

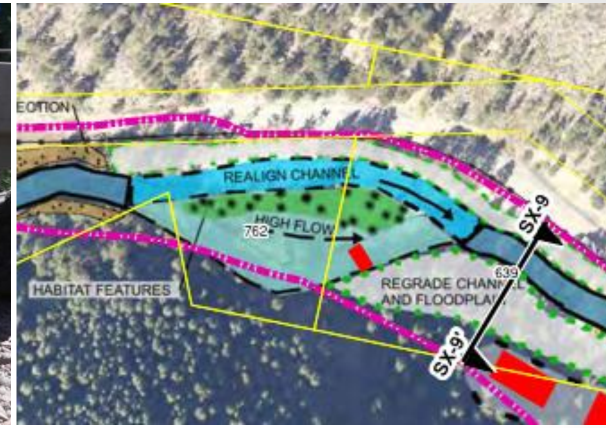

DEVELOPING RAPID GEOMORPHIC DATASETS TO IDENTIFY RISK AND GUIDE RIVER RESTORATION AND LONG-TERM WATERSHED PLANNING:

A RIVER STYLES CASE STUDY

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otak®
HanmiGlobal Partner

Outline

1. Project Background and Goals
2. Methods
3. Geomorphic Risk
4. Conclusions

1. Background and Goals

- In response to September 2013 floods, CWCB made funds available to develop watershed master plans
- Primary purpose to address and coordinate the response to key restoration issues in the aftermath of the flood
- 5 Goals for the Plan:
    1. Assess flood, geomorphic, ecosystem risk
    2. Recommend actions to update regulatory flood mapping
    3. Provide recommendations on channel restoration
    4. Identify projects that address long-term recovery
    5. Determine implementation strategies

Presentation Focus

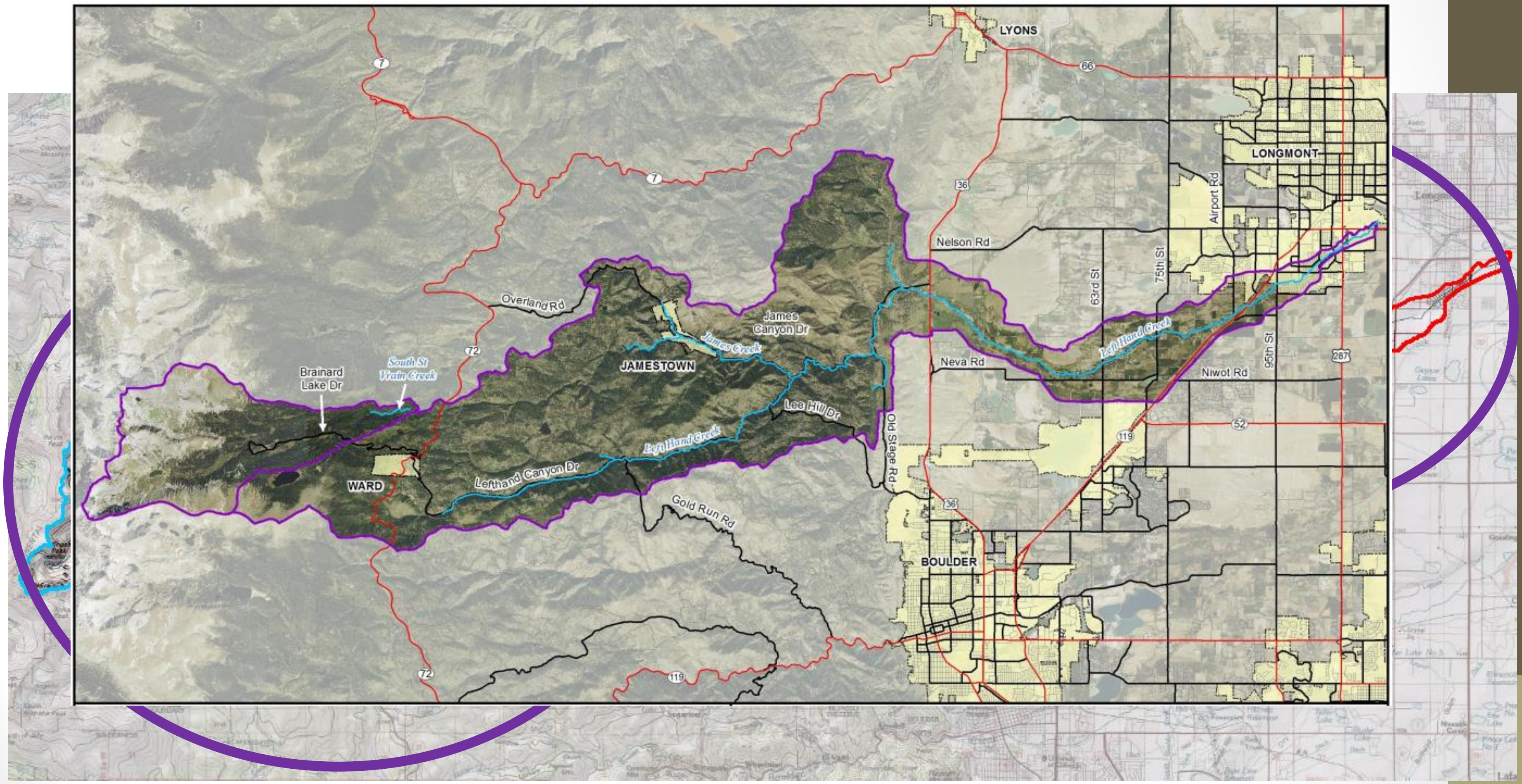
- The tools that geomorphologists can use to rapidly develop data to be incorporated in planning and design projects

June Conceptual **November**

America is all about speed. Hot, nasty, bad#@! speed.
-Eleanor Roosevelt, 1936

Study Area

1. **Background and Goals**
2. Methods
3. Geomorphic Risk
4. Conclusions



Recent Fire History

1. **Background and Goals**
2. Methods
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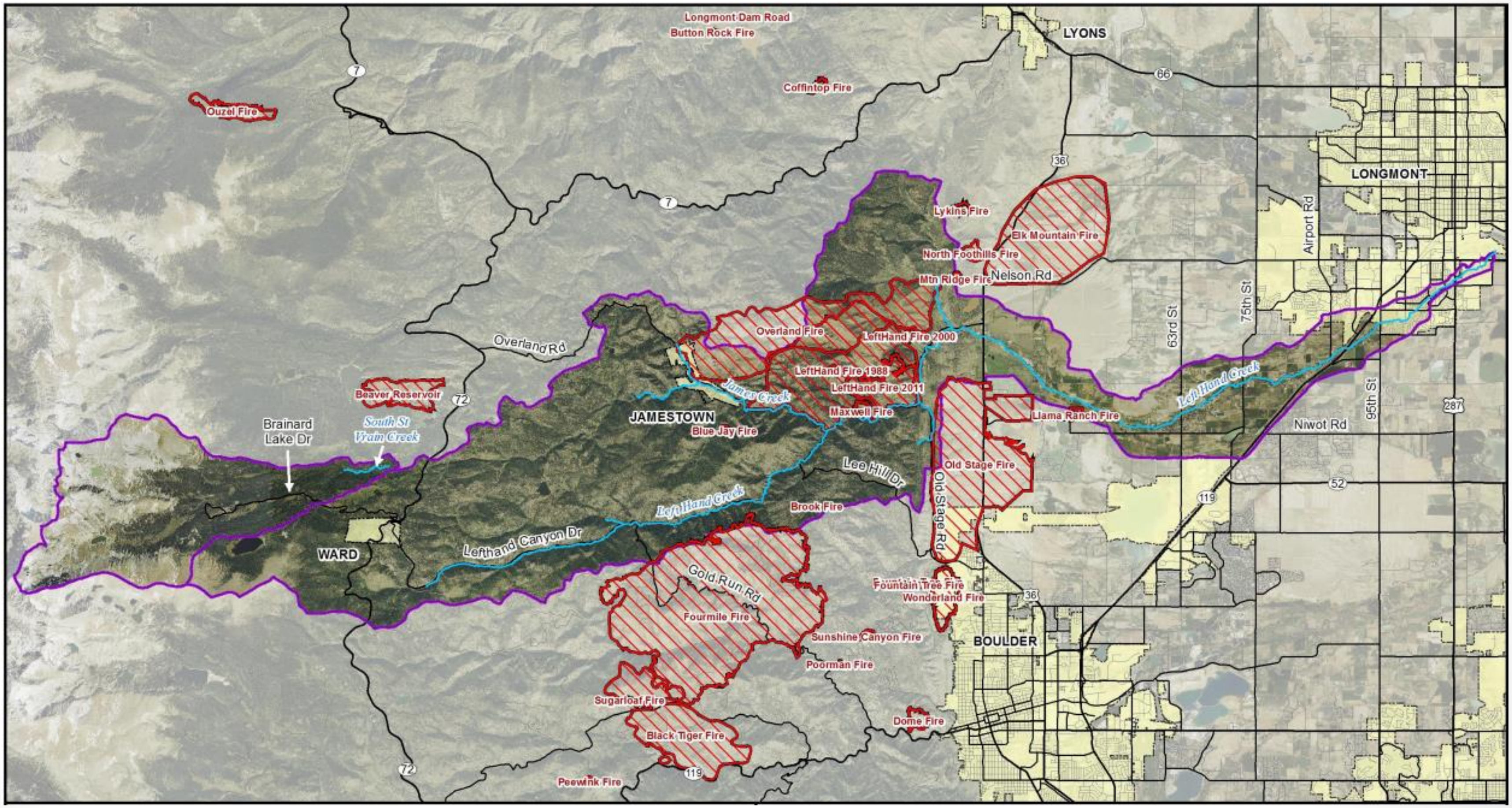

