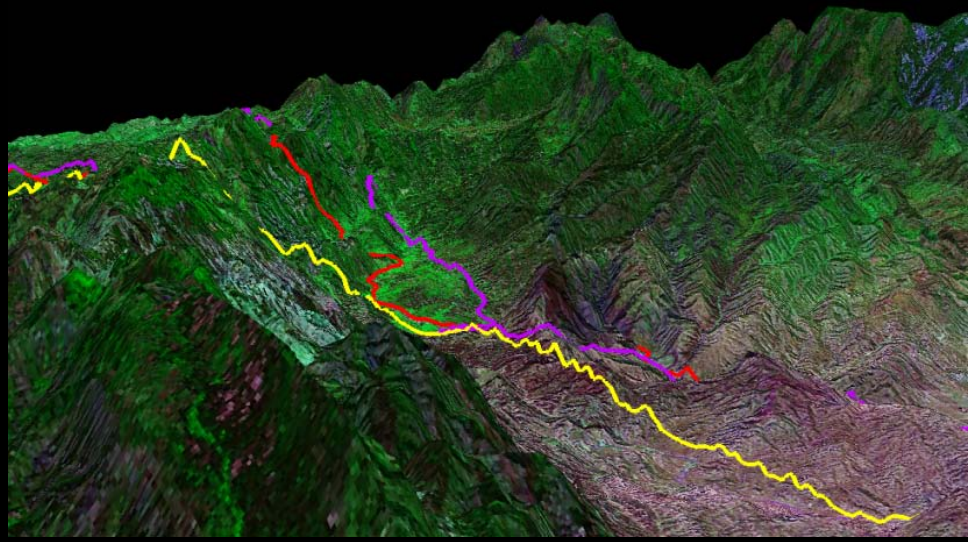
Geographical Information Systems Pipeline Route Optimization (GISPRO)

A qualitative approach to pipeline scoping



Geoff Price

Pipeline Routing Forum
November 4, 2009

Overview

- GIS Data overview
- GIPRO Routing and Costing Models
- Benchmarking GISPRO
- Scenario walk through
- Comparing GISPRO outputs
- LandPipe inputs/outputs

GISPRO…

…enables timely cost estimates for early phase pipeline opportunities based on optimal routing anywhere in the world.

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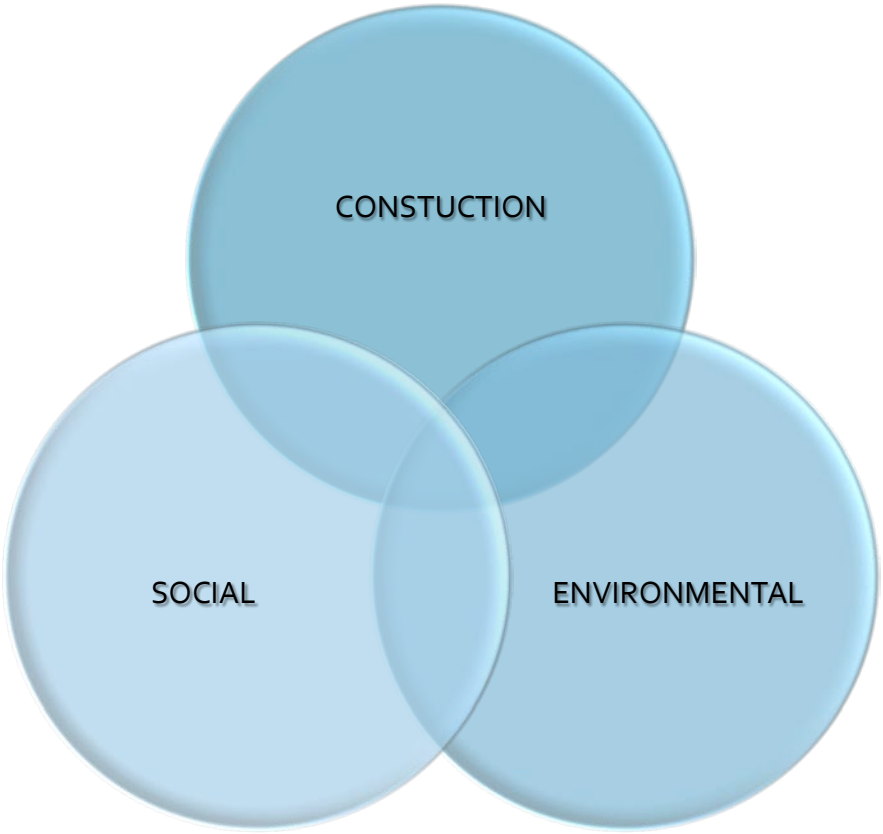
Balancing Costs



Pipeline Routing Business Rules

- Avoid steep slopes
- Minimize crossings
- Avoid environmentally sensitive areas
- Maximize use of existing corridors

GIS Data

- Digitized from existing maps
  - USGS Topo
- Survey or GPS
  - As-Built
  - TeleAtlas/Google Maps
- Remote Sensing
  - Spaceborne
    - SRTM
    - LandSat
  - Airborne
    - DOQQ
    - LiDAR

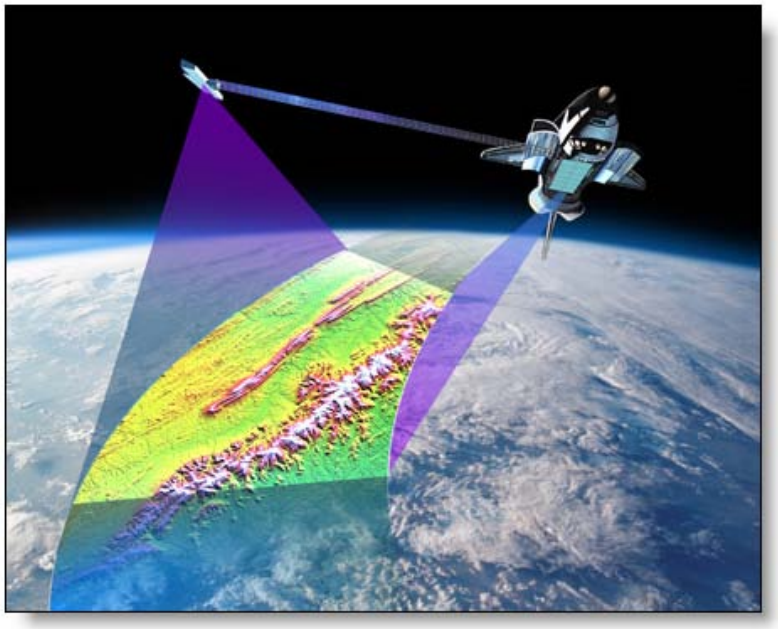
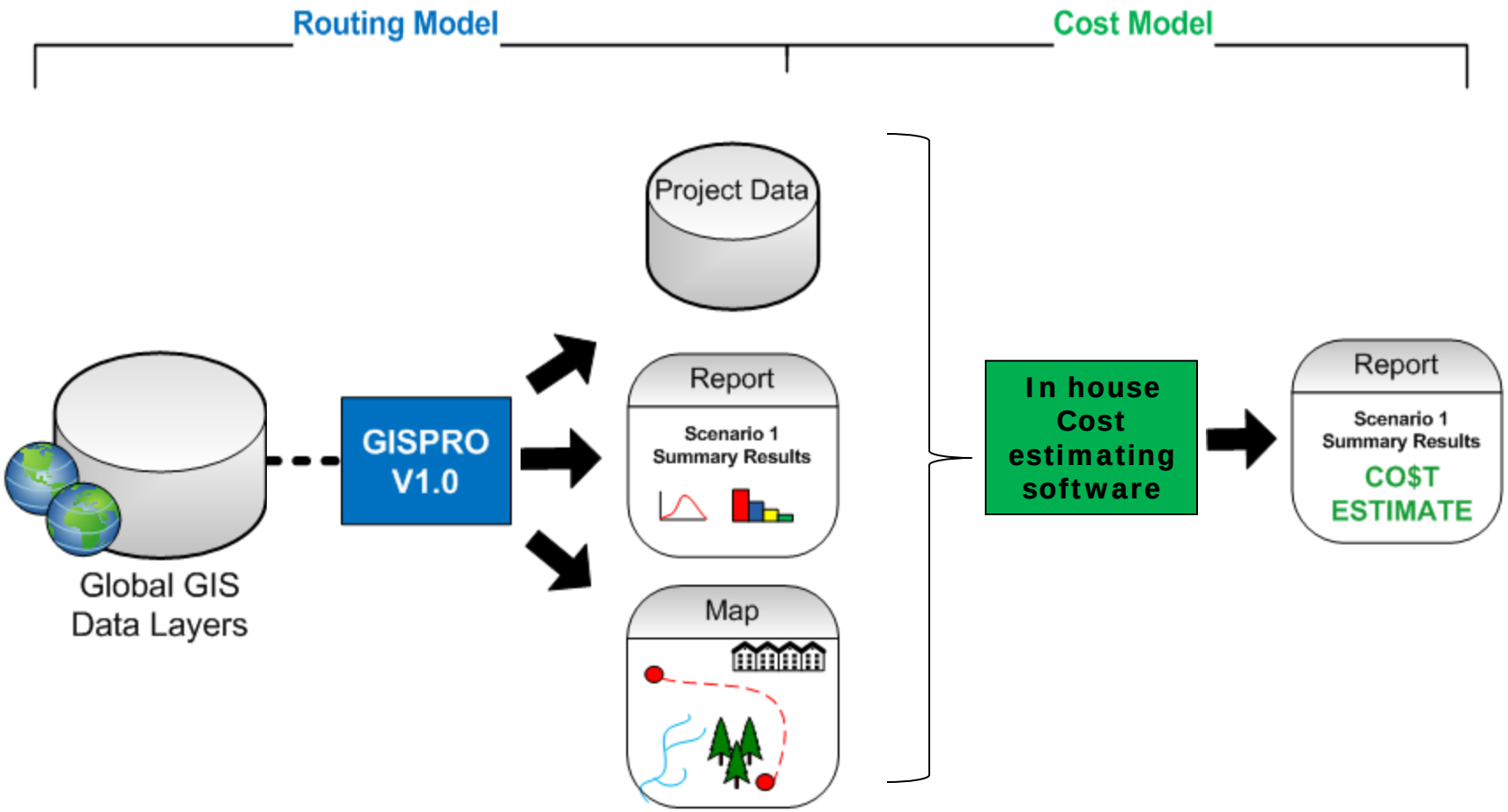
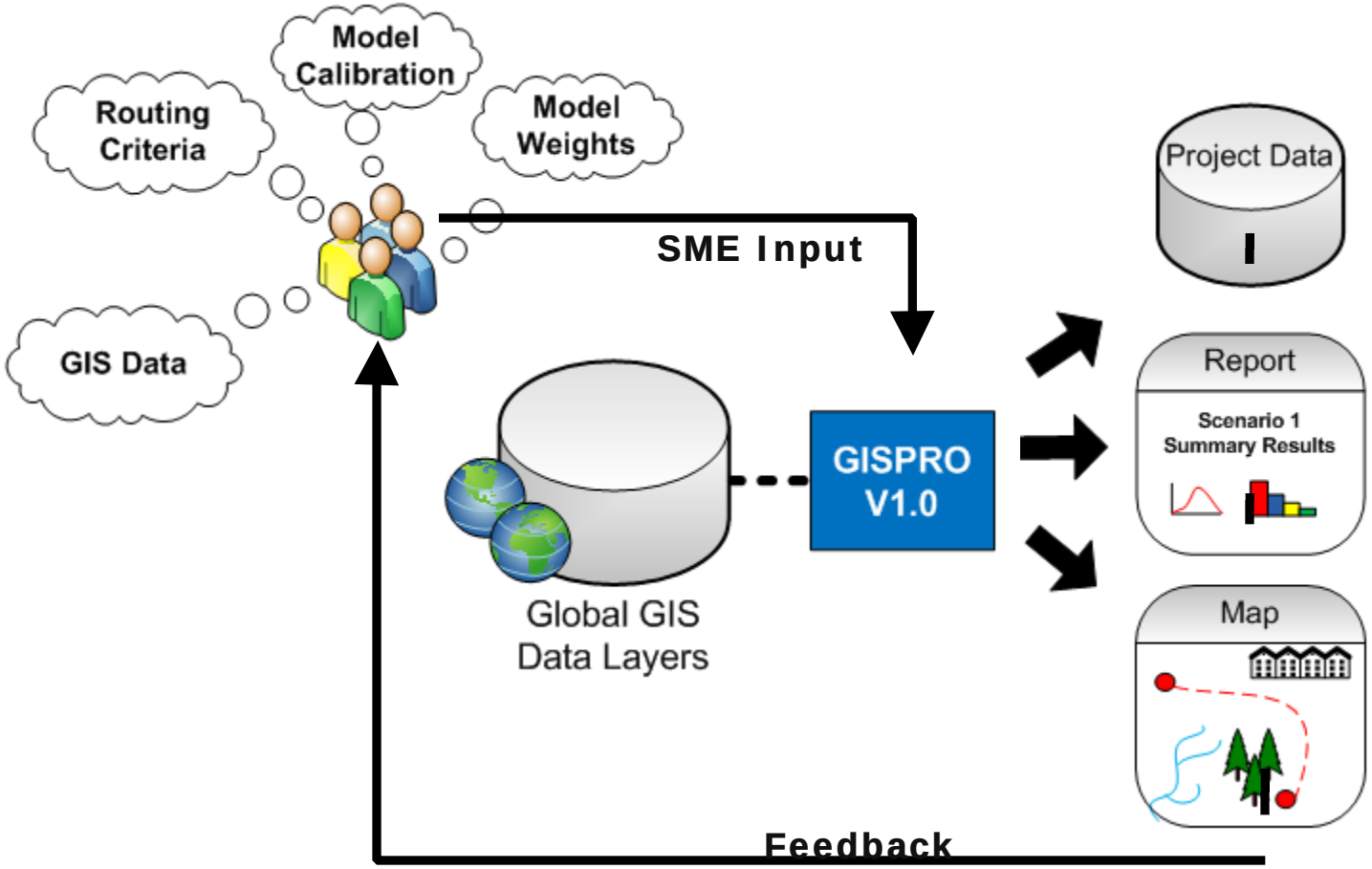


