2.4 WINTER STORM

Canadian and Arctic cold fronts that push cold temperatures, ice, and snow into the State generally cause winter storms, blizzards, and ice storms in Ohio. Severe winter weather in Ohio consists of freezing temperatures and heavy precipitation, usually in the form of snow, freezing rain, or sleet. Severe winter weather affects all parts of the State.

Blizzard conditions occur when the following conditions last three hours or longer:

35 mph or greater wind speeds,

considerable snowfall and blowing snow bringing visibility below ¼ mile, and

temperatures of 20º F or lower.

Severe blizzards have wind speeds exceeding 45 mph, visibility near zero, and temperatures of 10º F or lower.

While Ohio residents and governments are accustomed to handling winter storm events, occasional extreme events can make conditions dangerous and disruptive. Heavy snow volume makes snow removal difficult. Trees, cars, roads, and other surfaces develop a coating of ice, making even small accumulations of ice extremely hazardous to motorists and pedestrians. The most prevalent impacts of heavy accumulations of ice are slippery roads and walkways that lead to vehicle and pedestrian accidents; collapsed roofs from fallen trees and limbs from heavy ice and snow loads; and felled trees, telephone poles and lines, electrical wires, and communication towers. As a result of severe ice storms, telecommunications and power can be disrupted for days.

The northeastern portion of Ohio near the Great Lakes experiences what is known as “lake-effect snow” (see Figure 2.4.a). As cold air passes over the relatively warm waters of the large lakes, the weather system absorbs moisture and heat, and releases this in the form of snow. Lake effect snowfall intensity is affected by:

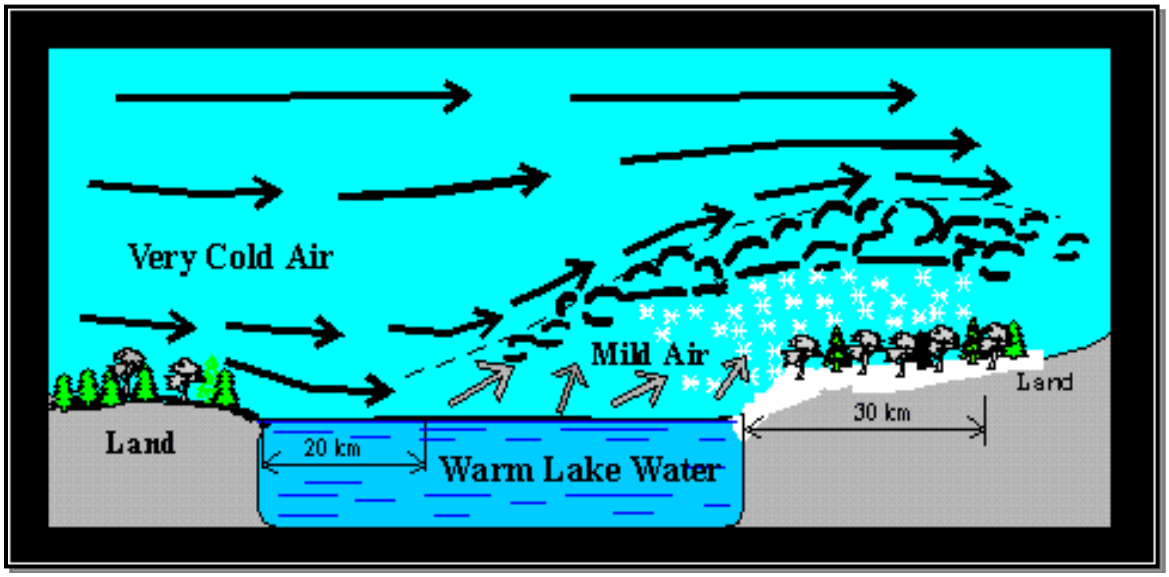
the contrast between lake and air temperatures,

the distance air has traveled over water, known as the fetch, and

the regional weather conditions-- a snow storm’s maximum penetration inland will generally be greatest during late autumn/early winter and shortest during the late winter.

Figure 2.4.a

Generation of Lake Effect Snow



Source: The Weather Doctor, http://www.islandnet.com/~see/weather/elements/lkefsnw2.htm

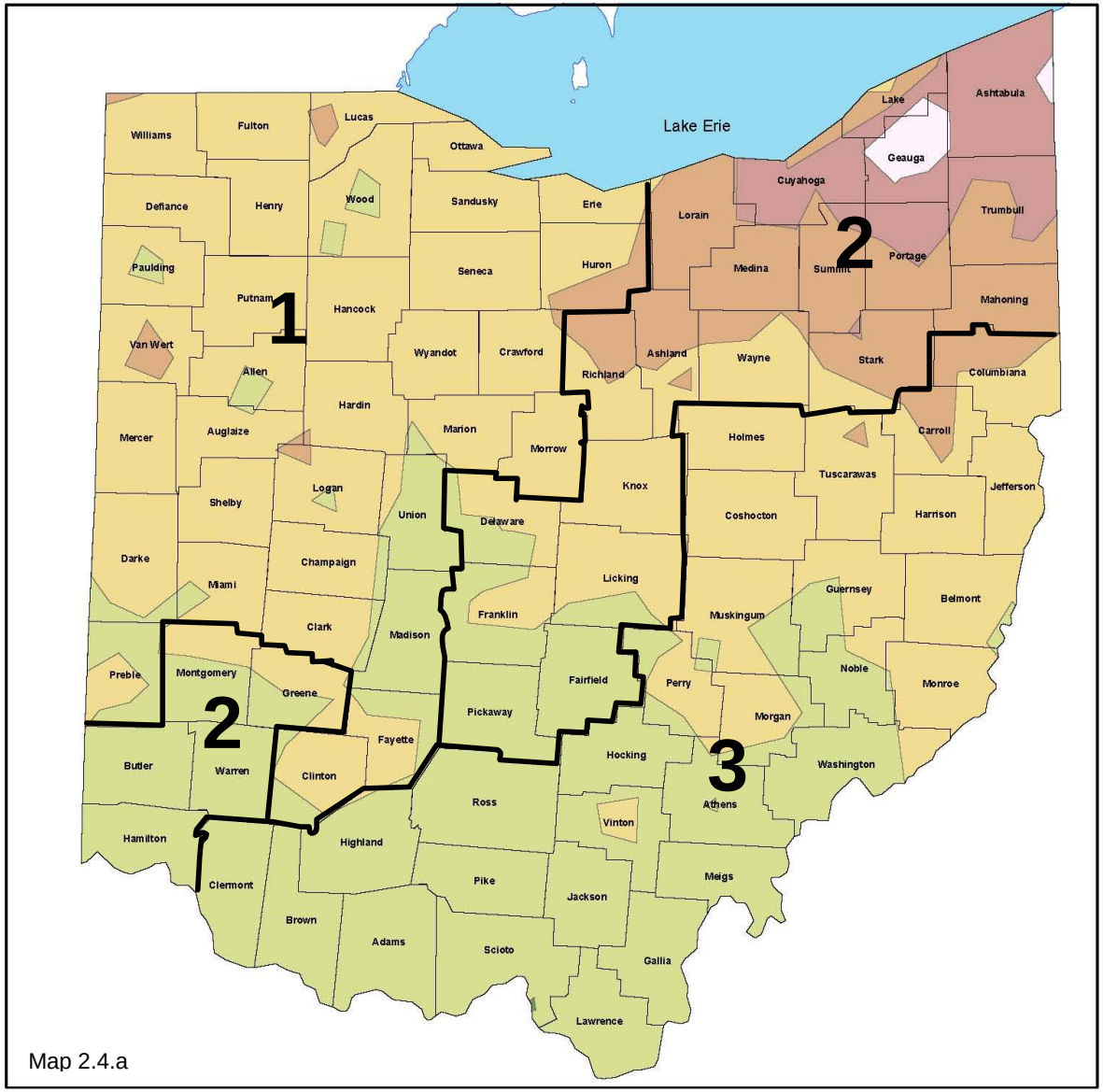
Lake-effect snowstorms have been known to cause continuous snowfall for as long as 48 hours over a sharply defined region. One single, intense local storm cell can yield as much as 48 inches of light-density snow in 24 hours or less. Consequently, snowfalls can vary greatly, with areas of deep snowfall adjacent to areas with relatively little snow.