Landslide/Debris Flow

1. **Background and Goals**
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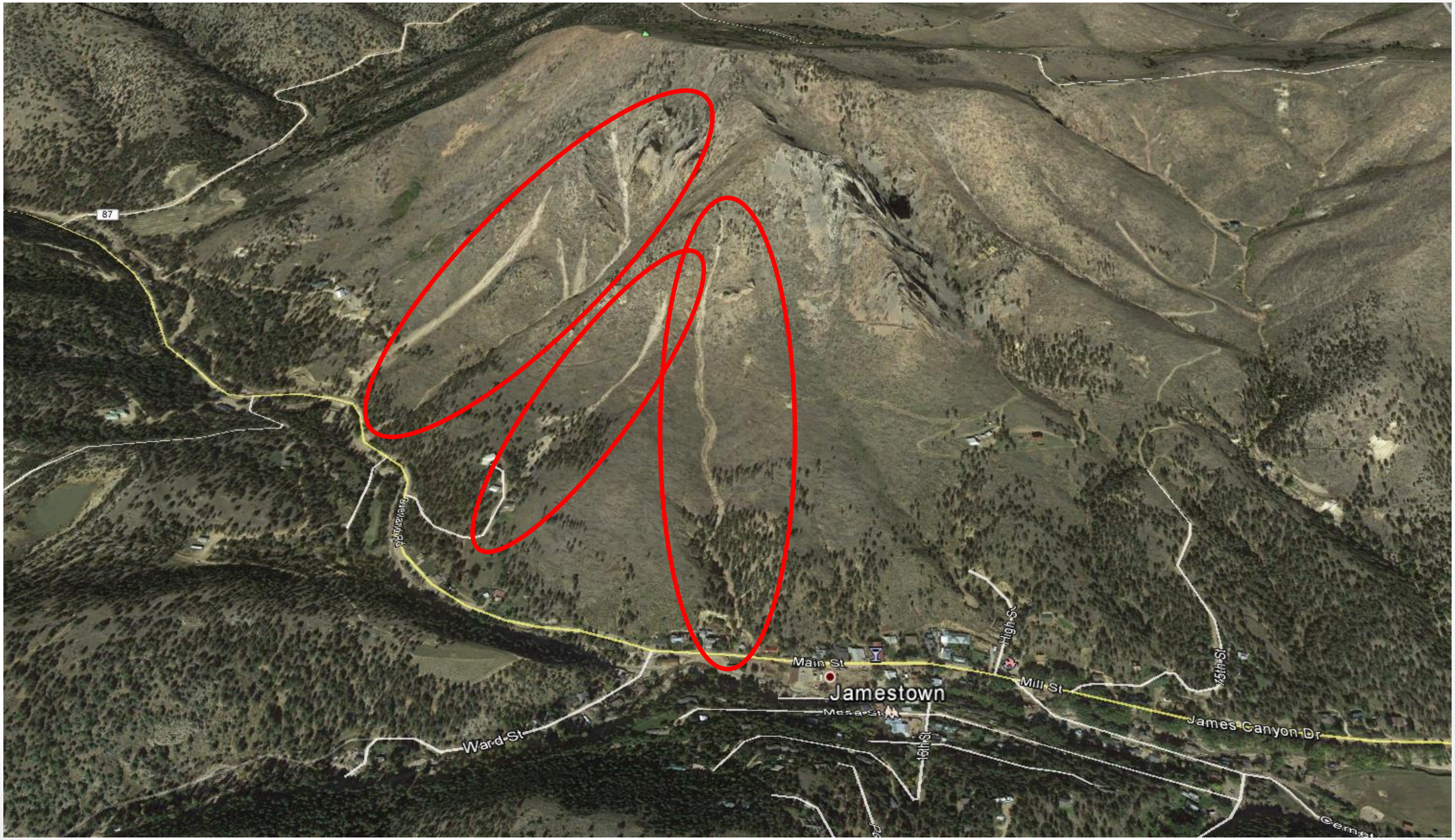

**See Anderson et al, 2015. Exhumation by debris flows in the 2013 Colorado Front Range storm. Geology. v. 43 no. 5 p. 391-394

Jamestown

1. **Background and Goals**
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Plains

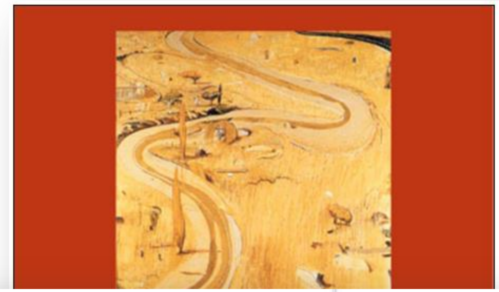
2. Methods

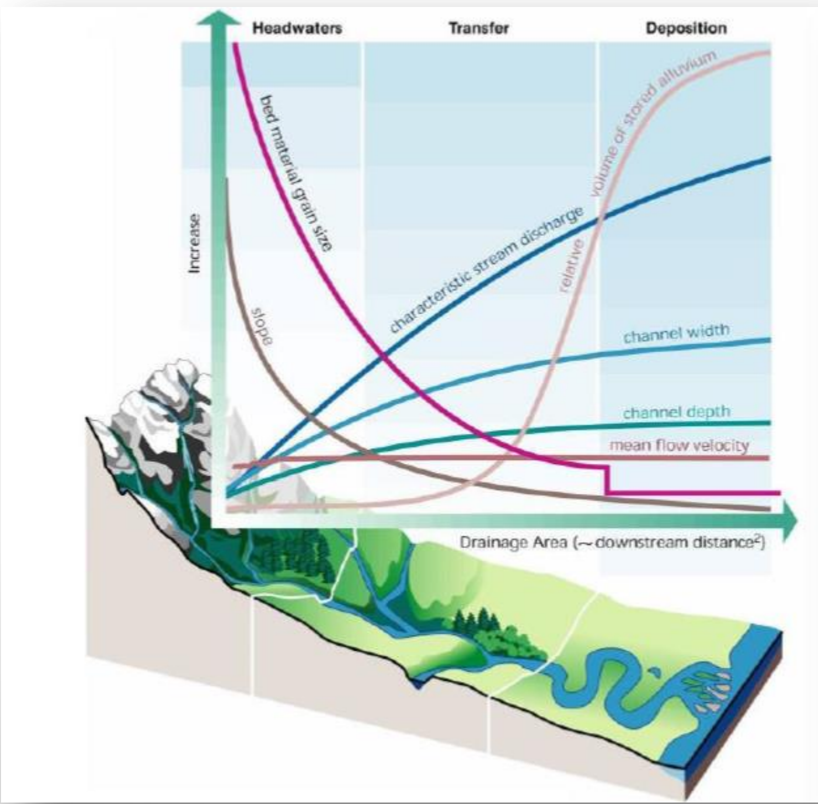
- Use River Styles to collect, organize and synthesize geomorphic data to meet project goals
- Data Collection Methods
    1. Terrain Analysis
    2. Rapid Field Assessments
    3. Historic Data Sources

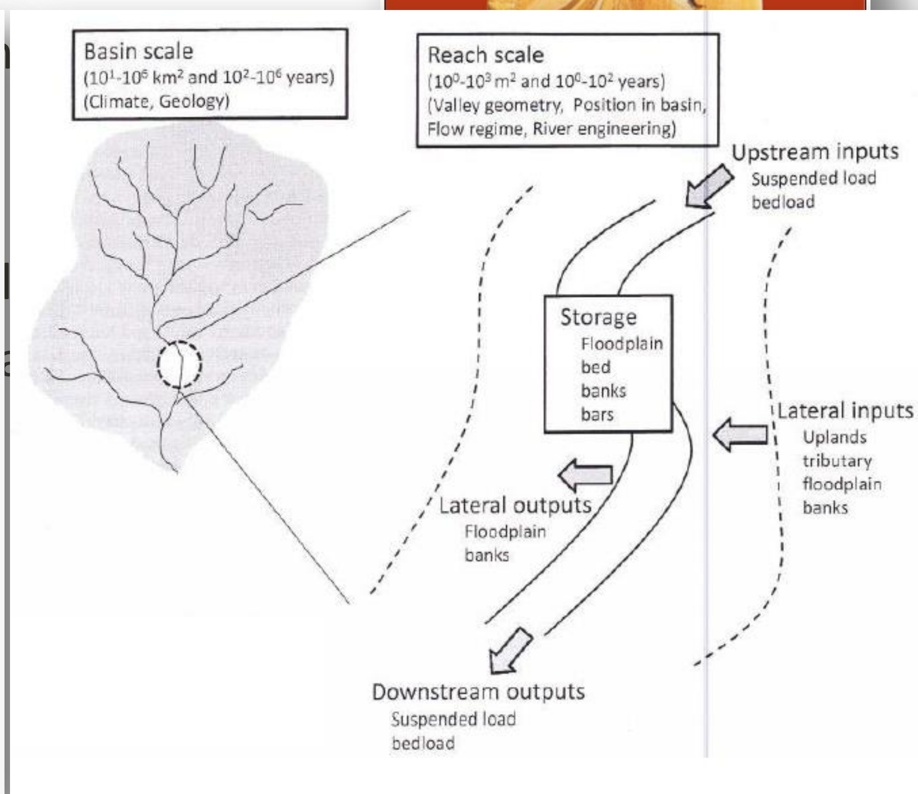
River Styles

Not another classification system!?

