Geomorphic Unit Toolkit

2015 CHaMP Camp – Advanced Workshop

Cove, Oregon – June 4th 2015

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BONNEVILLE POWER ADMINISTRATION

ISEMP

CHaMP

THREE PRIMARY MOTIVATIONS

1. Geomorphic Units comprise fish habitat -> Build stronger fish habitat relationships
2. Geomorphic Units are readily derivable from topography, if we have clearer topographic definitions
3. Geomorphic Unit Assemblages are predictable by reach type & condition

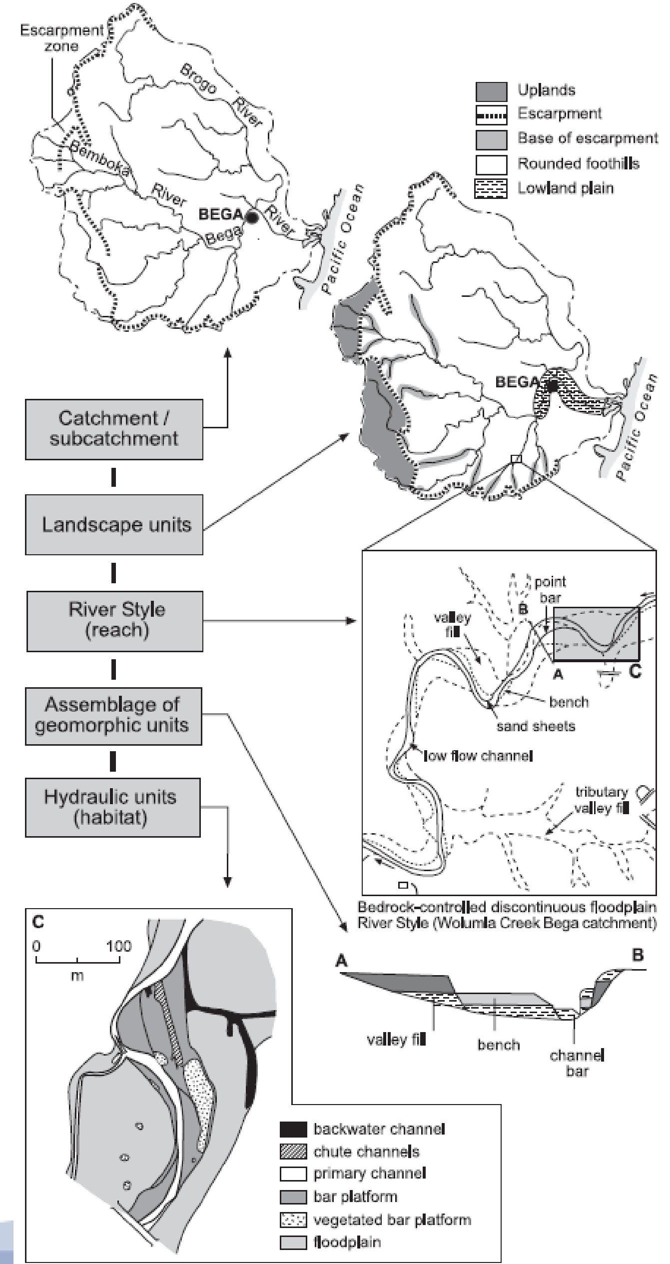
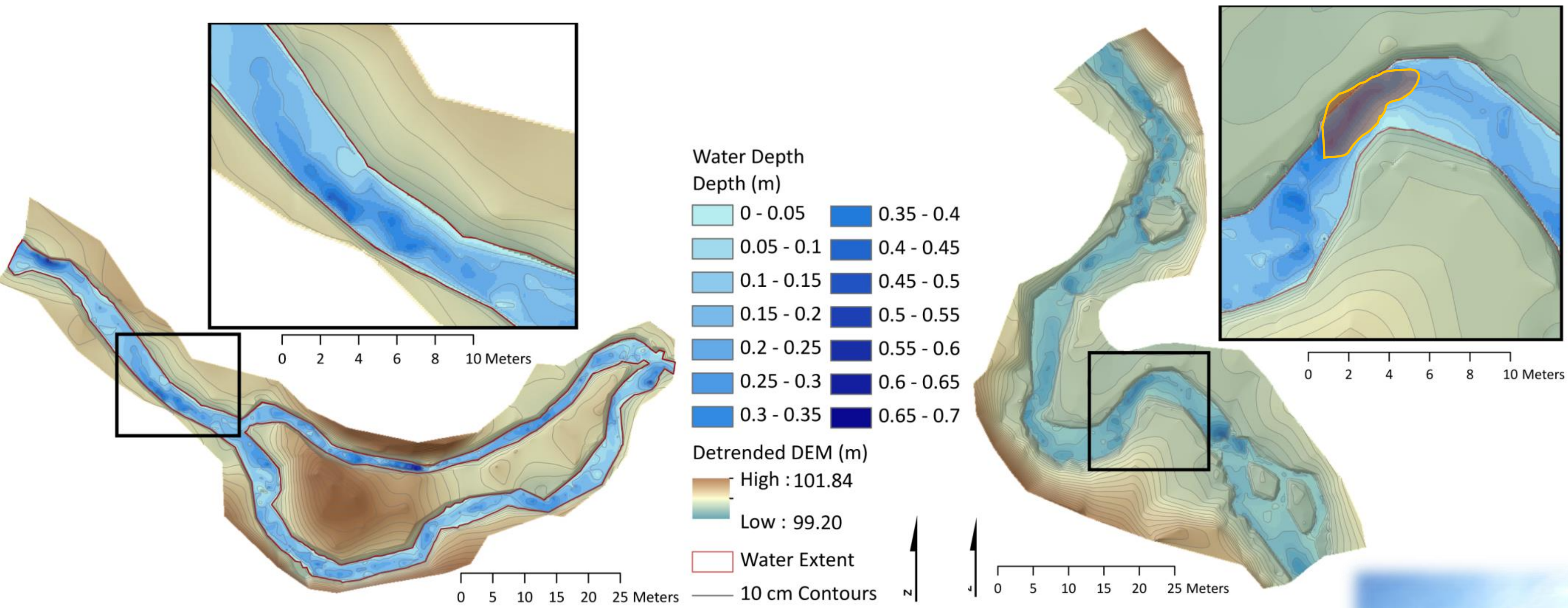


Figure from: Brierley & Fryirs (2005)

IN CHaMP, CREWS TAUGHT HOW TO PAINT

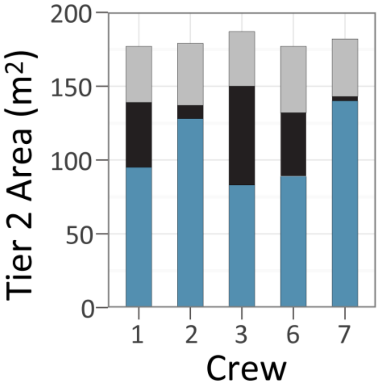


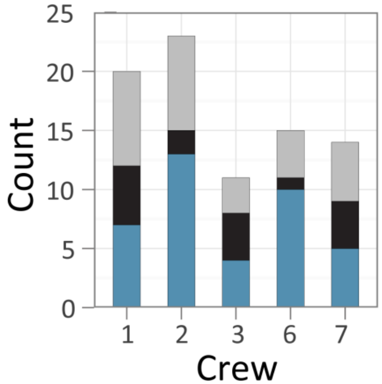
- As surveyors, they are artists… painting a quantitative picture of habitat with topography

CHANNEL UNITS & CREW VARIABILITY

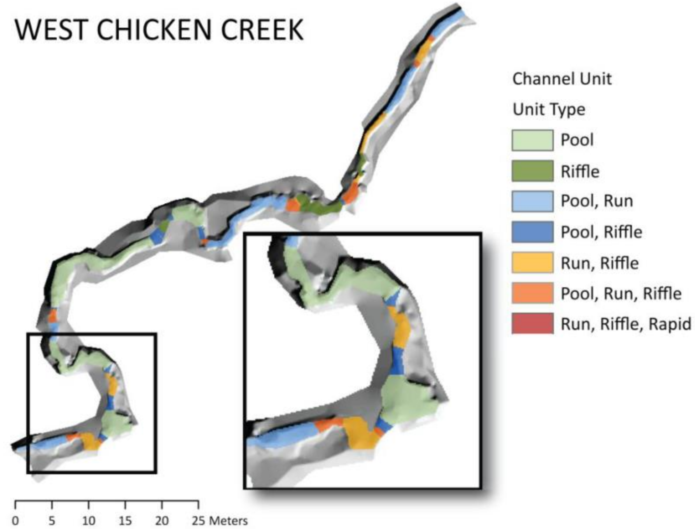
Comparing Simple vs Complex Sites

WEST CHICKEN CREEK

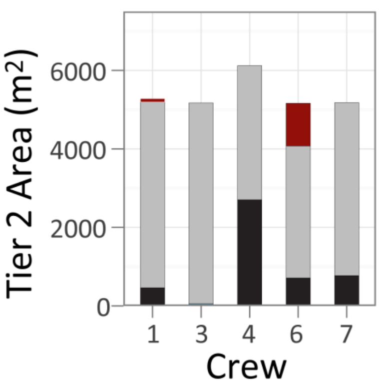


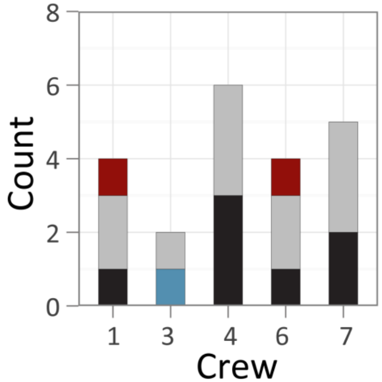


WEST CHICKEN CREEK



GRANDE RONDE RIVER - UPPER





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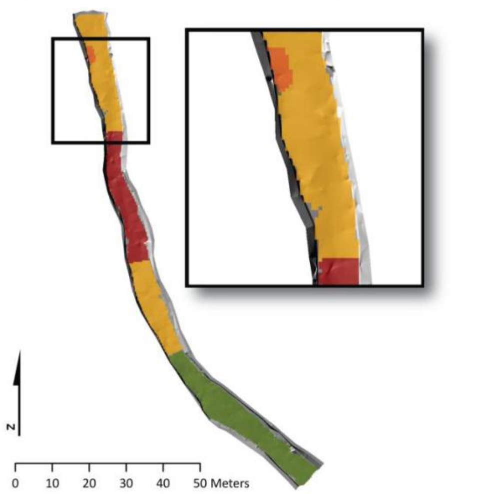
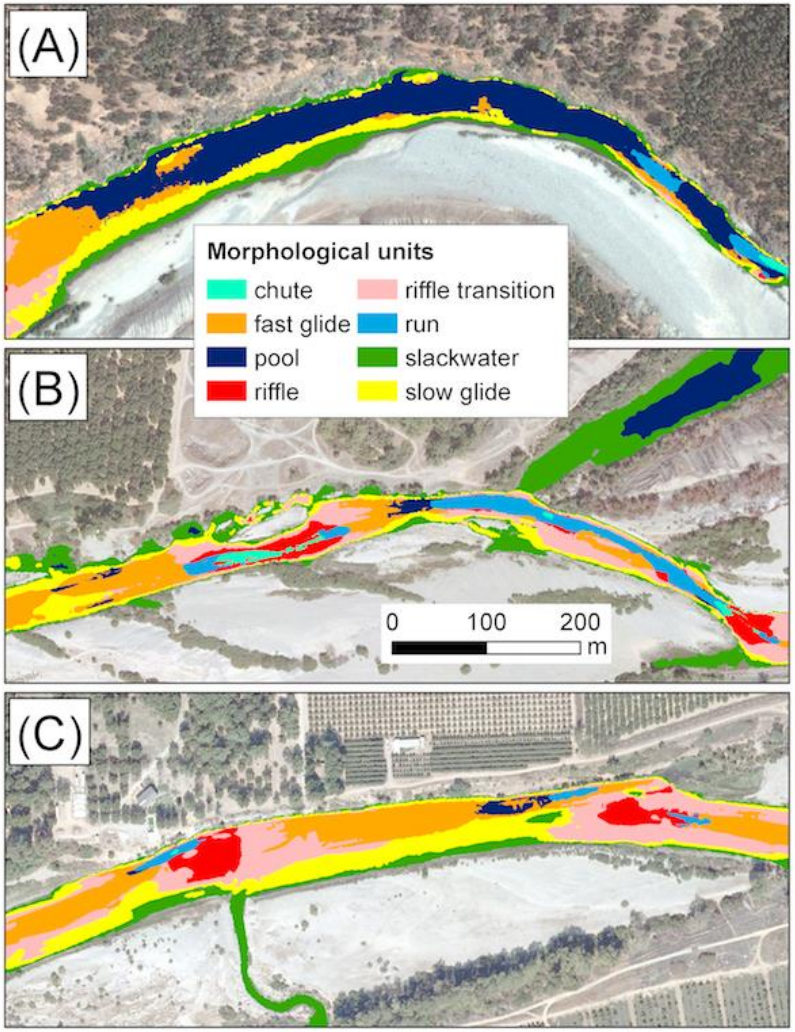


Pool Non-Turbulent Riffle Rapid

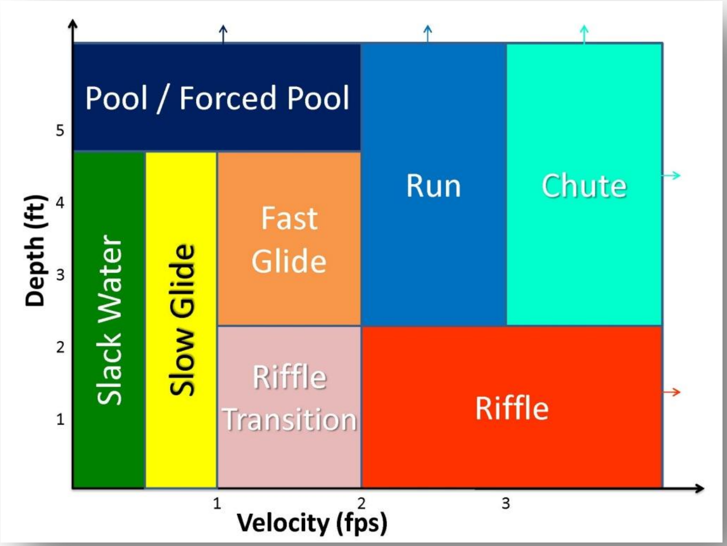
Take home: A lot of crew variability

From Bangen (2012)

HYDRAULICALLY INFORMED MUs



- 2D Hydraulic classification to determine morphological units

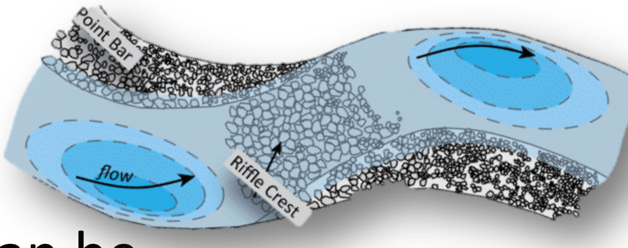


- See Wyrick & Pasternack (2014) *Geomorphology*

http://pasternack.ucdavis.edu/research/projects/near-census-river-science/2dmus/

GEOMORPHIC UNIT DEFINITION

- A geomorphic unit is a landform that is a byproduct of erosion and deposition of sediment
- Fluvial geomorphic units are the result of fluvial (by water) erosion and deposition

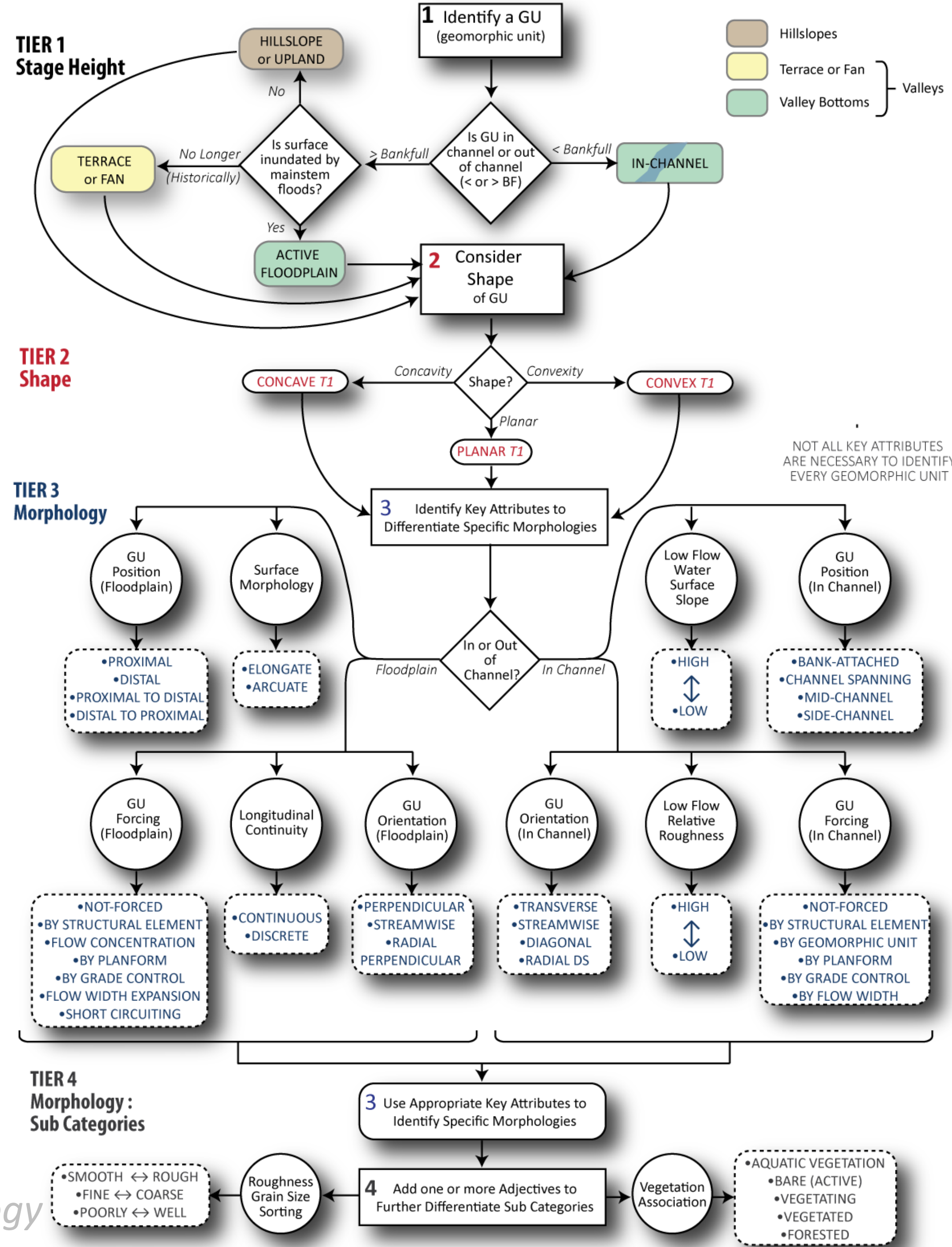


For mapping purposes:

- GU's are spatially continuous areas that can be topographically defined
- GU's can be represented on a cell-by-cell basis by probabilistic or fuzzy membership in a class (e.g. probability of being a bar)
- GU's are often represented as polygons

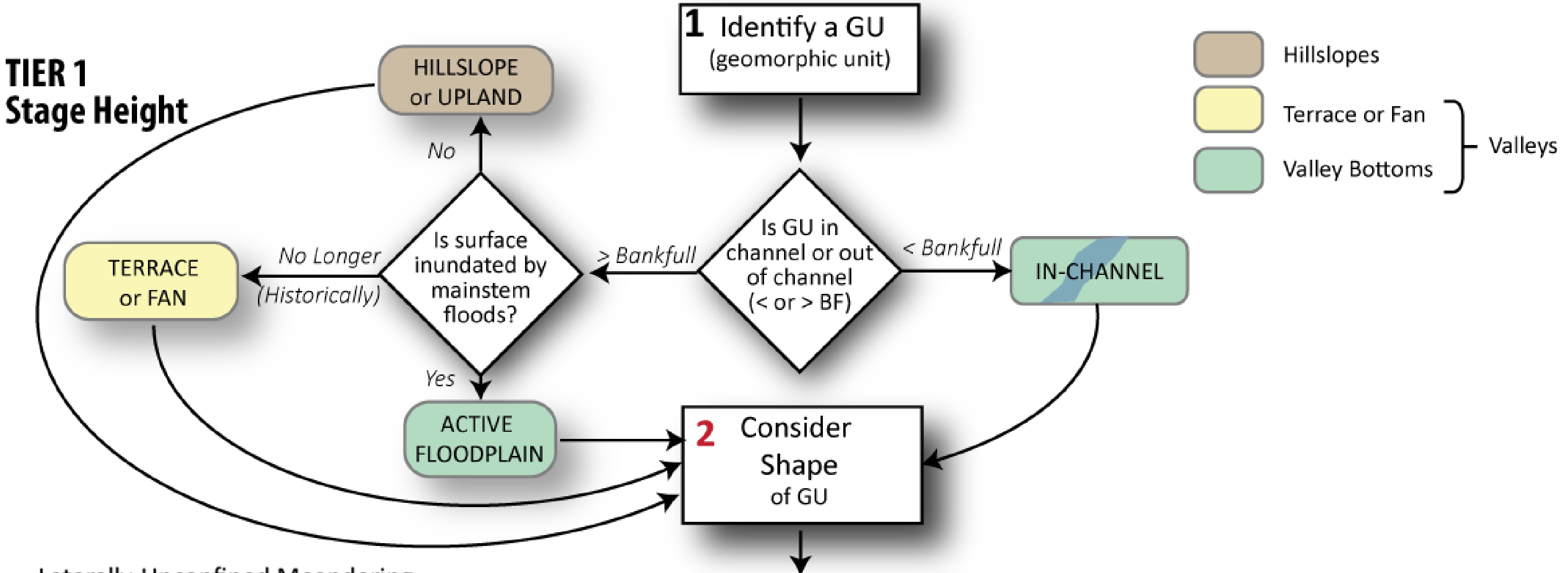
TAXONOMY FOR MAPPING FLUVIAL LANDFORMS

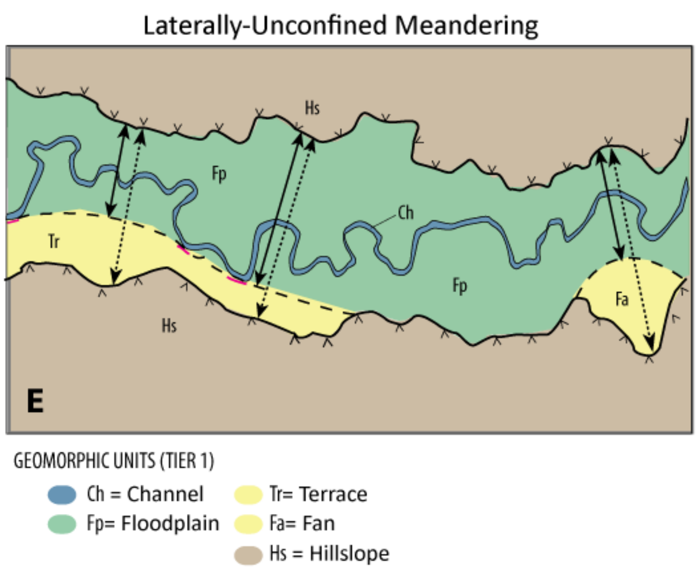
- Four Tiers
  - Stage Height
  - Shape
  - Morphology
  - Roughness/Vegetation
- Over 95 fluvial geomorphic units found in literature, of which 70 are distinctive
- Clearer, topographically based defintions



Wheaton et al. (Accepted) - *Geomorphology*

TIER 1 – STAGE HEIGHT -> LEADS TO GEOMORPHIC MAP





- The building blocks of a Valley?

vs.

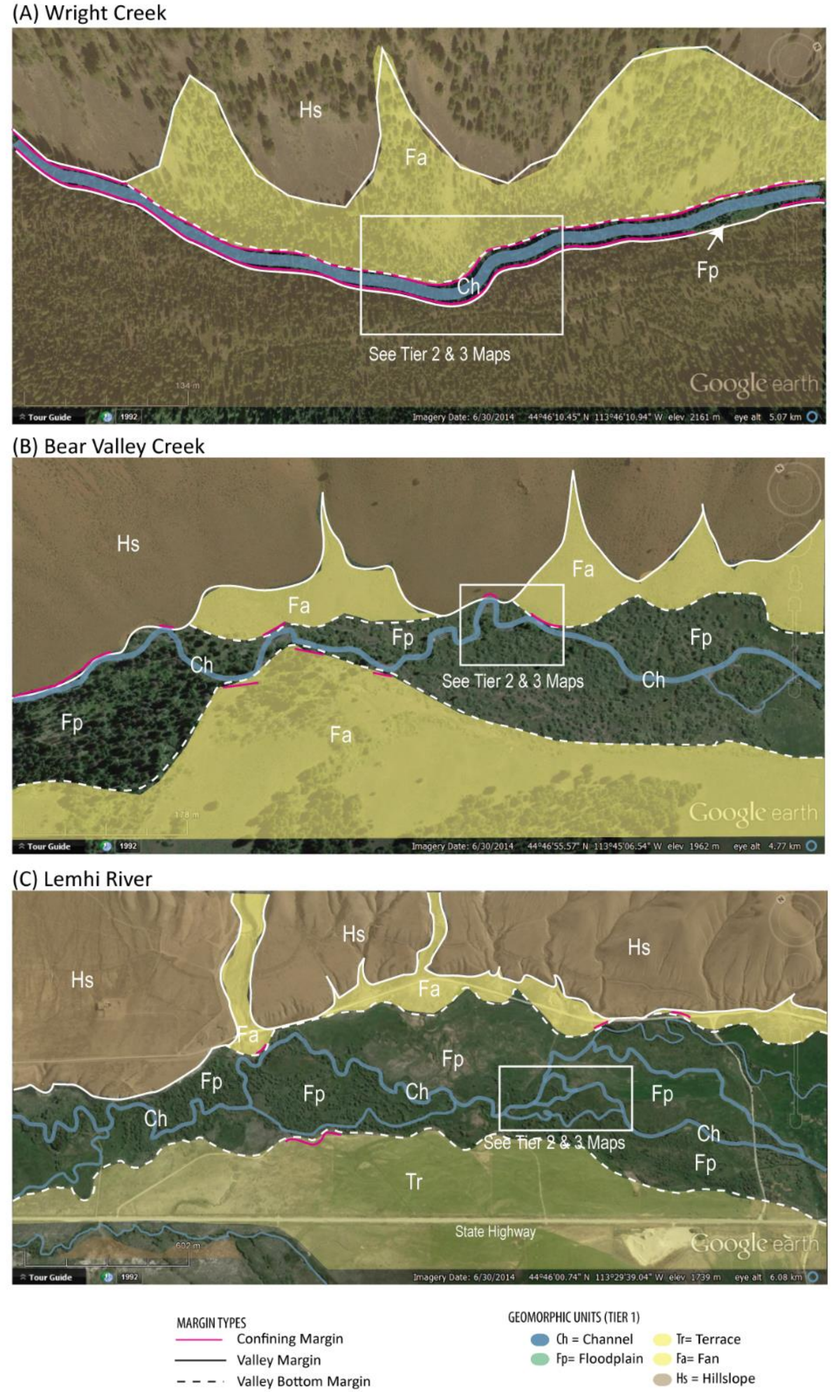
- The building blocks of a Valley Bottom?

Wheaton et al. (Accepted) - *Geomorphology*

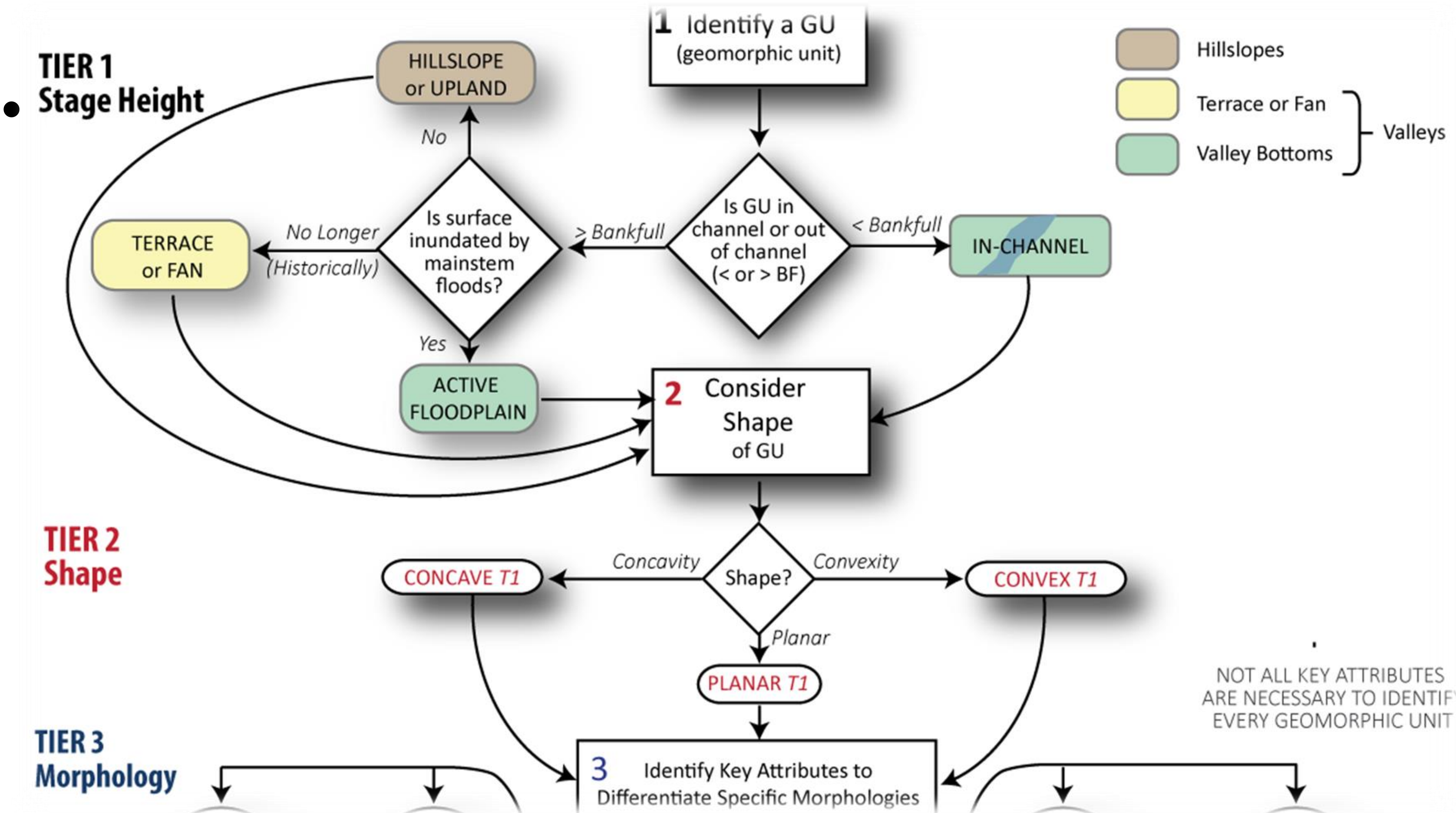
TIER 1 APPLIED

- Contrasting valley settings show different distributions of tier 1 geomorphic Units…

Wheaton et al. (Accepted) - *Geomorphology*



TIER 2 - SHAPE



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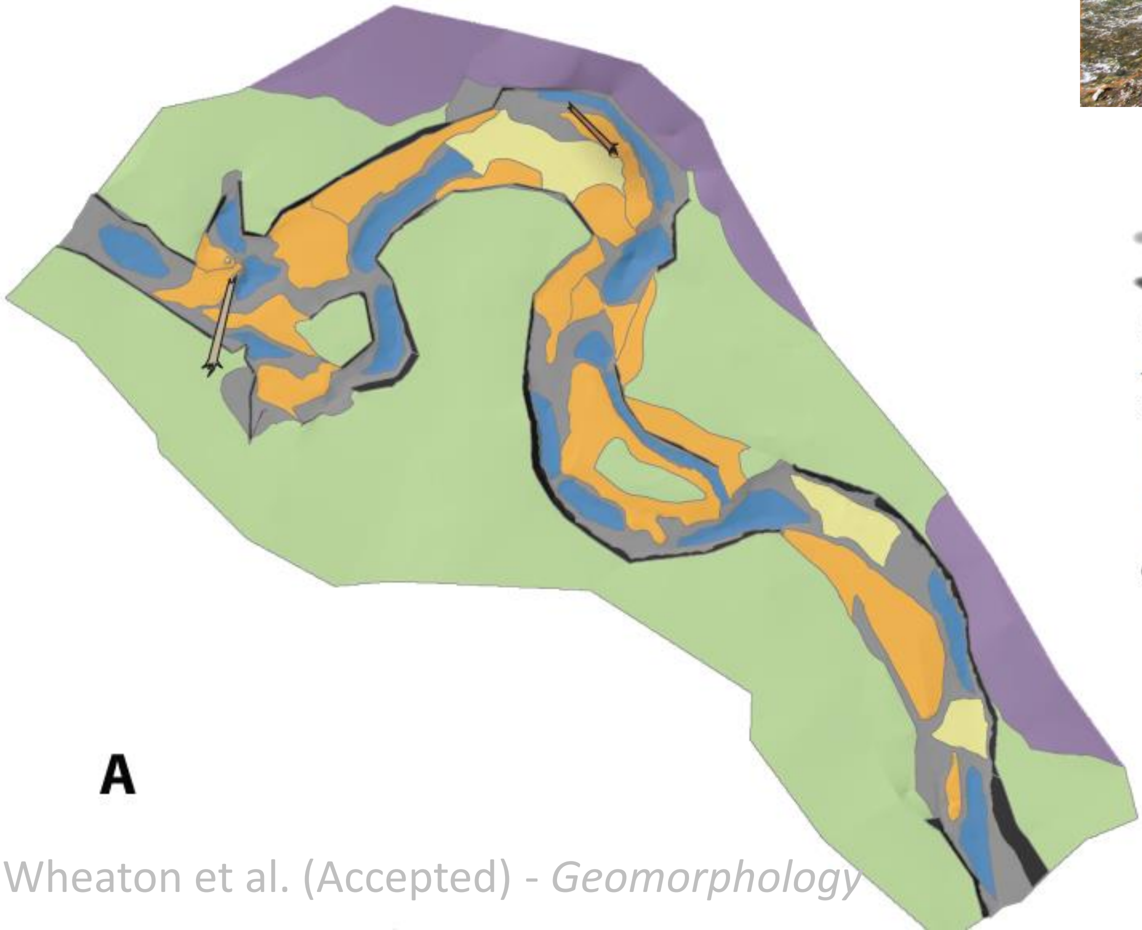
TIER 2 APPLIED



GEOMORPHIC UNITS
TIER 2 - Shape / Type

- Transition Zones
- Channel Margin

Structural Elements

- LWD

IN-CHANNEL

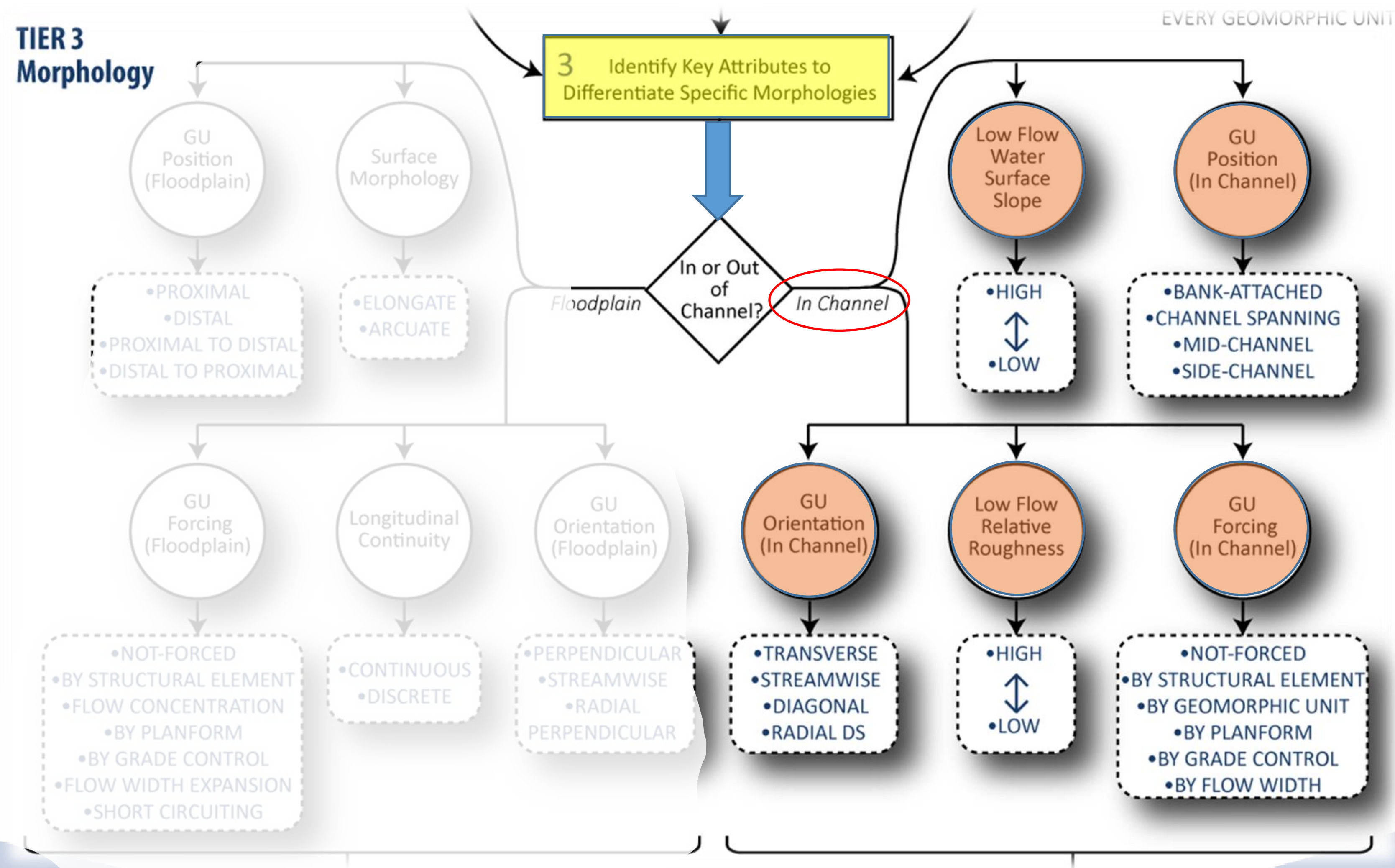
- Concave In-Channel (i.e. Pools)
- Convex In-Channel Features (i.e. Bars)
- Planar In-Channel Features

OUT-OF-CHANNEL

- Convex Fan
- Planar Active Floodplain

Wheaton et al. (Accepted) - *Geomorphology*

TIER 3 - MORPHOLOGY



Key Tier 3 Attributes:	Types	Description
GU Forcing		Occurs when a non-uniform hydraulic flow pattern creates a flow environment conducive to forcing the formation, maintenance or accentuation of a geomorphic unit.
	∟ **Not Forced**	The GU forms on its own (e.g. free bars)
	∟ **By Structural Element**	Forcing can be caused by structural elements (e.g. large woody debris causing a plunge pool or an eddy bar)
	∟ **By Geomorphic Unit**	Forcing can be caused by another geomorphic unit (e.g. a pool can be forced by a bar)
	∟ **By Planform**	Forcing can be induced by sinuosity (e.g. flow separation on inside bends leading to point bars)
	∟ **By Flow Width**	Forcing is often associated with flow width expansion for depositional units and flow with constriction for erosional units
GU Orientation		The orientation is defined by the longest axis of the geomorphic unit and relative to dominant flow direction.
	∟ **Transverse**	Transverse units are oriented perpendicular to the flow (e.g. *riffles)*
	∟ **Streamwise**	Streamwise units are oriented parallel to the flow (e.g. *forced pools* are elongated in a streamwise fashion associated with the convergent flow jet)
	∟ **Diagonal**	Diagonal units intersect the channel at an angle and flow is shunted diagonally over them at high flows.
	∟ **Radial DS**	Some units have lobate shapes (e.g. *lobate bars*) which
GU Position		Defines the position of the GU within the low-flow channel
	∟ **Bank-Attached**	Many units are appended to the channel margins (e.g. *point bars*); Note 'bank-attached' is common termionology in the fluvial literature even though the entire length of all channels are bound by true banks. Channel margins is a more generic term, but less common.
	∟ **Channel Spanning**	Some units are bank-attached on both sides and span the entire low flow channel (e.g. *riffles*)
	∟ **Mid-Channel**	Some units are not attached to a channel margin and occur in the center of a channel (e.g. *longitudinal bar*)
	∟ **Side-Channel**	For some mapping purposes, it is helpful to differentiate units that only occur in side and/or secondary channels
Low Flow Water Surface Slope		Especially for in-channel, planar units, low flow water surface slope is a helpful way of differentiating across the spectrum from low-slope glides, through intermediate slope runs and riffles, through high slope rapids, up to very high slope cascades.
	∟ **Flat**	Water surface slope = 0
	∟ **Shallow**	Water surface slope < 0.005
	∟ **Moderate**	Water surface slope > 0.005 & < 0.03
	∟ **Steep**	Water surface slope > 0.03
Low Flow Relative Roughness		Relative roughness is defined as the ratio of roughness height to flow depth (z_0/h).
	∟ **Low**	Relative roughness < 0.5 (i.e. majority of flow depth not obstructed by substrate)
	∟ **Moderate**	Relative roughness between 0.5 and 1 (i.e. majority of flow depth obstructed by substrate, but substrate not protruding from water surface)
	∟ **High**	Relative roughness > 1 (i.e. particles protruding from water surface)
	∟ **Very High**	Relative roughness >> 1 (i.e. flow depth is negligible relative to massive boulders protruding from water surface)

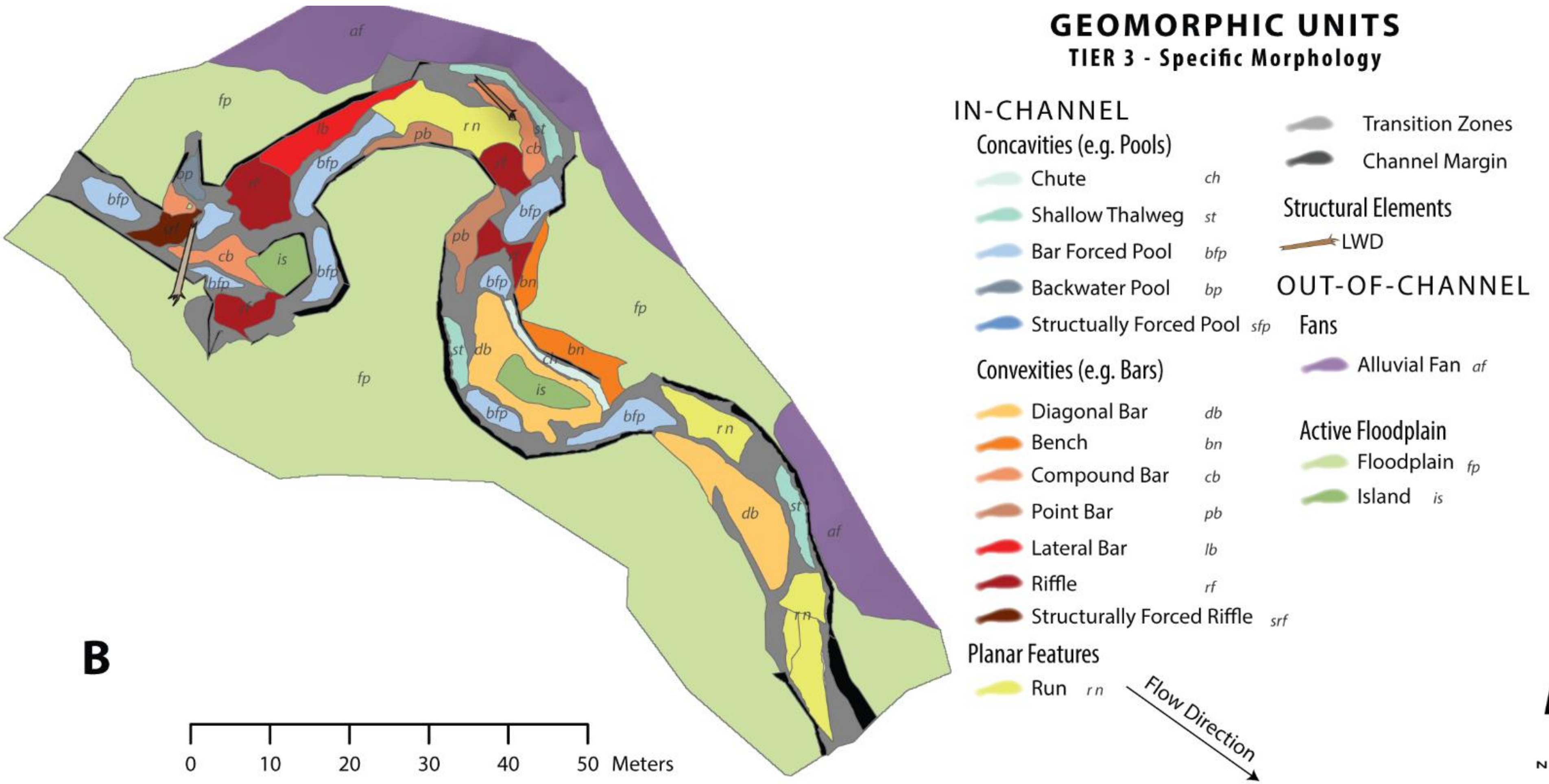
Tier 1	Tier 2	Tier 3							
Stage Height	Shape/Type	Specific Morphology	Key Attributes to Differentiate Specific Morphologies						
			GU Forcing	Low Flow Relative Roughness	GU Orientation	GU Position	Low Flow Water Surface Slope	Also Known As	Similar to or Confused With
∟	Planar								
		∟ Bench	Not Forced	Varies	Streamwise	Bank-Attached	Varies	Inset Floodplain	Ledge, but depositional feature; Terrace, but within active bankfull channel
		∟ Ledge	Not Forced	Varies	Streamwise	Bank-Attached	Varies	Inset Floodplain	Bench, but erosional feature; Terrace, but within active bankfull channel
		∟ Glide	Not Forced	Low (< 0.5)	Streamwise	Varies	Shallow	NA	Run, but much lower gradient water surface and low relative roughness
		∟ Run	Not Forced	Moderate (< 1)	Streamwise	Varies	Shallow to Moderate	NA	Sometimes confused with riffles or glides
		∟ Rapid	Varies	High (> 1)	Streamwise	Varies	Moderate to Steep	NA	Cascade, but less relative roughness and lacking vertical drops
		∟ Cascade	Varies	Very High (>>1)	Streamwise	Varies	Steep	NA	Rapid, but more relative roughness, steeper water surface, and vertical drops; Sometimes confused with step-pools
∟	Concavity (e.g. Pool)								
		∟ Backwater	Grade Control	Low (< 0.5)	Varies	Side Channel	Flat	Slackwater	Similar to other pools but found in disconnected side channels or secondary channels
		∟ Bar-Forced Pool	By Bar	Low (< 0.5)	Streamwise	Bank-Attached	Shallow	NA	Structurally forced pool, but forced by bar shunting flow against resistant boundary
		∟ Beaver Pond	Grade Control from Beaver Dam SE	Low (< 0.5)	Streamwise	Channel Spanning	Flat	Beaver Pool	A specific example of a dammed pool
		∟ Chute	Planform	Varies	Streamwise	Bank-Attached or Mid-Channel	Moderate	NA	Shallow thalweg, but generally steeper and dissecting bar; Also confused with flood channels, but these are in-channel short-circuiting forms
		∟ Confluence Pool	Planform	Low (< 0.5)	Streamwise	Varies	Shallow	Scour Pool	
		∟ Dammed Pool	DS Grade Control from SE	Low (< 0.5)	Streamwise	Channel Spanning	Shallow	NA	Beaver pond, but forcing SE can be any channel spanning obstruction. Also confused with the upstream pool in a step pool
		∟ Plunge Pool	US Grade Control from SE	Low (< 0.5)	Transverse	Varies	Flat	Scour Pool	
		∟ Ramp	Planform	Varies			Varies	NA	
		∟ Return Channel	Forced by Eddy Bar	Varies	Streamwise	Bank-Attached	Varies	NA	Chute, but flow is upstream in association with eddy
		∟ Shallow Thalweg	Forced by planar GU or occasionally bars	Varies	Streamwise	Bank-Attached	Varies, but Typically Moderate	NA	Chute, but does not dissect a bar surface
		∟ Secondary Channel	Planform	Varies	Streamwise	Mid-Bankfull Channel	Varies	NA	Anabranch or Secondary Channel, except that area separating secondary and primary channel is < bankfull
		∟ Structurally-Forced Pool	Flow Width Constriction Forced by SE	Low (< 0.5)	Streamwise	Bank-Attached or Mid-Channel	Varies	NA	Sometimes called 'scour pool'

FILTERING THROUGH TAXONOMY

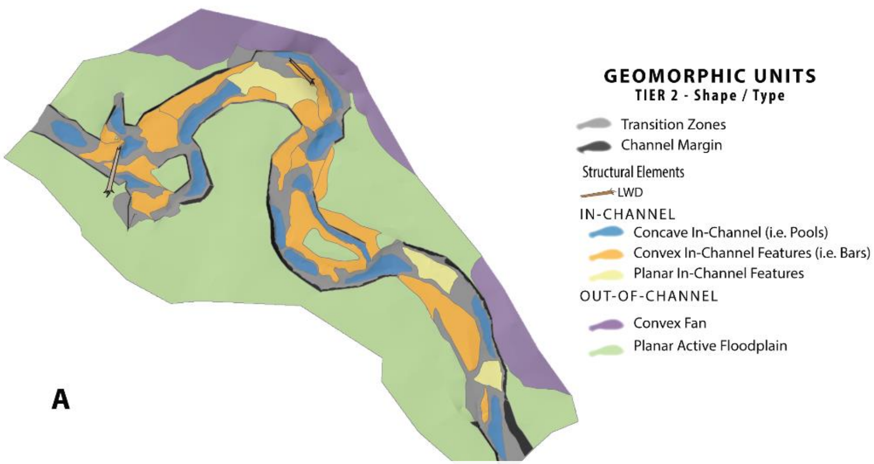
Tier 1:	In-Channel	Active Floodplain	Terrace	Fan	Hillslope		Total:
Tier 1 Count	1	1	1	1	1		5
Tier 2 Count	3	3	3	3	3		15
Tier 3:							
∟ Concavities	12	12	1	1	1		27
∟ Convexities	18	5	0	3	1		27
∟ Planar	6	5	2	0	1		14
Tier 3 Subtotal:	36	22	3	4	3		68

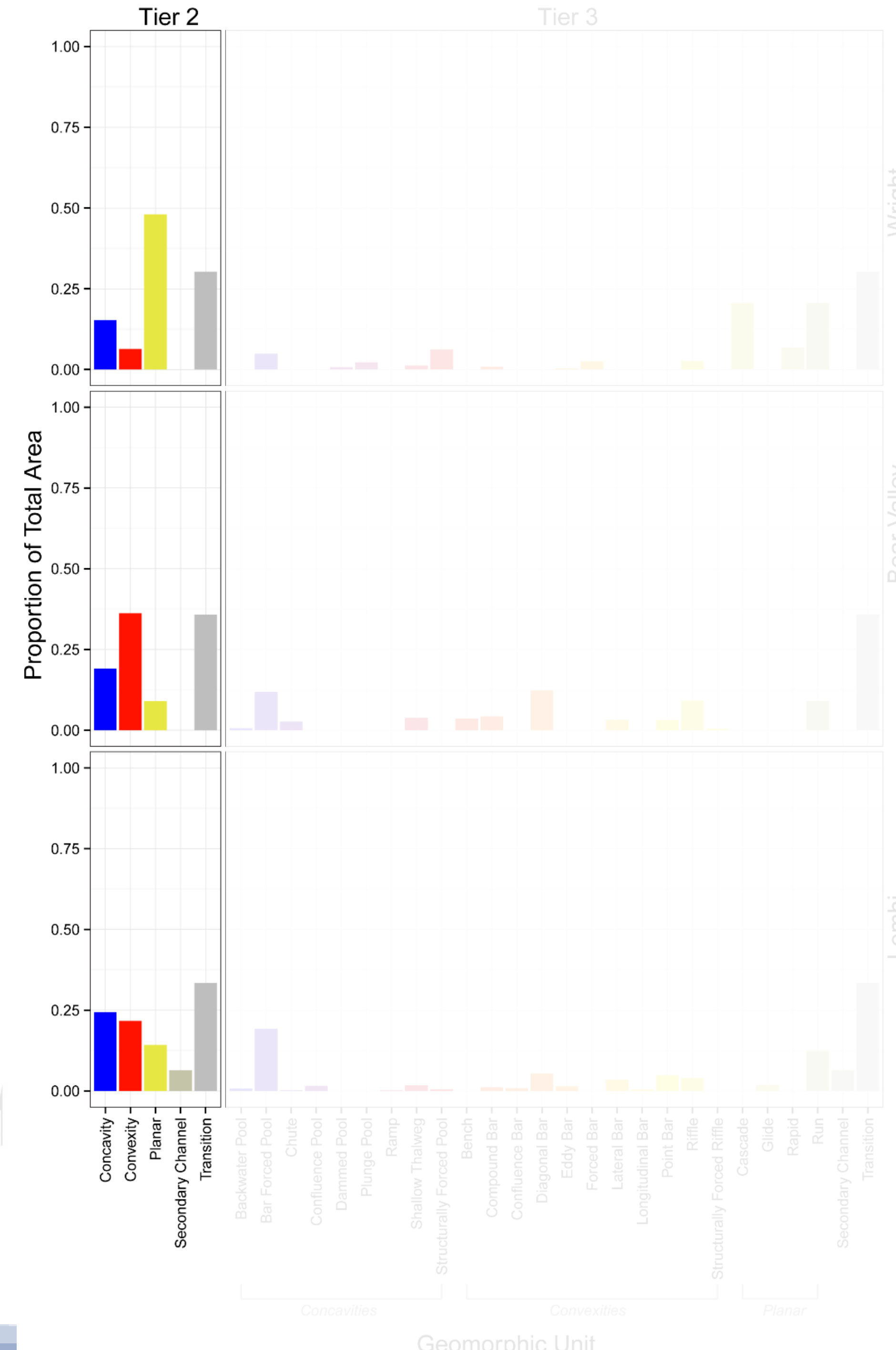
- Prior to Tiers… could be one of 68
- @ Tier 1, knowing I'm in channel, one of 36
- @ Tier 2, knowing I'm a concavity, one of 12
- @ Tier 3, knowing I'm forced, one of

TIER 3 APPLIED



ASSEMBLAGES

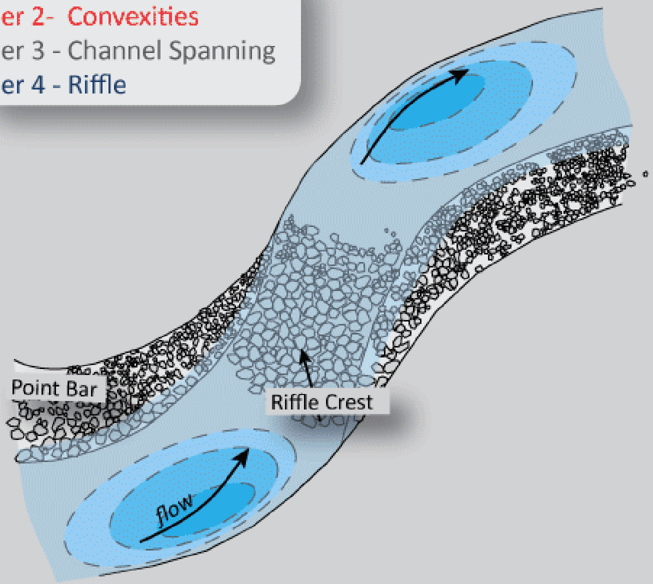


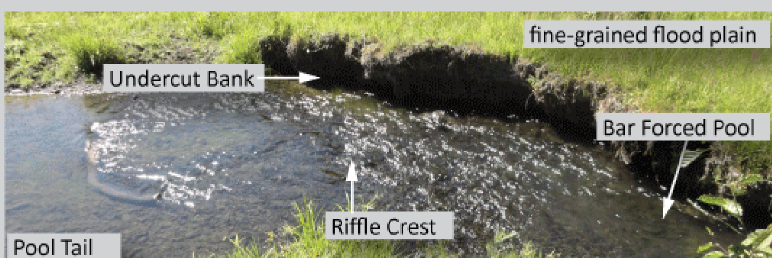


IF I LAND ON A RIFFLE, BUT DON'T KNOW IT

RIFFLE

Tier 1 - (< or > bankful)
Tier 2- Convexities
Tier 3 - Channel Spanning
Tier 4 - Riffle





Jungle Creek, Middle Fork John Day Watershed, OR

GEOMORPHIC FORM

Riffles form as topographic highs along an uneven longitudinal profile, between bends in sinuous alluvial channels. Alluvial riffles are shallow, step-like, channel-spanning features.

Middle Fork John Day River, OR

PROCESS INTERPRETATION

Riffles are zones of sediment accumulation that increase channel roughness during high flow stages, and are maintained or built at various flow stages by the consequent increased turbulence and reduced velocity over the steepened surface. Riffles are often dissected at low flow stages, and reworked or removed altogether at stages higher than bankful.

TYPICAL *ADJACENT* GEOMORPHIC UNITS

Riffles are commonly associated geomoprhic units that help to force it as a channel spanning bar: the *riffle crest* and steepened planar surface separates the upstream and downstream *Bar-Forced Pools, Bank-attached bars (i.e., Point Bars),* and undercut banks.

TYPICAL SALMONID FISH HABITAT ASSOCIATIONS

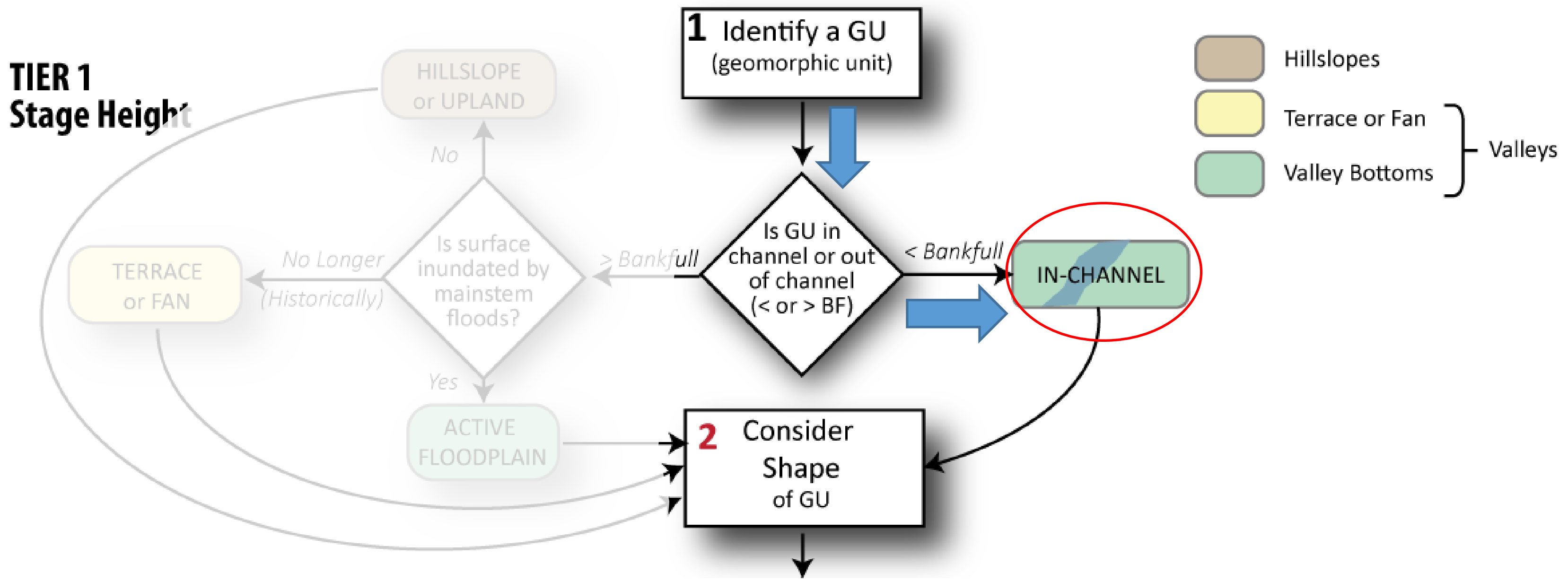
Typical fish habitat is focused at pool tails at the tops of riffles where holding occurs, and pool heads at their bases, where fish can forage on food items being washed down from the steepened ramp above.

Anadromous life stages	Fry	Parr (Juvinile)	Smolt	Adult
Foraging				
Energy Refugia	O	O	O	O
Predation Refugia	✓	✓	✓	✓
Thermal Refugia	X	X	X	X

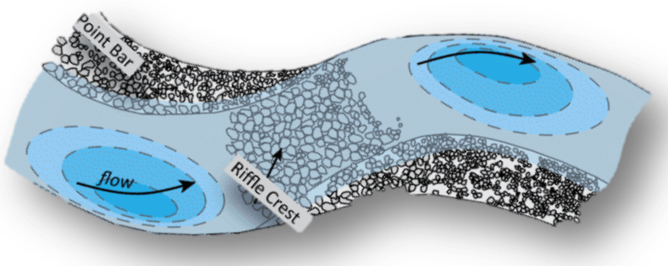
na- Not Applicable ; X - Not Typically Important ; O - Occasionally Provided ; ✓ Critical

Tier 1	Tier 2	Tier 3							
Stage Height	Shape/Type	Specific Morphology	Key Attributes to Differentiate Specific Morphologies						
			GU Forcing	Low Flow Relative Roughness	GU Orientation	GU Position	Low Flow Water Surface Slope	Also Known As	Similar to or Confused With
In-Channel									
	∟ **Convexity (e.g. bar)**								
		∟ Backwater Bar	Grade Control	Varies	Varies	Side Channel	Varies	Slackwater deposit	Similar to other bars but found in disconnected side channels or secondary channels
		∟ Boulder Bar	Flow Width	Varies	Streamwise	Bank-Attached or Mid-Channel	Varies	Boulder Berm	Similar to other bars, but in much higher gradient systems.
		∟ Compound Bar	Varies	Varies	Varies	Varies	Varies	Bar complex	An amalgamation of multiple unit bars and other bar types (complex history)
		∟ Confluence Bar	Grade Control	Varies	Radial DS & Streamwise	Bank-Attached	Varies	NA	Expansion bar, except in response to gradient drop from tributary to mainstem.
		∟ Diagonal Bar	Planform & Flow Width Expansion	Varies	Diagonal	Mid-Channel	Varies	Mid-Channel Bar	Point bar, but no longer bank-attached (separated by chute)
		∟ Eddy Bar	Planform, SE, and/or Flow Width Constriction	Varies	Streamwise	Bank-Attached or Mid-Channel	Varies	Separation Bar	
		∟ Expansion Bar	Flow Width	Varies	Transverse	Mid-Channel	Varies	NA	Transverse bar, but in response to slope lowering, and does not span channel
		∟ Forced Bar	Varies	Varies	Streamwise	Bank-Attached or Mid-Channel	Varies	NA	Eddy Bar
		∟ Forced Riffle	Channel Spanning SE	Moderate (< 1)	Transverse	Channel Spanning	Shallow	NA	Riffle, but forced by channel spanning structural element buried in bed
		∟ Lateral Bar	By Planform or By Flow Width	Varies	Streamwise	Bank-Attached	Varies	Alternate Bar	Point bars, but can be in bends with lower curvature or channels with lower sinuosity or straight
		∟ Lobate Bar	Grade Control	Varies	Radial DS	Mid-Channel	Varies	Mid-Channel Bar	Similar to other mid-channel bars but distinctive in DS tear-dropped shape and avalanche faces
		∟ Longitudinal Bar	Flow Width	Varies	Moderate (< 1)	Mid-Channel	Varies	Mid-Channel Bar	Similar to other mid-channel bars but distinctive in elongated streamwise orientation and upstream convexity at bar head
		∟ Point Bar	Planform forced	Varies	Streamwise	Bank-Attached	Varies	Bank-Attached Bar	Alternate bars, but in bends with higher curvature
		∟ Reattachment Bar	Varies	Varies	Streamwise	Bank-Attached	Varies	NA	Eddy Bar, but occurs DS of both flow separation and reattachment point
		∟ Ridge	Forced by SE and Flow Separation	Varies	Streamwise	Bank-Attached	Varies	NA	Scroll bar or levee; generally straighter, more linear feature
		∟ Riffle	Flow Width Expansion	Moderate (< 1)	Transverse	Channel Spanning	Moderate	Transverse Bar	Sometimes confused with runs
		∟ Scroll Bar	Planform & Flow Width Expansion	Varies	Streamwise	Bank-Attached	Varies	NA	Ridge, but positioned on point bar and generally curved
		∟ Unit Bar	Flow Width Expansion	Varies	Varies	Varies	Varies	NA	The fundamental building block of all bars

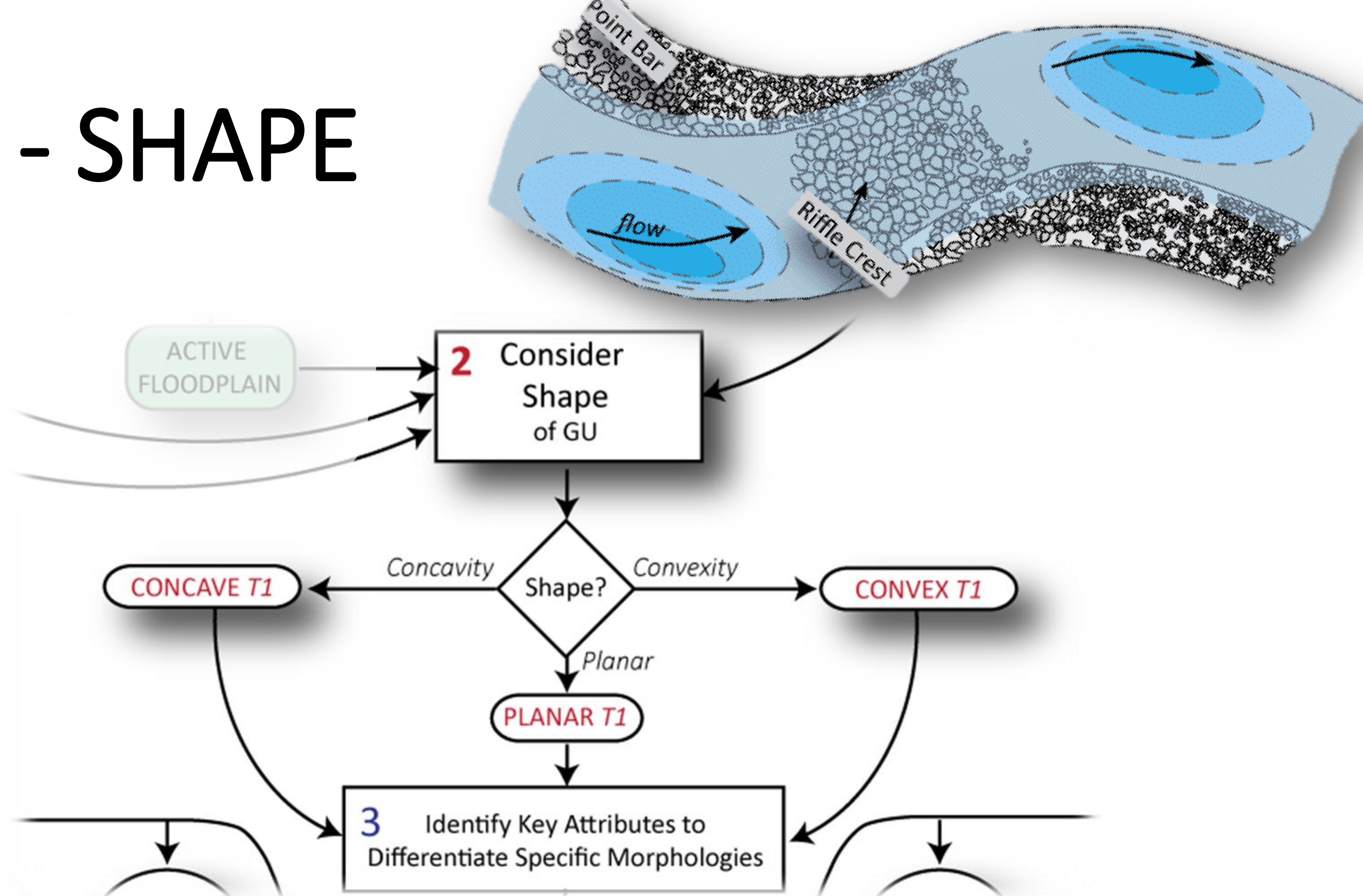
TIER 1 – ON THAT RIFFLE



- Not so bad…



TIER 2 - SHAPE



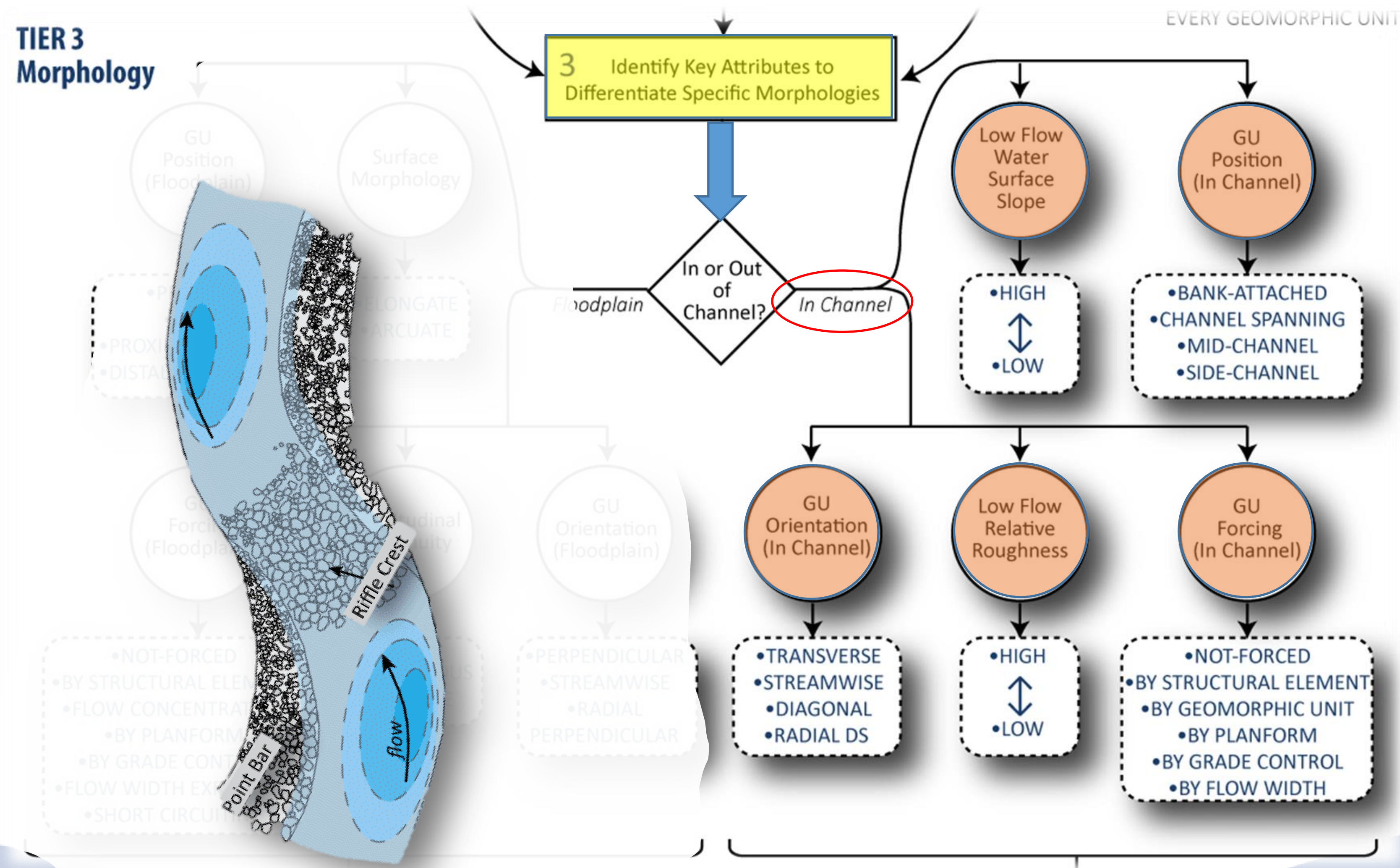
- Just add a verb to tier 1, so it’s a Concave In Channel Unit (i.e. concavity)

Concave

Planar

Convex

TIER 3 - MORPHOLOGY



Key Tier 3 Attributes:	Types	Description
GU Forcing		Occurs when a non-uniform hydraulic flow pattern creates a flow environment conducive to forcing the formation, maintenance or accentuation of a geomorphic unit.
	∟ **Not Forced**	The GU forms on its own (e.g. free bars)
	∟ **By Structural Element**	Forcing can be caused by structural elements (e.g. large woody debris causing a plunge pool or an eddy bar)
	∟ **By Geomorphic Unit**	Forcing can be caused by another geomorphic unit (e.g. a pool can be forced by a bar)
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	∟ **By Flow Width**	Forcing is often associated with flow width expansion for depositional units and flow with constriction for erosional units
GU Orientation		The orientation is defined by the longest axis of the geomorphic unit and relative to dominant flow direction.
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	∟ **Streamwise**	Streamwise units are oriented parallel to the flow (e.g. *forced pools* are elongated in a streamwise fashion associated with the convergent flow jet)
	∟ **Diagonal**	Diagonal units intersect the channel at an angle and flow is shunted diagonally over them at high flows.
	∟ **Radial DS**	Some units have lobate shapes (e.g. *lobate bars*) which
GU Position		Defines the position of the GU within the low-flow channel
	∟ **Bank-Attached**	Many units are appended to the channel margins (e.g. *point bars*); Note 'bank-attached' is common termionology in the fluvial literature even though the entire length of all channels are bound by true banks. Channel margins is a more generic term, but less common.
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	∟ **Side-Channel**	For some mapping purposes, it is helpful to differentiate units that only occur in side and/or secondary channels
Low Flow Water Surface Slope		Especially for in-channel, planar units, low flow water surface slope is a helpful way of differentiating across the spectrum from low-slope glides, through intermediate slope runs and riffles, through high slope rapids, up to very high slope cascades.
	∟ **Flat**	Water surface slope = 0
VARIES	∟ **Shallow**	Water surface slope < 0.005
	∟ **Moderate**	Water surface slope > 0.005 & < 0.03
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Low Flow Relative Roughness		Relative roughness is defined as the ratio of roughness height to flow depth (z_0/h).
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VARIES	∟ **Moderate**	Relative roughness between 0.5 and 1 (i.e. majority of flow depth obstructed by substrate, but substrate not protruding from water surface)
	∟ **High**	Relative roughness > 1 (i.e. particles protruding from water surface)
	∟ **Very High**	Relative roughness >> 1 (i.e. flow depth is negligible relative to massive boulders protruding from water surface)

Tier 1	Tier 2	Tier 3							
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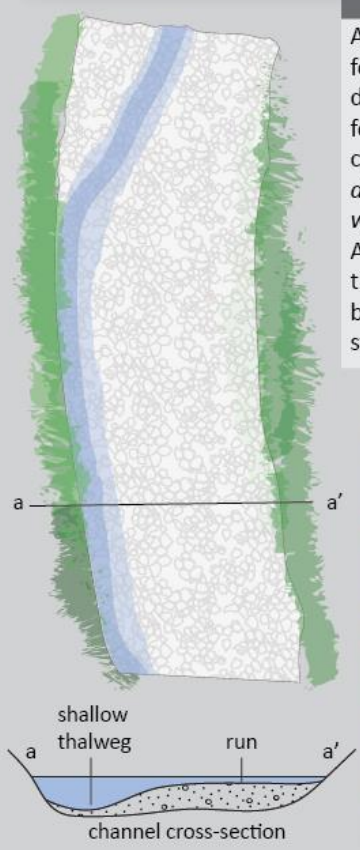
In-Channel									
∟	**Convexity (e.g. bar)**								
		∟ Backwater Bar	Grade Control	Varies	Varies	Side Channel	Varies	Slackwater deposit	Similar to other bars but found in disconnected side channels or secondary channels
		∟ Boulder Bar	Flow Width	Varies	Streamwise	Bank-Attached or Mid-Channel	Varies	Boulder Berm	Similar to other bars, but in much higher gradient systems.
		∟ Compound Bar	Varies	Varies	Varies	Varies	Varies	Bar complex	An amalgamation of multiple unit bars and other bar types (complex history)
		∟ Confluence Bar	Grade Control	Varies	Radial DS & Streamwise	Bank-Attached	Varies	NA	Expansion bar, except in response to gradient drop from tributary to mainstem.
		∟ Diagonal Bar	Planform & Flow Width Expansion	Varies	Diagonal	Mid-Channel	Varies	Mid-Channel Bar	Point bar, but no longer bank-attached (separated by chute)
		∟ Eddy Bar	Planform, SE, and/or Flow Width Constriction	Varies	Streamwise	Bank-Attached or Mid-Channel	Varies	Separation Bar	
		∟ Expansion Bar	Flow Width	Varies	Transverse	Mid-Channel	Varies	NA	Transverse bar, but in response to slope lowering, and does not span channel
		∟ Forced Bar	Varies	Varies	Streamwise	Bank-Attached or Mid-Channel	Varies	NA	Eddy Bar
		∟ Forced Riffle	Channel Spanning SE	Moderate (< 1)	Transverse	Channel Spanning	Shallow	NA	Riffle, but forced by channel spanning structural element buried in bed
		∟ Lateral Bar	By Planform or By Flow Width	Varies	Streamwise	Bank-Attached	Varies	Alternate Bar	Point bars, but can be in bends with lower curvature or channels with lower sinuosity or straight
		∟ Lobate Bar	Grade Control	Varies	Radial DS	Mid-Channel	Varies	Mid-Channel Bar	Similar to other mid-channel bars but distinctive in DS tear-dropped shape and avalanche faces
		∟ Longitudinal Bar	Flow Width	Varies	Moderate (< 1)	Mid-Channel	Varies	Mid-Channel Bar	Similar to other mid-channel bars but distinctive in elongated streamwise orientation and upstream convexity at bar head
		∟ Point Bar	Planform forced	Varies	Streamwise	Bank-Attached	Varies	Bank-Attached Bar	Alternate bars, but in bends with higher curvature
		∟ Reattachment Bar	Varies	Varies	Streamwise	Bank-Attached	Varies	NA	Eddy Bar, but occurs DS of both flow separation and reattachment point
		∟ Ridge	Forced by SE and Flow Separation	Varies	Streamwise	Bank-Attached	Varies	NA	Scroll bar or levee; generally straighter, more linear feature
		∟ Riffle	Flow Width Expansion	Moderate (< 1)	Transverse	Channel Spanning	Moderate	Transverse Bar	Sometimes confused with runs
		∟ Scroll Bar	Planform & Flow Width Expansion	Varies	Streamwise	Bank-Attached	Varies	NA	Ridge, but positioned on point bar and generally curved
		∟ Unit Bar	Flow Width Expansion	Varies	Varies	Varies	Varies	NA	The fundamental building block of all bars

SHALLOW THALWEG

Tier 1 - in-channel
∟Tier 2 - Concavity (in channel cross section)

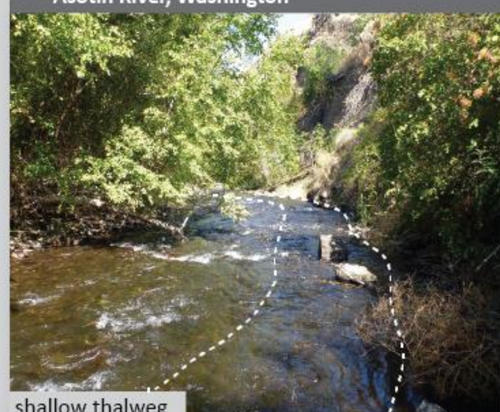
Key Attributes to Differentiate Specific Morphologies				
GU Forcing	Low Flow Relative Roughness	GU Orientation	GU Position	Low Flow Water Surface Slope
Forced by planar GU or occasionally bars	Varies	Streamwise	Bank- Attached	Varies, but typically moderate



GEOMORPHIC FORM

A shallow thalweg is an in-channel concavity, found on the outside bend of a channel that is distinctive because although it shows a concave form in cross section, longitudinally it lacks a concavity or residual pool. *A thalweg is simply the deepest part of the cross section of the channel, which can be traced as a line along any channel.* A shallow thalweg is a concave geomorphic unit that surrounds this line and is distinctive for its bank-attached position and its elongate and streamwise orientation along the thalweg.

Asotin River, Washington

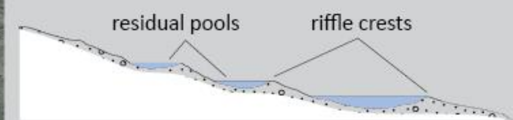


TYPICAL CONFIGURATIONS

Shallow thalwegs are typically found along the banks of the outside bends of channels, where the main channel is dominated by planar geomorphic units (e.g. runs, glides, rapids), or occasionally poorly defined, broad-faced bars. Their position is one in which you often expect to find a pool, but this concavity lacks a residual pool of qualifying size.

Wenatchee River, Washington

The long profile of a channel associated with a shallow thalweg, lacking pools or residual pool features. The shallow thalweg would not have a puddle left over if the river were drained.



A long profile with riffles and pools and residual pool features shown

PROCESS INTERPRETATION

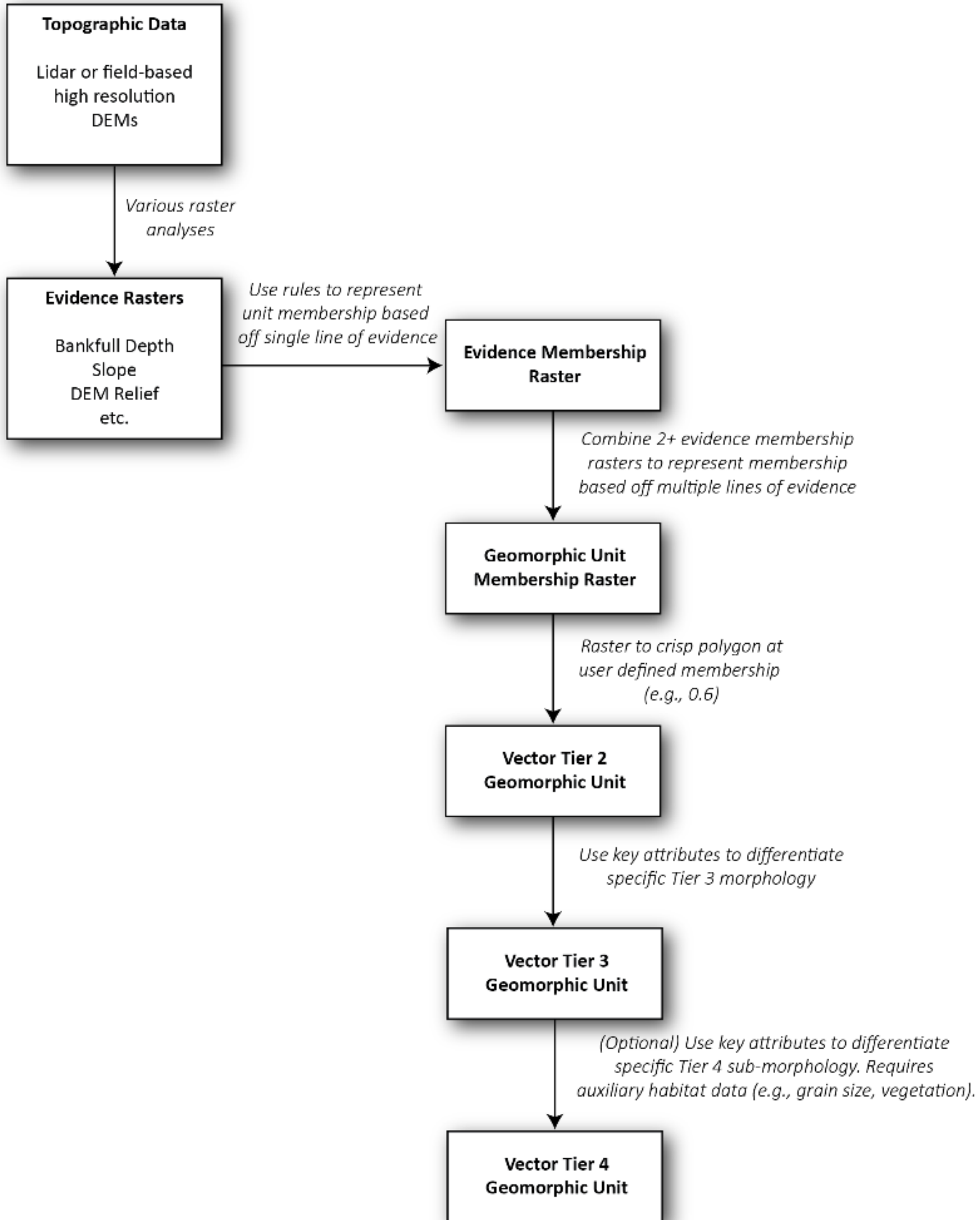
Shallow thalwegs are typically stable geomorphic units characterized by modest erosion in an outside bend (usually of low curvature), that is inadequate to excavate or maintain a pool. They form adjacent to planar geomorphic units or broad bars that steer the flow towards the edge of the channel so they winnow out a thalweg where those flows are concentrated. Shallow thalwegs are maintained most often in stable channels that are transport limited (e.g. plane-bed). They also form in non-transport limited situations where active bars or planar units force lateral migration and bank erosion where the rate of retreat is overwhelmed by deposition from the bar, which prevents a pool from fully forming (for pools to form in this situation would require a more resistant bank to concentrate the flow energy).

SIMILAR TO OR MISTAKEN WITH

Shallow thalwegs are similar to elongated bar-forced pools on outside bends and could be confused with them if the pool is weakly formed. They could also be confused with a chute, which tends to short-circuit flows across bar or floodplain surfaces and not be located on an outside bend.

GUT Workflow

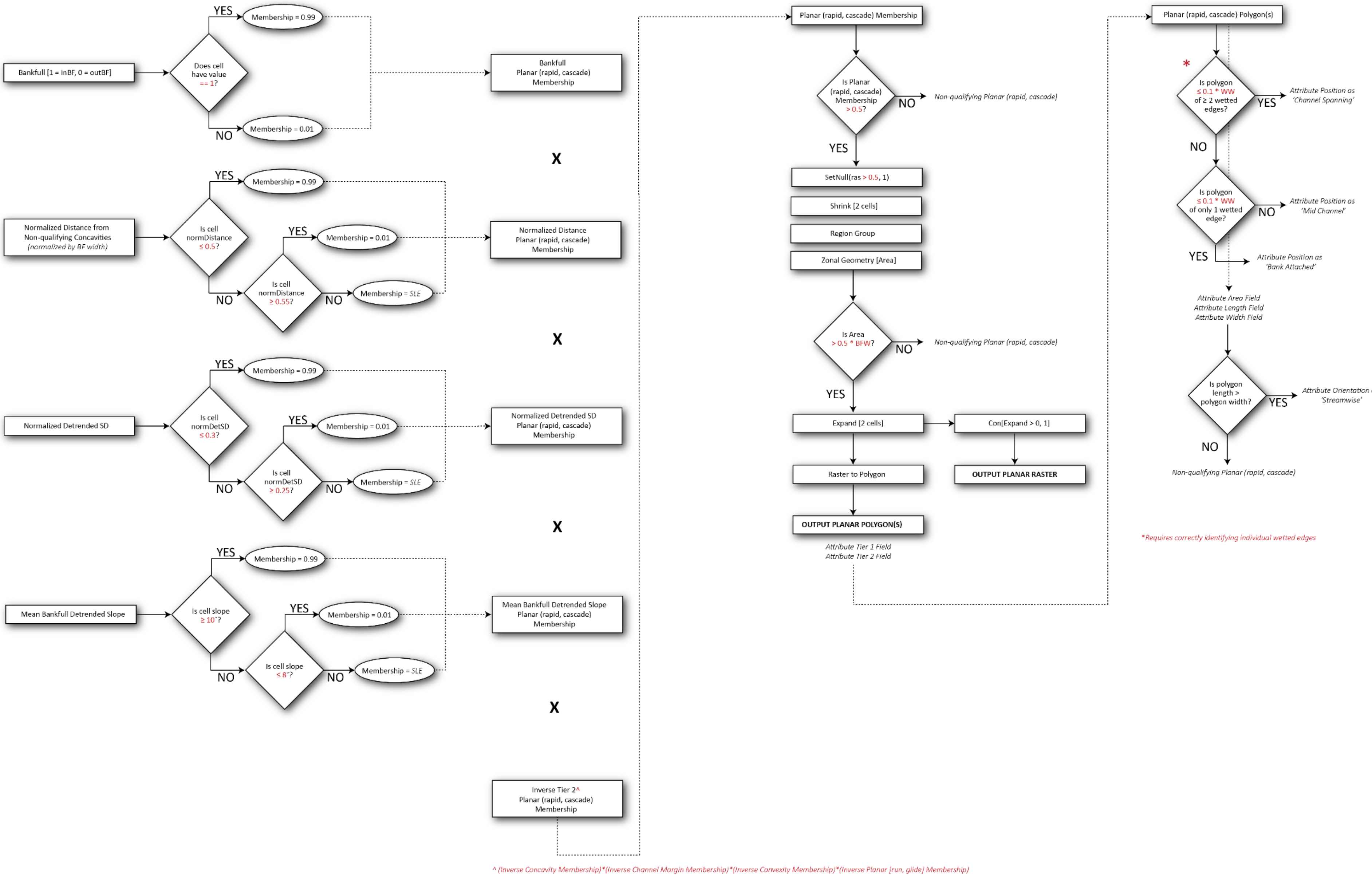
Geomorphic Unit Toolbar Workflow



A little more 'under the hood':

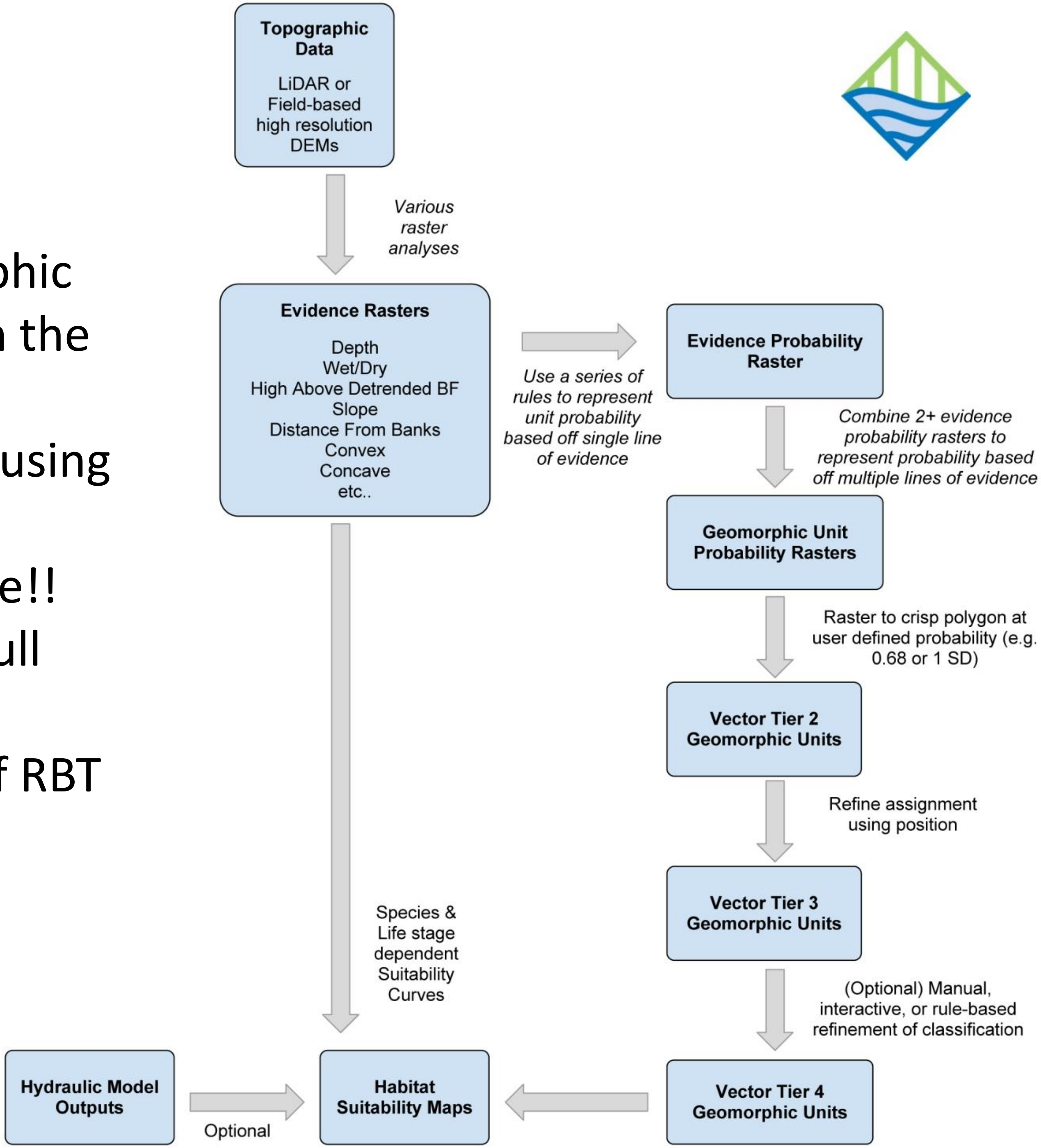
PLANAR (RAPID, CASCADE) DELINEATION

Process 1: *Individual Membership* **Process 2:** *Combined Membership* **Process 3:** *Filter* **Process 4:** *Attribute*

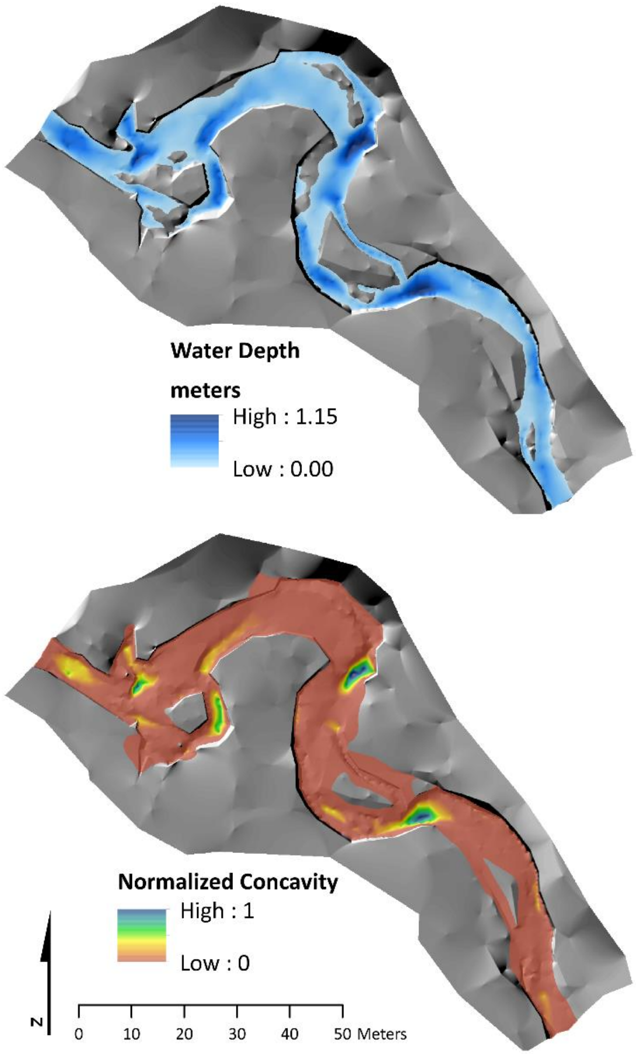


AUTOMATED METHODS

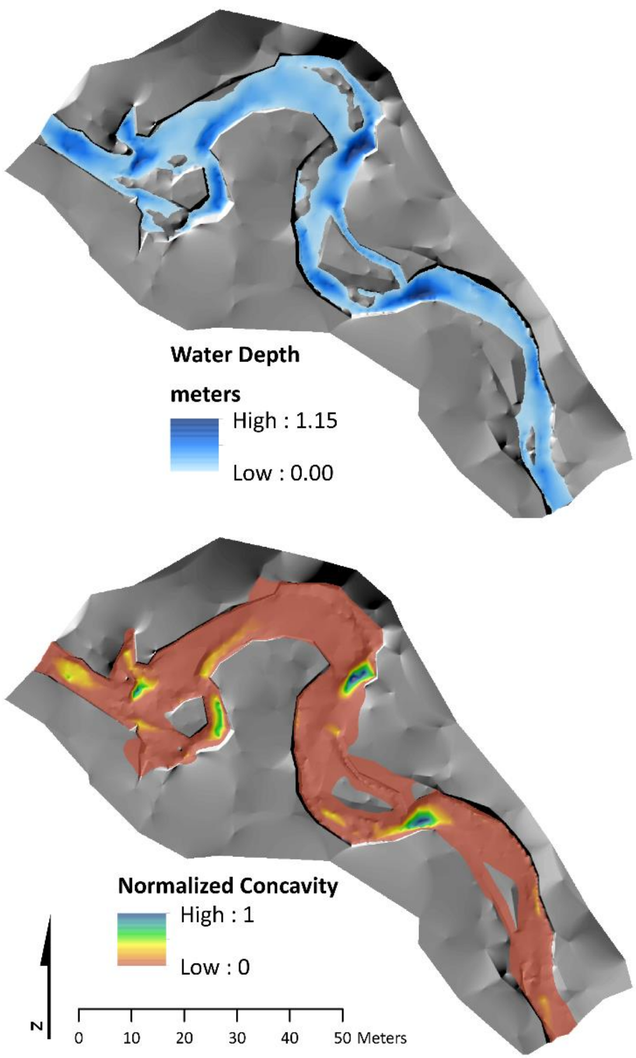
- All CHaMP topographic surveys run through the RBT
- Developing/testing using sites we know well
- Make rules scaleable!! (e.g. 10% avg bankfull width NOT 2 m)
- **GUTs** will be part of RBT tool

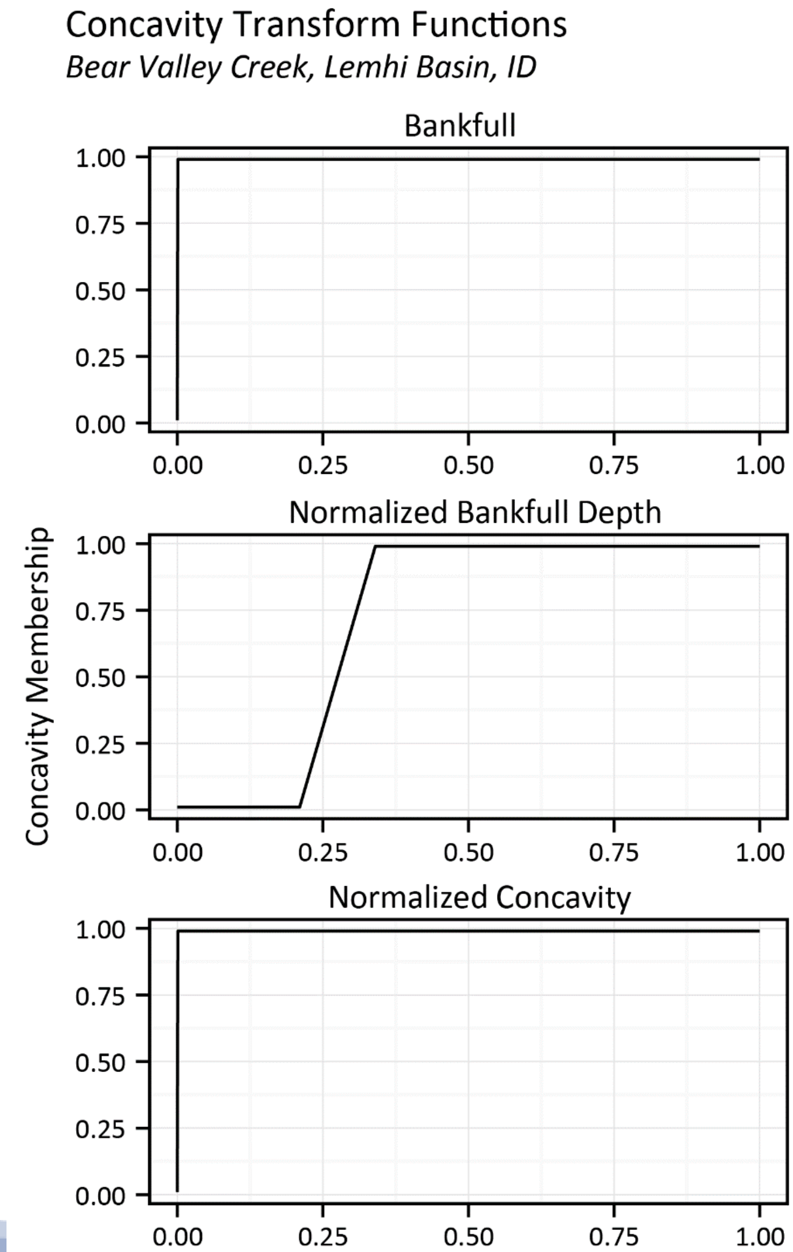


TOPOGRAPHIC LINES OF EVIDENCE

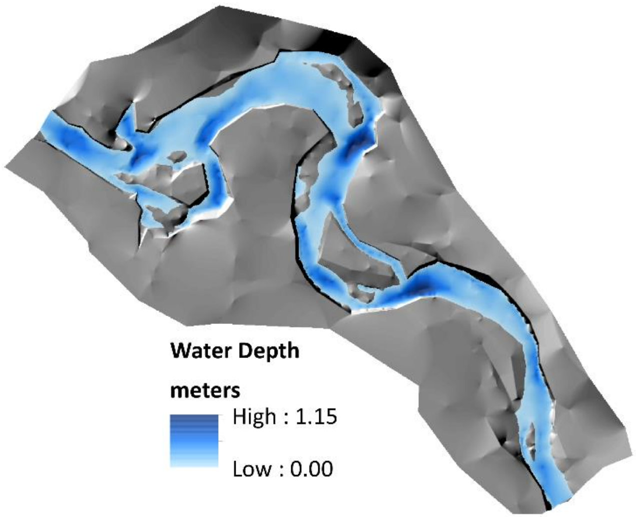


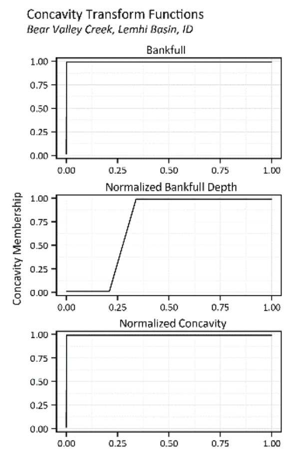
TRANSFORM FUNCTIONS…

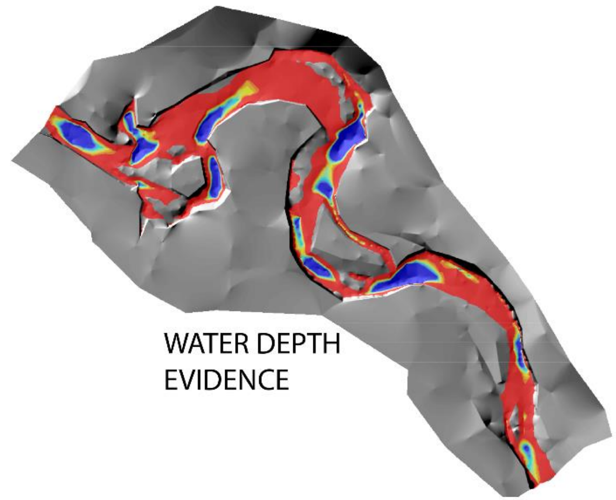


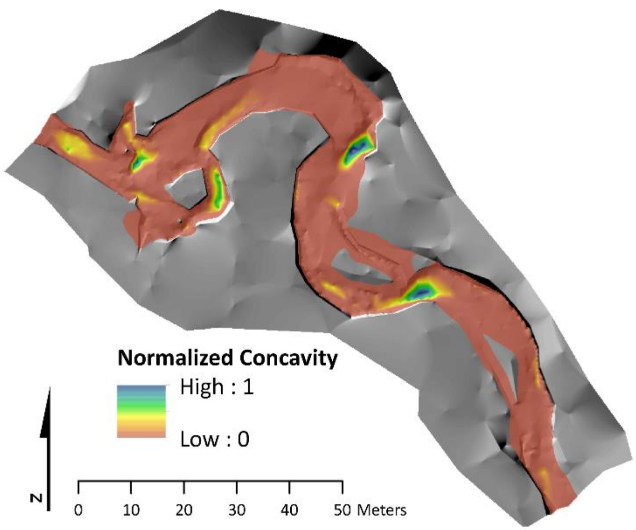


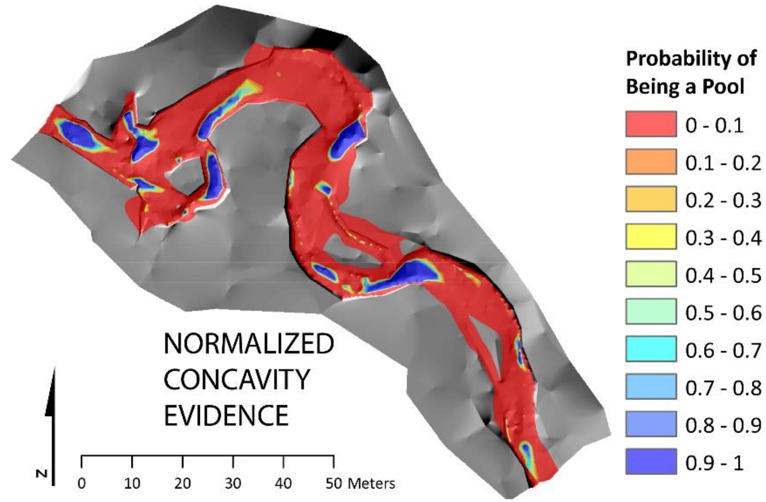
TFs TRANSFORM IT TO A PROBABILITY



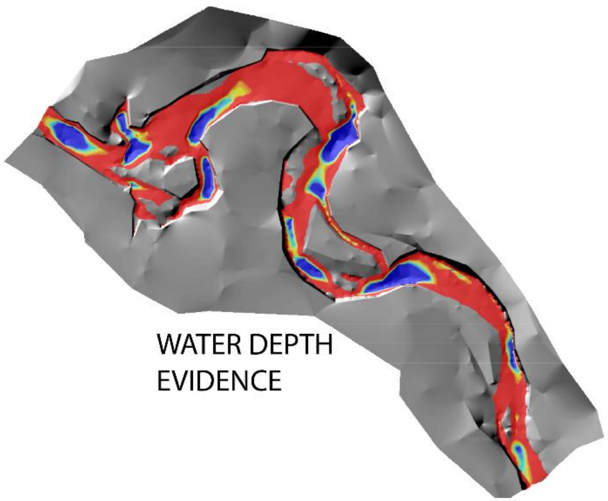


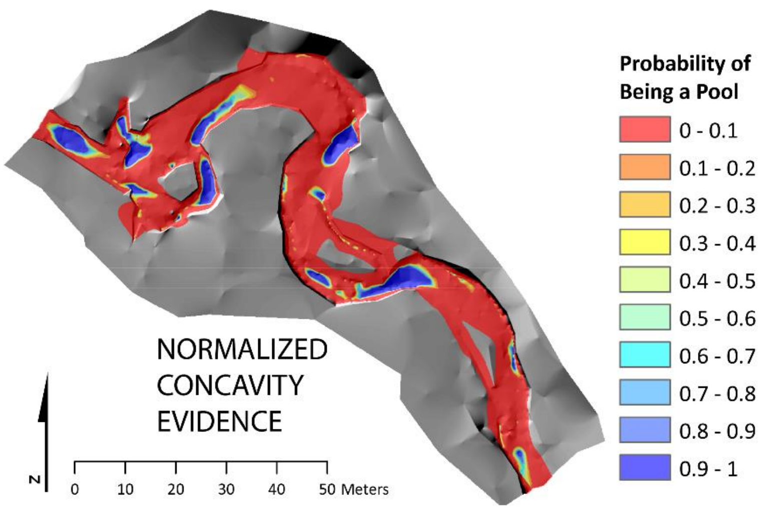


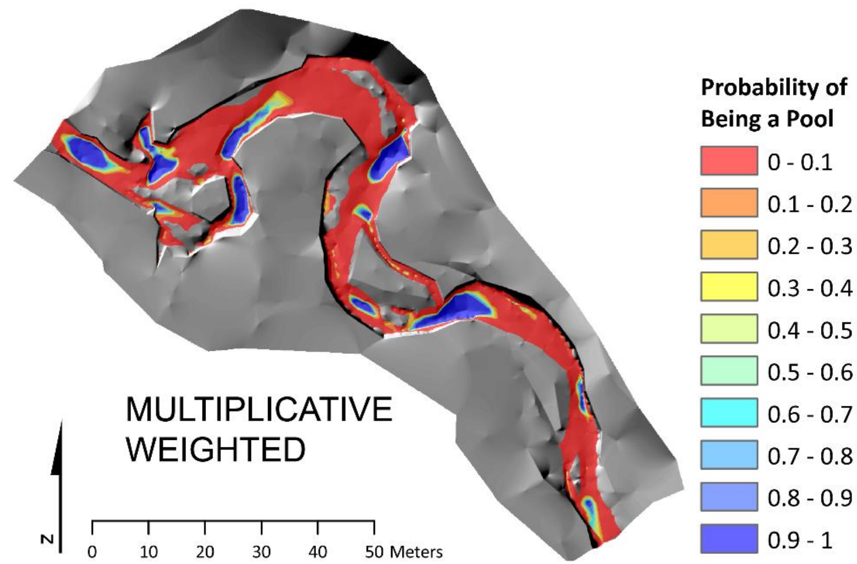




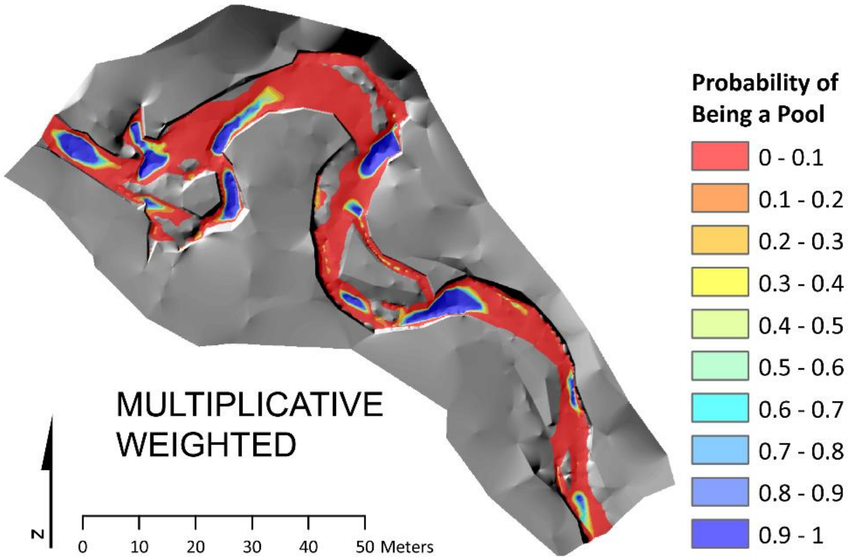
COMBINE PROBABILITIES

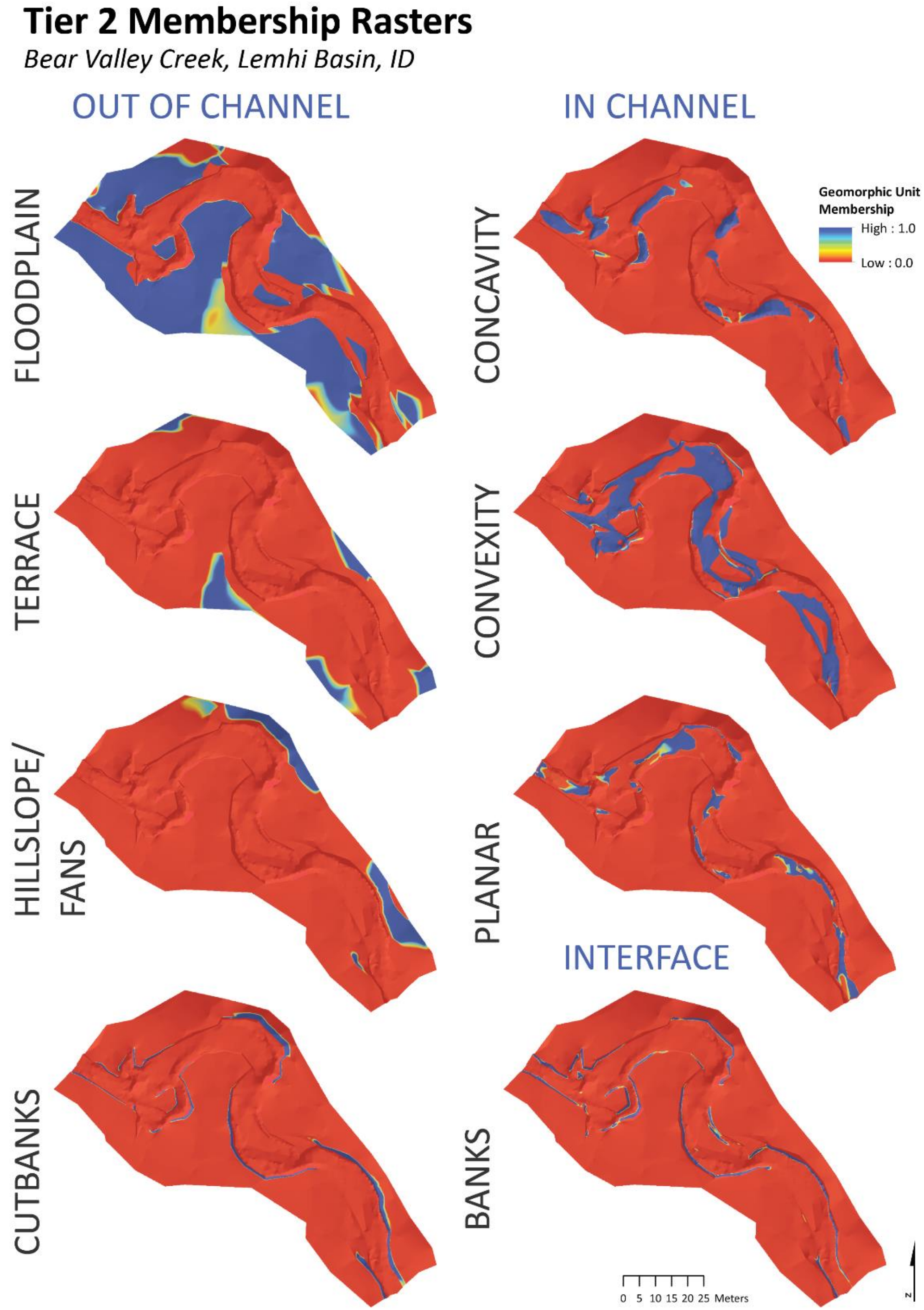




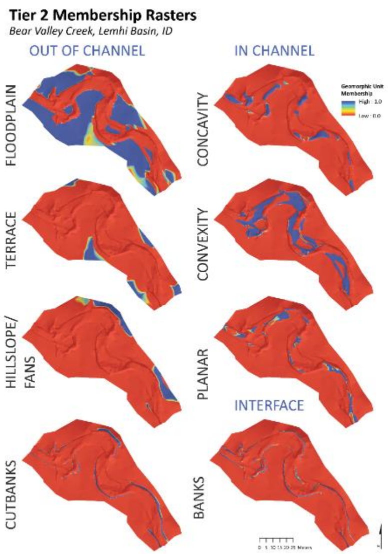


REPEAT FOR ALL CATEGORIES



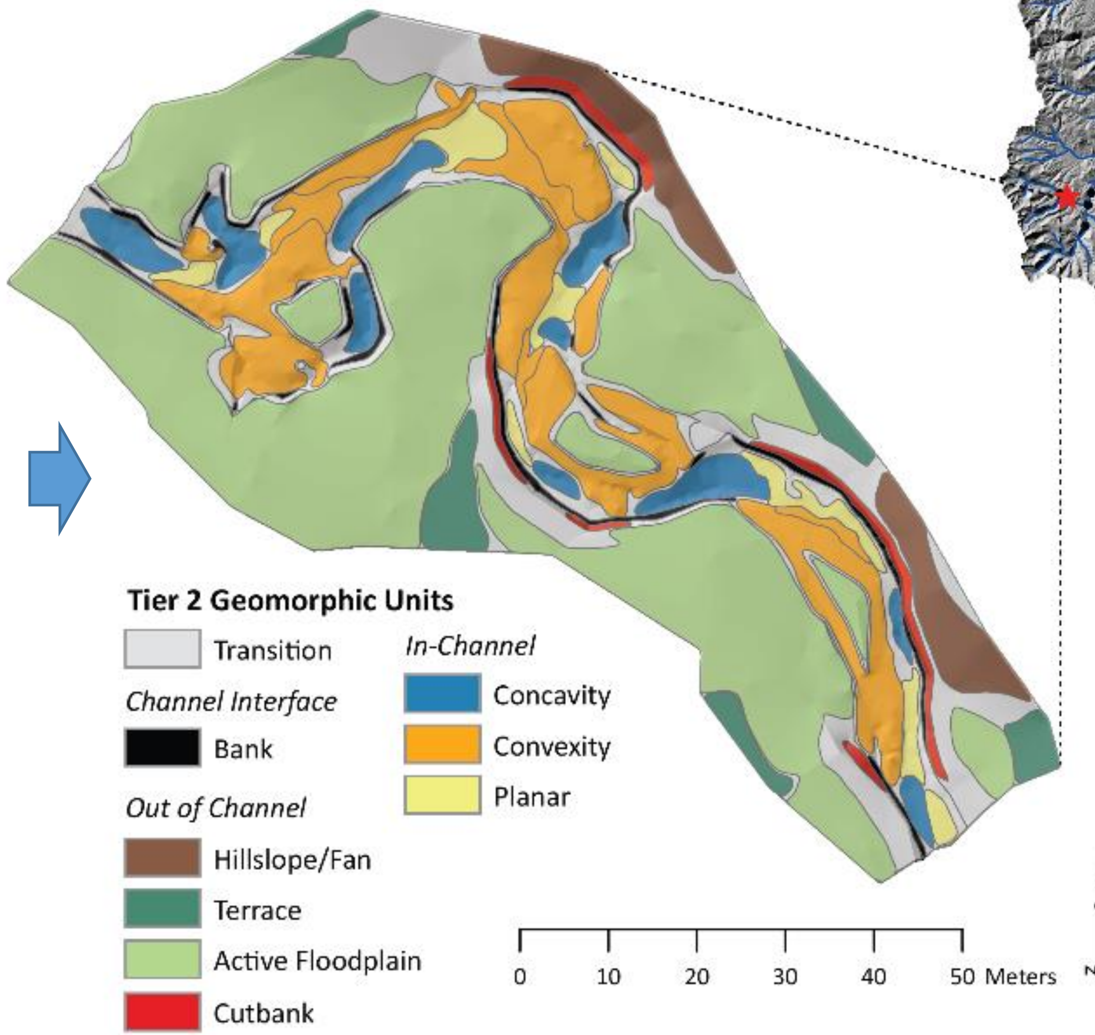


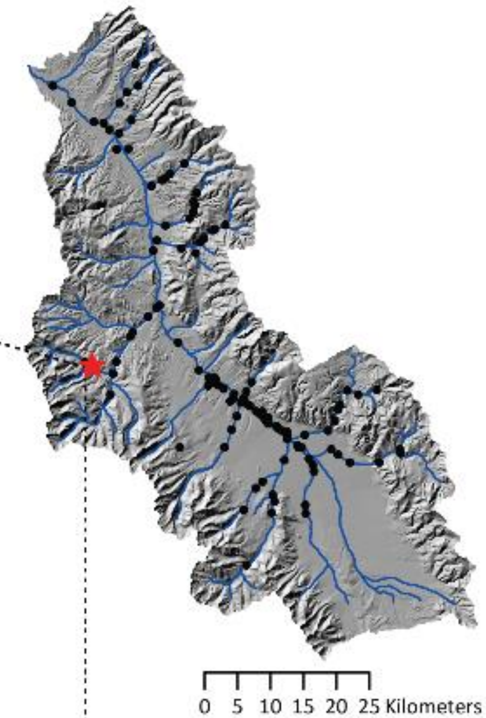
THRESHOLD MEMBERSHIP



Tier 2 Geomorphic Units

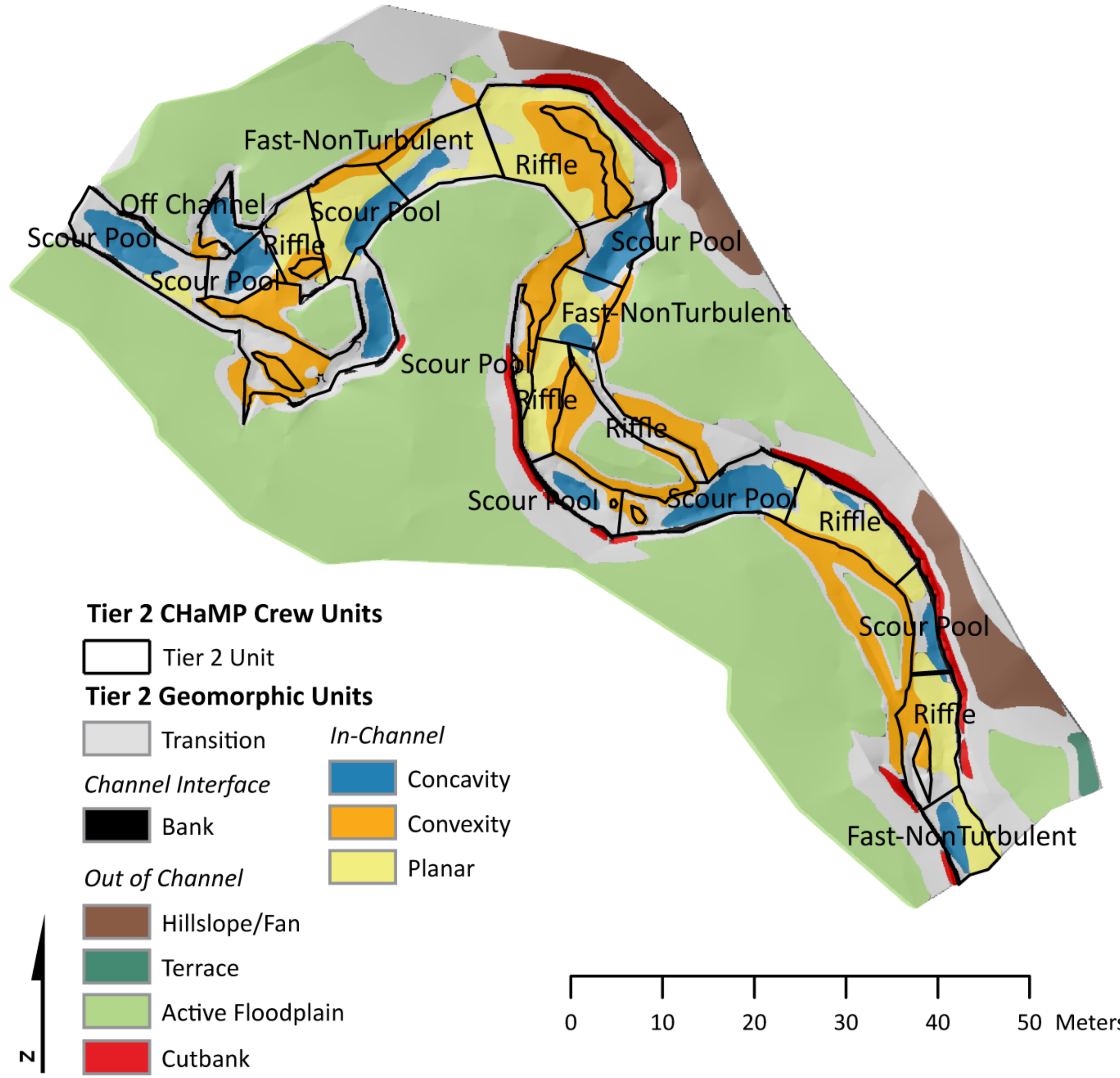
Bear Valley Creek, Lemhi Basin, ID





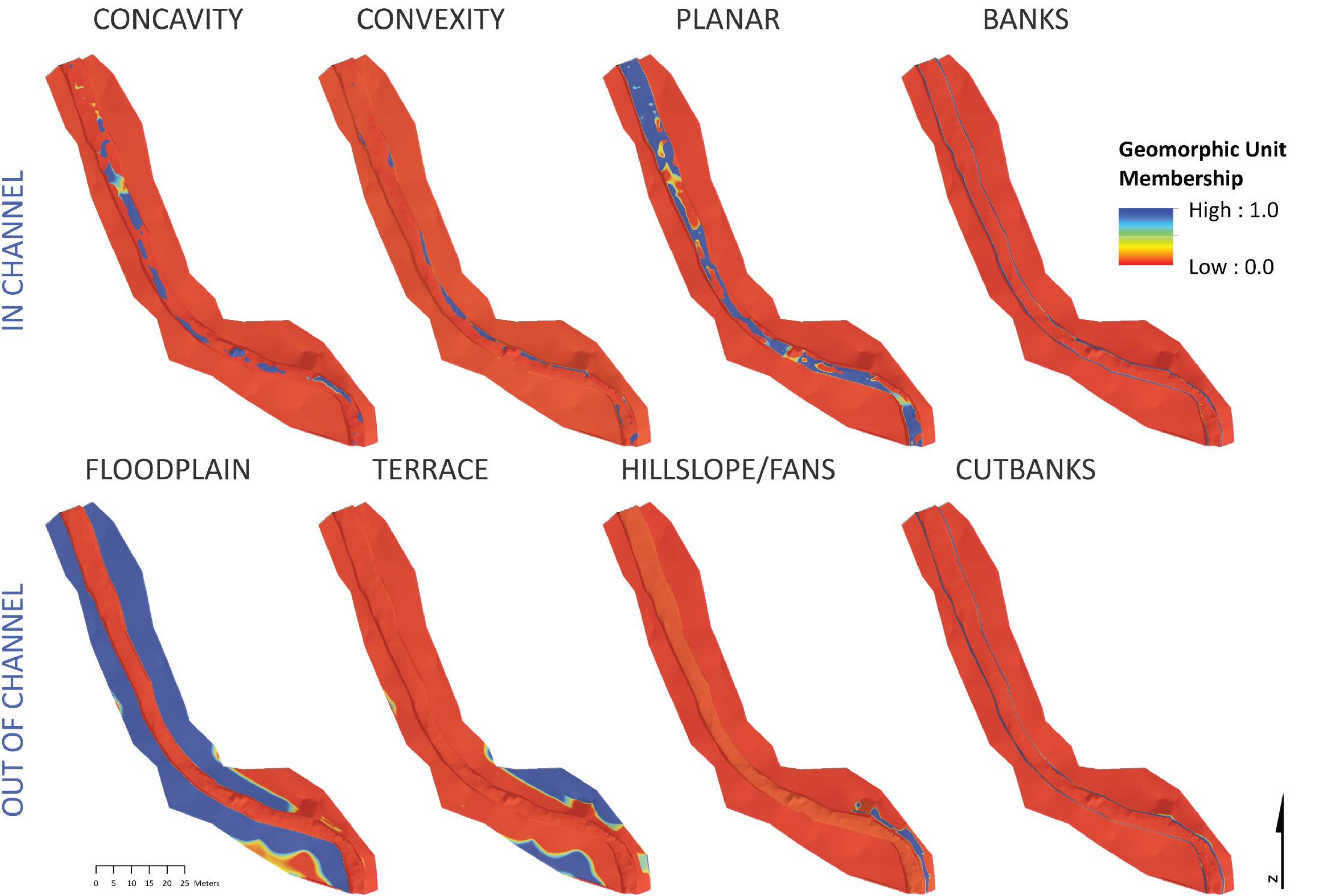
Tier 2 Geomorphic Units

Bear Valley Creek, Lemhi Basin, ID

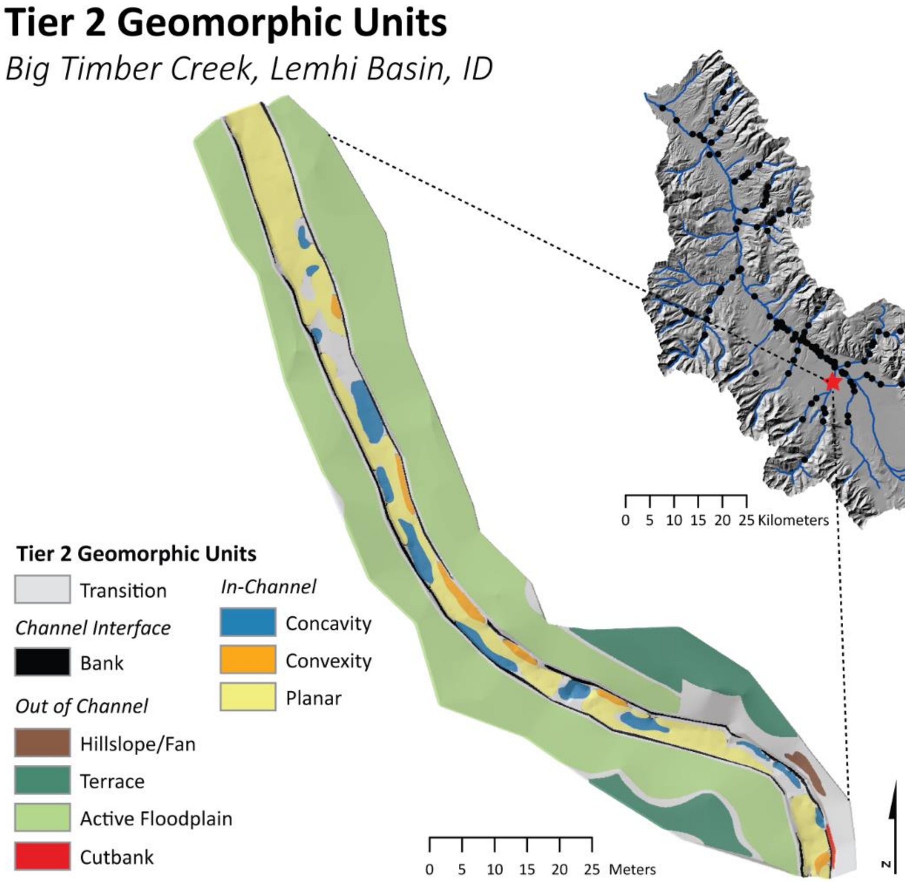


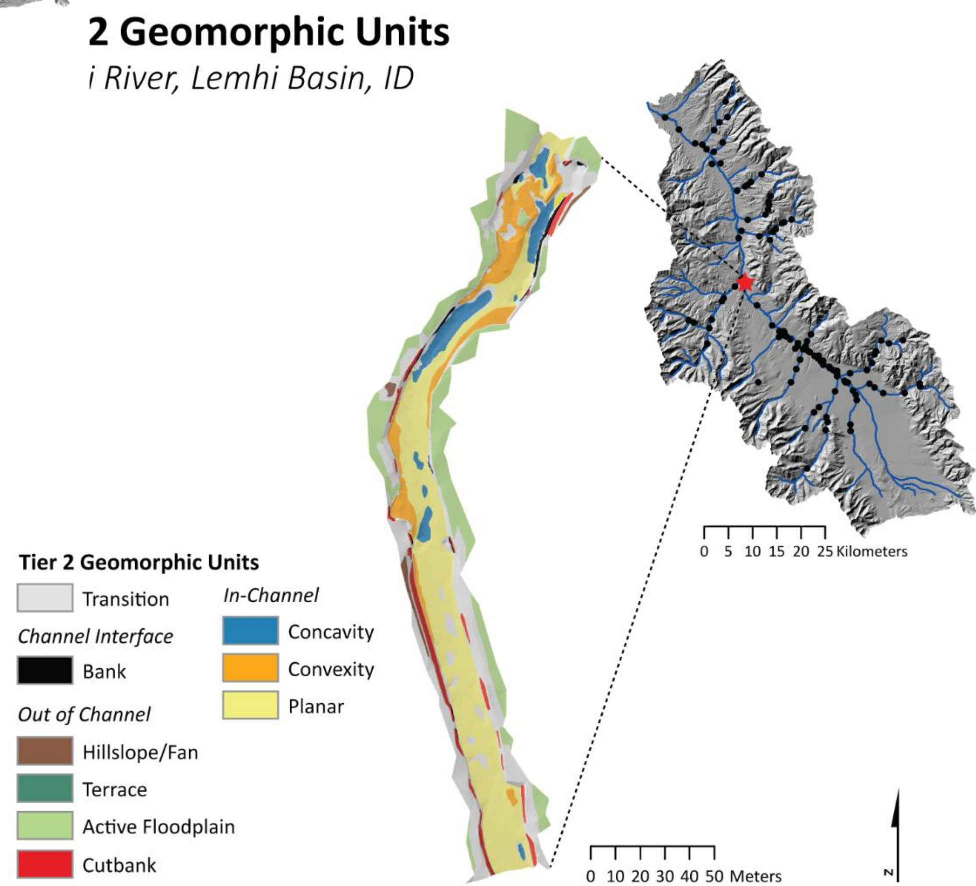
Tier 2 Membership Rasters

Big Timber Creek, Lemhi Basin, ID



SOME OTHER EXAMPLES



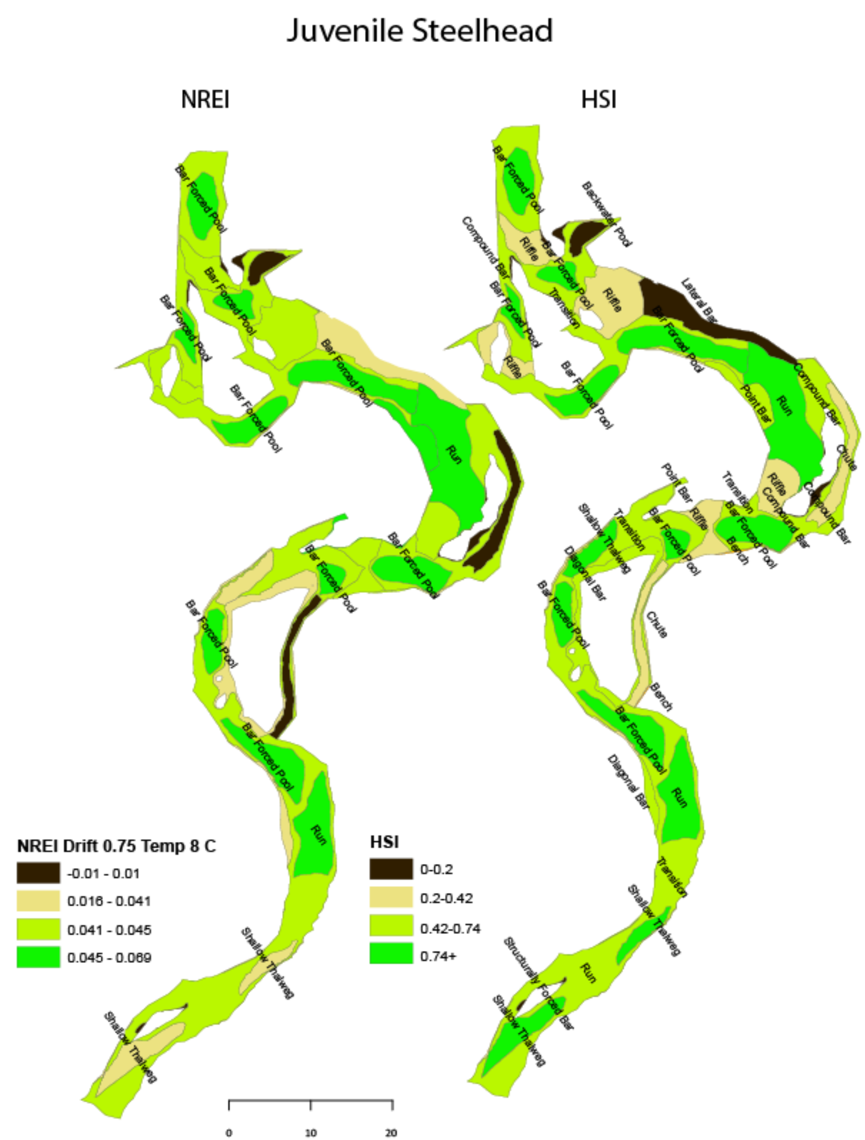


GUT STATUS & CHAMP

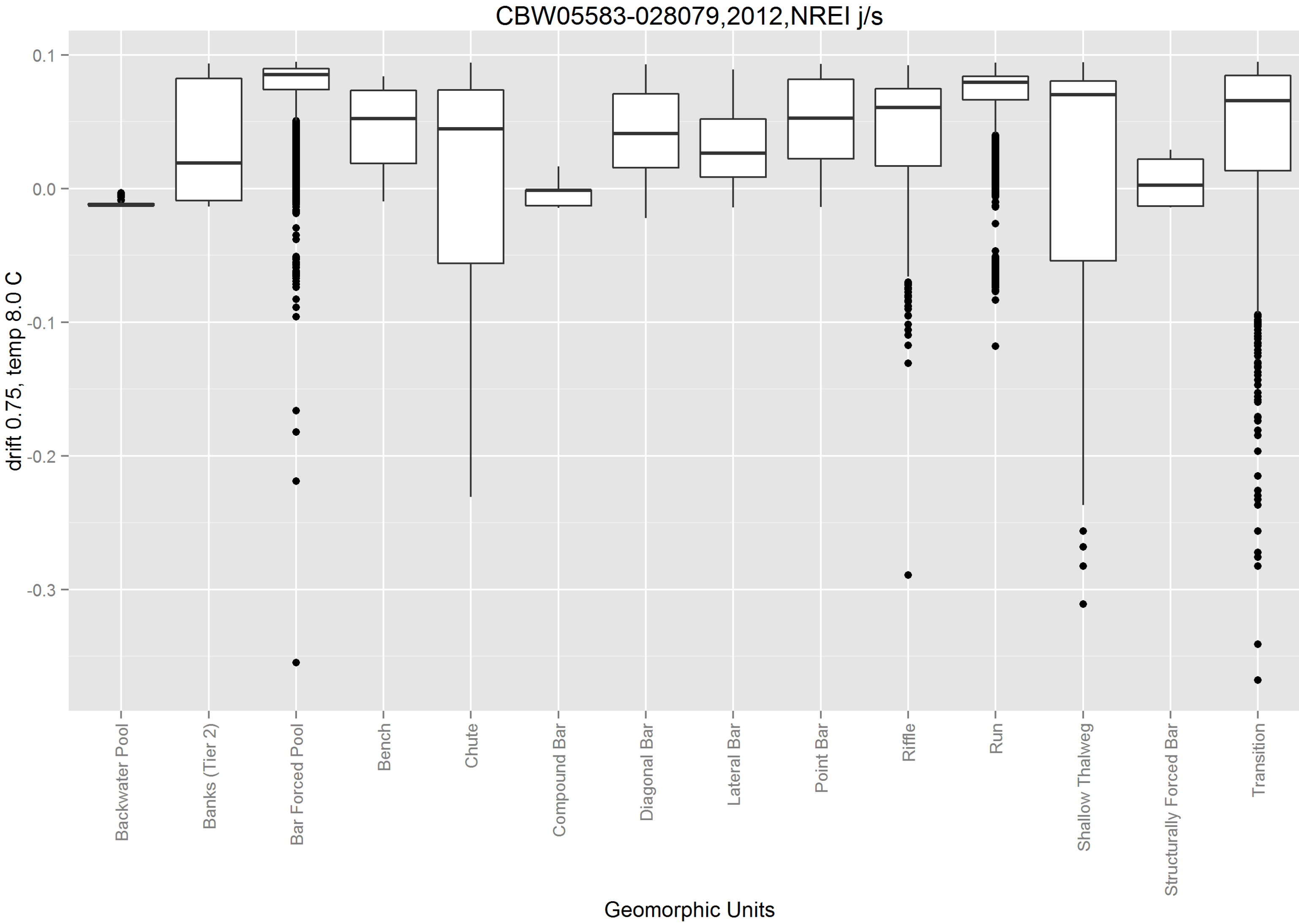
- GUT UI beta training for advanced crews
  - Important for crews to have understanding of different units used in the classification.....
- Tier 2 ☑
- Tier 3 ?
- Semi-automated workflow
  - Crews can over-ride automatic classification
  - Split units
- Track edits – hugely helpful for further development

GU Relationship to NREI & HSI

Preliminary work… but coherent relationships…

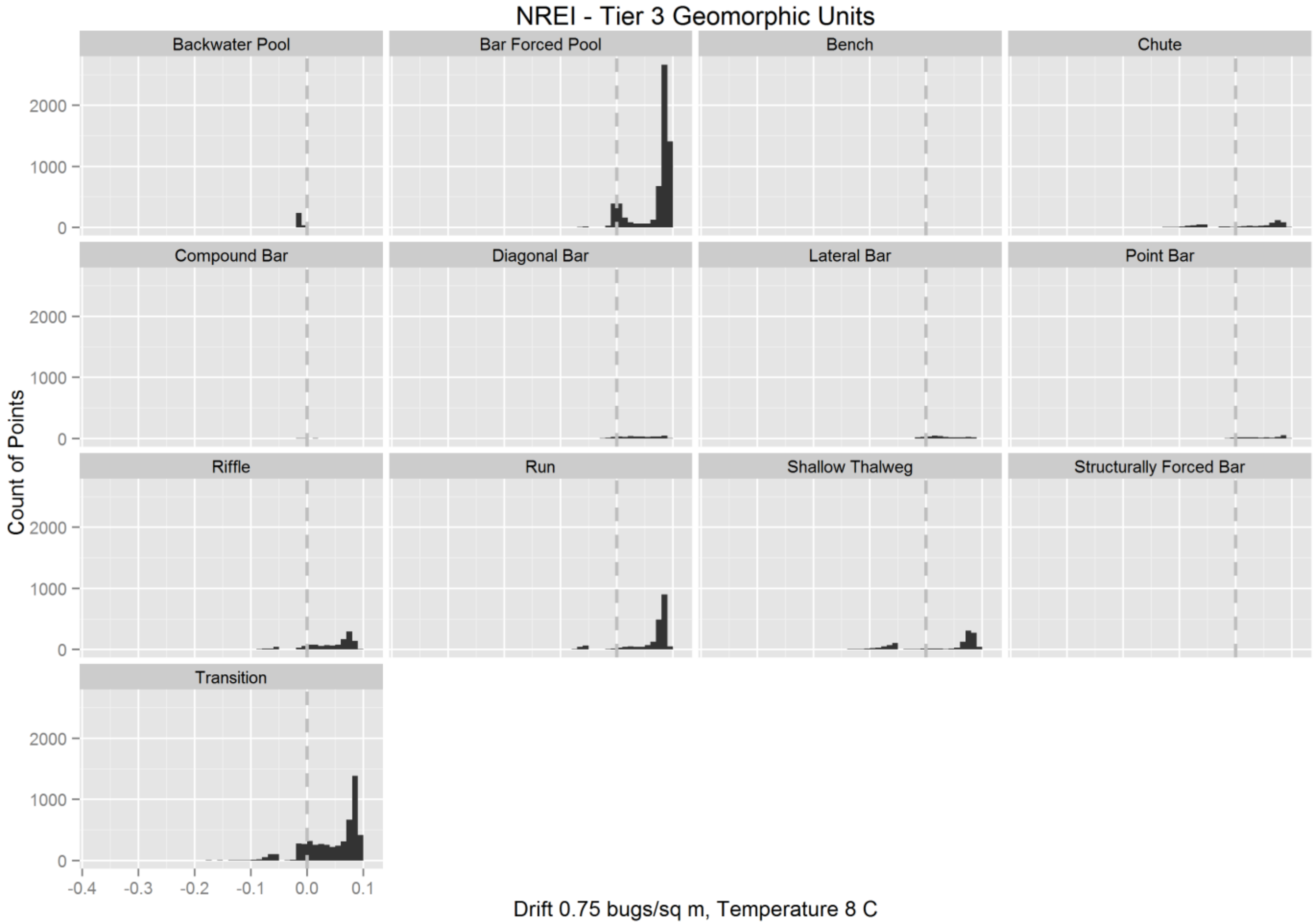


NREI vs. GU



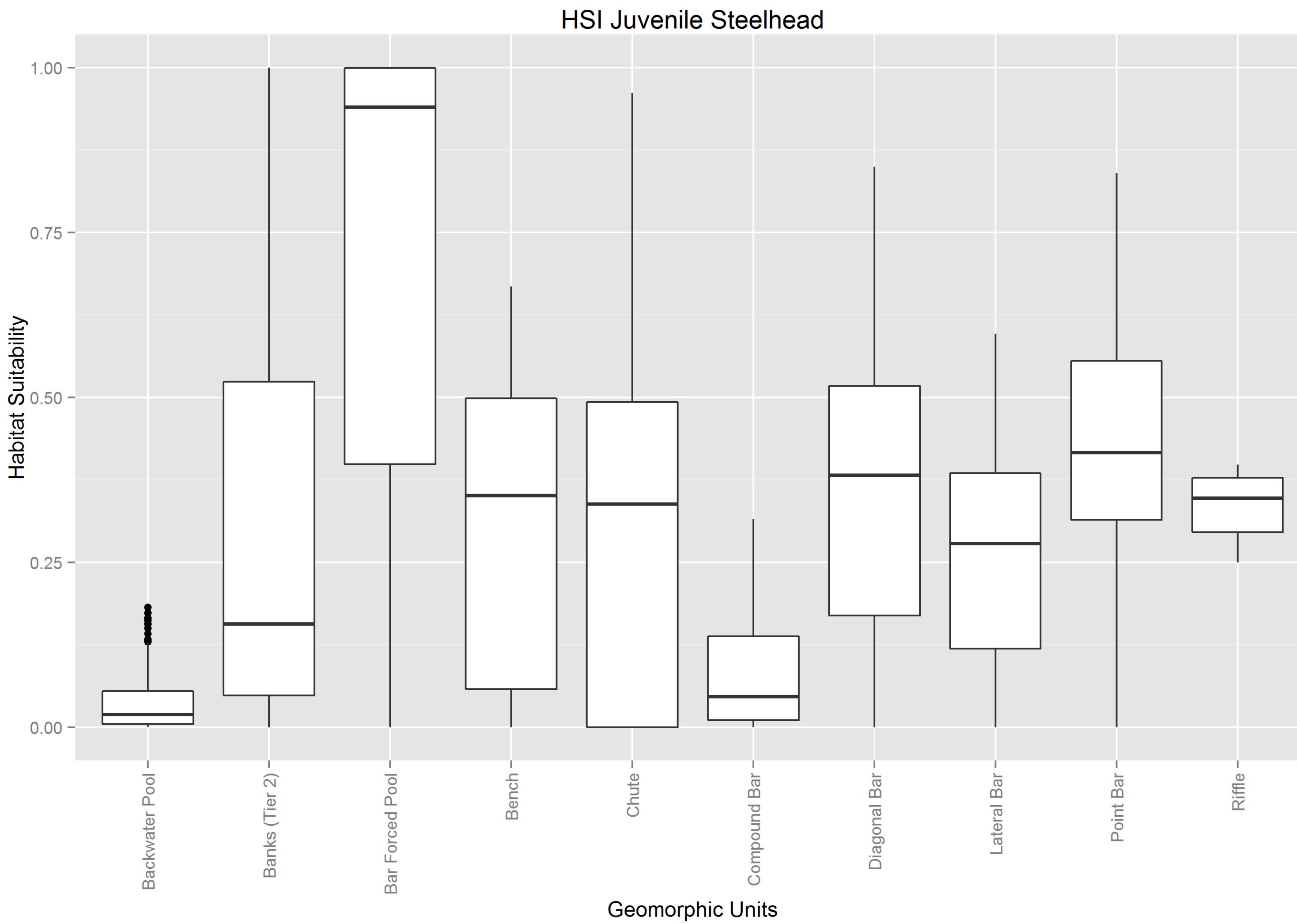
CBW05583-028079,2012,NREI j/s
0.1
0.0
-0.1
-0.2
-0.3
drift 0.75, temp 8.0 C
Backwater Pool
Banks (Tier 2)
Bar Forced Pool
Bench
Chute
Compound Bar
Diagonal Bar
Lateral Bar
Point Bar
Riffle
Run
Shallow Thalweg
Structurally Forced Bar
Transition
Geomorphic Units

Juvenile Steelhead NREI vs. GU



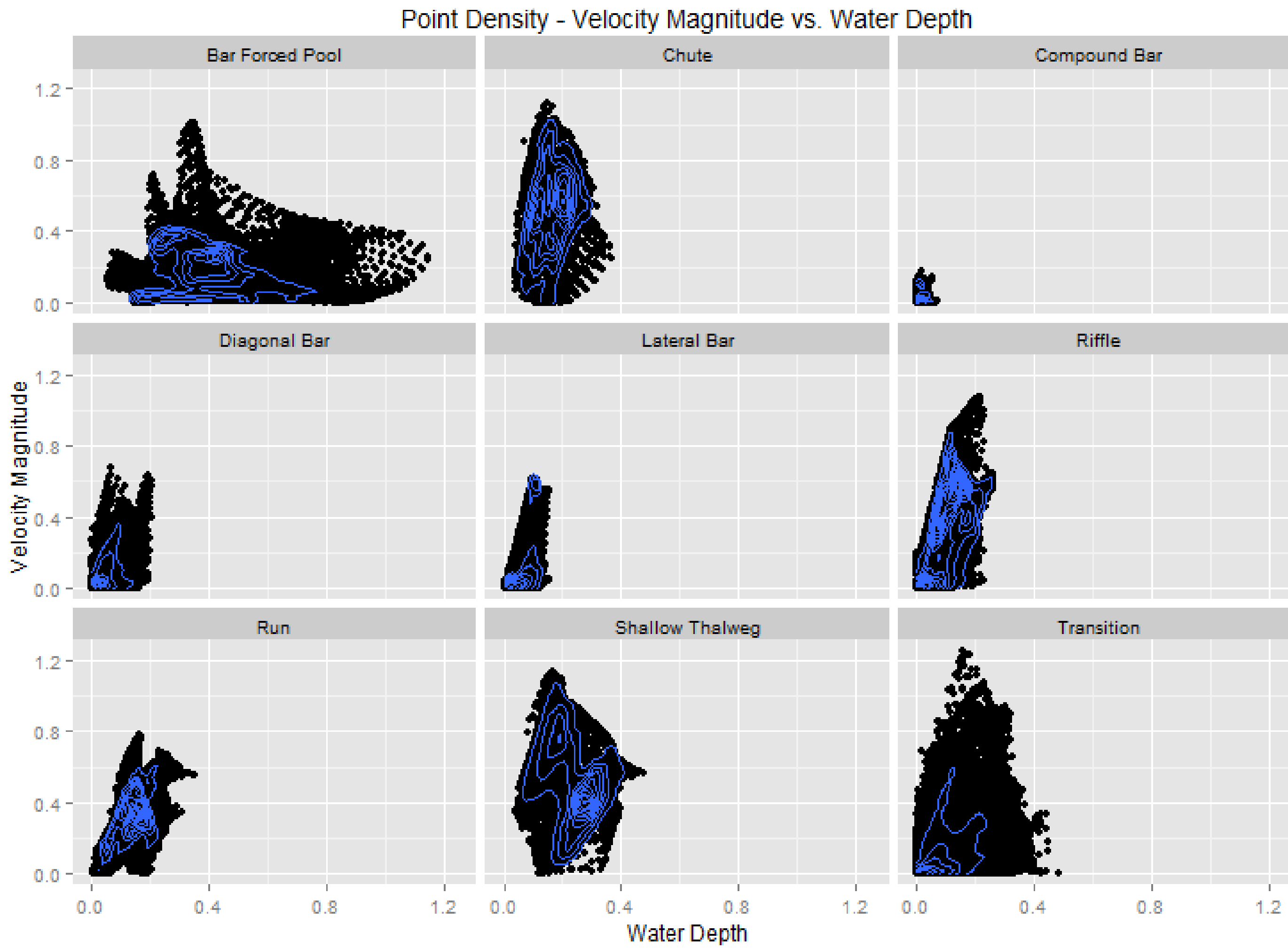
- Another way of looking at it…

Juvenile Steelhead HSI vs. GU



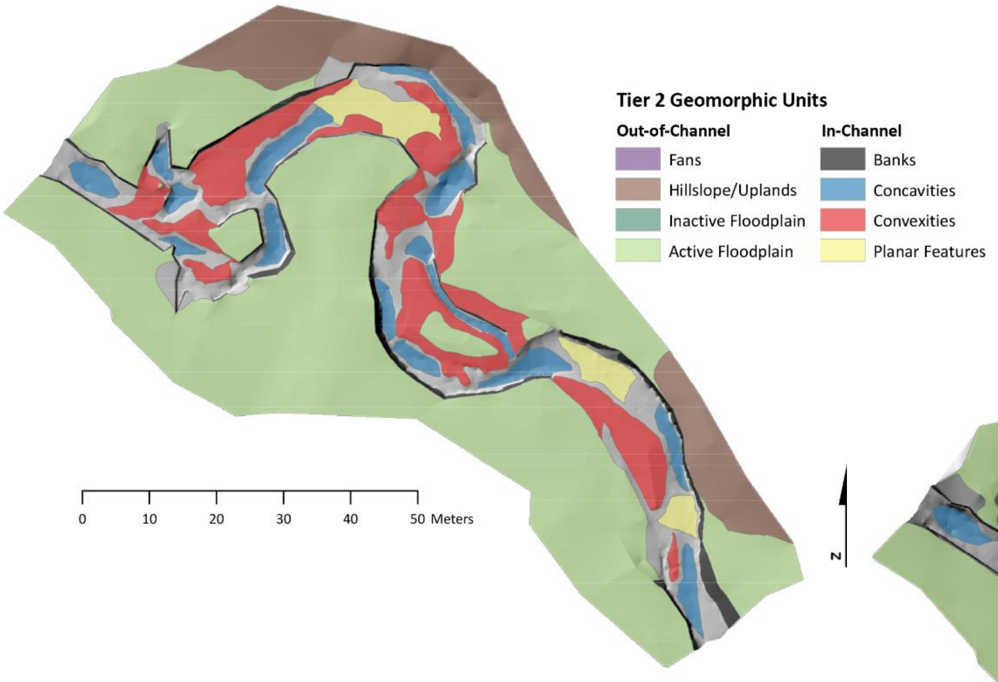
- d

VELOCITY VS. DEPTH TO GUs

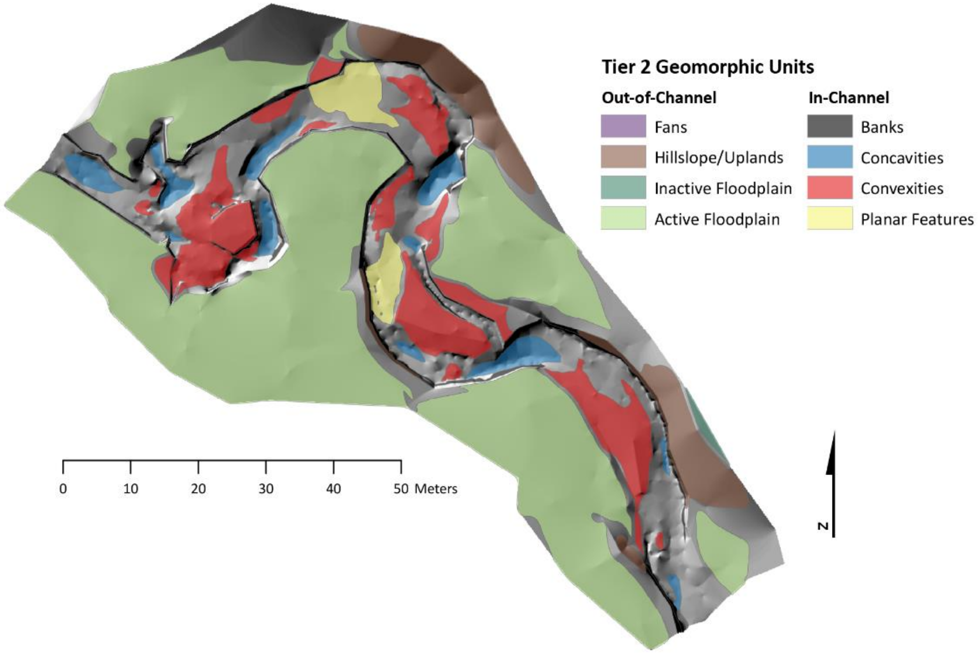


- Coherent and consistent patterns…

HOW WELL DO WE DO?



- Automatically Mapped



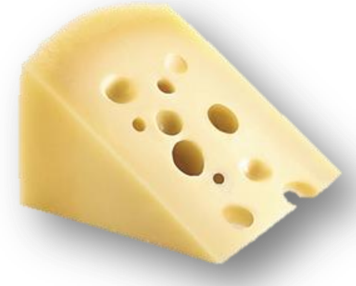
- Manually Mapped

MANUAL VS. MODELED AGREEMENT

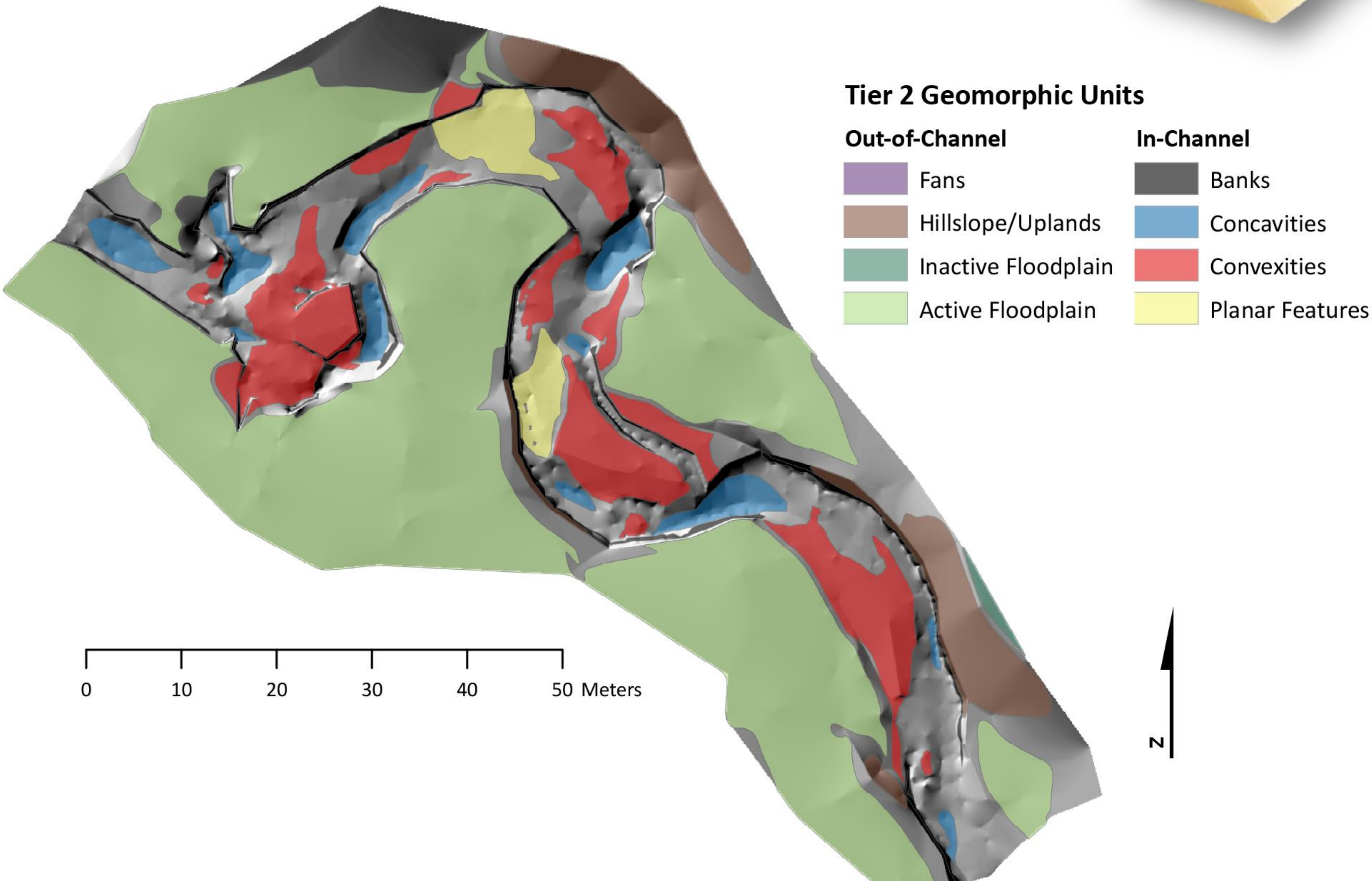
		Manually Mapped						
		Out of Channel						*In Channel*
		Hillslope/ Uplands	Inactive Floodplain	Active Floodplain	Banks	Concavities	Convexities	Planar Features
Modeled	Hillslope/Uplands	**85%**	0%	1%	1%	0%	0%	0%
	Inactive Floodplain	0%	**100%**	0%	0%	0%	0%	0%
	Active Floodplain	15%	0%	**96%**	0%	0%	0%	0%
	Banks	0%	0%	0%	**97%**	1%	1%	0%
	Concavities	0%	0%	0%	0%	**85%**	0%	0%
	Convexities	0%	0%	3%	2%	4%	**92%**	26%
	Planar Features	0%	0%	0%	0%	7%	6%	**74%**

- Generally very good cell-to-cell agreement
- Where discrepant, typically only 1 or 2 other possibilities
- Poorest agreement between planar features (being picked up as bars)

WHAT ABOUT THESE GREY AREAS?



TRANSITION ZONES



RECALL A PROCEDURAL TREE

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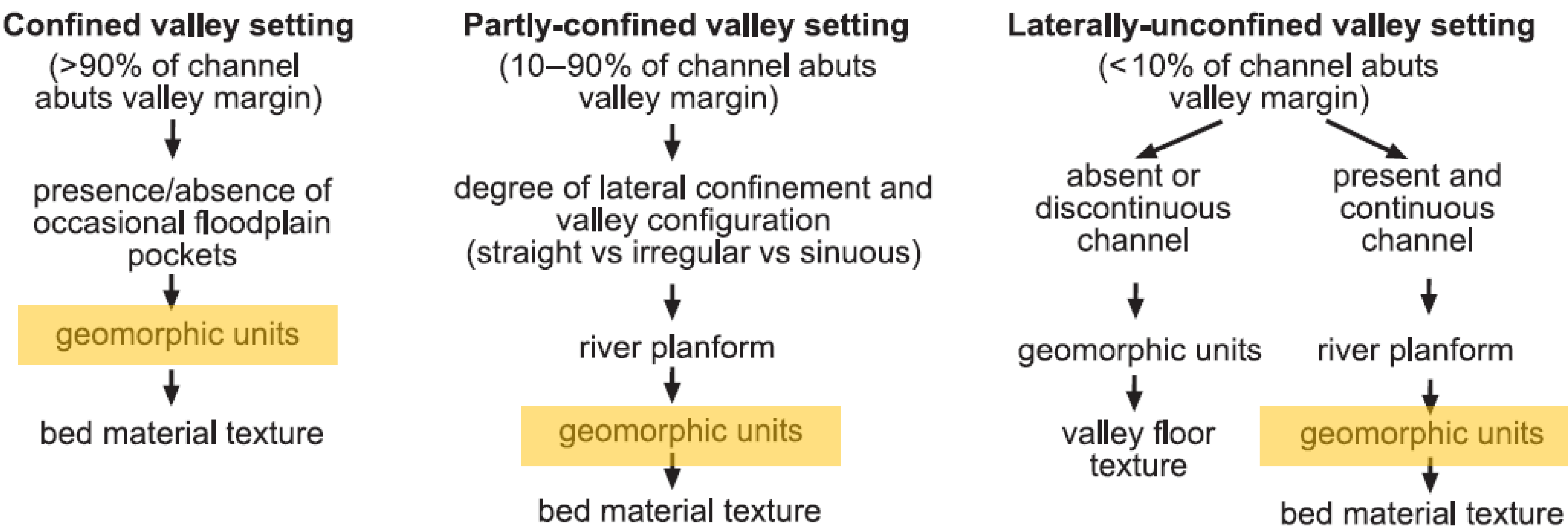


Figure 9.6 The River Styles procedural tree
Each River Style is identified on the basis of its planform, assemblage of geomorphic units, and bed material texture. Depending on the valley setting, different sequences of procedures are applied to identify the River Style. Modified from Brierley et al. (2002). Reproduced with permission from Elsevier, 2003.

- Fruit @ end of tree… i.e. an Expectation or Prediction

SPECIFIC RIVER STYLES TREE

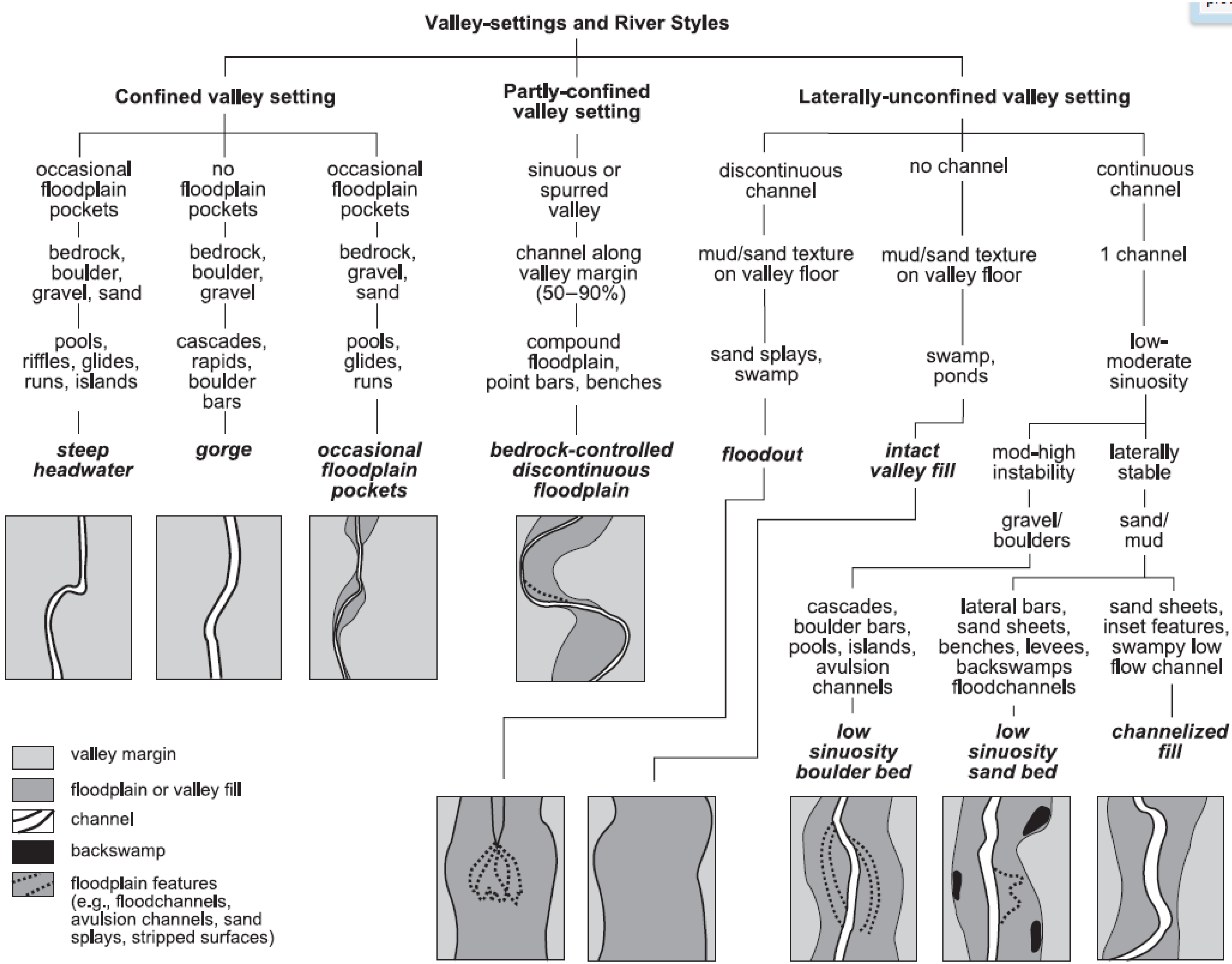
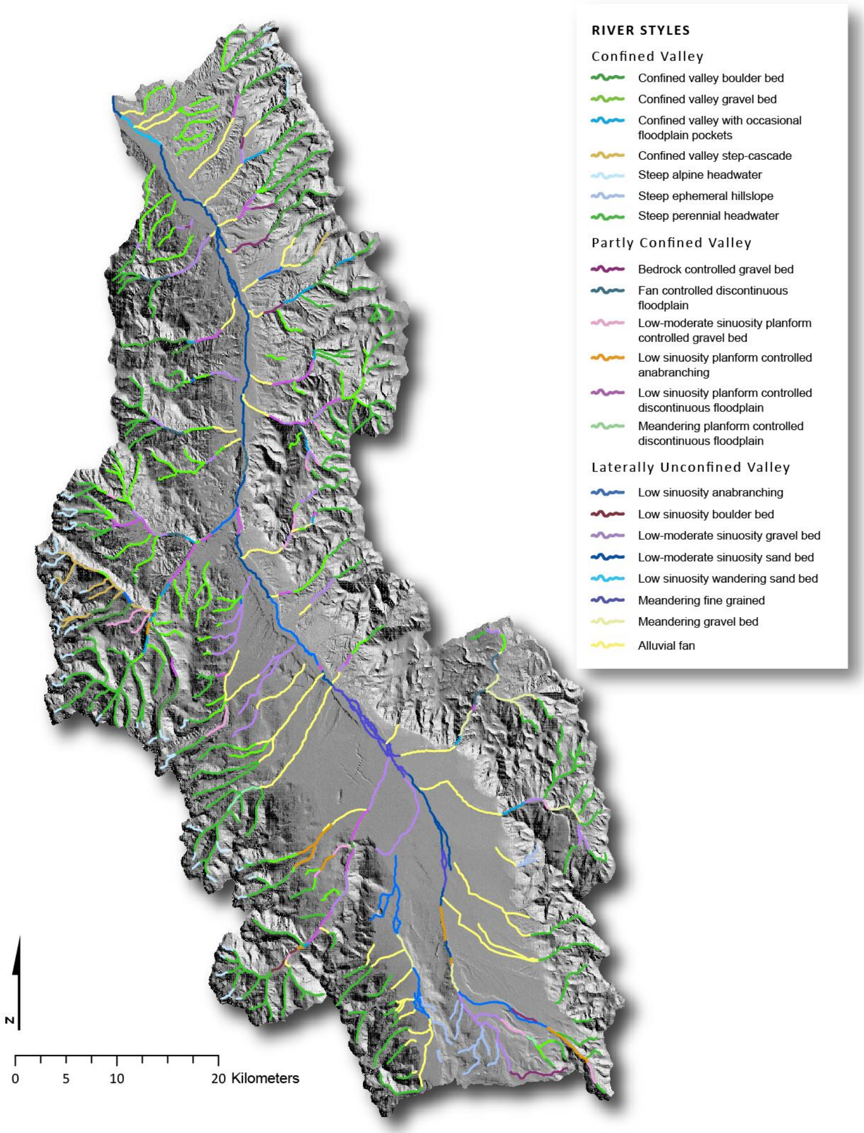
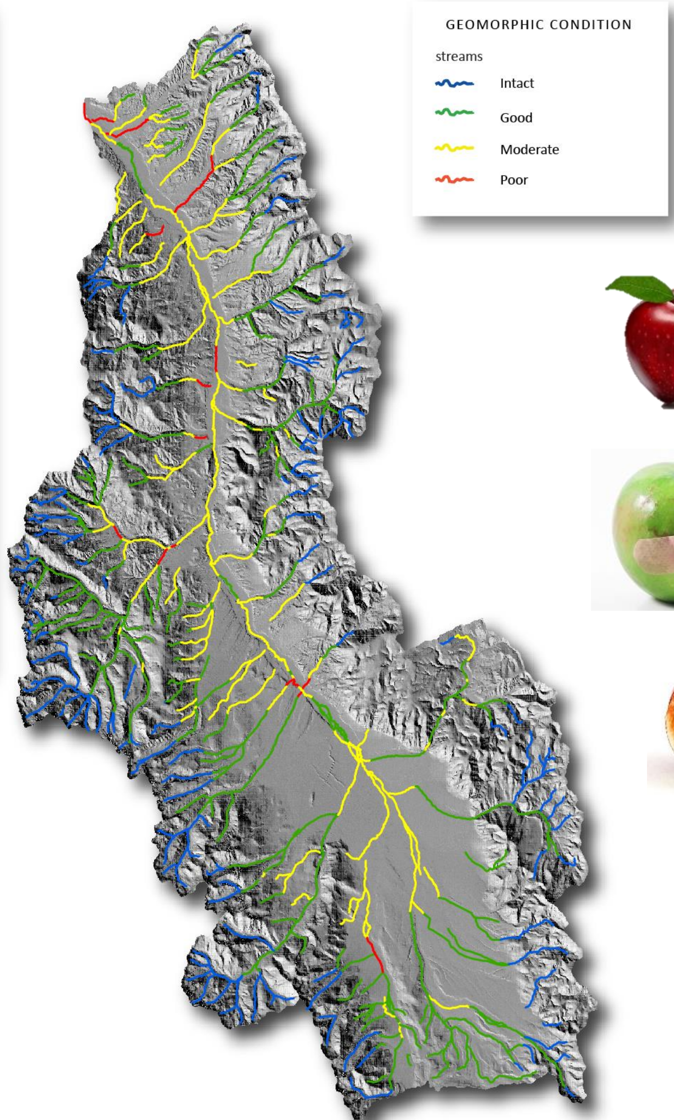


Figure 9.10 The Bega catchment River Styles tree (from Fryirs, 2001)

IF I KNOW REACH TYPE & CONDITION…





TAKE HOMES…

- Clearer definition of GU's allows better process inferences & functional habitat inferences
- GU's can be consistently derived from topography alone
- Emergence of transition zones from probabilistic treatment a fundamentally important unit itself!
- Promising correspondence with fish habitat… could help in mechanistic link for upscaling
- Look out for **GUT** to explore GUTs of your reach!