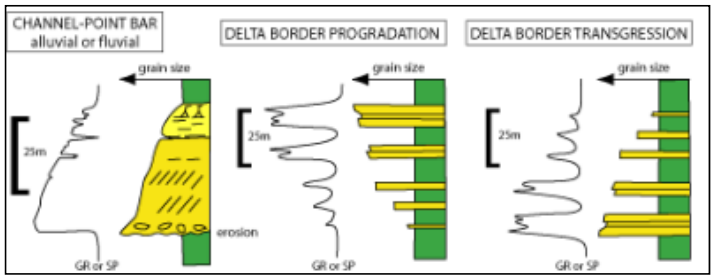
Develop hypothesis from regional study

2



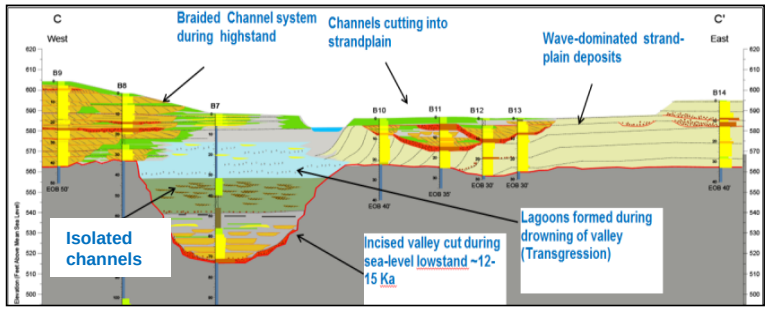
Process CPT log/bore-hole data

3



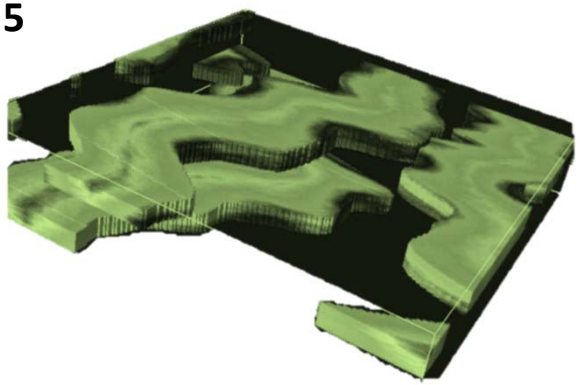
Compare with established models

4



Correlate and determine local depositional environment (hypothesis confirmation)

5



Predict contamination flow-path

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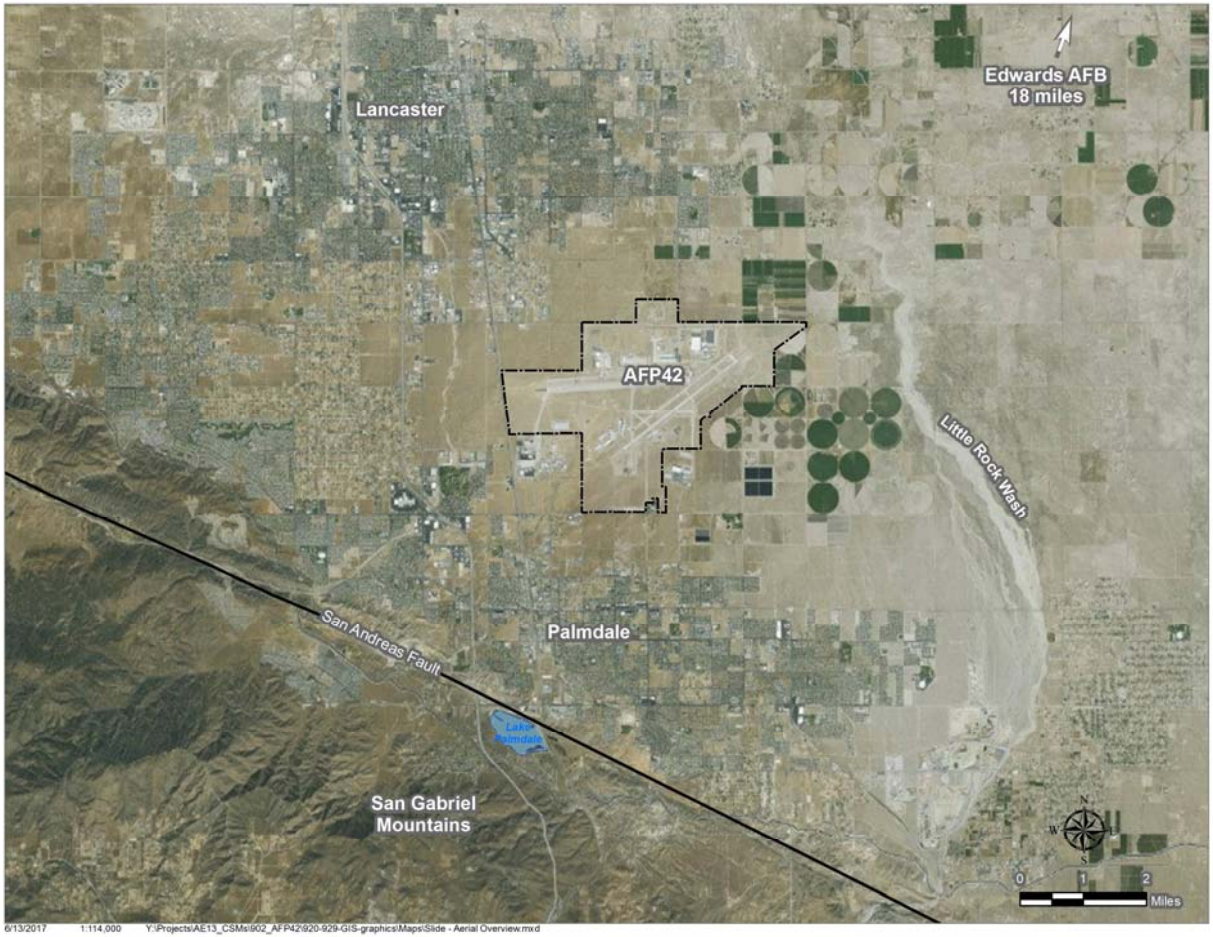
02

