

Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto



EUropean Congress on **REgional GEOscientific Cartography** and Information Systems Bologna | Italy june 12th - 15th 2012

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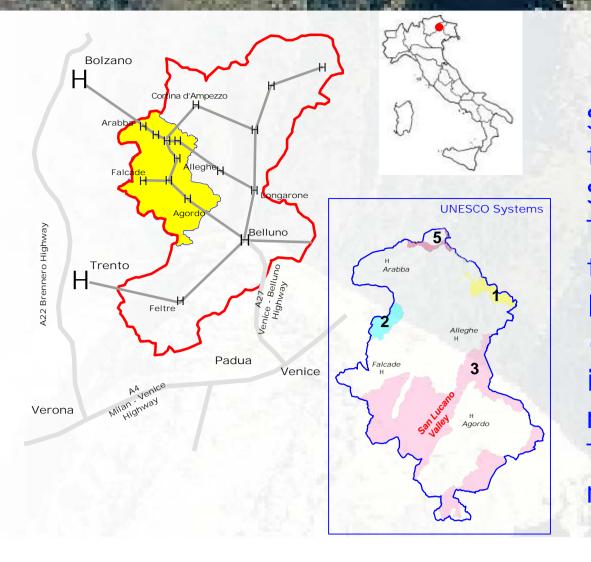
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INTRODUCTION

San Lucano Valley (Taibon, Belluno, Italy) is situated in the heart of the Agordine Dolomites, included in the UNESCO System n.3: Pale of San Martino - San Lucano-Belluno Dolomites (Fig. 1).

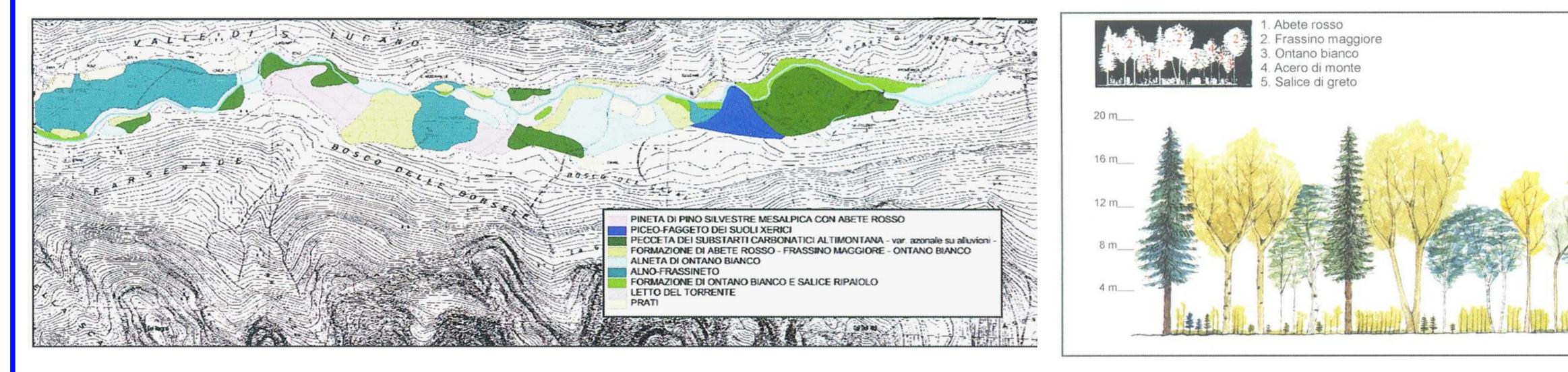
The valley is a prototype study area for a research project issued from the collaboration among the Dynamics of Environmental Processes Institute (IDPA-CNR-Milano), the Technical Mining Industry Institute (ITIM, Agordo), and the Agordina Mountain Community (CMA), also involving other qualified subjects for environmental and land management (ARPAV; Civil Engineering Treviso).

The project aims to verify the applicability of the methodology referred as Watershed Assessment of River Stability and Sediment

Supply (WARSSS - Rosgen, 2006) in the morphological and geological context of the Alps. The long-term perspective based on longer observations is three fold:

- monitoring trends in fluvial and geomorphic condition over time; expanding the investigation to the adjacent basins and define a "Dolomites physiographic region"

