Starting a Geotechnical Asset Management Program with Existing Data

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  - Landslide Technology

LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

Southwest Geotechnical Engineers Conference – May 2024

What are we talking about?

- Transportation Asset Management (TAM)

    “Strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle” – AASHTO

- TAM for Bridges and Pavements is required, *encouraged* for ancillary assets

    What it means: No Federal directive or requirement … may be (likely?) considered optional by management

Why Apply TAM to Geotechnical Assets?

Trans Alaska Pipeline

Dalton Highway

Yukon R. Bridge

O&G accounts for
85% of State Revenue

Major Landslide


WEIGH
STATION
1 MILE


MAINTENANCE & OPERATIONS
35682


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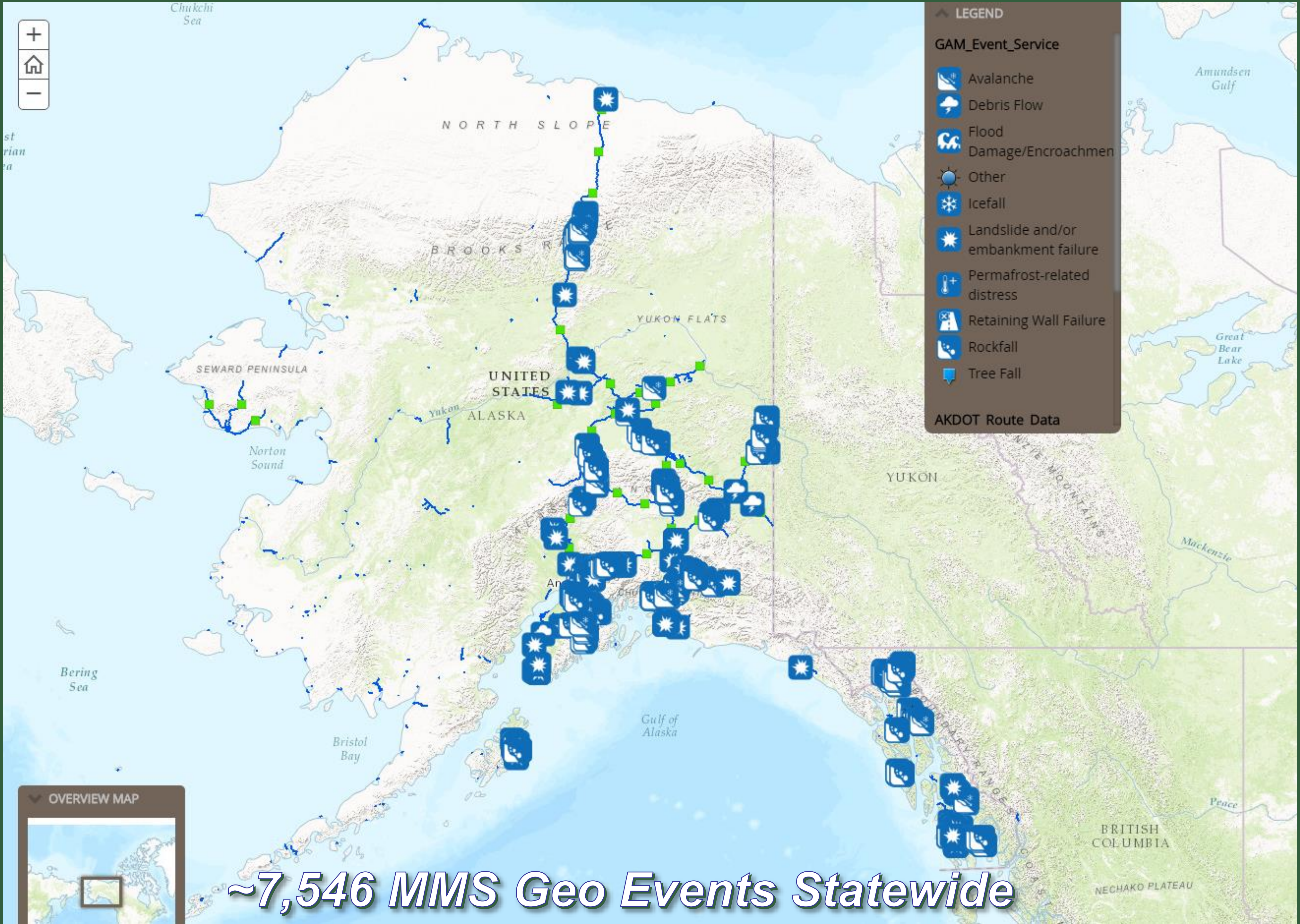
MARKET
VIDEO RENTALS



~7,546 MMS Geo Events Statewide

Why a Section-led Jump-Start?

- Failures cause frequent disruption & unplanned costs
- Top-down directive is lacking – Federal regs don't require (but encourage) ancillary assets
- Materials/Geotech still expected to know where GAM assets are and their condition
  - How many bridges does bridge manage… is 'I don't know' acceptable?
- Risk analysis (safety, mobility, long-term costs)
- Permits budgeting, forecasting, informed decision making
- How Geotech/Materials will manage their assets

What you Want in the End

- Performance Measures
- Inventory and Condition Assessments
- Performance Measurement
- Rates of Deterioration
- Investment Models
- Condition Forecasting
- Corridor Planning

What you Want in the End

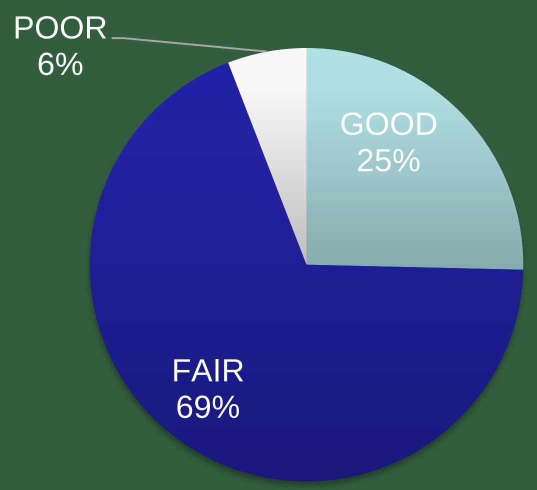
“My Department has 5,000 geotechnical assets and 70% meet performance criteria. If we do nothing, in 10 years it will be 65% and will result in accumulated direct costs of $10,000,000 and indirect costs of $30,000,000. We’re forecast to have 8 road closures per year, growing to 9.

If we invest $2,500,000 per budget cycle, we’ll reduce unforeseen state expenditures by 50%, reduce forecast road closures to 7, and project that 75% meet performance criteria.”

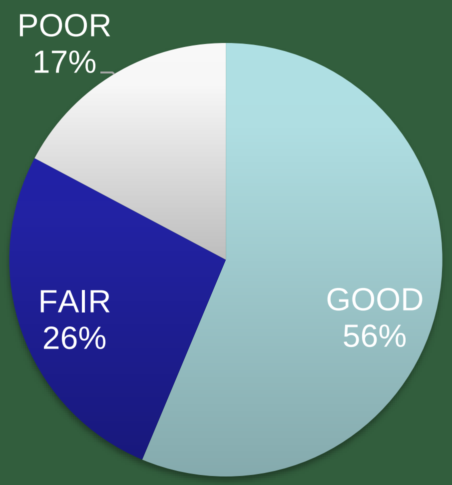
Asset Condition

- Majority of inventoried rock slope square footage in Fair condition
- Majority of inventoried soil slope/embankment footage in Good condition
- Retaining walls inventoried in Ketchikan, Juneau, and Sitka largely in Good condition

