A Review of Ordinary High Water Mark Research in the Western U.S. and Future Studies

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Outline

1. Review of CRREL OHWM research in the Arid West
2. Overview of Western Mountain OHWM study
3. OHWM concepts / “technical definition”
4. Ongoing and future OHWM studies

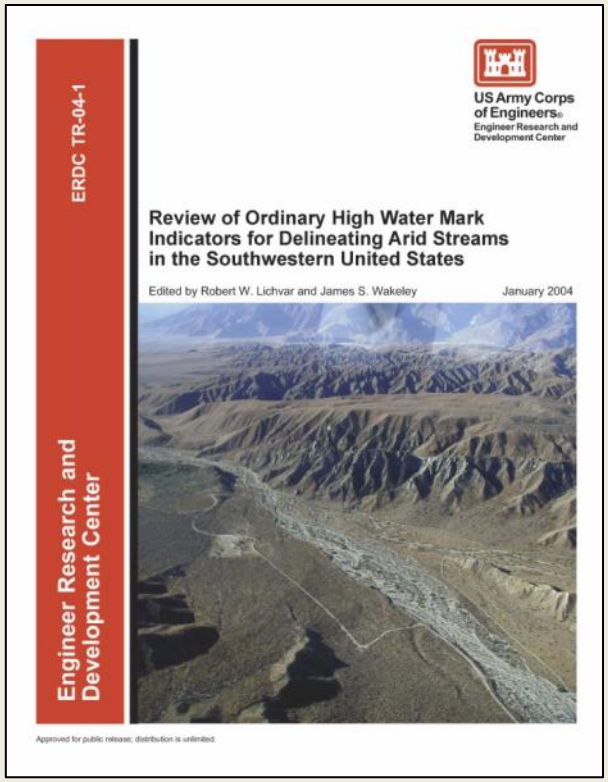
What is the Ordinary High Water Mark?

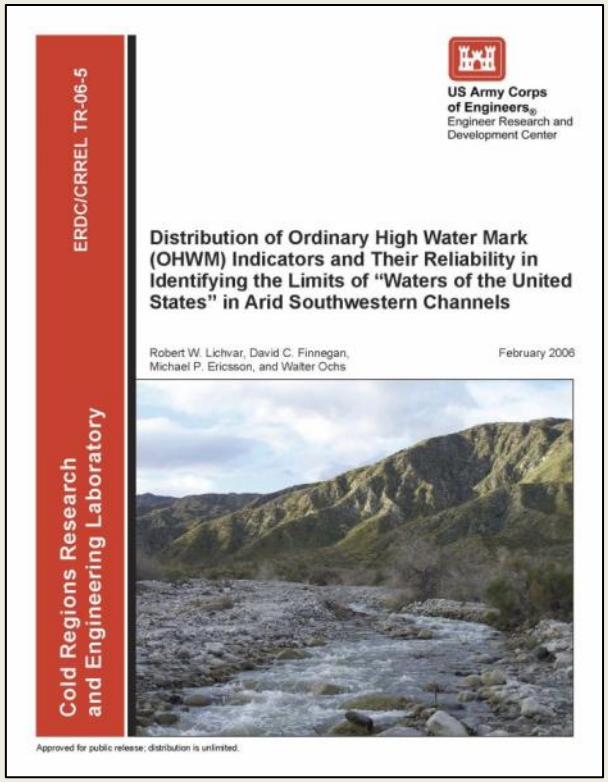
Federal regulations (33 CFR 328.3(e)) define the Ordinary High Water Mark (OHWM) as:

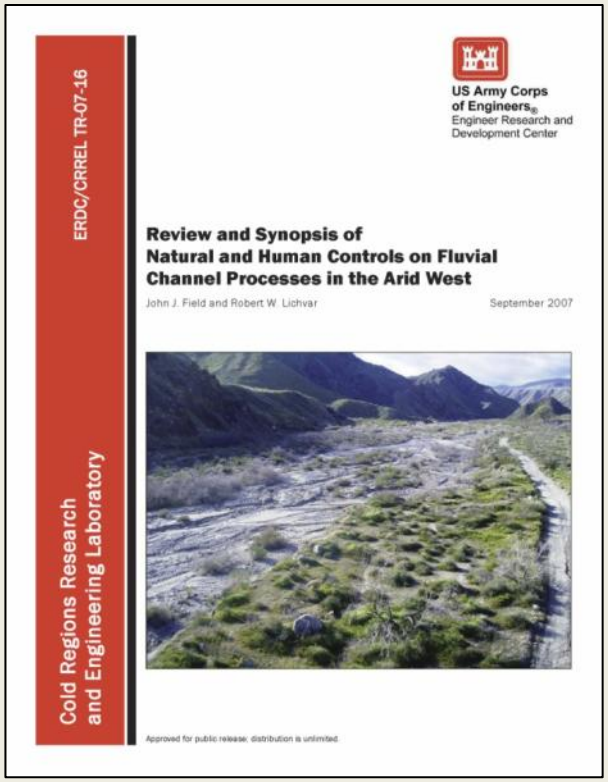
> **"...that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."**

Under Section 404 of the Clean Water Act, the OHWM defines the lateral limits of Federal jurisdiction over non-tidal waters of the United States, in the absence of adjacent wetlands.

