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TUNNEL IN THE SKY

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TUNNEL IN THE SKY

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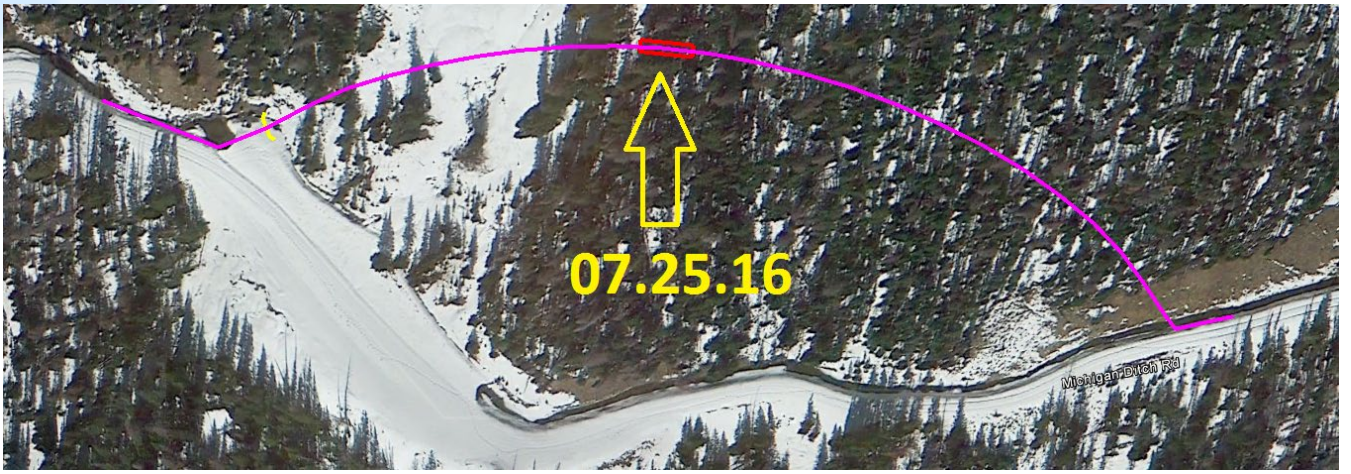
Cameron Pass is a serene gap between the southern end of the Medicine Bow Mountains and the northern end of the Never Summer Range. Trans-mountain water began to stall in 2015 due to a large slow moving landslide and many options were discussed to solve this problem. The City of Fort Collins decided that an 8' diameter wood-lined tunnel was the best plan to connect the two stagnant sides of Michigan Ditch.

Capturing water from the headwaters of the Michigan River, a tributary of the North Platte River, the construction of the Michigan Ditch started in the late 1800's and it was designed to supply water to nearby farmers by way of Joe Wright Creek, a tributary of the Cache La Poudre River. This Ditch runs along the side of a mountain which also hosts a variety of hiking and biking trails terminating at Joe Wright Reservoir. The Michigan Ditch trail runs 4.4 miles out and back and ends just below Lake Agnes.

Pre-tunnel construction started in April with massive amounts of snowfall still on the ground. Hydro Construction, BT Construction and the City of Fort Collins cleared the narrow windy dirt road that led up to the tunnel site and constructed turn outs along the route for vehicles to safely pass one another. Site survey control followed shortly after with a second survey firm setting monuments along the ditch outside of the slide area.

Acklam Land Surveying and Mapping, led by Robert Loane III and Will Spencer Jr, verified the onsite control set and began laying out the entrance portal for the tunnel. Once the entry portal was complete, the tunnel boring machine was placed on guide rails and its initial position was calculated through a series of measurements. These were performed by Acklam and VMT, who had Ivan Nirov

The tunnel boring machine surfaces after a few months of tunneling. BTC Construction begins to excavate the 8′ diameter cutterhead from the upstream side of the Michigan Ditch.