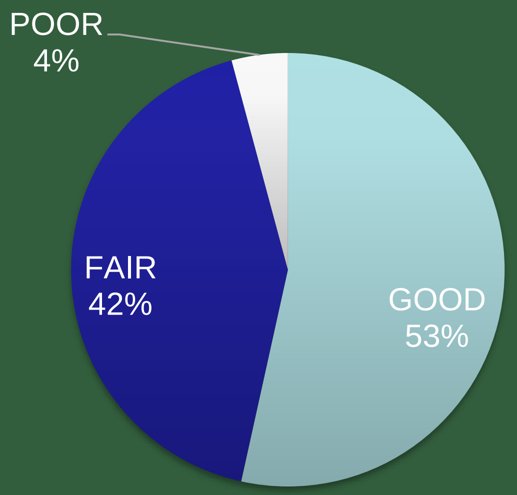
Rock Slope Condition State



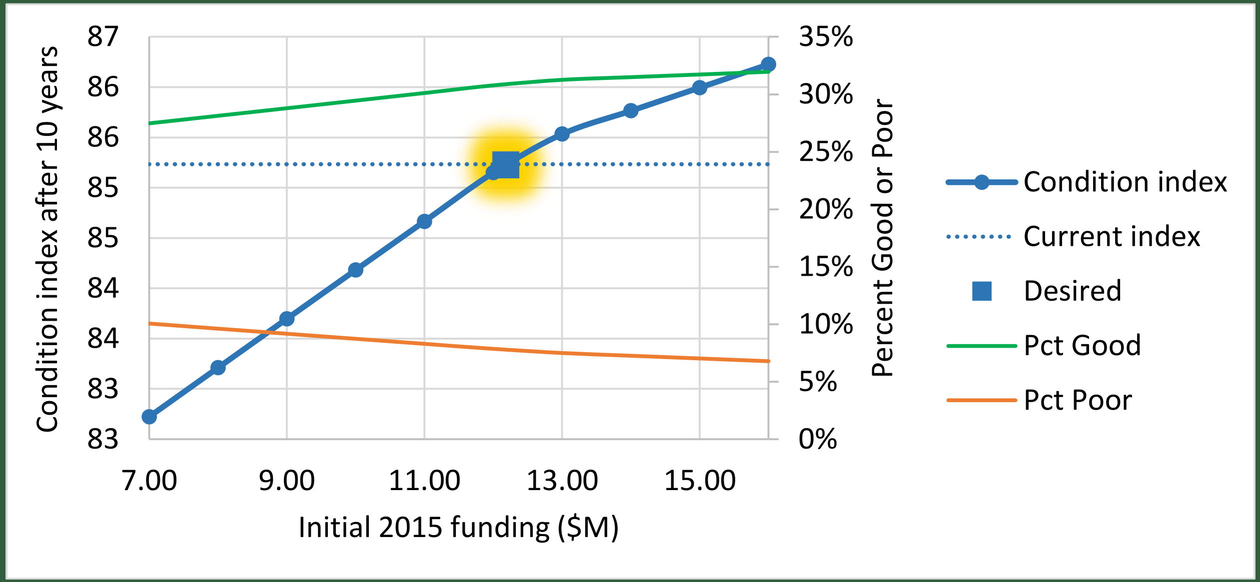
Soil Slope Condition State



Retaining Wall Condition State



Funding vs performance



For example, funding of $12.2 M/year is expected to yield 31% Good and 8% Poor

- More funding gives better condition (as expected)
- 10-year fiscally-constrained condition targets based on expected funding allocated to slopes
- Computed from current condition, deterioration and cost models

Where to begin – 5 Step Process

1. Identify Purpose and Need for GAM
2. Identify Existing Data
3. Identify Data Gaps
4. Acquire New Data
5. Improve Data Gathering and Analysis Tools

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Step 1: ID Purpose and Need

- Agency Mission Statement

  "To responsibly provide our customers the safest and most reliable transportation system possible, given available resources." – Maine DOT

- Agency TAM Plan or Long-Range Transportation Plan
- Section's Own Responsible, Informed Decision Making and Planning
- Acceptance of 'If you can't measure it, it doesn't exist'
- Are Geotech Assets Undermining or Supporting Goals?

I-90 Failures

- MP 24 before/after

I-90 Failures

- MP 6.5 before/after

I-90 Failures

- MP 22 before/after

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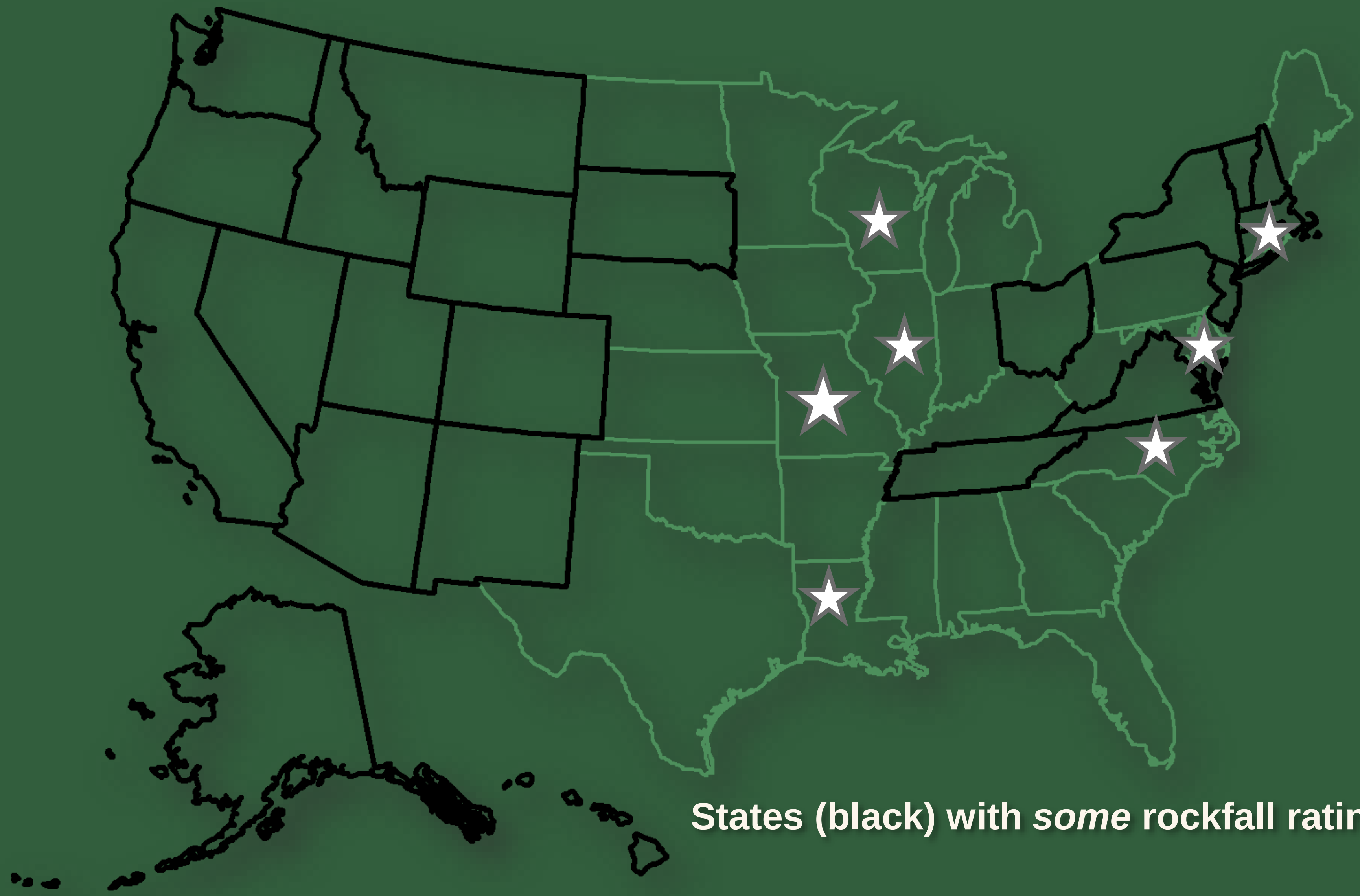
Step 2: Identify Existing Data

- Unstable Slope Inventories (RHRS, RHRON, USMS, etc.)
- As-built inventories (Walls, Culverts, Subgrade Improvements)
- Maintenance (Management Systems, Job Activity Codes, Employee Recollections)
- Geotechnical Section Histories (Oral, Reports, Photo Files)
- Other Agency Data