- Process-based
- Addresses spatial scales

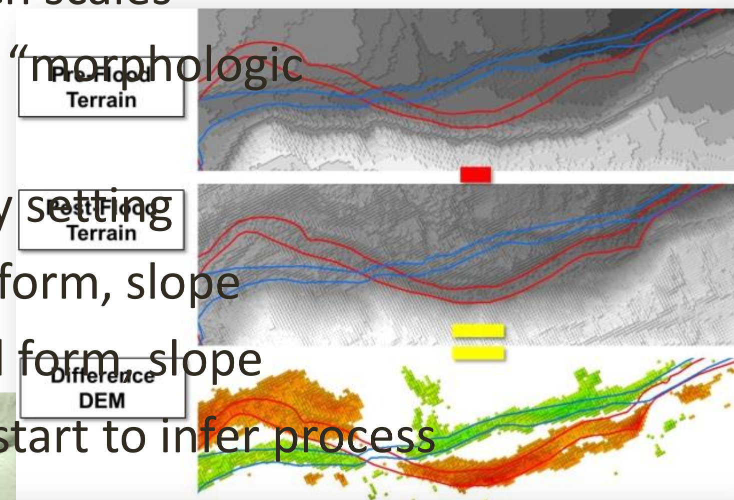


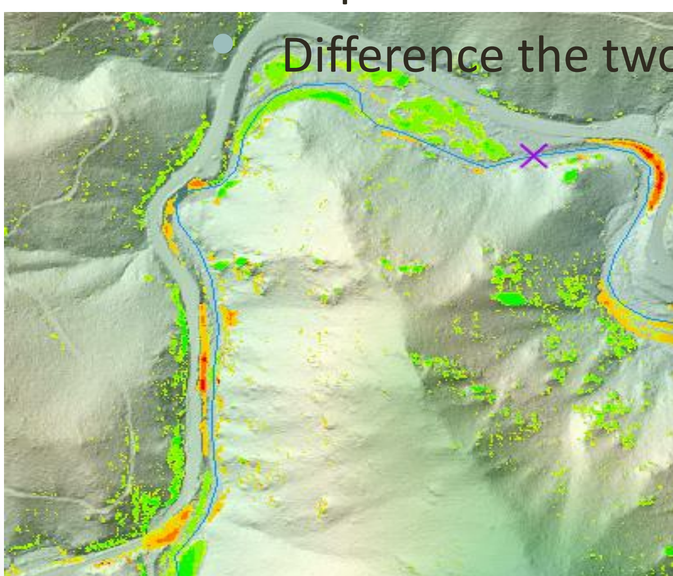


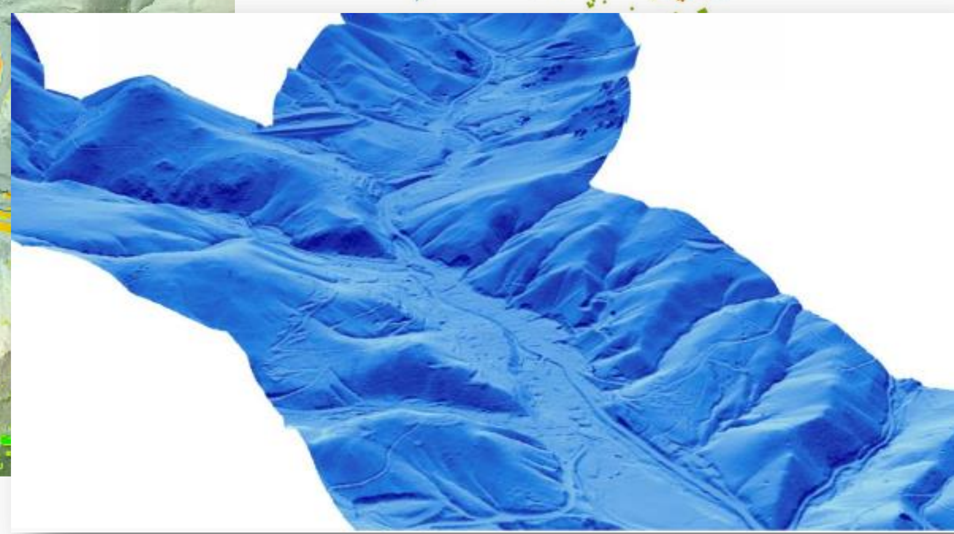


Terrain Analysis

- Focused on Watershed and Reach scales
- Facilitates the application of the "morphologic approach" to geomorphology
  - Channel planform and valley setting
  - ID pre-disturbance channel form, slope
  - ID post-disturbance channel form, slope
  - Difference the two, we can start to infer process







Field Assessment

- Collected at one representative observation point per reach, focusing on the reach/channel and geomorphic unit scales

GEOMORPHOLOGIC FIELD DATA SHEET

SITE IDENTIFICATION

Stream Name:	Left Hand Creek	Date:	16-Aug-14
Reach ID:	9 (1)	Time:	11:26 AM

GPS Coordinates	Downstream	Upstream
Latitude (N):		
Longitude (W):		

Recorder:	DLS
Field Crew:	DLS, GRA
Photo #'s:	

REACH SETTING

		Notes:
24-hour Precipitation:	Showers (Intermittent)	light, brief thunderstorm
Current Stream Flow:	Low Flow	
Landscape Unit and Within-Catchment Position:	cconfined valley/canyon	
Adjacent Land Use(s): (e.g., forest, pasture, urban)	n/a; road	
Existing Infrastructure: (e.g., roads, culverts, bridges)	road, culverts	
Flow Inputs/Outputs: (e.g., tribs, irrigation, outfalls)	no major tribs	

STREAM CLASSIFICATION

		Notes:
Reach Planform:	Straight	
Valley Confinement:	Fully Confined	road, bedrock, valley wall
Bed Morphology:	Step-pool	flood recovery mode - no pronounced bedforms; can use grade control; continuous riffle
Stream Stage Behavior: (e.g., low flow channels, high flow channels, oxbow ponds)		

CHANNEL GEOMETRY

		Notes:
Longitudinal Bed Gradient:	2.57%	see GIS
Bankfull Width:	25 ft	
Bankfull Height at Thalweg:	3 ft	
Channel Entrenchment / Floodplain Connectivity:	Confined Valley, Negligible Floodplain	~2 ft high lateral flood terrace on TR, approximately 1 channel width wide
Constrictions / Expansions (Note % Change in Width):	some floodplain pockets/deposition areas	

RIPARIAN VEGETATION CHARACTERISTICS

	Left Bank	Right Bank	Notes (e.g., vegetation species, maturity, forest fire evidence):
% Bank Covered By Woody Vegetation and Rock:	30%	10%	
	Marginal	Poor	
Riparian Zone Width (# of Bankfull Channels Wide):	0 to 0.5	0.5 to 1	
	Poor	Marginal	

BED SUBSTRATE CHARACTERISTICS

% Embeddedness = Burial of gravel & cobble by fine sediment in riffles (5 samples):	Moderate (25%-50%)	
Is bed substate composition similar to previously assessed downstream reach?	No	* Perform new Pebble Count for the reach (See Pebble Count Worksheet) - DO NOT EDIT TABLE BELOW
Clay (Stick Mud):	0%	Notes:
Silt (Mud):	0%	See Pebble Count Worksheet
Sand (< 2 mm):	1%	
Fine Gravel (< 8 mm; ladybug):	8%	
Coarse Gravel (< 64 mm, golf ball):	48%	
Cobble (< 256 mm; tennis ball):	39%	
Boulders (> 256 mm; basketball):	4%	
Bedrock (> 4096 mm; 13.5 ft):	0%	

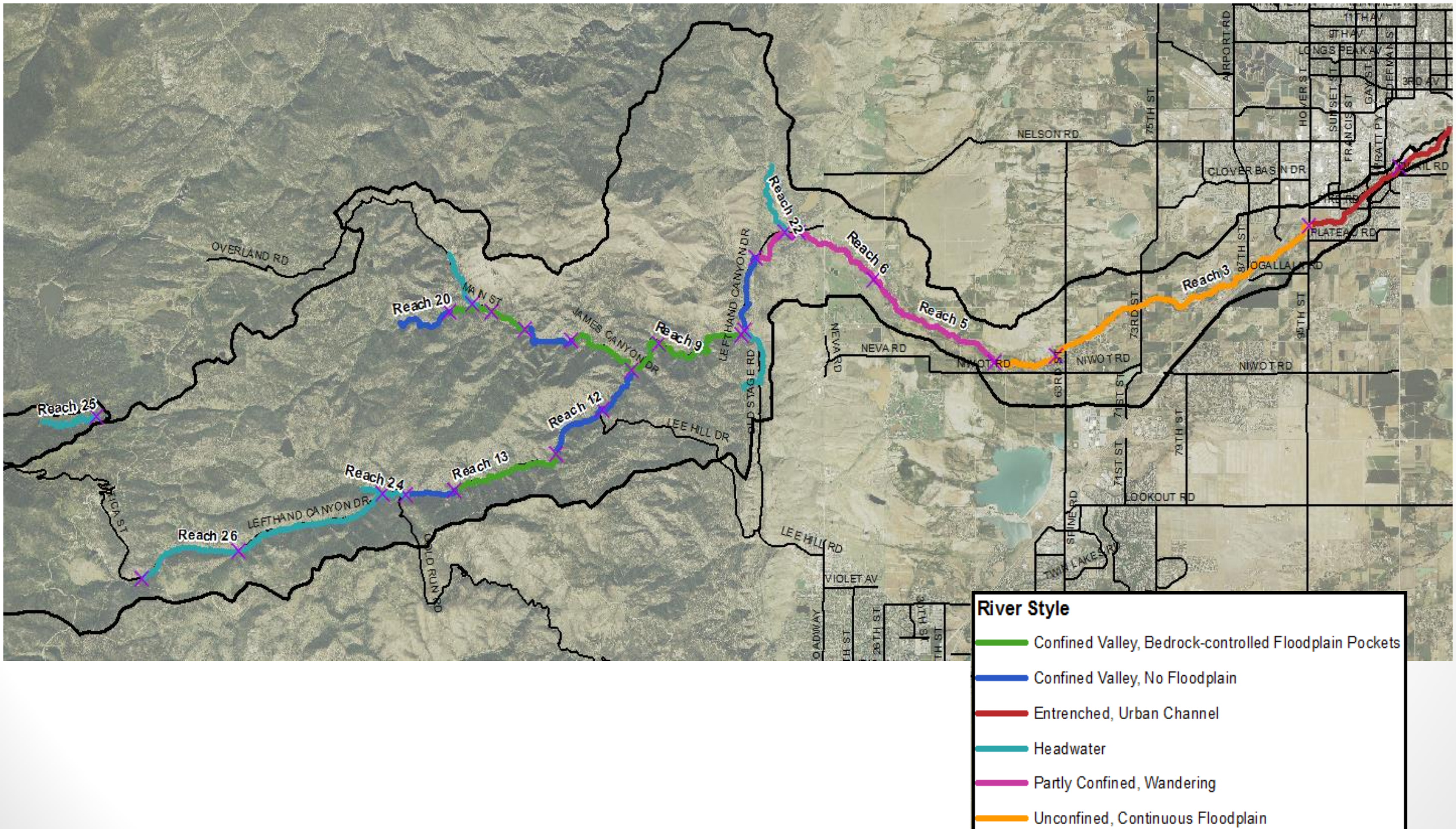
SEDIMENT DYNAMICS AND CHANNEL STABILITY ASSESSMENT

