Climax Molybdenum
A Freeport-McMoRan Company

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Climax Molybdenum Standards Update to Stakeholders

April 23, 2019

Welcome and Introductions

Overview

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- **Regulatory Background – Jerry Raisch, Vranesh & Raisch**
- **Status of Scientific Basis – Jerry Raisch, Vranesh & Raisch**
- **Status of Water Quality Monitoring – James Haag, Climax**
- **Investigation Regarding Molybdenum Sources, Source Controls, and Treatment Options – Jim Finley, Stantec**
- **Discussion**

Regulatory Background

Molybdenum (Mo) Water Quality Standards

- **2010 Basic Standards Rulemaking: Water quality standard (WQS) for Mo water supply**
  - **WQCD proposed 35 µg/L based on Kovalskiy (1961)**
  - **WQCC adopted 210 µg/L based on Fungwe (1990)**
- **2014 Upper Colorado River Basin Rulemaking:**
  - **Lower Tenmile Creek Mo water supply WQS = 210 µg/L**
  - **WQCC adopts temporary modification of "current conditions," based on significant uncertainty with underlying Mo standard**
    - **210 µg/L based on Fungwe (1990)**
    - **Two more robust Mo studies were available, a third was anticipated in the future**

2017 Special Rulemaking Hearing for Mo WQS

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- **Climax proposed a WQS of 9,000 µg/L for Mo water supply based on the three new studies**
- **WQCD responded that no change to the WQS was appropriate until:**
  - **Third Mo study is peer reviewed and published**
  - **ATSDR revises its draft Mo toxicological profile or EPA revises draft 1993 health advisory**
    - **Draft ATSDR profile did not consider third Mo study**
    - **Draft EPA health advisory still based on Kovalskiy**
- **Rulemaking continued in two parts:**
  - **Jan. 2018: consider extension of temporary modification**
  - **Nov. 2019: consider revisions to Mo WQS**

2018 Rulemakings on Lower Tenmile Creek Temporary Modification for Mo

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- **January 2018 Rulemaking:**
  - **WQCC extended temporary modification of "current conditions" on Lower Tenmile Creek until June 30, 2020**
  - **WQCC Statement of Basis and Purpose (SBP): Climax should investigate Mo sources, source controls, and treatment alternatives**
- **December 2018 Rulemaking:**
  - **WQCC took no action on the temporary modification**
  - **WQCC SBP: Climax to submit report regarding the Jan. 2018 SBP by July 1, 2019**

Status of Scientific Basis

Status of Resolving Uncertainty

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- **Third Mo study has been peer reviewed and published**
  Murray FJ, Sullivan FM, Hubbard SA, Hoberman AM, Carey S, A two-generation reproductive toxicity study of sodium molybdate dihydrate administered in drinking water or diet to Sprague-Dawley rats, Reproductive Toxicology (Mar. 2019), https://doi.org/10.1016/j.reprotox.2018.11.004
- **ATSDR working on revising its draft toxicological profile for Mo to include consideration of this third study**
  - **Timing is uncertain**
- **EPA recognizes draft 1993 health advisory is out of date, but unlikely to be revised soon because of other federal priorities**
  - **EPA recognizes that the three recent studies are best science available**
- **Rulemaking hearing to consider Mo WQS scheduled for November 2019**

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Status of Water Quality Monitoring

Tenmile Creek Monitoring Program

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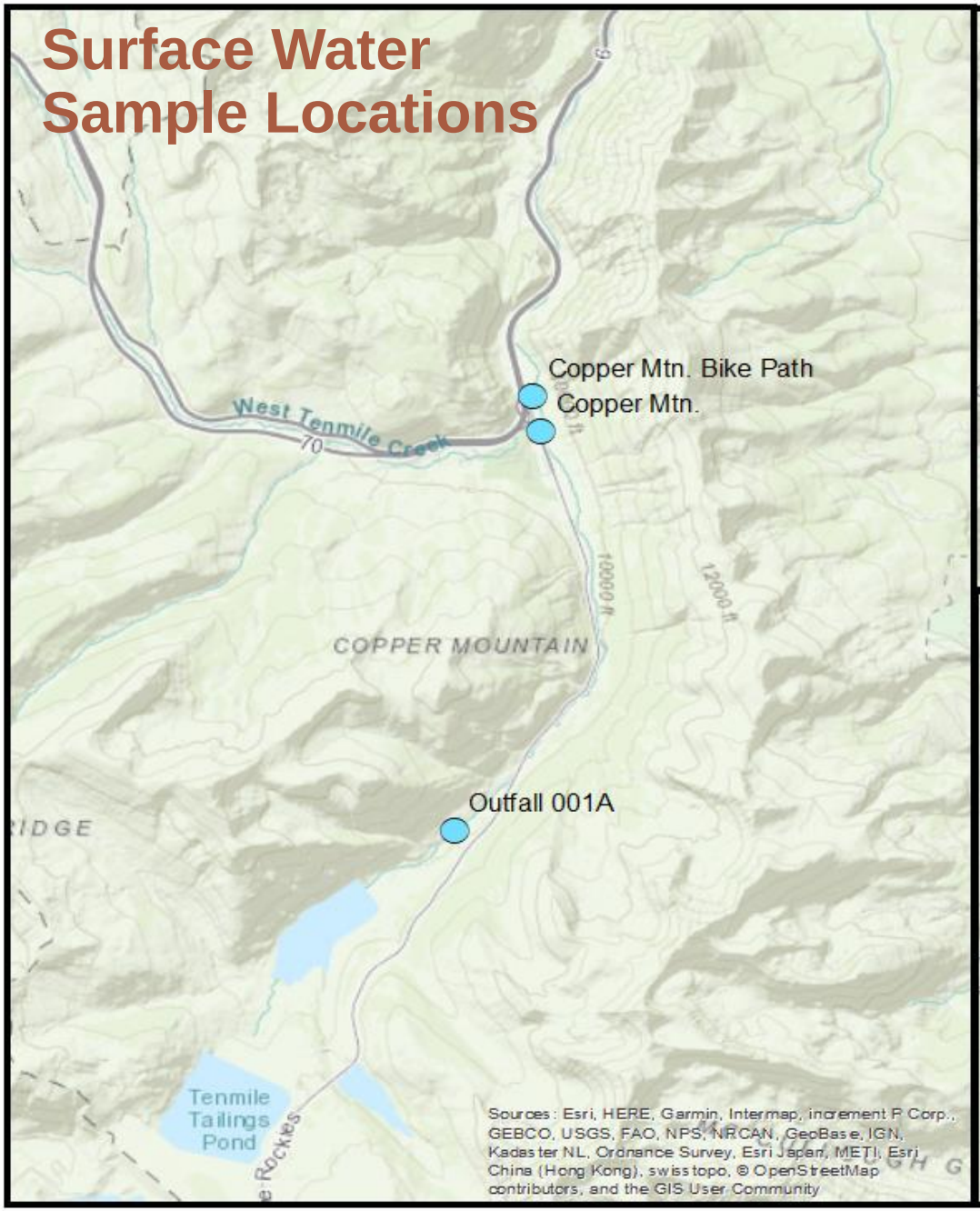
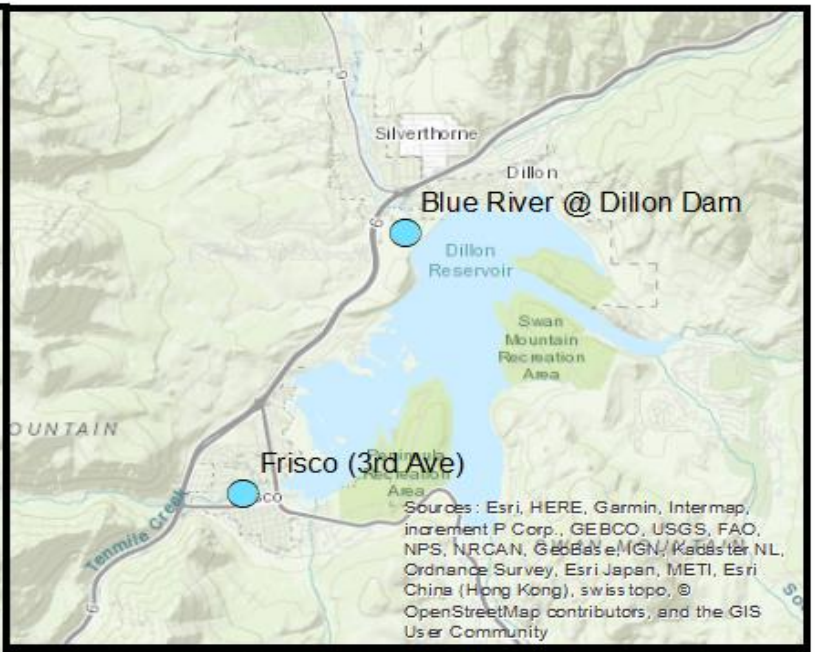
- **In addition to CDPS Permit Outfall 001A (beginning of Tenmile Creek-Segment 13) Climax Mine has been monitoring molybdenum concentrations in Tenmile Creek downstream of Climax since 2011 to characterize trends over time**
  - **Segment 13**
    - **Copper Mtn. (Near Gas Station)**
  - **Segment 14**
    - **Copper Mtn. Bike Path (downstream of confluence with Segment 13)**
    - **Frisco 3rd Ave. (at 3rd Avenue footbridge)**
  - **Blue River below Dillon Dam**

