UNIVERSITAS TRISAKTI

Mine Plan

Genap 23/24

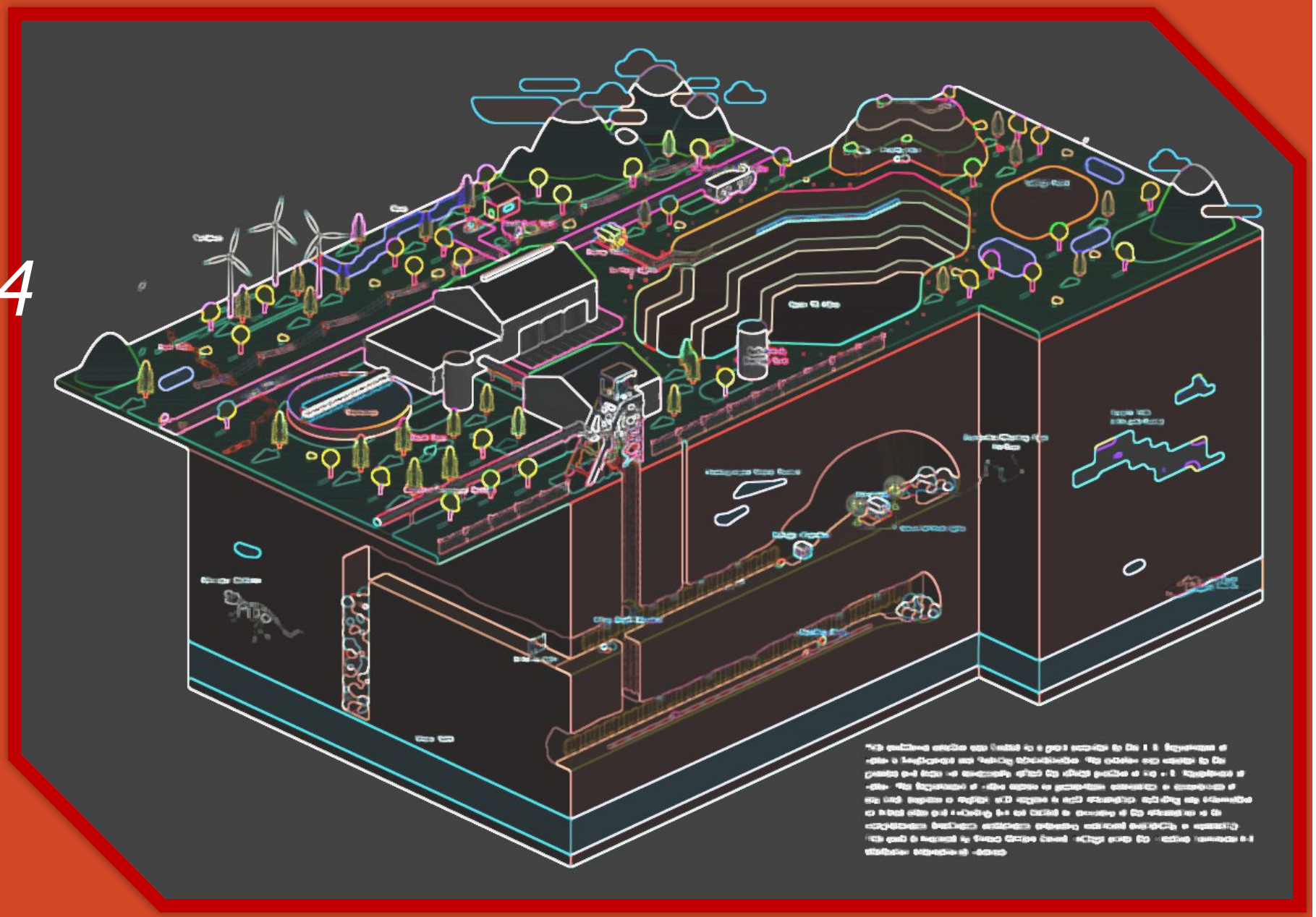
1st Session

Mine Business and Mine Plan Methodologies

Speaker

Ir. Andre Alis, ST, MBA, IPM

Danu Putra, ST, MT, IPP



Ilustrasi : (Q:) Ap

(A:) Hasil Evaluasi Kelayakan

atau yang telah beroperasi

Diharapkan terwujud :
Economic sustainability
Perusahaan Tambang

Kerangka Kerja Universal Pelaporan HE– S/d– C/d

- sebagai refleksi penerapan konsep keekonomian tambang -

Hasil Eksplorasi

Peningkatan tingkat pengetahuan dan keyakinan geologi

Sumberdaya Mineral

Cadangan Mineral

- Tereka
- Tertunjuk
- Terukur

Terkira

Terbukti

Mine Planning, Engineering Method

Pertimbangan faktor penambangan, pengolahan, metalurgi, ekonomi, pemasaran, hukum, lingkungan, infrastruktur, sosial dan pemerintahan

Faktor Pengubah

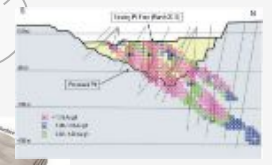
- Teknis
- Sosial – LH
- Ekonomis

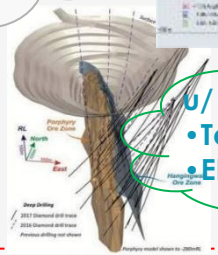
Metodologi Mine Planning, mengkonversi Sumberdaya → Cadangan, dgn mempertimbangkan 10 faktor pengubah

Mine Planner harus mengandalkan keahlian[2] lain

Kerja Tim, Multi-disiplin

Indikator kelayakan komersial Proyek Baru atau Re-evaluasi





U/ Batas Layak
- Teknis + Sosio-LH &
- Ekonomis

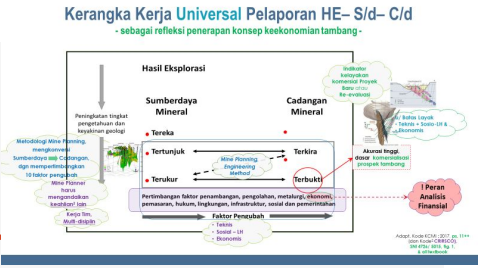
Akurasi tinggi, dasar komersialisasi prospek tambang

! Peran Analisis Finansial

Adapt. Kode KCMI : 2017, ps. 11++
(dan Kode[2] CRIRSCO),
SNI 4726/ 5015, fig. 1,
& all textbook

Framework Terkait *Mine Planning*

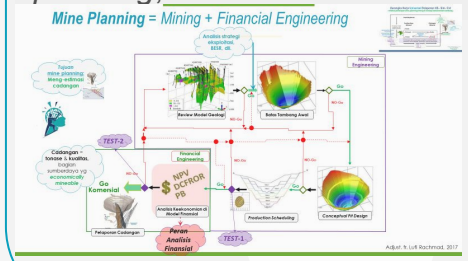
- perlu dikuasai untuk diterapkan - *to achieve mine planning objectives*-



sebagian besar materi pembelajaran

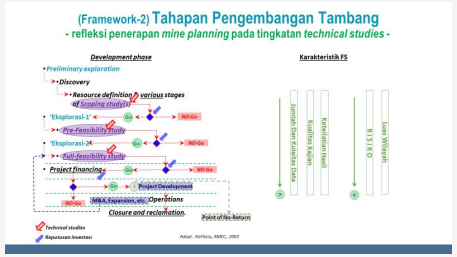
(*Framework*-A) Metodologi *Mine Planning*

Langkah- langkah *mine planning*,



(*Framework*-c) Tahap Pengembangan Prospek Tambang

Terkait *technical studies level*



(*Framerwork*-b) Proses Bisnis Operasi-Produksi Tambang

Kegiatan dari Lokasi Tambang s.d. Penjualan Produk Akhir

Tujuan *Mine Planning*

Metodologi & Praktik Terbaik

Metodologi (Methodology)

(Bristish Dictionary)
the system of methods and principles used in a particular discipline

Atau (bisa juga) a series of rules, techniques, or procedures for accomplishing a certain task (**serangkaian aturan**, **teknik**, atau **prosedur** untuk **menyelesaikan** suatu **tugas tertentu**)

dapat di-representasi dengan *flowchart*

Praktik terbaik (Best practices)

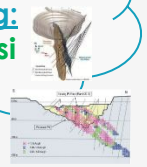
(Cambridge Dictionary)
a working method or
set of working methods
that is officially accepted
as being the best to use
in a particular business or industry

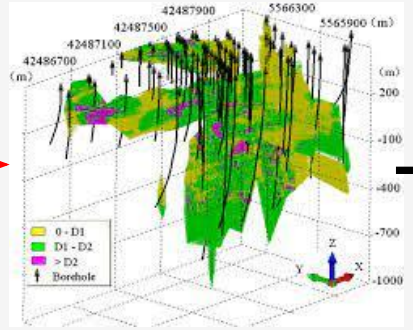
(suatu **metoda kerja**
atau kumpulan metoda kerja
yang **diakui** atau **diterima**
sebagai **yang terbaik** untuk **digunakan**
dalam **bisnis** atau **industri** tertentu)

(Framework-A) Mine Planning = Mining + Financial Engineering

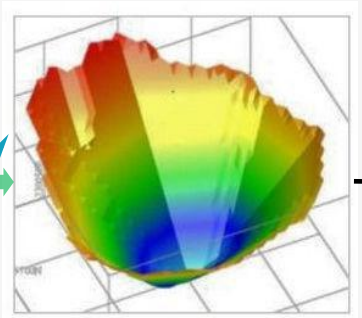
Analisis strategi eksploitasi, BESR, dll.

Tujuan mine planning: Meng-estimasi cadangan

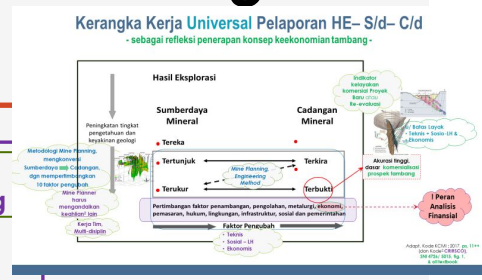




Mining Engineering



Shell Hasil Optimisasi



Go

NO-Go

Go

NO-Go

TEST-2

Cadangan = tonase & kualitas, bagian sumberdaya yg *economically mineable*

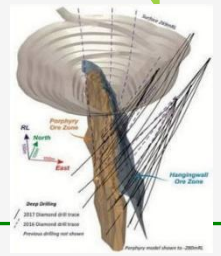
Financial Engineering

NO-Go

NO-Go

NO-Go

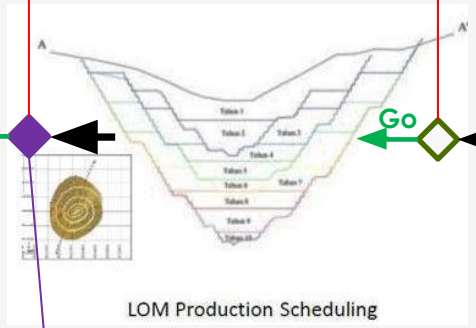
Go Komersial



$ NPV DCFROR PB

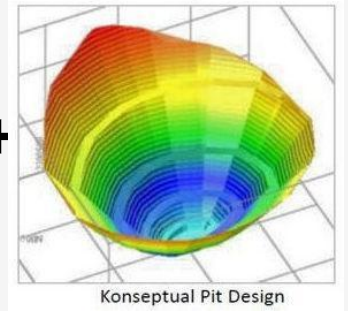
Evaluasi Keekonomian

Go



LOM Production Scheduling

Go



Konseptual Pit Design

- Test-1 : layak teknis & Sosial-LH
- Test-2 : layak ekonomis

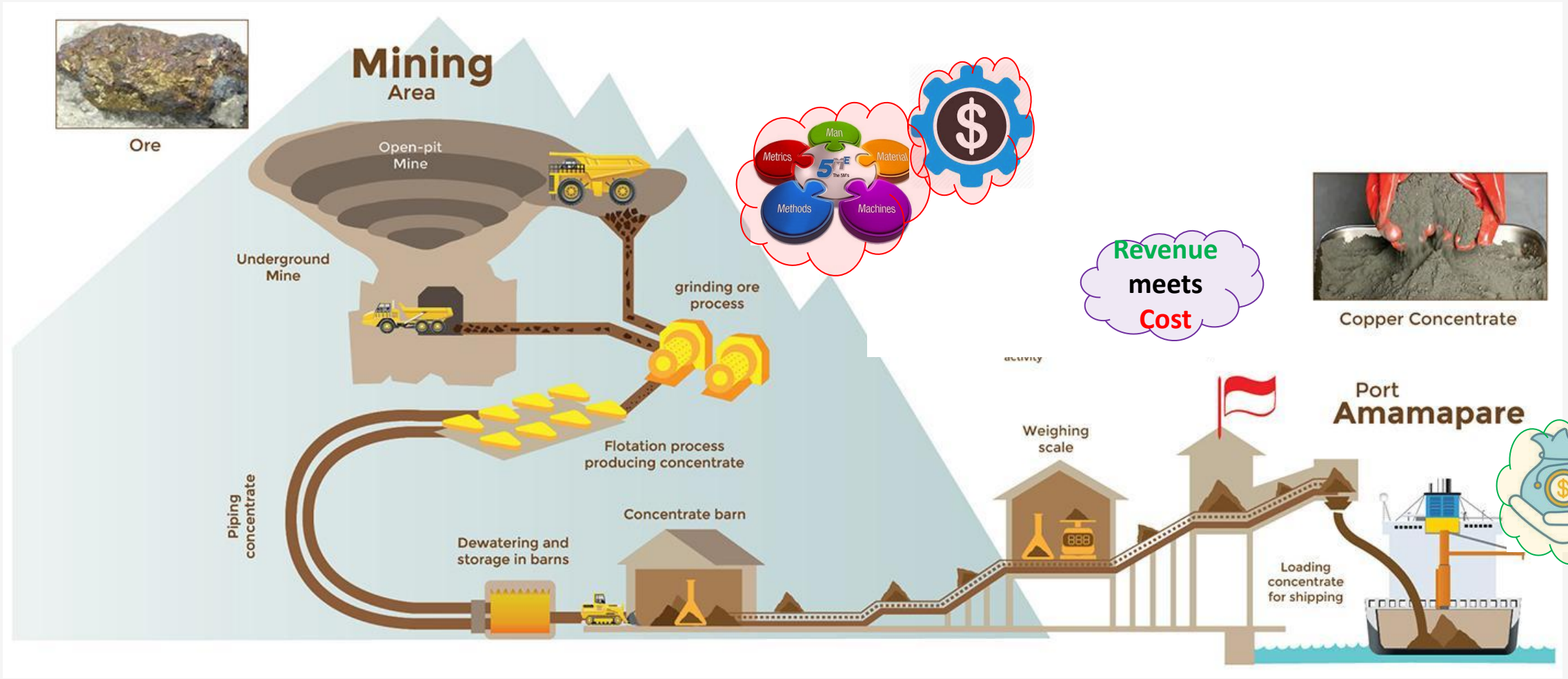
Peran Analisis Finansial

TEST-1

Adjust. fr. Lufi Rachmad, 2017

(*Framework*-b) Elaborasi Proses Operasional Tambang

- Refleksi Terjadinya Pendapatan & Biaya -



ref https://ptfi.co.id/

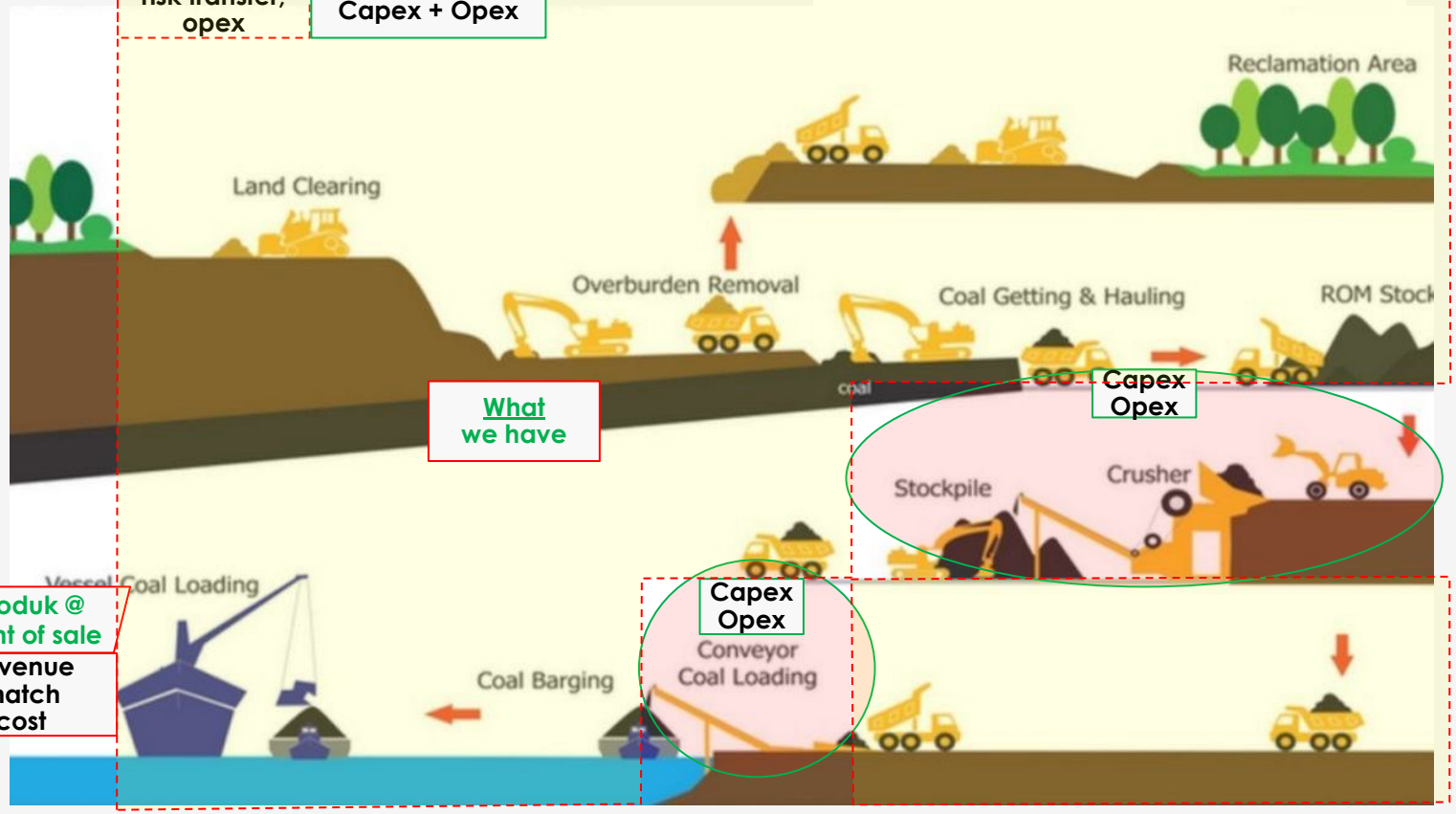
(*Framework*-b) Elaborasi Proses Operasional Tambang

- Refleksi Terjadinya Pendapatan & Biaya -

Initial Cost
- Exploration,
- Licensing,
- Acquisition

Outsourcing, risk transfer, opex

Or Own-operation Capex + Opex



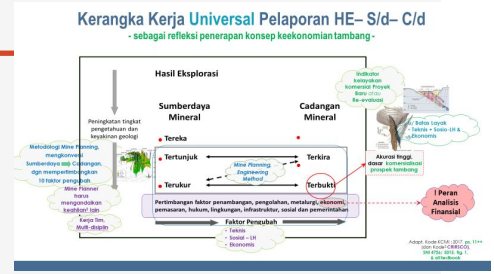
What we have

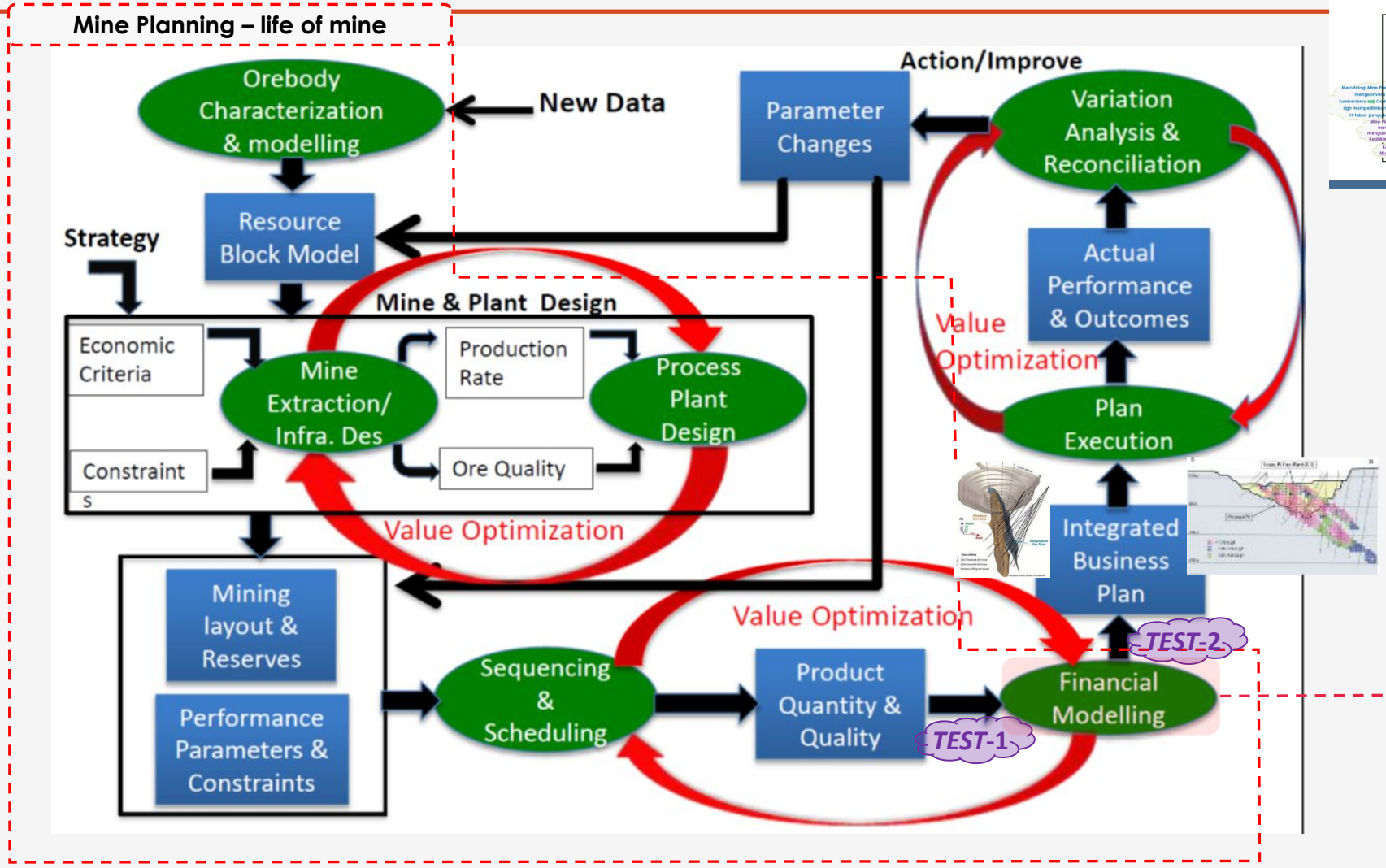
produk @ point of sale

Revenue match cost

ref internet

Integrasi *Mine Planning (Framework-A)* dan *Business Plan*#



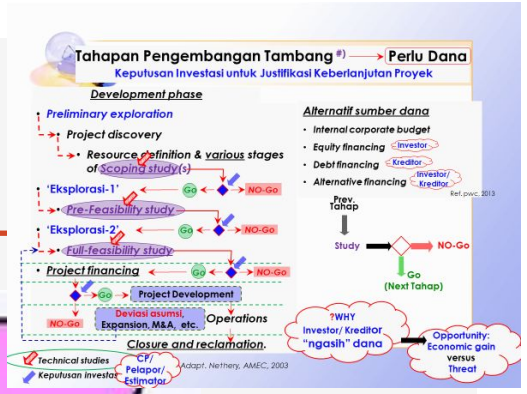


- Test-1 : layak teknis & Sosial-LH
- Test-2 : layak ekonomis

Ref. Howes, 2016

(*Framework-c*) *Mining Value Chains Process*

- Refleksi Terjadinya Pendapatan & Biaya -



Support activity

General management, human resources, technology and procurement

Resource-related activities → ← Downstream, industrial-type activities

Primary activity

Full-FS

Exploration | Planning & Development | Engineering & Construction | Operations & Logistics | Sales & Marketing

Produk

Revenue

Mineral resource management → ← Project management → ← Operations management → ← Marketing management

Low exploration success ratio

based on **Porter's** Value Chain

Adapt. Camus, 2011

Konsep Bisnis

- refleksi penerapan *mine planning* pada tingkatan *technical studies* -

? 'se-berapa besar laba-nya'

Pengertian Bisnis (Pride, dkk)

Upaya **terorganisir** dari para individu (***individuals***)
untuk memproduksi (***to produce***) dan menjual (***to sell***),
dalam rangka memperoleh laba (***profit***),
barang (***goods***) atau jasa (***services***)
untuk memuaskan (***to satisfy***)
kebutuhan masyarakat (***society's needs***)

Tujuan Bisnis

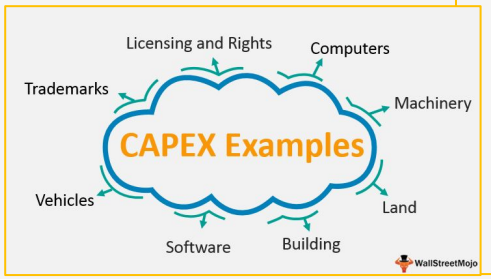
Laba = Pendapatan - Biaya

Customer
Stakeholders

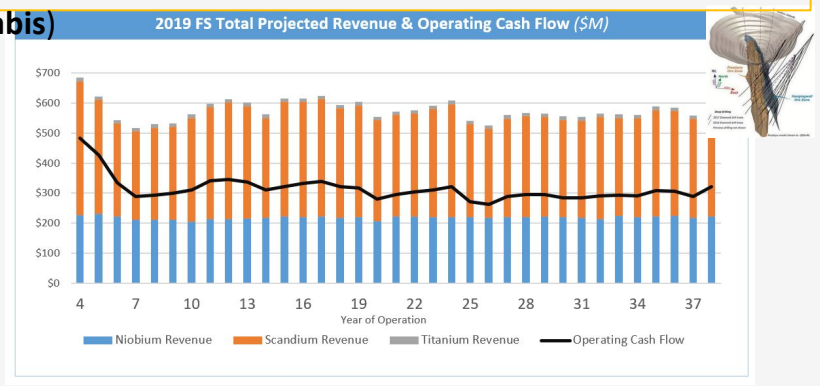
Biaya 'to *generate*' *Revenue*

Biaya
(ref **Gitman**)
Capital expenditure: penggunaan **dana** diharapkan menghasilkan ***benefit*** **> 1 tahun**

& Operational expenditure : penggunaan **dana** diharapkan menghasilkan ***benefit*** **<= 1 tahun**



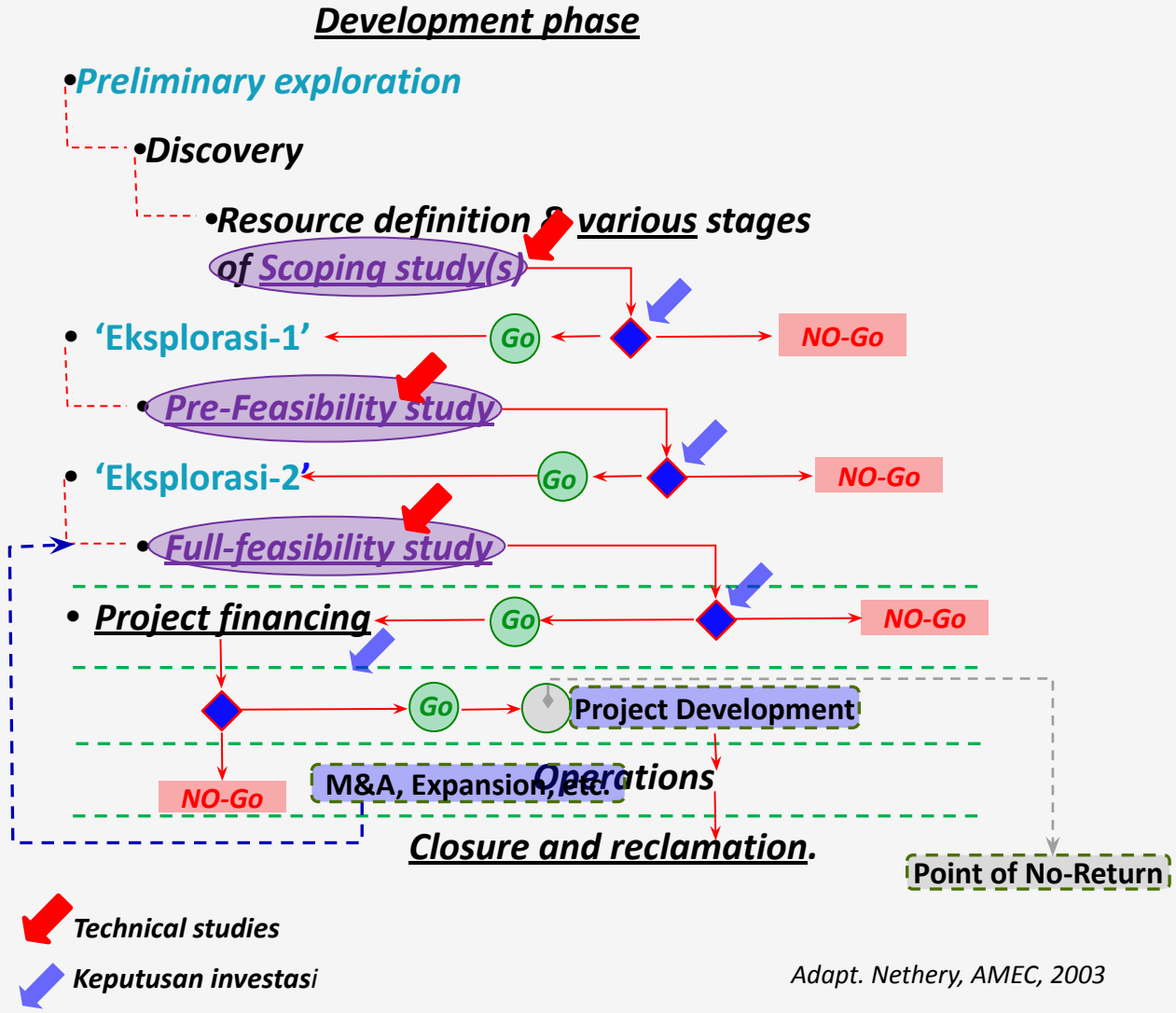
Pendapatan (*sustained* sampai **Cadangan Batubara habis**)



Ref. *various*

(*Framework*-c) Tahapan Pengembangan Tambang

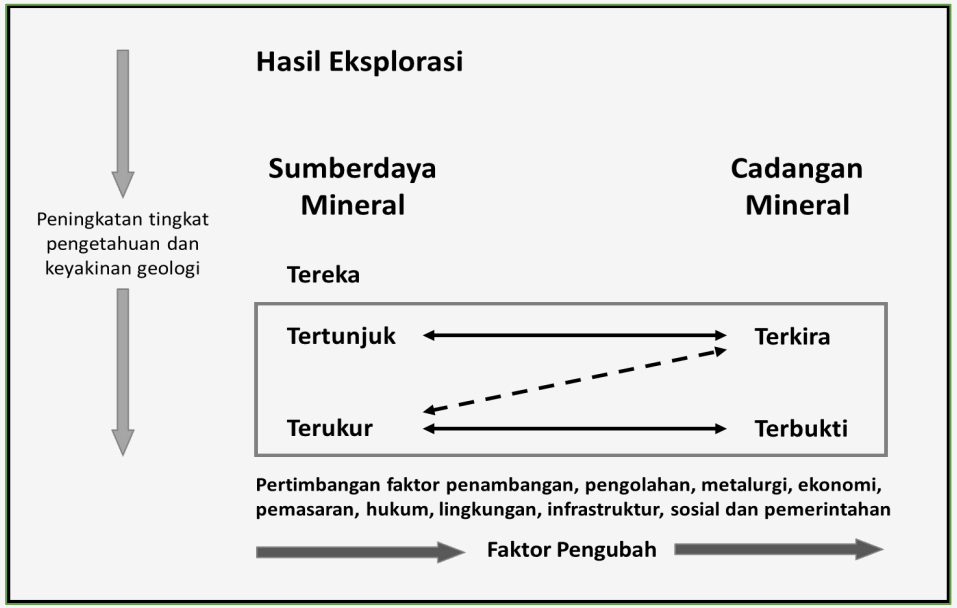
- refleksi penerapan *mine planning* pada tingkatan *technical studies* -



Adapt. Nethery, AMEC, 2003

Relevansi Mine Plan dengan Pelaporan

SNI 5015 : 2019



RINGKASAN EKSEKUTIF

BAB I PENDAHULUAN

- 1.1. Latar belakang dan tujuan
- 1.2. Lingkup kajian dan pendekatan
- 1.3. Studi pendukung dan laporan yang relevan
- 1.4. Institusi yang mengelularkan laporan
- 1.5. Standar akurasi estimasi

BAB III DESKRIPSI PROYEK

- 2.1. Lokasi dan akses
- 2.2. Aspek legalitas dan perizinan
- 2.3. Hasil kunjungan lapangan

BAB III KONDISI GEOLOGI DAN LOKAL

- 3.1. Geologi regional
- 3.2. Geologi lokal

BAB IV PROGRAM EKSPLORASI DAN SURVEI

- 4.1. Pengeboran eksplorasi
- 4.2. Logging geofisika
- 4.3. Pencatatan litologi
- 4.4. Pengambilan dan preparasi sampel
- 4.5. *Collar survey*
- 4.6. Survei topografi

BAB V PEMODELAN GEOLOGI, ESTIMASI DAN PELAPORAN SUMBER DAYA BATUBARA

- 5.1 Interpretasi *database* eksplorasi
- 5.2 Pemodelan geologi
- 5.3 Estimasi sumber daya
- 5.4 Kualifikasi dan pernyataan orang yang berkompeten

BAB VI KAJIAN TEKNIS

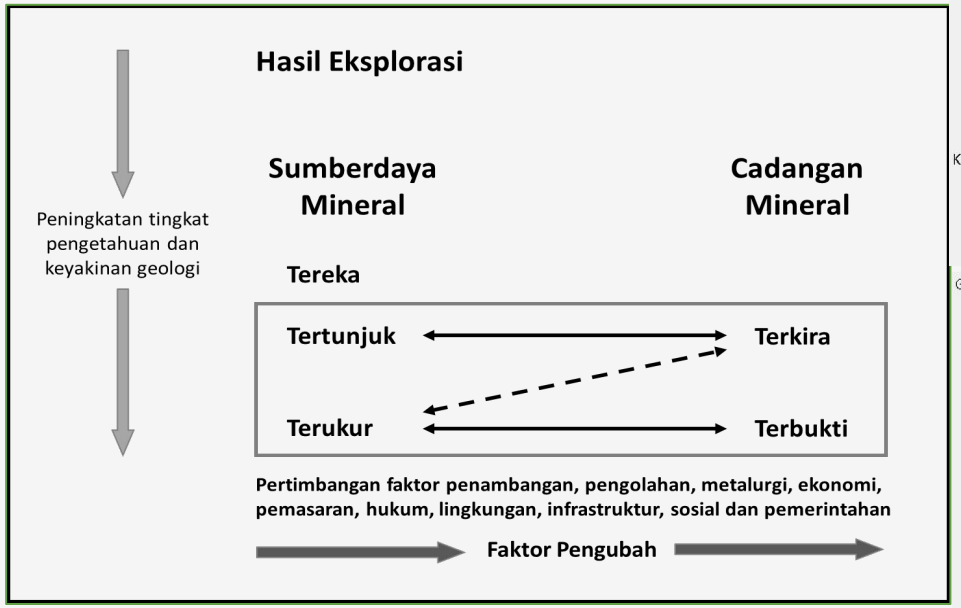
- 6.1 Kajian geoteknik
- 6.2 Kajian hidrologi – hidrogeologi
- 6.3 Kajian air asam tambang
- 6.4 Kajian metalurgi dan pengolahan
- 6.5 Kajian pendukung lainnya yang relevan

BAB VII PELAPORAN CADANGAN BATUBARA

- 7.1 Verifikasi dan validasi pemodelan geologi sumber daya
- 7.2 Optimisasi penambangan
- 7.3 Desain penambangan
- 7.4 Perencanaan sepanjang umur tambang (*Life-of-mine plan*)
- 7.5 Evaluasi keekonomian proyek tambang
- 7.6 Tinjauan faktor pengubah
- 7.7 Kriteria klasifikasi
- 7.8 Estimasi cadangan

Relevansi Mine Plan dengan Pelaporan

Kepmen ESDM 1806 K 30 MEM 2018 – Hal. 1632-1648



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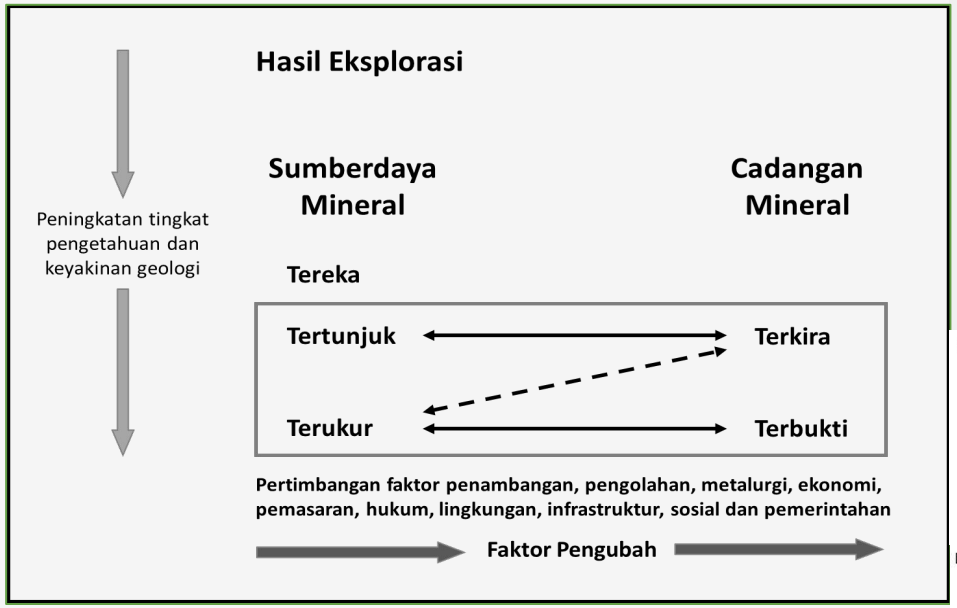

Ada Pertanyaan?

UNIVERSITAS TRISAKTI

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Genap 23/24

3rd Session

Geological Model and Strategy

Speaker

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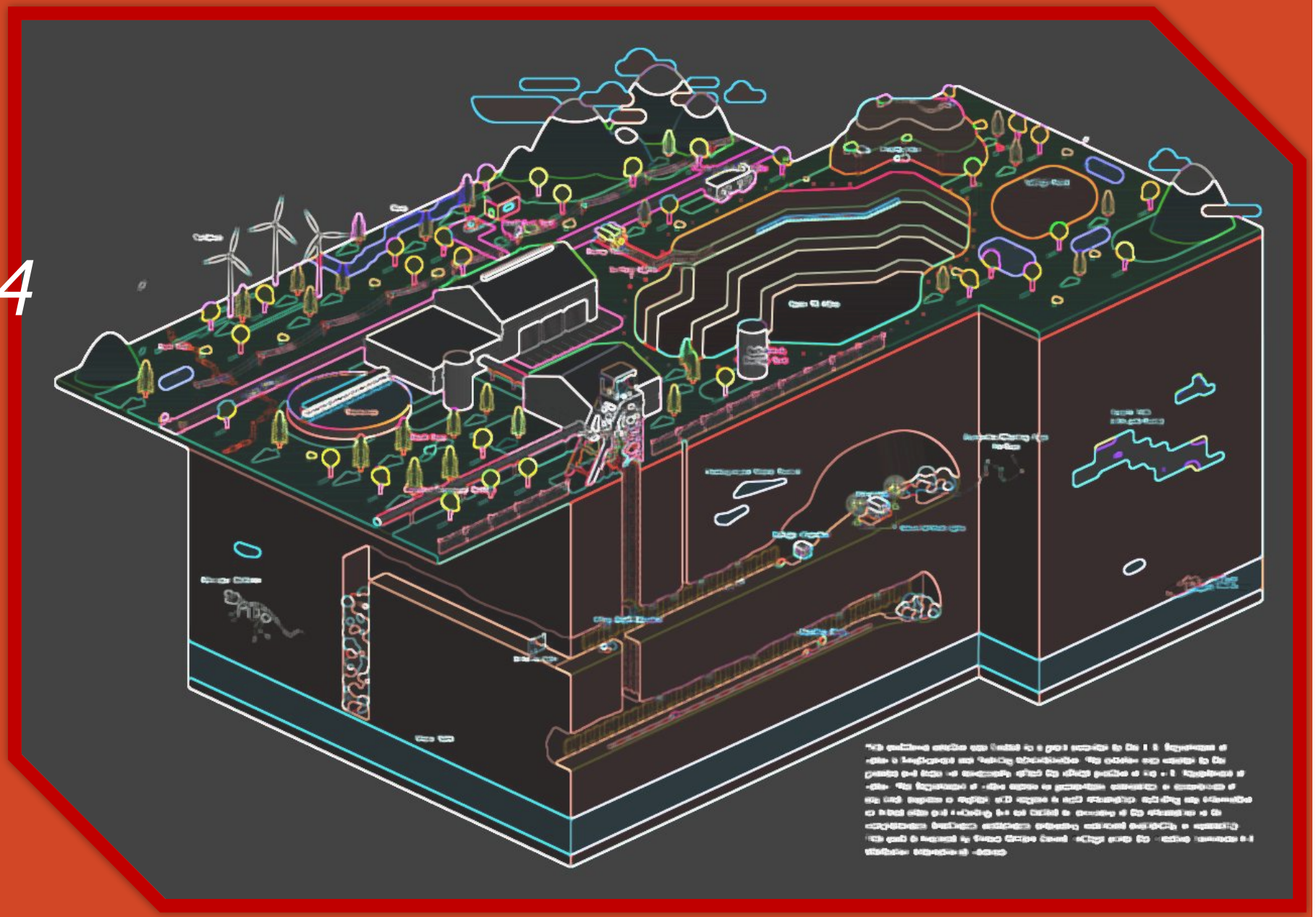

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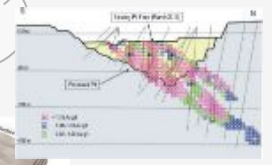

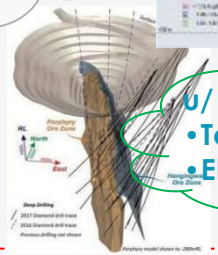

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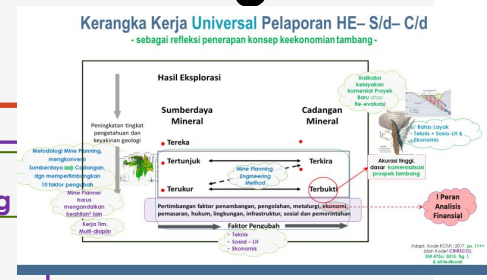
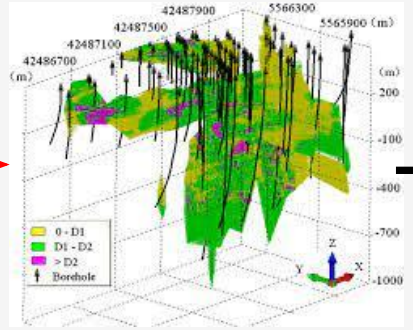
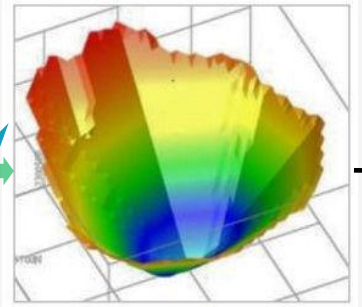


Analisis strategi eksploitasi, BESR, dll.