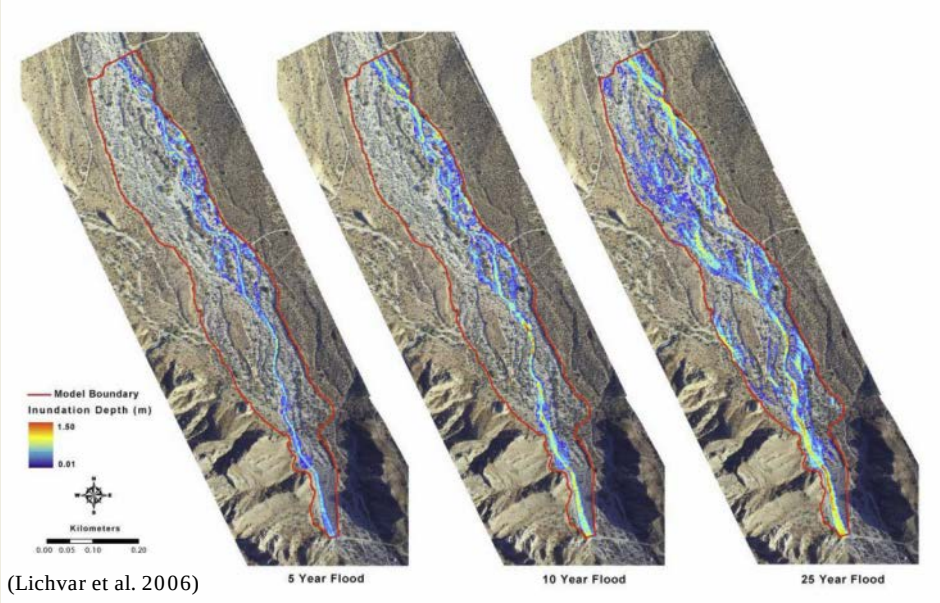
OHWM in the Arid Southwest





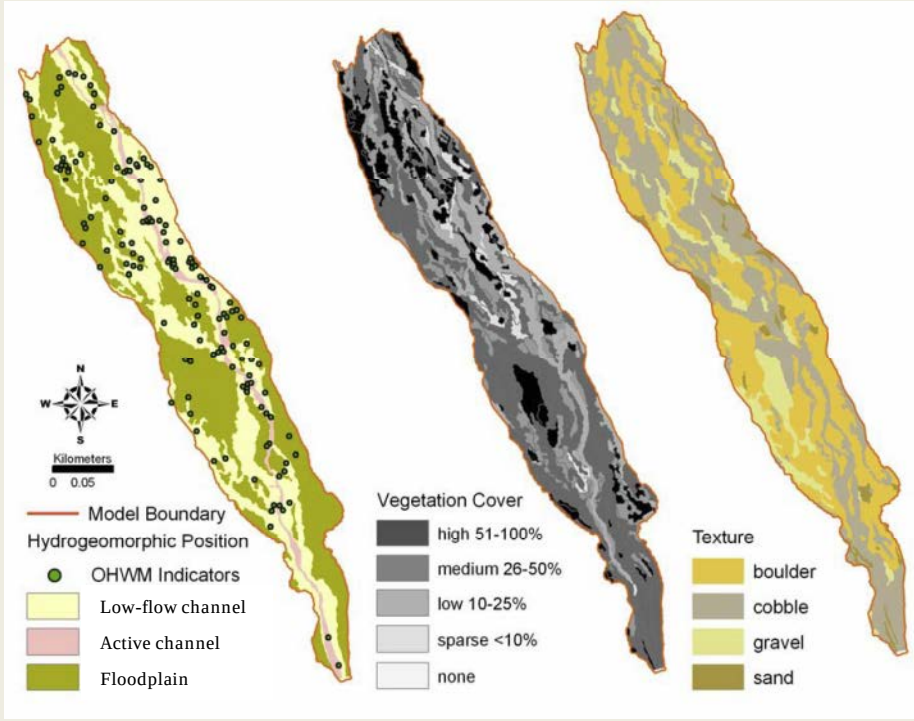


OHWM in the Arid Southwest



(Lichvar et al. 2006)

LiDAR mapping, HEC-RAS, and stream gage records used to model a series of return intervals along a reach of Mission Creek, CA.

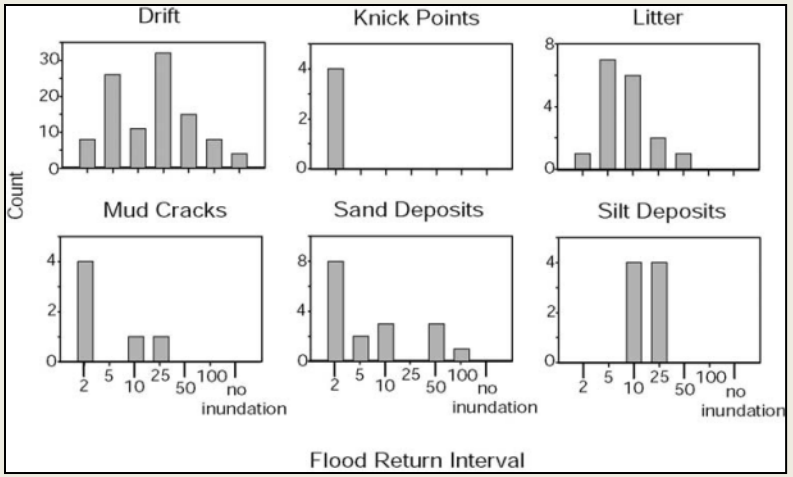


Geomorphic units, vegetation cover, and sediment textures mapped in the field.

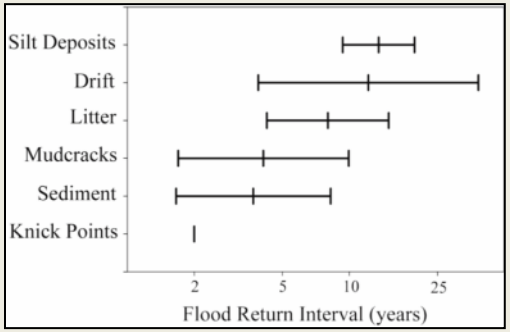
OHWM in the Arid Southwest

Table 1. OHWM indicators, Mission Creek 2003.

OHWM indicators	Number of occurrences	Brief description
Drift	104	Organic debris oriented to flow direction(s) (larger than small twigs)
Mud cracks	6	Desiccation cracks within silt deposits
Silt deposits	8	Silt found in micro-depressions
Sand deposits	17	Sand oriented downstream to flow direction(s)
Knick points	4	Abrupt change in channel slope
Litter	17	Organic debris oriented to flow direction(s) (small twigs and leaves)



- 6 potential OHWM indicators shown to be randomly distributed and not correlated with either geomorphic units (channel, floodplain, terrace) or with specific discharge recurrence intervals (e.g. 2-yr. flood)



Mean ± one standard deviation for each indicator type identified within the Mission Creek study reach.

OHWM in the Arid Southwest

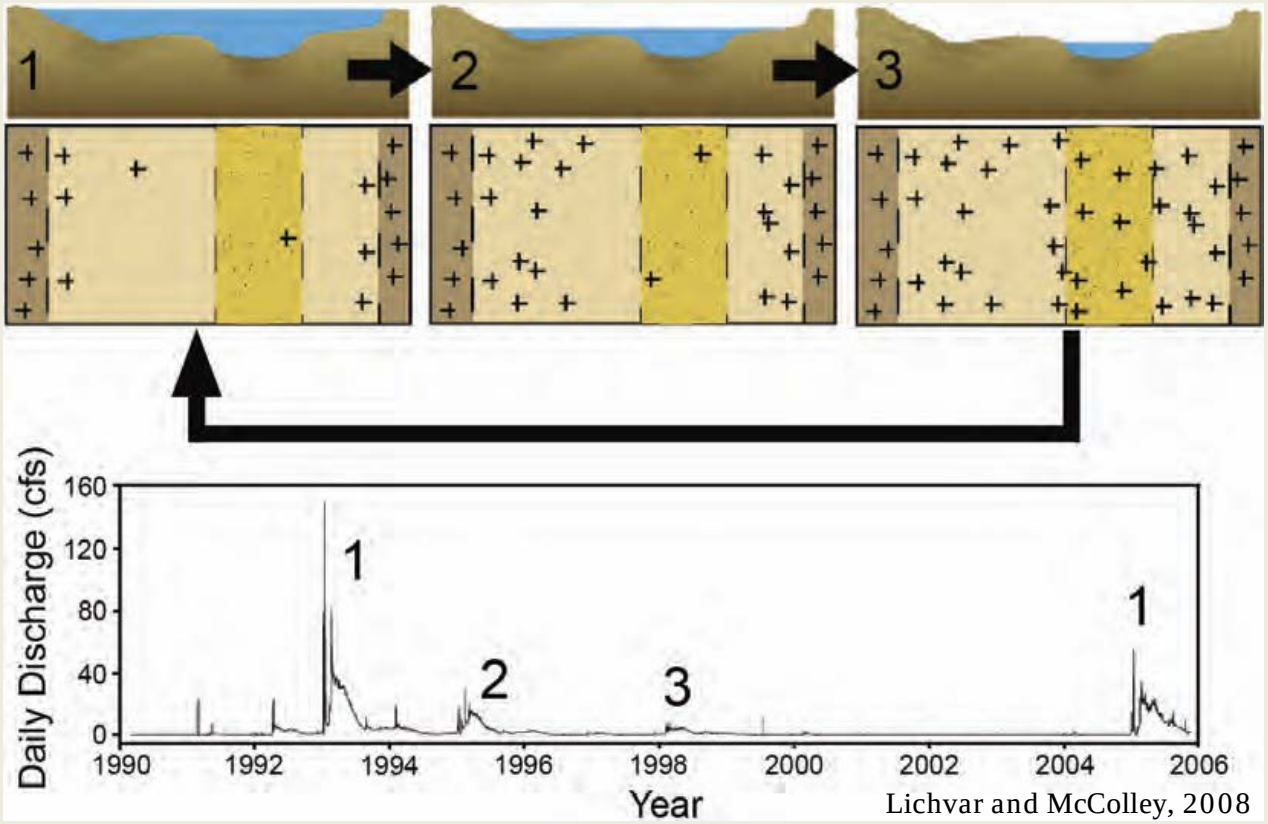
Conceptual Model of OHWM Indicator Distribution

