

The background is an underwater scene with greenish-blue water, some seaweed on the right, and a faint image of a fish on the left. Overlaid on this is a logo consisting of a blue wavy line and a black arch-like shape. The text 'river' is in white, bold, sans-serif font, with the 'r' partially covered by the blue wavy line. The text 'rchitect' is in white, bold, sans-serif font, with the 'a' partially covered by the black arch shape. Below this, the text 'The next generation stream design' is in white, bold, sans-serif font. At the bottom of the logo section, the URL 'https://riverarchitect.github.io' is in a smaller, white, sans-serif font.

river rchitect

The next generation stream design

<https://riverarchitect.github.io>

Highlights



Source: S. Schwindt



Source: Greg Pasternack @RiverSciLife

Motivation

State-of-the-Art stream design involves subjective and individual approaches that sometimes miss their objectives (ecological abundance and long-living)

Methods

Parametric and transparent design concepts

Product

Ecologically sustainable and long-living fluvial landscapes with economic assessment

Highlights

Lifespan & Design Mapping

Longevity assessments of single features

Morphology

Terrain modification to yield self-sustaining fluvial landscapes and mass movement assessments

Ecohydraulics

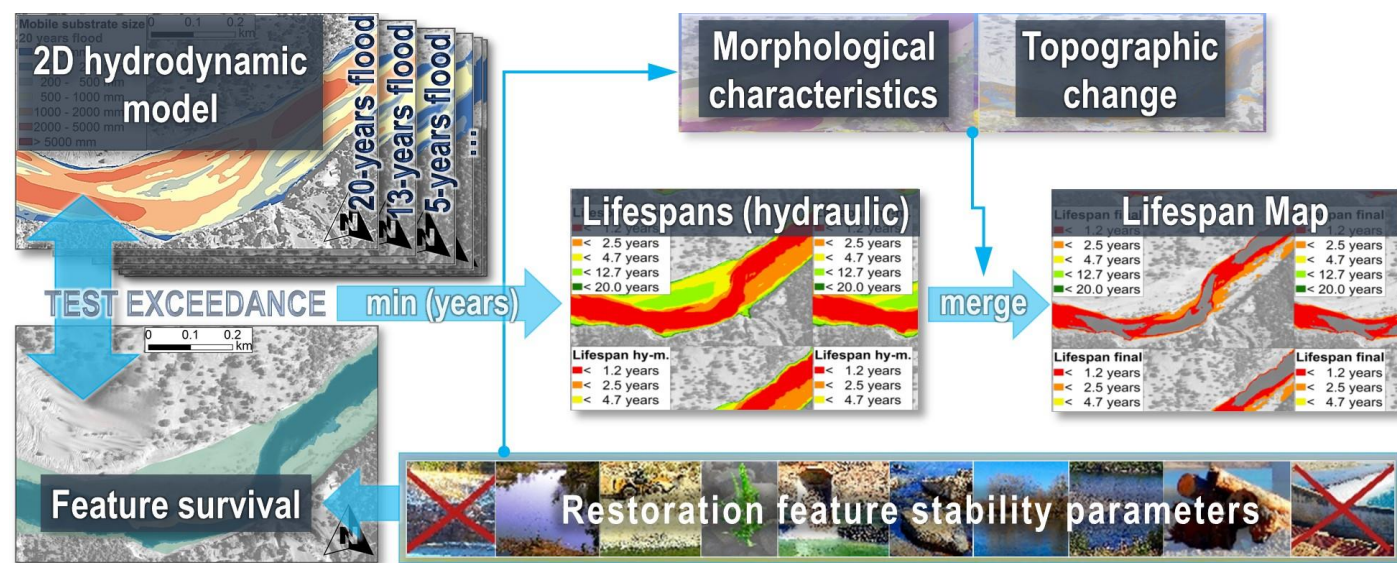
Habitat quality and connectivity assessment for target species and their lifestages