Case Study: AFP 42

Depositional Setting



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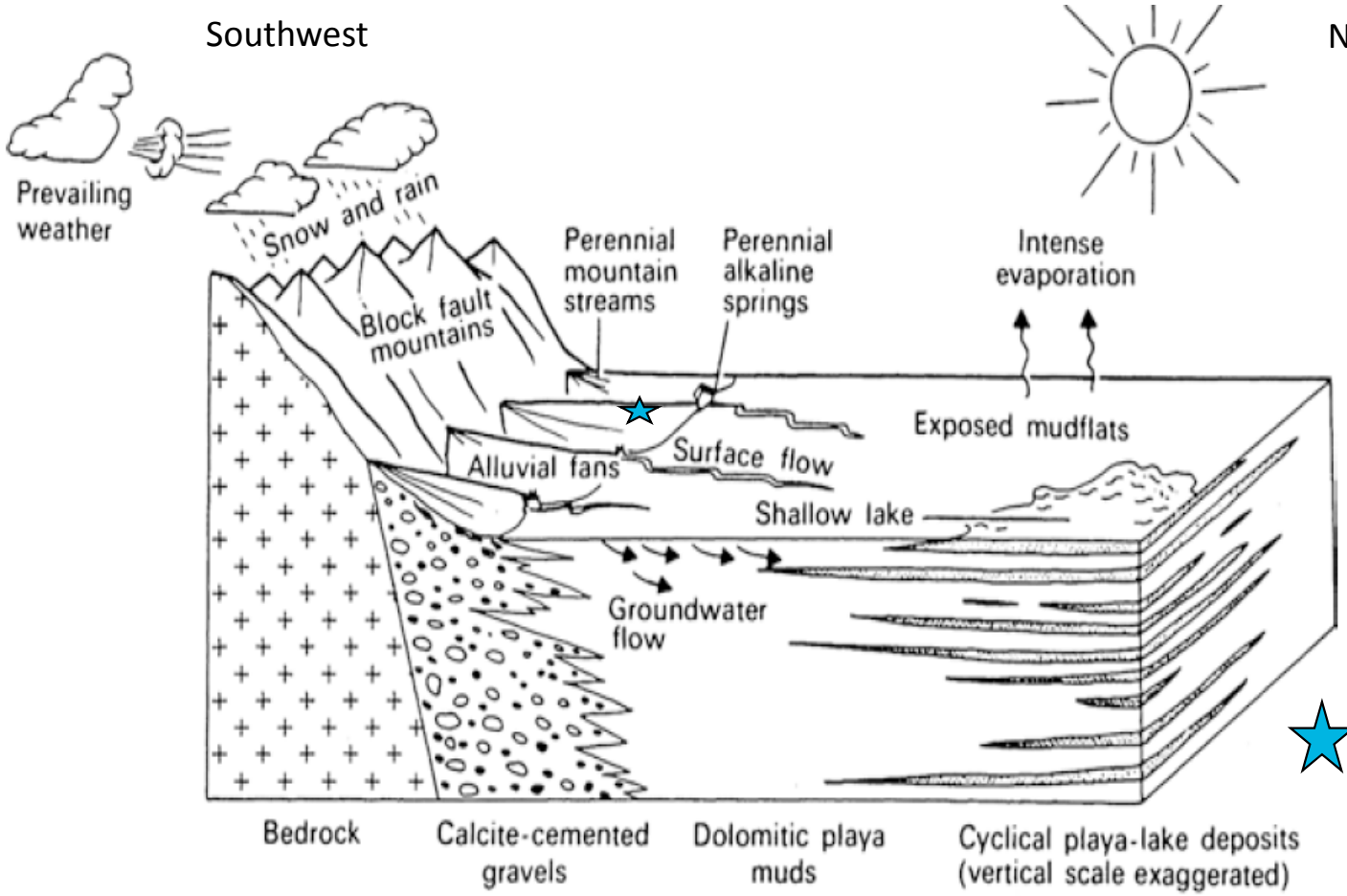
Schematic block diagram



