Determination of acid producing potential using pXRF: A case study from Cypress Mine, Stockton Plateau

Christine McLachlan

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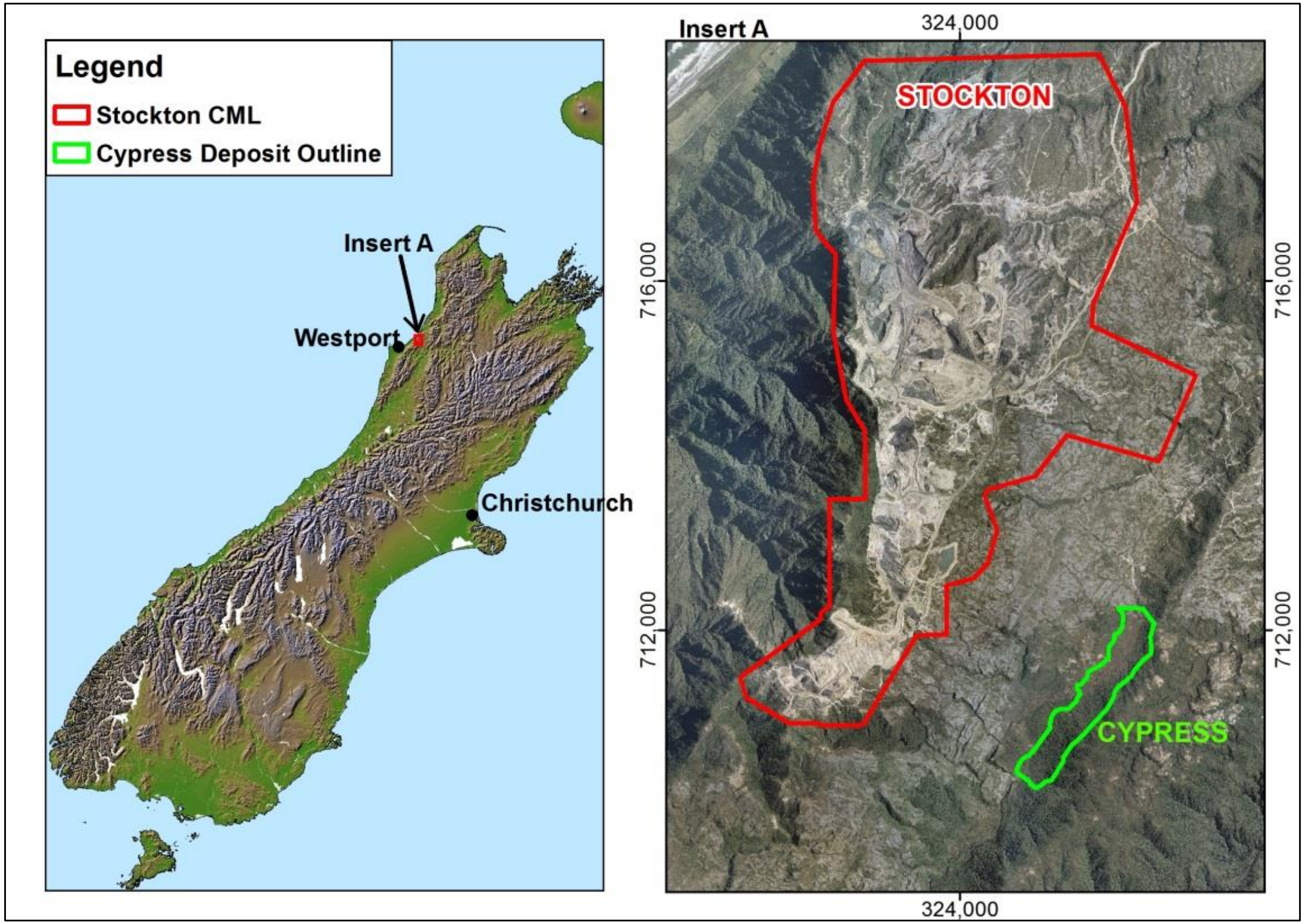
Location of Cypress and Stockton Mines



Map by Hamish Pescini

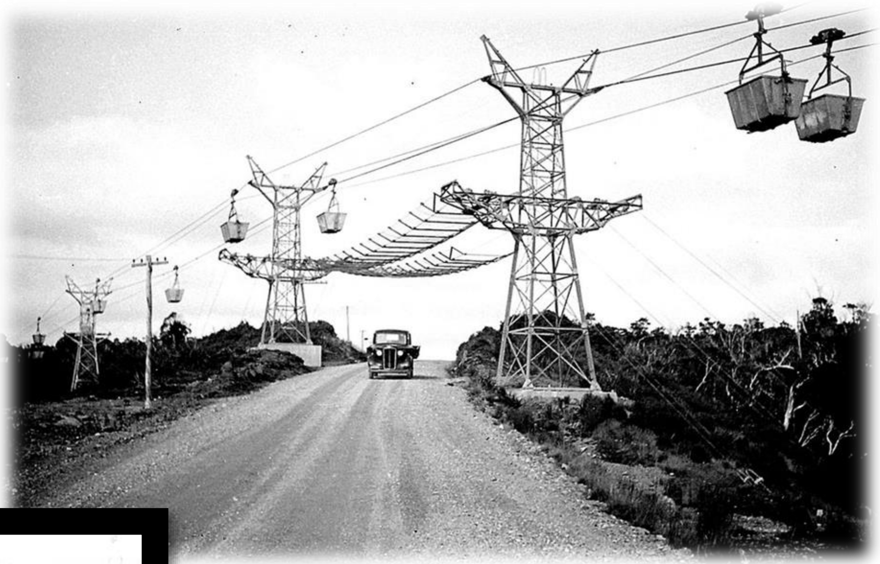
Cypress and Stockton Mines

- Purchased by BT Mining in 2017
- Both mines produce metallurgical coal for export
- Cypress coal required as a blending partner for Stockton coal

Stockton
- Historical underground mine since 1906
- Opencast started in 1950's
- ~1100 ha disturbed with ~400 ha rehabbed
- NZ's largest opencast mine

Cypress
- New mine which commenced in 2014
- ~80 ha disturbed
- Cypress is in a pristine valley adjacent to Stockton

Cypress climate
- 5100 mm rainfall per year
- Mean temp 8.7 °C
- Summer temp 12.8 °C
- Winter temp 5 °C



Stockton Aerial Ropeway Circa 1953 (westcoast.recollect.co.nz)

Ladies in white hats. Earliest known photo of Mine Creek, Stockton (Coaltown Museum, Westport – Ref MN15.nz)