Project Maker

Presentation-ready wrap up of project costs and benefits

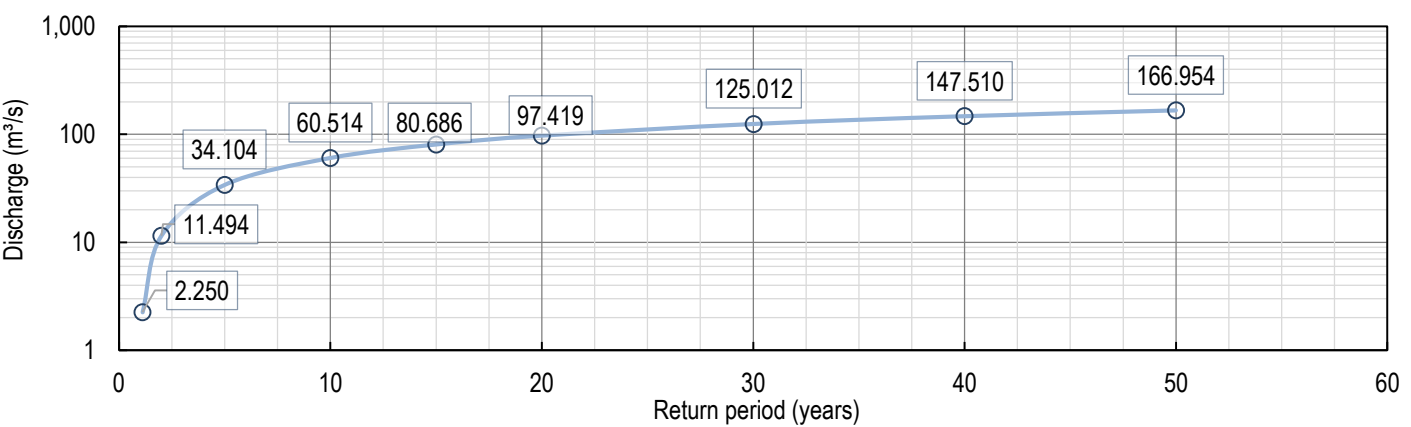
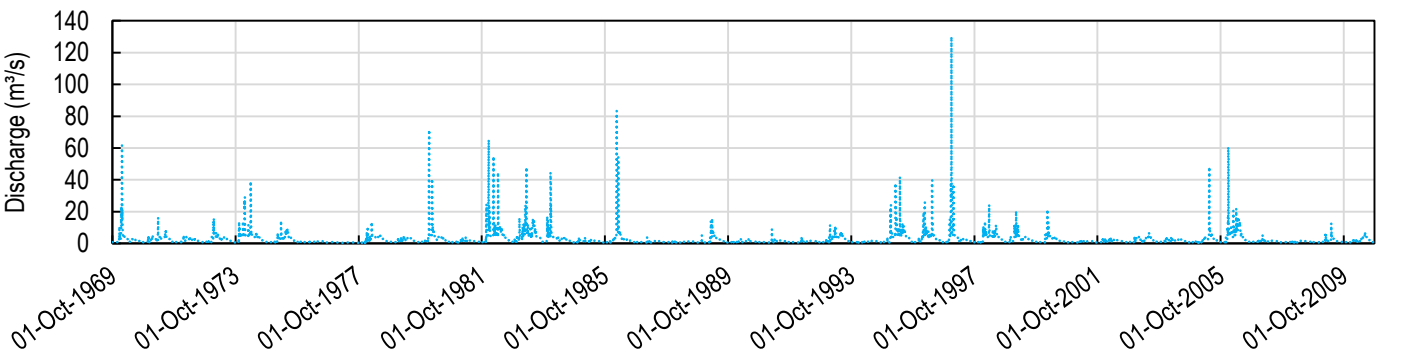
Lifespan & Design Mapping.

Lifespan mapping



Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Hydro-morphological parameters generate lifespan maps for stream restoration management. *Journal of Environmental Management* 232, 475-489. doi: 10.1016/j.jenvman.2018.11.010

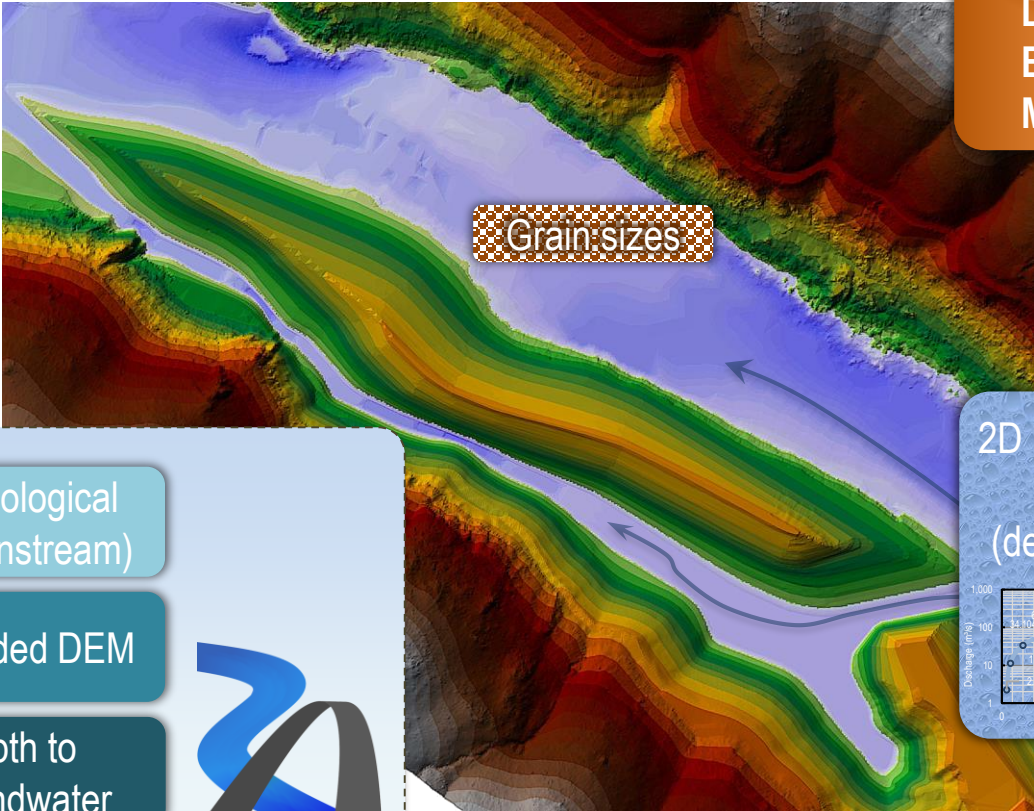
Lifespan mapping



Input

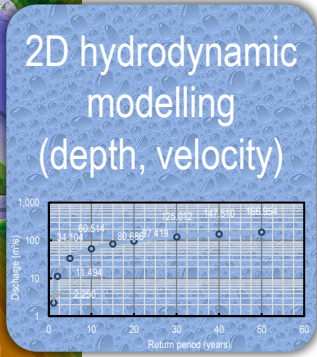
Flow data

Lifespan mapping



Digital
Elevation
Model

- Morphological Units (instream)
- Detrended DEM
- Depth to Groundwater



Input → Rasters

Features

► Stream design feature groups



GROUP 1: Berm setback, calm water zones, grading, side channels, bank scalloping



GROUP 2: Vegetation plantings & other (soil) bioengineering



GROUP 3 – Longitudinal connectivity: Sediment budget modification, flow regulation, lateral barrier removal (not yet fully considered in River Architect)

► Parametrization: Survival threshold values

Parameter (unit)	Depth to ground water (m)	Dim.less bed shear stress (--)	Froude number (--)	Flow depth (m)	Flow velocity (m/s)	TCD: Fill (m/year)	TCD: Erosion (m/year)
Grading	2 - 4	0.047	na	na	na	na	0.01
Etc.

