IDAHO TRANSPORTATION DEPARTMENT

RESEARCH REPORT

Development of a Statewide Landslide Inventory Database for Idaho

RP 278

By

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Idaho Geological Survey

Prepared for

Idaho Transportation Department

ITD Research Program, Contracting Services

Highways Construction and Operations

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16. Abstract

Landslide inventory databases are fundamental tools for documenting and assessing slope stability hazards. They are often used by emergency managers and government agencies to catalog the location and contributing factors of landslides, and to prioritize mitigation efforts. Prior to this project, Idaho did not have a comprehensive, public landslide inventory database. The last statewide landslide inventory was published in 1991 as a static map and is not suitable for modern digital analyses. In this project, the Idaho Geological Survey produced a statewide landslide inventory database to document known slope failures. The goal of this project is to compile and update landslide data in a central database that is publicly accessible via interactive webmap or downloadable digital files. We compiled and reviewed historical landslide data from several sources and added newly mapped landslides to create a comprehensive landslide inventory. The database is available as an ArcGIS service, which supports an interactive webmap hosted by IGS, and is accessible by ITD as a data layer compatible with its internal IPLAN mapping system. The database is designed to be updated as new data are collected.

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Technical Advisory Committee

Each research project is overseen by a Technical Advisory Committee (TAC), which is led by an ITD project sponsor and project manager. The TAC is responsible for monitoring project progress, reviewing deliverables, ensuring that study objectives are met, and facilitating implementation of research recommendations, as appropriate. ITD's Research Program Manager appreciates the work of the following TAC members in guiding this research study.

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  - John Bilderback
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Table of Contents

List of Tables

List of Figures

List of Abbreviations and Acronyms

DEM .... Digital Elevation Model

DOGAMI .... Oregon Department of Geology and Mineral Industries

FHWA .... Federal Highway Administration

GIS .... Geographical Information Systems

IGS .... Idaho Geological Survey

IOEM .... Idaho Office of Emergency Management

ITD .... Idaho Transportation Department

MSE .... Mechanically Stabilized Earth

NAD27 .... North American Datum 1927

NED .... National Elevation Dataset

PDF .... Portable Document Format

PLSS .... Public Land Survey System

SH- .... State Highway

TAC .... Technical Advisory Committee

US- .... U.S. Highway

USGS .... U.S. Geological Survey

Executive Summary

Landslide inventory databases are fundamental tools for documenting and assessing slope stability hazards. They are often used by emergency managers and government agencies to catalog the location and contributing factors of landslides, and to prioritize mitigation efforts. Prior to this project, Idaho did not have a comprehensive, public landslide inventory database. The last statewide landslide inventory was published in 1991 as a static map and is not suitable for modern digital analyses. In this project, the Idaho Geological Survey produced a statewide landslide inventory database to document known slope failures. The goal of this project is to compile and update landslide data in a central database that is publicly accessible via interactive webmap or downloadable digital files. We compiled and reviewed historical landslide data from several sources and added newly mapped landslides to create a comprehensive landslide inventory. We assessed the accuracy of historical landslide data and assigned each record with a qualitative measure of spatial accuracy. Limited field verification was performed as part of this project, in which selected sites from all six ITD districts were visited by IGS geologists to compare the database mapping to existing conditions in the field. The field verification suggested that most mapped landslides are real and are accurately mapped, but many landslides in the field are not included in the database. The database is available as an ArcGIS service, which supports an interactive webmap hosted by Idaho Geological Survey and is accessible by Idaho Transportation Department as a data layer compatible with its internal IPLAN mapping system. The database is designed to be updated as new data are collected.

1. Introduction

Landslides are an important geological hazard in Idaho, and an inventory of their location and circumstances of occurrence is a critical public dataset. This project was developed to meet the needs of the Idaho Geological Survey (IGS), Idaho Transportation Department (ITD), and a variety of other users. The IGS is tasked with providing geologic data, including hazards data, to the public. ITD uses landslide hazard data to prioritize and mitigate hazards along state roadways in order to protect public safety and maintain free movement of goods and people. The Idaho Office of Emergency Management (IOEM) uses hazard databases to develop and update the State Hazard Mitigation Plan, which describes hazards and outlines steps to mitigate them.

Geologic, Topographic, and Climatic Setting

The geologic setting in Idaho is diverse and complicated. The underlying bedrock lithology ranges from Proterozoic metasedimentary rocks, to Cretaceous intrusive granitic rocks, to Quaternary glacial deposits. The geology underlying Idaho can be generalized into several broad categories, from oldest to youngest: 1) Mesoproterozoic Belt Supergroup rocks in northern and northeastern Idaho; 2) Neoproterozoic and Paleozoic sedimentary rocks exposed in the Idaho-Wyoming Thrust Belt and Basin and Range Province in eastern and southeastern Idaho; 3) Paleozoic and Mesozoic exotic accreted terrane rocks in western Idaho; 4) Cretaceous intrusive plutonic rocks in central Idaho; 5) Miocene flood basalts in western Idaho; and 6) Miocene and younger rhyolite and basalt erupted along the track of the Yellowstone hot spot (Figure 1.1; Idaho State University, 2020). The mineralogy, groundwater, structure, and weathering properties of each rock type contribute to unique slope stability characteristics when exposed at the surface and can influence landslide susceptibility.

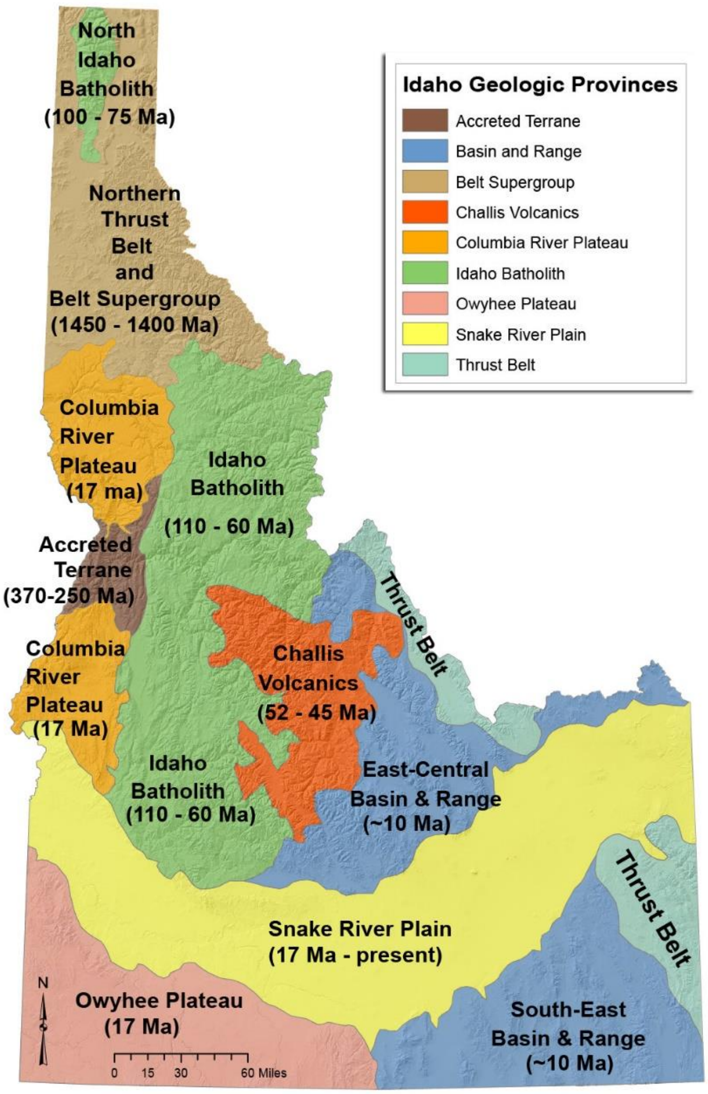

Figure 1.1 Map of the Geologic Provinces in Idaho. From Idaho State University, 2020

Idaho is a mountainous state and where the topography is rugged, steep, and high relief it can contribute to landslide hazards. The elevation in Idaho ranges from approximately 700 feet above sea level near Lewiston, to over 12,000 feet above sea level at Borah Peak. Tectonic uplift of broad regions of the state, as well as stream capture of large drainage basins, have contributed to rapid river incision during the last few million years. This river incision has resulted in deep river canyons with steep walls. Even in relatively low-relief parts of the state, like the Snake River Plain, modern rivers have incised sharply and left behind steep canyon walls susceptible to slope failure.

While Idaho is generally arid, precipitation varies widely across the state. The average annual precipitation in southwestern Idaho is less than 10 inches, while in the mountains areas of north Idaho it is over 60 inches (Figure 1.2; National Oceanic and Atmospheric Administration, 2020a). Precipitation often facilitates landslides, but despite the dramatic gradient of precipitation, landslides occur across the state. This suggests that while precipitation can play in important role in landslide processes, other factors may exert stronger controls.

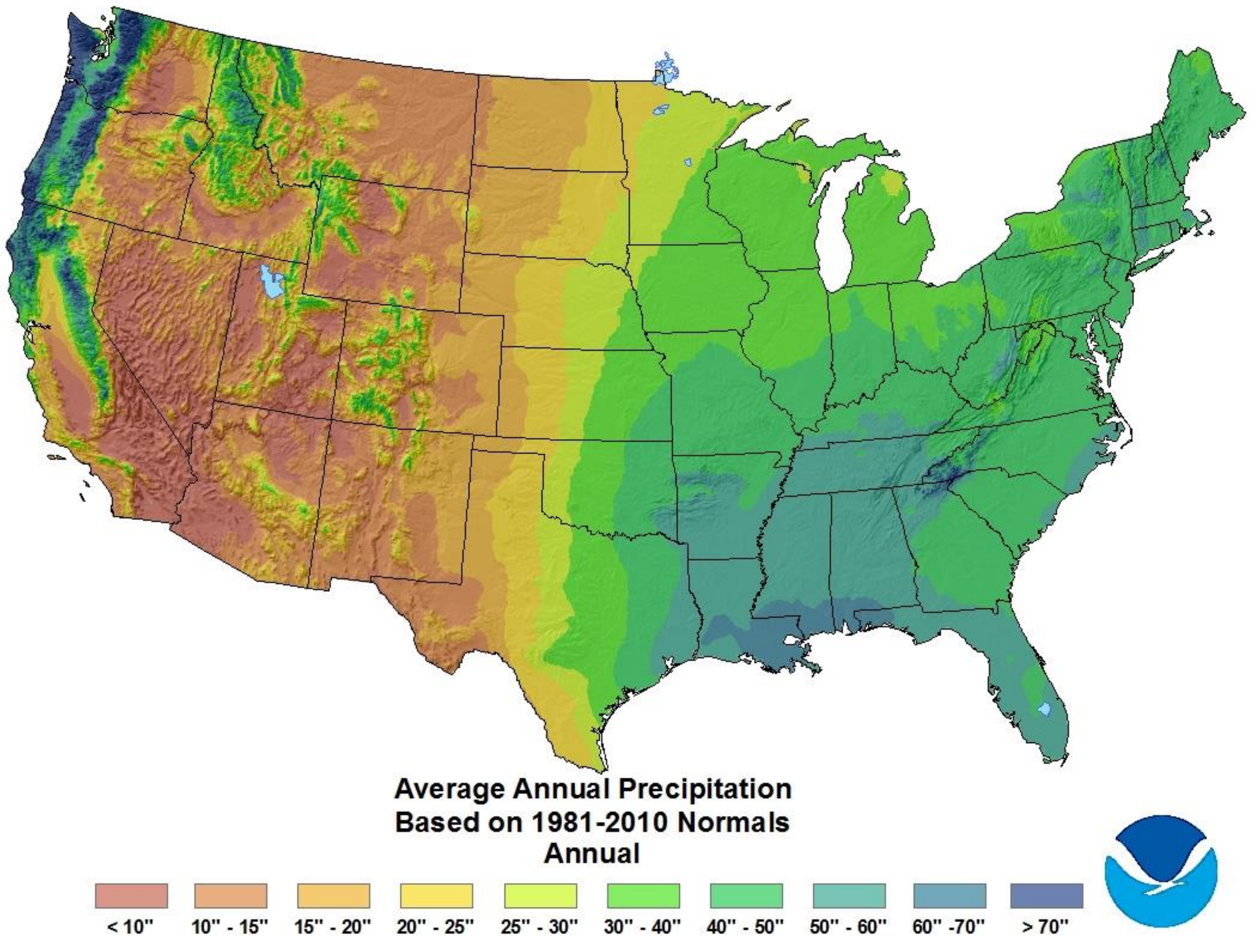

Figure 1.2 Map of Average Annual Precipitation (inches) in the Lower 48 United States from 1981 to 2010 (National Oceanic and Atmospheric Administration, 2020a).