Tujuan mine planning: Meng-estimasi cadangan

Mining Engineering





Shell Hasil Optimisasi

Go

NO-Go

Go

NO-Go

TEST-2

Financial Engineering

NO-Go

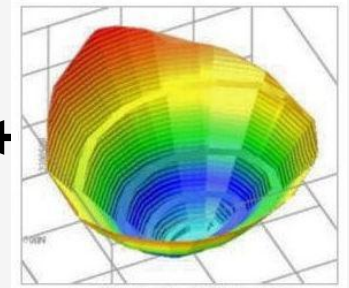
NO-Go

NO-Go

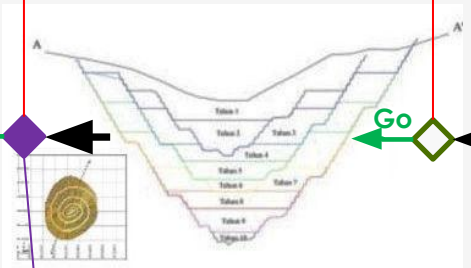
Go

Go

Go



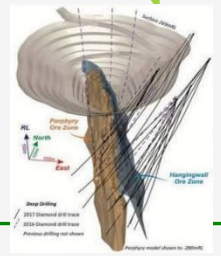
Konseptual Pit Design



LOM Production Scheduling

Cadangan = **tonase** & **kualitas**, bagian sumberdaya yg *economically mineable*

Go Komersial



$ NPV DCFROR PB

Evaluasi Keekonomian

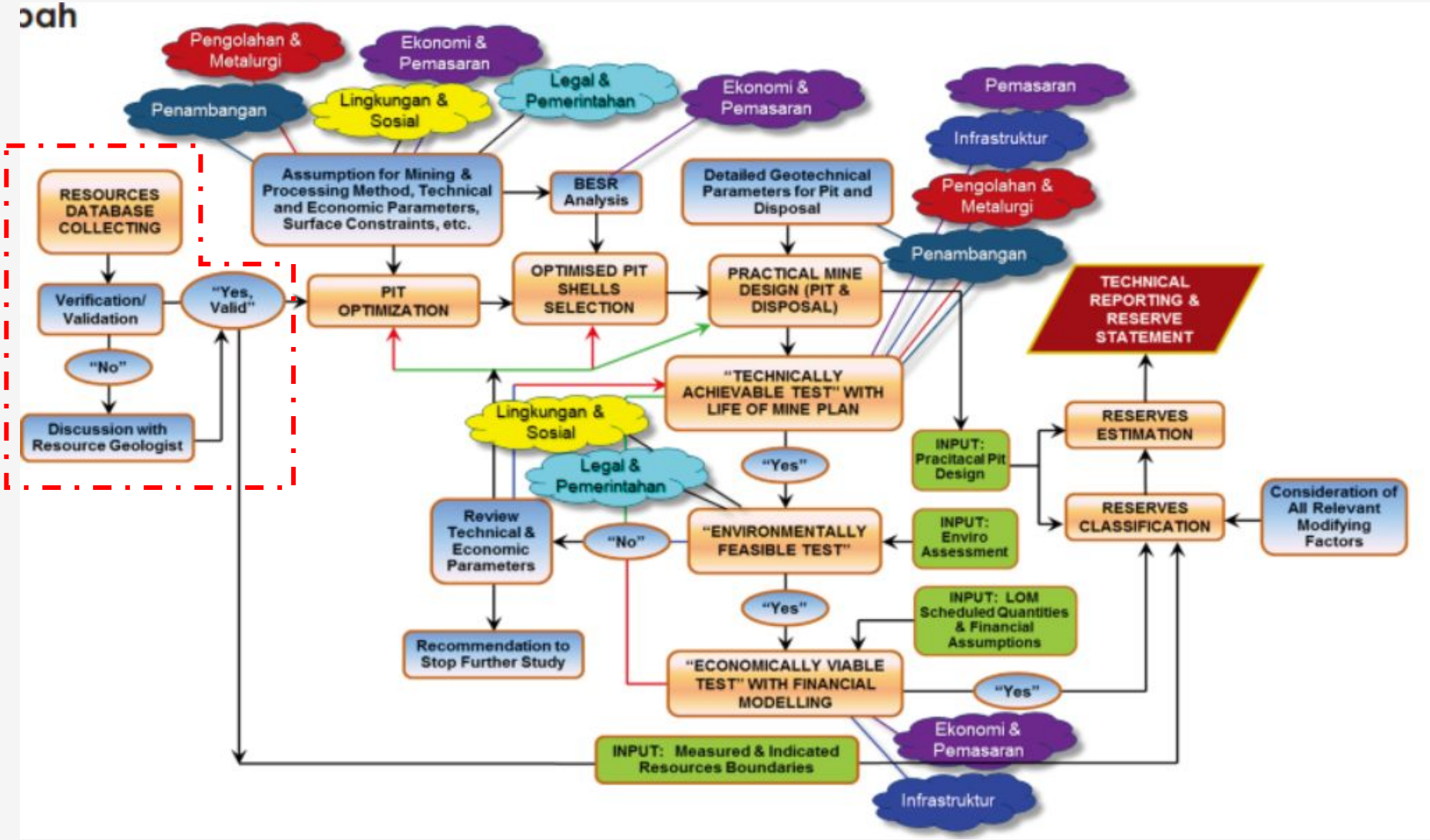
- Test-1 : layak teknis & Sosial-LH
- Test-2 : layak ekonomis

Peran Analisis Finansial

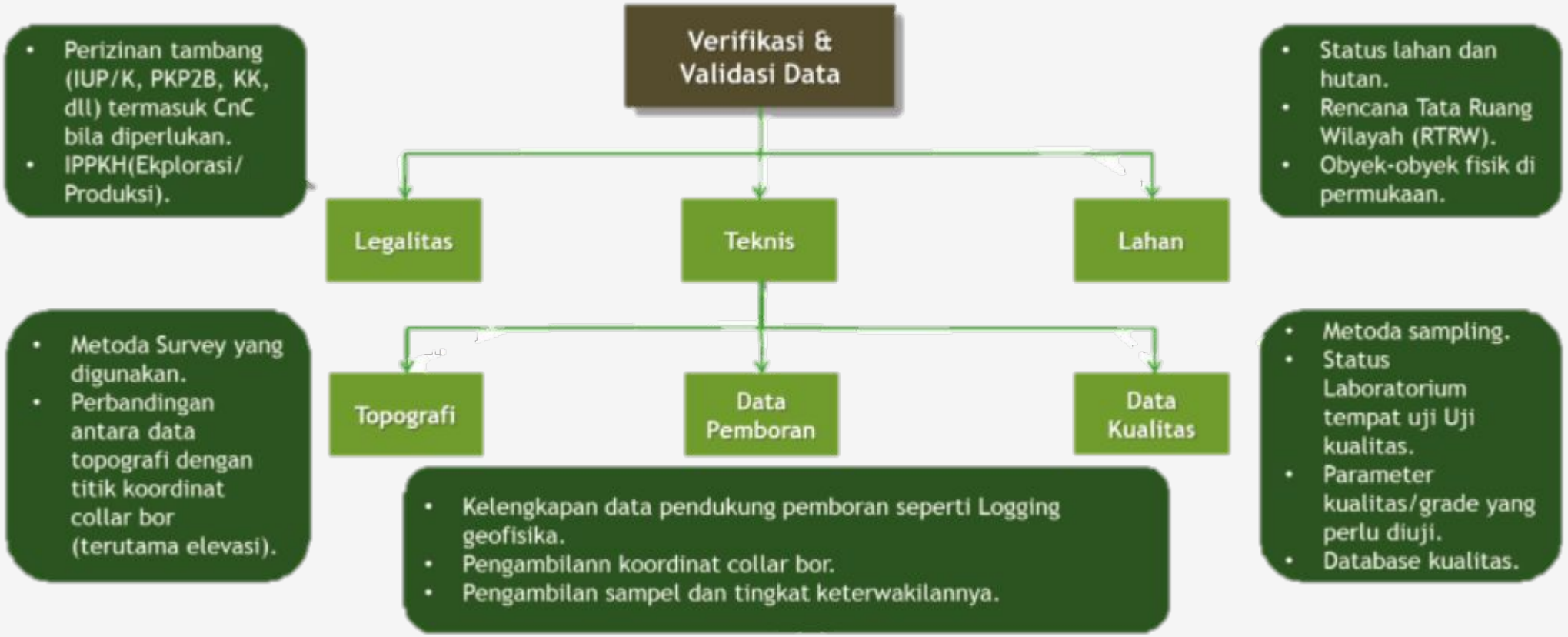
TEST-1

Adjust. fr. Lufi Rachmad, 2017

(*Framework-A*) ***Mine Planning*** = *Mining + Financial Engineering*



Verifikasi dan Validasi Basis Sumberdaya



Verifikasi dan Validasi Basis Sumberdaya

Legalitas

Legalitas

- Perizinan
- IPPKH
- Boundary hukum lain

Topografi

- Metode Survey
- Perbandingan topografi dan borehole collar

Teknis

Data Pemboran

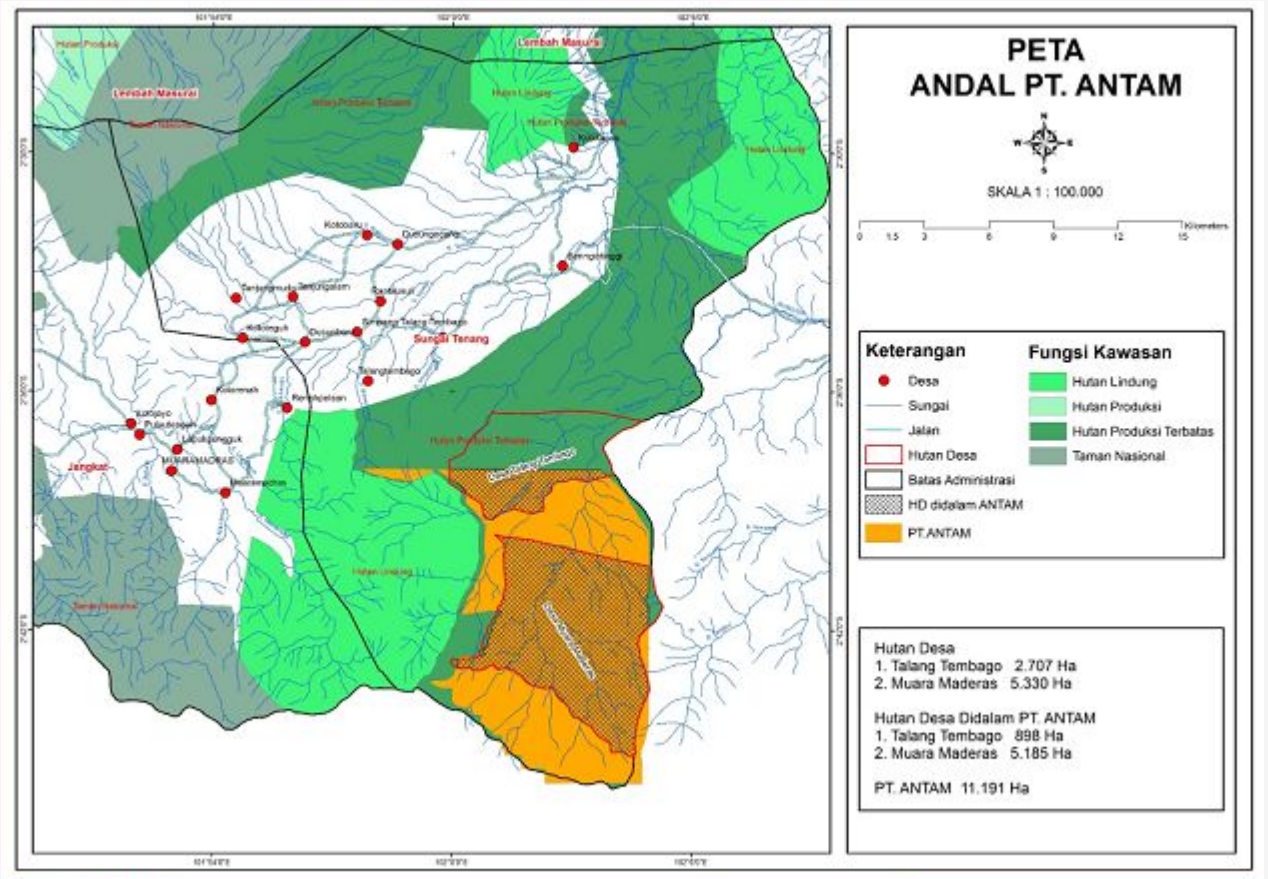
- Logging geofisika
- Data collar bore
- Sampling

Lahan

- Status lahan
- Rencana tata ruang
- Obyek fisik permukaan

Data Kualitas

- Metode sampling
- Status lab
- Parameter kualitas
- Database kualitas



Verifikasi dan Validasi Basis Sumberdaya

Topografi

Legalitas

- Perizinan
- IPPKH
- Boundary hukum lain

Topografi

- Metode Survey
- Perbandingan topografi dan borehole collar

Teknis

Data Pemboran

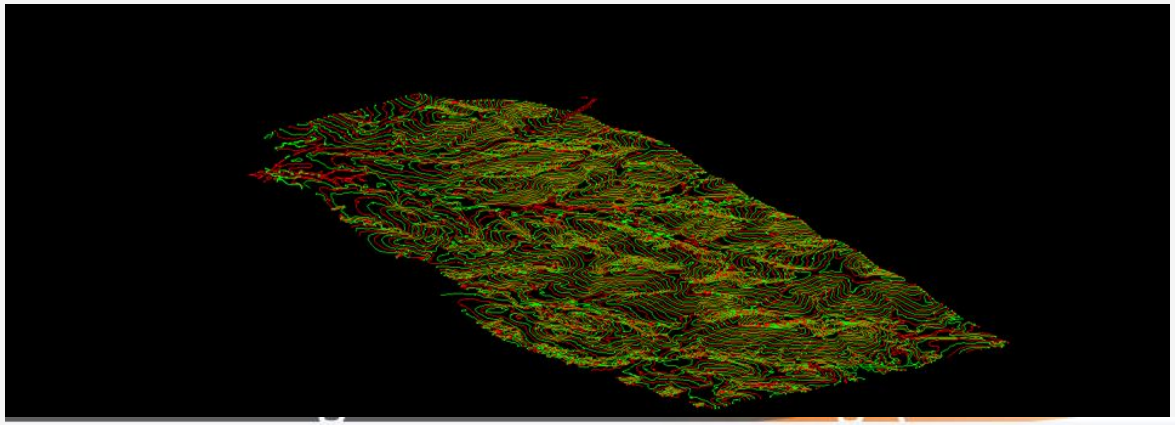
- Logging geofisika
- Data collar bore
- Sampling

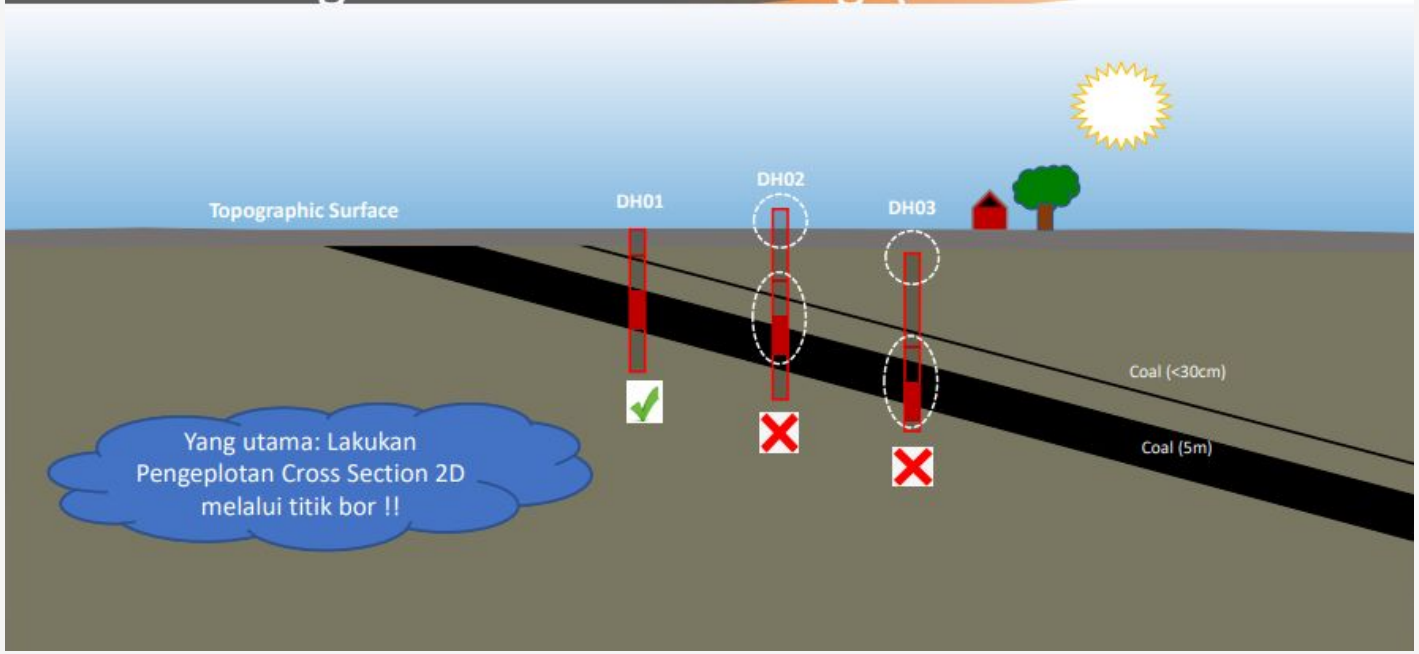
Lahan

- Status lahan
- Rencana tata ruang
- Obyek fisik permukaan

Data Kualitas

- Metode sampling
- Status lab
- Parameter kualitas
- Database kualitas





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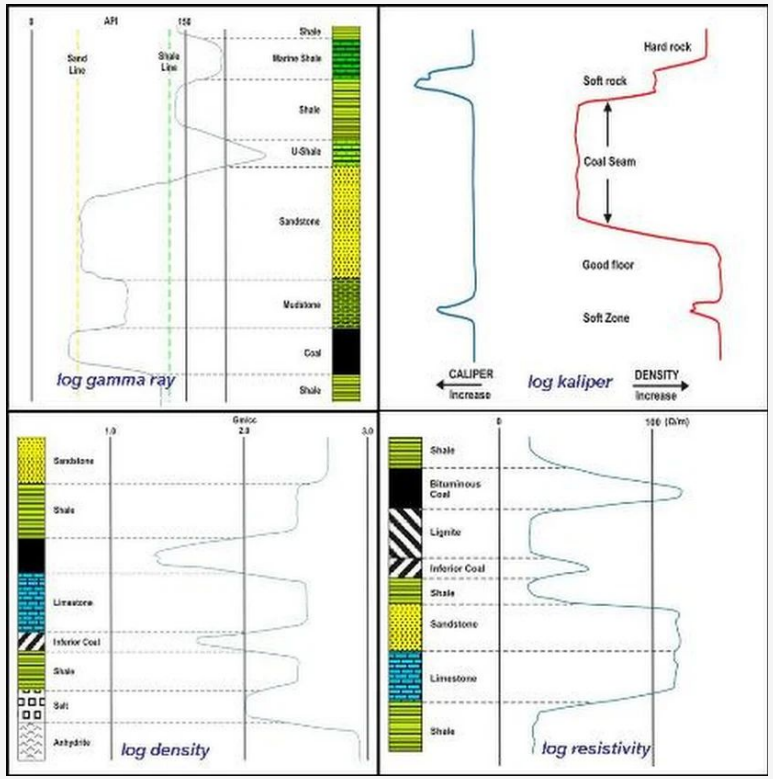

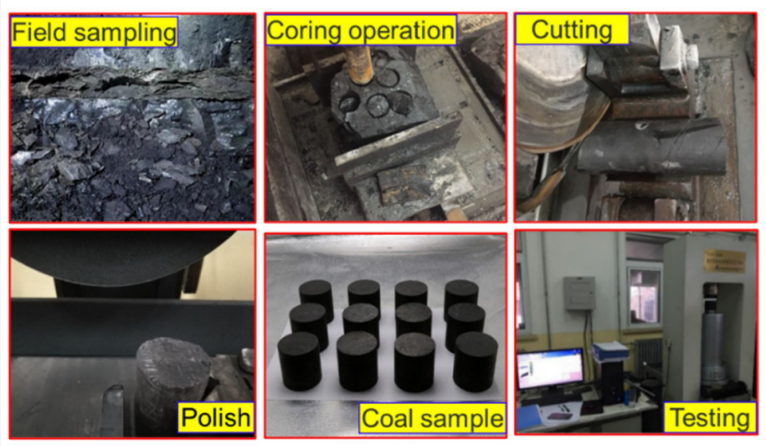

Hole_ID	East	North	RL	EOH	Dip	Azimuth
AXE001	10600	12400	367.7	38	-60	90
AXE003	10700	12400	367.6	60	-60	90
AXE005	10800	12400	367.5	60	-60	90
AXE007	10900	12400	368.1	60	-60	90
AXE009	11000	12400	368.3	52	-60	90
AXE011	11100	12400	368.9	54	-60	90
AXE013	11200	12400	369.7	37	-60	90
AXE014	11200	12200	369.9	33	-60	90
AXE015	11100	12200	367.9	52	-60	90

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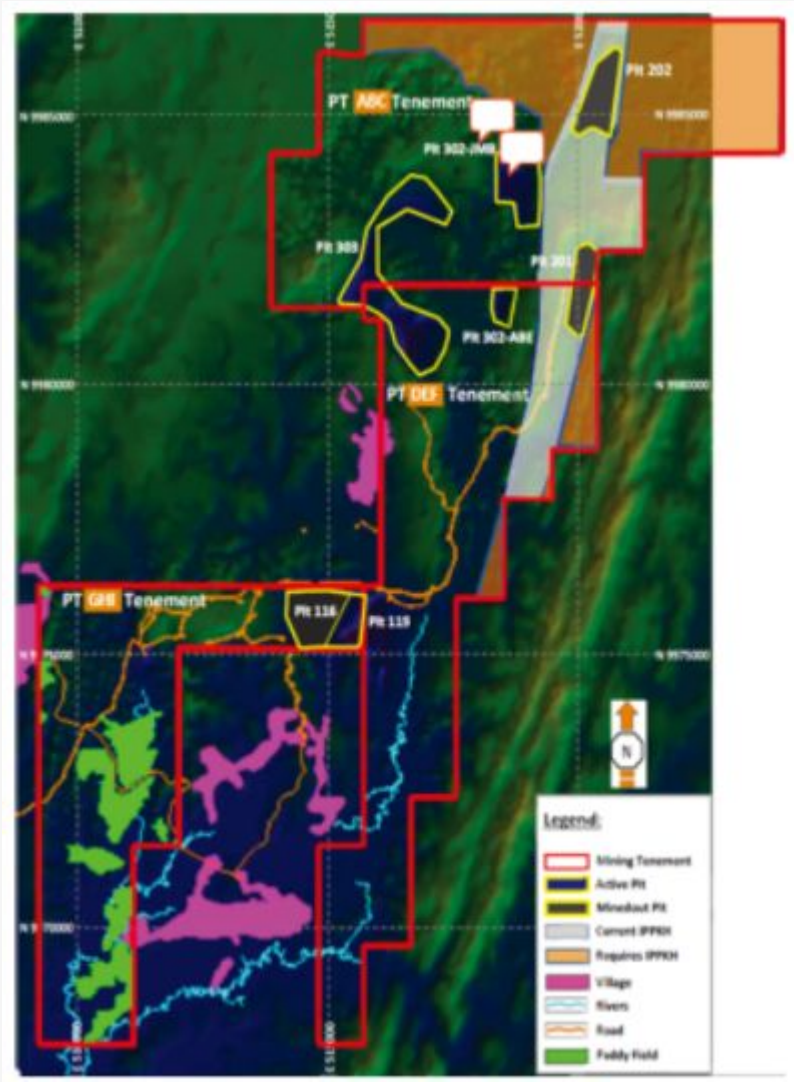

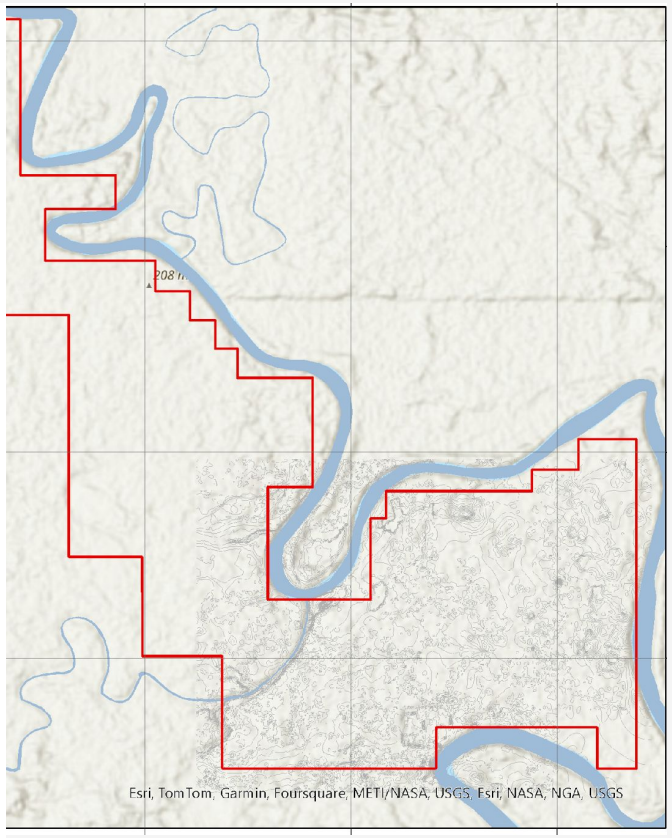

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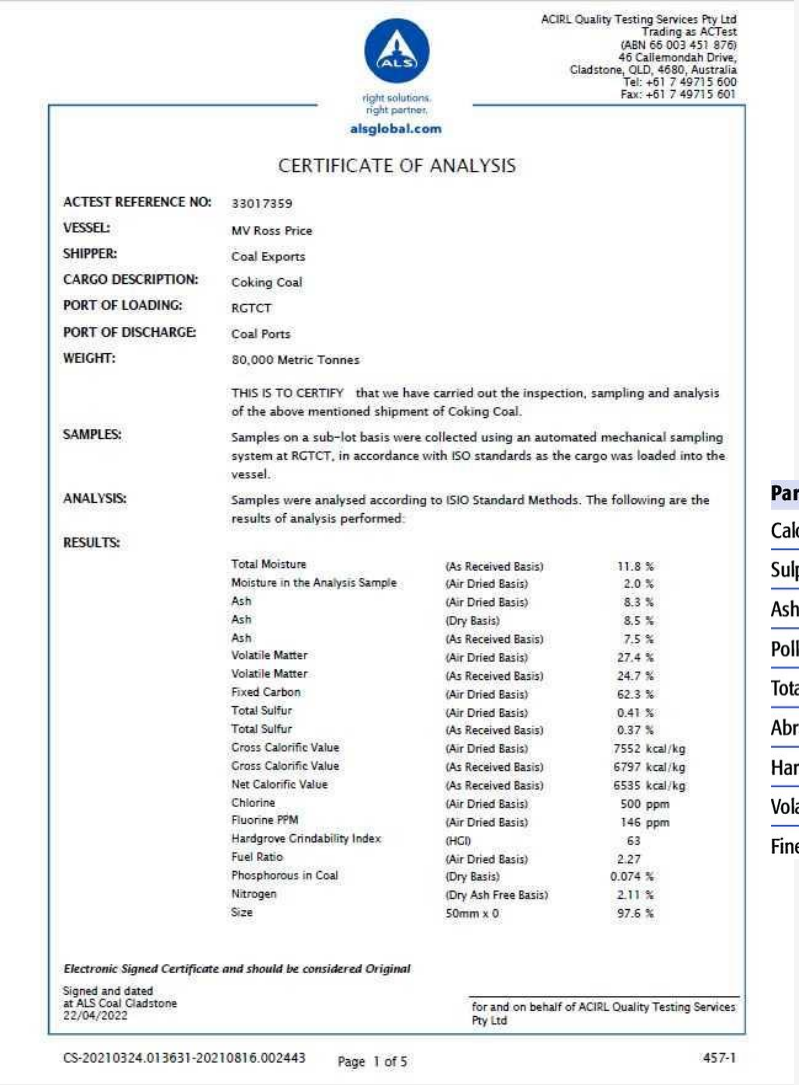

ACIRL Quality Testing Services Pty Ltd
Trading as ACTest
(ABN 66 003 451 876)
46 Callemondah Drive,
Cladstone, QLD, 4680, Australia
Tel: +61 7 49715 600
Fax: +61 7 49715 601

right solutions. right partner.
alsglobal.com

CERTIFICATE OF ANALYSIS

ACTEST REFERENCE NO:	33017359
VESSEL:	MV Ross Price
SHIPPER:	Coal Exports
CARGO DESCRIPTION:	Coking Coal
PORT OF LOADING:	RGTCT
PORT OF DISCHARGE:	Coal Ports
WEIGHT:	80,000 Metric Tonnes

THIS IS TO CERTIFY that we have carried out the inspection, sampling and analysis of the above mentioned shipment of Coking Coal.

SAMPLES: Samples on a sub-lot basis were collected using an automated mechanical sampling system at RGTCT, in accordance with ISO standards as the cargo was loaded into the vessel.

ANALYSIS: Samples were analysed according to ISIO Standard Methods. The following are the results of analysis performed:

RESULTS:

Total Moisture	(As Received Basis)	11.8 %
Moisture in the Analysis Sample	(Air Dried Basis)	2.0 %
Ash	(Air Dried Basis)	8.3 %
Ash	(Dry Basis)	8.5 %
Ash	(As Received Basis)	7.5 %
Volatile Matter	(Air Dried Basis)	27.4 %
Volatile Matter	(As Received Basis)	24.7 %
Fixed Carbon	(Air Dried Basis)	62.3 %
Total Sulfur	(Air Dried Basis)	0.41 %
Total Sulfur	(As Received Basis)	0.37 %
Cross Calorific Value	(Air Dried Basis)	7552 kcal/kg
Cross Calorific Value	(As Received Basis)	6797 kcal/kg
Net Calorific Value	(As Received Basis)	6535 kcal/kg
Chlorine	(Air Dried Basis)	500 ppm
Fluorine PPM	(Air Dried Basis)	146 ppm
Hardgrove Grindability Index	(HGI)	63
Fuel Ratio	(Air Dried Basis)	2.27
Phosphorous in Coal	(Dry Basis)	0.074 %
Nitrogen	(Dry Ash Free Basis)	2.11 %
Size	50mm x 0	97.6 %

Electronic Signed Certificate and should be considered Original

Signed and dated
at ALS Coal Cladstone
22/04/2022

for and on behalf of ACIRL Quality Testing Services Pty Ltd

CS-20210324.013631-20210816.002443 Page 1 of 5 457-1

KAN
Komite Akreditasi Nasional
Lembaga Sertifikasi Sistem Mutu

SNI
Standar Nasional Indonesia

Parameters	Remarks
Calorific value	Calorific value of coal directly proportional to price of coal
Sulphur content	Lowering sulphur content increases the price
Ash content	Increase in ash content lowers the price and vice versa
Pollutants other than sulphur	Acceptable within certain range; any increase further, lowers the price
Total moisture content	
Abrasivity	Higher the abrasivity lower the price (typical example: South Africa)
Hardness/Softness	Within a certain range, softer the coal lower the price
Volatile content	Limited evidence of influence
Fine or coarse grades (sizes)	Depends upon consumer and supplier agreement

Verifikasi dan Validasi Basis Sumberdaya

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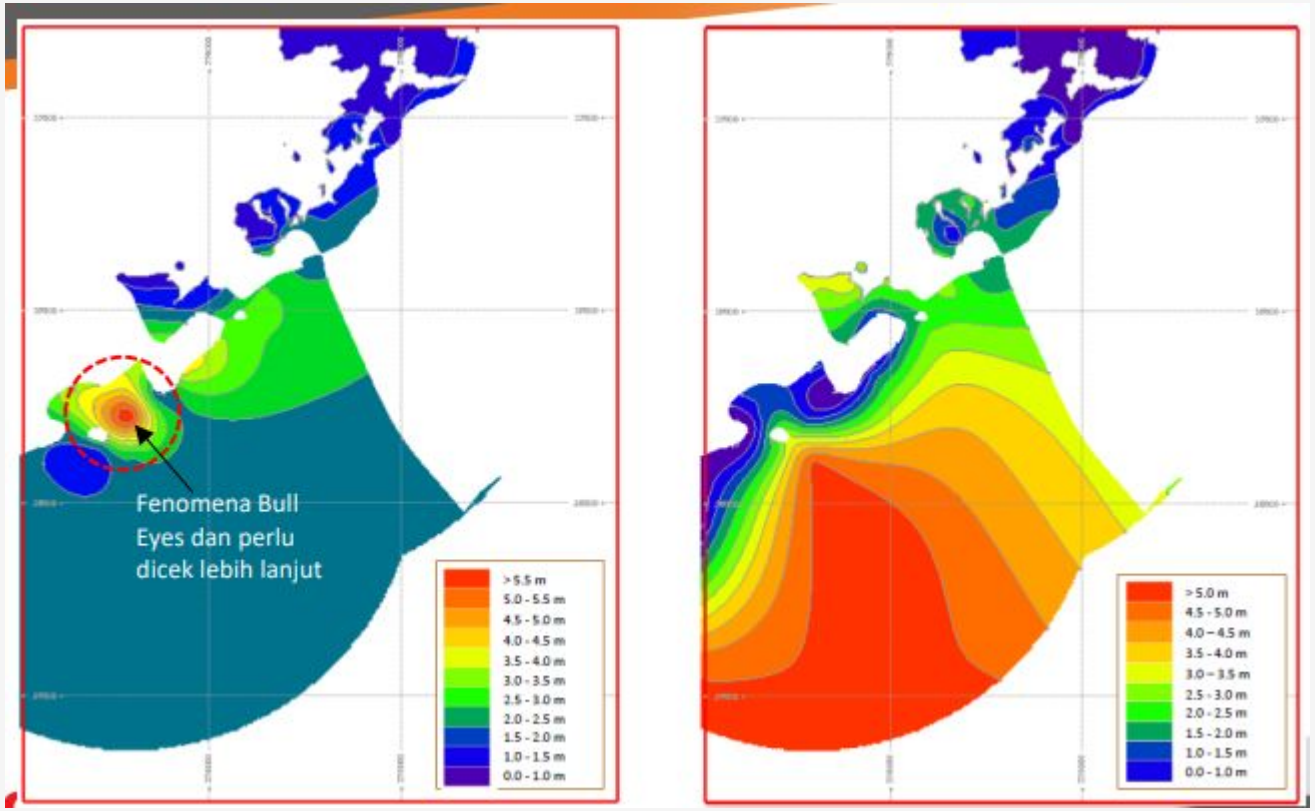
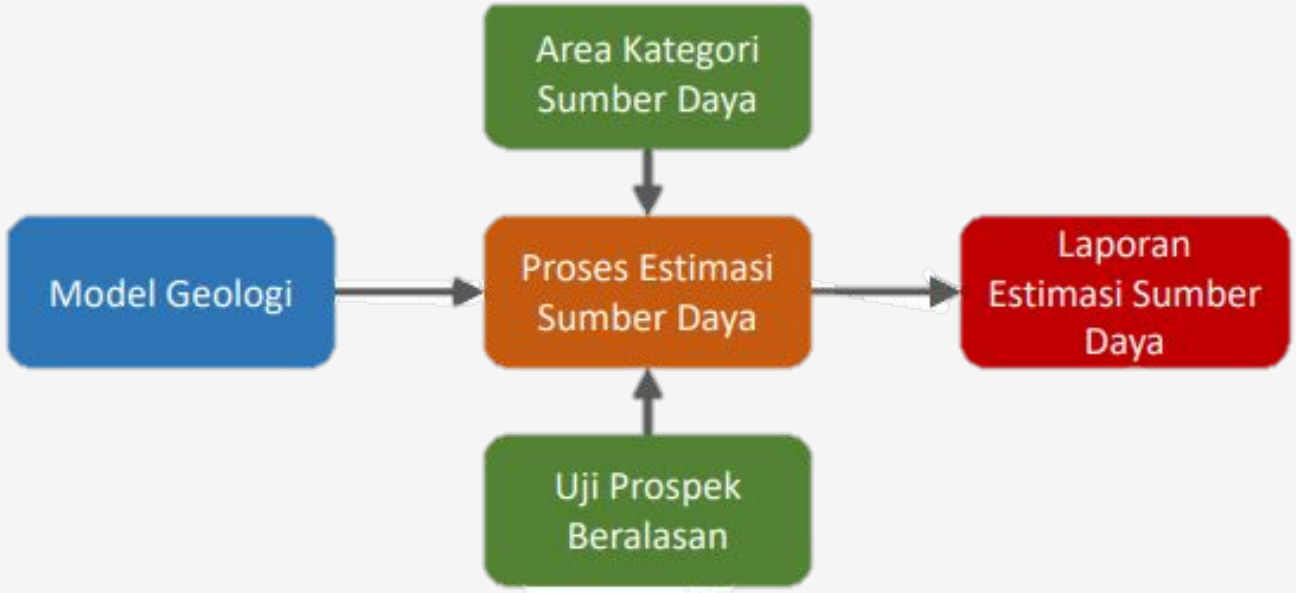
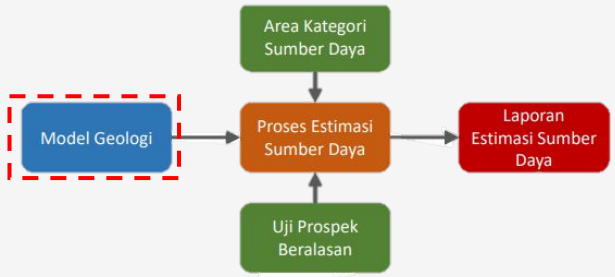


(Ilustrasi) Review Sumber Daya (1/)



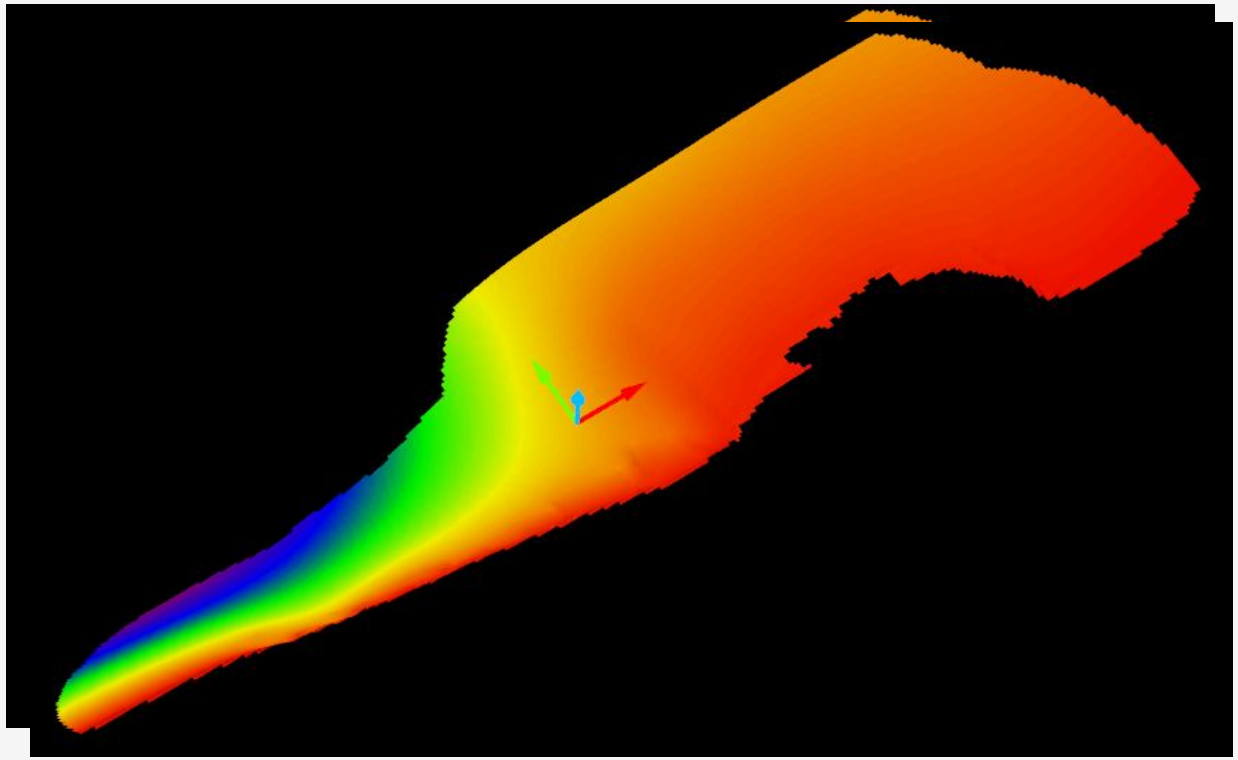
Ref Dwi Prasetya, 2021

(Ilustrasi) Review Sumber Daya (1/)



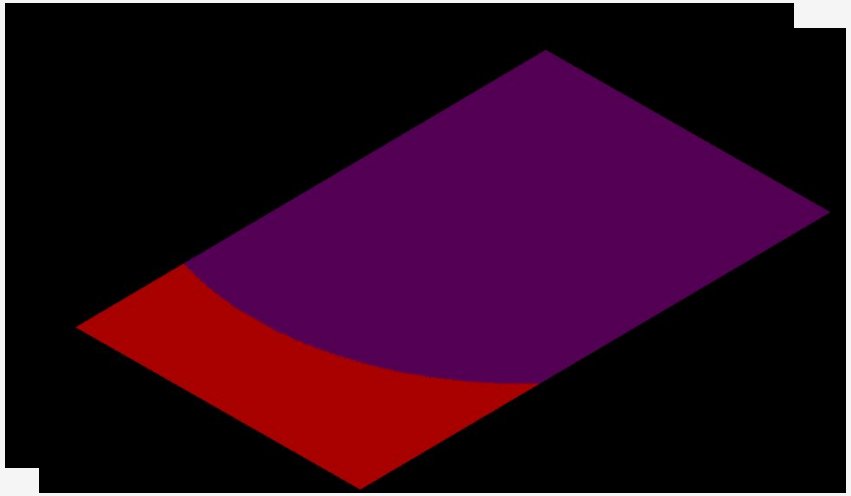
Contoh Grid Model

Surface Model



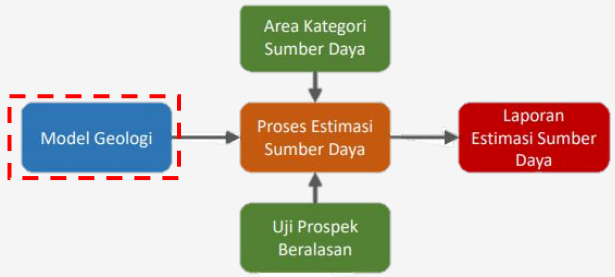
Roof and Floor

Quality Model



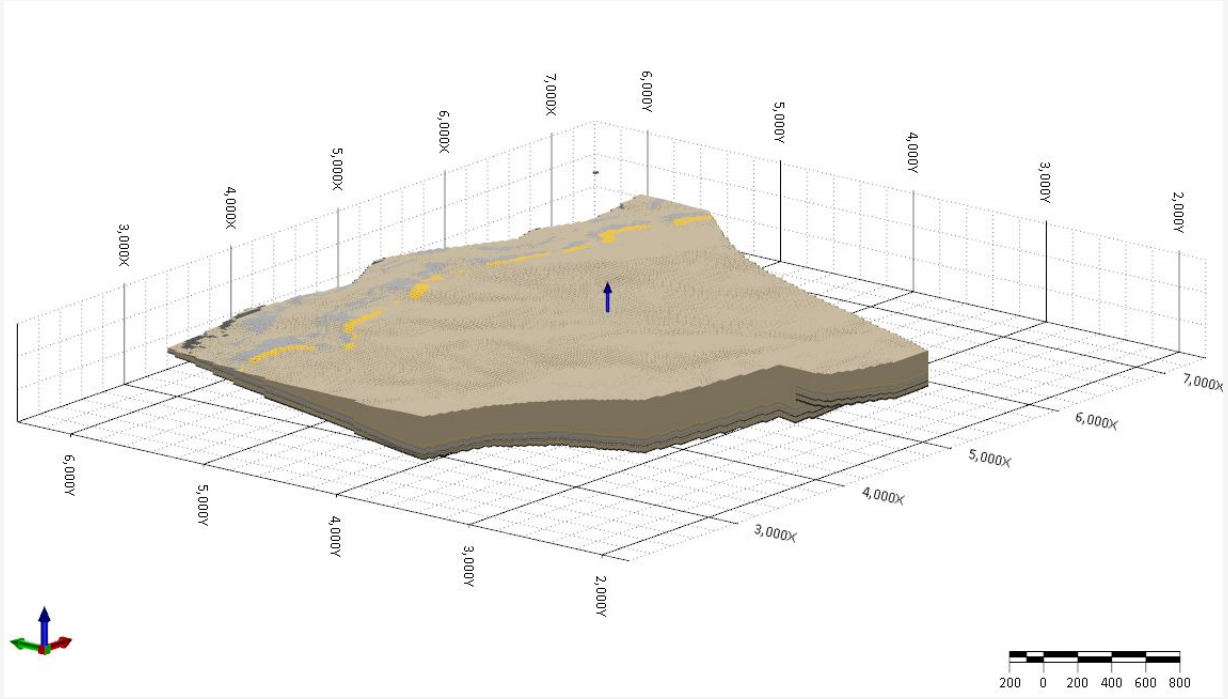
TS, VM, Dst..

(Ilustrasi) Review Sumber Daya (1/)

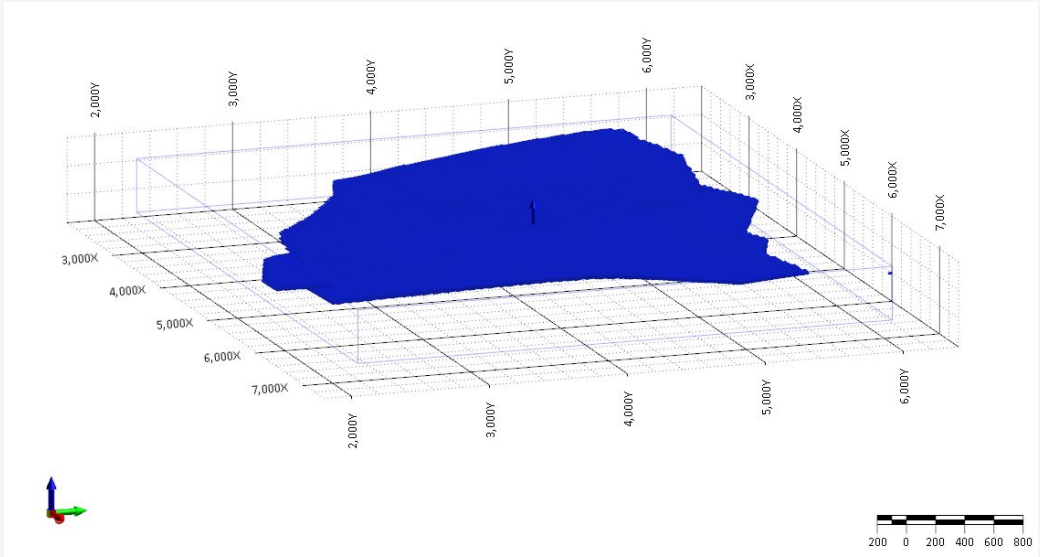


Contoh Model Block

Rock Model



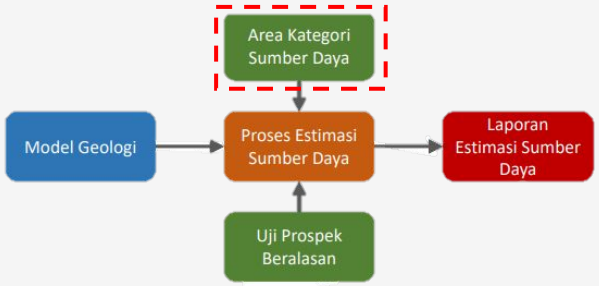
Quality Model

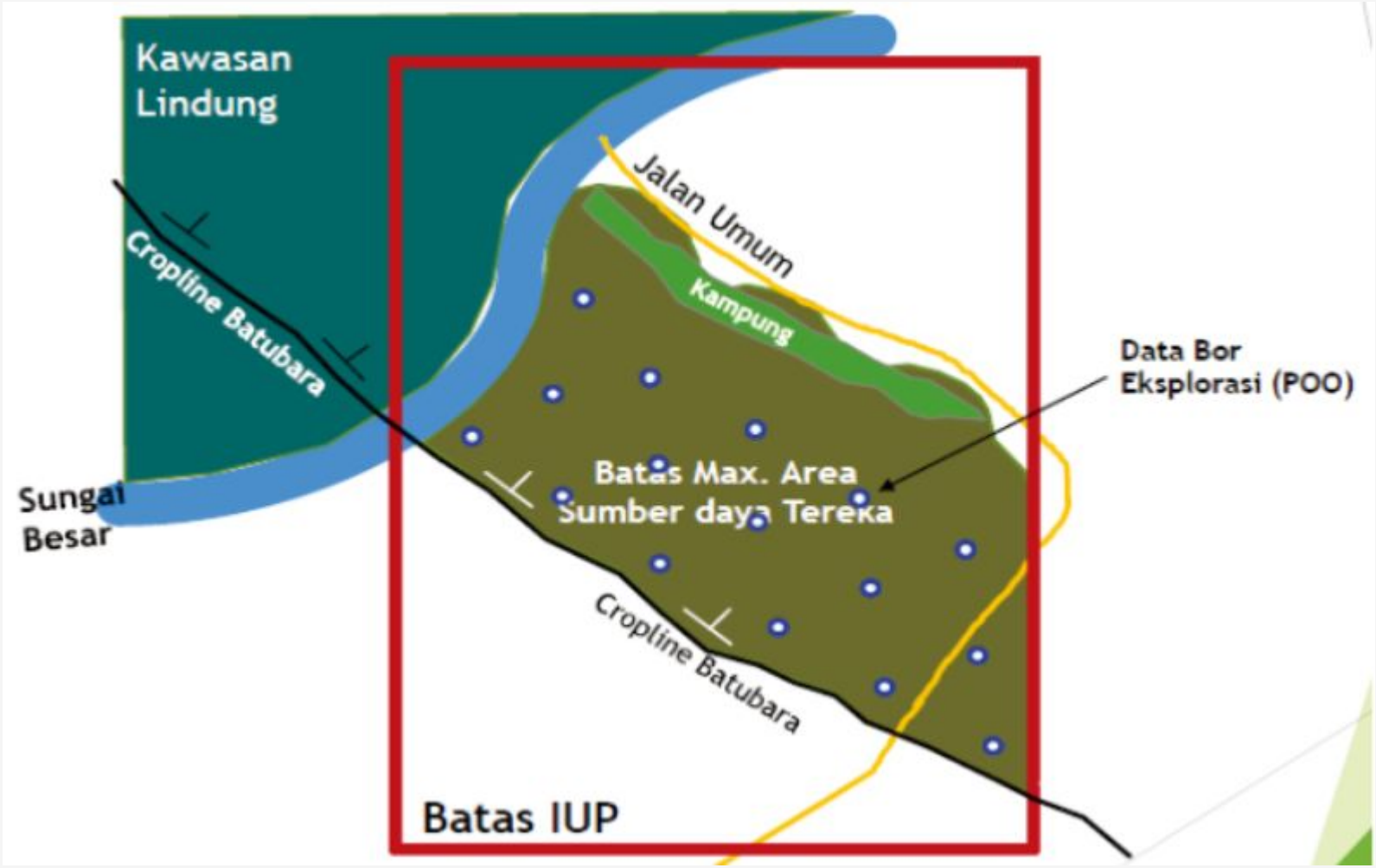


TS, VM, Dst..

Coal and burden

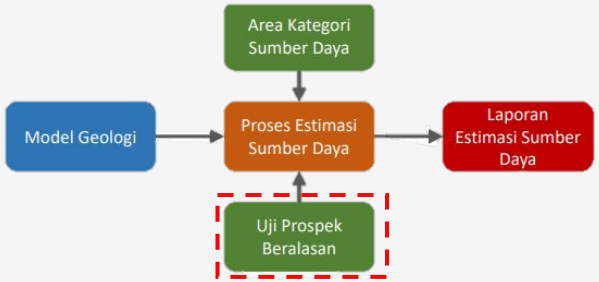
(Ilustrasi) Review Sumber Daya (1/)

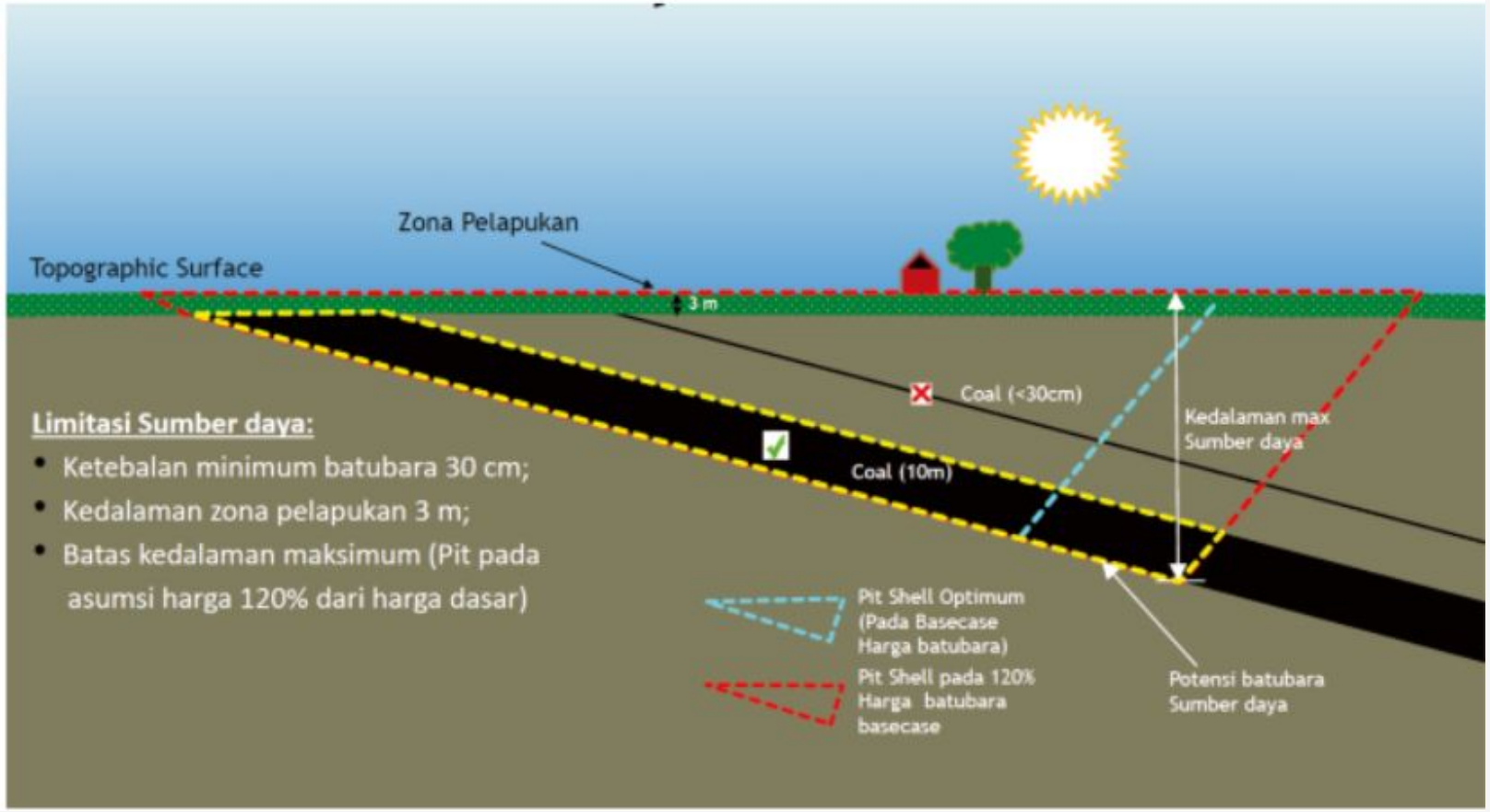




Panduan Praktis Komoditas Batubara, KCMI 2017

(Ilustrasi) Review Sumber Daya (1/)





Panduan Praktis Komoditas Batubara, KCMI 2017

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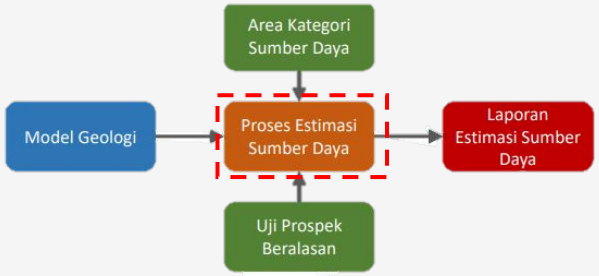
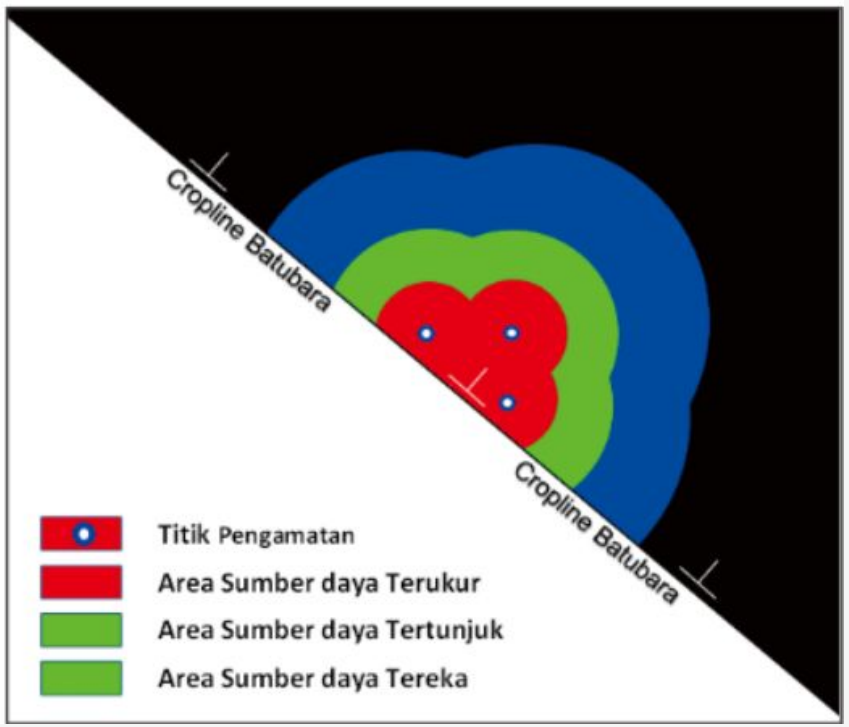
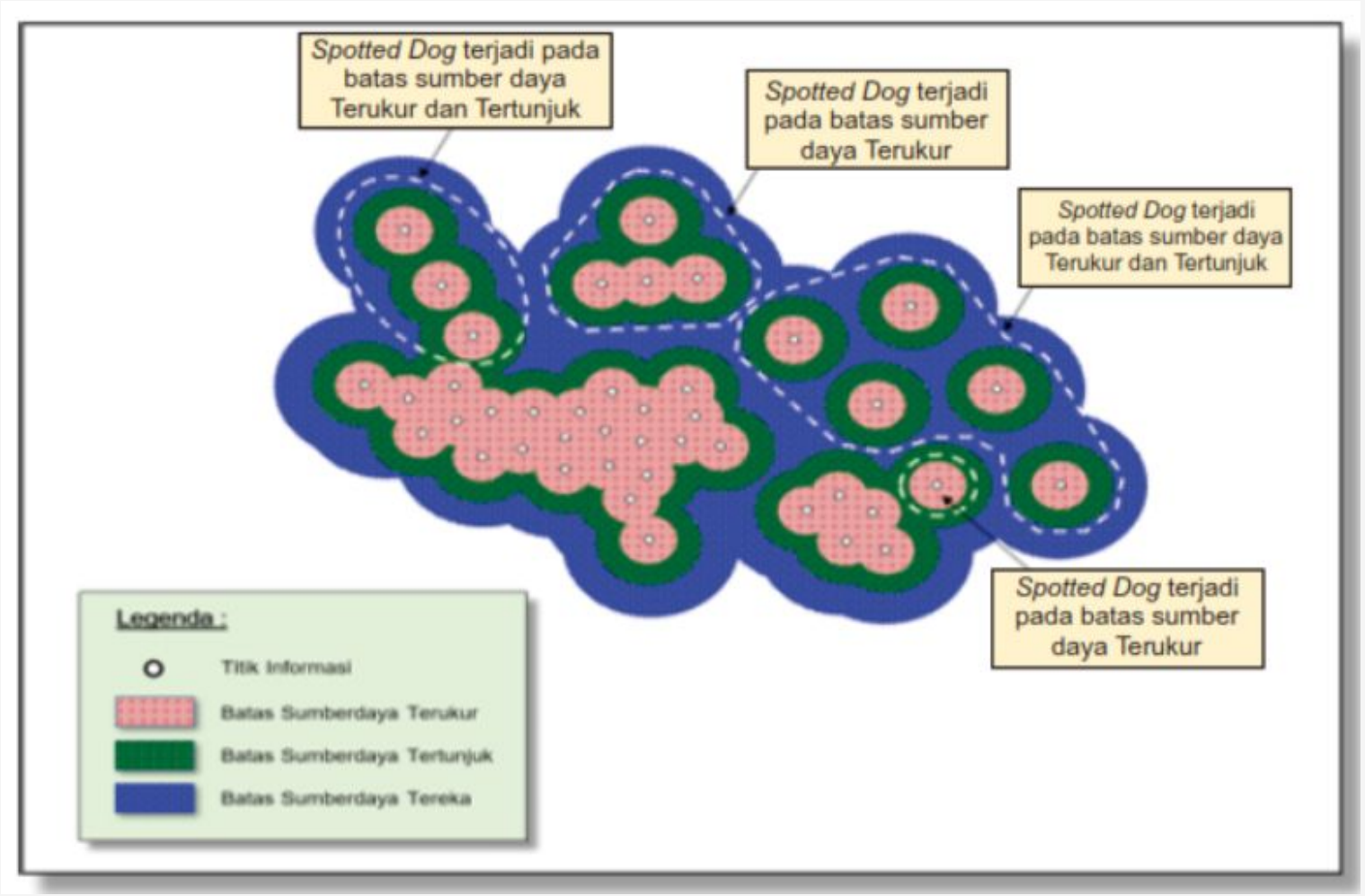
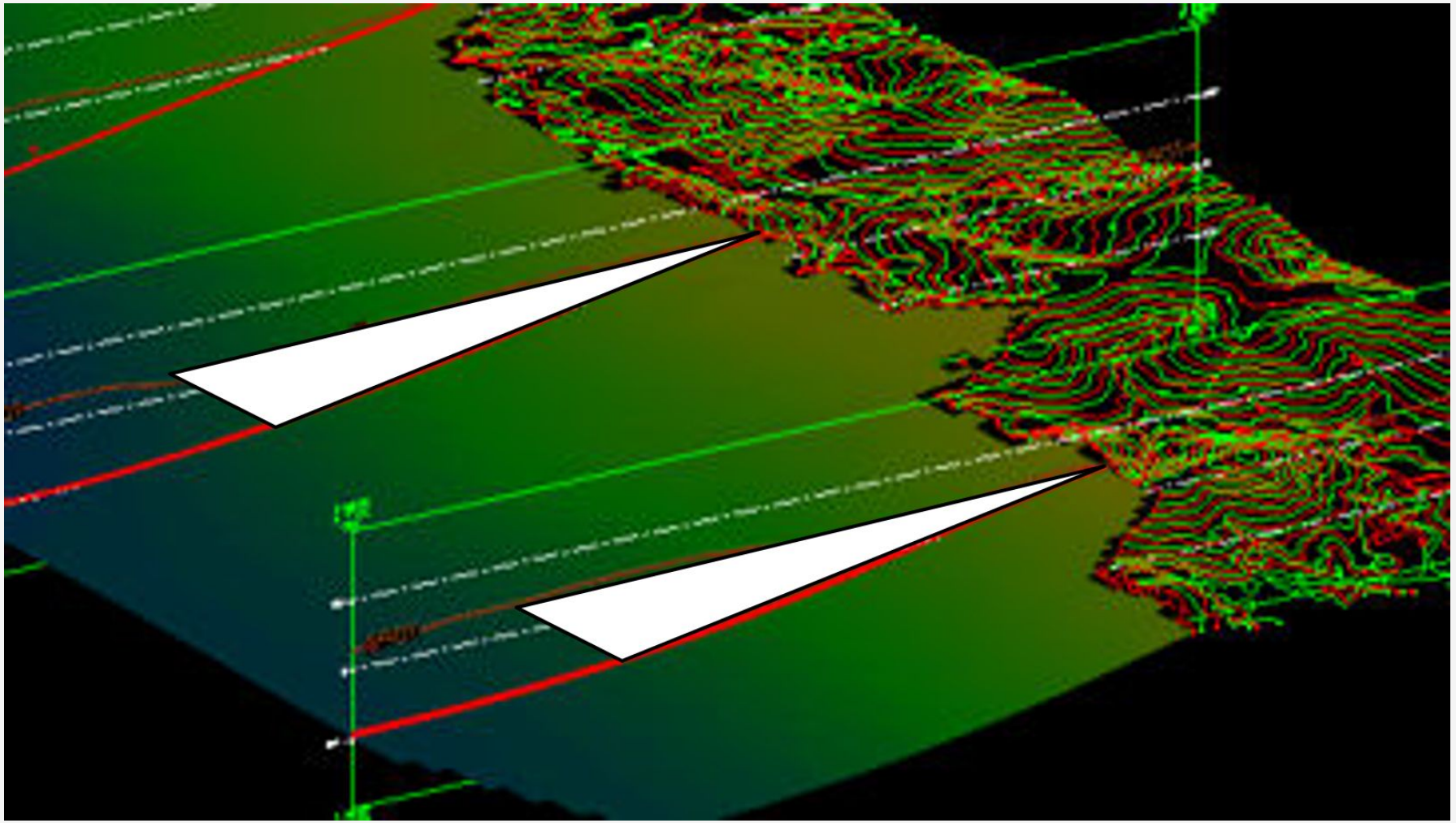








Ada Pertanyaan?

UNIVERSITAS TRISAKTI

Mine Plan

Genap 23/24

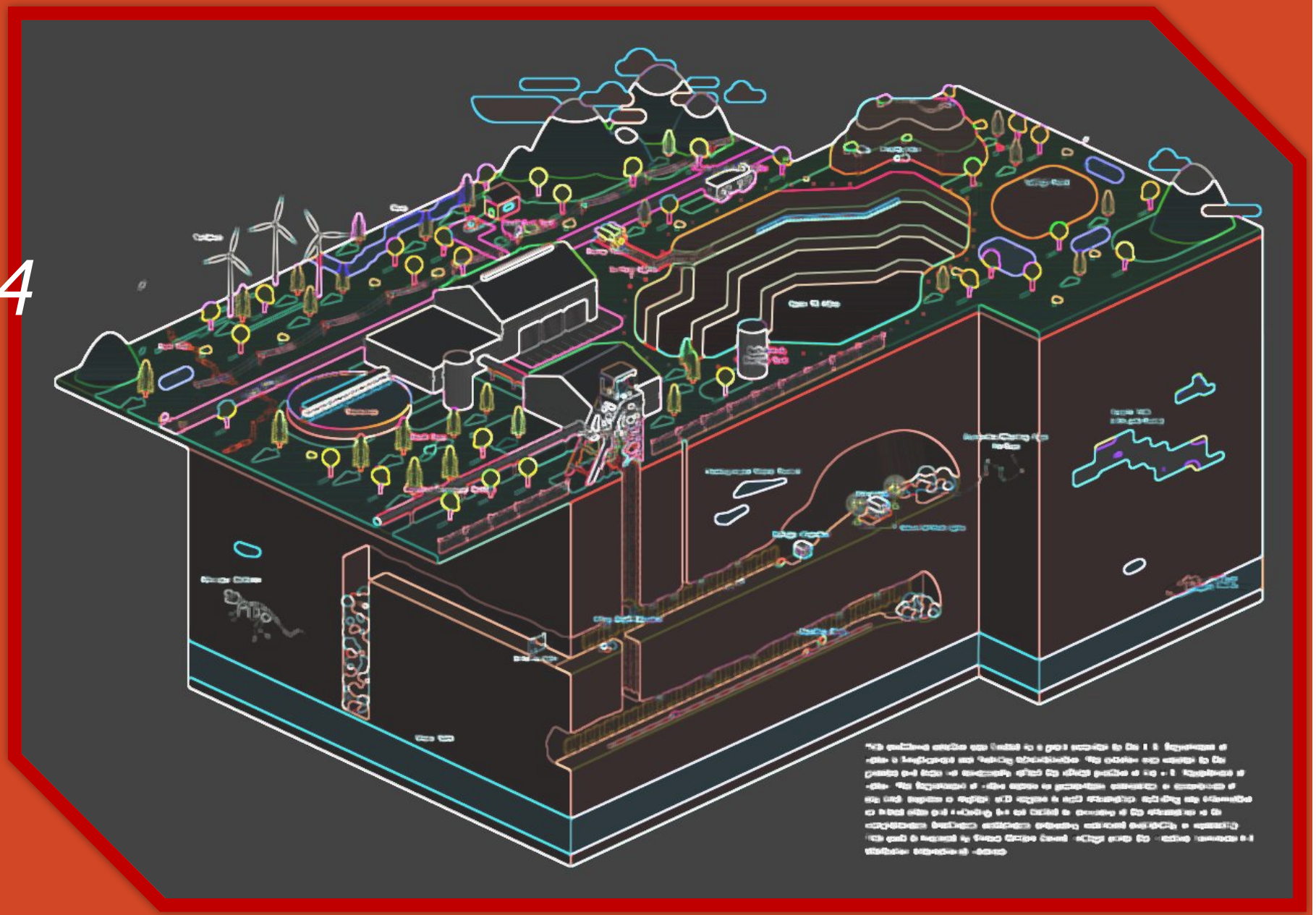
4th Session

Geotehcnical and Slope Stability Recommendation

Speaker

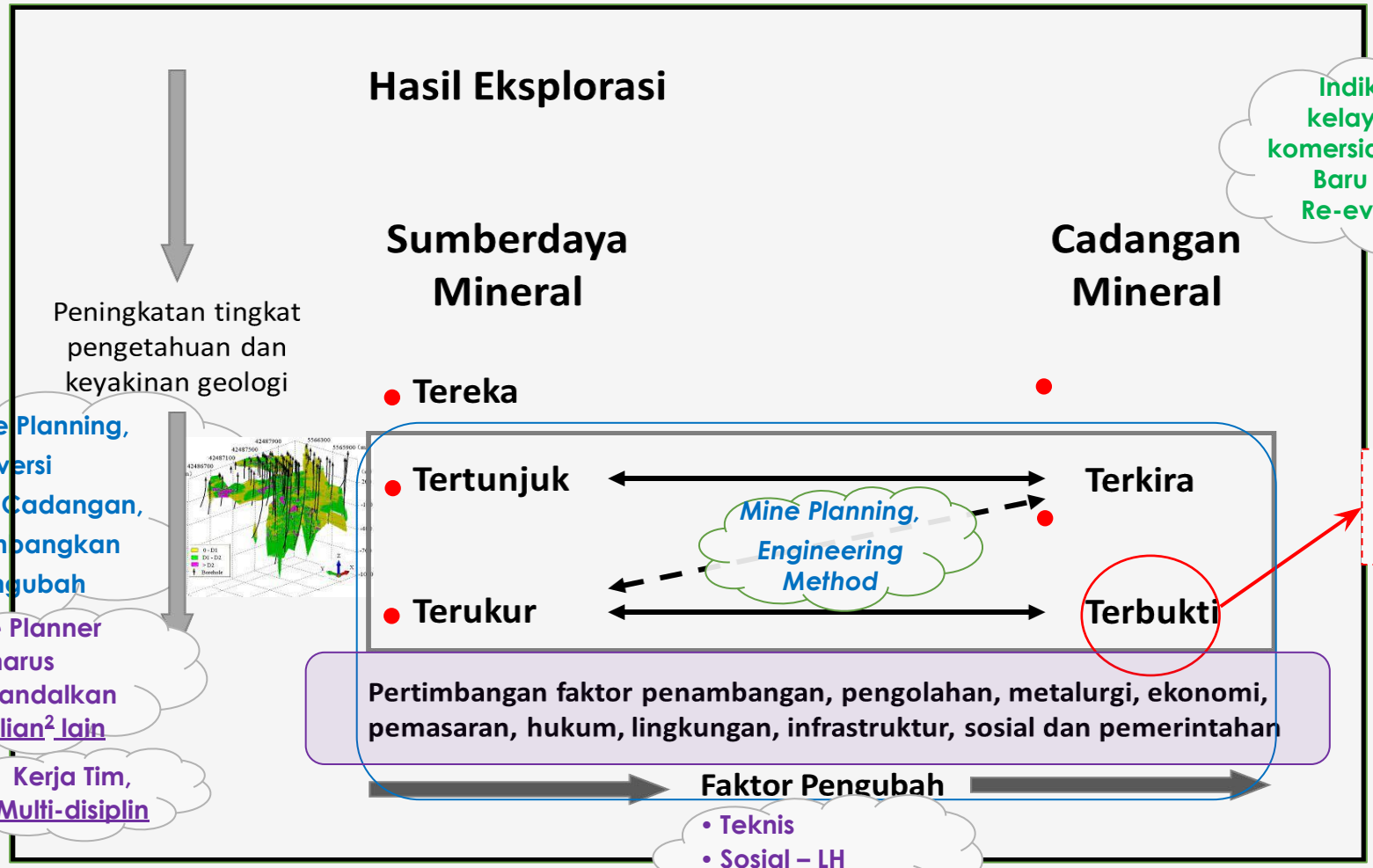
Dr. Ir. Pantjanita Novi Hartami, MT, IPM

Yuga Maulana, MT, IPM



Kerangka Kerja Universal Pelaporan HE– S/d– C/d

- sebagai refleksi penerapan konsep keekonomian tambang -

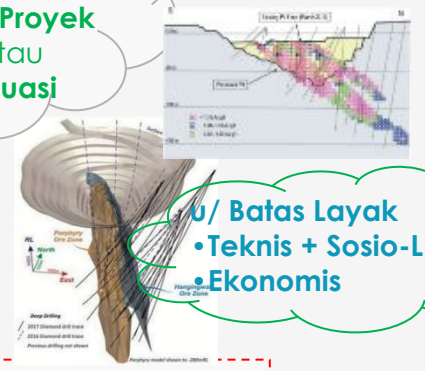


Metodologi Mine Planning, mengkonversi Sumberdaya → Cadangan, dgn mempertimbangkan 10 faktor pengubah

Mine Planner harus mengandalkan keahlian[2] lain

Kerja Tim, Multi-disiplin

Indikator kelayakan komersial Proyek Baru atau Re-evaluasi



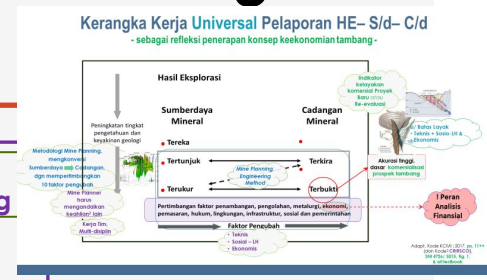
U/ Batas Layak
•Teknis + Sosio-LH &
•Ekonomis

Akurasi tinggi, dasar komersialisasi prospek tambang

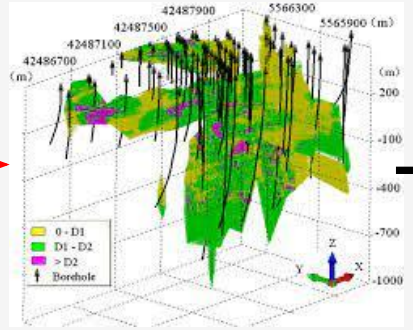
Adapt. Kode KCMI : 2017, ps. 11++
(dan Kode[2] CRIRSCO),
SNI 4726/ 5015, fig. 1,
& all textbook

(Framework-A) Mine Planning = Mining + Financial Engineering

Slope Stability and Geometryl Recommendation

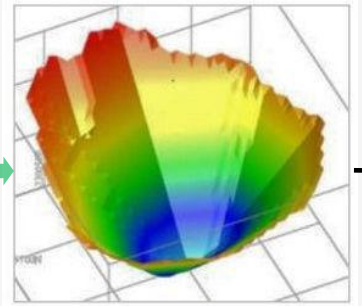


Mining Engineering



Go

NO-Go



Shell Hasil Optimisasi

Go

NO-Go

Financial Engineering

NO-Go

NO-Go

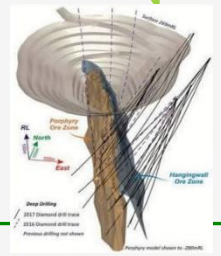
NO-Go

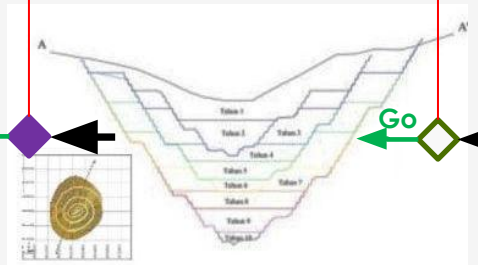
$ NPV DCFROR PB

Evaluasi Keekonomian

Go

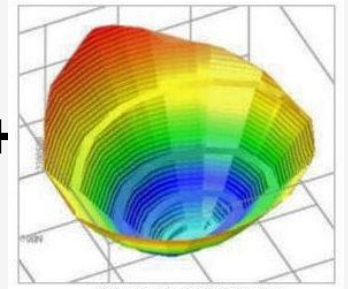
Go Komersial





LOM Production Scheduling

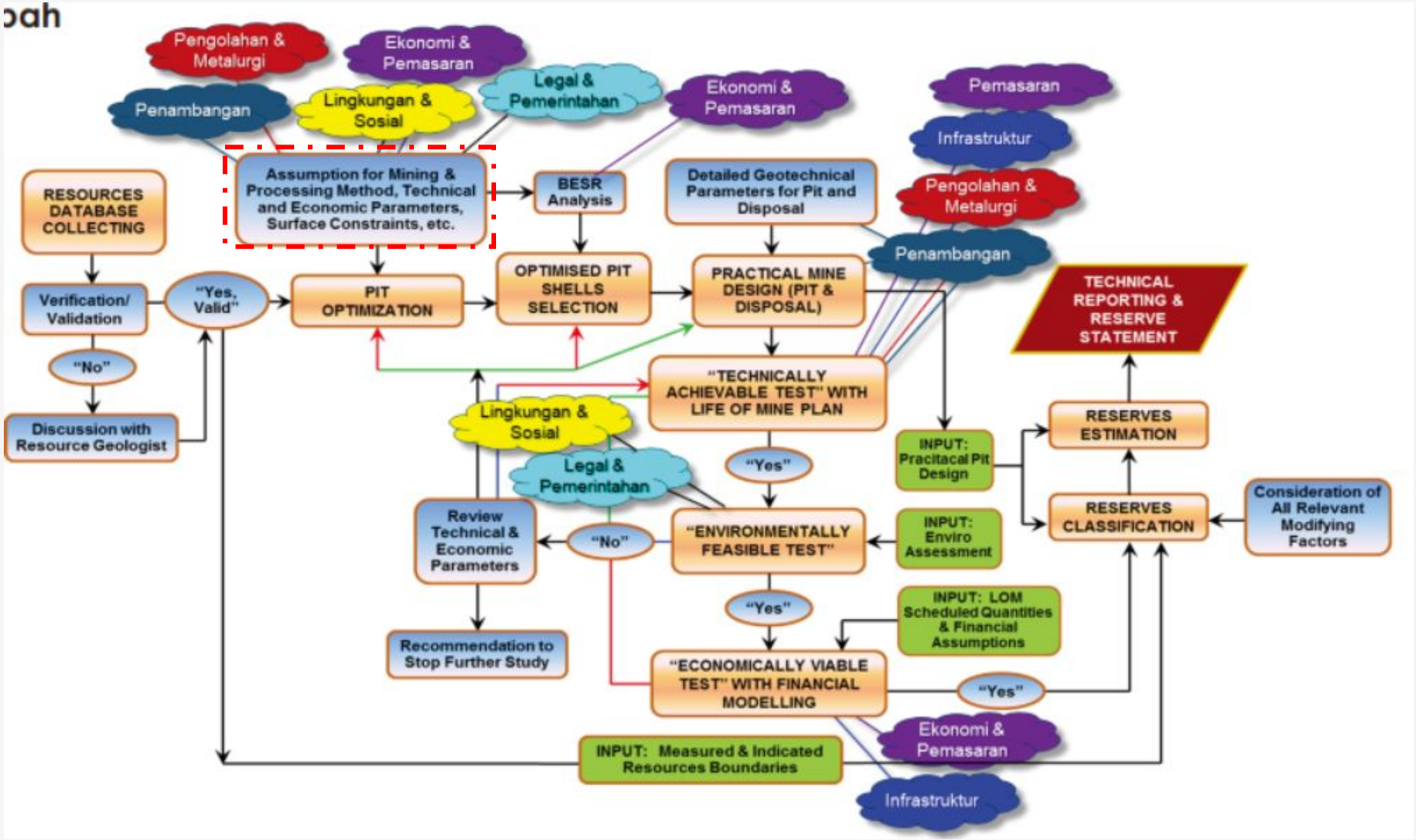
Go



Konseptual Pit Design

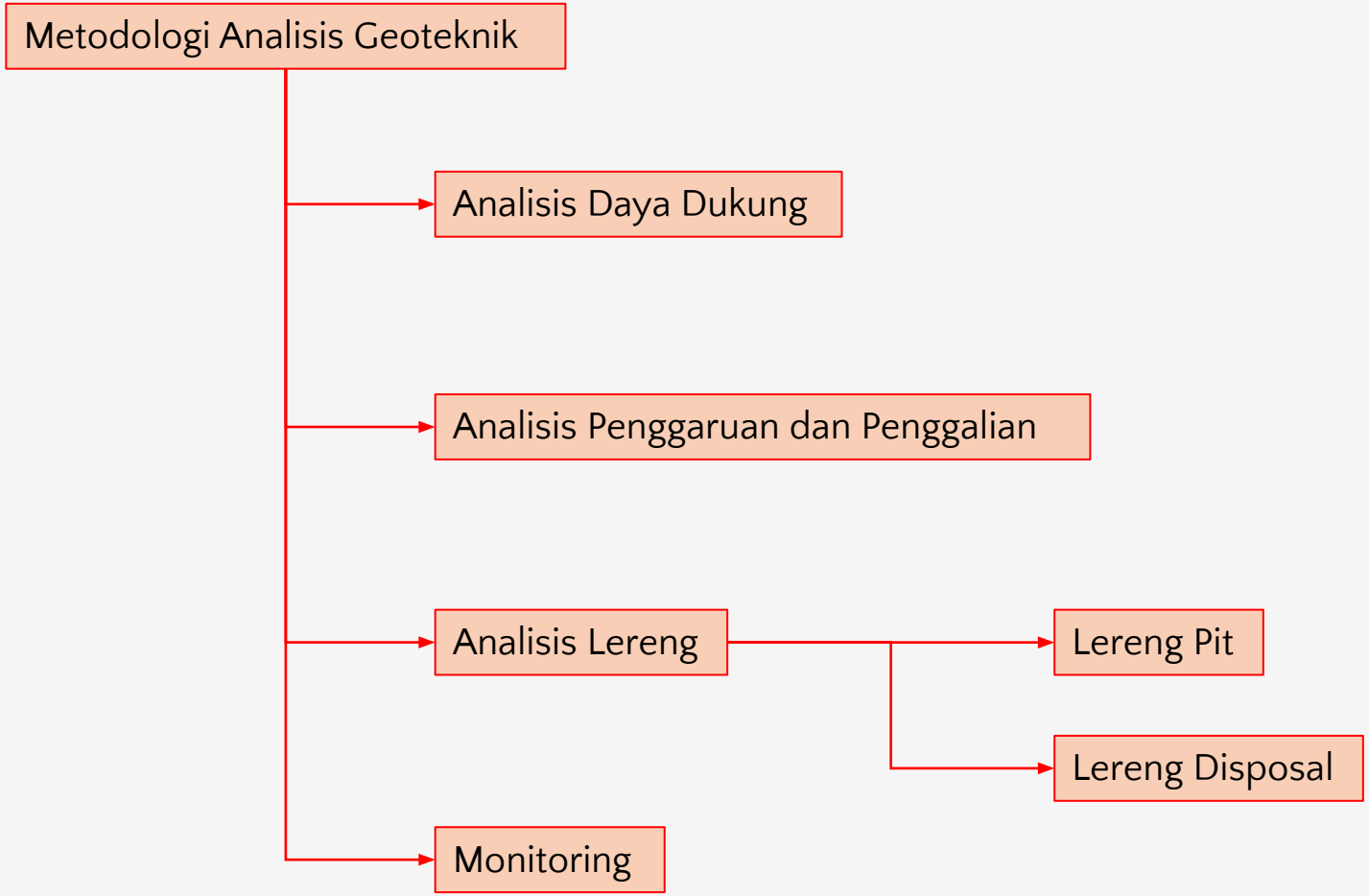
Adjust. fr. Lufi Rachmad, 2017

(*Framework-A*) ***Mine Planning*** = *Mining + Financial Engineering*

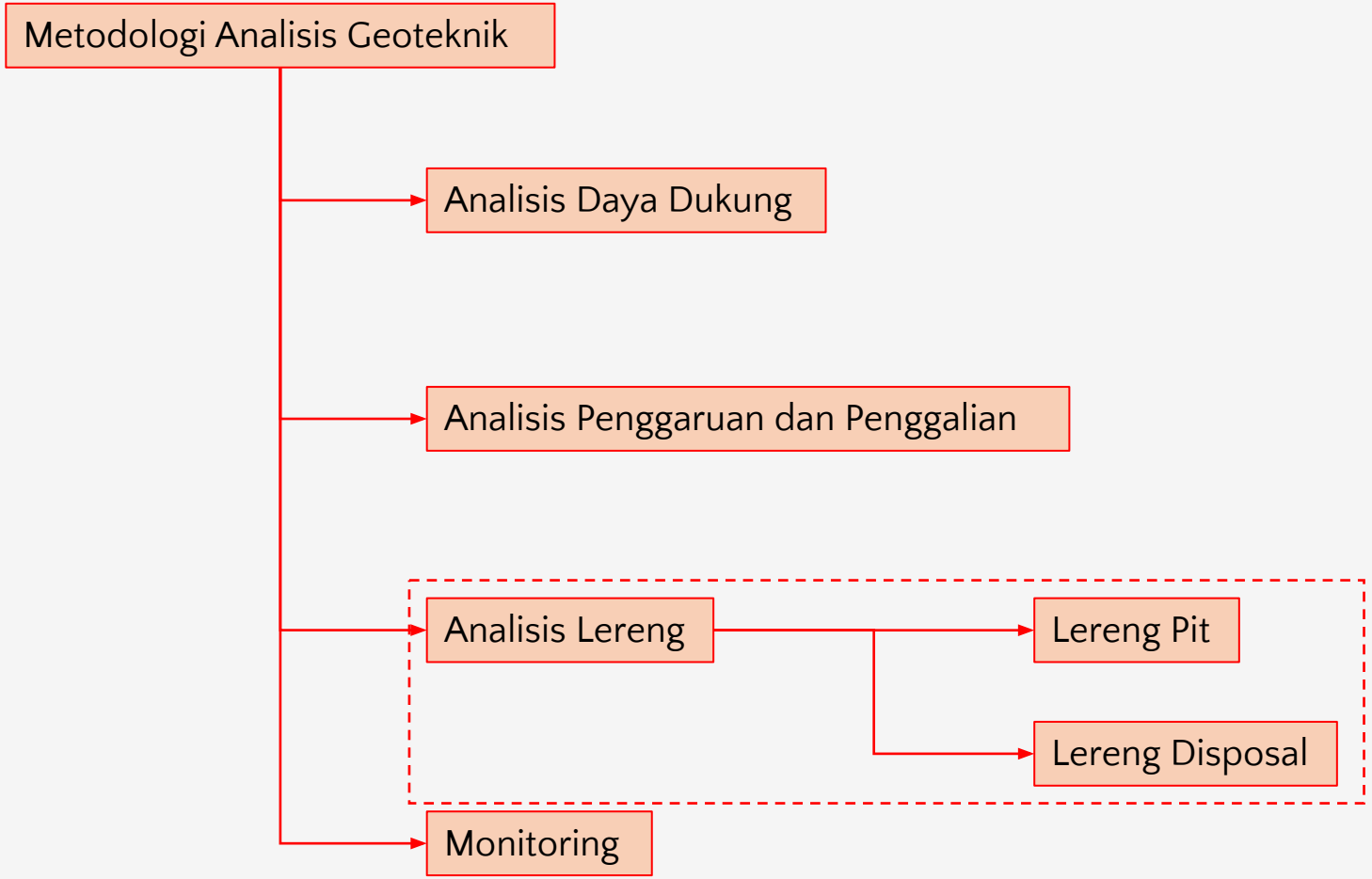


Panduan Praktis Komoditas Batubara, KCMI 2017

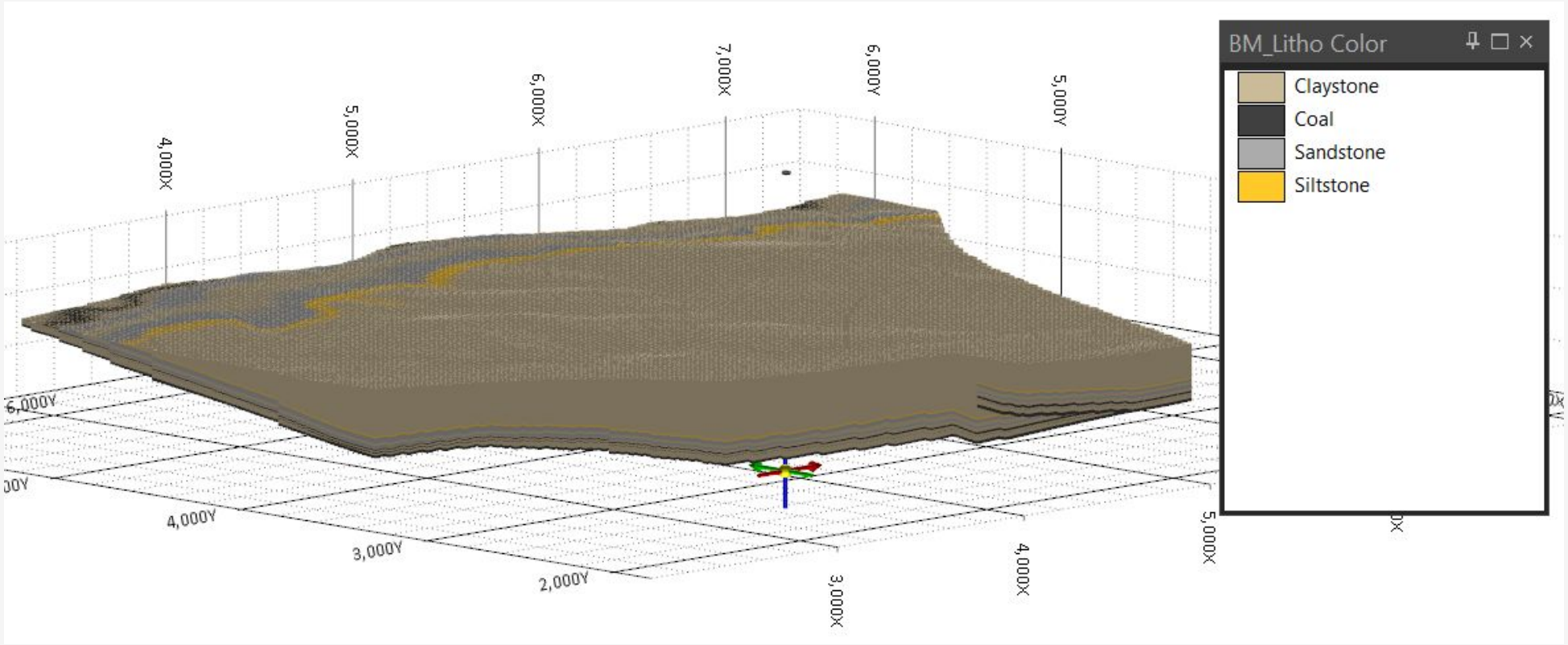
Metodologi Analisis Geoteknik untuk Keperluan Studi Kelayakan



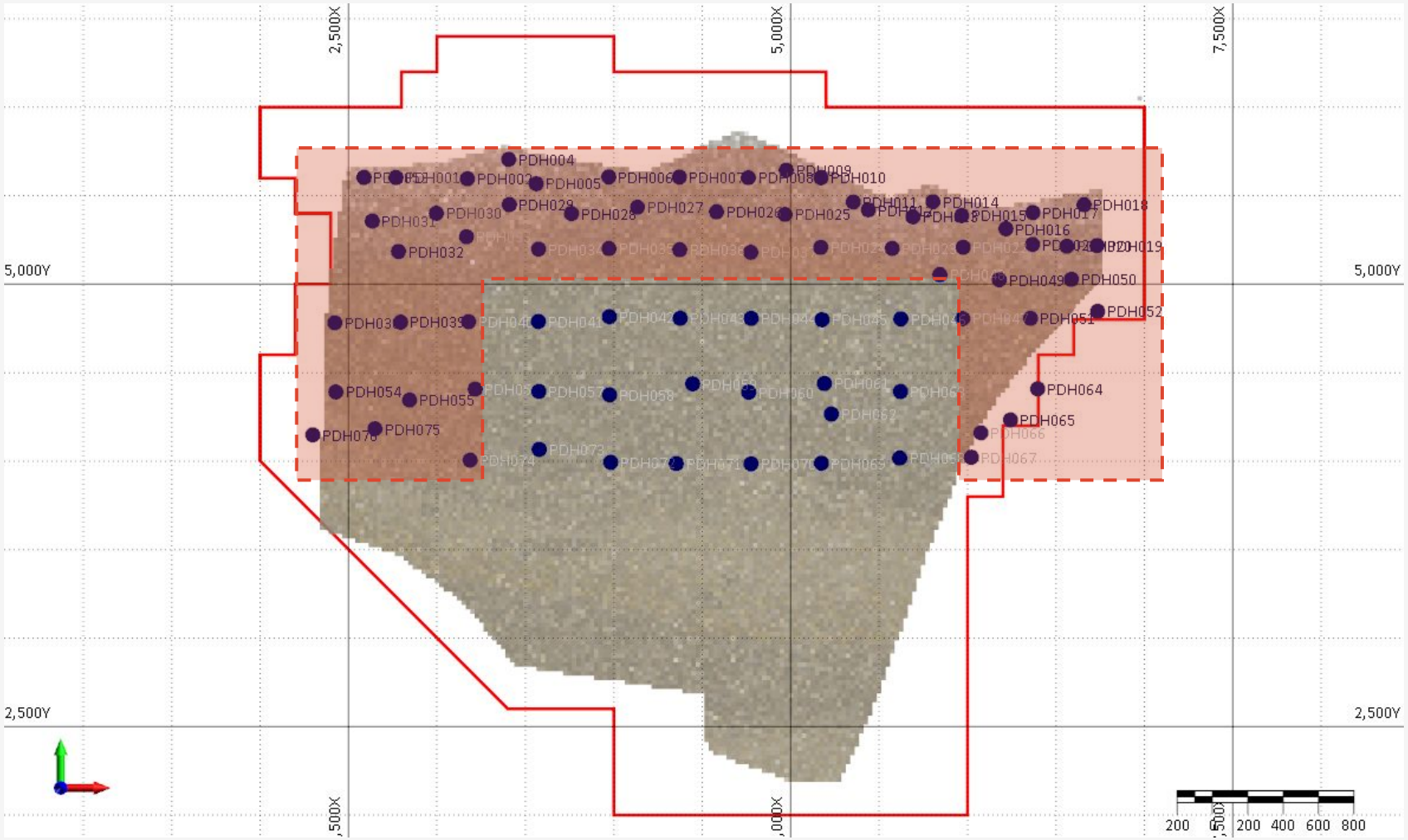
Sebaran Bor Geoteknik



Rock and Soil Material



Sebaran Bor Geoteknik



Ilustrasi sebaran bor geoteknik

Akusisi Data (Contoh sebaran sampel/conto beserta uji)

No.	Blok Sampel	Physical Properties	Uniaxial Compressive Strength	Brazilian	Direct Shear	Triaxial	Total =
1	Blok A	5	5	5	6	7	28
2	Blok B	8	8	8	9	15	48
3	Blok C	12	12	12	33	15	84
4	Blok D	6	6	6	27	3	48
5	Blok E	5	5	5	12	6	33

Lokasi pengambilan sampel

- Jika lebih dari satu blok penambangan
- Memisahkan material dan analisis berdasarkan blok

Jumlah sampel yang di mekanik

- Jumlah sampel yang di uji pada masing-masing blok

Jumlah sampel yang di uji sifat fisik

- Jumlah sampel yang di uji pada masing-masing blok

Jumlah total sampel

- Jumlah total sampel pada masing-masing blok

- Menunjukkan kecukupan sampel pada masing-masing blok
- Menunjukkan kecukupan sampel pada masing-masing domain

Akusisi Data (Contoh hasil Uji)

PHYSICAL PROPERTIES									
HOLE ID	LITHOLOGY	DEPTH	ρ_n (gr/cm3)	ρ_d (gr/cm3)	ρ_s (gr/cm3)	W (%)	S (%)	n (%)	e
Sample ID - 1	Mudstone	20.73 - 21.13	2.08	2.07	2.15	0.86	21.43	8.33	0.09
	Coal	45.47 - 45.75	1.41	1.35	1.42	4.09	79.53	6.96	0.07
	Sandy/Mud	16.00 - 16.40	2.11	2.07	2.16	1.79	42.86	8.64	0.09

DIRECT SHEAR									
HOLE ID	LITHOLOGY	DEPTH	σ_n (MPa)	t (MPa)		Cohesion (MPa)		Int. Fric. Angle (°)	
				Peak	Residual	Peak	Residual	Peak	Residual
Sample ID - 1	Mudstone	21.13 - 21.53	0.067	0.160	0.108	0.129	0.087	24.77	17.39
			0.137	0.192	0.130				
			0.205	0.224	0.151				

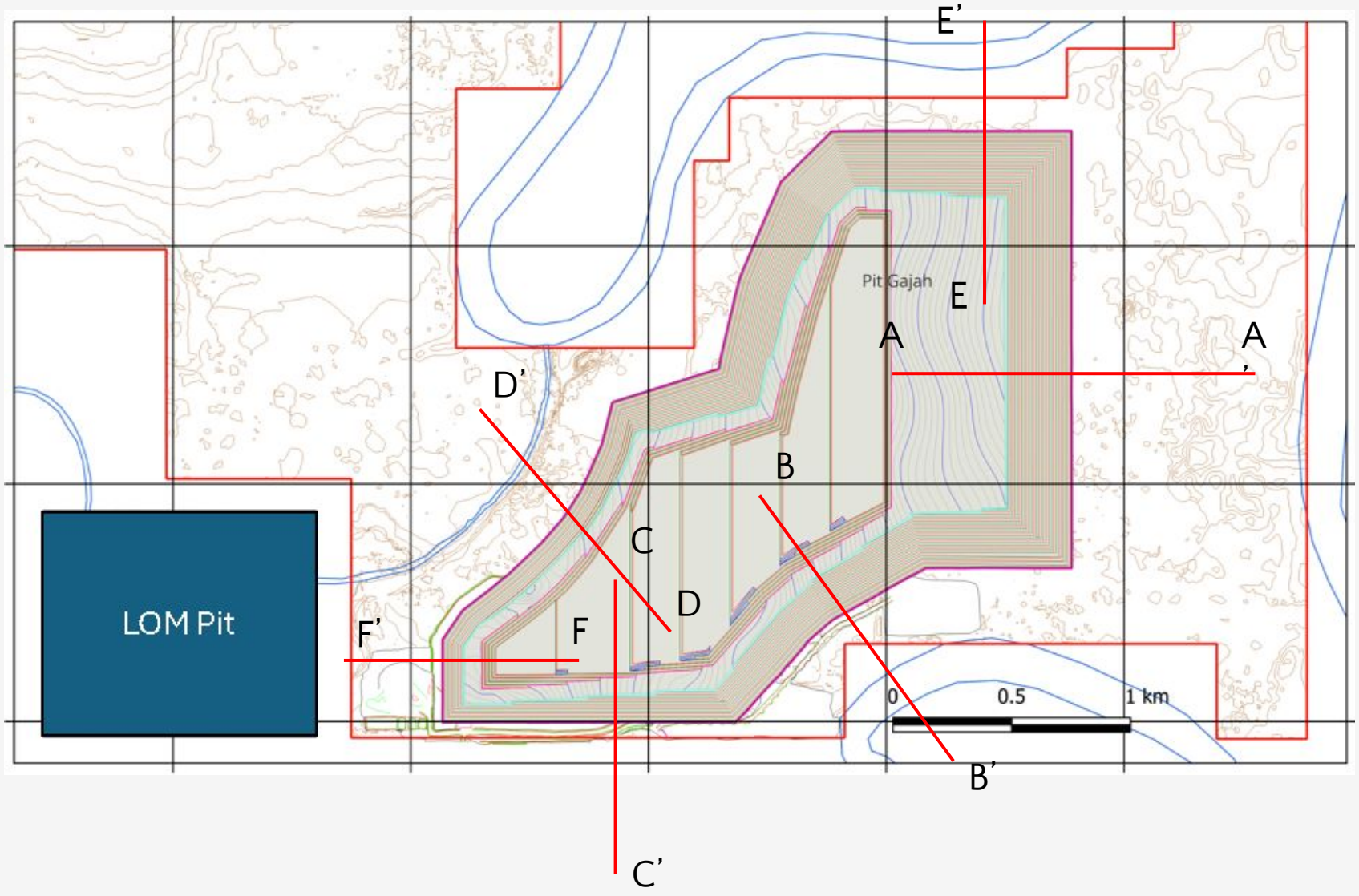
TRIAXIAL						
HOLE ID	LITHOLOGY	DEPTH	σ_3 (MPa)	σ_1 (MPa)	c (MPa)	Φ (...°)
Sample ID - 1	Coal	45.47 - 45.75	2.00	12.71	2.41	28.70
		50.90 - 51.08	4.00	21.23		
		46.07 - 46.35	8.00	30.36		

Akusisi Data (Contoh hasil Uji - Lanjutan)

UNIAXIAL COMPRESSIVE STRENGTH (UCS)					
HOLE ID	LITHOLOGY	DEPTH	sc (MPa)	E (MPa)	u
Sample ID - 1	Mudstone	20.73 - 21.13	0.69	13.53	0.31
	Coal	45.75 - 45.92	9.00	1,001.64	0.26
	Sandy/Mud	16.00 - 16.40	1.47	19.03	0.31

BRAZILIAN							
HOLE ID	LITHOLOGY	DEPTH	Length (mm)	Diameter (mm)	Force (kN)	Correction Factor	σ_t (MPa)
Sample ID - 1	Mudstone	20.73 - 21.13	33.57	60.37	0.75	1.09	0.26
	Coal	45.47 - 45.75	35.20	60.23	1.75	1.09	0.57
	Sandy/Mud	16.00 - 16.40	31.30	61.73	1.25	1.10	0.45

Penentuan Penampang Analisis Geoteknik Pit



Section High Wall

A – A'

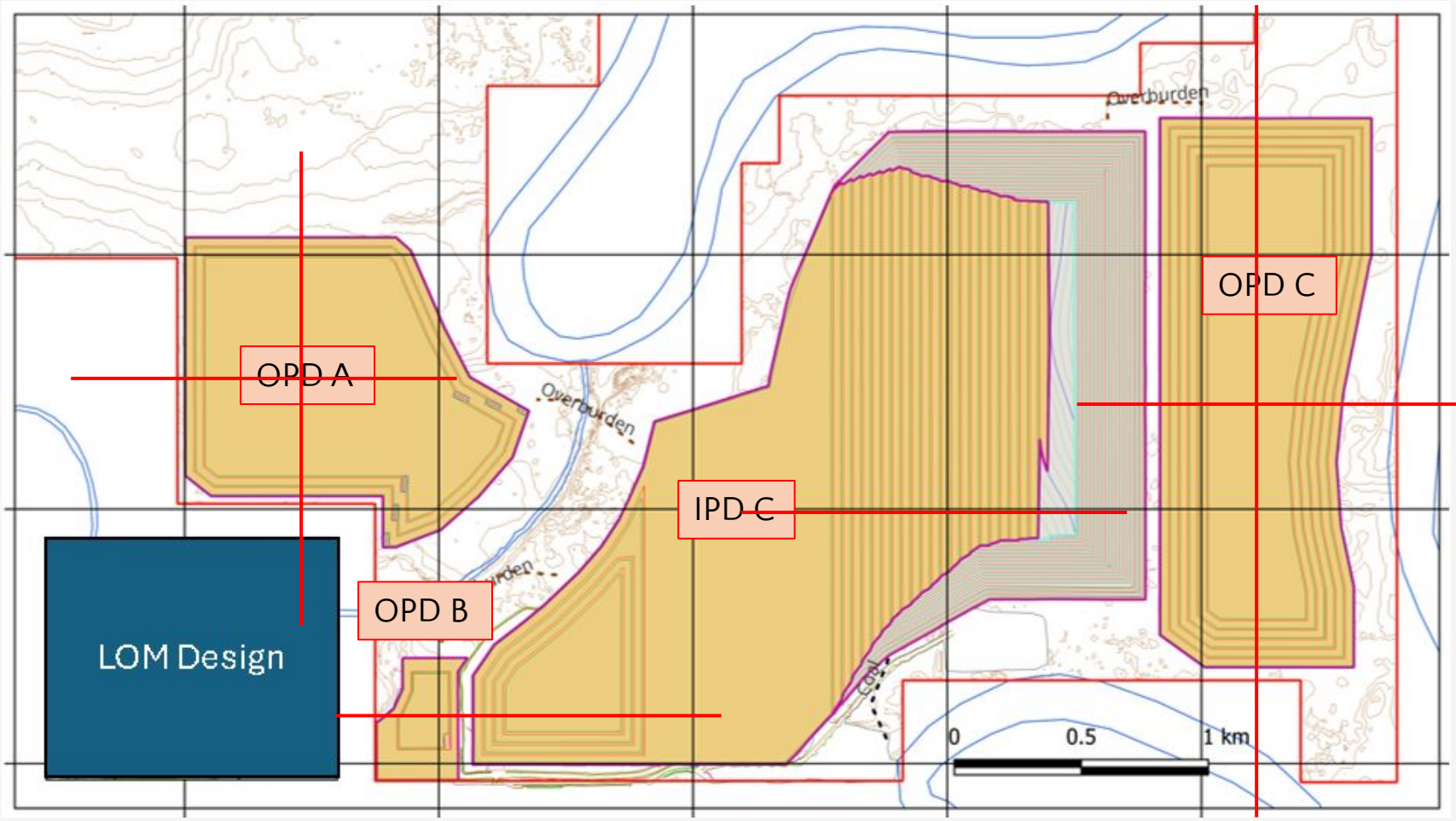
Section Low Wall

F – F'

Section Side Wall

B – B'
C – C'
D – D'
E – E'

Penentuan Penampang Analisis Geoteknik Disposal



Section OPD A

???

Section OPD B

???

Section OPD C

???

Section IPD A

???

Penentuan Parameter Analisis Pit (Deterministik dan Statistik)

Parameter Deterministik

Untuk FK Deterministik

No.	Pit	Sisi	Material	Simbol Warna	Berat Satuan	Kohesi	Sudut Gesek Dalam
					(kN/m^3)	(kPa)	(°)
1	A	Barat	Sandstone		23.5	146.8	32.5
			Mudstone		21.1	135.45	26
			Coal		13.9	111.3	42.21

Parameter Statistik

Untuk PoF

No.	Pit	Sisi	Material	Simbol Warna	Property	Distribusi	Mean	Std. Dev	Real. Min	Real. Max
1	A	Barat	Sandstone		Cohesion	Log Normal	146.8	2	132.12	161.48
					Phi	Normal	32.5	2	29.25	35.75
			Mudstone		Cohesion	Beta	135.45	2	121.9	148.9
					Phi	Gamma	26	2	23.4	28.6
			Coal		Cohesion	Log Normal	111.3	2	100.17	122.43
					Phi	Normal	42.21	3.1	37.98	46.43

Penentuan Parameter Analisis Disposal (Deterministik dan Statistik)

Parameter Deterministik

Untuk FK Deterministik

No.	Waste Dump	Material	Simbol Warna	Berat Satuan (kN/m^3)	Kohesi (kPa)	Sudut Gesek Dalam (°)
1	IPD A	Material A		19.7	67.8	8
		Material B		20.13	55.1	4.2
		Material C		21.1	129	24.77
		Material D		15	40.15	5.5

Parameter Statistik

Untuk PoF

No.	Waste Dump	Material	Simbol Warna	Property	Distribusi	Mean	Std. Dev	Real. Min	Real. Max
1	Inpit RTN	Material A		Cohesion	Normal	67.8	1	66.8	68.8
				Phi	Normal	8	1.24	1.85	1.86
		Material B		Cohesion	Normal	55.1	8	16	16.7
				Phi	Normal	3.8	1.24	1.85	1.86
		Material C		Cohesion	Normal	40.15	1	35.5	37.5
				Phi	Normal	5.5	1.24	1.85	1.86

Standar Aman

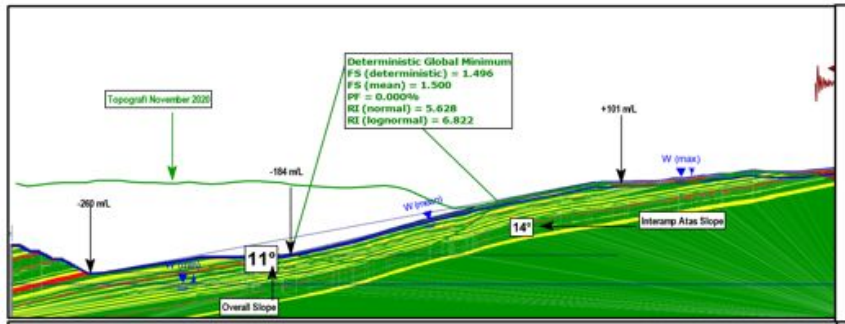
Jenis Lereng	Keparahan Longsor (*Consequences of Failure/ CoF*)	Kriteria dapat diterima (*Acceptance Criteria*)		
		Faktor Keamanan (FK) Statis (Min)	Faktor Keamanan (FK) Dinamis (min)	Probabilitas Longsor (*Probability of Failure*) (maks) PoF (FK≤1)
Lereng tunggal	Rendah s.d. Tinggi	1,1	Tidak ada	25-50%
Inter-ramp	Rendah	1,15-1,2	1,0	25%
	Menengah	1,2-1,3	1,0	20%
	Tinggi	1,2-1,3	1,1	10%
Lereng Keseluruhan	Rendah	1,2-1,3	1,0	15-20%
	Menengah	1,3	1,05	10%
	Tinggi	1,3-1,5	1,1	5%

Metode Analisis - Empiris

Metode Analisis - Analitis

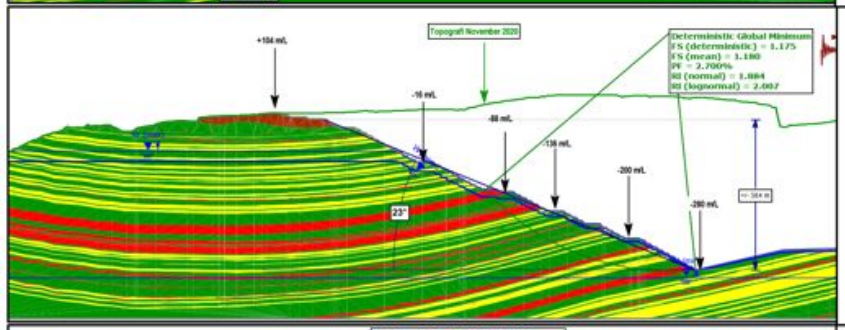
Contoh Hasil Analisis Kestabilan Lereng Pit

Lereng Keseluruhan



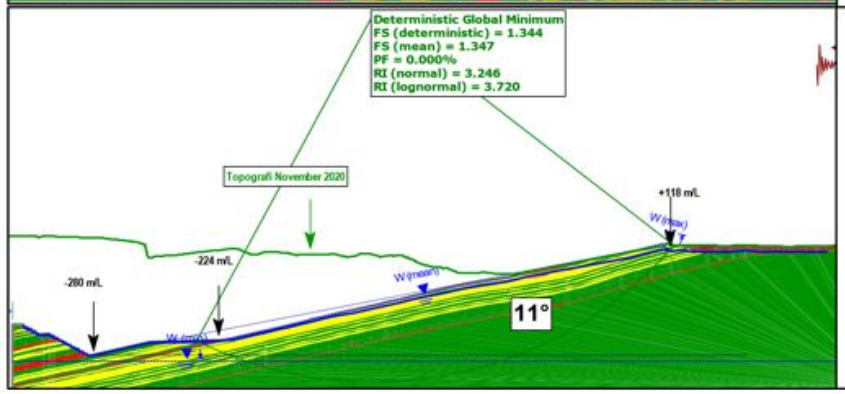
Penampang Desain
Low-wall LOM Pit
Sisi Barat (Section B-B')

Fos (mean) : 1.500
(Stable)
PoF : 0%
Overall Slope : 11°
Overall Height : 361 m



Penampang Desain
Highwall LOM Pit
Sisi Barat (Section C-C')

Fos (mean) : 1.180
(Stable)
PoF : 2.70 %
Overall Slope : 23 °
Overall Height : 384 m

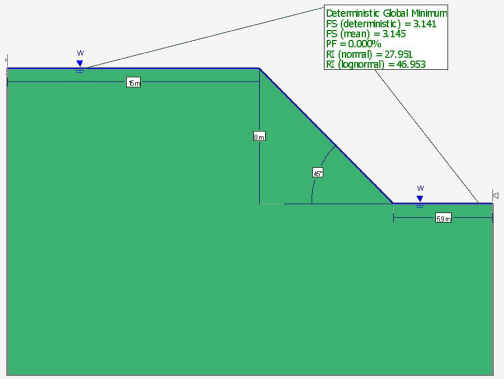


Penampang Desain
Low-wall LOM Pit
Sisi Timur (Section C-C')

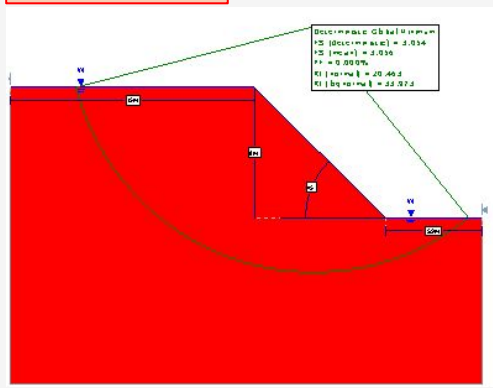
Fos (mean) : 1.347
(Stable)
PoF : 0 %
Overall Slope : 11 °
Overall Height : 398 m

Lereng Tunggal

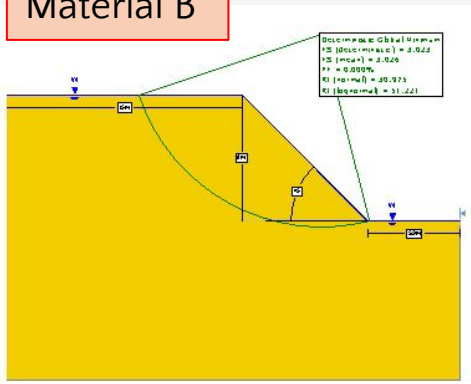
Material A



Material C

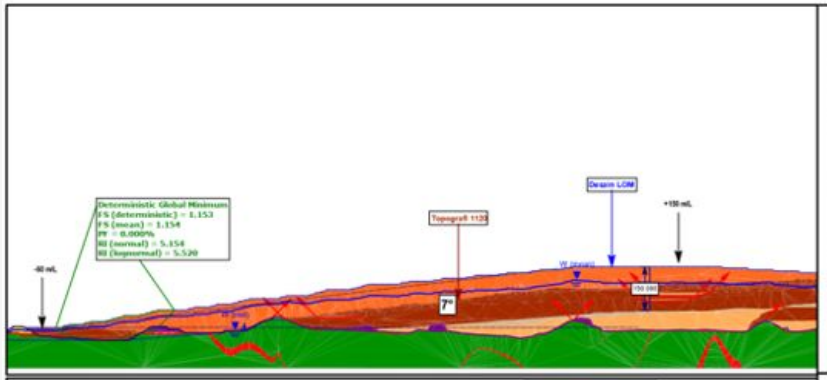


Material B



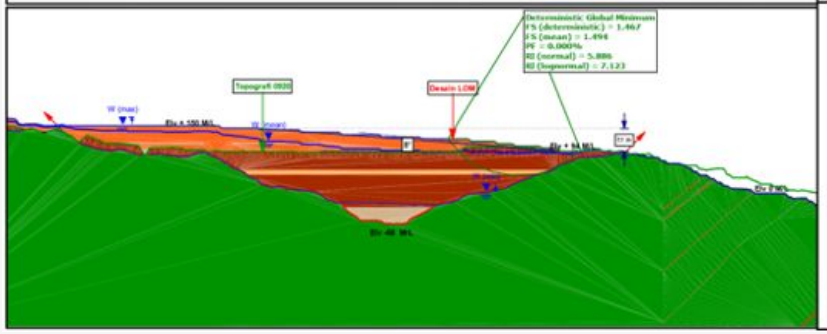
Contoh Hasil Analisis Kestabilan Lereng Disposal

Lereng Keseluruhan



Penampang Desain IPD (Section A-A')
Utara – Selatan

Fos (mean) : 1.154 (*Stable*)
PoF : 0 %
Overall Slope : 7 °
Overall Height : 230 m



Penampang Desain IPD (Section B-B')

Fos (mean) : 1.494 (*Stable*)
PoF : 0 %
Overall Slope : 5 °
Overall Height : 51 m

Tabulasi Hasil Analisis Kestabilan Lereng Pit

Lereng Tunggal

LERENG TUNGGAL PIT A							
Tinggi (m)	Sudut Lereng (°)	Mudstone		Sandstone		Batubara	
		FK	PK (%)	FK	PK (%)	FK	PK (%)
8	45	3.145	0	3.026	0	3.056	0
	60	2.864	0	2.719	0	2.797	0
	70	2.642	0	2.5	0	2.571	0
	80	2.357	0	2.209	0	2.273	0
10	45	2.588	0	2.511	0	2.503	0
	60	2.219	0	2.118	0	2.096	0
	70	1.946	0	1.84	0	1.804	0
	80	1.688	0	1.578	0	1.517	0
12	45	2.189	0	2.14	0	2.083	0
	60	1.84	0	1.772	0	1.72	0
	70	1.615	0	1.535	0	1.462	0
	80	1.377	0	1.292	0	1.194	0

Lereng Keseluruhan

Tabel Rekapitulasi Hasil Analisis LOM									
No.	Pit	Sektor	Sisi	Penampang	Design Pit				
					FK	PK (%)	Overall Slope (°)	Overall Height (m)	Status
1	A	I	Timur	B-B'	1.141	1.20	22	287	Stable
2		II	Timur	C-C'	1.146	2.40	23	224	Stable
3		IV	Barat	D-D'	1.127	3.70	23	266	Stable

Tabulasi Hasil Analisis Kestabilan Lereng Disposal

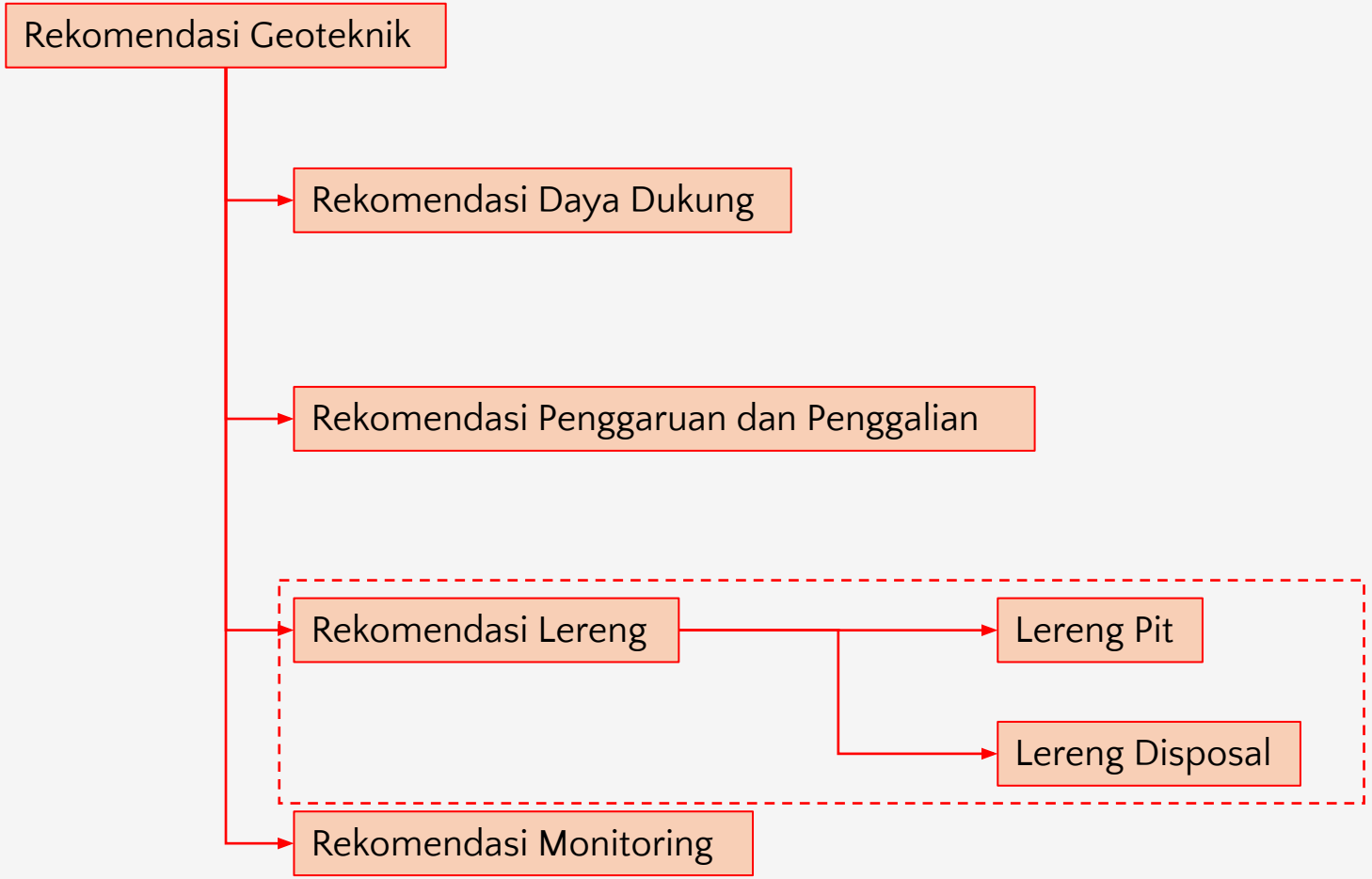
Lereng Tunggal

LERENG TUNGGAL IPD A							
Tinggi (m)	Sudut Lereng (°)	Mudstone		Sandstone		Batubara	
		FK	PK (%)	FK	PK (%)	FK	PK (%)
5	35	3.145	0	3.026	0	3.056	0
	40	2.864	0	2.719	0	2.797	0
	45	2.642	0	2.5	0	2.571	0
	50	2.357	0	2.209	0	2.273	0
8	35	2.588	0	2.511	0	2.503	0
	40	2.219	0	2.118	0	2.096	0
	45	1.946	0	1.84	0	1.804	0
	50	1.688	0	1.578	0	1.517	0
10	35	2.189	0	2.14	0	2.083	0
	40	1.84	0	1.772	0	1.72	0
	45	1.615	0	1.535	0	1.462	0
	50	1.377	0	1.292	0	1.194	0

Lereng Keseluruhan

Tabel Rekapitulasi Hasil Analisis LOM OPD & IPD							
WD	Sisi	Penampang	Design WD/IPD				
			FK	PK (%)	Overall Slope (°)	Overall Height (m)	Status
IPD A	Utara-Selatan	A-A'	1.154	0.00	7	230	Stable
	Barat-Timur	B-B'	1.494	0.00	5	51	Stable

Rekomendasi Geoteknik



Rekomendasi Geoteknik (Lereng Pit)

Contoh Rekomendasi (dalam bentuk statement)

Dimensi slope pada Pit untuk zona normal biasanya dibentuk setelah melalui zona lemah dan berjenjang sampai ke final desain tambang. Desain slope standar untuk Pit pada kondisi normal yang digunakan adalah berdasarkan pada ketentuan seperti yang telah ditetapkan pada dokumen Feasibility Study yaitu :

- Tinggi jenjang (bench height) (h) : 8 m
- Lebar bench (bench width) (b) : 5.9 m
- Sudut individual (single slope) : 45°
- Sudut keseluruhan (overall slope) : 27°
- Pada setiap setiap 7 bench, sebaiknya dibuat bench lebar/interramp sebagai buffer zone selebar minimal 30 m.

Kriteria desain pada kondisi normal tersebut juga berlaku pada Low Wall dengan bedding dip ≥ 45°.

Untuk Low Wall dengan bedding dip 15° - 30° :

- Tinggi jenjang (bench height) (h) : 15 m
- Lebar bench (bench width) (b) : 5.9 m (atau mengikuti lebar datar lapisan batuan)
- Sudut individual (single slope) : sejajar dengan kemiringan dip (bedding dip).

Contoh Rekomendasi (dalam bentuk tabel)

No	Lokasi	Lereng Tunggal						
		Highwall				Lowwall		
		Sudut	Tinggi	Lebar	Inter Ramp	Sudut	Tinggi	Lebar
		(°)	(m)	(m)	(°)	(°)	(m)	(m)
1.	Blok A							
1.1	Pit A	65-75	10-15	6-8	41-44	9-12	355	-

No	Lokasi	Lereng Keseluruhan						
		Highwall				Lowwall		
		Sudut	Tinggi	Lebar	Inter Ramp	Sudut	Tinggi	Lebar
		(°)	(m)	(m)	(°)	(°)	(m)	(m)
1.	Blok A							
1.1	Pit A	27-36	220-370	11-13	290	27-36	220-370	11-13

Rekomendasi Geoteknik (Lereng Pit)

Contoh Rekomendasi (dalam bentuk statement)

Desain Slope standar untuk Waste Dump pada kondisi normal adalah sebagai berikut:

- Tinggi jenjang (bench height) (h) : 5 m
- Lebar bench (bench width) (b) : 10 m
- Sudut individual (single slope) : 30°
- Sudut keseluruhan (overall slope) : 16°
- Pada setiap ketinggian bench setinggi 50 m atau setiap 10 bench, maka harus dibuat bench lebar/interramp sebagai buffer zone selebar 50 m.
- Dalam kondisi lebar bench 12 meter maka sudut lereng individu yang digunakan adalah 45°.

Desain Slope standar untuk Waste Dump pada kondisi lemah untuk base mempunyai kemiringan > 1 % adalah sebagai berikut :

-Tinggi jenjang (bench height) (h) : 5m
-Lebar bench (bench width) (b) : 15 m
-Sudut individual (single slope) :30° (terhadap garis horizontal)
-Sudut keseluruhan (overall slope) :10° - 16°
-Pada setiap ketinggian bench setinggi 50 m atau setiap 10 bench, maka harus dibuat bench lebar/interramp sebagai buffer zone selebar 50 m.

Contoh Rekomendasi (dalam bentuk tabel)

		Lereng Tunggal								
No	Lokasi	Expit						Inpit		
		Base Weathered			Base Material soft/Alluvium			Sudut	Tinggi	Lebar
		Sudut	Tinggi	Lebar	Sudut	Tinggi	Lebar			
		(°)	(m)	(m)	(°)	(m)	(m)	(°)	(m)	(m)
1	Pit A	33-37	10	40-65	-	-	-	33-37	10	40-90

		Lereng Keseluruhan								
No	Lokasi	Expit						Inpit		
		Base Weathered			Base Material soft/Alluvium			Sudut	Tinggi	Lebar
		Sudut	Tinggi	Lebar	Sudut	Tinggi	Lebar			
		(°)	(m)	(m)	(°)	(m)	(m)	(°)	(m)	(m)
1	Pit A	8-11	50-100	-	-	9-11	420-440	8-11	50-100	-

Ada Pertanyaan?

UNIVERSITAS TRISAKTI

Mine Plan

Genap 23/24

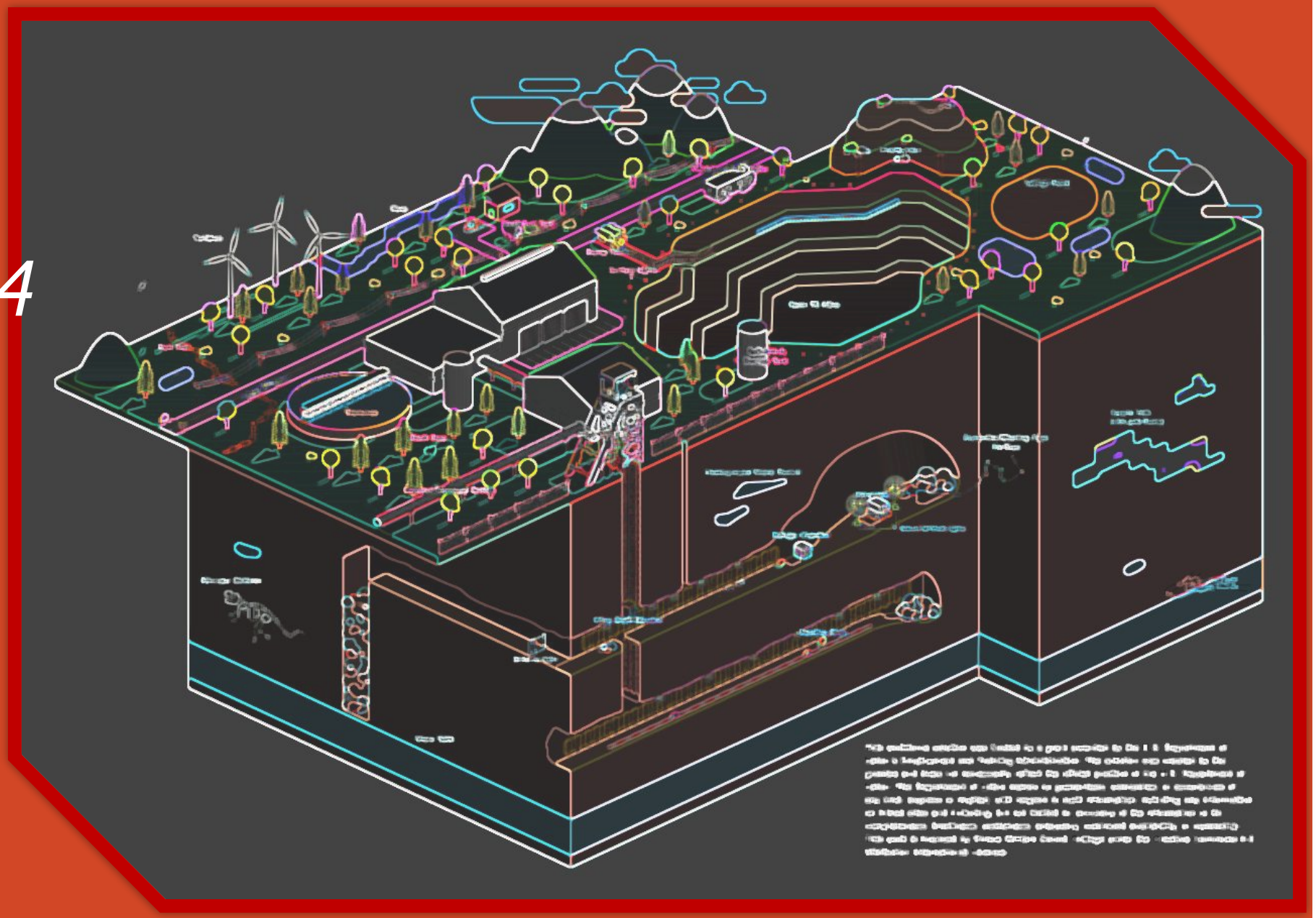
5th Session

Perencanaan dan Optimasi Pit

Speaker

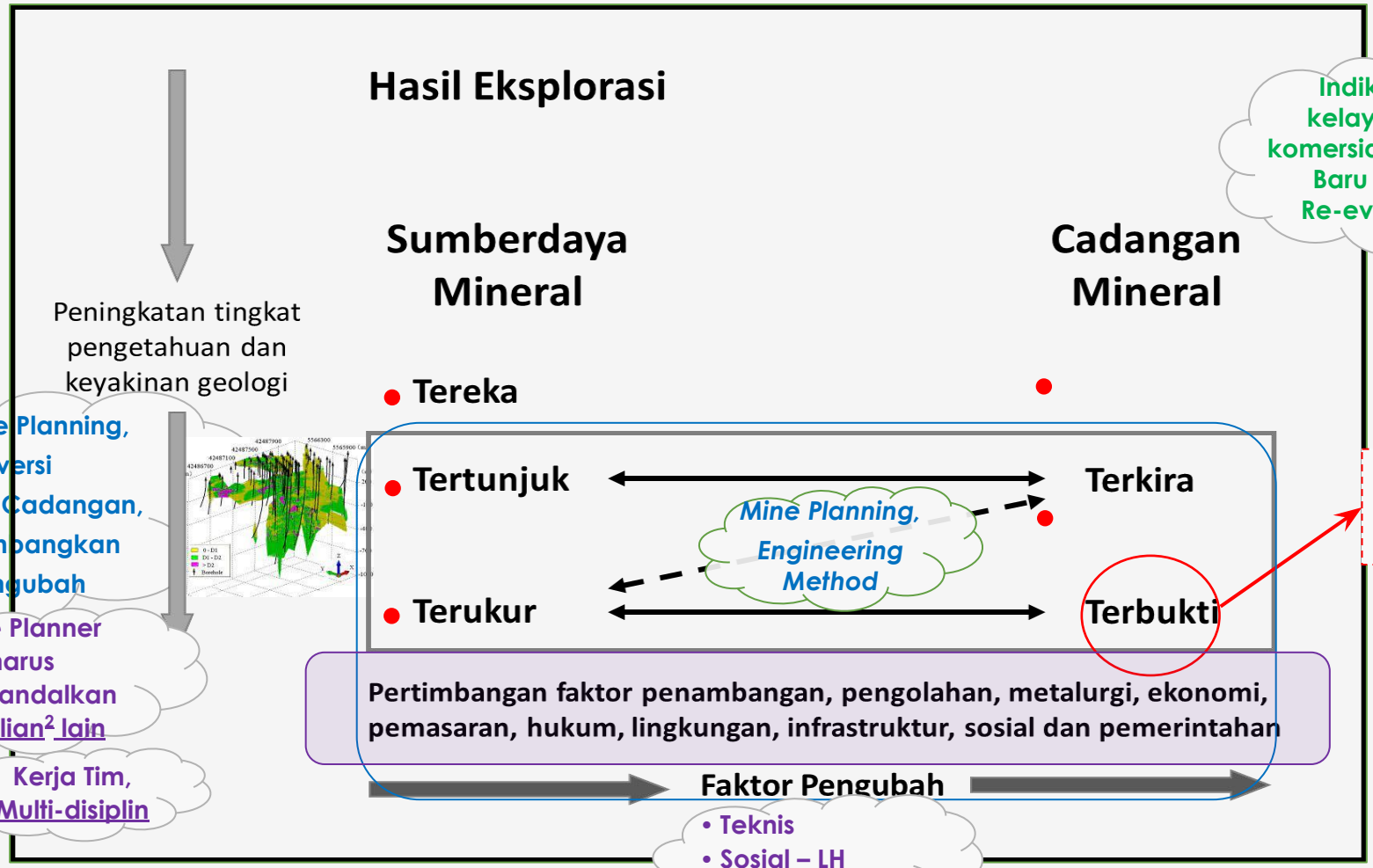
Ir. Andre Alis, ST, MBA, IPM

Danu Putra, ST, MT, IPP



Kerangka Kerja Universal Pelaporan HE– S/d– C/d

- sebagai refleksi penerapan konsep keekonomian tambang -

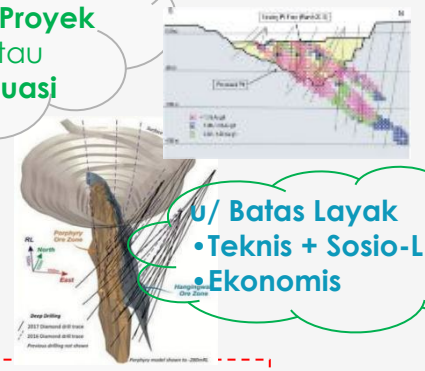


Metodologi Mine Planning, mengkonversi Sumberdaya → Cadangan, dgn mempertimbangkan 10 faktor pengubah

Mine Planner harus mengandalkan keahlian[2] lain

Kerja Tim, Multi-disiplin

Indikator kelayakan komersial Proyek Baru atau Re-evaluasi

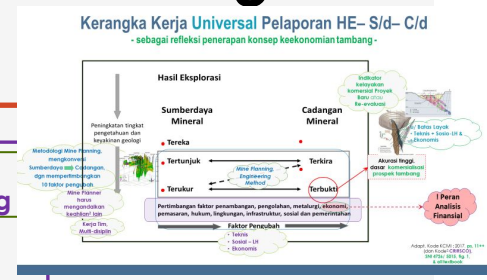


U/ Batas Layak
•Teknis + Sosio-LH &
•Ekonomis

Akurasi tinggi, dasar komersialisasi prospek tambang

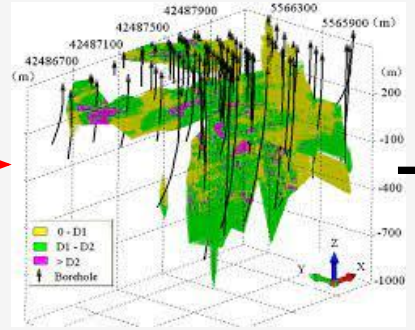
Adapt. Kode KCMI : 2017, ps. 11++
(dan Kode[2] CRIRSCO),
SNI 4726/ 5015, fig. 1,
& all textbook

(Framework-A) Mine Planning = Mining + Financial Engineering

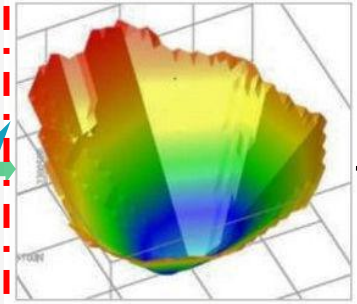


Analisis strategi eksploitasi, BESR, dll.

Tujuan mine planning: Meng-estimasi cadangan



Mining Engineering



Shell Hasil Optimisasi

Go

NO-Go

Go

NO-Go

TEST-2

Financial Engineering

NO-Go

NO-Go

NO-Go

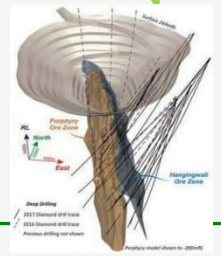
Go

Go

Go

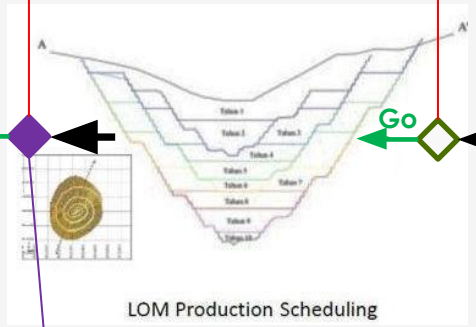
Cadangan = **tonase** & **kualitas**, bagian sumberdaya yg *economically mineable*

Go Komersial

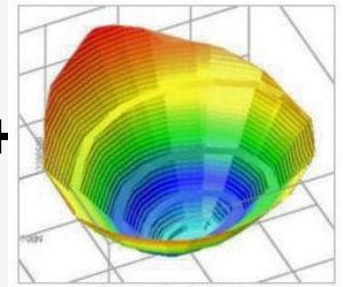


$ NPV DCFROR PB

Evaluasi Keekonomian



LOM Production Scheduling



Konseptual Pit Design

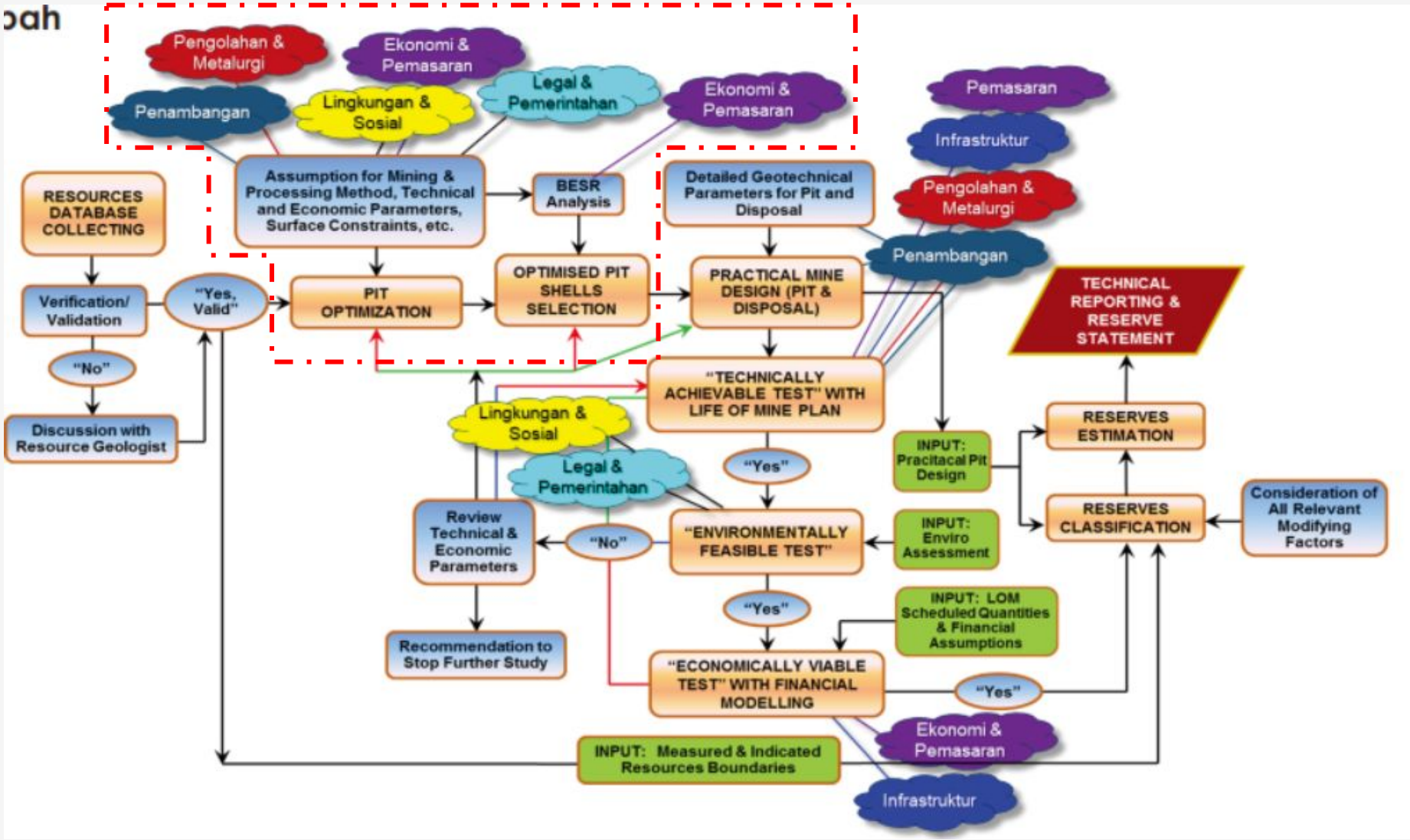
- Test-1 : layak teknis & Sosial-LH
- Test-2 : layak ekonomis

Peran Analisis Finansial

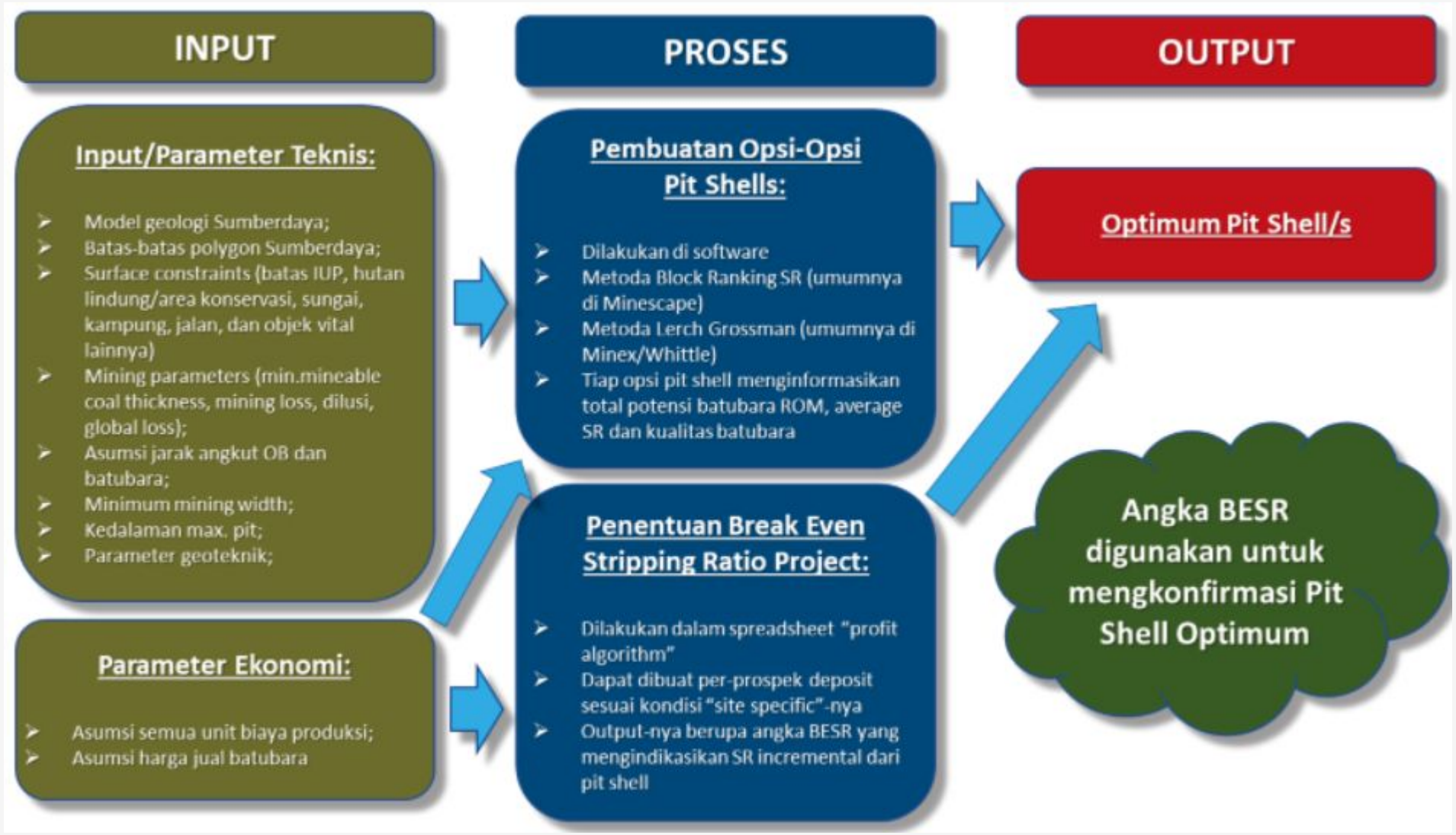
TEST-1

Adjust. fr. Lufi Rachmad, 2017

(*Framework-A*) ***Mine Planning*** = *Mining + Financial Engineering*



Metode Optimasi – General Optimzation flow



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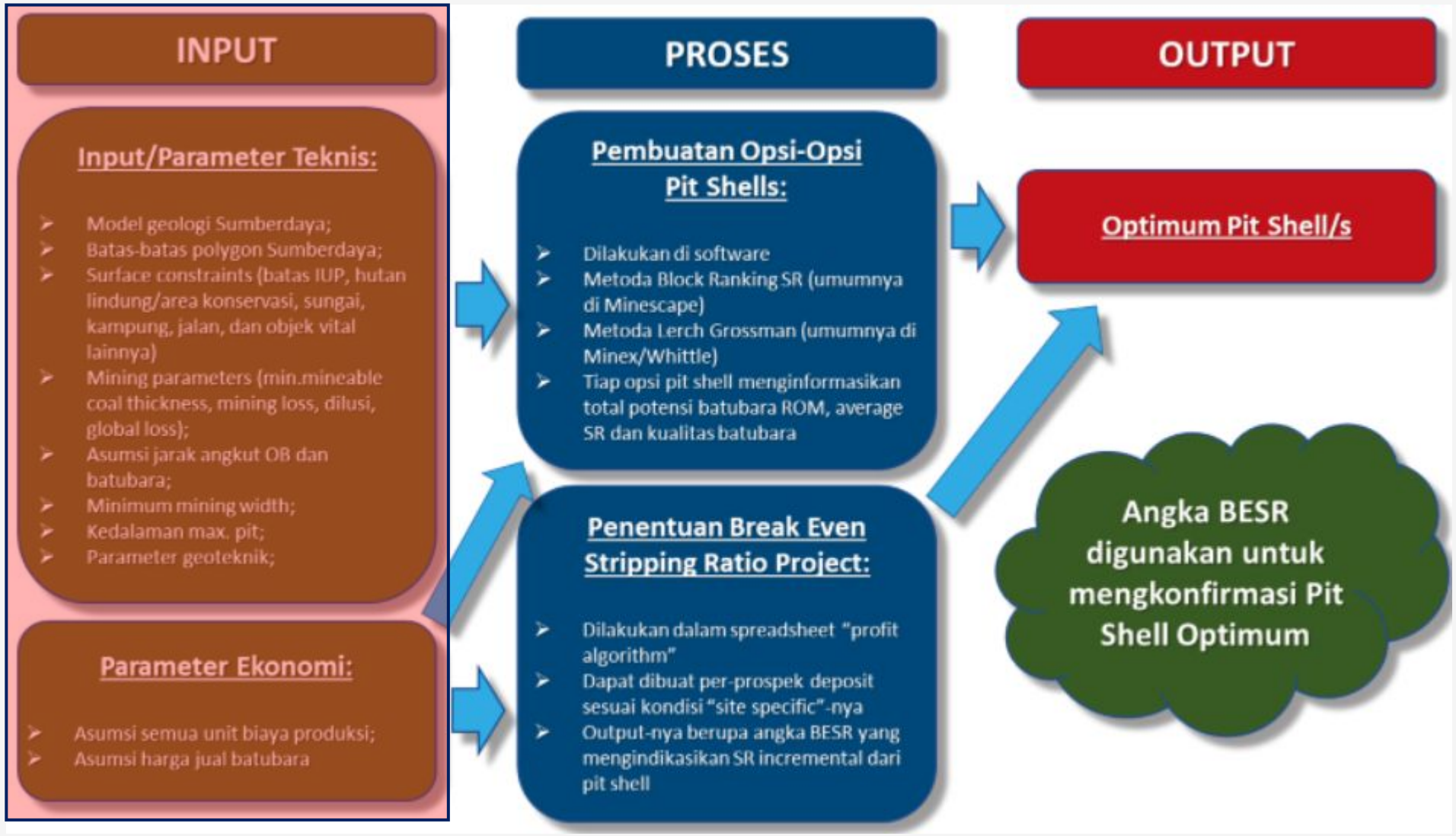
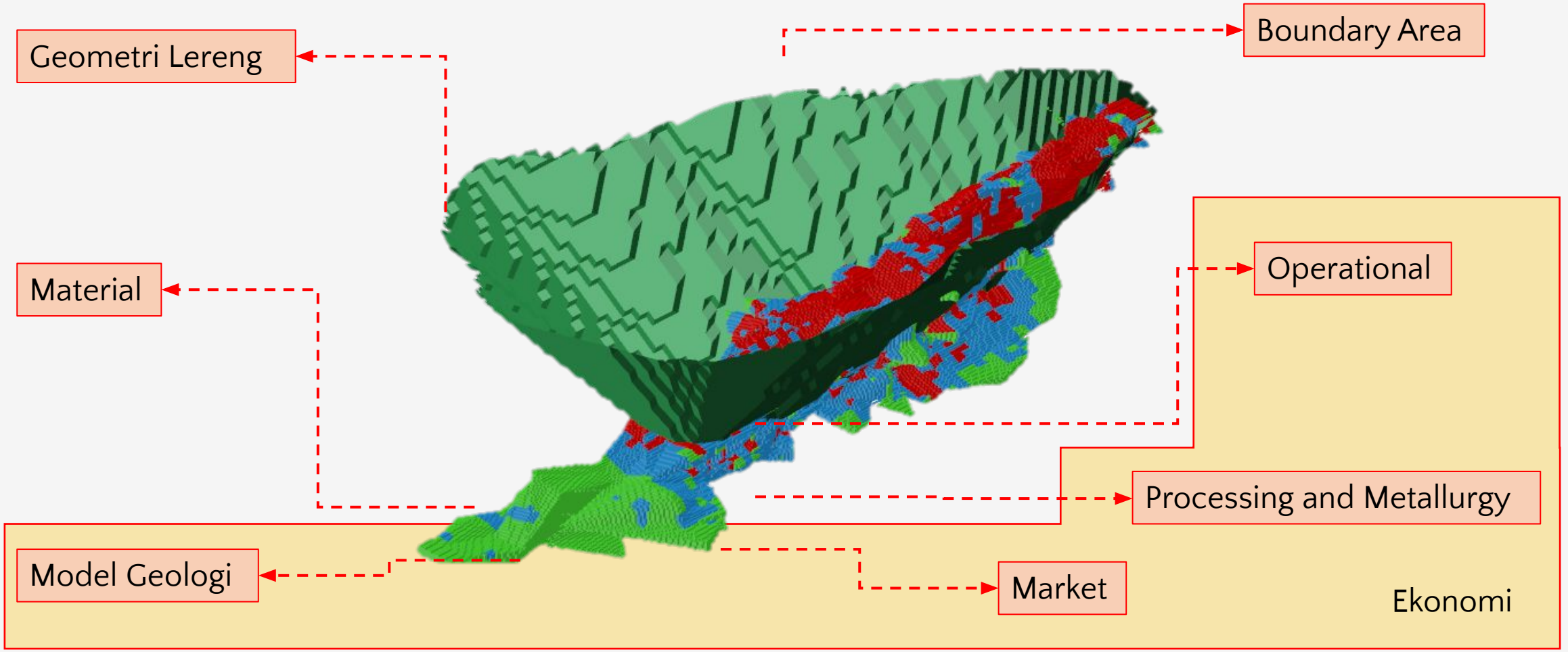
Metode Optimasi – General Optimzation flow



Panduan Praktis Komoditas Batubara, KCMI 2017

Parameter Optimasi (General)

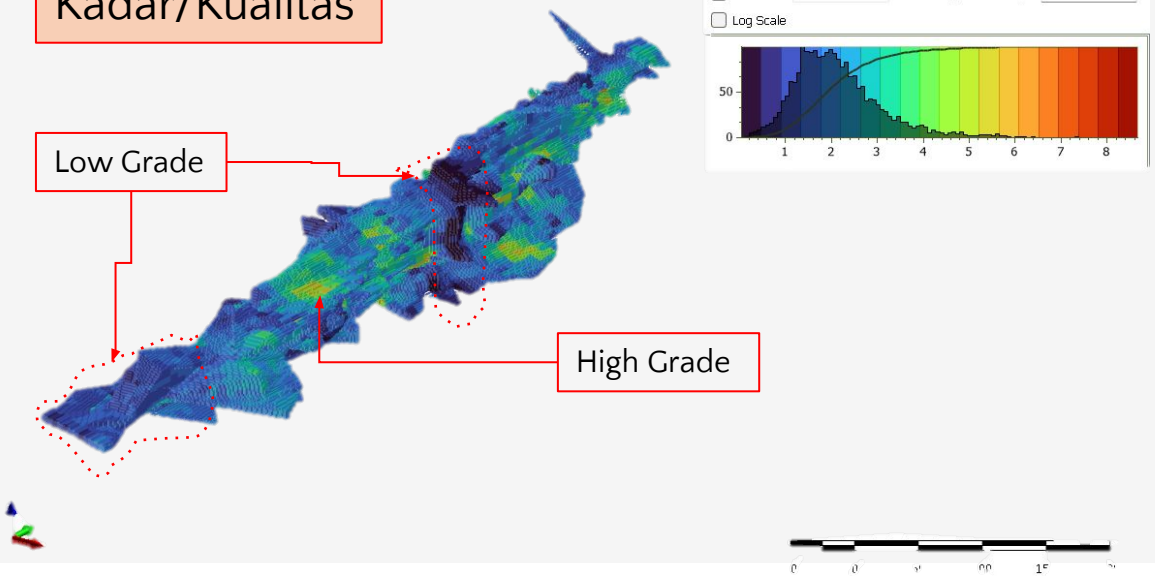


Parameter Optimasi – Model Geologi (Coal and Mineral)

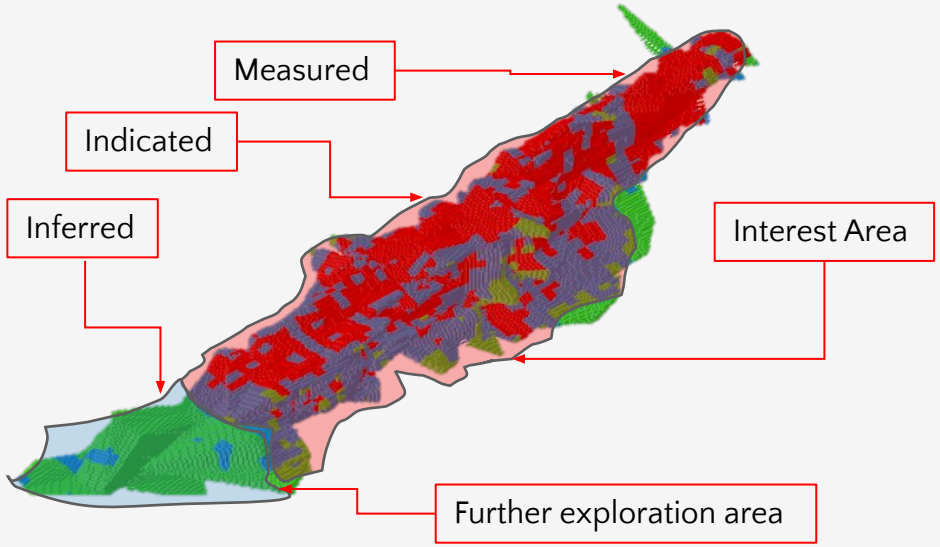
Model geologi

- Kadar
- Volume
- Densitas
- Tonnase
- Resource Category
- Ekonomi (?)
- Cut-off grade (?)
- Additional properties (?)
- *dst*

Kadar/Kualitas



Resource Category

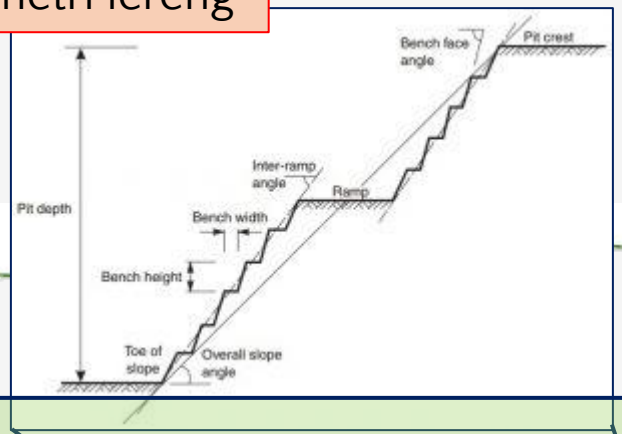


Parameter Optimasi – Geometri Lereng (Coal and Mineral)

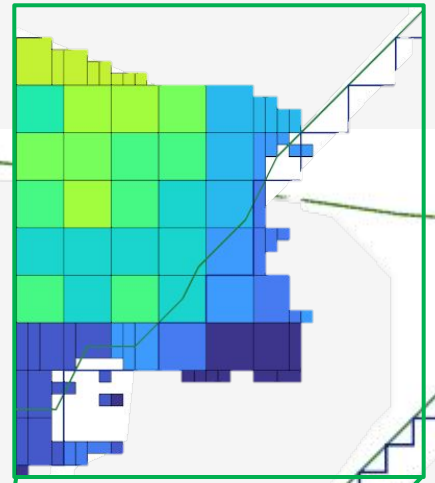
Geometri Lereng

- Single slope height
- Single slope angle
- Inter-ramp slope
- Overall slope height
- Overall slope angle
- Max slope height

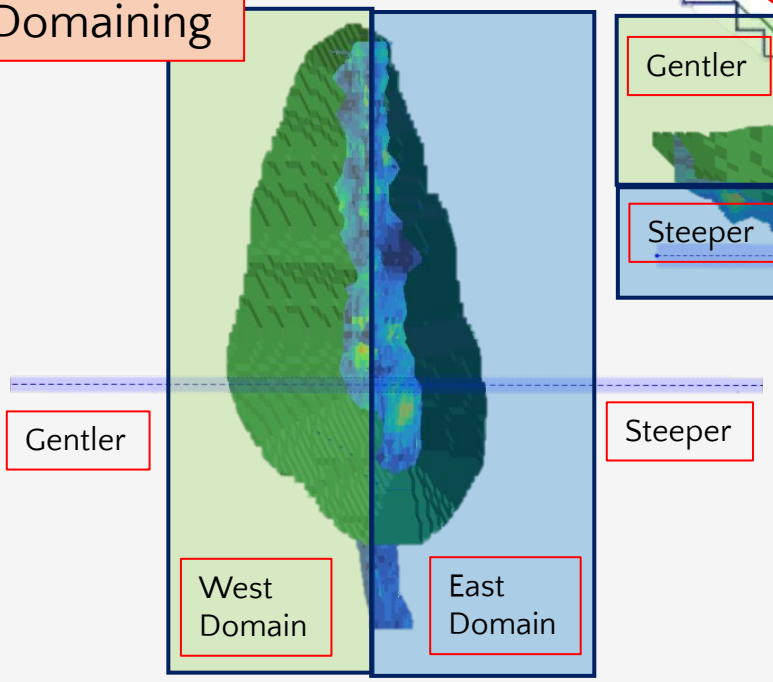
Geometri lereng

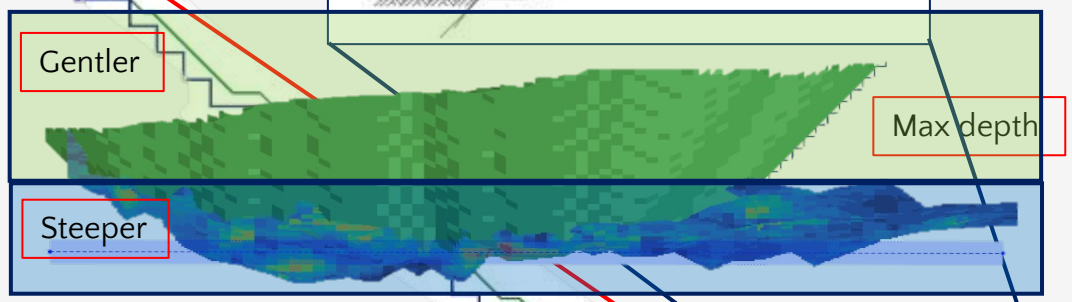


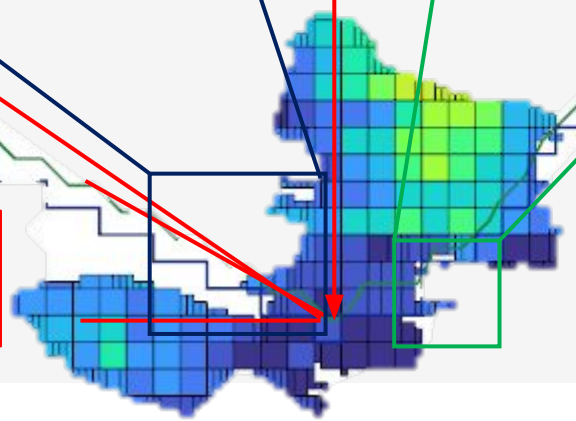
Block model vs slope



Domaining





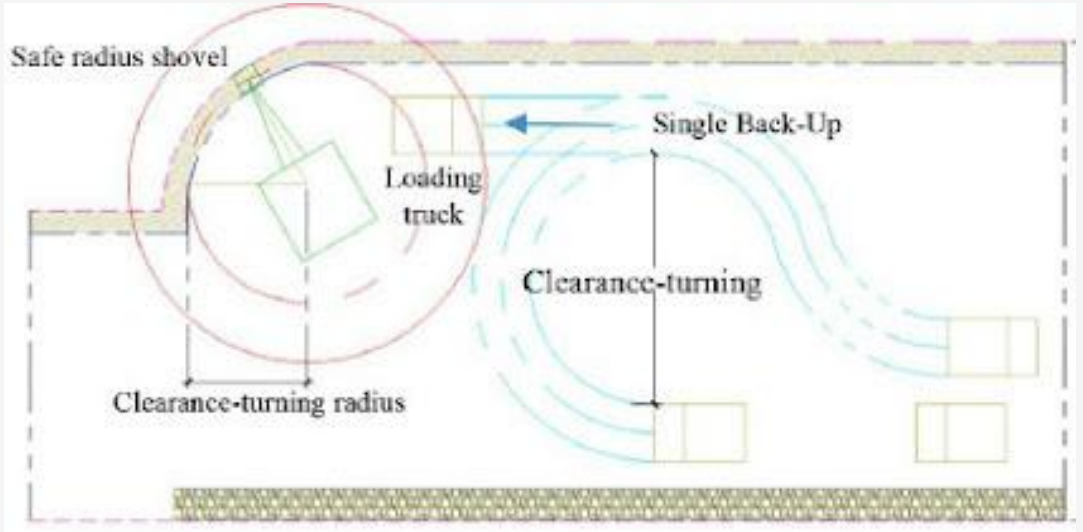


Overall slope
Interramp slope
Single slope

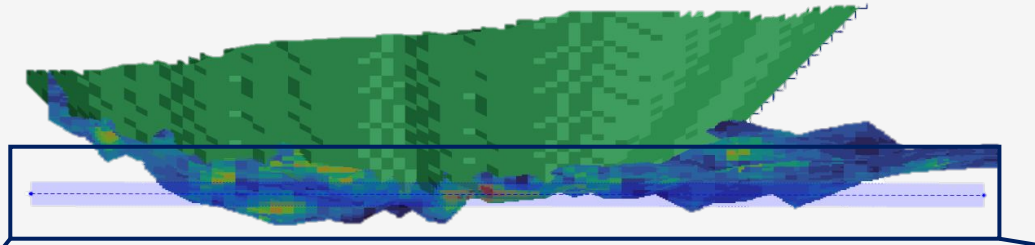
Parameter Optimasi – Operational (Coal and Mineral)

Operational

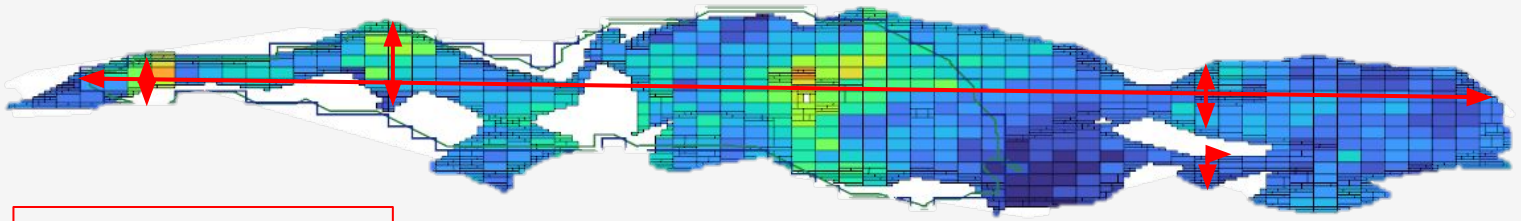
- Minimum work area
- Global Looses/Recovery
- Global Dilution



Minimum Mining Width



Working area



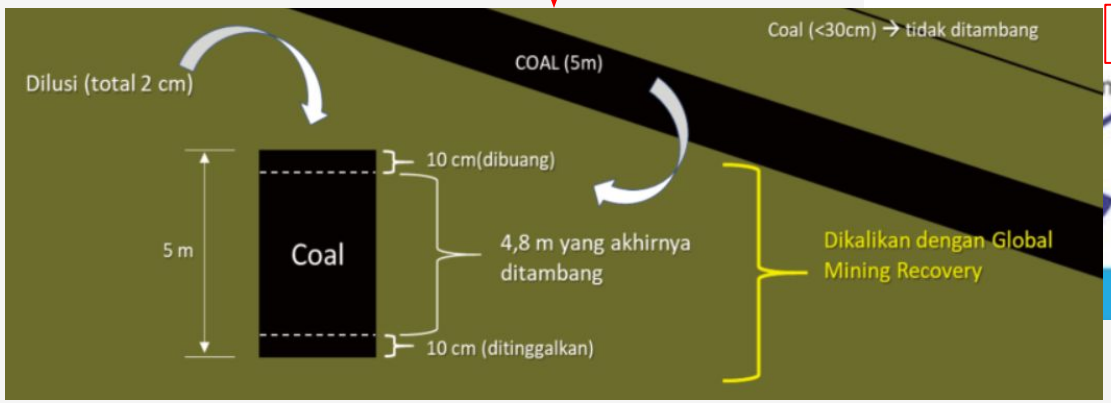
Minimum Mining Width

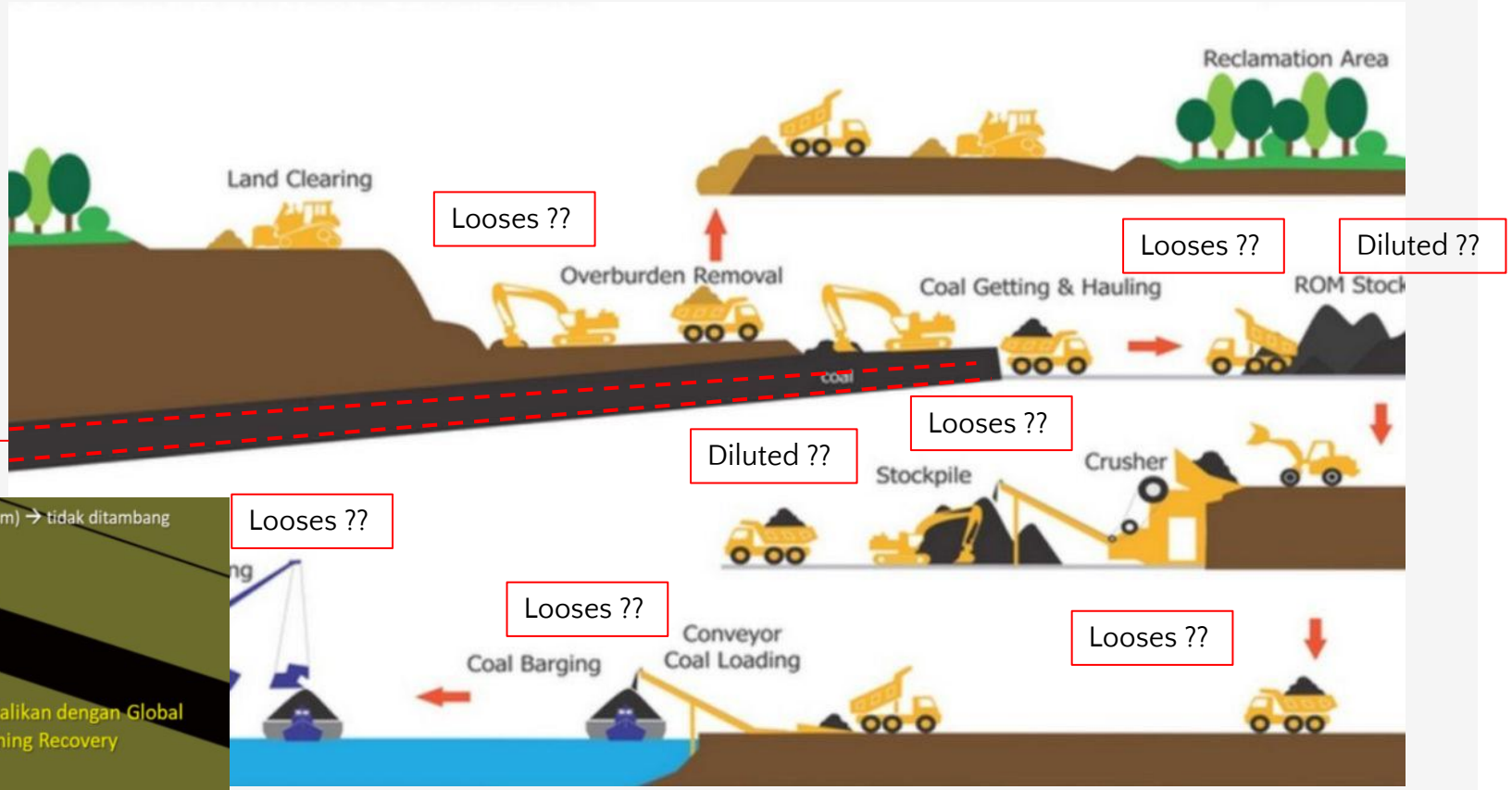
Two bottom pit potential

Parameter Optimasi – Operational (Coal)

Operational

- Minimum work area
- Global Looses
- Global Recovery





Overall Mining Process

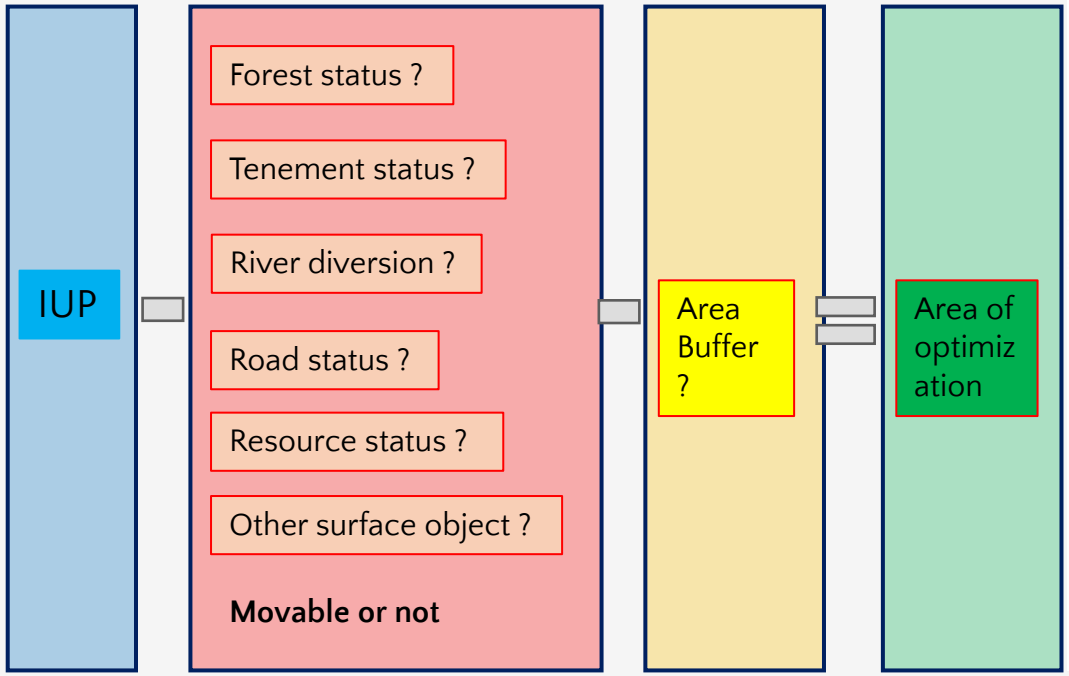
- **Global Recovery/Looses**
- **Global Dilution**

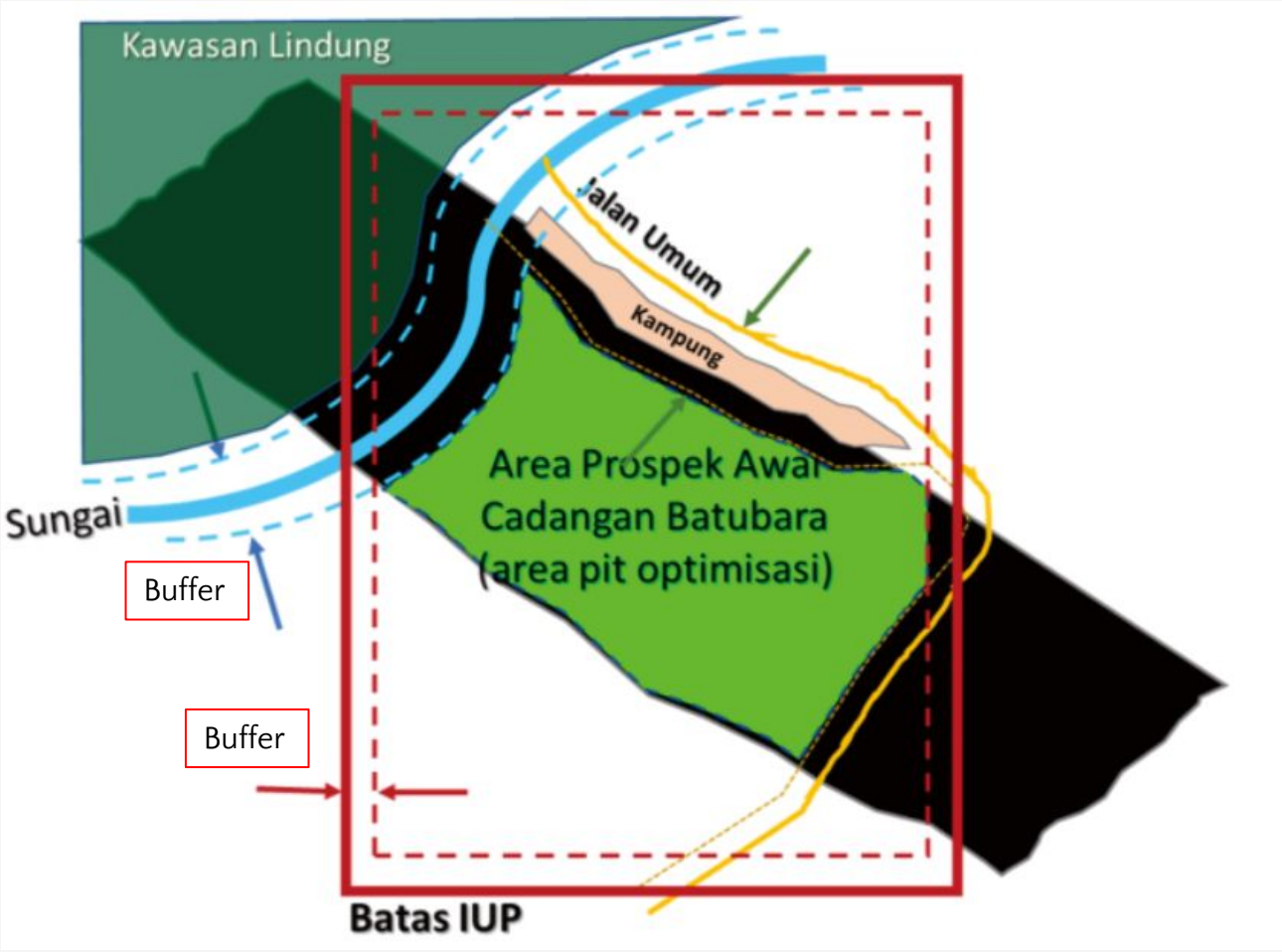
Panduan Praktis Komoditas Batubara, KCMI 2017

Parameter Optimasi – Area constraint

Boundary / Constrant

- Area constraint
- Geomechanical constraint
- Resources Constraint





Panduan Praktis Komoditas Batubara, KCMI 2017

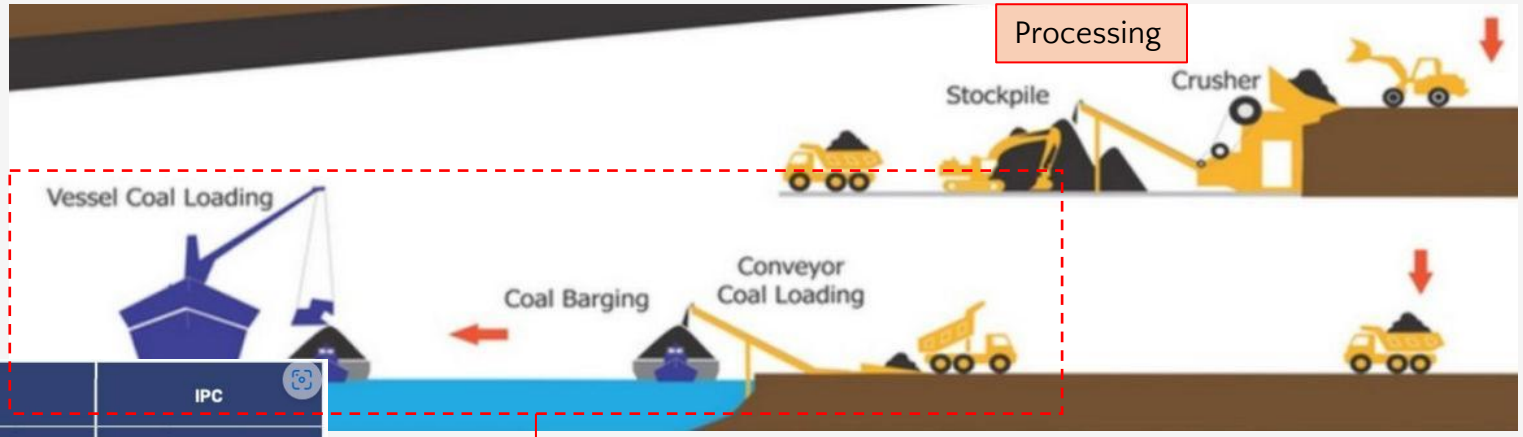
Parameter Optimasi – Processing and Metalurgy (Coal) & a bit of economics

Processing and Metallurgy

- Material
- Processing plant
- Metallurgycal process

Marker

- Product



Parameter		Bukit Asam							IPC		
Parameter		BA–42	BA–46	BA–48	BA–50	BA–61	BA–67	BA–71	GAR 4600	GAR 4700	GAR 4800
CV	Kcal/Kg.ar	4,200	4,500	4,800	5,000	6,100	6,700	7,100	4,600	4,700	4,800
TM	%, ar	33.00	31.00	30.00	28.00	16.00	11,00	7,00	31	28	27
IM	%, adb	16.00	15.00	14.00	13.00	6,00	4,00	3,00	15	15	15
Ash	%, adb	8.00	4.00	8.00	7.00	7,00	10,00	8,00	6	6	6
VM	%, adb	39.00	43.00	39.00	40.00	40,00	25,00	28,00	38	38	38
FC	%, adb	37.00	38.00	39.00	40.00	47,00	61,00	61,00	By Diff	By Diff	By Diff
TS	%, adb	0.60	0.54	0.68	0.42	0.39	0,64	0,65	0.5	0.5	0.5
Ash Fushion Temperatures (oC)	Deformation	1,218	1,216	1,321	1,302	1,331	1,479	1,461	-	-	-
-	Spherical	1,240	1,246	1,332	1,325	1,366	1,476	1,486	-	-	-
-	Hemisphere	1,268	1,384	1,340	1,350	1,405	1,480	1,489	-	-	-
-	Flow	1,288	1,413	1,373	1,392	1,445	1,485	1,495	-	-	-
HGI	-	60	58	55	57	55	63	77	42	42	42

No additional metallurgical process

Export %?

Domestic %?

Market Plan

Intl. prices $?

Dom. prices $?

Revenue Plan

Domestic Market Obligation (DMO)

Tax

Value ?

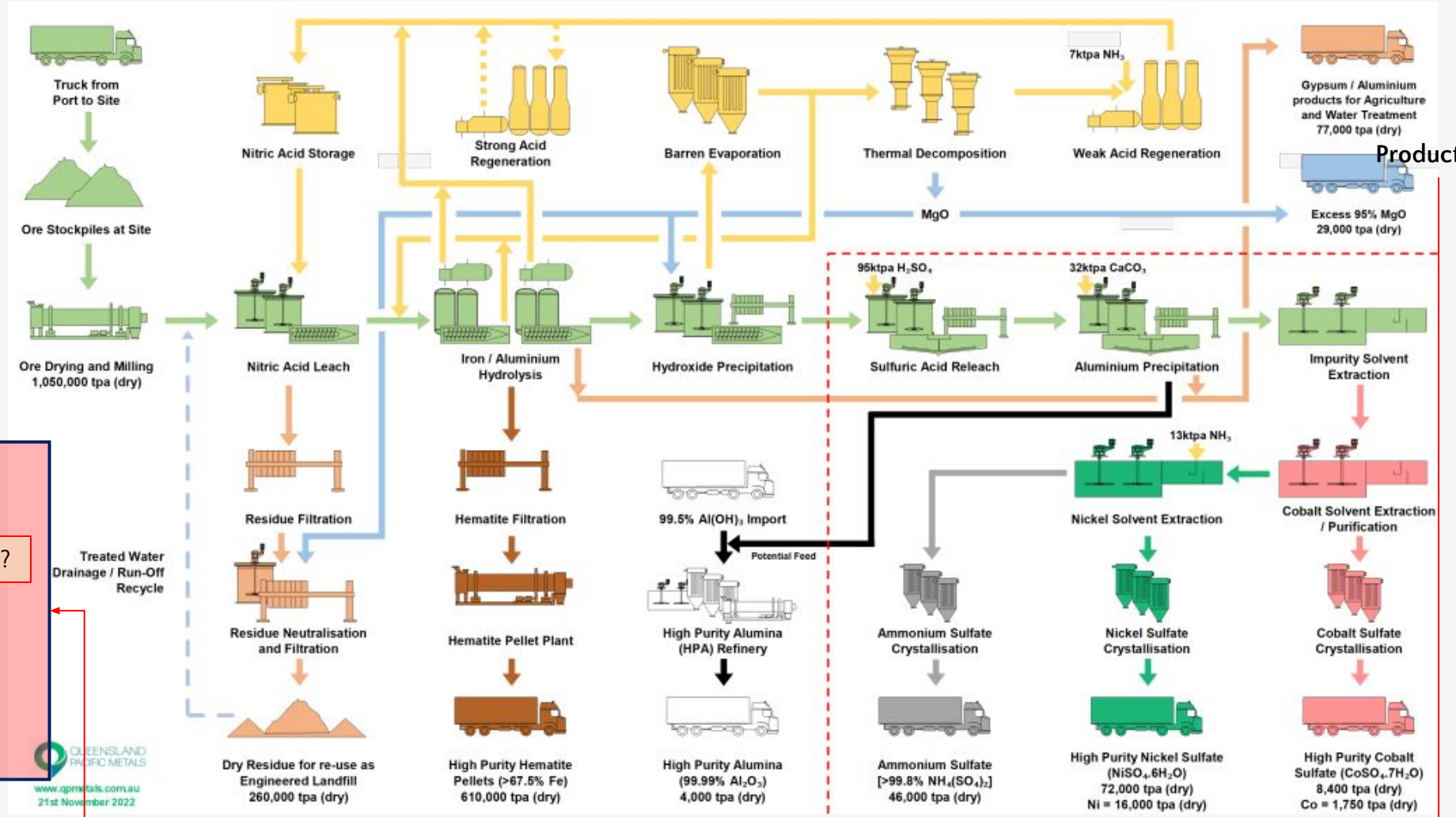
Parameter Optimasi – Processing and Metalurgy (Nickel)

Processing and Metallurgy

- Material
- Processing plant
- Metallurgycal process

Marker

- Product



Intl. prices $?

Dom. prices $?

Revenue Plan

Export %?

Domestic %?

Market Plan

Tax

Parameter Optimasi – Economics (Costs - Coal)

Business Process

- Mining
- Processing
- Metallurgy
- Marketing
- Selling

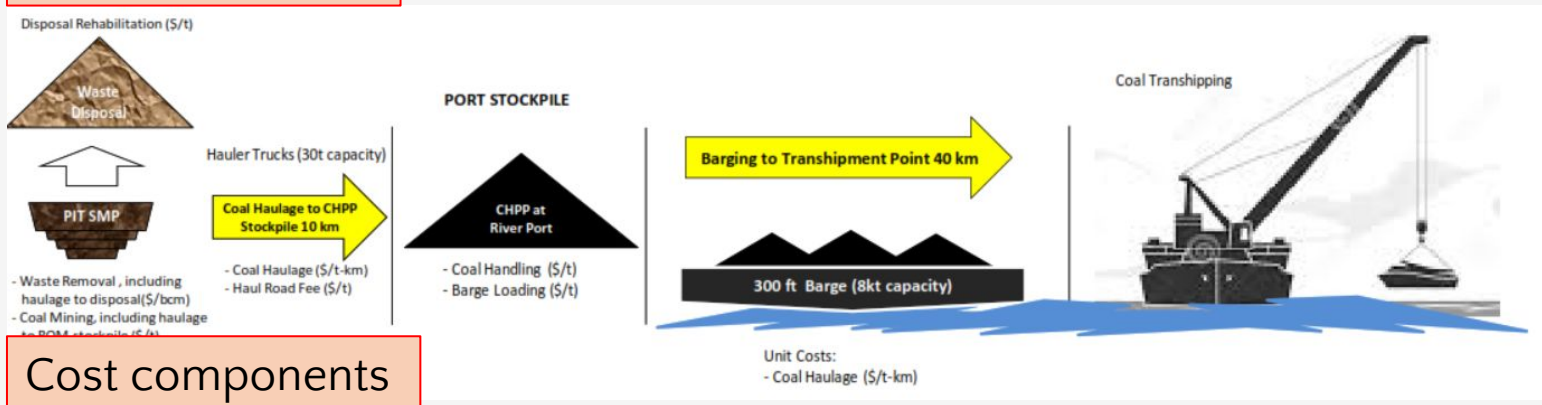
Costs

- Activity Based Costing (ABC)
- Capital

Prices

- Products

Business Process



Cost components

Total cost

- Mining cost
  - Coal mining cost
  - Overburden removal cost
- G&A cost
- Enviro cost
- Selling cost

Direct Unit Costs (including VAT where applicable)			
OB removal (to maximum 1.5 km haulage distance)	$/bcm	2.23	Assumption based on previous related JORC Study
Overhaulage distance charge	$/bcm-km	0.47	
Coal getting	$/t	0.79	
Coal haulage from pit to port stockpile	$/t-km	0.13	
Road maintenance	$/t	0.03	
Coal handling and processing at port (without drying)	$/t	1.10	
Coal natural drying when required	$/t	0.50	
Coal barge loading	$/t	1.30	
Coal barging	$/t-km	0.02	
Coal transhipping to mother vessel	$/t	2.00	
Indirect Unit Costs			
Administration and overhead	$/t	2.00	Assumption based on previous related JORC Study
CSR and community development	$/t	0.50	
Safety, environmental and rehabilitation	$/t	0.50	
Marketing Commision	$/t	1.00	
Government Royalti		3%	

Cash cost

Parameter Optimasi – Economics (Capital - Coal)

Business Process

- Mining
- Processing
- Metallurgy
- Marketing
- Selling

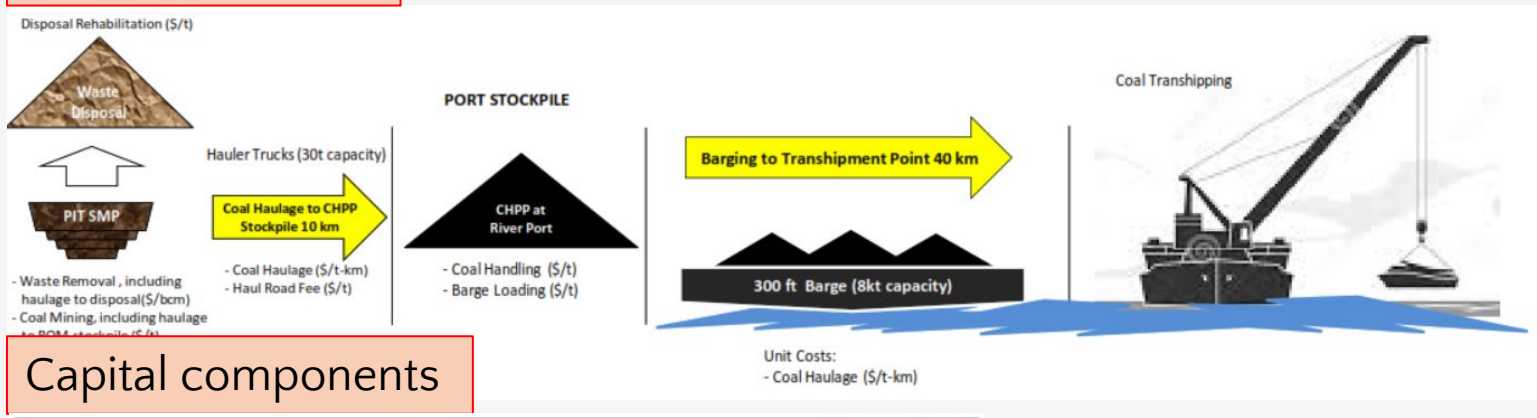
Costs

- Activity Based Costing (ABC)
- Capital

Prices

- Products

Business Process



Capital components

CAPEX	Mil. US$
10 km haul road construction (including landcomp, underpass, culvert etc)	3.00
Permit & Exploration	0.75
Jetty construction (including covered stockpile and barge loading facilities)	14.50
Powerline relocation	2.00
Land compensation for mining (700Ha)	24.14
Reclamation and Mine Closure Guarantee	3.86
Contingency for capex (15%)	7.24
Total of Capital Cost	**55.49**

Parameter Optimasi – Economics (Prices - Coal)

Business Process

- Mining
- Processing
- Metallurgy
- Marketing
- Selling

Costs

- Activity Based Costing (ABC)

Prices

- Products

Product

Parameter		Bukit Asam							IPC		
Parameter		BA-42	BA-46	BA-48	BA-50	BA-61	BA-67	BA-71	GAR 4600	GAR 4700	GAR 4800
CV	Kcal/Kg.ar	4,200	4,500	4,800	5,000	6,100	6,700	7,100	4,600	4,700	4,800
TM	%, ar	33.00	31.00	30.00	28.00	16.00	11,00	7,00	31	28	27
IM	%, adb	16.00	15.00	14.00	13.00	6,00	4,00	3,00	15	15	15
Ash	%, adb	8.00	4.00	8.00	7.00	7,00	10,00	8,00	6	6	6
VM	%, adb	39.00	43.00	39.00	40.00	40,00	25,00	28,00	38	38	38
FC	%, adb	37.00	38.00	39.00	40.00	47,00	61,00	61,00	By Diff	By Diff	By Diff
TS	%, adb	0.60	0.54	0.68	0.42	0.39	0,64	0,65	0.5	0.5	0.5
Ash Fushion Temperatures (oC)	Deformation	1,218	1,216	1,321	1,302	1,331	1,479	1,461	-	-	-
-	Spherical	1,240	1,246	1,332	1,325	1,366	1,476	1,486	-	-	-
-	Hemisphere	1,268	1,384	1,340	1,350	1,405	1,480	1,489	-	-	-
-	Flow	1,288	1,413	1,373	1,392	1,445	1,485	1,495	-	-	-
HGI	-	60	58	55	57	55	63	77	42	42	42

Selling location

Target

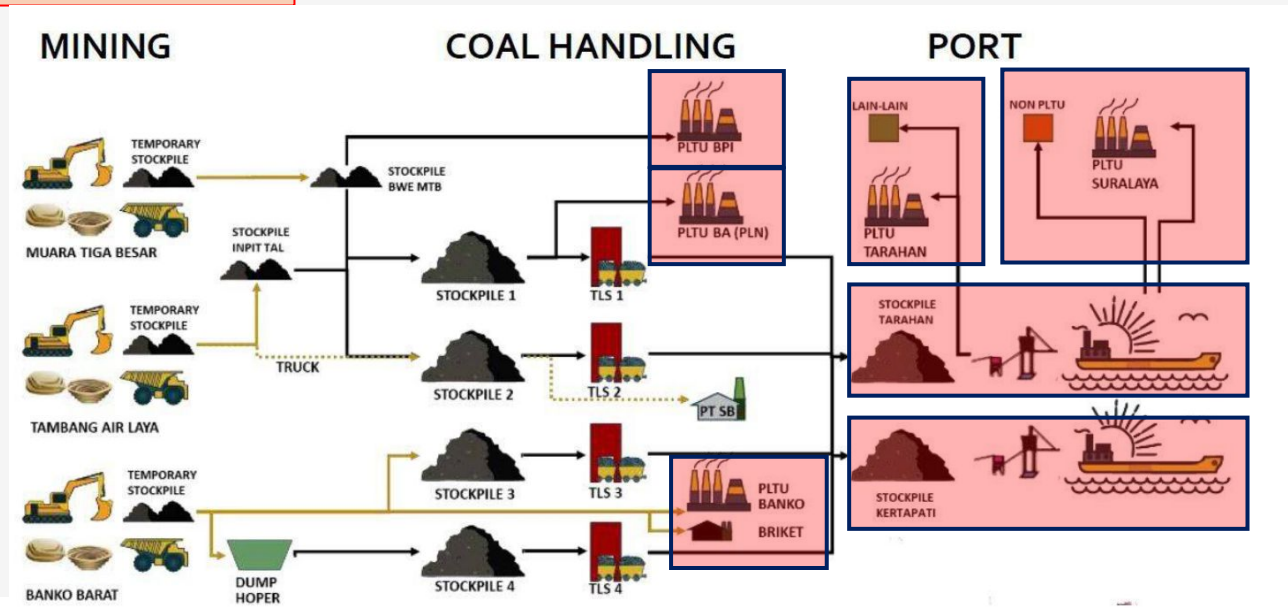
- Intl. market %?
- Location 1, etc
- Dom. market $?
- Location 1, etc

Market Plan

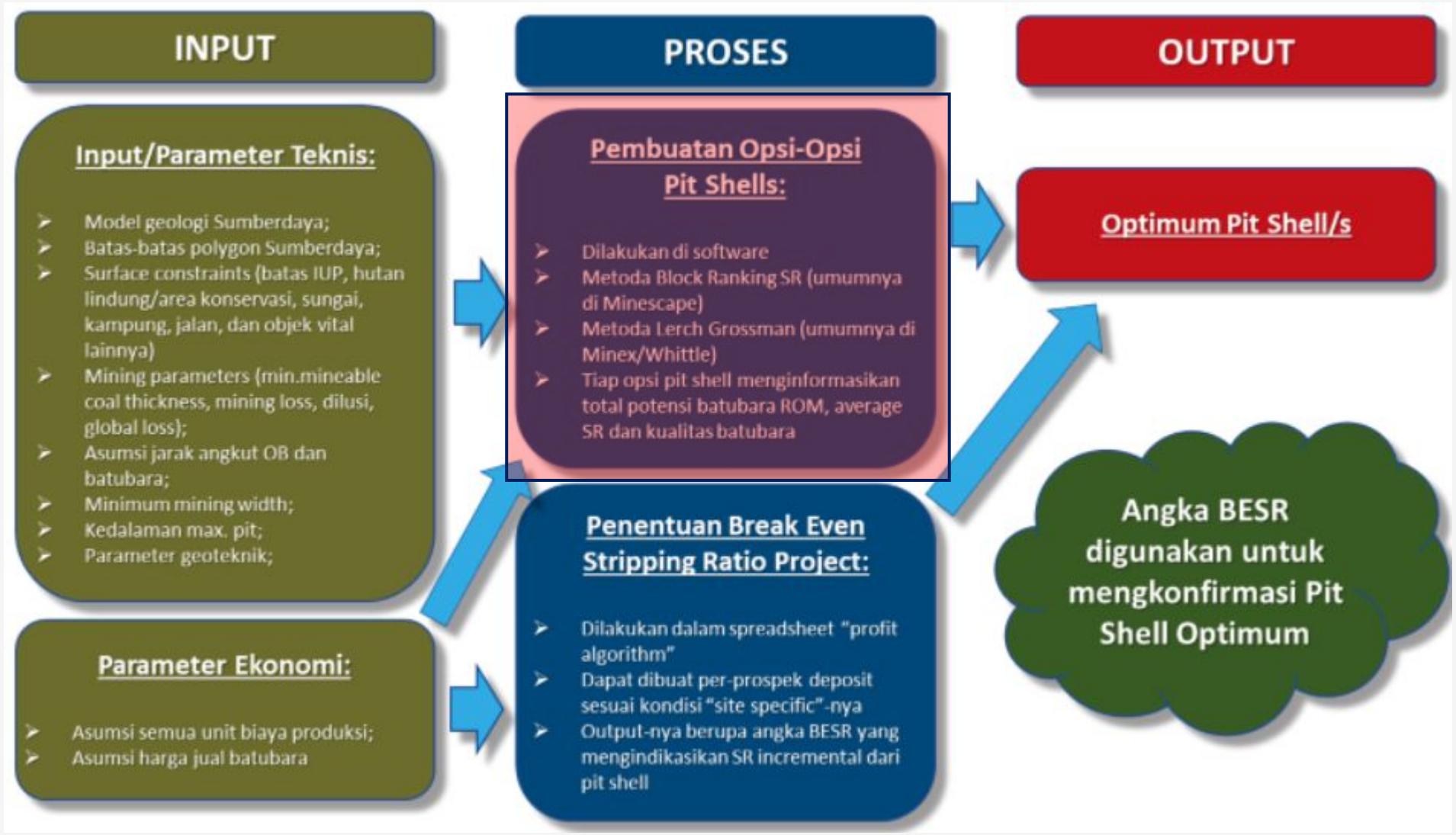
Prices

- Intl. prices $?
- Newcastle. Etc.
- Dom. prices $?
- HBA adjusted. PLTU

Revenue Plan



Metode Optimasi – General Optimzation flow



Panduan Praktis Komoditas Batubara, KCMI 2017

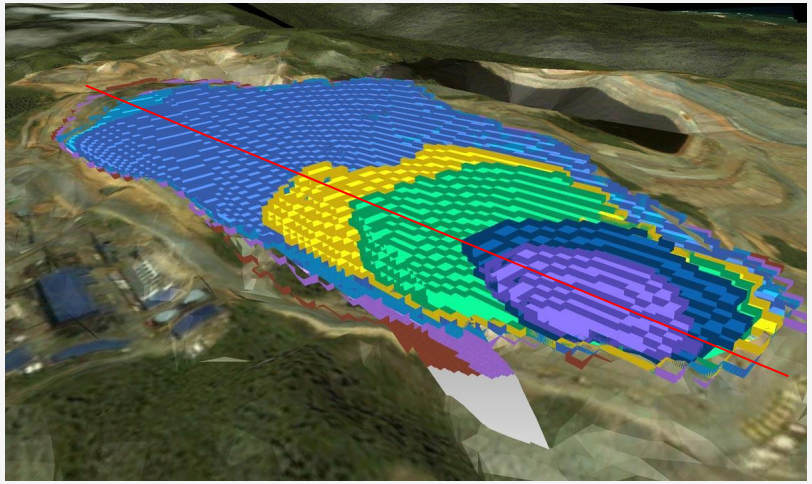
Metode Optimasi – Optimizer (Lerch Grossman)

Parameter Optimasi

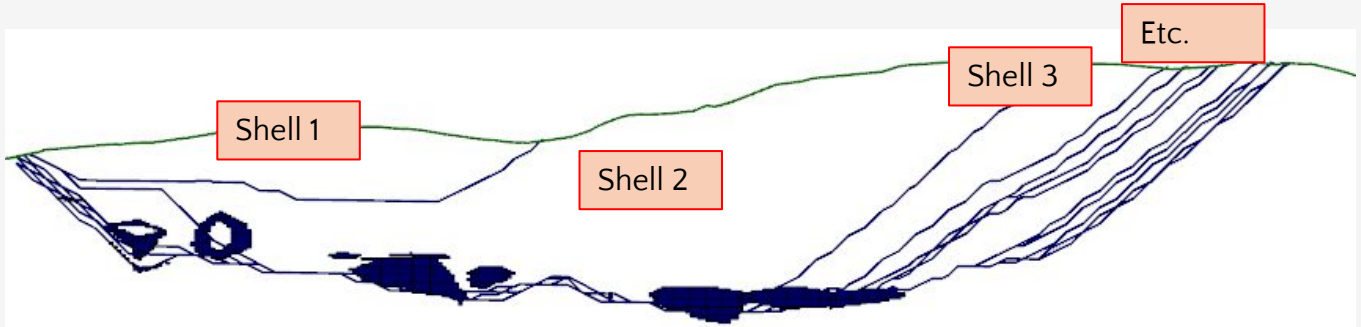
Revenue Adjustment Factor (RAF)

Pit Shell(s)

Optimum Pit Shell/s



OPSI PIT	OB (kbcm)	Coal (kt)	Avg. SR (bcm/t)	Inc.SR (bcm/t)	Weighted Average Pit Quality						
					CV (kcal/kg-adb)	CV (kcal/kg-ar)	Ash (%-adb)	IM (%-adb)	TM (%-ar)	TS (%-adb)	iRD
PIT-1	13,874	6,837	2.03		6658	6328	6.14	13.77	18.04	0.43	1.35
PIT-2	24,599	9,250	2.66	4.44	6665	6336	6.05	13.76	18.03	0.43	1.35
PIT-3	30,637	10,494	2.92	4.86	6681	6355	5.92	13.70	17.90	0.43	1.35
PIT-4	34,627	11,616	2.98	3.56	6692	6359	5.84	13.60	17.90	0.43	1.35
PIT-5	48,252	13,862	3.48	6.07	6710	6375	5.64	13.58	17.89	0.43	1.35
PIT-6	60,070	15,663	3.84	6.56	6725	6389	5.57	13.47	17.79	0.43	1.35
PIT-7	86,883	19,101	4.55	7.80	6740	6398	5.51	13.30	17.70	0.43	1.35
PIT-8	109,959	21,410	5.14	9.99	6742	6396	5.44	13.32	17.77	0.41	1.35
PIT-9	131,925	23,382	5.64	11.14	6750	6386	5.15	13.23	17.90	0.41	1.35
PIT-10	141,965	24,062	5.90	14.76	6755	6366	5.34	12.78	17.80	0.40	1.35
PIT-11	164,718	24,882	6.62	27.75	6760	6392	5.15	13.23	17.95	0.41	1.35
PIT-12	186,305	25,662	7.26	27.68	6762	6381	5.34	12.78	17.70	0.40	1.35



Shell option

Optimum Pit Shell ?

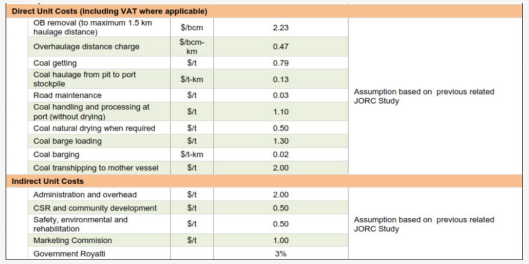
Metode Optimasi – Optimizer (Lerch Grossman)

Parameter Optimasi

Revenue Adjustment Factor (RAF)

Pit Shell(s)

Optimum Pit Shell/s



Direct Unit Costs (including VAT where applicable)			
OB removal (to maximum 1.5 km haulage distance)	$/bcm	2.23	Assumption based on previous related JORC Study
Overhaulage distance charge	$/bcm-km	0.47	
Coal getting	$/t	0.79	
Coal haulage from pit to port stockpile	$/t-km	0.13	
Road maintenance	$/t	0.03	
Coal handling and processing at port (without drying)	$/t	1.10	
Coal natural drying when required	$/t	0.50	
Coal barge loading	$/t	1.30	
Coal barging	$/t-km	0.02	
Coal transhipping to mother vessel	$/t	2.00	
Indirect Unit Costs			
Administration and overhead	$/t	2.00	Assumption based on previous related JORC Study
CSR and community development	$/t	0.50	
Safety, environmental and rehabilitation	$/t	0.50	
Marketing Commision	$/t	1.00	
Government Royalti		3%	

Additional Calculation to be Performed

or

Calculated by software

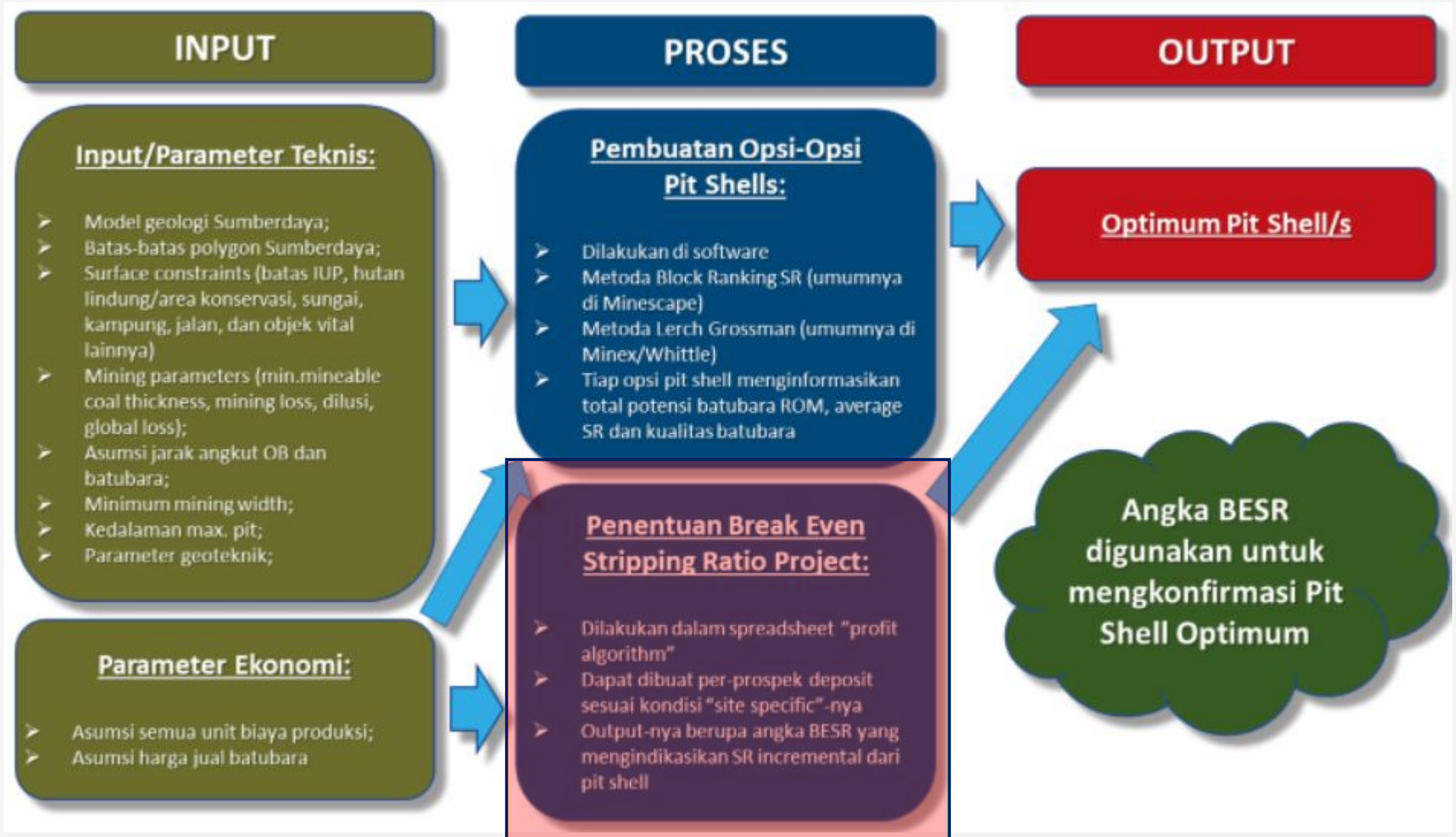
OPSI PIT	OB (kbcm)	Coal (kt)	Avg. SR (bcm/t)	Inc.SR (bcm/t)	Weighted Average Pit Quality							US$'000				Total Cost (US$'000)	Revenue (US$'000)	Profit Margin (US$'000)
					CV (kcal/kg-adb)	CV (kcal/kg-ar)	Ash (%-adb)	IM (%-adb)	TM (%-ar)	TS (%-adb)	iRD	OB Cost	Coal Cost	Indirect Costs	Capital Costs			
PIT-1	13,874	6,837	2.03		6658	6328	6.14	13.77	18.04	0.43	1.35	32,049	143,636	41,489	80,500	297,673	424,240	126,567
PIT-2	24,599	9,250	2.66	4.44	6665	6336	6.05	13.76	18.03	0.43	1.35	56,824	194,343	56,135	80,500	387,802	574,749	186,947
PIT-3	30,637	10,494	2.92	4.86	6681	6355	5.92	13.70	17.90	0.43	1.35	70,772	220,471	63,682	80,500	435,426	654,036	218,610
PIT-4	34,627	11,616	2.98	3.56	6692	6359	5.84	13.60	17.90	0.43	1.35	79,988	244,049	70,493	80,500	475,030	724,425	249,396
PIT-5	48,252	13,862	3.48	6.07	6710	6375	5.64	13.58	17.89	0.43	1.35	111,462	291,241	84,124	80,500	567,327	866,704	299,376
PIT-6	60,070	15,663	3.84	6.56	6725	6389	5.57	13.47	17.79	0.43	1.35	138,761	329,078	95,053	80,500	643,391	981,411	338,020
PIT-7	86,883	19,101	4.55	7.80	6740	6398	5.51	13.30	17.70	0.43	1.35	200,699	401,302	115,914	80,500	798,415	1,198,526	400,111
PIT-8	109,959	21,410	5.14	9.99	6742	6396	5.44	13.32	17.77	0.41	1.35	254,006	449,827	129,931	80,500	914,264	1,342,962	428,698
PIT-9	131,925	23,382	5.64	11.14	6750	6386	5.15	13.23	17.90	0.41	1.35	304,747	491,252	141,896	80,500	1,018,395	1,464,415	446,019
PIT-10	141,965	24,062	5.90	14.76	6755	6366	5.34	12.78	17.80	0.40	1.35	327,939	505,539	146,023	80,500	1,060,001	1,502,292	442,291
PIT-11	164,718	24,882	6.62	27.75	6760	6392	5.15	13.23	17.95	0.41	1.35	380,498	522,767	150,999	80,500	1,134,765	1,559,718	424,954
PIT-12	186,305	25,662	7.26	27.68	6762	6381	5.34	12.78	17.70	0.40	1.35	430,364	539,155	155,733	80,500	1,205,752	1,605,799	400,047

Recommended Optimum Pit Shell

Inc. SR to be compared with BESR

Shell Economic Value

Metode Optimasi – General Optimzation flow



Metode Optimasi – BESR & Block Ranking (Perhitungan BESR)

$$BESR = \frac{\text{(Harga jual batubara - Total biaya produksi non-OB)}}{\text{Unit biaya pemindahan OB (termasuk kelebihan jarak angkut)}}$$

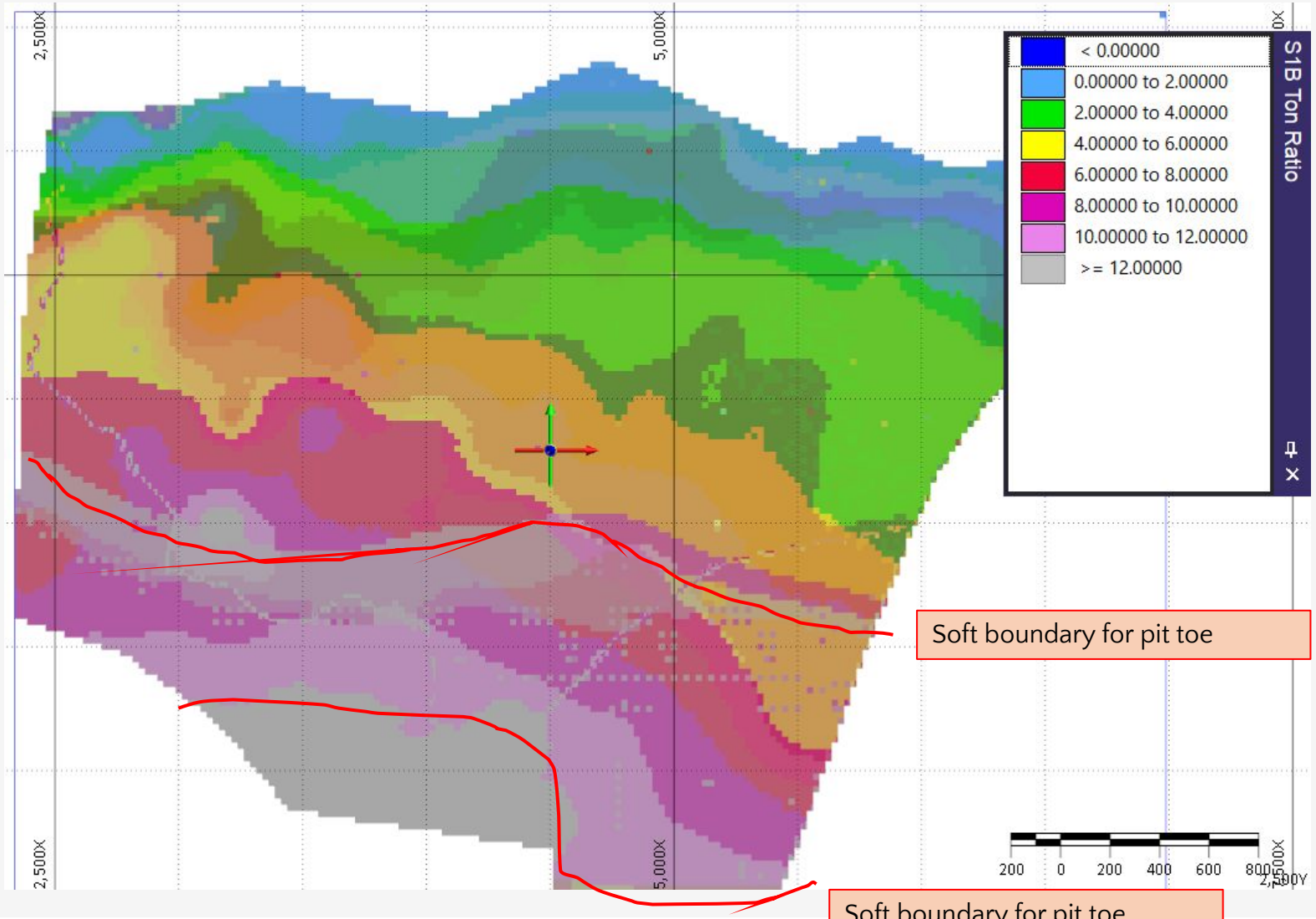
Contoh Unit Biaya Produksi - Kontraktor	Satuan	Nilai (setelah PPN)
Biaya Langsung (Direct Cost)		
Biaya Pemindahan OB		
Pemindahan OB (maks. 1km) - termasuk clearing, topsoil, D&B	$/bcm	2.31
Kelebihan jarak angkut (overhaulage distance)	$/bcm-km	0.50
Biaya Batubara		
Penambangan batubara (coal ge◆ng termasuk pengangkutan ke ROM SP)	$/t	1.65
Pengolahan, pemrosesan dan penanganan batubara (crushing/processing) di ROM SP	$/t	1.27
Dewatering	$/t	0.44
Pengangkutan batubara (coal hauling) ke Port	$/t-km	0.11
Fee penggunaan jalan angkut	$/t	6.60
Pemuatan ke tongkang	$/t	1.49
Pengangkutan batubara dengan tongkang	$/t-km	0.02
Pemuatan ke vessel	$/t	1.98
Surveyor Independent (di stockpile & barge)	$/t	0.22
Biaya Tidak Langsung (Indirect Costs)		
Administrasi dan overhead	$/t	1.00
Comdev / CSR	$/t	0.50
Rehabilitasi Lingkungan	$/t	0.30
Komisi marke◆ng	$/t	0.50
Royal◆ Pemerintah	%	7.00

	PT ABC	
	Kuan◆tas	Ongkos Produksi/t
BESR (bcm/t)	**11.58**	
Kelebihan Jarak Angkut (km)	0.00	
Pemindahan OB ($/bcm)		2.31
Pemindahan OB ($/t)		26.76
	1	1.65
	1	1.27
	1	0.44
Jarak Angkut (km)	85	9.35
	1	6.60
	1	1.49
Jarak Angkut (km)	0	-
	0	-
	1	0.22
	1	1.00
	1	0.50
	1	0.30
	1	0.50
	1	3.77
Total Biaya Produksi	$/t	53.84
Harga batubara	$/t	53.84
Simple Margin	$/t	-

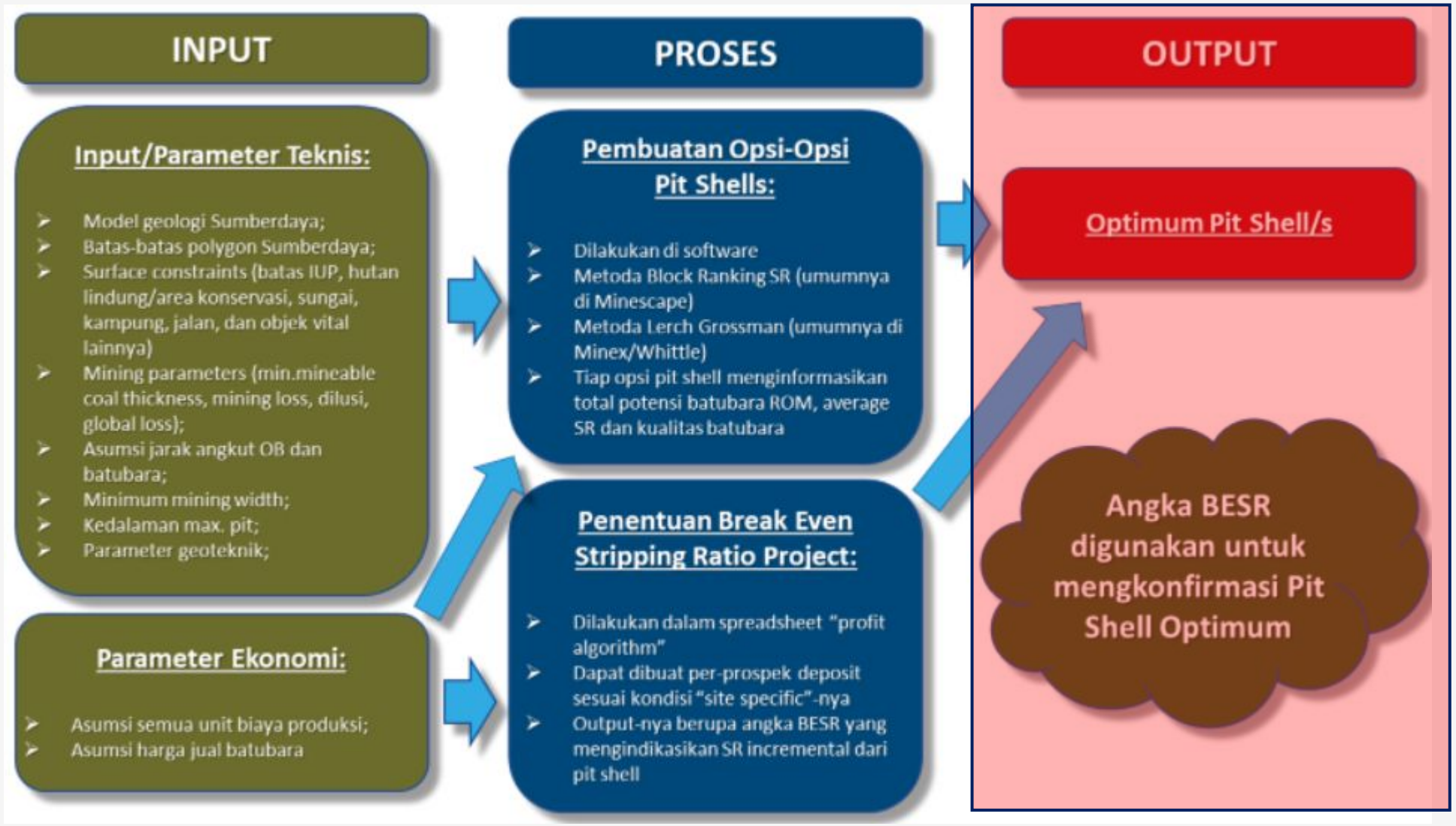
To be compared with Lerch Grossman Optimzer

6.18	Adjustment pengurangan harga karena basis
1.98	penjualan di barge (bukan di vessel)

Metode Optimasi – BESR & Block Ranking (Block Ranking)



Metode Optimasi – General Optimzation flow



Panduan Praktis Komoditas Batubara, KCMI 2017

Metode Optimasi – Komparasi BESR dan Optimizer

Contoh Unit Biaya Produksi - Kontraktor	Satuan	Nilai (setelah PPN)
Biaya Langsung (Direct Cost)		
Biaya Pemindahan OB		
Pemindahan OB (maks. 1km) - termasuk clearing, topsoil, D&B	$/bcm	2.31
Kelebihan jarak angkut (overhaulage distance)	$/bcm-km	0.50
Biaya Batubara		
Penambangan batubara (coal ge◆ng termasuk pengangkutan ke ROM SP)	$/t	1
Pengolahan, pemrosesan dan penanganan batubara (crushing/processing) di ROM SP	$/t	1
Dewatering	$/t	0
Pengangkutan batubara (coal hauling) ke Port	$/t-km	0
Fee penggunaan jalan angkut	$/t	6
Pemuatan ke tongkang	$/t	1
Pengangkutan batubara dengan tongkang	$/t-km	0
Pemuatan ke vessel	$/t	1
Surveyor Independent (di stockpile & barge)	$/t	0
Biaya Tidak Langsung (Indirect Costs)		
Administrasi dan overhead	$/t	1
Comdev / CSR	$/t	0
Rehabilitasi Lingkungan	$/t	0
Komisi marke◆ng	$/t	0
Royal◆ Pemerintah	%	7

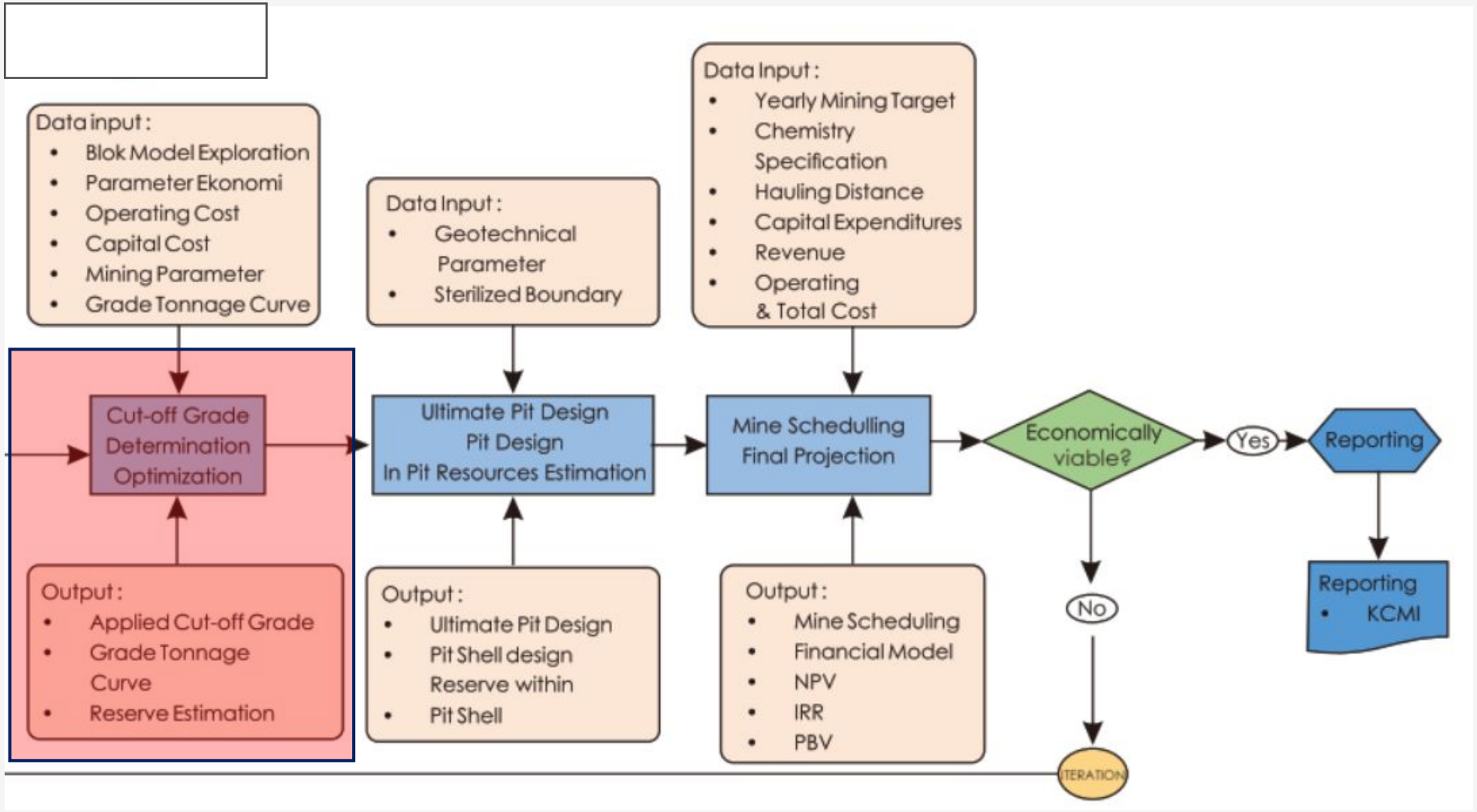
	PT ABC	
	Kuan◆tas	Ongkos Produksi/t
BESR (bcm/t)	**11.58**	
Kelebihan Jarak Angkut (km)	0.00	
Pemindahan OB ($/bcm)		2.31
Pemindahan OB ($/t)		26.76

OPSI PIT	OB (kbcm)	Coal (kt)	Avg. SR (bcm/t)	Inc.SR (bcm/t)	Weighted Average Pit Quality							US$'000				Total Cost (US$'000)	Revenue (US$'000)	Profit Margin (US$'000)
					CV (kcal/kg adb)	CV (kcal/kg ar)	Ash (%-adb)	IM (%-adb)	TM (%-ar)	TS (%-adb)	IRD	OB Cost	Coal Cost	Indirect Costs	Capital Costs			
PIT-1	13,874	6,837	2.03		6658	6328	6.14	13.77	18.04	0.43	1.35	32,049	143,636	41,489	80,500	297,673	424,240	126,567
PIT-2	24,599	9,250	2.66	4.44	6665	6336	6.05	13.76	18.03	0.43	1.35	56,824	194,343	56,135	80,500	387,802	574,749	186,947
PIT-3	30,637	10,494	2.92	4.86	6681	6355	5.92	13.70	17.90	0.43	1.35	70,772	220,471	63,682	80,500	435,426	654,036	218,610
PIT-4	34,627	11,616	2.98	3.56	6692	6359	5.84	13.60	17.90	0.43	1.35	79,988	244,049	70,493	80,500	475,030	724,425	249,396
PIT-5	48,252	13,862	3.48	6.07	6710	6375	5.64	13.58	17.89	0.43	1.35	111,462	291,241	84,124	80,500	567,327	866,704	299,376
PIT-6	60,070	15,663	3.84	6.56	6725	6389	5.57	13.47	17.79	0.43	1.35	138,761	329,078	95,053	80,500	643,391	981,411	338,020
PIT-7	86,883	19,101	4.55	7.80	6740	6398	5.51	13.30	17.70	0.43	1.35	200,699	401,302	115,914	80,500	798,415	1,198,526	400,111
PIT-8	109,959	21,410	5.14	9.99	6742	6396	5.44	13.32	17.77	0.41	1.35	254,006	449,827	129,931	80,500	914,264	1,342,962	428,698
PIT-9	131,925	23,382	5.64	11.14	6750	6386	5.15	13.23	17.90	0.41	1.35	304,747	491,252	141,896	80,500	1,018,395	1,464,415	446,019
PIT-10	141,965	24,062	5.90	14.78	6755	6366	5.34	12.78	17.80	0.40	1.35	327,939	505,539	146,023	80,500	1,060,001	1,502,292	442,291
PIT-11	164,718	24,882	6.62	27.75	6760	6392	5.15	13.23	17.95	0.41	1.35	380,498	522,767	150,999	80,500	1,134,765	1,559,718	424,954
PIT-12	186,305	25,662	7.26	27.68	6762	6381	5.34	12.78	17.70	0.40	1.35	430,364	539,155	155,733	80,500	1,205,752	1,605,799	400,047

Pit shell yang direkomendasikan dipilih

Incremental SR yang perlu dibandingkan dengan BESR

Metode Optimasi – General Optimzation flow



Panduan Praktis Komoditas Nickel, KCMI 2017

Metode Optimasi – Cut Off Grade Determination

Parameter Optimasi

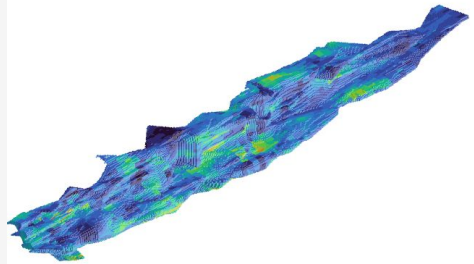
Cut off Grade Determination

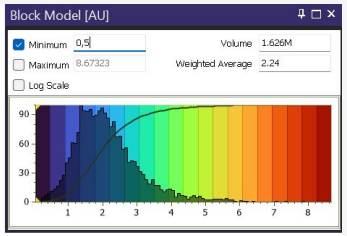
Revenue Adjustment Factor (RAF)

Pit Shell(s)

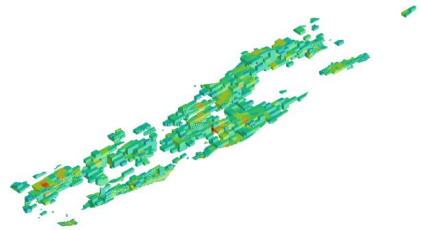
Optimum Pit Shell/s

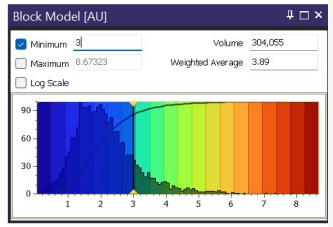
CoG 0.5



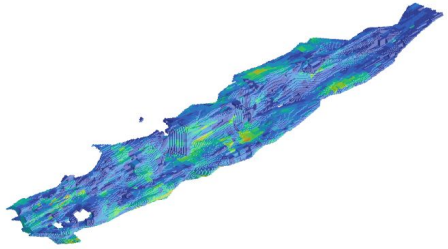


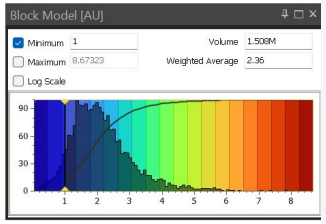
CoG 3



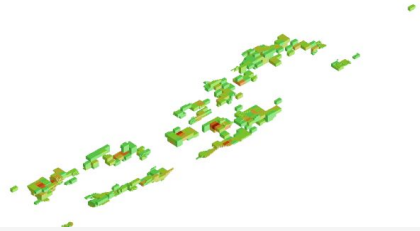


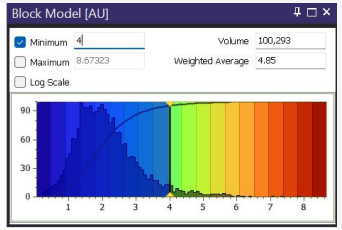
CoG 1



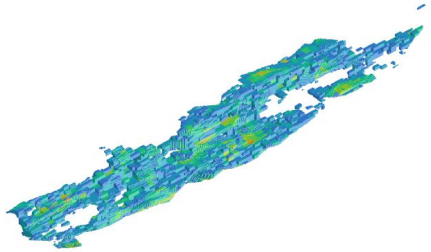


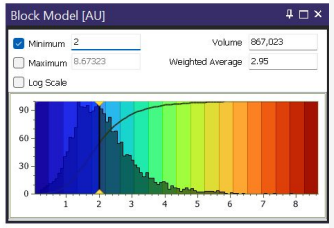
CoG 4





CoG 2





Panduan Praktis Komoditas Nickel, KCMI 2017

Metode Optimasi – Cut Off Grade Determination

Parameter Optimasi

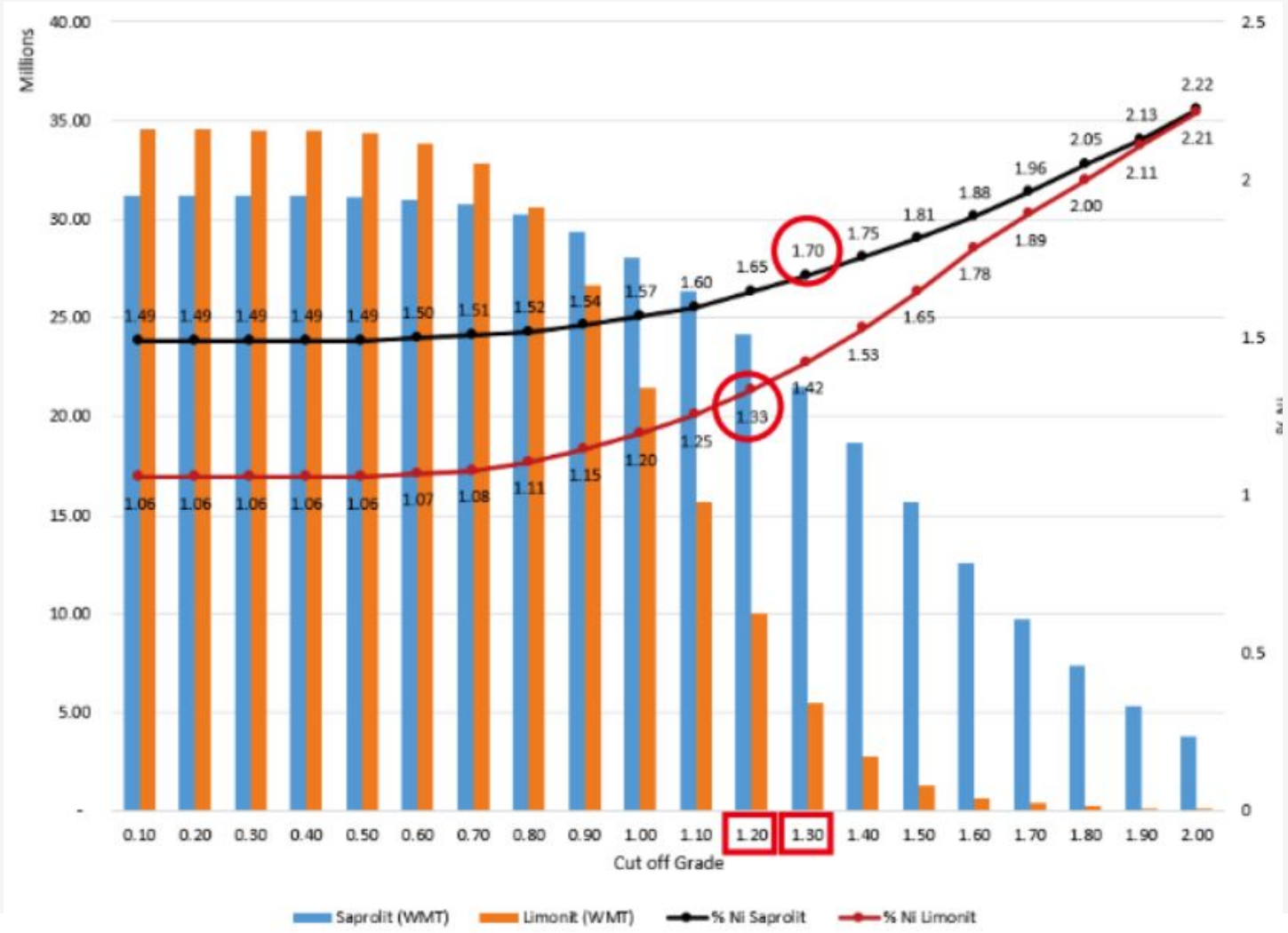
Cut off Grade Determination

Revenue Adjustment Factor (RAF)

Pit Shell(s)

Optimum Pit Shell/s

Nickel grade to target market



Panduan Praktis Komoditas Nickel, KCMI 2017

Metode Optimasi – Cut Off Grade Determination

Parameter Optimasi

Cut off Grade Determination

Revenue Adjustment Factor (RAF)

Pit Shell(s)

Optimum Pit Shell/s

BECOG determination

Project Years	TOTAL	Unit Cost (USD/Ton)	Remark
Material			
Overburden	12,731,358		BCM
Total Ore	4,798,704		Ton
Royalty, Dead Rent, Land and Building Tax			
Royalty	16,434,396	3.42	
Dead Rent	74,283	0.02	
Land and building tax	2,641,320	0.55	
Cost of Good Sold			
Saprolit Mining Cost (Ore Getting, Load, Haul, Dump)	47,987,037	10.00	
Grade Control	3,359,093	0.70	
Surveys and Production Drilling	2,508,033	0.52	
Land Use and Crop Compensation	2,508,033	0.52	
Environmental Safety	4,012,853	0.84	
Health, safety, and work and Work Equipments	2,491,313	0.52	
Salary and employee benefit	4,848,864	1.01	
Reclamation and Rehabilitation	4,012,853	0.84	
Repair and Maintenance	2,508,033	0.52	
Other Costs (Production Related)	2,976,200	0.62	
Seeling and General Administration			
Selling Expenses	3,287,838	0.69	
General Administration, Salaries, Overhead	8,187,978	1.71	
Subtotal - Operational Cost	**107,838,128**	**22.47**	
Interest & Depreciation			
Interest Expenses	183,805	0.04	
Depreciation & Amortisation	1,148,780	0.24	
Subtotal - Other Cost	**1,332,585**	**0.28**	
Grand Total Cost	**109,170,713**	**22.75**	

Ni grade check for equal price

Break even

Total prod. cost

KETERANGAN

Total biaya yang diperlukan untuk penambangan 1 ton bijih adalah **US$22,75.**

Panduan Praktis Komoditas Nikel, KCMI 2017

Metode Optimasi – Cut Off Grade Determination

Parameter Optimasi

Cut off Grade Determination

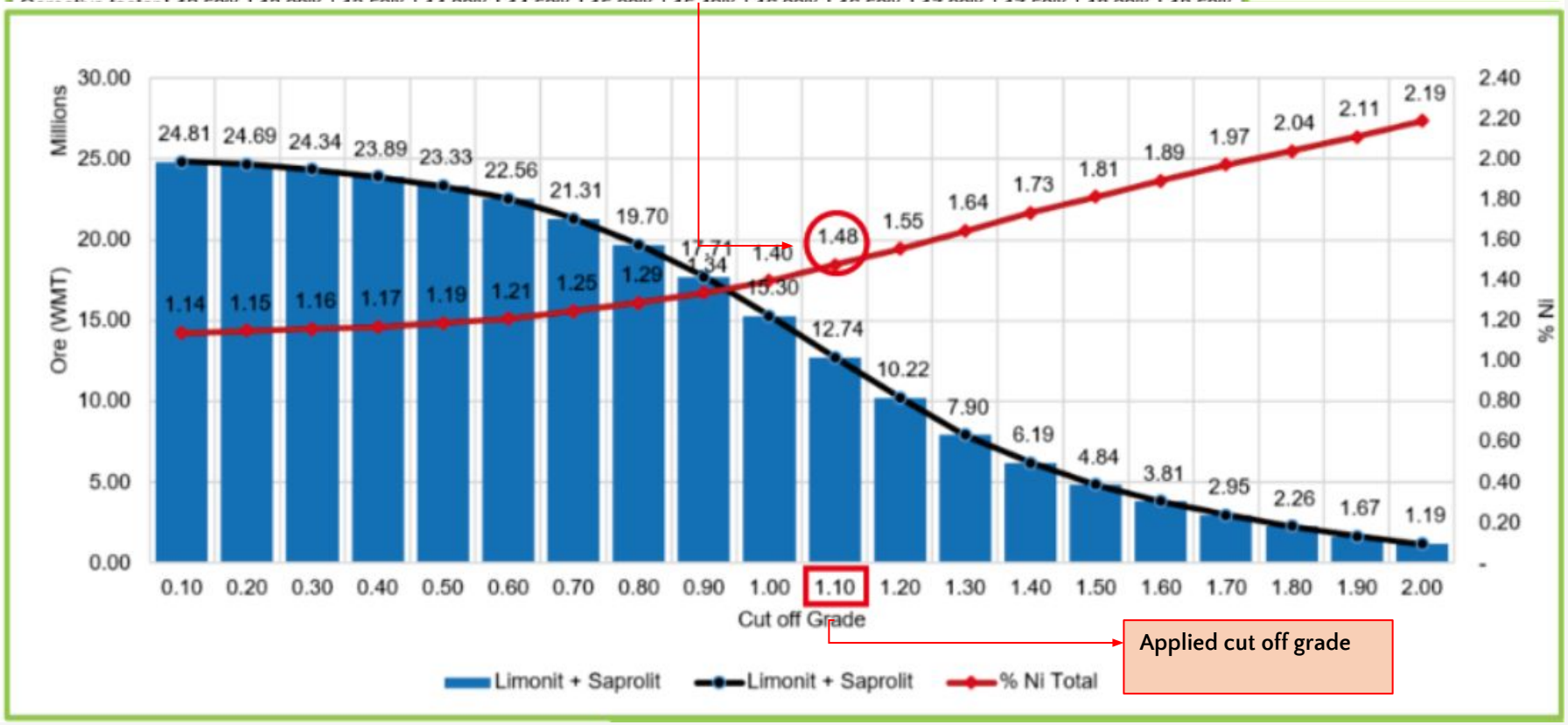
Revenue Adjustment Factor (RAF)

Pit Shell(s)

Optimum Pit Shell/s

COG determination

Ni Grade	1.15%	1.20%	1.25%	1.30%	1.35%	1.40%	1.45%	1.50%	1.55%	1.60%	1.65%	1.70%	1.75%



Panduan Praktis Komoditas Nikel, KCMI 2017

Metode Optimasi – Pit Shell Determination

Parameter Optimasi

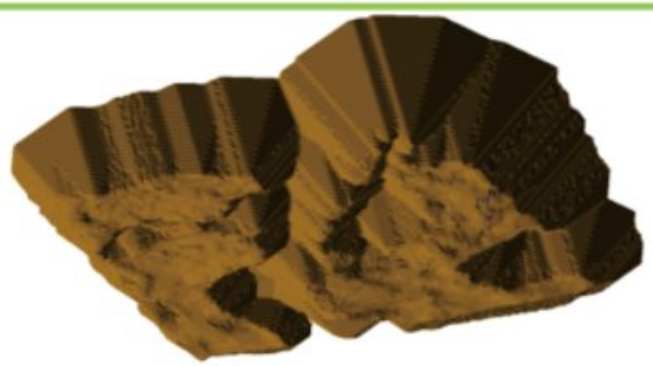
Cut off Grade Determination

Revenue Adjustment Factor (RAF)

Pit Shell(s)

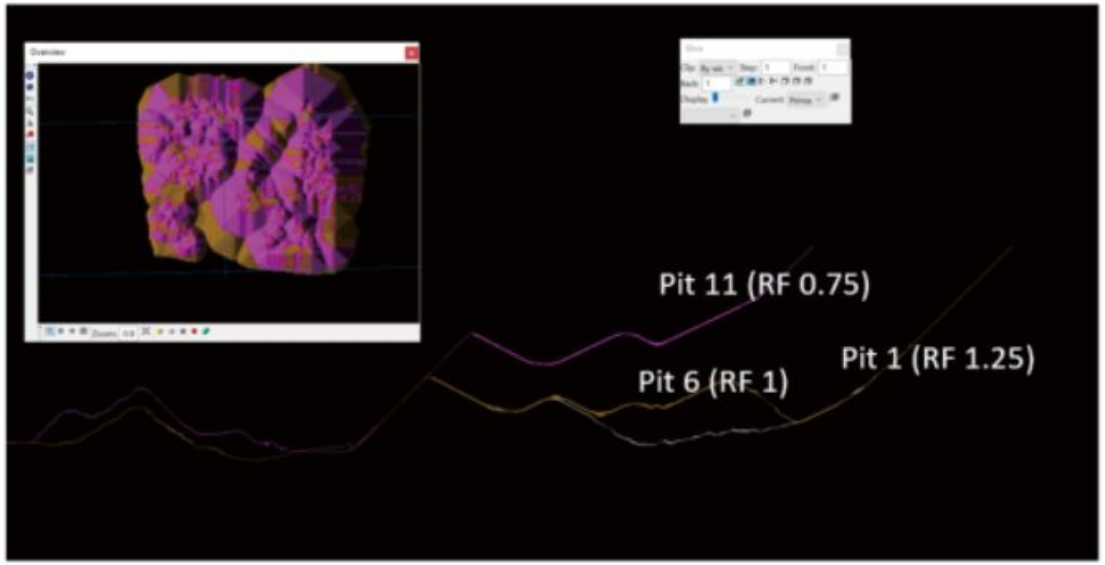
Optimum Pit Shell/s

Pit Shell determination



```
ultant pit intersects the maximum extent of the block model

 1: Factor Index =  11    Value =      0.75000
 2: Factor Index =  10    Value =      0.80000
 3: Factor Index =   9    Value =      0.85000
 4: Factor Index =   8    Value =      0.90000
 5: Factor Index =   7    Value =      0.95000
 6: Factor Index =   6    Value =      1.00000
 7: Factor Index =   5    Value =      1.05000
 8: Factor Index =   4    Value =      1.10000
 9: Factor Index =   3    Value =      1.15000
10: Factor Index =   2    Value =      1.20000
11: Factor Index =   1    Value =      1.25000
ime.....: 0:02:57
```




```
File  Edit  Format  View  Help
Total time.....: 0:02:38

Pit: 9 Trial number: 1 Revenue factor index: 9
 - Number of blocks for the optimiser.....: 258632
 -     565   Ore blocks   (+),
 -    1977   Waste blocks (-),
 -  256090   Air blocks   (0).
Initialization time.....: 0:00:02
 - Economic value from the optimum pit.....: US$ 2921874.36
 - Number of blocks to be mined.....: 106127 blocks.
 -     362   Ore blocks   (+),
 -     712   Waste blocks (-),
 -  105053   Air blocks   (0).
Computation time.....: 0:00:07
Total time.....: 0:02:47

Pit: 10 Trial number: 1 Revenue factor index: 10
 - Number of blocks for the optimiser.....: 106127
 -     210   Ore blocks   (+),
 -     864   Waste blocks (-),
 -  105053   Air blocks   (0).
Initialization time.....: 0:00:02
 - Economic value from the optimum pit.....: US$ 595337.59
 - Number of blocks to be mined.....: 47329 blocks.
 -     133   Ore blocks   (+),
 -     374   Waste blocks (-),
 -   46822   Air blocks   (0).
Computation time.....: 0:00:03
Total time.....: 0:02:52

Pit: 11 Trial number: 1 Revenue factor index: 11
 - Number of blocks for the optimiser.....: 47329
 -      64   Ore blocks   (+),
 -     443   Waste blocks (-),
 -   46822   Air blocks   (0).
Initialization time.....: 0:00:02
 - Economic value from the optimum pit.....: US$ 1430.94
 - Number of blocks to be mined.....: 27794 blocks.
 -       1   Ore blocks   (+),
 -       1   Waste blocks (-),
 -   27792   Air blocks   (0).
Computation time.....: 0:00:02
Total time.....: 0:02:56
```

Panduan Praktis Komoditas Batubara, KCMI 2017

Ada Pertanyaan?

UNIVERSITAS TRISAKTI

Mine Plan

Genap 23/24

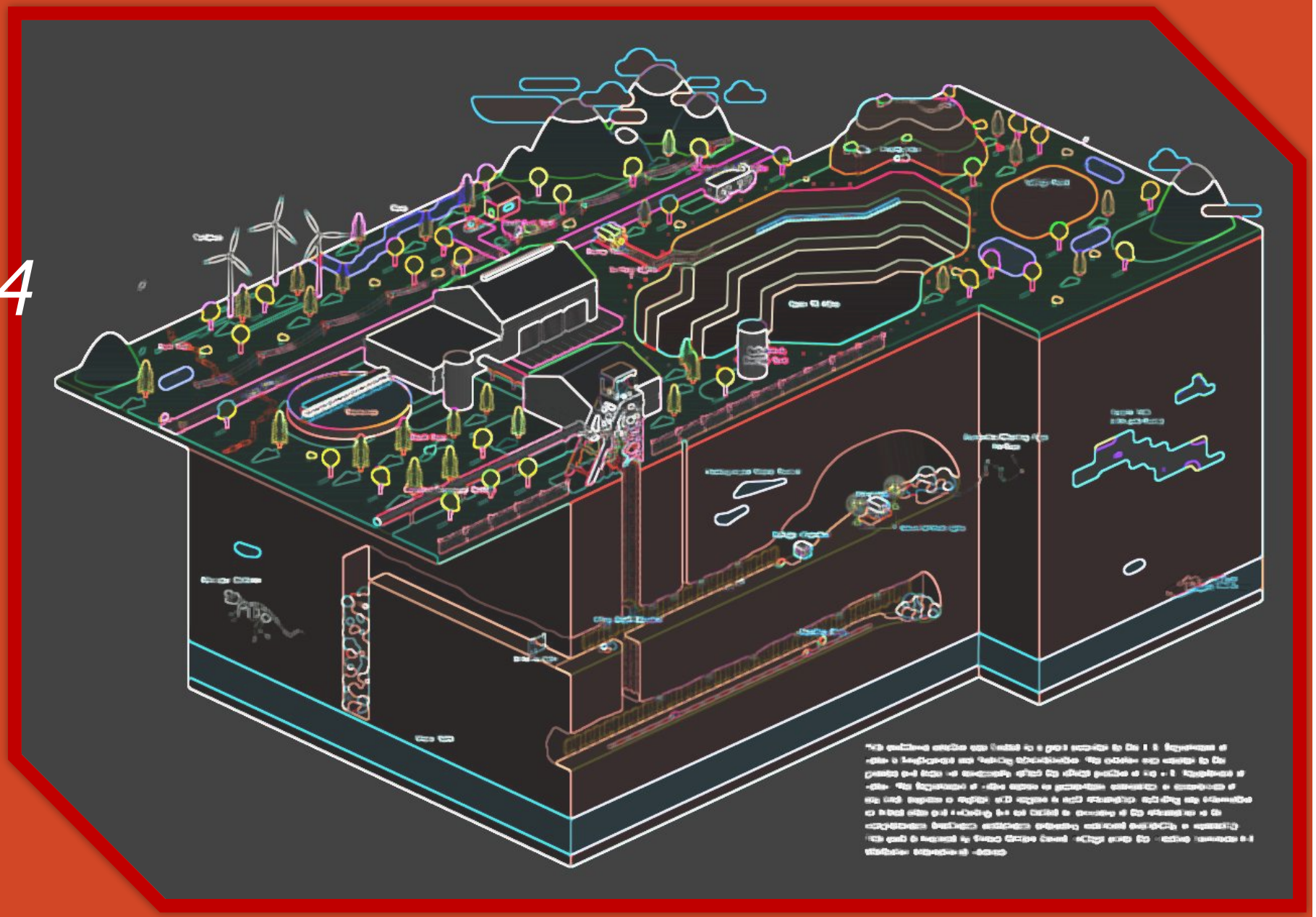
5th Session

Mine Design

Speaker

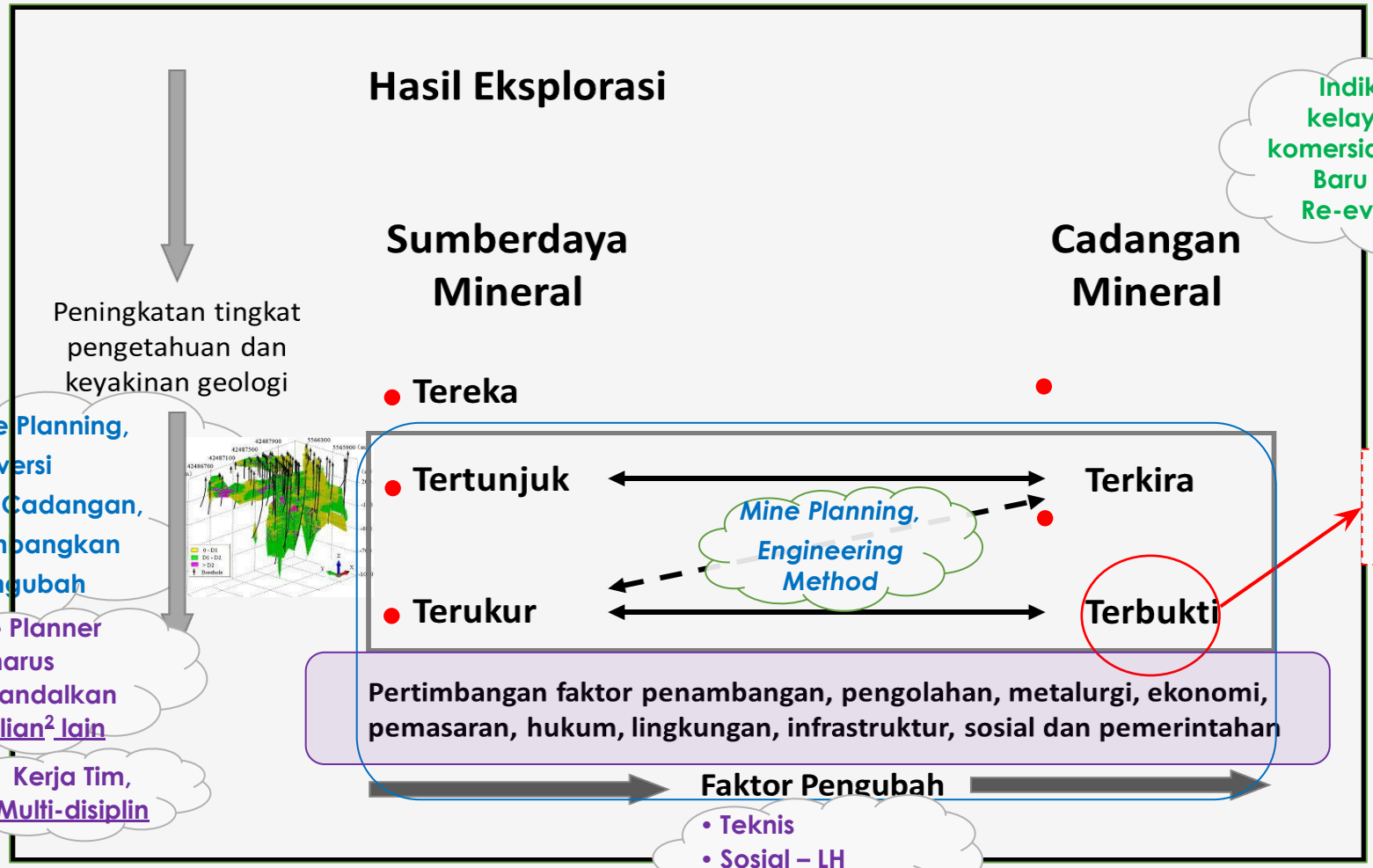
Ir. Andre Alis, ST, MBA, IPM

Danu Putra, ST, MT, IPP



Kerangka Kerja Universal Pelaporan HE– S/d– C/d

- sebagai refleksi penerapan konsep keekonomian tambang -

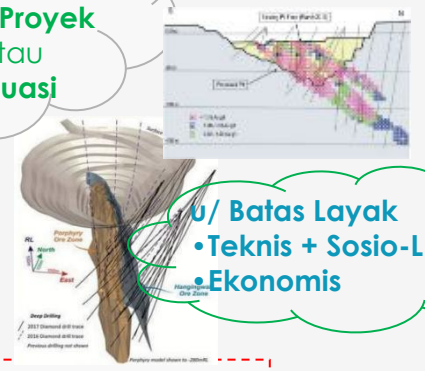


Metodologi Mine Planning, mengkonversi Sumberdaya → Cadangan, dgn mempertimbangkan 10 faktor pengubah

Mine Planner harus mengandalkan keahlian[2] lain

Kerja Tim, Multi-disiplin

Indikator kelayakan komersial Proyek Baru atau Re-evaluasi

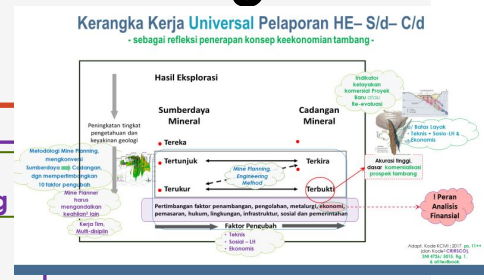


U/ Batas Layak
•Teknis + Sosio-LH &
•Ekonomis

Akurasi tinggi, dasar komersialisasi prospek tambang

Adapt. Kode KCMI : 2017, ps. 11++
(dan Kode[2] CRIRSCO),
SNI 4726/ 5015, fig. 1,
& all textbook

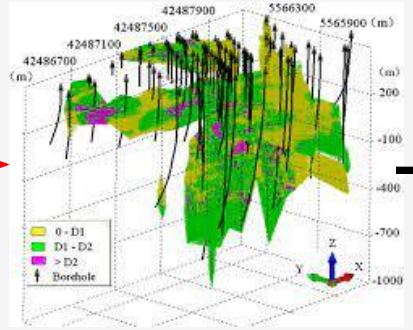
(Framework-A) Mine Planning = Mining + Financial Engineering



Analisis strategi eksploitasi, BESR, dll.

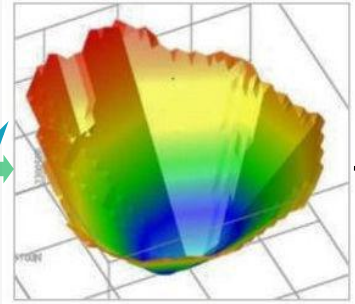
Tujuan mine planning: Meng-estimasi cadangan

Mining Engineering



Go

NO-Go



Shell Hasil Optimisasi

Go

NO-Go

TEST-2

Cadangan = **tonase** & **kualitas**, bagian sumberdaya yg *economically mineable*

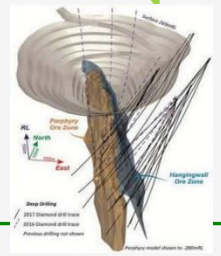
Financial Engineering

NO-Go

NO-Go

NO-Go

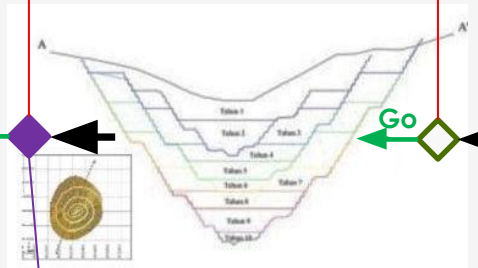
Go Komersial



$ NPV DCFROR PB

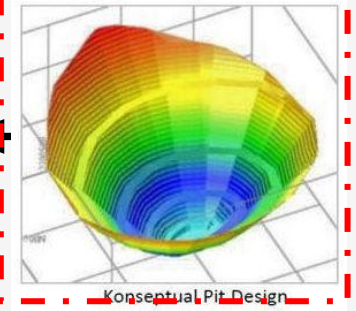
Evaluasi Keekonomian

Go



LOM Production Scheduling

Go



Konseptual Pit Design

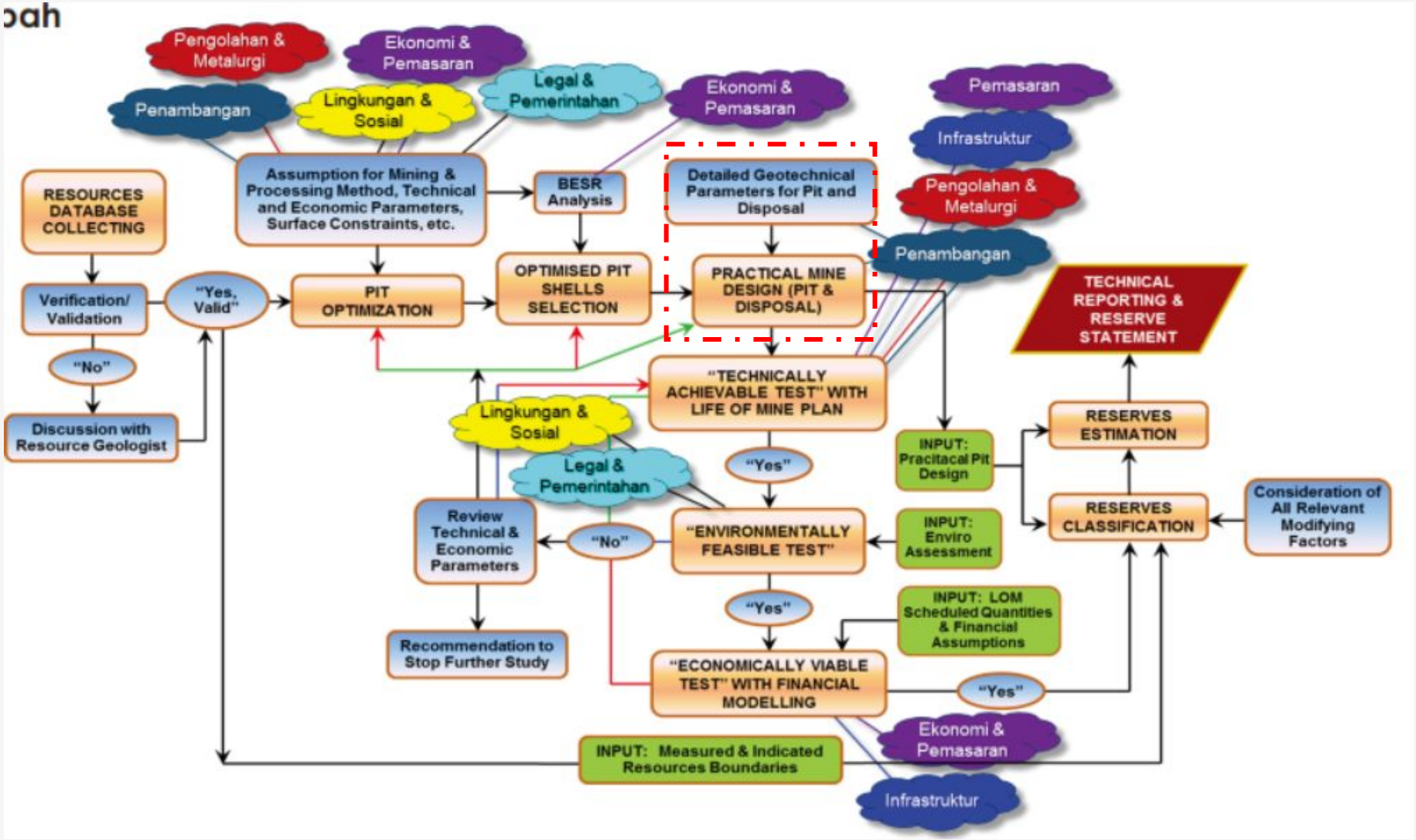
- Test-1 : layak teknis & Sosial-LH
- Test-2 : layak ekonomis

Peran Analisis Finansial

TEST-1

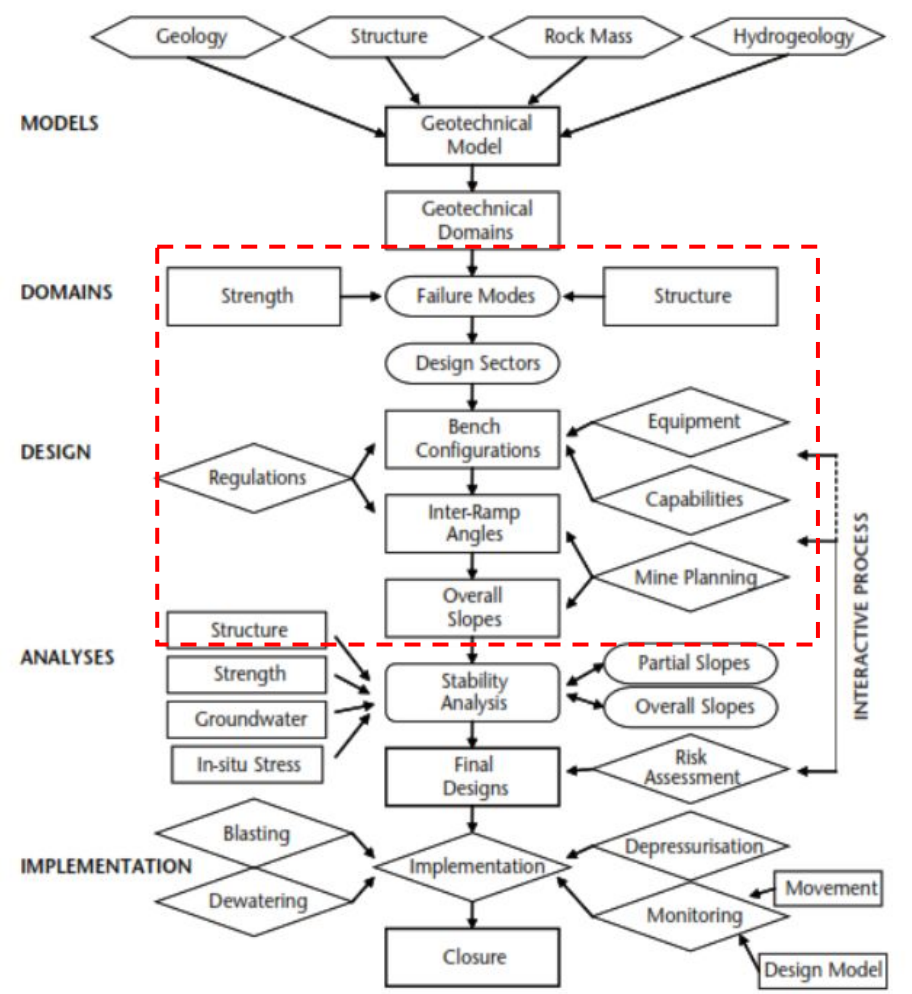
Adjust. fr. Lufi Rachmad, 2017

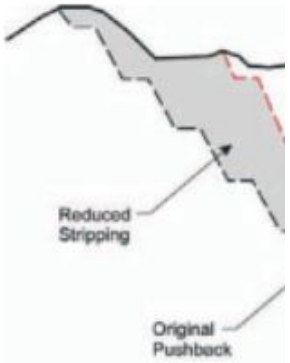
(*Framework-A*) ***Mine Planning*** = *Mining + Financial Engineering*

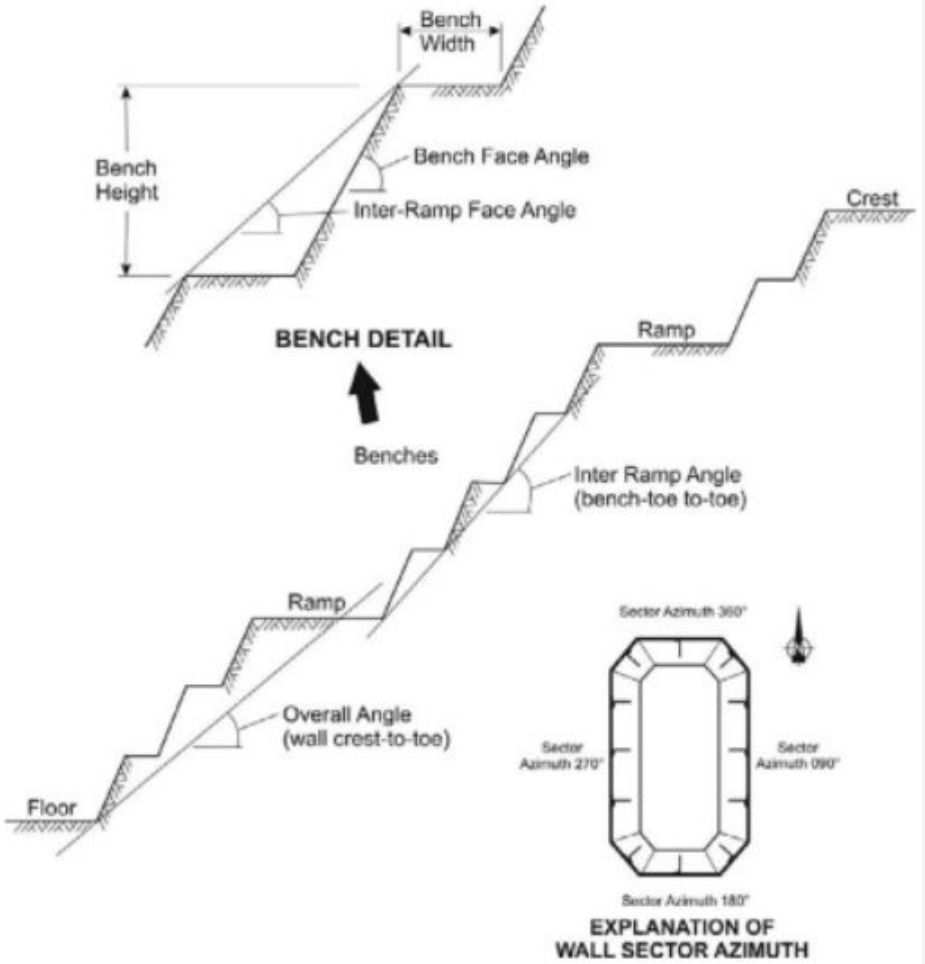


Panduan Praktis Komoditas Batubara, KCMI 2017

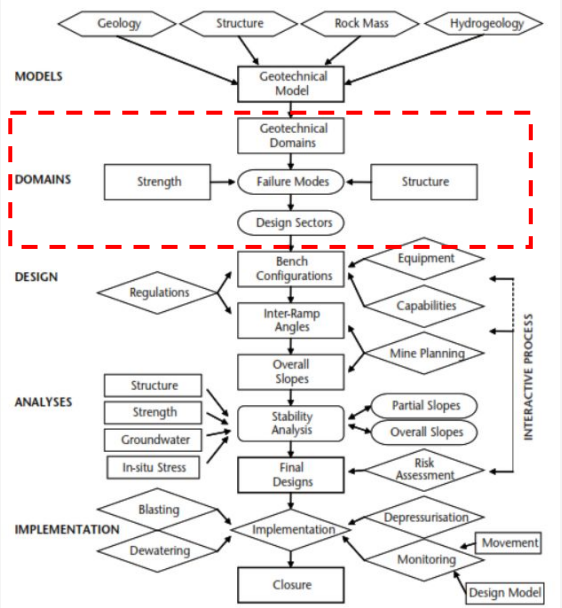
Desain Lereng Tambang

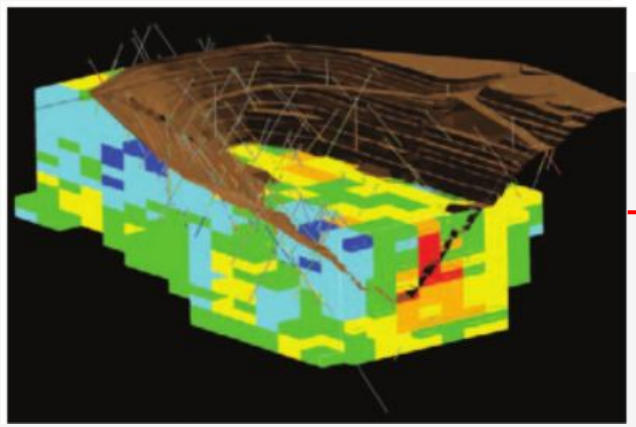


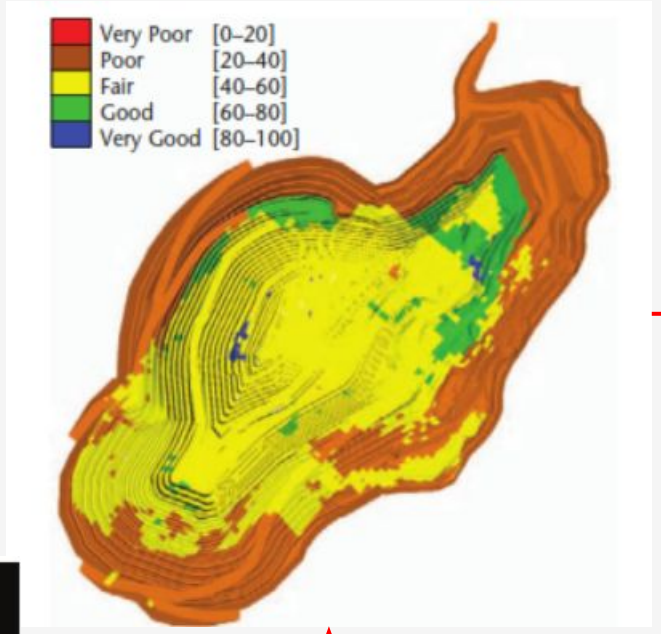




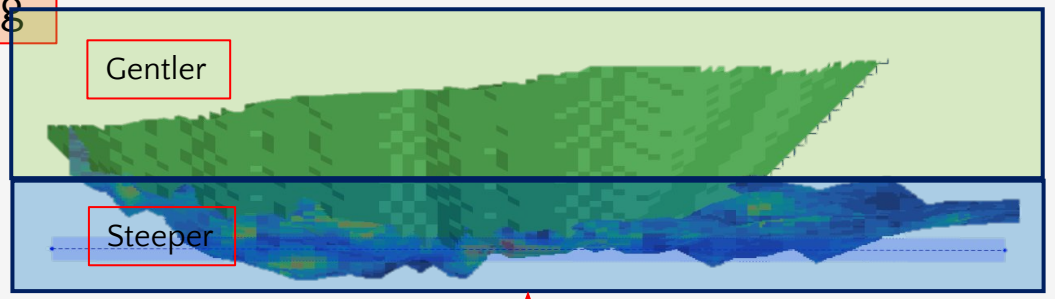
Desain Lereng Tambang - *Parameter Geoteknik*

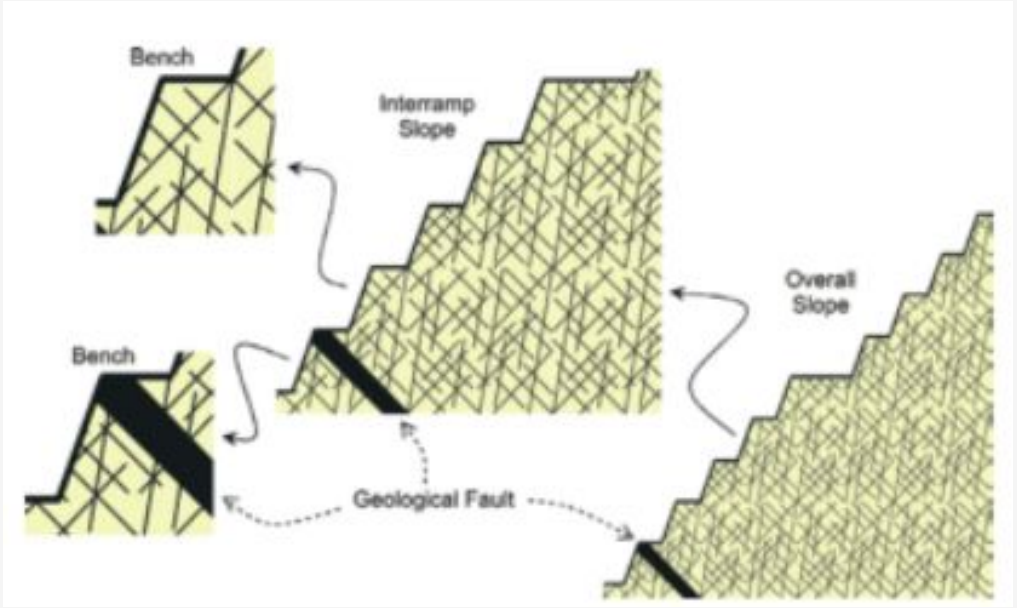






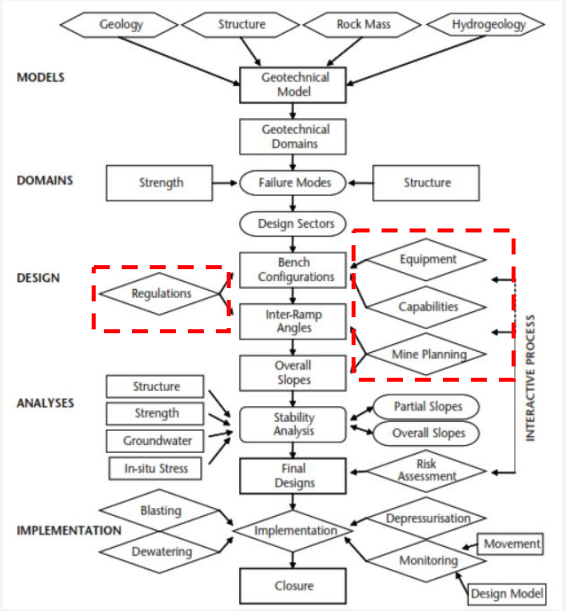
Domaining

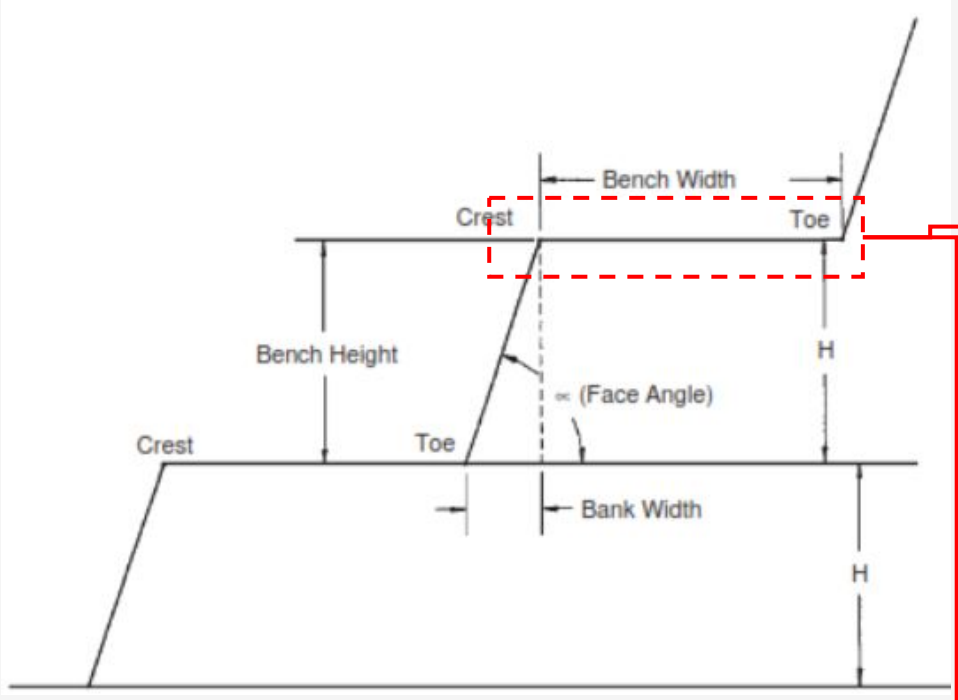


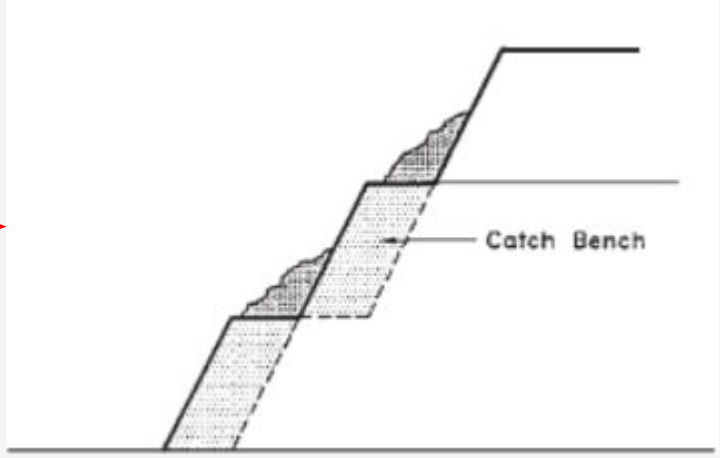


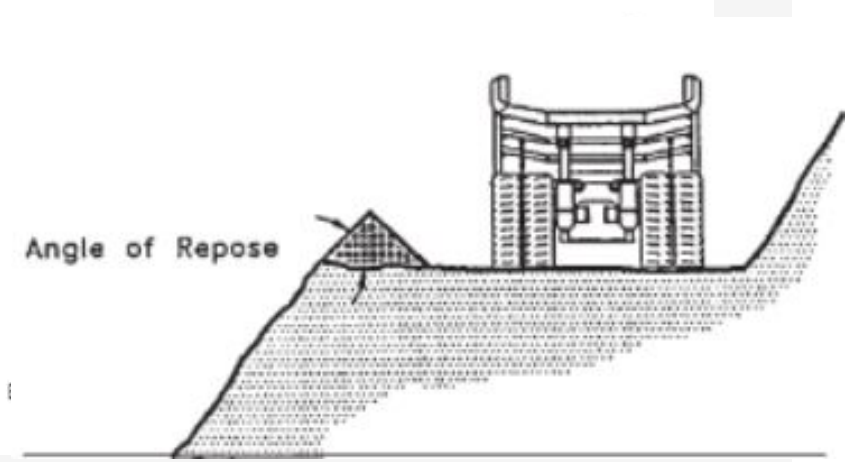
J. Read, P. Stacery; 2010

Desain Lereng Tambang - Parameter Operasional



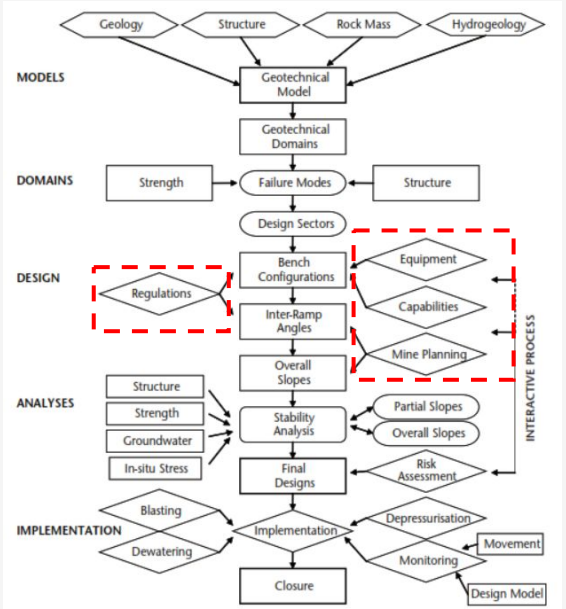


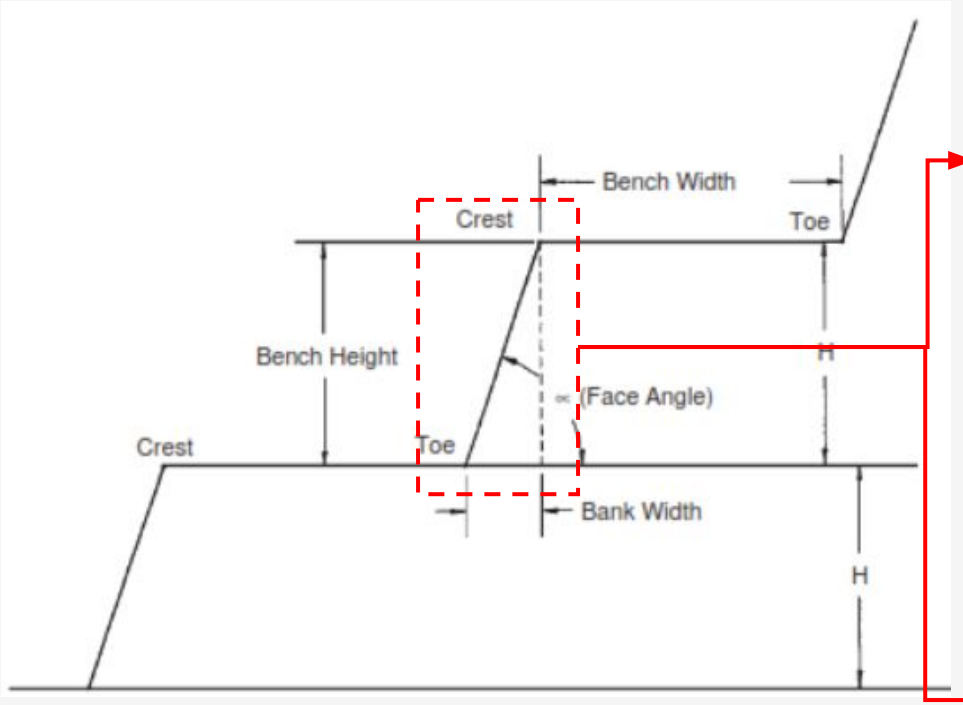


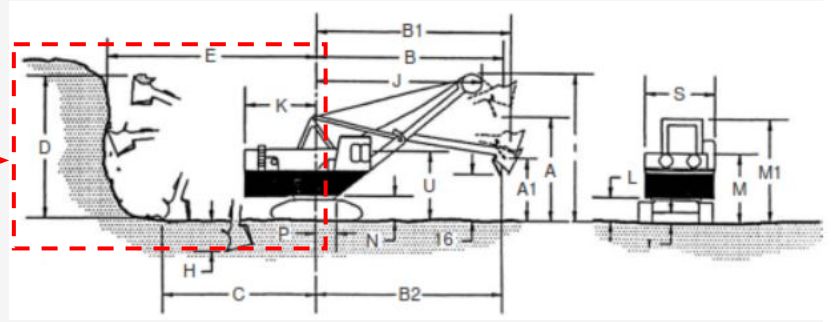


J. Read, P. Stacery; 2010

Desain Lereng Tambang - Parameter Operasional





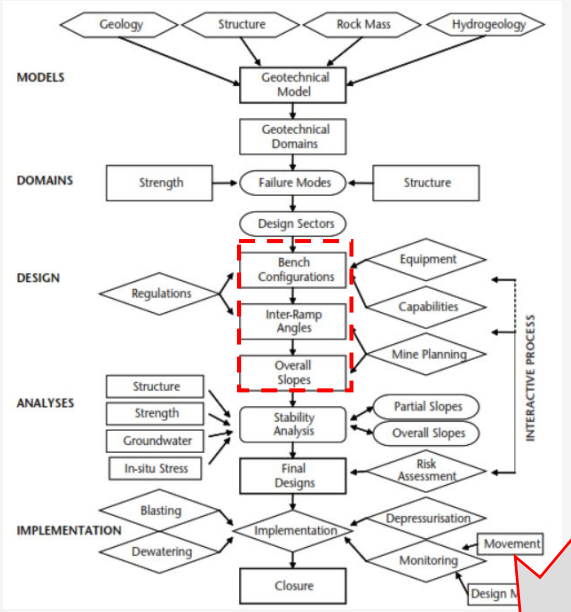


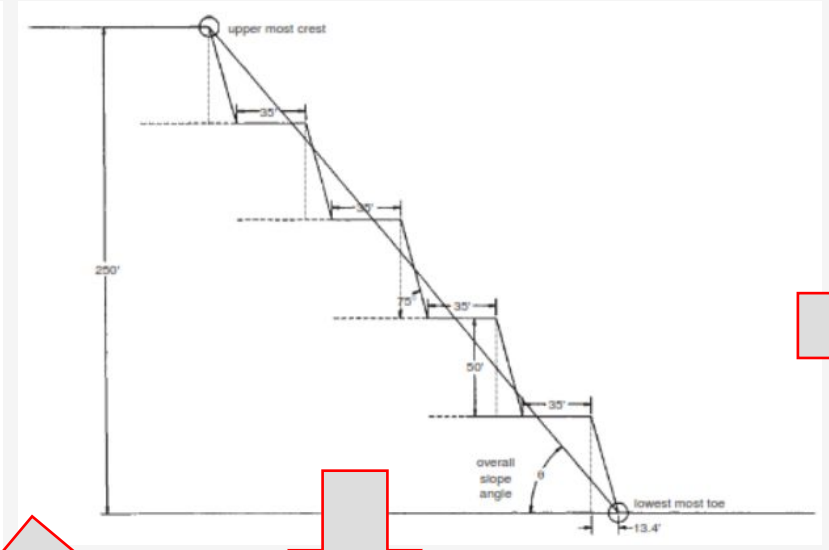
Shovel Working Range

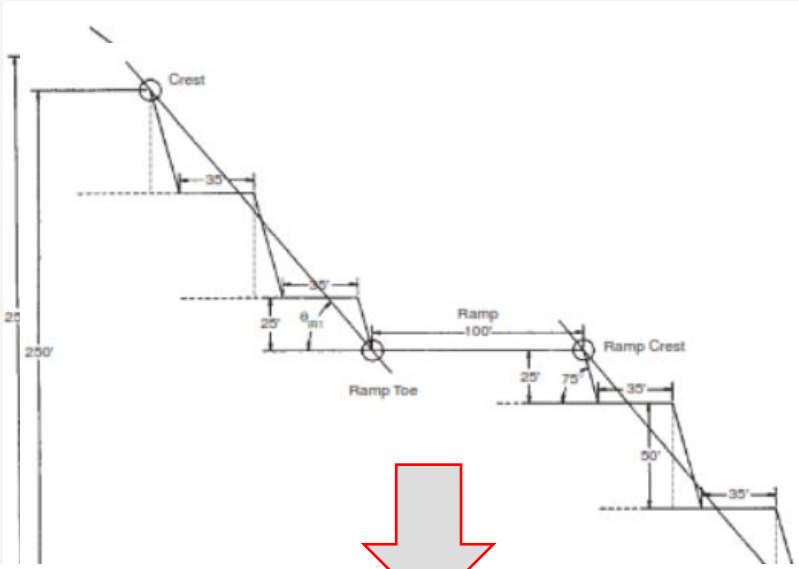
	Dipper Capacity (Nominal) cu.yds	9	
	Dipper Capacities (Range) cu.yds	6 ½–6	
	Length of Boom	41'–6"	
	Effective length of dipper handle	25'–6"	
	Overall length of dipper handle	30'–9"	
	These dimensions will vary slightly depending upon dipper selection.		
	Angle of boom	45°	
A	Dumping height – maximum	28'–0"	A
A1	Dumping height at maximum radius – B1	20'–6"	A1
B	Dumping radius at maximum height – A	45'–6"	B
B1	Dumping radius – maximum	47'–6"	B1
B2	Dumping radius at 16'0" dumping height	47–0"	B2
D	Cutting height – maximum	43'–6"	D
E	Cutting radius – maximum	54'–6"	E
G	Radius of level floor	35'–3"	G
H	Digging depth below ground level – maximum	8'-6"	H
I	Clearance height – boom point sheaves	42'–3"	I
J	Clearance radius – boom point sheaves	40'–0"	J
K	Clearance radius – revolving frame	19'–9"	K
L	Clearance Under frame – to ground	6'–2"	L
M	Clearance height top of house	18'–10"	M
M1	Height of A-frame	31'–2"	M1
N	Height of boom foot above ground level	9'–11"	N
P	Distance – boom foot to center of rotation	7'–9"	P
S	Overall width of machinery house & operating cab	22'–6"	S
T	Clearance under lowest point in truck frame	14"	T
U	Operator's eye level	18'–0"	U

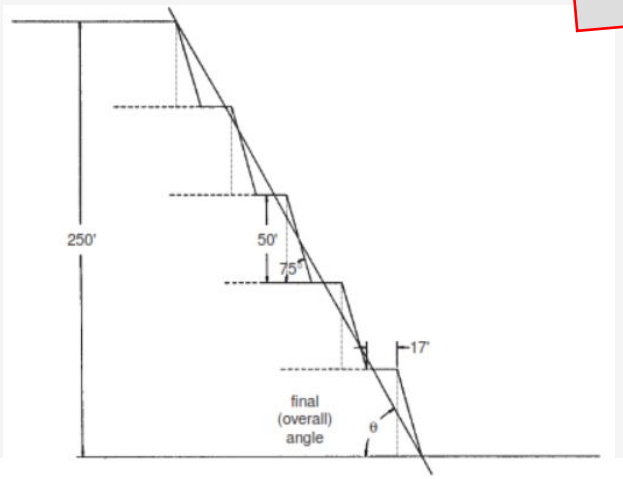
Hustrulid; 2015

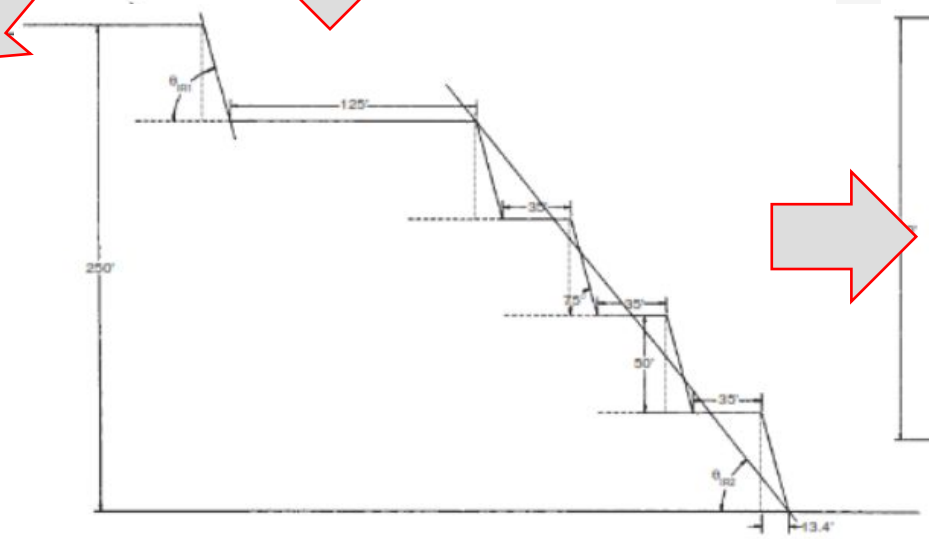
Desain Lereng Tambang – Konfigurasi lereng tambang