Lifespan mapping

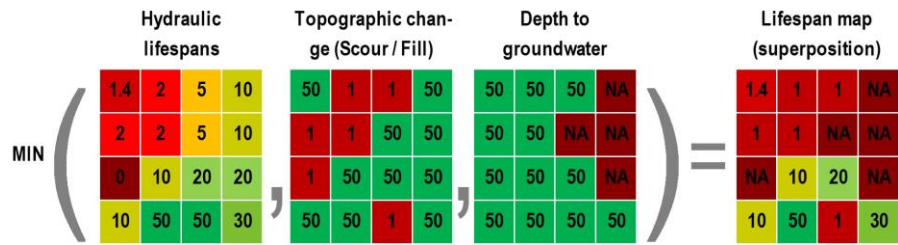
► Sustainability Criteria – Thresholds

	VEGETATION PLANTINGS				BIOENGINEERING (OTHER)		
Feature Name	Box Elder	Cottonwood	White Alder	Willow	Streamwood	Angular boulders	Soil stabilization
Critical dimensionless bed shear stress	0.047		0.047	0.100		0.047	
Depth to groundwater (min)	3.0	5.0	1.0	1.0			
Depth to groundwater (max)	6.0	10.0	5.0	5.0			12.0
Detrended DEM (min)							
Detrended DEM (max)							
Flow depth	1.0	2.1		2.1	3.4		
Flow velocity		3.0					
Froude number					1.0		
Grain size							
Design map frequency threshold					10.0	20.0	
Safety factor						1.3	
Terrain slope							0.20
Topographic change: fill rate		3.36					
Topographic change: scour rate		1.68	3.00	1.68		3.00	

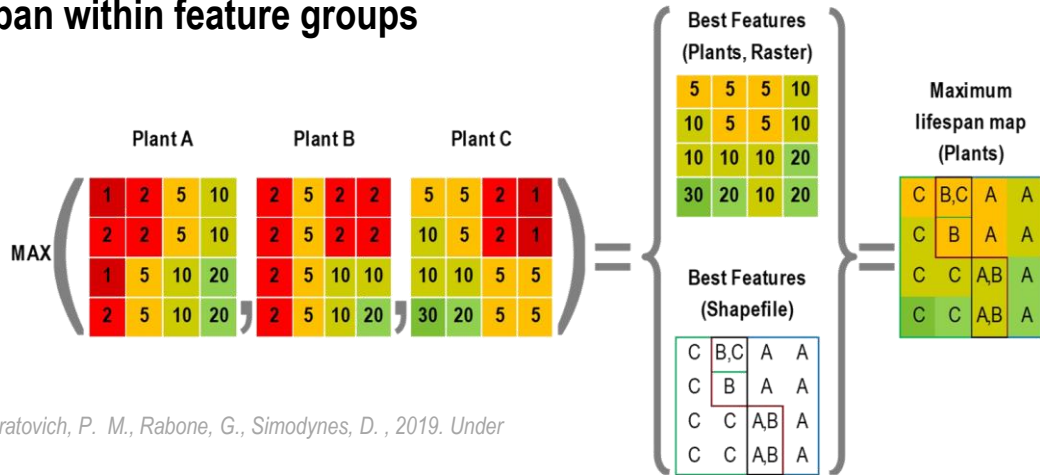
Source: https://github.com/RiverArchitect/program/blob/master/LifespanDesign/templates/threshold_values.xlsx

Lifespan mapping

► Lifespan Calculation (Raster overlay)



