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Section 100 Introduction

The rehabilitation decision for highway slope failures is one of the many important tasks to be tackled by Ohio Department of Transportation (ODOT). A rational approach to manage the unsafe or failed slopes/embankments should ideally include a systematic process for collecting the information needed for decision making. This involves database management by recording the descriptive inventory and risk assessment of the failed slope. Essentially, this manual provides the information about the following:

(i) procedure for landslide data collection,
(ii) landslide hazard assessment using ODOT rating matrix
(iii) guidance on the use of a global positioning system (GPS) and an internet website for the ODOT landslide database.

The following terms have been identified for use in this Manual:

Landslide: the down-slope gravitational movement of material that is comprised of at least 51 percent soil comprised of boulders, cobbles, gravel, sand, silt, and/or clay particles.

Soil Cut: any slope which has been modified by construction activities through the removal of soil materials. Typically, these slopes are present above the roadway.

Full Height Embankment: roadway support constructed with engineered fills where both side slopes are greater than 5 feet in height not associated with a drainage structure. Embankments associated with drainage structures will not be included within this Manual, but should be assessed associated with the Culvert Inventory for spans less than 10 foot, or the Bridge Inventory for spans 10 feet or greater.

Side Hill Embankment: roadway support constructed with engineered fills where one side slope is greater than 5 feet in height, but the opposite side has a fill height less than 5 feet, or consists of at grade, cut slope, or natural slope.

Natural Backslope: any slope which has not been modified through construction activities. These slopes can be present above a soil cut or below fill slopes.

The process and procedures outlined within this manual are based upon research conducted by Dr. Robert Liang, PhD at the University of Akron. Results of this research were published in two volumes and can be found at the ODOT Office of Statewide Planning and Research.
This Manual was developed by ODOT, Office of Geotechnical Engineering (OGE) to inventory soil slopes, to identify potential hazardous slopes, to assess relative risk for those slopes, to determine degree of monitoring required, and to allow for actions to be taken to reduce, minimize, or eliminate the risk to the public’s safety and to protect the highway system. This document is not a design manual. The intent of this Manual is to facilitate the creation of a statewide landslide inventory process through the development of a statewide inventory procedure and the establishment of office and field methods. These methods should be used during the initial population of the inventory, inventory of new sites following the initial population, and for maintenance and monitoring of the sites.

The data collection procedures are grouped into three (3) primary sections with subsections:

- Site Inventory and Preliminary Rating
- Non-Rated Sites
- Rated Sites

A landslide inventory will be performed for the state highway system as noted in ODOT’s policy on geohazards. This inventory will include all natural and man-made slopes without exposed bedrock. The field portion of the inventory shall be completed by a Field Team(s). For safety concerns, a Field Team should consist of a minimum of two members. For a multi-discipline approach, the Field Team shall consist of a geologist and either an engineering geologist or geotechnical engineer. The optimum time for the performance of the field work along slopes that have high relief and/or are highly vegetated is October through April. However, it should be noted that snow may also limit field activities in December through February. Field activities may be suspended during periods of inclement weather as directed by ODOT. Slopes that have low relief and/or low to moderate vegetation may be evaluated year round.

Within this Manual, slope instabilities that are being inventoried will generally be referred to as a landslide. The Preliminary Rating will segregate the lower priority sites from the groups that will receive detailed data collection efforts. This Manual will outline a tiered data collection methodology which will allow landslides within Ohio to be rated for relative risk of slope instability to the public and Ohio’s highway system. The data collected from each site will be incorporated into an Enterprise Database and integrated into a GIS system. All information collected by personnel in the field or office should be presented in standard database format, Excel spreadsheets, and GIS ArcView file(s) utilizing ODOT’s standardized file naming conventions.

The data collected from the inventory process will be stored within the Geologic Hazard Management System (GHMS) and other related components of the ODOT GeoMS.
Section 200 Landslide Inventory and Data Collection

201 Purpose and General Process
The inventory will consist of identifying and locating Inventory Sites within the soil slopes situated along Ohio's highway system. Generally, this inventory will be concerned with slopes located below the roadway, unless a landslide event above the road could result in adverse impacts to the highway system. As part of the landslide inventory, a Preliminary Rating will be performed on each site. The Preliminary Rating will provide guidance as to what level of data collection (Detailed Rating) is required.

The Field Team(s) should evaluate all slopes not containing exposed bedrock to determine if there is evidence of slope movement or not. For slopes where no indication of slope movement is present no additional work is required. For slopes where indications of slope movement are present a Preliminary Rating needs to be completed. The Preliminary Rating consists of visually evaluating two criteria for each Inventory Site. These criteria are:

1) Probability of additional movement of the slope.
2) Probability of significant impact to roadway, structures, or adjacent property or features.

This evaluation will be based upon best professional judgment and past experience of the Field Team(s). A probability of Low, Moderate, High, or Very High will be used for each criteria with an associated numerical value assigned. Section 202.3 Field Procedures discussed the creating of an Inventory Site and Preliminary Rating.

For those sites where a Detailed Rating is not required, the slope will be listed as non-rated within the GHMS, with assigned data parameters required during the field data collection. The remaining sites will be considered Rated Sites within the GHMS. A detailed explanation of the procedures will be presented in the subsequent sections.

The methodology for data collection is outlined in the following sections:

- Section 202 Site Inventory and Preliminary Rating
- Section 203 Non-Rated Data Collection
- Section 205 Rated Data Collection

Each section will outline the office and field procedures to collect all the required data for the site.
All sites will require the Non-rated data collection, which is the minimum required data inputs, for the Landslide Inventory. Sites that are categorized as a Moderate Rated site from the Preliminary Rating will require Non-Rated data augmented with basic Rated data collection. For sites that are categorized as either High or Very High Rated sites from the Preliminary Rating will require all levels of data collection. Figure 200.1 outlines the data collection process for the Landslide Inventory.

The District Geotechnical Engineer (DGE) and the Office of Geotechnical Engineering (OGE) shall be notified within 24 hours of when a Very High Rated site has been evaluated.
202 Inventory Site Establishment

202.1 General
The Project Manager and Field Team(s) will begin their work based upon the selection of the counties and routes as designated by OGE and District personnel. Study routes will encompass Interstate Routes, US Routes, and State Routes throughout the state including routes within municipalities. The Project Manager and Field Team(s) will evaluate and select the most efficient travel pattern or routes for completion of the fieldwork prior to starting the field data collection.

Priority selection of counties will be based on National Highway System (NHS) Routes (Interstate Routes, US Routes, and designated State Routes), then the remaining State Routes (non-arterial) within those counties. Routes that have had historical landslide events should be completed before routes that do not have a historical record of landslides.

202.2 Office Procedures
Prior to commencement of the field work, the Project Manager and Field Team(s) should have an idea as to the location of unstable slopes that have a landslide potential in relation to Ohio’s highways. The following sections outline the general office procedures for the development of a work plan for site investigations.

202.2.1 ODOT Interview(s)
Prior to commencing the fieldwork, the Field Team(s) shall contact and schedule interviews with the ODOT DGE/Geologist for each respective District, the ODOT County/Transportation Manager(s) for each respective county, and any other applicable ODOT personnel (e.g. highway workers) who are familiar with the landslide maintenance for the selected area. In addition, interviews may be conducted with county and/or city engineers or maintenance crews for locations where personnel outside of ODOT perform the roadway maintenance or have additional knowledge of the roadway.