Cross-section

Plan view

'+' = indicator
'gold' = low-flow channel
'tan' = active channel
'brown' = floodplain

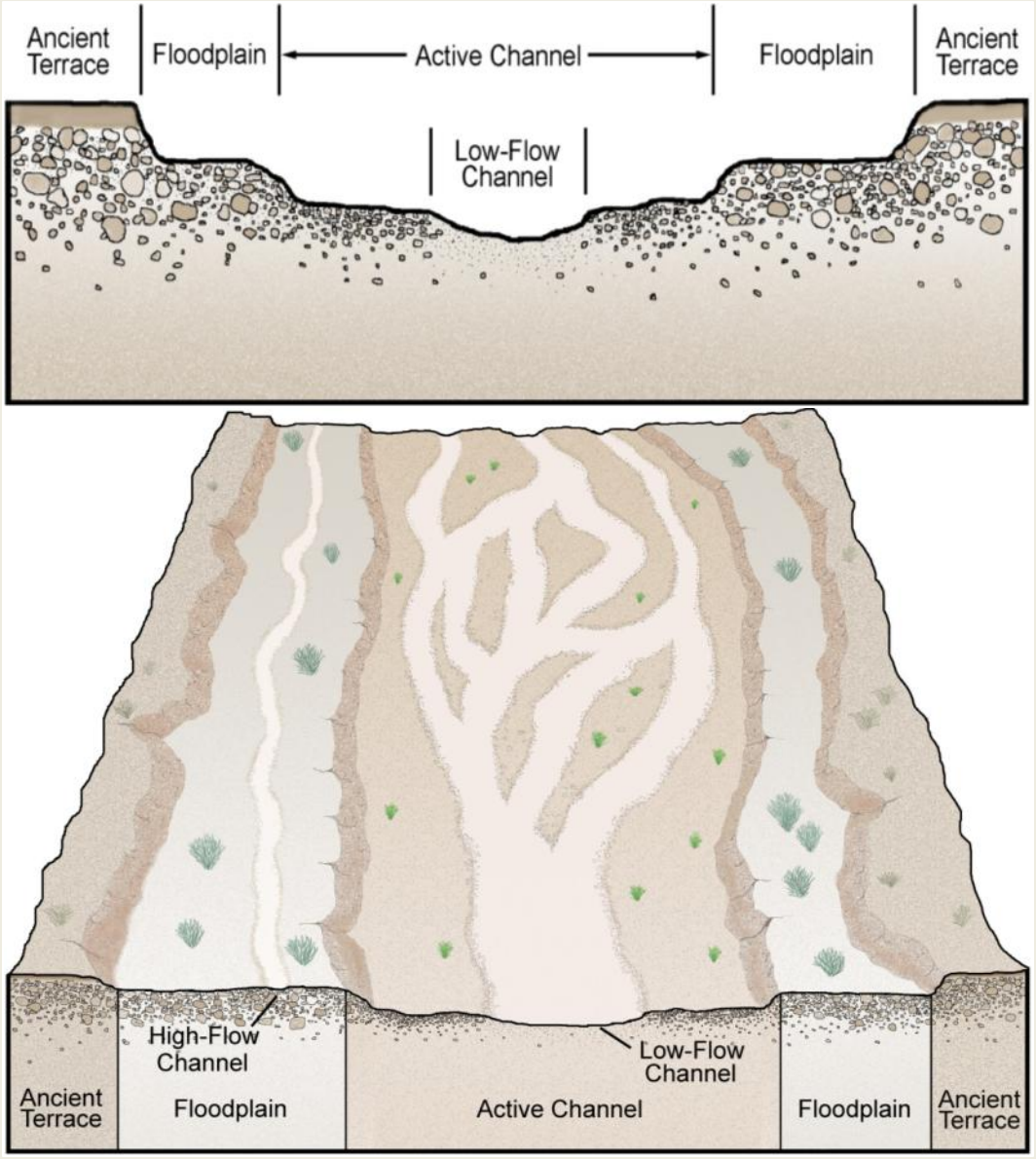
Hydrograph
(Mission Creek, CA)



Lichvar and McColley, 2008

- Cycle of deposition and removal, whereby OHWM indicators are cleared from the active channel during low to moderate flow events and concentrated at the active channel edges, and are then deposited throughout the active channel over time by relatively small events.
- Conclusion that the active channel boundary is the most reliably identifiable hydrogeomorphic feature on the landscape

OHWM in the Arid Southwest



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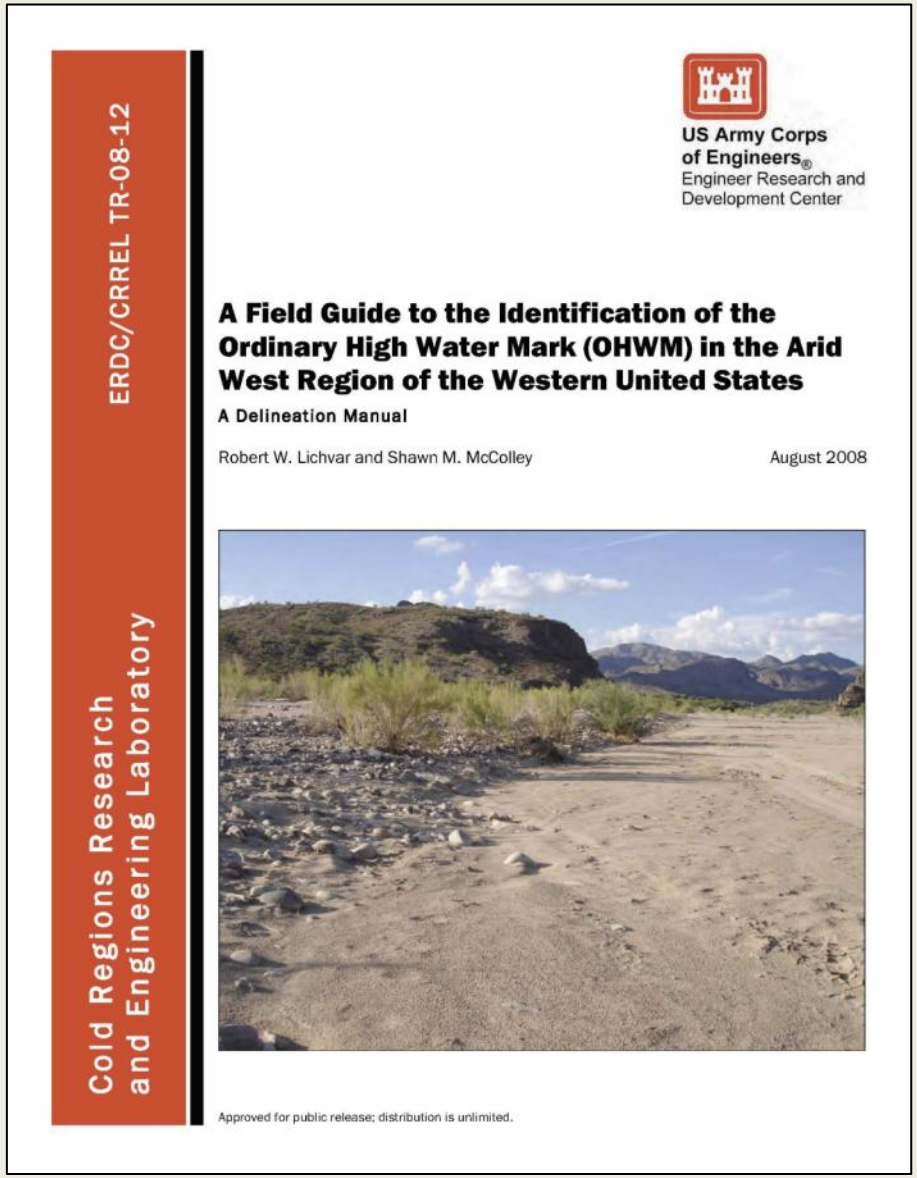