= approximate location of AFP42

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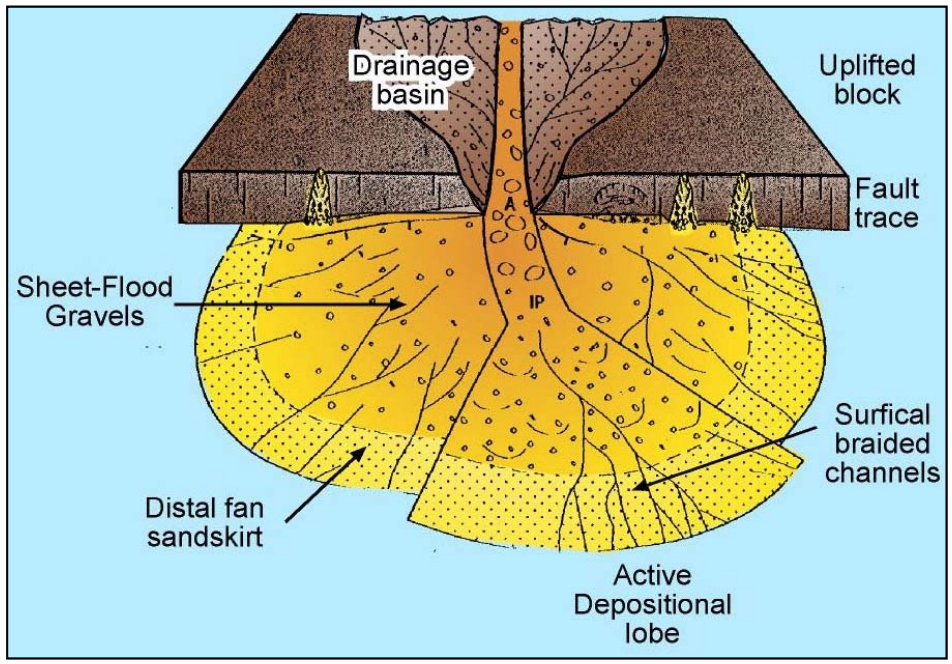
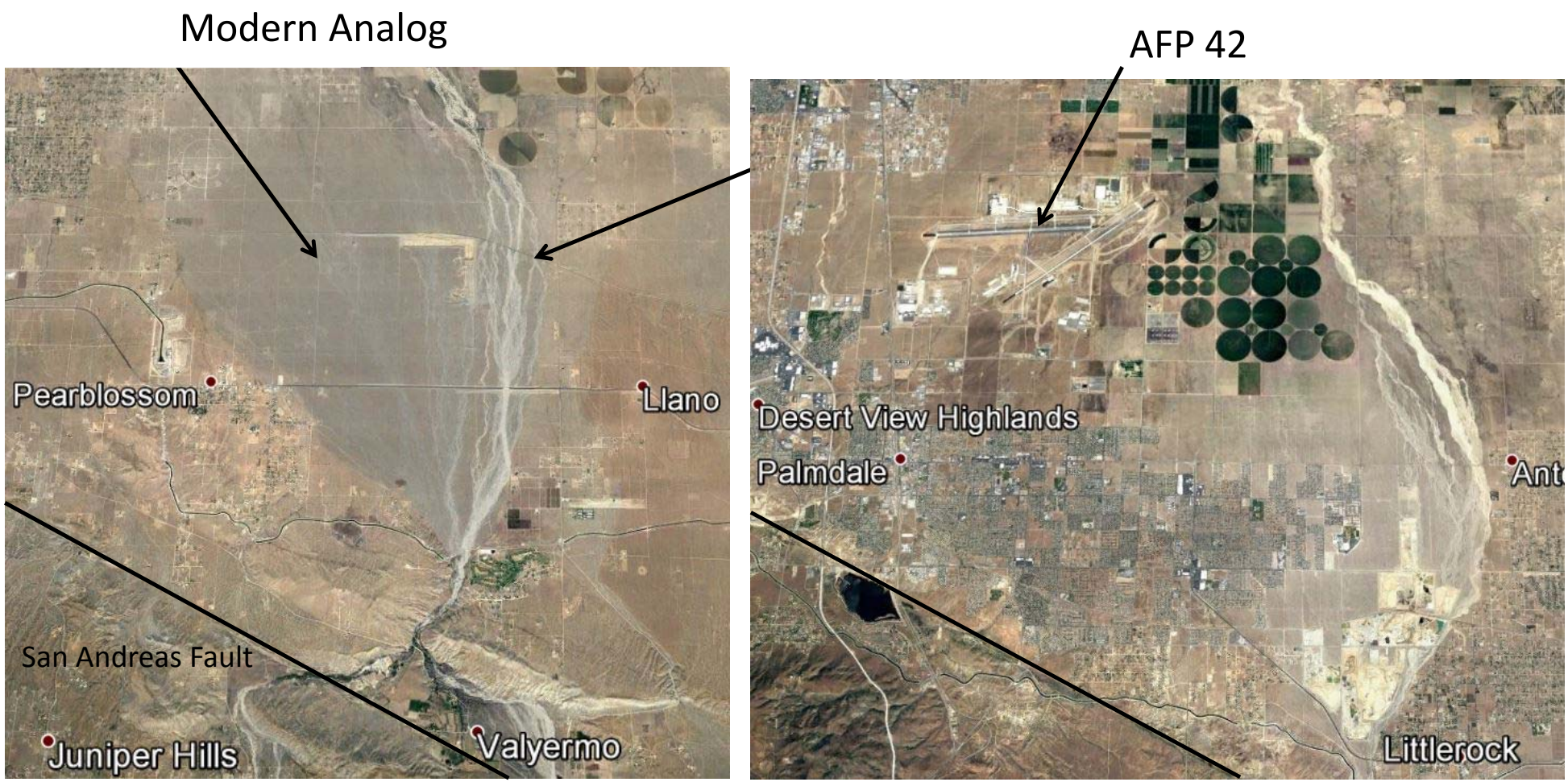
Mechanics of an Alluvial Fan