	Left Bank	Right Bank	Notes:
% Bank Manmade Armor:	0%	0%	there will bee - much of reach along raod
% Bank Failure (Severe Fluvial or Mass Wasting)	100%	100%	
	Severe	Severe	
Degree of Bed Armoring (Note - cell will automatically update after pebble count):	Partial Armor Layer, Reduced Bedload Transport		
Dominant Sediment Sources: (e.g., Fluvial, Bank Failure, Hillslope, Debris Flow)	banks, debris flow		
In-Stream Large Wood: (abundance, size, stability)	very little lwd visible; possible to use in floodplain pocket		
Sediment Storage Elements: (e.g., overbank, bedforms, log jams, grade controls)	lateral flood terraces; boulders		
Post Flood Impacts: (e.g., sediment plugs, debris jams, severe erosion)	straightening, widening; scour and subsequent deposition in pockets		
Stage of Channel Evolution: (see graphic below)	Stage IV - Incision and Widening		immediate post-flood
Additional Evidence of Aggradation, Degradation, or Stability (see list below):	incision into loose large unconsolidated cobble, gravel		

RECOMMENDED ACTIONS

Additional Field Assessment Needs:	none
Potential Restoration / Stream Enhancements:	channel could benefit from wood; establish natural roughness to stabilize banks; channel perched TR excavation lower than channel above bend; need to address road damage - pinch points; repairs still to occur; several sub-reaches that require stream restoration design in conjunction; with roadway - limited width! Goal to protect road, possibly with hard armor, therefore imperative to create energy expenditure upstream and downstream; opportunities to control energy/debris above and below pinch points; sstreawm set up in iddeal configuration - not many opportunities for realignment; see notes on mapsheet LHC 21

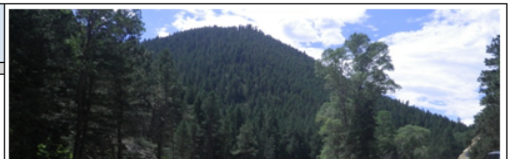
River Styles



Defining Properties

Confined Valley with Bedrock-Controlled Floodplain Pockets

Properties: Reaches are generally tightly confined by the valley margin except for breaks in the bedrock where the valley widens. This channel type mainly occurs in the canyon landscape z
the bedrock accumulate
colluvium, which causes
channel gradient. These
floodplain, storing sedim
and dissipating flood en



Reaches Observed:

RIVER CHARACTER
Valley Setting
Channel Planform
Bed Morphology
Geomorphic Units
RIVER BEHAVIOR
Flood Response
Stage Behavior
Restoration Considerations

adjacent infrastructure.

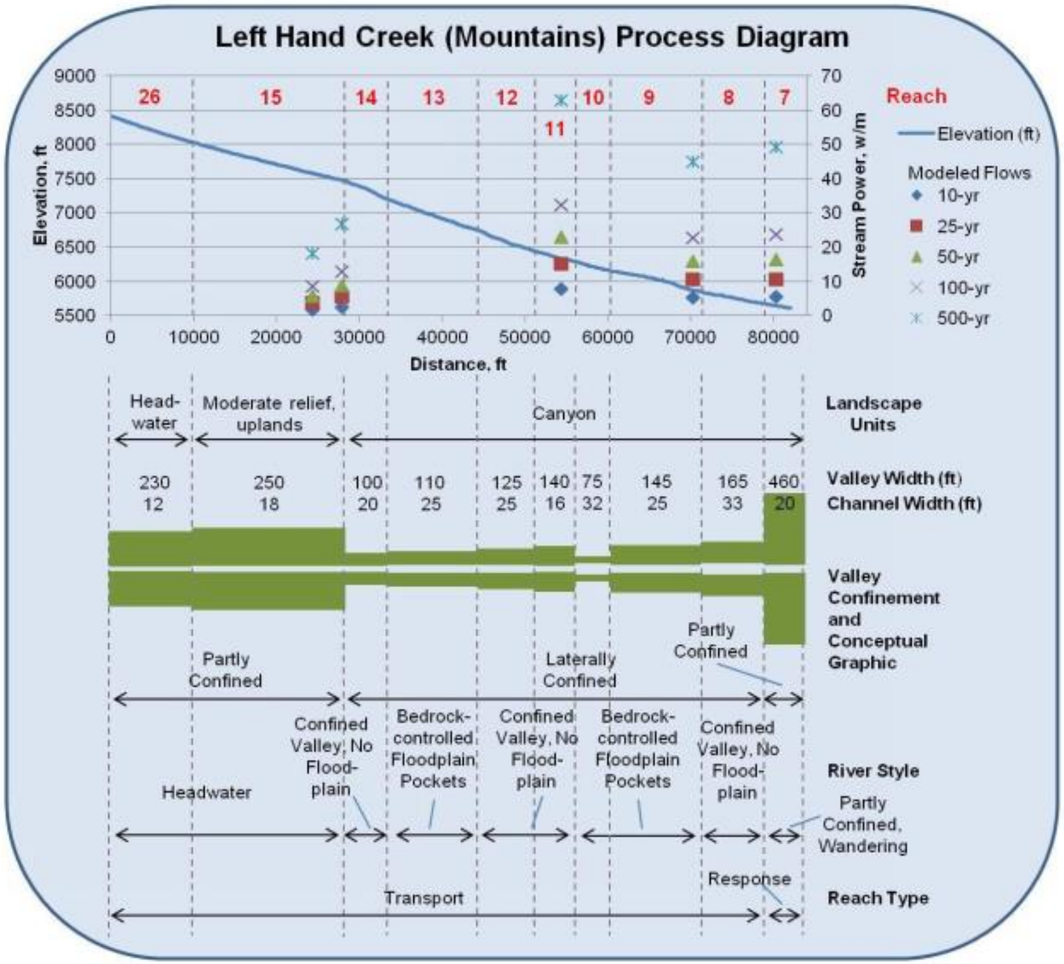
Typical Plan - Confined Valley with Bedrock-Controlled Floodplain Pockets

Confined Valley with Bedrock-Controlled Floodplain Pockets River Style (Cont.)	Conditions Assessment Criteria	
Good	**Fair**	**Poor**
• Laterally and vertically stable or flood re-working in established pockets • Floodplain pockets accessible • Little man-made armor • Intact riparian vegetation • Structural wood present • Well-established bedforms (step-pool sequences with some pool-riffle and rapid elements • Clean gravels (low embeddedness) organized in instream units • Fines present, but exist as transient deposits	• Eroding Banks (fluvial) • Degraded riparian veg. • Armor (riprap, concrete) present in few locations • Floodplain pockets somewhat accessible • Channel may be perched above pocket, post-flood • Large wood in channel, but may not be structural • Fines present but organized in bedforms (moderate embeddedness) • Bedforms present but not stable	• Banks destroyed by mass wasting • Little riparian veg. • Banks heavily armored, grouted riprap used • Floodplain pockets inaccessible, channel entrenched • Channel stripped of large wood • Channel geometry obscured • High embeddedness Channel bedforms absent

Reach Condition

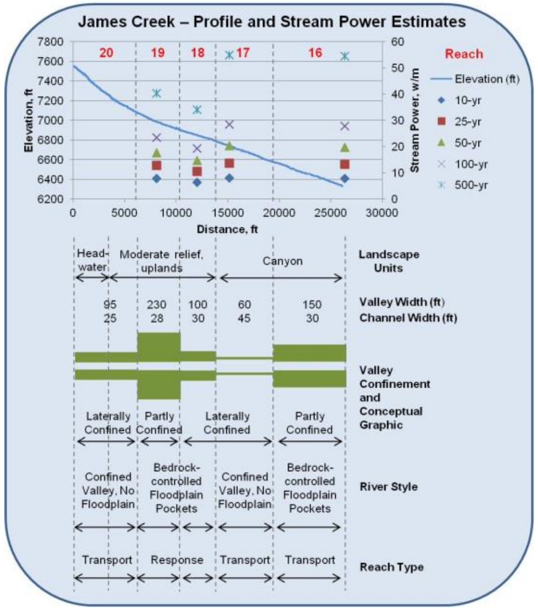
Reach	Stability	Bed Character	Planform	Geomorphic Condition
Entrenched, Residential Channel				
1	Fair	Poor	Fair	Poor
2	Fair	Poor	Poor	Poor
Unconfined, Continuous Floodplain				
3	Fair	Poor	Fair	Poor
4	Poor	Fair	Poor	Poor
Partly confined, wandering				
5	Fair	Fair	Fair	Fair
6	Poor	Fair	Fair	Poor
7	Fair	Poor	Fair	Poor
Confined Valley with Bedrock-Controlled Floodplain Pockets				
9	Poor	Fair	Fair	Poor
10	Poor	Fair	Fair	Poor
13	Fair	Fair	Good	Fair
16	Poor	Poor	Poor	Poor
18	Good	Good	Good	Good
19	Good	Good	Good	Good
Confined Valley, No floodplain				
8	Fair	Fair	Good	Fair
11	Fair	Poor	Fair	Poor
12	Fair	Fair	Fair	Fair
14	Fair	Fair	Good	Fair
17	Poor	Poor	Poor	Poor
20	Fair	Good	Fair	Fair
Headwater				
15	Fair	Fair	Good	Fair
21	Poor	Poor	Poor	Poor
23	Fair	Fair	Fair	Fair
24	Poor	Fair	Fair	Poor
25	Good	Good	Good	Good
26	Good	Good	Good	Good
22	Poor	Poor	Fair	Poor