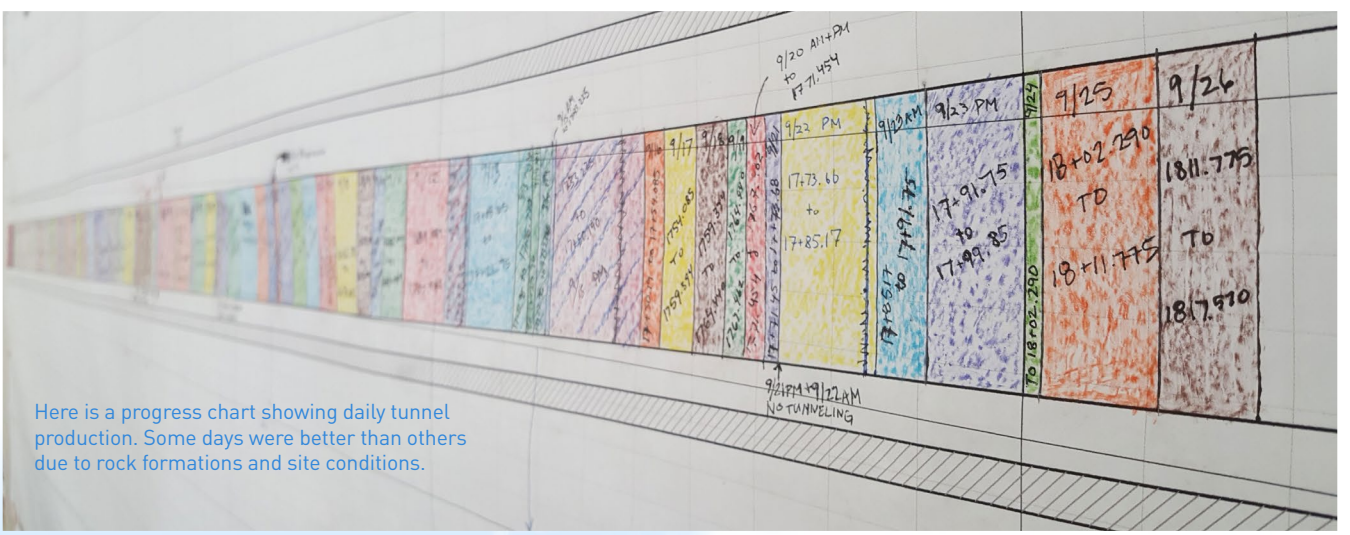
The center of tunnel alignment is plotted along with the position of the tunnel boring machine in Carlson. The data is then transformed into a .kmz shapefile and exported to Google Earth.

Acklam's Trimble S3 total station is shown near the tunnel entrance with a beautiful backdrop of the Rocky Mountains.

onsite to help program the alignment into the guidance system which would be the source of navigation for the 720 Series tunnel boring machine custom designed by Akkerman.

Robert and Will affixed reflective sticker targets on the boring machine and used them as a secondary check for position throughout the tunneling process. The measurements obtained from the sticker targets allowed Acklam to check the roll, pitch and stationing against the VMT guidance system. The boring machine was controlled by a Leica TS15 total station set up on metal brackets built by BT Construction.

The initial tunneling began with a large metal sleeve that was slid into the tunnel to reinforce the entrance. The Leica TS15 total station was set up on a bracket outside of



Here is a progress chart showing daily tunnel production. Some days were better than others due to rock formations and site conditions.

Above: The face of the cutter head is shown after excavation.

Below: Robert T. Loane III, PS is shown calculating the initial position of the tunnel boring machine through a series of measurements on the front shield.

the tunnel just behind the boring machine and its accessories. A back sight prism was set outside of the slide area to provide the total station a point of reference.

The 764-foot tunnel design was completed by Stantec and Lithos Engineering, with almost the entire alignment along a 630' radial curve. The beginning elevation of the tunnel centerline alignment was 10320.31 feet and its terminus was 10324.13 feet allowing enough slope (0.005%) for water flow through the soon to be installed 5' diameter Hobas® pipe that will sit inside of the flowfill grouted wood-plank and steel ring lined tunnel.

Throughout the tunneling process, the Leica total station would move forward approximately 40 feet at a time due to line of sight limitations on the curve. Robert and Will made several trips up to Cameron Pass during this process to verify the bracket coordinates and TBM position. After each 4' push of the boring machine, wooden lag beams would be installed for reinforcement.

The Tunnel System included a rail track which was used to remove the spoil carts. These carts were filled from a large conveyor that sat behind the cutting head of the boring machine. The carts were then pulled back to the tunnel entrance and emptied outside of the tunnel.

During the tunneling, Don Meyer and Joe Barger of BT Construction figured out a way to neutralize the vibrations that were causing some problems with the Leica total station. They decided to reinforce the metal brackets with a metal arm welded at a 45

Shown is some of the key personnel from various companies that were essential in the project's success.

degree angle below the bracket. Don also set specially ordered rebar that was machined for a quick release adapter inside the tunnel that Acklam used for resection setups from the brackets to eliminate set up error.