Snow and strong easterly wind conditions ahead of a warm front usually cause ice storms. The snow, however, changes temporarily to sleet and then to rain that freezes when it hits the ground, covering exposed surfaces with a layer of ice. Local accumulations of ice may be heavy if the storm halts over a region for extended periods of time. Ice storms lasting more than 12 hours usually produce ice accumulations several inches thick and affect an area that may range from a few square miles to areas covering several states. The typical ice storm swath is 30 miles wide and 300 miles long.

RISK ASSESSMENT

Location

Winter storms are considered to be non-spatial hazards. As a result, it is difficult to determine the actual location of the damage that may result from a winter storm event. In an effort to conquer this limitation the annual mean snow depth from 1961 to 2003 was mapped (see Map 2.4.a).



Map 2.4.a

State of Ohio
Annual Mean Snow Depth
1961-2003

Legend

Snow Depth

- 6.1 - 12.0 Inches
- 12.1 - 24.0 Inches
- 24.1 - 36.0 Inches
- 36.1 - 48.0 Inches
- 48.1 - 72.0 Inches
- > 72.0 Inches

The NOAA Storm Events Database contains data from the followingsources: All Weather Events from 1993 - 1995, as entered intoStorm Data. (Except 6/93 - 7/93, which is missing) (No Latitude/Longitude) All Weather Events from 1996 - Current, as entered into Storm Data. (Including Latitude/Longitude).

Produced by URS and Ohio EMA
Disclaimer: The information presented on this map has been compiled through various sources, the Ohio EMA does not guarantee its accuracy.

Source: HAZUS-MH

N

0 15 30 60
Miles

Most of the counties in Region 1 have experienced a mid level (24.1" – 36") of snow in the time frame specified. However, Lucas, Van Wert, Auglaize, Logan, and Hardin counties have sparse areas where higher snow levels have been experienced.

Historically, Region 2 has experienced the highest annual mean snow depth. The Region contains all of the counties that have experienced the highest annual mean snow depth, with parts of Geauga and Ashtabula counties having the highest in the state, and Lake, Cuyahoga, Portage, and Trumbull having the second highest in the state.

The largest number of counties within the lower portion of Region 3 has had a moderate annual mean snow depth. The upper section of the region has, for the most part, a medium depth with parts of Columbiana, Carroll, and Tuscarawas having higher depths than other counties in the region. As a result, it appears that the lower portions of this region have the least chance of receiving a significant event than upper portions of the region.

Past Occurrences

Ohio experienced more than 270 severe winter storms between 1925 and 2003. Several storms were notable and, since 1964, two involved federal declarations.

In January 1978, the Great Blizzard of 1978 closed homes and businesses for one week and caused the deaths of 51 people. Wind gusts reached 69 mph and caused blowing and drifting snow. The NWS classified the Great Blizzard of 1978 as a severe blizzard.

In February 1994, heavy freezing rain and sleet fell across southern and central Ohio counties. Ice accumulations averaged 0.75 - 2 inches, leading to downed trees and power lines. Supplies of salt, already low from previous storms, were not readily available in some areas, hindering ice removal. Very low temperatures, in the teens and single digits, also slowed ice removal. Travel on foot and by vehicle was treacherous, producing a record number of injuries, mostly due to falls. Six vehicular fatalities and one death due to cold exposure occurred.

In January 2002, low pressure passed to the northwest of Ohio. Freezing rain developed to the north of a warm front extending east from this low. Up to one-half inch of ice accumulation occurred in Lucas County with an excess of one-quarter inch of ice in Wood, Ottawa and Sandusky Counties. Scattered power outages resulted from downed power lines and trees. In Lucas County alone, over 400 trees and limbs were downed. This ice storm caused damage in the amount of $3 million.

In February 2003, warm air currents in southeastern Ohio caused the precipitation to accumulate as heavy ice. This ice storm was known as the Ironton Ice Storm Incident. This ice adhered to the branches of trees and formed a thick layer, with some people reporting two to five inches of accumulation. As

the ice accumulated, the branches began to snap. In some instances, the weight of the ice caused tree trunks to break completely, and in other cases trees became uprooted by the weight of the ice in their crowns. Some trees broke off at the crown, while on others, the side branches snapped. Branches and trees fell across roadways and electrical lines throughout Gallia, Lawrence, and Scioto Counties. A large portion of Lawrence County went without electric or phone service for weeks. Large areas of the County remained inaccessible, until roads were cleared. Damage to District facilities, roads, and trails appeared to be extensive. Early estimates indicated that 75 to 80 percent of the District's 131 miles of trails were impacted. In March 2003 this event was federally declared as DR-1453 for 31 of the state's 88 counties with the largest number of those counties residing in Region 3.

