



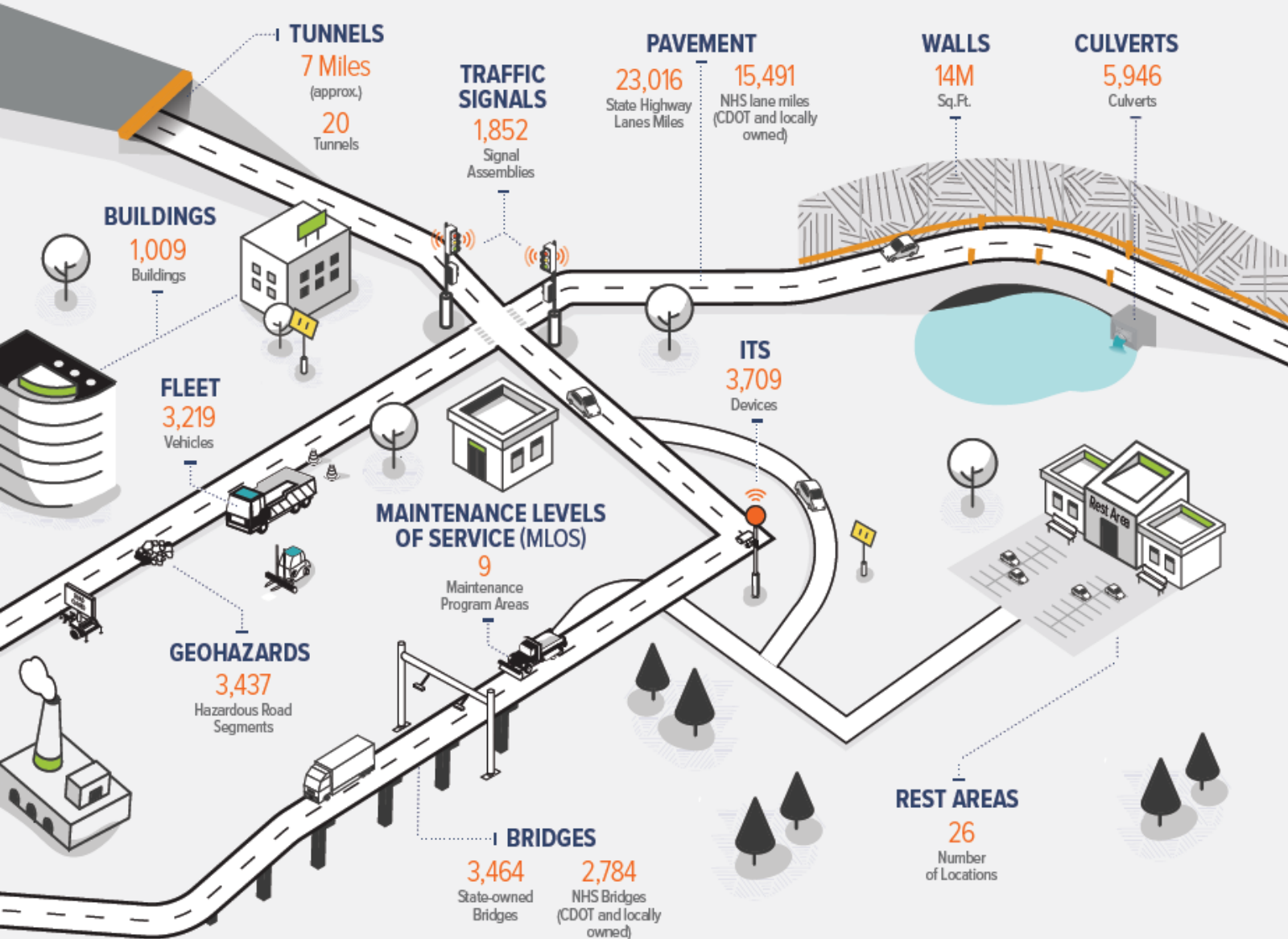
COLORADO
Department of Transportation

Geohazards in CDOT TAMP

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Assets in TAM



Asset Category	Annual TAM Planning Budget (From FY 25)
PAVEMENT	\$229M
BRIDGES	\$38.3M
BUILDINGS	\$15.5M
CULVERTS	\$8.2M
FLEET	\$21M
GEOHAZARDS	\$9.7M
ITS	\$16.6M
MAINTENANCE LEVELS OF SERVICE (MLOS)	\$263.5 - \$321M
REST AREAS	\$4.0M
SIGNALS	\$8.2M
TUNNELS	\$9.8M
WALLS	\$5.7M



TAMP Organization



Introduction: Section 1 (this section) features CDOT's vision for the plan, describes the improvements made to the TAMP Program since the previous TAMP period, and establishes the structure of CDOT's 2022 TAMP.