The Field Team(s) will interview all applicable personnel as to locations of landslides within their county and/or District. Additionally, the interviews should reveal where landslides are actively occurring or has been a historical problem. Information from these interviews should include, but are not limited to:

- Straight Line Mile (SLM) location(s) of natural or modified slope(s) where stability is in question
- SLM locations of previous or active roadway maintenance as a result of the slope instability
- Amount (size and volume) of debris generated from slope instability
• Length and width, referenced to the roadway, where instability of a slope has been noted
• Accidents resulting from a landslide including date, damage to State or private property, injuries, and/or fatalities
• Scheduled maintenance of slope instability and associated ditch line, including but not limited to, ditch cleaning of earth debris, pavement patch, re-grading of slope, realignment of guardrail sections
• Any landslide remediation work performed in the past

202.2 ODOT GeoMS
Prior to commencing the fieldwork, the Field Team(s) shall review the ODOT GeoMS for currently identified landslide locations provided by the GHMS and historical records provided by Falcon to verify any active or archived locations of past instability. Past geotechnical explorations performed for slope instability associated with ODOT’s roadway facilities are categorized within Falcon as either geohazard or geohazard remediation. This listing is not all inclusive of all past geotechnical work or past slope instabilities, but is the most complete listing of records available.

202.3 Field Procedures
202.3.1 Inventory Site Determination
For each route, it is preferred that the Field Team begin at County Log Mile (CLM) 0.00, which will have a corresponding Straight Line Mile (SLM) 0.00. However, any known SLM referenced point can be utilized as a beginning point. To begin, the DMI should be adjusted to zero at the county line or beginning of the route. If starting at a known referenced point (e.g. structure or interchange) adjust the DMI reading to the corresponding SLM. If the Field Team has to stop for the day, or the need to re-zero the DMI is required, each structure has a SLM recorded at its right side of the rear abutment in the cardinal direction, and a SLM is available for each center point of roadway intersections. All mile marker records for the landslide inventory should be referenced to SLMs. The DMI records will be in a True Log Mile format and will need to be adjusted to the corresponding SLM. Straight Line diagrams referencing the SLM can be obtained from Office of Technical Services (OTS).

Using a zeroed DMI reading (from a reference point), proceed in the cardinal or non-cardinal direction, until a landslide is encountered.

The Field Team should evaluate each landslide encountered. For bifurcated highways with slopes encountered on both sides of the travel lane, the slopes for both sides of the travel direction should be evaluated at the same time. For divided highway, all slopes along the right side of the roadway should be evaluated. Then, all the slopes on the opposite side of the roadway should be evaluated while driving in the opposite
direction. For non-divided highways slopes can be evaluated on both sides of the roadway at the same time. Care must be taken in correcting for the Beginning Mile Point (BMP) along the opposite slope. Figure 200-04 provides examples of how the slope shall be evaluated based upon roadway type.

![Diagram of slope evaluation based on road type](image)

**Figure 200-02. Slope Evaluation Based on Road Type**
Each slope location can be evaluated as a single or multiple Inventory Site(s). An Inventory Site is defined as: *any continuous roadway section where a slope has the same characteristics.* *A minimum slope height of 5-feet is required to be an Inventory Site, unless the Field Team determines that a slope with a height less than 5 feet poses a danger to safety of the traveling public.*

Common evidence of ground movement to look for to indicate that possible slope instability is present are, but not limited to:

- head scarps
- toe bulges
- tension cracks
- hummocky appearance of a slope surface
- convex or concave slope appearance
- misalignment of guardrail, power lines, or drainage pipes
- tilting trees not associated with growth toward sunlight
- “J” shaped trees
- cracking of surface drainage channel
- expansion and/or closing of the bridge joints
- loss of alignment of building foundation
- patching of the roadway surface
- longitudinal dips in pavement surface
- water seepage on slope
- debris blockage or poorly flowing ditches along the toe of the slope

It should be noted that some of these conditions can be noted, but will not represent slope instability. Typically, when slope instability is occurring multiple characteristics are present. Examples of these conditions are presented in Appendix B: Photographic Examples – Landslide Characteristics.

Additionally, the following guidelines should be followed in establishing Inventory Sites:

1. A series of small instabilities closely associated with each other should be combined into a single Inventory Site; because, as the problem develops corrective actions will typically be applied to the larger area as a whole, especially as an excavation and replacement project.
2. When the slope is disrupted due to the presence of a structure abutment with similar characteristics on either side of the abutment, the slope should be
broken into multiple sites. The risk of the slope instability is greater when an associated structure is present relative to strictly roadway cut or embankment.

3. Erosion by itself does not indicate the presence of slope instability. However, when erosion is not addressed it can progress to the point where the impact to the slope will result in overall global instability.

4. In no case should an Inventory Site extend more than one mile (+/-) or cross county lines. A new Inventory Site should be created at a county border.

5. A site should not extend from either a mainline section onto a ramp, or vice versa, unless the length of the extension will be minimal. A separate site should be established for each roadway segment.

202.3.1 a) Site Determination for Ramps
Sites located on ramps will be referenced to the SLM of the mainline. The selected mainline for the SLM referencing will use the following conventions:

- Interstates over US Routes and State Routes
- US Routes over State Routes
- If there are two Interstates, US Routes or State Routes, the lower numbered route will be the referenced route.

Figure 200-03 presents an example for site determination relative to Ramp BMP’s.
203 Preliminary Rating of Inventory Site

Each Inventory Site will have a Preliminary Rating completed to determine the level of data collection required. The Preliminary Rating consists of visually evaluating two criteria based upon best professional judgment and past experience. These criteria are:

1) Probability of additional movement of the slope.
2) Probability of significant impact to roadway, structures, or adjacent property or features.

Potentials of Very High, High, Moderate, or Low are used, with numerical values (4, 3, 2, 1, respectively) assigned for each. A Preliminary Rating is then calculated by multiplying the rows and columns together. Preliminary Rating Scores will range between 1 and 16 points.

Locations where the Preliminary Rating Score is 1 or 2 points, the Inventory Site is considered a Non-Rated Site. For Non-Rated sites the information required for the Inventory Site Location is required. This data is considered “Part A” data within the GHMS.

Locations where the Preliminary Rating Score is greater than 2 points, the Inventory Site is considered a Rated Site. For scores of 3 or 4 points, the site is considered to be a Moderate Rated site. For scores of 6, 8, or 9 points, the site is considered to be a High Rated site. For scores of 12 or 16 points, the site is considered to be a Very High Rated site. All Inventory Sites which are considered rated will require the collection of the Non-Rated data in addition to the required Rated data. This Rated Data consists of detailed information about the slope, roadway geometry and traffic data.

Table 200.01 and 200.02 present the Probability Table and Preliminary Rating Score breakdown of each level of risk.

<table>
<thead>
<tr>
<th>Probability of Additional Movement (A)</th>
<th>Probability of Significant Impact to the Roadway, Structures, Adjacent Property or Features (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High (4)</td>
<td>Very High (4)</td>
</tr>
<tr>
<td></td>
<td>High (3)</td>
</tr>
<tr>
<td></td>
<td>Moderate (2)</td>
</tr>
<tr>
<td></td>
<td>Low (1)</td>
</tr>
<tr>
<td>Very High (4)</td>
<td>Very High 16</td>
</tr>
<tr>
<td></td>
<td>Very High 12</td>
</tr>
<tr>
<td></td>
<td>High 8</td>
</tr>
<tr>
<td></td>
<td>Moderate 4</td>
</tr>
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<td>High (3)</td>
<td>Very High 12</td>
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<tr>
<td></td>
<td>High 9</td>
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<tr>
<td></td>
<td>High 6</td>
</tr>
<tr>
<td></td>
<td>Moderate 3</td>
</tr>
<tr>
<td>Moderate (2)</td>
<td>High 8</td>
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<td>High 6</td>
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<tr>
<td></td>
<td>Moderate 4</td>
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<td></td>
<td>Low 2</td>
</tr>
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<td>Low (1)</td>
<td>Moderate 4</td>
</tr>
<tr>
<td></td>
<td>Moderate 3</td>
</tr>
<tr>
<td></td>
<td>Low 2</td>
</tr>
<tr>
<td></td>
<td>Low 1</td>
</tr>
</tbody>
</table>
The Preliminary Score is calculated by multiplying Column A (Probability of Additional Movement) by Column B (Probability of Significant Impact to the Roadway, Structures, Adjacent Property or Feature.

