RESEARCH NOTES
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Landslide Hazard Maps for State Highway Corridors Help Planning and Mitigation

Each year, hundreds of landslides are mobilized along highway corridors that can affect public safety as well as the trip quality, reliability and maintenance cost of the transportation network. Modern GIS-based technologies have created new opportunities for improved assessment of landslide hazards by enabling comprehensive synthesis of vast amounts of spatial data developed from field evaluations, various remote sensing techniques, and an assortment of archival information residing with federal, state, local and private entities.

Figure 1 – 1997 Mill Creek Landslide

Why We Pursued This Research

Caltrans expends approximately $22 million annually in managing landslides along an estimated 1200 miles of landslide prone highways. This represents a significant portion of the estimated $106 million annual landslide costs for U.S. highways for repairs and maintenance. California is one of the many states along the Pacific Coast, the Rocky Mountains, and the Appalachian Mountains with high costs associated with landslides. An average of 200 landslides and 10 road closures occur per year along California highways that require clean up and/or mitigation. Impacts of landslides include not only road closures with the resulting traffic delays and economic effects, but also can produce adverse environmental impacts ranging from view degradation to water-quality issues.

Landslide hazards often go unrecognized until it is too late and costs have already been incurred. Seemingly inadvertent alterations to roadway or drainage systems associated with routine maintenance or minor alignment alterations can reduce stability and even initiate conditions that trigger a slide. Furthermore, the extent of landslide hazards is generally not recognized, and the focus tends toward recently active slides. Although Caltrans' geo-professionals can identify slide risks if alerted, the vast majority of routine corridor planning and maintenance activity does not involve their input. Therefore, a simple and direct means of communicating the broad context of landslide-hazards to all levels of staff was needed.

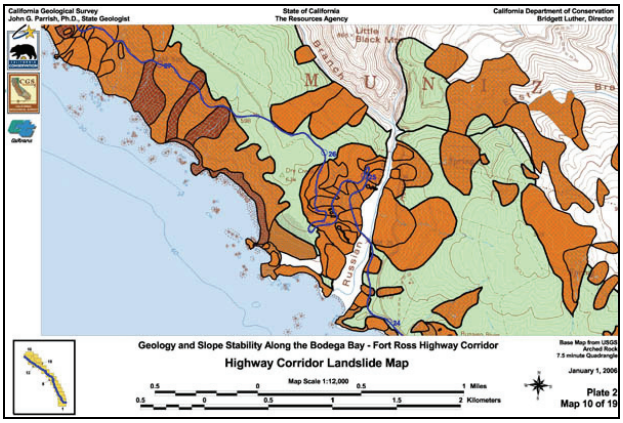

Figure 2 – Example of Landslide Hazard Map

What We Did

Under the direction of the Caltrans GeoResearch Group (GRG), the California Geological Survey (CGS) piloted the development of corridor-scale landslide hazard maps to meet the needs of various Caltrans users. The project team delivered a variety of mapping products, identifying the location and severity of the landslide threat along selected highway corridors. User guidelines and region-specific mitigation strategies were developed for a variety of geologic, climatological, and

environmental conditions. The maps and guidelines can provide planners, designers and responders with a readily accessible and fully synthesized resource summarizing the geologic setting of a corridor from a broad perspective. This, in turn, will have immediate, positive, and long-term impact on planning, maintenance, and emergency response strategies for these corridors.

Initially, the project team assembled a list of over 1200 miles of slide-prone highway corridors based on Caltrans' project experience. The team then identified 187 route miles along seven corridors in five Districts for mapping under this research-funded demonstration project as shown in Table 1.

Dist	Cty	Rte	Segment	PM Limits	Miles
1	DN	101	Wilson Creek to Cresent City	12 to 27	15
1	MEN	101	Leggett to Red Mtn. Creek	90 to 98	8
1	HUM	299	Blue Lake to Willow Creek	8 to 39	31
4	SON	1	Bodega Bay to Fort Ross	10 to 34	24
5	MON	1	Big Sur to Point Lobos	44 to 70.42	27
			County Line to Big Sur	0 to 44	44
	SLO		San Carpoforo Creek to County Line	71.4 to 74.3	3
7	LA	5	Jct Route 126 to Gorman Creek	55 to 80	25
8	RIV	60	Redlands Blvd to Junction Route 10	20 to 30	10

Table 1 – Corridors Selected for the Pilot Study

Research Results

GIS-based maps prepared at 1:12,000 scale were selected as the optimal means for compiling and archiving available data and interpretations. Attributes for the maps include landslide type (i.e. rock slide, debris slide, debris flow, earth flow), activity (active or historic, dormant-young, dormant-mature, dormant-old), and confidence of interpretation (i.e., definite, probable, questionable). Additional attributes assigned to all slides include the interpreted depth of slide, azimuth of movement, geologic unit, lithology, and data sources. Significant landslides are assigned additional information including size, recency of movement, probable rate of movement, and possible consequences for the highway. A corridor-specific report is also generated for each route, summarizing geologic setting and key landslide features.

Considering the cost of the research project and the potential annual savings over the course of the next ten years, a benefit-cost factor of 26 was calculated if the maps are fully implemented. That is, for every dollar spent on the research, an estimated $26 could be saved. The overall economic benefits and costs, direct and indirect, to the traveler are difficult to quantify, however, the reduced congestion resulting from mitigating landslide failures are significant. For example, the previously mentioned Mill Creek Landslide had an estimated impact of over $1 million per day over the month that it closed the highway.

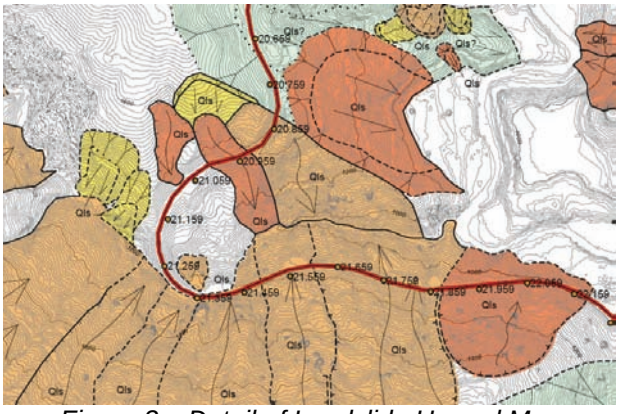

Figure 3 – Detail of Landslide Hazard Map

The Researchers Recommend

This project developed a standard methodology for integrated archive and display of landslide hazards along a highway corridor to aid in risk assessment. Caltrans staff associated with the demonstration routes are encouraged to use and distribute these maps/reports (and web-based tools in the future) as resources to inform planning decisions, communicate with other agencies/public, and to guide maintenance practices for long-term proactive landslide hazard mitigation. Caltrans staff responsible for the other 1000-plus miles of slide-prone corridors are encouraged to examine these demonstration products, evaluate their utility, and decide whether similar mapping might warrant prioritization of future non-research budget resources.

For More Information on GeoResearch Projects

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