Landslide Hazards

Landslide is a generic term used here to describe "the movement of a mass of rock, debris, or earth down a slope" (Cruden, 1991; Cruden and Varnes, 1996). Many classification schemes have been developed to classify landslides by material, size, movement type, and age (e.g., Varnes, 1978; Cruden and Varnes, 1996), but ultimately all landslides are gravity-driven failures of earth materials (Figure 1.3). ITD differentiates between landslides and rockfall because rockfall is very common, often too small to map, and is cleaned from roadways as fast as possible. ITD has separate systems and tools for documenting and analyzing rockfall. For these reasons, and because of time and budget constraints, this project focuses on landslides other than rockfall.

Landslides occur in all six Idaho Transportation Department districts, and they impact the safety, mobility, and economic opportunity of Idahoans throughout the state. Landslide mitigation is typically reactive and is expensive and disruptive. Tools for cataloging and ranking landslide hazards would help improve mitigation planning and prioritization. The Idaho Geological Survey developed a new, centralized landslide database for the State of Idaho.

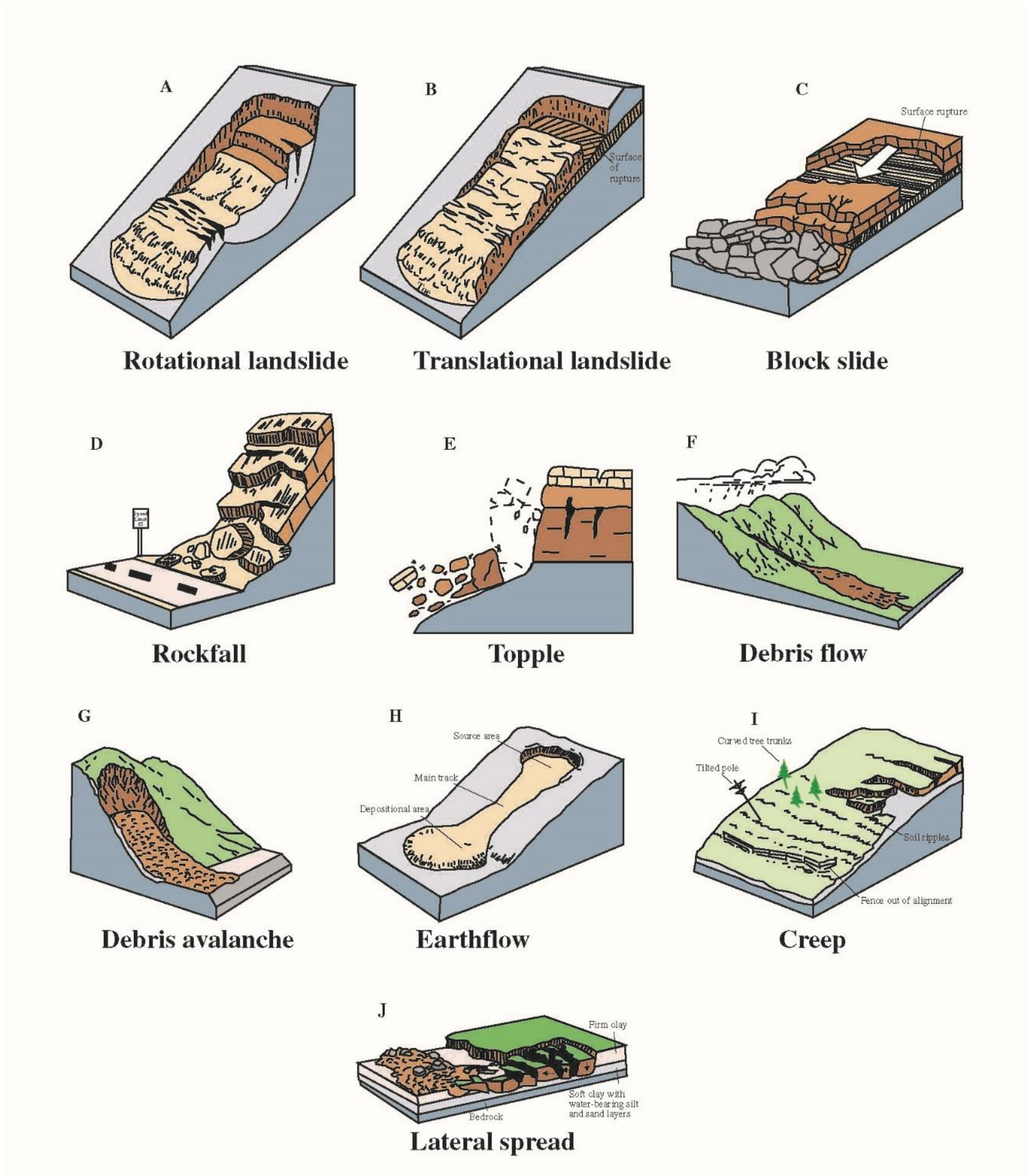

Figure 1.3 Classification of Landslide Types. From Varnes (1978) and U.S. Geological Survey (2004)

Landslides are a significant hazard in Idaho because they are widespread, destructive, disruptive, and their exact timing and location is unpredictable. Idaho's underlying geology and steep topography create favorable conditions for landslides. Furthermore, the location of many of Idaho's transportation corridors within narrow, steep-sided canyons compounds the threat by exposing critical infrastructure to these landslide hazards. The U.S. Geological Survey (2005) estimates that in the United States landslides cause 25-50 deaths and $3.5 billion in damages annually. In ITD District 1, 15 landslides were documented in 2017, seven of which closed or partially closed a road. The total emergency costs for these 15 landslides totaled $910,000, and the estimated permanent cost for two of these landslides is over $3.7 million. Similar estimates of the number of landslides and associated costs for the entire state are not readily available, highlighting the need for a centralized, statewide landslide database.

Motivation

In 1997, following a major winter storm and significant landslide activity around the state, the Governor's Landslide Task Force issued 10 recommendations for addressing landslide hazards in Idaho. This project addresses at least four of the Task Force's recommendations:

- Recommendation #2: Assess landslide hazards and produce landslide hazard maps of critical areas.
- Recommendation #5: Initiate field-based, interdisciplinary technical studies of landslide processes to improve hazard assessment techniques.
- Recommendation #8: Update and maintain an existing statewide landslide database and provide for periodic surveillance in problem areas.
- Recommendation #10: Develop a method for prioritizing landslide mitigation projects.

There is currently no up-to-date, centralized landslide inventory for the state of Idaho. The last state landslide inventory produced by the IGS was published in 1991 (Adams and Breckenridge, 1991). That inventory is a static paper map (available as a PDF), with no metadata or source data; both the format and the data compilation methodology must be updated.

Project Goals

The overall objective of this project is to create a centralized, modern digital landslide database that brings together landslide data from a variety of sources. The database will help users understand the occurrence, distribution, and character of landslides in Idaho. Specific objectives of the proposed project include:

1. Compiling landslide data from ITD records, IGS mapping, and other sources.
2. Creating and populating a digital landslide database for the state of Idaho. The database is easily integrated into ITD's existing IPLAN online mapping system and is available to the public as an interactive webmap and as stand-alone landslide GIS database published by IGS.
3. Developing robust criteria for ranking landslide hazards. The goal of this ranking is not to address risk (i.e., the probability of loses due to a given hazard), but to define the basic geologic hazard. The hazard classifications can be used by ITD to estimate risk.
4. Improving ITD's ability to prioritize landslide mitigation planning.

To accomplish the goals of this research project, IGS performed the following tasks:

1. Reviewed landslide databases from other states to help establish a robust database framework. For example, the Oregon Department of Geology and Mineral Industries (DOGAMI) published a detailed landslide inventory mapping protocol (Burns and Madin, 2009) which provides valuable guidance.
2. In collaboration with ITD, determined the data attributes included in the database. These attributes include data such as the date of the landslide, the location in latitude and longitude coordinates or road mileposts, the type of landslide, the underlying materials, and ITD response or mitigation. The database structure is designed to easily integrate into ITD's existing IPLAN online map system.
3. Defined the hazard ranking system and the criteria used to define each hazard rank. The landslide hazard ranking is defined by several factors, including proximity to infrastructure, age of activity, or inclination of slope.
4. Acquired and compiled landslide records from ITD. These include records of landslide occurrence, response, and mitigation.
5. Compiled additional records of landslide activity from IGS reports and maps, academic literature, and agency reports.
6. Populated the landslide database with landslide records compiled in tasks 4 and 5.
7. Developed an online map interface for the landslide database. The IGS website already hosts several interactive maps linked to databases, and there are several other options available for hosting maps, including ESRI online maps and web map services.
8. Determined a method and schedule for updating the landslide database.
9. Conducted desktop mapping of landslides using existing, public lidar datasets to identify potential new hazards, as time and budget allow. For example, new public lidar data is available for the Clearwater drainage, covering large parts of Nez Perce, Lewis, Clearwater, and Latah counties and swaths along the SH-14 and US-95 corridors.
10. Field checked selected landslides to confirm mapping, data attributes, and hazard classification.
11. Prepared this final report describing the methods and outcomes of the project.

The deliverables produced by this research project are a centralized digital landslide database and an online map interface to access the database. The landslide database is in ArcGIS geodatabase format with complete metadata documentation. The online map interface is an interactive online map hosted by IGS and available to the public.

The results from this project are available in an ArcGIS geodatabase, which is hosted online as a web map and available for download. The database includes complete metadata, and each landslide feature has associated attributes that can be queried. The database will be updated periodically as new landslide events occur and are documented. This will provide users with a centralized resource for landslide data. Hazard rankings can be used to help prioritize mitigation planning. Users will also be able to perform their own analysis on the database to create derivative products such as landslide density maps or landslide susceptibility maps.

A statewide landslide database is a fundamental geologic dataset that will provide a single source of well-documented landslide data. The database will be easily accessible through an interactive online map interface, or as a downloadable ArcGIS geodatabase.

This research helps ITD achieve its mission of safety, mobility, and economic opportunity by providing important data to improve prioritization and planning of hazard avoidance and mitigation. The landslide database can be used to budget mitigation spending, plan for resource allocation to priority areas, and to estimate risk probabilities.

A statewide landslide inventory provides ITD and other agency Emergency Managers with the necessary location, hazard classification, and geologic data for prioritizing and planning avoidance and mitigation. Avoiding or anticipating landslides will protect human safety, reduce the number of accidents, and save money. Prioritizing and planning for mitigation of landslides will help reduce costs, improve efficiency, and allow ITD to proactively address landslide hazards.

2. Background

Landslide Inventories

Landslide inventories are important tools for assessing landslide hazards. They typically document the location of known landslides, as well as other attributes like type, age, and activity level. Landslide inventories can be used to analyze landslide distribution, susceptibility, and risk (Damm and Klose, 2014; Guzzetti et al. 2005, 2012; Trigila, et al. 2010; Bălteanu et al. 2010). Inventory databases are used by many state, provincial, and national agencies to document slope stability hazards. For example, the state geological surveys and/or transportation departments of Arizona, California, Colorado, Kentucky, Ohio, Oregon, and Washington all publish statewide landslide inventory databases that are used by the public for a variety of land use planning and mitigation purposes.

Past Work in Idaho

Several existing sources of landslide mapping were compiled in this inventory database. These sources include a previously published landslide inventory, student theses, U.S. Forest Service mapping, and IGS bedrock mapping. Each source was produced with different methods, purposes, and scales, thus the quality and accuracy vary greatly. Figure 2.1 shows the distribution of existing landslide records for each original source used in the compilation.