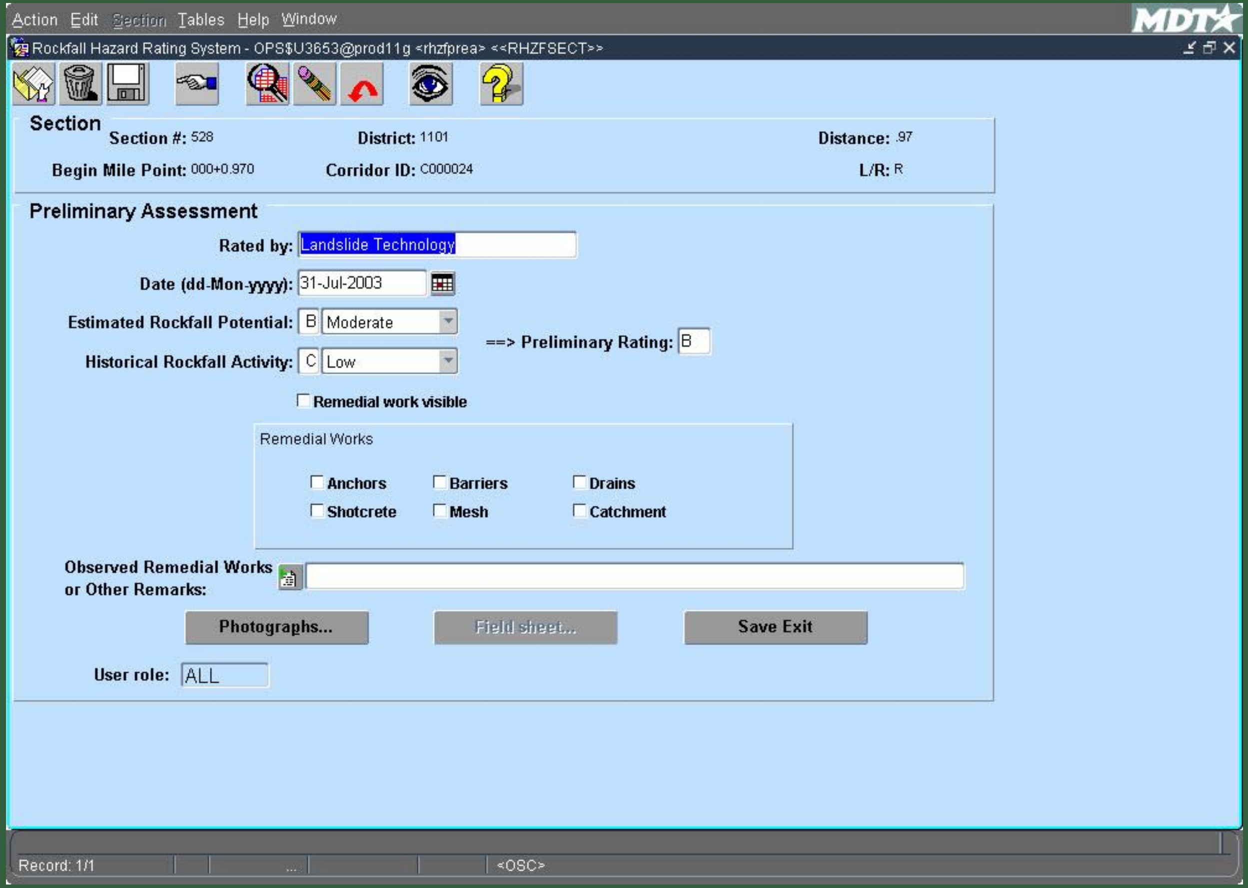
Step 2: Identify Existing Data

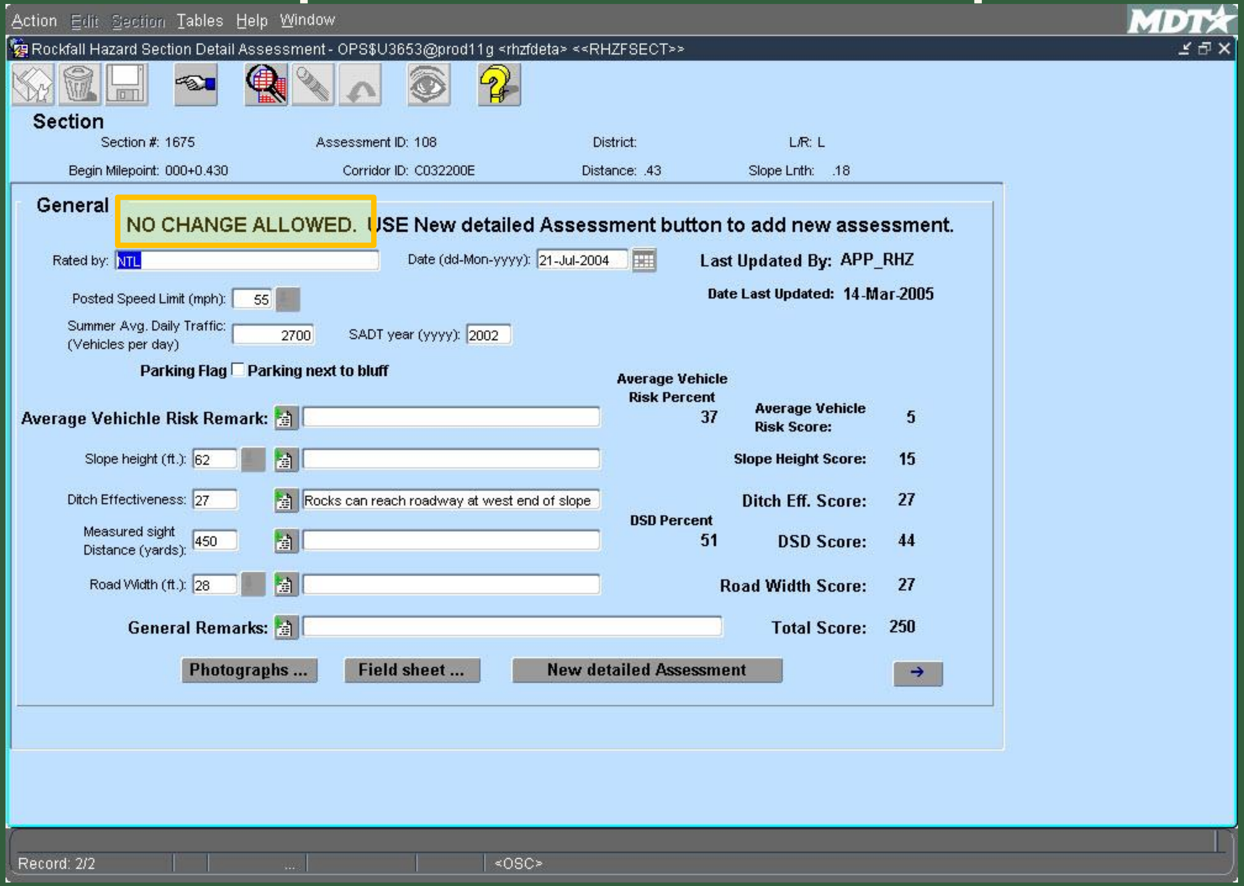


States (black) with *some* rockfall rating systems, 2010

Data Formats

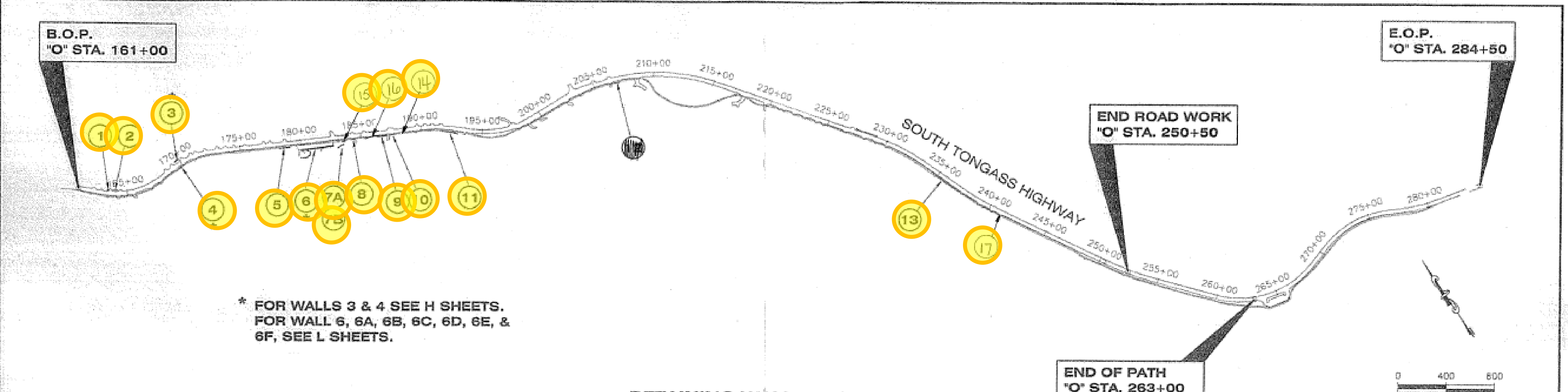
- Data formats – Excel, Access, Enterprise DB, GIS, Paper





MDT's Oracle Enterprise RHRS Screens, circa 2004

As-Built Plan Data Extraction



RETAINING WALL LAYOUT PLAN

MSE & CONCRETE RETAINING WALL TABLE						
WALL NO.	BEGIN "O" STATION	END "O" STATION	OFFSET (ft)	MSE AREA (ft2)	CONCRETE AREA (ft2)	REMARKS
3	169+60	169+98	34.5 LT			SEE H SHEETS FOR DETAILS
4	169+58	170+00	30.9 RT			SEE H SHEETS FOR DETAILS
6	178+83	180+87	67.5 RT			SEE L SHEETS FOR DETAILS
9	186+30	187+12	27 RT			
10	187+40	187+76	27 RT			
13	234+83	237+20	27-30 RT	1850		
7B2	183+4	183+72		29		

ROCKERY WALL TABLE					
WALL NO.	BEGIN "O" STATION	END "O" STATION	OFFSET (ft)	ROCKERY AREA (ft2)	REMARKS
1	163+33	163+52	26 LT	68.0	
2	163+74	164+24	26 LT	181.5	
5	178+20	179+10	33.5 RT	517.0	
~~6A~~				~~55~~	~~SEE L SHEETS FOR DETAILS~~
~~6B~~				~~56~~	~~SEE L SHEETS FOR DETAILS~~
~~6C~~				~~31~~	~~SEE L SHEETS FOR DETAILS~~
~~6D~~				~~44~~	~~SEE L SHEETS FOR DETAILS~~
~~6E~~				~~60~~	~~SEE L SHEETS FOR DETAILS~~
6F				320.7	SEE L SHEETS FOR DETAILS
7A2	183+21	183+70	32 RT	389.8	
7B	~~183+05~~	~~183+56~~	~~60-60 RT~~	~~330~~	CHANGED TO MSE
8	184+22	184+49.5	27 RT	123.5	
11	191+74	193+06	30.5-38.5 RT	682.4	
~~12~~	~~208+70~~	~~208+85~~	~~31 RT~~	~~45~~	
14	188+37	188+50	RT	28.6	
15	184+65	185+25	RT	128.9	
16	186+50	187+20	LT	512	
17	241+90	243+95	RT	777.6	

RETAINING WALL NOTES:

1. FOR RETAINING WALL LOCATIONS & DETAILS, SEE SHEETS K1–K3. FOR ALL LAYOUT PLANS & PROFILES, SEE SHEETS K4–K12.

Project As Built Drawings have been reviewed by the Project Engineer. To the best of his/her knowledge, they represent the project as constructed.

