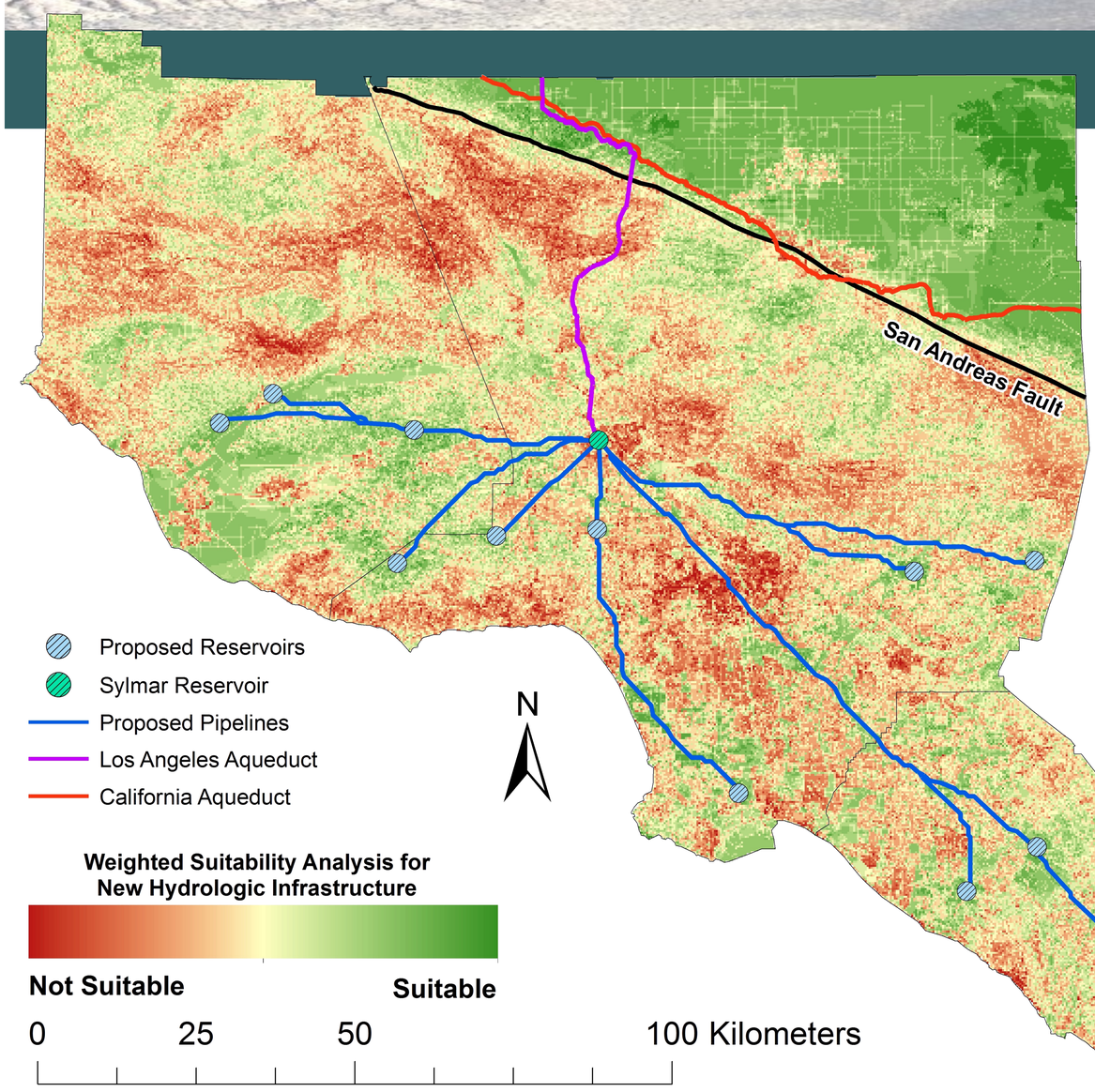
Cut Off

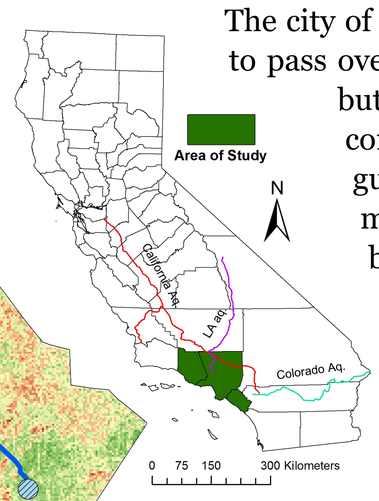
An Earthquake Hazard Assessment

Identifying suitable regions for hydrologic infrastructure in Ventura, Los Angeles, and Orange Counties; CA, USA



SoCal's Water Problem

Southern California receives most of its water from three aqueducts: the California Aqueduct (collected from Northern California and the Sierra Nevadas), the Los Angeles Aqueduct (collected from the Eastern Sierra Nevadas), and the Colorado Aqueduct (collected from the Colorado River). Together, they supply the Los Angeles Metropolitan area with approximately 88% of its total water resources each year, with the LA aqueduct providing the majority. These aqueducts are inherently flawed, however, as they all cross the San Andreas Fault (a right-lateral strike slip fault) at some point, making them susceptible to severe damage during a major earthquake (>6.5 moment magnitude). This damage would effectively cut almost all of LA off from a steady supply of water for weeks or even months.



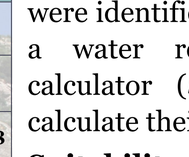
The city of Los Angeles is currently attempting to construct a "flexible" pipeline to pass over the San Andreas Fault that cannot be damaged by an earthquake, but the project costs upwards of $15 billion and will take decades to complete, according to recent article by the LA Times. There is also no guarantee that the pipes will remain completely undamaged during a massive earthquake. As water infrastructure is southern California's biggest vulnerability, other options must be explored.

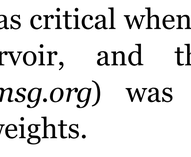