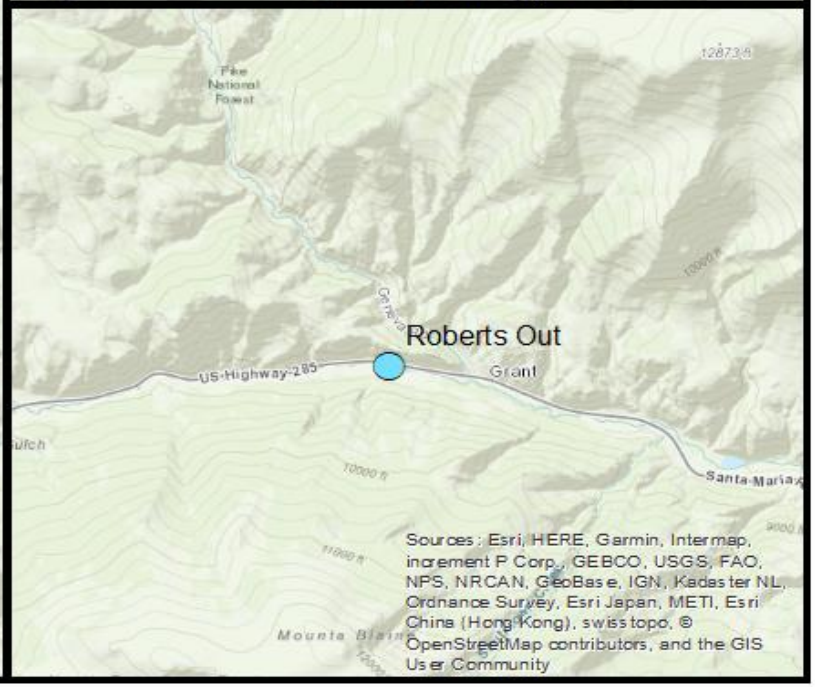
Summit Municipal Water and Roberts Tunnel

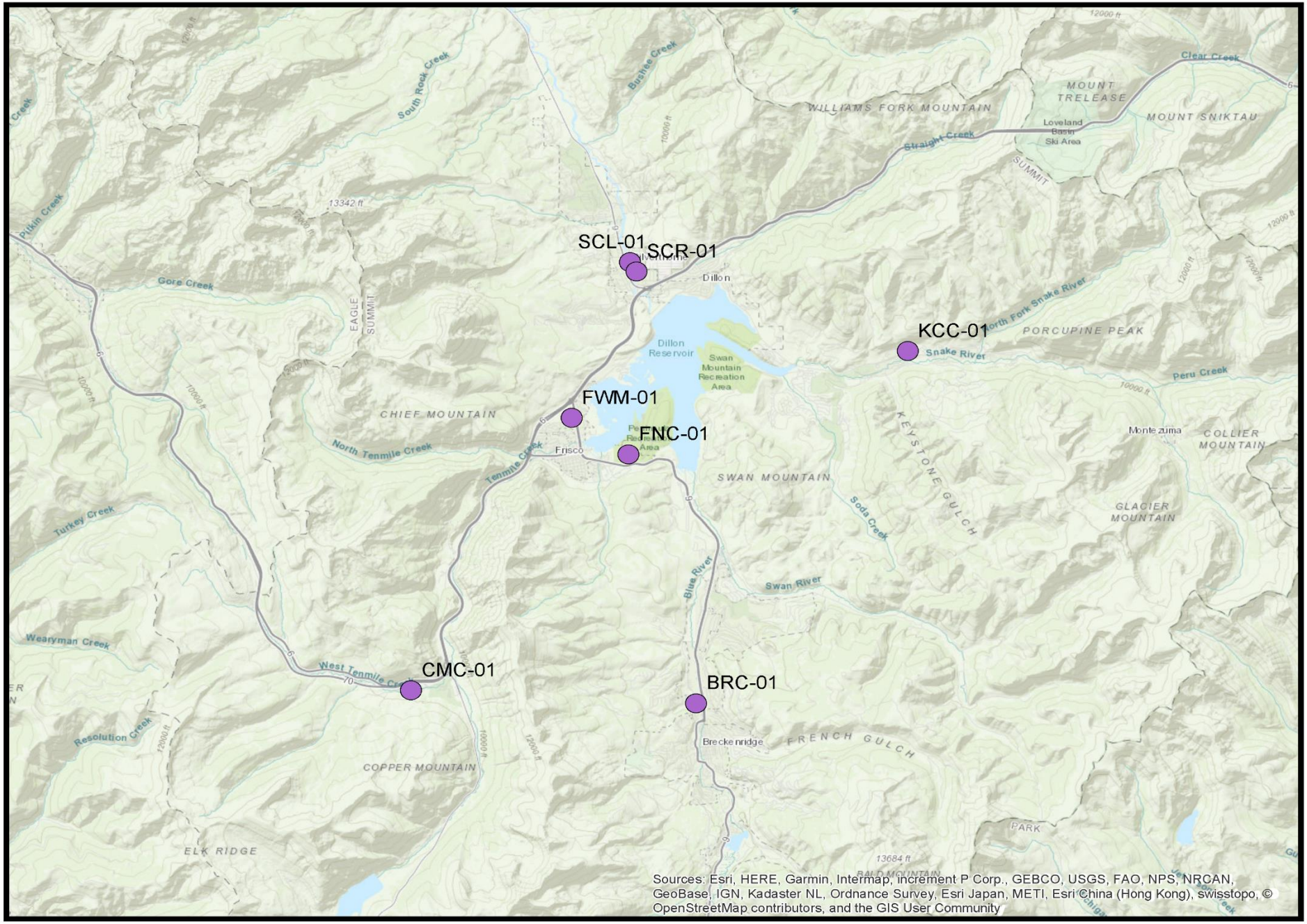
- **In 2018 Climax began monitoring molybdenum concentrations in Summit County municipal waters to characterize regional occurrence**
- **Sites selected in consultation with Summit County officials**
  - **CMC-01 – Copper Mountain Conference Center**
  - **FNC-01 – Frisco Nordic Center (Now FWM-01 Frisco Wal-Mart)**
  - **BRC-01 – Breckenridge Recreation Center**
  - **KCC-01 – Keystone Conference Center**
  - **SCL-01 – Summit County Library North Branch (Silverthorne)**
    - **Duplicate Samples Taken at Silverthorne Rec Center.**
- **Surface water samples also collected from North Fork of the South Platte River below Roberts Tunnel (from Dillon Reservoir)**