Proj. Eng. [signature] Date 4-

DO NOT SCALE FROM THESE DRAWINGS USE DIMENSIONS

CHECKED BY: P. CARROLL

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES
S.E. REGION DESIGN & ENGINEERING SERVICES DIVISION

SOUTH TONGASS HIGHWAY WIDENING & RECONSTRUCTION PROJECT #71670

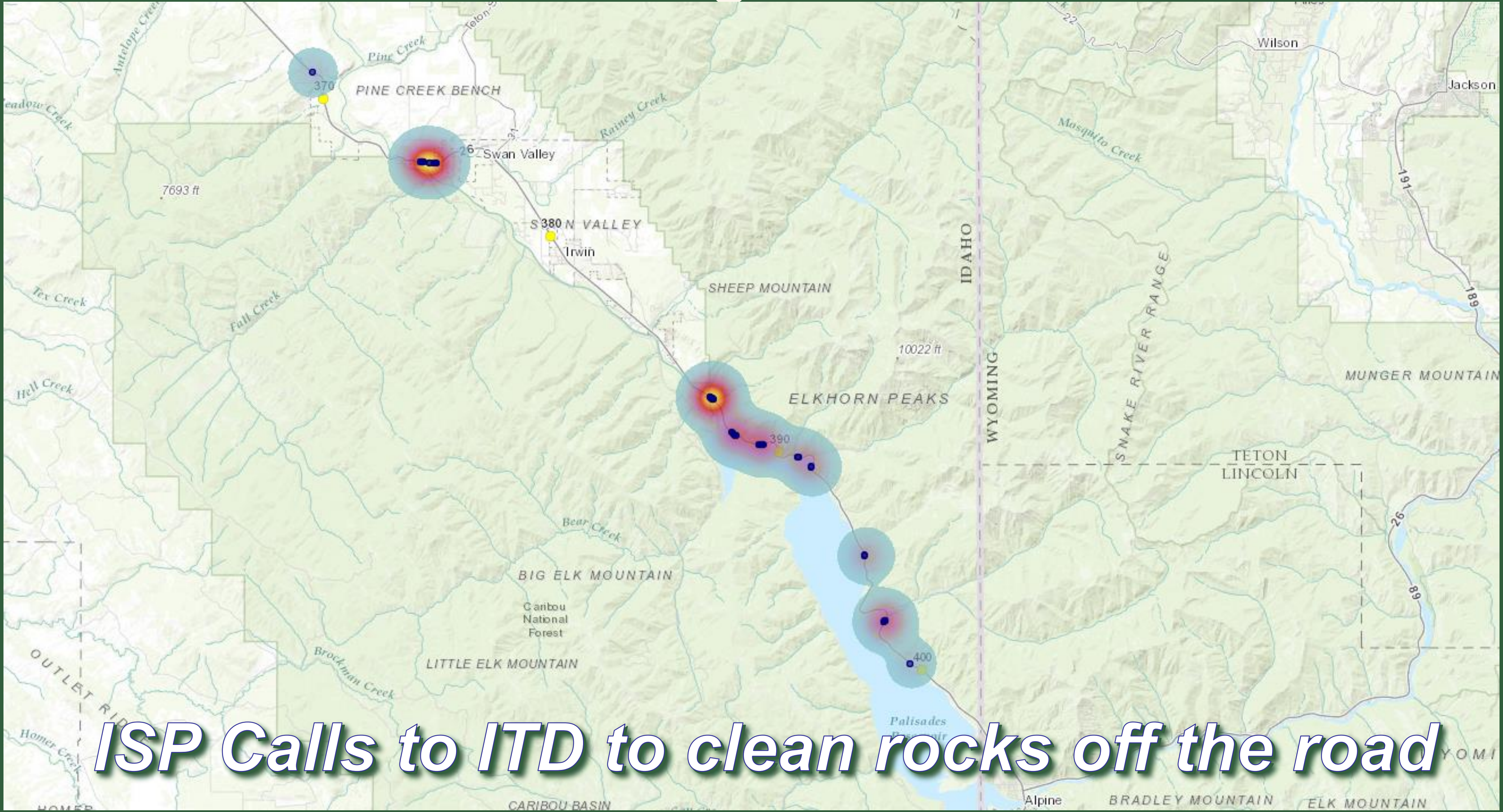
RETAINING WALL DETAILS

DESIGNED BY: C. HOWARD
DRAWN BY: R. SNYDER

4-26-06

PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
MGS-STP-0902(20)	2006	K1	179

Event DB: State Clearinghouse Call-out Locations



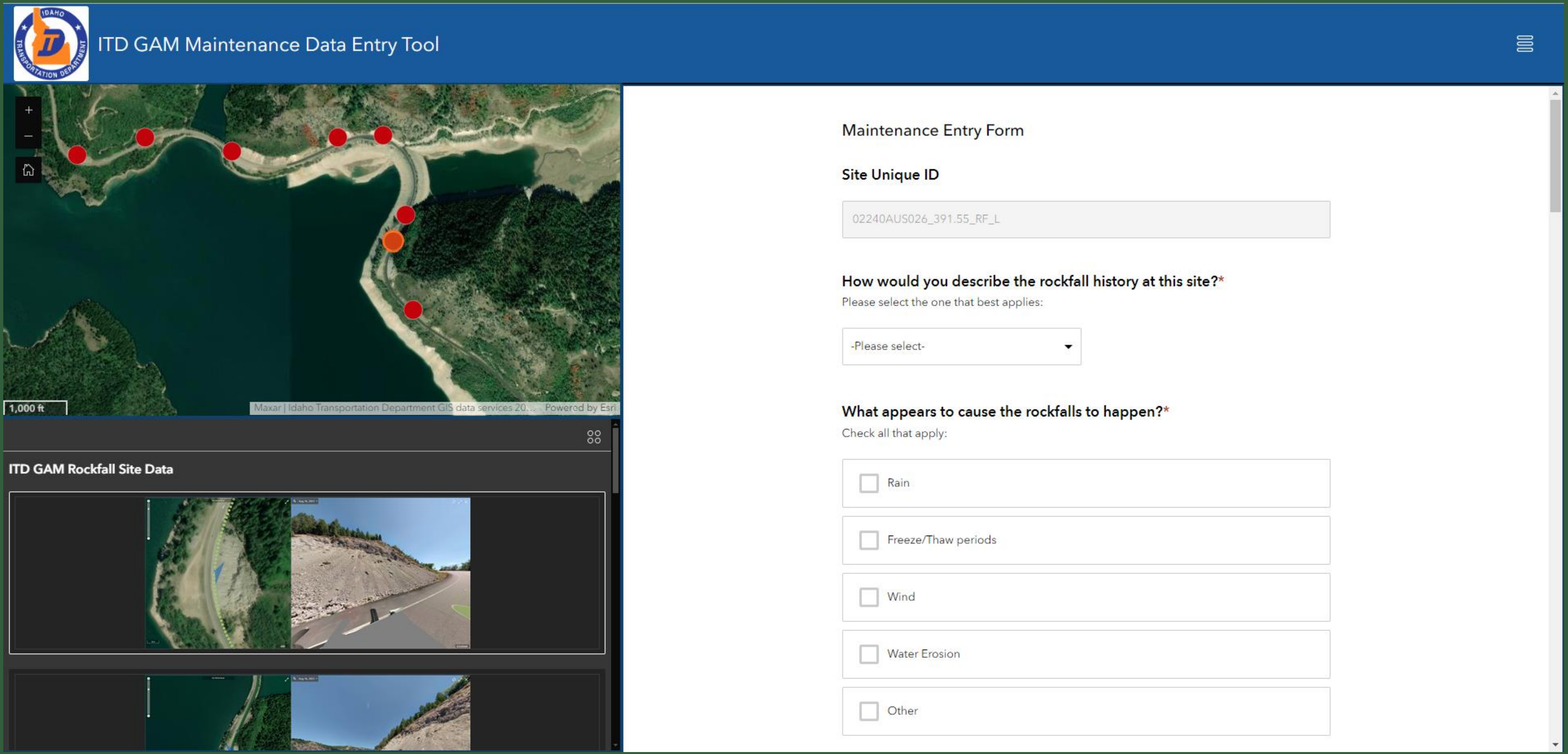
ISP Calls to ITD to clean rocks off the road

Example: Maintenance Survey

Questions	Answers	Comments
1. Rockfall History, please select one that best applies.	○ Few Falls Rockfalls occur only a few times a year (or less), or only during severe storms. This category is also used if no rockfall history is available. ○ Occasional Falls Rockfall occur regularly. Rockfall can be expected several times per year and during most storms. ○ Many Falls Typically, rockfall occurs frequently during a certain season, such as the winter or spring wet period, or the winter freeze/thaw, etc. This category is for sites where frequent rockfalls occur during a certain season but are not a significant problem during the rest of the year. This category may also be used where severe rockfall events have occurred over a period of several years. ○ Constant Falls Rockfalls occur frequently throughout the year. This category is also used for sites where severe rockfall events are common.	
2. What appears to be the triggering mechanism of rockfalls? Check all that apply.	☐ Rain ☐ Freeze/Thaw periods ☐ Wind ☐ Water Erosion ☐ Other (fill in comment box)	
3. Would you describe the rockfall events as composed of single blocks or many blocks of different sizes?	____ ▾	
4. What is the average and maximum rock block size?	____ ▾ Average size ____ ▾ Maximum size	

5. What is the average and maximum volume of rockfall debris in cubic yards per event? Enter a number only. (Not required for single block events)	Average Maximum	
6. Where do the rocks come to rest?	____ ▾	
7. Have there been accidents or vehicle damage events due to rockfall?	____ ▾	
8. How many times a year is ditch maintenance required to remove rockfall debris? Enter a number only.	time(s) per year	
9. A road patrol to check for rockfall debris on the road is required (check one):	○ Daily year round. ○ Daily during seasons/weather indicated in 1 and 2 above, as reported the rest of the time. ○ Weekly during seasons/weather indicated in 1 and 2 above, as reported the rest of the time. ○ Only as reported year round. ○ Other (fill in comment box)	
10. From a maintenance perspective, how would you evaluate the rockfall problem:	○ A - Significant rockfall problem ○ B - Moderate rockfall problem ○ C - Low rockfall problem	