Block model of an alluvial fan

Alluvial Fan – Death Valley National Park

Modern Analog



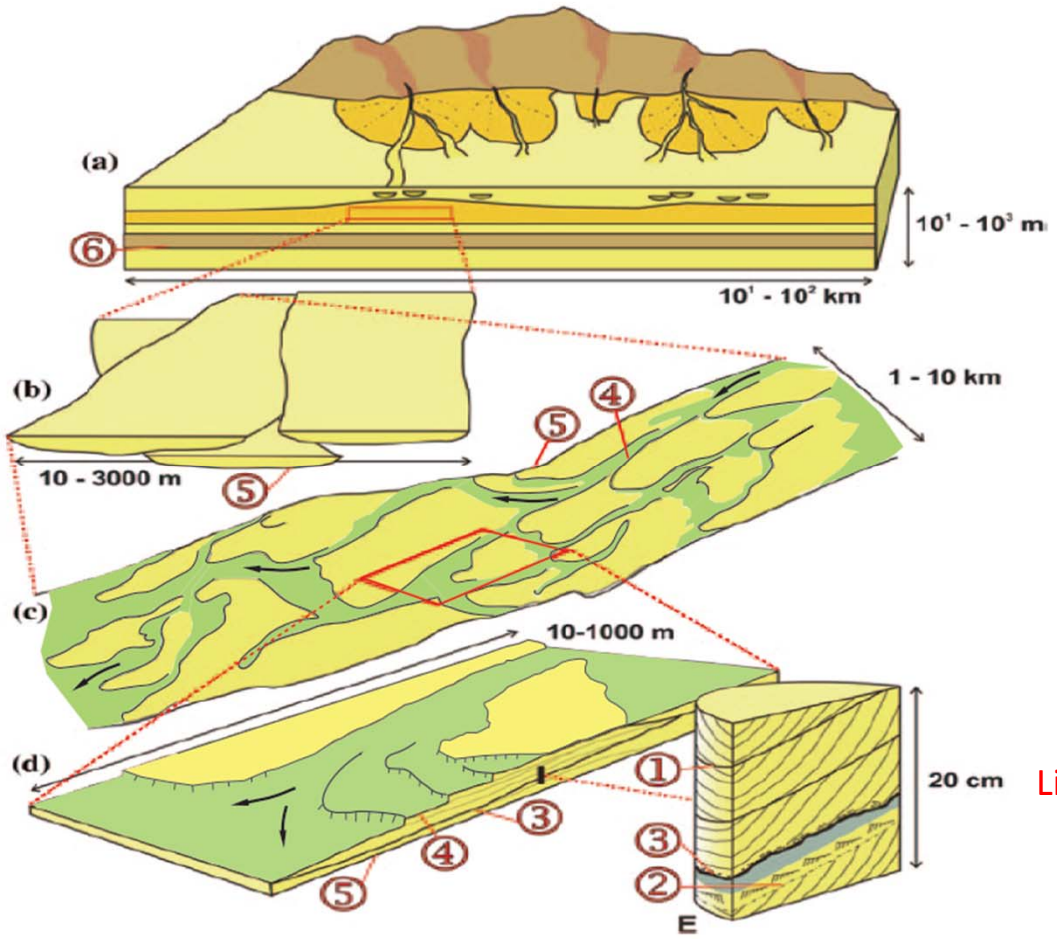
Relative Scales

Regional Scale

Channel Belt Complex

Channel Belt

Channel



Lithologic Log

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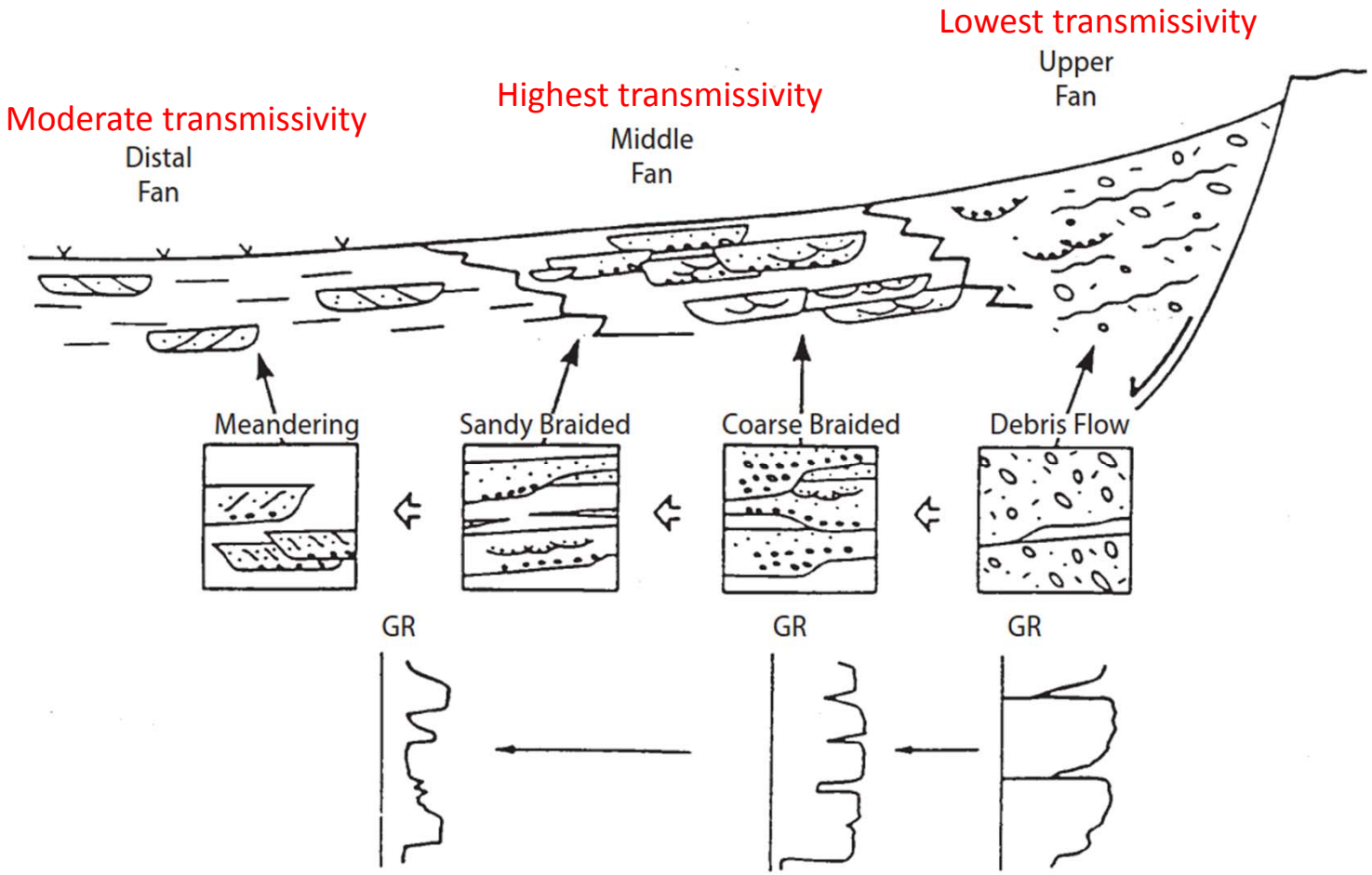
Regional Scale