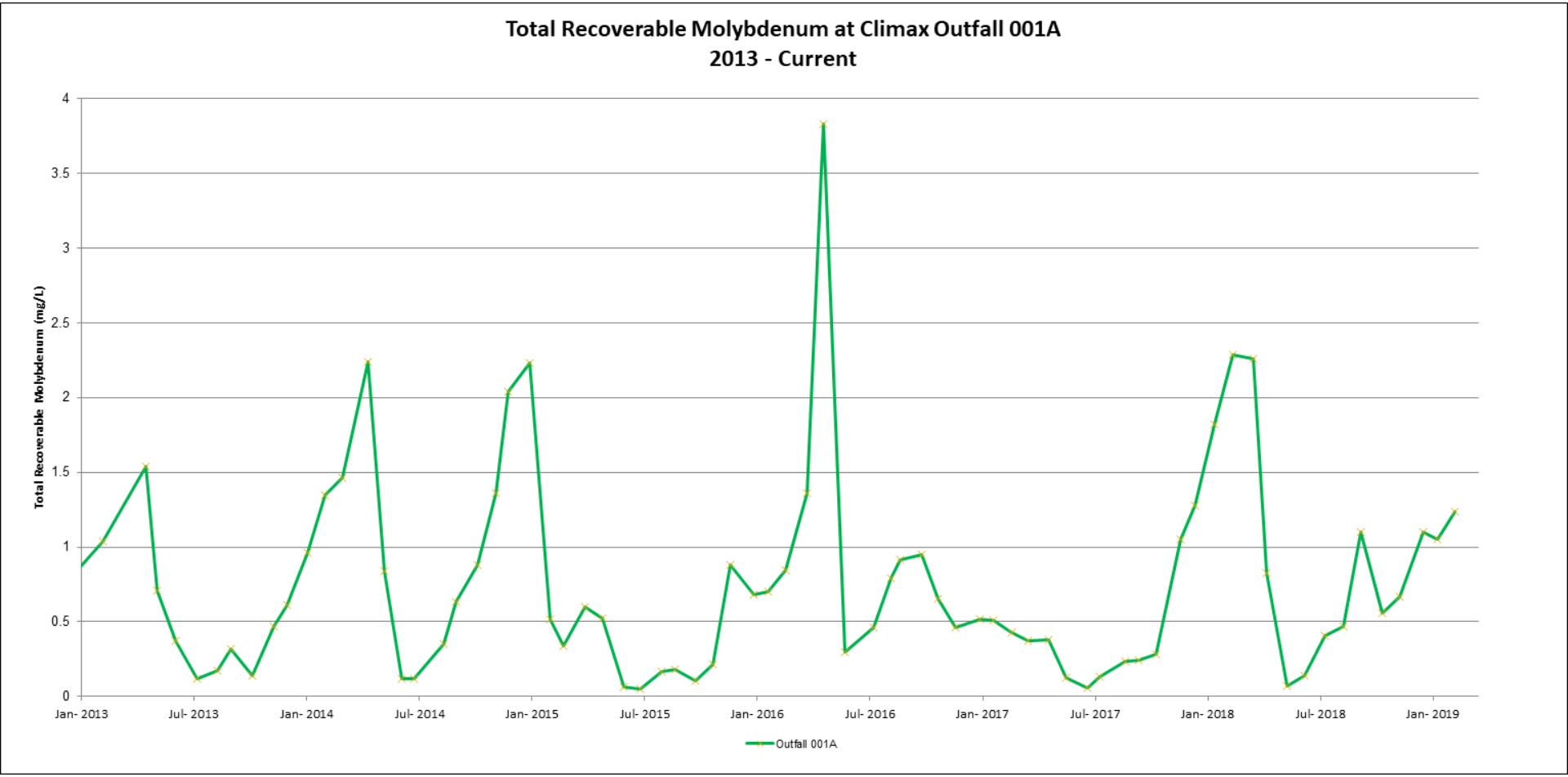
Surface Water Sample Locations

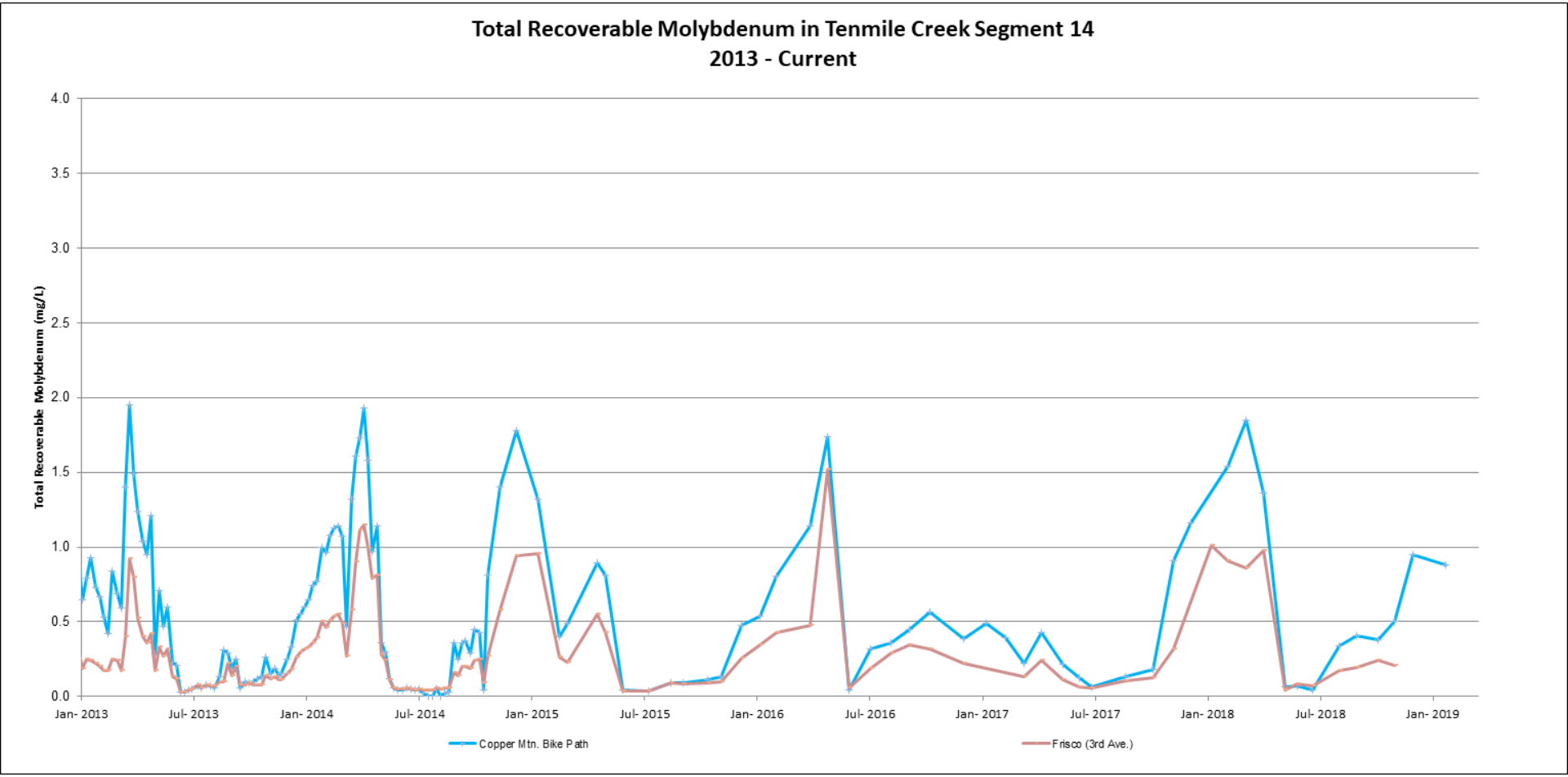


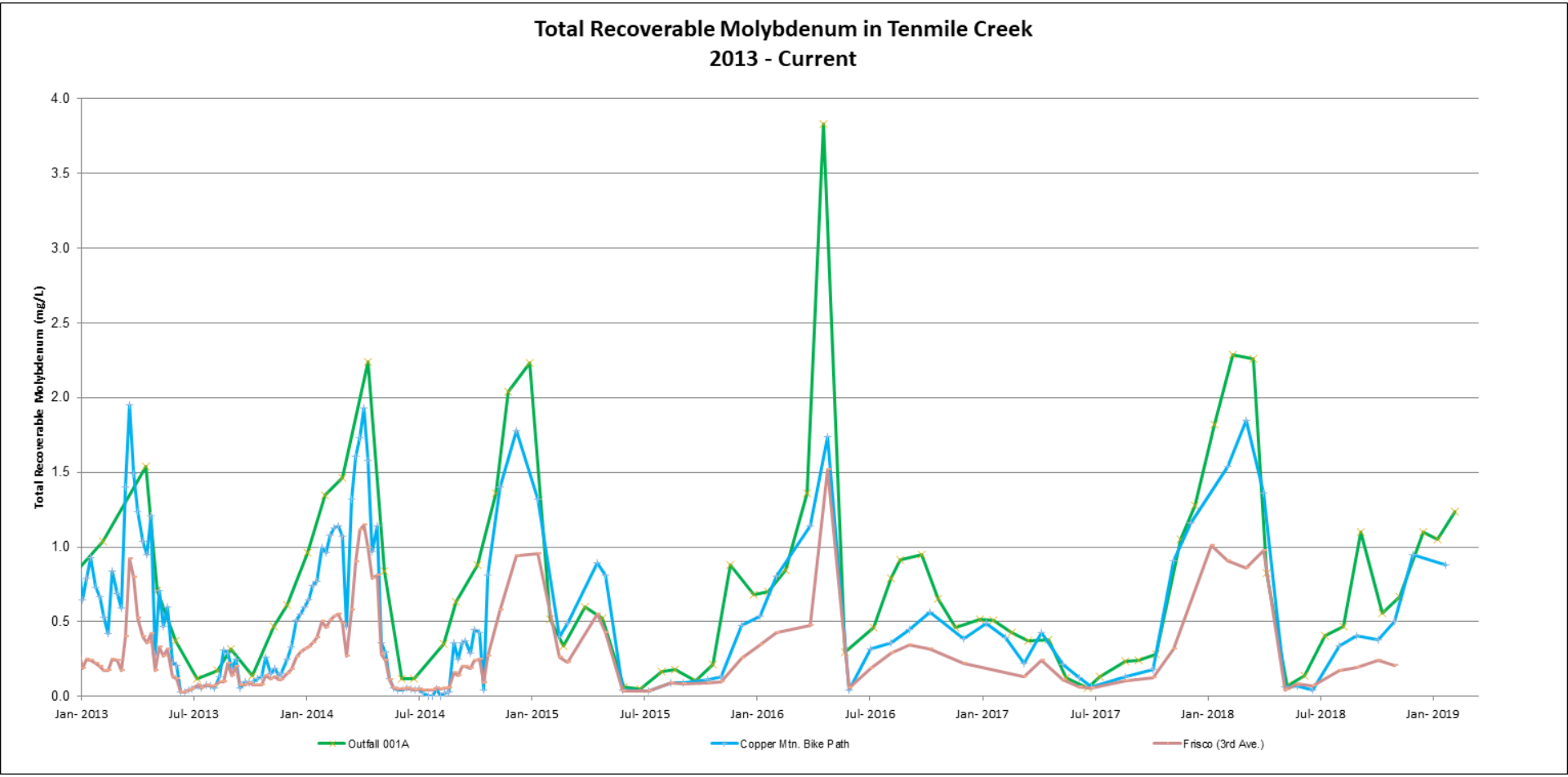





SCL-01
SCR-01
KCC-01
FWM-01
FNC-01
CMC-01
BRC-01
Dillon
Dillon Reservoir
Swan Mountain Recreation Area
Frisco
Breckenridge
Montezuma
Loveland Basin Ski Area
Snake River
North Fork Snake River
Straight Creek
Clear Creek
Gore Creek
Tenmile Creek
North Tenmile Creek
West Tenmile Creek
Blue River
Swan River
Soda Creek
Peru Creek
Turkey Creek
Wearyman Creek
Resolution Creek
Pikin Creek
South Rock Creek
Bushtee Creek
WILLIAMS FORK MOUNTAIN
MOUNT TRELEASE
MOUNT SNIKTAU
PORCUPINE PEAK
CHIEF MOUNTAIN
SWAN MOUNTAIN
KEYSTONE GULCH
COLLIER MOUNTAIN
GLACIER MOUNTAIN
FRENCH GULCH
COPPER MOUNTAIN
ELK RIDGE
PARK
EAGLE SUMMIT
SUMMIT
13342 ft
13684 ft
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community


Total Recoverable Molybdenum at Climax Outfall 001A
2013 - Current
Total Recoverable Molybdenum (mg/L)
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan- 2013
Jul- 2013
Jan- 2014
Jul- 2014
Jan- 2015
Jul- 2015
Jan- 2016
Jul- 2016
Jan- 2017
Jul- 2017
Jan- 2018
Jul- 2018
Jan- 2019
Outfall 001A


Total Recoverable Molybdenum in Tenmile Creek Segment 14
2013 - Current
Total Recoverable Molybdenum (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan- 2013
Jul- 2013
Jan- 2014
Jul- 2014
Jan- 2015
Jul- 2015
Jan- 2016
Jul- 2016
Jan- 2017
Jul- 2017
Jan- 2018
Jul- 2018
Jan- 2019
Copper Mtn. Bike Path
Frisco (3rd Ave.)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0.0