\[
\text{Eq. #1: Preliminary Score } = A \times B
\]

**Table 200-02.**
Risk Type Based on Preliminary Rating Score

<table>
<thead>
<tr>
<th>Preliminary Rating Score</th>
<th>Risk Type</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td><strong>Non-Rated</strong></td>
<td>No Detailed Rating Needed</td>
</tr>
<tr>
<td>3 or 4</td>
<td><strong>Moderate Rated</strong></td>
<td>Detailed Rating Needed</td>
</tr>
<tr>
<td>6, 8, or 9</td>
<td><strong>High Rated</strong></td>
<td>Detailed Rating Needed</td>
</tr>
<tr>
<td>12 or 16</td>
<td><strong>Very High Rated</strong></td>
<td>Detailed Rating Needed</td>
</tr>
</tbody>
</table>

204 Non-Rated Additional Data
All Inventory Sites will require the collection of Non-Rated Data. This data provides the basic component of location for the site to allow for future ratings of the location and are discussed in detail below.

204.1 Site Location
The following data is required to identify the Inventory Site Location. This data is recorded in *Part A: Site Location* of the GHMS.

The following data is included under the *Basic Information* tab within the GHMS Section Site Location.

- District
- County
- Route System
- Route Number (5-digit ODOT designated route number)
- Jurisdiction Code:
  (C-County, H-Turnpike Commission, M-Municipal, S-State, T-Township)
• Slope orientation (in degrees from north (azimuth coordinate), relative to the BMP, running parallel to the direction of traffic flow)
• Measured length of the Inventory Sites (in feet) along roadway
• Beginning Mileage Point (BMP) (as the SLM value determined from the DMI reading [Note that the BMP is the lowest SLM value for the site])
• Ending Mileage Point (EMP) (as a SLM value determined based upon the Inventory Site length and BMP)
• Record if the site is located along the roadway in the cardinal direction (Yes = northbound or eastbound, No = southbound or westbound)
• Horizontal Position of the Slope (Right or Left relative to cardinal mainline direction or to driving direction for ramps)
• Driving direction: (North, South, East, West)
• Vertical Position (Above, Below or Both)
• Estimated depth of the sliding surface (in feet)
• USGS Quadrangle Name
• The Network Linear Feature Identification Code (NLFID Code) will be auto generated for the location (update button). The NFLID designation is a tracking code consisting of:
  ▪ Jurisdiction Code
  ▪ County
  ▪ Classification Code
  ▪ Route Number

Default code to complete the NLFID Code (**C)

Example 200-01 presents the format for the NFLID Code
**EXAMPLE 200-01:** NLFID Coding Standard

NLFID CODE - STUSUS00250**C

<table>
<thead>
<tr>
<th>S</th>
<th>TUS</th>
<th>US</th>
<th>00250</th>
<th>**C</th>
</tr>
</thead>
</table>

Where:
- A is the Jurisdiction Code
- B is the County Code
- C is the Classification Code
- D is the Route Number
- E is the default code

Additional Information concerning the site consists of:

- Hazard width, perpendicular to the road
- Distance from Toe of cut to shoulder

The following data is included under the *GPS Information* tab within the GHMS:

- Beginning Latitude
- Beginning Longitude
- Beginning Elevation
- Offset Distance, in feet, and Bearing, in degrees from north (azimuth coordinate), if the positional data is not able to be collected at the exact position of the BMP location

The beginning and end of the Inventory Site should be indicated in the field by placing a minimum 18-inch long white line perpendicular to the roadway made with surveyor’s paint at either end of the site along the edge of the pavement. The BMP should be indicated with a “B”, and the EMP should be indicated with an “E”.

Note: it can be helpful for large sites, if while measuring the Inventory Site length, place tick marks along the roadway shoulder at regular intervals (say 100 or 200 feet) to use in locating features.

**204.1.1 Beginning Mile Point (BMP)**

The BMP shall be determined based upon the DMI reading recorded at the beginning point of the Inventory Site. The BMP shall always be the lowest SLM point of the
Inventory Site. If the DMI reading at the BMP was started at SLM 0.00 then the BMP is the adjusted DMI reading. However, if the DMI reading recorded at the BMP was started at a location other than SLM 0.00, the BMP needs to be calculated by adding the starting point SLM and the adjusted DMI reading. The adjusted DMI reading is the true log mile reading adjusted for the station equations to calculate the SLM.

Record the BMP value to the nearest 0.01 miles.

When a site is re-inventoried the established Global ID will not change. If the point of origination moves because the slope instability had progressed then the BMP may have to be adjusted to account for this.

204.1.2 Inventory Site Length
The length of the Inventory Site is a direct measurement between the BMP and the EMP. Generally, this measurement is made with either a measuring tape, measuring wheel, or a laser range finder.

Record the Inventory Site Length to the nearest foot.

204.1.3 Ending Mile Point (EMP)
For mainline sections, the EMP can be calculated based upon the length of the Inventory Site divided by 5280 ft/mile then added to the BMP. An alternative is to record the position utilizing the adjusted DMI reading as outlined in Section 202.4.1 Beginning Mile Point (BMP).

Record the EMP value to the nearest 0.01 miles.

When a site is re-inventoried the established Global ID will not change. If the point of termination moves because the slope instability had progressed then the EMP may have to be adjusted to account for this.
EXAMPLE 200-02: Sites with DMI Readings starting at SLM 0.00:

<table>
<thead>
<tr>
<th>Inventory Site Attribute</th>
<th>SLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI Reading from SLM 0.00</td>
<td>2.91</td>
</tr>
<tr>
<td>Beginning SLM (BMP)</td>
<td>2.91</td>
</tr>
<tr>
<td>Length of Site</td>
<td>1850 ft</td>
</tr>
<tr>
<td>1850 ft ÷ 5280 ft/mile = 0.35 mile</td>
<td></td>
</tr>
<tr>
<td>Ending SLM (EMP)</td>
<td>3.26</td>
</tr>
<tr>
<td>BMP 2.91 + 0.35 mile</td>
<td></td>
</tr>
</tbody>
</table>

EXAMPLE 200-03: Sites with DMI Readings not starting at SLM 0.00:

<table>
<thead>
<tr>
<th>Inventory Site Attribute</th>
<th>SLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLM at Starting Intersection</td>
<td>12.58</td>
</tr>
<tr>
<td>DMI Reading from Intersection</td>
<td>2.91</td>
</tr>
<tr>
<td>Beginning SLM (BMP)</td>
<td>15.49</td>
</tr>
<tr>
<td>Length of Site</td>
<td>1850 ft</td>
</tr>
<tr>
<td>1850 ft ÷ 5280 ft/mile = 0.35 mile</td>
<td></td>
</tr>
<tr>
<td>Ending SLM (EMP)</td>
<td></td>
</tr>
<tr>
<td>BMP 15.49 + 0.35 mile</td>
<td>15.84</td>
</tr>
</tbody>
</table>

For ramps where the BMP and/or the EMP is not visible from the mainline then that value does not need to be recorded.

204.1.4 Centroid
After calculating the initial EMP, the field crew members will determine the center position, or centroid, for the site by dividing the calculated length by 2 and adding to the BMP. The location of centroid should be marked on the right shoulder by placing a “C” using surveyor’s paint. The location of BMP, EMP and Centroid points are illustrated in Figure 2.9.
When a site is re-inventoried the established Global ID will not change. If the point of origination or termination moves because the slope instability had progressed then the BMP and/or EMP may have to be relatively adjusted to account for this. However, the Centroid position will remain fixed to the original calculated position to allow for reference to orientation of the progression of the landslide over time.