► Identify best lifespan within feature groups

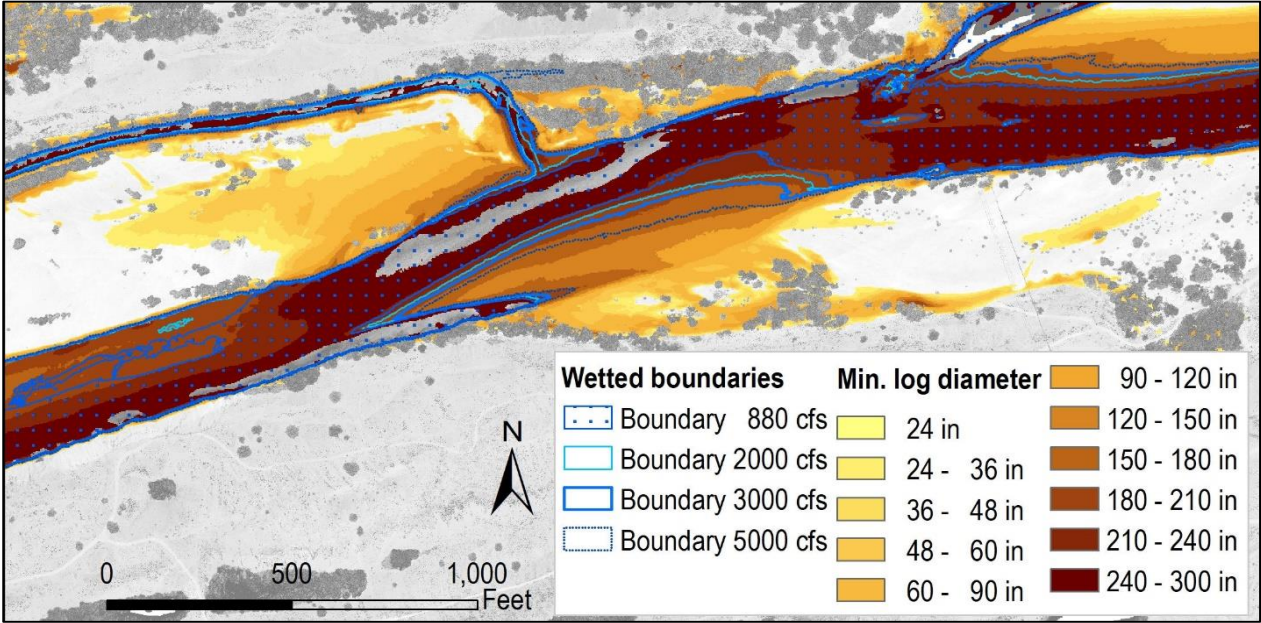


Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Under preparation



Lifespan mapping

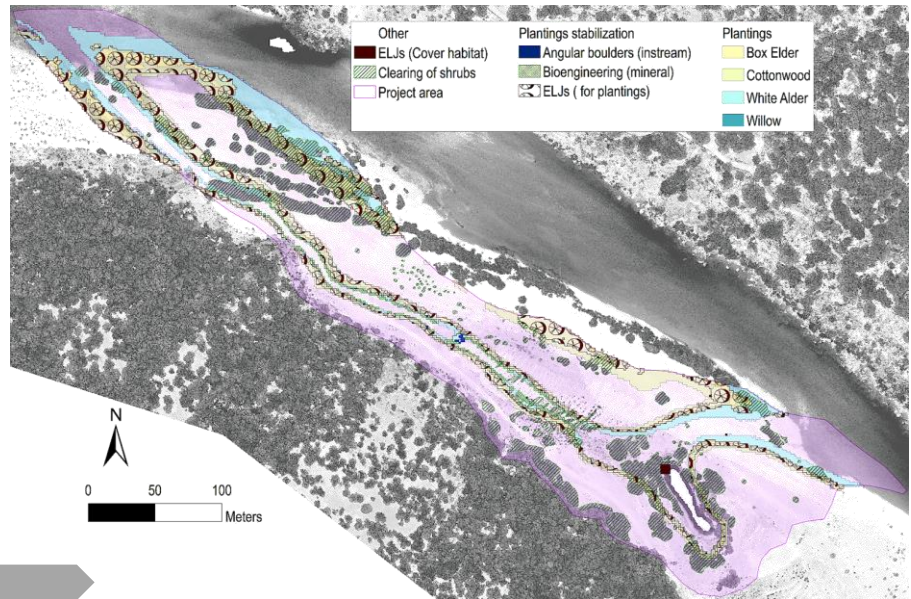
► Example: Identify stable log diameters for streamwood placement



Lifespan mapping

Result processing

- ▶ Use for planning terraforming actions: Manual action required
- ▶ Use for full-automated planning of vegetation plantings & other bioengineering features
- ▶ And more ...
 - ... gravel augmentation
 - ... streamwood
 - ... mass movement

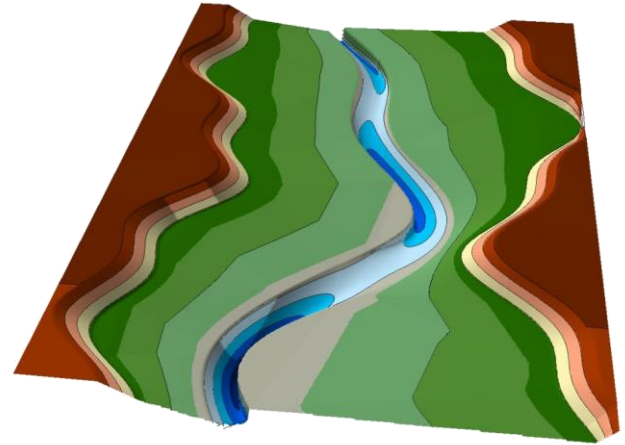


 **Morphology.**

Morphology

Use Threshold-based terraforming or River Builder to design riverscapes

- ▶ Threshold-based terraforming: Grading or River widening
- ▶ River Builder
- ▶ Volumetric Terraforming assessment
 - ... these routines proceduralize currently best available science
 - ... we are developing new strategies to improve procedural terraforming based on physical boundary conditions

