A Modern Resource and Reserve Modelling Process for Structurally Complex Coal Deposits

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Introduction

- SRK has consulted to 252 coal sites worldwide at different stages of development, offering consulting services related to:
  - exploration, geo-environmental, geological modelling, resources, mine planning, tailings, reserves and mine closure studies
- 43 sites in Canada and 14 sites in the U.S.A.

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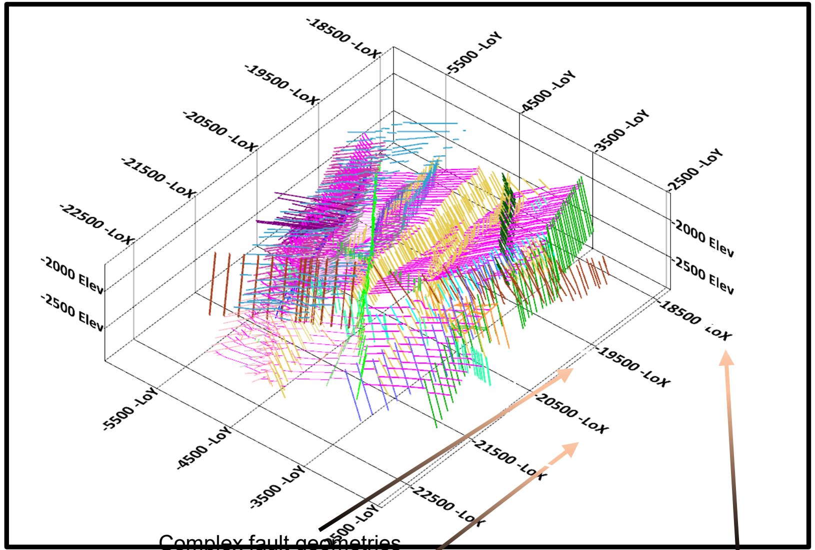
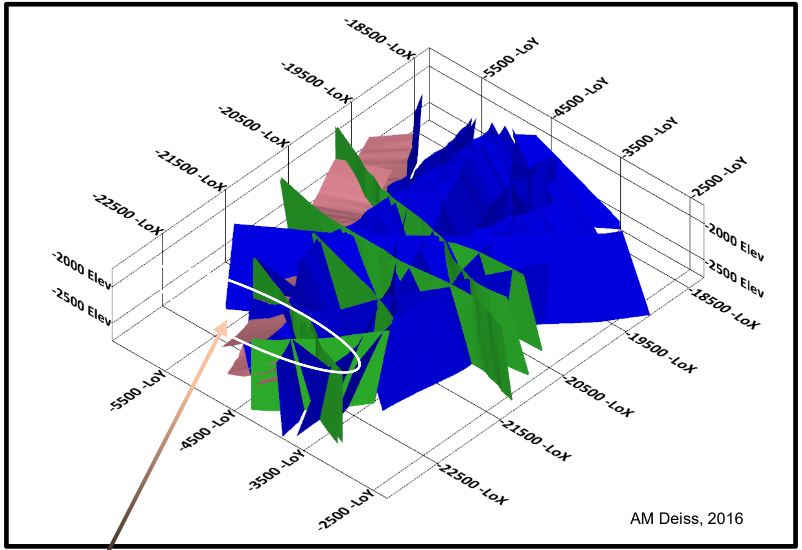
- 43 sites in Canada and 14 sites in the U.S.A.
- Geological modelling trends changing from explicit to implicit due:
  - Volume (measured and user interpreted) and rate of information being received
  - The need for consistent application of geological rules (auditability) in geological modelling
  - Reasonable representation of complex geological morphologies and relationships
  - Operations requiring a short turn around in geological and grade control models for mine planning purposes
  - Consultants require tools to reduce manual processing of geological shapes (clipping, complex shape interaction)
  - Most 3D modelling software today has some implicit modelling capability
- Coal quality estimation trends:
  - 2D to 3D (LVA)
  - Considering geostatistics to establish continuity ranges rather than fixed ranges e.g., 88-21 Hughes et. al., 1989 and JORC)
- Generally, seam aggregation (working sections) use a rigid compositing technique
- Required a flexible scenario testing tool
- Leapfrog Geo™ selected to developed a coal modelling workflow to deal with complex coal geology (FastRBF™, data sources, vein system, repeatable and leader)
- Datamine Studio RM™ selected as an interim work around (block models, resource estimates, additional attributes and scripting)
- MinePlan™ (MineSight) selected to process the working sections as the standard for coal mine planning in Canada