Asset Management at CDOT: Section 2 outlines CDOT's approach to asset management and how it aligns with organizational goals and objectives. This includes asset management's relationship with other planning processes and how the agency plans to continue to advance asset management to help meet statewide infrastructure goals. It also describes the asset-management planning process as it relates to the Statewide Transportation Improvement Program (STIP).



Performance Management: Section 3 presents both federal- and state-established performance measures and CDOT's targets for the entire State Highway System and for NHS pavement and bridges.



Asset Inventory and Condition: Section 4 provides a summary of inventory and condition data for CDOT's pavement and bridge assets. This section also identifies the current condition of these assets, who owns the assets, and which assets are part of the NHS.



Life-Cycle Planning: Section 5 describes how CDOT approaches life-cycle planning. It includes a discussion of how deterioration is modeled and how appropriate treatments are selected. The section also discusses CDOT's management strategies for minimizing life-cycle costs.



Risk and Resilience Management: Section 6 outlines CDOT's approach to risk management within asset management, including processes the Department uses to identify and manage top-priority risks to the overall agency and to asset programs.



Financial Plan: Section 7 explains CDOT's 10-year financial plan for pavement and bridges, including an overview of revenue streams, sources, and uses; the process for asset-management resource assignment and budget allocation; and asset values. The section also describes the cost to achieve CDOT's "state-of-good-repair" targets.



Investment Strategies: Section 8 identifies investment strategies for CDOT's asset management program. The strategies include estimated spending by work type.



Performance-Gap Analysis: Section 9 describes gaps between current performance and target performance for both federal- and state-established performance measures and CDOT's targets for the entire State Highway System and for the NHS.



Future Improvements: Section 10 identifies process enhancements that CDOT plans to implement. The section discusses near-term opportunities to improve asset management, including ways to strengthen the project selection and prioritization process to advance multiple goal areas.