204.1.5 BMP Position

Record the BMP position as a GPS point at the right shoulder of the BMP. The BMP position shall include the latitude, longitude, and elevation and be determined using a Trimble GPS unit, or equivalent or better, as a point in decimal degrees to six (6) digits to the right of the decimal. GPS guidelines for data collection are presented in Appendix E.

If a GPS reading cannot be taken along the shoulder of the roadway at the BMP of the Inventory Site due to poor signal, or physical obstruction, use an offset reference point which has good access and an adequate GPS signal. After recording the GPS coordinates at the offset location, collect and record a bearing, the offset distance from the reference point to the BMP, and change in ground surface elevation to the shoulder location at the Inventory Site BMP position. The bearing value should be obtained in degrees from north (azimuth coordinate), and the offset distance and change in ground height need to be recorded as a physical measurement to the nearest foot.
The raw data collected at the site will be recorded as an .ssf file. A separate .cor file should be created for each Inventory Site upon completion of the post processing of the raw data. Both the .ssf and .cor files should be saved.

<table>
<thead>
<tr>
<th>EXAMPLE 200-04: BMP Position Data:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP Latitude = 40.125524958</td>
</tr>
<tr>
<td>BMP Longitude = -81.789859546</td>
</tr>
<tr>
<td>BMP Elevation = 765 ft</td>
</tr>
<tr>
<td>Offset Bearing = 127°</td>
</tr>
<tr>
<td>Offset Distance = 185 ft</td>
</tr>
<tr>
<td>Change in Elevation = 7 ft</td>
</tr>
</tbody>
</table>

If the BMP Position is adjusted during the re-inventory this position should be collected and the corrected positional data entered into the GHMS.

204.1.6 Non-Rated Additional Data
For non-rated sites the principal data collection will be the Preliminary Score and the Inventory Site Location data as previously discussed. Additional data field required for these sites are:

- Hazard Width
- Hazard Length
- Number of Lanes
- Road Width
- Position

205 Rated Data Collection
The data required to be collected for rated sites is essentially the same for Moderate Risk, High Risk and Very High Risk sites. A site determined to be a high or very high risk based on the Preliminary Risk Score is required to have Hydrological Information provided. The Rated Sites data collection is housed within two parts in the GHMS. Part B data contains the traffic and maintenance information. Part C contains the slope information.
205.1 Traffic Information
Within the GHMS, Part B – Traffic Information, seven data fields need to be collected. These fields are:

1. Posted Speed Limit
2. Decision Site Distance (DSD)
3. Actual Site Distance (ASD)
4. Percent Decision Site Distance (PDSD)
5. ADT
6. ADTT
7. AVT

The following sections outline the procedure for each data field.

205.5.1 Posted Speed Limit
The designated posted speed limit can be determined by observing the signage along the roadway which presents the posted speed limit. An alternative to this is the data can be obtained through the ODOT GIS Statewide Roadway Inventory or the Base Transportation Reference System (BTRS).

205.5.2 Decision Site Distance (DSD)
The Decision Site Distance (DSD) shall be determined by the latest version of the “Geometric Design of Highways and Streets”. The DSD is based upon the posted speed limit of the roadway and represents the distance required for a driver to react and stop to an obstruction present within the roadway without striking it. Table 200-03 outlines the general DSD values for highways.
### TABLE 200-03

<table>
<thead>
<tr>
<th>Design Speed (MPH)</th>
<th>DSD (ft)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ≥</td>
<td>375</td>
</tr>
<tr>
<td>30</td>
<td>450</td>
</tr>
<tr>
<td>35</td>
<td>525</td>
</tr>
<tr>
<td>40</td>
<td>600</td>
</tr>
<tr>
<td>45</td>
<td>675</td>
</tr>
<tr>
<td>50</td>
<td>750</td>
</tr>
<tr>
<td>55</td>
<td>865</td>
</tr>
<tr>
<td>60</td>
<td>990</td>
</tr>
<tr>
<td>65</td>
<td>1050</td>
</tr>
<tr>
<td>70</td>
<td>1105</td>
</tr>
<tr>
<td>75</td>
<td>1180</td>
</tr>
</tbody>
</table>

* Based upon the 2005 edition, Exhibit 3-3, Avoidance Maneuver C.

Note: For Design Speeds less than 25 MPH use a DSD of 375 feet.

#### 203.5.3 Actual Site Distance (ASD)

The Actual Site Distance (ASD) is the shortest distance along a roadway, either approaching or within the Inventory Site, at which a six inch object is continuously visible to a driver, and is a physical measurement based on the following method:

Place a 6-inch high traffic cone or hard hat near the edge of the roadway within the Inventory Site. From that point move away from the object until it is no longer visible from a height of 3.5 feet above the road surface (estimated height for a driver’s field of vision). From this point measure the distance to the object. All observations should be made in the direction of the traffic flow.

For Inventory Sites having relatively long lengths, curves, and/or varying road slopes, collect a series of ASD beginning at the BMP and proceeding toward the EMP. Compare the ASD values collected and utilize the smallest recorded value as the ASD for the Inventory Site.

#### 205.5.4 Percent Decision Sight Distance (PDSD)

After the ASD and the DSD has been determined for the Inventory Site, calculate the percent decision site distance (PDSD). The following equation shall be utilized to calculate the PDSD:
Eq. #2: \[ PDSD = \frac{ASD}{DSD} \times 100 \]

If the calculated value is greater than 100 percent it is assumed that a driver will have sufficient time to stop prior to striking a drop, crack, or debris within the roadway. The PDSD is an auto-calculated field within the GHMS in *Part B: Traffic Information*. Example 200-07 presents the calculation of the PDSD.

**Example 200-05: Percent Decision Site Distance**

*Inventory Site with the following field data:*

- BMP @ MP 2.91
- EMP @ MP 3.26
- Inventory Site Length = 1851 ft.
- Speed Limit = 55 mph
- DSD = 865 ft.
- ASD Readings = 850 ft., 865 ft., 799 ft., 860 ft., 579 ft.
- Site ASD = 579 ft.

\[ PDSD = \frac{ASD}{DSD} \times 100 \]

\[ PDSD = \frac{579}{865} \times 100 \]

\[ PDSD = 67\% \]

**205.5.5 Traffic Reports**

Record the Average Daily Traffic (ADT), Average Vehicular Traffic, including Type A commercial vehicles, (AVT), and Average Truck Traffic (ATT) values, for the section of roadway which contains the Inventory Site. These values can be obtained from the Traffic Survey Reports which can be accessed from the web. The traffic reports allow the user to select a report based upon county and year that the survey was completed. A complete report for each selected county is then provided that includes all state highways. Each Route is subdivided based on straight line miles within a “Traffic Section”, which gives a general description of where the data was recorded, section length in miles, and columns for passenger & type A commercial vehicles, type B & C commercial vehicles, and total vehicular traffic. The passenger & A commercial vehicle column refers to the AVT value, B & C commercial traffic.
column refers to the ATT value, and the total vehicular traffic column refers to the ADT. The most recent survey should be utilized to determine the individual counts.

205.6 Maintenance Information
Within the GHMS, Part B – Maintenance Information, three data field need to be collected. These fields are:

1. Annual Maintenance Frequency
2. Maintenance Response
3. Suggested Remedial Measures

205.6.1 Suggested Remedial Measures
When evaluating the Inventory Site with slope instability the evaluation team should determine what remedial options are potentially applicable for corrective action repairs. Typically, the three most applicable options should be selected.