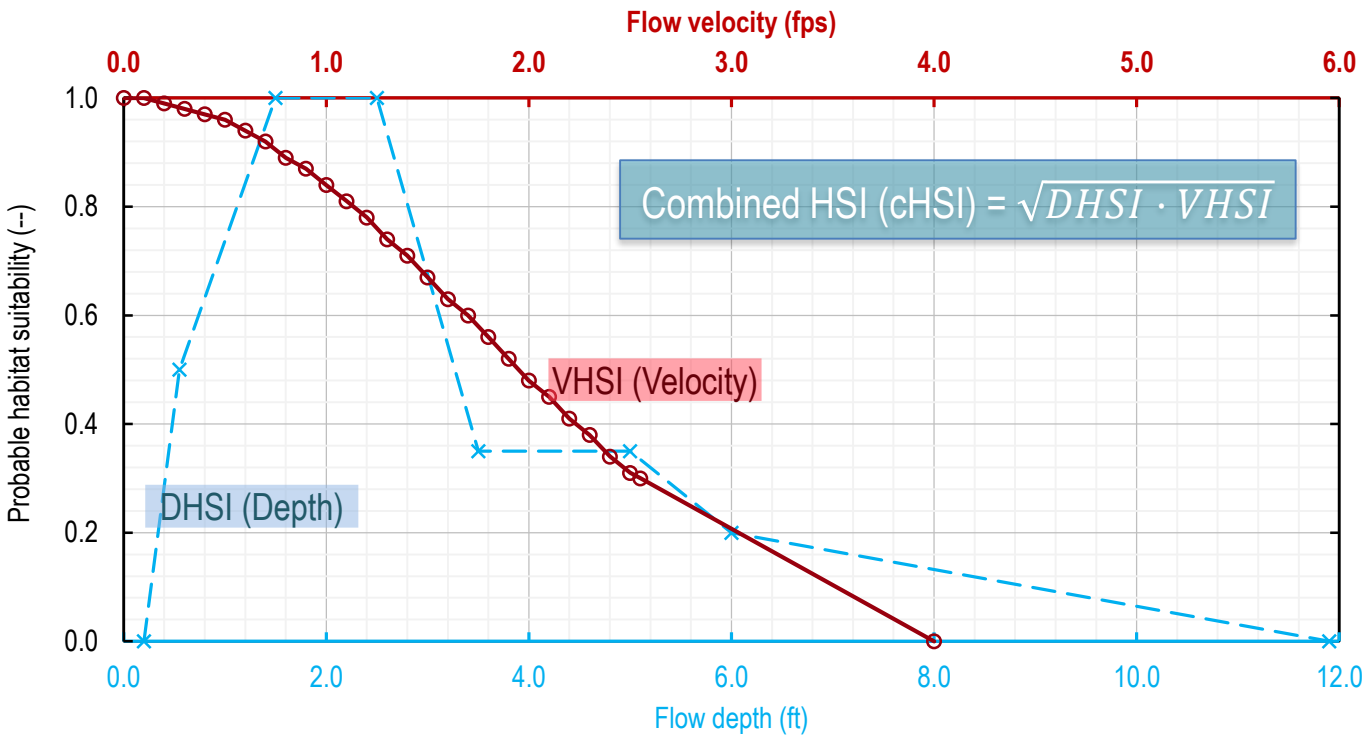


Synthetic river valley created with River Builder
(source: Gregory B. Pasternack)



Ecohydraulics

► Habitat assessment (1): Habitat Suitability Index (HSI) of juv. Chinook salm.

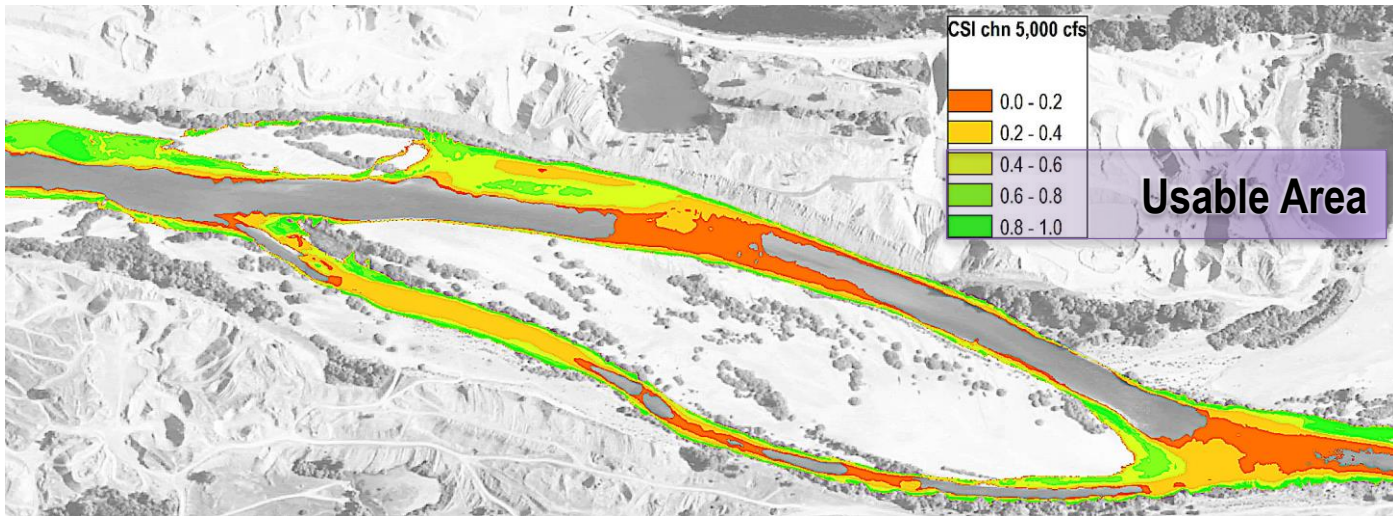


Source: Schwindt, S., Pasternack G. B., Rabone, G., 2020. [submitted manuscript].