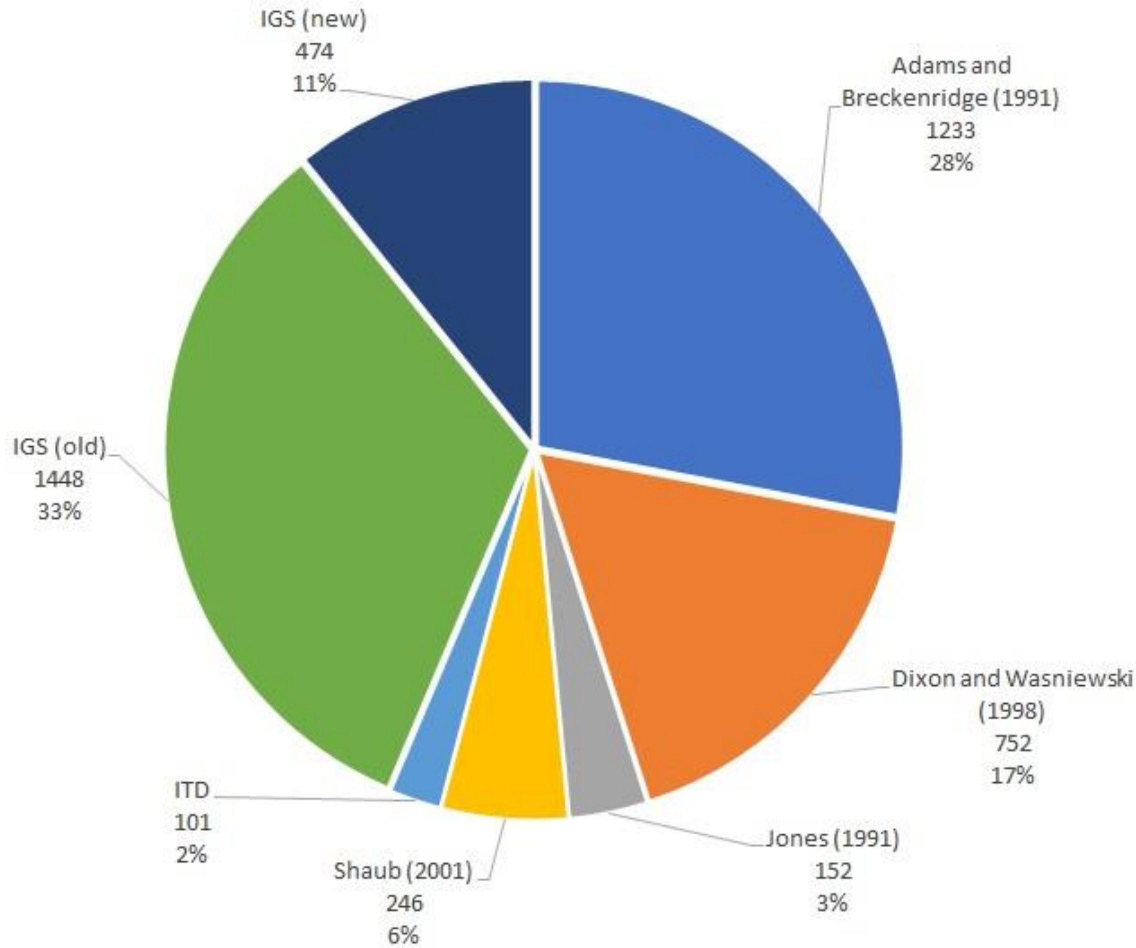

Figure 2.1 Distribution of Landslides by Data Source

Adams and Breckenridge, 1991

The previously published landslide inventory (Adams and Breckenridge 1991) was the last statewide collection of slope failure data. It is currently only available as a static PDF map, displaying landslide point locations at a scale of 1:500,000. The format and scale make difficult digital analysis or querying at finer scales. Adams and Breckenridge (1991) compiled data from many sources, but the methods and sources of the compilation were not well documented. The acknowledgments in Adams and Breckenridge (1991) simply states that the data were compiled from published and unpublished sources too numerous to list. Some of the methodology used in the compilation is described in an earlier master's thesis by Adams (1988). Adams (1988) lists 36 sources of landslide mapping, most of which were not previously published. The point data in Adams and Breckenridge (1991) were originally mapped in the Public Land Survey System (PLSS) of township, section, and range scheme. These records were later converted to the more modern North American Datum 1927 (NAD27) coordinate system using a physical mylar transparency overlay. Because PLSS is a rectangular measurement system and does not define locations with precise point coordinates, the conversion to latitude and longitude position introduces some error. In 2015, Idaho Geological Survey staff digitized the Adams and Breckenridge (1991) landslide data to create a geographic information systems (GIS) layer.

Jones, 1991

A University of Idaho master's thesis by Jones (1991) was used as a primary source for landslides in this inventory. Jones (1991) focused on mapping landslides in the Salmon River and Little Salmon River canyons in Idaho County. Landslide were mapped at 1:24,000 scale based on aerial photographs, field observations, and literature review. Data from Jones (1991) include both points and polygons. Attributes for each landslide included information about landslide type, size, soil and bedrock material, age, and aspect. Original digital GIS vector data were incorporated into the new database.

Dixon and Wasniewski, 1998

Following a significant storm at the end of 1996 and beginning of 1997 (the "New Year 1997 storm") that triggered numerous landslides around the state, the Payette National Forest conducted a study (Dixon and Wasniewski, 1998) to document the location and contributing factors of these landslides. The resulting digital inventory includes 752 landslide records used in this database. Landslides were mapped using aerial photographs and field observations, and attributes included aspect, slope, date, slope position, vegetation cover, and an interpretation of the contributing factors.

Shaub, 2001

We incorporated 246 landslides mapped in the Boise National Forest near Lowman, Idaho as part of a Boise State University master's thesis by Shaub (2001). Approximately 48% of the study area was burned in a wildfire in 1989 and the thesis focused on studying the impact of wildfire on slope stability. Shaub (2001) mapped landslides as points in a digital database, which included attribute information about the slope, aspect, elevation, and data of each event.

Idaho Geological Survey published maps

We also incorporated into the new database landslide polygons mapped and published by the Idaho Geological Survey between 1992 and 2015 at a scale of 1:24,000 to 1:100,000. The maps included:

- Bonnichsen and Godchaux, 2006
- Breckenridge et al., 2014
- Burmester et al., 2016
- Garwood et al., 2014
- Kauffman et al., 2009; 2014
- Kiilsgaard et al., 2001; 2006
- Lewis and Stanford, 2002a; 2002b

- Lewis et al., 2000; 2002; 2005; 2007; 2008
- Link and Stanford, 1999
- Othberg and Stanford, 1992
- Othberg et al., 2012

Geologic units mapped as Qls (Quaternary landslide), Qlsa (Quaternary landslide active), and Qlsd (Quaternary landslide deposit) were extracted from the published map databases and added to the new database as polygon features. Polygons that were originally mapped as Qlsa were attributed as "active" landslides in the new database. Because most of these original maps were focused on bedrock geology rather than surficial geology, the mapped polygons do not have complete attribute data describing the conditions or other data specific to slope stability.

Idaho Transportation Department

ITD provided historical landslide data from several districts. These data varied in their format and metadata but were accurate based on our review. A polygon shapefile of landslides in ITD District 1 included 29 features. ITD District 3 provided a spreadsheet of 75 rock fall records, but only 51 of those records included exact coordinates. ITD District 6 provided a polygon shapefile of 21 initial features. All of these features were added to the compiled inventory database. If additional data from other districts are available, those will be added to the inventory database.

3. Database

Compilation and Review of Existing Landslide Data

We compiled existing landslide data records to include in the inventory database. The primary sources of data are listed above in *Past Work in Idaho*. Each data source was reviewed to evaluate the data quality and completeness, and to determine which common attributes were recorded. The data sources were merged into two feature classes, one for point data and one for polygon data. Common attribute fields that were shared by more than one data source were combined.

Accuracy Assessment

Point Data

We performed an accuracy assessment of the historical landslide point data that were incorporated into the database. Each source of landslide data used different techniques, scales, and basemaps, so an accuracy assessment is needed to determine the quality of the data. The assessment involved two parts. First, we calculated the maximum location uncertainty for points that were converted from their original PLSS locations. Second, we chose 100 random landslide point records from the inventory database to compare to modern satellite imagery to determine the accuracy of the original mapping. Where original landslide mapping did not already include a measure of spatial accuracy, we have assigned a qualitative value of “good”, “fair”, or “poor” based on our analysis.

The original PLSS locations from the previously published landslide inventory (Adams and Breckenridge, 1991) define a rectangular area within which the landslide is located. When the PLSS locations were converted to a modern digital GIS format, each landslide was assigned a latitude and longitude coordinate at the centroid of the PLSS township and range in which it was originally located (Figure 3.1). The maximum uncertainty within a full section (1 mile x 1 mile square) is 1,138.5 meters. The maximum uncertainty within a quarter-quarter section (¼ mile x ¼ mile square) is 285 meters.

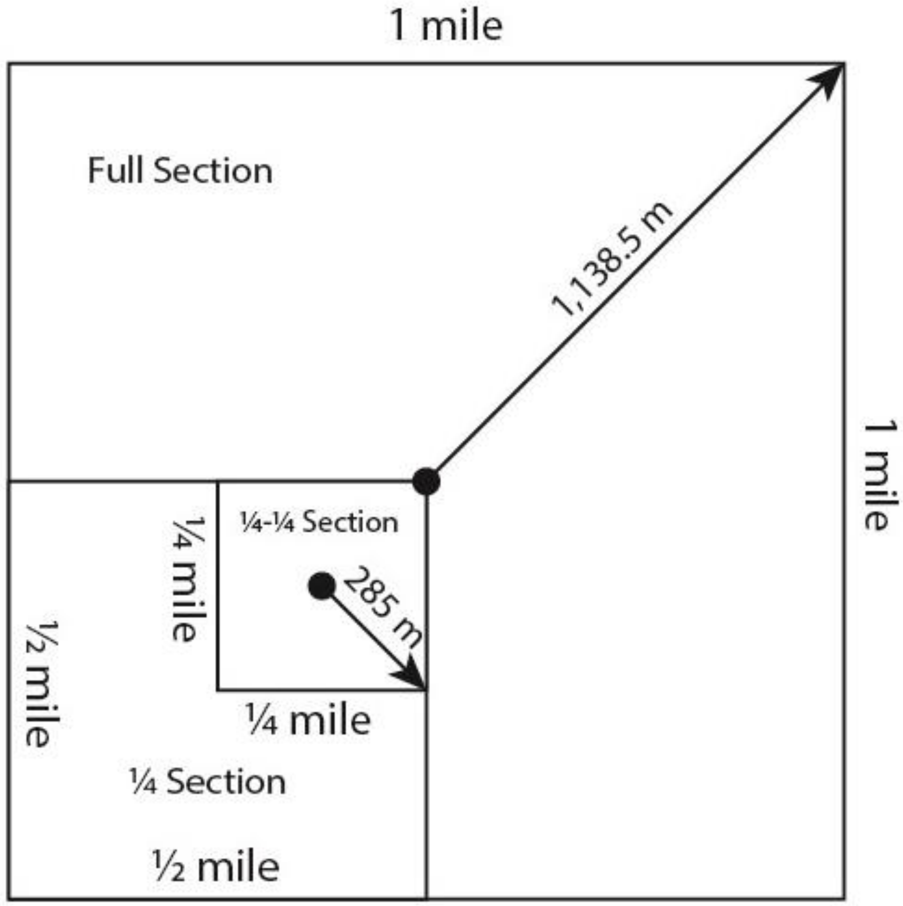

Figure 3.1 Schematic Diagram of Maximum Uncertainty from Center of PLSS Section and ¼-¼ Section

We also assessed the accuracy of 100 randomly selected point landslides in the inventory, including landslides from Adams and Breckenridge (1991), Jones (1991), Dixon and Wasniewski (1998), and Shaub (2001). The selected landslide points were mapped on a basemap of Google Earth satellite imagery. Each point was reviewed by a geologist to determine if the point was located within a real landslide as interpreted from the satellite imagery. Where vegetation is dense, we could not determine if the points were mapped on real landslides, and in those cases, we noted that the accuracy was unknown. We also measured the distance from the mapped point to the approximate center of the interpreted landslide. Of the 44 points from Adams and Breckenridge (1991), 73% of the points were located within a landslide, and the average distance to the center of the landslide was 238 meters. Of the 8 points from Jones (1991), 100% of the points were located within a landslide, with an average distance to the center of the landslide of zero meters. Of the 35 points from Dixon and Wasniewski (1998), 66% of the points were located within a landslide, with an average distance of 20 meters from the center of the landslide. Of the 13 points from Shaub (2001), 62% were within a landslide, with an average distance to the center of the landslide of 11 meters (Table 3.1).

Table 3.1 Accuracy Assessment of Selected Point Landslides in Existing Inventory

Data Source	Number of Mapped Landslides	Number within Landslide	Unknown	Percent within Landslide (%)	Distance from Point to Center of Landslide (meters)
Adams and Breckenridge (1991)	44	30	3	73	238
Jones (1991)	8	8	0	100	0
Dixon and Wasniewski (1998)	35	19	6	66	20
Shaub (2001)	13	8	0	62	11

Landslide points mapped by Dixon and Wasniewski (1998), Jones (1991), and Shaub (2001) were assigned a spatial accuracy of "good". Based on our accuracy assessment of the uncertainty from coordinate system conversion and mapping accuracy, we have assigned a spatial accuracy of "poor" to the Adams and Breckenridge (1991) landslide data. The spatial accuracy of the mapping should be considered when using these historical landslide data for any future analyses.

Polygon Data

Landslide polygon features include records compiled from Jones (1991), IGS published maps, ITD mapping, and from new unpublished IGS mapping using lidar basemaps. Landslide polygons provided by ITD were assigned a spatial accuracy of "good". Landslide polygons extracted from published IGS maps or mapped with lidar basemaps were assigned a spatial accuracy of "good". Landslide polygons mapped by Jones (1991) were found to be accurately located, but their boundaries are not as well defined as more recently mapping. Thus, the Jones (1991) polygons are assigned a spatial accuracy of "fair".

Database Design

We constructed the digital database with ESRI ArcGIS software for this landslide inventory. Landslide point and polygon feature classes were added to a new File Geodatabase. All data in the geodatabase are in Idaho Transverse Mercator projection. Data attributes were developed to capture relevant landslide parameters (Table 3.2). Several attributes were developed specifically for internal use by ITD. Corresponding information from the data sources were compiled into the appropriate attribute fields. Domains of controlled vocabulary were created and applied to some fields of both feature classes to constrain possible input and ensure consistency when new data are added in the future.