206 Detailed Information
For those sites where the Preliminary Rating indicates that the site is to be rated, detailed slope information is required.

206.1 Landslide Movement Type
Determine the type of instability which is resulting in the landslide based on the visual evidence of the Inventory Site. Select from the following landslide movement types:

1. Slide
2. Spread
3. Flow

Each of these types can be further subdivided and are discussed in the subsequent sections.

206.1.1 Slides
A slide is the down slope movement of a soil mass predominantly on surfaces of rupture, or on a relatively thin zone, of intense shear strain. Movement does not always occur simultaneously over the whole of what will eventually become the surface of rupture; the volume of displaced material enlarges from an area of local failure. Often the early sign of ground movement is cracks in the original ground surface along which the main scarp of the slide develops. Two distinct types of slides are typically found within Ohio. These are rotational and translational.
206.1.1.a Rotational Slide
A rotational slide moves along a surface of rupture that is curved and concave. As the surface of rupture is roughly circular the displaced material mass may move along the surface with little internal deformation. The head of the displaced material may move almost vertically downward, whereas the upper surface material tilts backwards toward the scarp. If the slide extends for a considerable distance along the slope perpendicular to the direction of motion, the surface of rupture may be roughly cylindrical. The axis of the cylindrical surface is parallel to the axis about which the slide rotates.

![Generalized Diagram of Rotational Slide](From Cruden and Varnes, 1996)

**Figure 200-05. Generalized Diagram of Rotational Slide**

206.1.1.b Translational Slide
A translational slide is where the failure soil mass is displaced along a planar or undulating surface or rupture, sliding out and over the original ground surface. Translational slides are usually shallower in depth than rotational slides. Therefore, the ratio of depth to length of a translational slide is typically less than 0.1. The surfaces of rupture of translational slides are often broadly channel-shaped in cross section.
206.1.2 Spreads

A spread is defined as an extension of a cohesive soil combined with a general subsidence of the failure soil mass of cohesive material into softer underlying material. Spread may result from liquefaction or flow of softer material. The cohesive material may also subside, translate, rotate, disintegrate, or liquefy and flow. Clearly these movements are complex.
206.1.3 Flows
Flows are a spatially continuous movement, in which surfaces of shear are short-lived, closely spaced and usually not preserved. The distribution of velocities in the displacing soil mass resembles that in viscous liquid. The lower boundary of the displaced mass may be a surface along which appreciable differential movement has taken place or maybe a thick zone of distributed shear.

![Examples of Flows](image)

Figure 200-08. Examples of Flows (Cruden and Varnes, 1996)

206.2 Rate of Movement
The field team needs to estimate the rates at which the instability is occurring. Consult the maintenance records for frequency of patching, difference between measurements from last inspection, or inclinometer records if available. Record the rate in inches per year, or unknown if unable to determine.
206.3 State of Activity
Report what the estimated current state of activity of the instability is at the time of assessment. The activity is recorded in Landslide Information tab, Landslide Characteristics subtab in Part C of the GHMS. Use the following choices:

- Active: The instability is currently progressing with downslope movement. This includes locations where previous mitigation measures were utilized which are not adequate.
- Inactive: The instability has reached a pseudo-static equilibrium where active downslope movement has been arrested until a new triggering event occurs.
- Mitigated: Corrective measures have been performed to permanently arrest the downslope movement. It should be noted that mitigated sites can become active.

206.4 Causes of Landslide
Within the GHMS Part C data collection in tab Landslide, subtab Cause of Landslide, the field team should indicate the possible human and natural activities which may have contributed to the slope instability. The following are the common activities to choose from:

<table>
<thead>
<tr>
<th>Table 200-04. Human Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation/undercutting</td>
</tr>
<tr>
<td>Groundwater pumping</td>
</tr>
<tr>
<td>Deforestation</td>
</tr>
<tr>
<td>Defective maintenance</td>
</tr>
<tr>
<td>Loose waste dumping</td>
</tr>
<tr>
<td>Water leakage from pipes</td>
</tr>
<tr>
<td>Artificial Vibration</td>
</tr>
<tr>
<td>Loading</td>
</tr>
<tr>
<td>Construction related</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 200-05. Natural Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall</td>
</tr>
<tr>
<td>Ground water</td>
</tr>
<tr>
<td>Inadequate Long Term Strength</td>
</tr>
<tr>
<td>Degradation of Construction Material</td>
</tr>
<tr>
<td>Snowmelt</td>
</tr>
<tr>
<td>Loss of Vegetation</td>
</tr>
<tr>
<td>Surface Water Change/Rapid Drawdown</td>
</tr>
<tr>
<td>earthquake</td>
</tr>
<tr>
<td>Toe erosion</td>
</tr>
</tbody>
</table>

206.5 Impact Assessment
Determine if the current instability will present an impact to the roadway or beyond the right of way. Utilize the following for options of these impacts.

Current and potential impact of landslide on roadway

- On Slope with a low potential to affect shoulder
On slope with a low potential to affect roadway
- On shoulder or on slope with a moderate potential to affect roadway
- On roadway, or on slope with a high potential to affect roadway or structure

Current or potential impact of landslide on the area beyond right of way

- On slope with a low potential to impact area beyond right of way.
- On slope with a moderate potential for impact area beyond right of way
- On slope with high potential to impact area beyond right of way
- On slope with a high potential to impact building or structure beyond right of way

206.6 Evidence of Impact to Roadway
Record if any evidence of slope instability is expressing itself within the roadway through either a dip or crack. If both are present then record the corresponding measurements for both and the highest risk score will be generated. These measurements are typically accomplished using a straight edge, such as a 4-foot long level as a reference beam.

206.6.1 Dip
If a dip is present within the roadway record the vertical displacement (VD) in inches. Figure 200-09 present a method for measuring the displacement.

![Figure 200-09. Displacement Measurement for a Dip](image)
206.6.2 Crack

If a crack is present within the roadway record the vertical displacement (VD) in inches and the horizontal displacement (HD) in inches. This is typically accomplished with using a straight edge, such as a 6-foot long level as a reference beam.

Figure 200-10. Example of Crack

Note the crack in the pavement indicated by the perpendicular white lines across the break.

Figure 200-11. Horizontal and Vertical Displacement Measurement for Crack

206.6.3 Earth Debris on Roadway
Record if there is evidence of earthen debris present within the ditch or roadway. If present, record the material volume to the nearest cubic yard.

206.7 Adjacent Structures and Area
Record what structures are present outside of the Inventory Site which may be impacted by the slope instability. For each potential structure which may be impacted indicates the potential impact risk associated with that structure as:

- Low
- Moderate
- High

Additionally, indicate the adjacent land usage. Multiple selections are possible if more than one structure or land usage is applicable. The following are the common selections for adjacent structures and land usage:

**Table 200-6. Common Adjacent Structure Types**

<table>
<thead>
<tr>
<th>Road/Drive</th>
<th>Commercial Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railroad</td>
<td>Bridge</td>
</tr>
<tr>
<td>Residential</td>
<td>Utilities</td>
</tr>
</tbody>
</table>

**Table 200-7. Common Surrounding Land Usage**

<table>
<thead>
<tr>
<th>Forest</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural</td>
<td>Housing Development</td>
</tr>
<tr>
<td>Rural</td>
<td>Other</td>
</tr>
</tbody>
</table>

206.8 Slope Type
Record the slope type in which the slope instability is present.

**Table 200-8. Slope types**

<table>
<thead>
<tr>
<th>Natural</th>
<th>Slope which has not been altered during construction of the roadway.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut</td>
<td>Slope which has been altered during construction of the roadway. Typically slope angle is steeper than the what the natural slope angle was prior to construction</td>
</tr>
<tr>
<td>Fill</td>
<td>Slope supporting the roadway which has been built up from the natural slope.</td>
</tr>
<tr>
<td>Cut and Fill</td>
<td>Area where one side of the roadway is supported through a cut slope and the opposite side of the roadway is support through fill placement.</td>
</tr>
</tbody>
</table>
206.9 **Slope Appearance**

Record the appearance of the slope in relationship to the slope instability.