Lateral Facies Across a Morphologic Fan



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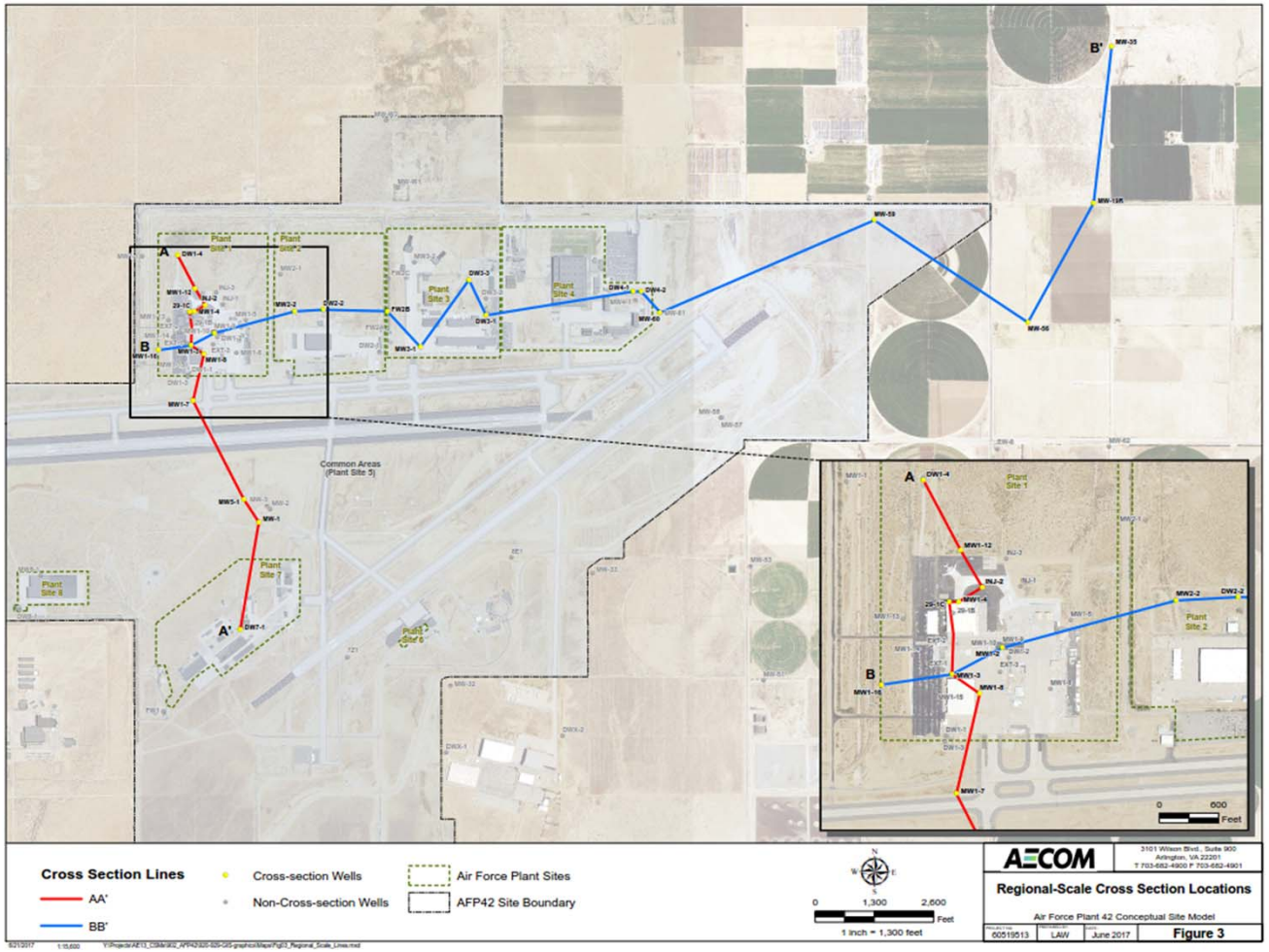
Cross Sections



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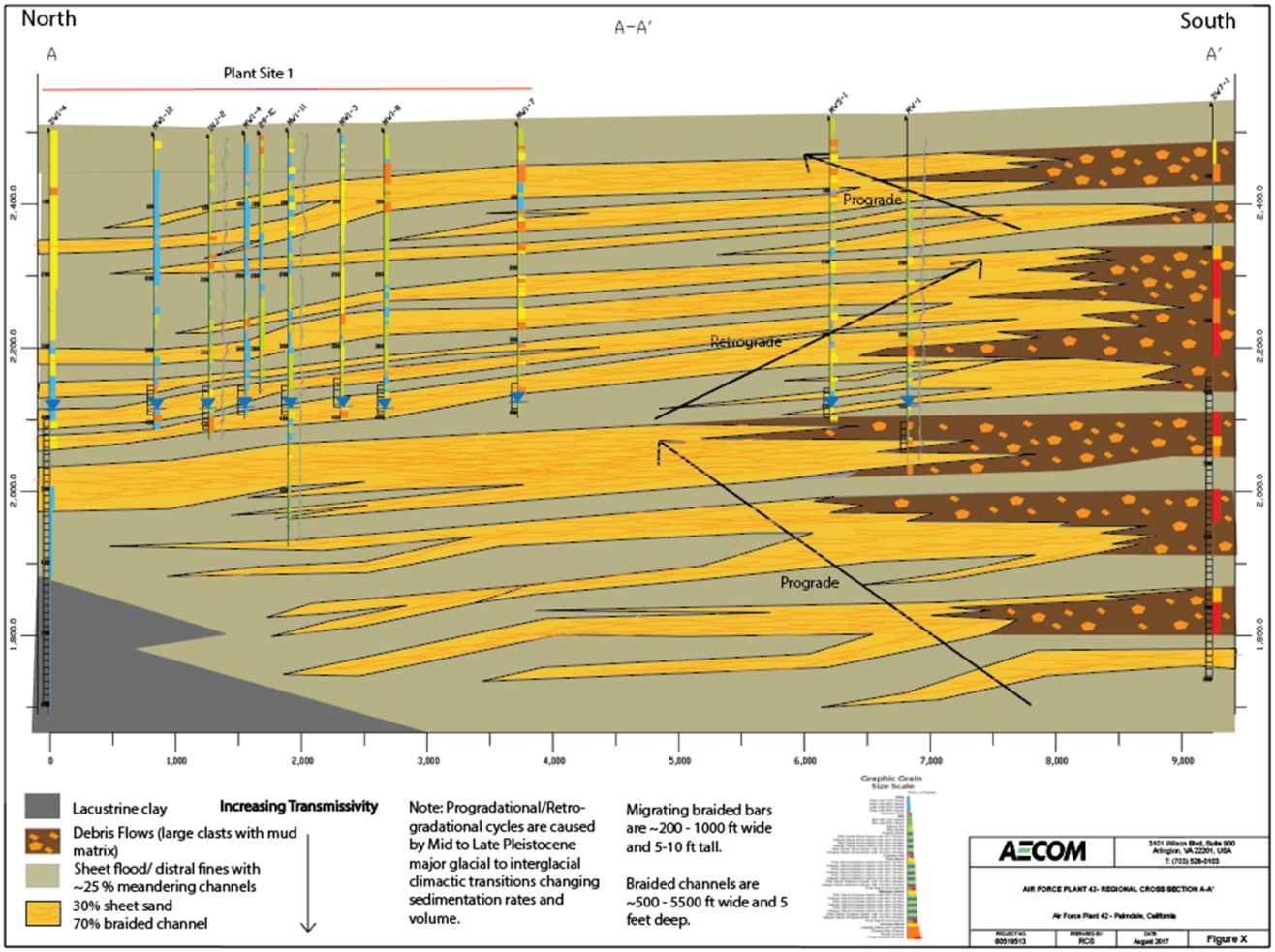
Regional Section A-A’



Progradational/Retrogradational cycles reflect glacial/inter-glacial periods.