Explicit versus Implicit modelling

- Explicit 2D grid (X,Y, attribute), 2.5D (X,Y,Z sectional) to 3D (XYZ)





Complex fault geometries

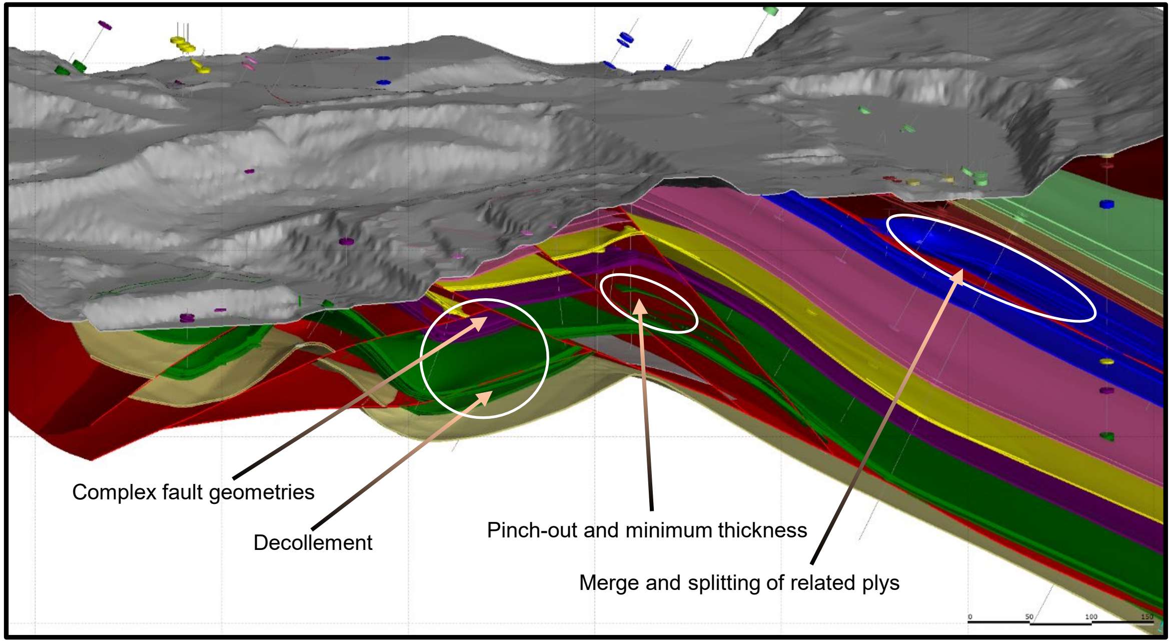
Decollement

Pinch-out and minimum thickness

Merge and splitting of related plys

Explicit versus Implicit modelling

- Solution Implicit modelling using a vein system



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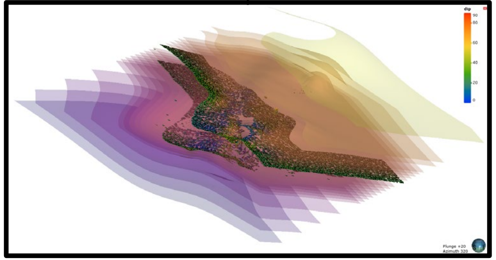
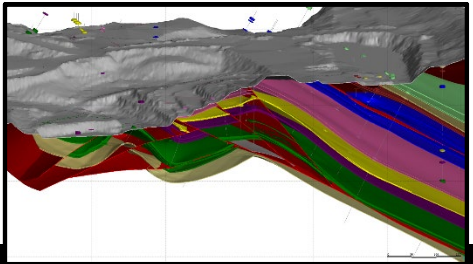
Simplified Coal Geology Model Workflow