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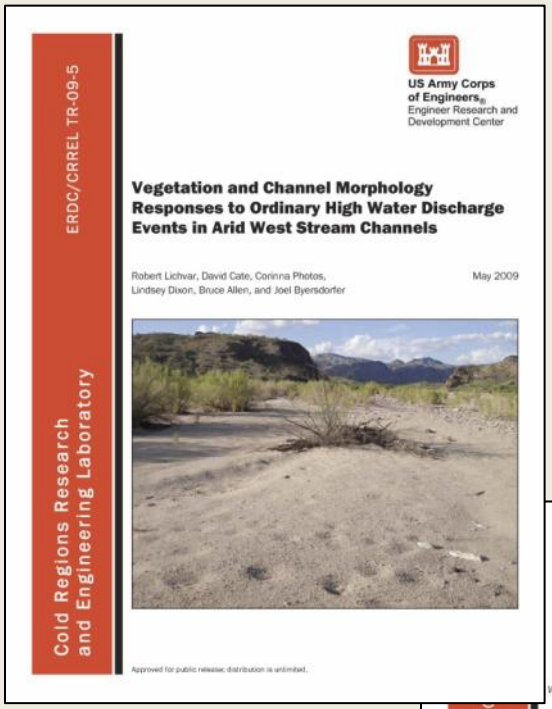
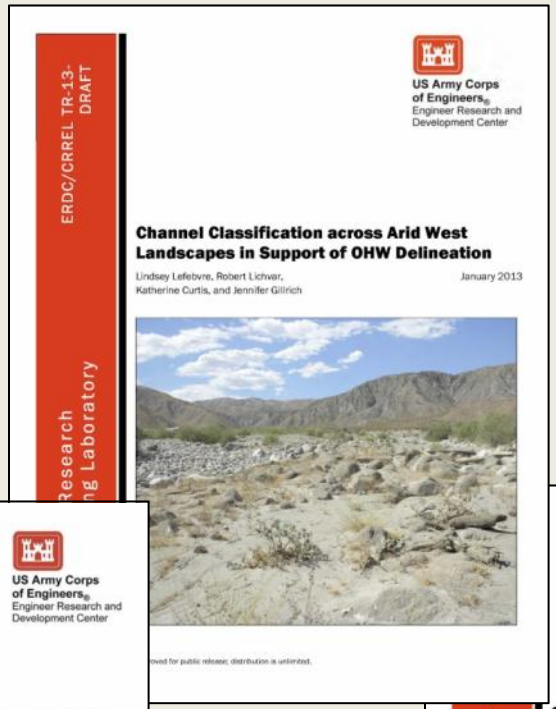
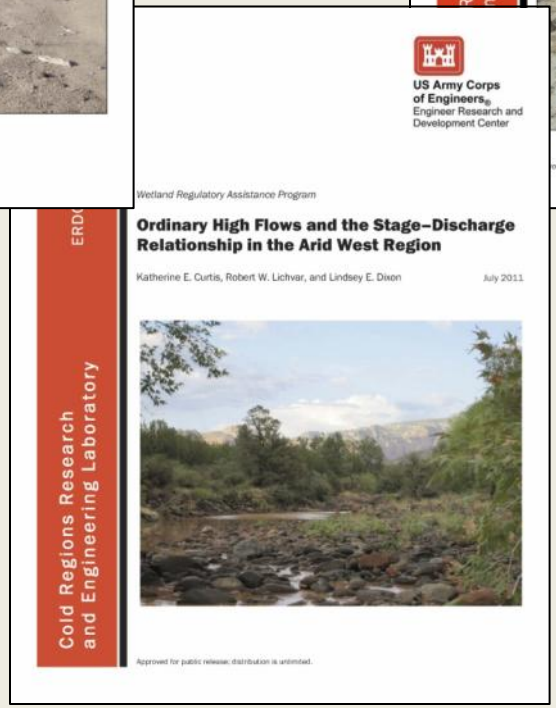
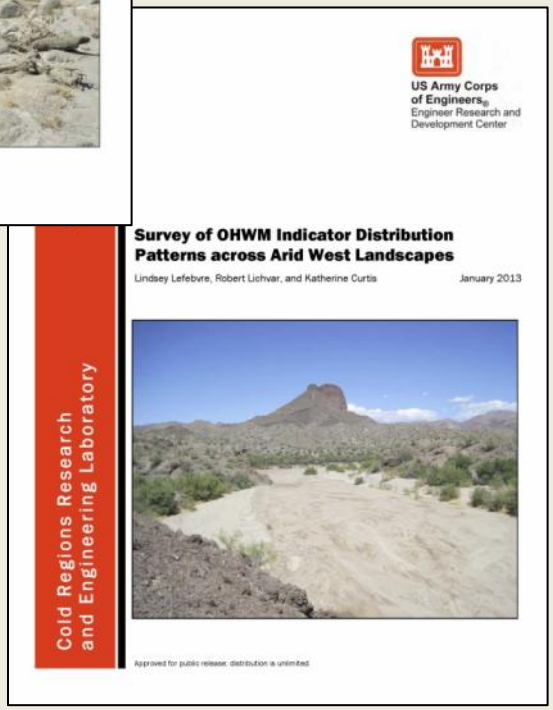