Northward-climbing lacustrine clay reflects the battle between lake sediments and encroaching alluvial fan sediments as the area gradually became more arid over time.

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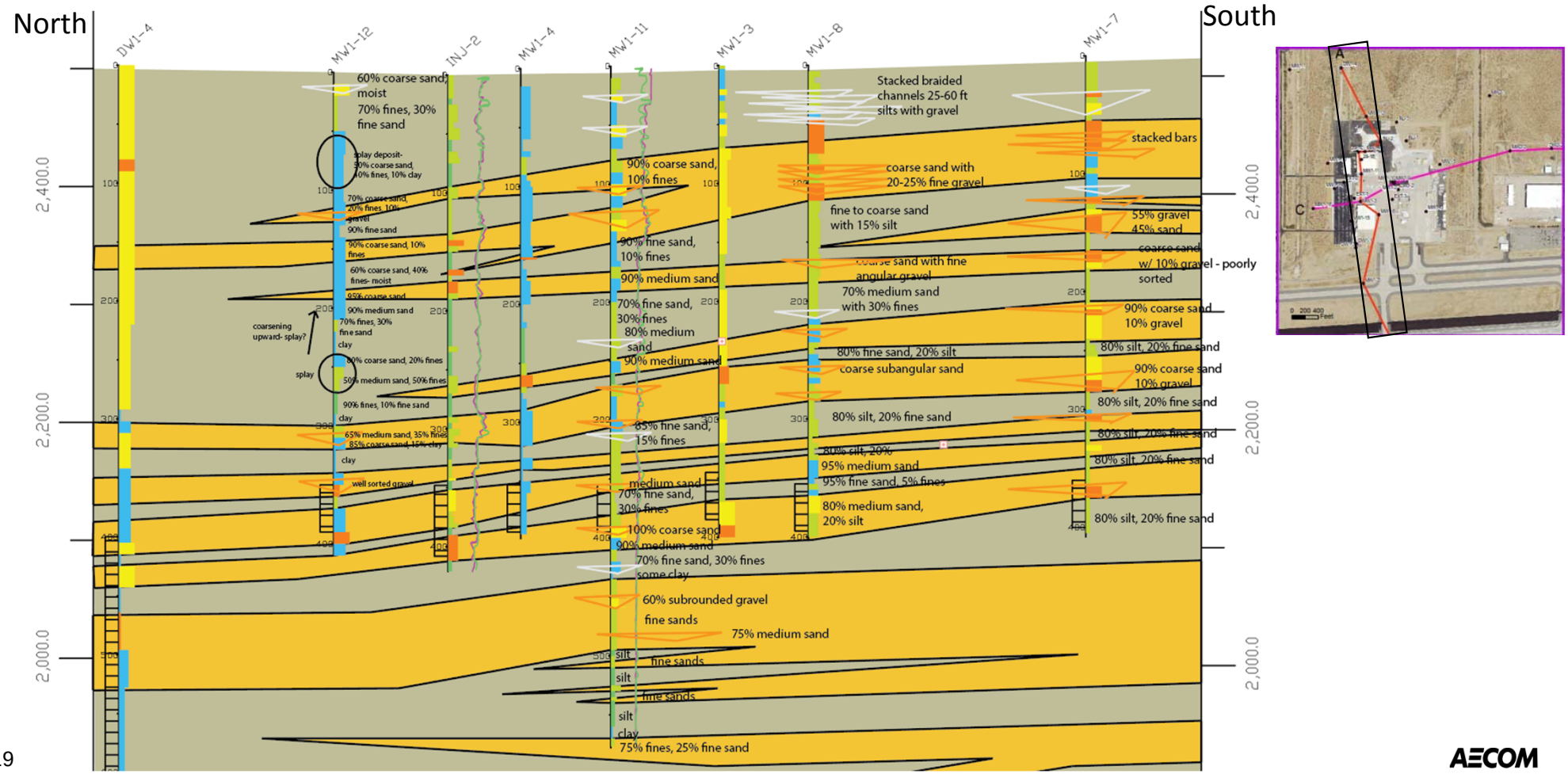
Plant Site 1- annotated