We used Attribute Assistant, an editor extension developed by ESRI for ArcGIS software, to automatically populate some of the landslide attribute fields. This tool allows users to set up functions that can be manually or automatically run on the entire database and whenever a new feature is added to a feature class. Attribute Assistant references ancillary data layers to extract or calculate data and populate a field. For example, a landslide point is intersected with an elevation raster layer to determine the elevation of that point, which is then written to the "ELEVATION" field of that feature. For polygon features, these operations are performed on the centroid point of the polygon. Ancillary data layers used in this database are listed in Table 3.2, and include elevation, slope, and aspect rasters; 1:100,000 quadrangle grid; 1:24,000 quadrangle grid; county boundaries; ITD district boundaries; soil survey maps; geologic map units; and climate zones.

Attribute Assistant relies on a pre-configured table, DynamicValue, to operate. This table is configured to describe the methods, values, and order of execution for each function to populate a given field. See Appendix B for an example of the DynamicValue table used for this database.

Table 3.2 Landslide Inventory Database Attributes

Field	Full Field Name	Description	Notes
ACT_INACT	Active or Inactive	Slide as active or inactive	Controlled vocabulary
IGS_ID	IGS ID	Unique reference ID assigned by IGS for this database	FORMAT: "LS??_XXXXX", where "??" is "PY" for polygons and "PT" for points, and "XXXXX" is a sequential number. Manual entry.
LATITUDE	Latitude	Latitude of landslide centroid	Decimal degree populated by Attribute Assistant.
LONGITUDE	Longitude	Longitude of landslide centroid	Decimal degree populated by Attribute Assistant.
ELEVATION	Elevation	Elevation of landslide centroid above mean sea level, mapped point or polygon centroid.	Populated by Attribute Assistant from 1/3-arcsecond National Elevation Dataset [idahoned.tif] (U.S. Geological Survey, 2020)
LS_DATE	Date	Date of last slope failure or movement, if known	Manual entry
COUNTY	County	County in which landslide occurred. If landslide overlaps more than one county, choose the county in which the greatest proportion of landslide occurs	Populated by Attribute Assistant from U.S. Census data [IdahoCounties_NAD83] (U.S. Census Bureau, 2018)
SLOPE	Slope Inclination	Average slope inclination (measured in degrees at point or polygon centroid) of the slope on which failure occurred	Populated by Attribute Assistant from slope map derived from 1/3-arcsecond National Elevation Dataset [ID_NED_Slope] (U.S. Geological Survey, 2020)
ASPECT	Slope Aspect	Azimuth (0-360 degrees) of average direction slope is facing	Populated by Attribute Assistant from aspect map derived from 1/3-arcsecond National Elevation Dataset

Field	Full Field Name	Description	Notes
			[ID_NED_Aspect] (U.S. Geological Survey, 2020)
CLIMATE	Climate	Climate zone	Populated by Attribute Assistant from national climate zone divisions [ClimateNAD83] (National Oceanic and Atmospheric Administration, 2020b)
GEOL_UNIT	Geologic Unit	Geologic map unit symbol derived from IGS published maps, preferably at 1:24,000 scale	Populated by Attribute Assistant from IGS state geological map [GeolNAD83] (Lewis et al., 2012)
MATERIAL	Material Type	Type of material involved in landslide (e.g. bedrock, debris, talus, etc.). Can also be a description of bedrock lithology, if appropriate	Prompt for manual entry
COVER	Cover	Soil or regolith cover, based on field observations or NRCS soils data	Populated by Attribute Assistant from soils data [MUPOLYGON] (Soil Survey Staff, 2020)
LS_TYPE	Landslide Type	Type of landslide, as defined by Varnes (1978) and Cruden and Varnes (1996). Classification is based on material type (rock, debris, or earth) and movement type (fall, topple, rotational sliding, translational sliding, and flow). Use "Complex" for landslides that may be a combination of types. Use "Other" for landslides that are not listed. Use "Landslide (undifferentiated)" for landslides whose type cannot be determined.	Prompt for controlled vocabulary
LNGTH	Length	Maximum downslope length of landslide, from toe to crown	Prompt for manual entry
WDTH	Width	Maximum width of displaced mass perpendicular to length	Prompt for manual entry
AREA_1	Area	Area of landslide polygon	Automatically calculated for polygons
DEEP_SHALL	Deep/Shallow	Estimated thickness of landslide	Prompt for controlled vocabulary
VOL	Volume	Estimate of landslide volume, if length, width, and thickness are known	Prompt for manual entry
ACTIVITY	Activity Level	Level of activity of slope failure	Prompt for manual entry
MOVE_RATE	Movement Rate	Estimated rate of movement. May not be possible to determine but note if known.	Prompt for controlled vocabulary

Field	Full Field Name	Description	Notes
LOC_META	Location Metadata	Description of how landslide was located, e.g. aerial stereo photographs, lidar, satellite photos, field mapping, etc. If possible, note the scale of imagery used.	Prompt for manual entry
QUAD_100K	100K Quadrangle	Name of 1:100:000 scale quadrangle map in which landslide is located	Populated by Attribute Assistant from 100K quadrangle index grid [q100K_NAD83] (ESRI, 2020a)
QUAD_24K	24K Quadrangle	Name of 1:24,000 scale (7.5') quadrangle map in which landslide is located	Populated by Attribute Assistant from 24K quadrangle index grid [q24K_NAD83] (ESRI, 2020b)
SOURCE	Source	Original source of mapped landslide. If from a published source, cite as Breckenridge et al., 2014, for example.	Prompted for manual entry
SOURCE_ID	Source ID	Unique ID assigned by original source	Manual entry
SOURCE_REF	Source Reference	Code for reference to original source for Adams and Breckenridge (1991) database	Manual entry
SPATIAL_ACC	Spatial Accuracy	Estimated level of confidence in the location of landslide	Prompted for controlled vocabulary
COMMENTS	Comments	Additional comments regarding the landslide. Can include notes on any additional contributing factors that may have influenced slope stability, such as precipitation events or human slope modification.	Prompted for manual entry
DISTRICT	ITD District	ITD district in which landslide is located	For ITD use. Populated by Attribute Assistant ITD GIS data [ITD_District_NAD83] (Idaho Transportation Department, 2020)
ROUTE	ITD Route	ITD route. For example, “US-95” or “SH-55”.	For ITD use. Prompted for controlled vocabulary.
START_LAT	Start Latitude	Latitude of the start of affected roadway	For ITD use. Manual entry.
START_LON	Start Longitude	Longitude of the start of affected roadway	For ITD use. Manual entry.
END_LAT	End Latitude	Latitude of the end of affected roadway	For ITD use. Manual entry.
END_LON	End Longitude	Longitude of the end of affected roadway	For ITD use. Manual entry.

Field	Full Field Name	Description	Notes
START_MP	Start Milepost	Milepost of the start of affected roadway	For ITD use. Manual entry.
END_MP	End Milepost	Milepost of the end of affected roadway	For ITD use. Manual entry.
AFFECT_SIDE	Affected Side	The side of the roadway affected, as measured when looking upstation.	For ITD use. Prompted for controlled vocabulary
ROAD_WIDTH	Road Width	Road width	For ITD use. Manual entry.
PSL	Posted Speed Limit	Posted speed limit	For ITD use. Manual entry.
ADT	Average Daily Traffic	Average daily traffic	For ITD use. Manual entry.
PMF	Potential for Major Failure	Potential for major failures	For ITD use. Manual entry.
DIST_2_SCARP	Distance to Headscarp	Distance from road to landslide headscarp	For ITD use. Manual entry.
ZIP	ZIP code	ZIP code provided for interaction with TIGER data	Populated by Attribute Assistant from U.S. Census data [ZIP_NAD83] (U.S. Census Bureau, 2020)

The names of ancillary data layers are enclosed in square brackets "[ ]".

Published Map Service

The geodatabase is stored on IGS servers and published as a service through ArcGIS Online. The service is used in a public webmap hosted by the Idaho Geological Survey's ArcGIS Online account. The webmap is an interactive, public-facing online map that is accessible from IGS's website: https://www.idahogeology.org/. The service can be accessed by ITD GIS staff an integrated into ITD's IPLAN GIS system. This allows ITD to view, query, and add new landslide records to the inventory database. This allows IGS and ITD to both make changes to the inventory database while allowing both to access the updated results.

Landslide Hazard Ranking

Idaho Geological Survey developed a set of criteria to create a hazard ranking for each landslide (

Table 3.3 and Table 3.4). These hazard rankings are not a quantification of risk, because risk includes the likelihood of a hazardous event and the consequences of its occurrence. Hazard ranking criteria can be used or modified by ITD to help determine where the greatest hazard is located, prioritize efforts, and plan mitigation. In this project we developed nine criteria to measure hazard, but since some of these criteria cannot be determined for historical events, we have not applied the ranking to all the historical events in the inventory database. As new events are documented and entered into the inventory database, these criteria may be easier to measure or estimate.

Table 3.3 Landslide Hazard Ranking Criteria

	Criteria	Points	Criteria	Points	Criteria	Points	Criteria	Points
Age of Activity	>15,000 years old	1	15,000 – 5,000 years old	3	5,000 – 100 years old	5	<100 years old	10
Slope Inclination	<5°	1	5° - 15°	3	15° - 25°	5	>25°	10
Distance to Infrastructure[1]	>100 ft	1	100 – 50 ft	3	50 – 25 ft	5	<25 ft	10
Material	Fresh granite, massive basalt	1	Weathered granite, vertically jointed columnar basalt	3	Adverse structure (e.g., bedding or foliation dipping down slope)	5	Lake sediments, clay, foliated bedrock, shale	10
Thickness	<1 ft	1	1 – 3 ft	3	3 – 10 ft	5	>10 ft	10
Groundwater (S%)[2]	Dry (S%=0-10)	1	Moist but unsaturated (S%=10-25)	3	Partly saturated (S%=25-50)	5	Saturated; Flowing seeps or springs (S%=>50)	10
Potential to Dam	No	1	-	-	-	-	Yes	10
Rate of Movement[3]	Inactive	1	Slow (5 ft/yr – 60 ft/yr)	3	Moderate (60 ft/yr - 5 ft/day)	5	Rapid (>5 ft/day)	10
Seismic Activity[4]	Neogene or older	1	Quaternary (<2.6 Ma); up to 125 miles away	3	Pleistocene (2.6 Ma - 15 ka); <100 miles away	5	Holocene (<15 ka); <100 miles away	10

Criteria modified in part from Varnes 1978; Keefer, 1984; Cruden and Varnes, 1996.

[1] Measured as the horizontal distance between the closest point of a mapped landslide point or polygon and the closest point of infrastructure.

[2] Saturation (S) = (volume of water/volume of voids)*100. Groundwater conditions are based on field observations, but these conditions may be unknown.

[3] Rate of movement may be difficult to measure, in which case an estimate can be used.

[4] Seismic activity is based on age of last activity on a fault, and the distance to the fault.

Table 3.4 Landslide Hazard Ranking Ranges

Total Points	Hazard Rank
≤9	Very Low
10-27	Low
27-45	Moderate
>45	High

New Mapping

We added new landslide records to the database by conducting new landslide mapping using recently available lidar topographic data, high resolution satellite imagery, or field observations. Lidar topographic data are ideal for mapping landslides and slope failures because they provide high-resolution elevation models of the ground surface with vegetation filtered out. These filtered elevation models are used to create "bare earth" maps. Bare earth maps allow geologists to analyze surface topography and interpret slope failure locations. Lidar is the gold standard for mapping landslides since it provides a perspective that is often superior to even field reconnaissance.

New landslide polygons were mapped with ArcGIS software and lidar or satellite imagery basemaps. Lidar topographic data were visualized as hillshade maps with variable illumination azimuths and as slope maps. The boundary of each landslide was traced with a polygon, and applicable attributes were assigned to each feature. Some attributes, such as activity level or depth, are not easily discernible on desktop imagery, and in those cases those attributes were left blank.

Field Verification

Following the compilation of the landslide inventory database, we performed field verification of selected landslides around the state to check the accuracy of the location, accuracy of the polygon boundaries, accuracy of the site conditions documented in the landslide attributes, and completeness of the inventory. IGS geologists traveled to all six ITD Districts during the project. We chose areas with high-profile landslides, areas known to have landslide susceptible geologic conditions, and areas with high densities of mapped landslides (Table 3.5).

