SOUTHWESTERN OHIO LANDSLIDE

DOCUMENTATION INVESTIGATION REPORT

SOUTHWESTERN OHIO

NORTHERN
KENTUCKY
UNIVERSITY

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FINAL REPORT
SOUTHWESTERN OHIO
LANDSLIDE DOCUMENTATION INVESTIGATION

INTRODUCTION

The greater Cincinnati area of northern Kentucky and southwestern Ohio has long been recognized as a region of unstable slopes. It is reported that landslides have been mentioned occurring as far back as 1850. As the metropolitan region has expanded onto the unstable slopes, landslides have become an increasingly significant problem that impacts the welfare of the citizens and the economic development of the community.

The susceptibility of this area to landslides is the result of a combination of factors. First, the region is a gently rolling upland dissected by deeply incised valleys of the Ohio River and its tributaries as well as those of ancient drainage systems. There is about 360 feet of relief between the Ohio River and the adjacent uplands and the slopes of these hillsides may become quite steep. Secondly, the region is underlain by a variety of surficial materials that contribute to slope instability. These include glacial tills on the uplands, lacustrine clays in the valleys and a clay-rich colluvium on the hillsides derived from the weathering of the underlying shales, particularly those of the Ordovician Kope Formation. These factors, when accentuated by periods of heavy precipitation along with the ever-present demand for hillside development, have combined to create an environment that is highly susceptible to slope instability. As a result, landslides have a significant social and economic impact on the northern Kentucky – southwestern Ohio region and the costs of landslide prevention and remediation in this area reportedly are among the highest in the nation.

As a result of the considerable costs resulting from landslides experienced in this region, the northern Kentucky-southwestern Ohio area has been the subject of several studies defining the economic and social impact of their occurrence. Fleming and Taylor (1980)

determined that the cost of landslide damage in Hamilton County, Ohio averaged about $5,170,000 per year between 1973 and 1978. Fleming and Taylor believed however that their estimates were lower than the actual costs incurred because many of the agency records were incomplete or unavailable and that indirect costs of damage, (e.g., legal fees, architectural fees), which were excluded from the estimates, could have equaled or exceeded the direct costs. A study by the Earth Surface Process Group (1987) indicated that the City of Cincinnati spent about $500,000 per year on emergency street repairs for damage due to landslides between 1983 and 1987. In addition, Pohana (1992) stated that Cincinnati's costs for landslide repair from 1988 to 1992 was $7.5 million and was projected to increase to $8.5 million from 1993 to 1997. An overview of landslide occurrence, cost estimates and mitigation considerations, along with a history of landslide investigations in the northern Kentucky-southwestern Ohio area, is presented by Baum and Johnson (1996).

To date however, it has been difficult to quantify the cost of landslide damage because of the variety and degree of applicability of accessible records available providing information on the extent of repair and replacement costs or the costs associated with the implementation of procedures to prevent landslide damage. This study is part of a Landslide Loss Estimation Pilot Project directed by the Geologic Hazards Committee of the Association of American State Geologists and the USGS Volcano Hazards and Landslides Hazards Program Office to determine, from selected local governments, what kind of information is currently available and if it is feasible to develop a program for more regularly kept records of landside losses.

OBJECTIVES

Being able to quantify the costs of landslide damage on an annual basis is an important way of demonstrating the real costs associated with landslides and for mobilizing greater efforts to reduce future damage. The objectives of this study have been to facilitate the

quantification process by investigating methodologies currently used for the collection, tabulation, and the availability of landslide cost-of-damage data for Hamilton, Clermont and Brown Counties of southwestern Ohio and Campbell, Kenton and Boone Counties of northern Kentucky and to evaluate the applicability of this data for defining reliable estimates of landslide damage costs. It is particularly significant that this study has coordinated efforts in two states to meet these objectives. Since the geologic and topographic conditions that contribute to the development of landslides are very similar on "both sides of the river" in this area, this cooperative study provided a unique opportunity not only to an expand the scope of work, but also to document similarities and or differences in approaches to landslide remediation efforts and the availability of landslide cost-of-damage data in adjacent states.

PROCEDURES

The work plan specified for this project (U. S. Geological Survey, Requisition No. 01HQ-R01917, 17 December 2001) described a number of individual tasks necessary to meet this objective. These tasks were to a certain extent sequential and were defined to be specific, identifiable components of the stated overall objective. It was anticipated that completion of these tasks would provide the opportunity to determine the thoroughness of current procedures for the documentation of landslide-damage costs and the feasibility of retrieving future landslide-damage data through regularly kept permit or other record systems. The individual tasks defined in the work plan are as follows:

A) Identify the most landslide-prone jurisdictions in Hamilton, Clermont and Brown Counties, Ohio

B) Contact private firms to evaluate records of repair or remediation of landslide damage