Included for Geohazards





Performance Management

Figure A.4-2 Equation Calculating Annual Risk Cost for Geohazards

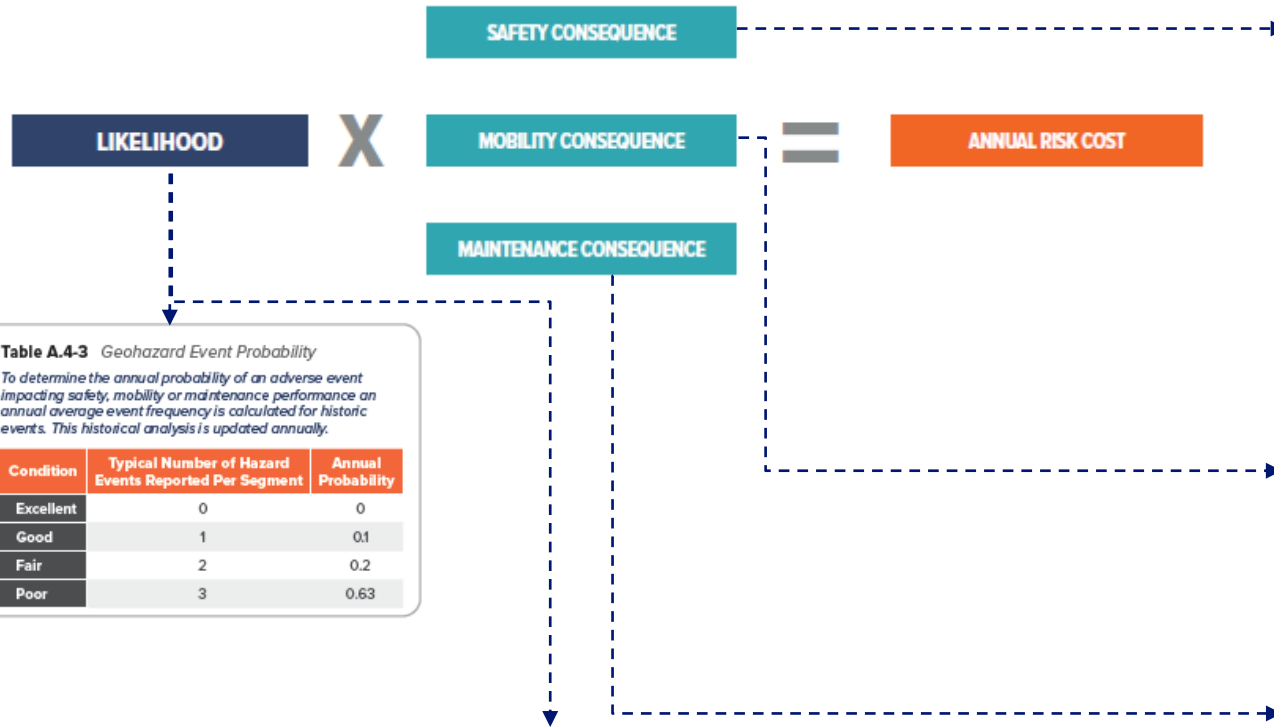


Table A.4-3 Geohazard Event Probability

To determine the annual probability of an adverse event impacting safety, mobility or maintenance performance an annual average event frequency is calculated for historic events. This historical analysis is updated annually.

Condition	Typical Number of Hazard Events Reported Per Segment	Annual Probability
Excellent	0	0
Good	1	0.1
Fair	2	0.2
Poor	3	0.63

Table A.4-4 Safety Threat Levels and Associated Costs

36 years of historical accident data was used to assign a threat level and associated cost value for each segment.

Threat Level	Historical Accident Description	Threat Cost
Low	No Reported Accidents	\$0
Medium Low	1 to 20 Accidents	\$3,500
Medium	3 to 4 Accidents	\$10,500
Medium High	5 to 10 Accidents or Injury	\$91,600
High	More than 10 Accidents or Fatalities	\$6,297,000

Table A.4-5 Safety Threat Incident Costs

Since 2014 when an actual incident occurs the segment safety threat-cost-per-incident is quantified using assigned costs for property damage, injury, or a fatality.

Incident Types	Cost
Property Damage	\$3,500 per vehicle
Injury	\$91,600 per incident
Fatality	\$6,297,000 per incident

Table A.4-6 Mobility Threat Levels and Costs

The mobility threat cost is estimated based on the anticipated length of disruption, an associated cost per vehicle and the segment AADT.

Threat Level	Measured Mobility Disruption Description	Assigned Threat Cost (per Vehicle)
Negligible	No closure – only work beyond travel lanes	\$0
Minor	Less than 1 hour of closure	\$10.50
Major	1 to 24 hours of closure	\$252
Critical	1 to 5 days of closure	\$1,008
Catastrophic	More than 5 days of closure	\$2,520

Table A.4-7 Maintenance Threat Levels and Costs

Maintenance threat levels are based on estimated cost ranges. A maintenance threat cost is assigned based on an assigned value within each cost range.

Threat Level	Maintenance Cost Description	Assigned Threat Cost
Incidental	Costs are less than \$25,000	\$5,000
Minor	Costs range from \$25,000 to \$100,000	\$50,000
Major	Costs range between \$100,000 to \$500,000	\$200,000
Critical	Costs exceed \$500,000	\$1,000,000



Performance Management

Table A.4-1 Geohazard Level-of-Risk Criteria

Level of Risk	Annual Risk Cost
A	< \$1,000
B	\$1,000 - \$5,000
C	\$5,000 - \$25,000
D	\$25,000 - \$50,000
F	> \$50,000

Table A.4-2 Performance Metric and Target for Geohazards

	Measure	Target	2021 Performance
GEOHAZARDS	 Percentage of hazardous road segments with a Level-of-Risk grade B or better	85%	75%





Inventory and Condition

Geohazard events and geotechnical asset failures

- Rockfall from natural slopes
- Rockfall from constructed rock cuts
- Rockslides
- Embankment distress
- Landslides
- Debris flow
- Sinkholes
- Subgrade distress below the pavement section

CDOT system divided into 4,000 highway segments (.1-mile long)