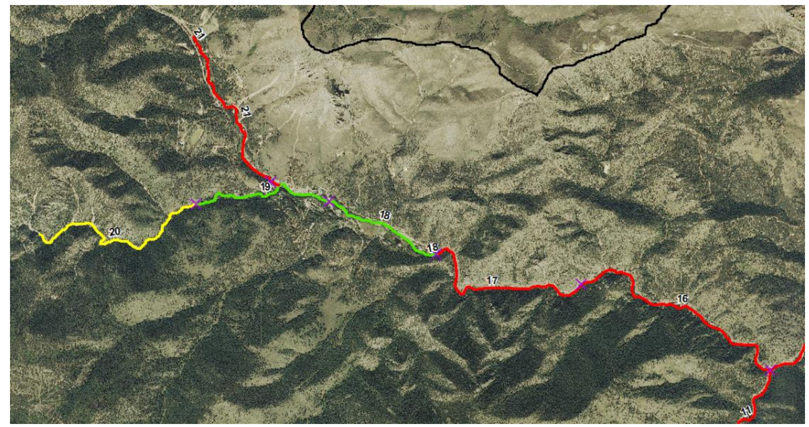
Process Diagrams



- Stack up reach-scale properties to see the position of the reach in the watershed and how each reach relates to those adjacent

Geomorphic Risk



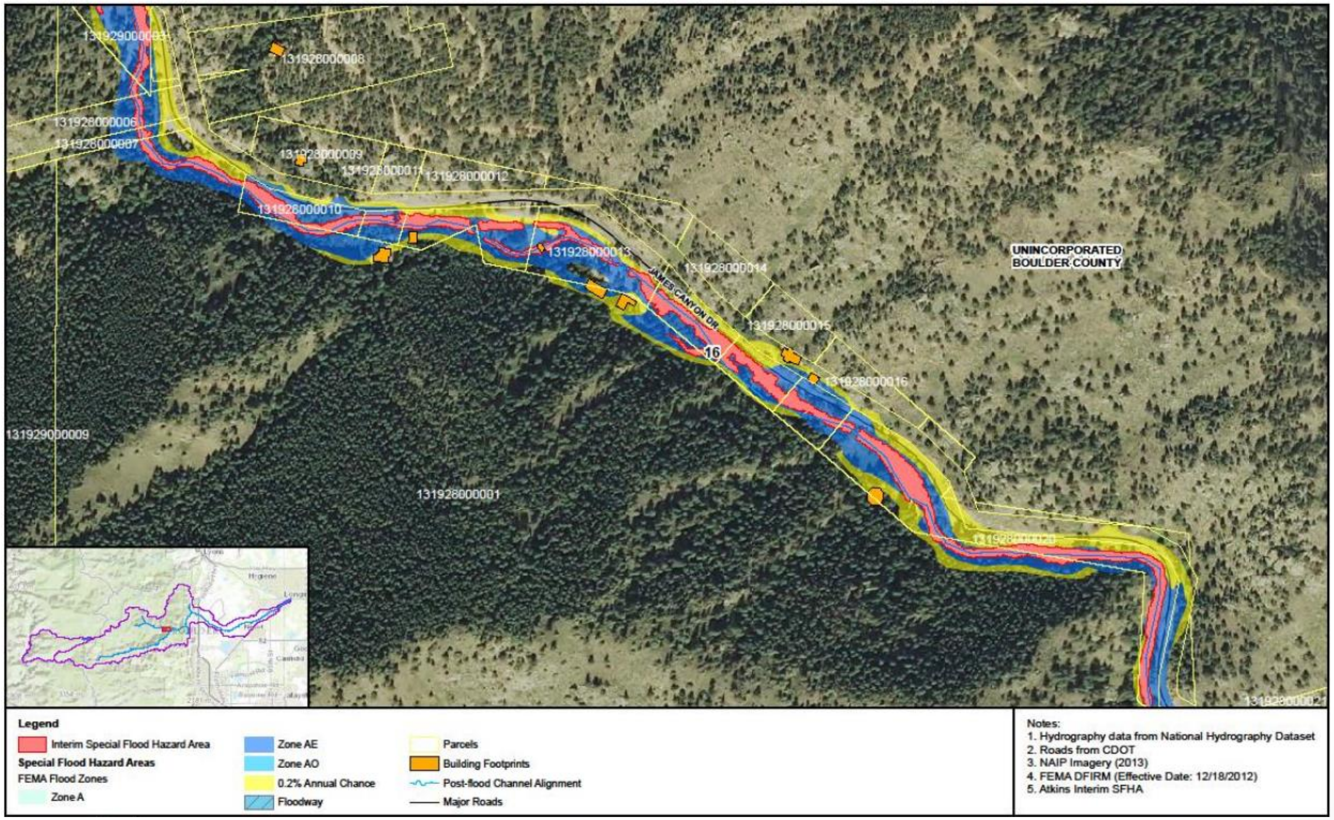


Process + Condition = Future Trajectory

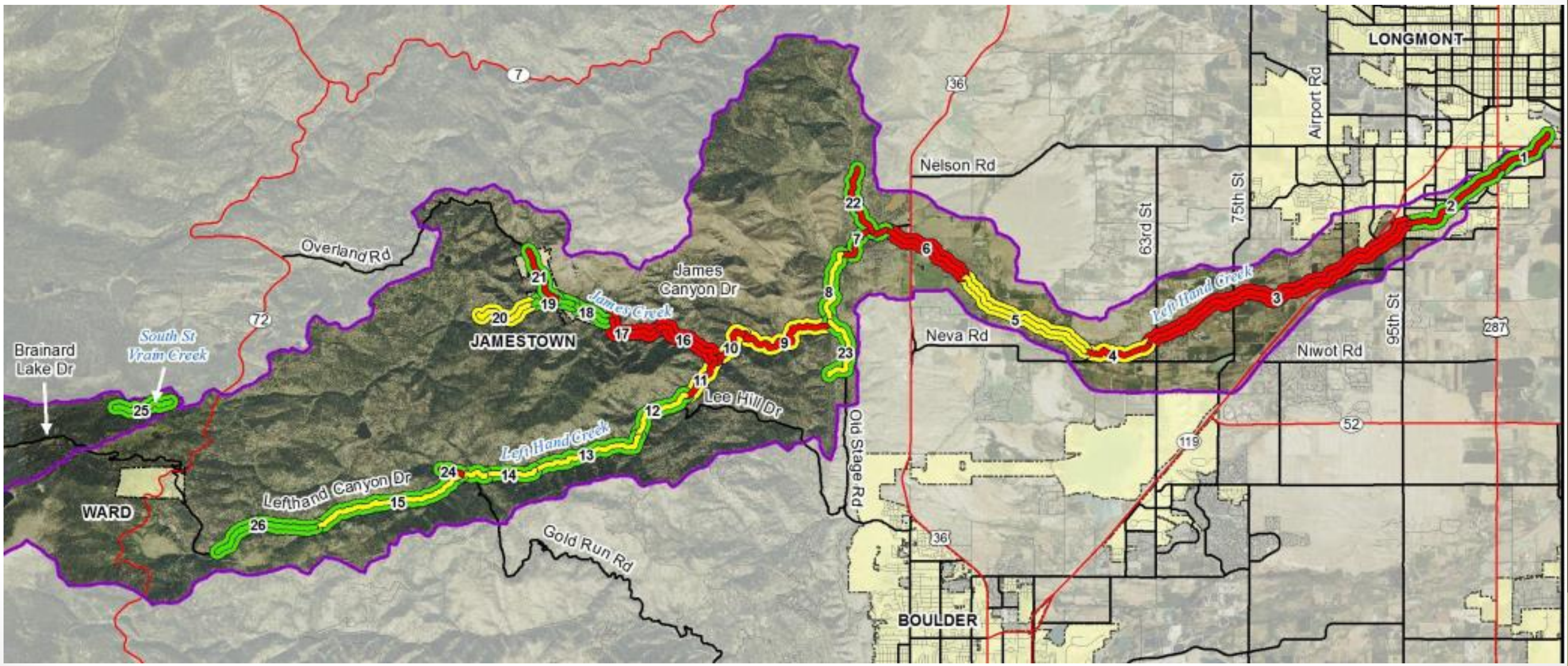
Risk = Trajectory + Vulnerable Infrastructure and Property

