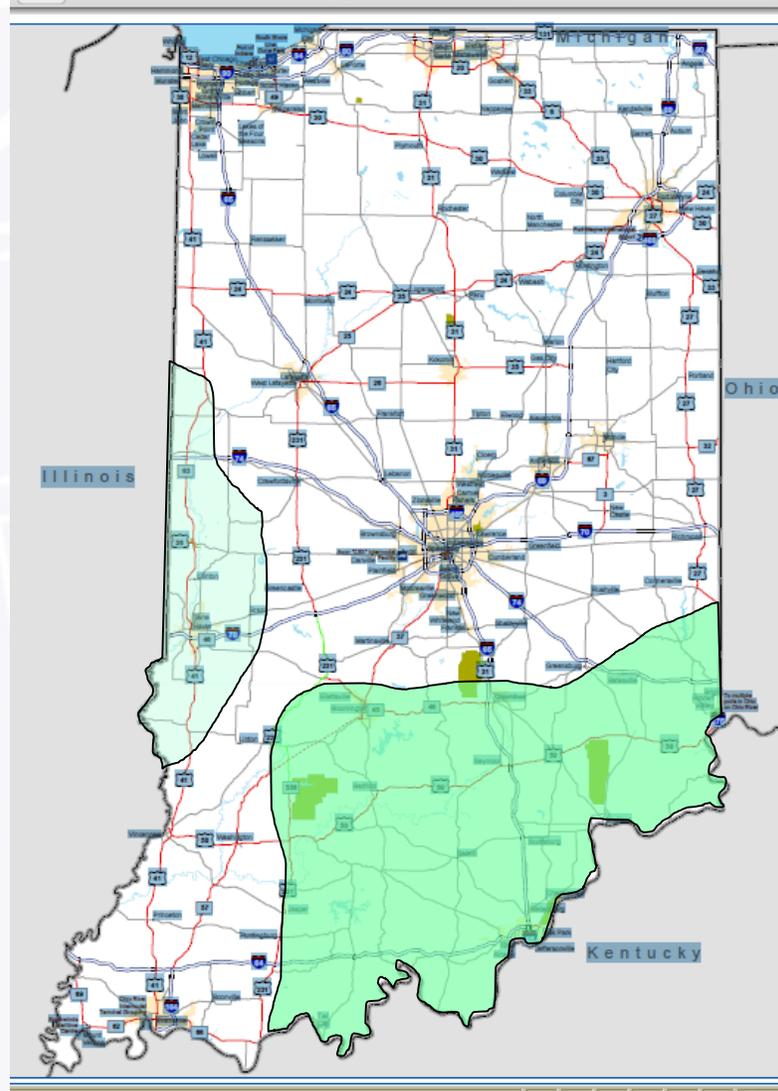


# Landslide Investigations and Reports

Joey Franzino

# Indiana State Map



# The Site Visit

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The main purpose of the site visit is to learn as much as we can about the slide, and to plan our next steps of the Geotechnical Investigation.

- Three possibilities that can come from a thorough observation:
  - We **think** we know what kind of slide we have.
  - We really have no idea what kind of slide we have.
  - In some cases, such as minor erosion or a very small slide, it might be obvious what the problem is.

# The Site Visit

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- When we think we know what kind of slide we have:
  - We are able to come up with preliminary possible slide corrections.
  - We might be able to do a single phase investigation.
  - We do appropriate borings and inclinometers for the purpose of confirming what we think, and to help us prepare for analyses of the corrections we have in mind.
  - Most of the time, the borings and inclinometers will confirm our theories.
    - In that case, we can analyze and propose feasible and potentially cost effective solutions.
  - In some cases, the borings might contradict our theory.
    - In that case, we might have to a second phase of the investigation to target alternative solutions.