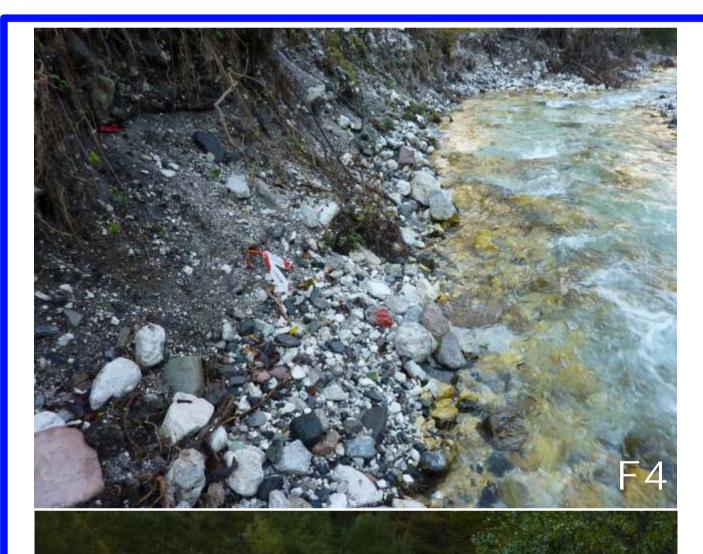
introducing the geomorphologic "Natural Channel Design" (NCD) approach in restoring fluvial mountain environment, without disregarding the natural environment quality preservation.



network

The San Lucano Valley is characterized by extensive riparian forests of high natural interest held by the Community directives. Alnus incana and Fraxinus excelsior dominate, followed by Mountain Maple and Spruce.

A) map types. B) Structure found in a formation. Since the disastrous flood of 1966, significant trees associations were differentiated along the creek and now deserve careful consideration and every possible attention to their stabilization until the next calamity.



ACTUAL NCD I N S. LUCANO VALLEY

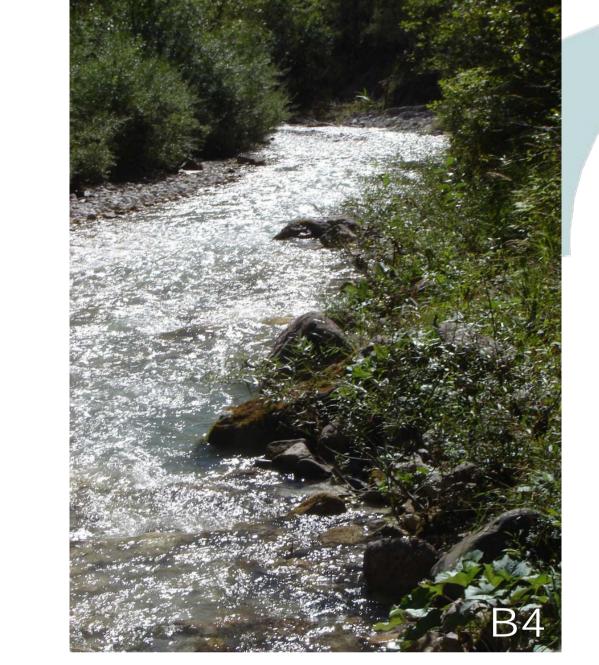
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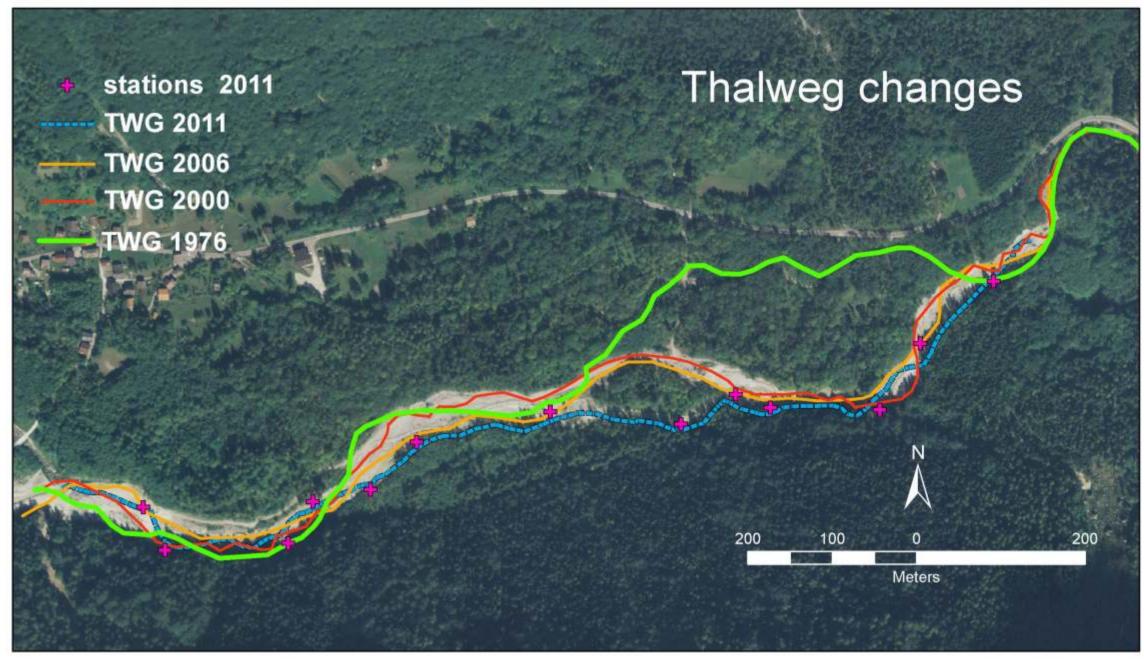
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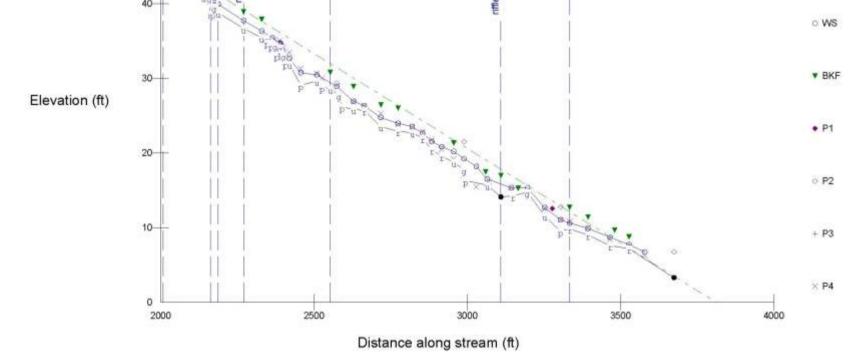
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Along the upper Tegnas, three segments of the stream with gradient ranging from 2.6% to 1.9%, are easily delimited: a first upstream disturbed reach (F4-type), a second stable (B4-type) reference reach (load transporting), and downwards, an aggraded reach (D4-type) flowing across a gravel deposit two hundred meters thick (Caielli et al. 2011). This area must periodically be quarried, in order to ensure the hydraulic protection of the sideway road, and a simple "V" shape, single channel, is mechanically rebuilt. Despite the good recovering ability shown by the riverside bush, the period elapsing between the removal activities is shorter than the natural process of re-naturalization. The recovered banks are quickly eroded, and the stream regress to a D4-type, becoming impracticable and completely unsuitable for spontaneous fish habitats and woods growth.

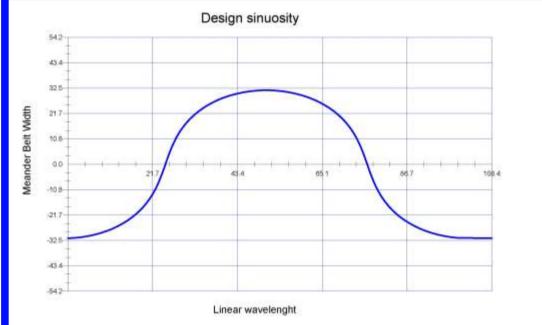


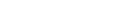


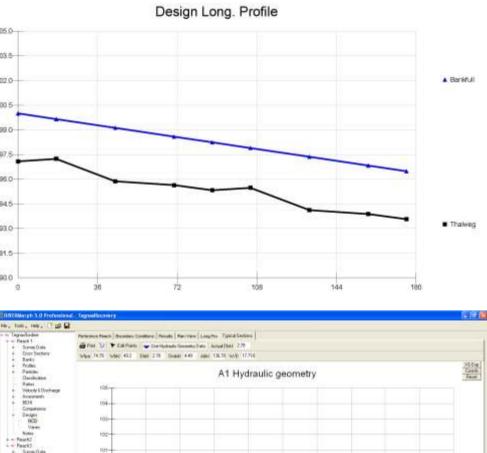




Longitudinal Profile Reference reach







METHODS

The basic principle for geomorphologic "Natural Channel Design (NCD) methodology, is that each natural undisturbed stream is shaped by both geomorphologic and climatic conditions into a physiographic region, then NCD requires surveys of several reference streams in order to understand their "stability" features: the measure of the proportion of a cross section of the bankfull stage is one of the key variables to quantify the morphology of the stream. Understanding the hydro-geometric correct ratios of a stable "reference reach", is the key to be able to design a new long-term stable channel, where you need to restore it.

This paper illustrates the results arising from detailed survey dataset collected in the valley bottom along the Tegnas River from year 2009 to 2011. A series of longitudinal profiles and cross sections, an extensive and diversified particle size analysis along the channel bed, can allow first to classify each reach type on the base of their hydraulics and geomorphologic parameters and then assign the real extent of the bankfull stage.

Bed particle size, width/depth ratio, entrenchment ratio and slope were calculated from field data in order to determine the stream classification as outlined by Rosgen (Rosgen, 1994). The bankfull slope was determined as the average height of bankfull and then used to calculate width, depth and area for each cross section at the bankfull stage.

The flow velocity at the bankfull stage was determined by using Manning's equation where the coefficient n was calculated using the estimation method from survey analysis of particle size (D84), with the approximations of roughness associated to Rosgen classification (Leopold 1994, Rosgen, 1996), and tabular information for different types of bed and banks material Stream classification itself does not attempt to predict the stability of the stream, the stability assessment procedure (in use for over twenty years in USA), documented in the EPA web document WARSSS (Rosgen, 2006), was applied to this case study.

orksheet 5-4. Morphological relations, including dimensionless ratios of river reach sites (Rosgen and Silvey, 200

1000	ream: Tegnas5ordine				_	Location: Reach - Reach3			
OŁ	bservers: Team3		Date:	08/29	/11	Valley Type: V Strea	m Type:	B 4	
		Rive	er Rea	ch Din	nens	sion Summary Data1			
Riffle Dimensions*.**. ***	Riffle Dimensions* *** ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	-	Min	Max
	Riffle Width (W _{bit})	32.8	32.8	32.8	ft	Riffle Cross-Sectional Area (Apid) (ft ²)	59.82	59.82	59.8
	Mean Riffle Depth (d _{bit})	1.83	1.83	1.83	ft	Riffle Width/Depth Ratio (W _{lot} / d _{lot})	17.90	17.90	17.9
	Maximum Riffle Depth (d _{max})	2.95	2.95	2.95	ft	Max Riffle Depth to Mean Riffle Depth (d_{nsc} / d_{Dr})	1.612	1.612	1.61
	Width of Flood-Prone Area (Wrpa)	49.5	49.6	49.6	ft	Entrenchment Ratio (Wrps / Wpsr)	1.514	1.514	1.51
	Riffle Inner Berm Width (Wp)	4.22	4.22	4.22	ft	Riffle Inner Berm Width to Riffle Width (Wb / Wbz)	0.096	0.096	0.09
	Riffle Inner Berm Depth (d _b)	0.21	0.21	0.21	ft	Riffle Inner Berm Depth to Mean Depth (d _{it} / d _{bid})	0.183	0.183	0.18
	Riffle Inner Berm Area (A _{io})	0.9	0.9	0.9	ft?	Riffle Inner Berm Area to Riffle Area (A ₆ / A _{0d})	0.018	0.018	0.01
	Riffle Inner Berm W/D Ratio (W _b / d _b)	19.8	19.8	19.8					2
	Pool Dimensions* *** ***	ol Dimensions* *** *** Mean Min Max Pool Dimensions & Dimensionless Ratios**						Min	Max
	Pool Width (W _{SHp})	48.6	48.6	48.6	ft	Pool Width to Riffle Width (Wpdg/ Wpd)		1.482	
:	Mean Pool Depth (d _{orp})	1.31	1.31	1.31	ft	Mean Pool Depth to Mean Riffle Depth (d _{bitp} / d _{bit})	0.716	0.716	0.71
-	Pool Cross-Sectional Area (A _{ptp})	63.5	63.5	63.5	ft.	Pool Area to Riffle Area (A _{toto} / A _{tot})	1.061	1.061	1.06
ions	Maximum Pool Depth (d _{map})	2.65	2.65	2.65	ft	Max Pool Depth to Mean Riffle Depth (dmap / dbid)	1.448	1.448	1.44
Dimensions*	Pool Inner Berm Width (W _{Ep})	19.6	19.6	19.6	ft.	Pool Inner Berm Width to Pool Width (Wip / Wistp)	0.403	0.403	0.40
Dir	Pool Inner Berm Depth (d _{to})	0.49	0.49	0.49	ft	Pool Inner Berm Depth to Pool Depth (dpp / dpirp)	0.374	0.374	0.374
Pool	Pool Inner Berm Area (App)	9.59	9.59	9.59	ft2	Pool Inner Berm Area to Pool Area (Aup / Aun)	0.151	0.151	0.15
	Point Bar Slope (Sco)	0.000		0.000	-	Pool Inner Berm Width/Depth Ratio (W _{to} / d _{to})	******		++++++++
_	,,			<u> </u>	-				
	Run Dimensions*	Mean 27.8	Min 27.8	Max 27.8	le.	Run Dimensionless Ratios**** Run Width to Riffle Width (Wpdr / Wpdr)	Mean 0.848	Min 0.848	Max 0.84
ons			-		-		-		
ansi	Mean Run Depth (d _{bin}) Run Cross-Sectional Area (A _{bin})	1.5	1.5	1.5	-	Mean Run Depth to Mean Riffle Depth (d _{outr} / d _{out})	-	0.820	-
Dime		41.8	41.8	41.8	-	Run Area to Riffle Area (A _{ost} , / A _{ost})	0.699	0.699	0.69
Ŭ.		0.00	0.00	0.00		Max Run Depth to Mean Riffle Depth (d _{main} / d _{bid})	4 404	4 404	4 40.
un Dimensions*	Maximum Run Depth (d _{max})	2.68	2.68	2.68	-	e entre entre	1.464	1.464	1.464
Run Dime		2.68 18.5	2.68 18.5	-	-	Contrast Contrast	1.464	1.464	1.464
	Maximum Run Depth (d _{max})	-	-	-	-	Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bidt} / d _{bidt})	18.5	18.5	18.5	ft		Mean		Max