Drilling, field mapping, geophysics and interpretation → Structural Model and define vein system hierarchy → Select coal plys with most coverage → Produce global Form Interpolants → Activate faulting (implicit veins produced) → Review and adjust offsets in adjacent blocks → Utilize data local or regional



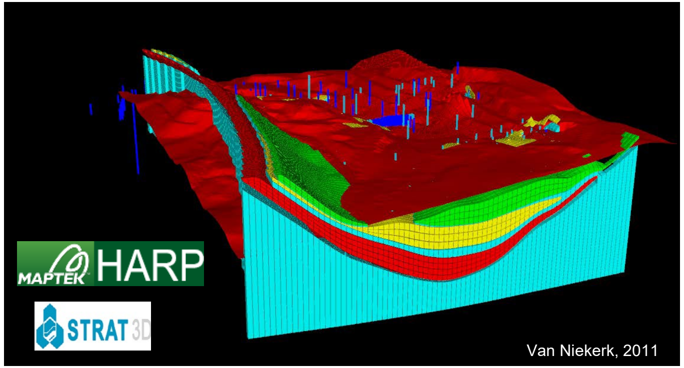


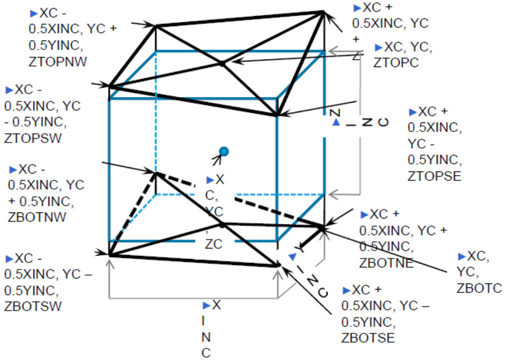
MinePlan Datamine

LF Limitation

Block Model Types and Considerations

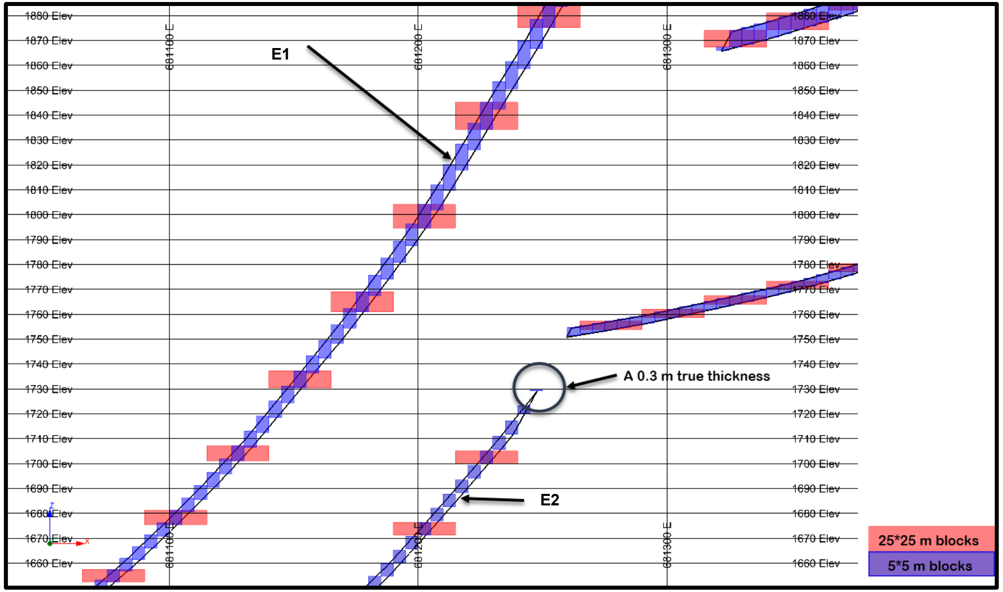
- 3-D prism block





Block Model Types and Considerations

- Parent cell / sub-cell or sub-block



Sensitivity on volume solid block model inside solid triangulation to solid triangulation (E1)