- Straight
- Concaved
- Convex
- Hummocky
- Terraced
- Complex

![Figure 200-12. Slope Appearances](image)

*From Abramson 1996 (modified from William Morris Davis 1907)*

*From FHWA, 1998*
206.10 Vegetation Cover
Record the percentage of cover based upon each type of vegetation present on the slope. The total percentage should add up to 100%. For areas where bedrock is exposed or barren soil is present record as “Other”.

- Grass
- Shrub
- Cultivated Land
- Reforestation
- Woodland

206.11 Orientation of Slope
Record the Slope orientation (in degrees from north (azimuth coordinate), relative to the BMP, running parallel to the direction of traffic flow).

206.12 Direction of Landslide
Record the direction in which the slope instability is moving. Typically, this will be perpendicular or an acute angle to the Orientation of Slope. Record the value in degrees from north (azimuth coordinate).

206.13 Slope Angle
Determine the average slope angle by evaluating each discrete angle along the slope length. Within the GHMS a distinct collection of data point will be required for each angle including the following:

- Slope angle name (auto populate)
- Estimated slope angle
- Slope length from section; hill to section toe
- Description

For multi-angle slopes, after each distinct angle for the slope and its characteristics have been recorded the GHMS will then auto calculate the weighted average slope angle for the Inventory Site. If collecting data utilizing conventional methods Figure 200.11 indicates how to calculate the average slope angle.
206.14 Slope Material
Record the estimated soil origin, soil type, and in-place rock type, if applicable. The soil origin can be approximated based on physiographic location within the State as well as proximity on the slope that the instability and Inventory Site are located. The following are the typical soil origins in Ohio:

<table>
<thead>
<tr>
<th>Table 200-9. Typical Soil Origins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colluvium</td>
</tr>
<tr>
<td>Alluvium</td>
</tr>
<tr>
<td>Fill</td>
</tr>
<tr>
<td>Till</td>
</tr>
</tbody>
</table>

In addition to the soil origin, estimate the soil type relative to exposed material in the failure, along the slope, or in adjacent exposures.

<table>
<thead>
<tr>
<th>Table 200-10. Soil Types Anticipated in Ohio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat</td>
</tr>
<tr>
<td>Organic</td>
</tr>
<tr>
<td>Clay</td>
</tr>
<tr>
<td>Silty Clay</td>
</tr>
<tr>
<td>Sandy Clay</td>
</tr>
<tr>
<td>Clay and Silt</td>
</tr>
<tr>
<td>Gravelly Clay</td>
</tr>
<tr>
<td>Silt</td>
</tr>
<tr>
<td>Clayey Silt</td>
</tr>
<tr>
<td>Sandy Silt</td>
</tr>
<tr>
<td>Gravelly Silt</td>
</tr>
<tr>
<td>Sand</td>
</tr>
<tr>
<td>Clayey Sand</td>
</tr>
<tr>
<td>Gravel</td>
</tr>
<tr>
<td>Sandy Gravel</td>
</tr>
<tr>
<td>Cobble &amp; Boulders</td>
</tr>
</tbody>
</table>

207 Hydrological Data
For sites which are rated as High or Very High, hydrological data needs to be collected by the field team. This data is recorded with the GHMS Part C, Hydrological tab.
207.1 Water Conditions
Indicate if a water condition is adversely affecting the slope stability. The types of water sources to consider are

a) Surface Water
b) Groundwater
c) Ice during winter

207.1.1 Surface Water
If surface water is present which is adversely affecting the stability of the slope specify the source type from the following:

Table 200-11. Surface Water Sources

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Creek</th>
<th>River</th>
<th>Surface Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake</td>
<td>Pond</td>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

Additionally, indicated the location on the slope where the water source is affecting the stability as:
- Above
- Below
- Both

207.1.2 Groundwater
If groundwater is present which is adversely affecting the stability of the slopes specify how the groundwater is affecting the slope as following:

- Into landslide
- Off landslide
- Both
- Unknown

Also, indicate the condition in which the groundwater is affecting the slope as:

- Spring
- Seep
- Both
- Unknown
Additionally, indicate the location on the slope where the water source is affecting the stability as:

- Above
- Below
- Both

207.1.3 Ice Present
During the winter season when ambient air temperature stays below freezing, the presence of water is typically expressed on the slope as ice buildup. The water source for the ice can be difficult to determine if it is surface water or groundwater. Therefore, just record the amount of ice through visual evaluation as either:

- Minimum
- Moderate
- Heavy

207.2 Precipitation History
The precipitation history should be recorded for the site. The 1-day, 3-day, 7-day and 15-day precipitation history from the date of field data collection should be reviewed and recorded. If more than one day was spent working on the field data collection for the Inventory Site, the precipitation history should be referenced to the actual day that site hydrogeology data was recorded. This information can be obtained commercially from NOAA, or a request can be made to the Ohio Department of Natural Resources, Division of Water.

*This data will be presented in GHMS Part C: Hydrogeological Information, Precipitation tab.*

Section 300 Risk Scoring for Inventory Sites
301 Landslide Inventory Site Risk Score
After completion of the field data collection, Inventory Sites which are Rated (moderate, high or very high) will need an associated Inventory Site Risk Score (Risk Score) developed. The Risk Score is calculated based on six (6) factors which are:

- Movement Location/Impact
- Hazard to Traveling Public
- Maintenance
- % Decision Sight Distance
- Adjusted ADT
- Accident History
Each factor will develop a raw value score based on the recorded field data. Each evaluation parameter has a specific equation in which the site specific raw value (RV) is a field input. A weighting factor is applied to each evaluation parameter to provide an evaluation parameter score. The evaluation parameters values are summed to calculate the Inventory Site Risk Score.

The following sections outline the scoring for each factor.

302 Movement Location/Impact

The Movement Location/Impact is a multi-variable factor relating to the current and/or potential movement of the landslide relative to either the roadway or to an area beyond the right of way. This score is based on either the impact to roadway or the impact beyond the right of way with the largest of the two variables being carried forward to the site risk score. The following scores are assigned relative to the following:

<table>
<thead>
<tr>
<th>Evaluation Parameter</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current and potential impact of landslide on roadway</td>
<td>3</td>
</tr>
<tr>
<td>On slope with a low potential to affect shoulder</td>
<td>On slope with a low potential to affect roadway</td>
</tr>
<tr>
<td>Current and potential impact of landslide on area beyond right or way</td>
<td>On slope with a low potential to impact area beyond right of way</td>
</tr>
</tbody>
</table>

A minimum of 3 points and a maximum of 81 point need to be assigned for this factor.

303 Hazard to Traveling Public

The Hazard to Traveling Public is a multi-variable factor relative to the amount of displacement within the roadway relative to the slope instability or how quickly the instability is occurring. The first variable is relative to the rate of displacement occurring to the roadway. If this rate is unknown then the risk is judged base of the evidence of displacement within the roadway.

The primary variable is the rate of displacement (inches per year) within the roadway. Utilize the following scoring matrix based upon the determined rate:

- \[1.0321 \times (RV^3) - 5.9063 \times (RV^2) + 11.763 \times RV\]
The alternative variable if the rate is unknown is based on the evidence of displacement (inches) within the roadway. For a dip within the roadway the vertical and horizontal displacements are normalized to develop the Displacement which is then used as the RV for the formula. For a crack within the roadway the vertical and horizontal displacements are normalized to develop the Displacement which is then used as the RV for the formula. If both a dip and a crack are present then the maximum RV between the two should be utilized. The following scoring matrix should be utilized for the displacement:

\[ 3 \times e^{(1.1193 \times RV)} \]

A minimum of 0 points and a maximum of 81 point need to be assigned for this section.