Table 3.5 Areas Visited for Field Verification

ITD District	Routes	Milepost Range	Notes
D1	US-2 US-95	64-80 430-538	The geologic conditions are characterized as unconsolidated Quaternary glacio-lacustrine deposits. Relatively high precipitation reduces slope stability. Many landslides occur on steep slopes formed by road cuts or river incision.
D2	SH-3 SH-11 SH-13 SH-14 US-12 US-95	0-14 0-8 11-26 0-49 12-74 171-291	The geologic conditions are characterized as foliated metamorphosed sedimentary rocks and thick basalt flows. Slope failure type varied from deep-seated landslides, to shallow flows, to rock fall. Many of the large landslides along the US-95 corridor near Pollock are accurately mapped in the inventory database. Landslides in the Clearwater River canyon are mapped in the inventory database, but large complexes could be further differentiated.
D3	SH-55 SH-21 US-95	45-156 0-105 161-171	The geologic conditions are characterized as foliated metamorphosed sedimentary rock, intrusive granitic Idaho Batholith rock, and unconsolidated Miocene lacustrine deposits. Many small landslides were observed in the field, especially in Miocene lacustrine deposits, that were not mapped in the inventory database.
D4	US-30 SH-78	173-224 94-99	The geologic conditions are characterized as intrusive granitic Idaho Batholith rock and unconsolidated Miocene lacustrine deposits. Many landslides occur in the steep walls of incised river canyons. The largest of these landslides are well represented in the inventory database, but new lidar will likely reveal many additional landslides that can be mapped.
D5	US-30 SH-34	360-405 58-113	The geologic conditions are characterized as Paleozoic fold and thrust belt rocks.
D6	US-26 US-93 SH-21 SH-28 SH-31 SH-33 SH-75	377-402 160-305 105-189 15-135 0-21 150-155 189-244	The geologic conditions are characterized as Paleozoic fold and thrust belt rocks. The landslides mapped in District 6 correspond well to the conditions that we observed on the ground.

Field inspection of selected landslides in these areas was conducted by vehicle, on foot, and by uncrewed aerial vehicle (UAV). Selected field photographs are shown in Figure 3.2 through Figure 3.10. In general, most of the landslides mapped in the inventory database were confirmed in the field. Some landslides were difficult to assess in the field because they were obscured by topography or vegetation. We observed several landslides in the field that did not exist in the inventory database, some of which may have occurred after they were originally mapped and published. We made the following general observations:

1. Landslide polygons mapped with lidar basemaps were very accurate. Furthermore, new lidar coverage will help identify additional landslides that are not currently included in the inventory database.
2. Landslide polygons extracted from IGS 1:24,000 scale geologic maps were generally accurate, but linework could be improved with lidar. In particular, large landslide complexes (near Hagerman and Lapwai) can be differentiated into smaller individual landslides.
3. Landslides mapped by Jones (1991) are in the correct locations, but polygon boundaries should be revised with modern satellite imagery or lidar basemaps to improve accuracy.

Figure 3.2 Oblique aerial photograph of rotational landslide next to SH-55 north of Horseshoe Bend (43.867773°N, -116.217664°E).

Figure 3.3 Oblique aerial photograph of rockfall along US-95 south of Riggins (45.331782°N, -116.347058°E).

Figure 3.4 Photograph of a landslide on the north side of the Salmon River, east of Riggins (45.426200°N, -116.290000°E).

Figure 3.5 Oblique aerial photograph of a landslide along SH-14 west of Elk City (45.828477°N, -115.584883°E).

Figure 3.6 Photograph of a rockfall along SH-14 west of Elk City (45.811995°, -115.631704°E).

Figure 3.7 Photograph of a landslide in a basalt roadcut along SH-3 south of Juliaetta (46.482196°N, -116.770068°E).

Figure 3.8 Oblique aerial photograph looking across the Snake River at the Bliss landslide near US-30 (42.918545°N, -114.957005°E).

Figure 3.9 Oblique aerial photograph looking west toward Palisades Reservoir at a large rock flow in Blowout Canyon along US-26 (43.299903°N, -111.074095°E).

Figure 3.10 Oblique aerial photograph looking northwest at a large landslide west of Salmon (45.168415°N, -113.913406°E).

4. Deliverables

As described in the proposal, IGS created three primary deliverables from this project:

1. A centralized landslide inventory of Idaho, available as a GIS digital database.
   The inventory consists of a polygon feature class and a point feature class, which are contained in an ESRI File Geodatabase. The geodatabase includes metadata. The geodatabase will be published by IGS as a Digital Database and available for free download from the IGS website.

2. An interactive online webmap.
   The inventory database is published as an ArcGIS service, which allows the data to be accessed by ITD in their internal GIS system. IGS will provide ITD with the service link. In addition, the ArcGIS service is used as the basis for an interactive webmap, hosted on IGS's ArcGIS Online account and available to the public via the IGS website.

3. This final report.
   The final report documents the data sources and methods used in the development of the landslide inventory database.

In addition, we also developed digital field forms for rockfall and MSE wall inventories to be used by ITD field staff. The field forms were not included in the original scope of work. ITD Districts will fill out these forms to collect new data in the field. These digital field forms can be used with ESRI Arc Collector software on mobile devices, which allows the option to sync new field data with the central database. The field form templates will be provided to ITD and can be hosted on ITDs ArcGIS Online account. ITD staff with an ArcGIS Online account will be able to access the forms with the ESRI Arc Collector mobile app. See Appendix C for a description of the field forms.

5. Summary

For this project, IGS developed a digital landslide inventory database for Idaho. We reviewed and compiled historical landslide mapping sources and developed unified data attributes so that all data records could be combined. New landslides were mapped and added to the inventory database as time permitted and where new lidar topographic data were available. Historical landslide data were assessed for accuracy and assigned a qualitative rank for spatial accuracy. We developed hazard ranking criteria to incorporate landslide parameters into a simplified system for ranking relative hazard. This hazard ranking system can be used by ITD for conducting risk analysis, planning, and prioritizing mitigation efforts. The landslide inventory database is published as a digital database download from IGS, and as an interactive webmap. The database is also published as a service through ArcGIS Online and made available to ITD for viewing, querying, and adding data. Limited field verification was performed as part of this project, in which selected sites from all six ITD districts were visited by IGS geologists to compare the database mapping to existing conditions in the field. The field verification suggested that most mapped landslides are real and are accurately mapped, but many landslides in the field are not included in the database. These omissions will likely decrease in the future as high-resolution lidar topographic data become available in more parts of Idaho. A large new lidar dataset covering most of southern Idaho is scheduled to be available in early 2021.

Recommendations for Future Work

This inventory is a dynamic database that is designed to be updated in the future as new landslides are identified and mapped. In addition, we expect the database will be revised and improved as new software and technology are developed. IGS will periodically add new landslide data to the inventory database as new maps are published and new landslides are identified. Furthermore, ITD can add landslide data to the inventory database through direct desktop editing of the feature classes or through mobile field forms that we developed for ESRI Arc Collector.

An important area of future work is related to high-resolution lidar topographic data. Existing and forthcoming lidar datasets provide high-resolution topographic basemaps for landslide mapping. In many cases, lidar basemaps are more accurate than field mapping because vegetation and land access can prevent accurate interpretation in the field. Two new publicly funded lidar datasets, one covering most of southern Idaho and another covering Boundary, Bonner, and Kootenai Counties, are expected to be release in 2021. These two datasets will provide an important opportunity for identifying and mapping landslides. Future work could include revising existing landslide polygon boundaries mapped before lidar data were available, converting historical point data to polygons, refining attributes, and mapping previously unmapped landslides. Future work could also include compiling additional landslide data from municipalities.

Our hazard ranking criteria are just one interpretation of hazard ranking. Since there are many ways to customize these criteria for specific uses, this may be an area of future research as ITD pursues risk analysis. The hazard ranking criteria presented here could be refined to better fit the goals of ITD’s future applications.

Another area of possible future work is geostatistical analysis. A detailed analysis of the spatial distribution of landslides may reveal significant patterns or relationships. For example, landslide occurrence may correlate with bedrock type, climate zone, or slope aspect. Furthermore, landslide density or heat map analysis may help develop landslide susceptibility maps.

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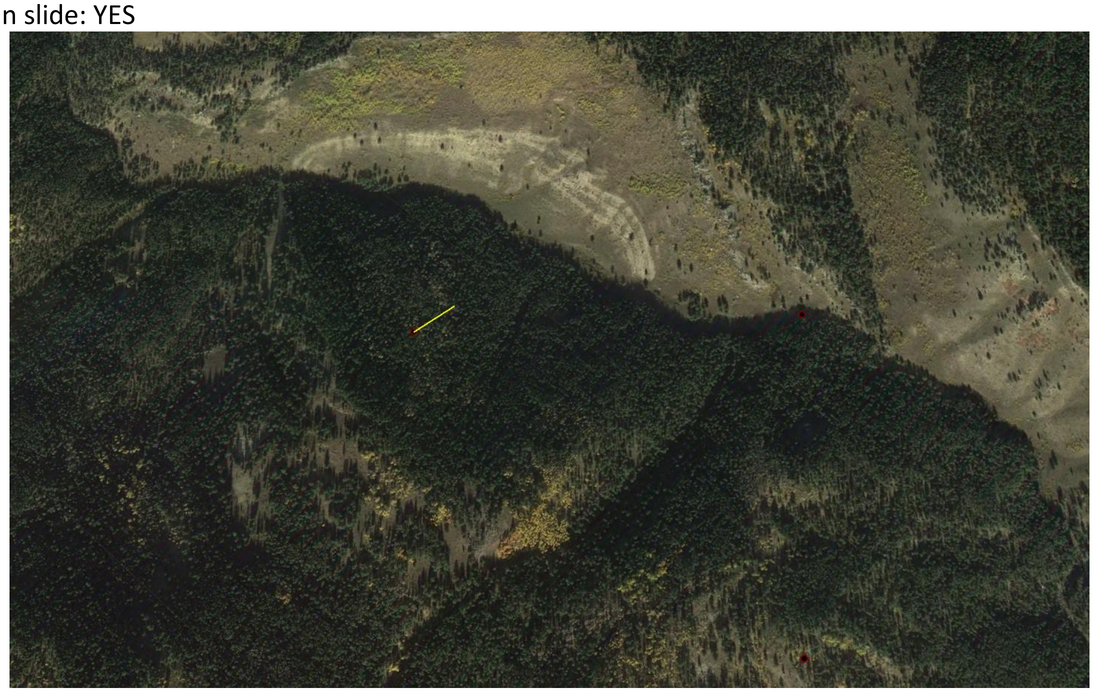
Appendix A. Accuracy Assessment

The following figures illustrate the accuracy assessment we performed on 100 randomly selected landslide points from historical data sources. Each point was reviewed in Google Earth to determine if the mapped point is within a real landslide, and how far from the landslide centroid the point is located. The temporary ID numbers were only used during the compilation process.

ID Temp ID- AB00097
Distance of point from centroid of slide: 200 meters (estimated extent of slide since no area provided)
Point in slide: YES

ID Temp ID- AB00255
Distance of point from centroid of slide: 40 meters
Point in slide: YES

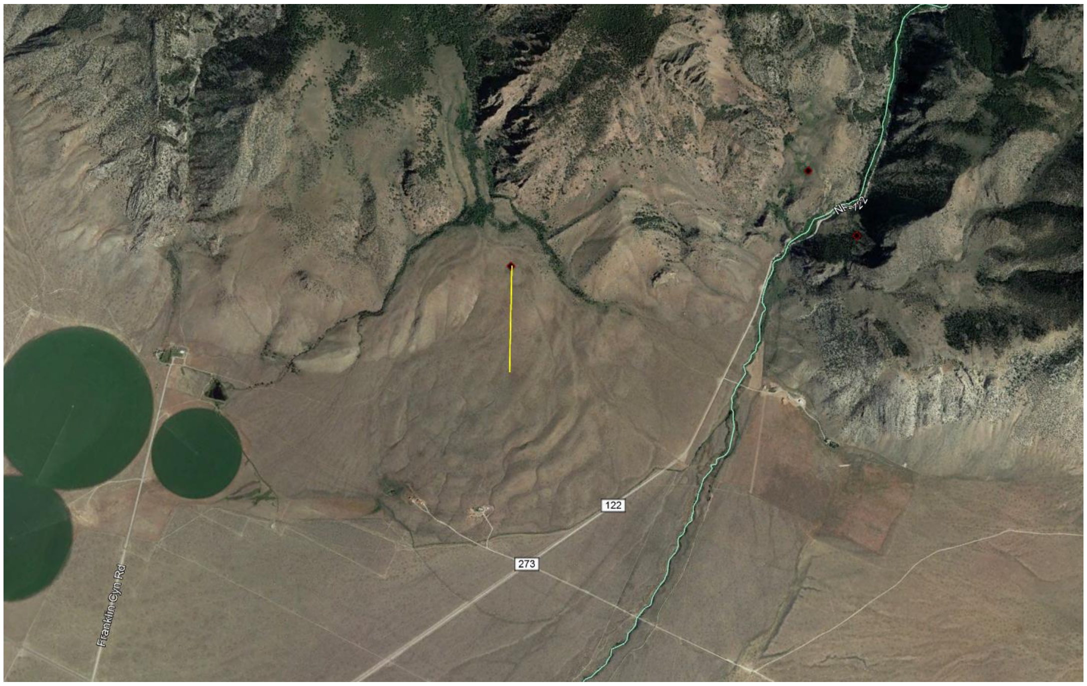
ID Temp ID- AB00343
Distance of point from centroid of slide: 100 meters
Point in slide: YES



ID Temp ID- AB00463
Distance of point from centroid of slide: 45 meters
Point in slide: NO (maybe at scarp)