Examples of Geohazard-Affected Segments



Table A.4-8 Current Condition of Hazardous Road Sections

Level of Risk Grade	Percentage of Segments
A	54%
B	21%
C	15%
D	7.5%
F	2.5%

Generalized Process

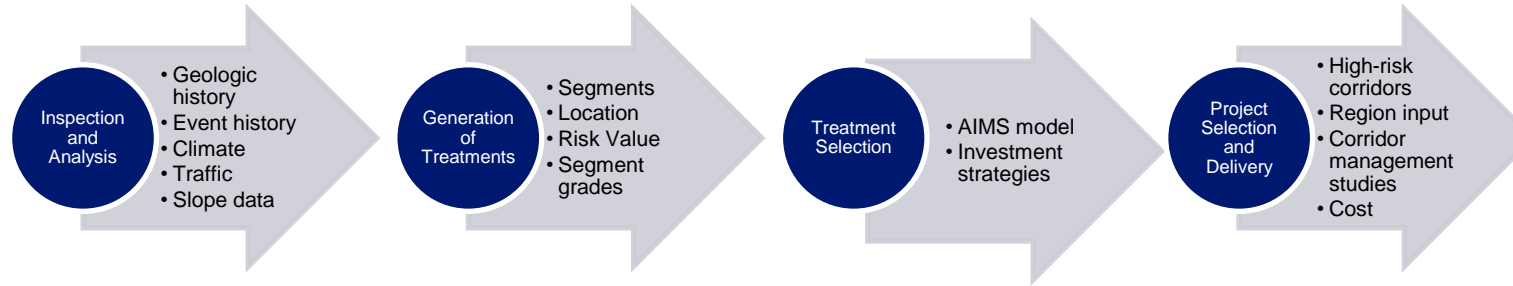


Figure A.4-5 Geohazards Project Selection, Cost-Benefit Analysis Example

Benefit-cost analysis is utilized to compare different treatment options over a 50-year timeframe. The example illustrates the results from analysis of two segments on State Highway 133 and the green highlighting identifies the preferred options.



Table A.4-10 *Top Geohazards Risks*

Risk Level	Threat	Risk Score ¹	Risk-Management Strategy
Multiple	Landslide causing loss of road and long-term mobility impacts/delays	56 (L)4 x (C)3.5 x (V)4	Treat or tolerate, depending on the area
Multiple	Rockfall incident with fatality	50.4 (L)3 x (C)4.2 x (V)4	Treat or tolerate, depending on the area
Multiple	Sinkholes resulting in road closure of at least several hours	48 (L)4 x (C)3 x (V)4	Tolerate
Multiple	Rockfall with loss of function/mobility for several days	46.8 (L)4 x (C)3.9 x (V)3	Treat or tolerate, depending on the area
Multiple	Severe weather event causing debris flows that damage pavement, culverts, or structures	46.8 (L)3 x (C)3.9 x (V)4	Tolerate
Multiple	Post-fire debris flows and resulting closures	44.4 (L)4 x (C)3.7 x (V)3	Treat or tolerate, depending on the area





Financial Plan

Typically Funds

- \$2 million per year contingency for unplanned work
- \$2 million per year set aside for anticipated maintenance of slopes and mitigation systems

Does not include geohazard preservation funded by Maintenance





Investment Strategies

BACKGROUND: DETERMINING INVESTMENT STRATEGIES

The current draft of an update to the Geohazards Management Plan focuses on three investment strategies:

Strategy 1—Conducting preventive maintenance.

While maintenance for many geohazards and accompanying mitigation devices is performed reactively, some mitigation can be performed on regular intervals, such as scaling to reduce the amount of rockfall at specific locations.

Strategy 2—Assessing preventive maintenance cost-effectiveness to identify alternative mitigation methods.

Mitigation devices are evaluated on the need to repair the device or update the mitigation method. For example, if a concrete barrier used

to enhance a rockfall catchment ditch requires replacement more than once per year, an updated mitigation strategy might offer an alternative with similar or higher level of protection, such as installation of rockfall netting.

Strategy 3—Enhancing the Geohazards program to reflect an asset management approach.

Examples include:

- » Provide a site-selection guideline that mitigates rockfall hazards identified in the Colorado Rockfall Hazard Rating System.
- » Manage existing geohazard assets constructed by previous projects or installed by CDOT Maintenance staff.