Example: Maintenance Survey



Other Data Sources

- Estimated Mitigation Cost Databases
  - Montana (RF), Washington (RF/LS), Others?
- Bid Tabs for Average Prices and Construction Cost Index
- AASHTO ‘Red Book’ for User Costs
- Accident causation records (limited)
- ‘Borrow’ risk analysis parameters from states with similar geology and network, if they’ve got them

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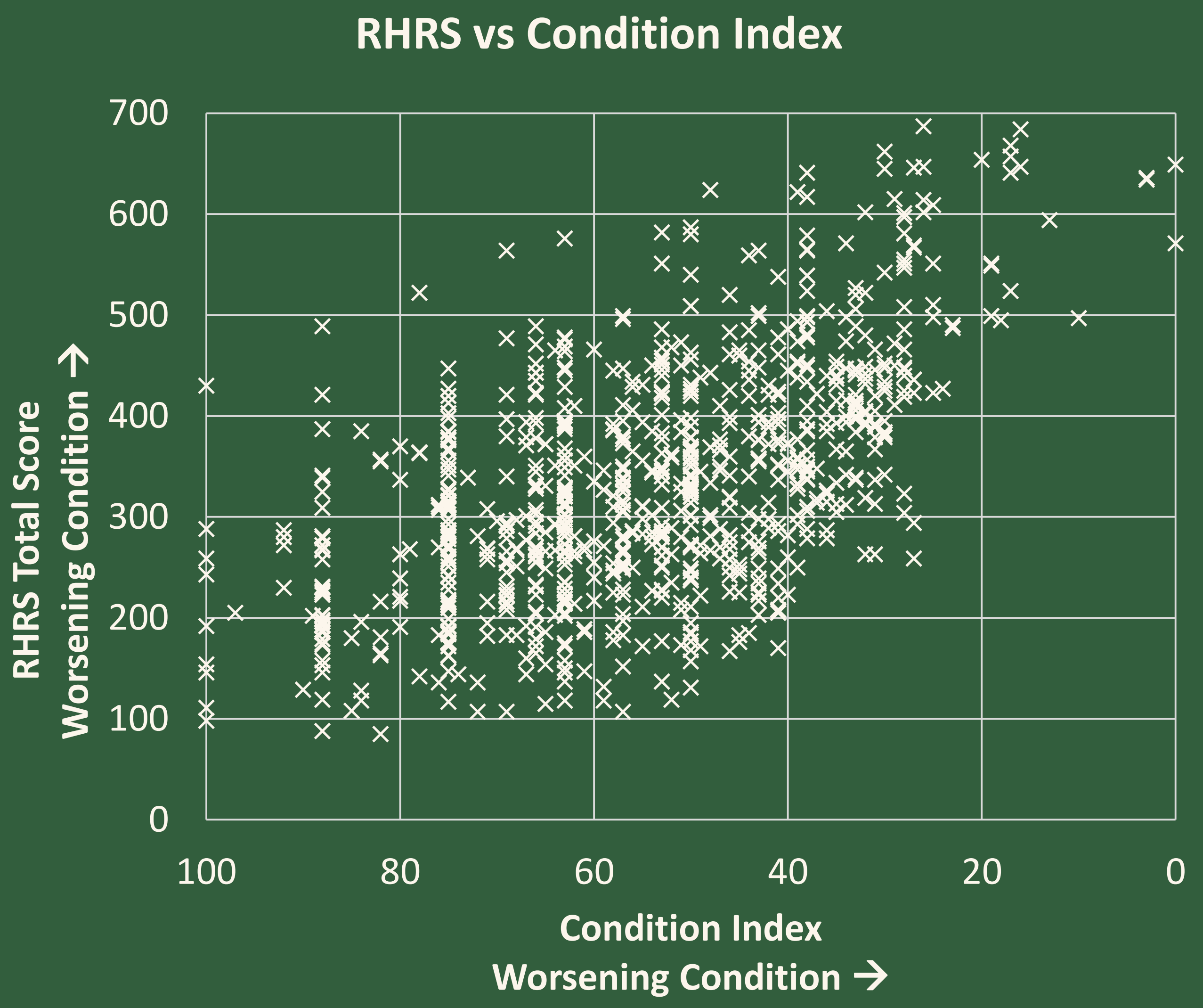
Step 3: Analyze Data and Close Gaps

- Address TAM Compatibility
- Formulate Derivative Condition Measures
  - Criteria that worsen in absence of maintenance/mitigation
- Compare Condition to Other Records
  - Maintenance costs, adverse events, mitigation costs, risk
  - Determine/Formulate Relationships

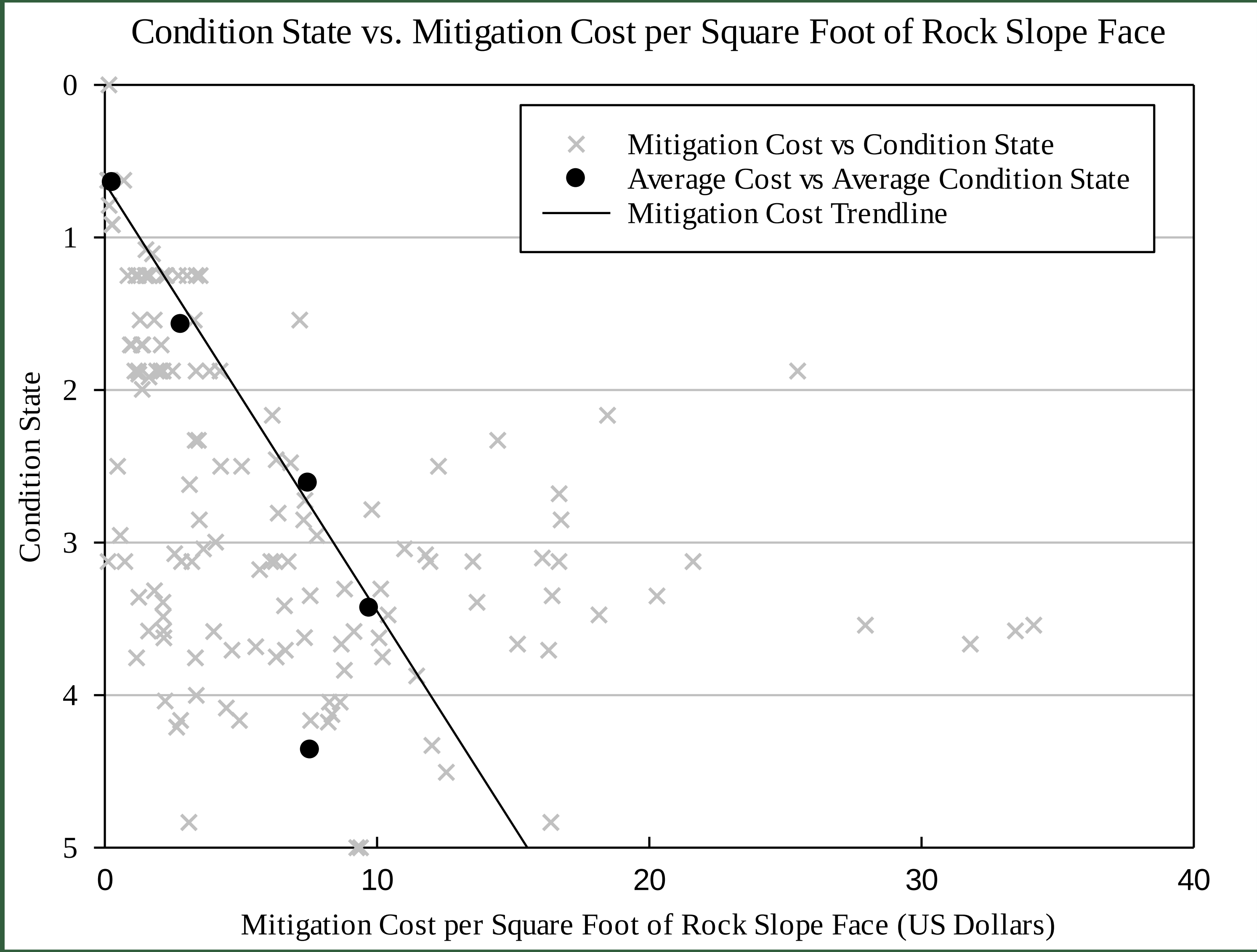
Example: Condition v. RHRS Scores

Cond. State	Condition Index Range		Analysis of MDT RHRS Values by Condition State Group		
	High	Low	Average RHRS Score	Average Score Percentile	Standard Deviation
1, Good	100	80	227	18	87
2, Fair	80	60	289	38	90
3, Fair	60	40	330	51	96
4, Poor	40	20	427	79	95
5, Poor	20	0	597	97	66



Example: Condition Relation v. Mit. Cost

Condition States Improved	Cost per sq ft	W/ OH Costs (105%)
1	$3.56	$7.30
2	$7.12	$14.60
3	$10.68	$21.90
4	$14.24	$29.20