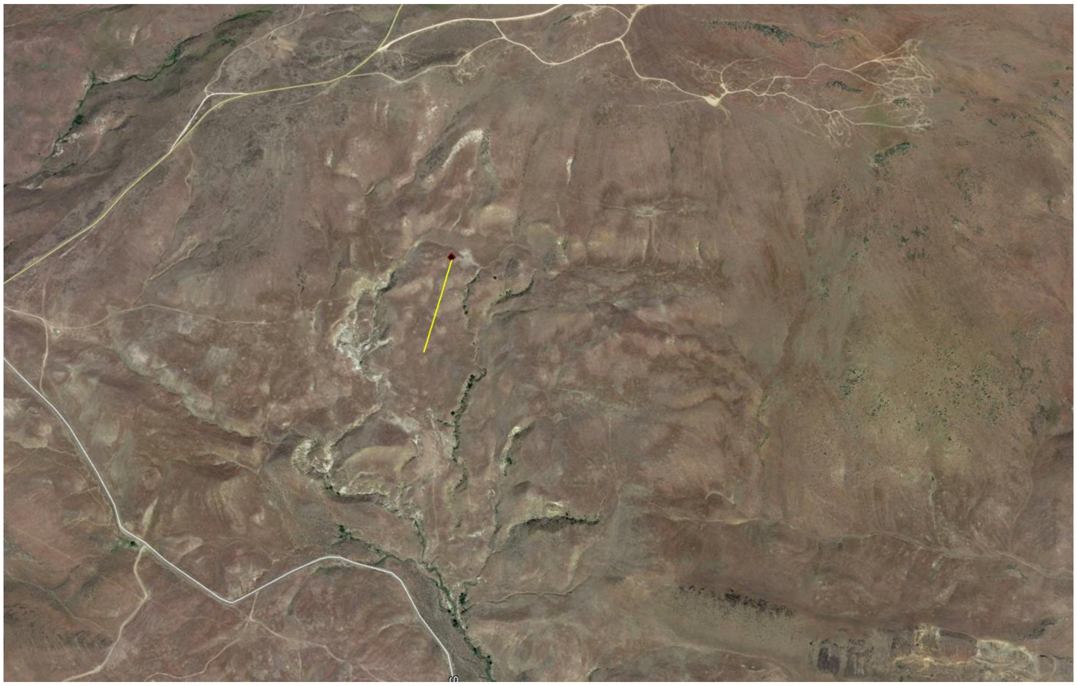
ID Temp ID- AB00482
Distance of point from centroid of slide: 95 meters
Point in slide: NO

ID Temp ID- AB00556
Distance of point from centroid of slide: 600 meters
Point in slide: YES



ID Temp ID- AB00832
Distance of point from centroid of slide: 1000 meters (polygon in database, estimated centroid)
Point in slide: YES

ID Temp ID- AB00884
Distance of point from centroid of slide: 340 meters
Point in slide: YES



ID Temp ID- DW01389
Distance of point from centroid of slide: 10 meters
Point in slide: YES at scarp

ID Temp ID- DW01584
Distance of point from centroid of slide: 30 meters
Point in slide: NO

ID Temp ID- DW01784
Distance of point from centroid of slide: 0-5 meters (building built after slide occurred)
Point in slide: YES

ID Temp ID- JO02097
Distance of point from centroid of slide: Centered in polygon, polygon accuracy seems reasonable
Point in slide: YES

ID Temp ID- JO02110
Distance of point from centroid of slide: Centered in polygon, polygon accuracy seems reasonable
Point in slide: YES

ID Temp ID- SH02163
Distance of point from centroid of slide: 15 meters
Point in slide: YES (at scarp)

ID Temp ID- SH02247
Distance of point from centroid of slide: 7 meters
Point in slide: NO

Appendix B. Attribute Assistant Tables

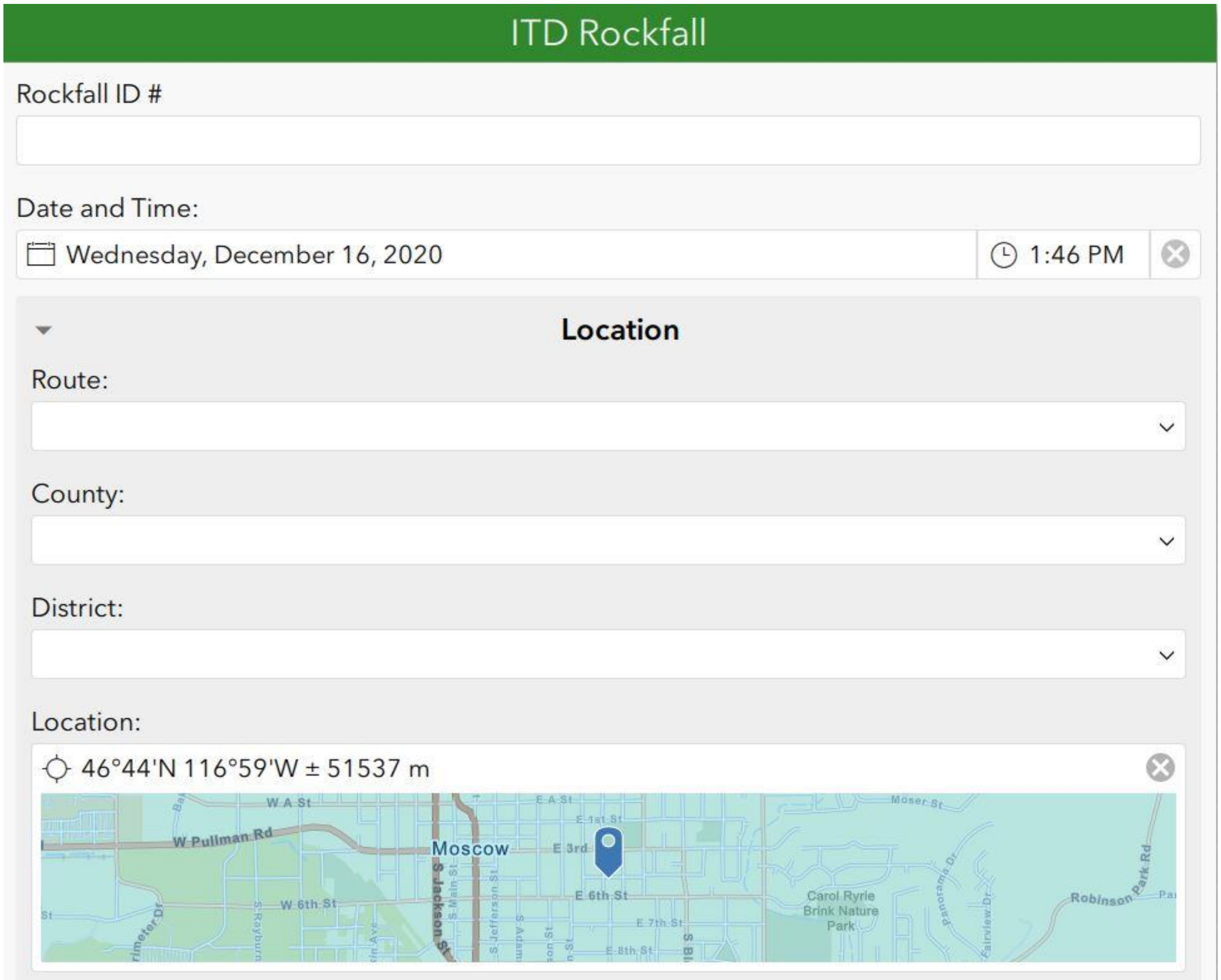
DynamicValue table used by ArcGIS Attribute Assistant to automatically populate selected fields.

TABLENAME	FIELDNAME	VALUEMETHOD	VALUEINFO
Landslide	LONGITUDE	LONGITUDE	Landslide|LONGITUDE
Landslide	LATITUDE	LATITUDE	Landslide|LATITUDE
Landslide	COUNTY	INTERSECTING_FEATURE	IdahoCounties_NAD83|NAME|CP|True
Landslide	QUAD_24K	INTERSECTING_FEATURE	q24K_NAD83|QUAD_NAME|CP|True
Landslide	QUAD_100K	INTERSECTING_FEATURE	q100K_NAD83|QUAD_NAME|CP|True
Landslide	CLIMATE	INTERSECTING_FEATURE	ClimateNAD83|NAME|CP|False
Landslide	COVER	INTERSECTING_FEATURE	Soils_NAD83|MUKEY|CP|True
Landslide	ZIP	INTERSECTING_FEATURE	ZIP_NAD83|ZIP_CODE|CP|True
Landslide	GEOL_UNIT	INTERSECTING_FEATURE	Geol_NAD83|genericSymbolizer|CP|True
Landslide	ELEV	INTERSECTING_RASTER	idahoned
Landslide	ASPECT	INTERSECTING_RASTER	ID_NED_Aspect
Landslide	SLOPE	INTERSECTING_RASTER	ID_NED_Slope
LandslideP	LONGITUDE	LONGITUDE	LandslideP|LONGITUDE
LandslideP	LATITUDE	LATITUDE	LandslideP|LATITUDE
LandslideP	COUNTY	INTERSECTING_FEATURE	IdahoCounties_NAD83|NAME|CP|True
LandslideP	QUAD_24K	INTERSECTING_FEATURE	q24K_NAD83|QUAD_NAME|CP|True
LandslideP	QUAD_100K	INTERSECTING_FEATURE	q100K_NAD83|QUAD_NAME|CP|True
LandslideP	CLIMATE	INTERSECTING_FEATURE	ClimateNAD83|NAME|CP|True
LandslideP	COVER	INTERSECTING_FEATURE	Soils_NAD83|MUKEY|CP|True
LandslideP	ZIP	INTERSECTING_FEATURE	ZIP_NAD83|ZIP_CODE|CP|True
LandslideP	ELEV	INTERSECTING_RASTER	idahoned
LandslideP	ASPECT	INTERSECTING_RASTER	ID_NED_Aspect

LandslideP	SLOPE	INTERSECTING_RASTER	ID_NED_Slope
Landslide	DISTRICT	INTERSECTING_FEATURE	ITD_District_NAD83|District|CP|True
LandslideP	DISTRICT	INTERSECTING_FEATURE	ITD_District_NAD83|District|CP|True
Landslide	IGS_ID	GENERATE_ID	IGS_SEQ_PY|5|LSPY[SEQ]
LandslideP	GEOL_UNIT	INTERSECTING_FEATURE	Geol_NAD83|genericSymbolizer|CP|True
Landslide	IGS_ID,COMMENTS, LOC_META, SOURCE,LS_TYPE,ACTIVITY		
Landslide	DEEP_SHALL,SPATIAL_ACC, MOVE_RATE,AFFECT_SIDE, PMF		
LandslideP	IGS_ID,COMMENTS, LOC_META, SOURCE,LS_TYPE,ACTIVITY		
LandslideP	DEEP_SHALL,SPATIAL_ACC, MOVE_RATE,AFFECT_SIDE, PMF		
Landslide	AREA_1	LENGTH	
LandslideP	IGS_ID	GENERATE_ID	IGS_SEQ_PT|5|LSPT[SEQ]
Landslide	ROUTE	INTERSECTING_FEATURE	Hwy500ft|Label|P|False

Appendix C. Rockfall and MSE Wall Inventory Field Forms

The Excel templates for the Rockfall and MSE Wall Inventory field forms will be provided to ITD as separate files. Below are screenshots of both field forms.