Image courtesy of The Boeing Company

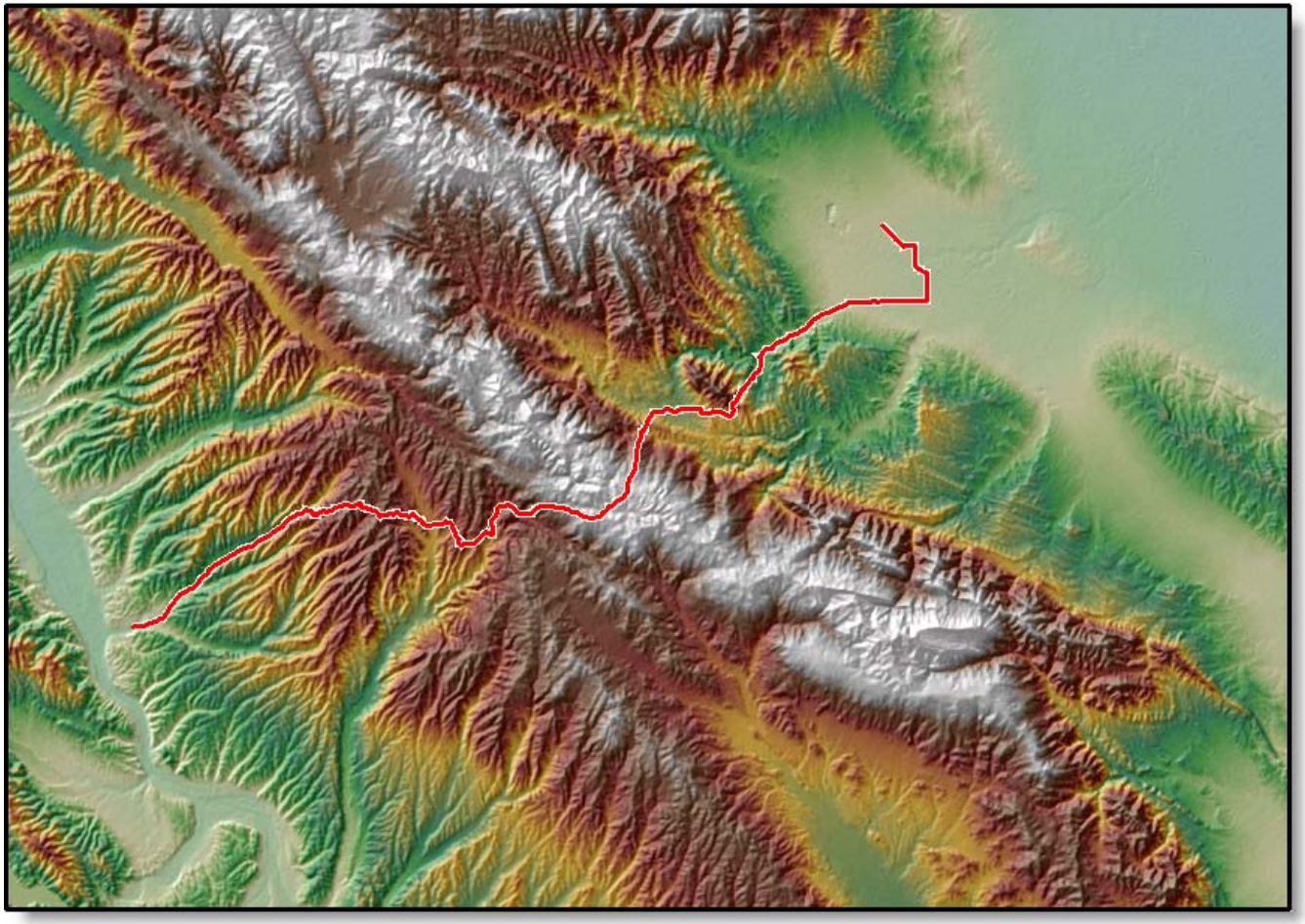
Routing & Cost Models



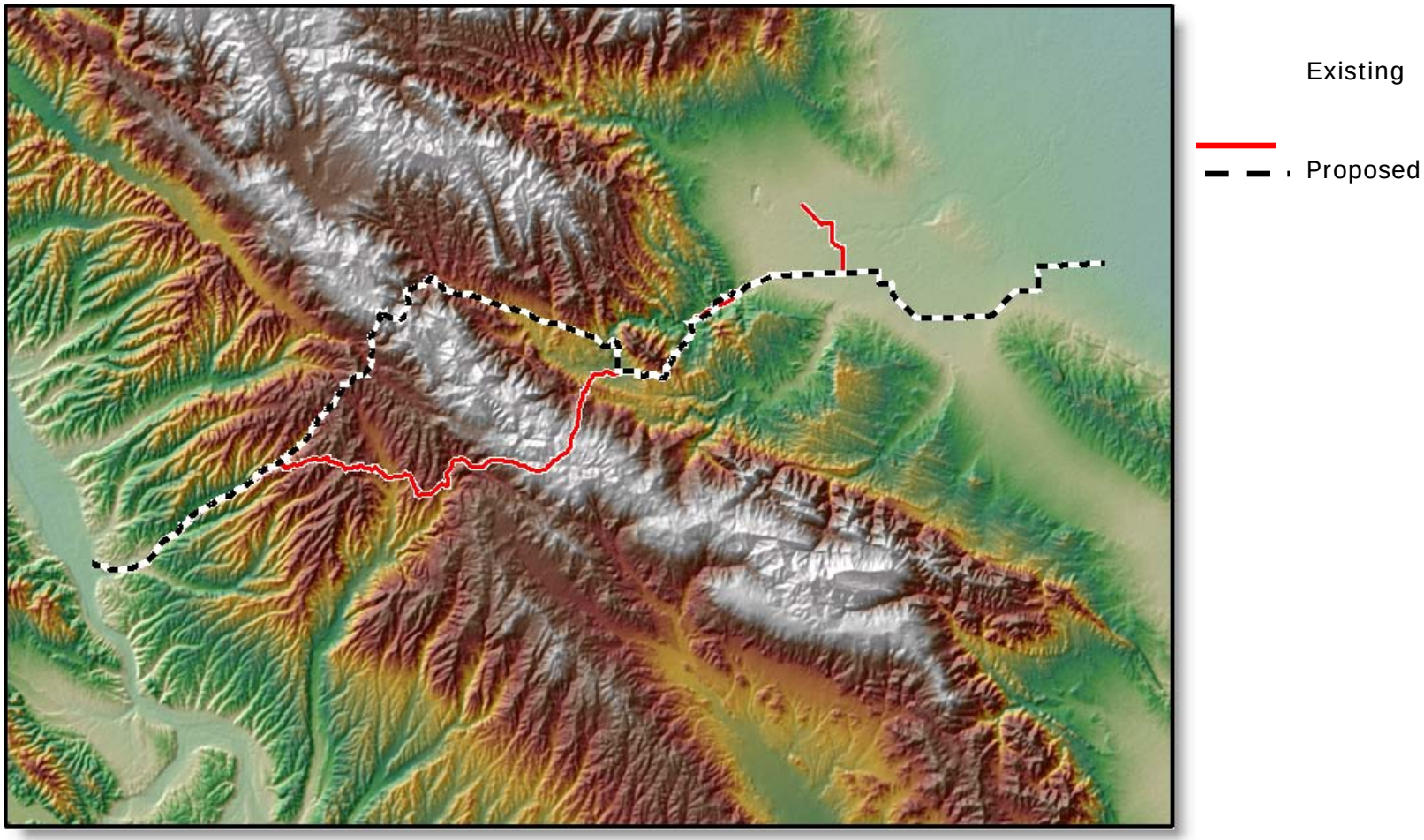
Routing Model Benchmark



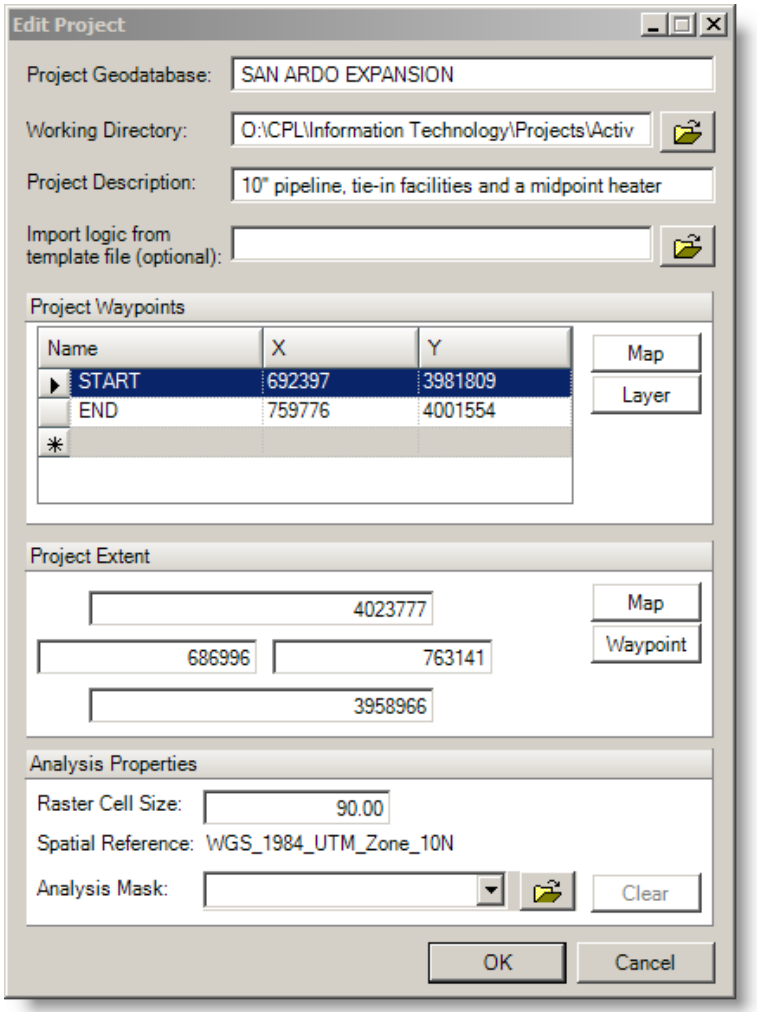
Pilot Overview

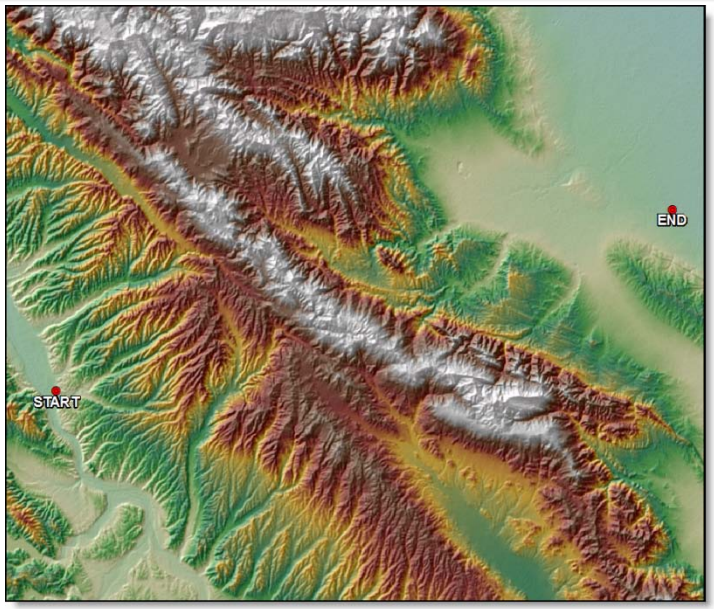


Pilot Overview (cont.)



Defining a GISPRO Project





- Name
- Description
- Area of Interest
- Waypoints
- Coordinate Information
- Working Directory

Defining a Scenario (Example Inputs)

Benchmark

Scenario 1 - Benchmark				
Theme	Input	Cost	% Weight	% Influence
Environmental	Cities	9	0.1	0.58
	Tundra	1	0.05	
	Trees	3	0.08	