C) Contact public-sector agencies to evaluate records

D) Assess kinds, quality and accessibility of landslide loss records

E) Plot locations of landslide events in Hamilton, Clermont and Brown Counties on 7.5- minute topographic maps

F) Design and develop a computerized database for capture of historic and future landslide data to include: types of landslides, causative factors, types of damage and resultant costs for remediation and stabilization

G) Analyze the quality, quantity and accessibility of landslide data

RESULTS

A) Identification of landslide-prone areas---

One of the major factors that determine the overall costs to a region or municipality for landslide prevention and/or mitigation is the amount of area that is susceptible to slope instability. In the northern Kentucky-southwestern Ohio region, the contributing factors of bedrock lithology, soil type and topography that correlate with unstable slopes have been defined in a previous study (Sowers and Dalrymple, 1980). From the results of their investigation, Sowers and Dalrymple developed a Landslide Susceptibility Map that identified and ranked areas of potential landslide susceptibility for the City of Cincinnati. Generally, it was found that the Kope and Faiview Formations, the Pate and Eden soil types and slopes greater than 20% most closely correlated with landslide occurrence. From the results of this study, four landslide susceptibility categories were established, based on the extent to which these parameters were present in an area. This concept has now been extrapolated to include all of Hamilton County, not just Cincinnati, and a preliminary study conducted during this project indicates that landslides in Clermont and Brown Counties primarily occur under similar geotechnical conditions.

B) Contact private firms---

The geotechnical engineering firms considered having significant experience in landslide investigations and design of landslide remediation projects were contacted for this task. This involved personal interviews with both engineering geologists and geotechnical

engineers. These firms were most cooperative and provided opportunities to review data on landslide occurrence, causative factors and remediation efforts and to discuss company policy on the availability of landslide-cost data and the limitations to its accessibility.

C) Contact public-sector agencies---

A broad spectrum of public-sector agencies were contacted for this study with the result that discussions were held with individuals having a broad range of both experience in and involvement with landslide remediation efforts. Those agencies that seemed to have the most applicable records on landslide costs included:

- Ohio Department of Transportation
- Brown County Engineers Office
- Clermont County Engineers Office
- Hamilton County Engineers Office
- City of Cincinnati Engineers Office
- Federal Emergency Management Agency
- Similar agencies in Kentucky, including the Kentucky Transportation Research Center

D) Assess kinds, quality and accessibility of landslide loss records---

As would be expected where a broad spectrum of firms and agencies are involved in landslide remediation activities, there is a wide range in the kinds, quality and availability of landslide-cost data. The results of this study suggest some general observations regarding the development of a landslide-cost database.

Landslide-cost data is much more readily available from public-sector agencies than from private firms. This is of course to be expected considering the confidentiality that must be respected in private practice. In addition however, it was noted that the firm doing the

landslide site investigation and remediation design in private practice may not necessarily be the firm involved in the construction phase of the project, thus may not have access to the total remediation cost. Landslide-cost records maintained by most private firms however reportedly are well documented and may be cross referenced by type of event as well as location in a computer database maintained by the firm.

In the public sector, the state Department of Transportation maintains a comprehensive database of landslide- remediation costs on state and federal highways. Landslide-remediation efforts are maintained as project files although it did not appear that the database included a category for just landslide events. The costs for landslide-remediation projects are included as part of the database. Annual maintenance costs were not considered in this database but are considered as an additional expense and part of the overall budget for maintenance expenses.

In the counties that have not experienced intense urban development (Brown, Clermont), it appeared that the county engineers' office had the most thorough documentation of landslide events, although the record was limited to county roads. Maintenance costs due to landslides are not separately identified but the costs resulting from major landslide remediation projects that must go out for bid are available for review.

Hamilton County has developed an excellent database for documentation of landslides occurring in the areas within the county engineers' jurisdiction. This includes a GIS-based system that identifies location as well as other appropriate parameters but does not include costs for remediation. The landslide-susceptibility map is used as part of the "Cut and Fill" ordinance that, where applicable, requires a study to define what caused the landslide and how it is to be remediated, but no data on costs. Cost data would be required to obtain a construction permit, but this is an anticipated cost and may not be representative of eventual cost. Costs of landslide-remediation projects and costs of annual maintenance on county road right-of-way are available from the county engineers office.

The City of Cincinnati has a landslide-documentation program to track landslides on public works (Pohana, 2002). In this program, landslides are identified and remediation costs documented on a project-by-project basis. It was noted however, that the costs documented are based on costs to the city and do not include costs met by matching funds. This is probably a limitation of all public-agency landslide-cost data documentation. This landslide-cost database does not include maintenance costs and includes only the costs of landslide remediation. The city does use the Landslide-Susceptibility Map to identify areas that are most subject to slope instability. Development projects proposed for those areas must have a geotechnical study completed as part of the permit application. It was noted however that cost data available from the construction-permit applications would not necessarily be appropriate because they represent only the cost of the actual construction and would not include the costs of investigation or design for a landslide-remediation project. In addition, they might be difficult to access because they would be filed by location, not project type.