ITD Rockfall

Rockfall ID #

Date and Time:

Wednesday, December 16, 2020 | 1:46 PM

Location

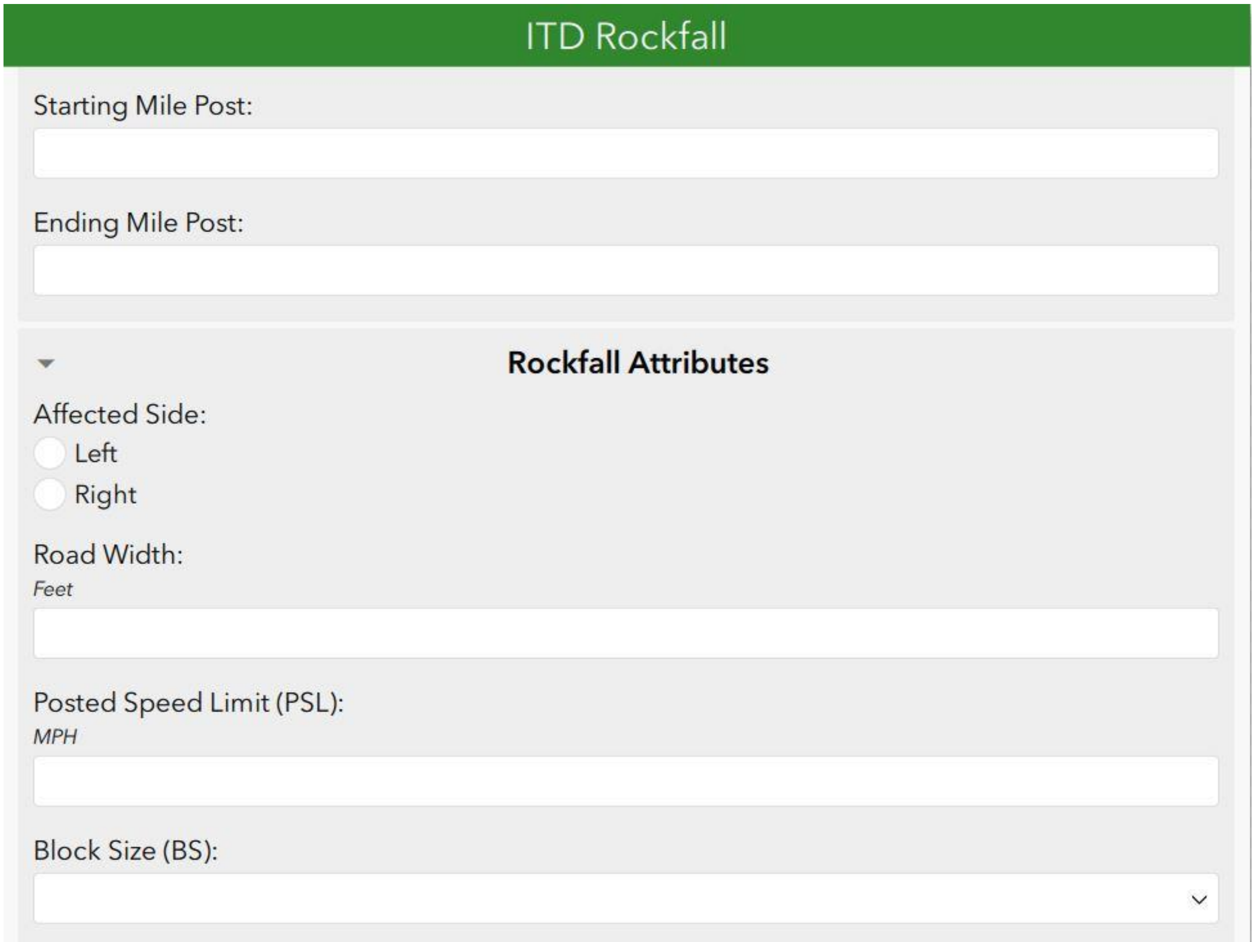
Route:

County:

District:

Location:

46°44'N 116°59'W ± 51537 m


ITD Rockfall

Starting Mile Post:

Ending Mile Post:

Rockfall Attributes

Affected Side:

- Left
- Right

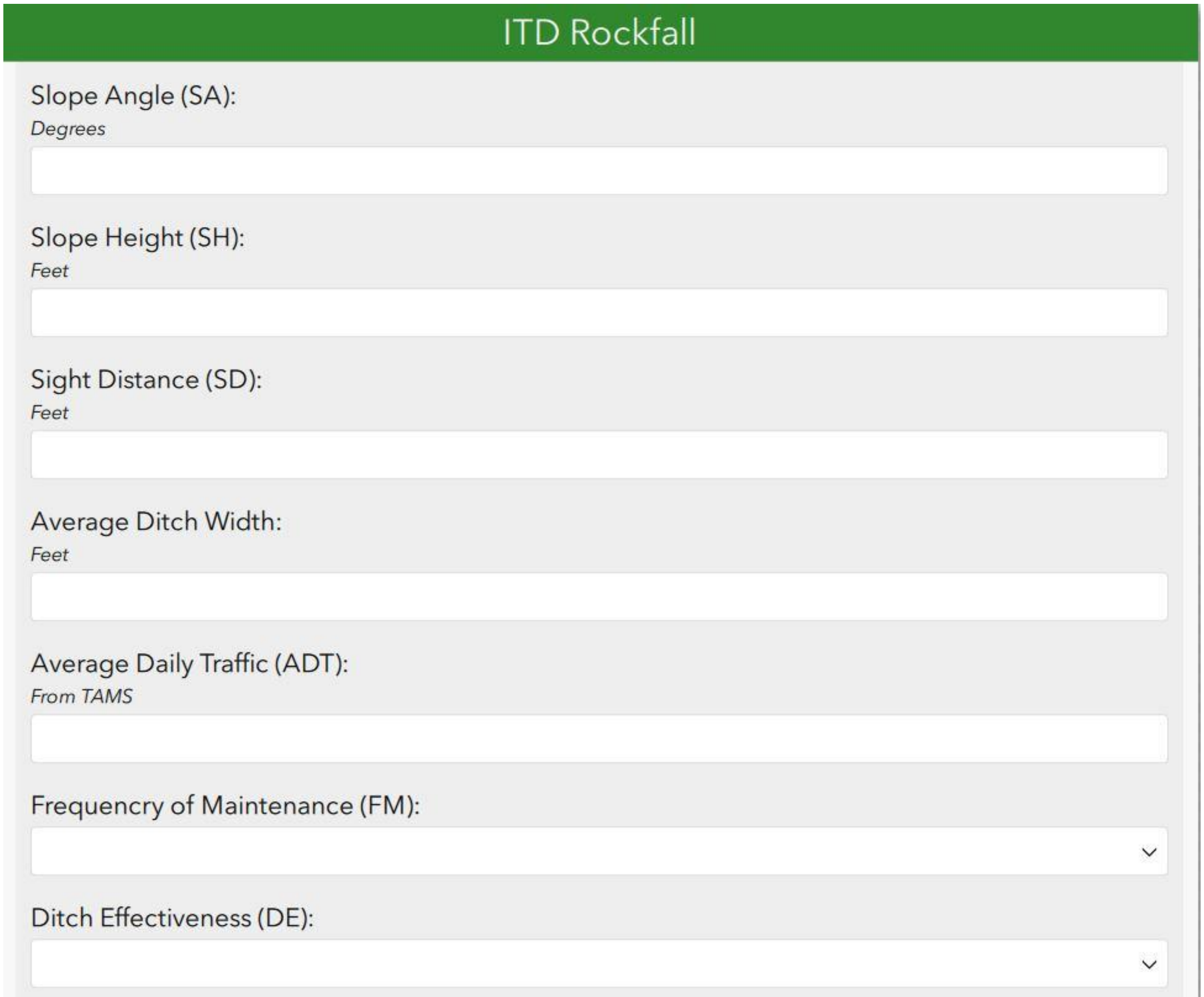
Road Width:

Feet

Posted Speed Limit (PSL):

MPH

Block Size (BS):



ITD Rockfall

Slope Angle (SA):
Degrees

Slope Height (SH):
Feet

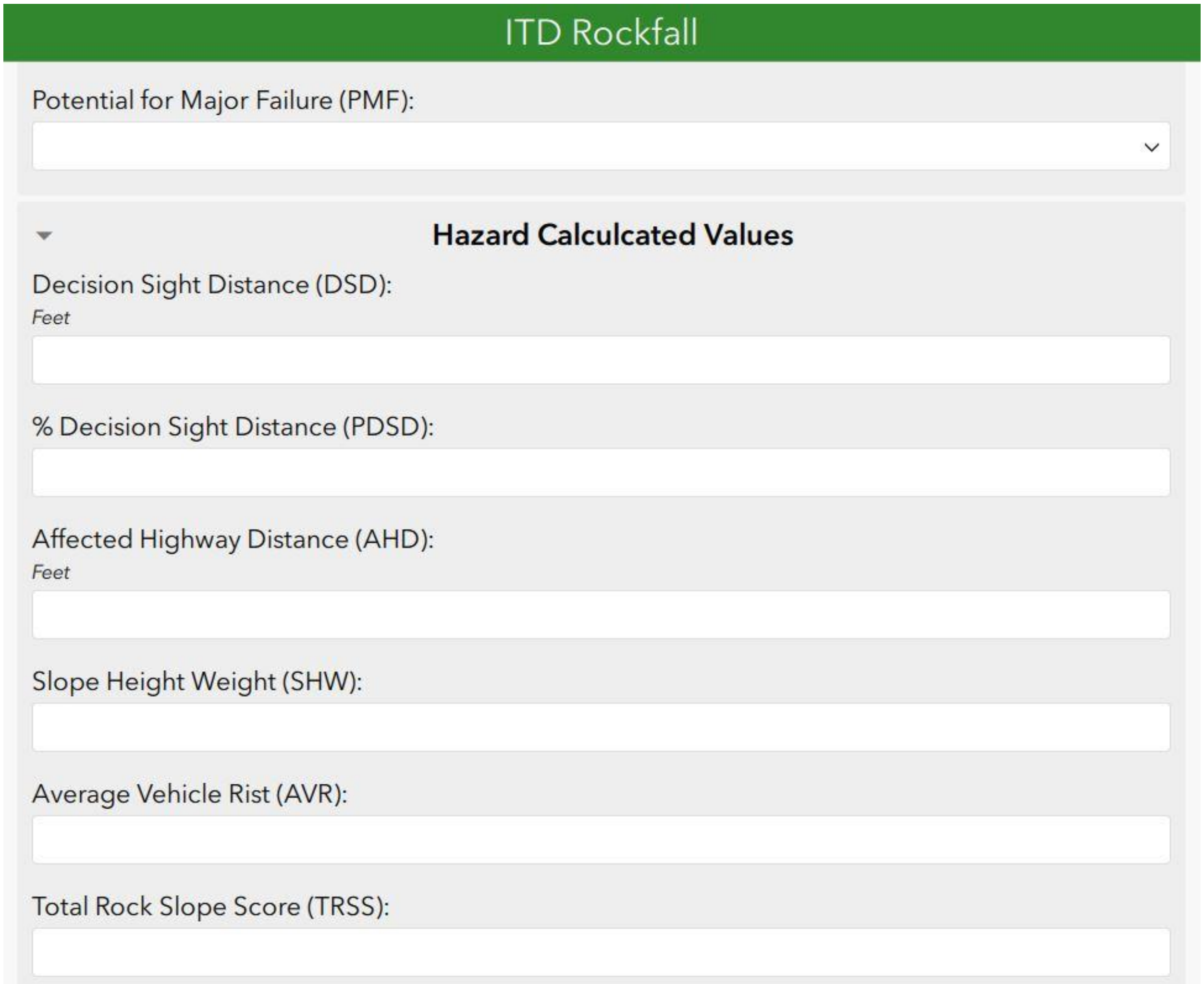
Sight Distance (SD):
Feet

Average Ditch Width:
Feet

Average Daily Traffic (ADT):
From TAMS

Frequencry of Maintenance (FM):

Ditch Effectiveness (DE):



ITD Rockfall

Potential for Major Failure (PMF):

Hazard Calculcated Values

Decision Sight Distance (DSD):
Feet

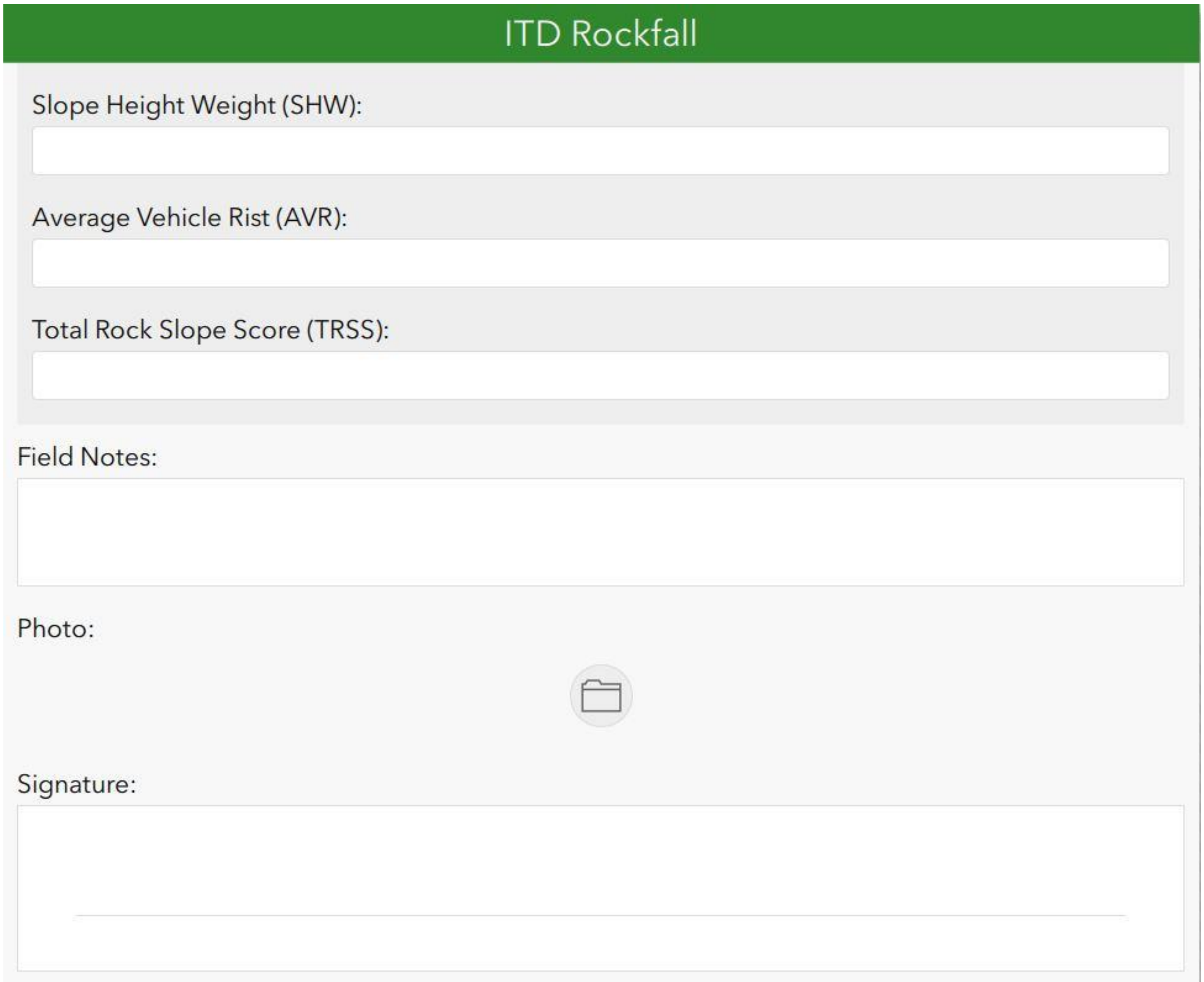
% Decision Sight Distance (PDSD):