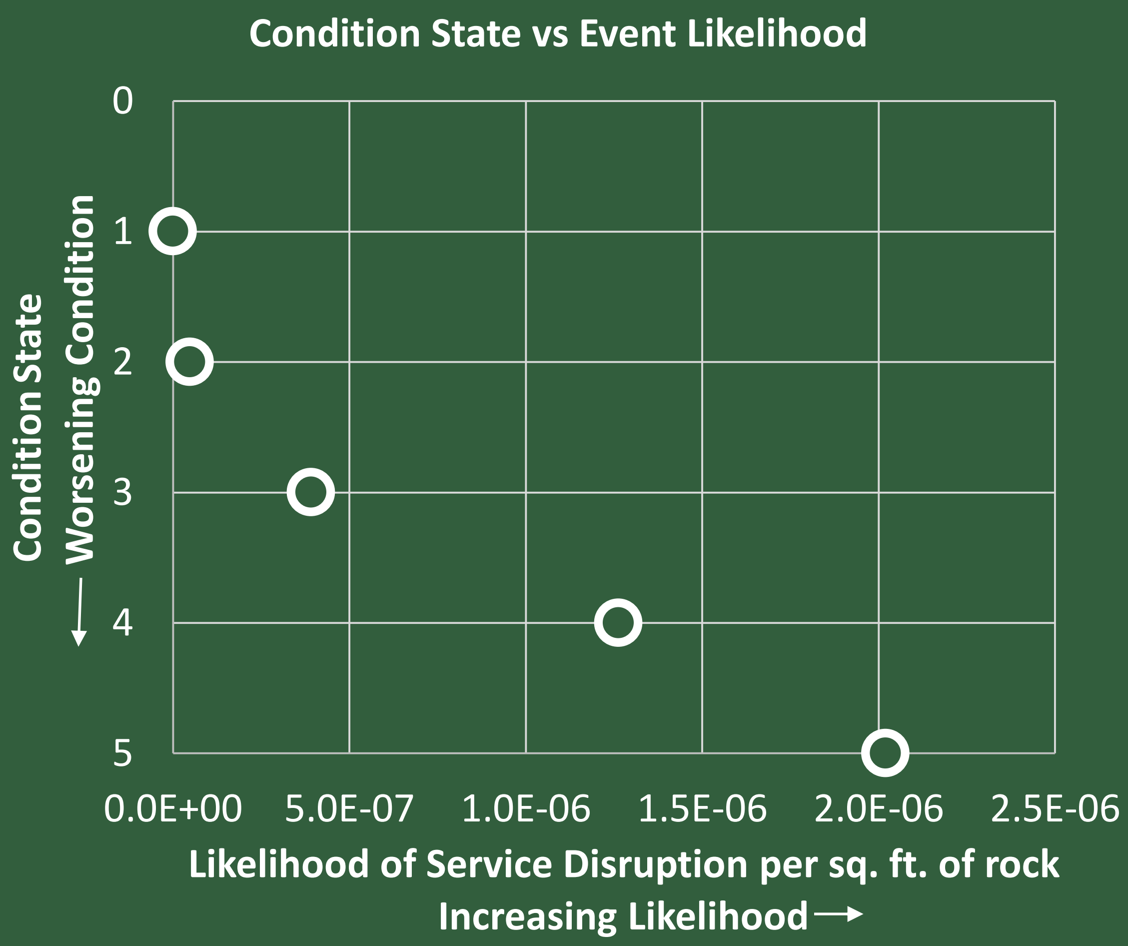


Example: Condition v. Event Occurrences

Analysis of MDT District 1 Survey Data by Condition State Group

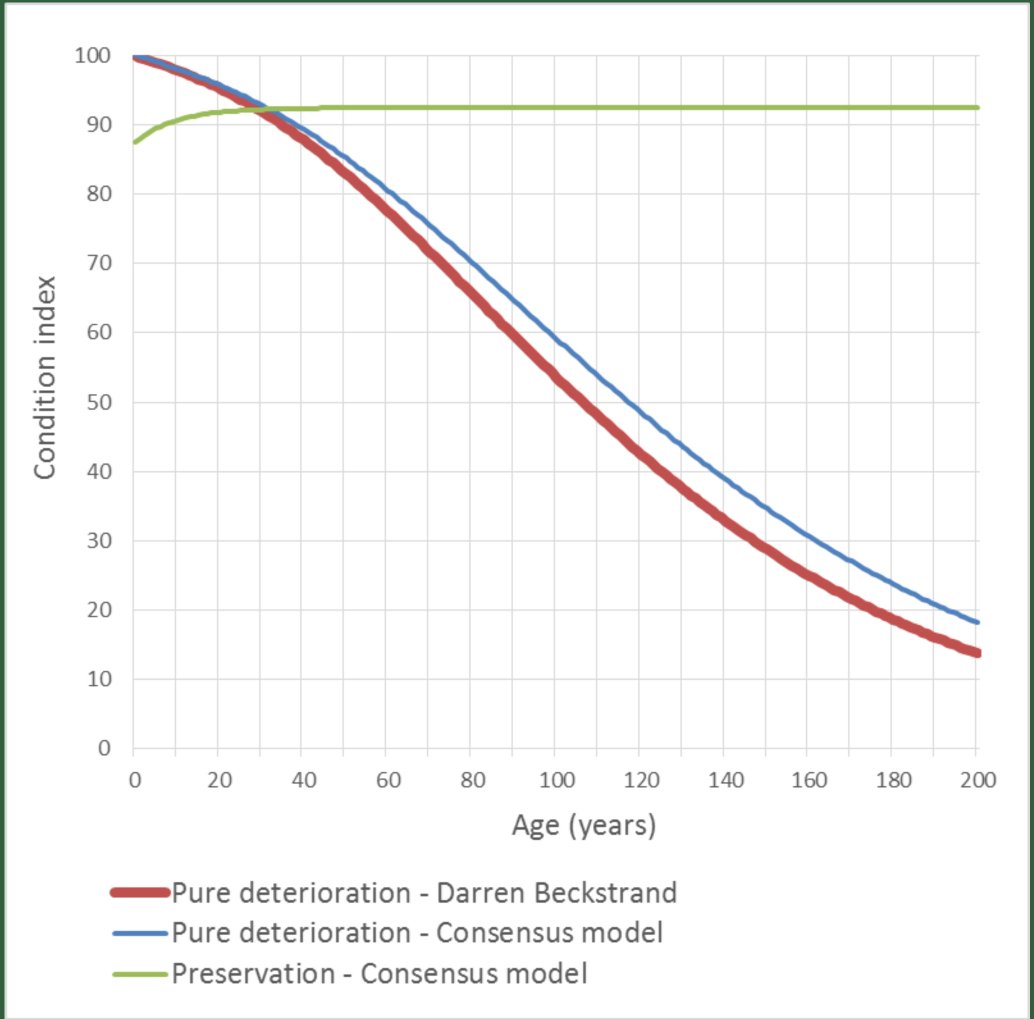
Cond. State	Reported Annual Events (closures and slowdowns)	Inventoried Square Footage	Likelihood per sq. ft. of rock slope face
1, Good	0	1,891,759	1.19E-08*
2, Fair	0.39	8,262,371	4.75E-08
3, Fair	2.14	5,461,018	3.91E-07
4, Poor	3.86	3,060,990	1.26E-06
5, Poor	0.57	282,968	2.02E-06

** CS-1 Likelihood estimated from CS-2 likelihood and engineering judgement*



Example: Expert Elicitation

- Structured Inquiry of Specialist's Experience & Judgement
  - Example: You have 100 Condition State 1 slopes. How many years until 50 of them have deteriorated to CS 2?
    - 35, 20, 75, 45, 30, 25 years…Consensus of 38.3 yrs
  - Same question for CS 2 deteriorating to CS 3 and so on.



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Step 4: Acquire New Data

- Fill the Gaps
  - Improve Event, Cost, Closure, Consequence Tracking
  - Complete Inventory & Condition Assessments
  - Determine Condition Assessment Intervals
  - Update Sites when Altered
- Improve/Refine Relationships
- Additional Analyses, Confirm Expert Elicitation

Step 4: Acquire New Data

- Explore Additional Data Gathering Techniques
  - Change Detection (Mobile LiDAR, Photogrammetry, etc.)
- Adjust Performance Measures to Event Frequency, Detected Changes
- Consider Additional Evaluation Criteria
  - Rock Mass Rating, Geologic Strength Index, Instrumented Landslides, Displacement Rates
- Build it into your Design Criteria
  - Target Condition State

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Step 5: Improve Data Sharing & Gathering

- Clear Communication
  - Planners will ask ‘What else can we do on this project’ rather than ‘There was no indication that work was needed’