In this study, we explore the option of creating new water reservoirs throughout the counties of Ventura, Los Angeles, and Orange that can safely store water for usage in the event of an earthquake. We also determine the best route for pipelines to connect these proposed reservoirs to the endpoint of the Los Angeles Aqueduct,: the Sylmar Water Reservoir. While this option does not completely solve SoCal's water problem, it can significantly hinder the impact that a "cut off" would have on the LA metropolitan area.

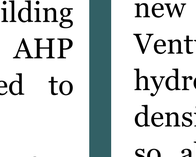
Methodology

Suitability Factor	Weight (%)	Suitability Score 1 (Most Suitable)	Suitability Score 2	Suitability Score 3	Suitability Score 4	Suitability Score 5 (Least Suitable)
Slope (Degrees)	19	0 - 6.2	6.2 - 13.9	13.9 - 22.1	22.1 - 31.5	31.5 - 72.3
Population Density (People per sq. km)	26	0	0 - 1,308	1,308 - 2,616	2,616 - 5,233	5,233 - 333,000
Road Density (Roads per sq. km)	18	0 - $2.7E^{-3}$	$2.7E^{-3}$ - $8.2E^{-3}$	$8.2E^{-3}$ - 0.013	0.013 - 0.022	0.022 - 0.078
Bedrock Geology	9	Crystalline Rock	Consolidated Sediment	Moderately Consolidated Sediment	Unconsolidated Sediment	Water
Fault Density (Faults per sq. km)	13	0 - $6.6E^{-5}$	$6.6E^{-5}$ - $1.8E^{-4}$	$1.8E^{-4}$ - $3.3E^{-4}$	$3.3E^{-4}$ - $4.8E^{-4}$	$4.7E^{-4}$ - $8.5E^{-4}$
Reservoir Density (Reservoirs per sq. km)	4	0 - $1E^{-9}$	$1E^{-9}$ - $3E^{-9}$	$3E^{-9}$ - $6E^{-9}$	$6E^{-9}$ - $9E^{-9}$	$9E^{-9}$ - $1.2E^{-8}$
National Forests and State Parks	3	Unclassified	N/A	N/A	N/A	USDA Classified Forest or Park
Liquefaction Zones	3	Unclassified	N/A	N/A	N/A	CGS Classified Liquefaction Zone
Landslide Zones	3	Unclassified	N/A	N/A	N/A	USGS Classified Landslide Zone
Tsunami Inundation Zones	2	Unclassified	N/A	N/A	N/A	CGS Classified T.I. Zone

