Lessons learned from operation of groundwater collection systems at the Faro Mine, Yukon

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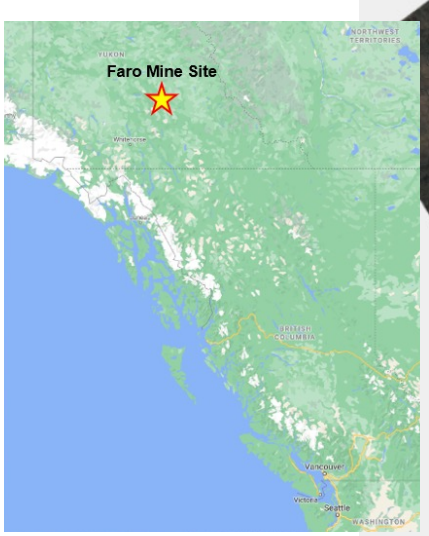
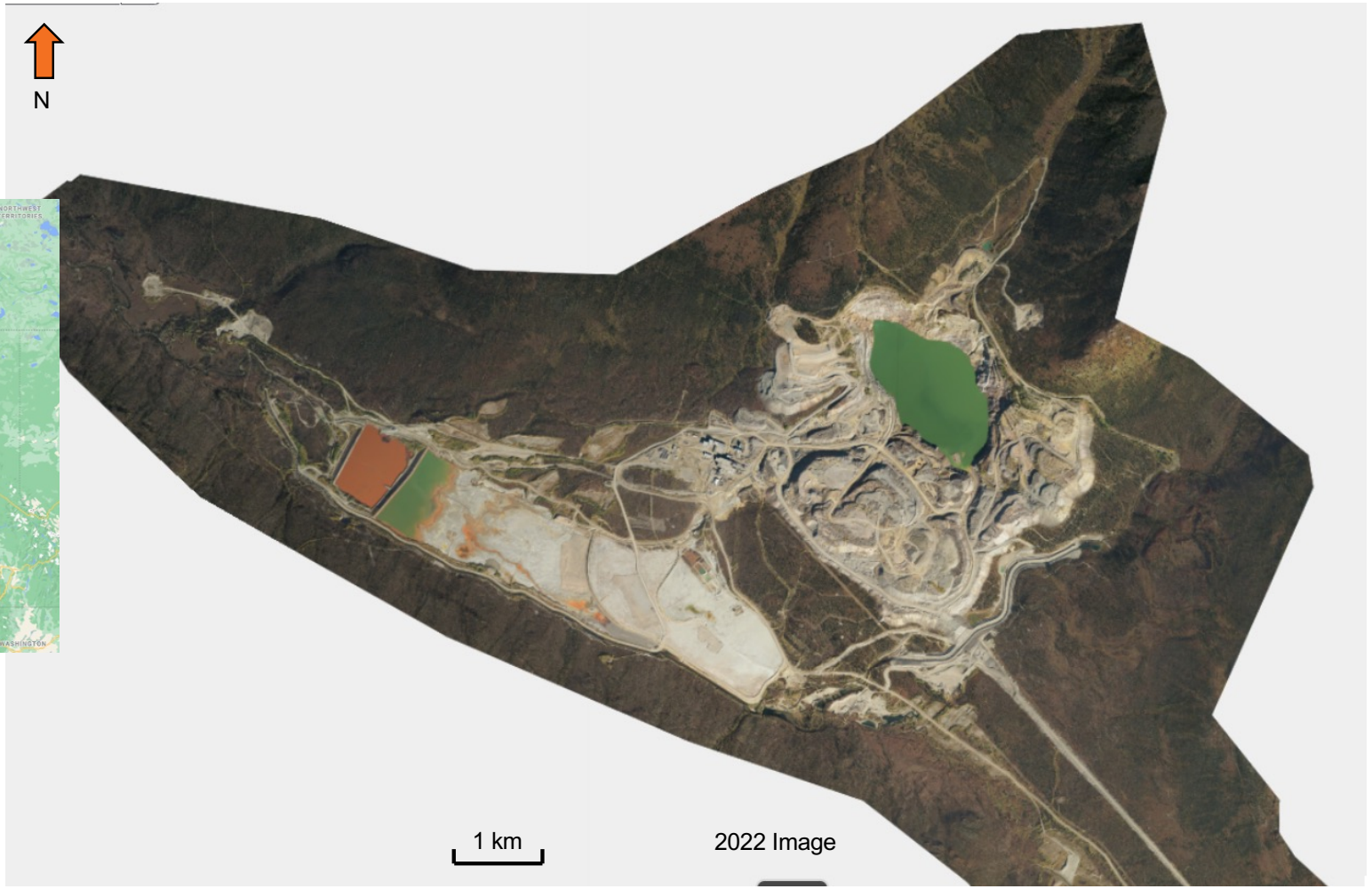
Faro Mine Site Location and Overview

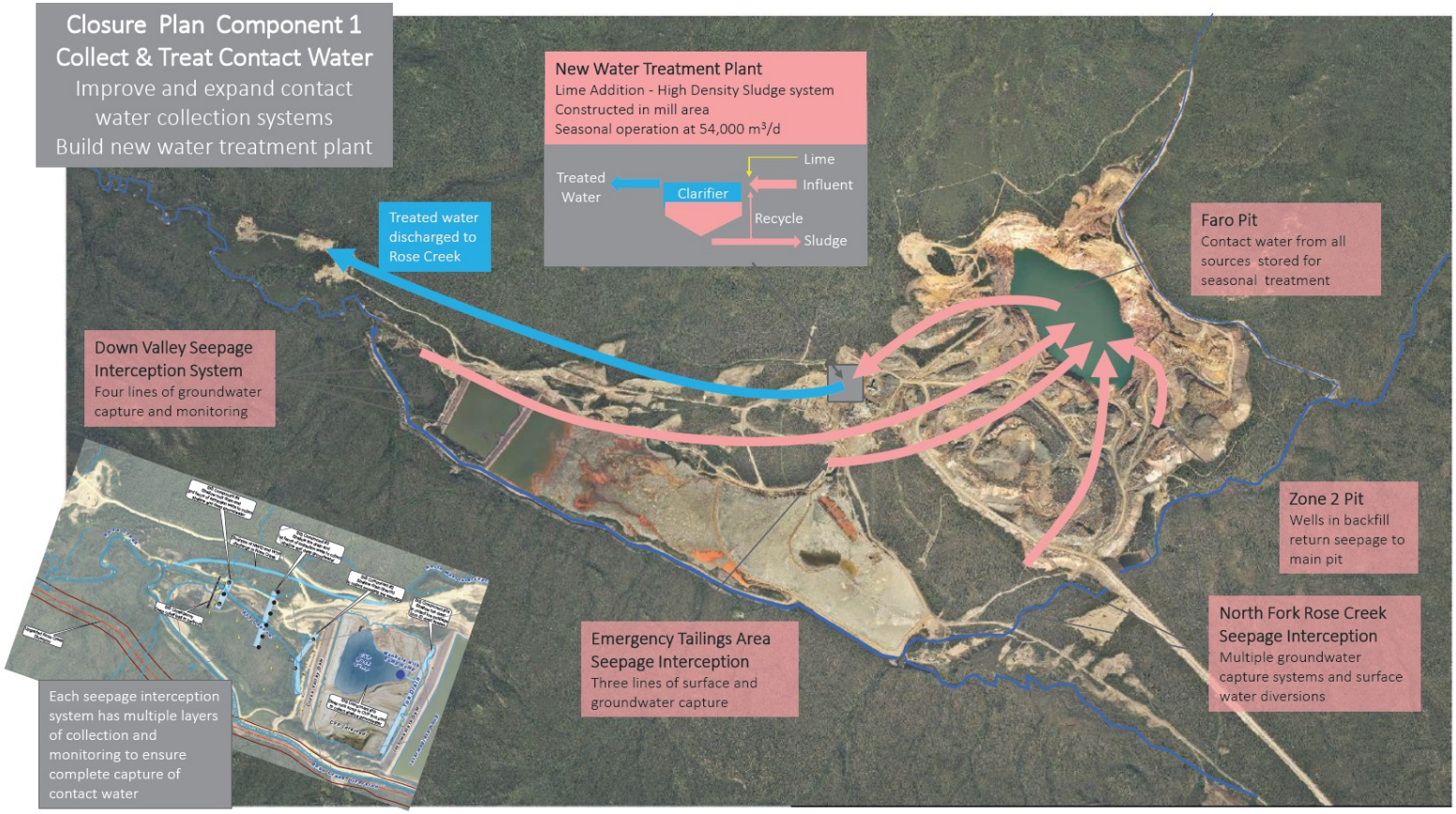




Outline

- Remediation Plan and Contact Water Collection Components
- North Fork Rose Creek Area Contact Water Systems
  - Key Features, Design and Performance of S-Wells and CWIM SIS's
  - Lessons Learned
- Down Valley Area Contact Water Systems
  - Key Features, Design and Performance of ST-DV-SIS
  - Lessons Learned
- Conclusions

Faro Remediation Plan – Contact Water



0 1 2 km

Notes:
Coordinate System: NAD 1983 CSRS UTM Zone 8N
Basemap Image: Aerial photography acquired by Peregrine Aerial Surveyors Inc. and Eagle Mapping in August 2012

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Job No: 1CA030.019
Filename: Faro_InfoGraphics_1CA030-019_Rev01_hlr.pptx

Faro Mine Remediation Project
Projet d'assainissement de la mine Faro

Faro Mine

Faro Mine Remediation Plan

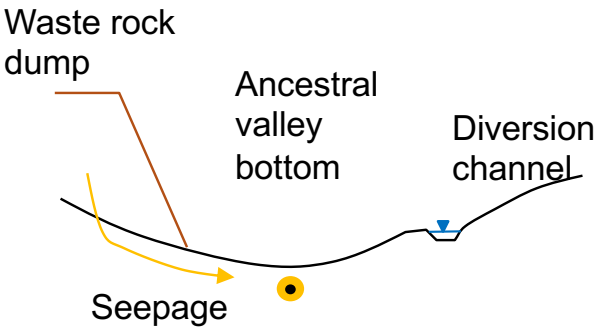
InfoGraphic 4 - Closure Plan Collect & Treat Contact Water

Date:	Approved:	Figure:
Mar 2018	xx	2.4

Contact Water Systems

NFRC – Urgent Works Components

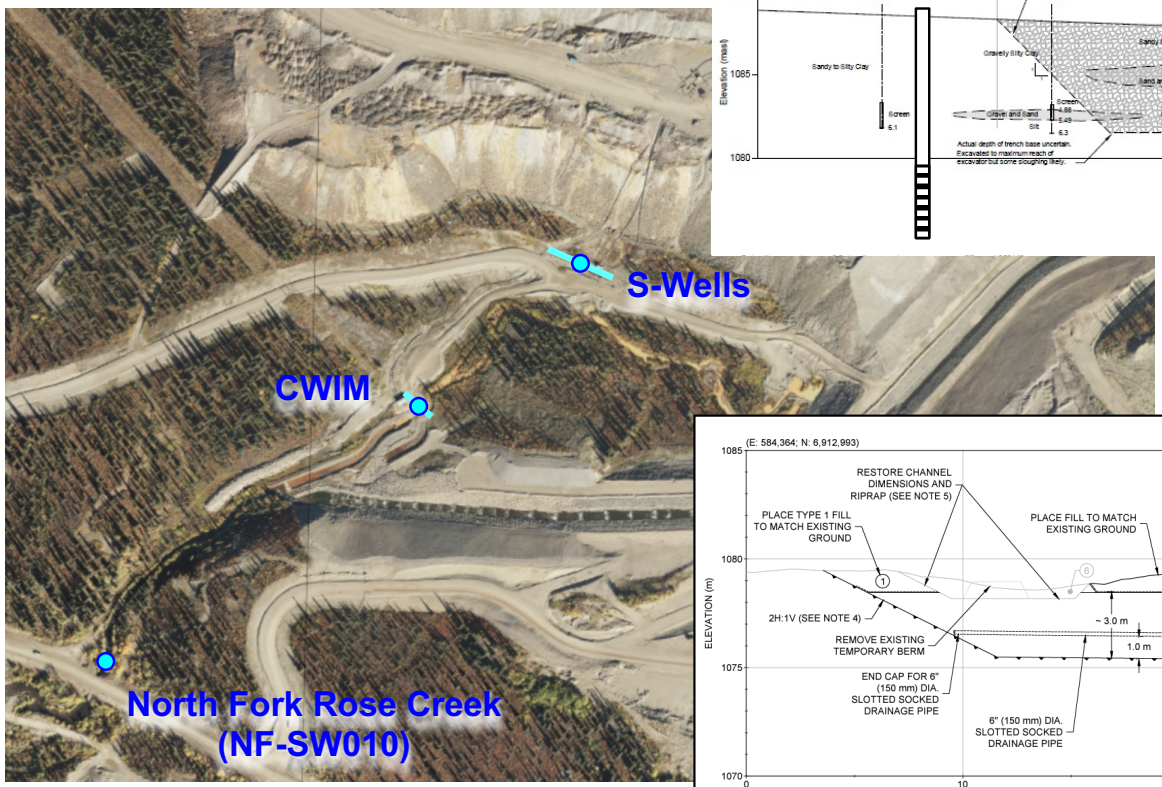
a)



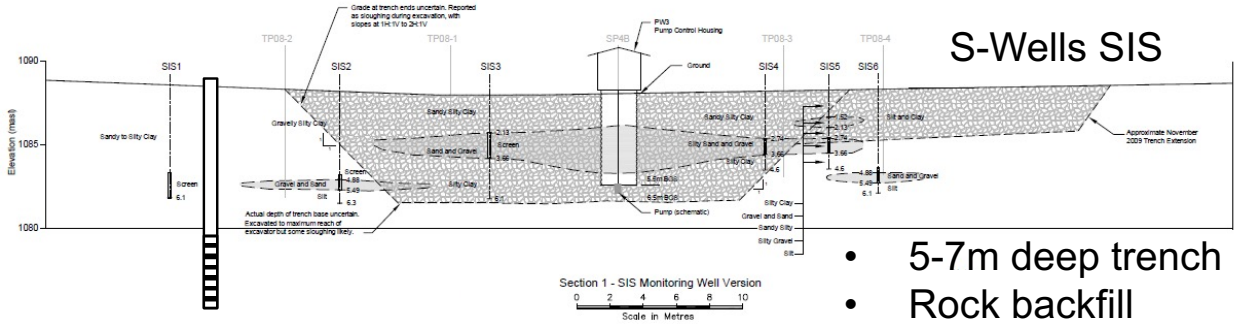
Creek directed into hillside diversion, hydraulically isolated from contact water seepage, which moves downgradient in ancestral valley bottom to collection systems:

- S-wells seepage interception system (SIS)
- CWIM (Contact water interim measure)

S-Wells and CWIM SIS Systems

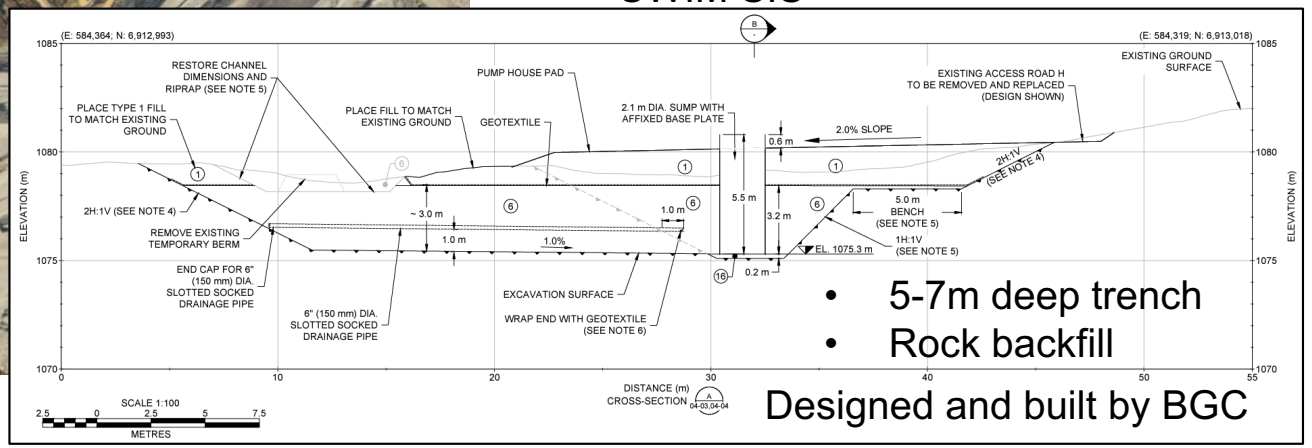


S-Wells SIS



- 5-7m deep trench
- Rock backfill
- Deep pumping well

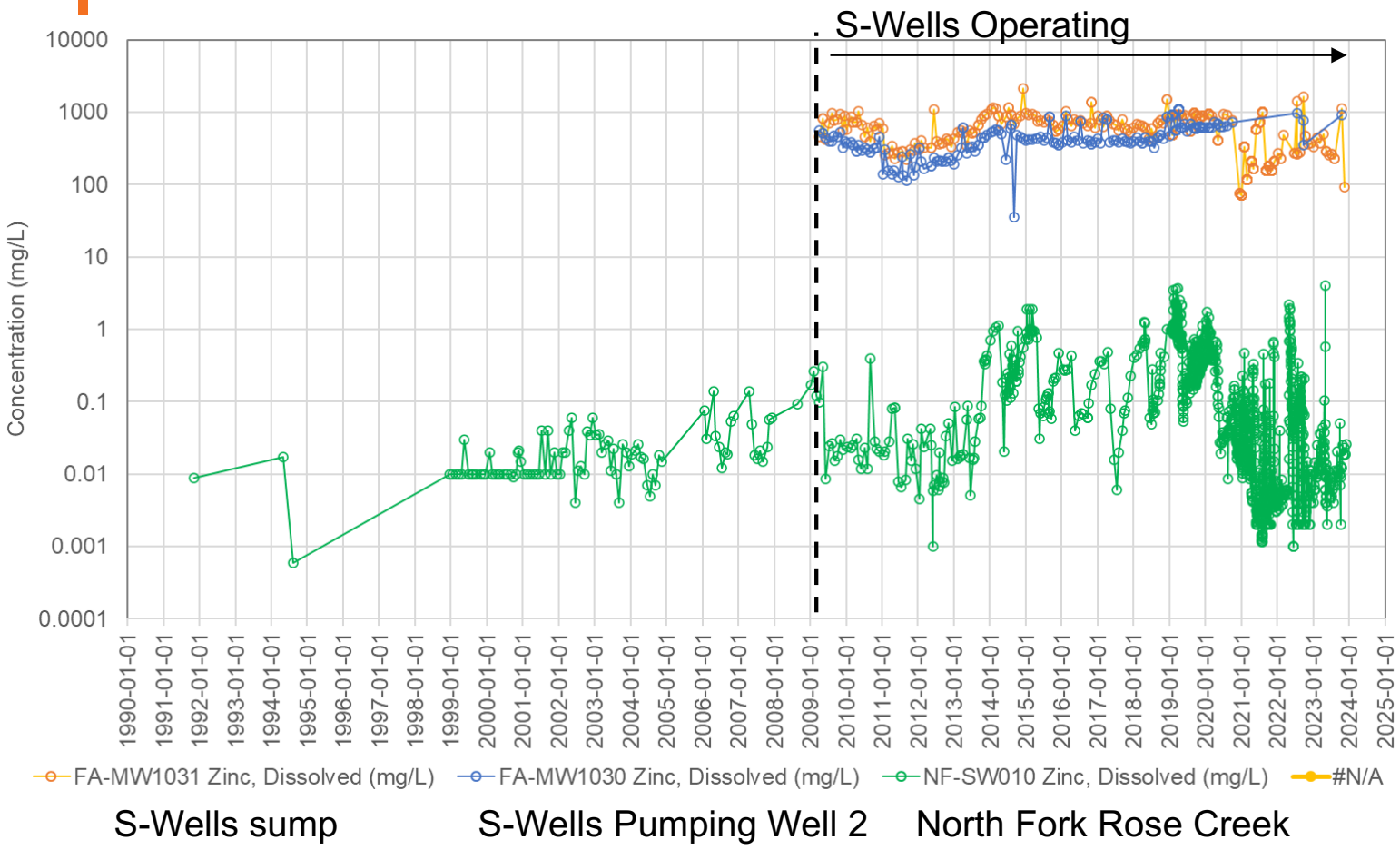
CWIM SIS



- 5-7m deep trench
- Rock backfill

Designed and built by BGC

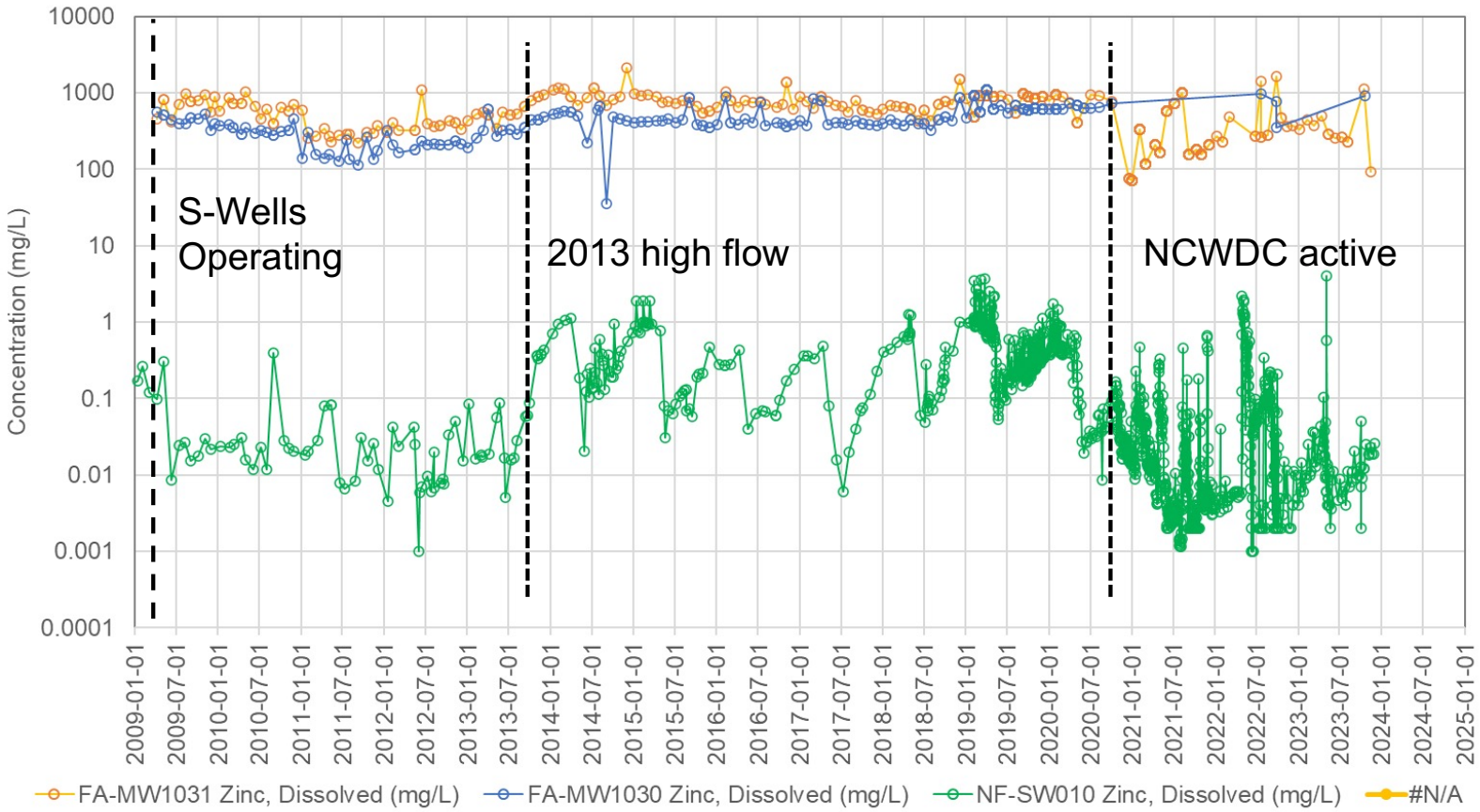
S-Wells SIS Performance



S-Wells sump S-Wells Pumping Well 2 North Fork Rose Creek

- Pumping Rate
  1- 3 L/s
- Zinc-D Load
  >150 kg/d
  >50 t/yr
- Largest single load collection point on project

S-Wells SIS Performance



S-Wells sump S-Wells Pumping Well 2 North Fork Rose Creek

Upgrades

- Sump deepened
- Flow capacity increased multiple times

Remarkably steady performance – looked great!

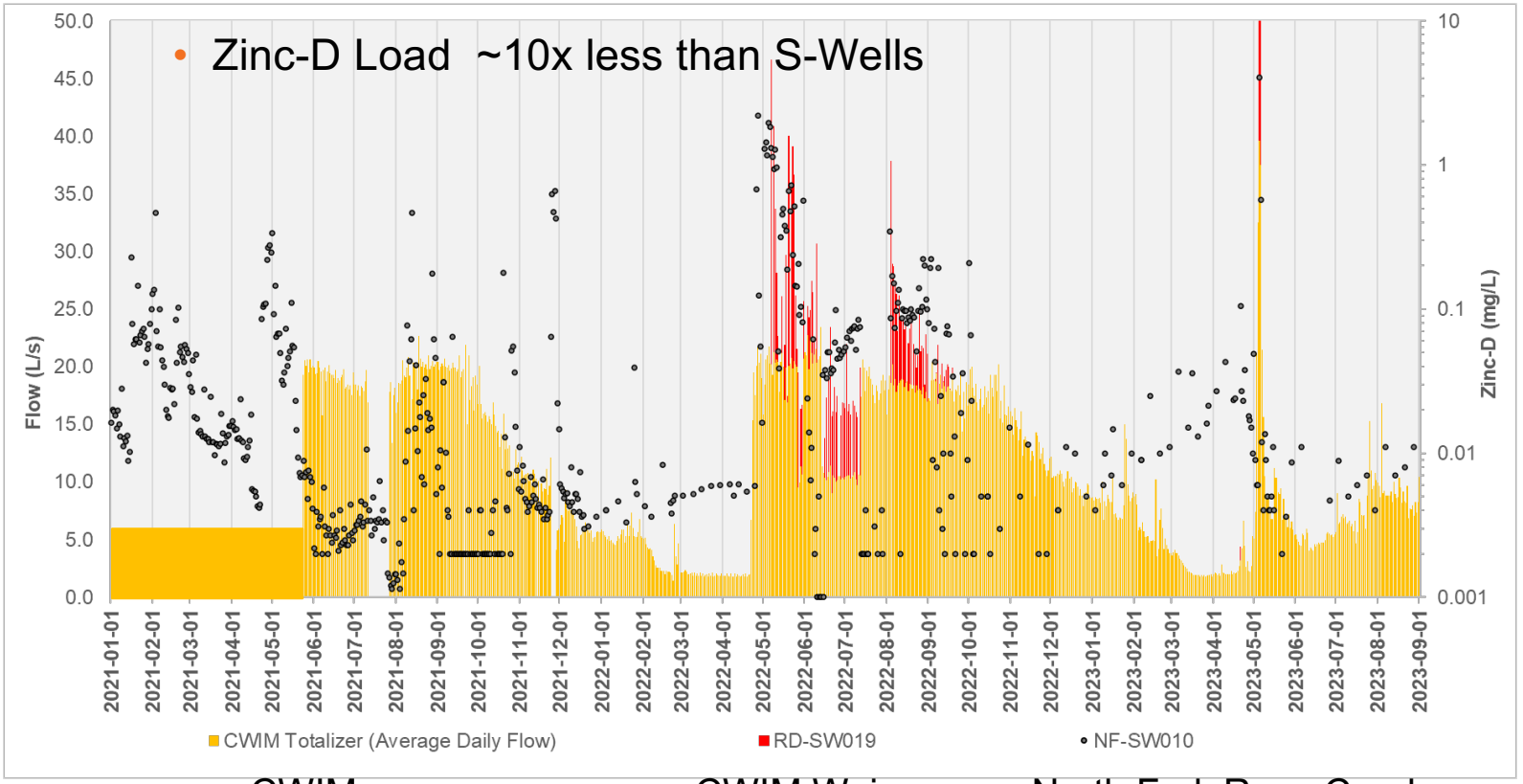
Dump seepage pathways changed in 2013

Diversion channel commissioned 2020

- External flow added to S-wells sump

CWIM SIS Performance

- Pumping Rate 3- 40 L/s
- Zinc-D Load ~10x less than S-Wells



CWIM sump CWIM Weir North Fork Rose Creek

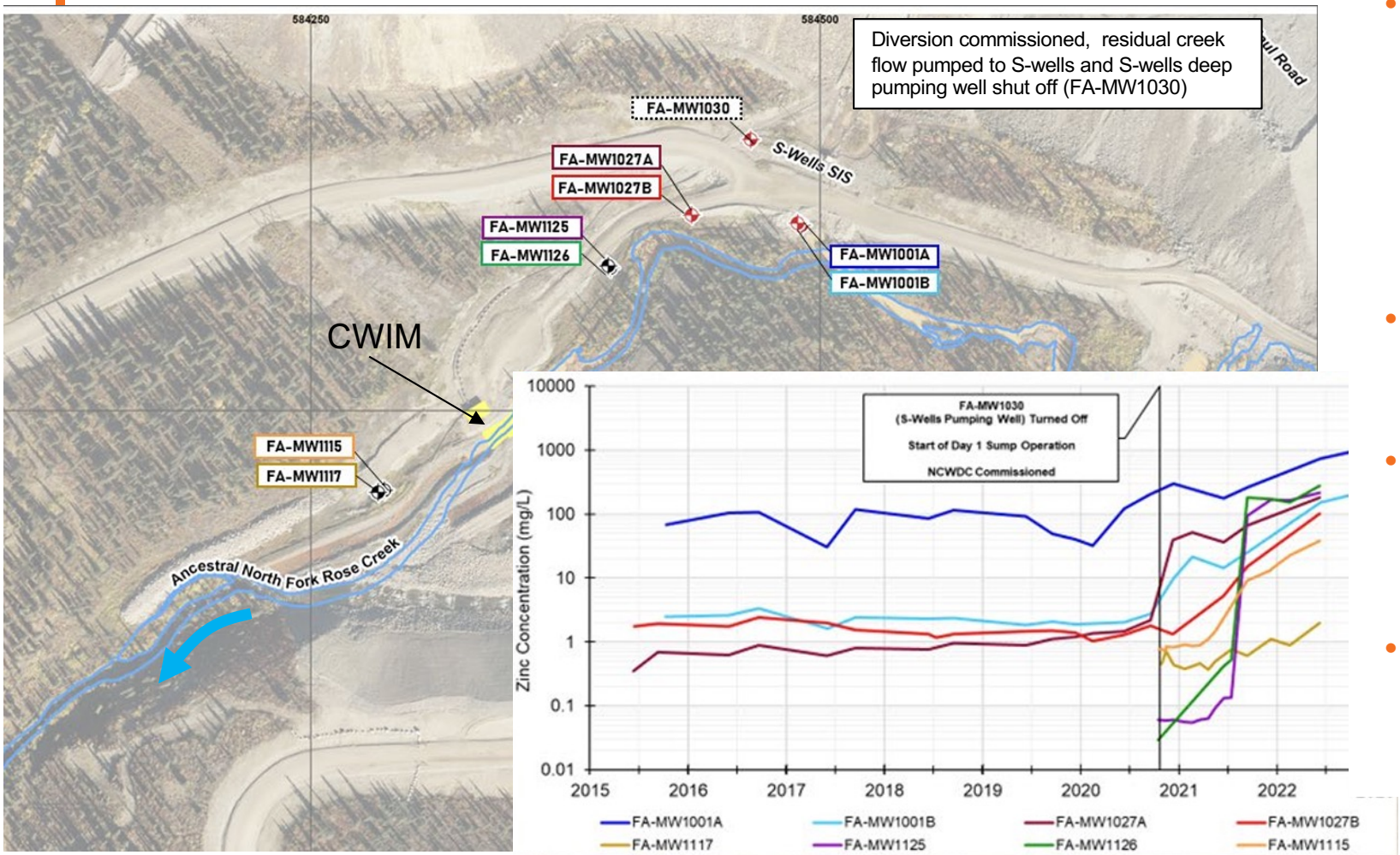
System works when pumping sufficient:
Except for deep winter, flows higher than expected in general = greater clean water bypass of diversion than expected

No storage capacity
When pumps off, sump bypass occurs and immediate effect in creek

2023 upgrades:

- 2x Flow capacity
  - 20 to 40 L/s
- Additional clean water diversion

Groundwater Trends

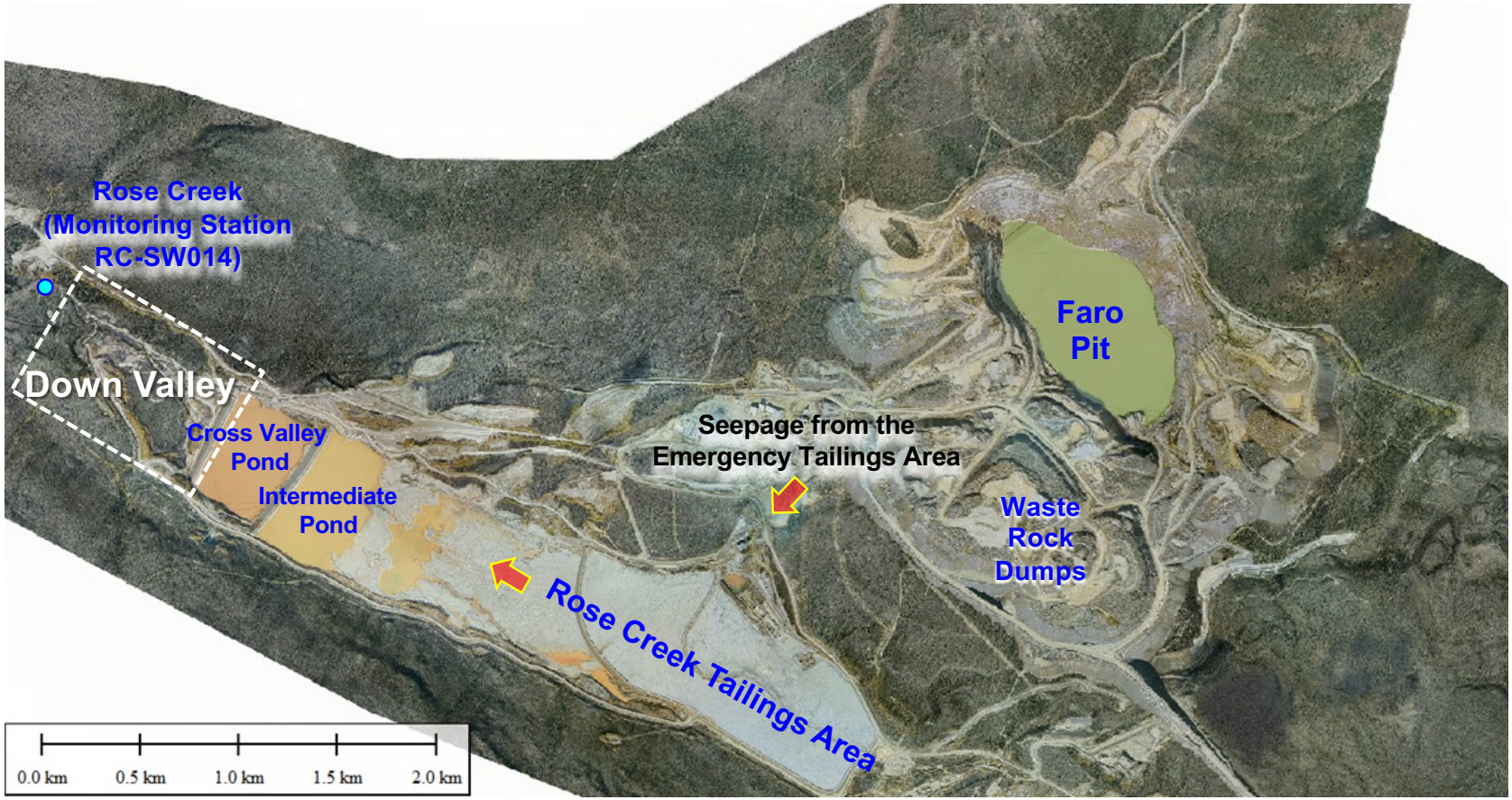


- When diversion commissioned, residual creek flow was pumped to S-wells to reduce flow to CWIM.
- Deep pumping well at S-Wells shut off
- Very rapid increase in groundwater concentrations
- Groundwater is passing under CWIM sump

Lessons Learned – S-Wells & CWIM

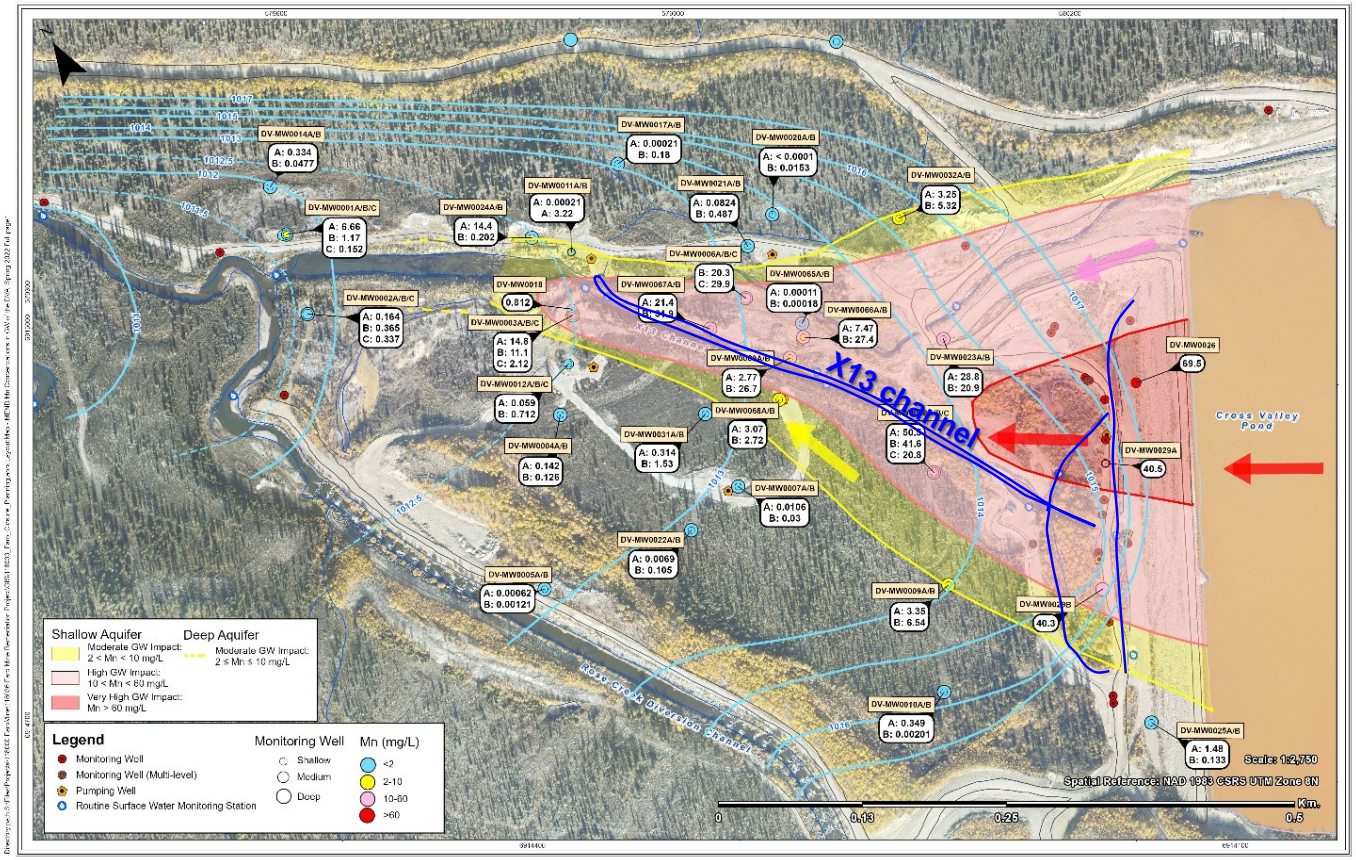
- Layered systems provide more protection, but…
- Always question and check your assumptions or initial conceptual models
  - Surface flows greater than expected
  - Groundwater transport and deterioration can occur faster than you might think!
- Importance of proper planning ahead of time
  - Don't defer design of backup systems
- Downsides of interception trenches
  - Limited storage when pumping not operating
  - Surface water inputs are important
- Good performance data monitoring
  - Without the data, it's hard to figure things out

Down Valley SIS
Key Features and Seepage Sources



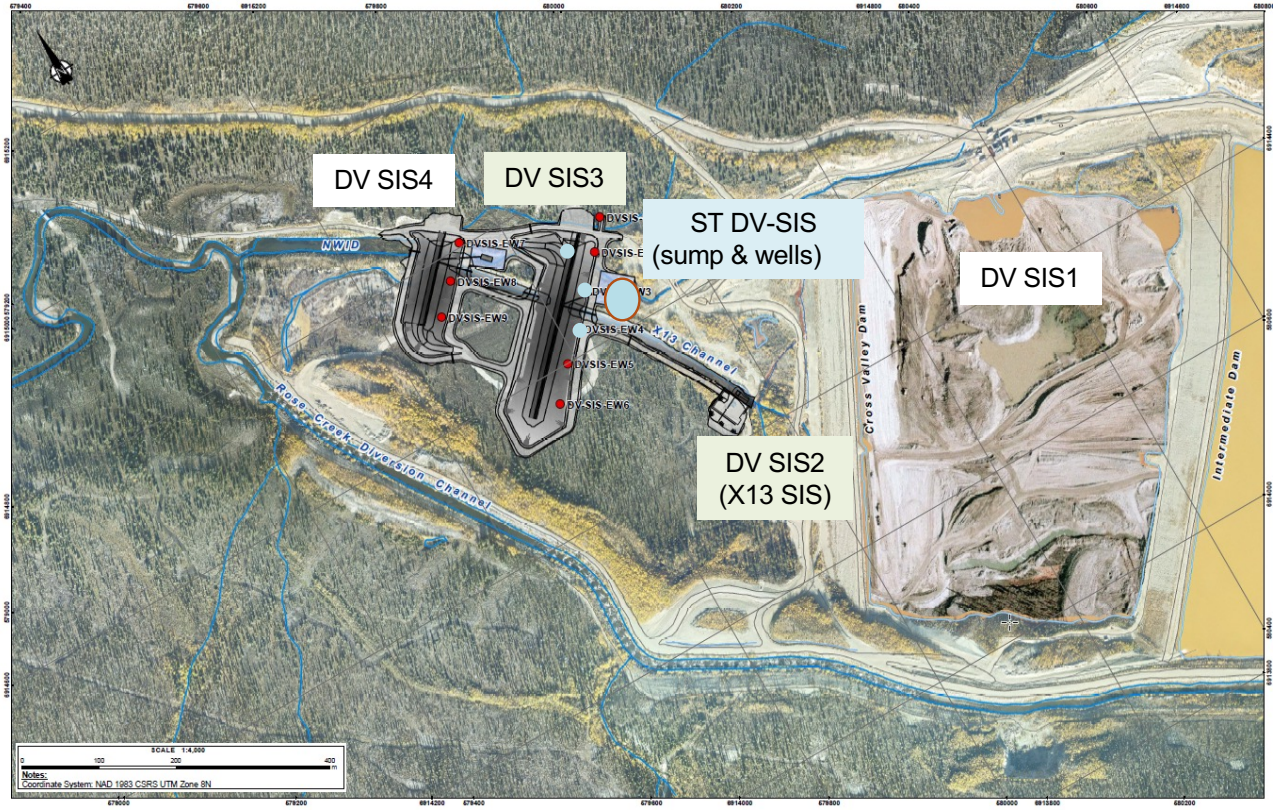
Inferred Flow Field and Manganese Plume

- Rose Creek Aquifer – highly heterogeneous sand and gravel aquifer up to 40 m thick.
- Flow is directed down valley from southeast to northwest and is converging to the center of the valley.
- Manganese is a key contaminant of concern for this area. Manganese plume advanced the furthest of all metals in groundwater.
- The northern portion of the aquifer is more impacted than the south-central portion.



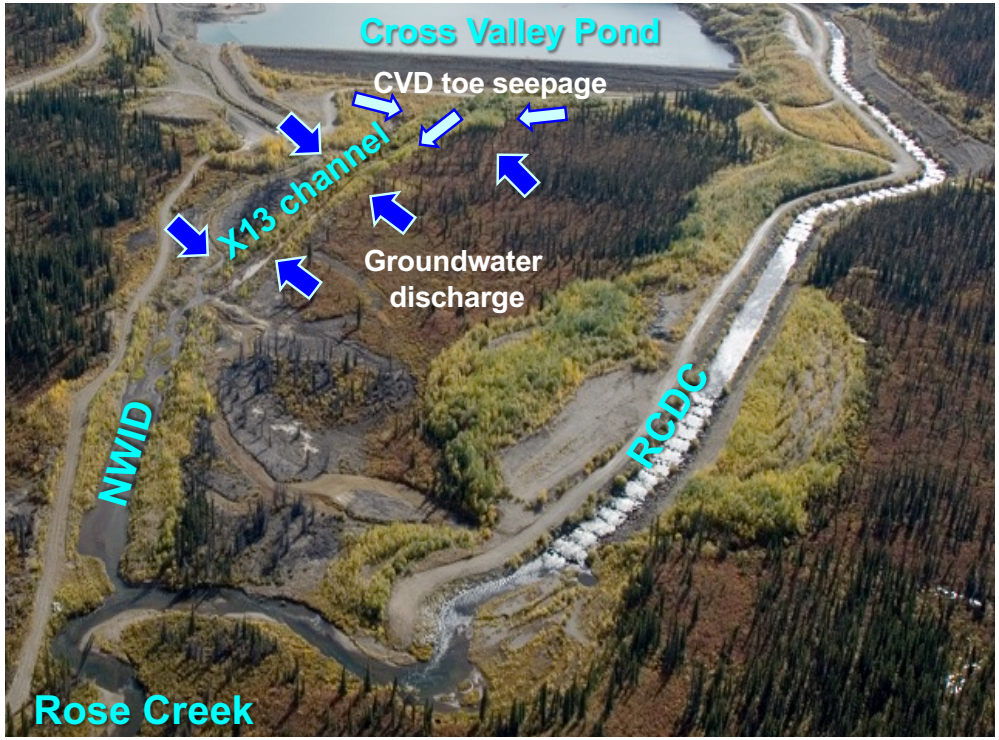
Down Valley SIS

- "X13 SIS"
  - "Urgent Works" - Collection of seepage at toe of CVD
- Short-term DV-SIS
  - "Urgent Works" - Interim solution downgradient of X13 SIS
- Early DV-SIS
  - Add DV-SIS3 component (as part of closure plan implementation)
- Final (Long-term) DV-SIS
  - Add DV-SIS1 and DV-SIS4 as part of closure plan implementation

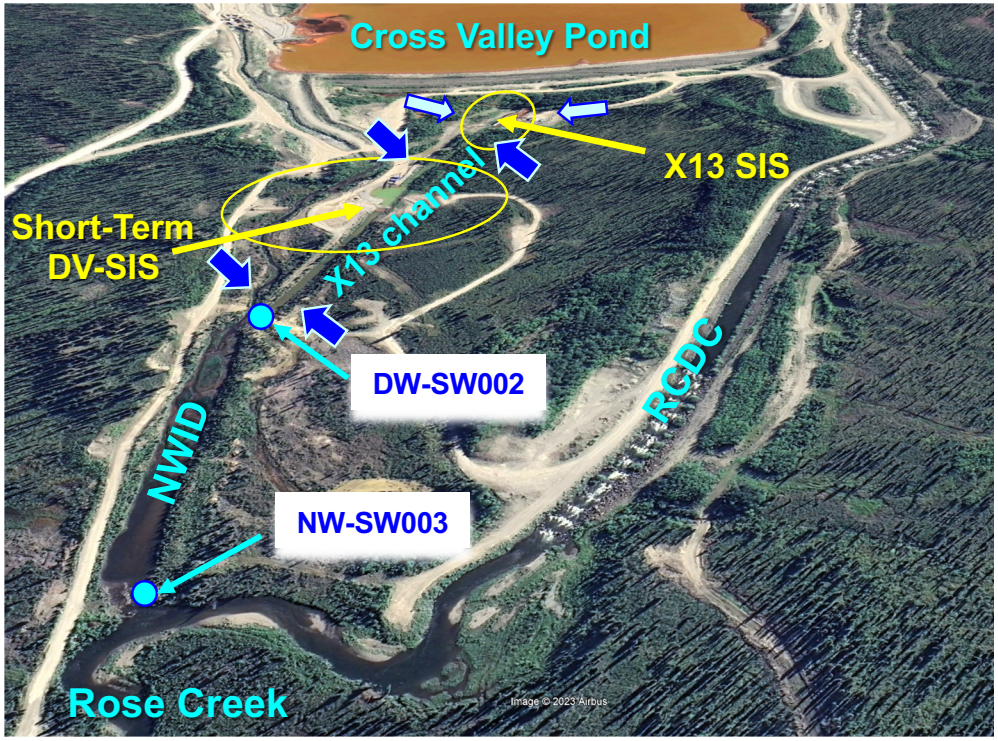


Down Valley Area
Existing Seepage Interception Systems

2019

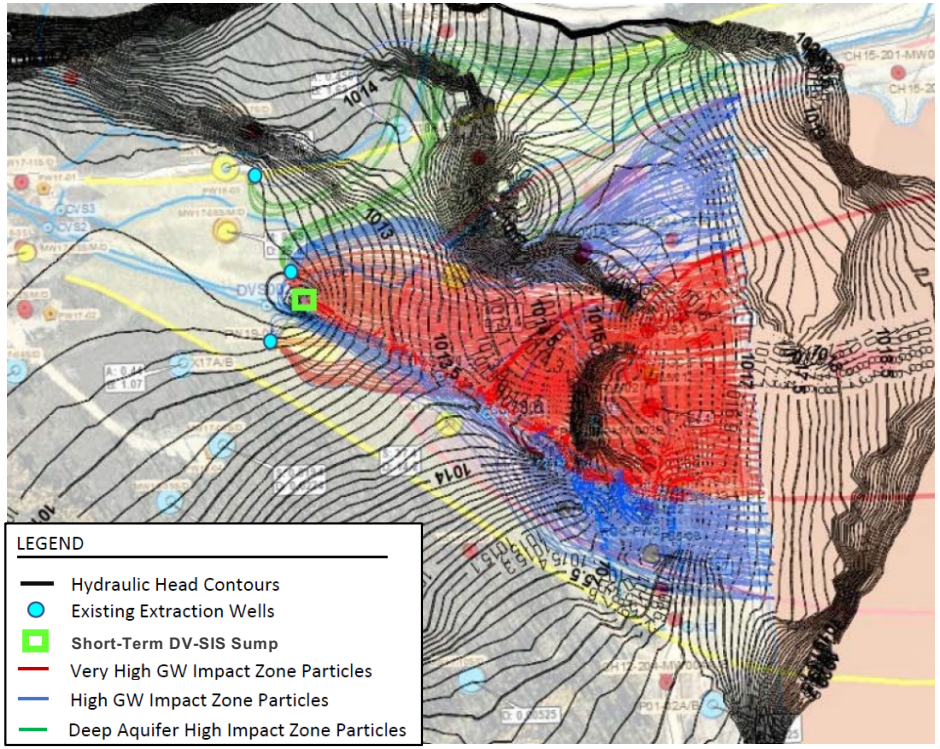


2022-2023

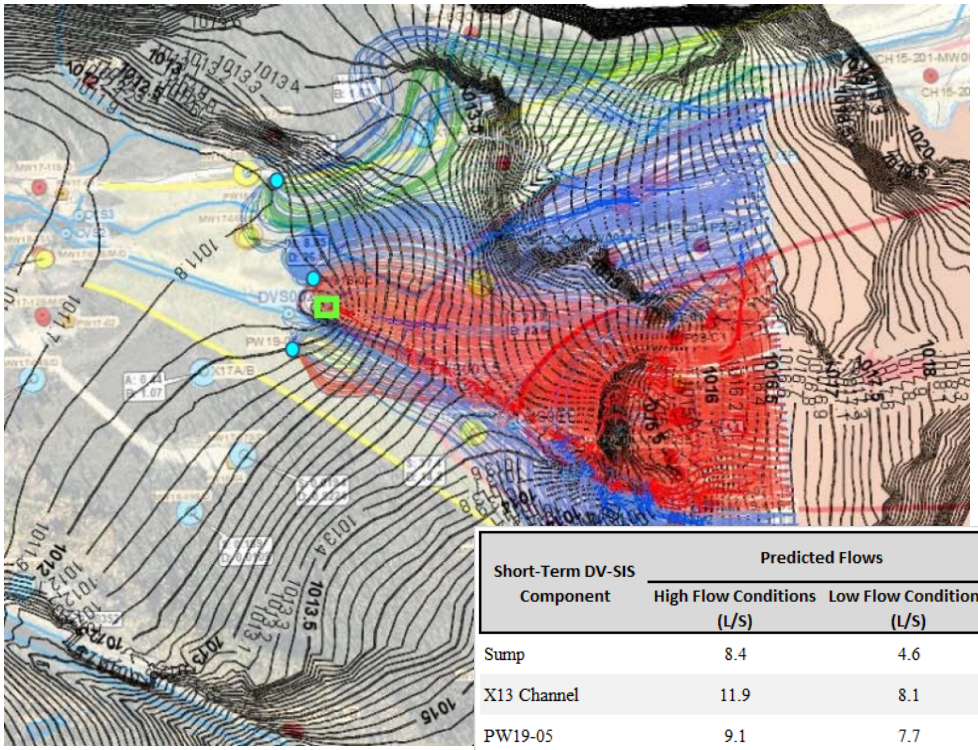


Short Term DV-SIS – Predicted Capture

High Flow

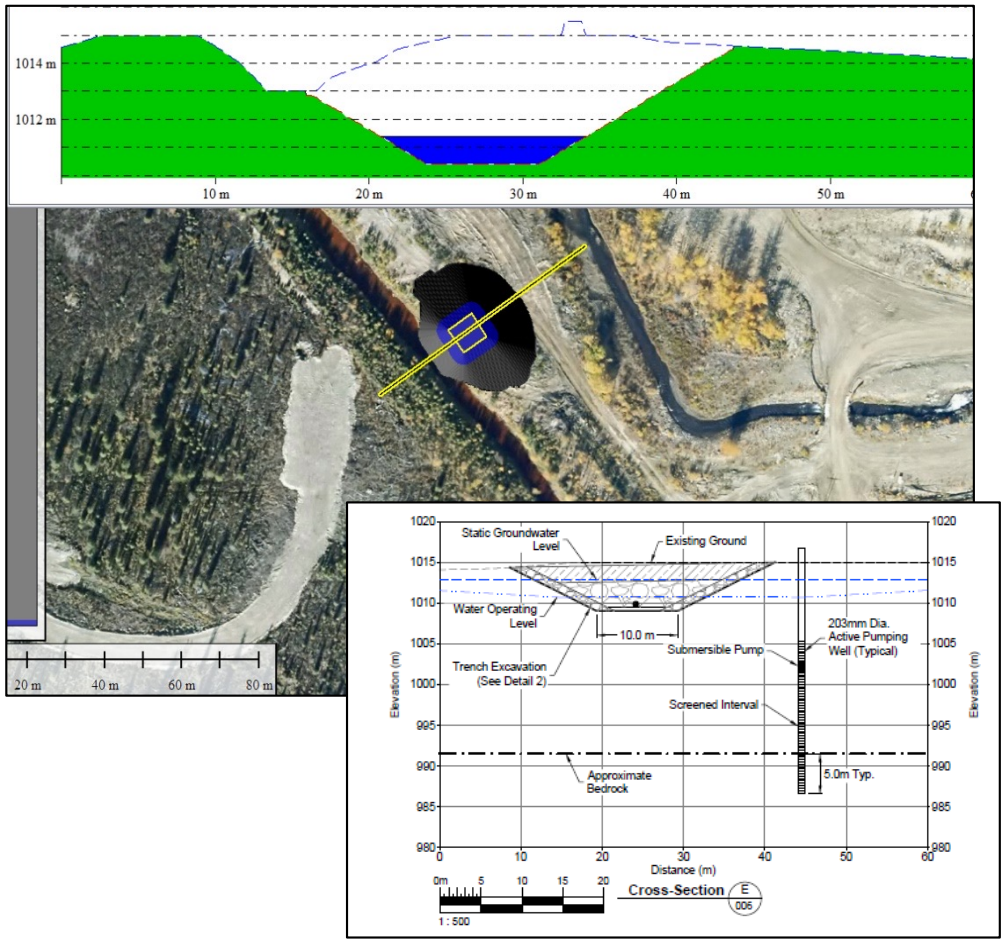


Low Flow



Short-Term DV-SIS Component	Predicted Flows	
	High Flow Conditions (L/S)	Low Flow Conditions (L/S)
Sump	8.4	4.6
X13 Channel	11.9	8.1
PW19-05	9.1	7.7
PW19-06	7.8	5.6
PW18-03	5.6	4.5
TOTAL:	**43**	**30**

Short Term DV-SIS – Design Overview



- Short-Term DV-SIS components:
  - Shallow sump (~5 m deep)
  - Three existing deep extraction wells (~30 m deep)

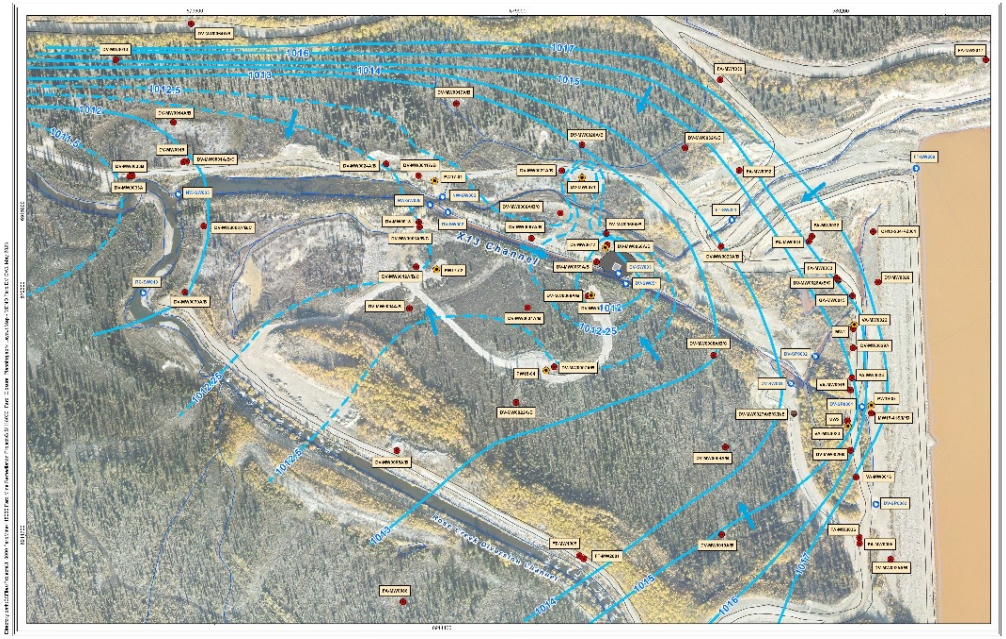
Short Term DV-SIS – 1st Season of Operation

- Commissioned in August 2022.
- Continuous operation started October 1, 2022.
- Operation only during shoulder and winter low flow period (Oct – May) due to limitations of treatment and storage capacity for contact water on site.
- 7-days shutdown in December 2022 due to power outage.
- Extended 2-months winter shutdown from February 24 to April 29, 2023 was necessary due to risk of freezing and damage to pumps.
- Operation stopped on June 12, 2023 for open water (high flow) period.

Short Term DV-SIS – Performance

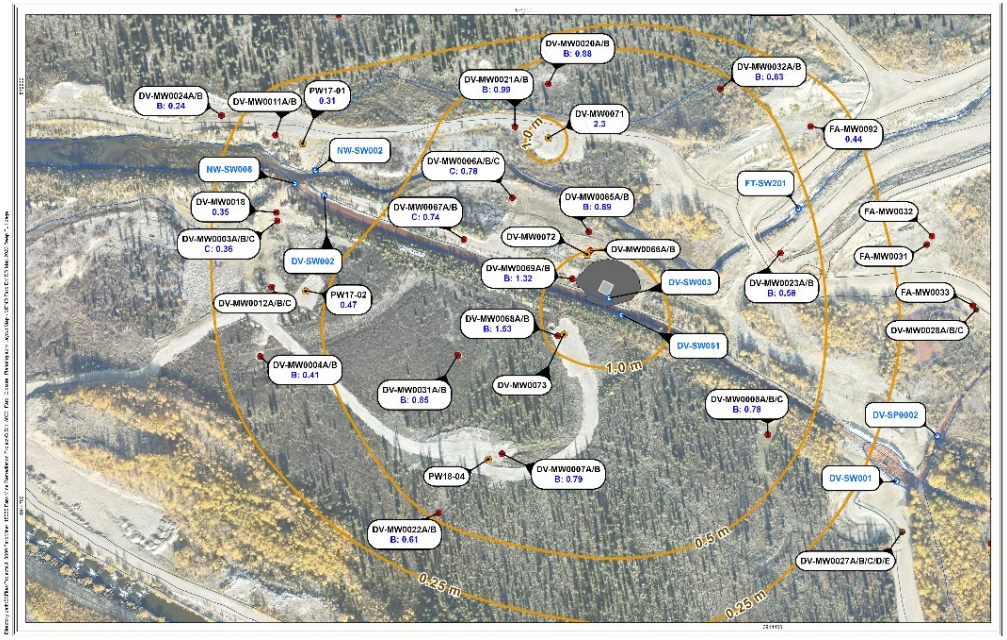
Flow Field after 8 months of operation

- **Full hydraulic control – reversal of gradients downstream, flow is concentric to the ST DV-SIS**
- **Hydraulic head difference between hinge point and sump >0.3m**



Groundwater drawdown in the deep aquifer

- **Drawdowns > 1m near the sump and extraction wells**



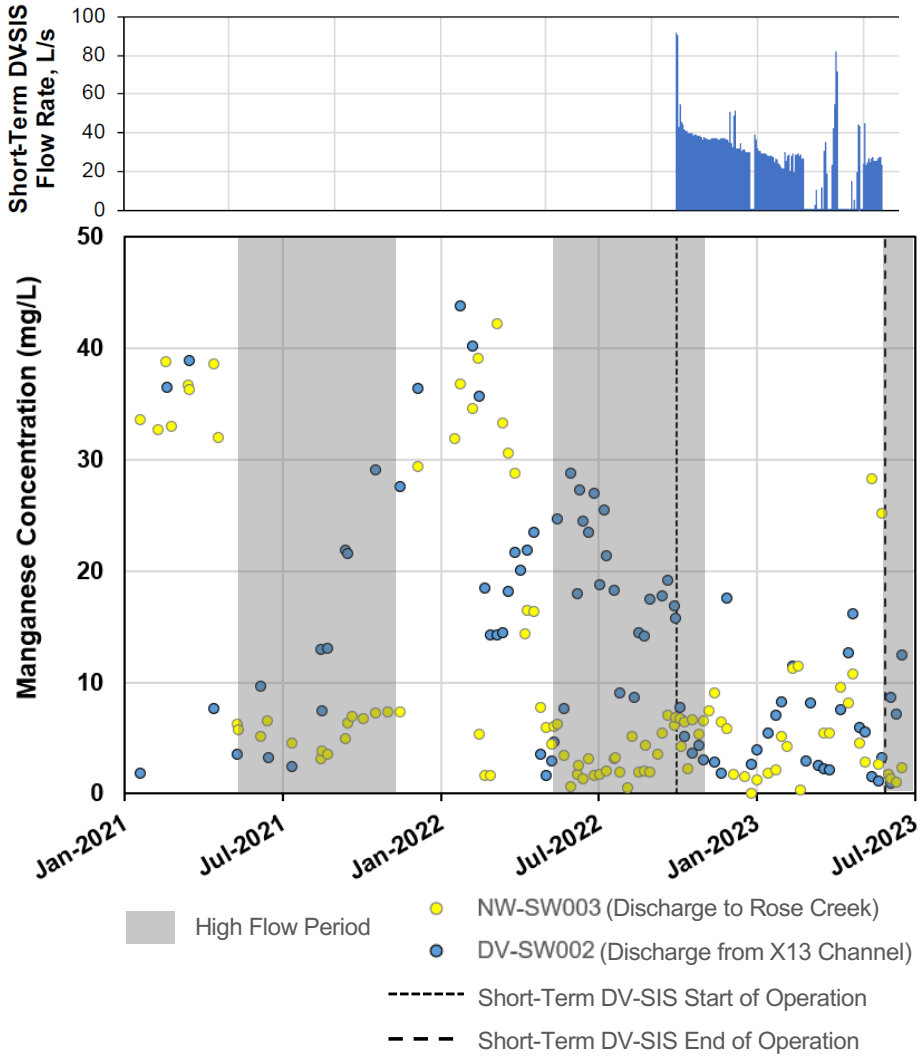
Water Quality Trends

Beneficial impact of the ST-DV-SIS operation on water quality discharging from X13 channel to Rose Creek:

- Mn concentrations decreased from 30-40 mg/L to <10 mg/L
- Fe concentrations decreased from 4 mg/L to <1 mg/L

Recorded flow rates:

- 40 L/s during the initial operation period
- ~20 L/s during winter low flow (lower than predicted)



Lessons Learned – Short Term DV-SIS

- System operated as designed during open water shoulder periods:
  - Pumping rates were close to model predicted rates.
  - Operation of the system resulted in a reversal of hydraulic gradients downstream of the sump and wells.
  - A significant decrease in flows and concentrations of contaminants of concern was observed in impacted water that discharges to Rose Creek.
- Problems during winter operation:
  - Model overestimated flows during winter low flow conditions.
  - Pump needs to be designed to cover a large range of flow for this shallow groundwater system with high seasonal variations in surface water and groundwater flows.
  - Sump was not excavated to the proper depth which resulted in an elevated risk of freezing and damage to pumps.
  - Planned/unplanned shutdowns need to be considered during design to avoid risks of damage to the equipment.

Conclusions

- SIS systems are intercepting significant mine seepage
- Check your assumptions if no prior operational observations
- Carefully think through pump design criteria!
- SIS pumps need to be able to handle a large range of flows and consider shutdowns of SIS components
- Appropriate performance monitoring (groundwater and surface water)
- Conditions can change quickly

Thank You

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- Julia Tancon

Parsons
- All the site staff!

toolbox

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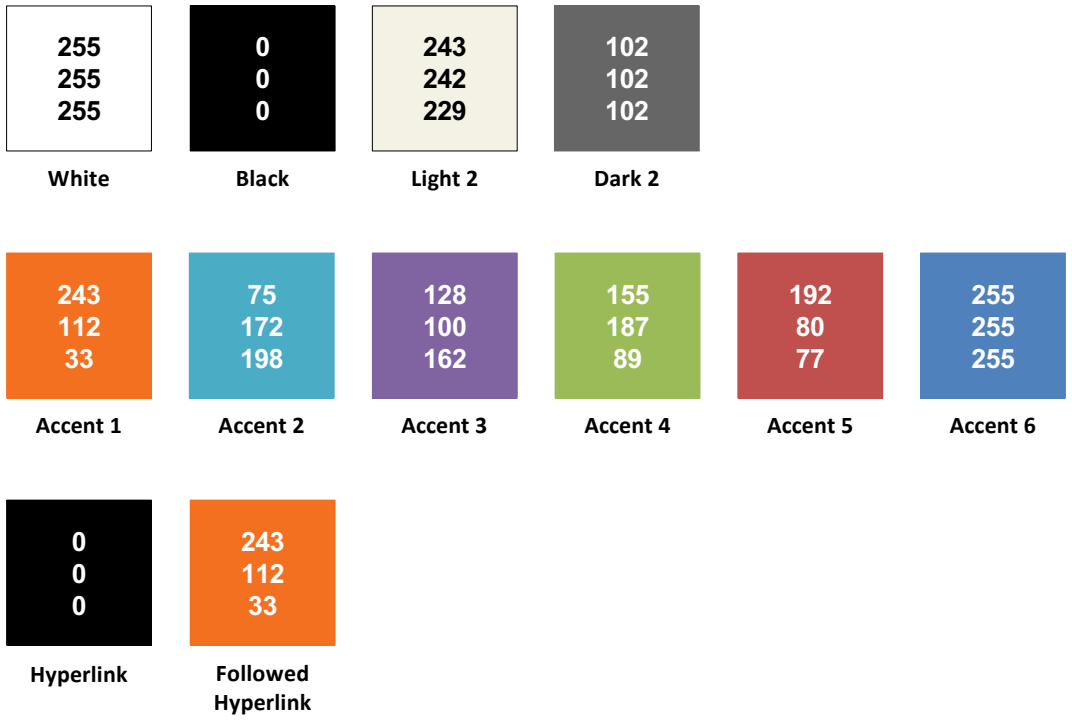
Suggestions:

- Use Dark 2 for headings within text.
- Use White, Black, Light 2, and Dark 2 for slide background colours.
- Add additional colours if needed.



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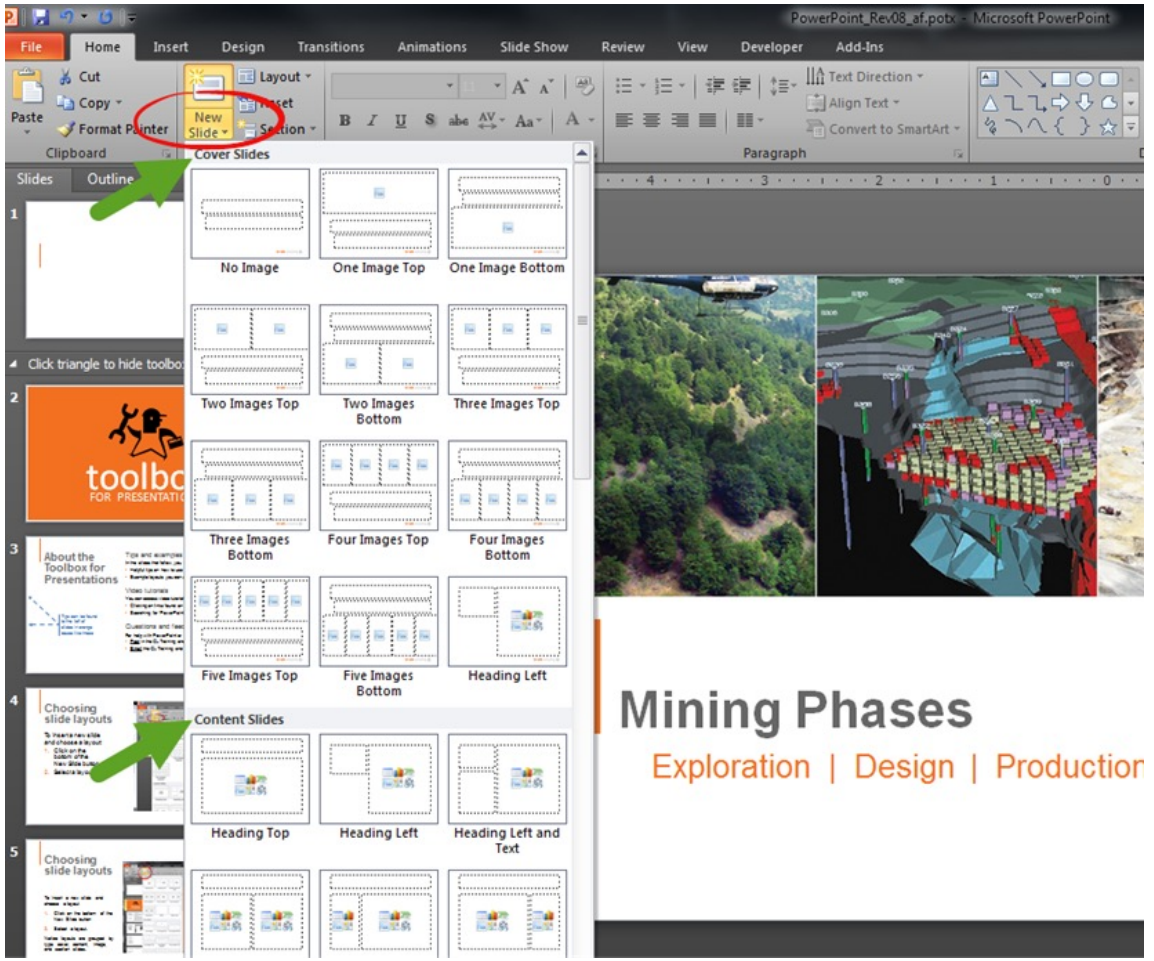

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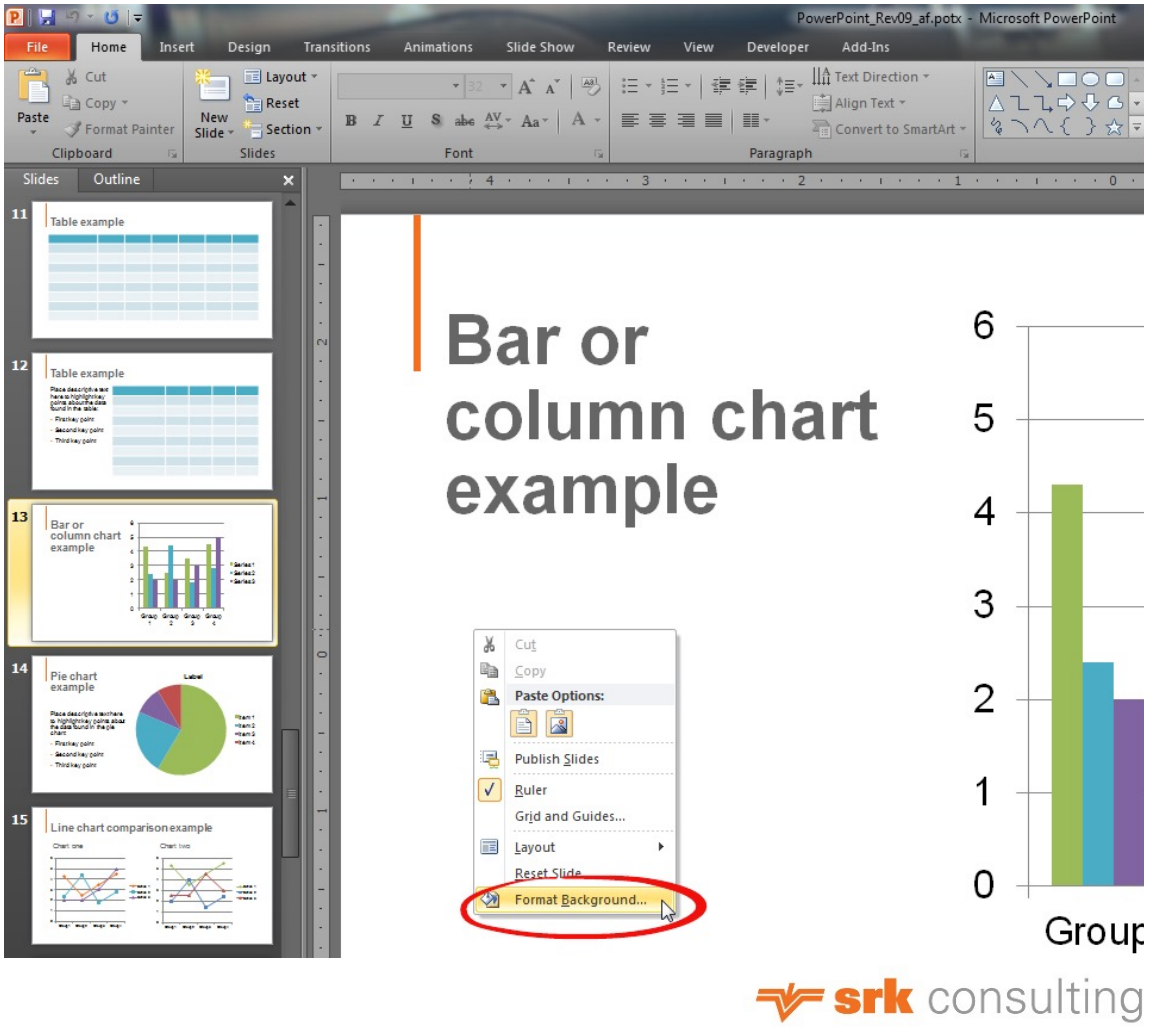

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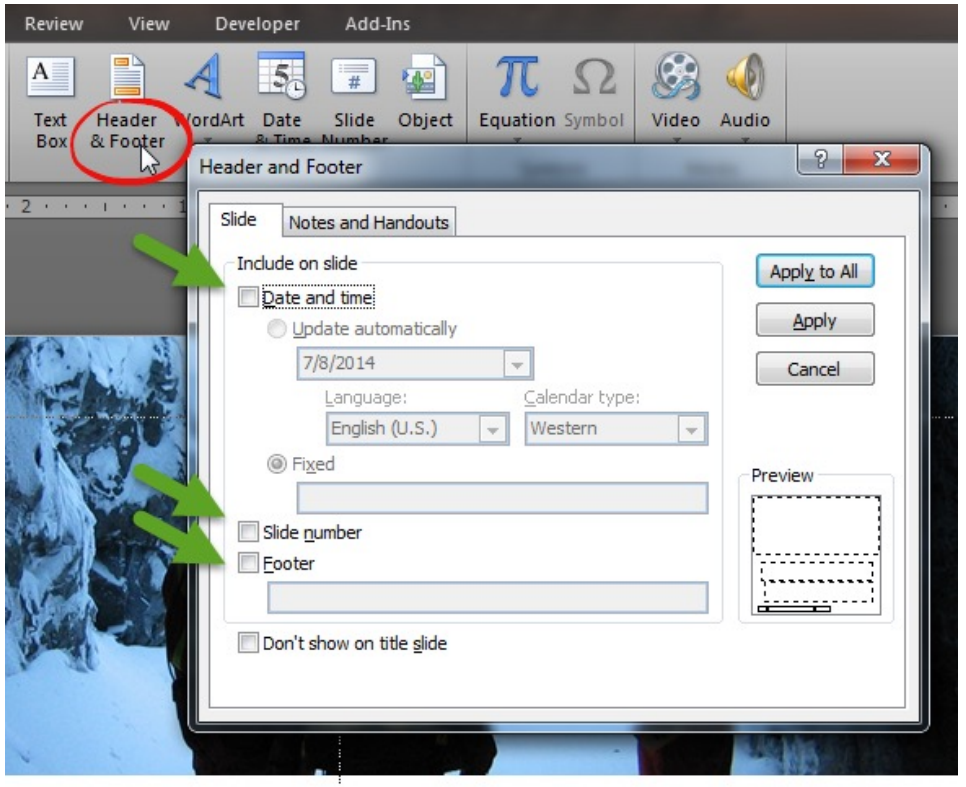

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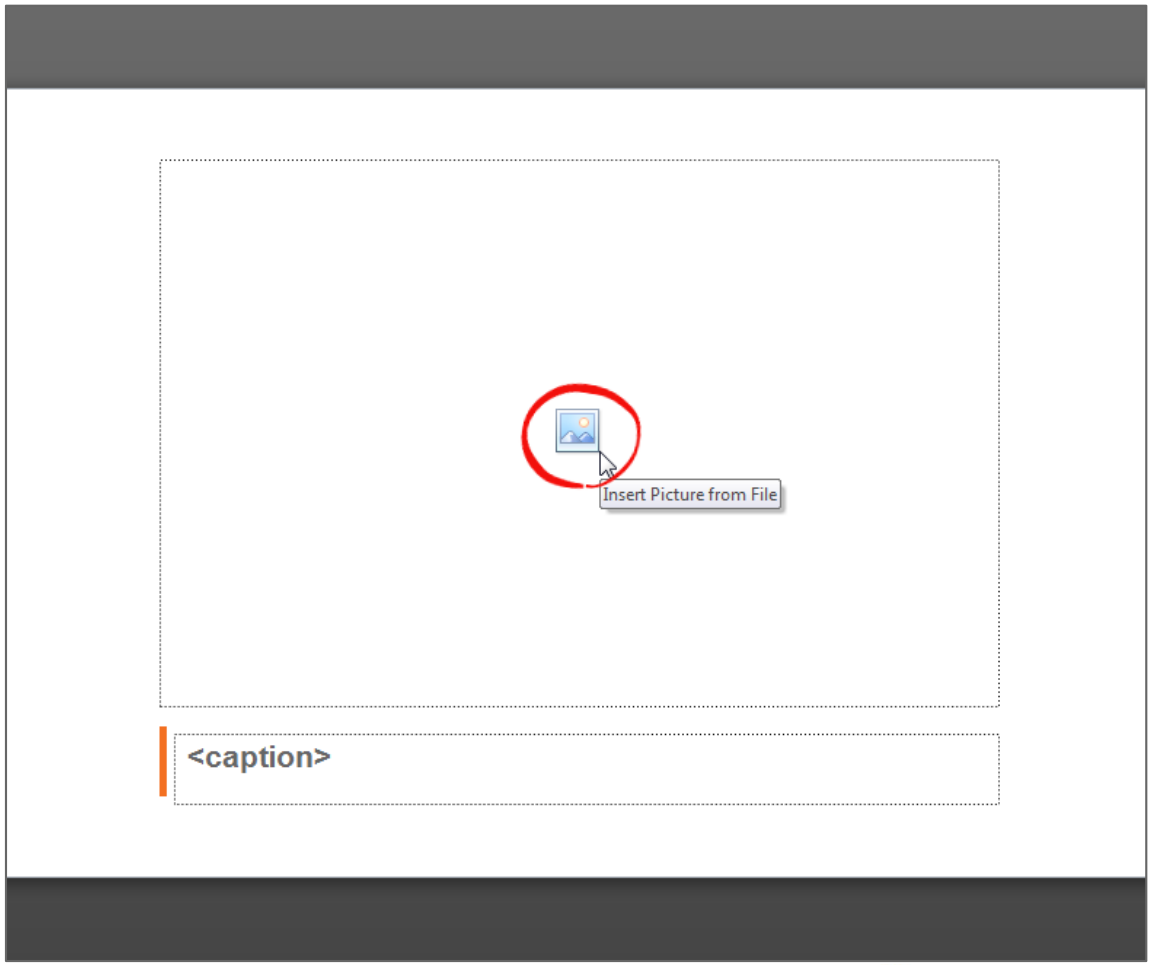

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Example section slide

Section One

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Cover slide example

Twelve cover slides are available in this template

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Table example

Table example

Place descriptive text here to highlight key points about the data found in the table:

- First key point
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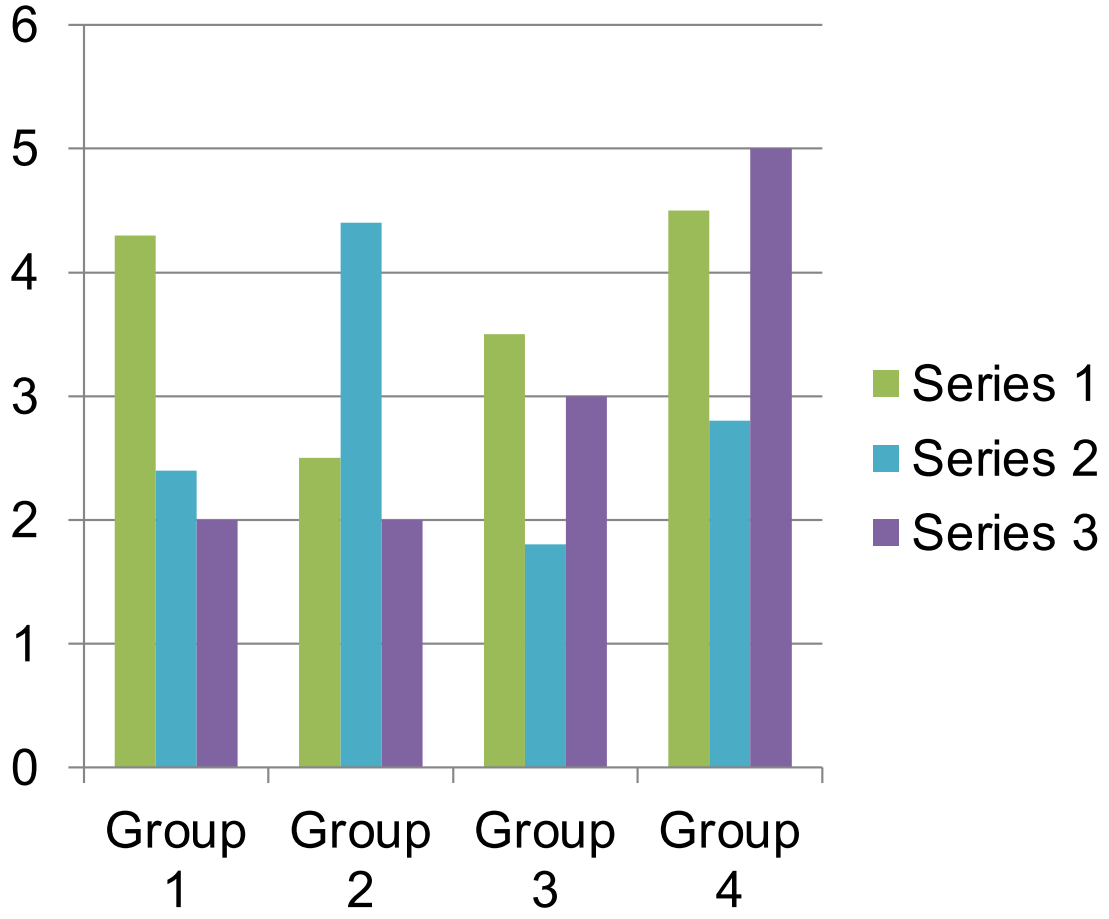
Bar or column chart example



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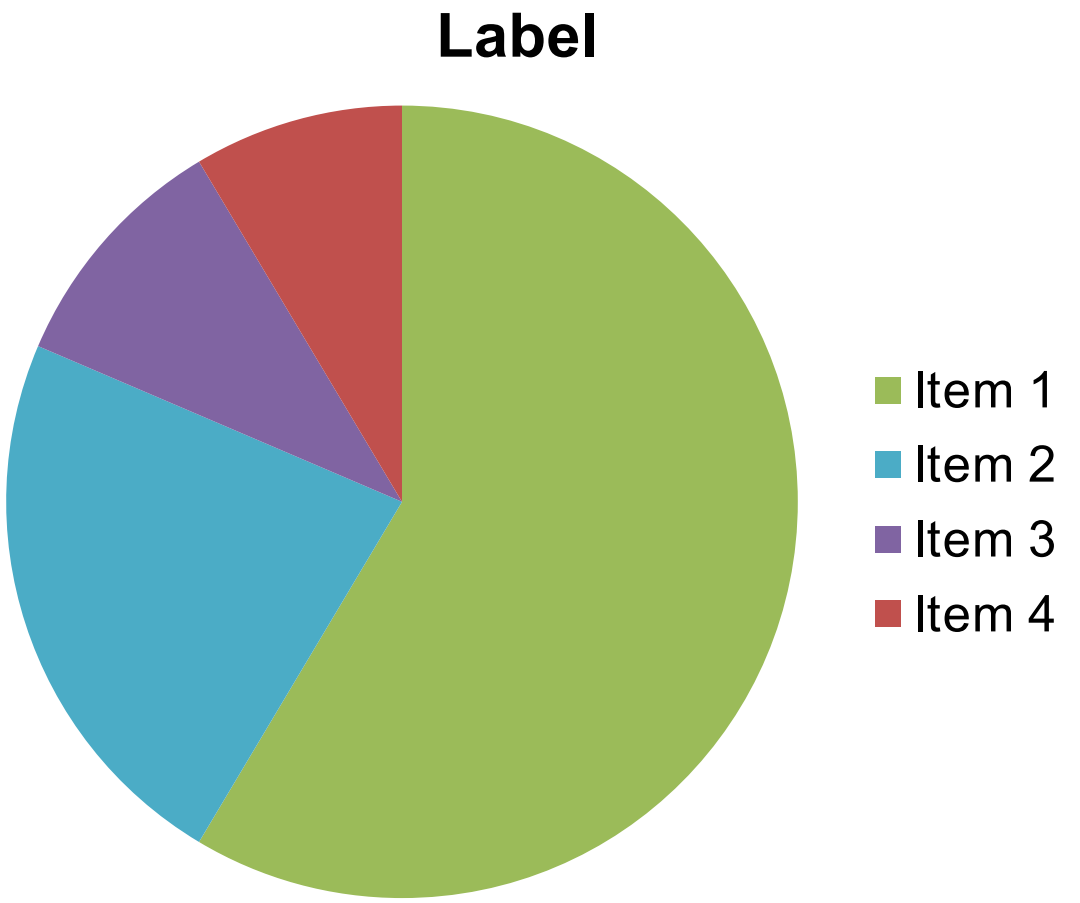

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Line chart comparison example

Chart one

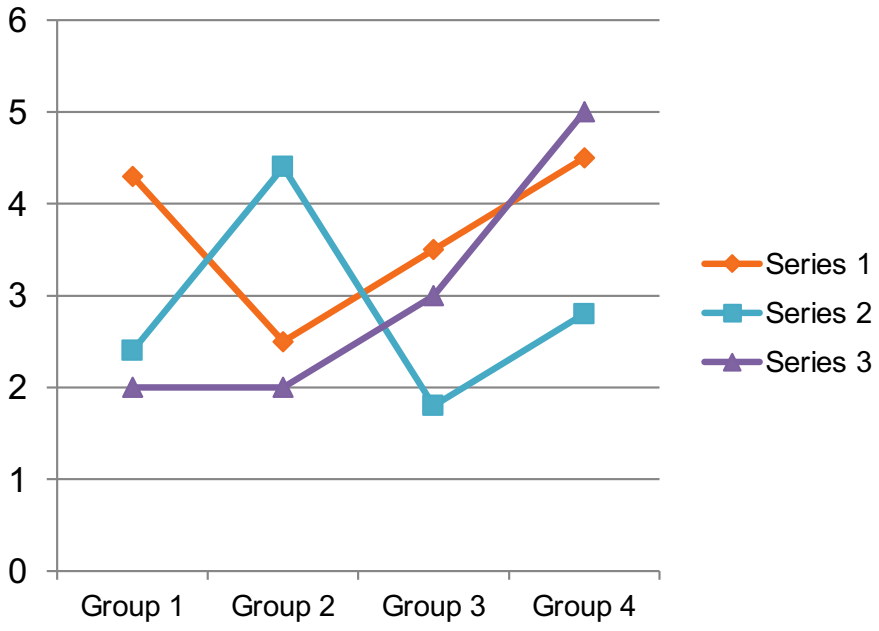
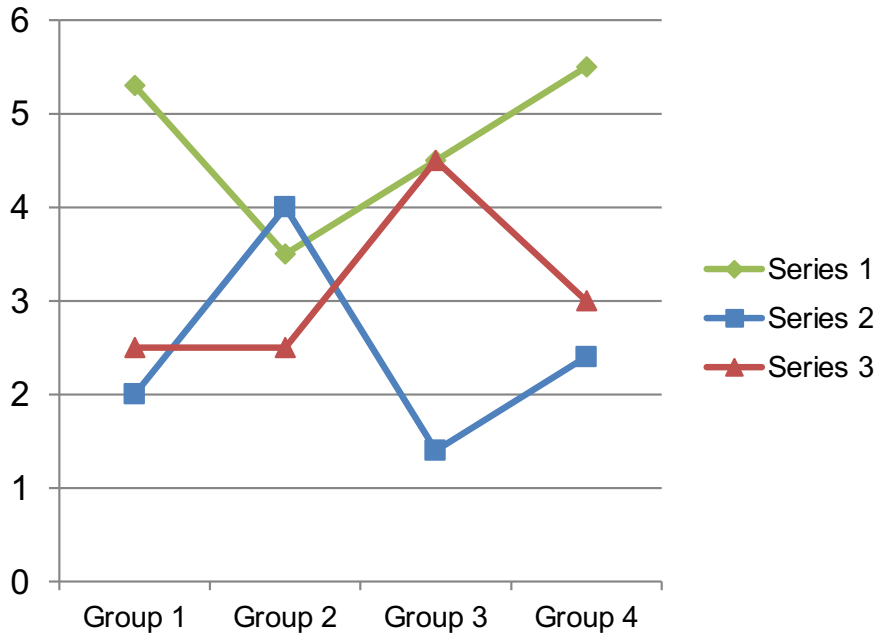


Chart two



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Caption for image one

Second image caption

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Caption for the first image on this slide

Image two caption

Caption for third slide

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Image caption number one

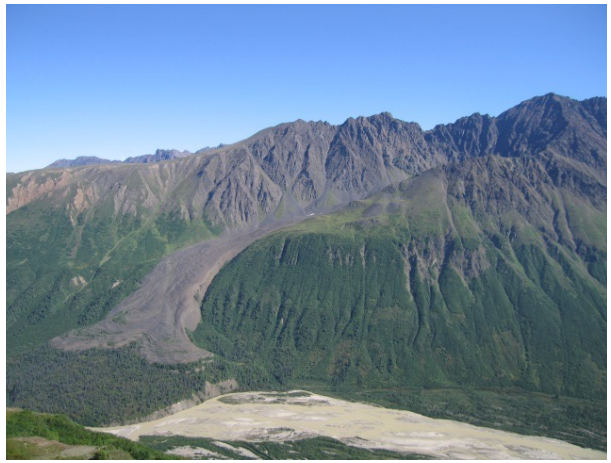
(a)

Caption two

(b)

(c)

Third caption



(d)

Fourth image caption

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