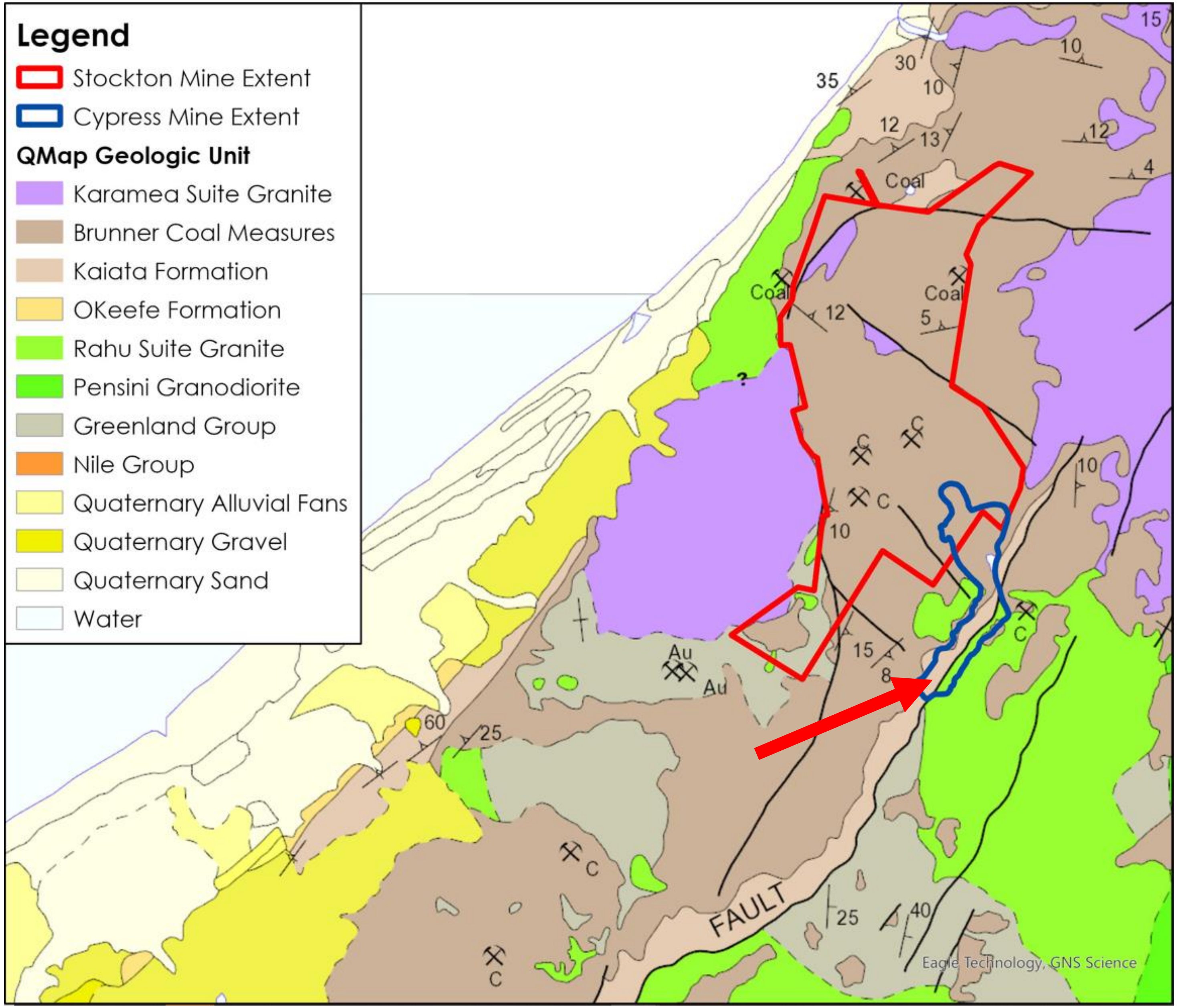
Coal Miner taking a break, Stockton, Buller District (Alexander Turnbull Library. natlib.govt.nz)

Cypress and Stockton Geology

- Coal contained in the acidic Brunner Coal Measures
- Kaiata Mudstone has eroded from most of the Stockton Plateau
- Wedge Kaiata Mudstone along the Mt William Fault on the eastern edge of the Cypress Mine

Acid potential in Cypress Mine

- Quaternary deposits – NAF (non-acid forming)
- Kaiata Mudstone – PAF and NAF
- Brunner Coal Measures – PAF (potentially acid forming)
- Basement - NAF



Map by Rosanna Canard

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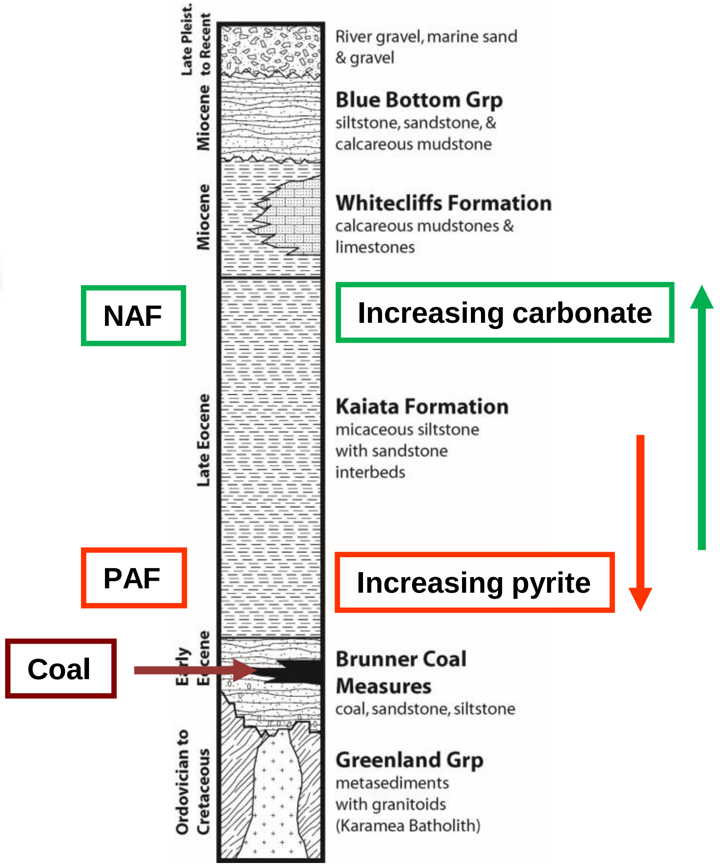
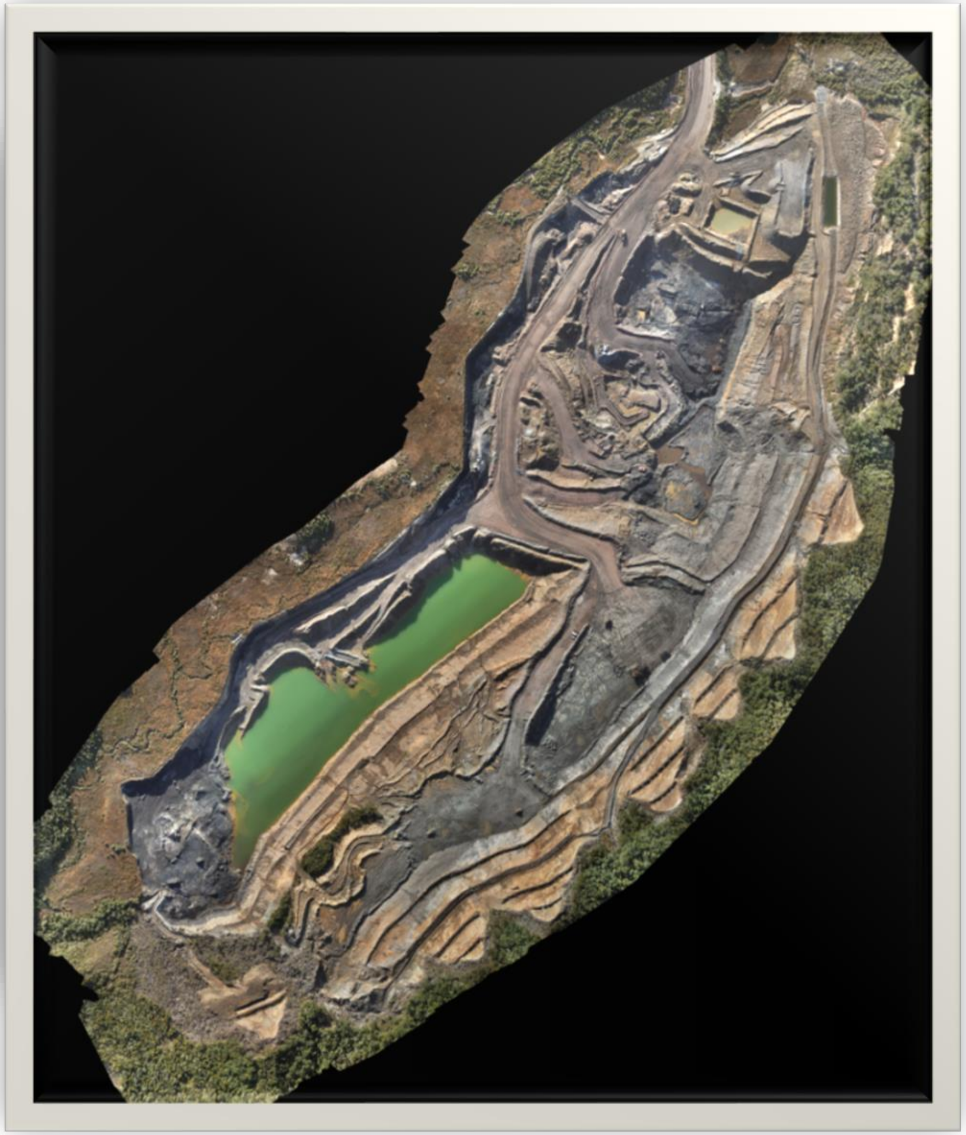
Kaiata Mudstone