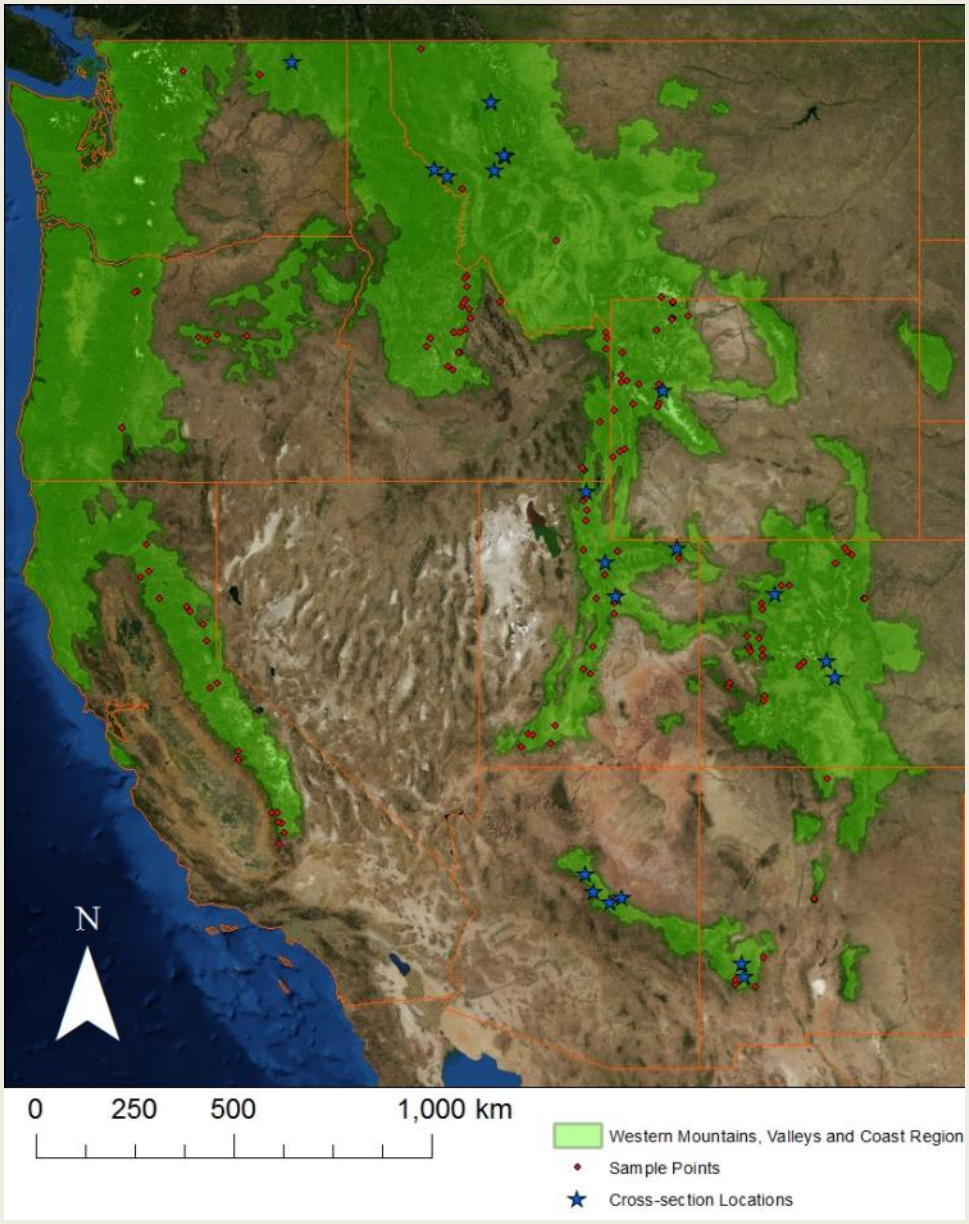




OHWM in the Western Mountains

Field Data

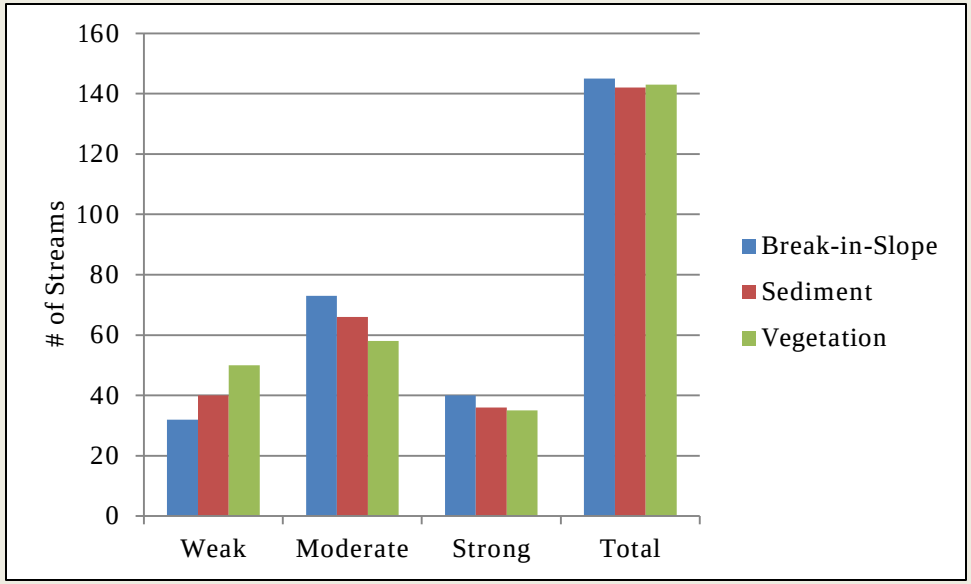
- 150 ephemeral or intermittent streams sampled in summer 2010 and 2011:
  - Potential OHWM indicators and their locations relative to the OHWM (above, at, or below) were recorded at each site
  - When suitable, indicators were ranked as weak, moderate or strong
- Cross-sections surveyed at 21 of the sample sites (3 to 4 XS at each site)

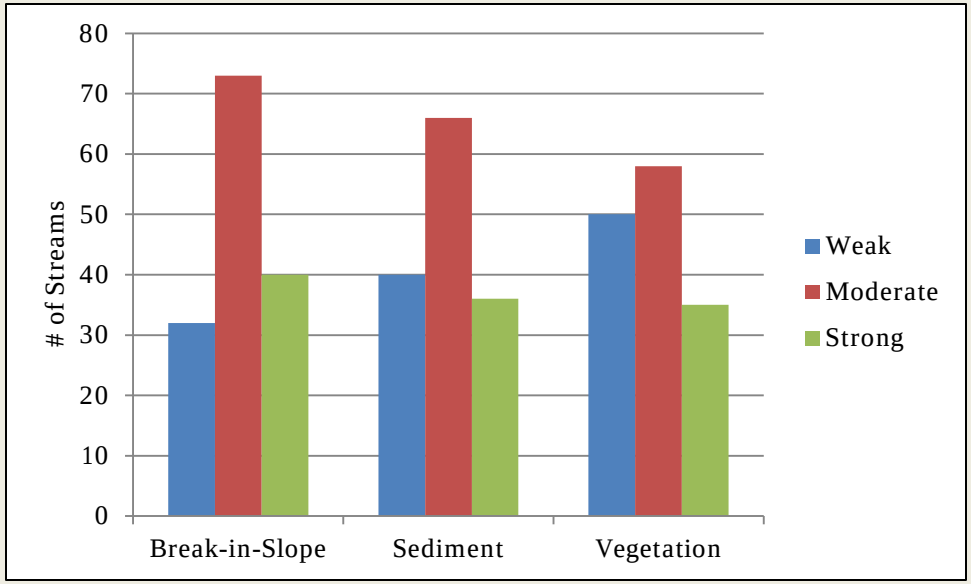


OHWM in the Western Mountains

- 3 "primary" OHWM indicators:
  1. Break-in-slope (topographic change)
  2. Change in sediment texture (size, shape, etc.)
  3. Change in vegetation characteristics (cover, growth stage, species)

- "Flow indicators" (e.g. drift and wrack lines) also common, but rarely in conjunction with primary indicators



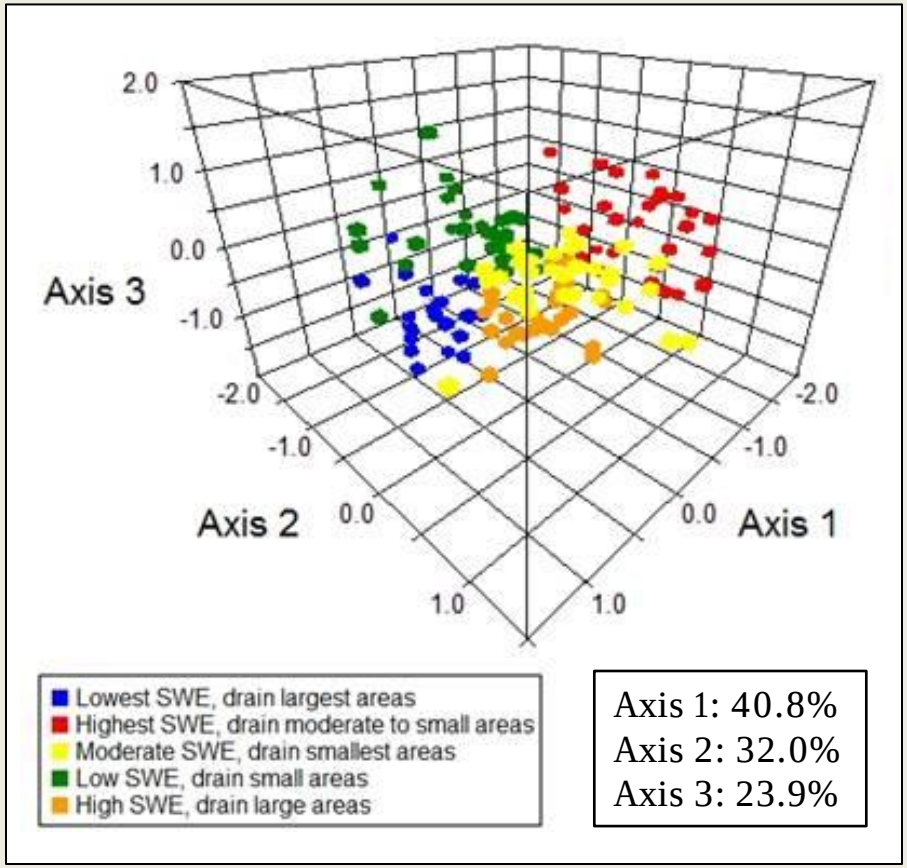


Watershed-scale Ordination

- GIS used to extract four "watershed-scale" variables:
  1. Watershed area
  2. Mean watershed elevation
  3. Mean annual precipitation
  4. Mean annual snow water equivalent (SWE)