Source	Volume	% Difference (BM-VF)/VF
WF	174,288,775	0.0%
HARP BM 5.0 m	175,988,897	1.0%
BM 25.0 m[1]	61,137,827	-64.9%
BM 5.0 m[2]	135,303,220	-22.4%
BM 2.5 m	152,616,703	-12.4%
BM 1.0 m	165,257,403	-5.2%
Model size	**Cells (Number)**	
BM 25.0 m	122,498	0.0%
BM 5.0 m	3,305,277	2598.2%
BM 2.5 m	13,220,995	10692.8%
BM 1.0 m	82,631,443	67355.3%
Model size	**Size (KB)**	
BM 25.0 m	22,280	0.0%
BM 5.0 m	400,644	1698.2%
BM 2.5 m	1,602,552	7092.8%
BM 1.0 m	6,997,184	31305.7%

Sensitivity on volume solid block model to solid triangulation (E1)

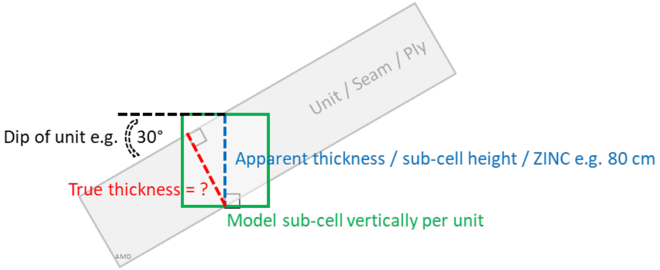
Source	Volume	% Difference (BM-VF)/VF
WF	174,288,775	0.0%
HARP BM 5.0 m	175,988,897	1.0%
BM 5.0 m	174,290,402	0.0%
BM 2.5 m	174,277,209	0.0%
BM 1.0 m	174,279,807	0.0%

Block Model Types and Considerations

- Regularized block (single and multi-percent for mine planning)

Datamine Block Model Bridge

- Dip and dip direction
- True thickness
- All estimates applied to single node
- Determination of mean values:
  - Dip weighted by 3D area
  - True thickness weighted by 3D area
  - Qualities weighted by volume / Tonnage?
- Example of csv output



$$True\ Thickness = Apparent\ thickness * \sin(90° - Dip)$$
$$= 80 * \sin(60)$$
$$= 69.28\ \text{cm}$$

EAST	NORTH	PLYID	FLTBLK	CLASS	ZTOP	ZMID	ZBOT	SDIP	ATCK	TTCK	ASHa	IMa	FCa	VMa	Sa	SGac
-149,810	-4,162,270	E1	4	1	6,094.29	6,093.84	6,093.39	15.69	0.91	0.88	10.34	0.60	67.58	21.14	0.87	1.36
-949,817	-4,162,277	E1	4	1	6,092.67	6,092.21	6,091.75	15.69	0.91	0.88	10.34	0.60	67.59	21.12	0.87	1.36
-949,824	-4,162,284	E11	4	1	6,091.04	6,090.58	6,090.12	14.35	0.91	0.89	9.54	0.60	68.74	20.74	0.89	1.35
-949,831	-4,162,292	E11	4	1	6,089.40	6,088.94	6,088.48	15.74	0.93	0.89	10.35	0.60	67.60	21.09	0.87	1.36
-949,786	-4,162,265	E2	4	1	6,094.52	6,094.06	6,093.61	15.64	0.91	0.88	9.53	0.60	68.75	20.74	0.89	1.35
-949,793	-4,162,273	E2	4	1	6,092.73	6,092.27	6,091.81	15.64	0.91	0.88	9.55	0.60	68.75	20.73	0.89	1.35
-949,799	-4,162,280	E2	4	1	1,090.95	1,090.49	1,090.04	15.72	0.91	0.88	9.57	0.60	68.74	20.71	0.89	1.35