	Rivers	7	0.2	
	Swamps	5	0.05	
	Lakes	8	0.1	
Engineering	Slope < 15%	1	0.30	0.42
	Slope 15-30%	2		
	Slope 30-45%	6		
	Slope 45-60%	7		
	Slope 60-75%	8		
	Slope >75%	Exclude		
	Roads	5	0.12	
		Totals	100%	100%

Variant 1

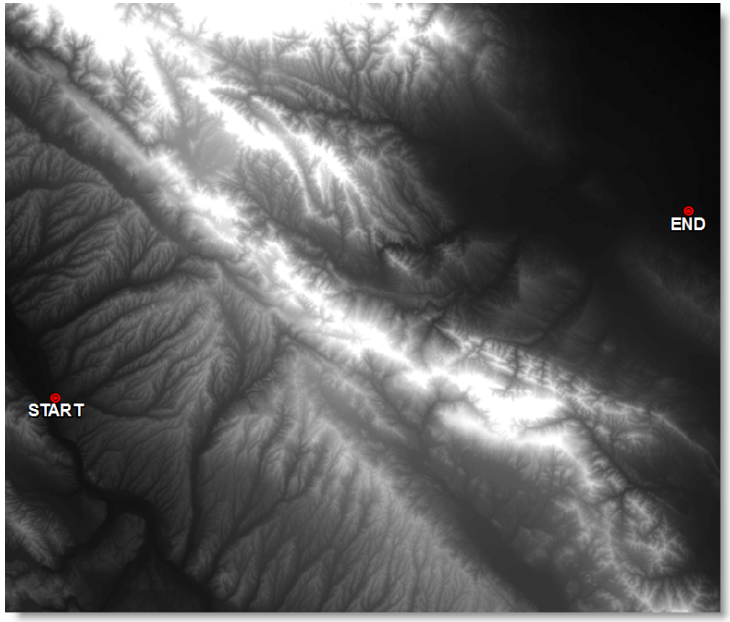
Scenario 2 - Environmental Influcence				
Theme	Input	Cost	% Weight	% Influence
Environmental	Cities	9	0.3	0.90
	Tundra	1	0.06	
	Trees	3	0.08	
	Rivers	7	0.2	
	Swamps	5	0.05	
	Lakes	8	0.21	
Engineering	Slope < 15%	1	0.07	0.10
	Slope 15-30%	2		
	Slope 30-45%	6		
	Slope 45-60%	7		
	Slope 60-75%	8		
	Slope >75%	Exclude		
	Roads	5	0.03	
		Totals	100%	100%