# Site Visit

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- When we have a slide that we really can't comprehend from the site visit:
  - These are usually very complex slides.
  - These slides will generally warrant a two phase investigation.
    - Phase 1 - Borings and inclinometers to get a feel for exactly what is happening
    - Phase 2 - Borings to target the solution we have in mind based on the Phase 1 findings
  - The initial assumption on many of these is that drilled shafts might be needed.
    - Drilled shafts are the gold standard repair, but also, by far, the most expensive in our arsenal.
    - When we hire a consultant or do an in-house investigation, our goal is to find out if there is anything more cost effective we can do to permanently repair the slide.
    - Innovative thinking becomes critical in these cases.
  - Sometimes, a brainstorming meeting can be very effective.
    - A large field meeting involving the Geotechnical Consultant, the INDOT Geotechnical Engineer and Geologist, an INDOT Construction Engineer, the INDOT Project Manager, and INDOT Maintenance
    - After the first submittal of a report from a consultant is reviewed, an office meeting between the INDOT Geotechnical Engineer and the Geotechnical Consultant

# Site Visit

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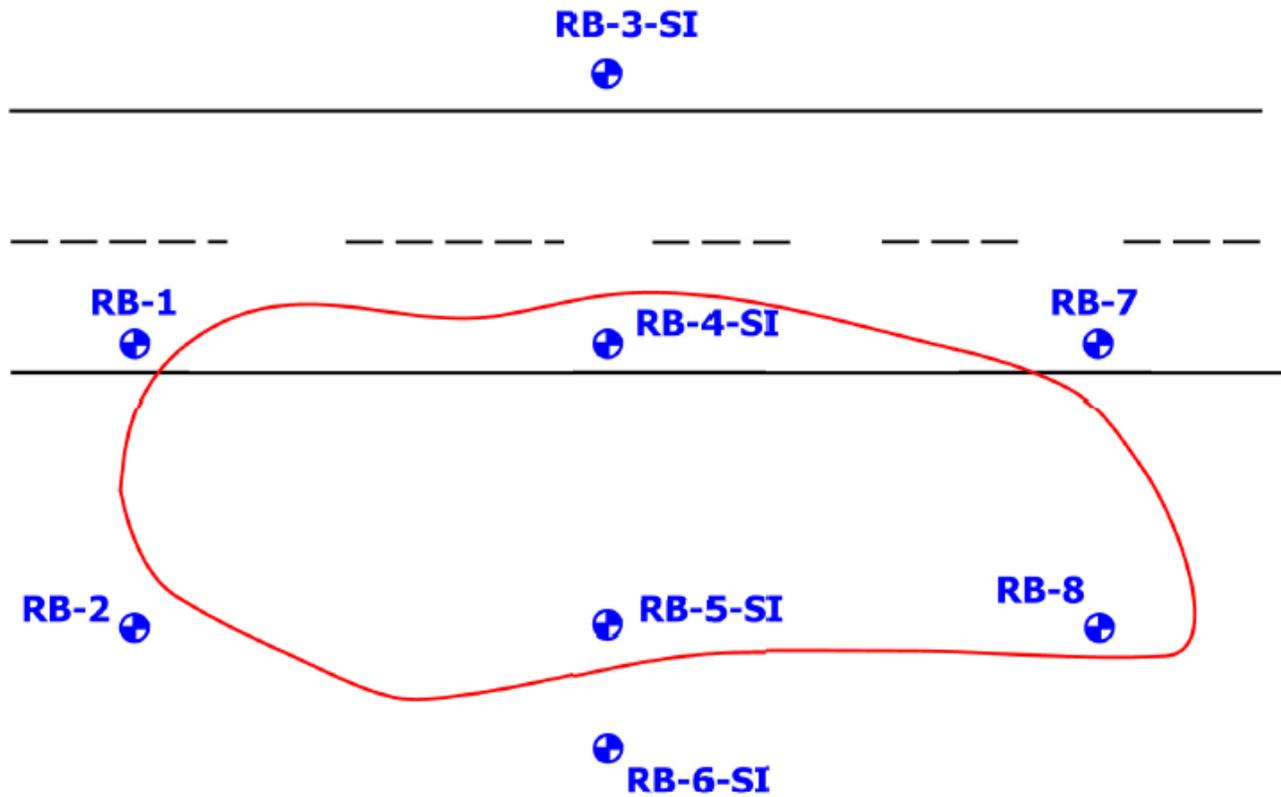
- In the case where we are able to determine definitively the mechanism of a landslide:
  - Generally, INDOT will make recommendations without borings or inclinometers, and generally, a consultant would not be hired for such a case.
  - If a consultant has been hired, and feels that they definitively know what is happening at a landslide and how to correct it, we are certainly open to hearing what the consultant has to say.
  - If the consultant can show us at the site why they feel that recommendations can be made without borings, we will agree to that if we feel the same level of confidence.