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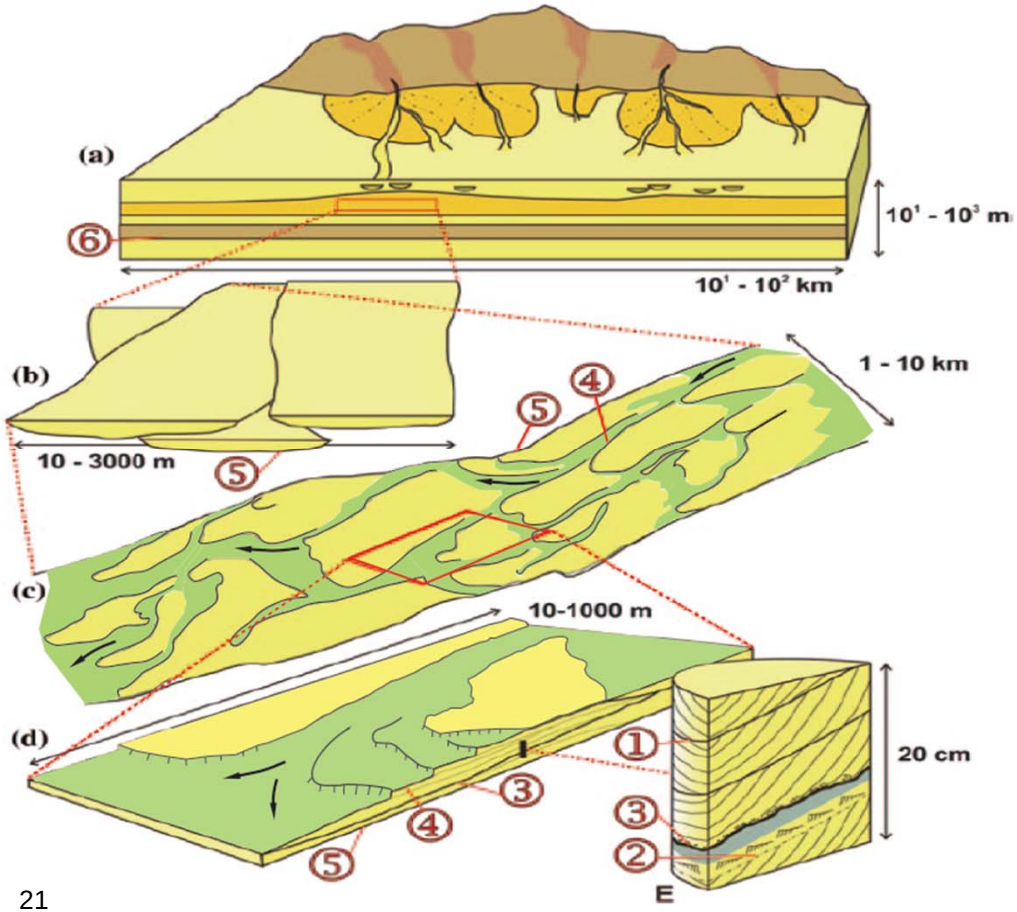
Plume Scale

Channel Belt Mechanics



Outcrop

Sand/Gravel bars

Suspended clays/silts settling out of water column

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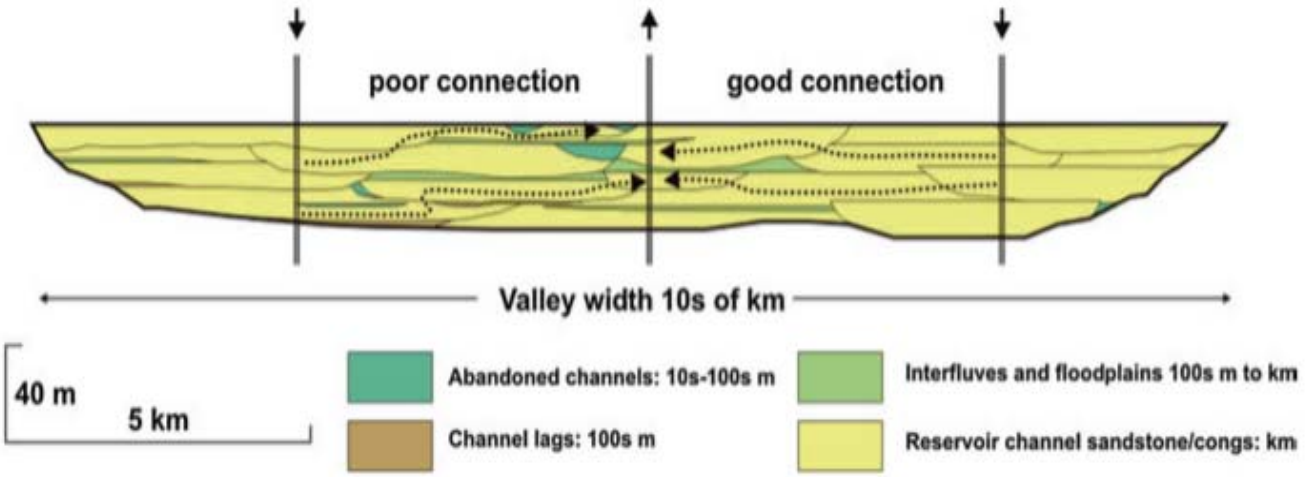
Bar Connectivity



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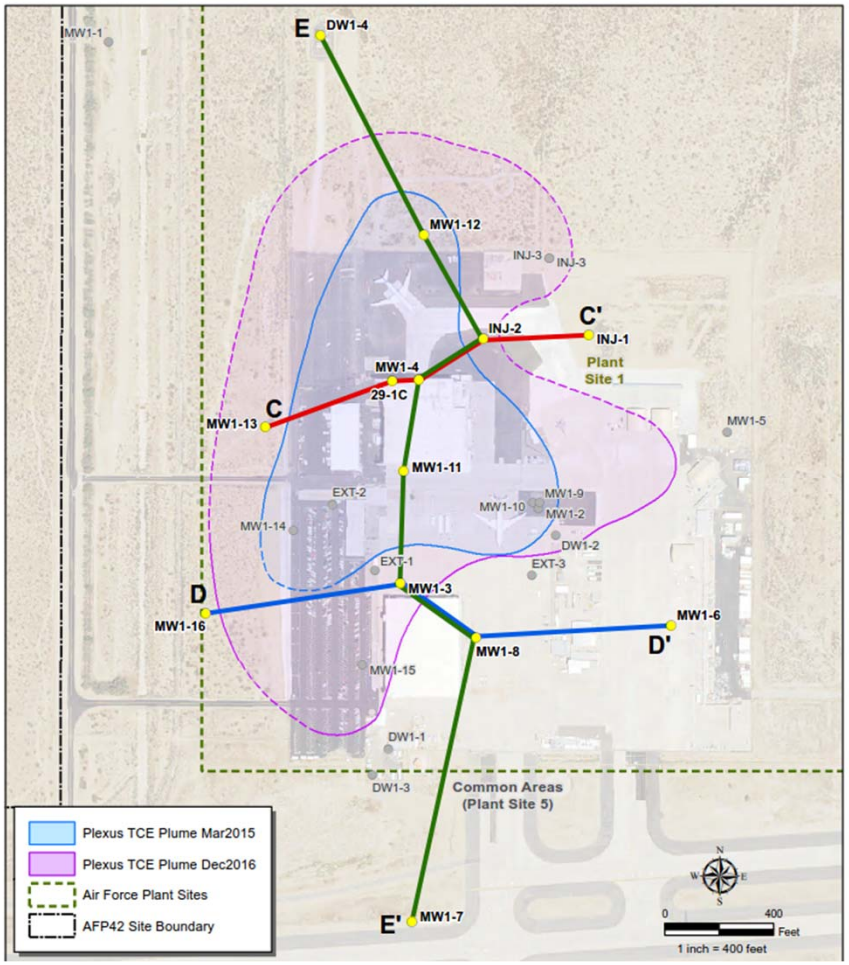
Plume Scale Cross Sections



