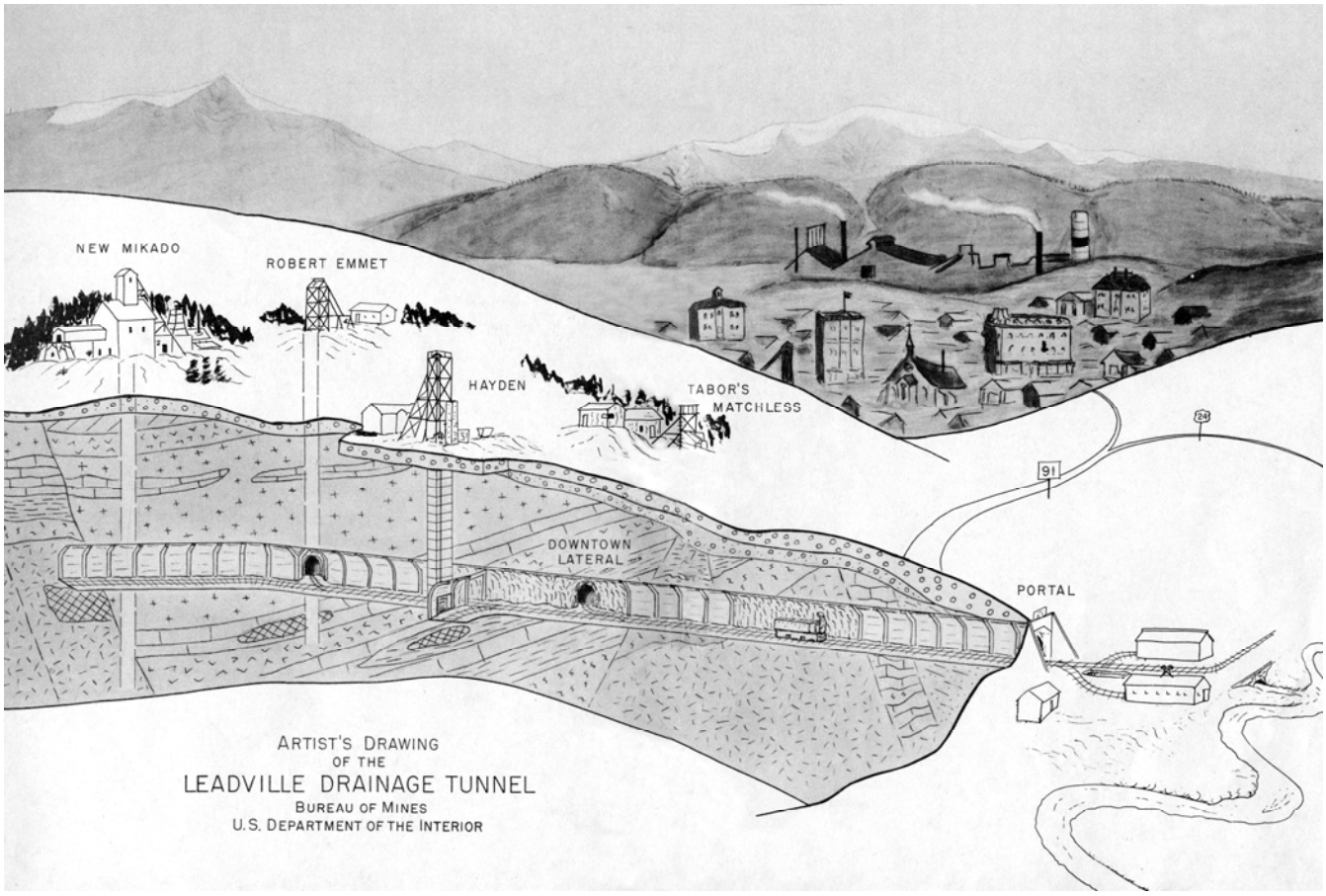
RECLAMATION

Managing Water in the West

Leadville Mine Drainage Tunnel Risk Assessment

Leadville Mine and Drainage Tunnel Project, Colorado
Great Plains Region



U.S. Department of the Interior
Bureau of Reclamation

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Introduction

The Bureau of Reclamation has completed a study to evaluate the stability and assess the risk associated with the Leadville Mine Drainage Tunnel (LMDT) in Leadville, Colorado. The risk assessment consists of the following four sections:

1. Existing Conditions of the Leadville Mine Drainage Tunnel
2. Results of the Geotechnical and Structural Analysis, Leadville Mine Drainage Tunnel
3. Potential Failure Modes and Effects Analysis, Leadville Mine Drainage
4. Comment Response Document

To complete the risk assessment, Reclamation utilized a similar process to that used to assess risk at its dams, a model that is a global standard for conducting risk assessments. The initial step was to gather available records, review those records and prepare a report detailing the LMDT including its history, details of construction, modifications, and current operations. Next, structural analysis of specific LMDT features was performed. With this information a group of Reclamation specialists gathered in a team setting and completed the risk assessment which included identifying potential failure modes and effects analysis (PFMEA), determining the likely consequences for each failure mode, and identifying opportunities for data gathering, risk reduction, and monitoring which can enhance project safety. The draft assessment was internally peer reviewed.

Finally, it was independently peer reviewed by experts not affiliated with Reclamation, including a geologic hazards specialist from the U.S. Geological Survey, a retired rock mechanics and mining engineering professor from the Colorado School of Mines, and a mining engineer from Leadville. This Consultant Review Board (CRB) confirmed Reclamation's conclusions that it is unlikely there would be a sudden release of water from the Leadville Mine Drainage Tunnel and that there is no imminent public safety hazard.

The risk assessment was released in final draft form on June 30, 2008 after incorporating the CRB comments and suggestions. The public and government agencies were then invited to submit technical comments on the final draft risk assessment to Reclamation. Comments along with Reclamation's responses are included in section 4 of this final risk assessment

Findings

The risk assessment found that a blockage in the tunnel near the Pendery Fault is likely to exist due to a zone of tunnel roof collapse located downstream from the

fault. The blockage is currently stable and is expected to be longer and stronger than Reclamation conservatively estimated in its stability analysis.

Even though it is highly unlikely, the study considered what would happen if the blockage near the Pendery Fault rapidly gave way. This would result in higher water pressure being transmitted to the downstream plug material and engineered bulkheads constructed by Reclamation in 1980 and 1991. Based upon this conservative assumption, this is how the tunnel and surrounding area would respond:

- The higher water pressure and forces on the downstream plug material and constructed bulkhead would not be great enough to move them.
- It would take a significant period of time for the increased water pressure to migrate from the upstream end of the downstream plug near Station 5+92 to the soils around the LMDT near the timber-lattice bulkhead and tunnel liner at Station 4+61. The elevated groundwater levels would likely drain off below ground surface into the surrounding terrace gravels.
- In the remote event that groundwater levels near the timber-lattice bulkhead and tunnel liner at Station 4+61 were to rise to levels which could collapse the concrete tunnel liner, a rapid release of water is not expected. Analysis shows that the elevated water pressure would not generate enough force to push this material out of the tunnel, and erosion of the collapsed material is unlikely.
- It is highly unlikely that the hillside above the portal would become unstable. The soils are too strong for that to occur, even with elevated groundwater conditions.

Summary

Reclamation used multiple layers of conservative assumptions throughout the engineering analysis (such as low soil strengths, neglecting tunnel roughness, considering the upper blockage fails rapidly, and using extremely high groundwater levels). Therefore, conditions are actually more stable than the analyses indicate. If the blockage near the Pendery Fault were to fail, it would likely occur over a time frame of weeks or months, not hours or days. Sensors in the LMDT would provide adequate warning of the changes in the tunnel.

Engineering analysis indicates that neither a rapid release of water nor slope failure is likely to occur. Even when earthquake loadings are added to the slope above the portal, analysis shows that the slopes would remain stable. The consequences of each potential failure mode were evaluated and the residents of Leadville and The Village at East Fork are safe. There could be some seepage of contaminated water into the surrounding rock and soils that would find its way to the Arkansas River.

Recommendations

The risk assessment team recommends Reclamation enhance its activities on site to monitor water pressures in the tunnel and surrounding hillside soils. Specifically, the team recommended adding water pressure monitoring instruments to the monitoring wells at Stations 3+00, 4+70, and 6+35 and connecting them to the existing Early Warning System.

The team also recommends that the Emergency Action Plan for the facility be updated, finalized and exercised. The update to the plan should include information about the new potential failure modes, including the likely indicators of potential failure mode initiation, and establishing clear written directions of actions to be taken.

Reclamation has accepted and is implementing these recommendations.