### 304 Maintenance Response

The Maintenance Response is a multi-variable factor based on the Inventory Site’s maintenance records. These records are obtained from the applicable County Garage, County or Transportation Manager, or District Geotechnical Engineer. Rating scores are assigned as follows:

- None to rare = 3 points
- Annual Maintenance = 9 points
- Seasonal Maintenance = 27 points
- Continuous Maintenance = 81 points

The alternative to the frequency is the Maintenance Response. Table 300-02 presents the Maintenance response section or the Inventory Risk Score.

**Table 300-02. Maintenance Response**

<table>
<thead>
<tr>
<th>Evaluation Parameter</th>
<th>Rating Scores for each Evaluation Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Maintenance Response</td>
<td>No response</td>
</tr>
<tr>
<td>Score</td>
<td></td>
</tr>
</tbody>
</table>

A minimum of 3 points and a maximum of 81 point will be assigned to each factor. The largest of the two factors will be carried forward to the Site Score Sheet.
305 Percent Decision Sight Distance (%DSD)
This Risk Scoring factor is based on the percentage decision sight distance. This is relative to the ability of a driver to react to an obstacle within the roadway. Percent Decision Sight Distance can be calculated as following:

Eq. #2: \( PDSD = \frac{ASD}{DSD} \times 100 \)

The following scoring matrix should be utilized based on the Percent Decision Sight Distance:

- \( 112.91 - (3.30465 \times RV) + (0.0334535 \times RV^2) - (0.0001163 + RV^3) \)

A minimum of 0 points and a maximum of 81 point need to be assigned for this section.

306 Adjusted ADT
The traffic counts, or ADT, should be adjusted to for the current year. Based on these traffic counts utilize the following scoring matrix:

- \( 4 \times (10^{-11}) \times (RV^3) - 4 \times 10^{-7} \times (RV^2) + 0.0032 \times RV \)

A minimum of 0 points and a maximum of 81 point need to be assigned for this section.

307 Accident History
The final factor is the Accident History of the Inventory Site relative to past landslide events. Accidents which did not involve debris generated from a landslide event should not be considered. This factor is based on the County maintenance records and Department of Public Safety records with scores assigned based as follows:

- No Accidents = 3 points
- Minor Property Damage = 9 points
- Major Property Damage = 27 points
- Death = 81 points

Table 300-03 presents the Accident History section of the worksheet.
### Table 300-03. Accident History

<table>
<thead>
<tr>
<th>Evaluation Parameter</th>
<th>Rating Scores for each Evaluation Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Landslide History</td>
<td>No Accident</td>
</tr>
<tr>
<td>Score</td>
<td></td>
</tr>
</tbody>
</table>

A minimum of 0 points and a maximum of 81 points need to be assigned for this section.

**Section 400 Inspection Frequency**

Each Inventory Site will require periodic re-inspection to determine if the site’s risk is remaining relatively stable, or progressing as an increased risk relative to the public safety. The frequency of re-inspection will be based on the Preliminary Rating of the previous inspection as presented in Table 400-01.

### Table 400-01. Re-Inspection Frequency

<table>
<thead>
<tr>
<th>Rating</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-rated</td>
<td>5 Years</td>
</tr>
<tr>
<td>Moderate Risk</td>
<td>3 Years</td>
</tr>
<tr>
<td>High Risk</td>
<td>2 Years</td>
</tr>
<tr>
<td>Very High Risk</td>
<td>Annually</td>
</tr>
</tbody>
</table>

Re-inspection will be required outside of the prescribed inspection table if one of the following events occur:

1. If a dip in the shoulder or guardrail becomes evident.
2. If a new dip or crack appears within the roadway.
3. Remedial activities to the slope, partial or full, are performed on a site to reduce the overall relative risk. The site should be re-inspected within one year upon completion of construction activities.
APPENDIX A

Glossary of Terms
**APPENDIX A – GLOSSARY OF TERMS**

**Technical Terms:** The following are descriptions of basic terms utilized within the Manual for Landslide Inventory. The following listing is presented in alphabetical order.

1-Day Precipitation History: The recorded amount of precipitation, including but not limited to, rainfall, ice, or snow, during the previous 24 hour period (1 day) prior to the field work.

3-Day Precipitation History: The recorded amount of precipitation, including but not limited to, rainfall, ice, or snow, during the previous 36 hour period (3 day) prior to the field work.

15-Day Precipitation History: The recorded amount of precipitation, including but not limited to, rainfall, ice, or snow, during the previous 360 hour period (15 day) prior to the field work.

AADT: (Adjusted Annual Daily Traffic) Scaled adjustment of the annual daily traffic counts performed within the field to account for increased traffic volume over time.

Accident: An incident that resulted in an injury or loss of private property due to a landslide event.

ADT: (Average Daily Traffic) The total amount of traffic, both truck and vehicle, for the given section of roadway over a 24-hour period.

ASD: (Actual Sight Distance) The shortest distance along a roadway over which a 6-inch object is continuously visible to a driver (assuming a height of 3.5 feet)

ATT: (Average Truck Traffic) The total amount of truck traffic for the given section of roadway over a 24-hour period.

AVR: (Average Vehicle Risk) A scaled factor for the risk to a vehicle associated with potential landslide calculated as:

\[
\left( \frac{\text{ADT} \times \text{Slope Length (miles)}}{24 \times \text{Posted Speed Limit}} \right) \times 100\%
\]

Cardinal Direction: The cardinal direction of travel is based on the roadway description (i.e., I-70, West/East or I-71, South/North) and not a site specific compass direction or bearing. By convention, roadways are considered to be oriented in a south to north or west to east direction.

Cleanout: The removal of accumulated materials from ditches and benches including sediments and loose materials transported down slope from the cut slope face or natural slope.

Concave Slope: Ground appearance where the slope is steeper near the top of the slope and flattens towards the toe of the slope.
Convex Slope: Ground appearance where the slope is flatter near the top of the slope and steepens towards the base of the slope.

County Code The county that the site is located within using the ODOT three letter county designation. The county code consists of the first three letters of the county name with the exceptions of:

<table>
<thead>
<tr>
<th>County</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashland</td>
<td>ASD</td>
</tr>
<tr>
<td>Ashtabula</td>
<td>ATB</td>
</tr>
<tr>
<td>Champaign</td>
<td>CHP</td>
</tr>
<tr>
<td>Harrison</td>
<td>HAS</td>
</tr>
<tr>
<td>Meigs</td>
<td>MEG</td>
</tr>
<tr>
<td>Monroe</td>
<td>MOE</td>
</tr>
<tr>
<td>Montgomery</td>
<td>MOT</td>
</tr>
<tr>
<td>Morgan</td>
<td>MRG</td>
</tr>
<tr>
<td>Morrow</td>
<td>MRW</td>
</tr>
</tbody>
</table>

A full listing of the County Codes are included in Appendix X.

Crack: Fracture between stable and unstable ground surfaces. Typically has a distinct separation with a vertical and horizontal component.

Cut Slope: The constructed slope along the roadway created by removal of overburden and/or bedrock from the ground surface to the road grade.

Cut Slope Angle: The angle from a horizontal datum/plane along the face of the constructed surface called the cut slope.

Cut Slope Height: The vertical distance measured from the top of the cut slope to the base of the cut slope.

Cut Slope Length: The distance measured parallel along the road from which the material has been removed.

Dip: Pronounced depression with in the roadway surface.