E) Plot locations of landslides in Hamilton, Clermont and Brown Counties---

Because of the availability of databases on landslide locations available from the city of Cincinnati and from Hamilton County, it was considered unnecessary to duplicate this effort for this study. The State Geologist concurred with this decision.

F) Design and develop a computerized database for capture of landslide information---

Several of the agencies contacted, such as the City of Cincinnati, Hamilton County and the Ohio Department of Transportation already have landslide documentation programs on a computerized database in some form or another. In addition, the Kentucky Transportation Research Center (Hopkins, 2002) is now near completion of a two-year project to develop a Comprehensive Geotechnical Database that includes very thorough documentation of the details of landslide events and the costs associated with landslide and rockfall remediation. Development of a computerized database for capture of

landslide information equivalent to those currently available or in process thus was considered to be unnecessary at this time but should be implemented for a comprehensive landslide cost-of-damage study.

CONCLUSIONS

Landslides and the cost of landslide remediation have a large economic impact in southwestern Ohio. As such, a large number of private firms and public-sector agencies are involved in landslide remediation and there is a broad spectrum of data available on the costs of this remediation. The completeness of the data, the type of data collected and the availability of the data documented however depends on the needs and responsibilities of the collecting agency, thus varies greatly from source to source. There is at this time no central location or authority responsible for the documentation of landslide events or the costs of landslide remediation.

This study provided a unique opportunity to analyze the quality, quantity and accessibility of landslide data in two distinct urbanization environments. Hamilton County and the City of Cincinnati are highly urbanized, the hillsides are under great pressure for development and these political entities have the financial ability to support technical staff necessary to implement programs to minimize the losses from potential landslides. As a result, these political entities have developed comprehensive programs for documentation of landslide events and, to the extent available, have records of landslide remediation costs for public works facilities. Clermont and Brown Counties however are not as urbanized and do not have the financial resources to support similar activities. Landslide remediation is the responsibility of the county engineer for county facilities and there is no existing support structure to develop a database for the costs of landslide remediation. This is probably a very typical situation and future activities to develop a statewide database to document the costs of landslides to the economy will have to consider the structure of the various political entities involved and their ability to participate in the program. However, Cincinnati and Hamilton County do have excellent programs for the documentation of data related to landslide costs and thus would be an

excellent venue for a future study of the impact of landslides on the economy of an urbanized area. In a different context, Clermont and Brown Counties would be excellent venues for a program designed to initiate the development of a landslide documentation program to evaluate the economic impact of landslides in urbanizing areas.

It appeared however, that the Department of Transportation, because of their experience in landslide remediation and the fact that their responsibilities cross political entities, have established a landslide database for the documentation of landslide remediation efforts that is most representative of those available. Although the existing procedures for documentation of landslide related costs do not seem to be organized for an evaluation of the total cost to the economy, records for costs associated with annual maintenance and for specific remediation projects are documented and should be available for evaluation.

The cost to the economy from landslides remediated in the private sector however will be much more difficult to define. Because of the limitations noted above, it is most likely that the data available for evaluation will be an "educated guess," based on an estimate of the number of landslide remediation projects on record and an average cost for a remediation project.

The results of this study do indicate that it appears as if there is a sufficient quantity of data available on the costs of landslide remediation so that it would be possible to determine a reasonable estimation of the overall economic impact of landslides to this area. The results also indicate however that the type, quality and availability of this information does vary considerably and that it would consist primarily of direct costs, thus there would be the potential for basing the report on an incomplete or not thoroughly representative database.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

A presentation of specific recommendations for further investigation based on the conclusions of this investigation would help build a case for additional federal funding of landslide-cost estimation projects. For example, a plan could be presented to create a landslide-cost/information database for Hamilton County/City of Cincinnati that is populated by querying databases already established, or to be established, by the City of Cincinnati, Hamilton County, and the Ohio Department of Transportation.

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Ohio Department of Natural Resources

BOB TAFT, GOVERNOR SAMUEL W. SPECK, DIRECTOR

Division of Geological Survey
Thomas M. Berg, Chief

September 9, 2002

Dr. James F. Davis
State Geologist and Director
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Dear Jim:

Here is Dr. John Rockaway's report of investigations for documentation of annual landslide damage in Hamilton, Clermont, and Brown Counties, Ohio. Dr. Rockaway, Professor of Geology at Northern Kentucky University, served as contractor to both the Ohio Geological Survey and the Kentucky Geological Survey for each survey's respective portion of the U.S. Geological Survey/Association of American State Geologists pilot project for documentation of landslide-damage losses.

Thank you for your hard work in directing this pilot project. I look forward to hearing if opportunities for follow-up investigations develop.

Sincerely yours,

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c: Dennis N. Hull

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