Affected Highway Distance (AHD):
Feet

Slope Height Weight (SHW):

Average Vehicle Rist (AVR):

Total Rock Slope Score (TRSS):


ITD Rockfall

Slope Height Weight (SHW):

Average Vehicle Rist (AVR):

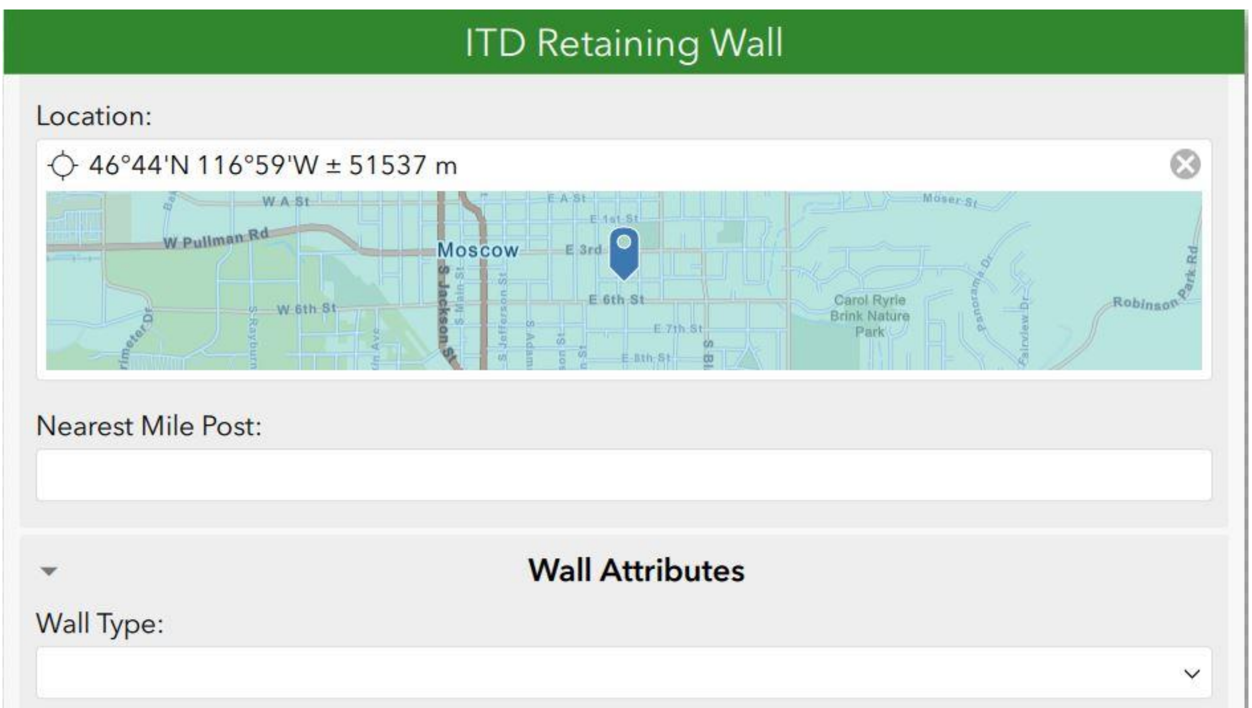
Total Rock Slope Score (TRSS):

Field Notes:

Photo:

Signature:


ITD Retaining Wall
Inspection Date:
Wednesday, December 16, 2020
Location
Detour Length:
Miles
Route:
County:
District:


ITD Retaining Wall
Location:
46°44'N 116°59'W ± 51537 m
W Pullman Rd
Moscow
E 3rd
W 6th St
E 6th St
Carol Ryrie
Brink Nature
Park
Nearest Mile Post:
Wall Attributes
Wall Type:

ITD Retaining Wall

Side of Road:
- Left
- Right

Wall Height at Highest Point:
Feet

Year Built:

Special Access Requirements:
If Any

ITD Retaining Wall

Wall Condition

Is soil coming out of joints as evidenced by loose soil in the joints or accumulating at the wall base in front of the wall?

Are the panel joints wider than 1"?

Is fabric visible in the joints?

Do joint widths vary by more than 1/4"?

Are the panels offset at the joints, either in or out of the wall more than 3/4"?

ITD Retaining Wall

Is there vegetation growing in the joints?

Are there cracks wider than hairline in the facing panels?

Are there other signs of concrete panel distress such as panel spalling and/or staining?

Is the wall face bowed or bulged?

Are there any signs of water flow along the wall base?

Is there erosion at the wall base or anywhere else near the wall?

ITD Retaining Wall

If there is erosion, is the leveling pad exposed?

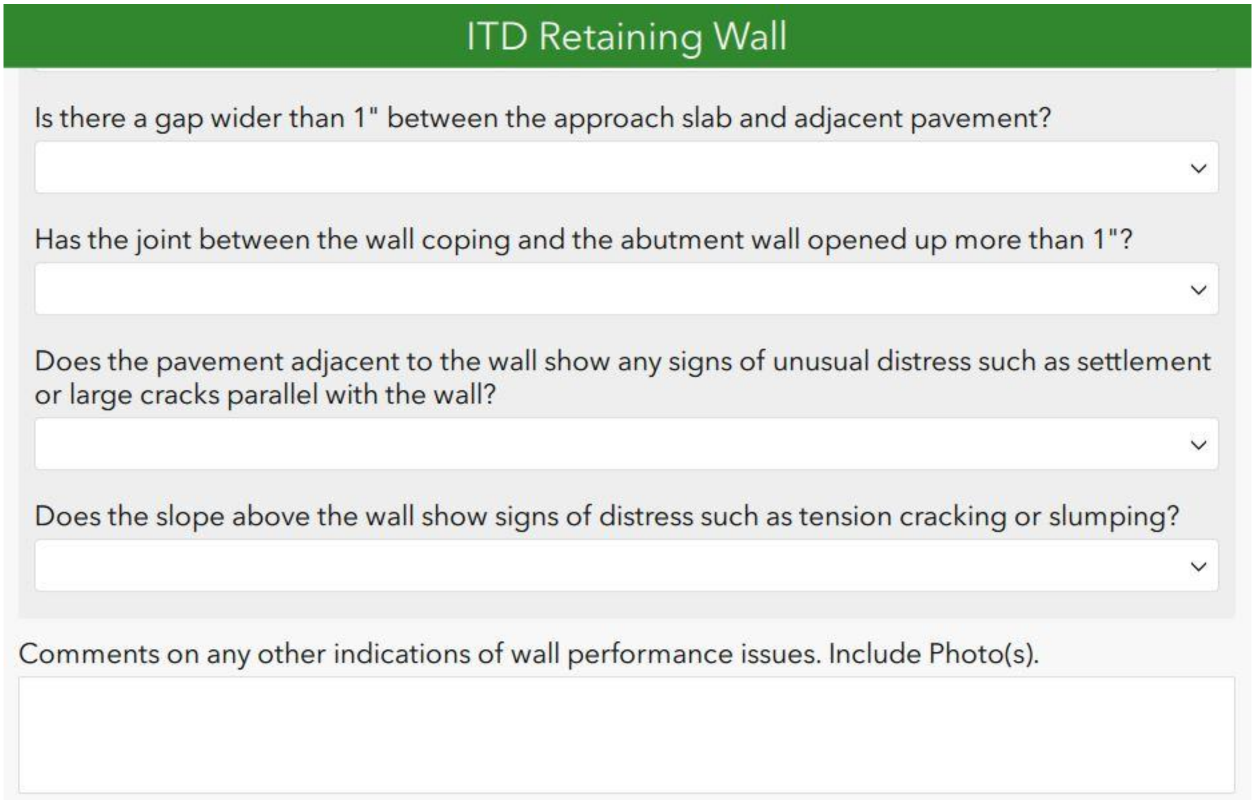
Are the catch basins or drain outlets near the wall blocked?

Is water collecting at top of wall or behind the concrete coping?

Is there ground settlement at top of wall?

Does the coping have open cracks wider than hairline?

Have the coping construction joints opened up?



ITD Retaining Wall

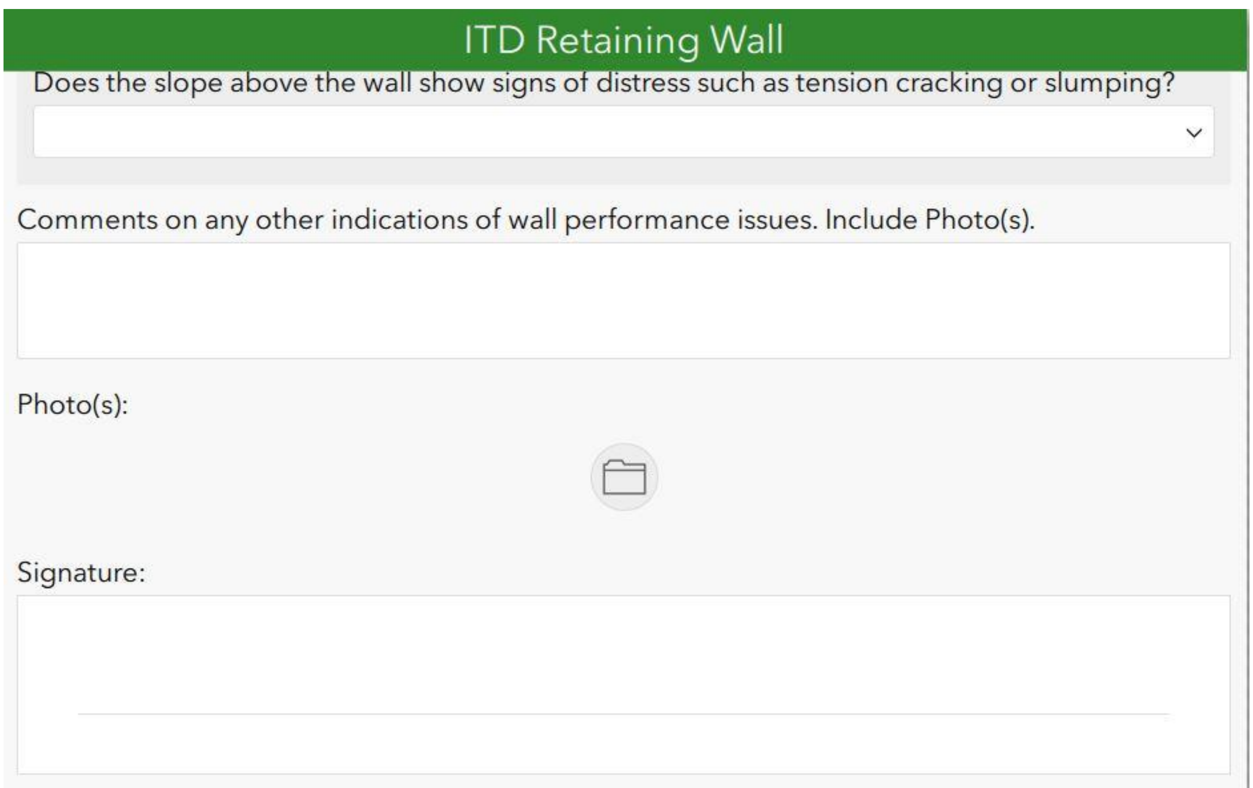
Is there a gap wider than 1" between the approach slab and adjacent pavement?

Has the joint between the wall coping and the abutment wall opened up more than 1"?

Does the pavement adjacent to the wall show any signs of unusual distress such as settlement or large cracks parallel with the wall?

Does the slope above the wall show signs of distress such as tension cracking or slumping?

Comments on any other indications of wall performance issues. Include Photo(s).



ITD Retaining Wall

Does the slope above the wall show signs of distress such as tension cracking or slumping?

Comments on any other indications of wall performance issues. Include Photo(s).

Photo(s):

Signature: