Wishbone Hill

Senior Mine Design Project
Spring 2009

By

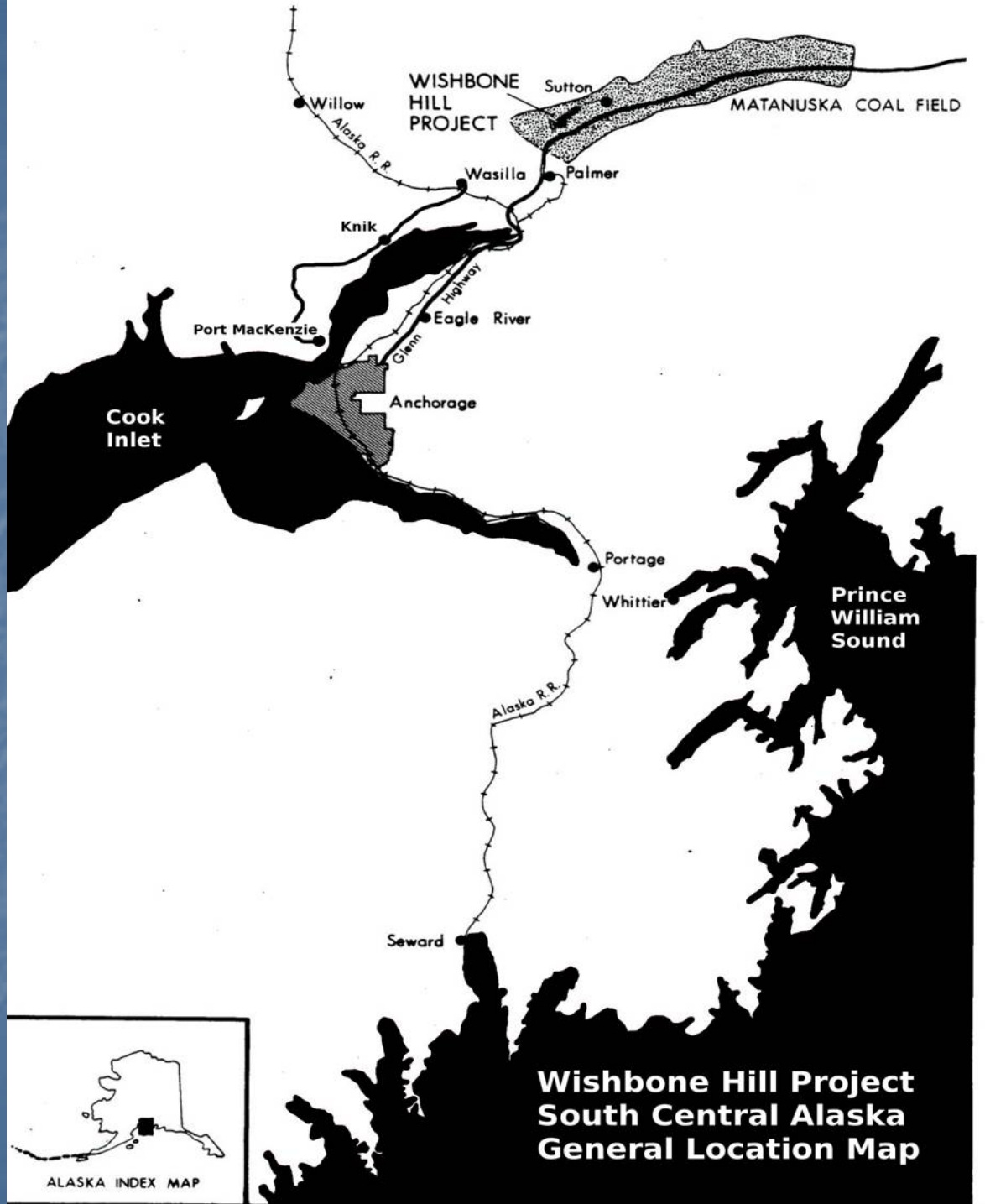
James Frost

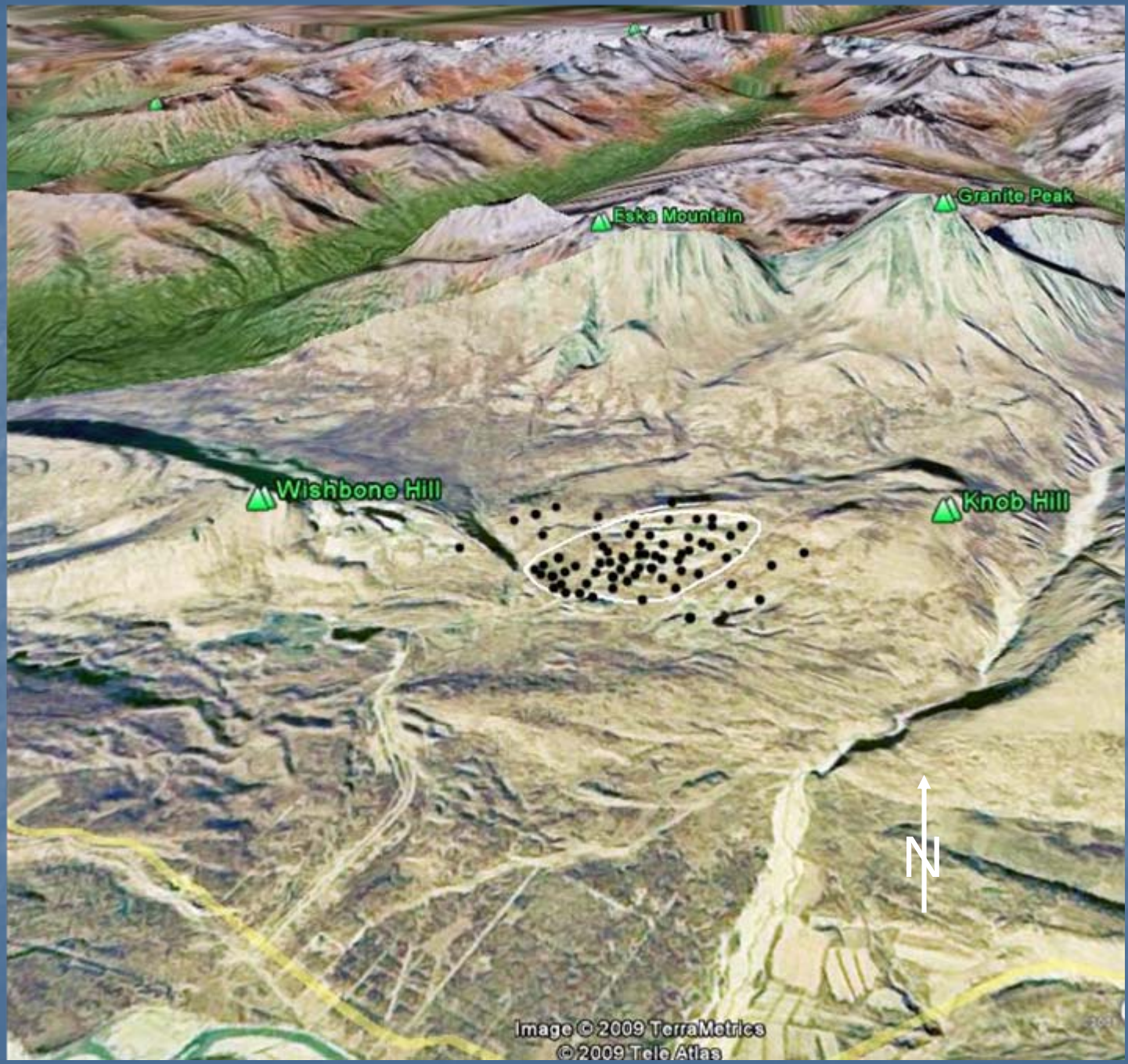
Kris Catabay

Keith Clark

Forward Looking Statement

- This project is a fictitious design conducted as an exercise for academic purposes. The results are based upon a number of assumptions that were necessary to complete the project, but which have not been field-validated. Results of this project should not be construed to represent actual conditions, intentions, or designs in this region. The project involved limited scope and resources, and should be regarded as a conceptual exercise. Entities which contributed data to this project bear no responsibility for the results contained.


WISHBONE HILL PROJECT
Sutton
MATANUSKA COAL FIELD
Willow
Alaska R.R.
Wasilla
Palmer
Knik
Highway
Eagle River
Port MacKenzie
Glenn
Anchorage
Cook Inlet
Portage
Whittier
Prince William Sound
Alaska R.R.
Seward
ALASKA INDEX MAP
Wishbone Hill Project
South Central Alaska
General Location Map


Granite Peak
Eska Mountain
Wishbone Hill
Knob Hill
N
Image © 2009 TerraMetrics
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Overview

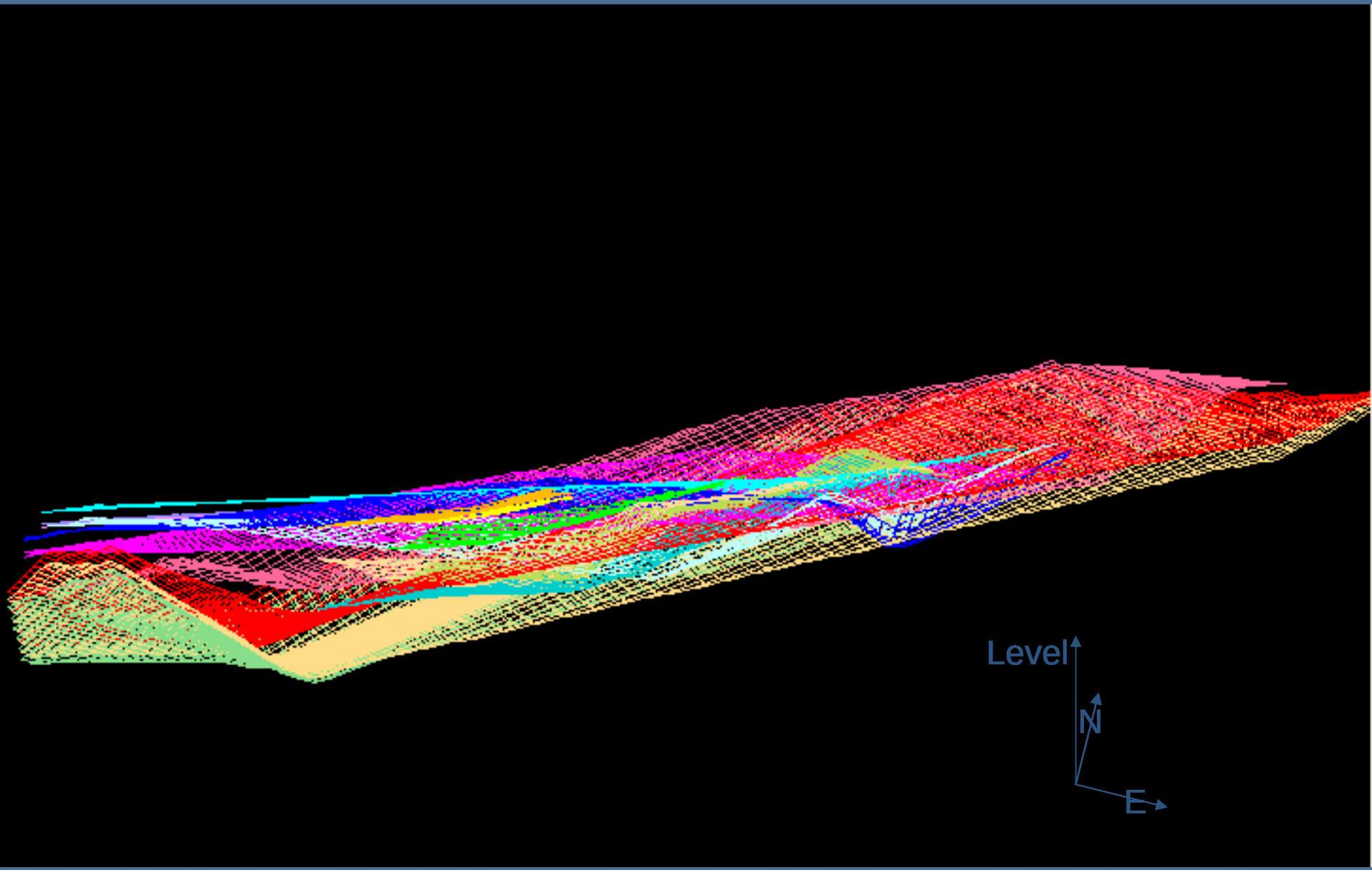
- From 1916-1968 7M tons mined in area
- Bituminous Coal with banded Shale
- Cleaned Coal: 11,710 btu/lb, 0.4% Sulfur, 15% ash
- Ownership: Union Pacific and Hawley (1983), Idemitsu (1988), CIRI (1995), Usibelli (1997-Present)
- Other Deposits Nearby
- Mine Designed for 1 Mtpy


Mine Dump
Topsoil Stockpile
Mine Admin
Mine Washplant
Slurry Pond
Sediment Pond
Alternate Mine Dump
DH-2
DH-4C
DH-4
DH-3
DH-55
DH-66
DH-64C
DH-5
DH-6
DH-67
DH-68
DH-8
DH-27
DH-12
DH-11
DH-11C
DH-7
DH-44
DH-10
DH-72
DH-65C
DH-43
DH-1
DH-54
DH-71
DH-31
DH-13
DH-53
DH-9
DH-26
DH-52
DH-41
DH-73
DH-40
DH-16
DH-17
DH-70
DH-69
DH-25
DH-37
DH-15
DH-18
DH-50
DH-38
DH-32
DH-14
DH-36
DH-20
DH-24
EA-3
DH-74
DH-33C
DH-76
DH-63C
DH-77
EA-5
DH-21
DH-34
DH-75
DH-19A
DH-19
DH-23C
DH-23
EA-1
EA-2
DH-28
DH-57
DH-22
DH-56A
DH-35

Reserves

- Total Seams = 17
- Total ROM Tons = 10,800,000 tons
- Total Clean Tons = 6,480,000
- Average Seam Thickness = 6’10”
- Max depth of deposit = 700’

Seam	Density(tons/ft3)	Recovery	Thickness (ft)	Cleaned Coal (tons)
BB	0.04	60.00%	14.92	203,647
JV1	0.04	60.00%	6.76	50,741
JV2	0.04	60.00%	7.01	40,073
BD1	0.04	60.00%	9.41	107,273
UN1	0.04	60.00%	4.72	91,318
UN2	0.04	60.00%	4.68	91,979
UN3	0.04	60.00%	4.32	101,837
CH	0.04	60.00%	3.25	123,009
MT	0.04	60.00%	6.89	280,810
MT1	0.04	60.00%	4.44	12,957
MT2	0.04	60.00%	5.25	15,308
DV	0.04	60.00%	7.23	432,428
EM	0.04	60.00%	6.44	366,807
MY	0.04	60.00%	4.50	440,308
ES	0.04	60.00%	7.34	1,229,667
SW	0.04	60.00%	11.53	1,931,617
MN	0.04	60.00%	7.37	957,544


Level
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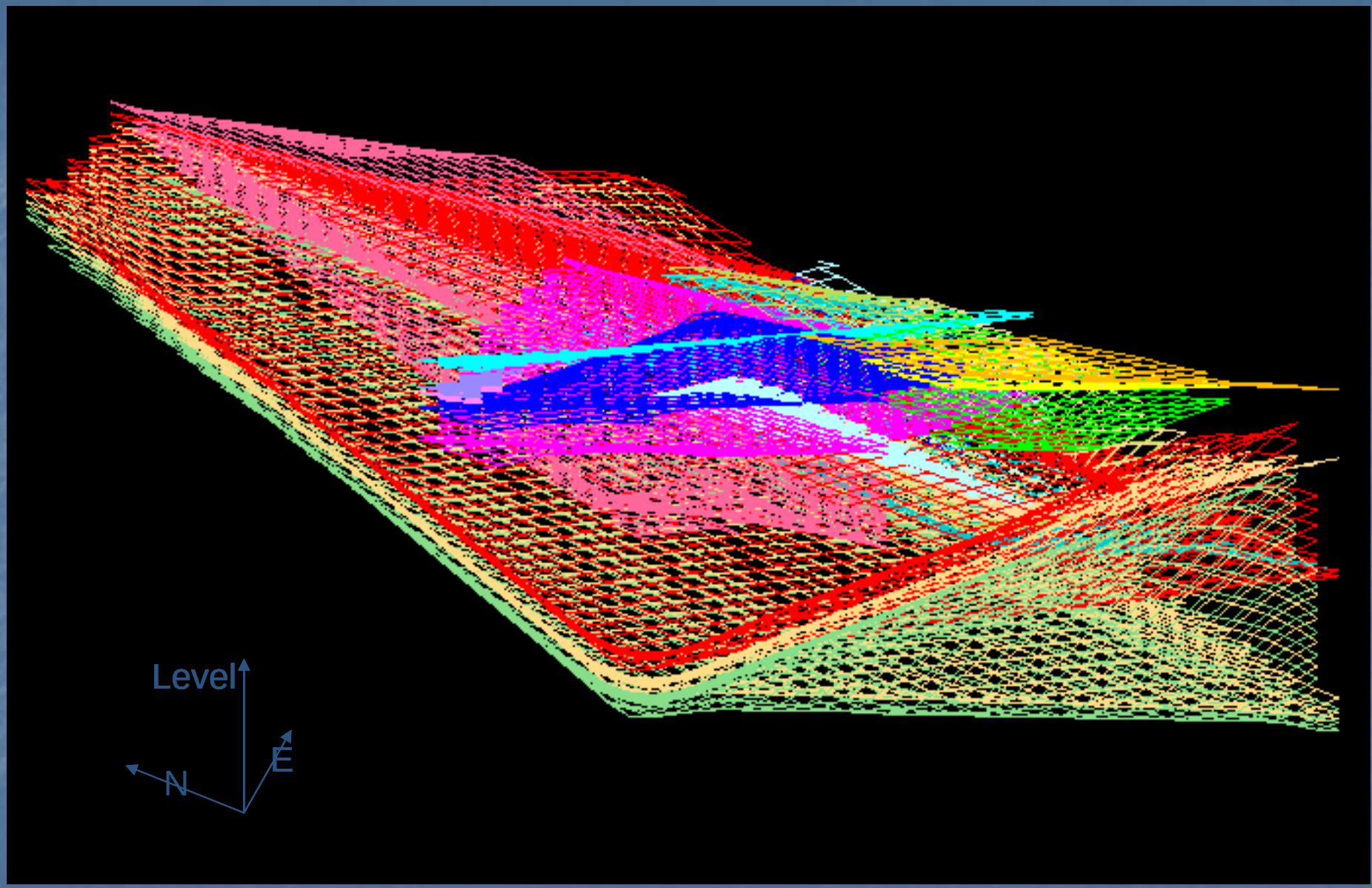
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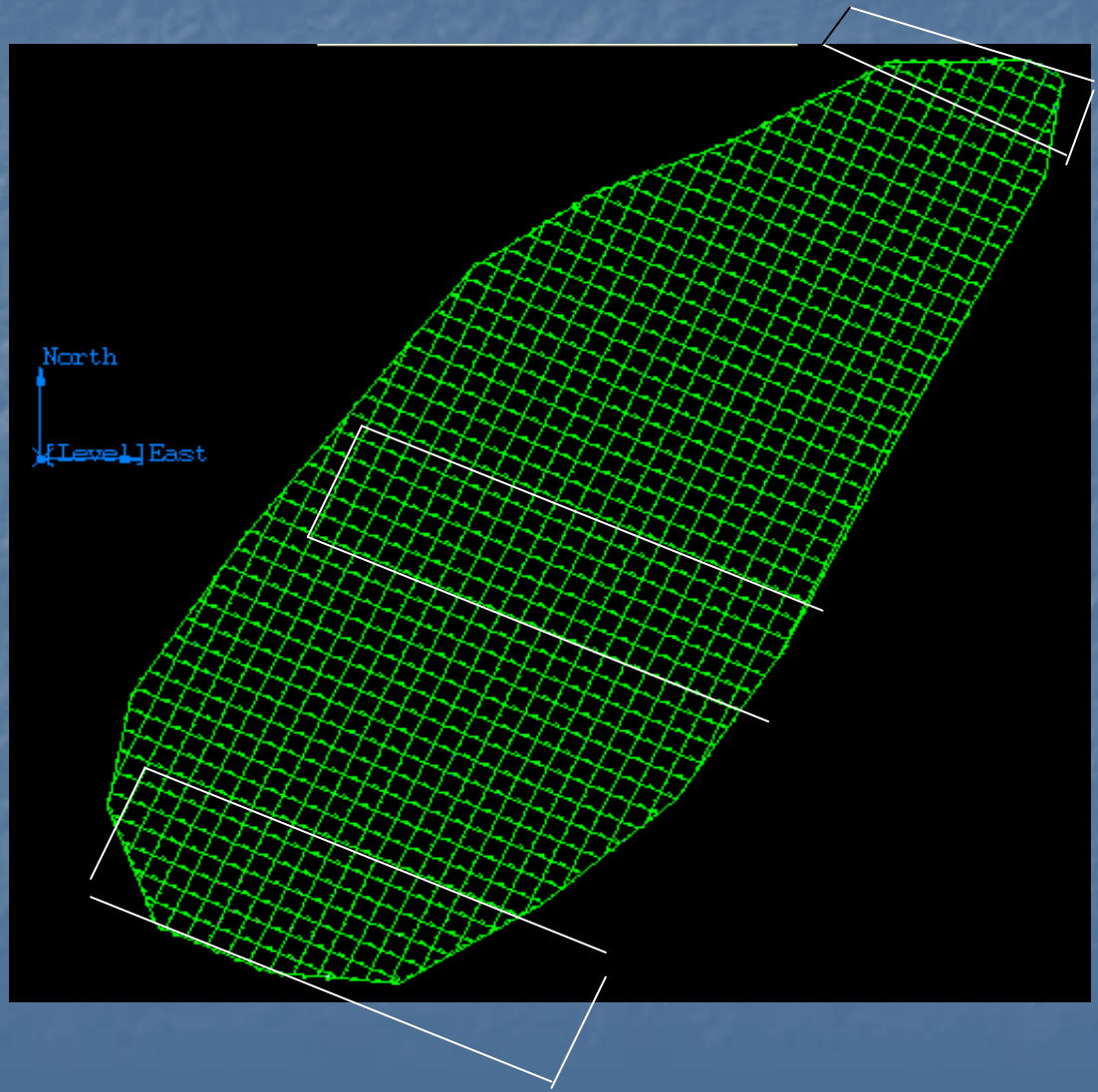
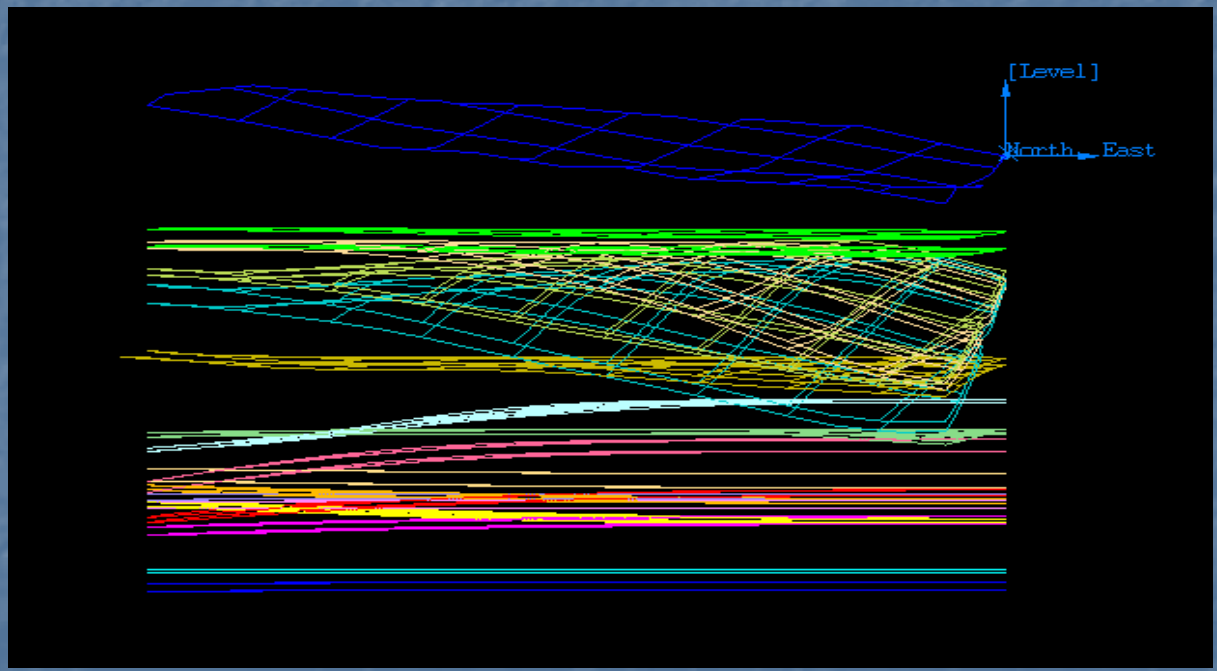
Wishbone Hill:
Stripping Ratios

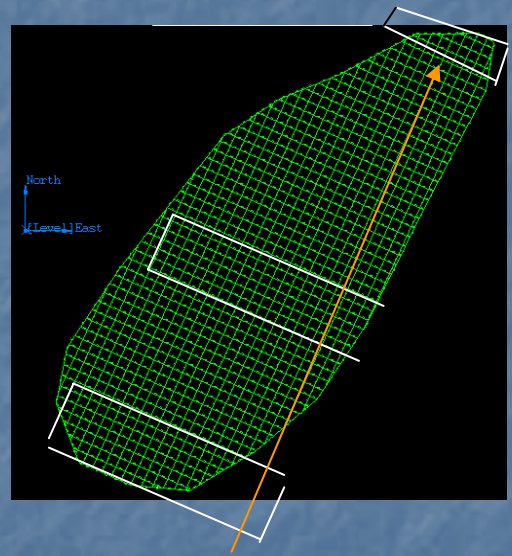
- Sections used to determine strip ratios



NORTHERN SECTION

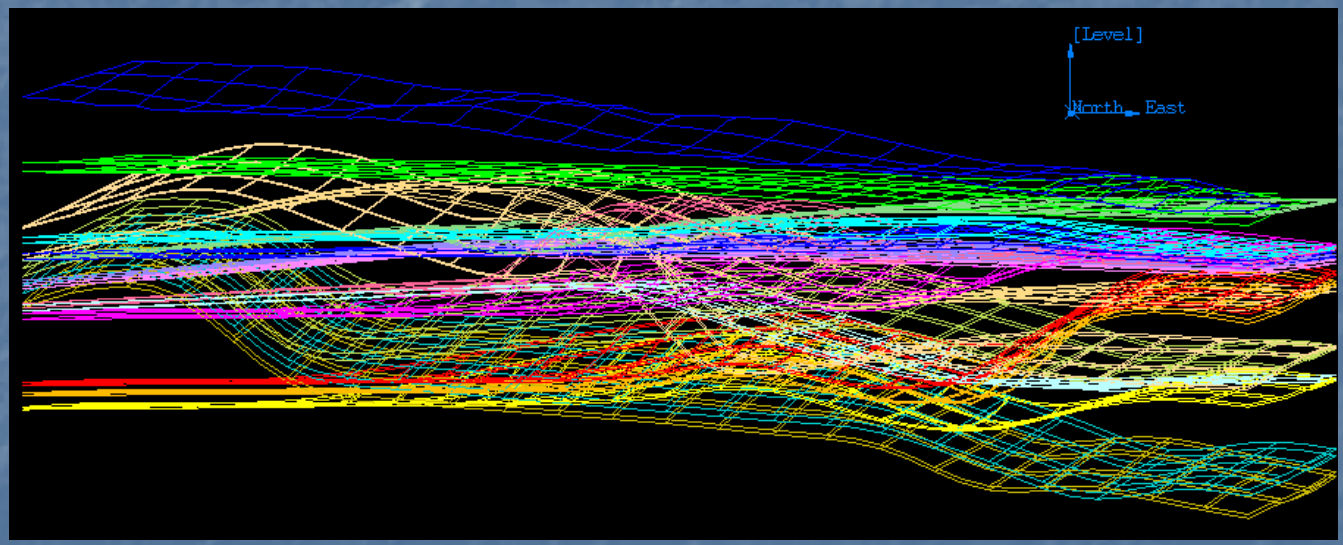
- 17,500,000 tons waste
- 2,000,00 tons coal
- 1:8.75 stripping ratio (tons coal : tons waste)

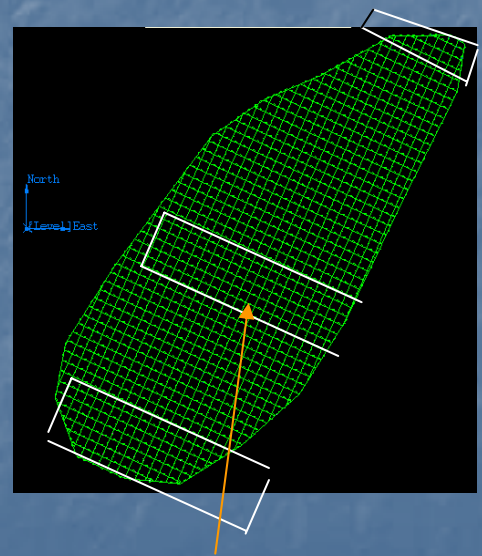




MID STRIP SECTION

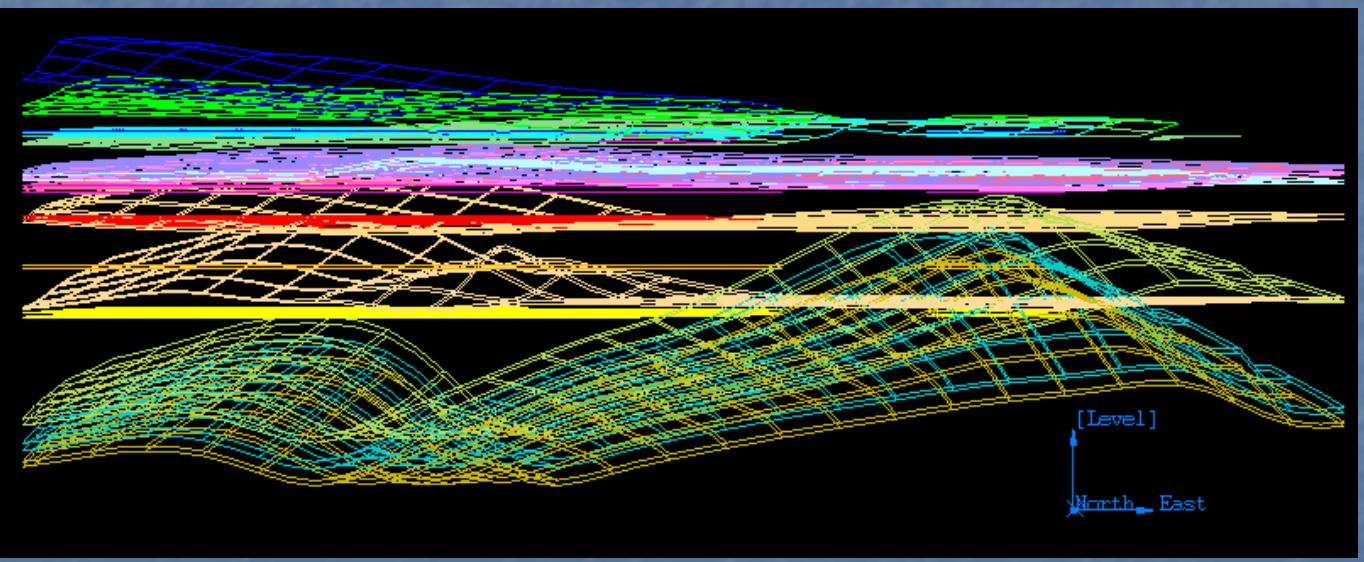
- 25,840,000 tons waste
- 4,000,000 ROM tons coal
- 1: 6.46 stripping ratio (tons coal : tons waste)

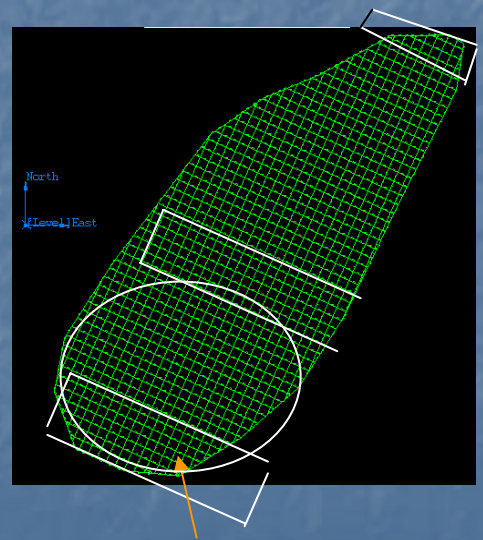




SOUTHERN SECTION (PIT SECTION)

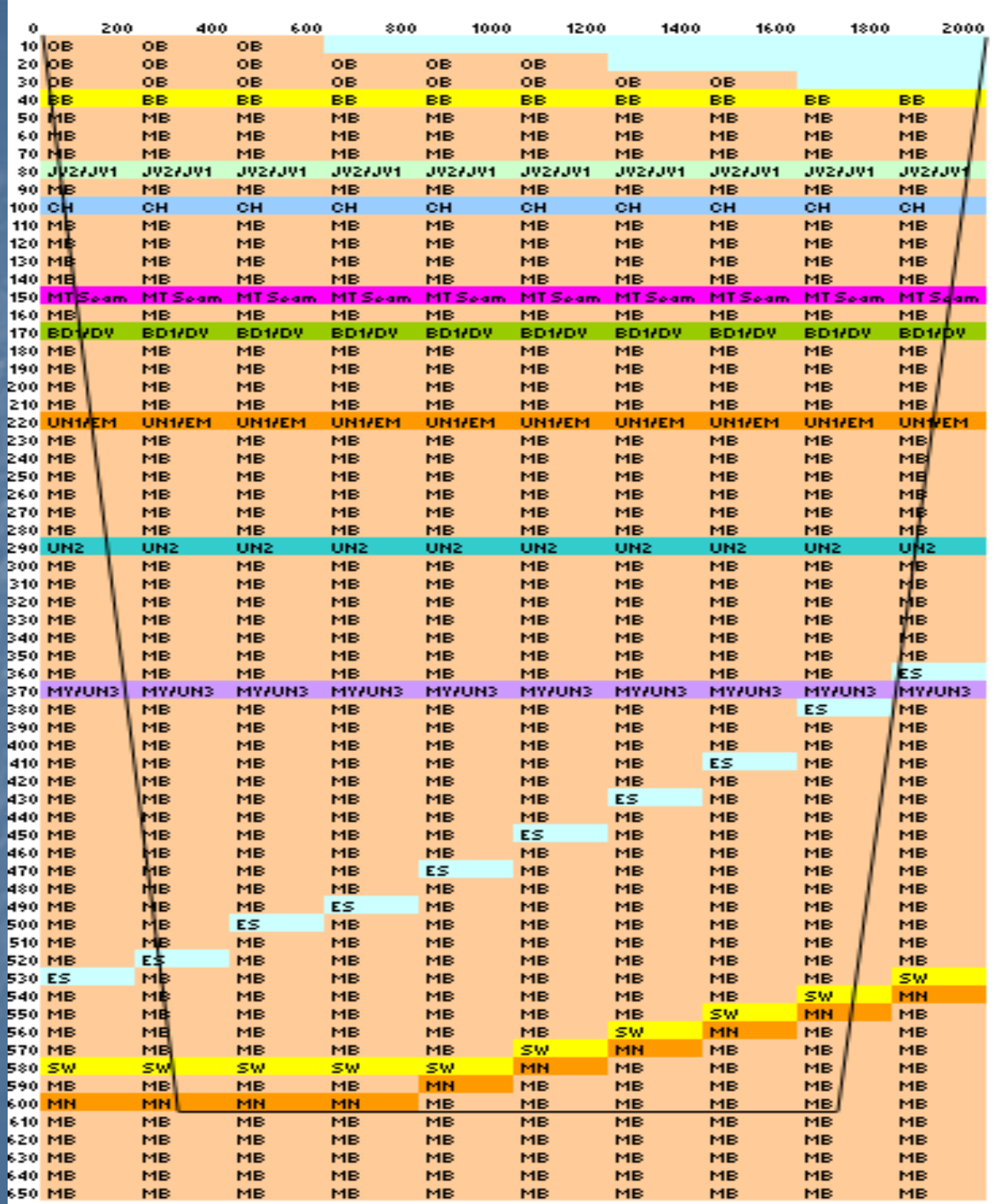
- 1000’ radius pit recovering approximately 95% of mineable coal @ 600’ Depth
- 27,011,221 tons waste
- 3,777,543 ROM tons coal from pit
- 1: 7.06 stripping ratio (tons coal : tons waste)





Overall Stripping Ratio

- 70,300,00 tons waste
- 10,000,000 tons coal
- 1:7 stripping ratio (tons coal: tons waste)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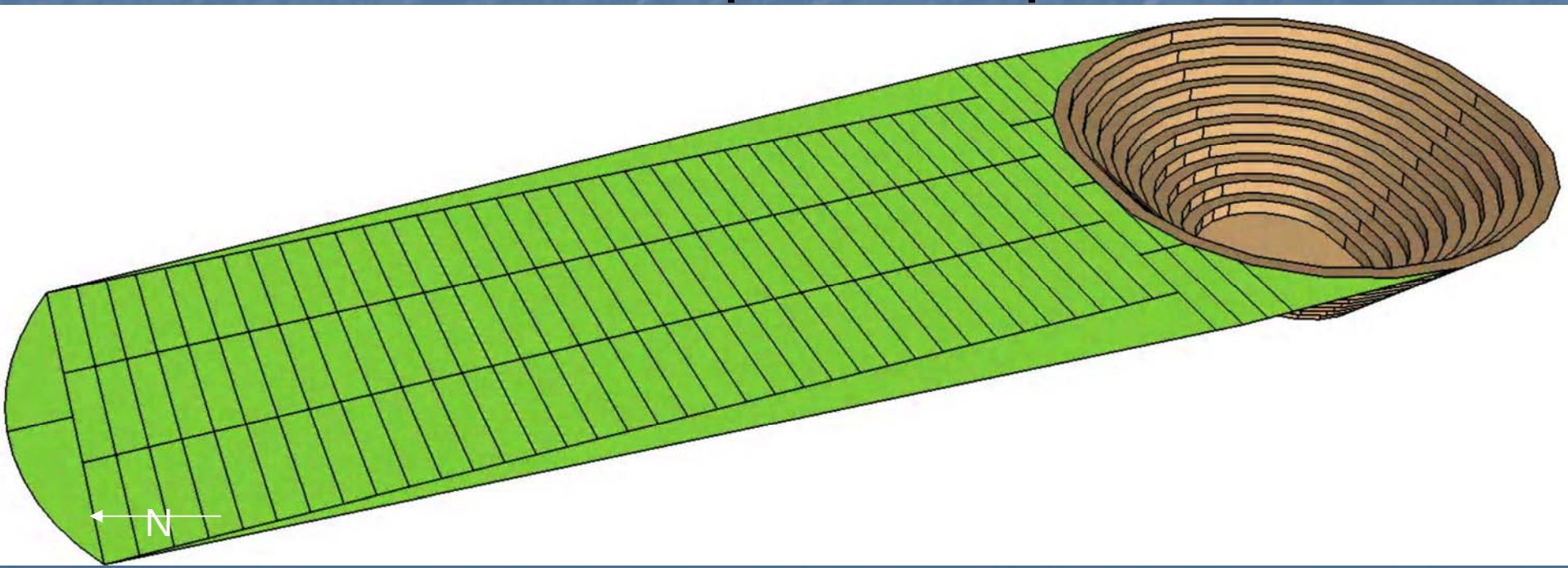
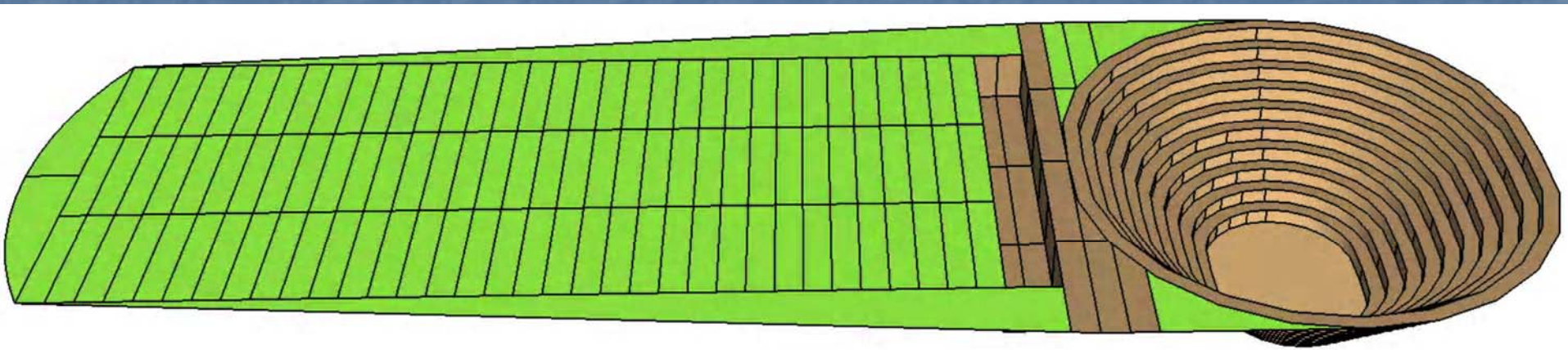
Wishbone Hill: Mining Method

- Develop Open Pit
  - 1000’ Radius
  - 600’ pit depth
  - 60 degree overall pit slope
  - 30’ benches
- Waste will be dumped/stockpiled



- Layout Strips 100’ wide x 500’ long
- Perform box cut to commence strip mining
  - Initial ultimate depth will be 400’
- Dump waste into existing open pit



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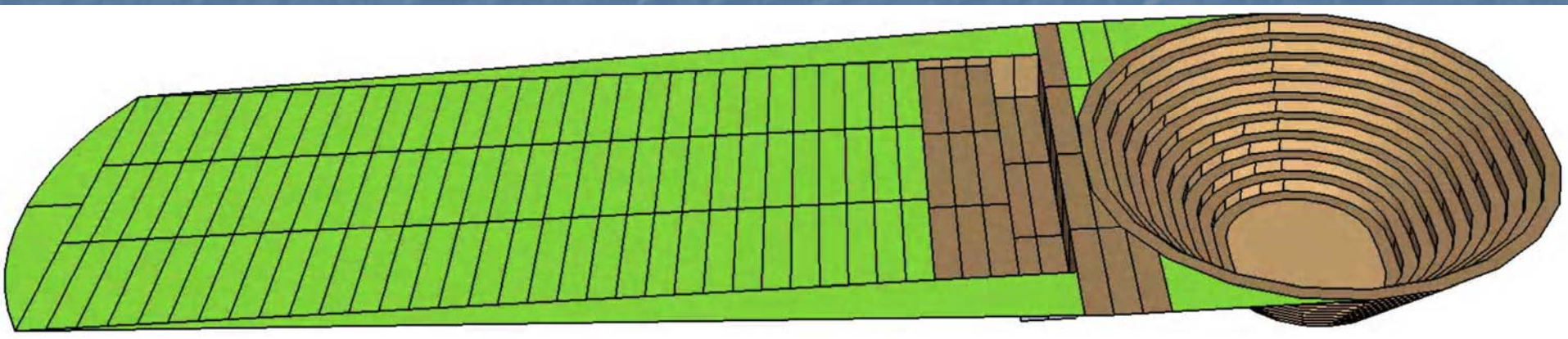
- Begin lead on sequence for strip mining
  - 3 strips x 100’ = 300’ strip development
  - 2 strips x 100’ = 200’ @ 400’ depth next to pit
  - Leave a strip at 200’ for containing dump material in pit



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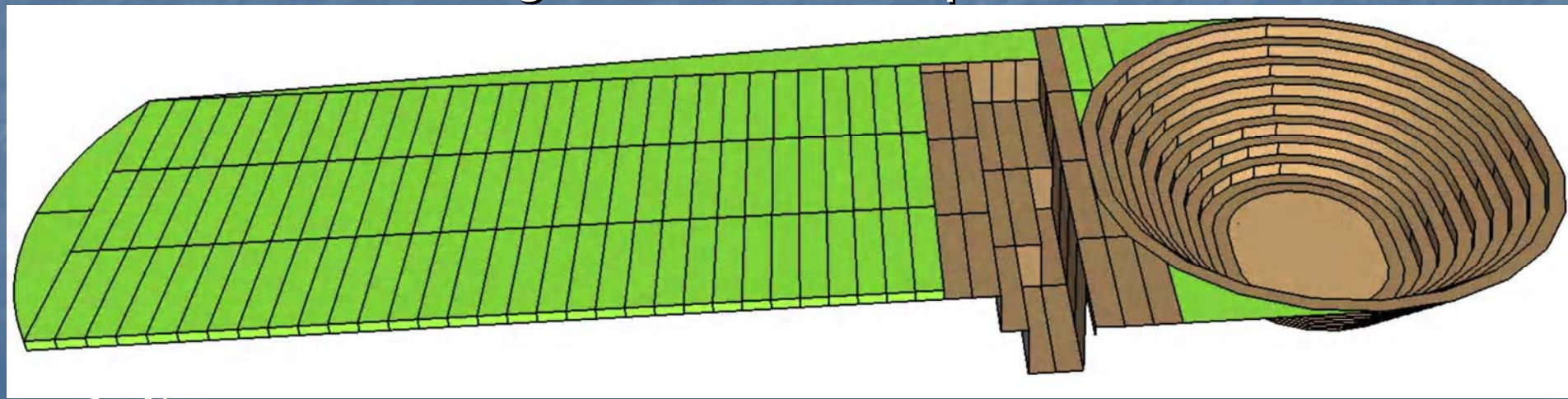
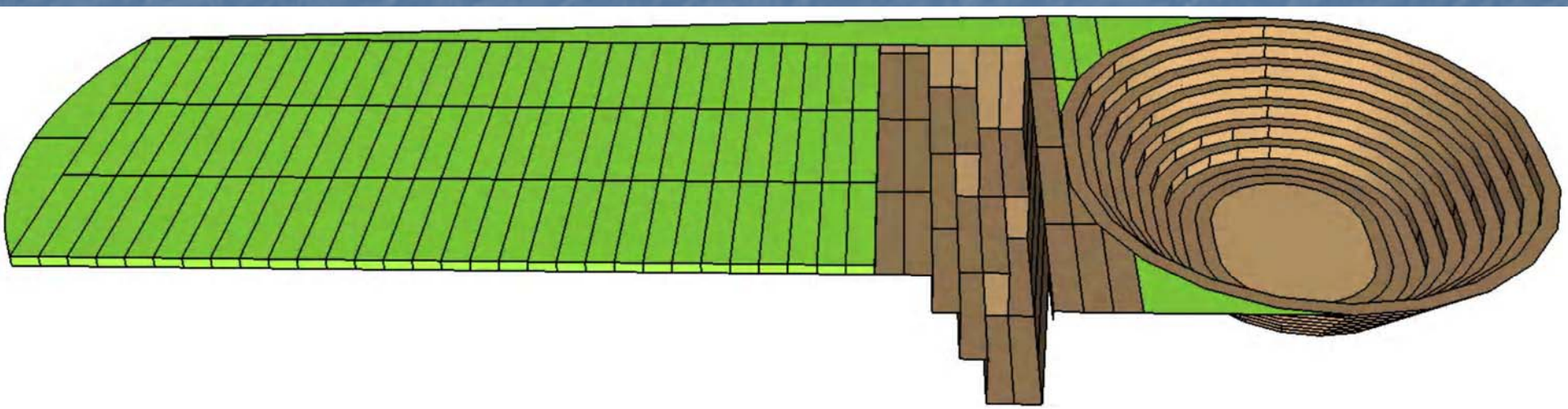
- Begin sequence:
  - 200’,400’ and 600’ depths for each step in sequence
  - No more than 200’ high wall
  - 200’ and 400’ depths will be mined to using conventional blasting techniques
  - 600’ depth will be reached using cast blasting into existing mined out strips

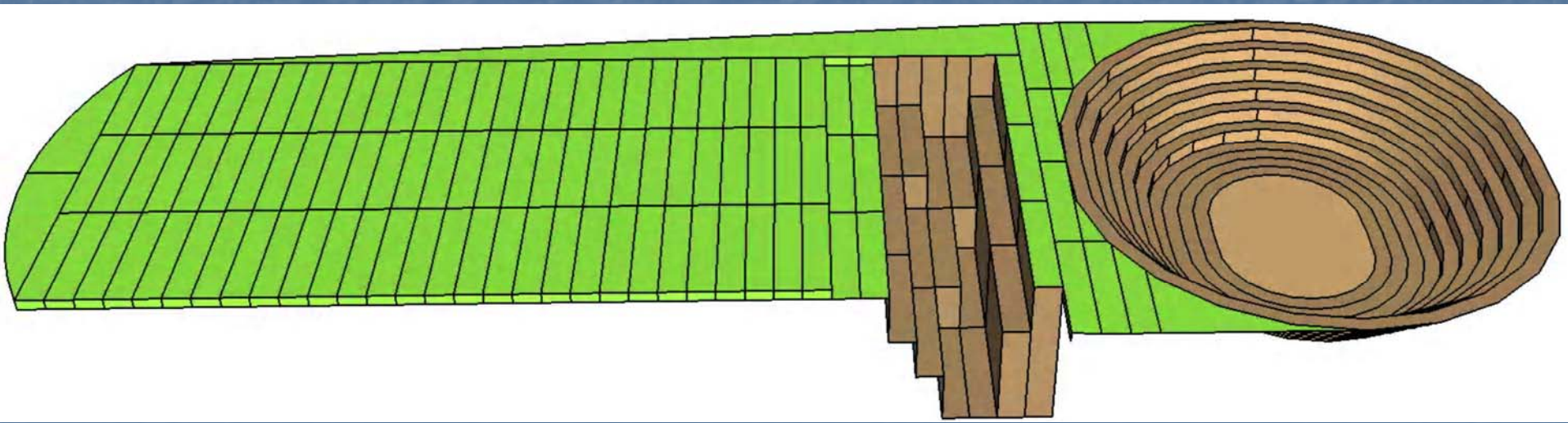


- Continue sequence
- Old pit is continually filled with excess swell rock created by blasting



Reclaim areas filled

- Reclamation must occur continuously with active strip mining within 500’
- Dump material will be moved back to mined out strips for reclamation



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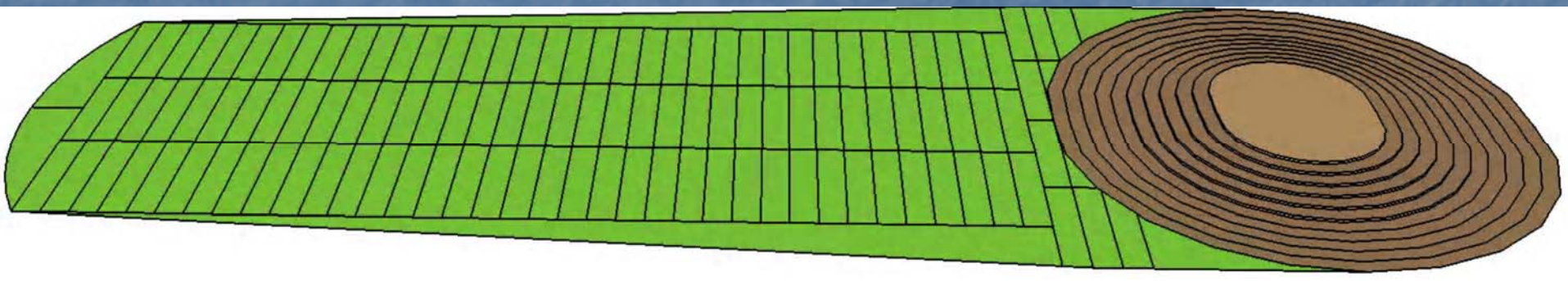
- Final reclamation
  - Pit is full and will now be a dump site
  - Slide indicates location of old pit and final strip
  - Reclamation will return land to original contour



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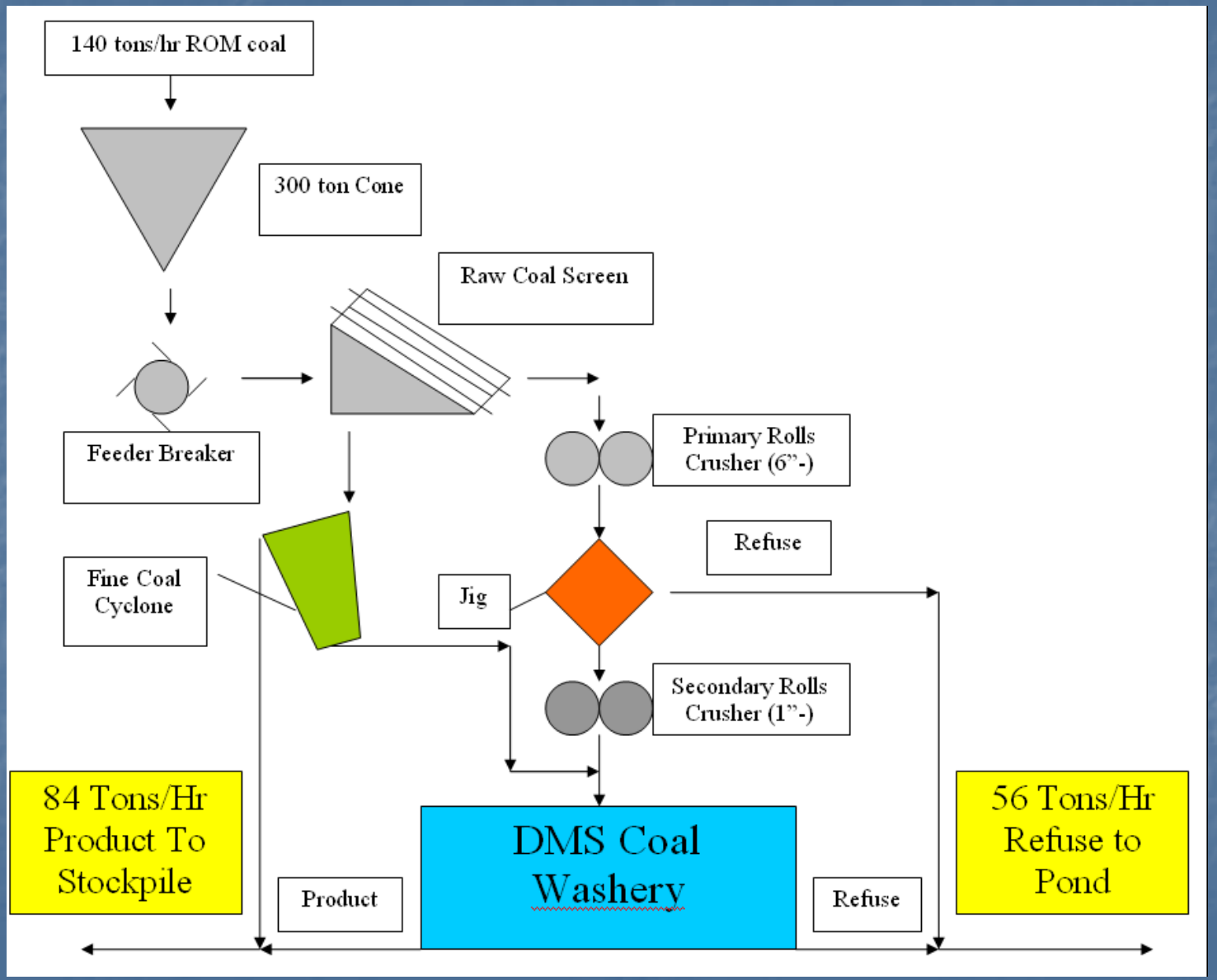
Wishbone Hill: Production

Wash Plant

- 3000 tons/day (feed)
- 1800 tons/day (product)
- 60% average recovery (by weight)
- 72 gallons per minute plant use and discharge
- $6.19/ton coal processing cost (tons product)
- Product: 15% ash, 0.4% sulfur and 11,710 Btu/lb.

Plant Flowsheet

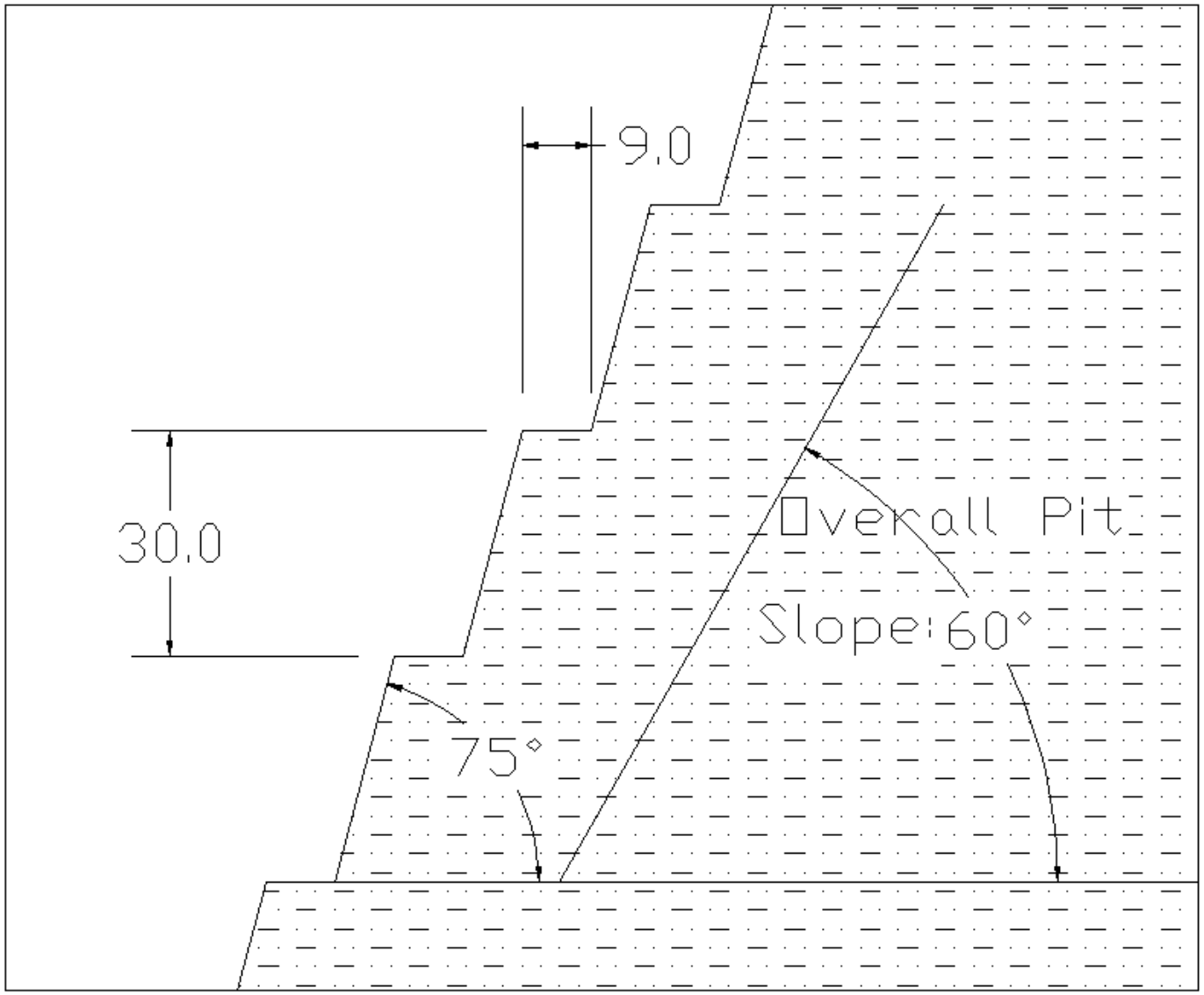


To Wash or Not To Wash?

Average Weekly Coal Commodity Spot Prices (Dollars per Short Ton)					
Week Ended	Central Appalachia 12,500 Btu, 1.2 SO2	Northern Appalachia 13,000 Btu, <3.0 SO2	Illinois Basin 11,800 Btu, 5.0 SO2	Powder River Basin 8,800 Btu, 0.8 SO2	Uinta Basin 11,700 Btu, 0.8 SO2
2/06/09	$66.45	$66.00	$55.00	$13.00	$73.00
2/13/09	$68.20	$66.00	$55.00	$13.00	$73.00
2/20/09	$68.20	$66.00	$55.00	$13.00	$73.00
2/27/09	$68.20	$66.00	$55.00	$13.00	$73.00
3/6/09	$68.20	$58.00	$55.00	$13.00	$73.00
3/13/09	$68.20	$58.00	$55.00	$13.00	$73.00
3/20/09	$68.20	$58.00	$48.00	$13.00	$73.00

Energy Information Administration

Pit Slope Design



Pit Slope Design

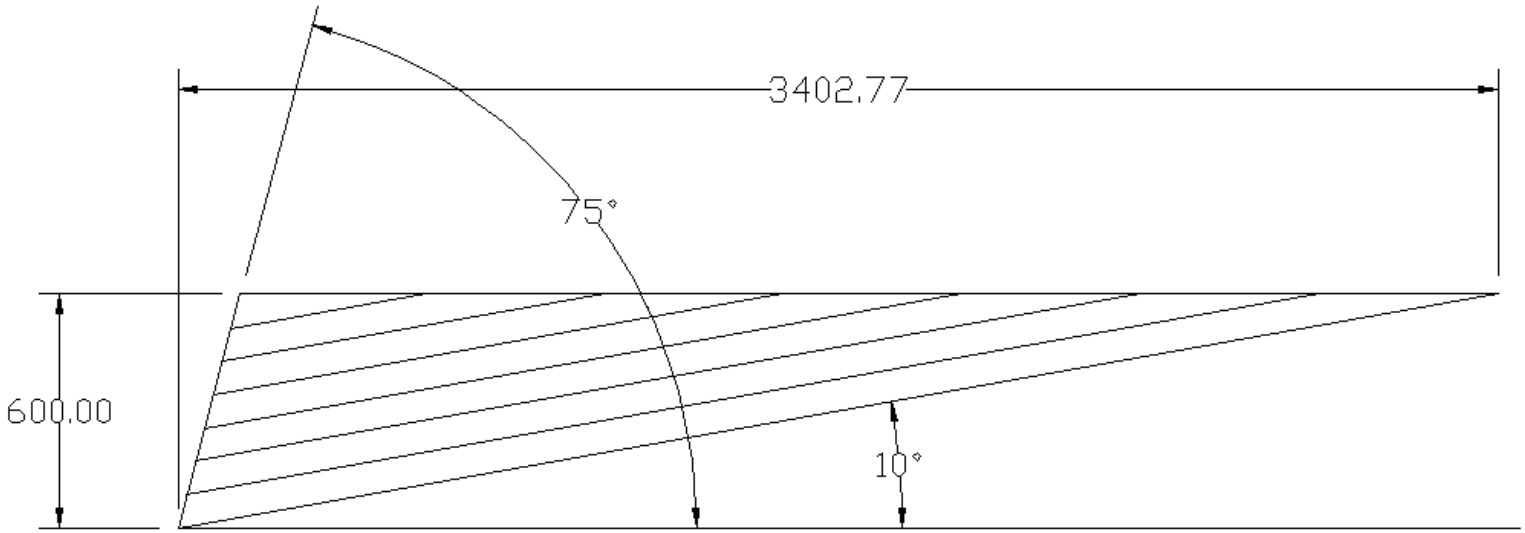
$$F.S. = \left(\frac{cA + w\cos\beta\tan\phi}{w\cos\beta} \right)$$

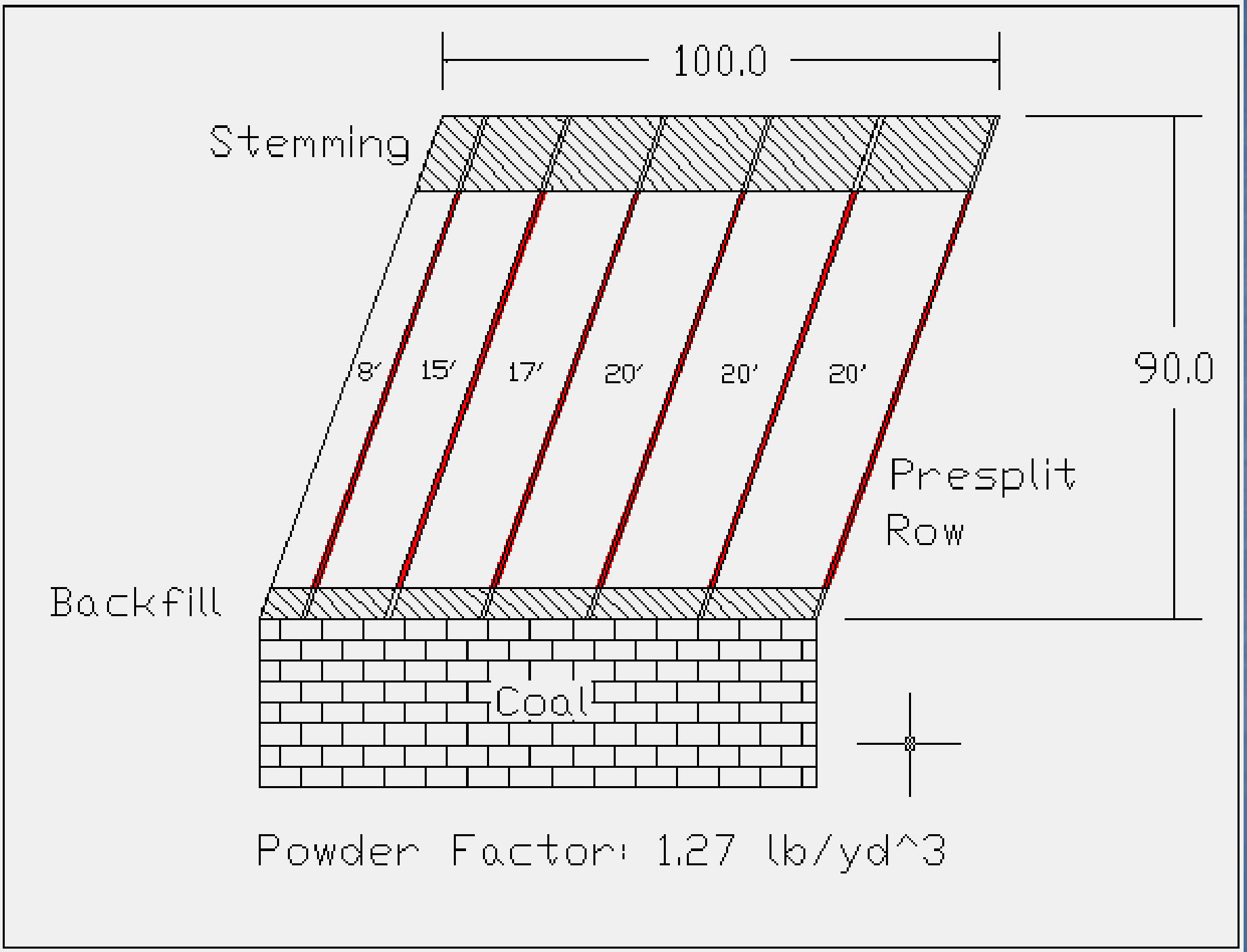
F.S. = Factor of Safety
c = cohesion (lb/ft2)
A= area of the failure plane
w = weight of block
β = angle of discontinuity from surface
φ = friction angle

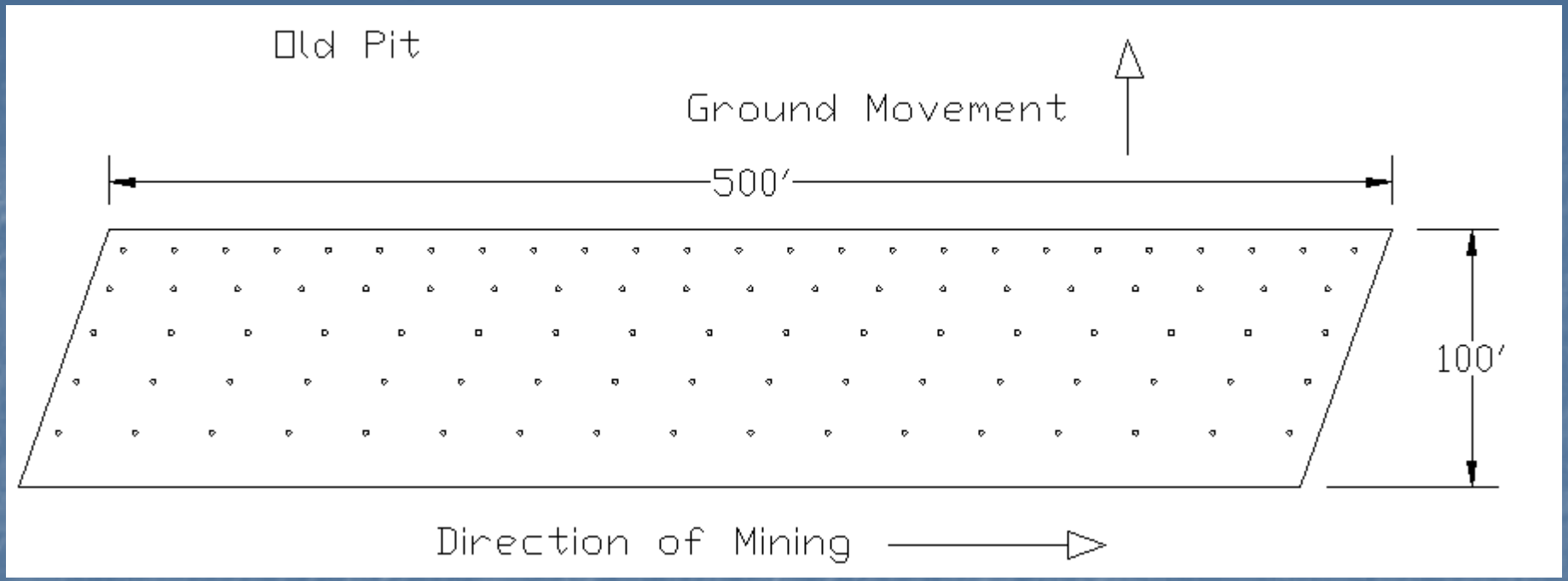
Assuming:
β = 10° (angle of dip)
φ = 50° (table value for sandstone)
c = 11,500 lb/ft2 (table value for soft rock)
Specific Gravity = 2.6

Then:
w = 154.991 x 106 lbs
A = 3455.2 ft2

FS = 8.23




100.0
Stemming
8'
15'
17'
20'
20'
20'
90.0
Presplit
Row
Backfill
Coal
Powder Factor: 1.27 lb/yd^3



Timing

- Used a TMIN of 55ms for 20' burden, and a multiplier of 2.0 for 2nd Row
- Used a Hole to Hole delay of 8ms within rows
- Used incremental row to row timing increases.

Row	Timing		Delay from Previous Row		
1	0	ms	0	ms	
2	110	ms	110	ms	
3	230	ms	120	ms	
4	360	ms	130	ms	
5	500	ms	140	ms	

Designed Pattern

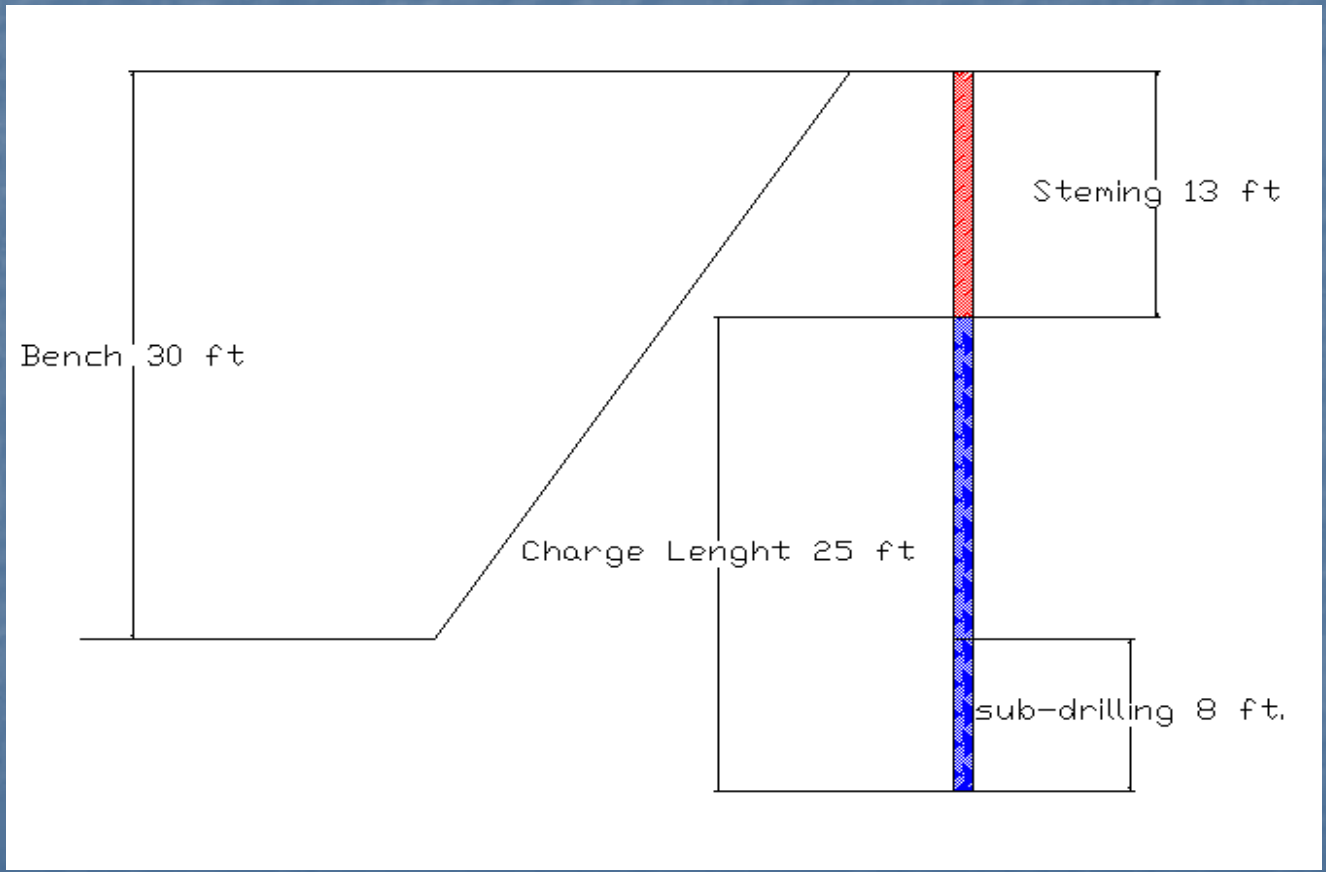
total lbs ANFO	210,235.00	lb	total ANFO	210,235.00	lbs
cost/lb ANFO	0.27	$/lb	BCY shot	166,666.67	BCY
cost/ booster	7.00	$	total pf	1.27	lb/yd^3
cost/ cap	30.00	$			
Material Cost	64,464.96	$			
drill rate	150.00	ft/hr			
drill cost	450.00	$/hr			
drill time 90'	0.60	hr	**Total Blast Cost**	**95,400.96**	$
drill/hole cost	270.00	$			
driller cost	55.00	$/hr	**Assumed %cast**		
driller time/hole	0.60	hr	**By Chart**	**56.00%**	
driller cost/hole	33.00	$			
powman cost	55.00	$/hr	**Total cost/yd cast**	**0.57**	$
powman time/hole	0.35	hr			
powman cost/hole	19.25	$	**Usibelli Avg**		
material/hole	671.51	$	**Truck/Shovel**		
drill+labor/hole	322.25	$	**Cost/yd**		
Total hole cost	993.76	$	**Excluding drill/blast**	1.03	$

Conventional Blasting

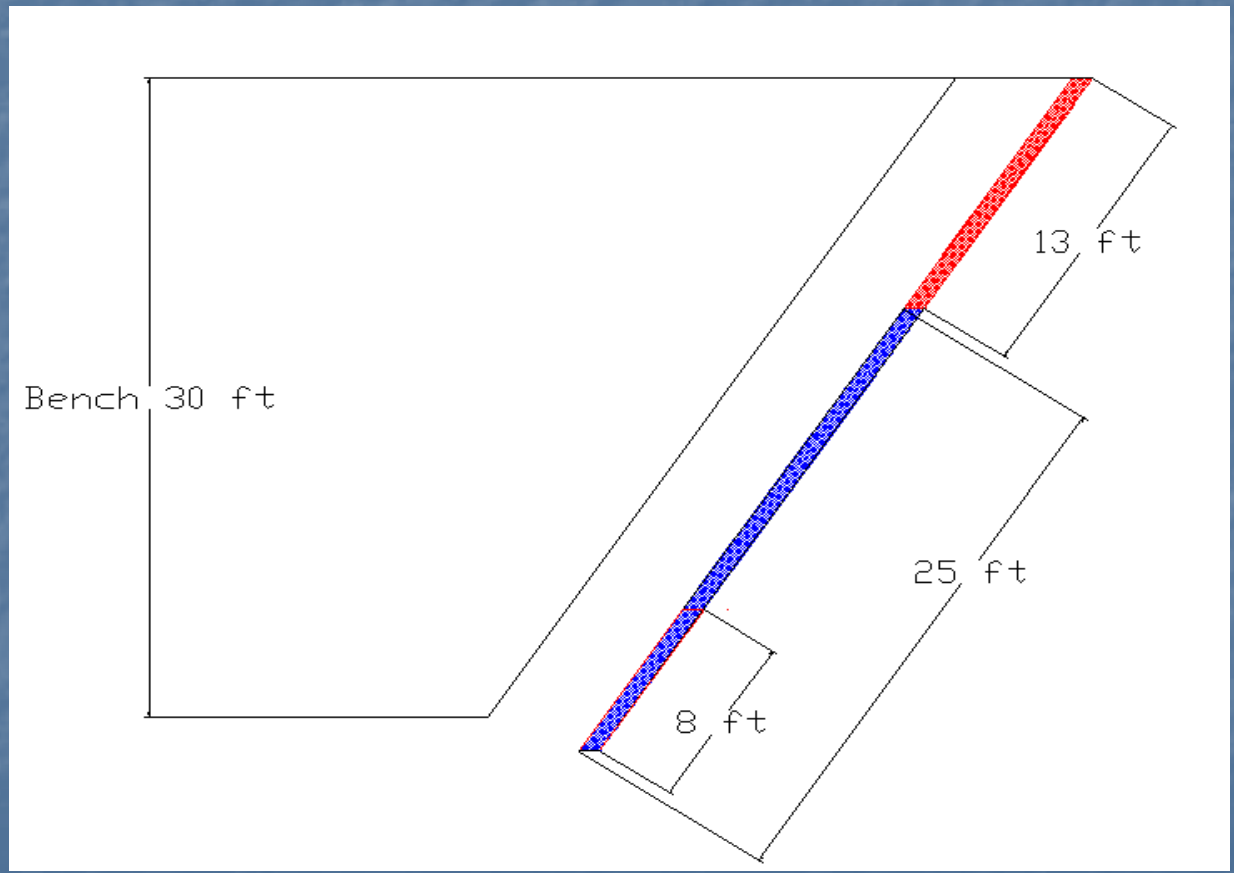
	OVERBURDEN		COAL	
(L) bench Height	30	ft	30	ft
(B) Burden	25	ft	25	ft
(d) Hole diameter	0.885	ft	0.885	ft
(J) sub Drilling	8	ft	8	ft
(T) Stemming	13	ft	13	ft
(H) Blast hole Height	38	ft	38	ft
(l) charge length	25	ft	25	ft
(S) Spacing	35	ft	35	ft
(We) Explosive Weight	761	lb per hole	761	lb per hole
cubic yards per hole				
V =	972	yd^3	972	yd^3

POWDER FACTOR				
	0.78	lb/cu.yd	0.78	Lb/cu.yd

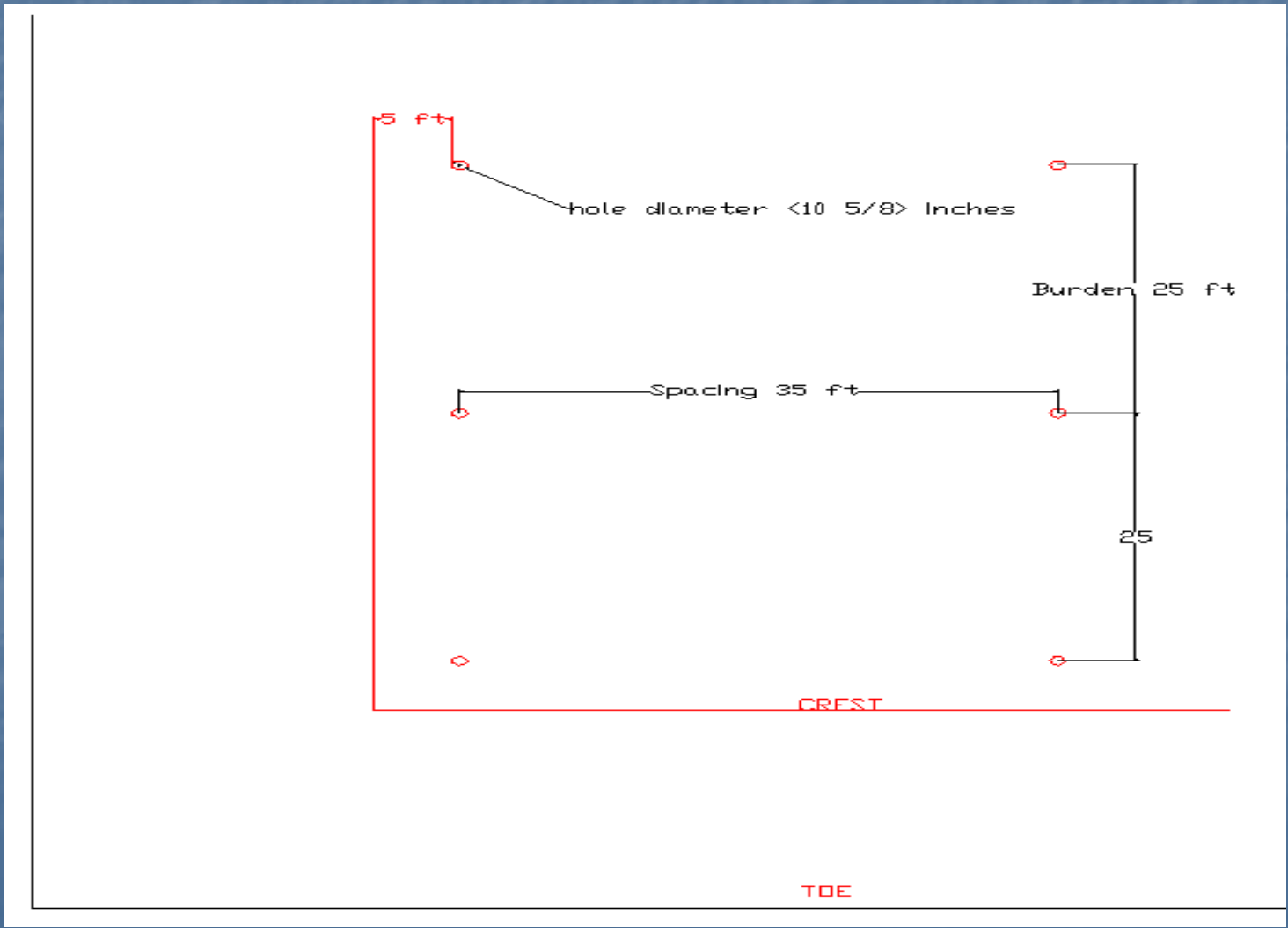
Conventional Blasting: Vertical Hole



Conventional Blasting: Angle Hole

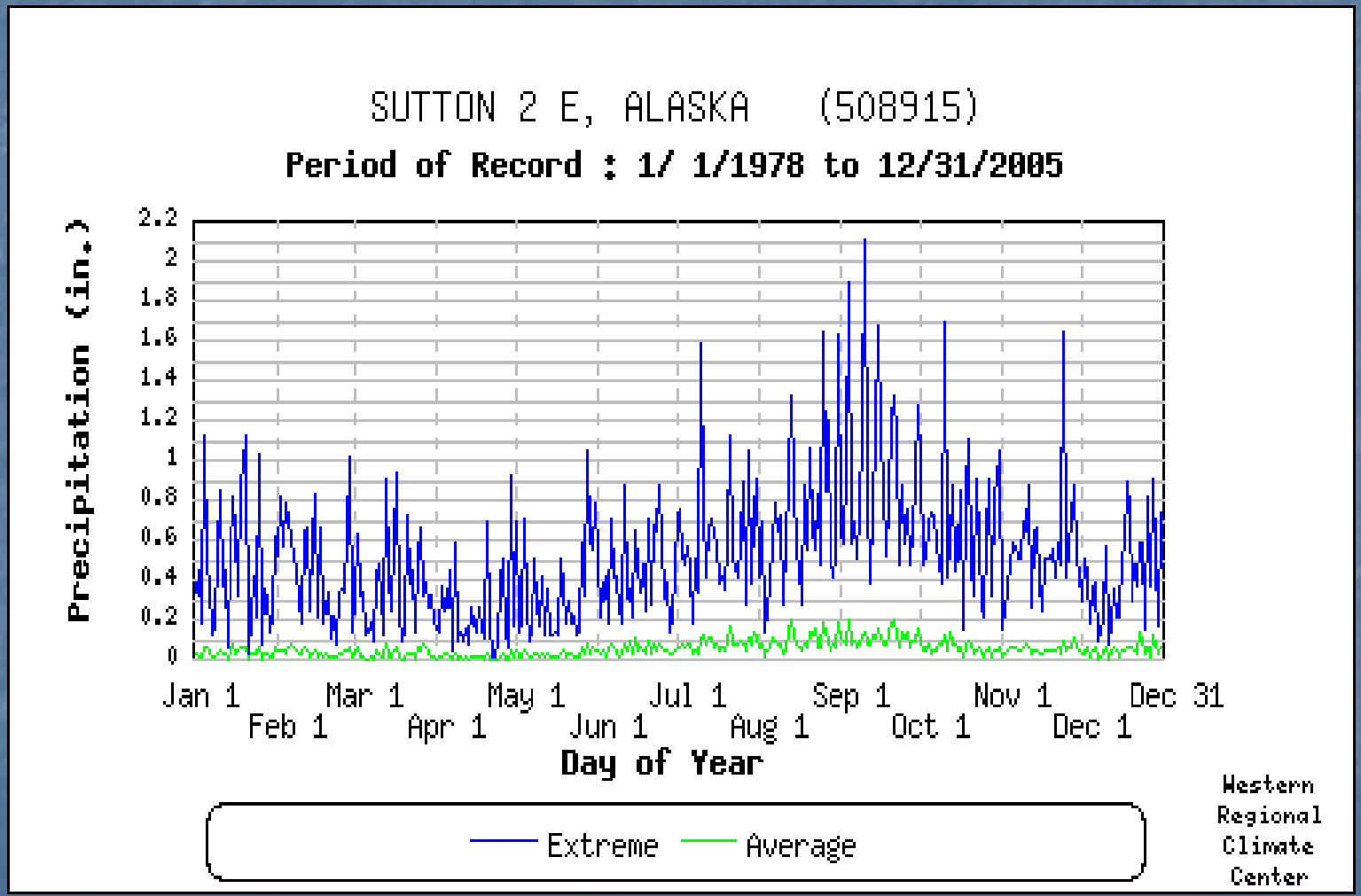


Conventional Blasting: Pattern

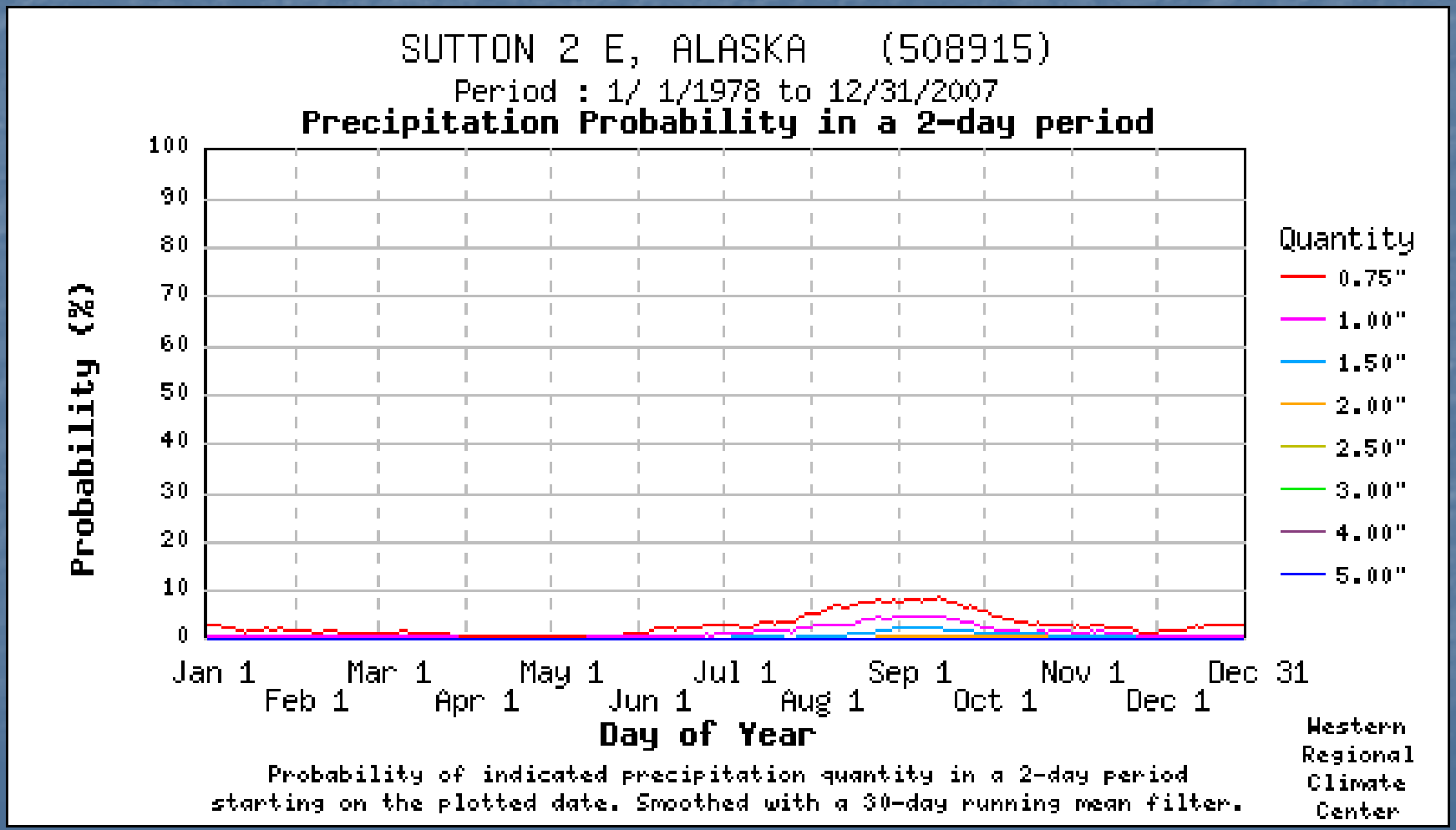


Wishbone Hill: Water Management

Precipitation



Precipitation Probability



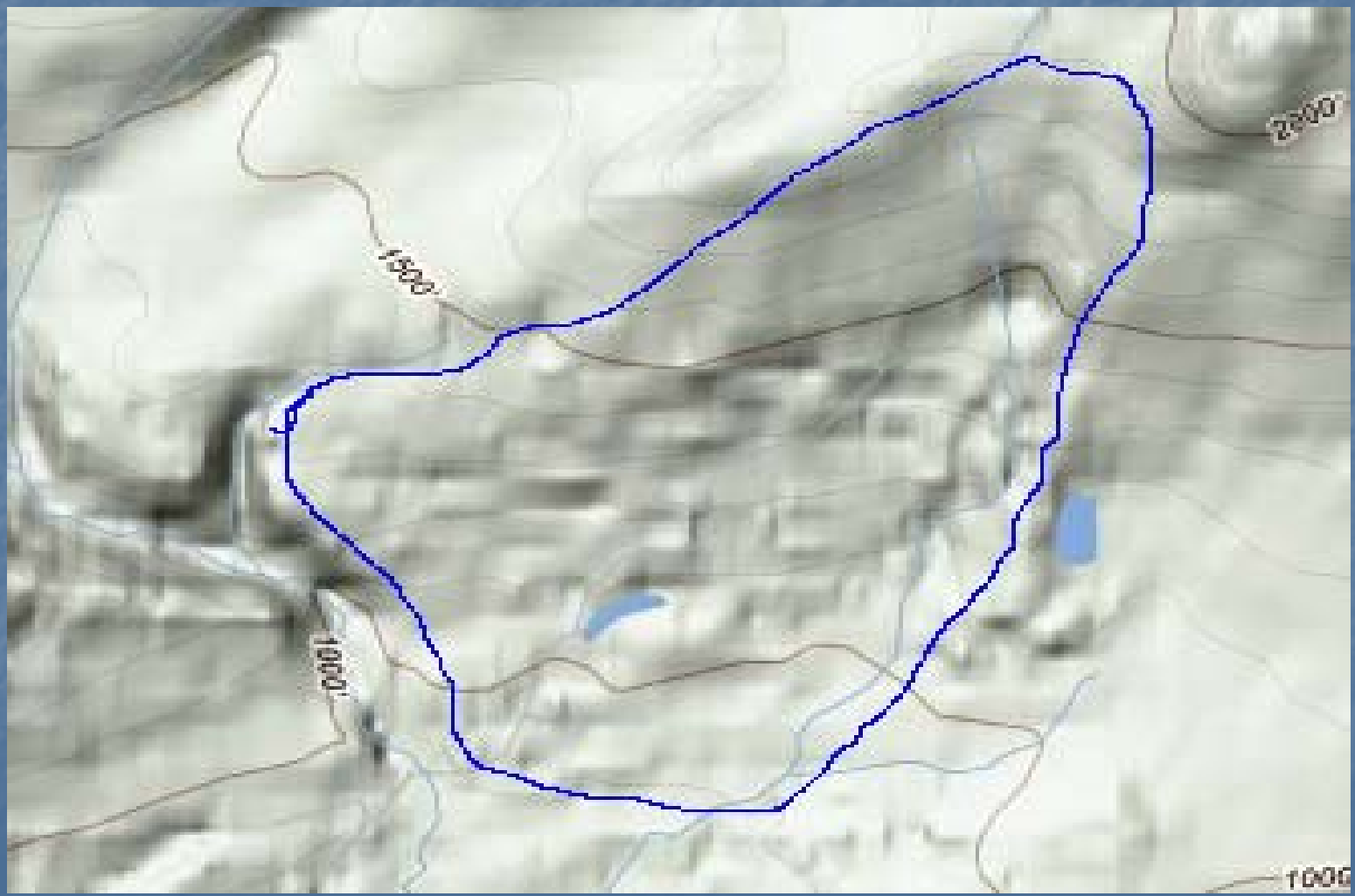
Storm Event

100 year 48 hours		
year	Precipitation (in.)	Probability (%)
1	0.01	72
2	0.1	42
3	0.15	35
4	0.3	23
7	0.5	15
11	0.75	9.5
18	1	5.5
22	1.5	4.5
25	2.11	4
50	4.22	2
100	8.44	1

Topics

- Peak Discharge Method
  - Peak Discharge
- Sediment Pond Design
  - Capacity
  - Soil loss
- Slurry Pond Design
  - Capacity
  - Embankment

Watershed Boundary



Sediment Pond
Runoff (Q) 100 yr – 48 hr storm

- **Q = 6.602 inches**
- **P = 8.44 inches**
- **CN = 84.7**
- **S = 1.81**
- **Runoff volume = 4.95 million cu. ft.**

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

$$S = \frac{1000}{CN} - 10$$

Sediment Pond
Peak Discharge 100 yr – 48 hr storm

$$q = q_u A Q F$$

- **q_u is about 400 cfs/mi^2/in**
- **A is 0.32 square miles**
- **Q is about 6.602 inches**
- **F is 0.81**
- **q = (400)(0.32)(6.602)(0.81) = 691 cfs**

Sediment Pond

- Settling Velocity
  - 0.001542593 ft/sec
- Using 10 feet Hydraulic Radius
- Total Volume
  - 1.32 million cubic feet
- Cover about 447,685 sq. ft.
- Annual Sediment accumulation
  - 0.43 tons/acre

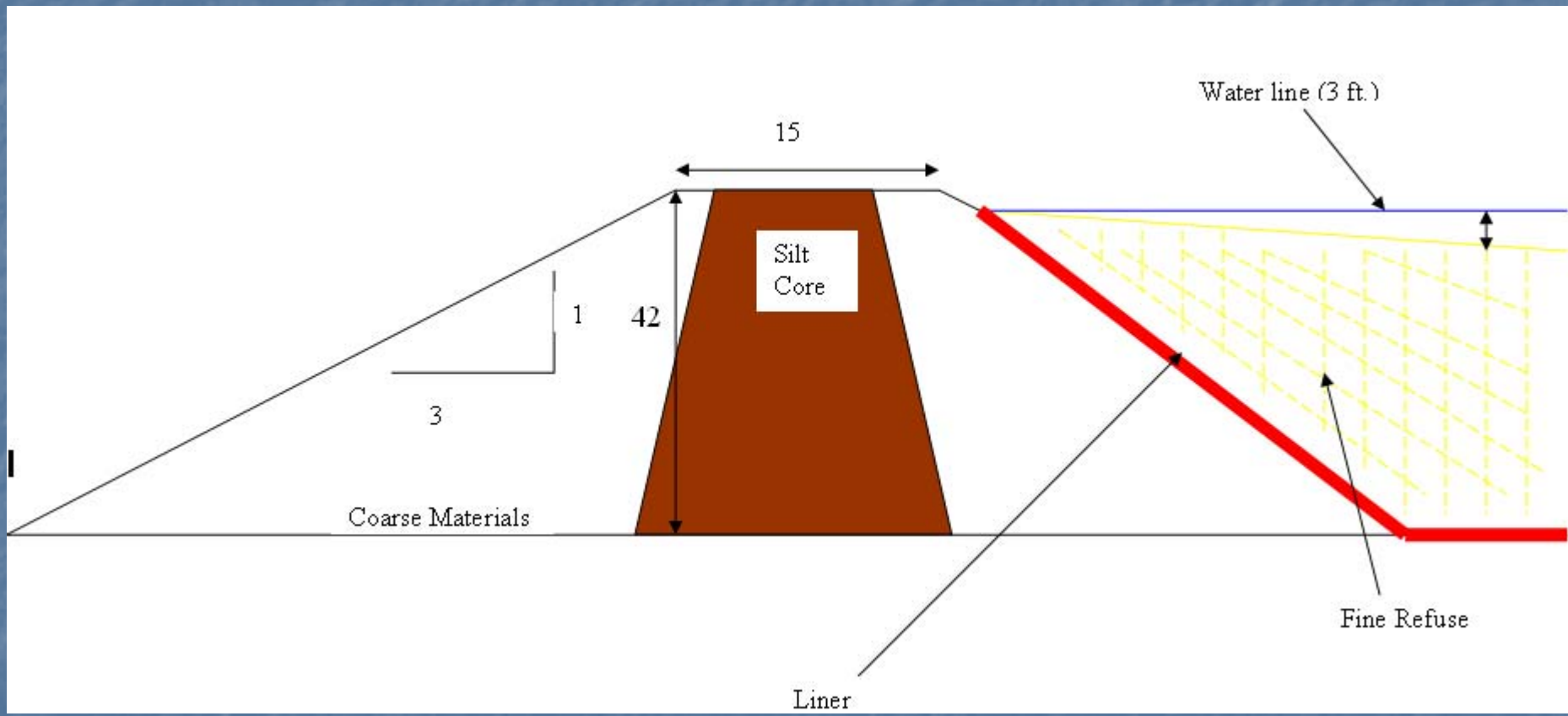
Slurry Pond

- total volume of fines for 10 year life
  - 15.3 M cubic feet
- maximum height of Embankment
  - 42 feet
- settling pond water volume
  - 605,284 cubic feet
- water depth of settling pond
  - 3 feet

Liner for Slurry Pond

- 60 mil HDPE
- Protection
  - 12 or more inches of granular materials

Downstream Method



Equipment Selection

Equipment Selection was designed around a 30,000 ton per day operation

Equipment Selection

Equipment	Provider	Model	Power (Hp)	Max Width(ft)	Max Length(ft)	Articulation(deg)	Velocity (mph)	# of Equipment	Cost
Haul Truck	CAT	785 C	1348	21.78	36.17	36	variable	6	$1,900,000
Loader	CAT	993K	950	19.4	50	40	variable	1	$2,000,000
Shovel	Bucyrus	295HD	-	-	-	-	slow	1	$3,000,000
Loader	CAT	930H	149	8.43	24.94	40	variable	1	$500,000
Dozer	CAT	D10	580	15.9	30.4	n/a	5	3	$500,000
Powder Truck	Aamcor LLC	HB09151	156	12	35	18	variable	1	$100,000
Motor Grader	CAT	16 M	297	16	38.3	47.5	10	1	$500,000
Man Carrier	FORD	F350	300	8	20	20	variable	6	$30,000
Maintenance Truck	FORD	F550	500	11	24	18	variable	2	$50,000
Drill	Atlas Copco	DM-M3	950	18.86	66.5	35	slow	1	$750,000
Water Truck	CAT	785C	1348	21.78	36.17	36	variable	1	$1,000,000

Equipment Selection

- 785 C Haul Trucks (150 ton capacity)
- 993 K Loader (22 cubic yards)

Equipment Selection

- D10 T Dozers
- 16 M Motor Grader

Equipment Selection

- Bucyrus 295 HD
  (17 cubic yards)
- Drill Master DM-M3

Wishbone Hill: Economics

Mine Economics
1,000,000 tons for 10 years

- Capital Costs
  - Equipment Fleet: $23.4 million
  - Support Equipment: $2.1 million
  - Site Infrastructure: $22.8 million
  - Development Costs: $26.2 million

  Total Capital Costs: $74.5 million

Mine Economics
1,000,000 tons for 10 years

- Operating Costs
  - Supplies & Materials : $13.77/ ton
  - Salaried Personnel: $2.01/ ton
  - Hourly Labor: $6.14/ton
  - Processing Cost: $6.19/ton
  - Trucking Cost: $16.50/ton

  Total Operating Costs: $44.61/ton

Mine Economics
1,000,000 tons for 10 years

- Total capital cost per ton: $12.42
- Operating cost per ton: $44.61
- Taxes & Royalty per ton: $3.92

Total cost per ton: $60.95

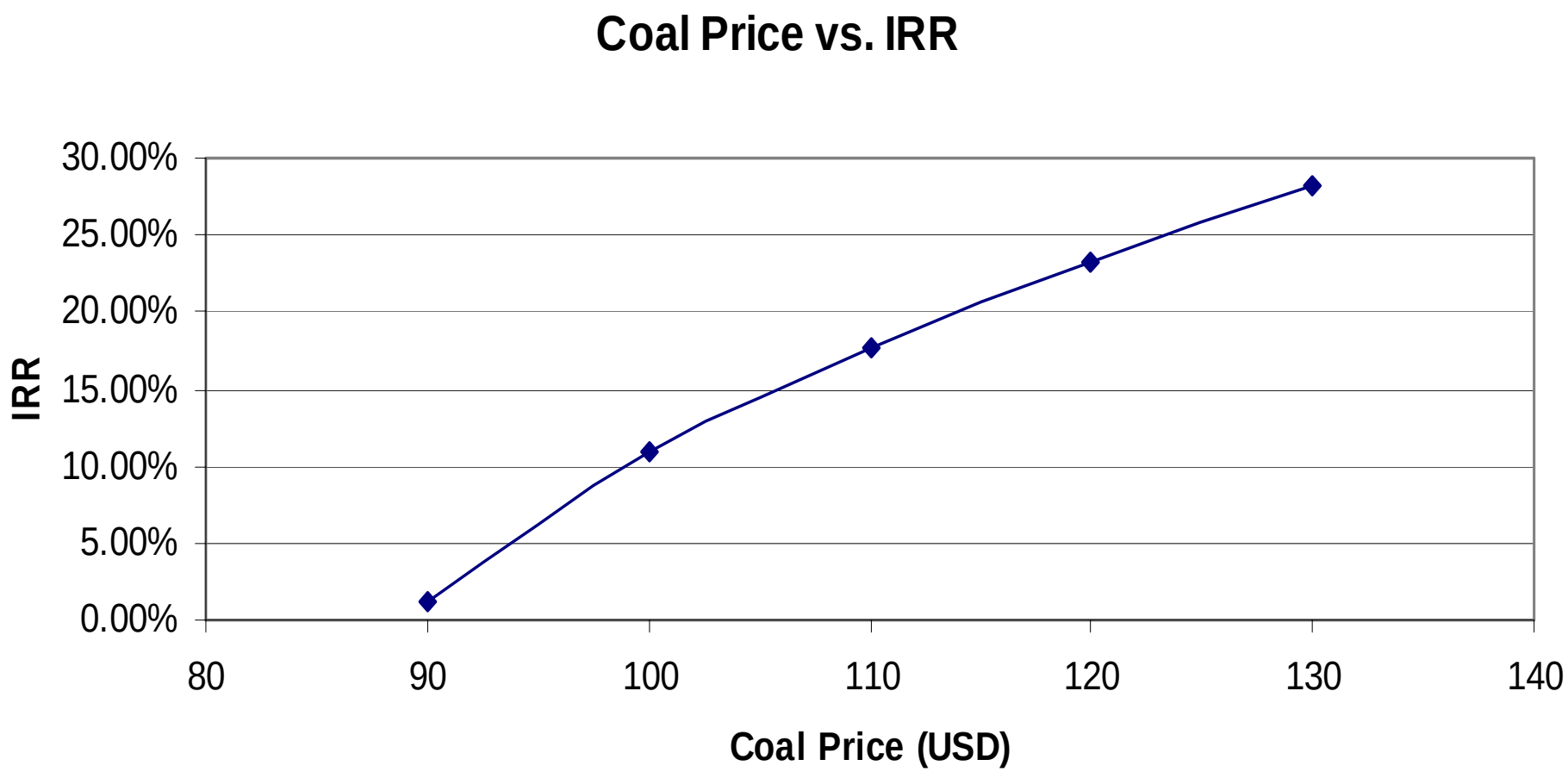
Blended coal price: $100/ton

Net profit per ton: $39.05($23.43 M/year)

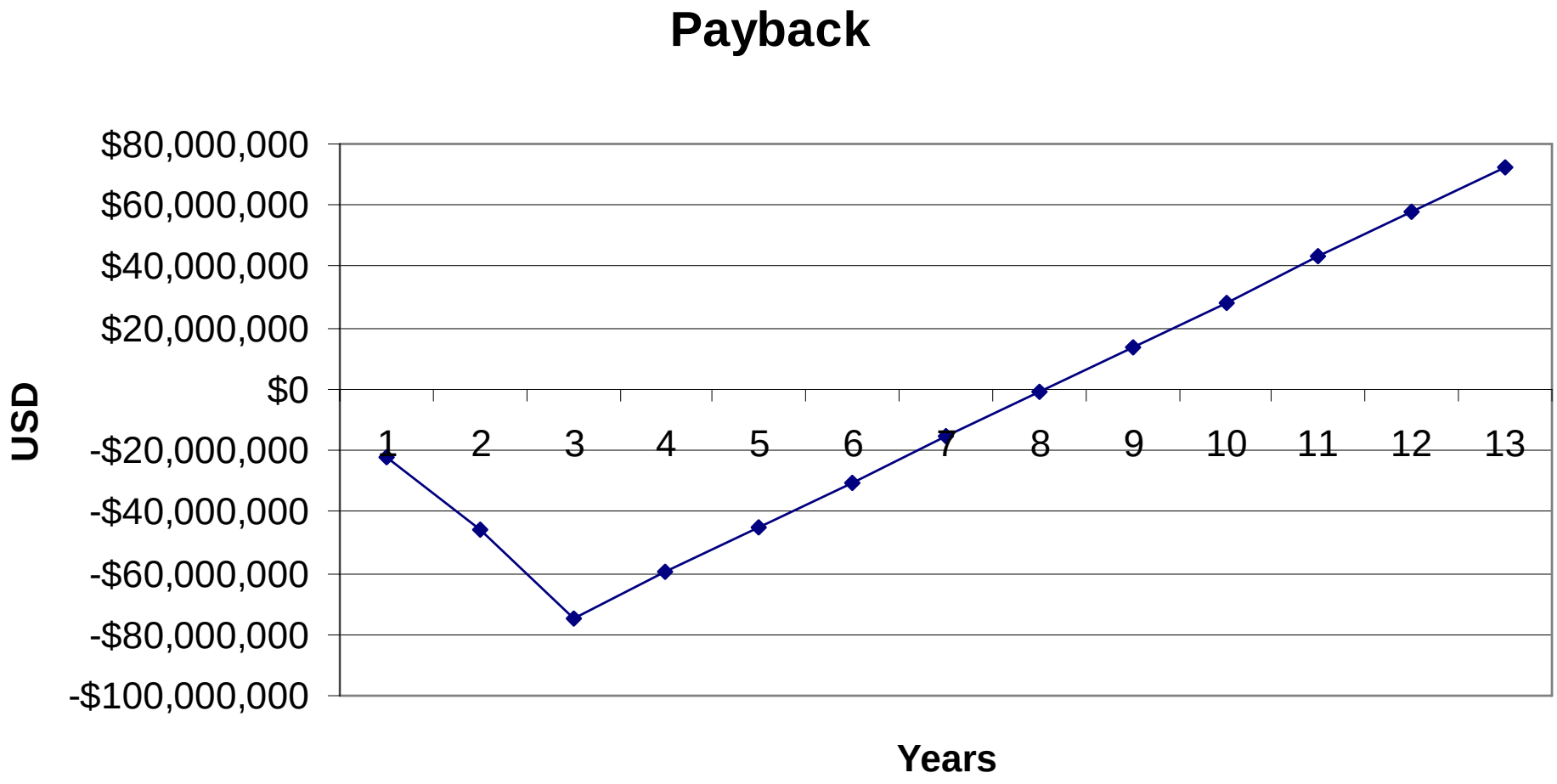
Mine Economics
1,000,000 tons for 10 years