Run	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bert} / d _{min}) Glide Dimensions*	18.5 Mean	18.5 Min	18.5 Max 25.3	ft ft	Glide Dimensions & Dimensionless Ratios****	Mean 0.773	Min	Max 0.77:
Run	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bith} / d _{bith}) Glide Dimensions* Glide Width (W _{bitp})	18.5 Mean 25.3	18.5 Min 25.3	18.5 Max 25.3 1.24	ft ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{old})	Mean 0.773 0.678	Min 0.773	Max 0.773
	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{berr} / d _{uidt}) Glide Dimensions* Glide Width (W _{berg}) Mean Glide Depth (d _{todg})	18.5 Mean 25.3 1.24	18.5 Min 25.3 1.24	18.5 Max 25.3 1.24	ft ft ft	Glide Dimensions & Dimensionless Ratios ^{exery} Glide Width to Riffle Width (W _{bitg} / W _{bit}) Mean Glide Depth to Mean Riffle Depth (d _{bitg} / d _{bit})	Mean 0.773 0.678 0.524	Min 0.773 0.678	Max 0.773 0.671 0.524
Dimensions*	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bith} / d _{bith}) Glide Dimensions* Glide Width (W _{bitp}) Mean Glide Depth (d _{bitp}) Glide Cross-Sectional Area (A _{bitp})	18.5 Mean 25.3 1.24 31.4	18.5 Min 25.3 1.24 31.4	18.5 Max 25.3 1.24 31.4	ft ft ft ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{bidg}) Mean Glide Depth to Mean Riffle Depth (d _{bidg} / d _{bid}) Glide Area to Riffle Area (A _{bidg} / A _{bid})	Mean 0.773 0.678 0.524 1.202	Min 0.773 0.678 0.524	Max 0.777 0.671 0.524 1.202
Dimensions*	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bith} / d _{bith}) Glide Dimensions* Glide Width (W _{bitp}) Mean Glide Depth (d _{bitg}) Glide Cross-Sectional Area (A _{tistp}) Maximum Glide Depth (d _{max})	18.5 Mean 25.3 1.24 31.4 2.2	18.5 Min 25.3 1.24 31.4 2.2	18.5 Max 25.3 1.24 31.4 2.2	ft ft ft ft/ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{bit}) Mean Glide Depth to Mean Riffle Depth (d _{bidg} / d _{bid}) Glide Area to Riffle Area (A _{bidg} / A _{bid}) Max Glide Depth to Mean Riffle Depth (d _{mag} / d _{bid})	Mean 0.773 0.678 0.524 1.202 #####	Min 0.773 0.678 0.524 1.202	Max 0.773 0.671 0.524 1.203
tensions* Run	Maximum Run Depth (d _{maxr}) Run Width/Depth Ratio (W _{berr} / d _{betr}) Glide Dimensions* Glide Width (W _{btrp}) Mean Glide Depth (d _{betrp}) Glide Cross-Sectional Area (A _{terrp}) Maximum Glide Depth (d _{maxp}) Glide Width/Depth Ratio (W _{betrp} / d _{betrp})	18.5 Mean 25.3 1.24 31.4 2.2 20.4	18.5 Min 25.3 1.24 31.4 2.2 20.4	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21	ft ft ft ft ft/ft ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bitg} / W _{bit}) Mean Glide Depth to Mean Riffle Depth (d _{bitg} / d _{bit}) Glide Area to Riffle Area (A _{bitg} / A _{bit}) Max Glide Depth to Mean Riffle Depth (d _{mag} / d _{bit}) Glide Inner Berm Width/Depth Ratio (W _{big} / d _{big})	Mean 0.773 0.678 0.524 1.202 ##### 0.246	Min 0.773 0.678 0.524 1.202	Max 0.773 0.671 0.524 1.203 ##### 0.246
Dimensions*	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bidt} / d _{bidt}) Glide Dimensions* Glide Width (W _{bidg}) Mean Glide Depth (d _{max}) Glide Cross-Sectional Area (A _{bidg}) Glide Cross-Sectional Area (A _{bidg}) Glide Width/Depth Ratio (W _{bidg} / d _{bidg}) Glide Inner Berm Width (W _{big})	18.5 Mean 25.3 1.24 31.4 2.2 20.4 6.21	18.5 Min 25.3 1.24 31.4 2.2 20.4 6.21	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21 0.24	ft ft ft ft ft ft ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{0.65} / W _{0.67}) Mean Glide Depth to Mean Riffle Depth (d _{0.65} / d _{0.67}) Glide Area to Riffle Area (A ₁₆₆₀ / A _{0.67}) Max Glide Depth to Mean Riffle Depth (d _{max} / d _{0.67}) Glide Inner Berm Width/Depth Ratio (W _{0.69} / d _{0.67}) Glide Inner Berm Width to Glide Width (W _{0.69} /W _{0.679})	Mean 0.773 0.678 0.524 1.202 ##### 0.246 0.194	Min 0.773 0.678 0.524 1.202 ##### 0.246	Max 0.777 0.671 0.524 1.202 ##### 0.244 0.194