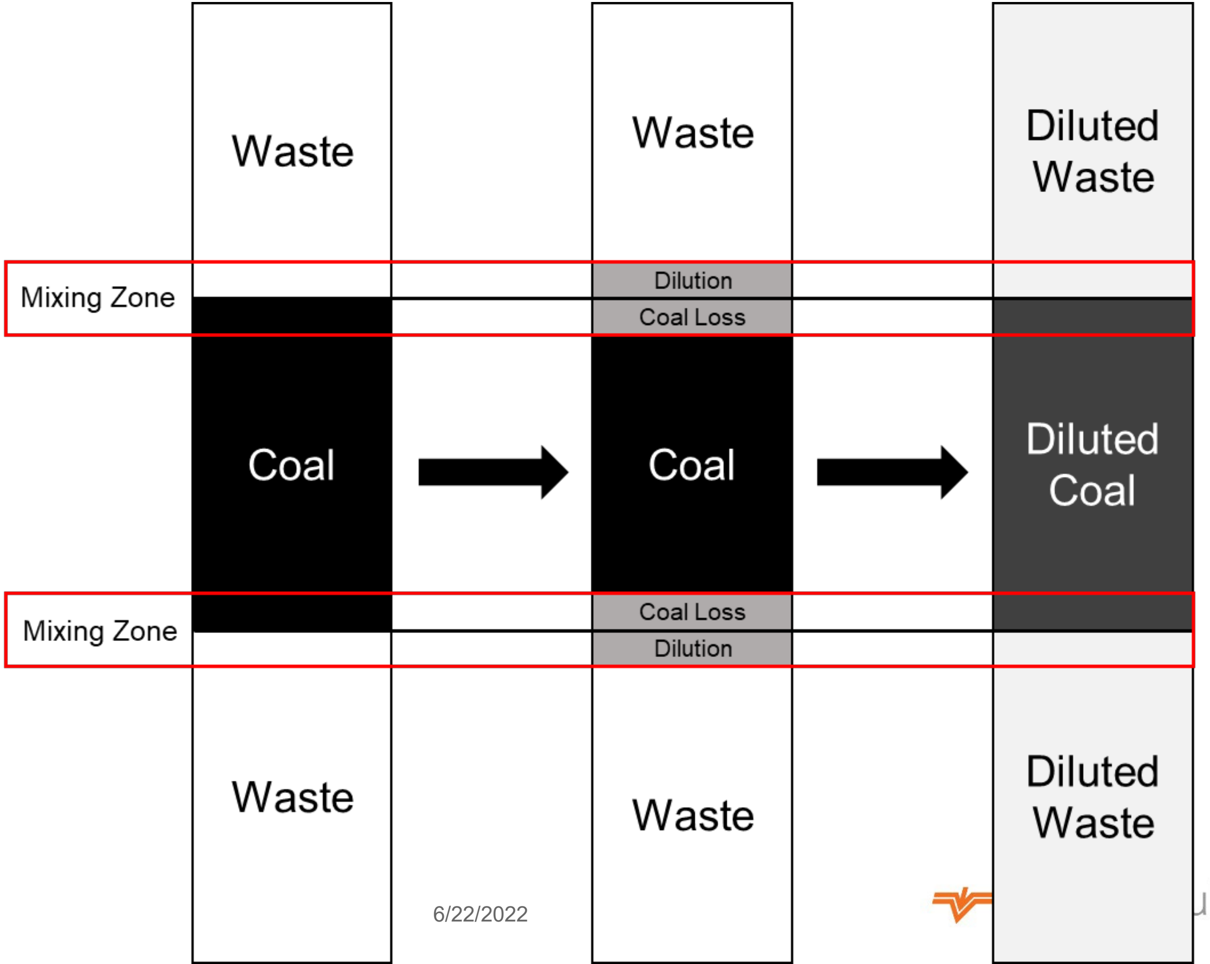
Advantages for Mining Engineers

- Working Sections / Seam Aggregation is controlled by the Mining Engineer
  - In existing methods, this is often controlled at compositing – limiting the ability of mining engineer to adjust
  - Engineers can now easily conduct cutoff sensitivity and review impacts of equipment/mining method adjustments
- Loss and Dilution is taken into account in working sections
  - Working Sections set minimum cutoff for true thickness and maximum cutoff for diluted ash
  - Diluted ash cutoff considers dilution both from included partings as well as mixing zones at exterior coal/waste contacts