PLANNED INVESTMENTS

Potential investments by the Geohazards Program are categorized by corridor and hazard type in corridor-management studies as described in the Life-Cycle Planning section of this Asset Plan. Nearly all the treatments will fall into the Rehabilitation work type described in **Table A.4-9**. Maintenance work is performed as part of CDOT's MLOS program. Reconstruction or replacement projects will be relatively rare.

Examples of projects planned and programmed for the next few years are shown below.

Figure A.4-6 Examples of Planned and Programmed Projects





Performance Gap Analysis

Figure A.4-7 Projection of Risk Grade for Geohazards

The anticipated annual budget of \$9.7 million will not meet the performance target of ensuring that the average percent of segments with a risk grade B or higher is greater than 85 percent. The annual cost of meeting the target by 2036, is about \$34.7 million, or an additional \$25 million per year.

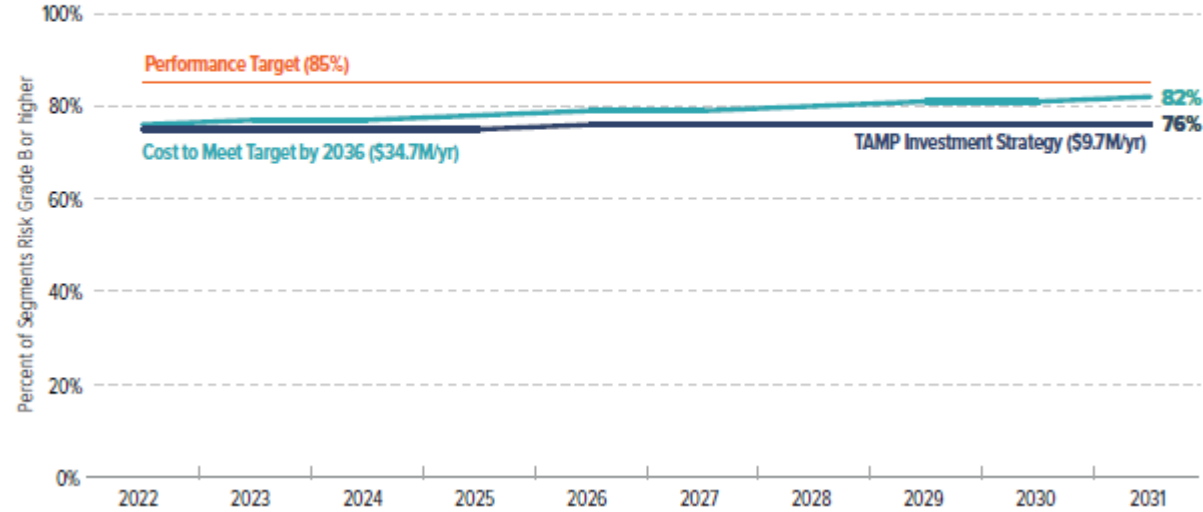


Figure A.4-8 Impact of Geohazards on Other Assets

As an example of geohazard impacts, landslides can result in service interruptions and create increased repair and maintenance costs for a range of CDOT asset classes.





Future Improvements

STAFF

The Geohazards Program intends to improve asset-management capabilities by fostering closer collaboration with Region Maintenance and Engineering personnel to facilitate more accurate and comprehensive event-data collection.

PROCESS

Because geohazard risk is not limited to sites where an event has taken place, the Geohazards Program plans to move from an event-based inventory to one that more holistically determines the risk to road segments. Key improvements to evaluating risk will include incorporating more data points, such as infrastructure type, infrastructure forecasting using rating data, weather information, and change-detection data. These data will help improve risk modeling.

Additionally, 0.1-mile road segments are inventoried by CDOT if they have had a geohazard event. However, conditions that cause an event on one segment may be present along nearby road segments as

well. Therefore, the Geohazards Program hopes to inventory all high-risk segments in the area of an event. The improved inventory would more accurately reflect the hazard area and provide greater accuracy and insight into the benefit of mitigation.

TECHNOLOGY AND ANALYSIS

Future technology and analysis improvements will establish improved data collection and forecasting, and integrate more robust asset management practices. The Geohazards Program will leverage new sources of data from technology such as remote sensing, enabling a shift from the current inventory that only tracks segments where a geohazard event occurred.

Additionally, the Geohazards Program intends to develop improved deterioration models for mitigation devices, geotechnical assets, and geohazards, and to measure the benefits of mitigation better. These improvements will enable CDOT to better forecast performance and choose mitigation projects.