Ecohydraulics : Habitat Enhancement

- ▶ Habitat assessment (2): composite Habitat Suitability Index (cHSI) map



- ▶ Repeat operation for multiple discharges (apply flow duration curve)
- ▶ Calculate usable habitat area (e.g., $\text{cHSI} > \theta = \dots$)

Source: Schwindt, S., Pasternack G. B., Rabone, G., 2020. [submitted manuscript].

Ecohydraulics: Habitat Enhancement

► Fish preferences in River Architect

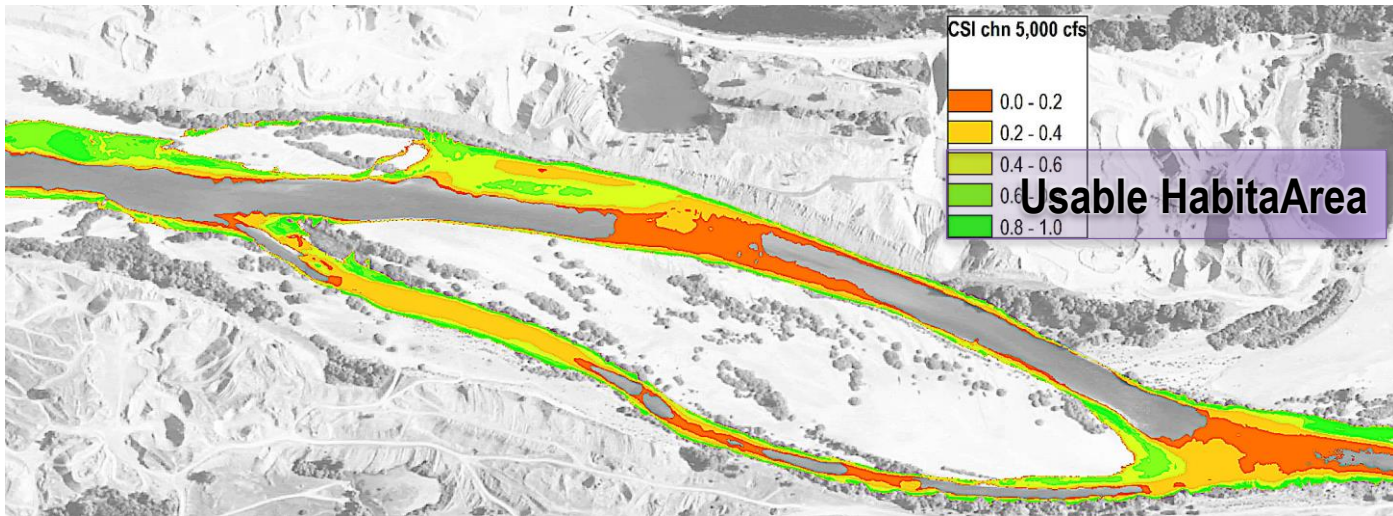
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1		SET UNIT SYSTEM	U.S. customary								u in (fps)		h in (ft)		D in (inch)		Rad. in (ft)			
2		Common name	Chinook Salmon								Rainbow / Steelhead Trout									
3		Genus	Oncorhynchus								Oncorhynchus									
4		Species	O. tshawytscha								O. mykiss									
5		Lifestages	spawning		fry		juvenile		adult		spawning		fry		juvenile		adult		spawning	
6		Season start	1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct	
7		Season end	30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep	
8			u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)
9			0.22	0.00	0.00	1.00	0.00	1.00			0.06	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	
10			0.85	0.20	0.10	0.99	0.10	1.00			0.77	0.10	0.10	1.00	0.10	1.00	0.50	0.50		
11			1.30	0.52	0.20	0.95	0.20	0.99			1.00	0.20	0.20	0.99	0.20	0.99				

► Usable habitat is where $\theta = \dots$

The screenshot shows the 'River Architect' software interface. The 'Hydraulic habitat conditions' section is highlighted with a green circle. It includes a 'Set Shallow Threshold' button and a 'Current CHSI = 0.5' label. The interface also shows various other settings and buttons for habitat enhancement.

Ecohydraulics: Habitat Enhancement

- Habitat assessment (2): composite Habitat Suitability Index (cHSI) map



- Repeat operation for multiple discharges (apply flow duration curve)
- Calculate usable habitat area (e.g., $cHSI > \theta = 0.7$)
- Sum of usable areas for one discharge = SHArea
- Sum of multiple season-specific discharges = **Seasonal Habitat Area**