- Non-metric multidimensional scaling (NMDS) used to ordinate 145 streams along three axes based on four extracted variables

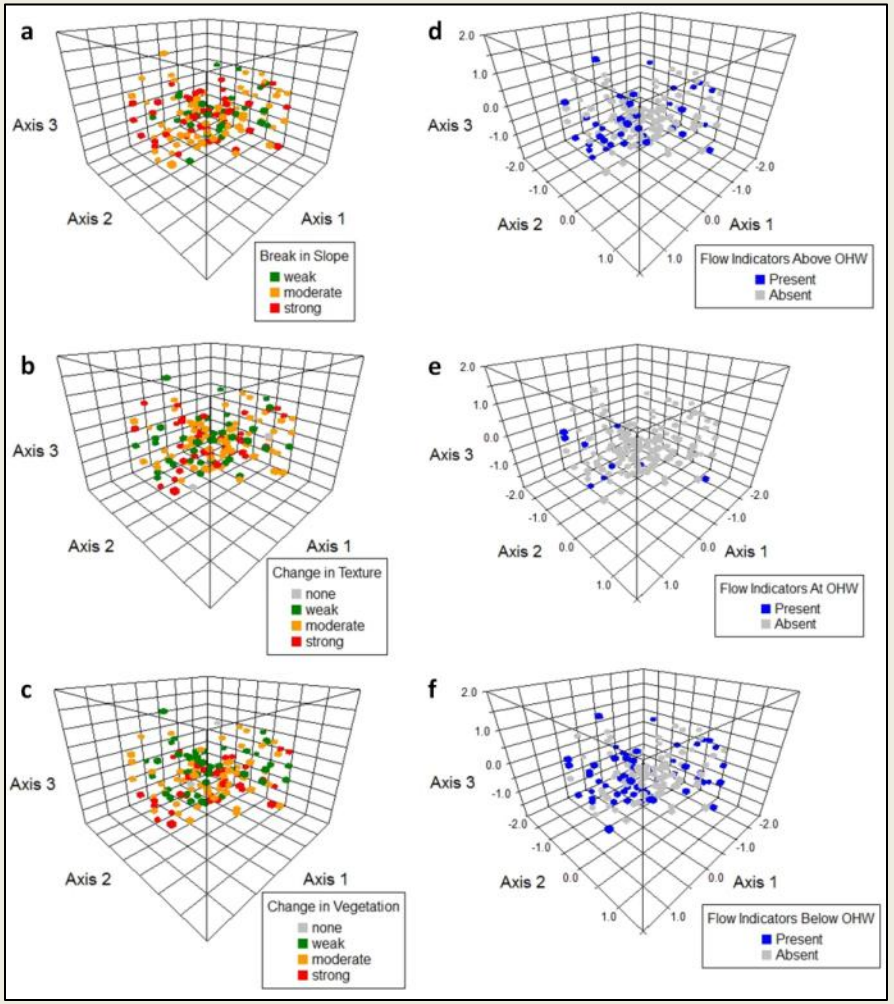
- Cluster analysis identified 5 statistically significant groups among the sampled streams



Axis 1		Axis 2		Axis 3	
Variable	**r**	**Variable**	**r**	**Variable**	**r**
Watershed area	0.06	Watershed area	-0.34	Watershed area	-0.97
Mean watershed elevation	0.59	Mean watershed elevation	0.64	Mean watershed elevation	-0.17
Mean annual precipitation	-0.67	Mean annual precipitation	0.67	Mean annual precipitation	0.10
30-year mean SWE	-0.80	30-year mean SWE	0.49	30-year mean SWE	0.23

Watershed-scale Ordination

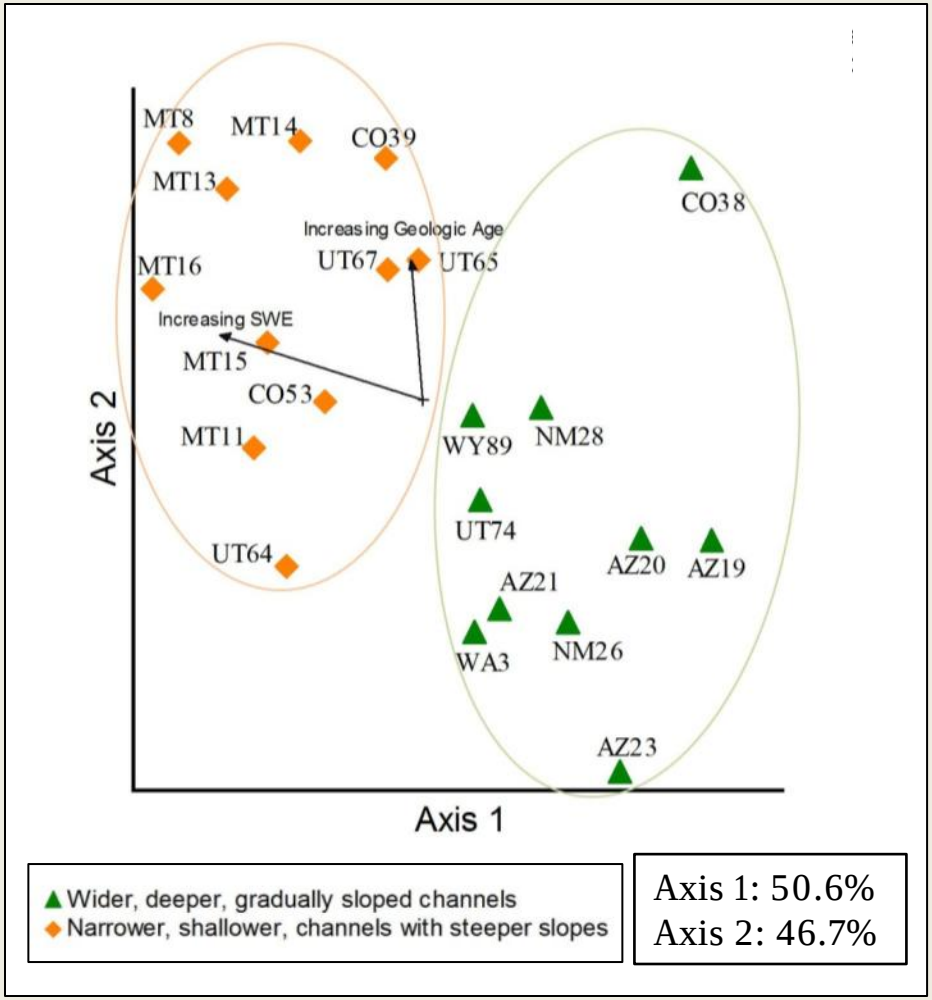
- 6 categorical OHWM variables overlain on watershed-scale ordination
- No distinct patterns in primary indicator rankings or flow indicator presence/absence data



Group	Break-in-slope Weak	Moderate	Strong	Total	Change in Sediment Texture Weak	Moderate	Strong	Total	Change in Vegetation Weak	Moderate	Strong	Total
Blue	2	12	7	21	6	10	5	21	6	9	6	**21**
Green	6	15	10	31	9	11	10	30	16	10	5	**31**
Orange	8	17	5	30	9	13	7	29	8	13	8	**29**
Yellow	8	13	12	33	10	16	6	32	10	15	8	**33**
Red	8	16	6	30	6	16	8	30	10	11	8	**29**
Total	**32**	**73**	**40**	**145**	**40**	**66**	**36**	**142**	**50**	**58**	**35**	**143**