Geomorphic Risk

- Asset evaluation

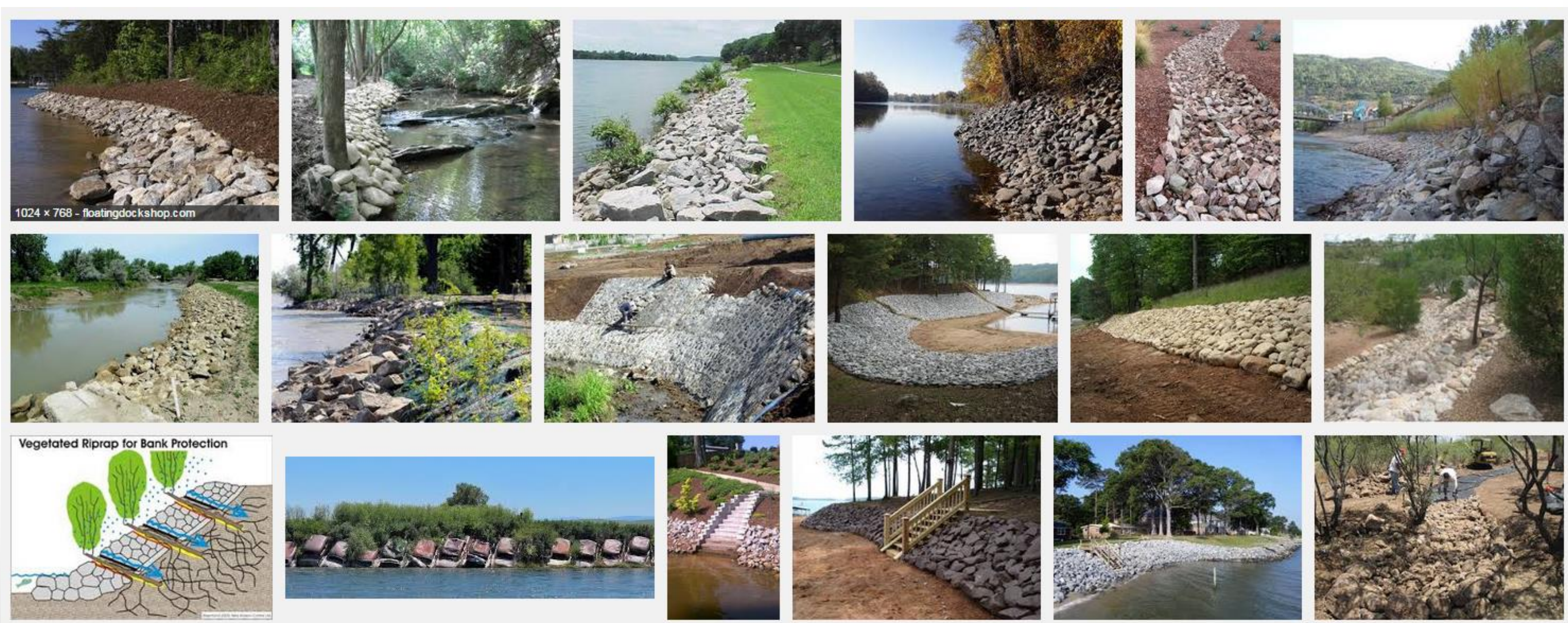


Geomorphic Risk



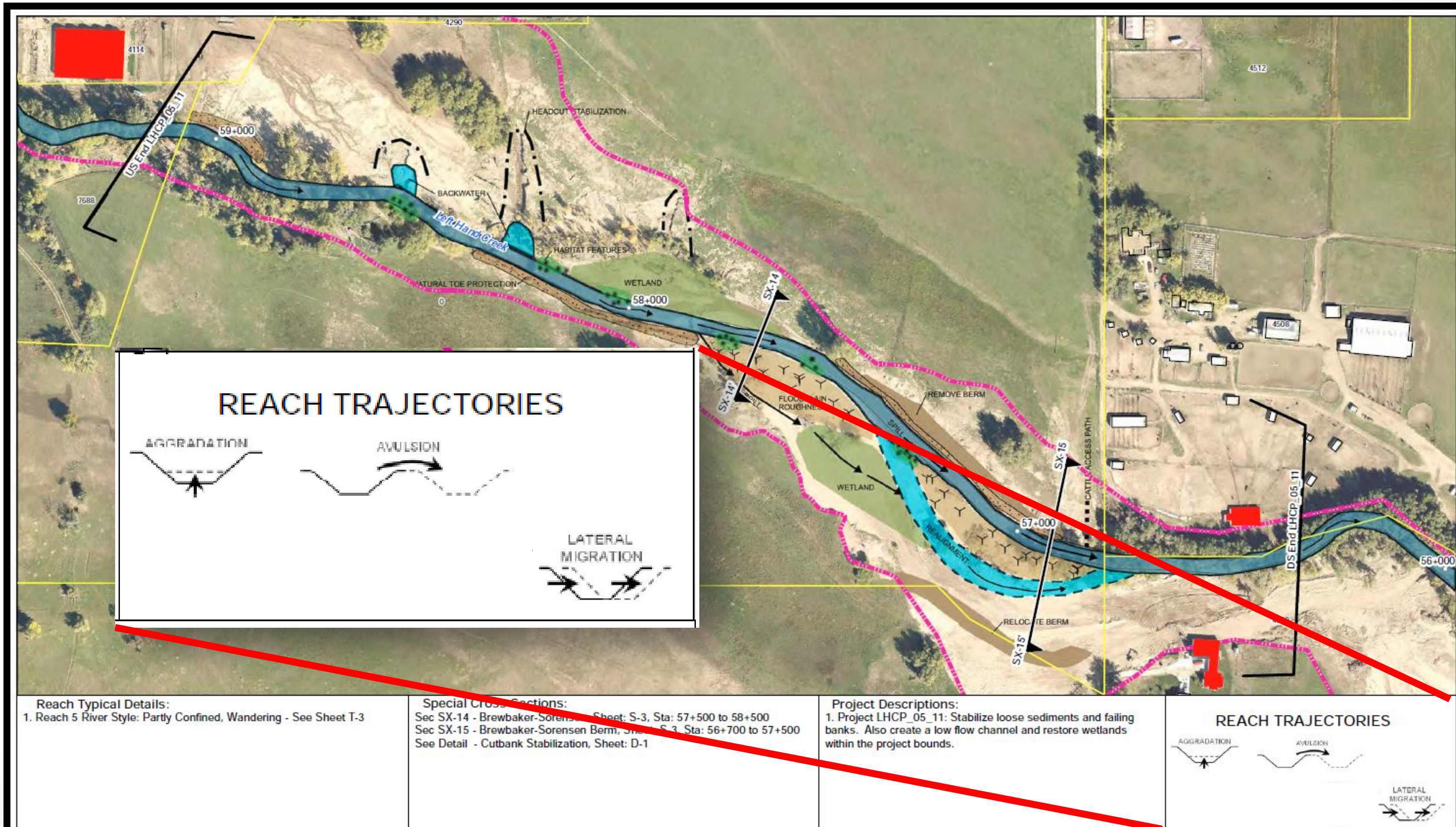
Geomorphic Risk

- So… no what?
  - What does this mean for planners and engineers?
  - How do they incorporate process-based geomorphic information into implementation projects?



Integrating Geomorphic Information

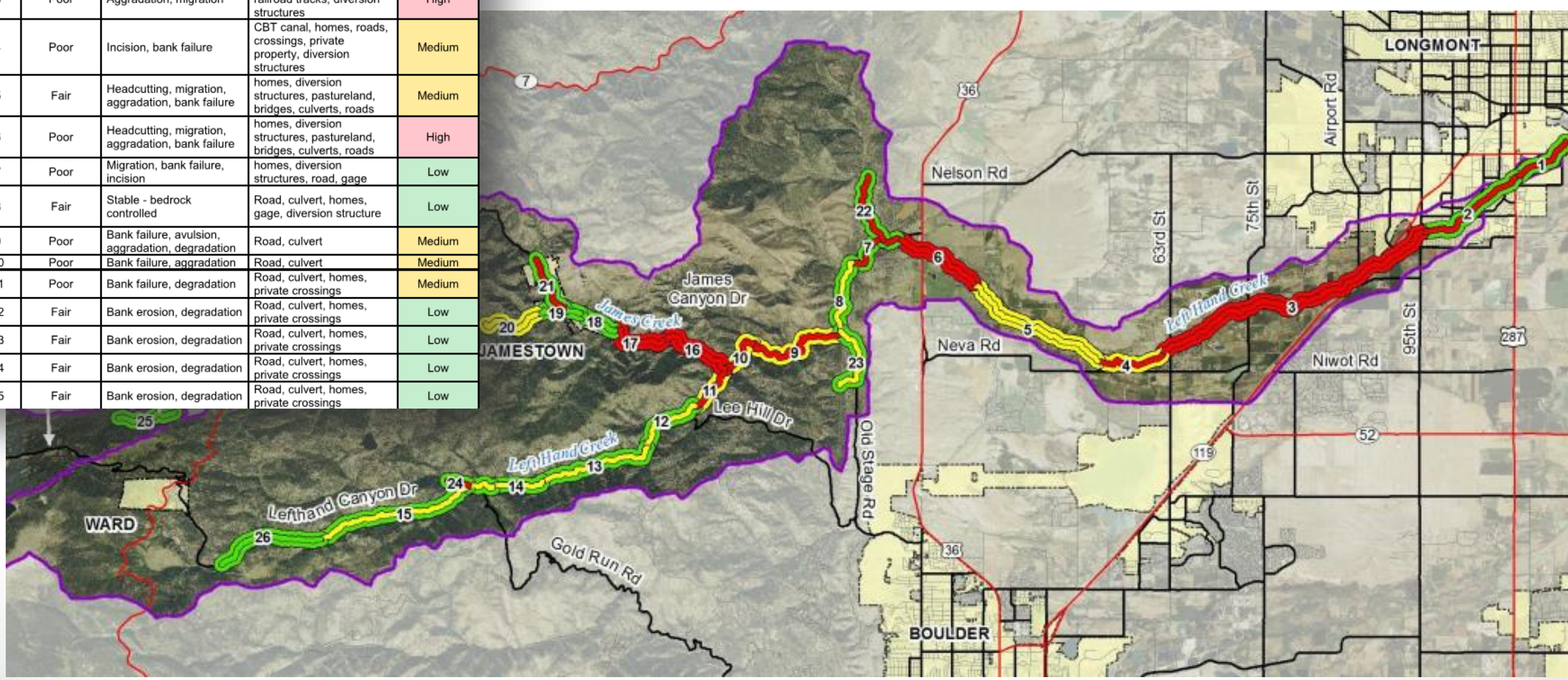
1. Background and Goals
2. Methods
3. **Geomorphic Risk**
4. Conclusions