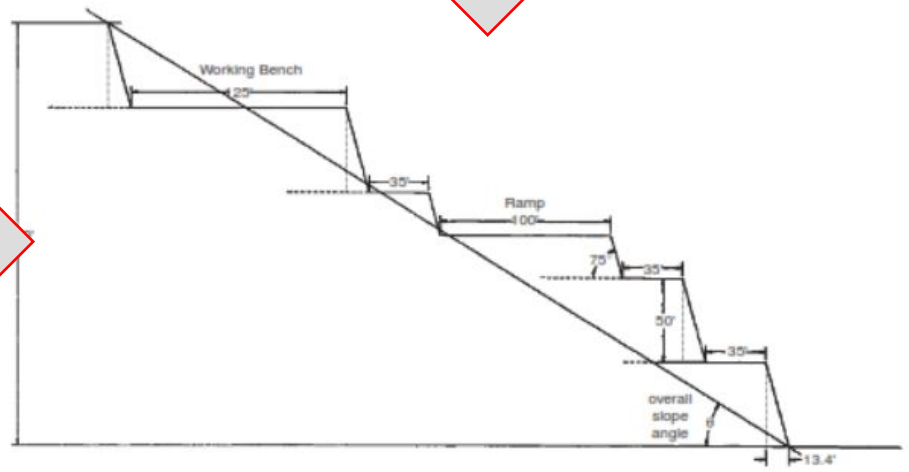






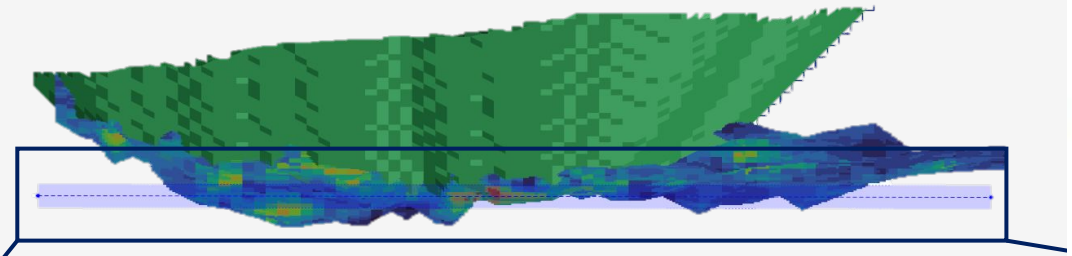




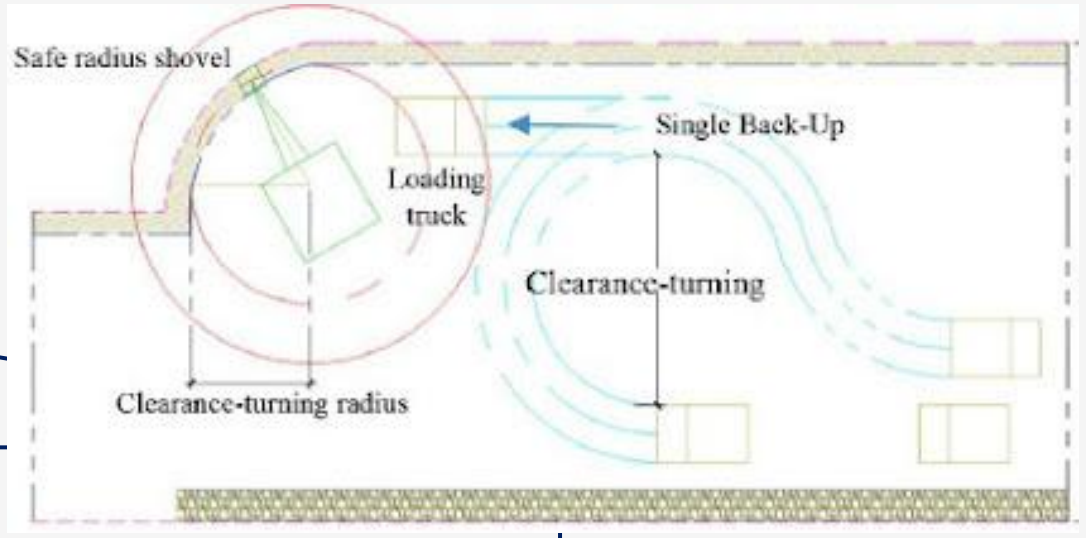


Hustrulid; 2015

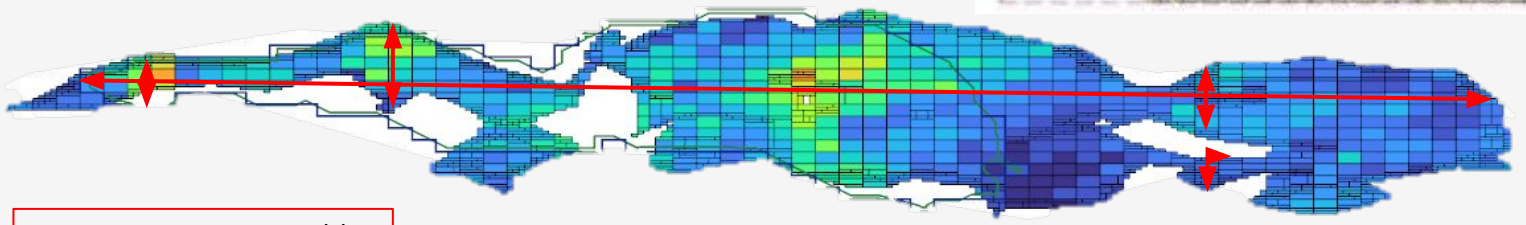
Luas Area Kerja



Working area



Minimum Mining Width

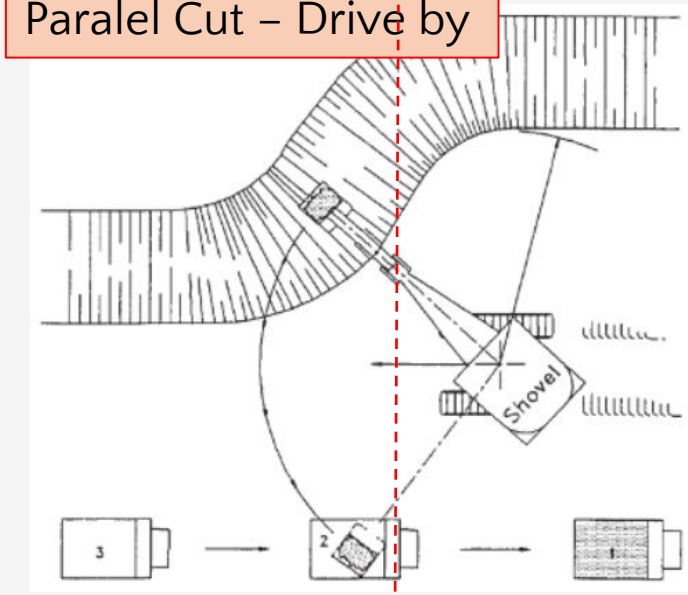


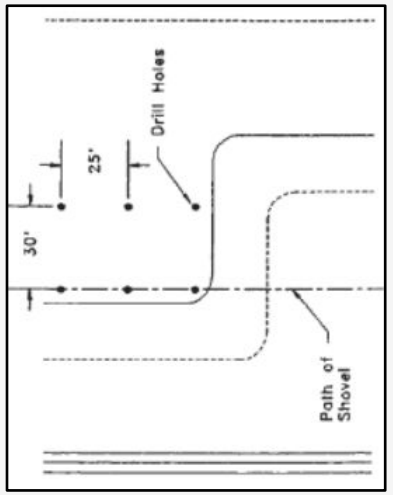
Minimum Mining Width

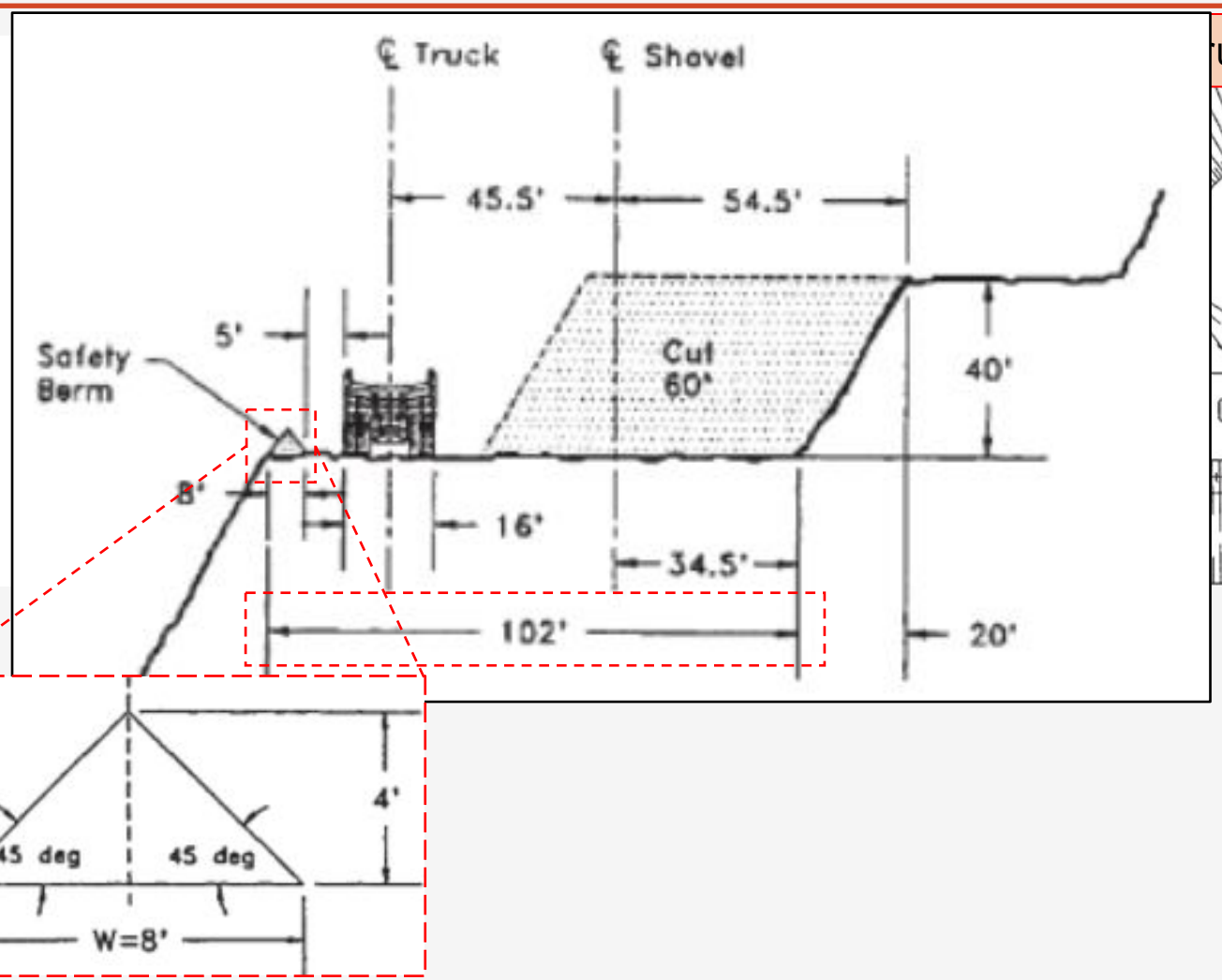
Two bottom pit potential

Luas Area Kerja – Tipe *Mine Front*

Paralel Cut – Drive by







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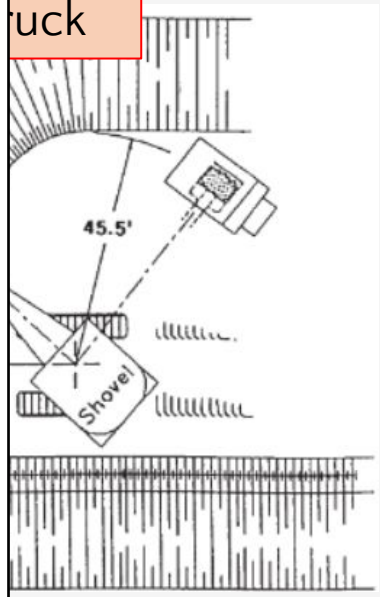
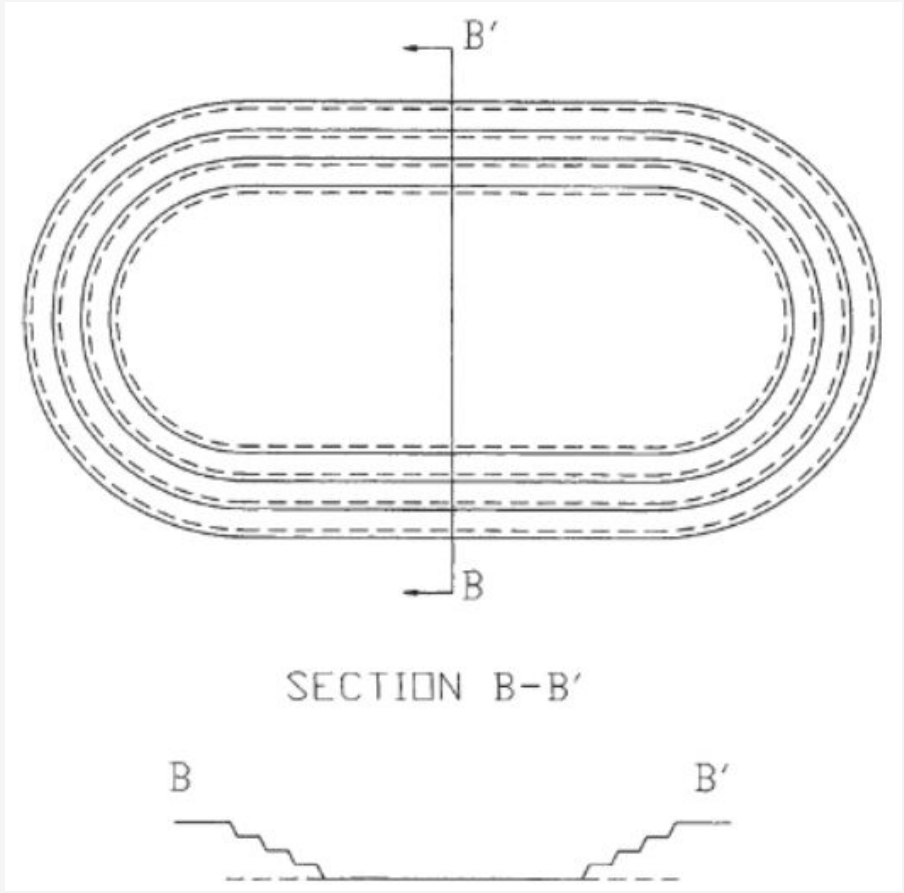
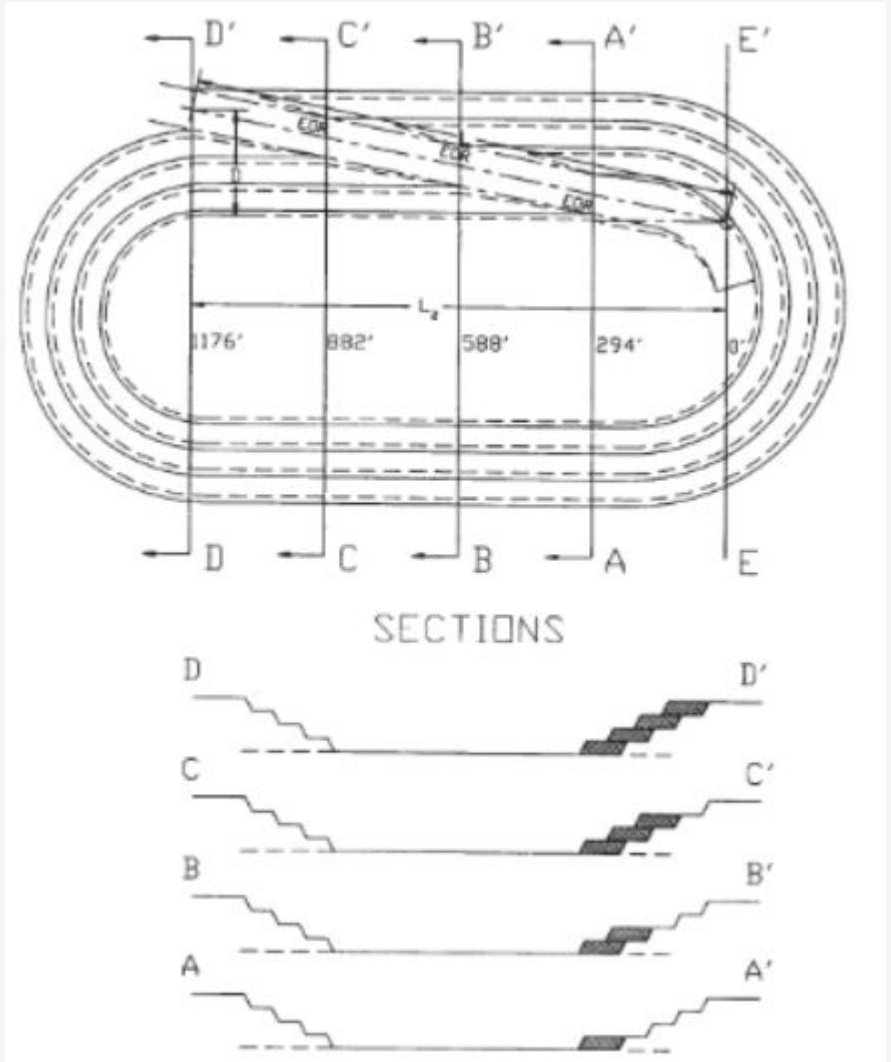


Desain Jalan Tambang – Proses Desain *Inpit Road*

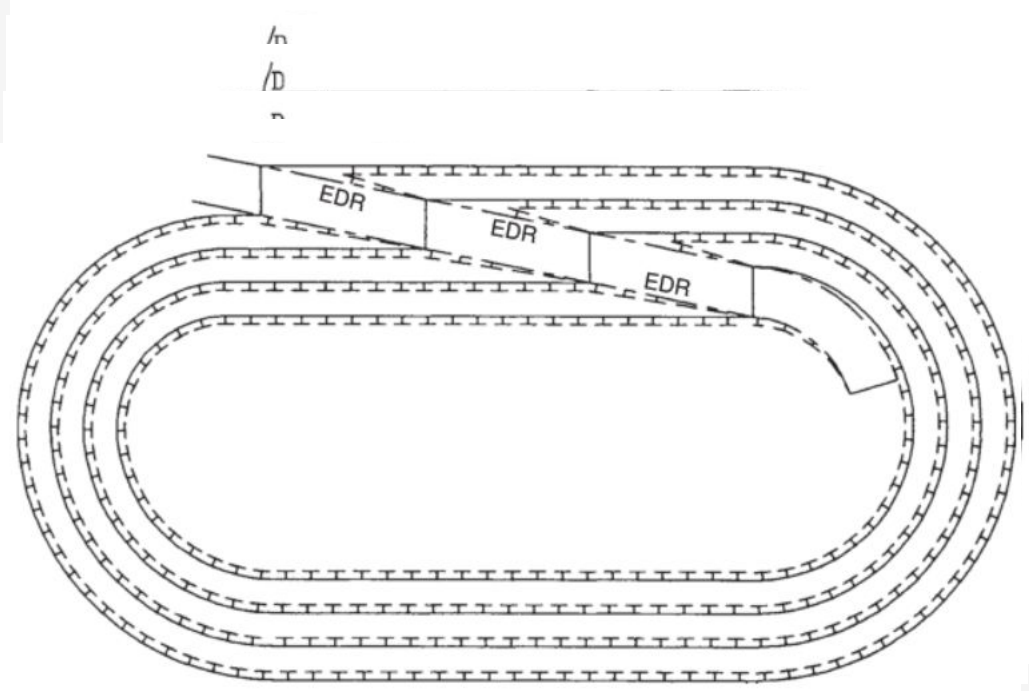




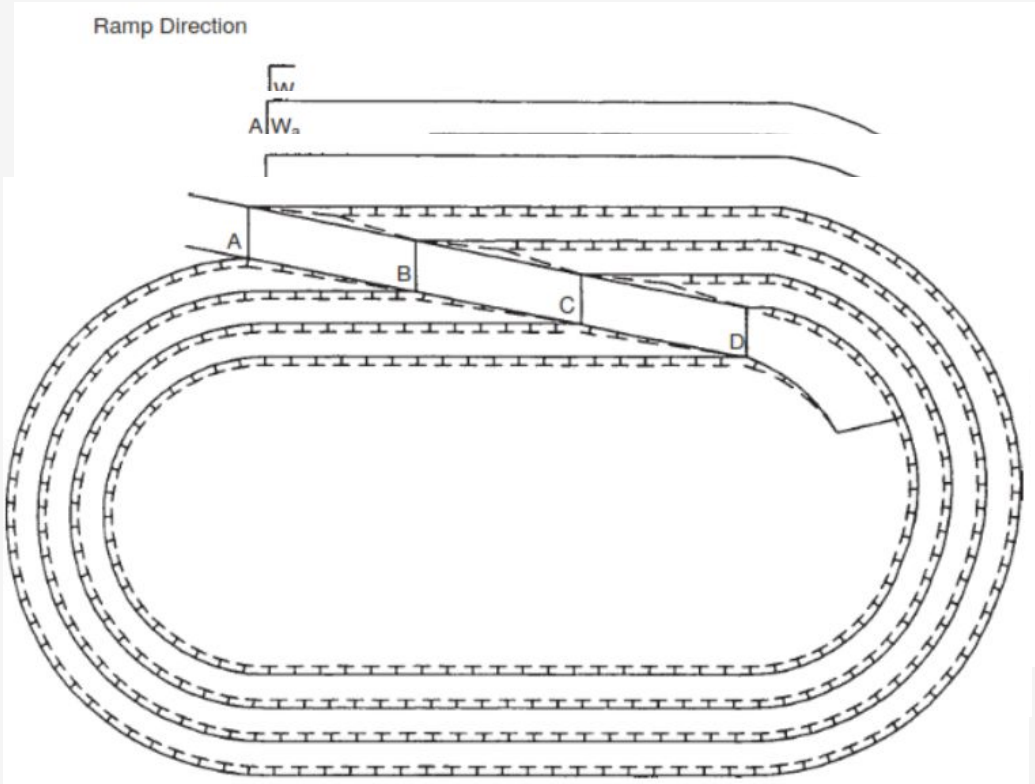
Hustrulid; 2015

Desain Jalan Tambang – Proses Desain *Inpit Road*

Inside Wall

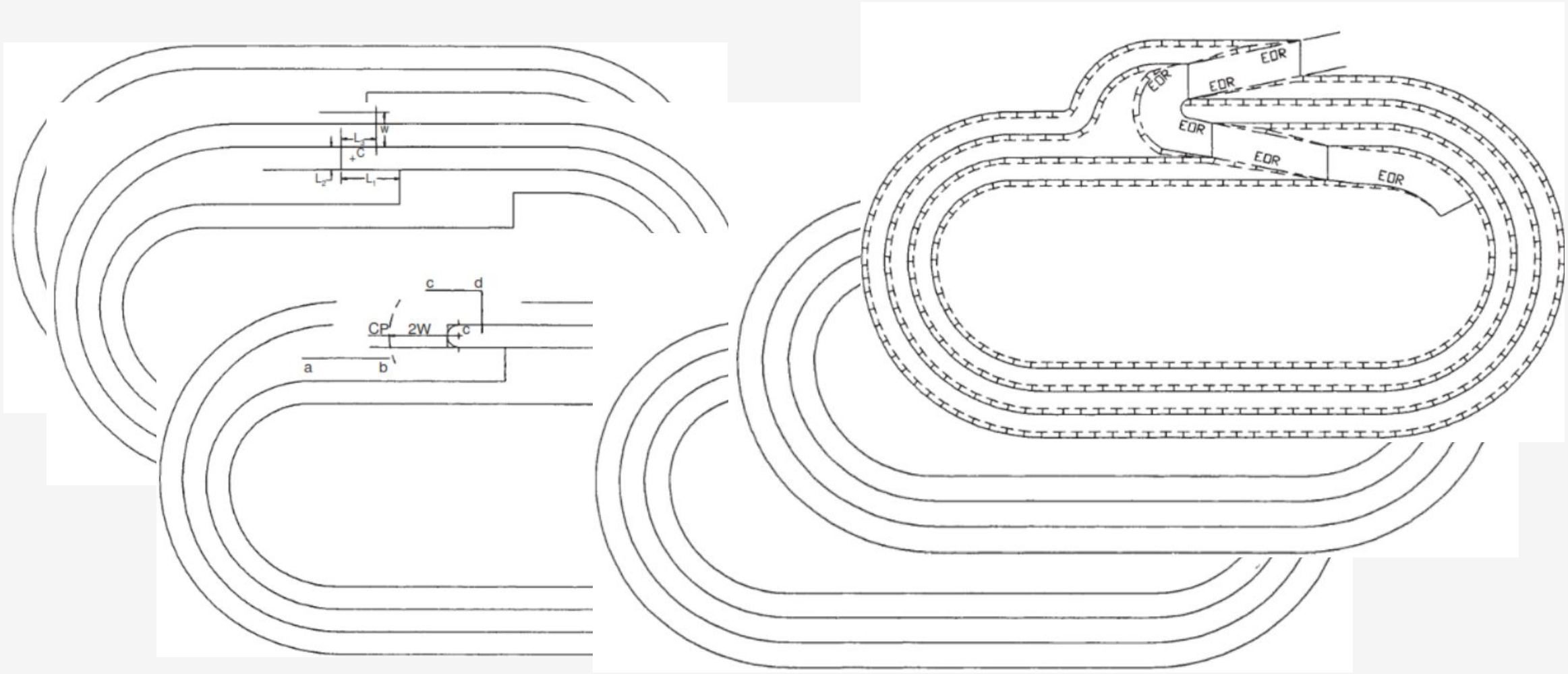


Outside Wall



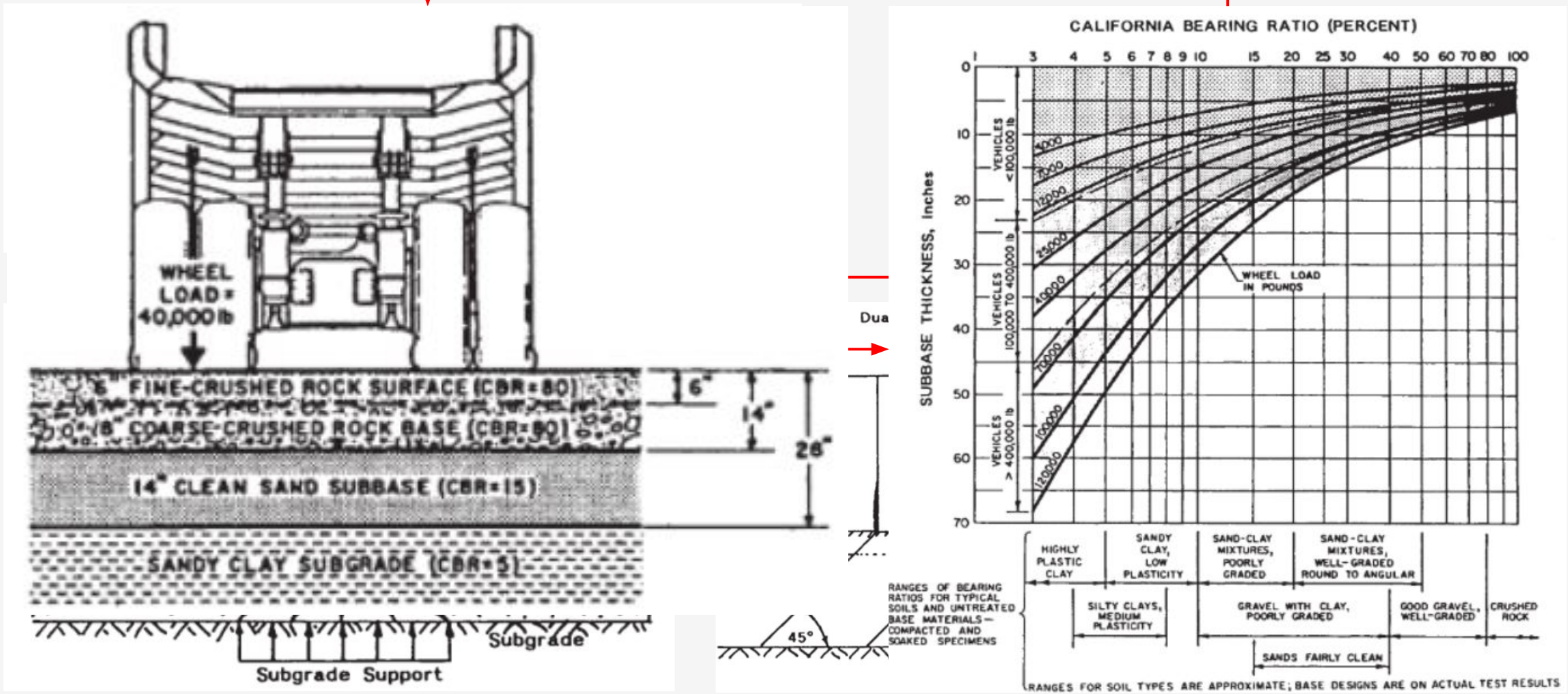
Hustrulid; 2015

Desain Jalan Tambang – Proses Desain *Switchback*



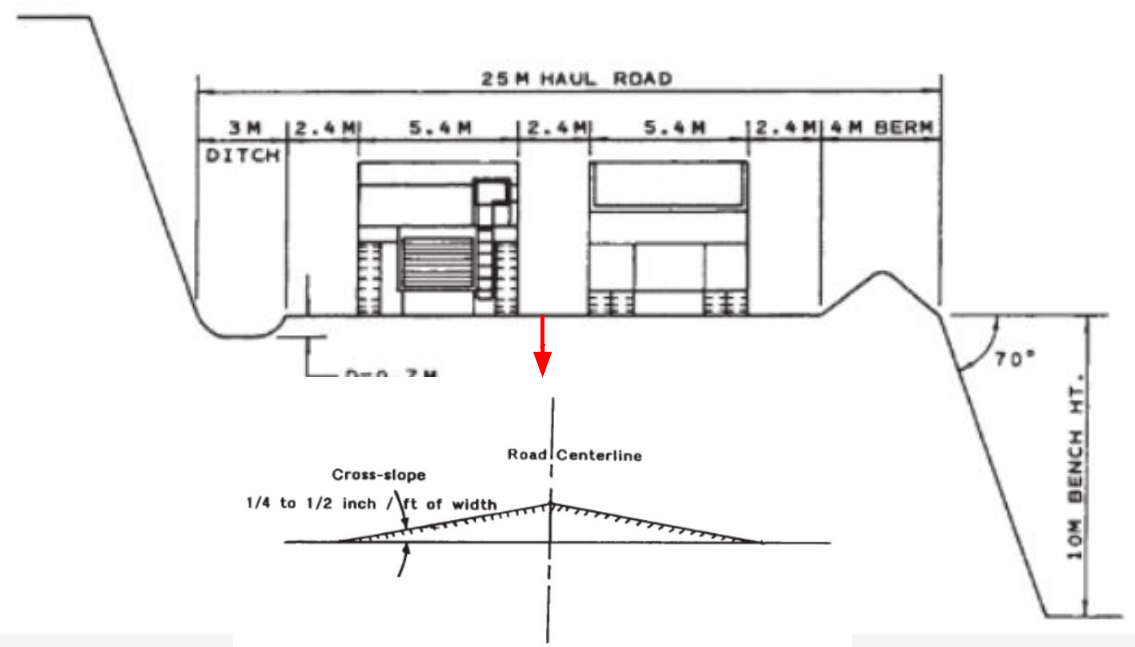
Hustrulid; 2015

Desain Jalan Tambang – Material Penyusun Jalan



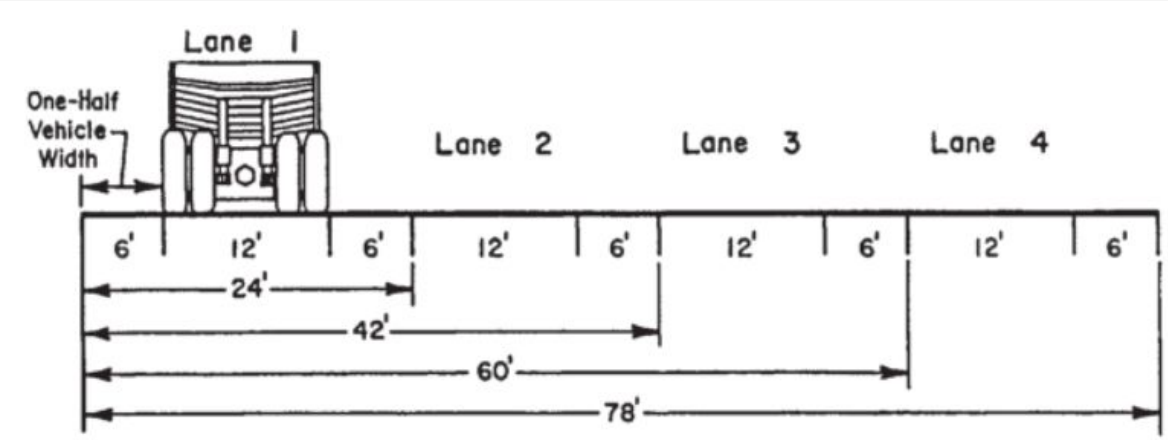
Hustrulid; 2015

Desain Jalan Tambang – Geometri Jalan Lurus



Tanpa Berm

Vehicle width (ft)	1 lane	2 lanes	3 lanes
8	16	28.0	40
9	18	31.5	45
10	20	35.0	50
11	22	38.15	55
12	24	42.0	60
13	26	45.5	65
14	28	49.0	70
15	30	52.5	75
16	32	56.0	80
17	34	59.5	85
18	36	63.0	90
19	38	66.5	95
20	40	70.0	100
21	42	73.5	105
22	44	77.0	110
23	46	80.5	115
24	48	84.0	120
25	50	87.5	125
26	52	91.0	130
27	54	94.5	135
28	56	98.0	140

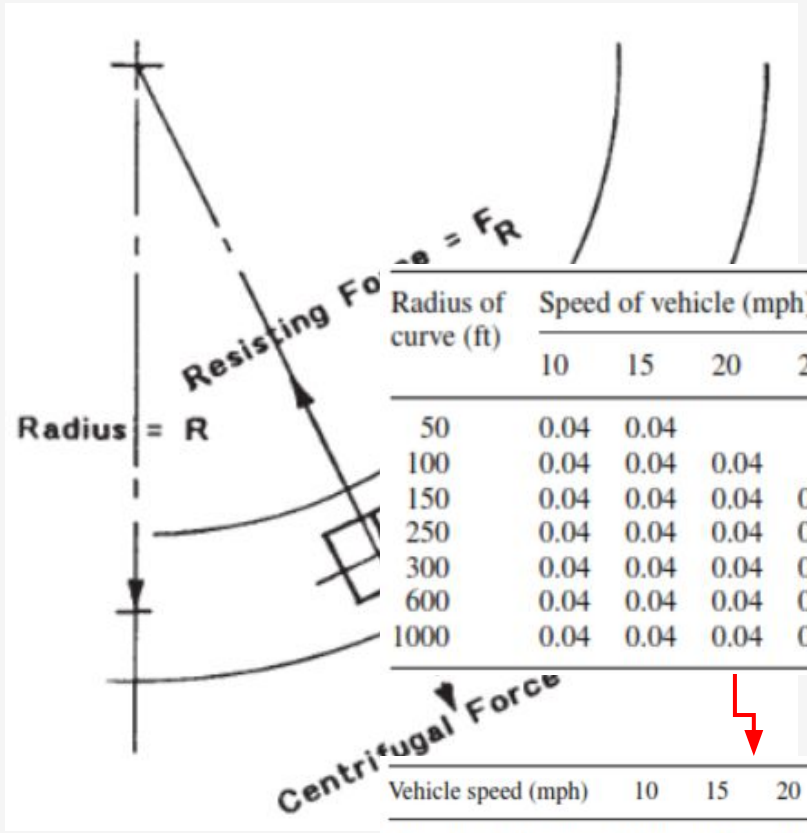


Dengan Berm

Truck size	Approx. width (m)	4 × width (m)	Design width	
			m	ft
35 st	3.7	14.8	15	50
85 st	5.4	21.6	23	75
120 st	5.9	23.6	25	85
170 st	6.4	25.6	30	100

Hustrulid; 2015

Desain Jalan Tambang – Geometri Jalan Berbelok



Vehicle weight classification	Gross vehicle weight (GVW) (lb)	Minimum turning radius (ft)
1	< 100,000	19
2	100–200,000	24
3	200–400,000	31
4	> 400,000	39

Radius of curve (ft)	Speed of vehicle (mph)					
	10	15	20	25	30	35 and over
50	0.04	0.04				
100	0.04	0.04	0.04			
150	0.04	0.04	0.04	0.05		
250	0.04	0.04	0.04	0.04	0.06	
300	0.04	0.04	0.04	0.04	0.05	0.06
600	0.04	0.04	0.04	0.04	0.04	0.05
1000	0.04	0.04	0.04	0.04	0.04	0.04

Vehicle speed (mph)	10	15	20	25	30	35 and above
Cross-slope change in 100-ft length of haulageway (ft/ft)	0.08	0.08	0.08	0.07	0.06	0.05

Non ADT

Table 4.10. Design widths (ft) for curves – single unit vehicles (Kaufman & Ault, 1977).

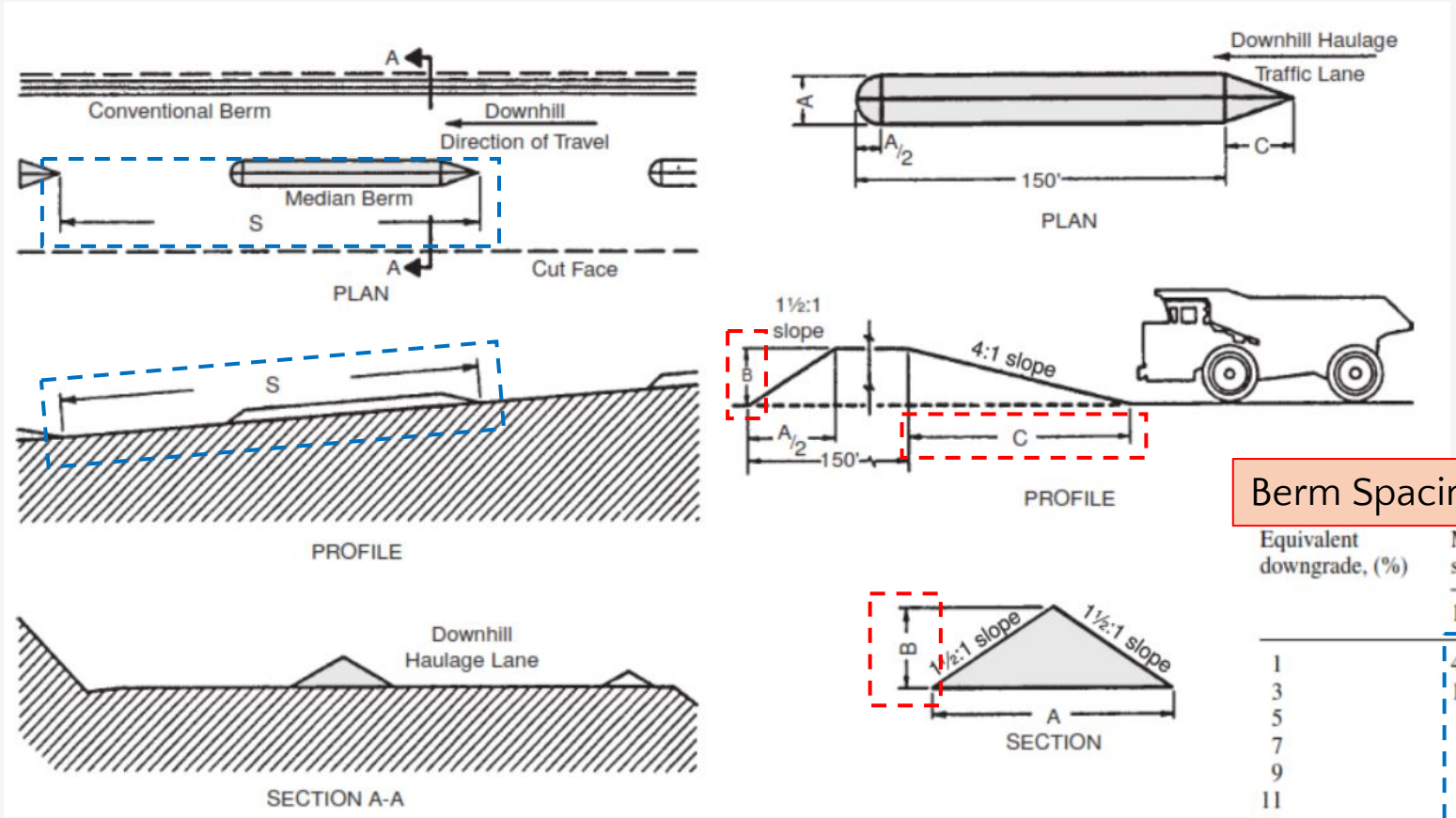
Radius (R) on inner edge of pavement (ft)	One-lane haulageway, vehicle category				Two-lane haulageway, vehicle category				Three-lane haulageway, vehicle category			
	1	2	3	4	1	2	3	4	1	2	3	4
Minimum	29	34	45	70	51	60	79	123	73	86	113	176
25	27	34	44	68	48	60	76	119	68	86	109	170
50	25	31	41	63	44	54	72	110	63	77	103	158
100	24	29	39	59	42	51	69	103	60	73	99	147
150	24	29	39	58	41	50	68	101	59	72	97	145
200	23	29	38	57	41	50	67	101	59	712	96	144
Tangent	23	28	37	56	40	48	65	98	57	69	93	140

ADT

Radius (R) on inner edge of pavement (ft)	One-lane haulageway, vehicle category			Two-lane haulageway, vehicle category			Three-lane haulageway vehicle category		
	2	3	4	2	3	4	2	3	4
25	38	68	86	66	119	151	95	170	215
50	32	57	71	56	99	124	80	142	177
100	28	48	58	50	83	101	71	119	144
150	27	44	52	47	76	91	68	109	130
200	26	42	49	46	73	85	66	104	122
Tangent	25	41	41	44	71	72	63	102	103

Hustrulid; 2015

Desain Jalan Tambang – Grade Jalan



Berm Dim. (A,B, C), In.

		B	C
Category 1 13 to 25 st <100,000 lb	11′–12′	3.5′–4′	14′–16′
Category 2 28 to 50 st 100,000–200,000 lb	12′–15′	4′–5′	16′–20′
Category 3 55 to 120 st >200,000–400,000 lb	15′–18′	5′–6′	20′–24′
Category 4 120 to 250 st > 400,000 lb	18′–32′	6′–11′	24′–44′

Berm Spacing (S). ft.

Equivalent downgrade, (%)	Maximum permissible vehicle speed or terminal speed at entrance to safety provision (mph)							
	15	20	25	30	35	40	45	50
1	418	1003	1755	2674	3760	5013	6433	8021
3	140	335	585	892	1254	1671	2145	2674
5	84	201	351	535	752	1003	1287	1604
7	60	144	251	382	537	716	919	1146
9	47	112	195	297	418	557	715	892
11	38	92	160	243	342	456	585	730
13	33	78	135	206	290	386	495	617
15	28	67	117	179	251	335	429	535

Hustrulid; 2015

Nisbah Kupas *(Stripping Ratio)*

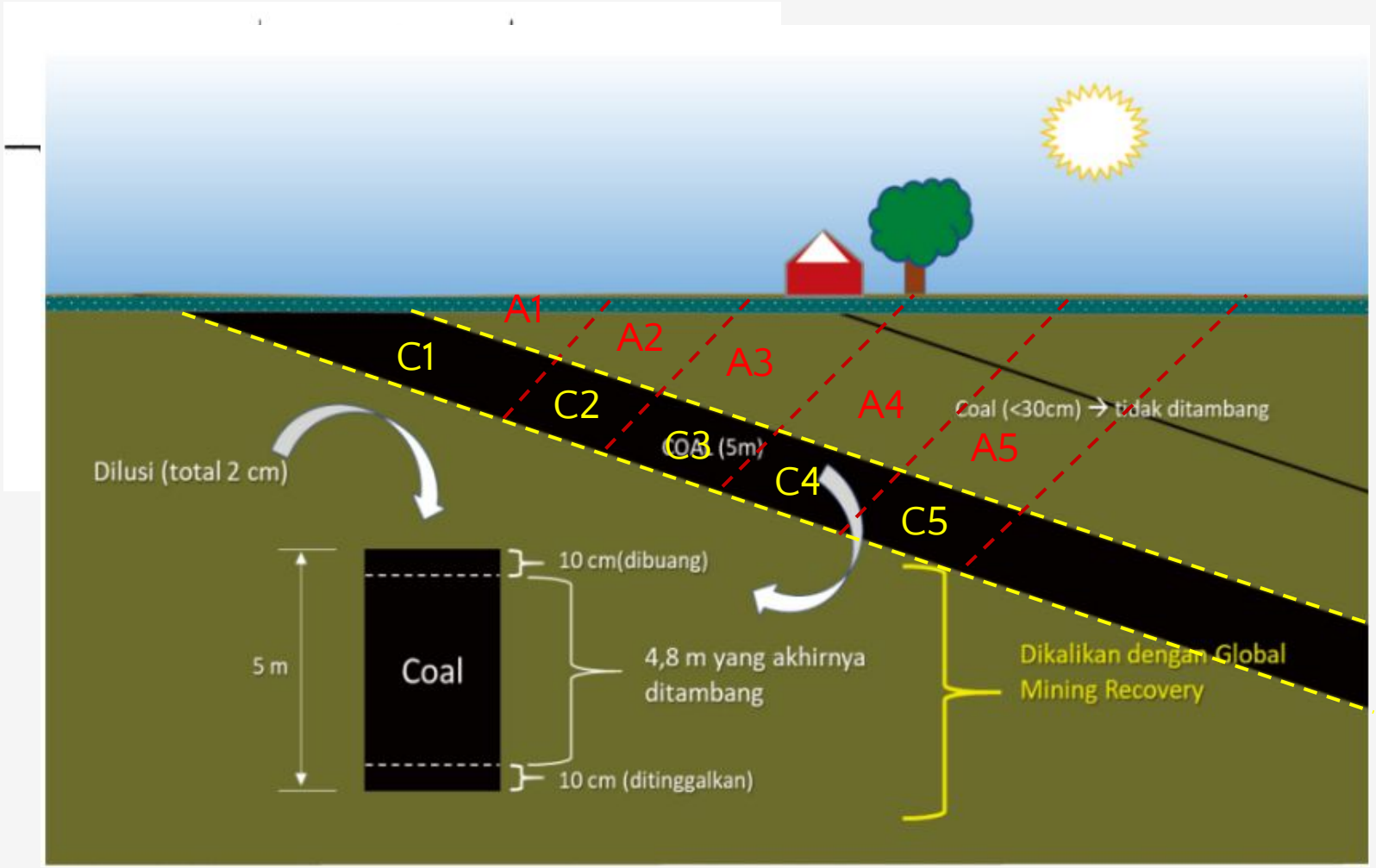
$$SR = \frac{\text{Waste (tons)}}{\text{Ore (tons)}}$$

$$SR = \frac{\text{Overburden thickness (ft)}}{\text{Coal thickness (ft)}}$$

$$SR = \frac{\text{Overburden } (yd^3)}{\text{Coal (tons)}}$$

$$SR = \frac{\text{Waste (volume)}}{\text{Ore (volume)}}$$

- *Overall SR*
- *Cummulative SR*
- *Incremental SR*
- *Instantaneous/Period SR*



Ada Pertanyaan?