Variant 2

Scenario 3 - Engineering Influcence				
Theme	Input	Cost	% Weight	% Influence
Environmental	Cities	9	0.04	0.30
	Tundra	1	0.06	
	Trees	3	0.01	
	Rivers	7	0.07	
	Swamps	5	0.05	
	Lakes	8	0.07	
Engineering	Slope < 15%	1	0.45	0.70
	Slope 15-30%	2		
	Slope 30-45%	6		
	Slope 45-60%	7		
	Slope 60-75%	8		
	Slope >75%	Exclude		
	Roads	5	0.25	
		Totals	100%	100%

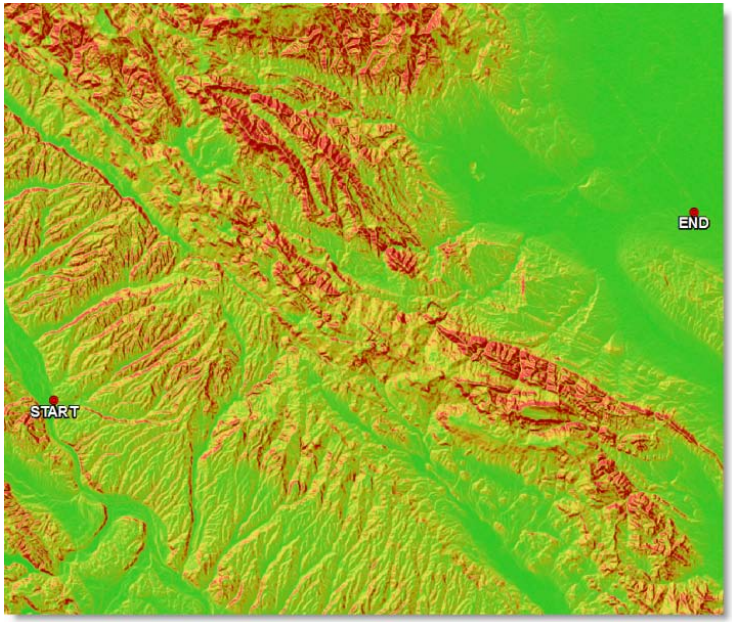
Least Slope Analysis

DEM



Elevation Range:
250’ – 5,000’

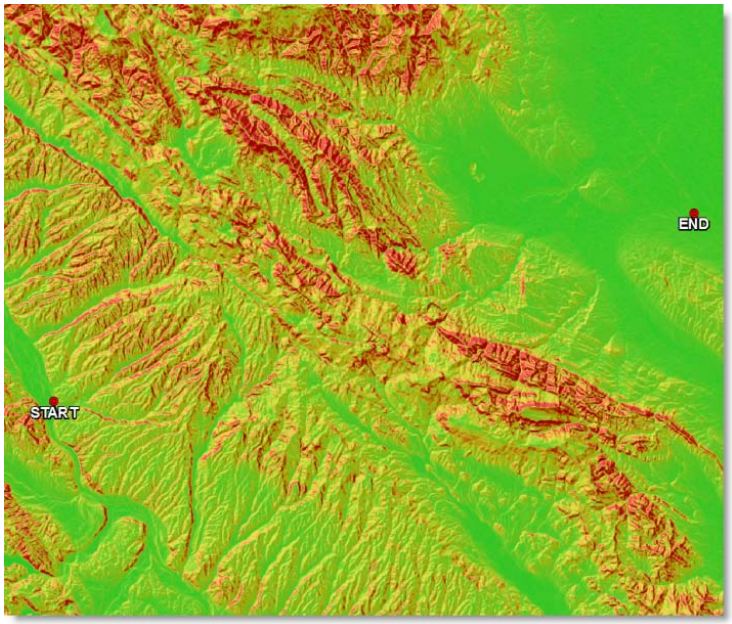
Terrain Slope



Slope Range:
0 – 90 deg

Least Slope Analysis (cont.)

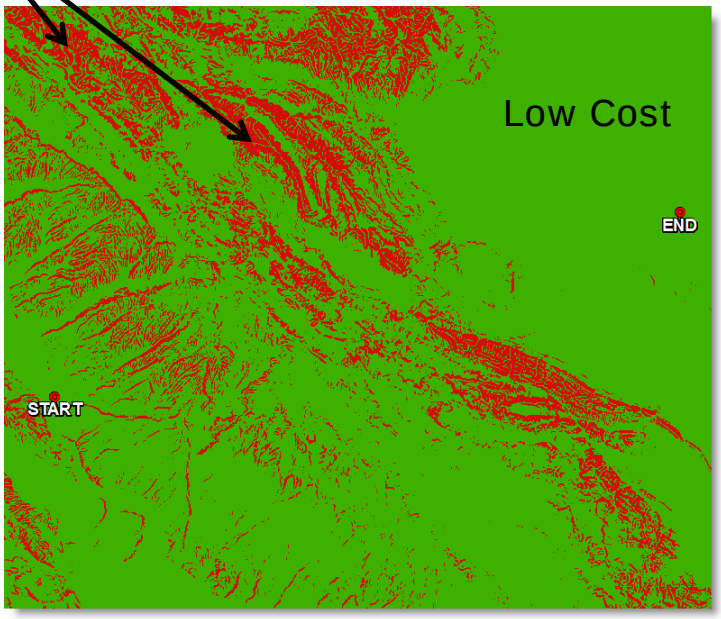
Terrain Slope



Slope Range:
0 – 90 deg

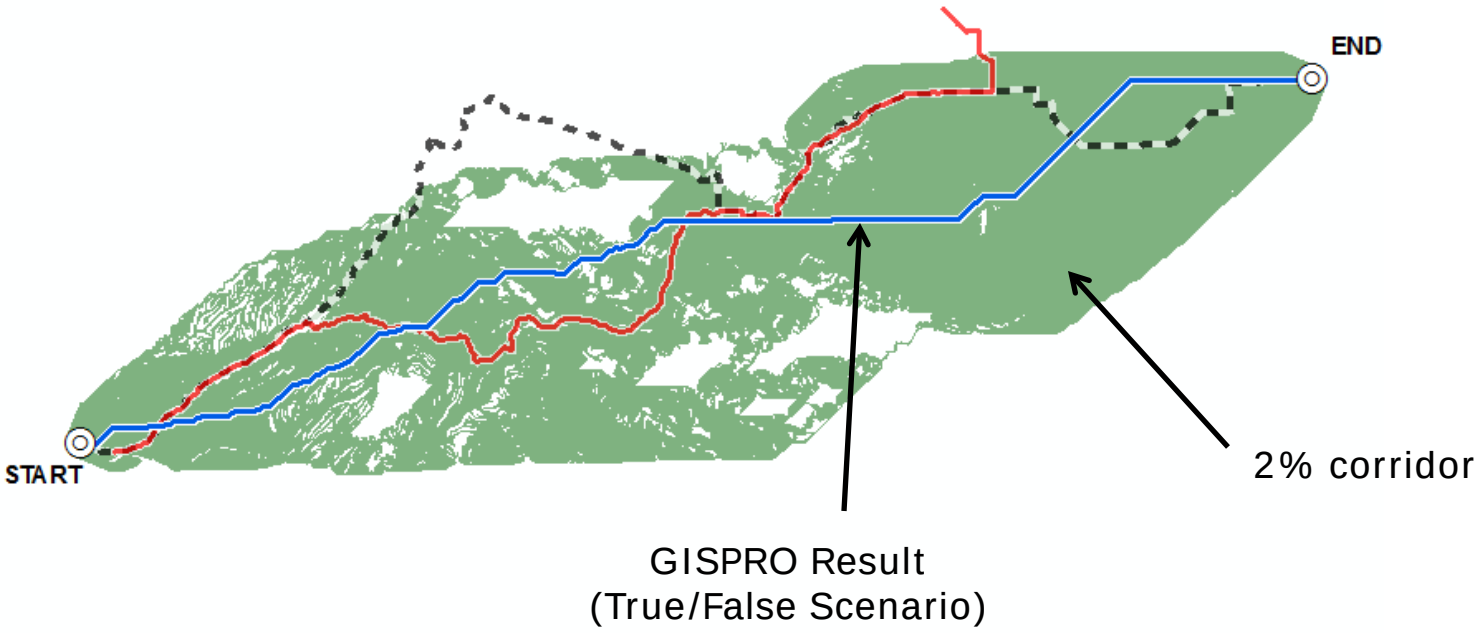
High Cost

Cost Surface



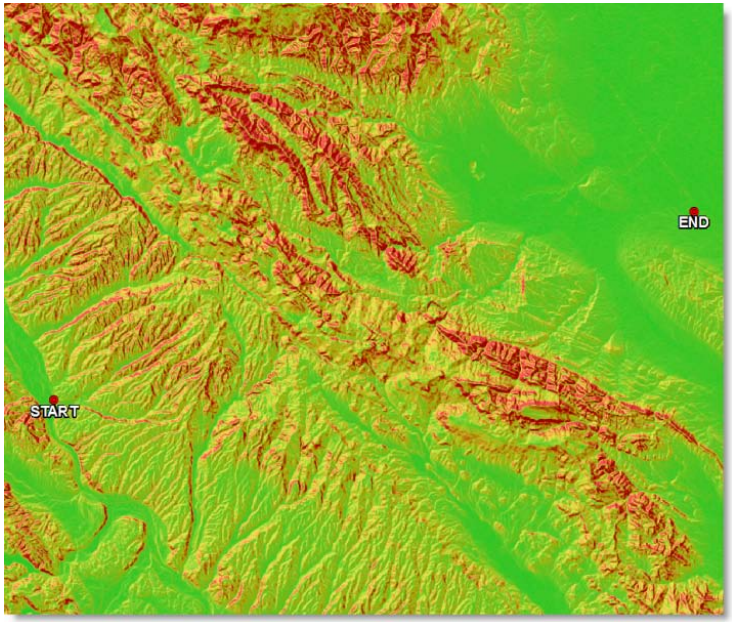
Slope Range Costs:
0 to 25 deg = 1
25 to 90 = 9

Least Slope Output



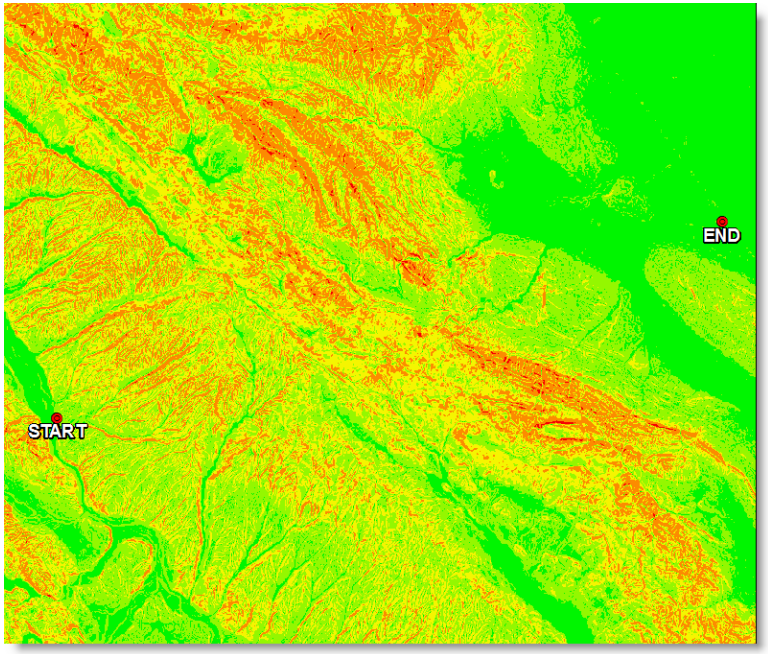
Least Slope Analysis Variant

Terrain Slope



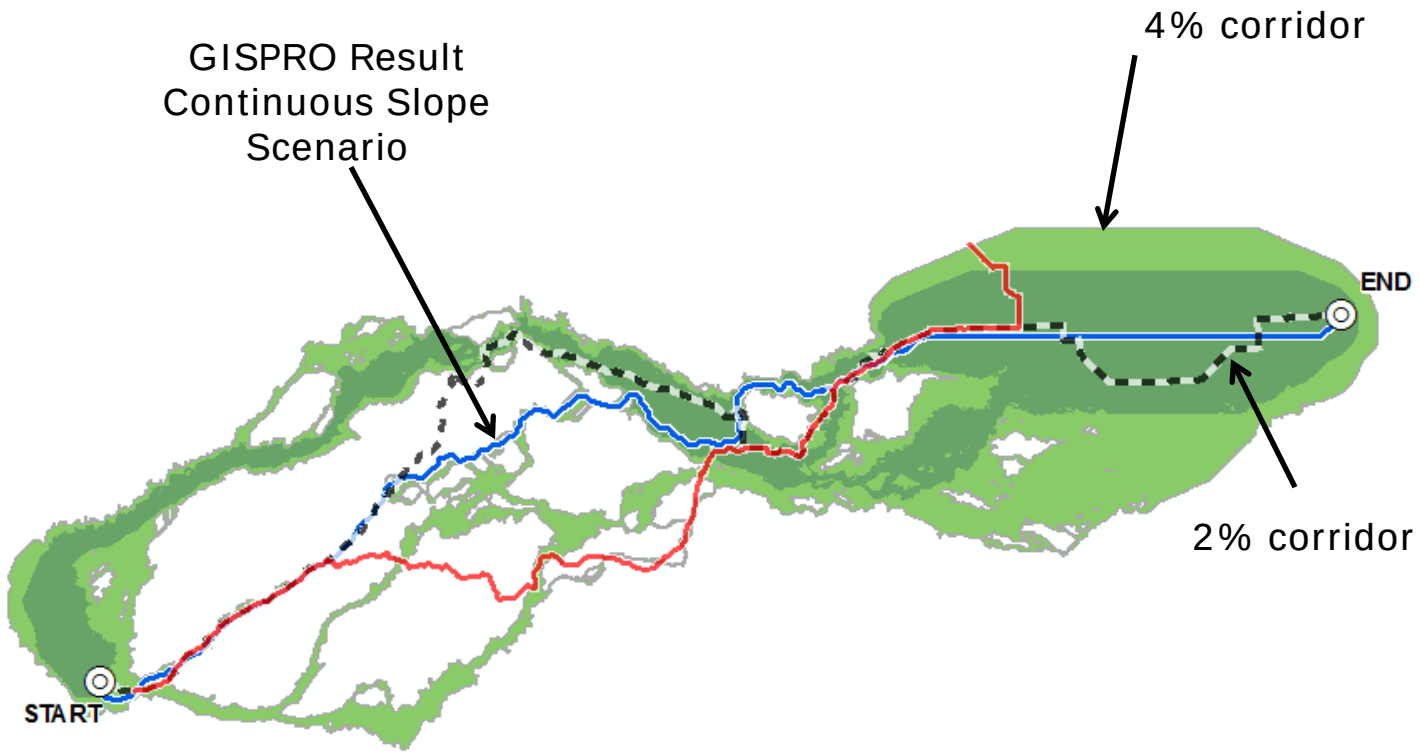
Slope Range:
0 – 90 deg

Revised Cost Surface

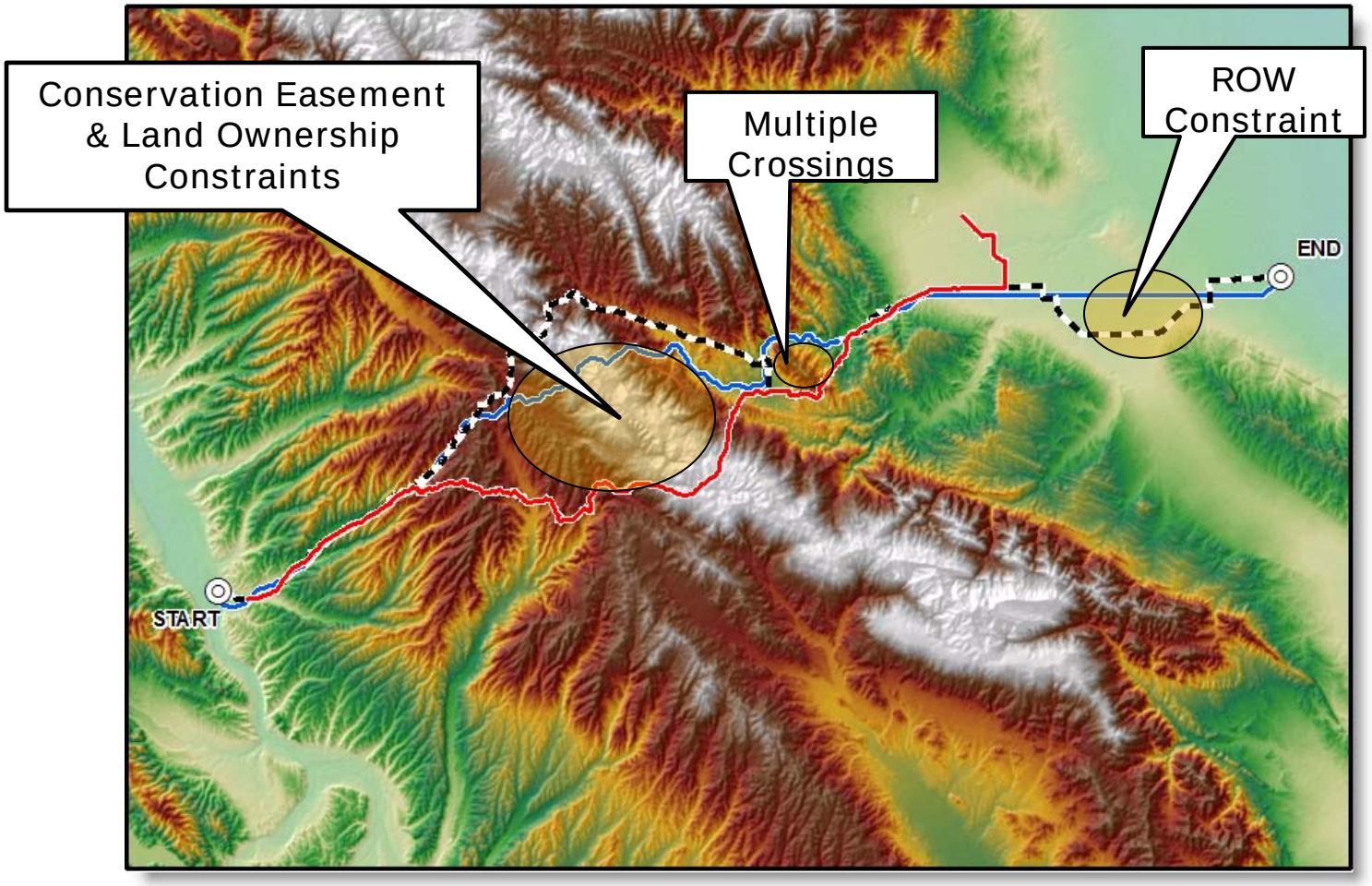


Slope Range Costs:
00 to 8 = 1 (green)
08 to 15 = 2
15 to 20 = 3
20 to 30 = 6
30 to 45 = 8
45 to 90 = 9 (red)

Variant Result



Scenario Comparison

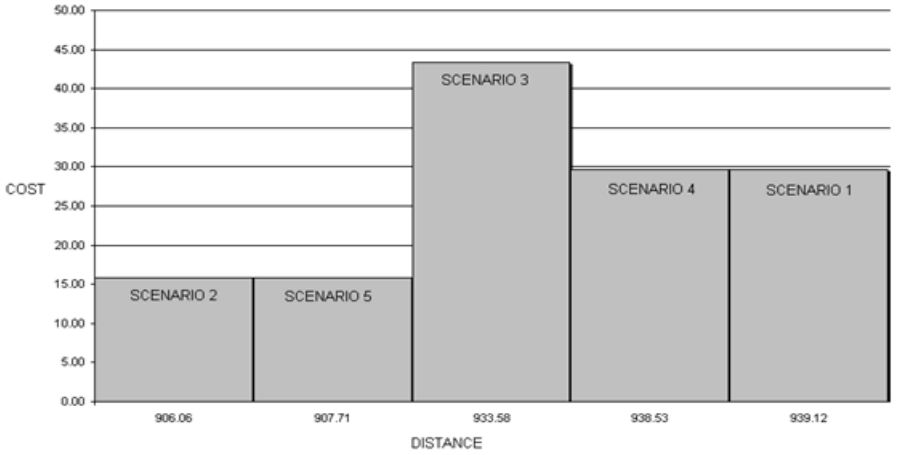


Meeting other Business Rules

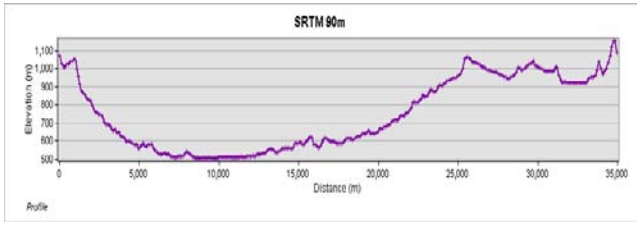
- Avoid Sensitive Areas
- Maximize Access
- Following Existing Corridors
- Avoid Crossings
- Proximity Gradients
- Manual Routes
- Tie-ins

GISPRO Reports (Example Outputs)

Charts



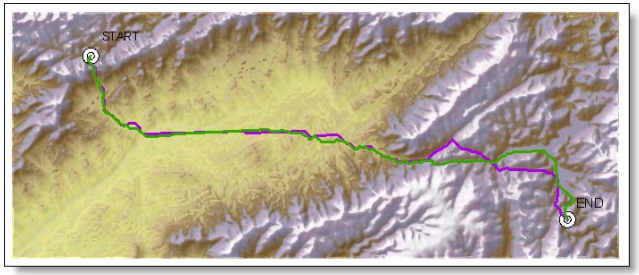
Profiles



Executive Summary & Detailed Report

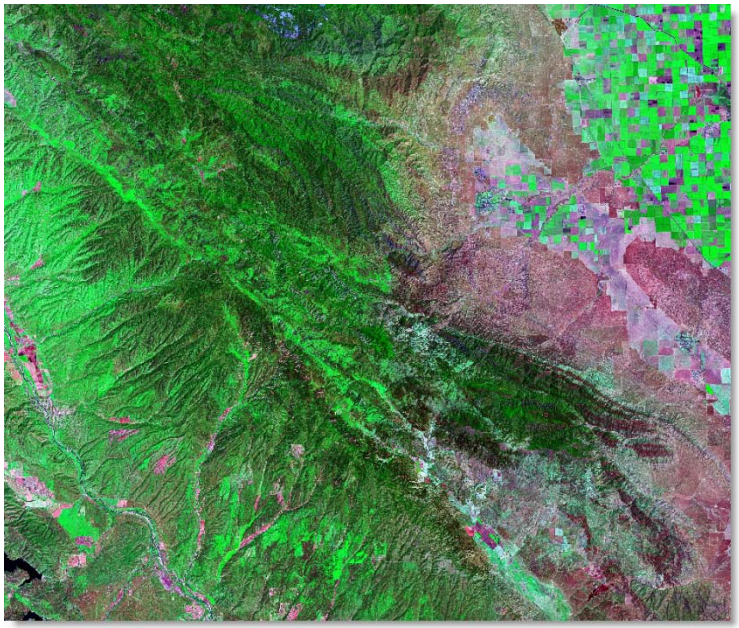
Scenarios	Cost Totals	Length (miles)
Scenario 1 -EQUAL WTS	29.69	939.12
Scenario 2 - Higher Environmental Weights	15.81	906.06
Scenario 3 - Higher Engineering Weights	43.29	933.58
Scenario 4 - Random Weights	29.69	938.53
Scenario 5 - Random Cost & Weights	15.80	907.71

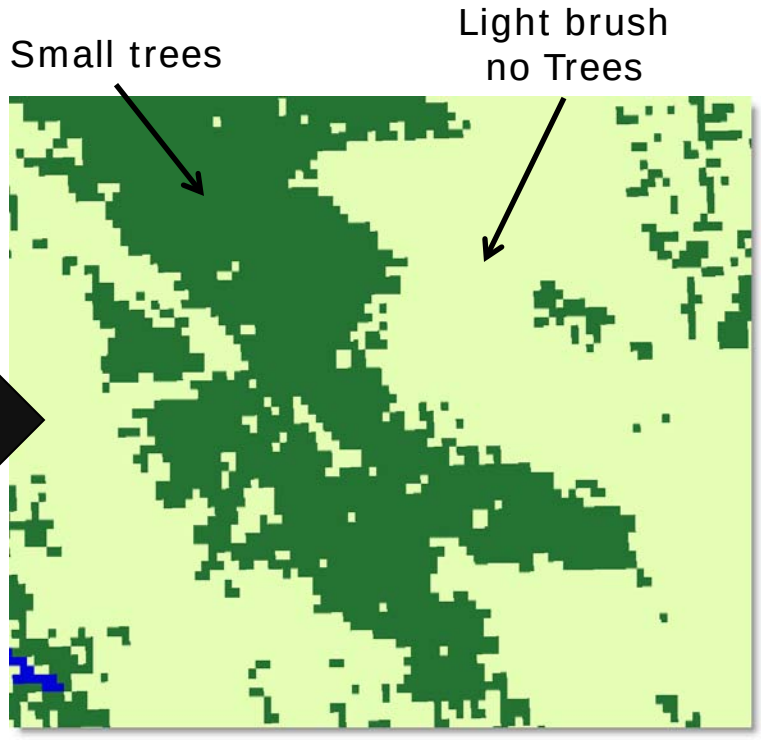
Maps



Surface Conditions (Construction Cost)

Remote Sensing Data

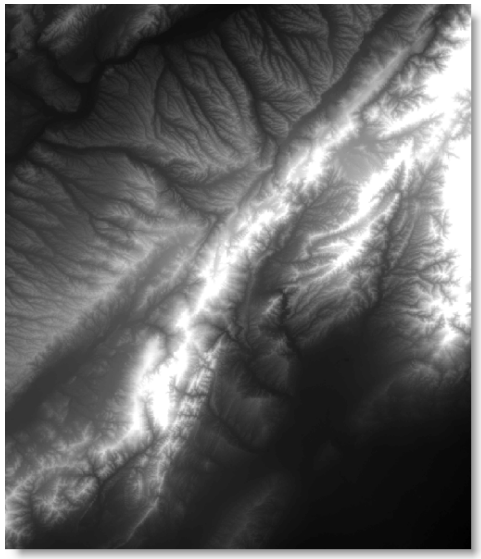


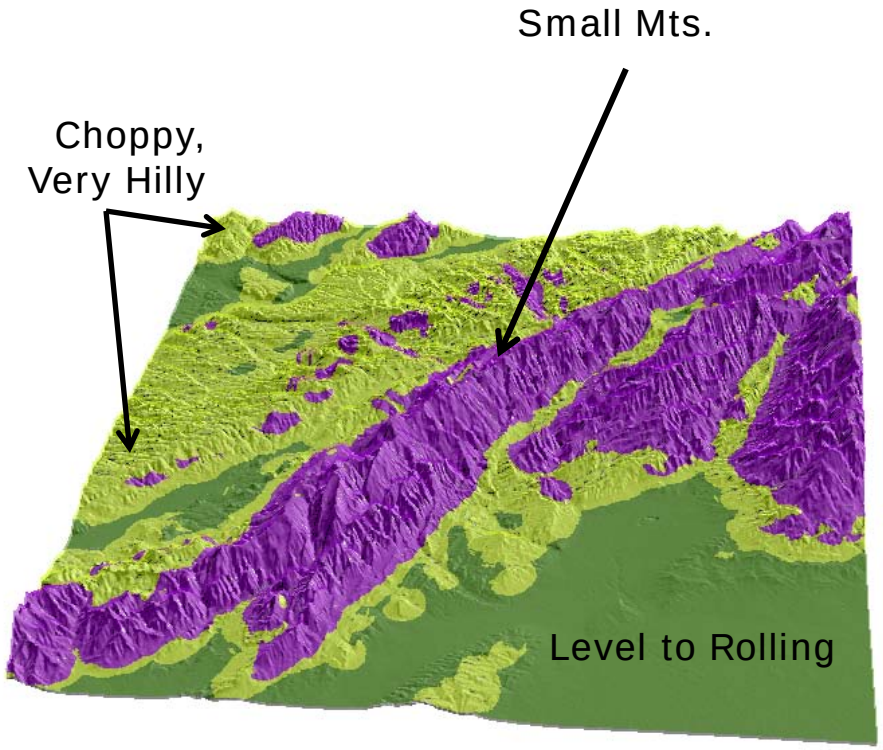


GISPRO Output & LandPipe Terrain Input

Defining Terrain (Construction Cost)

Digital Elevation Model



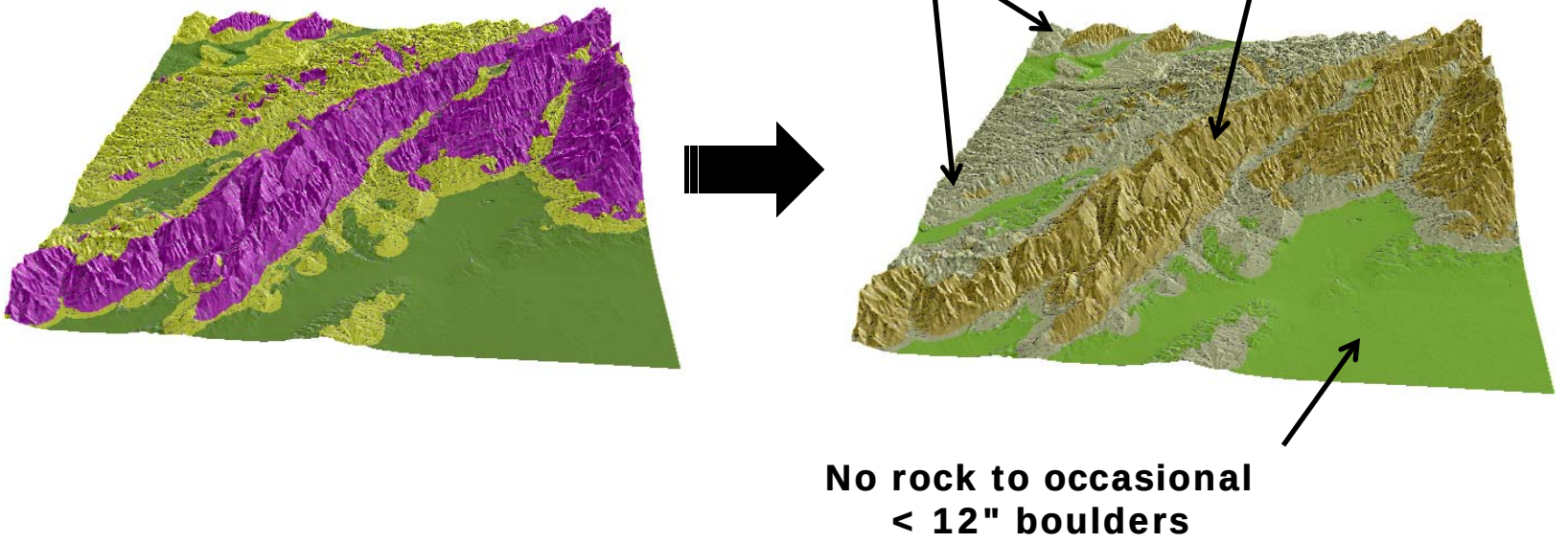


GISPRO Output & LandPipe Terrain Input

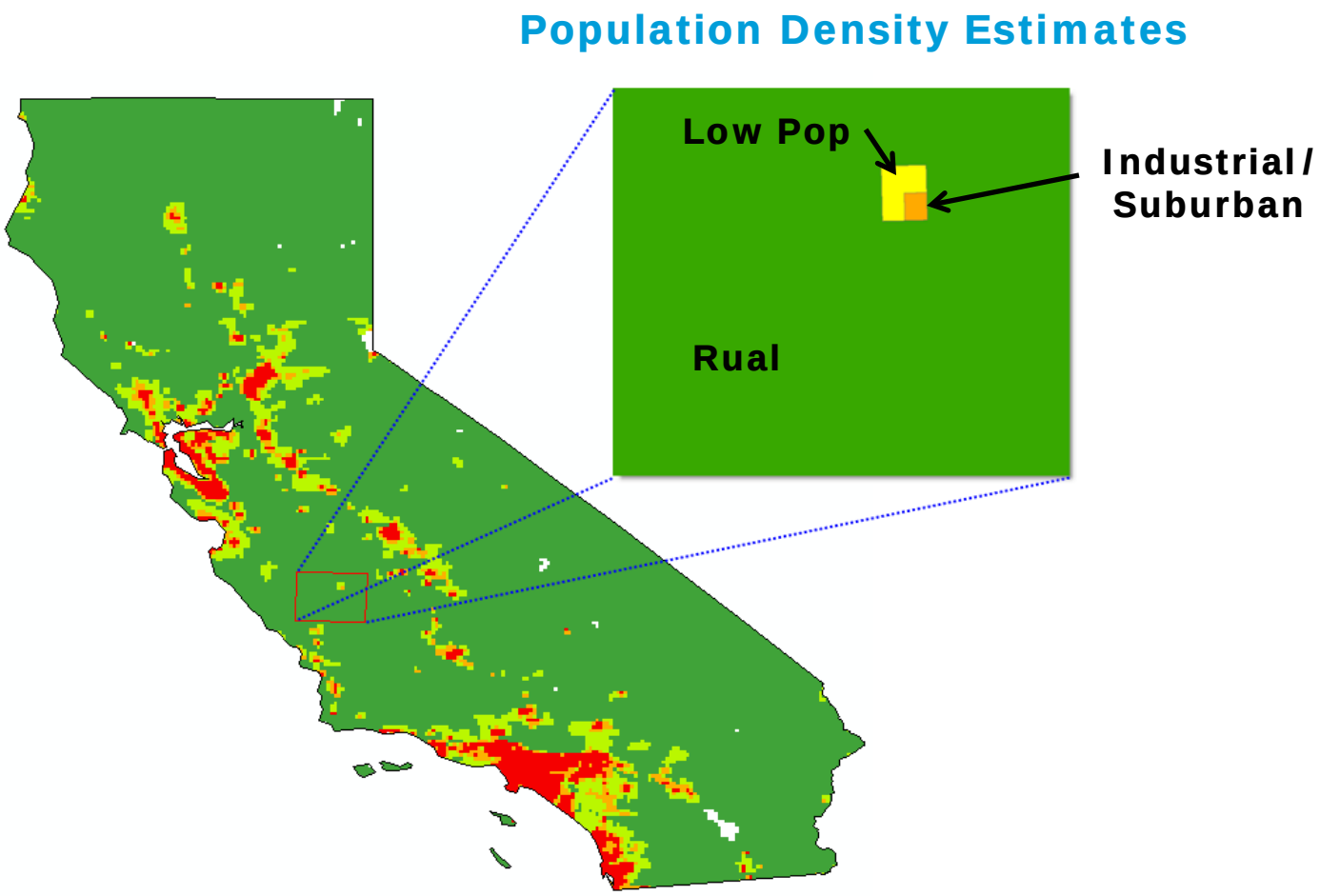
Rock Formation (Construction Cost)

Terrain Formation

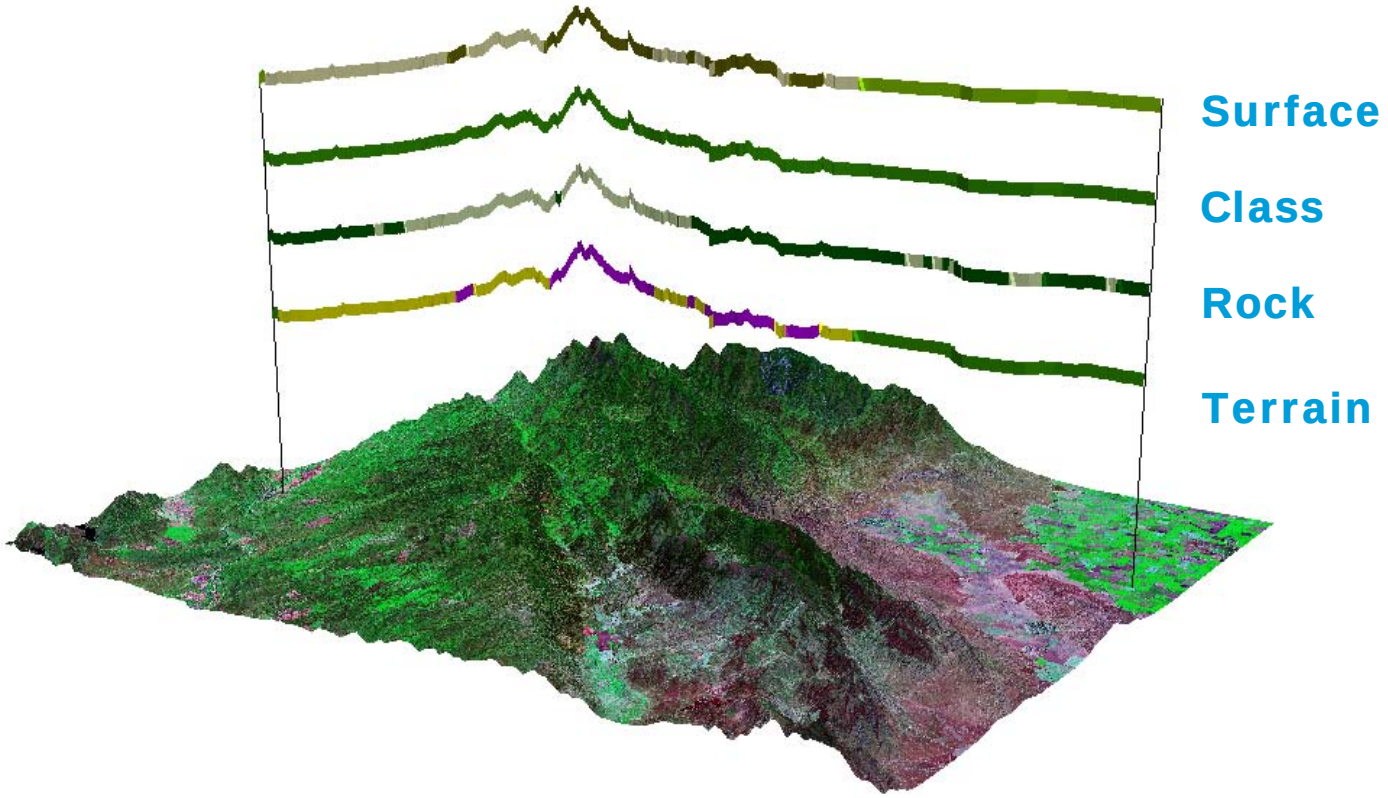
Rippability Inference



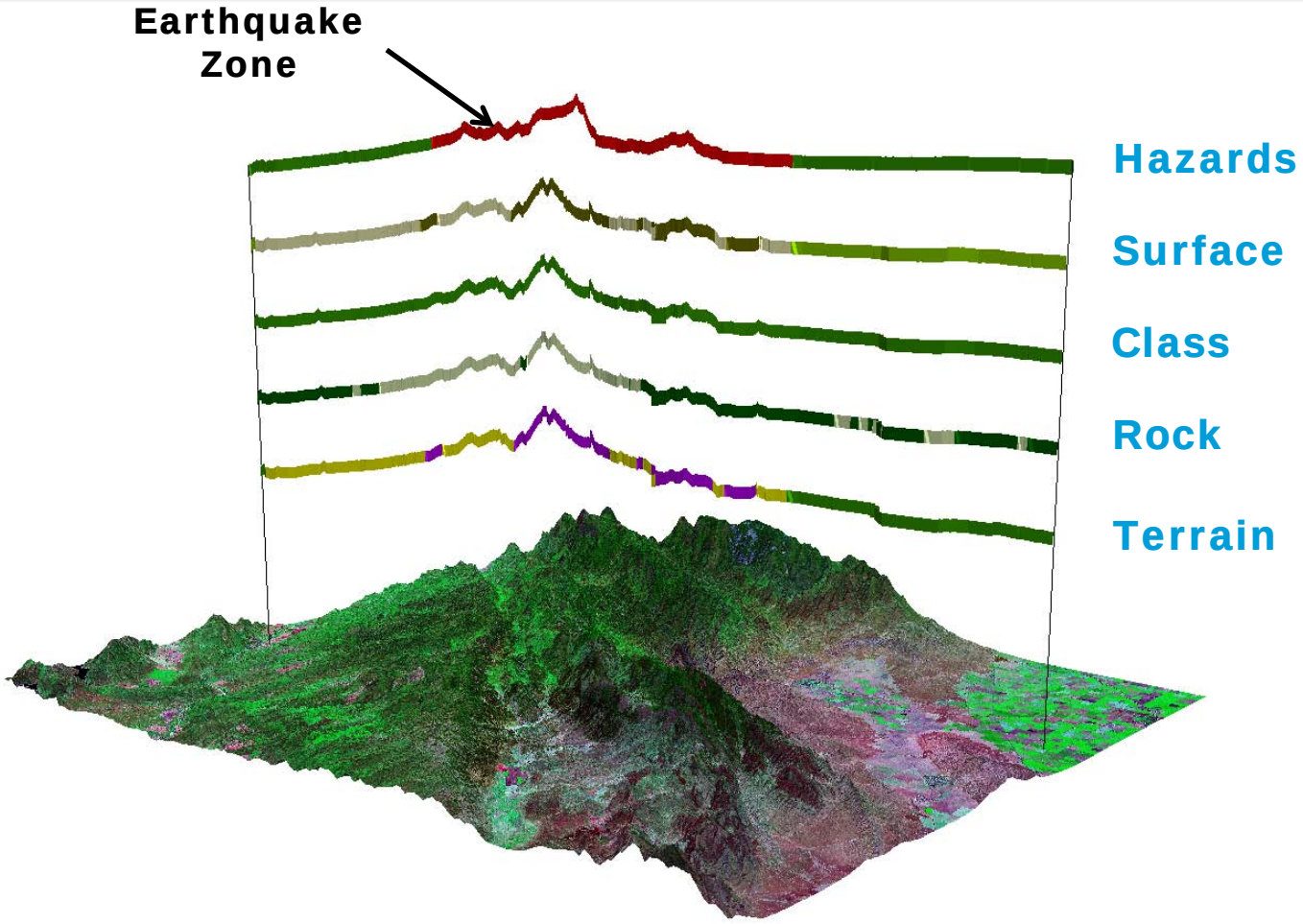
Classification (Material Cost)



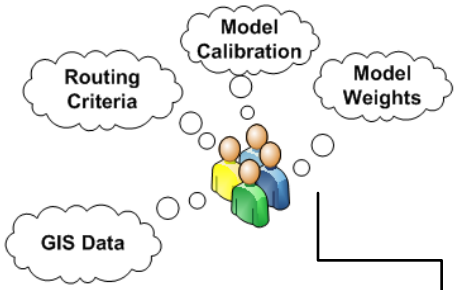
Dynamic Segmentation

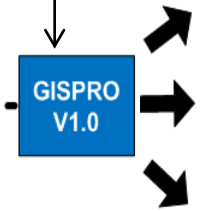


Dynamic Segmentation



Qualitative to Quantitative Workflow





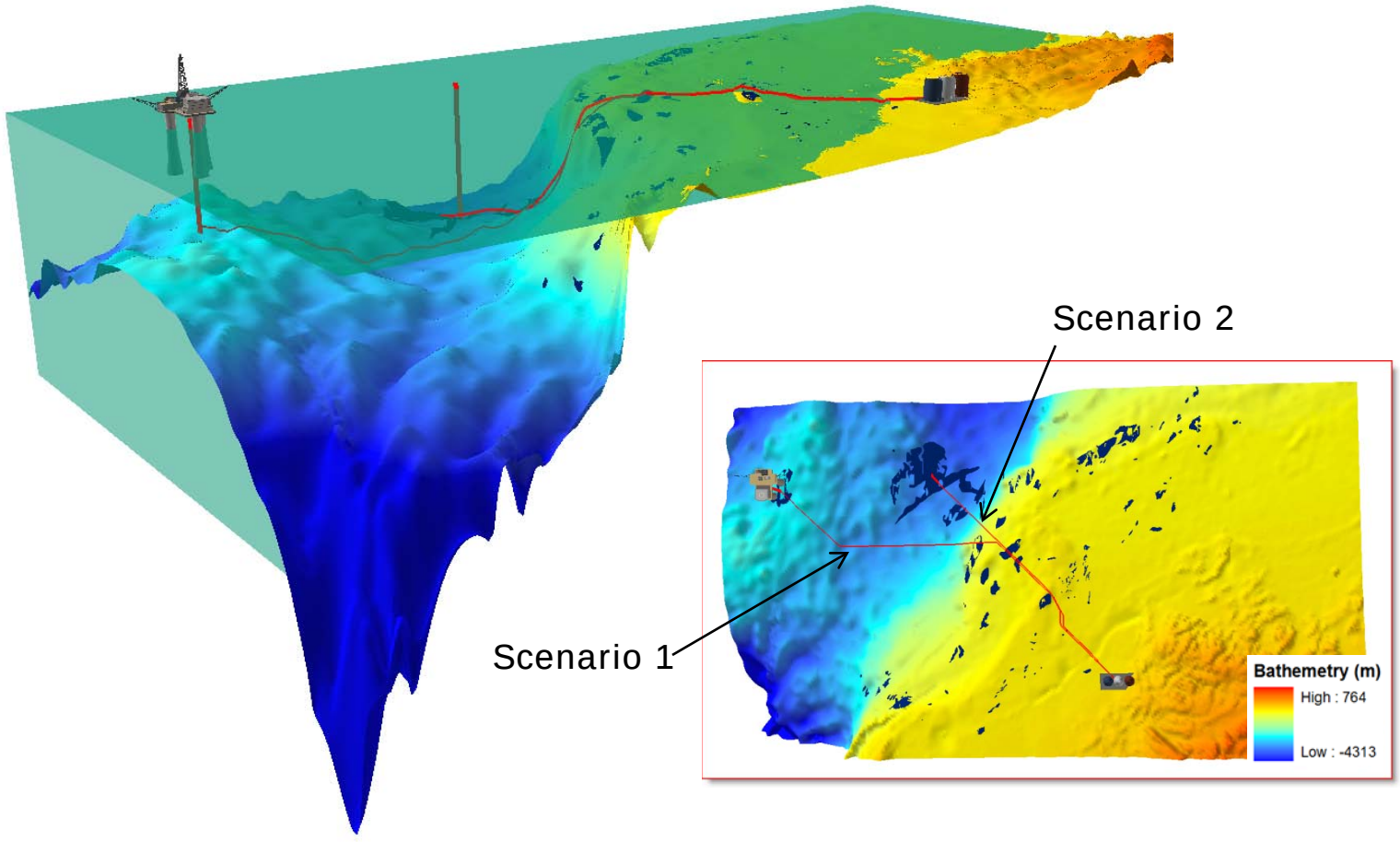
Engineering Discretion/ Scenario Analysis

In house Cost estimating software

FINAL OUTPUT +/- 50% Cost Estimate

Scenario	Length (miles)	Overall Productivity Factor	Unit Cost	Construction Cost	Material Cost
PROPOSED	58	0.59	$156,052	$9,051,016	$6,840,686
GISPRO	55	0.61	$151,839	$8,351,135	$6,486,857
Delta	-3	-0.02	-$4,213	-$699,881	-$353,829

Future Applications (Mock Scenarios)



QUESTIONS?

Berry, K., J., 2000, Optimal Path Analysis and Corridor Routing: Infusing Stakeholder Perspective in Calibration and Weighting of Model Criteria, www.innovativegis.com.

McAllister, E. W. *Pipeline Rules of Thumb Handbook : Quick and Accurate Solutions to Your Everyday Pipeline Problems.* 6th ed. Burlington, MA: Gulf Professional Pub., 2005.

Mohitpour, Mo, H Golshan, and A Murray. *Pipeline Design & Construction : a Practical Approach.* 3rd ed. New York: ASME Press, 2007.

Rizkalla, Moness. *Pipeline Geo-environmental Design and Geohazard Management.* New York, NY: ASME, 2008.