4. Conclusions

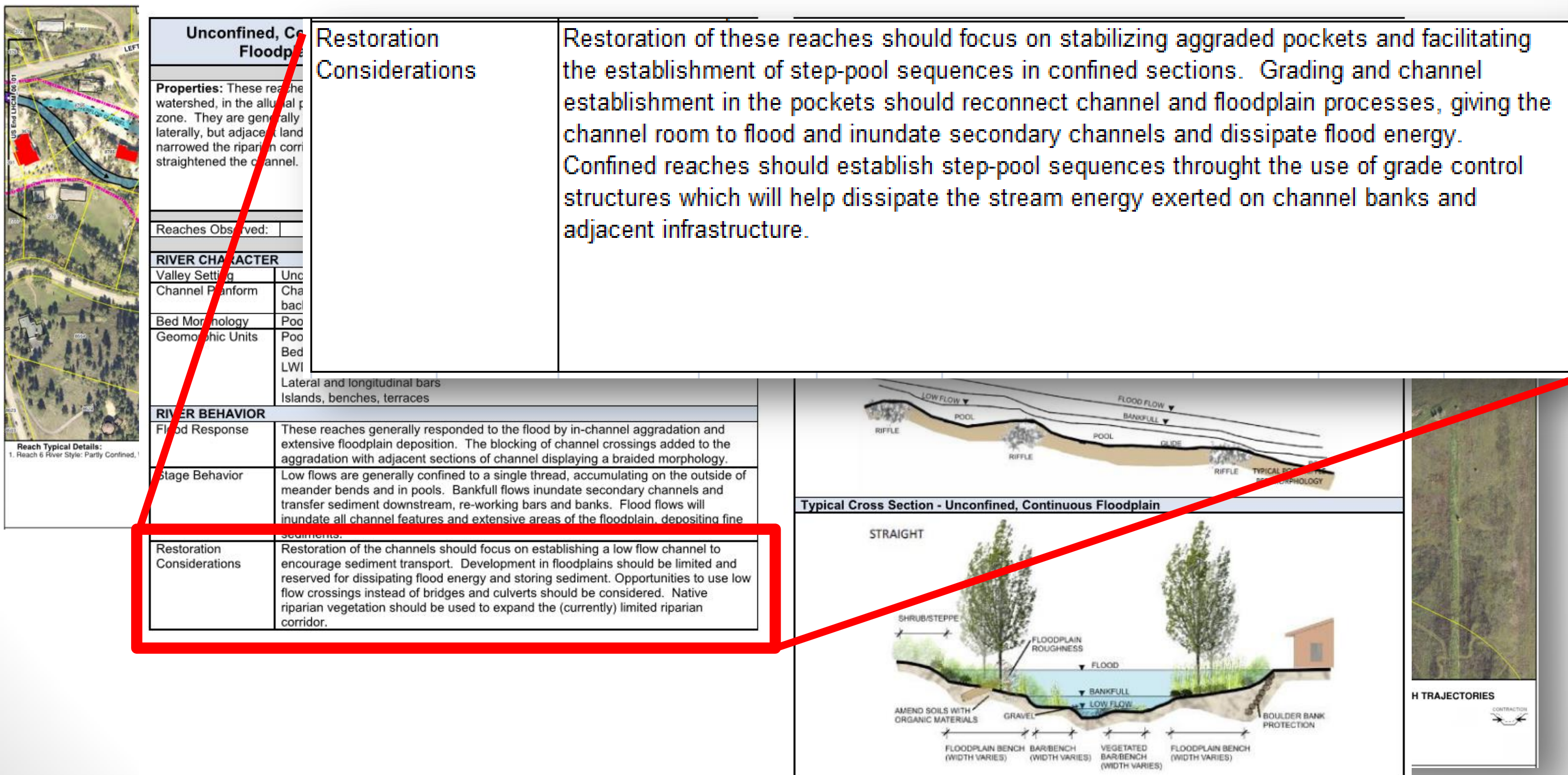
- Re-visiting the project goals:
  - We have a *working* understanding of geomorphic risk and the processes likely to be controlling the trajectory of the reach

	Reach	Geomorphic Condition	Trajectory	Vulnerabilities	Geomorphic Risk
PLAINS REACHES	1	Poor	Aggradation	Bridges	Low
	2	Poor	Aggradation	Homes, roads, bridges, businesses	Low
	3	Poor	Aggradation, migration	Bridges, homes, roads, railroad tracks, diversion structures	High
	4	Poor	Incision, bank failure	CBT canal, homes, roads, crossings, private property, diversion structures	Medium
	5	Fair	Headcutting, migration, aggradation, bank failure	homes, diversion structures, pastureland, bridges, culverts, roads	Medium
	6	Poor	Headcutting, migration, aggradation, bank failure	homes, diversion structures, pastureland, bridges, culverts, roads	High
MOUNTAIN REACHES	7	Poor	Migration, bank failure, incision	homes, diversion structures, road, gage	Low
	8	Fair	Stable - bedrock controlled	Road, culvert, homes, gage, diversion structure	Low
	9	Poor	Bank failure, avulsion, aggradation, degradation	Road, culvert	Medium
	10	Poor	Bank failure, aggradation	Road, culvert	Medium
	11	Poor	Bank failure, degradation	Road, culvert, homes, private crossings	Medium
	12	Fair	Bank erosion, degradation	Road, culvert, homes, private crossings	Low
	13	Fair	Bank erosion, degradation	Road, culvert, homes, private crossings	Low
	14	Fair	Bank erosion, degradation	Road, culvert, homes, private crossings	Low
	15	Fair	Bank erosion, degradation	Road, culvert, homes, private crossings	Low



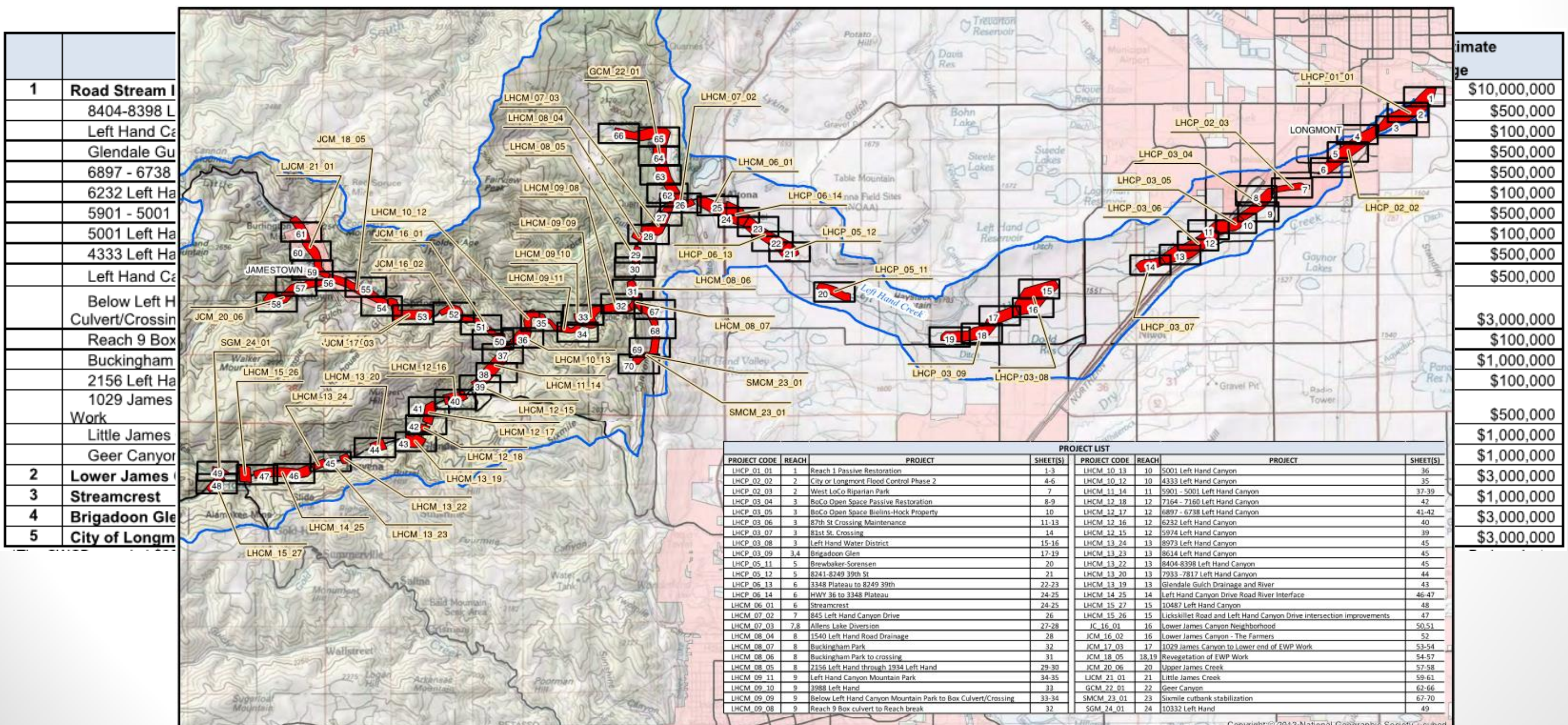
4. Conclusions

- Re-visiting the project goals:
  - Restoration recommendations for projects and any portion of the channel not covered by a project