Jan- 2013
Jul- 2013
Jan- 2014
Jul- 2014
Jan- 2015
Jul- 2015
Jan- 2016
Jul- 2016
Jan- 2017
Jul- 2017
Jan- 2018
Jul- 2018
Jan- 2019
Outfall 001A
Copper Mtn. Bike Path
Frisco (3rd Ave.)

Municipal Sample and Roberts Tunnel Results

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Total Recoverable Molybdenum in µg/L

	Breckenridge Recreation Center	Copper Mountain Conference Center	Frisco (Nordic Center/Wal-Mart)	Keystone Conference Center	Summit County Library - North Branch	Silverthorne Rec Center	North Fork of South Platte River at Roberts Tunnel Outlet
1/31/2018	0.47B	0.21B	0.54B	0.55B	44	--	--
2/26/2018	<0.5	<0.5	<0.5	<0.5	40.6	--	3.2
3/29/2018	<0.5	<0.5	<0.5	<0.5	40.7	--	80.6
4/30/2018	<0.5	<0.5	<0.5	<0.5	29.4	--	90.2
5/31/2018	0.5	<0.5	<0.5	<0.5	37.2	--	70
6/20/2018	0.6	<0.5	<0.5	<0.5	37	--	56.4
7/25/2018	0.6	<0.5	<0.5	<0.5	37.8	--	50.2
8/21/2018	0.5	<0.5	<0.5	<0.5	36.1	--	46.7
9/27/2018	0.7B	1.2B	0.8B	0.5B	29.3	--	45.2
10/31/2018	<0.5	(closed)	<0.5	<0.5	30	--	37.6
11/27/2018	0.5B	1.1B	0.6B	(Inaccessible)	39	--	37.4
12/27/2018	0.9B	2B	<0.5**	0.7B	28.3	--	(Inaccessible)
1/28/2019	0.4B	<0.5	<0.5	0.4B	35	37.3	(Inaccessible)
2/19/2019	0.4B	0.3B	<0.2	0.5	37.8	37.3	(Inaccessible)

Note: Samples marked with "B" means the constituent was measured, but it was below lab detection limit therefore, it may not be a precise value.

** Transition from Nordic Center to Wal-Mart sample location.

Mo Stakeholder Outreach and Data Sharing

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- **Climax emailed Mo Update to stakeholders March 11**