- Sulfur avg 1.6 wt% , up to 4 wt%
- Framboidal and euhedral Pyrite (Weber et al, 2006) – quick to oxidise meaning no lag time to the onset of acid production
- Carbonate increasing upwards – material change from PAF to NAF
- Compaction down to 10^{-9} by running of machinery on it. No specific compaction
- O at <5% at 0.6 m and <0.5% at 1.5 m below running surface
- Grey to brown, bioturbated, massive, mudstone and siltstone – shallow marine (foraminifera) – Nathan et al. 1986
- Conformably overlies and interfingers with Brunner Coal Measures (Flores and Sykes, 1996)



Cypress Boxcut and Push-back



The importance of material designation

- PAF material requires specific treatment to decrease and/or mitigate acid to protect waterways
- Limited short term and long-term storage space for PAF
- Excess PAF material
- PAF is consented to be saturated
- NAF resource for rehabilitation

Need to ensure

- PAF goes to the PAF dump
- NAF goes to the NAF dump

NAPP values

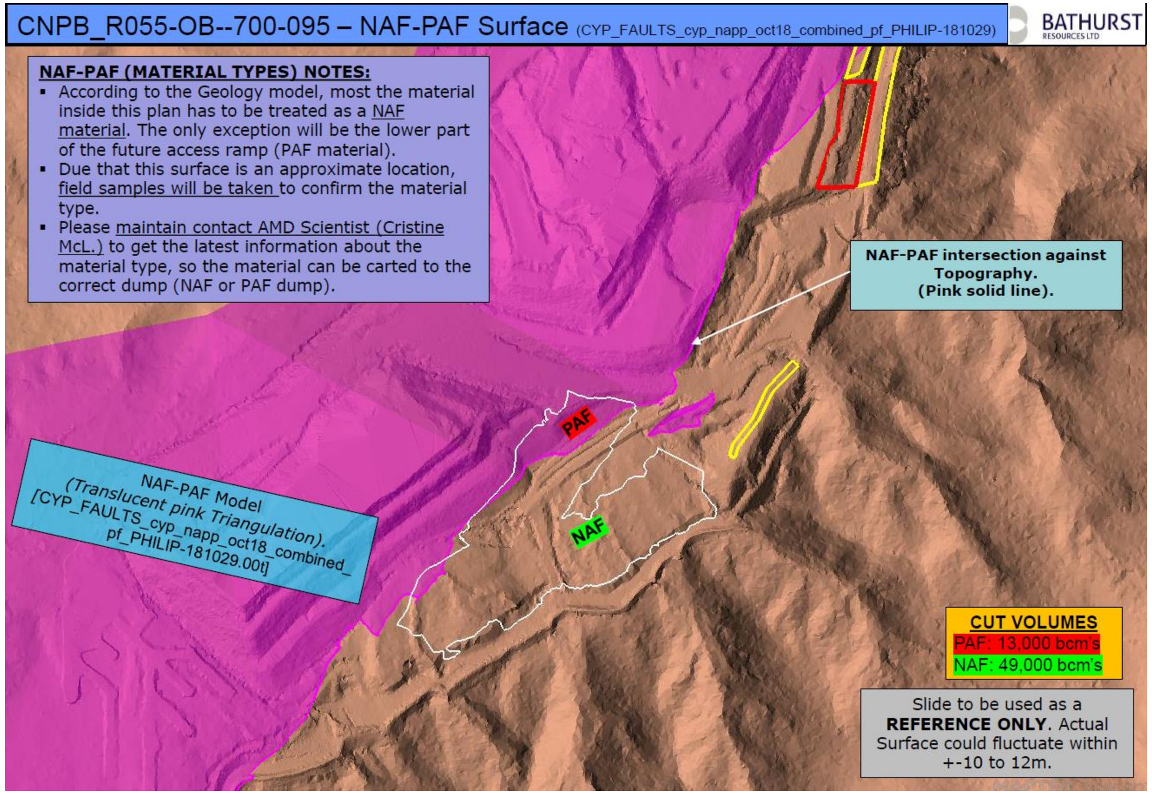
- NAPP > 0 – PAF
- NAPP < 0 – NAF
- NAPP (kg H_2SO_4/t) = (wt%S x 30.6) – ANC (kg H_2SO_4/t)

History of the NAPP = 0 kg H_2SO_4/t surface

- Created in 2018 using all available data.
- NAPP surface updated 2019 in southern area with additional data
- Suitable classification tool for boxcut on the valley floor.
- Several issues in the push-back (cut back into the flanks of Mt William).