4. Conclusions

- Re-visiting the project goals:
  - We have a basic scoping for ~50 individual projects covering ~27 miles of stream

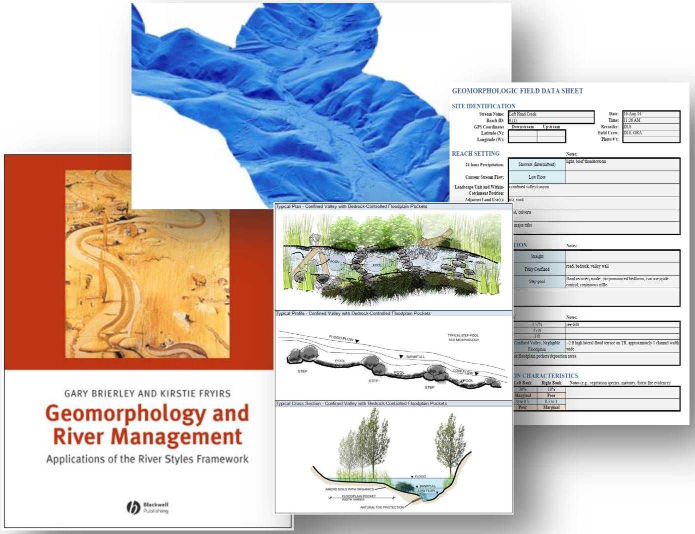


PROJECT LIST

PROJECT CODE	REACH	PROJECT	SHEET(S)	PROJECT CODE	REACH	PROJECT	SHEET(S)
LHCP_01_01	1	Reach 1 Passive Restoration	1-3	LHCM_10_13	10	5001 Left Hand Canyon	36
LHCP_02_02	2	City or Longmont Flood Control Phase 2	4-6	LHCM_10_12	10	4333 Left Hand Canyon	35
LHCP_02_03	2	West LoCo Riparian Park	7	LHCM_11_14	11	5901 - 5001 Left Hand Canyon	37-39
LHCP_03_04	3	BoCo Open Space Passive Restoration	8-9	LHCM_12_18	12	7164 - 7160 Left Hand Canyon	42
LHCP_03_05	3	BoCo Open Space Bielins-Hock Property	10	LHCM_12_17	12	6897 - 6738 Left Hand Canyon	41-42
LHCP_03_06	3	87th St Crossing Maintenance	11-13	LHCM_12_16	12	6232 Left Hand Canyon	40
LHCP_03_07	3	81st St. Crossing	14	LHCM_12_15	12	5974 Left Hand Canyon	39
LHCP_03_08	3	Left Hand Water District	15-16	LHCM_13_24	13	8973 Left Hand Canyon	45
LHCP_03_09	3,4	Brigadoon Glen	17-19	LHCM_13_23	13	8614 Left Hand Canyon	45
LHCP_05_11	5	Brewbaker-Sorensen	20	LHCM_13_22	13	8404-8398 Left Hand Canyon	45
LHCP_05_12	5	8241-8249 39th St	21	LHCM_13_20	13	7933 -7817 Left Hand Canyon	44
LHCP_06_13	6	3348 Plateau to 8249 39th	22-23	LHCM_13_19	13	Glendale Gulch Drainage and River	43
LHCP_06_14	6	HWY 36 to 3348 Plateau	24-25	LHCM_14_25	14	Left Hand Canyon Drive Road River Interface	46-47
LHCM_06_01	6	Streamcrest	24-25	LHCM_15_27	15	10487 Left Hand Canyon	48
LHCM_07_02	7	845 Left Hand Canyon Drive	26	LHCM_15_26	15	Lickskillet Road and Left Hand Canyon Drive intersection improvements	47
LHCM_07_03	7,8	Allens Lake Diversion	27-28	JC_16_01	16	Lower James Canyon Neighborhood	50,51
LHCM_08_04	8	1540 Left Hand Road Drainage	28	JCM_16_02	16	Lower James Canyon - The Farmers	52
LHCM_08_07	8	Buckingham Park	32	JCM_17_03	17	1029 James Canyon to Lower end of EWP Work	53-54
LHCM_08_06	8	Buckingham Park to crossing	31	JCM_18_05	18,19	Revegetation of EWP Work	54-57
LHCM_08_05	8	2156 Left Hand through 1934 Left Hand	29-30	JCM_20_06	20	Upper James Creek	57-58
LHCM_09_11	9	Left Hand Canyon Mountain Park	34-35	LJCM_21_01	21	Little James Creek	59-61
LHCM_09_10	9	3988 Left Hand	33	GCM_22_01	22	Geer Canyon	62-66
LHCM_09_09	9	Below Left Hand Canyon Mountain Park to Box Culvert/Crossing	33-34	SMCM_23_01	23	Sixmile cutbank stabilization	67-70
LHCM_09_08	9	Reach 9 Box culvert to Reach break	32	SGM_24_01	24	10332 Left Hand	49

In summary

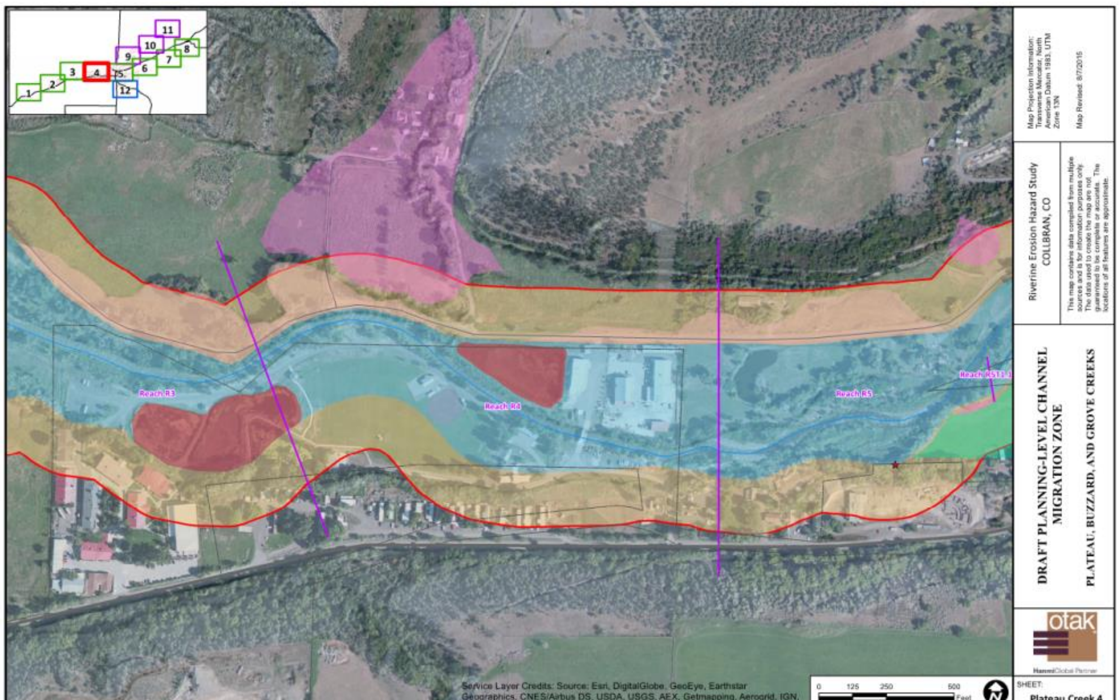
- Tools available for rapidly producing process-based geomorphic data sets
    1. Terrain
    2. Historic data sources
    3. Rapid field assessments
    4. Classification systems

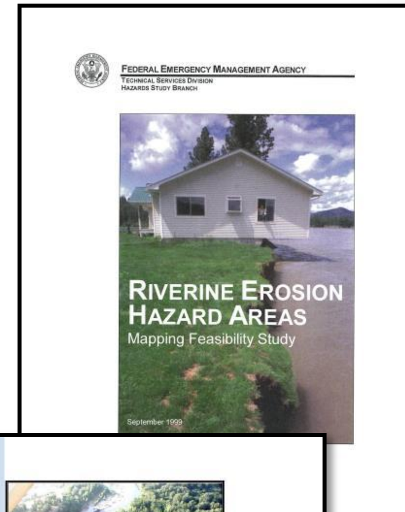


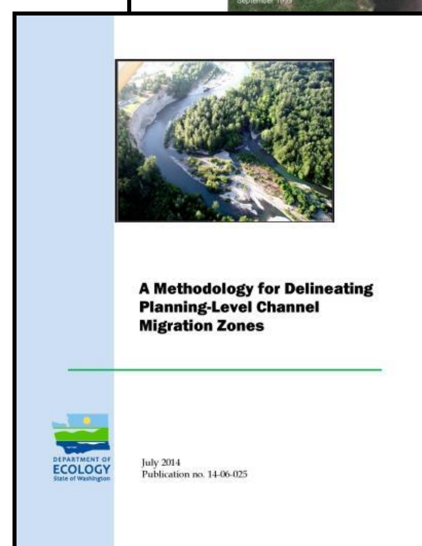
→ Customize the application to the project requirements

In summary

- Risk is probability and consequence, but probabilities are difficult to determine
- More appropriate tools







Questions?

- Thanks to the project team:
  - Graeme Aggett (Lynker Technologies)
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  - Tracy Emmanuel (Otak)
  - Ryan Golten (CDR)
  - Laura Sneeringer (CDR)

Lefthand Water Oversight Group

Lefthand Ditch Company

James Creek Watershed Initiative