TABLE 1







Suitability Factors: 10 factors were identified as critical when building a water reservoir, and the AHP calculator (*bpmsg.org*) was used to calculate their weights.

Suitability Analysis: Raster calculator was used to perform the suitability analysis. Table 1 provides the weights used for each factor and a description for the scores applied to each factor.

Cost Path: Another Suitability Analysis (not shown) was performed, as the weights for pipelines are different than those for reservoirs. Cost Back Link and Cost Path were then used to calculate the best routes for pipelines.

Conclusions

The results indicate that small clusters of area are suitable for building new water reservoirs in the LA metropolitan area, particularly in Ventura County. But, overall, these counties are not suitable for hydrologic infrastructure. The most important factors (slope, pop. density, road density, unconsolidated sediment, and fault density) are so abundant that proposed areas are mostly squeezed into small clusters of suitable area, which might still be susceptible to earthquake damage. Were these counties not so densely populated, it might be easier to build reservoirs in even more suitable areas.

Even though population and roads were weighted heavily in the cost path analysis, proposed routes for pipelines still go straight through the center of Los Angeles. While pipelines can be routed underground, the construction would present significant noise and dust problems for city residents.

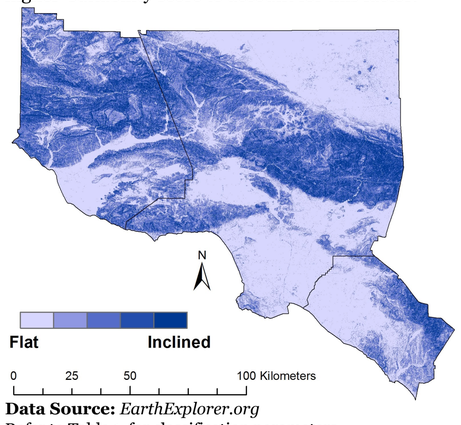
This spatial analysis illustrates just how difficult it is to solve SoCal's water problem. For future studies, more suitability factors should be employed and finer rasters should be considered to provide a more accurate assessment of hydrologic infrastructure suitability in SoCal.

Tufts Urban and Environmental Policy and Planning

Cartographer: Mattison H. Barickman
Class: UEP-294 (Advanced GIS)
Projection: NAD (2011) State Plane; California V
December 21st, 2017

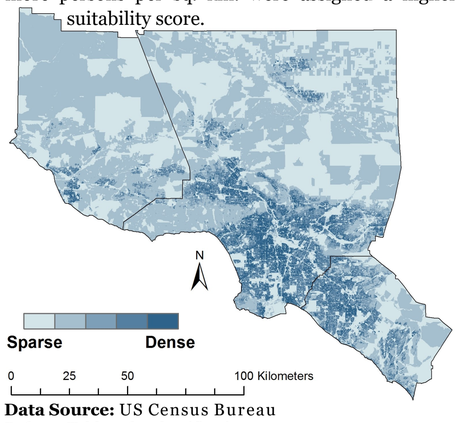
Acknowledgements: Special thanks to Sumeeta Srinivasan, John VanDerHeide, and Carolyn Talmadge for their insight and guidance.

Slope It's difficult to build infrastructure on an inclined slope. Large slope angles were assigned a higher suitability score to account for this factor.