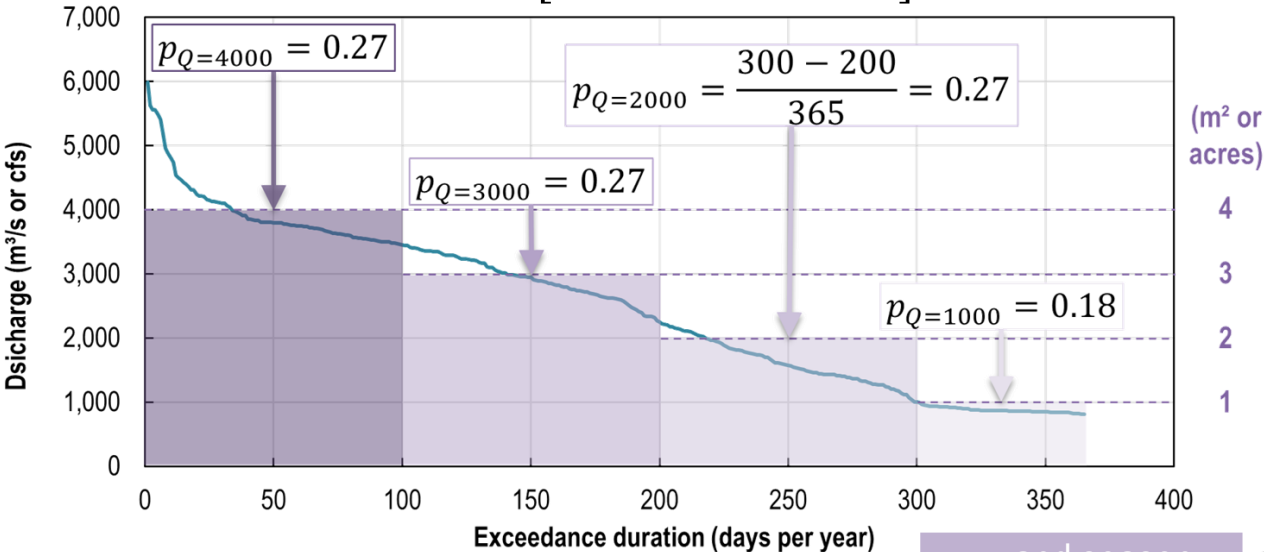
Source: Schwindt, S., Pasternack G. B., Rabone, G., 2020. [submitted manuscript].



Ecohydraulics: Habitat Enhancement

► Habitat assessment (3): Calculate **Seasonal Habitat Area** (*SHArea*)

$$SHArea = \sum_{p_{Qi}}^{p_{Qn}} \left[\sum pixels(cHSI > \vartheta) \right] \cdot p_{Qk}$$



... and season

Season start	1-Oct
Season end	30-Sep

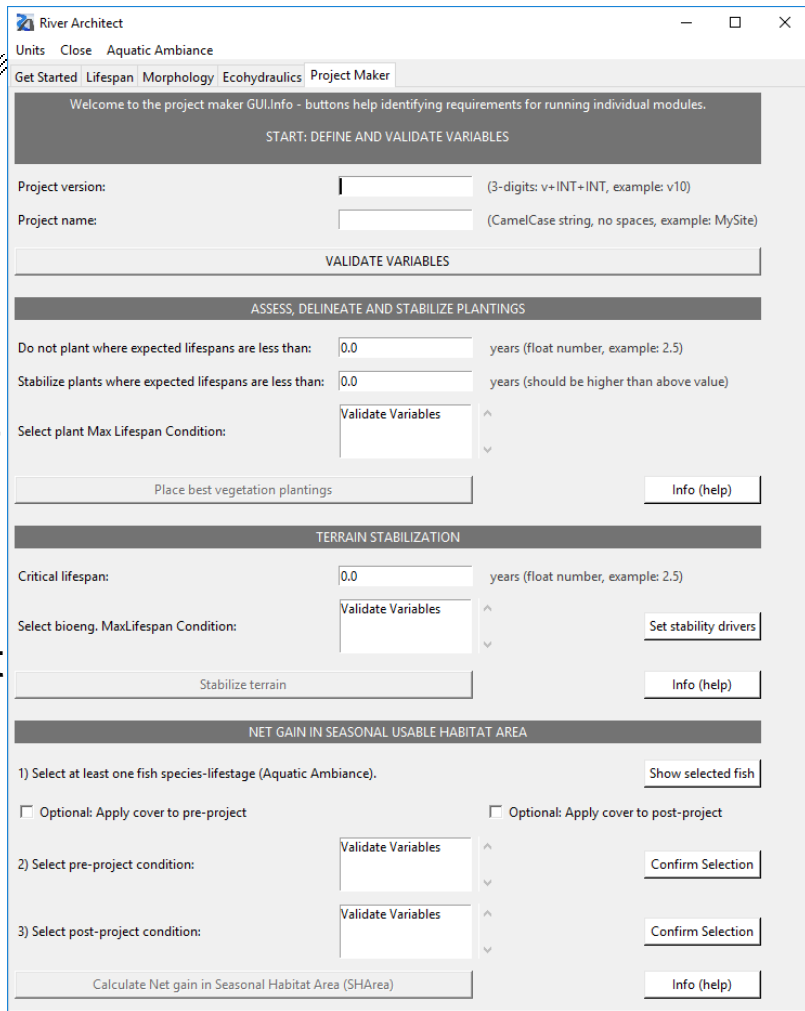
More: https://riverarchitect.github.io/RA_wiki/SHArC#herunSHArea



Project Maker (Cost-Benefit Analysis).

Project Maker

- Site-wise metrics
- Automated terraforming assessment
- Automated vegetation plantings & other bioengineering placement
- Automated cost assessment



River Architect

Units Close Aquatic Ambiance

Get Started Lifespan Morphology Ecohydraulics Project Maker

Welcome to the project maker GUI. Info - buttons help identifying requirements for running individual modules.

START: DEFINE AND VALIDATE VARIABLES

Project version: (3-digits: v+INT+INT, example: v10)

Project name: (CamelCase string, no spaces, example: MySite)

VALIDATE VARIABLES

ASSESS, DELINEATE AND STABILIZE PLANTINGS

Do not plant where expected lifespans are less than: years (float number, example: 2.5)

Stabilize plants where expected lifespans are less than: years (should be higher than above value)

Select plant Max Lifespan Condition: Validate Variables

Place best vegetation plantings

Info (help)

TERRAIN STABILIZATION

Critical lifespan: years (float number, example: 2.5)

Select bioeng. MaxLifespan Condition: Validate Variables

Set stability drivers

Stabilize terrain

Info (help)

NET GAIN IN SEASONAL USABLE HABITAT AREA

1) Select at least one fish species-lifstage (Aquatic Ambiance).