Issues with the original NAPP surface

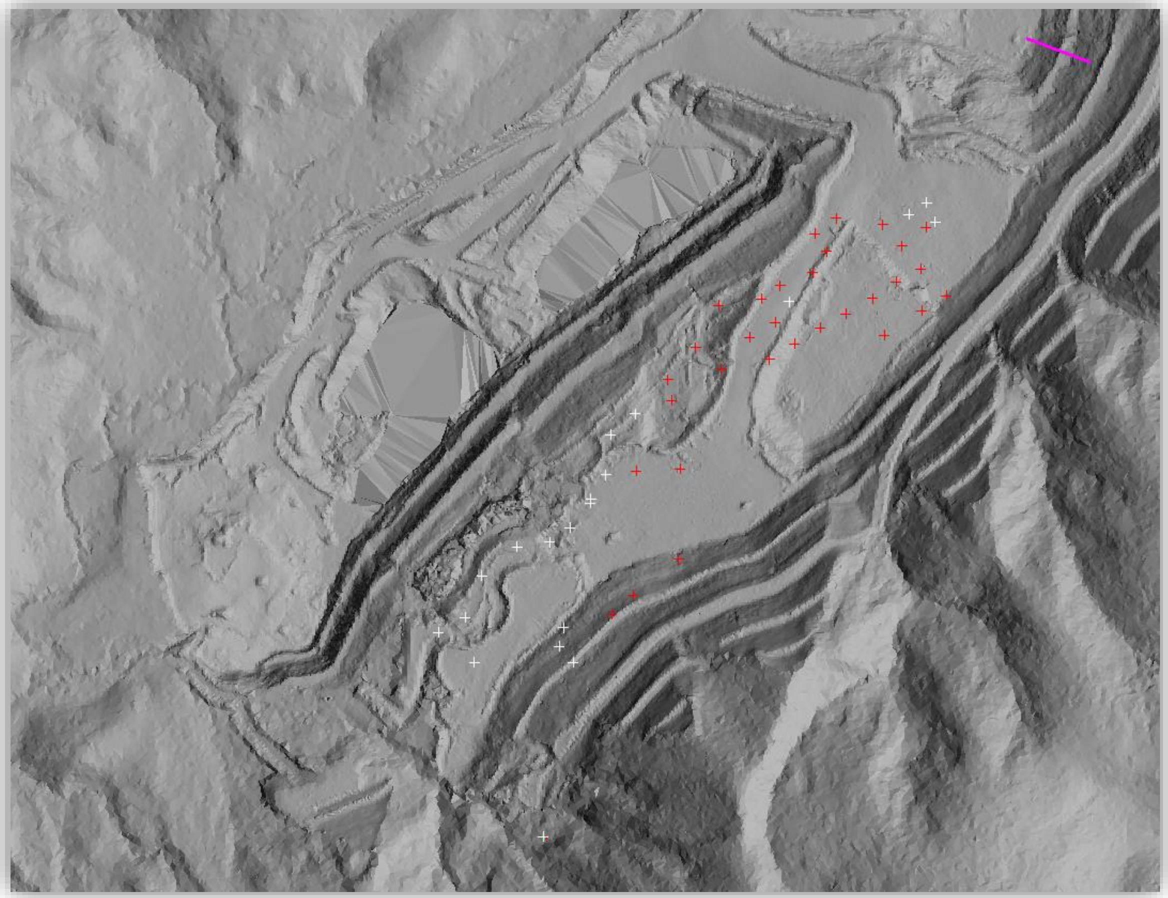
- Composition of the NAF dump was being affected
- Limited data in the pushback
- Pushback behaving differently to the boxcut.
- PAF occurring where it was not expected by the model.
- Unable to keep up with in pit testing due to changing material
- NAF sent to the PAF dump – policy, if in doubt sent to PAF
- PAF on the NAF dump decreasing the integrity of the dump
- LAF zone created PAF transition zone



➢ This led to the creation of a LAF zone

AMD drill program

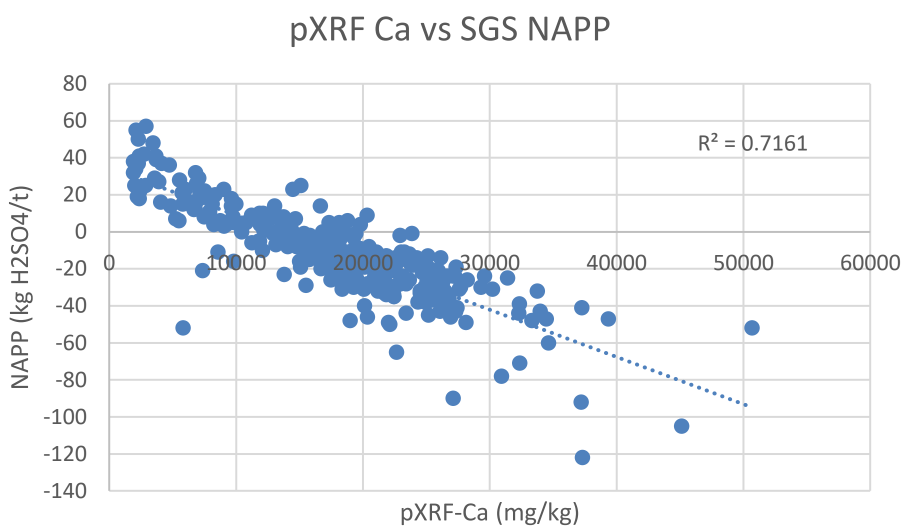
- 50 reverse circulation (RC) drillholes
- Between 9 and 48 m in depth
- 1,019 m of RC drill chip
- Limited in a few places due to limitations in the topography

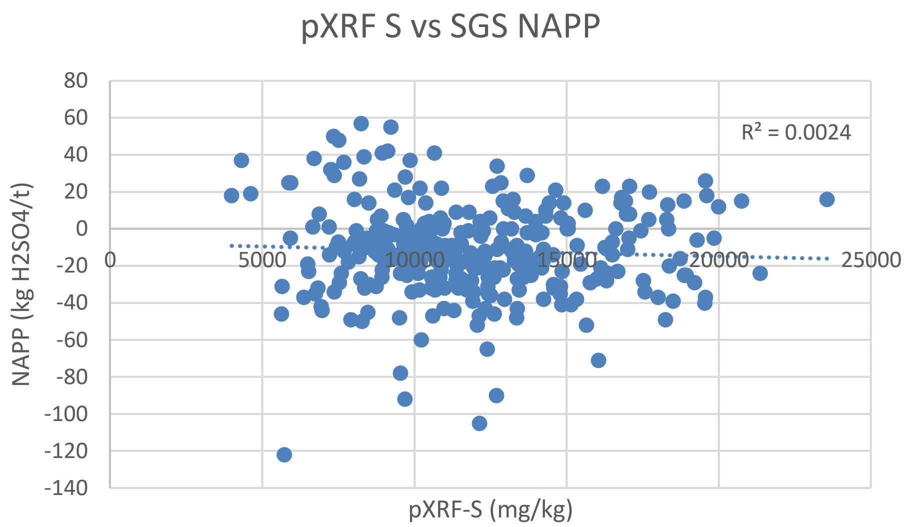


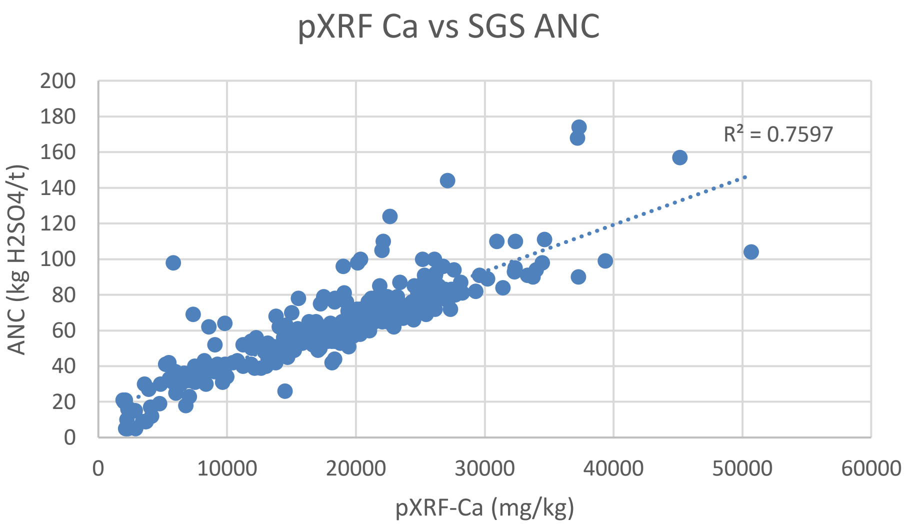
Methodology

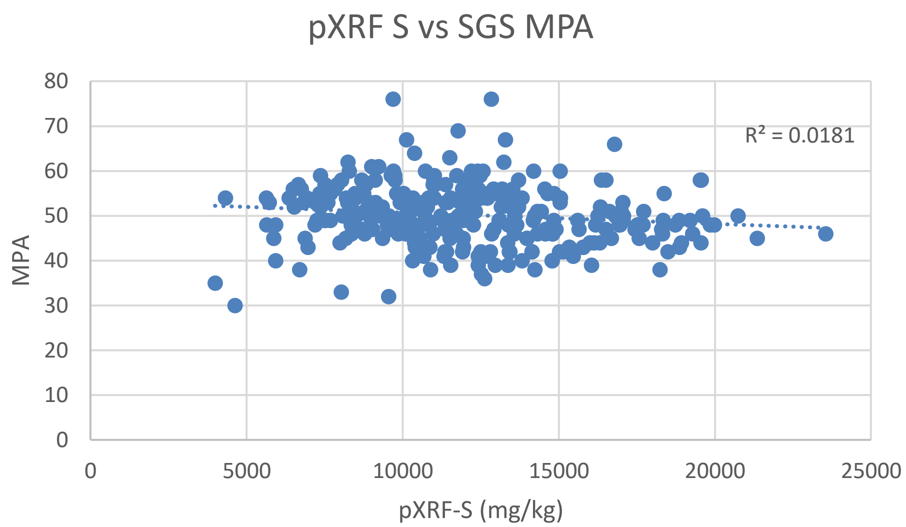
- RC drilling (produces a reasonably homogenized, dry core chip
- Sample collected as 1 m intervals
- 1 m sections riffle split into ~2-4 kg bags
- Each 1 m interval was analysed 4 x with the pXRF (4,076 analyses)
- Results were corrected for the blank and calibration reference samples and averaged
- 318 of the 1,019 samples from 18 of the drillholes were lab analysed for %S and ANC (ABA)
- Lab analyses used to validate and confirm Ca-pXRF value as appropriate
- A Ca-pXRF value of 14,000 mg/kg was used as the cut off between NAF and PAF
    - ➢ Note: there is often a distinct step change at ~14,000 mg/kg

pXRF and Lab result comparison





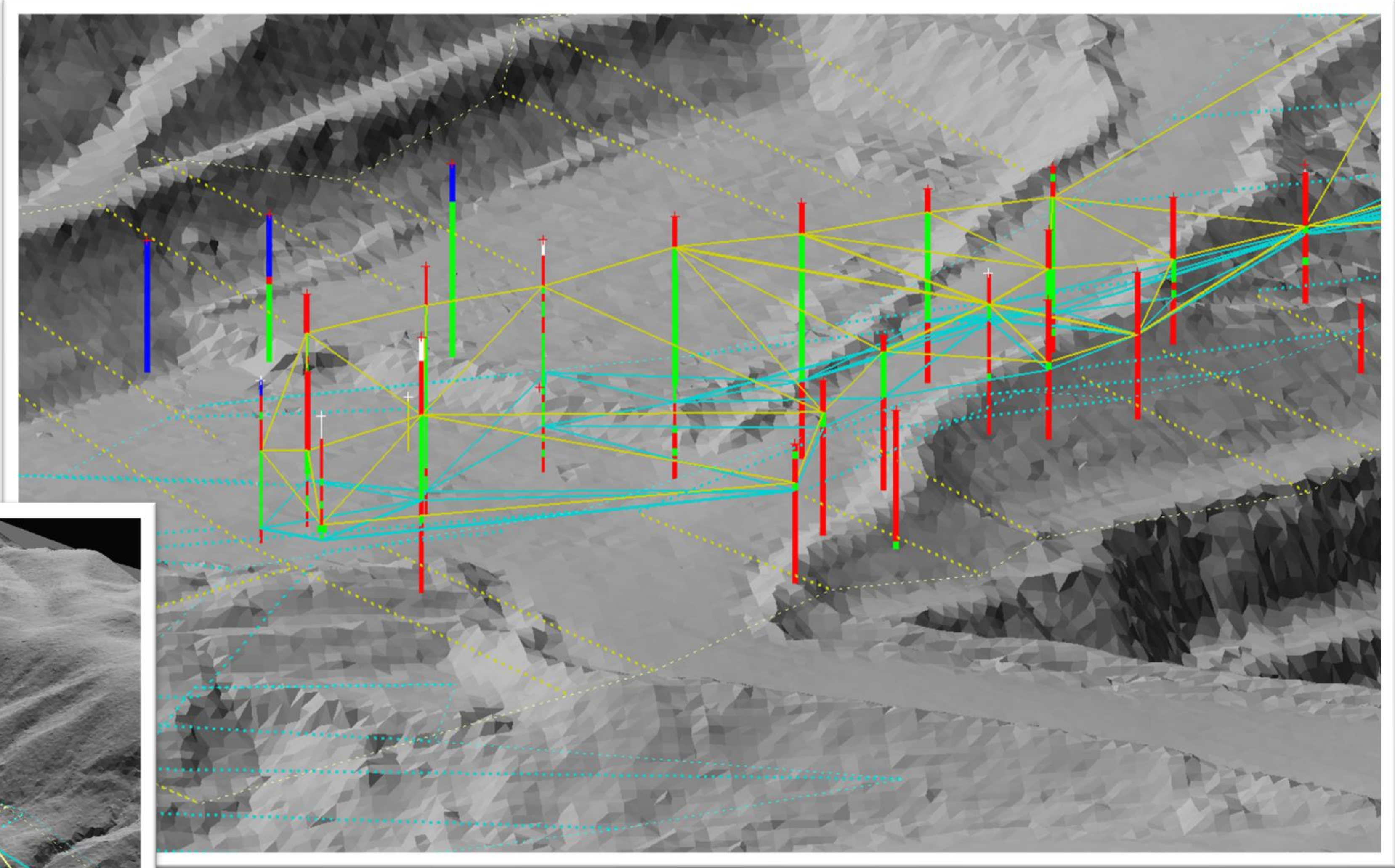


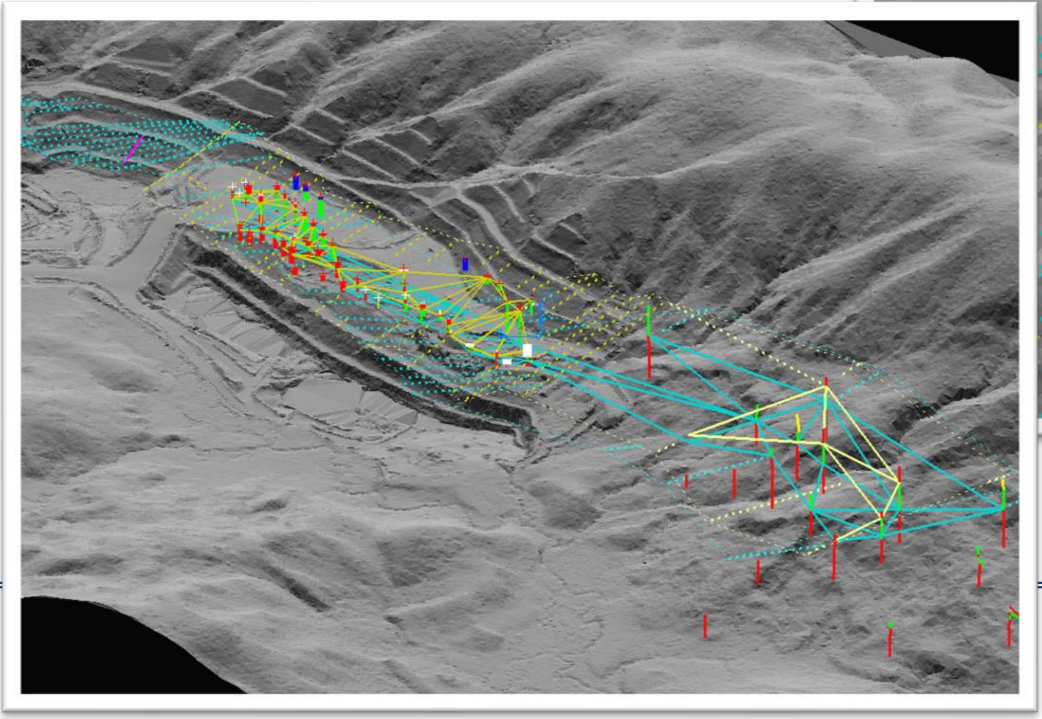


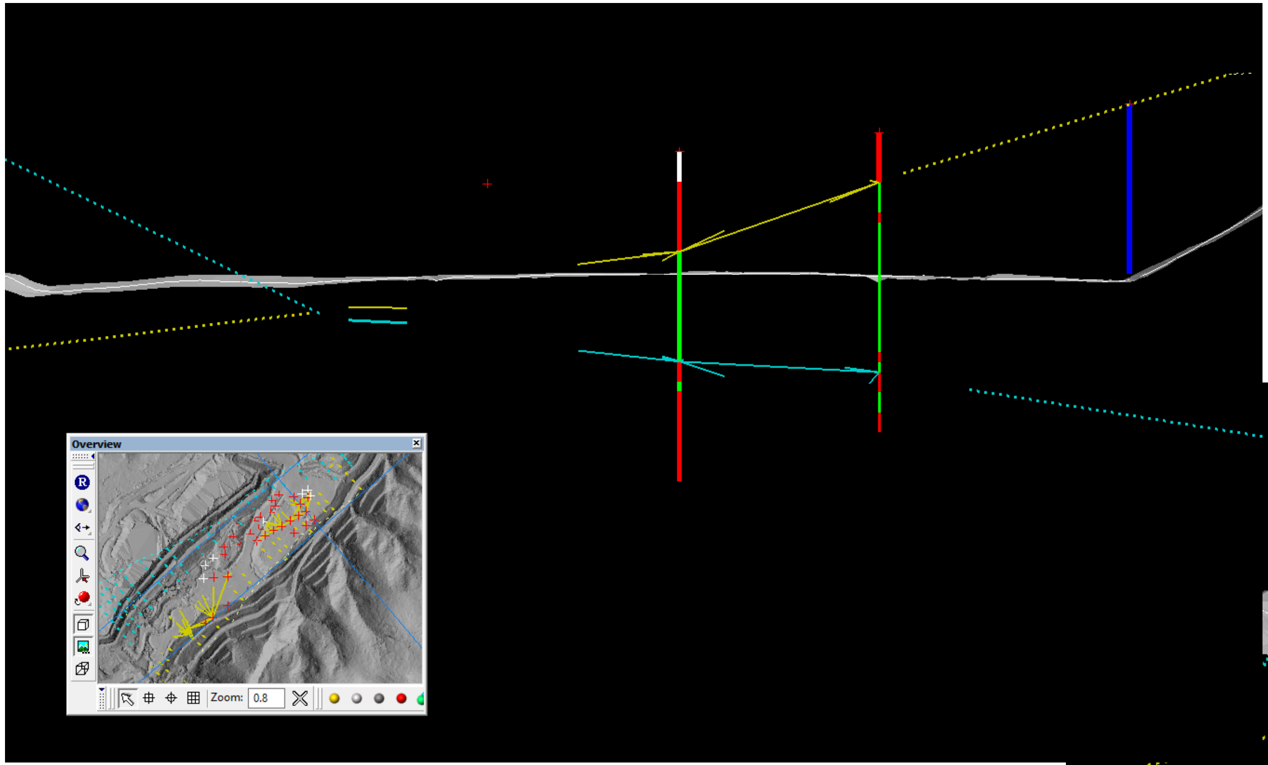
DH 3878R pXRF-Ca (14000	SGS NAPP	DH 3539 pXRF-Ca (14000	SGS NAPP	DH 3909 pXRF-Ca (14000	SGS NAPP	DH 3973 pXRF-Ca (14000	SGS NAPP	DH 4011 pXRF-Ca (14000	SGS NAPP	DH 4078 pXRF-Ca (14000	SGS NAPP
3666	41	1371		1140		5458		3995		1653	
6795	32	1411		548		2218		2466		1440	
3711	39	2361	41	1095		2737	42	2208	19	1699	
3444	48	4133	37	831		3905	27	3585	29	2575	
2891	57	16284	-13	2031		18779	-14	13137		2771	
2112	55	9848	5	4100		32369	-71	8240	4	2812	
2295	50	21430	-26	15931		26110	-39	14753	-4	4830	14
4743	36	24860	-38	17170		20600	-17	11914	4	20084	-31
2413	22	24472		28574		22866	-14	15207	-3	34642	-60
19344	-23	21803		24065		24246	-14	13945	-1	20878	
26914	-46	24563		23812		29299	-30	18344	3	19403	
34467	-47	23800		31634		39358	-47	17481	-26	32728	
33748	-32	35891		20323		19428	-8	23914	-18	19695	
26381		22224		25840		18189	-4	17828	-21	25154	
14 pXRF NAF values		23325		24647		20909	-14	22455	-21	31003	
removed		21818		26352	-26	23255	-11	26183	-35	21627	
21418		22737		18866	-11	25155	-20	27415	-41	26405	-32
27113	-24	25933		17080	-11	17884	3	22922	-2	23202	-25
13034	14	17684	-7	33318	-48	25617	-21	17504	-3	9023	23
16408	-4	26255	-28	32349	-39	28239	-26	19793	4	6961	17
17529	-12	33983	-43	18795	6	25941	-21	22638	-65	19261	-30
17194	-4	6007	23	22110	-50	27116	-90	20492	-8	5802	15
17943	-16	6730	14	21429	-20	27141	-23	25113	-13	9879	
13825	1	7052	29	9055	3	9974	15	16639	14	7010	
19266	-3	6335		8054	16	11773	-5	12081	-10	5155	
22936				4842		6401	16	7909	11	5185	
11 pXRF NAF values				14182		9833		16716	-9	5565	
removed						5802		10792	5	4738	
25495						5 pXRF PAF values				5967	
18916	-22					removed				5783	
13208	0										

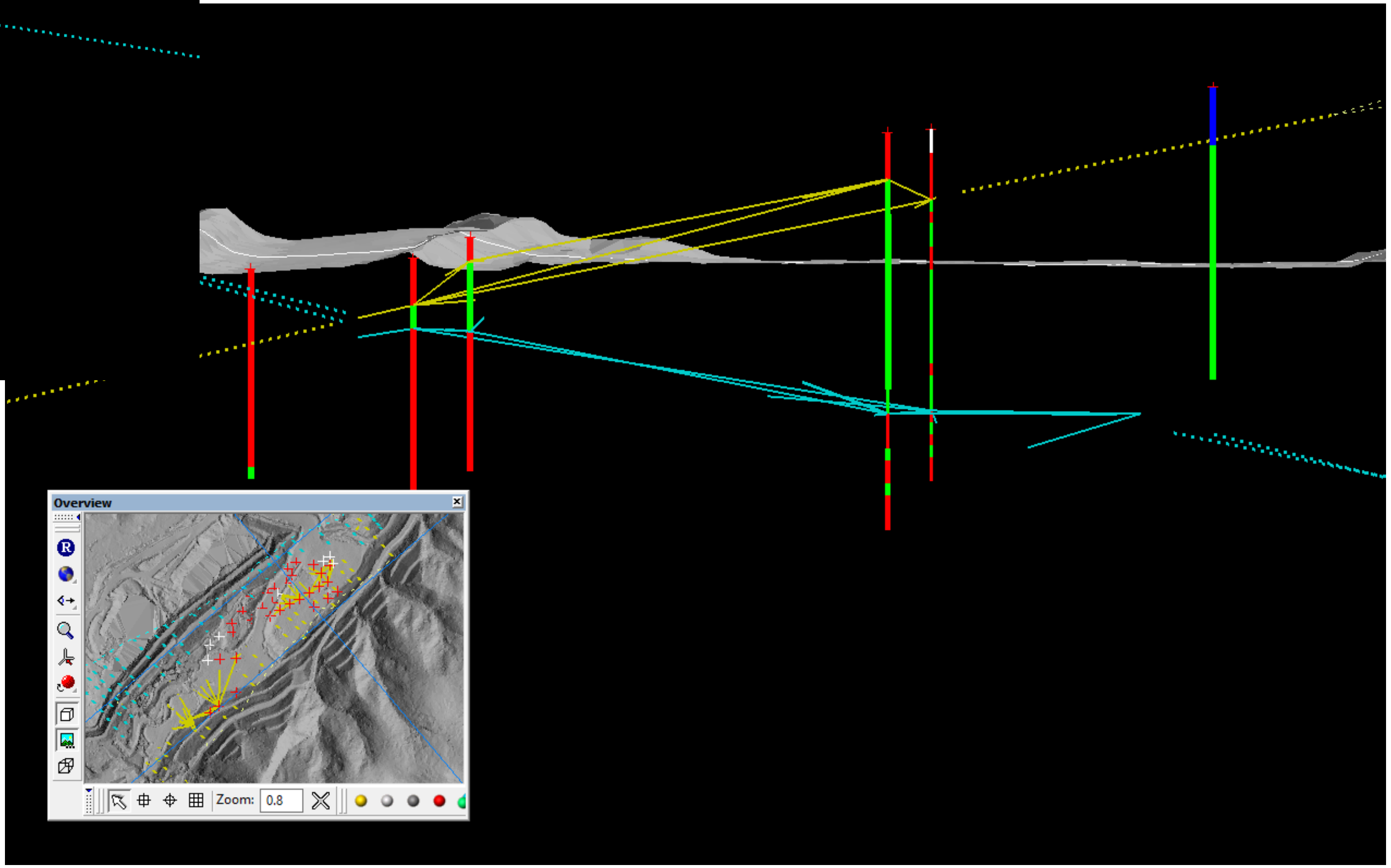
Creating the Geochemical Block Model

- Classifications were based on the NAPP data
- When the Ca-pXRF and Lab NAPP values differed, the geological – geochemical model and NAPP data was used to determine the NAPP surface
- Only distinction was between NAF and PAF.



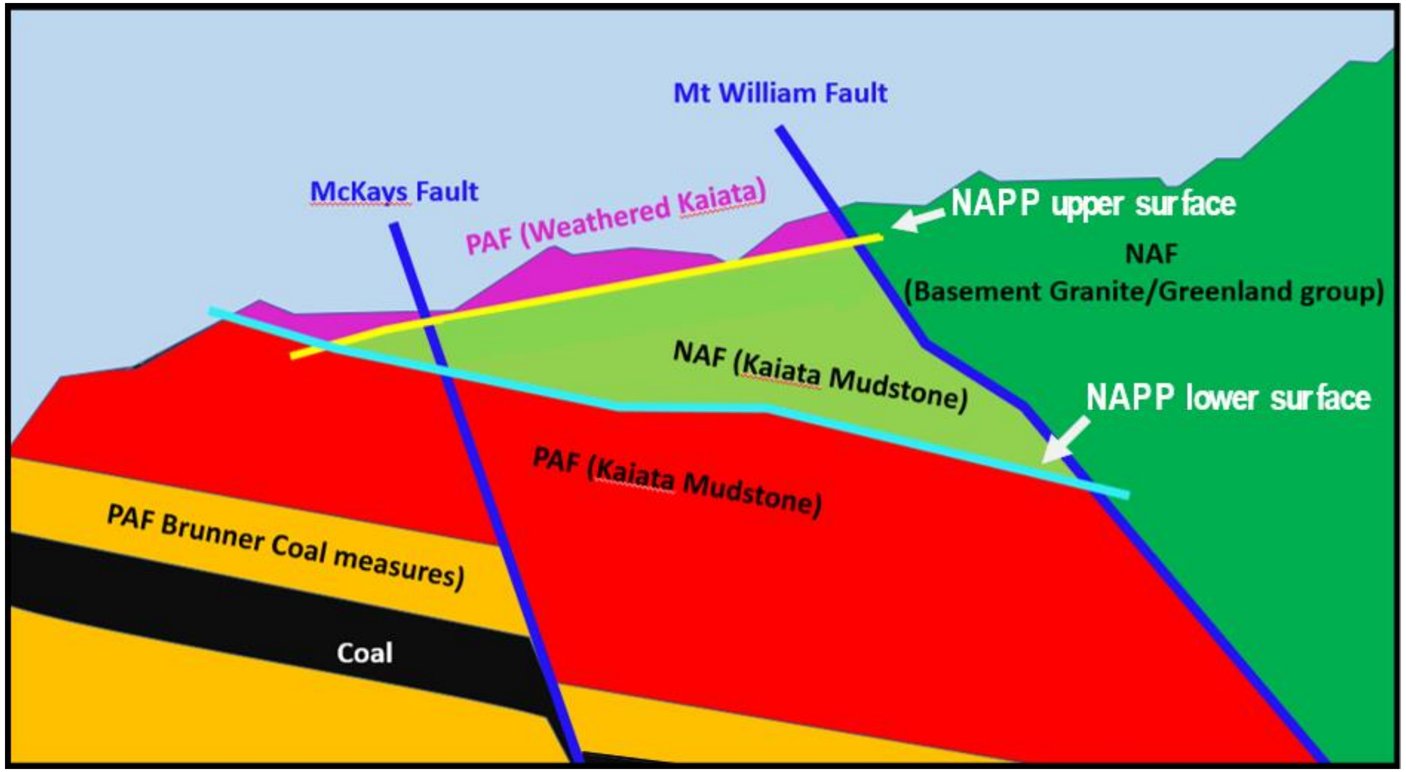



Overview
Zoom: 0.8


Overview
Zoom: 0.8

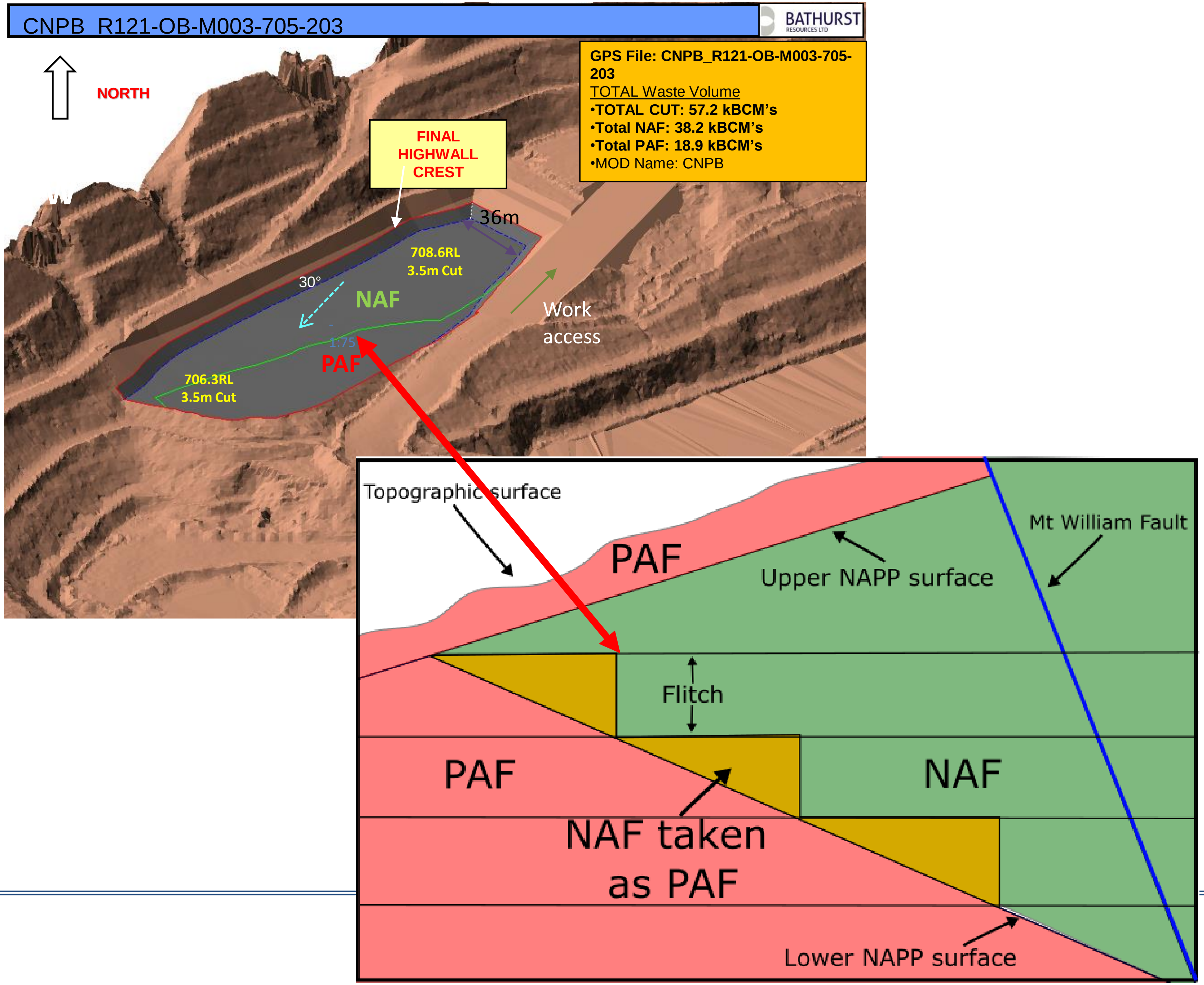
New NAPP surfaces

- The Kaiata Mudstone behaved differently on the flanks of Mt William in the pushback
- 2 NAPP surfaces created
  - ➢ Upper surface – topographically controlled
  - ➢ Lower surface – stratigraphically controlled
- Eastern boundary of NAF Kaiata is the Mt William Fault with granite behind it
- Creates a wedge of NAF



NAPP surface use in the field

- Conservatism built into the surface through the method of digging the material
- Because of the angle of the NAPP surface and the lifts being taken in 3 or 5 m flitches there is a triangle of NAF that is taken as PAF in each flitch
- Enhances the integrity of the NAF dump
- Loss of valuable NAF material
  - ➢ Work needs to be done here



Operational benefits of the pXRF and NAPP surfaces

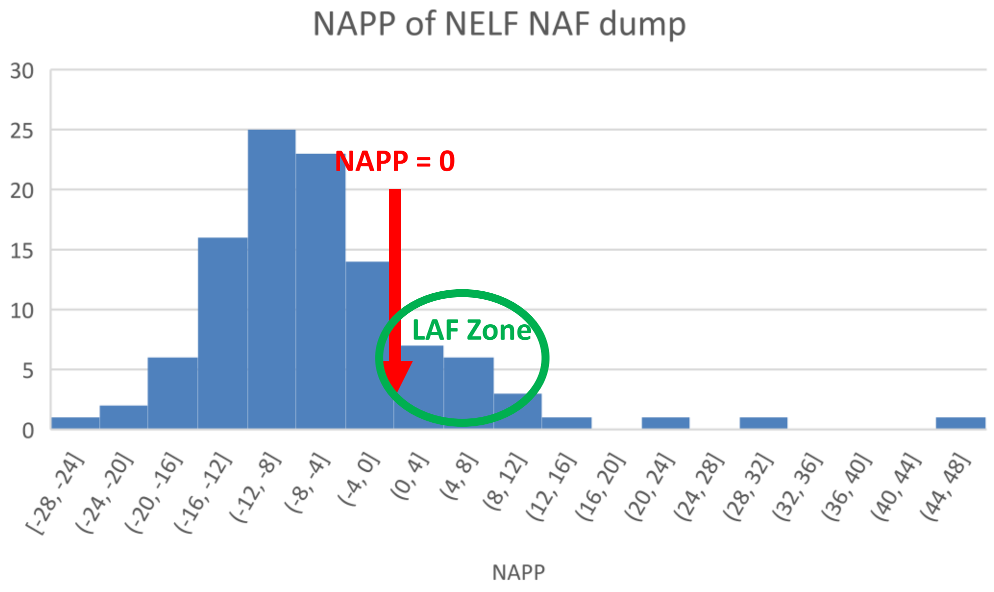
The use of the pXRF has allowed

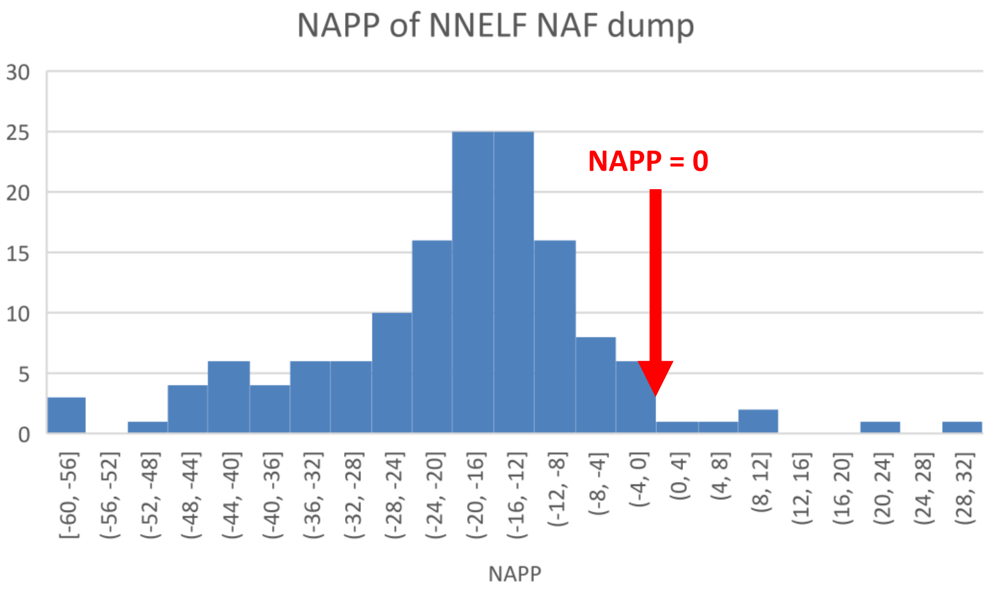
- Decreased in pit sampling
- In pit sampling by pXRF gives instant results
- Less disruption to operations
- Inexpensive
- Unlimited sampling
- Time and convenience

NAF Dump integrity (Composition)

	No. samples	Median NAPP	Average NAPP
NELF NAF	107	-7	-5.5
NNELF NAF	142	-16	-19

A low negative NAPP does not reflect an acidic material
Granite can have low %S and ANC resulting in a low negative NAPP





Acknowledgements

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References

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