A few times the TBM encountered much harder rock than was anticipated which dramatically slowed the TBM's progress. This also dulled the cutter head which required more frequent changing of the cutter head bits, further slowing progress.

BT Construction's pilots kept the TBM within 2 inches of the alignment throughout the entire tunneling process. The plan was to stay inside and above the proposed curve because steering corrections would be far less difficult. The exit of the tunnel was staked prior to the breakthrough and was reported that the tunnels overall accuracy at break through was "within a dime" from its theoretical position. ■

Acknowledgments

Acklam would like to thank Akkerman, Stantec, Lithos Engineering, Coffey Engineering and Surveying, Hydro Construction, BT Construction, BTrenchless and the City of Fort Collins for the opportunity to work with a great team on this project. Special thanks to Brenda Chinn, and Wayne Chinn for Acklam's onsite photos and to Robin Dornfest of Lithos Engineering for the daily field photos. And a special thanks to Curt Acklam, Kym Forgrave, Lawrence Sinco and Henry Taylor for helping out with the article.

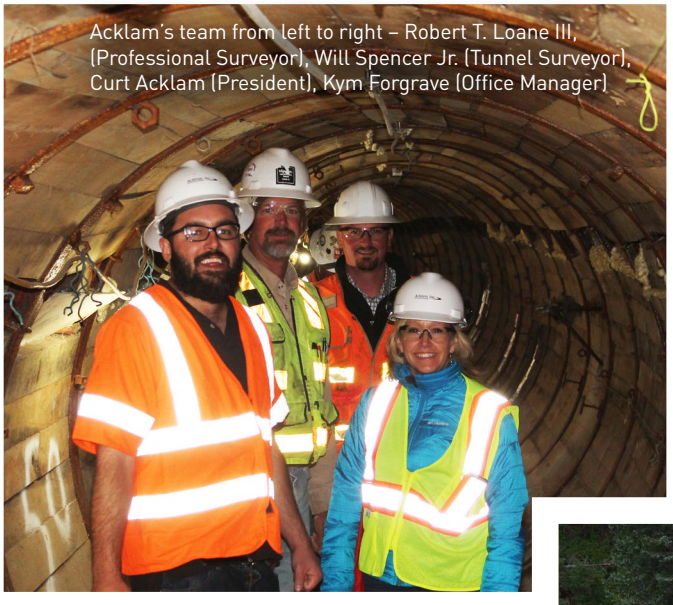
About Acklam

Established in 2010, Acklam is based in Brighton, Colorado, providing Professional Land Surveying and Mapping services in the Front Range. Collectively, Acklam's Professional staff has over 86 years of progressive, responsible and professional experience, providing boundary, civil survey, mapping and design related land surveying services. Acklam is owned and managed by Curt Acklam.

Robert T. Loane III, PS received his Bachelors of Science in Geomatics Engineering from Florida Atlantic University and is pursuing his Masters of Science in Geomatics from the University of Florida. He has worked on major construction projects across the United States and currently holds the position of Project Surveyor at Acklam. Robert is also an Academic Professional Lecturer at the University of Wyoming.

Mark A. Hall, PS, is the Director of Surveying at Acklam. He brings more than 25 years of pipeline and construction surveying experience. Mr. Hall has supervised all aspects of route surveying including initial route mapping, route selection, land owner contact, monumented land surveys, field routing and realignment, construction staking, right of way easement descriptions and plats, as built mapping,

A rainbow over Cameron Pass emerges on a cloudy day.



Acklam's team from left to right – Robert T. Loane III, (Professional Surveyor), Will Spencer Jr. (Tunnel Surveyor), Curt Acklam (President), Kym Forgrave (Office Manager)

Above: Acklam's Will Spencer Jr. sets stakes for the centerline of tunnel alignment at the entrance portal.

Below: A drone's eye view of the tunnel entrance.

and survey control processing. In his role as a professional land surveyor he planned, executed, and supervised the preparation of ALTA/ACSM Land Title Surveys, monumented land surveys, ILC's, recorded exemption plats and minor & major subdivision plats.

Douglas W. Chinn, PS is the Sr. Project Manager at Acklam and has more than 26 years of professional land, pipeline and construction surveying experience including major pipelines, electric transmission lines, boundaries, topography, subdivisions and a wide variety of infrastructure projects. His project management includes supervising, crew scheduling, quality control, and quality assurance. Currently, Mr. Chinn is licensed in seven states, including Colorado.