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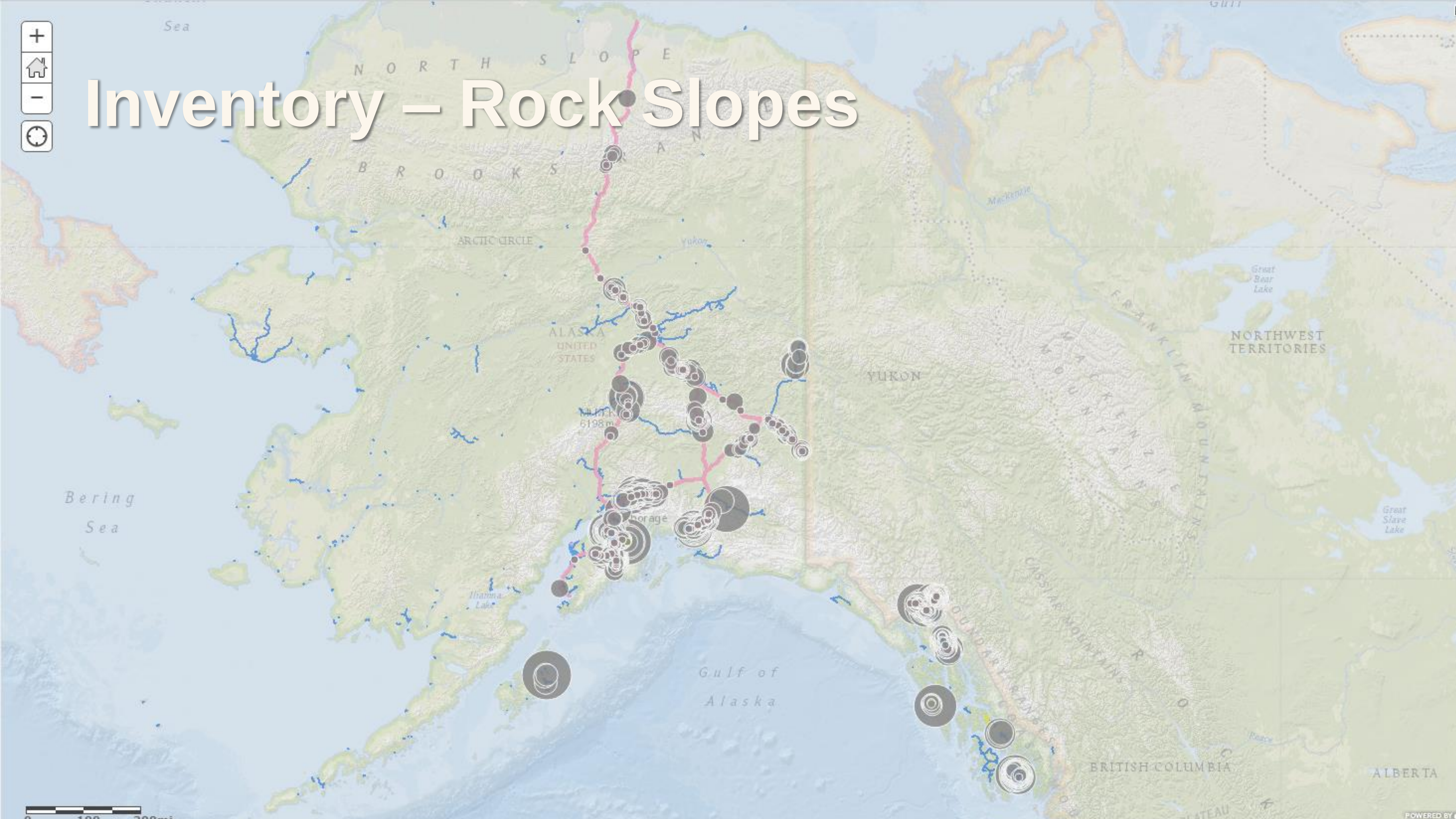
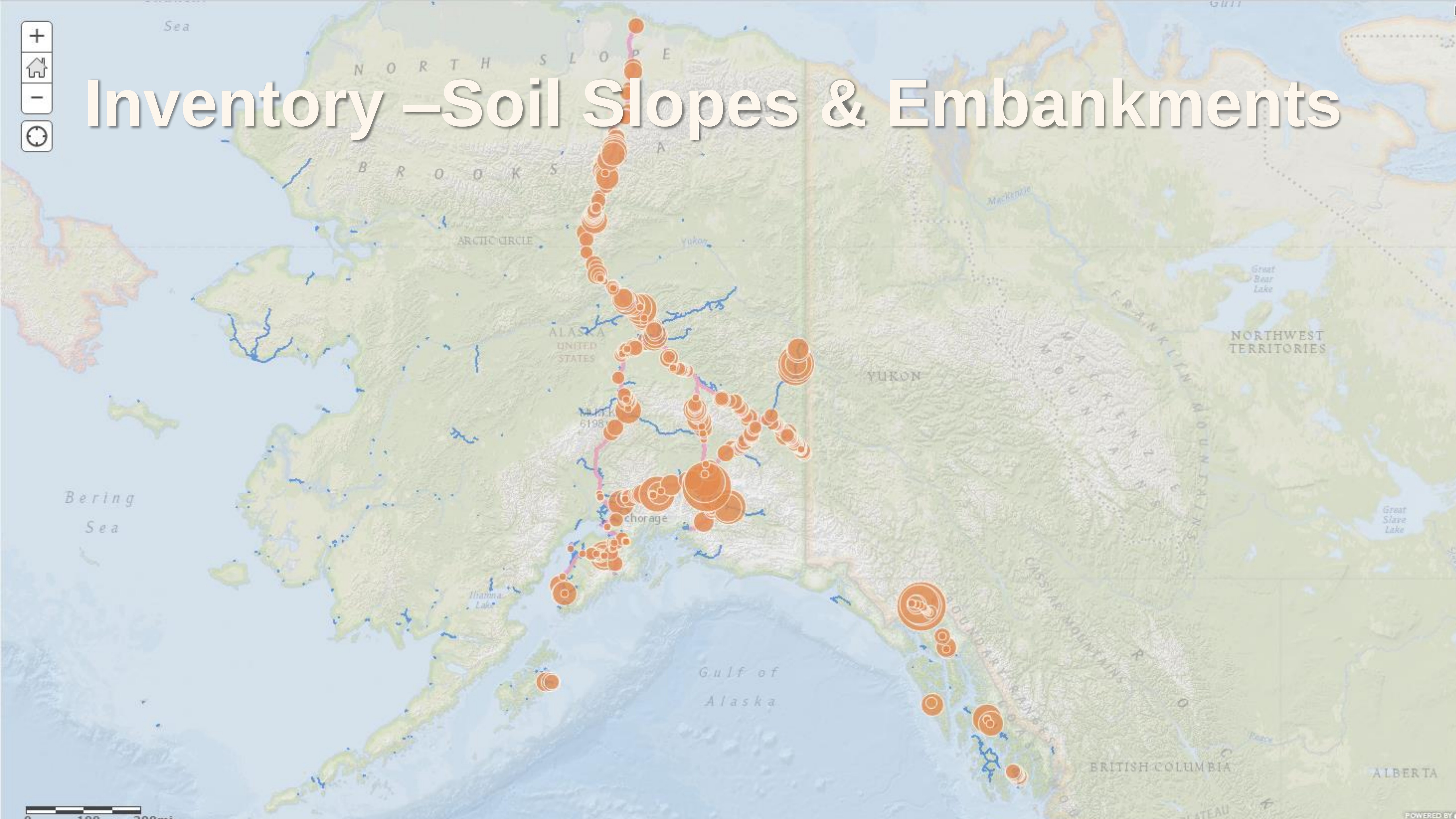
- Clear Communication
  - Planners will ask ‘What else can we do on this project’ rather than ‘There was no indication that work was needed’
  - MAPS!

Inventory – Rock Slopes



Inventory –Soil Slopes & Embankments



Step 5: Improve Data Sharing & Gathering

- Clear Communication
  - Prepare Easy-to-Follow Explanation of the Program

Geotechnical Features for US 26 Swan Valley Planning

US-26 Swan Valley Geotechnical Investigations

Executive Summary

Purpose

The goal of this project was to create a comprehensive geotechnical asset dataset for the US 26 corridor from the Swan Valley Bridge to the Wyoming border. The assets investigated in the field included cut slopes, rock slopes, and embankments. From these assessments, a geodatabase was generated compiling site-specific information and site photos. Web-based applications make the results accessible to various users. Geotechnical hazards and their potential impact on the highway are described and illustrated for managing these assets and for planning future highway improvements.