# Boring Locations

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- How frequently should borings be done for a landslide?????
  - Depends on the slide
  - General Ideas:
    - Ideally, borings along the same cross section at various points on the slide should be done.
    - The most critical section(s) of the slide should have inclinometers for each boring of the given the cross section(s).
    - If there are locations in which borings are needed, but access is difficult, consider doing those borings in the second phase of the investigation. Sometimes, the borings in the first phase of the investigation will provide enough information, that the landslide engineer will feel comfortable moving forward with recommendations without the missing borings. That does become a judgment call and should be agreed upon by INDOT and our consultant.

# Boring Locations



# Laboratory Testing

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- Classifications
- Atterberg Limits
- Moisture Tests
- Strength Tests
- If the solution will depend on a bedrock socket, such as is usually the case with drilled piers and tiebacks, some rock strength tests would help.
- If there are going to be an extreme amount of tests, it would be wise for the consultant to discuss it with the INDOT Geotechnical Engineer to verify that we are all in agreement with the testing program.

# Geotechnical Report

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- **Part 1**

- Date
- Project Information
  - Des Number, County and District
  - Exact Location description
- Thorough Description of the Slope Failure
  - Length (beginning and ending station)
  - Description of slide surroundings
    - What is at the top
    - What is at the toe
    - Drainage patterns
  - Length and width of pavement affected
  - Steepness of slope (including changes in steepness parallel to the slide and within a given cross section)
  - Height of slope
  - Description of location of the failure plane

# Geotechnical Report

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- Part 2

- Geology of the Area

- Description of historical glaciation
    - Description of soils anticipated
    - Thickness of anticipated soils (unconsolidated deposits) above bedrock
    - Bedrock description
      - Age
      - Type
      - Relevant properties of that type of bedrock
    - Description of any underground mining activities, past and present, and any karst features

# Geotechnical Report

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- **Part 3**
  - Possible causes of the slide
- **Part 4**
  - Findings
    - Soils and bedrock actually encountered in the borings
    - Moisture conditions
    - Strength conditions
- **Part 5**
  - Good photos are an added bonus

# Added Bonus



# Geotechnical Report

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- **Part 6**

- Considerable options

- Most of my reports contain 3-5 possible options.
    - The scenarios for each option are as follows:
      - One or two of the options can be considered the “Preferred Option”. The Preferred Option(s) should be analyzed.
      - Some options might be considered feasible but not preferred. These options can be analyzed upon INDOT request.
      - Some options might be listed and discarded due to feasibility issues (won’t provide a 1.5 FOS or difficult to construct).
      - Some options might be listed and discarded due to cost effectiveness (for many slides, drilled piers would be an example).

- **Part 7**

- Recommendations for the Preferred Option(s)

- At least one option should be thoroughly analyzed.
    - The analyzed option(s) should have complete recommendations, sufficient for a designer to prepare final plans.

# Geotechnical Report

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- Part 8
  - Closing remarks, Signature and Seal
  
- Part 9
  - Appendices
    - General Site Plan
    - Boring Location Plan
    - Boring Logs
    - Lab Test Results
    - All Analyses
    - Special Provisions if necessary

# ANY QUESTIONS????????

