

2.12 SEVERE SUMMER STORMS

Severe summer storms traditionally precede an approaching cold air mass. In the northern hemisphere, the spin of the earth naturally produces weather patterns affecting North America, which travel from west to east across the continent. Key components to the formation of storms are a low-pressure zone, high-pressure zone and the jet stream.

The troposphere is the lowest portion of Earth's atmosphere containing approximately 75% of the atmosphere's mass and almost all of its water vapor. Air at this level is acted upon by the earth surface (land and water) and the heating cycle associated with sunlight. Unlike other portions of the atmosphere, which are largely homogenous, at the surface discrete areas or bubbles exist of differing temperature, water vapor content and pressure. Warm areas (low pressure) tend to rise, pressing on the borders of surrounding cool areas (high pressure). It is where the pressure zones interface that temperature changes cause water vapor in the air to condense creating precipitation. The warmer the overall temperature of the atmosphere and the greater the volume of water vapor present, the larger the associated perception event.

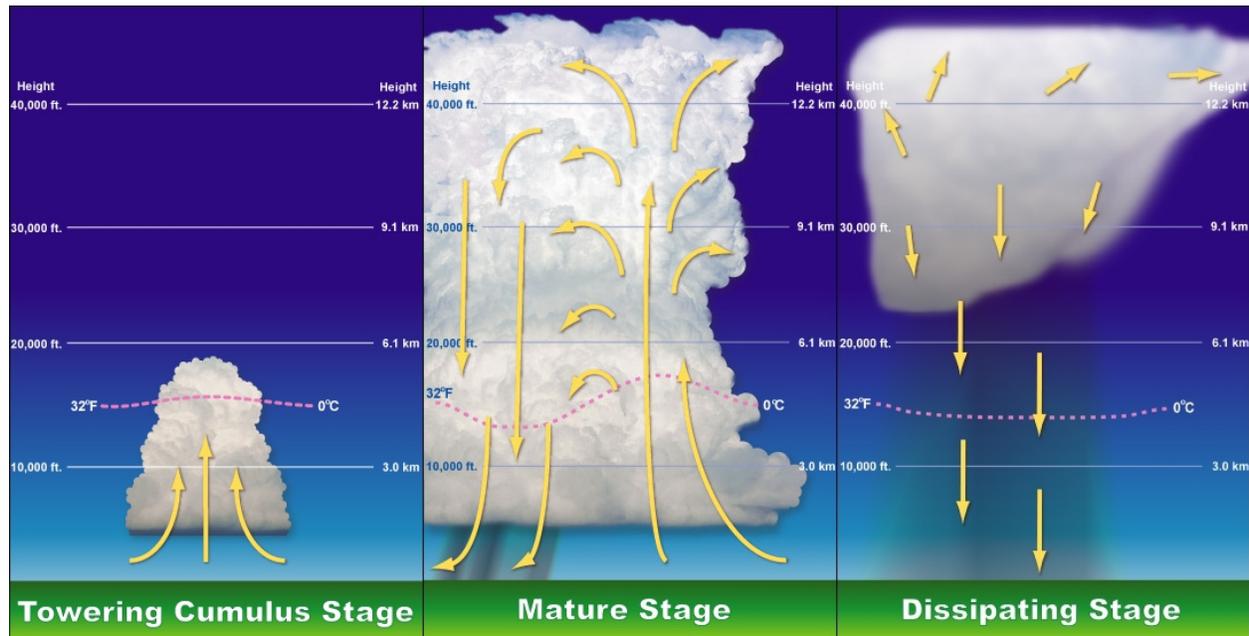
Jet streams are fast flowing, relatively narrow air currents found in the atmosphere around 11 kilometers (36,000 ft.) above the surface of the Earth. They form at the boundaries of adjacent air masses with significant differences in temperature, such as of the polar region and the warmer air toward the equator. These air currents migrate north and south in a snakelike pattern changing their relative location as the planet's axis tilts with each passing year. These winds act on the high and low-pressure zone moving them across the continent and shifting them north and south.

Thunderstorms develop when large differences exist between adjacent zones combined with significant water vapor. As warm air begins to lift, it eventually starts to cool and condensation takes place. When the moisture condenses, heat is released which further aids in the lifting process. If enough instability is present in the atmosphere, this process will continue long enough for cumulonimbus clouds to form, which supports lightning and thunder (see Diagram 2.12a). As water droplets rise into the colder air, they can freeze. When the velocity of wind becomes great enough, the ice pellets are repeatedly lifted and dropped in the storm adding layers of ice with each cycle. Once the wind cannot support the weight of the ice pellet, it falls the ground in the form of hail.

One key component to a thunderstorm is lightning, an atmospheric discharge of electricity. High-speed videos (examined frame-by frame) show that most lightning strikes are made up of multiple individual strokes. A typical strike is made of 3 to 4 strokes. The sudden increase in pressure and temperature from lightning produces rapid expansion of the air surrounding and within a bolt of lightning. In turn, this expansion of air produces a sonic shock wave, which produces the sound of thunder. Lightning, other storm components, often seeks a path though the tallest object available. Trees, utility line/poles, tall buildings and even humans can be sought as a pathway for the discharging electricity.

Summer storms are considered high wind events by the National Climactic Data Center when surface winds meet or exceed 50 knots or 57.6 miles per hour. It is possible for winds in strong storms to exceed 100 miles per hour, with gusts even stronger.

Figure 2.12a



Source: Wikipedia <http://en.wikipedia.org/wiki/Thunderstorm>

RISK ASSESSMENT

LOCATION

Severe summer storms and associated thunderstorm/high winds, lightning, and hail events are common throughout Ohio and reported hundreds of times each year. For the purpose of this plan, thunderstorm wind events, hail events, and lightning events will be assessed separately under *Severe Summer Storms* (2.12) section. Each of these are statewide hazards. For thunderstorm wind and hail events, past occurrences will be reported based on days with events unless specified otherwise. For lightning, each reported event will be counted as a single event.

PAST OCCURRENCES

According to the NCDC Storm Database, there has been 453 thunderstorm wind events from January 1, 2008 to December 31, 2017. From these events, about \$145,609,158 (2017 dollars) in property and crop damages have been reported and have directly caused 8 deaths and 100 injuries. For hail during the same timeframe, there were 359 days with events that resulted in \$187,455,392 (2017 dollars) in property and crop damage and have directly caused zero deaths and two injuries.

From January 1, 1996 to December 31, 2017, there were 229 reported lightning events that resulted in \$18,204,489 in property and crop damages and have directly caused 25 deaths and 120 injuries. However, based on the NCDC data from the period of January 1, 1996 to December 31, 2017, it could be assumed that an event was not recorded unless damages were reported or resulted in the death or injury of a person. According to National Geographic, lightning detecting systems in the United States monitor an average of 25 million strokes of lightning and about 100,000 thunderstorms per year.

Within the January 2008 to December 2017 analysis period, the costliest hail event from happened on May 25, affecting Hancock County and had cost \$85,000,000 in damages. The event had produced hail as

large as baseballs. The western half of the city of Findlay was especially hard hit. As many as 4,000 homes and business in this area may have been damaged by the hail. Thousands of automobiles also sustained damage from the hail. This event could end up being one of costliest hailstorms in Ohio history.

On November 5, 2017, a cold front moved across the Ohio Valley and southern Great Lakes resulting in thunderstorm wind events affecting many. These winds caused \$18,032,500 in property and crop damages within Ohio counties. The costliest high wind event happened on September 14, 2008 as a result of Hurricane Ike. High winds affected most parts of the state. The NCDC Storm Database reports that \$771,955,000 had been caused in property and crop damage.

Table 2.12.a

Thunderstorm Events by County (January 1, 2008 to December 31, 2017)														
Region 1					Region 2					Region 3				
County	Number of Events	Number of Deaths	Number of Injuries	Total Property and Crop Damage (2017 Dollars)	County	Number of Events	Number of Deaths	Number of Injuries	Total Property and Crop Damage (2017 Dollars)	County	Number of Events	Number of Deaths	Number of Injuries	Total Property and Crop Damage (2017 Dollars)
ALLEN	50	0	0	\$ 54,093	ASHLAND	50	0	0	\$ 1,359,403	ADAMS	57	0	0	\$ 408,154
AUGLAIZE	79	0	2	\$ 1,018,487	BUTLER	96	0	0	\$ 437,804	ASHTABULA	69	0	0	\$ 1,591,711
CHAMPAIGN	44	0	0	\$ 413,232	CLINTON	100	0	0	\$ 599,913	ATHENS	56	0	6	\$ 5,319,926
CLARK	78	0	0	\$ 438,238	CUYAHOGA	122	0	0	\$ 11,381,899	BELMONT	44	0	0	\$ 1,306,337
CRAWFORD	51	0	0	\$ 1,412,685	DELAWARE	69	0	4	\$ 329,520	BROWN	79	0	0	\$ 743,335
DARKE	72	0	0	\$ 680,641	FAIRFIELD	78	0	0	\$ 427,608	CARROLL	74	0	0	\$ 1,285,670
DEFIANCE	37	0	0	\$ 303,920	FAYETTE	48	0	1	\$ 349,108	CLERMONT	100	0	0	\$ 638,244
ERIE	49	0	1	\$ 3,266,554	FRANKLIN	185	0	7	\$ 1,857,879	COLUMBIANA	102	0	2	\$ 2,090,858
FULTON	37	0	0	\$ 119,490	GEAUGA	57	0	0	\$ 1,676,326	COSHOCTON	56	0	0	\$ 1,688,786
HANCOCK	70	0	0	\$ 7,617,705	GREENE	93	0	0	\$ 302,650	GALLIA	38	0	0	\$ 2,827,548
HARDIN	29	0	0	\$ 415,186	HAMILTON	132	0	1	\$ 1,260,551	GUERNSEY	53	0	0	\$ 1,609,770
HENRY	57	0	1	\$ 38,970	KNOX	52	0	1	\$ 2,328,393	HARRISON	43	0	0	\$ 1,002,081
HURON	70	0	0	\$ 1,878,667	LAKE	48	0	0	\$ 1,154,940	HIGHLAND	91	0	1	\$ 517,609
LOGAN	55	0	0	\$ 355,037	LICKING	99	2	4	\$ 722,624	HOCKING	51	0	0	\$ 298,045
LUCAS	92	1	0	\$ 2,373,721	LORAIN	112	0	0	\$ 3,097,829	HOLMES	40	0	0	\$ 1,085,380
MARION	42	0	1	\$ 5,312,356	MADISON	37	0	0	\$ 306,518	JACKSON	36	0	1	\$ 2,069,534
MERCER	41	0	2	\$ 478,753	MEDINA	59	1	3	\$ 2,084,871	JEFFERSON	51	1	2	\$ 1,630,829
MIAMI	57	0	1	\$ 682,945	MONTGOMERY	168	0	2	\$ 542,686	LAWRENCE	60	0	1	\$ 2,354,513
OTTAWA	56	0	5	\$ 2,075,367	MORROW	34	0	0	\$ 2,380,416	MAHONING	55	0	0	\$ 2,537,080
PAULDING	38	0	0	\$ 214,200	PICKAWAY	49	0	1	\$ 439,594	MEIGS	22	0	0	\$ 2,653,249
PREBLE	54	0	0	\$ 361,302	PORTAGE	56	0	0	\$ 3,840,670	MONROE	19	0	0	\$ 412,702
PUTNAM	39	0	1	\$ 283,652	RICHLAND	69	0	2	\$ 2,450,743	MORGAN	33	0	0	\$ 720,113
SANDUSKY	59	0	0	\$ 4,794,635	STARK	62	0	0	\$ 766,638	MUSKINGUM	63	1	1	\$ 1,929,222
SENECA	69	0	0	\$ 3,635,084	SUMMIT	77	0	0	\$ 8,465,984	NOBLE	29	0	0	\$ 383,735
SHELBY	53	0	0	\$ 215,542	UNION	38	0	0	\$ 149,309	PERRY	68	0	0	\$ 2,230,567
VAN WERT	61	0	0	\$ 466,957	WARREN	110	0	1	\$ 1,019,811	PIKE	63	0	5	\$ 491,191
WILLIAMS	32	1	1	\$ 315,840	WAYNE	57	0	0	\$ 492,966	ROSS	59	0	0	\$ 529,848
WOOD	76	0	0	\$ 2,514,480	TOTAL			3	\$ 50,226,651	SCIOTO	107	1	1	\$ 719,654
WYANDOT	25	0	0	\$ 2,206,990						TRUMBULL	112	0	38	\$ 2,999,909
TOTAL			2	\$ 43,944,727						TUSCARAWAS	89	0	0	\$ 2,464,457
										VINTON	33	0	0	\$ 641,756
										WASHINGTON	54	0	0	\$ 4,255,968
										TOTAL			3	\$ 51,437,780

Statewide High Winds – September 2008 (FEMA DR-1805-OH) - <https://www.fema.gov/disaster/1805>

Usually, tropical storms and hurricanes directly affecting other states result in extended rainfall in Ohio. NOAA Operational Significant Event Imagery shows that the windstorms of 2008 were a legacy from Hurricane IKE, which arced clockwise from the Gulf of Mexico to the western basin of Lake Erie and the Saint Lawrence Seaway. Ohio was affected from Hamilton County in southwest Ohio to the northeastern counties of Ashland, Carroll and Summit. Unlike other secondary effects of a diminishing hurricane, high winds in excess of 65 miles per hour were primarily the cause of damage for many counties, causing power outages across these portions of the state. It was reported that winds equal to a Category 1 hurricane (winds up to 74 miles per hour) caused at least \$1.255 billion in insured losses.

The Ohio Insurance Institute (OII) Windstorm Loss Survey - FEMA DR-1805-OH

Following the statewide High Winds event of September 2008 (FEMA DR-1805-OH), the Ohio Insurance Institute (OII) conducted a windstorm loss survey in which 24 property and casualty companies participated. This represented:

- 68% of Ohio's personal auto insurance market
- 72% of the homeowners' market
- 33% of the state's commercial lines market based on 2007 Ohio premium volume

The OII survey concluded Ohio's insured losses totaled \$1.255 billion and government costs for protection and clean up were \$38.6 million. Insurance companies reported a record-high number of claims filed across the state. At least 270,000 were filed in Ohio, including 220,000 homeowners, 30,000 commercial and 20,000 auto insurance claims.

Severe Storms, Flooding and Landslides – April & May 2011 (FEMA DR- 4002-OH) -

<https://www.fema.gov/disaster/4002>

The impact of this event was widespread and costly due to the prolonged and record-setting spring rainfall during the months of March, April and May. According to the National Weather Service (NWS), a persistent upper valley weather channel over the eastern U.S. led to an active storm track over the Ohio Valley. During the month of April and into mid-May, the local NWS offices serving Ohio issued flood watches, flood warnings, flash flood watches and advisories and/or special weather statements for the Ohio River Watershed and Drainage Basin for 31 of the 44 days. Eighty-one percent of the watches, warnings and advisories were issued directly for the impacted counties; however, all of the counties had high stream levels on their watersheds. Also during this time period, there were road closures almost every day due to flooding and/or high water. A notable incident was a small plane crashed near Ravenna, Ohio with three injuries due to saturated soil absorbing much of the impact. According to the Highway Patrol, had it not been for soft, soaked earth and mud, all three on board would have perished upon impact. Other incidents included 7,630 customers in power outages, trees uprooted, parts of buildings sustaining moderate damage and the loss of a countywide 911 system. As a result, the 21 affected Ohio counties received \$44,506,071 in public assistance funds.

Severe Storms and Straight Line Winds – June 2012 (FEMA DR-4077-OH) - : <https://www.fema.gov/disaster/4077>

An anomalously strong storm ridge centered across the Southeast and brought record heat to the Upper Ohio Valley with the area in a flow on the northern edge of the ridge. A weak frontal boundary extended from northern Indiana into western Pennsylvania. Abundant moisture, strong instability, moderate shear,

and a short wave just south of the boundary provided the ingredients for a long-tracked mesoscale convective system, classified by the Storm Prediction Center as a derecho, to track all the way from northern Indiana across eastern Ohio, southwestern Pennsylvania, northern WV, and western Maryland. As the system crossed the area, widespread wind damage was reported across areas primarily south and west of Pittsburgh. There were several reports of structural damage and damage led to a fatality when a barn collapsed in Muskingum County. Power outages were widespread with up to 130,000 outages reported immediately after the storms passage, most of which, were in Ohio. Muskingum and Guernsey counties sustained \$712,000 and \$500,000 in damages respectively. This also became one of the costliest disasters to hit Ohio, right behind Hurricane Ike in 2008. Two fatalities and eight injuries occurred during this event with \$40,440,000 in property damage and \$105,000 in damage to crops. As a result, of this event, 37 affected Ohio counties received \$22,538,519 in public assistance funds.

Hurricane SANDY – October 2012 (FEMA DR-4098-OH) - <https://www.fema.gov/disaster/4098>

On October 29, 2012, Hurricane Sandy made landfall near Atlantic City, New Jersey, however, the storm continued to produce significant wind, storm surge, rainfall and inland-flooding hazards across the Northeastern United States. High wind warnings as well as flood and flash flood watches and warnings for portions of Ohio and Indiana. The National Weather Service reported winds up to 80 miles per hour during the height of the storm system. First Energy Nuclear Operating Company reported sirens without AC power near Perry Nuclear Power Plant (Lake County-15 sirens, Geauga County-1 siren, Ashtabula-1siren) and Beaver Valley Power Station (Beaver County, PA-1siren). In Cuyahoga County, 80 people with functional needs were evacuated to a high school in Cleveland Heights, while another 11 shelters were being opened. The storm delivered a blow to Ashtabula County, but it was not the big uppercut some people had feared. As expected, strong wind toppled trees and dropped power lines, causing power outages across the county. Incessant rain toppled trees and flooded some thoroughfares in the area. Some of the hardest-hit areas were along the lakeshore, including Conneaut, North Kingsville, and Saybrook Township. Outages were reported in every city, village and township in the county, according to Illuminating Company information. Trees and limbs that collapsed on power lines were a big culprit, officials said. Lake County had residents from 142 homes near the mouth of the Chagrin River evacuated to the Mentor Community Center with another 70 evacuated to a shelter in Painesville. First Energy reported 55,516 customers without power in northeast Ohio. No fatalities were reported; however, one occurred. Property damage was estimated at \$55,234,000 with no damage to crops. As a result, of this event, 37 affected Ohio counties received \$17,810,815 in public assistance funds.

Severe Storms, Landslides, and Mudslides – February 2018 (FEMA DR-4360-OH) -

<https://www.fema.gov/disaster/4360>

Beginning on February 14, 2018, and continuing through February 25, 2018, a persistent band of moderate to severe storms moved across Region V impacting Illinois, Indiana, Michigan, Ohio, and Wisconsin. While precipitation levels and storm-related damages varied, Ohio experienced a significant amount of flooding and subsequent damage along the southern portion of the state. The snowmelt and continued rain throughout the incident period, combined with the frozen soils, led to flooding along area streams, rivers, and low-lying areas. Numerous flood gauges in this area rose to moderate flood stage, and rainfall totals in the impacted areas during the incident period ranged from a total of five to nine inches. Following these storms, there were several road closures as well as reports of inaccessible areas throughout southern Ohio due to standing water.

On March 26, the Governor requested a Presidential Disaster Declaration. On April 17, 2018, a disaster was declared for the State of Ohio, due to severe storms, flooding, and landslides that occurred during

the incident period of February 14, 2018, through February 25, 2018. As a result of that declaration, Public Assistance has been made available for Adams, Athens, Belmont, Brown, Columbiana, Gallia, Hamilton, Jackson, Lawrence, Meigs, Monroe, Muskingum, Noble, Perry, Pike, Scioto, Vinton, and Washington Counties. The Disaster impact data is fluid as only half of the Public Assistance projects have been awarded as of January 2019.

HURRICANES AND TROPICAL STORMS

In more recent years, a number of disaster declarations for Ohio was declared in result of remnants from hurricanes and tropical storms. Notably, wind events caused by remnants of Hurricane IKE in September 2008 had resulted in large damages across Ohio. High winds, rain, and flooding events from Hurricane SANDY followed through to portions of Ohio.

PROBABILITY OF FUTURE EVENTS

The historical period used for thunderstorm winds and hail analysis began with January 1, 2008 and closed December 31, 2017 based on statistics tabulated by the NCDC. During this period, there were 453 days with thunderstorm wind events and 359 days with hail events. For the period from January 1, 1996 to December 31, 2017, there were 229 lightning events. Based on available documented occurrences, severe summer storms are the most prevalent natural hazard events in Ohio with a 100% chance of occurring any given year. According to National Geographic, the odds of being a lightning victim in the U.S. in any given year is about one in 700,000.

LHMP DATA

Henry County: The County's Hazard Mitigation Plan of 2018 states that from January of 1950 to June of 2017 in Henry County. These events have caused two injuries, over \$800,000 in property damage, \$600,000 in crop damage, and no deaths. Based on historical information, Henry County can expect to endure at least three severe storms in any given year.

Darke County: The 2011 Updated Hazard Mitigation Plan cites that there have been a total of 2 lightning events, 64 hail events, and 148 thunderstorm/wind events in Darke County from June 9, 1958 through December 31, 2010. Based on NCDC data, Darke County can expect at least four severe summer storm events each year along with smaller events. Some of the significant events are described in the following paragraphs.

Fairfield County: The 2016 Fairfield County Natural Hazards Mitigation Plan references 219 severe thunderstorm events from 1968 to 2016. From the period of 1961 to 2016, the County experienced 58 Hail events creating \$52,000.00 in property damages. No deaths or injuries as a result of Hailstorms.

VULNERABILITY ANALYSIS AND LOSS ESTIMATION

METHODOLOGY

THUNDERSTORM WINDS AND HAIL

During data development for the thunderstorm/high wind and hail hazard, it quickly became apparent the two must be addressed separately. Hail events have a much greater financial impact in urbanized areas. Events of the same magnitude can create substantially more damage in an urban setting, or as it would in forested or agricultural area. The extreme range of the data for hail would skew any useful thunderstorm/high wind analysis. As a result, there will be one analysis for lightning, thunderstorm/high winds, and heavy rainfall and another separate analysis for hail events.

To determine the estimated annual damage down to the county level, a hybrid approach was taken using historical data and the taxable value of real property for each county within the state. First, a historical analysis was done first for each county. The total reported property damage of each event was adjusted to 2017 dollars and summed up to for each county. This was then divided by 10 for the number of years assessed. The result of this is the estimated annual damage for each county. This number was then divided by the total taxable value of real property within the county to determine the percentage of estimated damage for each of the 88 county in any given year.

To offset the possibility of under-reporting damages, the sum of the ten-year damages across the state \$145,609,158 for thunderstorm winds, and \$187,455,392 for hail was divided by 10 to determine the annual loss. This figure as well as the statewide real value of property was respectively divided by the 88 (counties in the state) to determine the average damage per county and the average taxable value per county in the state. The first was then divided by the latter resulting in the percentage of estimated damage the average county, 0.006116% for thunderstorm and 0.007874% for hail, in Ohio in any given year. These percentages were then used for any county that reported less than average damages relative to their value of taxable real property.

LIGHTNING

Determining the dollar loss estimate for lightning events is extremely difficult because it is an extremely common hazard that is also greatly under-reported. It could be assumed based on the NCDC data from the period of January 1, 1996 to December 31, 2017 that an event was not recorded unless damages were reported or resulted in the death or injury of a person. Based on what was reported, however, the average damage to property is approximately \$827,477 per year statewide. On average, one person is killed and six injured from lightning events in any given year.

RESULTS - THUNDERSTORM WINDS (TABLE 2.12.A)

The total estimated annual severe thunderstorm winds loss for Region 1 is \$5,129,520. Within the Region, Marion County is estimated to have the highest annual loss each at approximate \$531,236. Hancock, however, had the highest estimate per capita loss at \$10.06 per person.

Region 2 has the highest estimated annual summer storm loss in the state at a total of \$10,711,819. While it is the most populated region in the state with the highest total taxable value of real property, the region also exhibits the lowest estimated annual per-capita loss of \$1.39. Within the Region, Morrow County has the highest estimated annual summer storm per-capita loss at \$1.88. Cuyahoga County has the highest estimated total damage at \$1,623,120 but an estimated per-capita loss of only \$1.30.

Region 3 is estimated to have \$5,308,796 in annual damages with an annual per-capita of loss of \$2.66. Athens County is estimated to have the highest loss at a total of \$531,993. Meigs County is estimated have the highest annual per-capita loss of \$11.50.

Table 2.12.a

Estimate of Potential Losses to Thunderstorm Winds by Region											
Region 1				Region 2				Region 3			
County	Population	Countywide Annual Damage	Annual Damage per Capita	County	Population	Countywide Annual Damage	Annual Damage per Capita	County	Population	Countywide Annual Damage	Annual Damage per Capita
Allen	103,198	\$ 111,695.39	\$ 1.08	Ashland	53,628	\$ 135,940.30	\$ 2.53	Adams	27,726	\$ 40,815.40	\$ 1.47
Auglaize	45,778	\$ 101,848.65	\$ 2.22	Butler	380,604	\$ 431,409.39	\$ 1.13	Ashtabula	97,807	\$ 159,171.10	\$ 1.63
Champaign	38,840	\$ 51,234.14	\$ 1.32	Clinton	42,009	\$ 55,247.40	\$ 1.32	Athens	66,597	\$ 531,992.60	\$ 7.99
Clark	134,557	\$ 136,929.05	\$ 1.02	Cuyahoga	1,248,514	\$ 1,623,120.46	\$ 1.30	Belmont	68,029	\$ 130,633.65	\$ 1.92
Crawford	41,746	\$ 141,268.50	\$ 3.38	Delaware	200,464	\$ 412,757.80	\$ 2.06	Brown	43,576	\$ 74,333.45	\$ 1.71
Darke	51,536	\$ 73,648.32	\$ 1.43	Fairfield	154,733	\$ 206,701.02	\$ 1.34	Carroll	27,385	\$ 128,567.00	\$ 4.69
Defiance	38,156	\$ 49,556.80	\$ 1.30	Fayette	28,752	\$ 42,904.11	\$ 1.49	Clermont	204,214	\$ 241,864.01	\$ 1.18
Erie	74,817	\$ 326,655.40	\$ 4.37	Franklin	1,291,981	\$ 1,596,431.89	\$ 1.24	Columbiana	103,077	\$ 209,085.80	\$ 2.03
Fulton	42,289	\$ 58,868.11	\$ 1.39	Geauga	93,918	\$ 182,631.81	\$ 1.94	Coshocton	36,544	\$ 168,878.60	\$ 4.62
Hancock	75,754	\$ 761,770.50	\$ 10.06	Greene	166,752	\$ 233,873.68	\$ 1.40	Gallia	29,973	\$ 282,754.80	\$ 9.43
Hardin	31,364	\$ 41,518.60	\$ 1.32	Hamilton	813,822	\$ 1,069,320.31	\$ 1.31	Guernsey	39,093	\$ 160,977.00	\$ 4.12
Henry	27,185	\$ 44,883.20	\$ 1.65	Knox	61,261	\$ 232,839.30	\$ 3.80	Harrison	15,216	\$ 100,208.10	\$ 6.59
Huron	58,494	\$ 187,866.70	\$ 3.21	Lake	230,117	\$ 335,138.54	\$ 1.46	Highland	42,971	\$ 45,969.85	\$ 1.07
Logan	45,325	\$ 72,444.99	\$ 1.60	Licking	173,448	\$ 228,566.27	\$ 1.32	Hocking	28,474	\$ 33,547.05	\$ 1.18
Lucas	430,887	\$ 421,014.28	\$ 0.98	Lorain	307,924	\$ 384,814.03	\$ 1.25	Holmes	43,957	\$ 108,538.00	\$ 2.47
Marion	64,967	\$ 531,235.60	\$ 8.18	Madison	44,036	\$ 65,604.48	\$ 1.49	Jackson	32,449	\$ 206,953.40	\$ 6.38
Mercer	40,873	\$ 66,418.01	\$ 1.62	Medina	178,371	\$ 295,275.69	\$ 1.66	Jefferson	66,359	\$ 163,082.90	\$ 2.46
Miami	105,122	\$ 134,669.74	\$ 1.28	Montgomery	531,542	\$ 532,156.37	\$ 1.00	Lawrence	60,249	\$ 235,451.30	\$ 3.91
Ottawa	40,657	\$ 207,536.70	\$ 5.10	Morrow	34,994	\$ 238,041.60	\$ 6.80	Mahoning	229,796	\$ 235,408.12	\$ 1.02
Paulding	18,845	\$ 27,399.66	\$ 1.45	Pickaway	57,830	\$ 73,815.24	\$ 1.28	Meigs	23,080	\$ 265,324.90	\$ 11.50
Preble	41,120	\$ 53,890.19	\$ 1.31	Portage	162,277	\$ 384,067.00	\$ 2.37	Monroe	13,946	\$ 41,270.20	\$ 2.96
Putnam	33,878	\$ 54,746.03	\$ 1.62	Richland	120,589	\$ 245,074.30	\$ 2.03	Morgan	14,709	\$ 72,011.30	\$ 4.90
Sandusky	59,195	\$ 479,463.50	\$ 8.10	Stark	372,542	\$ 418,899.80	\$ 1.12	Muskingum	86,149	\$ 192,922.20	\$ 2.24
Seneca	55,243	\$ 363,508.40	\$ 6.58	Summit	541,228	\$ 683,319.46	\$ 1.26	Noble	14,406	\$ 38,373.52	\$ 2.66
Shelby	48,759	\$ 68,870.65	\$ 1.41	Union	56,741	\$ 96,589.41	\$ 1.70	Perry	36,024	\$ 223,056.70	\$ 6.19
Van Wert	28,217	\$ 42,329.97	\$ 1.50	Warren	228,882	\$ 367,661.32	\$ 1.61	Pike	28,270	\$ 49,119.10	\$ 1.74
Williams	36,784	\$ 46,102.25	\$ 1.25	Wayne	116,038	\$ 139,618.01	\$ 1.20	Ross	77,313	\$ 74,131.44	\$ 0.96
Wood	130,492	\$ 251,448.00	\$ 1.93	Total	7,692,997	\$ 10,711,818.99	\$ 1.39	Scioto	75,929	\$ 58,145.24	\$ 0.77
Wyandot	22,029	\$ 220,699.00	\$ 10.02					Trumbull	200,380	\$ 299,990.90	\$ 1.50
Total	1,966,107	\$ 5,129,520.32	\$ 2.61					Tuscarawas	92,297	\$ 246,445.70	\$ 2.67
								Vinton	13,092	\$ 64,175.60	\$ 4.90
								Washington	60,418	\$ 425,596.80	\$ 7.04
								Total	1,999,505	\$ 5,308,795.73	\$ 2.66

RESULTS - HAIL (TABLE 2.12.B)

The total estimated annual loss for Region 1 is \$12,430,433. Within the Region, Hancock County is estimated to have the highest annual loss each at approximate \$9,317,669. This figure however, may be skewed by an event on May 25, 2011 that reported \$85,000,000 in damages. Consequently, Hancock County also had the highest estimate per capita loss at \$123 per person.

Region 2 has the highest estimated annual hail loss in the state at a total of \$19,338,917. While it is the most populated region in the state with the highest total taxable value of real property, the region only has an estimated annual per-capita loss of \$2.51. Within the Region, Stark County has the highest estimated total damage at \$6,926,028 and also the highest estimated per-capita loss of \$18.59.

Region 3 is estimated to have \$2,741,032 in annual damages to hail with an annual per-capita of loss of \$1.37. Clermont County is estimated to have the highest loss at a total of \$311,373. Harrison County is estimated have the highest annual per-capita loss at \$2.58.

Table 2.12.b

Estimate of Potential Losses to Hail by Region											
Region 1				Region 2				Region 3			
County	Population	Countywide Annual Damage	Annual Damage per Capita	County	Population	Countywide Annual Damage	Annual Damage per Capita	County	Population	Countywide Annual Damage	Annual Damage per Capita
Paulding	18,845	\$ 35,273.97	\$ 1.87	Fayette	28,752	\$ 55,234.22	\$ 1.92	Scioto	75,929	\$ 74,855.44	\$ 0.99
Hardin	31,364	\$ 39,221.24	\$ 1.25	Morrow	34,994	\$ 59,756.36	\$ 1.71	Pike	28,270	\$ 28,110.62	\$ 0.99
Crawford	41,746	\$ 53,725.09	\$ 1.29	Clinton	42,009	\$ 71,124.81	\$ 1.69	Vinton	13,092	\$ 13,412.35	\$ 1.02
Van Wert	28,217	\$ 54,495.07	\$ 1.93	Ashland	53,628	\$ 75,754.79	\$ 1.41	Meigs	23,080	\$ 24,877.85	\$ 1.08
Henry	27,185	\$ 57,782.06	\$ 2.13	Madison	44,036	\$ 84,458.38	\$ 1.92	Athens	66,597	\$ 71,910.62	\$ 1.08
Williams	36,784	\$ 59,351.46	\$ 1.61	Pickaway	57,830	\$ 95,028.81	\$ 1.64	Jefferson	66,359	\$ 75,971.88	\$ 1.14
Defiance	38,156	\$ 63,798.80	\$ 1.67	Knox	61,261	\$ 99,030.66	\$ 1.62	Jackson	32,449	\$ 37,176.01	\$ 1.15
Champaign	38,840	\$ 65,958.18	\$ 1.70	Union	56,741	\$ 124,347.98	\$ 2.19	Perry	36,024	\$ 42,752.16	\$ 1.19
Preble	41,120	\$ 69,377.56	\$ 1.69	Richland	120,589	\$ 149,006.85	\$ 1.24	Lawrence	60,249	\$ 71,888.79	\$ 1.19
Putnam	33,878	\$ 70,479.34	\$ 2.08	Wayne	116,038	\$ 179,742.46	\$ 1.55	Trumbull	200,380	\$ 242,200.77	\$ 1.21
Fulton	42,289	\$ 75,786.06	\$ 1.79	Geauga	93,918	\$ 235,117.89	\$ 2.50	Ross	77,313	\$ 95,435.88	\$ 1.23
Auglaize	45,778	\$ 82,354.85	\$ 1.80	Portage	162,277	\$ 258,589.01	\$ 1.59	Columbiana	103,077	\$ 128,895.17	\$ 1.25
Marion	64,967	\$ 85,200.87	\$ 1.31	Fairfield	154,733	\$ 266,104.29	\$ 1.72	Mahoning	229,796	\$ 303,061.45	\$ 1.32
Huron	58,494	\$ 85,263.96	\$ 1.46	Licking	173,448	\$ 294,253.33	\$ 1.70	Morgan	14,709	\$ 19,686.86	\$ 1.34
Mercer	40,873	\$ 85,505.70	\$ 2.09	Greene	166,752	\$ 301,086.03	\$ 1.81	Muskingum	86,149	\$ 117,339.66	\$ 1.36
Seneca	55,243	\$ 86,316.04	\$ 1.56	Medina	178,371	\$ 380,134.19	\$ 2.13	Gallia	29,973	\$ 40,965.44	\$ 1.37
Shelby	48,759	\$ 88,663.21	\$ 1.82	Lake	230,117	\$ 431,453.12	\$ 1.87	Ashtabula	97,807	\$ 134,528.33	\$ 1.38
Wyandot	22,029	\$ 89,586.80	\$ 4.07	Warren	228,882	\$ 473,322.54	\$ 2.07	Brown	43,576	\$ 59,944.98	\$ 1.38
Logan	45,325	\$ 93,264.76	\$ 2.06	Lorain	307,924	\$ 495,404.72	\$ 1.61	Highland	42,971	\$ 59,181.00	\$ 1.38
Darke	51,536	\$ 94,813.91	\$ 1.84	Delaware	200,464	\$ 531,379.18	\$ 2.65	Coshocton	36,544	\$ 51,360.06	\$ 1.41
Sandusky	59,195	\$ 121,999.60	\$ 2.06	Butler	380,604	\$ 555,391.00	\$ 1.46	Tuscarawas	92,297	\$ 136,838.93	\$ 1.48
Ottawa	40,657	\$ 134,219.14	\$ 3.30	Montgomery	531,542	\$ 685,091.39	\$ 1.29	Hocking	28,474	\$ 43,188.05	\$ 1.52
Allen	103,198	\$ 143,795.23	\$ 1.39	Summit	541,228	\$ 990,636.40	\$ 1.83	Washington	60,418	\$ 91,737.16	\$ 1.52
Erie	74,817	\$ 153,383.81	\$ 2.05	Hamilton	813,822	\$ 1,376,629.47	\$ 1.69	Clermont	204,214	\$ 311,372.67	\$ 1.52
Miami	105,122	\$ 173,372.12	\$ 1.65	Franklin	1,291,981	\$ 2,055,226.26	\$ 1.59	Guernsey	39,093	\$ 60,681.33	\$ 1.55
Clark	134,557	\$ 176,280.72	\$ 1.31	Cuyahoga	1,248,514	\$ 2,089,584.79	\$ 1.67	Belmont	68,029	\$ 108,302.45	\$ 1.59
Wood	130,492	\$ 231,485.92	\$ 1.77	Stark	372,542	\$ 6,926,027.80	\$ 18.59	Holmes	43,957	\$ 75,493.60	\$ 1.72
Lucas	430,887	\$ 542,008.47	\$ 1.26	Total	7,692,997	\$ 19,338,916.74	\$ 2.51	Noble	14,406	\$ 26,699.43	\$ 1.85
Hancock	75,754	\$ 9,317,669.20	\$ 123.00					Adams	27,726	\$ 60,124.20	\$ 2.17
Total	1,966,107	\$ 12,430,433.16	\$ 6.32					Monroe	13,946	\$ 31,222.42	\$ 2.24
								Carroll	27,385	\$ 62,595.68	\$ 2.29
								Harrison	15,216	\$ 39,221.24	\$ 2.58
								Total	1,999,505	\$ 2,741,032.48	\$ 1.37

Property damage is not the only loss associated with summer storms and hail. Over the analysis period, 13 deaths and 98 injuries were attributed to these events. Of the injuries reported, 20 are attributed to a single event in Franklin County, which involved a campground.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

The Vulnerability Analysis and Loss Estimation above estimated the damage to each county by using the historical available for that county and the average statewide loss to determine an annual “total building value loss” percentage. This percentage was multiplied by the countywide taxable value of real property to determine an estimated annual damage. To estimate the losses for State-owned and State-leased critical facilities, the total value of State-owned and State-leased Critical Facilities of each county was multiplied by the county’s respective percentage of Total Building Value loss. The results are tabulated in Tables 2.12.c and 2.12.d below.

Results- Thunderstorm Winds (Table 2.12.c)

Estimated Annual Damage to State-owned and State-leased Critical Facilities- Thunderstorm Winds											
Region 1				Region 2				Region 3			
County	Number of Critical Facilities	Value of State Critical Facilities	Estimated Annual Damage	County	Number of Critical Facilities	Value of State Critical Facilities	Estimated Annual Damage	County	Number of Critical Facilities	Value of State Critical Facilities	Estimated Annual Damage
Allen	120	\$ 90,950,176.00	\$ 5,562.47	Ashland	143	\$ 64,539,880.00	\$ 9,118.85	Adams	24	\$ 6,622,981.00	\$ 653.42
Auglaize	21	\$ 11,545,804.00	\$ 1,124.25	Butler	21	\$ 17,563,033.00	\$ 1,074.15	Ashtabula	62	\$ 20,008,110.00	\$ 1,863.93
Champaign	24	\$ 5,161,316.00	\$ 315.66	Clinton	22	\$ 11,528,821.00	\$ 705.10	Athens	31	\$ 45,496,640.00	\$ 26,501.19
Clark	17	\$ 8,868,061.00	\$ 542.37	Cuyahoga	84	\$ 248,840,544.00	\$ 15,218.98	Belmont	62	\$ 54,856,808.00	\$ 5,209.80
Crawford	13	\$ 10,357,812.00	\$ 2,144.42	Delaware	37	\$ 46,217,477.00	\$ 2,826.64	Brown	18	\$ 36,403,605.00	\$ 3,554.26
Darke	27	\$ 8,619,026.00	\$ 527.14	Fairfield	78	\$ 86,519,830.00	\$ 5,291.51	Carroll	17	\$ 3,661,999.00	\$ 592.21
Defiance	11	\$ 7,562,674.00	\$ 462.53	Fayette	26	\$ 5,118,182.00	\$ 313.03	Clermont	38	\$ 17,885,810.00	\$ 1,093.89
Erie	54	\$ 162,265,731.00	\$ 27,208.88	Franklin	249	\$ 2,147,726,878.00	\$ 131,354.03	Columbiana	38	\$ 13,835,662.00	\$ 1,767.10
Fulton	16	\$ 4,397,188.00	\$ 268.93	Geauga	24	\$ 8,594,197.00	\$ 525.62	Coshocton	19	\$ 12,943,450.00	\$ 3,350.99
Hancock	23	\$ 16,195,898.00	\$ 6,872.05	Greene	25	\$ 10,629,296.00	\$ 650.08	Gallia	71	\$ 35,860,837.00	\$ 19,488.86
Hardin	12	\$ 4,141,282.00	\$ 345.17	Hamilton	35	\$ 173,140,806.00	\$ 10,589.22	Guernsey	54	\$ 39,704,477.00	\$ 8,293.19
Henry	14	\$ 3,113,844.00	\$ 190.44	Knox	34	\$ 40,507,246.00	\$ 7,498.82	Harrison	30	\$ 9,054,441.00	\$ 1,821.45
Huron	22	\$ 10,543,997.00	\$ 1,829.21	Lake	21	\$ 5,525,021.00	\$ 337.91	Highland	8	\$ 9,690,902.00	\$ 592.69
Logan	1	\$ 735,568.00	\$ 44.99	Licking	64	\$ 168,043,312.00	\$ 10,277.45	Hocking	19	\$ 7,123,096.00	\$ 435.65
Lucas	47	\$ 276,597,391.00	\$ 16,916.57	Lorain	90	\$ 110,138,241.00	\$ 6,736.01	Holmes	25	\$ 10,336,112.00	\$ 1,170.04
Marion	100	\$ 128,613,896.00	\$ 63,140.00	Madison	109	\$ 321,691,881.00	\$ 19,674.53	Jackson	18	\$ 15,130,501.00	\$ 6,631.88
Mercer	26	\$ 7,655,738.00	\$ 468.22	Medina	22	\$ 18,601,644.00	\$ 1,137.67	Jefferson	37	\$ 7,592,901.00	\$ 1,283.33
Miami	23	\$ 10,005,576.00	\$ 611.94	Montgomery	71	\$ 77,351,496.00	\$ 4,730.78	Lawrence	27	\$ 11,760,373.00	\$ 3,032.74
Ottawa	75	\$ 65,291,745.00	\$ 7,949.00	Morrow	21	\$ 6,874,959.00	\$ 2,156.32	Mahoning	66	\$ 72,389,280.00	\$ 4,427.30
Paulding	3	\$ 1,387,796.00	\$ 84.88	Pickaway	133	\$ 195,643,558.00	\$ 11,965.47	Meigs	18	\$ 8,512,106.00	\$ 7,147.86
Preble	24	\$ 4,859,547.00	\$ 297.21	Portage	25	\$ 7,594,529.00	\$ 888.12	Monroe	22	\$ 11,202,381.00	\$ 1,165.88
Putnam	18	\$ 5,590,738.00	\$ 341.93	Richland	73	\$ 109,750,465.00	\$ 14,212.53	Morgan	10	\$ 3,700,608.00	\$ 1,065.79
Sandusky	15	\$ 5,519,069.00	\$ 2,222.72	Stark	41	\$ 102,066,812.00	\$ 6,242.36	Muskingum	25	\$ 10,647,135.00	\$ 1,378.30
Seneca	49	\$ 33,546,722.00	\$ 11,123.63	Summit	67	\$ 201,182,298.00	\$ 12,304.22	Noble	31	\$ 50,299,353.00	\$ 5,692.01
Shelby	35	\$ 26,824,309.00	\$ 1,640.56	Union	53	\$ 88,869,557.00	\$ 5,435.22	Perry	16	\$ 3,884,728.00	\$ 1,595.85
Van Wert	13	\$ 7,459,562.00	\$ 456.22	Warren	109	\$ 150,201,626.00	\$ 9,186.27	Pike	10	\$ 3,878,547.00	\$ 533.61
Williams	13	\$ 5,459,757.00	\$ 333.92	Wayne	6	\$ 7,056,104.00	\$ 431.55	Ross	142	\$ 265,584,512.00	\$ 16,243.03
Wood	36	\$ 67,981,624.00	\$ 5,814.18	Total	1,683	\$ 4,431,517,693.00	\$ 290,882.42	Scioto	55	\$ 171,351,723.00	\$ 10,479.80
Wyandot	19	\$ 10,280,904.00	\$ 4,293.17					Trumbull	60	\$ 55,012,652.00	\$ 5,364.99
Total	871	\$ 1,001,532,751.00	\$ 163,132.66					Tuscarawas	53	\$ 56,132,900.00	\$ 7,959.81
								Vinton	20	\$ 5,854,782.00	\$ 2,205.71
								Washington	55	\$ 29,149,164.00	\$ 10,647.63
								Total	1,181	\$ 1,105,568,576.00	\$ 163,244.16

Results- Hail (Table 2.12.d)

Estimated Annual Damage to State-owned and State-leased Critical Facilities- Hail											
Region 1				Region 2				Region 3			
County	Number of Critical Facilities	Value of State Critical Facilities	Estimated Annual Damage	County	Number of Critical Facilities	Value of State Critical Facilities	Estimated Annual Damage	County	Number of Critical Facilities	Value of State Critical Facilities	Estimated Annual Damage
Allen	120	\$ 90,950,176.00	\$ 7,161.06	Ashland	143	\$ 64,539,880.00	\$ 5,081.61	Adams	24	\$ 6,622,981.00	\$ 962.53
Auglaize	21	\$ 11,545,804.00	\$ 909.07	Butler	21	\$ 17,563,033.00	\$ 1,382.84	Ashtabula	62	\$ 20,008,110.00	\$ 1,575.36
Champaign	24	\$ 5,161,316.00	\$ 406.38	Clinton	22	\$ 11,528,821.00	\$ 907.73	Athens	31	\$ 45,496,640.00	\$ 3,582.23
Clark	17	\$ 8,868,061.00	\$ 698.24	Cuyahoga	84	\$ 248,840,544.00	\$ 19,592.72	Belmont	62	\$ 54,856,808.00	\$ 4,319.21
Crawford	13	\$ 10,357,812.00	\$ 815.53	Delaware	37	\$ 46,217,477.00	\$ 3,638.98	Brown	18	\$ 36,403,605.00	\$ 2,866.28
Darke	27	\$ 8,619,026.00	\$ 678.63	Fairfield	78	\$ 86,519,830.00	\$ 6,812.23	Carroll	17	\$ 3,661,999.00	\$ 288.33
Defiance	11	\$ 7,562,674.00	\$ 595.46	Fayette	26	\$ 5,118,182.00	\$ 402.99	Clermont	38	\$ 17,885,810.00	\$ 1,408.26
Erie	54	\$ 162,265,731.00	\$ 12,776.16	Franklin	249	\$ 2,147,726,878.00	\$ 169,103.51	Columbiana	38	\$ 13,835,662.00	\$ 1,089.37
Fulton	16	\$ 4,397,188.00	\$ 346.22	Geauga	24	\$ 8,594,197.00	\$ 676.67	Coshocton	19	\$ 12,943,450.00	\$ 1,019.12
Hancock	23	\$ 16,195,898.00	\$ 84,056.18	Greene	25	\$ 10,629,296.00	\$ 836.91	Gallia	71	\$ 35,860,837.00	\$ 2,823.54
Hardin	12	\$ 4,141,282.00	\$ 326.07	Hamilton	35	\$ 173,140,806.00	\$ 13,632.42	Guernsey	54	\$ 39,704,477.00	\$ 3,126.17
Henry	14	\$ 3,113,844.00	\$ 245.17	Knox	34	\$ 40,507,246.00	\$ 3,189.38	Harrison	30	\$ 9,054,441.00	\$ 712.91
Huron	22	\$ 10,543,997.00	\$ 830.19	Lake	21	\$ 5,525,021.00	\$ 435.02	Highland	8	\$ 9,690,902.00	\$ 763.02
Logan	1	\$ 735,568.00	\$ 57.92	Licking	64	\$ 168,043,312.00	\$ 13,231.07	Hocking	19	\$ 7,123,096.00	\$ 560.84
Lucas	47	\$ 276,597,391.00	\$ 21,778.18	Lorain	90	\$ 110,138,241.00	\$ 8,671.85	Holmes	25	\$ 10,336,112.00	\$ 813.82
Marion	100	\$ 128,613,896.00	\$ 10,126.55	Madison	109	\$ 321,691,881.00	\$ 25,328.75	Jackson	18	\$ 15,130,501.00	\$ 1,191.32
Mercer	26	\$ 7,655,738.00	\$ 602.78	Medina	22	\$ 18,601,644.00	\$ 1,464.62	Jefferson	37	\$ 7,592,901.00	\$ 597.83
Miami	23	\$ 10,005,576.00	\$ 787.80	Montgomery	71	\$ 77,351,496.00	\$ 6,090.35	Lawrence	27	\$ 11,760,373.00	\$ 925.97
Ottawa	75	\$ 65,291,745.00	\$ 5,140.81	Morrow	21	\$ 6,874,959.00	\$ 541.31	Mahoning	66	\$ 72,389,280.00	\$ 5,699.65
Paulding	3	\$ 1,387,796.00	\$ 109.27	Pickaway	133	\$ 195,643,558.00	\$ 15,404.20	Meigs	18	\$ 8,512,106.00	\$ 670.21
Preble	24	\$ 4,859,547.00	\$ 382.62	Portage	25	\$ 7,594,529.00	\$ 597.96	Monroe	22	\$ 11,202,381.00	\$ 882.03
Putnam	18	\$ 5,590,738.00	\$ 440.19	Richland	73	\$ 109,750,465.00	\$ 8,641.32	Morgan	10	\$ 3,700,608.00	\$ 291.37
Sandusky	15	\$ 5,519,069.00	\$ 565.57	Stark	41	\$ 102,066,812.00	\$ 103,210.28	Muskingum	25	\$ 10,647,135.00	\$ 838.31
Seneca	49	\$ 33,546,722.00	\$ 2,641.34	Summit	67	\$ 201,182,298.00	\$ 17,837.94	Noble	31	\$ 50,299,353.00	\$ 3,960.37
Shelby	35	\$ 26,824,309.00	\$ 2,112.04	Union	53	\$ 88,869,557.00	\$ 6,997.24	Perry	16	\$ 3,884,728.00	\$ 305.87
Van Wert	13	\$ 7,459,562.00	\$ 587.34	Warren	109	\$ 150,201,626.00	\$ 11,826.28	Pike	10	\$ 3,878,547.00	\$ 305.38
Williams	13	\$ 5,459,757.00	\$ 429.88	Wayne	6	\$ 7,056,104.00	\$ 555.57	Ross	142	\$ 265,584,512.00	\$ 20,911.07
Wood	36	\$ 67,981,624.00	\$ 5,352.60	Total	1,683	\$ 4,431,517,693.00	\$ 446,091.75	Scioto	55	\$ 171,351,723.00	\$ 13,491.56
Wyandot	19	\$ 10,280,904.00	\$ 1,742.70					Trumbull	60	\$ 55,012,652.00	\$ 4,331.48
Total	871	\$ 1,001,532,751.00	\$ 162,701.95					Tuscarawas	53	\$ 56,132,900.00	\$ 4,419.68
								Vinton	20	\$ 5,854,782.00	\$ 460.98
								Washington	55	\$ 29,149,164.00	\$ 2,295.09
								Total	1,181	\$ 1,105,568,576.00	\$ 87,489.16