Channel-scale Ordination

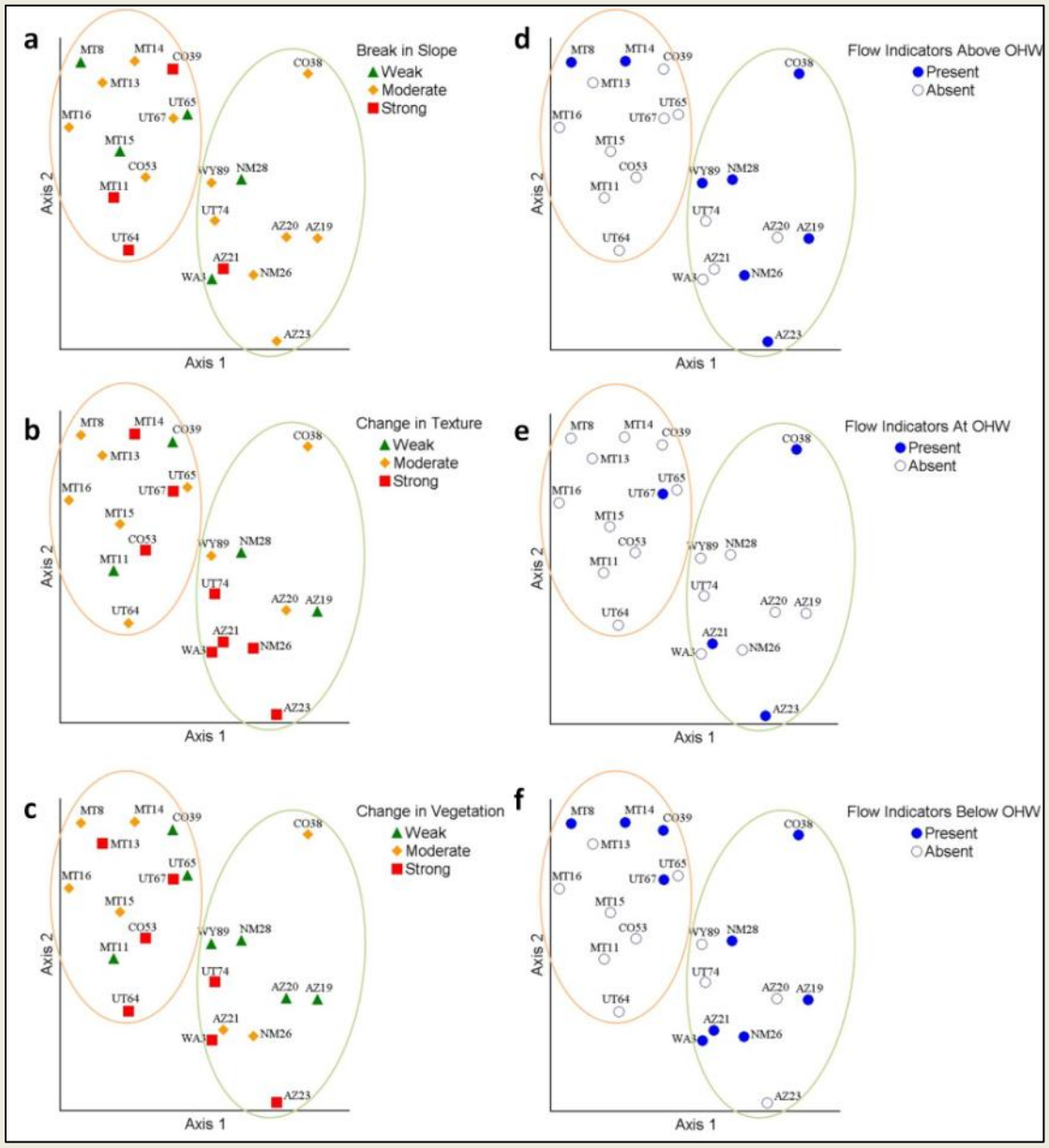
- 66 surveyed cross-sections used to extract four “channel-scale” variables:
  1. Maximum channel width
  2. Maximum channel depth
  3. Width to depth ratio
  4. Channel slope
- 21 streams ordinated along two axes based on four extracted variables
- Cluster analysis identified 2 statistically significant groups among the sampled streams



Axis 1		Axis 2	
Variable	**r**	**Variable**	**r**
Maximum channel width	0.87	Maximum channel width	-0.70
Maximum channel depth	0.17	Maximum channel depth	-0.88
Width to depth ratio	-0.81	Width to depth ratio	0.08
Channel slope	-0.74	Channel slope	0.90

Channel-scale Ordination

- 6 categorical OHWM variables overlain on channel-scale ordination
- No distinct patterns in primary indicator rankings or flow indicator presence/absence data



Western Mountain Summary

- Results suggest that 3 primary indicators – break-in-slope, change sediment texture, and change in vegetation characteristics – are the most common and reliable OHWM indicators on non-perennial streams throughout the Western Mountain Region.
- Flow indicators (drift, wrack, leaf-litter removal, etc.) are frequently present throughout the Western Mountain Region, but rarely in the same location as the primary indicators, and are thus considered to be unreliable OHWM indicators.
- These findings show no distinctions with regard to climate, environment, geology, channel dimensions, etc.
- It is the combination of multiple primary indicators that makes the "OHWM signature." Individual primary indicators can be highly misleading out of context.
- Study report and Western Mountain field guide in prep.

Limitations of OHWM Studies

- OHWM studies generally rely heavily on investigator's subjective assessment of field indicators and interpretation of "ordinary"
- Testing of OHWM "accuracy" is difficult given its vague legal definition and unclear hydrologic basis for the OHWM or the indicators used to identify it.

"The term ordinary high water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."

Common Assumptions About the OHWM

Assumption	Limitations
The OHWM occurs at the stage of the 1.5- or 2-year annual peak return interval	Return intervals can be highly variable with respect to geomorphic features and OHWM indicators. Hydrologically-based definitions are hard to implement (i.e. delineate) in the absence of stream gages.
The OHWM occurs at mean stage or mean annual peak stage	
Vegetation does not occur below the OHWM or trees don't occur below the OHWM	Vegetation is dynamic and varies spatially and temporally. Vegetation lines often shift seasonally, and many species can withstand periods of inundation (even trees!).
The OHWM occurs at the transition from riparian to upland vegetation.	Deep-rooted riparian species can occur well beyond the boundaries of a stream. Riparian/upland transitions are often gradual.
The OHWM occurs at bankfull stage.	Inconsistent definitions of bankfull and its indicators. Questionable application to arid, non-perennial, or unstable streams.
The OHWM occurs at the stage of effective discharge	Difficult to measure or validate.

- All of these assumptions are limited by either their scientific validity, universal applicability, or practicability.
- So we're stuck with physical indicators, but which ones and why?

OHWM Technical Definition

Proposed technical definition:

"The ordinary high water mark is the most spatially and temporally consistent physical signature (i.e. one or more physical features) established by the fluctuations of water at a given location along a stream channel."

- Supposes that indicators which are more stable (i.e. remain in the same location over time) are more representative of ordinary flow conditions than less-stable indicators.
- Consistent, universally applicable, testable

Northeastern OHWM Study Design

- Develop a regional stream classification (or borrow from existing).
- Choose a variety of study sites that cover the range of stream types in the region. Use gaged sites where possible.
- Record all potential OHWM indicators at each site, seasonally.
- Assess the stability of potential indicators over time.
- Assess relationships between indicators and hydrology (at gaged sites).
- Assess variability in OHWM indicators with regard to stream type, landscape, climate, etc.
- Potentially apply this sampling strategy to other parts of the country.