  - **Described data sharing since 2018 during Summit Water Quality Committee (SWQC) meetings that include Summit County officials and representatives from municipalities (Frisco, Dillon, Silverthorne, Keystone, and Breckenridge), Copper Mountain Metro District, and Denver Water, as well as other interested parties**

- **Climax Molybdenum Company website launched March 11**
  - **Includes information pertaining to company, community and sustainability efforts, past Mo updates, and molybdenum research**
    - **ClimaxMoinCo.com**
  - **Website also provides water quality monitoring maps and data**
    - **http://climaxmoinco.com/wp-content/uploads/2019/02/ClimaxMoly-map-sheet-R401.pdf**
    - **http://climaxmoinco.com/wp-content/uploads/2019/02/ClimaxMoly-map2-R102.pdf**

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Stantec Investigation Regarding Sources, Source Control, and Treatment Options

January 2018 WQCC Statement of Basis and Purpose

fcx.com FCX LISTED NYSE ICMM International Council on Mining & Metals

Stantec

Climax Molybdenum Company
Water Treatment Alternatives Analysis

Project Status Update
23 April 2019

Agenda

1. Safety share
2. Background
3. Source identification
4. Options analysis
5. Next steps

Safety Moment

High-water safety during snowmelt

Background

Statement of Basis and Purpose

- Stantec contracted to conduct evaluation and analysis to address elements of the SBP

Climax will conduct investigations for molybdenum including:

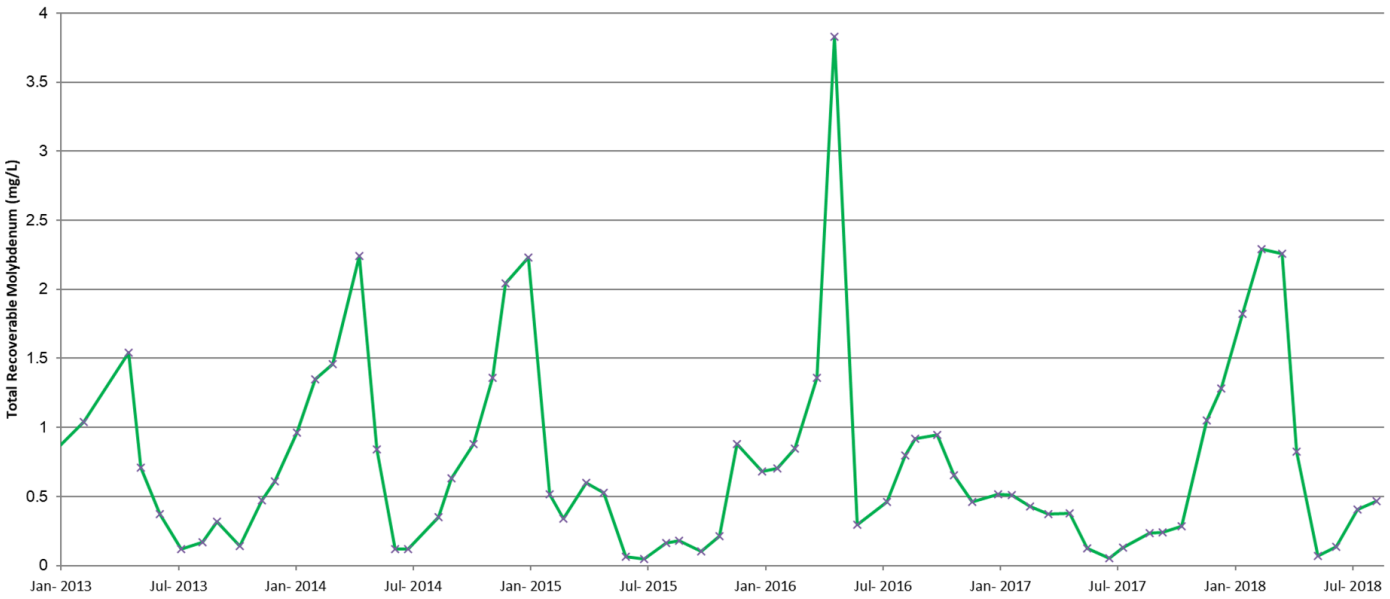
- Identification of sources
- Influent control measures
- Investigation of potential treatment alternatives
- Treatment optimization
- Available blending

Climax will identify:

- Treatment options
- Source controls
- Water management alternatives
- Expected effluent quantity and quality that could be achieved with each alternative
- Estimated cost of each alternative

Background

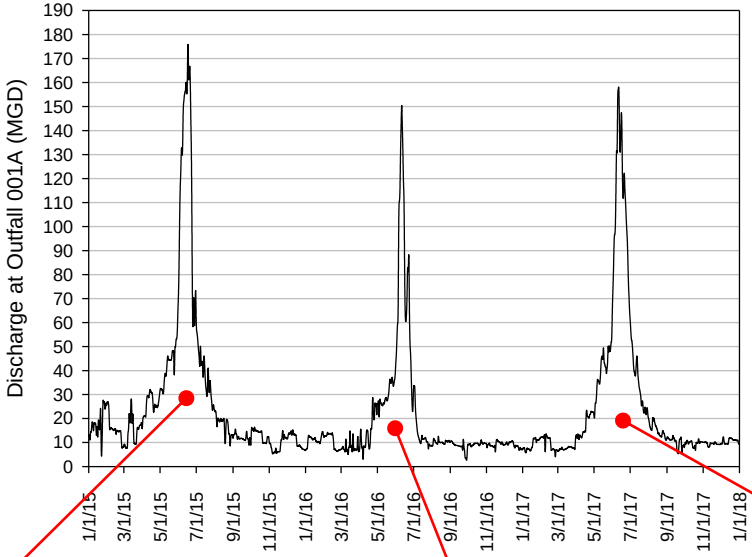
Concentration of Molybdenum at Outfall 001A

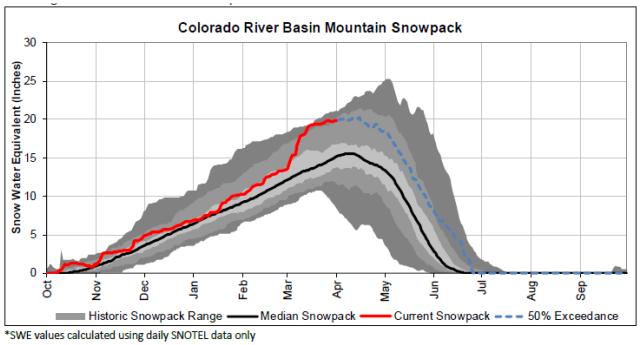


- Seasonality related to snowmelt
- Temporal variations in function of the Climax process water management system
- Fluctuations in molybdenum mass loading related to ore mineralogy