Ditch Depth: The vertical distance from the bottom of the ditch to the top of the ditch at the roadway shoulder.

Ditch Width: The horizontal distance of the ditch from the top of the ditch at the roadway shoulder to ground surface projected as a horizontal plane.

Drag Patch: Asphalt layer placed as a maintenance fix where a section of roadway has dropped in elevation relative to the rest of the roadway to maintain rideability. Typically, asphalt is placed with a loader, backhoe, or grader.

DSD: (Decision Site Distance) The required spacing along a roadway from which a driver has time to avoid an obstacle within the roadway. The value can be obtained from a design chart that considers speed limit, use of roadway, and possibly curvature and grade of the roadway. (Refer to Table 3 within the Manual Text)
**%DSD:**
(Percentage Decision Site Distance)

Ratio between the DSD and the ASD, calculated as

\[
%\text{DSD} = \frac{\text{ASD}}{\text{DSD}} \times 100
\]

**Field Team**
Field personnel consisting of a geologist and an engineering geologist or a geotechnical engineer, who will complete the required field data collection for the landslide inventory.

**Flow:**
Flows are a spatially continuous movement, in which surfaces of shear are short-lived, closely spaced and usually not preserved. The distribution of velocities in the displacing soil mass resembles that in viscous liquid. The lower boundary of the displaced mass may be a surface along which appreciable differential movement has taken place or maybe a thick zone of distributed shear.

**Flow Rate:**
Rate at which water is discharging from the ground surface in gallons per minute (gpm).

**Foreslope:**
The slope between the roadway shoulder and the bottom of the ditch. (See Figure 1)

**Foreslope Angle:**
The angle of the slope between the roadway shoulder and the bottom of the ditch. (See Figure 1)

**Full Height Embankment**
Roadway support constructed with engineered fills where both side slopes are greater than 5 feet in height not associated with a drainage structure. Embankments associated with drainage structures will not be included within this Manual, but should be assessed associated with the Culvert Inventory for spans less than 10 foot, or the Bridge Inventory for spans 10 feet or greater.

**Groundwater:**
Flowing or non-flowing water discharging from the bedrock at the slope surface.

**Hazard Length:**
The distance, measured parallel to the roadway, within which slope instability is present.

**Hazard Width:**
The distance, measured perpendicular to the roadway, within which the slope instability is present.

**Head Scarp:**
Steep surface separating the undisturbed material/slope and failed mass associated with the landslide.

**Hummocky Slope:**
Ground appearance where the slope has a strongly undulating surface.

**Landslide:**
The down-slope gravitational movement of material that is comprised of at least 51 percent soil consisting of boulders, cobbles, gravel, sand, silt, and/or clay particles.

**Natural Backslope:**
Any slope which has not been modified through construction activities. These slopes can be present above a soil cut or below fill slopes.
Rotational Slide: A rotational slide moves along a surface of rupture that is curved and concave. As the surface of rupture is roughly circular the displaced material mass may move along the surface with little internal deformation. The head of the displaced material may move almost vertically downward, whereas the upper surface material tilts backwards toward the scarp. If the slide extends for a considerable distance along the slope perpendicular to the direction of motion, the surface of rupture may be roughly cylindrical. The axis of the cylindrical surface is parallel to the axis about which the slide rotates.

Route Classification: State Route, US Route, or Interstate Route along which the field team will travel and complete the required inventory.

Seepage: Non-flowing groundwater noted discharging from the slope surface measured in gallons per minute (gpm).

Shoulder: The graveled or paved area between the outside travel lane and the ditch.

Side Hill Embankment Roadway support constructed with engineered fills where one side slope is greater than 5 feet in height, but the opposite side has a fill height less than 5 feet, or consists of at grade, cut slope, or natural slope.

Site Number: Designation number for each specific inventory site assigned by ODOT.

SLM: (State Line Mile) Numerical designation of any point along an ODOT maintained roadway, based on the actual centerline mileage as measured from the western or southern county line or other true beginning.

Soil Cut Any slope which has been modified by construction activities through the removal soil materials. Typically, these slopes are present above the roadway.

Spread: A spread is defined as an extension of a cohesive soil combined with a general subsidence of the failure soil mass of cohesive material into softer underlying material. Spread may result from liquefaction or flow of softer material. The cohesive material may also subside, translate, rotate, disintegrate, or liquefy and flow.

Spring: Flowing groundwater noted discharging from the slope surface measured in gallons per minute (gpm).

Straight Slope: Ground appearance where the slope gradient is more or less an even gradient from the top of the slope to the base of the slope.

Surface Water Flow: Area of flowing water along either the face of the cut slope or along the natural backslope. Generally, surface water flow will be in a down slope direction and accumulates within the ditch at the base of the slope.
Tension Crack: Break, or fracture, within the ground surface caused by tensile stress with the soil mass. Typically, indicative of the initiation of, or further slope instability.

Terraces Slope: Ground appearance where the slope has the presence of flat steps along the contour, referred to as terraces, along the slope face.

Toe Bulge: The lowest margin of the displaced mass associated with the slope instability.

Translational Slide: A translational slide is where the failure soil mass is displaced along a planar or undulating surface or rupture, sliding out and over the original ground surface. Translational slides are usually shallower in depth than rotational slides. Therefore, the ratio of depth to length of a translational slide is typically less than 0.1. The surfaces of rupture of translational slides are often broadly channel-shaped in cross section.

Travel Lane or Lane: Paved section of roadway in which vehicular traffic moves.
APPENDIX B:

PHOTO EXAMPLES OF LANDSLIDE CHARACTERISTICS
Comment: Head scarp indicated by a crack located with the pavement (outlined by yellow line). Both horizontal and vertical displacements are evident along the head scarp. Also noted the asphalt drag patch placed as a maintenance item to maintain rideability.
Comment: Head scarp indicated by yellow arrows.

Comment: Head scarp outlined in yellow. Note the exposed guardrail post.
Toe Bulge

Comment: Toe bulge from stability impacting roadway by heaving the pavement. Toe bulge is outlined by yellow line.

Comment: Note the toe bulge covering the ditch line and encroaching onto the white line.
Comment: Toe bulge is overriding the side walk and encroaching the pavement. Note the distressed failing retaining wall in the foreground outlined by the dashed yellow line.

Comment: Toe bulge filling drainage ditch above roadway. Toe bulge outlined in yellow.
Tension Crack
Note patching of tension cracks, including areas where sections of concrete pavement are missing.
Hummocky Terrain
J Shaped Trees, Tilting Trees or Poles
Misalignment of guardrail
Failure of structures
Failure of Drainage Structures

Separation of paved gutter

Separation of Pipe Sections
APPENDIX C:

PHOTO EXAMPLES OF RATED SITES
Comment: Rotational slide within soil cut slope which is not rated because it has reached a pseudo-static state which is considered a low risk to impacting the roadway.
Moderate Risk Site

Comment: Rotational slide within an embankment and natural soil slope which was triggered due to stream erosion along the toe of slope. The probability of additional movement is high, but the probability of impact to the road is low.

High Risk Site

Comment: Rotational slide within a soil cut slope which has a toe bulge impacting the shoulder. This site has a moderate probability of additional movement but high probability of impacting the road.
Comment: Rotational slide within a side hill embankment fill where the tension cracks and head scarp is indicating that the slide is impacting both lanes of traffic.
Comment: Very High Rated site where a rotational slide is occurring with natural slope where the roadway is creating a switchback. The toe bulge can be seen in the ditch line above the lower section of roadway. The head scarp is present within the upper section of roadway. Fresh asphalt patch can be seen along the upper roadway indicating that the slide is active. As seen to the right the roadway is experiencing significant horizontal and vertical displacement.
TRANSLATIONAL SLIDE

Moderate Risk
Very High Risk