☐ Optional: Apply cover to pre-project ☐ Optional: Apply cover to post-project

2) Select pre-project condition: Validate Variables

3) Select post-project condition: Validate Variables

Confirm Selection

Confirm Selection

Calculate Net gain in Seasonal Habitat Area (SHAarea)

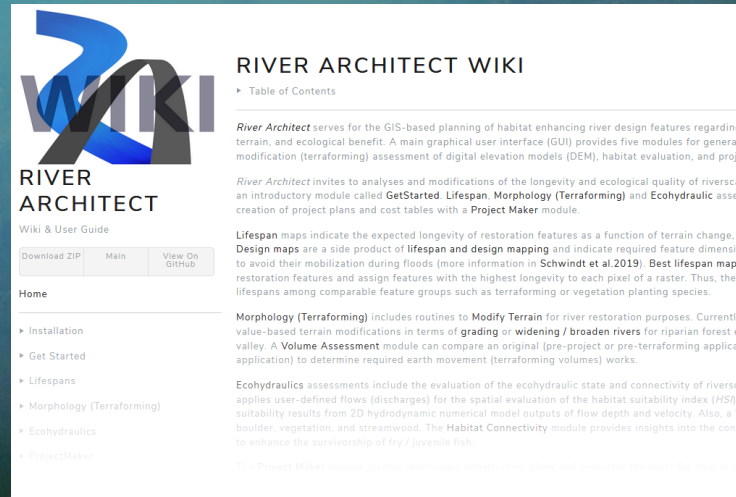
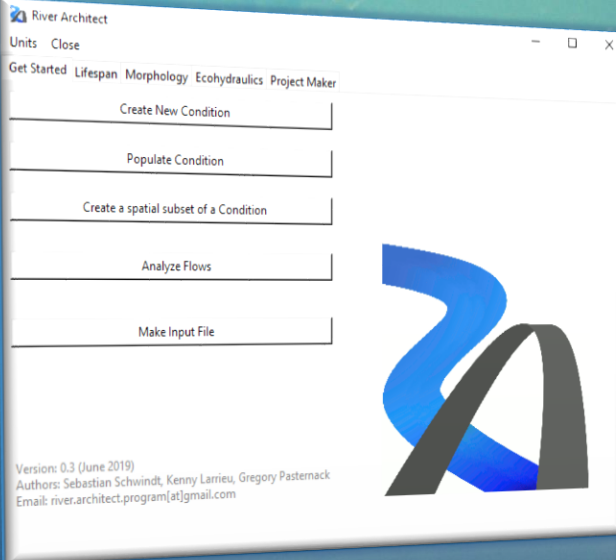
Info (help)

Project Maker

Reach: REACH NAME	Total costs: \$4,576,446.64	Project return
Site: Site Name	Net gain in AUA (aclyr): 2.5	(US \$ per ac net gain in AUA) \$1,816,541.54

Layer	Task	Costs per	Unit	Quantity	Total (US \$)	Remarks	Literature Sources
Framework (terraforming)	Clearing (vegetation)	\$ 220.00	acre	2.0	\$441.41		LCH (2012)
	Excavate/fill alluvial material (includes transport)	\$ 10.52	yd³	external	\$1,411,446.10	Use terraforming_volumes sheet	CCC (2003) King et al. (1994) LCH (2012)
	Groin cavities	\$ 1,200.00	piece		\$0.00		Zeh (2007)
	SUM (Terraforming)				\$1,411,887.51		
Bioengineering (stabilization)	Anchoring (logs for plantings)	\$ 80.00	yd'	6.0	\$480.00	refers to log length	LCH (2012)
	Engineered log jam: log-wise (for plantings)	\$ 775.00	log	0.7	\$558.00	log length = 25 ft, Ø = 24 in	Cramer (2012) Virginia University (2004)
	Engineered log jam: root-wise	\$ 49.88	rootwad		\$0.00		King et al. (1994) Zeh (2007)
	Engineered log jam: complete	\$38,750.00	piece		\$0.00		Cramer (2012) Knutson (2015)
	Angular boulder placement (instream)	\$ 130.00	yd²	175.0	\$22,750.00		Zeh (2007) Cramer (2012)
	SUM (Plant-stabilizing bioengineering)				\$23,788.00		
Bioengineering (planting)	Ball method (small trees)	\$ 210.00	piece		\$0.00		Zeh (2007) Virginia University (2004)
	Container trees	\$ 33.00	tree		\$0.00		King et al. (1994)
	Plant method (C. rubra/rostrata)	\$10,447.50	piece		\$0.00	Cutting length = 7-12 ft, Ø = 6 in	King et al. (2012)
SUM (TOTAL CONSTRUCTION WORKS)					\$3,389,960.47		
APPLICATION OF FEES & RATES							
CIVIL ENGINEERING							
Site (de-)mobilization (from total costs)		0.10	[H]	1.0	\$338,996.05		LCH (2012)
Unexpected (from total costs)		0.10	[H]	1.0	\$338,996.05		LCH (2012)
ENGINEERING FEES							
From total costs		0.15	[H]	1.0	\$508,494.07		LCH (2012) Cramer (2012)
TOTAL COSTS					\$4,576,446.64		

... Project key metrics



download <https://riverarchitect.github.io/>
 docu https://riverarchitect.github.io/RA_wiki/
 maintenance S. Schwindt, K. Larrieu, G. Pasternack