Probability of Future Events

Map 2.4.a depicts National Climatic Data Center figures of Ohio's annual mean snow depth for the years 1961 to 2003. Southern portions of Ohio have mean snow depths of 12 to 24 inches and central Ohio has between 24 and 36 inches. However, the northeastern corner of the state has mean snow depths of 48 to more than 72 inches. In terms of probability, the snow depth with a 5% chance of being exceeded in any given year is between 50 and 60 inches in parts of Ohio. However, the vast majority of Ohio has the same chance of exceeding only 10 to 30 inches. The higher snowfall totals and probability for the northeastern portion of Ohio can be attributed to the lake effect snows caused by the area's proximity to the Great Lakes.

Global climate change may have an impact on the probability of future events; however, it is unclear as to the extent of this impact.

LHMP Data

Cuyahoga County. The Countywide All Natural Hazards Mitigation Plan of December 2003 states that severe winter storms are second on their hazard identification and risk assessment with 51 events from 1950 to 2003 costing $40,960,000. The frequency of winter storms is high as the county "sees numerous winter storms each year" due to lake effect snow. This type of storm also produces secondary effects such as flooding, ice jams on streams and rivers, and debris.

Lake County. The Lake County Hazard Risk Assessment of July 2006 indicates there have been 74 severe winter storms from 1950 to 2003. These types of storms are known to expend 15% of the snow removal budget and have left 185,000 customers without power. After extensive examination and spreadsheet calculations, loss estimates show $83,866,400 in structure damage, 4,715,400 for contents and business functional loss of 870,070 for a total of $89,451,870.

Ashtabula County. The HIRA of the Ashtabula County Countywide All Natural Hazards Mitigation Plan of January 2006 examines subcategories of winter storms: blizzards, ice storms, lake effect snow on the southeastern Lake Erie Snow Belt and extreme cold. From 1993 to 2005, there were 88 severe winter

events causing a total of $200.2 million in property and crop damage. The frequency is the expectation of eight storms in any given year.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

Methodology

The 10-year winter storm losses (1993-2003) for each county provided the basis for estimating potential vulnerability and losses. To yield the per capita 10-year damage total for each county, the total damage for the decade was divided by the 2001 population. That figure divided by ten, resulted in the annual per capita damage figure for severe winter storms in each county (in raw dollar unadjusted for inflation). This is the figure that appears in the right column in Table 2.4.a.

Results

Using 2001 population estimates and winter storm loss data spanning a decade, the state can expect an annual winter storm loss of $13.07 per capita, which equates to a statewide winter storm loss of approximately $1,481,380,006 (see Table 2.4.a). The 10-Year loss includes all residential, commercial, governmental structures, as well as infrastructure and public facilities for each county.

Table 2.4.a

Estimate of Potential Losses to Winter Storms by Region

Region 1

County	2001 Pop.	10-Year Winter Storm Losses	Per-Capita Annual Winter Storm Losses
Allen	108,522	$1,375,000	$1.27
Auglaize	46,453	$15,651,000	$33.69
Champaign	39,210	$16,551,000	$42.21
Clark	143,969	$16,551,000	$11.50
Clinton	41,277	$17,536,000	$42.48
Crawford	46,695	$13,196,000	$28.26
Darke	53,178	$71,151,000	$133.80
Defiance	39,195	$6,250,000	$15.95
Erie	79,321	$19,598,000	$24.71
Fayette	28,387	$15,361,000	$54.11
Fulton	42,334	$12,367,000	$29.21
Hancock	71,745	$14,658,000	$20.43
Hardin	31,945	$1,405,000	$4.40
Henry	29,090	$1,812,000	$6.23
Huron	59,775	$15,986,000	$26.74
Logan	46,115	$1,875,000	$4.07
Lucas	454,029	$27,592,000	$6.08
Madison	40,158	$16,651,000	$41.46
Marion	65,639	$11,841,000	$18.04
Mercer	40,886	$15,651,000	$38.28
Miami	99,329	$16,551,000	$16.66
Morrow	32,319	$14,686,000	$45.44
Ottawa	41,036	$21,667,000	$52.80
Paulding	20,163	$1,425,000	$7.07
Preble	42,344	$16,556,000	$39.10
Putnam	34,741	$1,405,000	$4.04
Sandusky	61,653	$21,837,000	$35.42
Seneca	58,314	$18,071,000	$30.99
Shelby	48,233	$1,375,000	$2.85
Van Wert	29,432	$1,401,000	$4.76
Williams	39,200	$11,255,000	$28.71
Wood	121,680	$21,487,000	$17.66
Wyandot	22,956	$10,006,000	$43.59
TOTAL	**2,159,323**	**$470,780,000**	**$21.80**

Region 2

County	2001 Pop.	10-Year Winter Storm Losses	Per-Capita Annual Winter Storm Losses
Ashland	52,786	$19,821,000	$37.55
Ashtabula	102,729	$42,823,000	$41.69
Butler	335,992	$18,686,000	$5.56
Cuyahoga	1,384,252	$43,876,000	$3.17
Delaware	118,215	$16,951,000	$14.34
Fairfield	125,109	$19,961,000	$15.95
Franklin	1,081,784	$16,125,000	$1.49
Geauga	92,294	$47,743,000	$51.73
Greene	148,530	$16,551,000	$11.14
Hamilton	838,134	$17,886,000	$2.13
Knox	55,250	$17,726,000	$32.08
Lake	227,324	$46,870,000	$20.62
Licking	149,080	$16,711,000	$11.21
Lorain	285,798	$42,236,000	$14.78
Mahoning	254,810	$22,344,000	$8.77
Medina	154,718	$20,481,000	$13.24
Montgomery	553,579	$16,551,000	$2.99
Pickaway	52,840	$14,961,000	$28.31
Portage	153,056	$40,279,000	$26.32
Richland	128,549	$13,726,000	$10.68
Stark	378,098	$32,379,000	$8.56
Summitt	542,899	$47,981,000	$8.84
Trumbull	223,513	$42,459,000	$19.00
Warren	168,229	$17,986,000	$10.69
Wayne	112,274	$17,534,000	$15.62
TOTAL	**7,719,842**	**$670,647,000**	**$8.69**

Region 3

County	2001 Pop.	10-Year Winter Storm Losses	Per-Capita Annual Winter Storm Losses
Adams	27,225	$26,381,000	$96.90
Athens	62,792	$11,415,000	$18.18
Belmont	69,605	$838,000	$1.20
Brown	43,425	$27,860,000	$64.16
Carroll	29,011	$6,635,000	$22.87
Clermont	180,970	$17,891,000	$9.89
Columbiana	111,684	$1,435,000	$1.28
Coshocton	36,803	$5,395,000	$14.66
Gallia	30,929	$12,710,000	$41.09
Guernsey	40,899	$1,835,000	$4.49
Harrison	15,813	$895,000	$5.66
Highland	40,875	$17,000,006	$41.59
Hocking	28,241	$19,945,000	$70.62
Holmes	39,539	$21,714,000	$54.92
Jackson	32,743	$12,655,000	$38.65
Jefferson	72,705	$335,000	$0.46
Lawrence	62,017	$12,055,000	$19.44
Meigs	22,920	$12,660,000	$55.24
Monroe	15,141	$6,400,000	$42.27
Morgan	14,961	$5,057,000	$33.80
Muskingum	84,783	$6,395,000	$7.54
Noble	14,052	$6,340,000	$45.12
Perry	34,212	$6,130,000	$17.92
Pike	27,982	$26,900,000	$96.13
Ross	73,437	$22,016,000	$29.98
Scioto	78,428	$26,351,000	$33.60
Tuscarawas	91,521	$7,135,000	$7.80
Vinton	12,953	$6,410,000	$49.49
Washington	62,798	$11,165,000	$17.78
TOTAL	**1,458,464**	**$339,953,006**	**$23.31**

STATEWIDE TOTAL

Population	Losses	Per Capita
11,337,629	**$1,481,380,006**	**$13.07**

The total 10-year winter storm loss for Region 1 is $470,780,000 which is the second highest in the state. Within the region, Darke County historically has had the highest 10-year loss at a total of $71,151,000 affecting approximately 53,178 people (see Table 2.4.a). Allen and Shelby counties have historically had the lowest 10-year loss at $1,375,000 in each county affecting 108,522 people in Allen County and 48,233 in Shelby County (see Table 2.4.a).

Region 2 has the highest 10-year winter storm loss in the state at a total of $670,647,000. Within the region, Summit County has historically had the highest 10-year loss at a total of $47,981,000 affecting approximately 542,899 people (see Table 2.4.a). The second highest is Geauga County with a total loss of $47,743,000 affecting approximately 92,294 people (see Table 2.4.a). Richland County has historically had the lowest 10-year loss at $13,726,000 affecting 128,549 people (see Table 2.4.a).

Region 3 has historically had the lowest 10-year winter storm loss. In total there has been a loss of $339,953,006, which has affected a population of approximately 1,458,464 persons. Brown County has had experienced the highest 10-year loss at a total of $27,860,000 affecting approximately 42,425 people (see Table 2.4.a). Jefferson County has had the least 10-year loss to winter storms at $335,000, which affected approximately 72,705 persons (see Table 2.4.a).

VULNERABILITY AND ESTIMATE OF POTENTIAL LOSSES OF STATE OWNED CRITICAL FACILITIES

Methodology

The methodology to determine the vulnerability of state-owned structures and critical facilities to winter storms were identified in Section 2.1.

Results

Since winter storms are non-spatial hazards and have the potential to affect all state-owned structures and critical facilities in the state this section defaults to the overall discussion of state-owned structures and critical facilities identified in Section 2.1, Table 2.1.a, and Appendix C.

2.5 LANDSLIDE

A landslide is the downward and outward movement of soil and rock material on slopes. There are three main types of landslides that occur in Ohio:

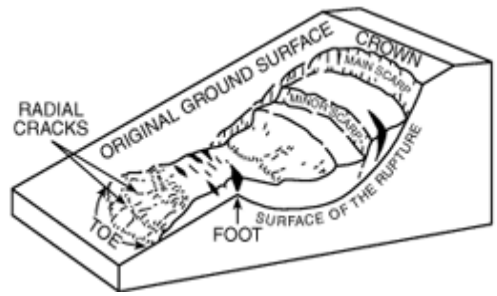


Figure 2.5.a

Major Components of a Rotational Slump.

Source: GeoFacts No. 8, ODNR, http://www.ohiodnr.com/geosurvey/geo_fact/geo_f08.htm

- *Rotational Slump*: the movement of a mass of weak rock or sediment as a block unit along a curved slip plane (Figure 2.5.a). In Ohio, these types of slides commonly involve hundreds of thousands of cubic yards of material and extend for hundreds of feet. The crown or head, located in the upper section of the ground surface, consists of one or more rupture zones (scarps) that form a stair-step pattern of displaced blocks. The surfaces of these blocks are commonly rotated backward (reverse slope) and form depressions along which water may accumulate, creating small ponds or swampy areas. Trees on these blocks may be inclined upslope, toward the top of the hill. The lower, downslope end (toe) of a rotational slump is a fan-shaped, bulging mass of material characterized by radial ridges and cracks. Trees on this portion of the landslide may be inclined at strange angles, giving rise to the descriptive terms "drunken" or "staggering" forest. Rotational slumps may develop comparatively slowly and commonly require several months or even years to reach stability; however, on occasion, they may move rapidly, achieving stability in only a few hours.
- *Earthflow:* involves rock, sediment, or weathered surface materials moving downslope in a mass. The most common form of earth movement in Ohio, earthflow involves a smaller area than a rotational slump and forms a hummocky topography of ridges and swales. Trees may be inclined at odd angles throughout the length of an earthflow. Earthflows are most common in weathered surface materials, do not necessarily indicate weak rock, and are also common in unconsolidated glacial sediments. The rate of movement of an earthflow is generally quite slow.
- *Rockfall:* an extremely rapid, potentially dangerous downslope movement of earth materials. Large blocks of massive bedrock suddenly become detached from a cliff or steep hillside and free fall in a rolling, bounding, or sliding manner downslope. Most rockfalls in Ohio involve massive beds of sandstone or limestone. Surface water seeps into joints or cracks in the rock, increasing its weight and causing expansion of joints in freezing temperatures, thus prying blocks of rock away from the main cliff. Weak

and easily eroded clay or shale beneath the massive bed is an important contributing factor to rockfall.

One or more of the following conditions contribute to the occurrence of landslide events:

- *Steep slope:* All landslides move downslope under the influence of gravity. Therefore, steep slopes, cliffs, or bluffs are a required element leading to a landslide, especially in conjunction with one or more of the conditions listed below.
- *Jointed rocks:* Fractures in rocks allow surface moisture to penetrate and weaken it. When the moisture freezes, it pries the rock masses apart at the joint.
- *Fine-grained, permeable rock or sediment:* Fine rock particles are particularly conducive to landslide development because large amounts of moisture can enter them easily, increasing the material's weight, reducing the bonding strength of individual grains, and dissolving grain-cementing materials.
- *Clay or shale units subject to lubrication*: Groundwater penetration of clay or shale can lead to a loss of binding strength between individual mineral grains and subsequent failure. Excess groundwater lubricates the contact between susceptible units and underlying materials and thus, promotes failure.
- *Large amounts of water*: Periods of heavy rainfall, excess snowmelt, or other events where water is accumulated saturate the zone above the normal water table and cause a landslide.