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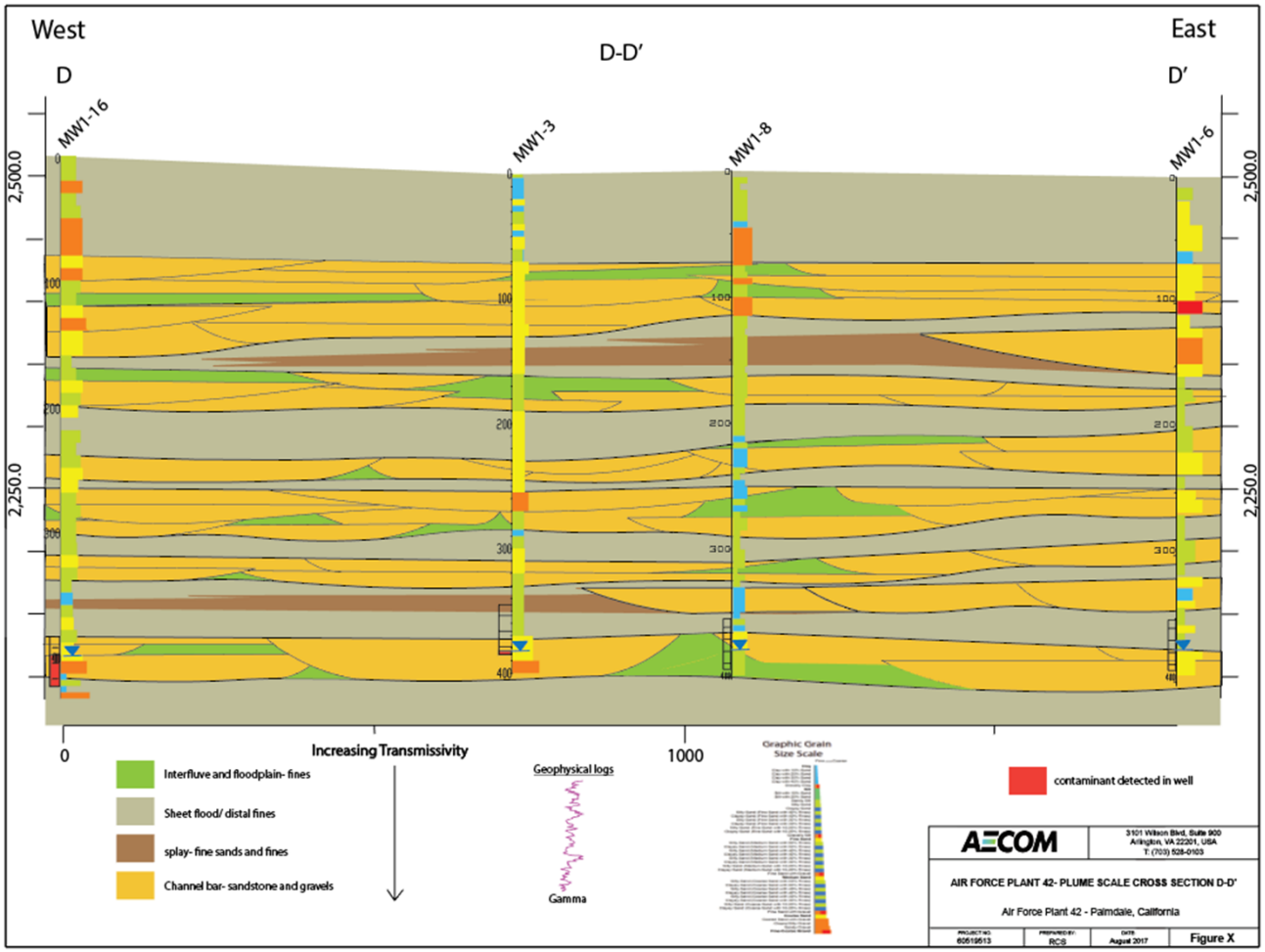
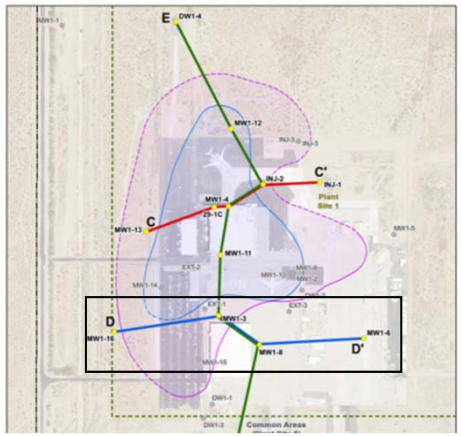
Cross Section D-D’





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ESS Conclusions

- Regional Scale:
  - Alluvial fan sediments are sourced from the uplifted San Gabriel Mountains to the south and dip to the north-northeast.
  - Despite variable grain-sizes, all units have at least some degree of vertical and horizontal transmissivity.
  - Water preferentially flows through braided channels (Middle fan facies) because they are the most transmissive.
  - Without the influence of pumping in the region, water would preferentially flow to the north-northeast.

- Plume Scale:
  - Water preferentially flows through coarse-grained channel bar deposits. Fine-grained floodplain and interfluve deposits may act as flow barriers.
  - Channel bar connectivity appears to be the predominant stratigraphic factor affecting the shape of the contaminant plume beneath AFP 42 Plant Site 1.

Thank You!

T (703) 399-3953
E Ryan.Samuels@aecom.com