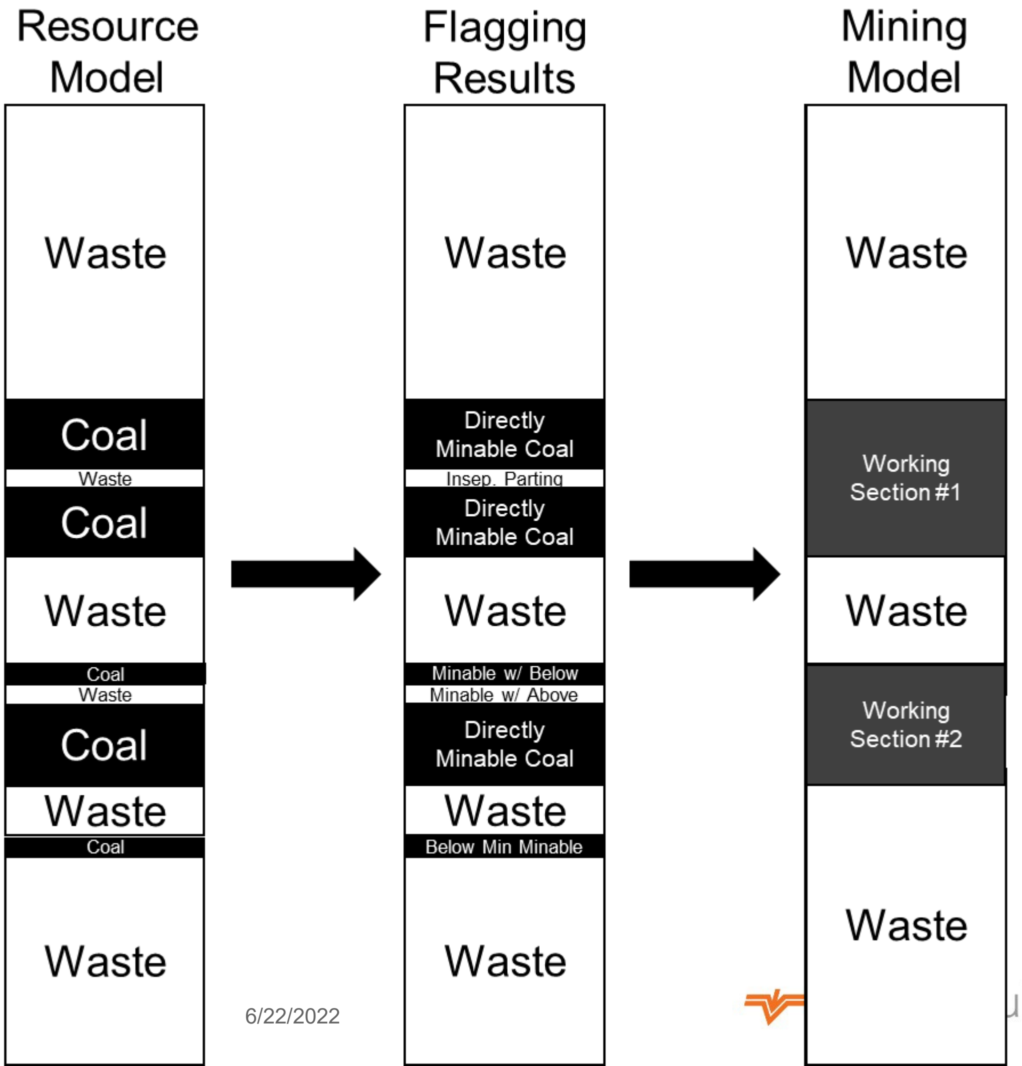
From Resource Model to Reserve Model

- Loss and Dilution
- Working Sections
- 3DBM Coding

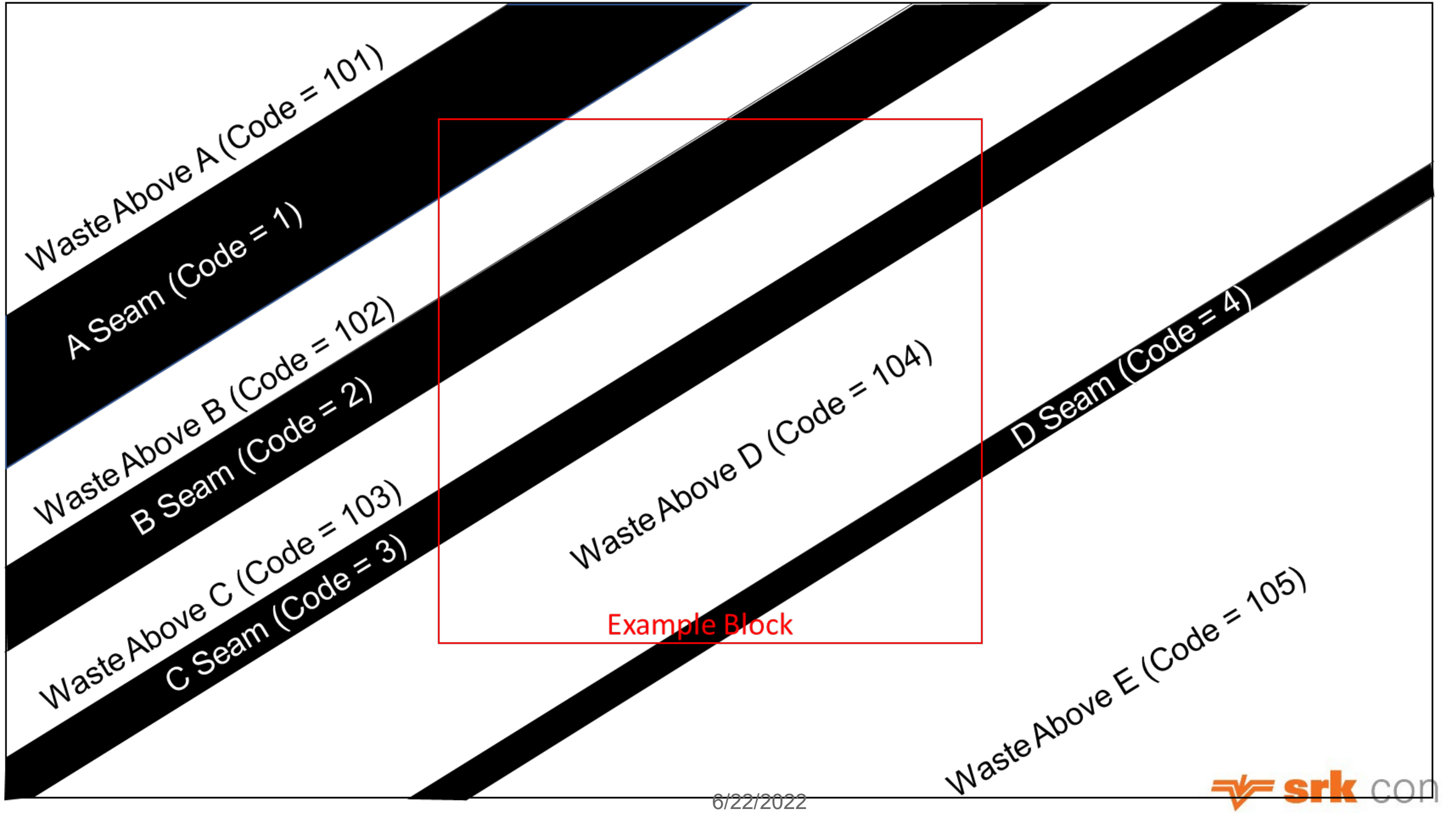
Applying Loss and Dilution



Flagging Working Sections



Coding the 3D Block Model



Future Work

Removal of intermediate processing steps

- Current process requires three software packages and intermediate steps
- Process should seamlessly transition from Leapfrog to MinePlan 3D Block Model

Working Sections directly on 3DBM

- Working section using 3DBM directly can improve positional accuracy by removing GSM step
- Currently must be mindful of cross-dip block dimension and steepness of dips in this direction to ensure positional accuracy of model

Questions?

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