Coal Price	IRR	NPV@20% interest
$85	-30.22%	-$43,976,030
$90	1.20%	-$35,877,791
$100	11.00%	-$20,288,144
$110	17.74%	-$5,636,189
$120	23.34%	$9,015,766
$130	28.25%	$23,667,721

Mine Economics
1,000,000 tons for 10 years

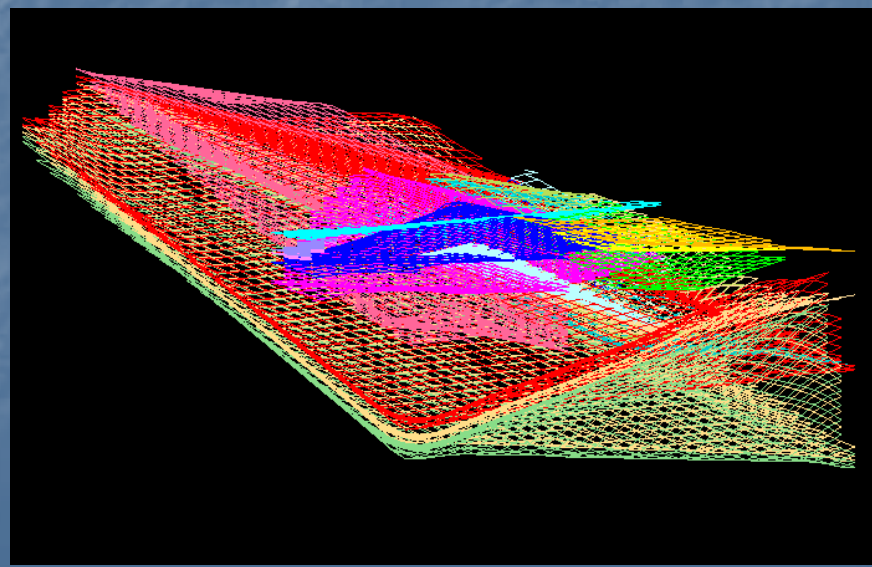


Mine Economics
1,000,000 tons for 10 years



Conclusions

- Project shows marginal economics on its own
- Economics would improve when combined with nearby deposits



Wishbone Hill: Support Slides

Cast Blasting

Key Parameters

Shot Length	500	ft
Bench Depth	90	ft
Bench Width	100	ft
Width/Depth	1.11	
HTH delay	8	ms
stemming	14.00	ft
backfill	6.00	ft

TMIN for 20'	55.00	ms
expl/hole	2,213.00	lbs
hole length	96.00	ft
charge length	72.00	ft
ANFO	0.80	SG
ANFO	10,000.00	VOD
Rock	2.60	SG
Drillhole	10.63	inch

Wishbone Hill
Time Study Results

Wishbone Hill Clean Coal
Stockpile to
Palmer Rail Loadout

27.9 Miles Round Trip

Trip No.	Trip Times (Round Trip)	Time of Day (start)	Comments
#1	0:57:07	1:39 PM	Moderate Traffic
#2	0:57:45	5:10 PM	Moderate Traffic
#3	0:53:11	4:29 AM	Very Light Traffic
#4	0:54:44	10:42 AM	Light Traffic
Longest Trip	0:57:45	5:10 PM	
Shortest Trip	0:53:11	4:29 AM	
Average cycle time	0:55:42		

Timing

- TMIN: 1.5 to 3.0 X TMIN ideal
- Rule of thumb, 100ms/row
- Incremental increase with rows
- Extra 60 ms or so for final rows for backbreak
- May use up to 25 ms within rows

Designed Pattern

Row	Burden	Spacing	PF	LBS/ft spacing	holes/500'	used holes	Timing	RTR delay	True Burden
1	8.00	20.00	3.89	110.65	25.00	25.00	0.00	0.00	8.51
2	15.00	25.00	1.66	88.52	20.00	20.00	110.00	110.00	15.96
3	17.00	30.00	1.22	73.77	16.67	17.00	230.00	120.00	18.09
4	19.00	30.00	1.09	73.77	16.67	17.00	360.00	130.00	20.22
5	20.00	30.00	1.04	73.77	16.67	17.00	500.00	140.00	21.28

Runoff Curve Numbers

Land Use, Crop, and Management	Hydrologic Soil Group A	B	C	D
CULTIVATED, with crop rotations				
Row Crops, poor management	72	81	88	91
Row Crops, conservation mgmt	65	75	82	86
Small Grains, poor management	65	76	84	88
Small Grains, conservation mgmt	61	73	81	84
Meadow	55	69	78	83
PASTURE, permanent w/moderate grazing	39	61	74	80
WOODS, permanent, mature, no grazing	25	55	70	77
ROADS, hard surfaces and roof areas	74	84	90	92

Hydrologic Soil Group Descriptions:

A -- Well-drained sand and gravel; high permeability.

B -- Moderate to well-drained; moderately fine to moderately coarse texture; moderate permeability.

C -- Poor to moderately well-drained; moderately fine to fine texture; slow permeability.

D -- Poorly drained, clay soils with high swelling potential, permanent high water table, claypan, or shallow soils over nearly impervious layer(s).

*For *average* antecedent mositure conditions in a watershed.

Source: *National Engineering Handbook*, USDA-NRCS, Hydrology Section 4, 1972.

Adjusted Curve Number

Adjustments to Runoff Curve Number (CN) for Dry or Wet Antecedent Soil Moisture Conditions

	Factors to Convert Curve Number for AMC II to AMC I or AMC III	
Curve Number (AMC II)	**AMC I (dry)**	**AMC III (wet)**
10	0.40	2.22
20	0.45	1.85
30	0.50	1.67
40	0.55	1.50
50	0.62	1.40
60	0.67	1.30
70	0.73	1.21
80	0.79	1.14
90	0.87	1.07
100	1.00	1.00

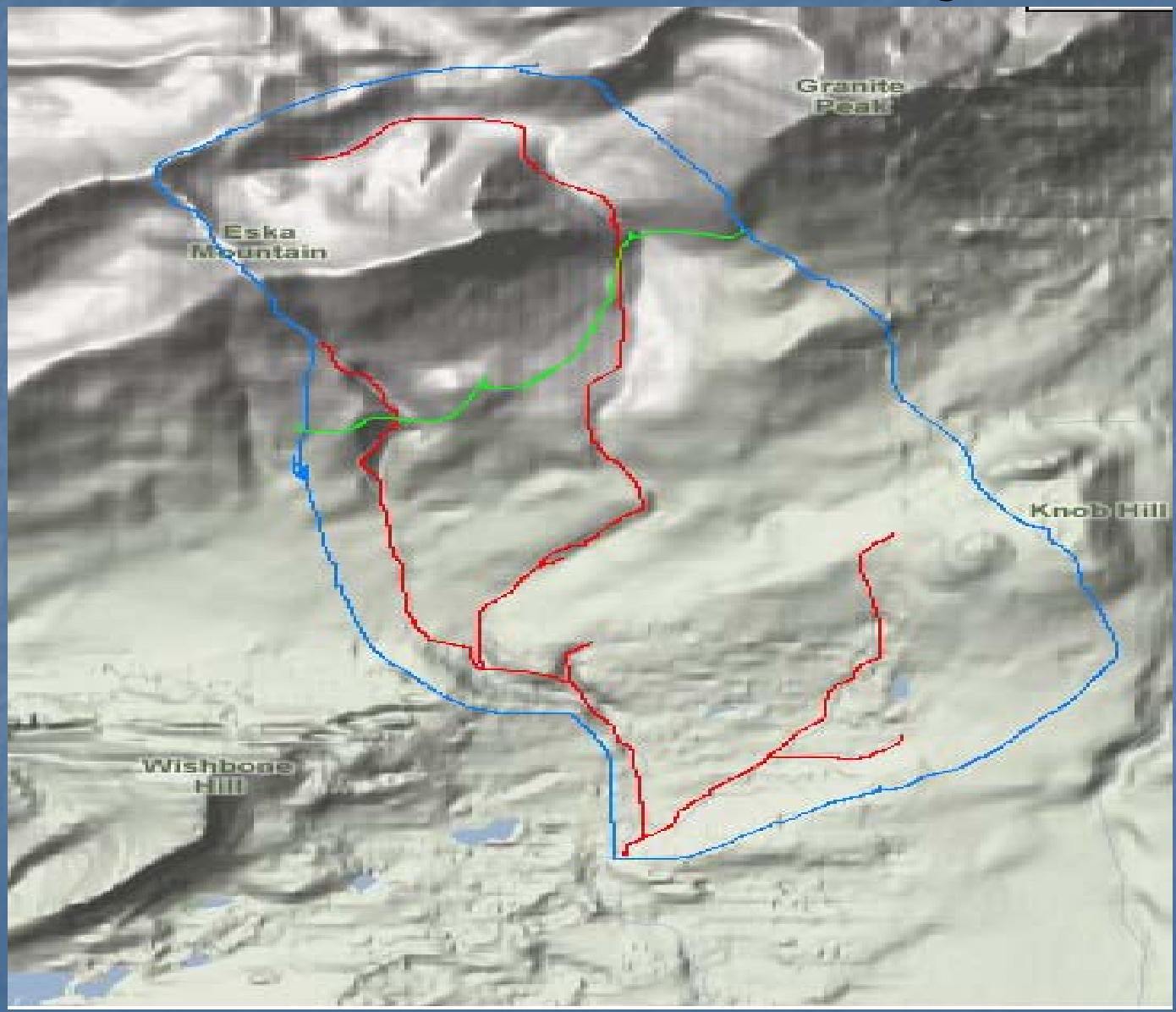
Sediment Pond

MAXIMUM PERMISSIBLE VELOCITIES FOR
DIVERSION DITCHES AND POND SPILLWAYS*

PART A - UNLINED CHANNELS

Material	Manning n	Clear Water Permissible Velocity (fps)
Fine sand, colloidal	0.020	1.50
Sandy loam, noncolloidal	0.020	1.75
Silt loam, noncolloidal	0.020	2.00
Alluvial silts, noncolloidal	0.020	2.00
Ordinary firm loam	0.020	2.50
Stiff clay, very colloidal	0.025	3.75
Alluvial silts, collodial	0.025	3.75
Shales and hardpans	0.025	6.00
Fine gravel	0.020	2.50
Graded loam to cobbles when noncolloidal	0.030	3.75
Graded silts to cobbles when colloidal	0.030	4.00
Coarse gravel, noncolloidal	0.025	4.00
Cobbles and shingles	0.035	5.00

Watershed Boundary



Matanuska River
Runoff (Q) 100 yr – 48 hr storm

- **Q = 6.77 inches**
- **P = 8.44 inches**
- **CN = 86.08**
- **S = 1.62**
- **Runoff volume = 181,618,323 cubic feet**

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

$$S = \frac{1000}{CN} - 10$$

Matanuska River
Peak Discharge 100 yr – 48 hr storm

$$q = q_u A Q F$$

- **q_u is about 185 cfs/mi^2/in**
- **A is 11.55 square miles**
- **Q is about 6.77 inches**
- **F is 0.98**
- **q = (185)(11.55)(6.77)(0.98) = 14,173 cfs**

L/D ratio

manning's coefficient (n)	Hydraulic Radius (r) L/D=8.04*(r^(1/6)/n)		
	1 ft	3 ft	10 ft
0.02	402	483	590
0.025	322	386	472
0.03	268	322	393
0.035	230	276	337

Settling Depth

manning's coefficient	Hydraulic Radius (r)		
	1 feet	3 feet	10 feet
0.02	3	2	2
0.025	4	3	2
0.03	4	4	3
0.035	5	4	3

Sediment Pond

Vs = 0.001542593 ft/sec

q = peak discharge (cfs)
l = Length (ft.)
w = width (ft.)

Vs = settling velocity (ft./sec)

Vs=Q/(l*w)

l=3w

w = 386 ft.

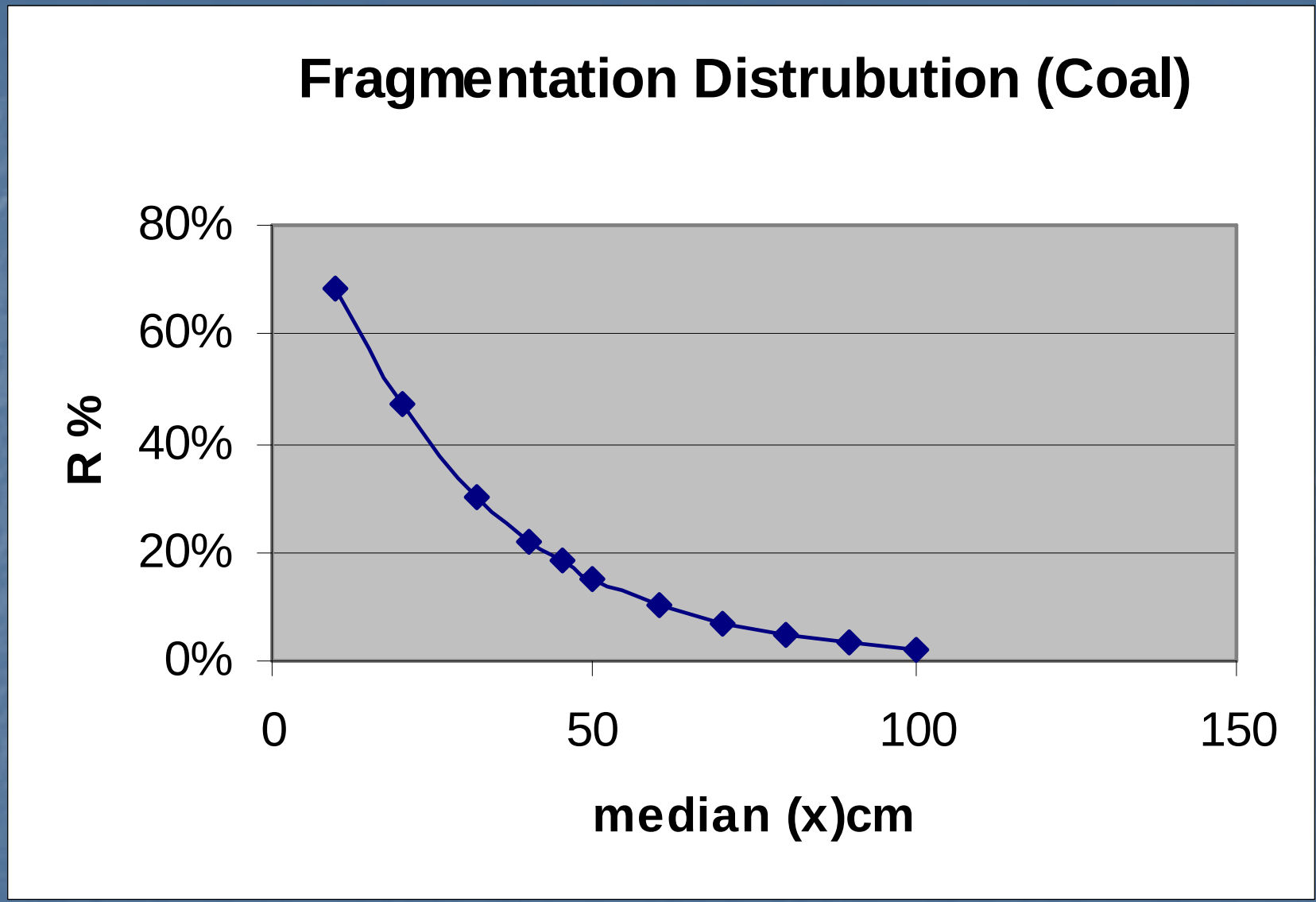
l = 1159 ft.

Area = 447,685 sq. ft.

vol=1,318,921 cu ft

Depth = 2ft

Hydraulic Radius= 10ft


Fragmentation Distrubution (Coal)
80%
60%
40%
20%
0%
R %
0
50
100
150
median (x)cm

Fragmentation Distrubution (Sandstone)