OHWM Datasheet

OHWM Datasheet

Project/Site: **Date:**

Location: **Lat/Long:**

Investigator(s):

Project/Site Description:

Sample Point: **Lat/Long:** **Photo Numbers:**

Sample Point Description (setting, disturbances, etc.):

Transect drawing (label OHWM locations, hydrogeomorphic units, and other features):

Stream Reach Characteristics

Water Presence: ☐ Flowing ☐ Pooled ☐ None

Gradient: ☐ Low (<2%) ☐ Moderate (2-10%) ☐ High (>10%)

Pattern: ☐ Braided ☐ Meandering ☐ Riffle-pool ☐ Rapids ☐ Step-pool ☐ Cascades ☐ Colluvial ☐ Bedrock

Notes:

Primary OHWM Indicators

Break in slope: ☐ Gentle (< 30°) ☐ Moderate (30 - 60°) ☐ Sharp (> 60°) ☐ None

Notes:

Change(s) in Vegetation: ☐ Density ☐ Maturity ☐ Composition ☐ None ☐ Other: _____

Vegetation Characteristics ABOVE the OHWM

Total Vegetation Cover: ____% Tree: ____% Shrub: ____% Herb: ____% Bare Ground: ____%

Mean Stage of Growth Forms: ☐ Young ☐ Moderate ☐ Mature

Species Present: _____ _____ _____ _____ _____ _____

Vegetation Characteristics BELOW the OHWM

Total Vegetation Cover: ____% Tree: ____% Shrub: ____% Herb: ____% Bare Ground: ____%

Mean Stage of Growth Forms: ☐ Young ☐ Moderate ☐ Mature

Species Present: _____ _____ _____ _____ _____ _____

Notes:

Change(s) in Sediment Texture: ☐ Yes ☐ No

Sediment Texture ABOVE the OHWM

☐ Clay/Silt (<0.1mm): ____% ☐ Sand (0.1-2mm) ____% ☐ Sm. Gravel (2-10mm): ____%

☐ Lg. Gravel (1-10cm): ____% ☐ Cobbles (10-25cm): ____% ☐ Boulders (>25cm): ____%

Sediment Texture BELOW the OHWM

☐ Clay/Silt (<0.1mm): ____% ☐ Sand (0.1-2mm) ____% ☐ Sm. Gravel (2-10mm): ____%

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Notes:

Secondary Indicators

Secondary Indicators ABOVE the OHWM

☐ Drift/Wrack Lines ☐ Mudcracks ☐ Ripples ☐ Point bars ☐ Shelving ☐ Exposed roots ☐ Silt deposits

☐ Undercutting ☐ Leaf clearing ☐ Leaf cover ☐ Organic Soil ☐ _____ ☐ _____

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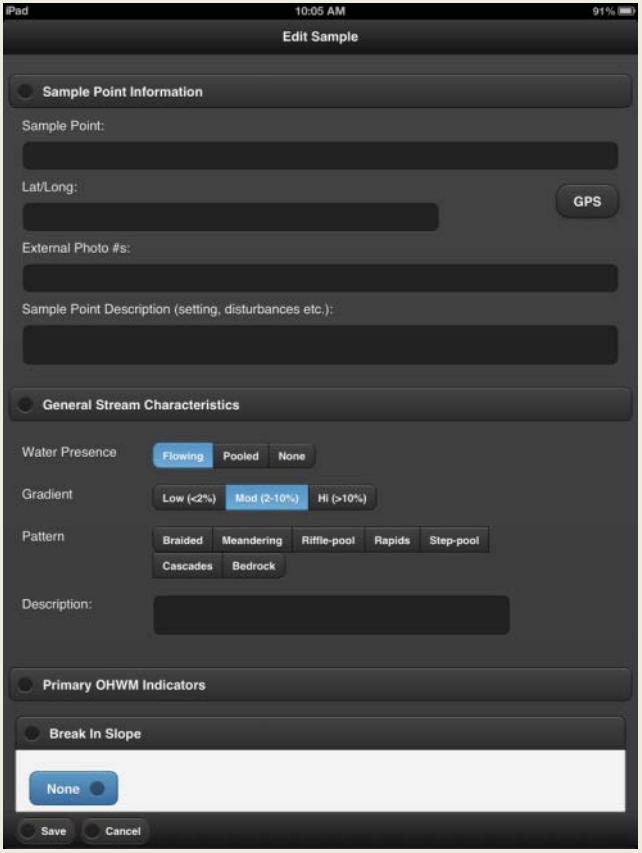
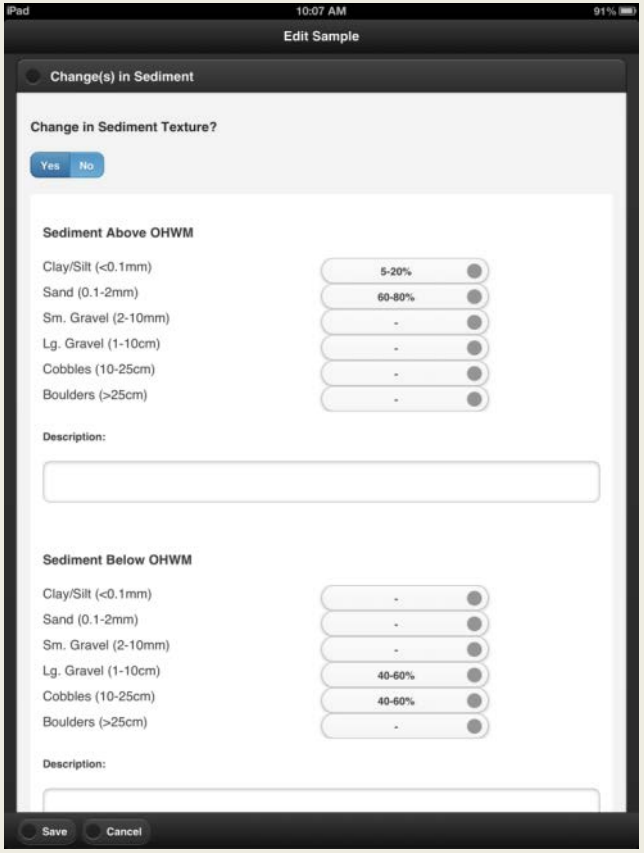
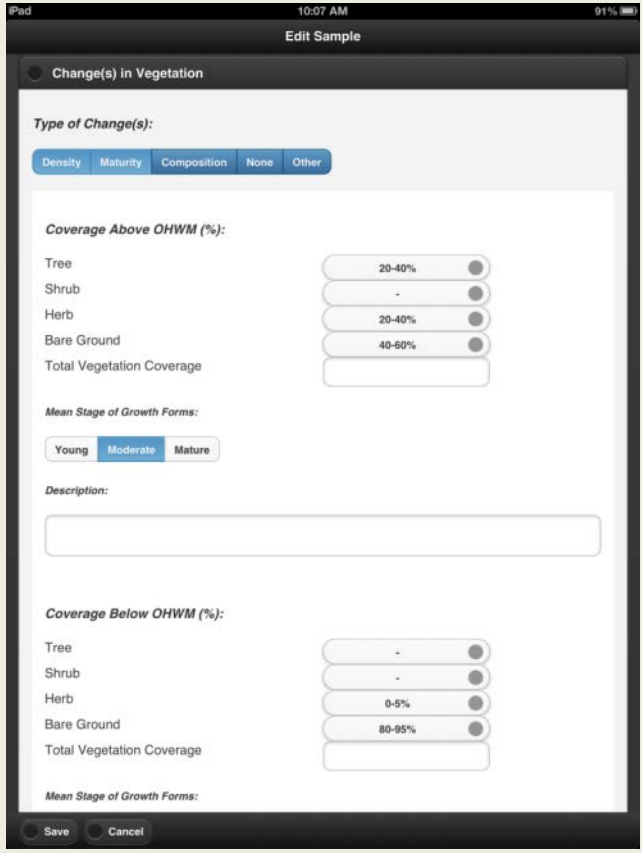
Notes:

OHWM Smartphone App







Apple and Android versions

Questions?