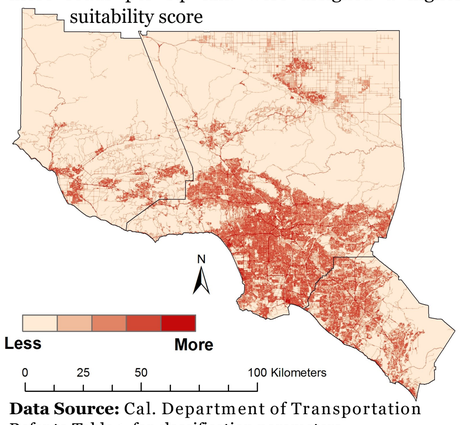
Data Source: *EarthExplorer.org*
Refer to Table 1 for classification parameters

Population Density Reservoirs should not impede on densely populated areas. Regions with more persons per sq. km. were assigned a higher suitability score.



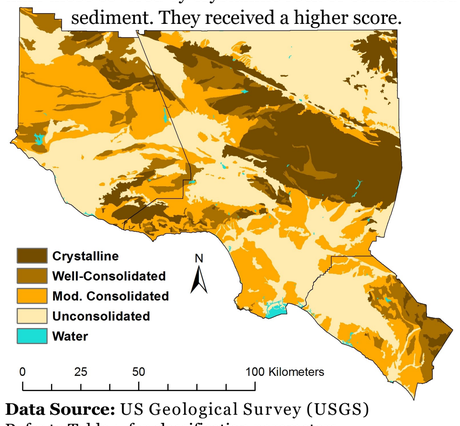
Data Source: US Census Bureau
Refer to Table 1 for classification parameters

Road Density Reservoirs should not be built on or near roads due to air pollution. Regions with more roads per sq. km. were assigned a higher suitability score



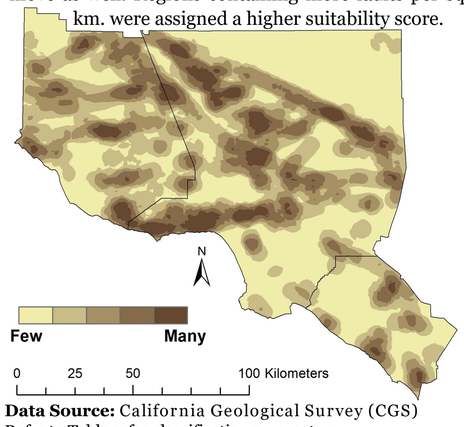
Data Source: Cal. Department of Transportation
Refer to Table 1 for classification parameters

Bedrock Geology Regions covered by unconsolidated sediment are less suitable to build on than those covered by crystalline rock or consolidated sediment. They received a higher score.



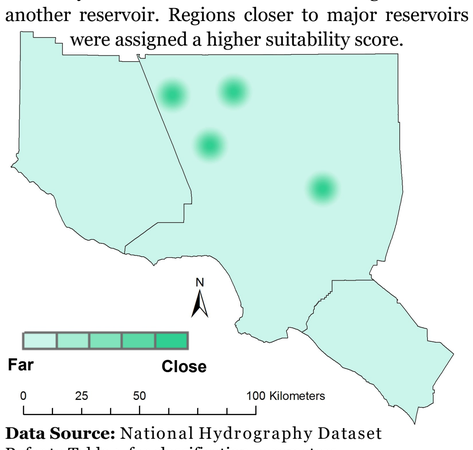
Data Source: US Geological Survey (USGS)
Refer to Table 1 for classification parameters

Fault Density If there is motion along the San Andreas Fault, it can cause other minor faults to move as well. Regions containing more faults per sq. km. were assigned a higher suitability score.



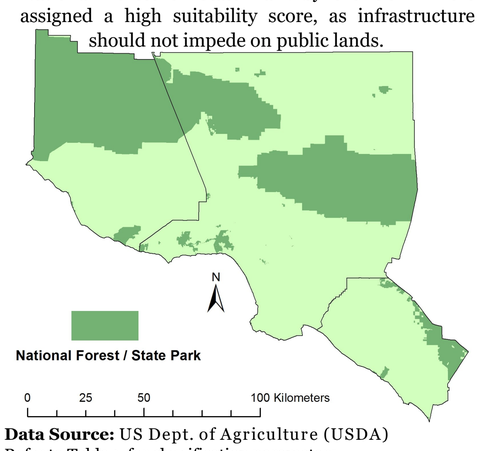
Data Source: California Geological Survey (CGS)
Refer to Table 1 for classification parameters

Current Major Reservoirs It's not necessary to construct a new reservoir right next to another reservoir. Regions closer to major reservoirs were assigned a higher suitability score.



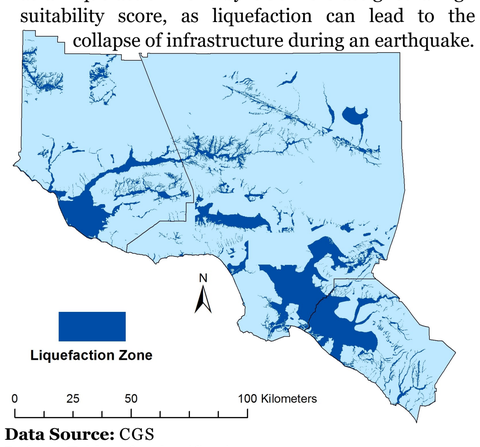
Data Source: National Hydrography Dataset
Refer to Table 1 for classification parameters

Forest or Park Regions classified as a National Forest or State Park by the USDA were assigned a high suitability score, as infrastructure should not impede on public lands.



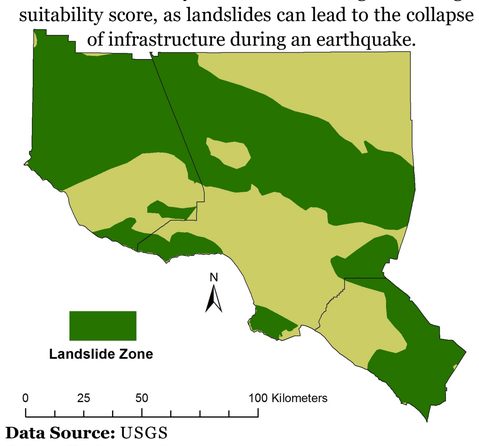
Data Source: US Dept. of Agriculture (USDA)
Refer to Table 1 for classification parameters

Liquefaction Zones Regions classified as a Liquefaction Zone by CGS were assigned a high suitability score, as liquefaction can lead to the collapse of infrastructure during an earthquake.



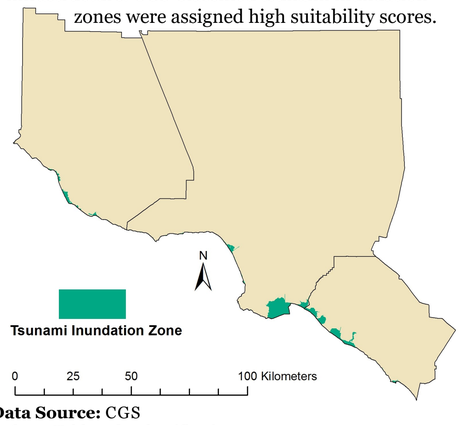
Data Source: CGS
Refer to Table 1 for classification parameters

Landslide Zones Regions classified as a Landslide Zone by USGS were assigned a high suitability score, as landslides can lead to the collapse of infrastructure during an earthquake.



Data Source: USGS
Refer to Table 1 for classification parameters

Tsunami Inundation Zones
Tsunamis can either pollute or rupture hydrologic infrastructure. CGS Classified tsunami inundation zones were assigned high suitability scores.



Data Source: CGS
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