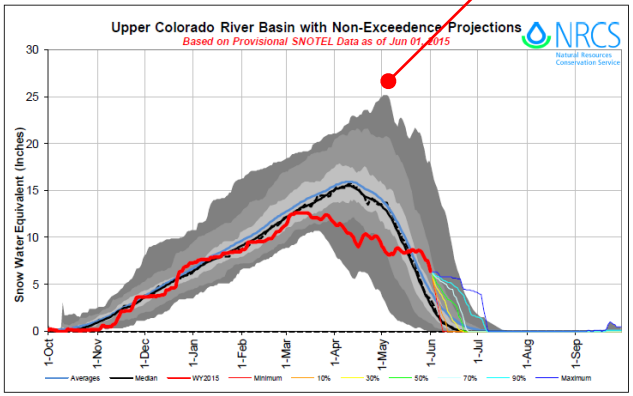
Background

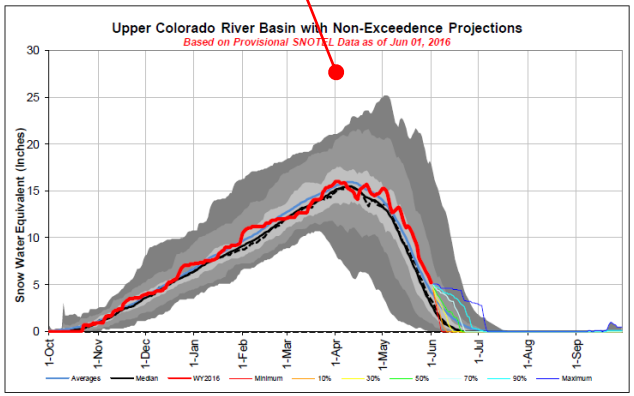
Snowpack influence on discharge

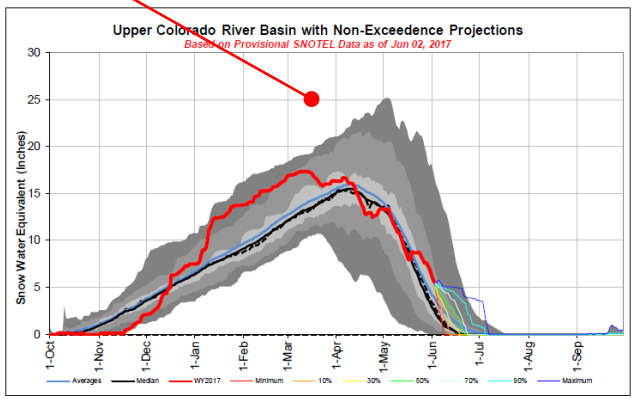




*SWE values calculated using daily SNOTEL data only







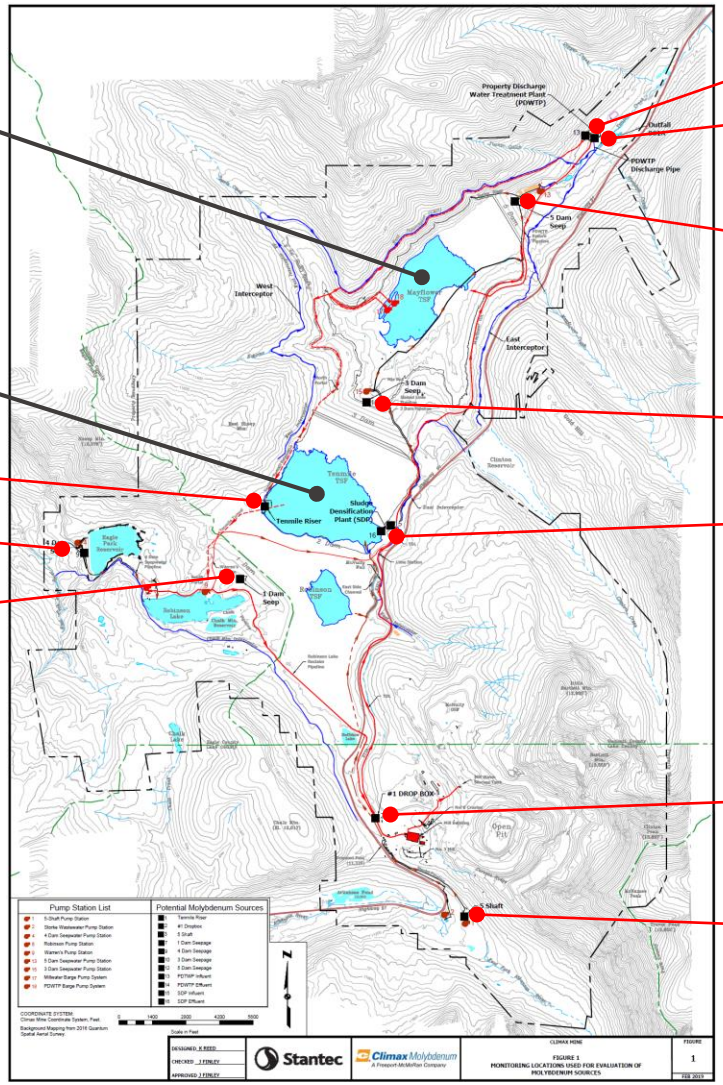
Source Identification

What are the sources of molybdenum

- Objective of Statement of Basis and Purpose
  - Identify sources of molybdenum
  - Evaluate source control options that could reduce the amount of molybdenum in the water management system

- Climax instituted an internal water chemistry monitoring program following the re-start of operations in 2012
  - Most thorough record of data for Stantec's analysis is 2015 through 2017

Source Identification



Mayflower TSF

Tenmile TSF

Tenmile Riser

4 Dam Seep

1 Dam Seep
(Warren's Pump Station)

PDWTP Influent/Effluent

Outfall 001A

5 Dam Seep

3 Dam Seep

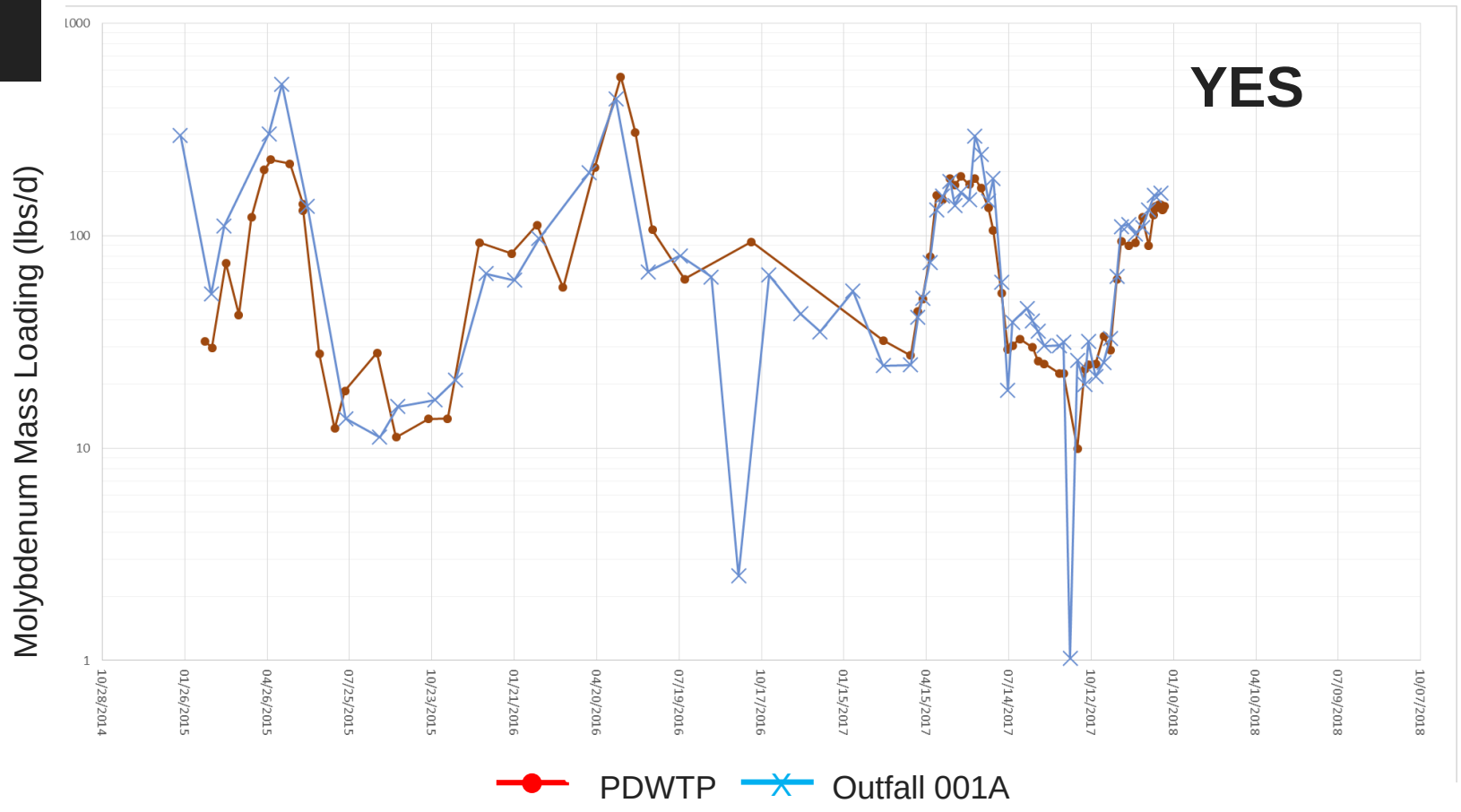
Sludge Densification Plant (SDP)

#1 Drop Box

5 Shaft

Source Identification

Is molybdenum contained within the Climax water management system?



from J. Erickson, WQCD

Summary of Dissolved and Total Recoverable Molybdenum at Key Locations

Location	Average Flowrate (gallons/day)	Chemical Mass Loading (lbs/day)	
		Molybdenum (Dissolved)	Molybdenum (Total Recoverable)
Warren's Pump	1,299,000	---	198
3 Dam Seep	3,136,000	431	442
5 Dam Seep	1,672,000	19	33
#1 Drop Box	12,327,000	217	257

Ranking of the Sources at the Climax Mine Based on Chemical Mass Loading

	By Chemical Mass Loading	
Rank	**Dissolved Molybdenum**	**TR Molybdenum**
1	3 Dam Seep	3 Dam Seep
2	#1 Drop Box	#1 Drop Box
3	5 Dam Seep	Warren’s Pump Station

Options Analysis

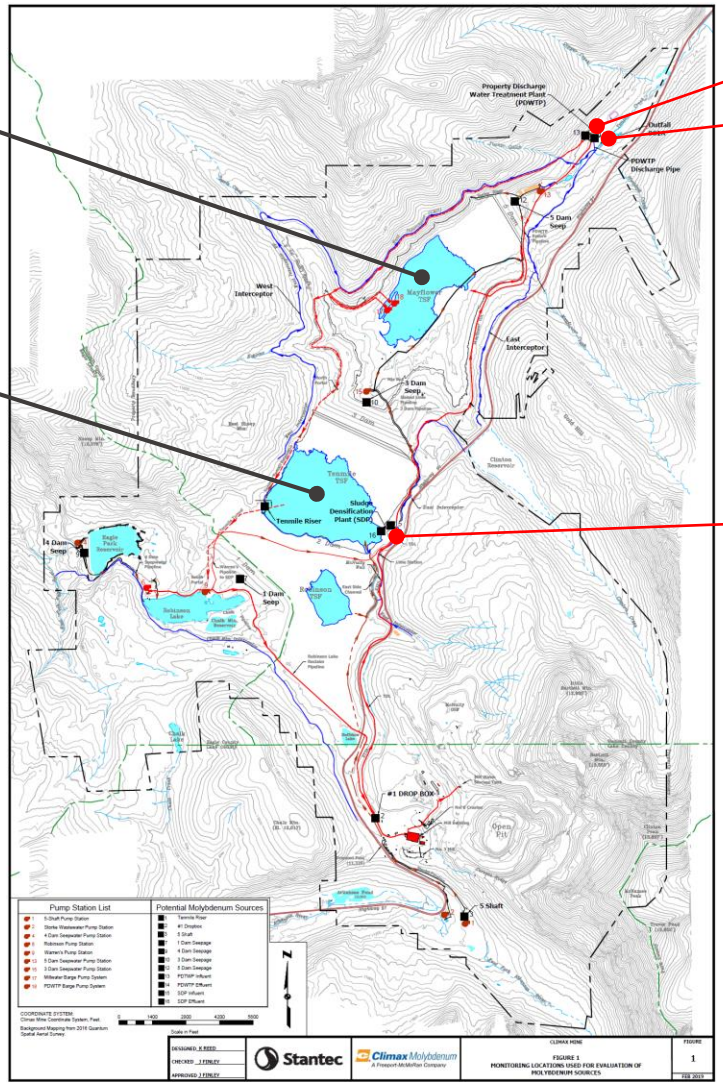
Strategy to address the SBP

- Recognize nature of materials at Climax
  - Historical features such as overburden stockpiles, tailings storage facilities, and mine workings (underground and open pit)
  - Current operations
    - Water management system
    - Active mining and ore processing
    - Placement of overburden in stockpile
    - Placement of tailings in Mayflower tailings storage facility
- Understand processes that mobilize molybdenum
- Next step is to identify options to remove soluble molybdenum prior to discharge of excess water

Framework and process to identify and evaluate options

- Initial set of options developed without regard for any limitations
- Stantec focused on options that could be implemented in a relatively short period of time (1-2 years) under the assumption that when a standard is established and implemented in the discharge permit, Climax will have a set time period to achieve compliance.
- Three general locations where options could be implemented
  - Mine/mill area
  - Within the water management system area
  - At the PDWTP before excess water is discharged from the site

Source Identification



Options and evaluation criteria

Identified and evaluated 31 options that could potentially be implemented

- **Effectiveness**
- **Time to Implement**
- **Cost Consideration**
- **Reliability**
- **Operability/Process Control**
- **Flexibility**
- **Waste Management**
- **Effect on Water Balance**
- **Hydraulic Capacity**

Initial Retained Options Matrix

Option	Method Summary
9	Build molybdenum removal plant based on current 30% design (CH2M Hill)
10a	SDP pH = 10 for Mn removal; PDWTP Reactor 1 at pH 8-10 for metals removal; PDWTP Reactor 2 at pH 4.5 to 5 for molybdenum removal; clarifiers at pH 4.5-5
10b	SDP as is; PDWTP Reactor 1 with pH adjusted for optimum removal of molybdenum with $PbCl_2$; PDWTP Reactor 2 at pH 10 for residual Pb and metals
11	SDP at 4.5 for molybdenum removal; PDWTP at pH 10 for metals removal
12	SDP at 10 for metals removal; PDWTP at pH 4.5 for molybdenum removal
13	Buildout PDWTP molybdenum water treatment plant at reduced capacity to run in conjunction with metals removal system at the PDWTP; influent flow to molybdenum plant varies seasonally in a slip-stream mode and will produce intermediate molybdenum concentration during high-flow periods.
14	Add reagents to the Tailings Disposal Line near Mayflower TSF to reduce the concentration of soluble Mo prior to deposition of tailings at Mayflower TSF

Final Retained Options Matrix

Option	Method Summary
9	Build molybdenum removal plant based on current 30% design (CH2M Hill)
10a	SDP pH = 10 for Mn removal; PDWTP Reactor 1 at pH 8-10 for metals removal; PDWTP Reactor 2 at pH 4.5 to 5 for molybdenum removal; clarifiers at pH 4.5-5
10b	SDP as is; PDWTP Reactor 1 with pH adjusted for optimum removal of molybdenum with $PbCl_2$; PDWTP Reactor 2 at pH 10 for residual Pb and metals
13	Buildout PDWTP molybdenum water treatment plant at reduced capacity to run in conjunction with metals removal system at the PDWTP; influent flow to molybdenum plant varies seasonally in a slip-stream mode and will produce intermediate molybdenum concentration during high-flow periods.
14	Add reagents to the Tailings Disposal Line near Mayflower TSF to reduce the concentration of soluble Mo prior to deposition of tailings at Mayflower TSF

Next Steps

Next Steps

- From SBP
  - Identify the expected effluent quantity and quality that could be achieved with each alternative
  - Identify the estimated cost of each alternative
- Working to finalize cost estimates
- Finish report for review by Division and stakeholders
- Submit final report to WQCC by July 1, 2019

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Discussion