Dimensions*	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bidt} / d _{bidt}) Glide Dimensions* Glide Width (W _{bidt}) Mean Glide Depth (d _{bidt}) Glide Cross-Sectional Area (A _{bidt}) Glide Width/Depth Ratio (W _{bidg} / d _{bidt}) Glide Inner Berm Width (W _{bidg}) Glide Inner Berm Depth (d _{bidg}) Glide Inner Berm Area (A _{bid})	18.5 Mean 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49	18.5 Min 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49	ft ft ft ft ft ft ft	Office Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{bid}) Mean Glide Depth to Mean Riffle Depth (d _{bidg} / d _{bid}) Glide Area to Riffle Area (A _{bidg} / A _{bid}) Max Glide Depth to Mean Riffle Depth (d _{mag} / d _{bid}) Glide Inner Berm Width/Depth Ratio (W _{bid} / d _{bid}) Glide Inner Berm Width to Glide Width (W _{bid} / d _{bid}) Glide Inner Berm Weith to Glide Depth (d _{bid} / d _{bid}) Glide Inner Berm Area to Glide Area (A _{bidg} / A _{bidg})	Mean 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048	Min 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048	Max 0.777 0.671 0.524 1.202 ##### 0.244 0.244 0.194
Dimensions*	Maximum Run Depth (d _{max}) Run Width/Depth Ratio (W _{bidt} / d _{bidt}) Glide Dimensions* Glide Width (W _{bidg}) Mean Glide Depth (d _{bidg}) Glide Cross-Sectional Area (A _{bidg}) Glide Cross-Sectional Area (A _{bidg}) Glide Cross-Sectional Area (A _{bidg}) Glide Undth/Depth Ratio (W _{bidg} / d _{bidg}) Glide Inner Berm Width (W _{big}) Glide Inner Berm Depth (d _{big}) Glide Inner Berm Area (A _{big}) Step Dimensions**	18.5 Mean 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Mean	18.5 Min 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Min	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Max	ft ft ft ft ft ft ft ft ft ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{bid}) Mean Glide Depth to Mean Riffle Depth (d _{bidg} / d _{bid}) Glide Area to Riffle Area (A _{bidg} / A _{bid}) Max Glide Depth to Mean Riffle Depth (d _{riftle} / d _{bid}) Glide Inner Berm Width/Depth Ratio (W _{bidg} / d _{bid}) Glide Inner Berm Width to Glide Width (W _{bidg} / d _{bid}) Glide Inner Berm Width to Glide Depth (d _{bid} / d _{bid}) Glide Inner Berm Area to Glide Area (A _{bidg} / A _{bidg}) Glide Inner Berm Area to Glide Area (A _{bidg} / A _{bidg}) Step Dimensionless Ratios****	Mean 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Mean	Min 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Min	Max 0.773 0.671 0.524 1.203 1.
Glide Dimensions* [Run	Maximum Run Depth (d _{maxt}) Run Width/Depth Ratio (W _{bith} / d _{bith}) Glide Dimensions* Glide Width (W _{bitp}) Mean Glide Depth (d _{bitp}) Glide Cross-Sectional Area (A _{tartp}) Glide Width/Depth Ratio (W _{bitp} / d _{bitp}) Glide Cross-Sectional Area (A _{tartp}) Glide Width/Depth Ratio (W _{bitp} / d _{bitp}) Glide Inner Berm Width (W _{tap}) Glide Inner Berm Depth (d _{bip}) Glide Inner Berm Area (A _{tap}) Step Dimensions** Step Width (W _{bidb})	18.5 Mean 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Mean 47.8	18.5 Min 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Min 47.8	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Max 47.8	11 11 11 11 11 11 11 11 11 11 11 11 11	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{bid}) Mean Glide Depth to Mean Riffle Depth (d _{bidg} / d _{bid}) Glide Area to Riffle Area (A _{bidg} / A _{bid}) Max Glide Depth to Mean Riffle Depth (d _{midg} / d _{bid}) Glide Inner Berm Width/Depth Ratio (W _{big} / d _{bid}) Glide Inner Berm Width/Depth Ratio (W _{big} / d _{bid}) Glide Inner Berm Width to Glide Depth (d _{bidg} / d _{bidg}) Glide Inner Berm Area to Glide Area (A _{bidg} / d _{bidg}) Glide Inner Berm Area to Glide Area (A _{bidg} / d _{bidg}) Step Dimensionless Ratios**** Step Width to Riffle Width (W _{bidfl} / W _{bidfl})	Mean 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Mean 1.459	Min 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Min 1.459	Max 0.773 0.671 0.524 1.203 1.
Glide Dimensions* [Run	Maximum Run Depth (d _{maxr}) Run Width/Depth Ratio (W _{bidt} / d _{bidt}) Glide Dimensions* Glide Width (W _{bidg}) Mean Glide Depth (d _{max}) Glide Cross-Sectional Area (A _{bidg}) Glide Cross-Sectional Area (A _{bidg}) Glide Cross-Sectional Area (A _{bidg}) Glide Undth/Depth Ratio (W _{bidg} / d _{bidg}) Glide Inner Berm Width (W _{bidg}) Glide Inner Berm Area (A _{big}) Glide Inner Berm Area (A _{big}) Step Dimensions** Step Width (W _{bidg}) Mean Step Depth (d _{bidg})	18.5 Mean 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Mean 47.8 1.48	18.5 Min 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Min 47.8 1.48	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Max 47.8 1.48	ft ft ft ft ft ft ft ft ft ft	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bitg} / W _{bit}) Mean Glide Depth to Mean Riffle Depth (d _{mitg} / d _{bit}) Glide Area to Riffle Area (A _{bitg} / A _{bit}) Max Glide Depth to Mean Riffle Depth (d _{mitg} / d _{bit}) Glide Inner Berm Width/Depth Ratio (W _{hig} / d _{bit}) Glide Inner Berm Width/Depth Ratio (W _{hig} / d _{bit}) Glide Inner Berm Width to Glide Depth (d _{bit} / d _{bit}) Glide Inner Berm Depth to Glide Depth (d _{bit} / d _{bit}) Glide Inner Berm Area to Glide Area (A _{bit} / A _{bitg}) Glide Inner Berm Area to Glide Area (A _{bit} / A _{bitg}) Step Dimensionless Ratios**** Step Width to Riffle Width (W _{bitfl} / W _{bit}) Mean Step Depth to Riffle Depth (d _{bitfl} / d _{bit})	Mean 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Mean 1.459 0.809	Min 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Min 1.459 0.809	Max 0,77: 0,671 0,524 1,202 ##### 0,244 0,194 0,194 0,044 Nax 1,455 0,801
Dimensions*	Maximum Run Depth (d _{maxt}) Run Width/Depth Ratio (W _{bith} / d _{bith}) Glide Dimensions* Glide Width (W _{bitp}) Mean Glide Depth (d _{bitp}) Glide Cross-Sectional Area (A _{tartp}) Glide Width/Depth Ratio (W _{bitp} / d _{bitp}) Glide Cross-Sectional Area (A _{tartp}) Glide Width/Depth Ratio (W _{bitp} / d _{bitp}) Glide Inner Berm Width (W _{tap}) Glide Inner Berm Depth (d _{bip}) Glide Inner Berm Area (A _{tap}) Step Dimensions** Step Width (W _{bidb})	18.5 Mean 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Mean 47.8	18.5 Min 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Min 47.8	18.5 Max 25.3 1.24 31.4 2.2 20.4 6.21 0.24 1.49 Max 47.8	ft ft ft ft ft ft ft ft ft ft ft ft ft f	Glide Dimensions & Dimensionless Ratios**** Glide Width to Riffle Width (W _{bidg} / W _{bid}) Mean Glide Depth to Mean Riffle Depth (d _{bidg} / d _{bid}) Glide Area to Riffle Area (A _{bidg} / A _{bid}) Max Glide Depth to Mean Riffle Depth (d _{midg} / d _{bid}) Glide Inner Berm Width/Depth Ratio (W _{big} / d _{bid}) Glide Inner Berm Width/Depth Ratio (W _{big} / d _{bid}) Glide Inner Berm Width to Glide Depth (d _{bidg} / d _{bidg}) Glide Inner Berm Area to Glide Area (A _{bidg} / d _{bidg}) Glide Inner Berm Area to Glide Area (A _{bidg} / d _{bidg}) Step Dimensionless Ratios**** Step Width to Riffle Width (W _{bidfl} / W _{bidfl})	Mean 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.246 0.194 0.048 Mean 1.459 0.809 1.182	Min 0.773 0.678 0.524 1.202 ##### 0.246 0.194 0.048 Min 1.459	Max 0,777 0,671 0,524 1,202 1,

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-	eam: Tegnas5ordine					55520	ocation: Re	ach - Re	ach3					
Ob	servers: Team3				08/29			/alley Type:	V		Stream	m Type:	B4	_
2	River Reach Summary Data2													
Hydraulics	Streamflow: Estimated Mean Velocity at Bankfull Stage (update) 7.906 ft/sec Estimation Method								3					
Ě	Streamflow: Estimated Discharge at Bankfull Stage ($Q_{tot})$					458.62	27 cfs	Drain	nage Area	a	8	.7	mi ²	
	Geometry	Min	in Max Dimensionless Geometry Ratios								Mean	Min	Max	
٦	Linear Wavelength (λ)	Mean 91	87	T. COLORADO								2.778		-
	Stream Meander Length (Ln)	82	50	115	ft	Stream	Meander Le	ength Rati	o (L _n /	W _{or})		2.503	1.526	3.51
ern.	Radius of Curvature (R _c)	55	18	118	ft	Radius	of Curvatur	e to Riffle	Width	(R _c /W _{ck}	ð	1.679	0.549	3.60
Pattern	Belt Width (W _{tit})	72	33	128	ft	Meander Width Ratio (W _{bit} / W _{bit})						2.198	1.007	3.90
Inel	Arc Length (L ₂)	25	89	ft Arc Length to Riffle Width (L _a / W _{att})							2.106	0.763	2.71	
Channel	Riffle Length (L,)	file Length (L,) 131 80.9 193 ft Riffle Length to Riffle Width (L,/W _{ind})							4.012	2.469	5.87			
	Individual Pool Length (Lp)	57.4	15.9	88	ft	Individu	al Pool Len	1.753	0.484	2.68				
	Pool to Pool Spacing (Ps)	186	111	298	n	Pool to Pool Spacing to Riffle Width (P1/Wbir)					ut)	5.662	3.375	9.05
										-	1			
		0325	ft/ft	-	-		e Slope (S)		.025	ft/ft	Sinuosity (1.2
	Stream Length (SL)	0	ft	Valley	ey Length (VL) 0 ft Sin						Sinuosity (a second d	
	Low Bank Height star (LBH) end		ft ft		Max De (d _{max})	1.00							start end	
	Facet Slopes	Mean	-	The second s			Dimensionless Facet Slope Ratios						Min	Ma
	Riffle Slope (Srit)	and the second s	0.020	-	-	Riffle Slope to Average Water Surface Slope (S _{rt} / S)						0.880		-
Profile	Run Slope (S _{run})	- Contractor	0.031	-	-	-		e to Average Water Surface Slope (S _{run} / S)					1.240	
	Pool Slope (Sp)		0.002		-	Pool Slope to Average Water Surface Slope (Sp / S)						0.460		0.84
Channel	Glide Slope (Sg)	0.011	0.003	0.019	ft/ft	Glide Sl	lope to Aver	rage Wate	r Surfa	ice Slope	(S _g /S)	0.444	0.105	0.74
Cha	Step Slope (S ₆)	0.000	0.000	0.000	ft/ft	Step Slope to Average Water Surface Slope (S ₅ / S)						0.000	0.000	0.00
	Max Depths ^a	Mean	-	Max			Dimensionless Depth Ratios						Min	Ma
	Max Riffle Depth (d _{mart})	2.51	1.17	3.5	-	Max Riffle Depth to Mean Riffle Depth (d _{maxit} / d _{ott})						1.37	0.639	
- 1	Max Run Depth (d _{manun})	3.38	2.83		-	Max Run Depth to Mean Riffle Depth (d _{menun} / d _{bit})						1.85	1.546	2.3
	Max Pool Depth (d _{map})	3.86	2.94	4 5.18 ft Max Pool Depth to Mean Riffle Depth (d _{map} / d _{tit})						/ d _{tet})	2.11	1.607	-	
	Max Glide Depth (dmag)	2.19	0.86	3.46	ft	Max Glin	de Depth to	Mean Rif	fle Dep	ith (d _{masp}	/ d _{tist})	1.2	0.47	1.8
	Max Step Depth (d _{ener})	2.13	1.05	3.53	ft	Max Ste	ep Depth to	Mean Riff	le Depl	th (d _{mass} /	(d _{tist})	1.16	0.574	1.9
	Re	each ^b	Rif	ffle ^c		Bar		Reach ^b	F	Riffle ^c	Bar	Protru	usion He	eight
0	% Silt/Clay 5	5.56				0	D ₁₀	15.43			0	8		mm
eria	% Sand	0			20.69		D _{D5}	31.25			6.21			mm
Mat	% Gravel 61	1.11			66	6.01	D _{S0}	49.75			11.64			mm
Inel	% Cobble 18	9.44			1	3.3	D _{B4}	227.11	1		46.06	18	3	mm
Channel Materials	% Boulder 13	3.89				0	Dies	340.82	133.17					mm
0	% Bedrock	0			1	0	Dim	D ₁₀₀ 511.99			205	1		mm



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RESULTS AND CONCLUSIONS

Comparing low-flow discharge data with local precipitations time series, and relating them with some surrounding watershed discharges, we can assume that the bankfull flow magnitude calculated for the stream is a realistic value. Then, without specific curves for alpine region, we can adopt the empirical Rosgen Colorado dataset and their relationships to evaluate several design solutions when you plan to restore natural channels (Rosgen, 2007) with a geomorphologic approach.

Decreasing sediment supply, also coming from side headwaters, and resettle a more confined C4 instead of D4-type, may be a useful approach for restoring plans in order to improve riverbed re-naturalization and natural quality, in a next future. Illustrated here are some suggestions to control the erosion-transport-deposition process with longlived, natural solutions, in order to stabilize the stream riverbed and their banks. In compliance with one of the highest environmental value areas of the Dolomite region, authors believe that an effort to make a stable and controlled balance between erosion and deposition is a good way to preserve the greatest heritage of the man/nature equilibrium.

2006 D4-type existing channel 2012 C4-type channel C4 Flooding 2006 100 50

Hypothetical Recovery Design

2000 channel restoration

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