In addition to the conditions noted above, a landslide requires a triggering mechanism to initiate downslope movement. Several events or circumstances, many of them human-caused, can trigger landslides, including:

- *Vibrations* such as those from human-caused like blasting or the passing of a heavy truck or from natural events like earthquakes, although no such occurrence has been documented in Ohio.
- *Oversteepened slope* caused by undercutting by stream or wave erosion, by human construction activities, or by the addition of fill material to the upper portion of a slope, disturb the equilibrium of a stable slope and cause the angle of stability to be exceeded.
- *Increased weight on a slope* caused by the addition of large amounts of fill, the construction of a building or other structure, or an unusual increase in precipitation, either from heavy rains or from artificial alteration of drainage patterns.
- *Removal of vegetation and trees*, because of the loss of roots which tend to hold the rock or sediment in place and soak up excess moisture.

Areas in southern and eastern Ohio have several conditions that can lead to the occurrence of landslide events. Thick deposits of broken and weathered bedrock fragments called colluvium, and lake silts, create slopes that are vulnerable to failure (among other geological factors). In addition, redbeds, soft shales that weather rapidly and slip, slide, and flow to form gentle contours that are quickly grassed over, have long presented landsliding conditions in the Appalachian Plateau.

RISK ASSESSMENT

Location

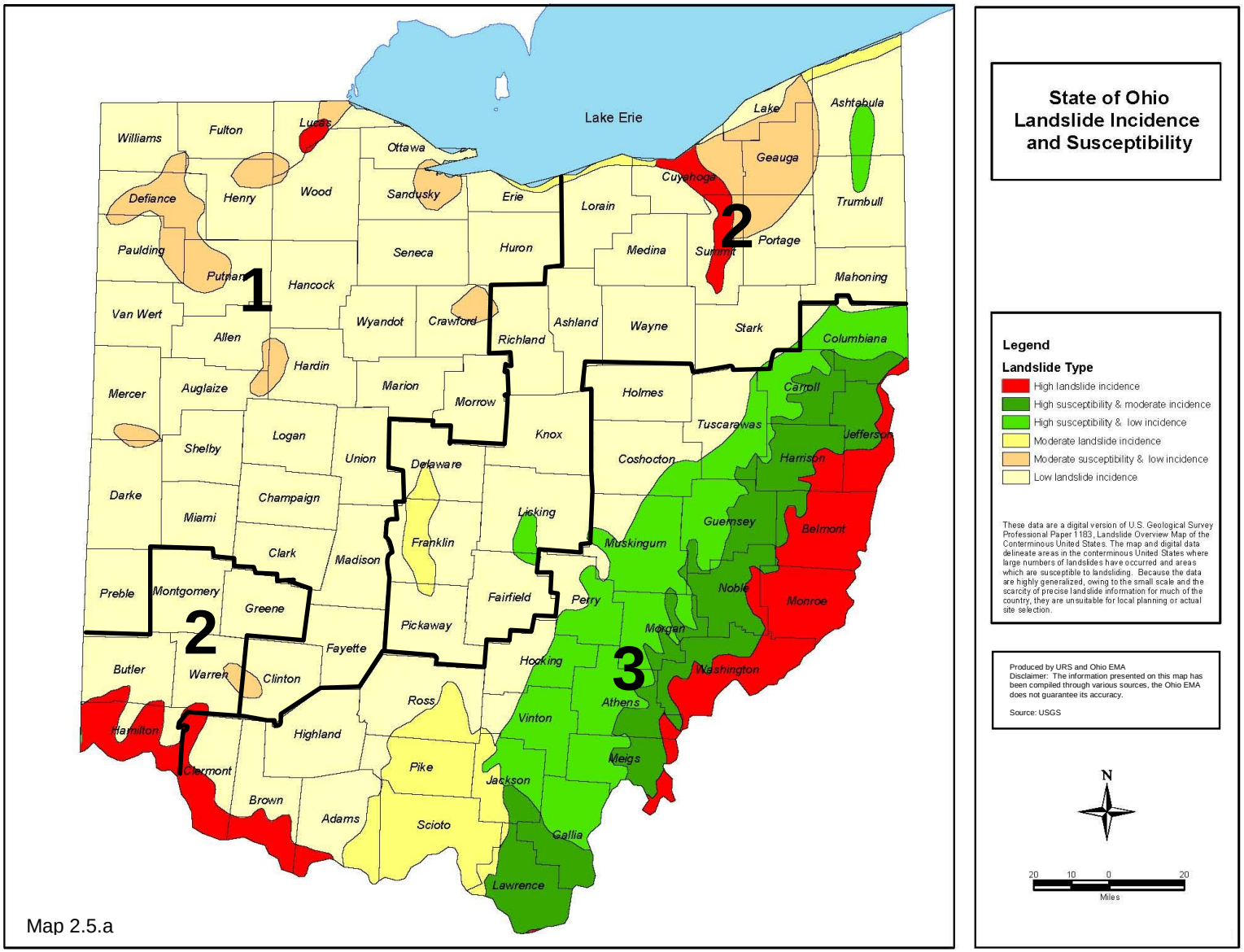
Region 1 primarily has a low landslide incidence. The most notable exception to this is Lucas County, which is reported to have a high landslide incidence. Several counties, Defiance, Paulding, Hardin, Mercer, Darke, Ottawa, Sandusky, Allen, Auglaize and Crawford have been identified as having a moderate susceptibility and low incidence (see Map 2.5.a).

In a similar fashion as Region 1, Region 2 also has a primary low landslide incidence. Within Region 2, Butler, Hamilton, Cuyahoga, and Summit are all identified as having a high landslide incidence, which does not reflect the regional trend. Additionally, Licking and Fairfield counties are identified as having a high susceptibility and low incidence (see Map 2.5.a).

Region 3 is identified as having the most area susceptible to landslide (*i.e.*, the Appalachian Plateau). The largest part of the region has a high susceptibility with a low or moderate incidence. However, most of Belmont and Monroe counties have a high landslide incidence with parts of Jefferson, Harrison, Washington, Athens, Meigs, Brown, and Clermont Counties having a high incidence as well (see Map 2.5.a).

LHMP Data

While Region 3 and parts of Region 2 have potential high susceptibility and incidence to landslide, Hamilton County and the City of Cincinnati has some of the highest cost per capita in the United States for historical landslide damages. According to the Hamilton County LHMP, landslides are considered to be their fourth area of concern for natural hazards, following flooding (number one), tornadoes, and severe storms. County officials based their decision on the lack of building regulations in areas deemed high hazard for landslides. Also, the removal of vegetation in riparian corridors can increase the landslide potential, and this is not regulated systematically. Finally, the lack of public education and awareness limits communities' understanding of such geophysical and regulatory relationships. Hamilton County's goal to mitigate landslide events involves identification of methodologies used by other, similar communities, and they want to increase public awareness through outreach initiatives.


State of Ohio
Landslide Incidence
and Susceptibility
Legend
Landslide Type
High landslide incidence
High susceptibility & moderate incidence
High susceptibility & low incidence
Moderate landslide incidence
Moderate susceptibility & low incidence
Low landslide incidence
These data are a digital version of U.S. Geological Survey Professional Paper 1183, Landslide Overview Map of the Conterminous United States. The map and digital data delineate areas in the conterminous United States where large numbers of landslides have occurred and areas which are susceptible to landsliding. Because the data are highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, they are unsuitable for local planning or actual site selection.
Produced by URS and Ohio EMA
Disclaimer: The information presented on this map has been compiled through various sources, the Ohio EMA does not guarantee its accuracy.
Source: USGS
N
20 10 0 20
Miles
Lake Erie
Williams
Fulton
Lucas
Ottawa
Defiance
Henry
Wood
Sandusky
Erie
Lorain
Cuyahoga
Lake
Geauga
Ashtabula
Trumbull
Portage
Summit
Medina
Huron
Seneca
Paulding
Putnam
Hancock
Mahoning
Van Wert
Allen
Wyandot
Crawford
Richland
Ashland
Wayne
Stark
Columbiana
Hardin
Marion
Morrow
Holmes
Carroll
Mercer
Auglaize
Knox
Tuscarawas
Jefferson
Logan
Shelby
Union
Delaware
Coshocton
Harrison
Darke
Champaign
Miami
Licking
Guernsey
Belmont
Clark
Madison
Franklin
Muskingum
Preble
Montgomery
Greene
Fairfield
Perry
Noble
Monroe
Pickaway
Morgan
Fayette
Butler
Warren
Clinton
Hocking
Washington
Ross
Athens
Hamilton
Highland
Vinton
Meigs
Clermont
Pike
Jackson
Brown
Adams
Scioto
Gallia
Lawrence
1
2
2
3

Map 2.5.a

Past Occurrences

Ohio has had a long history of damage from landslides. Geologists at the University of Cincinnati report that the Cincinnati metropolitan area has one of the highest per capita costs of landslide damage of any metropolitan area in the United States. As shown by Figure 2.5.b, landslides in this area damage or destroy buildings, roads, and public utilities, and cost millions of dollars annually in lost productivity and repairs.

While landslides have been problematic in Cincinnati since the early to mid 1800s, documentation is limited. As the city began to expand and infrastructure was improved in the early 1900s, landslide hazards became better documented.

When large construction projects such as highway construction, began in the 1950s, geotechnical concerns received little consideration, and major landslides soon developed. In the 1960s and 1970s, landslides were so frequent that the area was included in a study of this hazard by the U. S. Geological Survey. The study found that landslide damages in Hamilton County, primarily due to public road construction, averaged more than $5 million each year between 1973 and 1978. Well-publicized landslides that occurred in the 1970s included those along Columbia Parkway, Hillside Avenue, Delhi Pike, and Huffman Court.

Figure 2.5.b

Clifton Avenue Construction

Clifton Ave -- Construction of parking lot on top of old slide produced widespread failure. University of Cincinnati Landslide Gallery, http://homepages.uc.edu:8000/%7Emaynarjb/362/Images/CliftonAveParkLot.htm

In 1996, Hamilton County experienced a series of rotational slump slides in soil and shale. The damage exceeded $10 million, making it one of Ohio's most damaging recent slides.

Rockfalls have also caused dangerous conditions. The Ohio Department of Natural Resources reports that on Christmas Eve in 1986, an individual traveling in an automobile was killed by falling rock along U.S. Route 52 in Lawrence County in southern Ohio.

Landslides can be triggered by heavy rainfall and flooding, leading to multiple disasters in the same location. The most recent example is from January 2004 when the State received a disaster declaration due to the severe storms, flooding, mudslides, and landslides that struck the southeastern counties of Ohio. Individual assistance was made available in the counties of Franklin, Jefferson, Licking, Morgan, Ross, Tuscarawas, and Washington. Federal funding also was available to State and eligible local governments on a cost-sharing basis for the repair or replacement of public facilities damaged by the severe storms, flooding, mudslides, and landslides in the counties of Athens, Belmont, Guernsey, Harrison, Jefferson, Monroe, Morgan, Noble, Perry, Ross, Tuscarawas, and Washington.

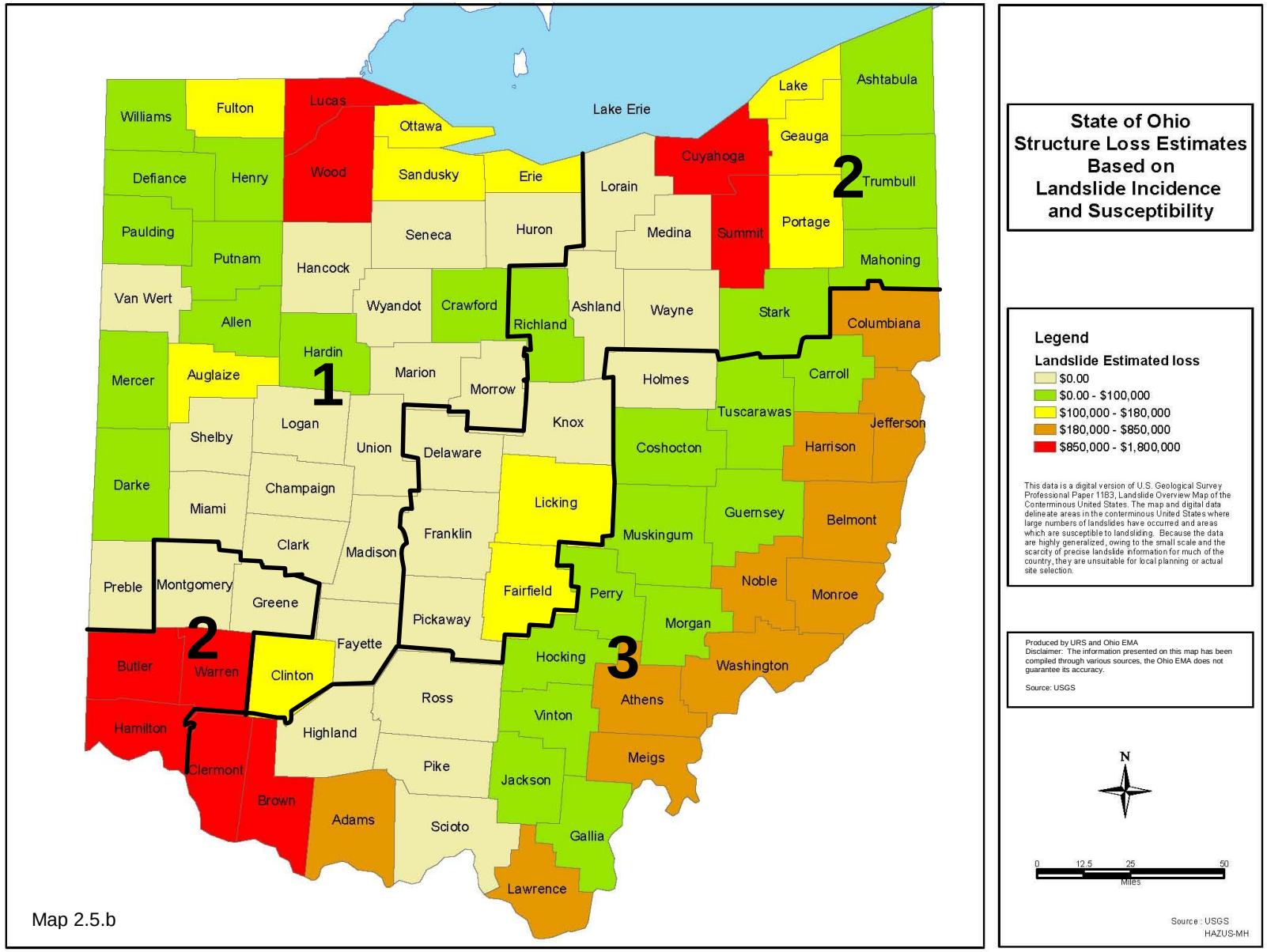
Probability of Future Events

Region 1 and Region 2 probability of future occurrence is illustrated on Map 2.5.b. Because Ohio geologists do not calculate exceedance for landslides, FEMA's MHIRA document reports were used to determine the probability of future landslide incidences for Region 3, and it is identified as having the highest risk to the hazard. FEMA's MHIRA document reports that USGS studies confirm Ohio's landslide and debris flow potential. The MHIRA indicates that the hilly and mountainous terrain of the southern and southeastern portions of Ohio has high landslide potential and high landslide susceptibility (see Table 2.5.a).

Table 2.5.a

ODOT District No.	District Counties	Average Annual Slides
8	Butler, Clermont, Clinton, Greene, Hamilton, Preble, & Warren	15
9	Adams, Brown, Highland, Jackson, Lawrence, Pike, Ross, & Scioto	12
10	Athens, Gallia, Hocking, Meigs, Monroe, Morgan, Noble, Vinton & Washington	180-200
11	Belmont, Carroll, Columbiana, Harrison, Holmes, Jefferson & Tuscarawas	20

Source: ODOT (Div. of Engineering Policy)


State of Ohio
Structure Loss Estimates
Based on
Landslide Incidence
and Susceptibility
Legend
Landslide Estimated loss
$0.00
$0.00 - $100,000
$100,000 - $180,000
$180,000 - $850,000
$850,000 - $1,800,000
This data is a digital version of U.S. Geological Survey Professional Paper 1183, Landslide Overview Map of the Conterminous United States. The map and digital data delineate areas in the conterminous United States where large numbers of landslides have occurred and areas which are susceptible to landsliding. Because the data are highly generalized, owing to the small scale and the scarcity of precise landslide information for much of the country, they are unsuitable for local planning or actual site selection.
Produced by URS and Ohio EMA
Disclaimer: The information presented on this map has been compiled through various sources, the Ohio EMA does not guarantee its accuracy.
Source: USGS
N
0 12.5 25 50
Miles
Source : USGS
HAZUS-MH
Lake Erie
Williams
Fulton
Lucas
Ottawa
Defiance
Henry
Wood
Sandusky
Erie
Lorain
Cuyahoga
Lake
Geauga
Ashtabula
Trumbull
Portage
Summit
Medina
Huron
Seneca
Paulding
Putnam
Hancock
Mahoning
Van Wert
Allen
Wyandot
Crawford
Richland
Ashland
Wayne
Stark
Columbiana
Mercer
Auglaize
Hardin
Marion
Morrow
Holmes
Carroll
Tuscarawas
Jefferson
Harrison
Shelby
Logan
Union
Delaware
Knox
Coshocton
Darke
Champaign
Miami
Licking
Guernsey
Belmont
Clark
Madison
Franklin
Muskingum
Preble
Montgomery
Greene
Fairfield
Perry
Noble
Monroe
Pickaway
Morgan
Fayette
Butler
Warren
Clinton
Hocking
Washington
Ross
Athens
Hamilton
Highland
Vinton
Meigs
Clermont
Pike
Jackson
Brown
Adams
Scioto
Gallia
Lawrence
1
2
2
3

Map 2.5.b

VULNERABILITY ANALYSIS & LOSS ESTIMATION

Methodology

The potential loss estimates, which do not include lifelines, are based upon high-level assumptions derived from the landslide history in each county. First, the counties were placed in three categories of potential loss, based upon landslide risk. The data come from the USGS's publication *Costly Landslide Events in the United* States. The highest risk level found anywhere in the county was applied to the whole county. For example, a county that is mostly low risk with a small amount of territory subject to high risk was designated as high risk. A county was designated as low risk only if the entire county was at a low risk for landslide. Next, since it's not possible to determine which individual structures are likely to be lost, the average structure value in each county was used to determine potential losses.

Results

The potential losses in a *High Potential Loss* county equal the average structure value in the county times ten potentially lost structures. *Medium Potential Losses* equal the average structure value in the county times one potentially lost structure. *Low Potential Losses* equal the average structure value in the county times zero potentially lost structures (*i.e.,* low landslide potential results in potential losses due to landslides). Table 2.5.b depicts estimated losses based on landslide incidence and susceptibility.

Table 2.5.b

Estimate of Potential Losses to Landslide by Region

Region 1				Region 2				Region 3			
County	Average Structure Value	Potential Loss	Estimated Loss	County	Average Structure Value	Potential Loss	Estimated Loss	County	Average Structure Value	Potential Loss	Estimated Loss
Allen	$89,013	Medium	$89,013	Ashland	$99,167	Low	$0	Adams	$62,190	High	$621,901
Auglaize	$103,509	Medium	$103,509	Ashtabula	$94,785	Medium	$94,785	Athens	$73,953	High	$739,530
Champaign	$102,764	Low	$0	Butler	$118,808	High	$1,188,077	Belmont	$64,053	High	$640,528
Clark	$115,714	Low	$0	Cuyahoga	$173,721	High	$1,737,211	Brown	$85,457	High	$854,572
Clinton	$105,185	Medium	$105,185	Delaware	$178,692	Low	$0	Carroll	$88,152	Medium	$88,152
Crawford	$84,341	Medium	$84,341	Fairfield	$118,382	Medium	$118,382	Clermont	$116,673	High	$1,166,732
Darke	$91,774	Medium	$91,774	Franklin	$129,404	Low	$0	Columbiana	$83,399	High	$833,994
Defiance	$88,758	Medium	$88,758	Geauga	$175,189	Medium	$175,189	Coshocton	$81,179	Medium	$81,179
Erie	$138,957	Medium	$138,957	Greene	$130,079	Low	$0	Gallia	$74,847	Medium	$74,847
Fayette	$89,871	Low	$0	Hamilton	$133,401	High	$1,334,012	Guernsey	$67,546	Medium	$67,546
Fulton	$112,365	Medium	$112,365	Knox	$93,432	Low	$0	Harrison	$59,105	High	$591,048
Hancock	$103,815	Low	$0	Lake	$153,500	Medium	$153,500	Highland	$84,108	Low	$0
Hardin	$74,821	Medium	$74,821	Licking	$111,871	Medium	$111,871	Hocking	$79,877	Medium	$79,877
Henry	$93,482	Medium	$93,482	Lorain	$133,971	Low	$0	Holmes	$105,362	Low	$0
Huron	$101,618	Low	$0	Mahoning	$89,778	Medium	$89,778	Jackson	$71,016	Medium	$71,016
Logan	$91,623	Low	$0	Medina	$148,346	Low	$0	Jefferson	$55,626	High	$556,255
Lucas	$109,511	High	$1,095,106	Montgomery	$106,758	Low	$0	Lawrence	$66,516	High	$665,162
Madison	$117,374	Low	$0	Pickaway	$114,886	Low	$0	Meigs	$60,499	High	$604,992
Marion	$91,612	Low	$0	Portage	$129,091	Medium	$129,091	Monroe	$59,355	High	$593,546
Mercer	$92,577	Medium	$92,577	Richland	$92,275	Medium	$92,275	Morgan	$71,635	Medium	$71,635
Miami	$118,581	Low	$0	Stark	$99,745	Medium	$99,745	Muskingum	$82,973	Medium	$82,973
Morrow	$98,524	Low	$0	Summit	$130,413	High	$1,304,129	Noble	$65,029	High	$650,286
Ottawa	$128,132	Medium	$128,132	Trumbull	$85,421	Medium	$85,421	Perry	$69,858	Medium	$69,858
Paulding	$71,783	Medium	$71,783	Warren	$143,151	High	$1,431,505	Pike	$83,147	Low	$0
Preble	$99,686	Low	$0	Wayne	$107,620	Low	$0	Ross	$80,576	Low	$0
Putnam	$96,294	Medium	$96,294	**TOTAL**	**$123,675**		**$8,144,971**	Scioto	$67,115	Low	$0
Sandusky	$100,864	Medium	$100,864					Tuscarawas	$93,030	Medium	$93,030
Seneca	$92,474	Low	$0					Vinton	$63,290	Medium	$63,290
Shelby	$105,897	Low	$0					Washington	$72,527	High	$725,271
Union	$121,528	Low	$0					**TOTAL**	**$75,451**		**$10,087,220**
Van Wert	$81,137	Low	$0								
Williams	$91,255	Medium	$91,255								
Wood	$116,308	High	$1,163,085								
Wyandot	$83,507	Low	$0								
TOTAL	**$100,137**		**$3,821,301**								

Source: USGS & HAZUS-MH

Region 1 has a landslide vulnerability of approximately $3,821,301. Within this region, Wood County has the highest potential for losses at an estimated $1,163,085. Additionally, several counties within the Region have *Low Potential Losses*, which equates to zero vulnerability (following our initial assumptions).

Region 2 has the second highest estimate of potential loss at a value of $8,144,971. Cuyahoga County has the highest estimate within the Region at a loss value of $1,737,211, and four other counties exhibit potential losses over $1 million.

Region 3 has the highest risk and vulnerability at a value of $10,087,220. Within this Region Clermont County has the highest estimated vulnerability of $1,166,732.

These results do not account for everything affected by landslide, especially roads. Landslides and mudslides affecting roads lead to costly repairs by state and local governments. In the six to seven year period leading up to 2002, repair, rehabilitation, and maintenance costs exceeded $34 million, at an average of $4.9 million per project. The massive floods of 1996-98 in eastern and southeastern Ohio counties each averaged $4.16 million in costs to the state, and landslides played roles in those disasters.

VULNERABILITY ANALYSIS & LOSS ESTIMATE OF STATE OWNED CRITICAL FACILITIES

Methodology

The methodology to determine the vulnerability of state-owned structures and critical facilities to landslides was identified in section 2.1. However, with regard to the discussion as it focuses on landslides, it will be confined to the areas that have a high susceptibility and low incidence or higher (see Map 2.5.b).

Results

Though Lucas County has sparse areas of high susceptibility to landslide in Region 1, at this time there have been no assessments completed on state structures in the Toledo area. As future opportunities arise, these data will be collected and analyzed for vulnerability (see Table 2.1.a and Appendix C).

Within Region 2 assessments have been conducted on 9 of the 25 counties (see Appendix C). Butler County, Fairfield County, Hamilton County, and Warren County all have sparse areas of high susceptibility, but to date have not been assessed for vulnerability to state owned structures and critical facilities. Cuyahoga, Licking, and Summit counties all have a high susceptibility to landslide incidence. In total there are 58 state-owned structures vulnerable to landslides at an estimated potential loss of $1,452,201,723. Out of those structures identified, nine are classified as critical facilities with an estimated potential loss of $11,763,212.

Five of the 29 counties within Region 3 have been assessed for vulnerable state-owned structures and critical facilities (see Table 2.1.a and Appendix C). A significant portion of Region 3 has a high susceptibility to landslides. Columbiana, Carroll, Harrison, Coshocton, Muskingum, Perry, Hocking, Morgan, Nobel, Monroe, Morgan, Washington, Hocking, Athens, Vinton, Jackson, Gallia, Lawrence, Clermont, Brown, and Adams Counties have been identified as having high susceptibility to landslides (see Map 2.5.a) However, at this time state owned structures have not been identified for those specific counties. Belmont, Guernsey, Jefferson, and Tuscarawas counties also have a high susceptibility to landslide incidence. In total there are 88 state-owned structures vulnerable to landslides at an estimated potential loss of $82,711,564. Out of those structures identified 10 are classified as critical facilities with an estimated vulnerability of $5,707,080.