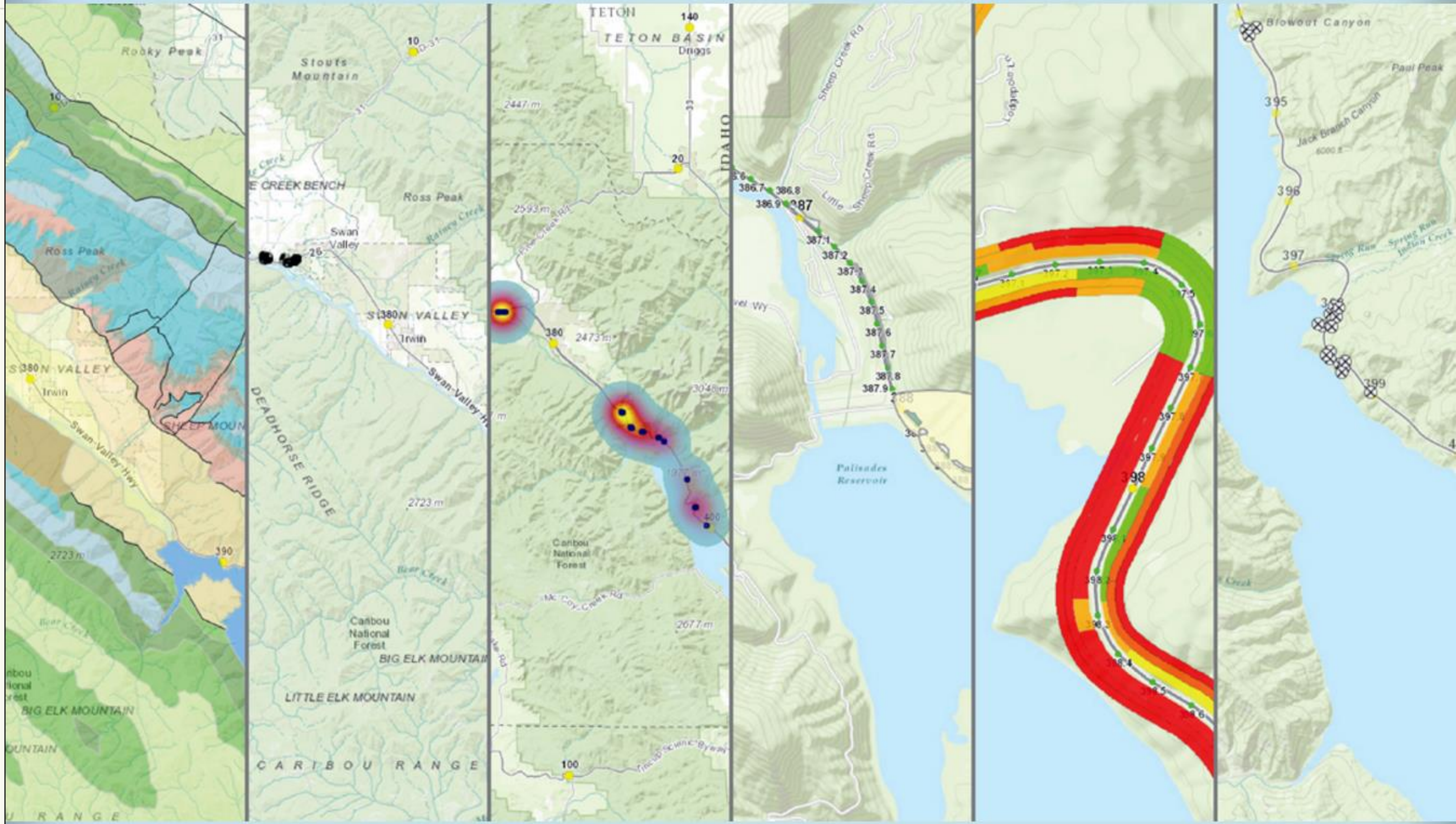
Methods

Data compilation began with reviewing and compiling previous subsurface investigations, available geo-spatial datasets, and geotechnical and roadway information supplied by ITD. Geotechnical investigations of landslides, rockfall, and embankments within this US 26 corridor section were systematically documented and entered into the geodatabase. Hazard condition assessment and risk evaluation frameworks were developed to identify specific site data to be obtained during the investigations and subsequent analyses. Attribute data was appended to spatial data in order to complete the final asset geodatabase.

Results Summary

From the information gathered, the geodatabase was transferred to an online ArcGIS platform. This resulted in a user-friendly, easy access product that not only ITD officials use, but also other agencies and public stakeholders. Due to this online application, the contents can be updated in the future, creating a living database and planning tool.

Recommendations for Improving the Geotechnical Planning Tool



Step 5: Improve Data Sharing & Gathering

- Data Tracking Tools
  - Geotechnical Event Trackers
    - ArcGIS Based
    - Paper Based
    - Email w/ photos

Data Entry Form

Unstable Slope Event Data Entry

Fill out all the information you have on the unstable slope event below. Failures would incorporate individual rockfall and landslide events, regardless of road closure. Costs are typically as contained in the MMS system. For sites entered directly from the MMS system, add only events that can be assigned to a single location of less that one mile post range.

For categories that require additional information or have documents available, please attach appropriate files at the end of the form.

1. Enter Information

Event Date

GAM Event Type

Enter Landslide or Rockfall. Landslides encompass all unstable soil slopes including debris flows, earth flows, and embankment failures.

SALLy Event Type

Avalanche, Debris Flow, Landslide, Shoulder Failure, Tree Fall, Rockfall, Frost Heave, Alligator Cracking

Rockfall - Largest Rock Size (ft)

The largest rock associated with the event. Enter an integer only.

Rockfall Event - Event Volume (cy)

The volume (cy) of rock associated with the event, combined in the ditch or on the road. Enter an integer only.

Landslide Event - Size (ft)

Length of the road affected. Enter an integer only.

Landslide Event - Volume (cy)

Volume of debris on road. Enter an integer only.

Event - Lanes Affected

Attach files

Select File

Attach photos, documents, etc (.jpeg, .png, .docx, .pdf, etc.) to this event.

2. Select Location

Specify the location for this entry by clicking/tapping the map or by using one of the following options.

Search Lat/Lon

Find address or place

Latitude: 60.99668, Longitude: -149.83882

3. Complete Form

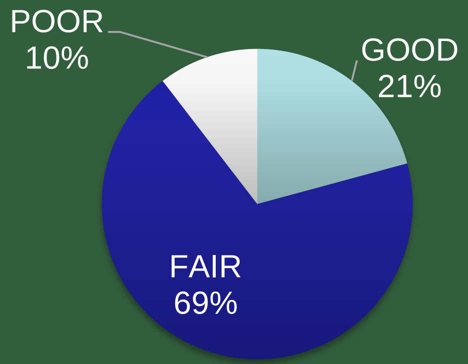
Add this information to the map.

Submit Entry View Submissions

Step 5: Improve Data Sharing & Gathering

- Performance Dashboard

Rock Slope Condition State



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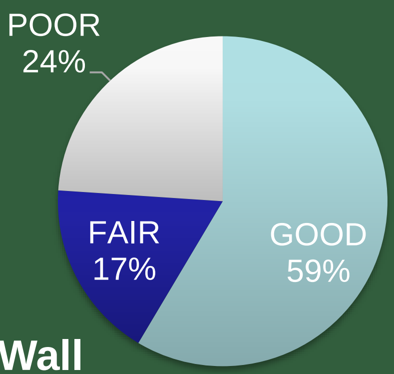

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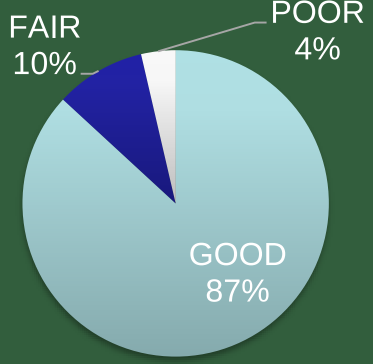

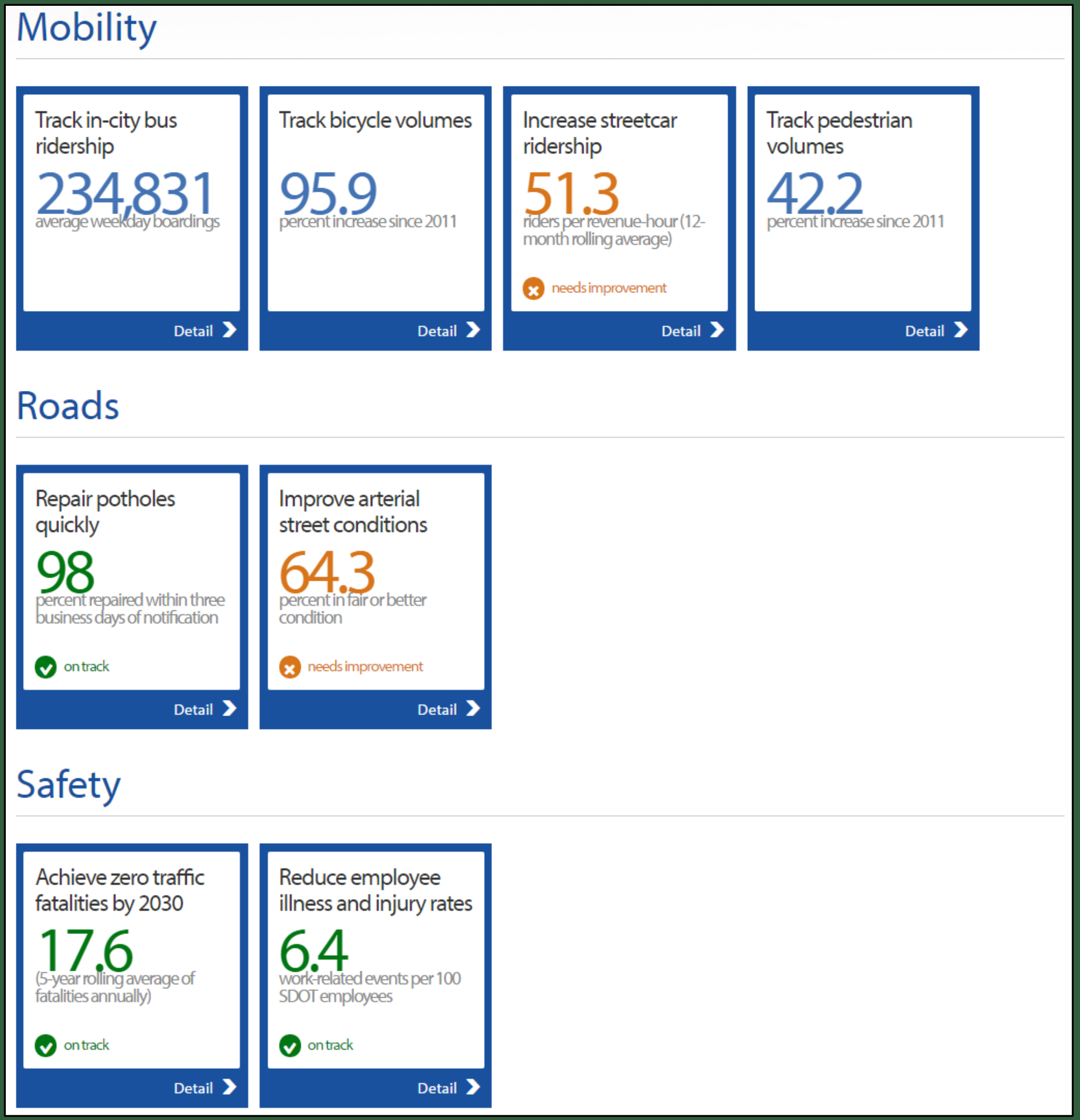

Closing

Closing

- Get Started!
- Be Comfortable with Network-Level Approach and Generalities
- Use the System as a Decision-Support Tool
- Engage Planners & Designers to Improve Fair Sites with other Projects
- Include GAM in TAM Plans