

J. F. Tunicliffe Medal Presentation 2021

James Heslington

“Construction of a Deep Shaft Sinking Operation in the United Kingdom, 2021”



Aims



Project background/overview



Personal involvement: Service Shaft Project Engineer



Engineering/ scope of the systems: muck handling, ventilation, dust collection, craneage, shaft protection, SBR/ shaft works



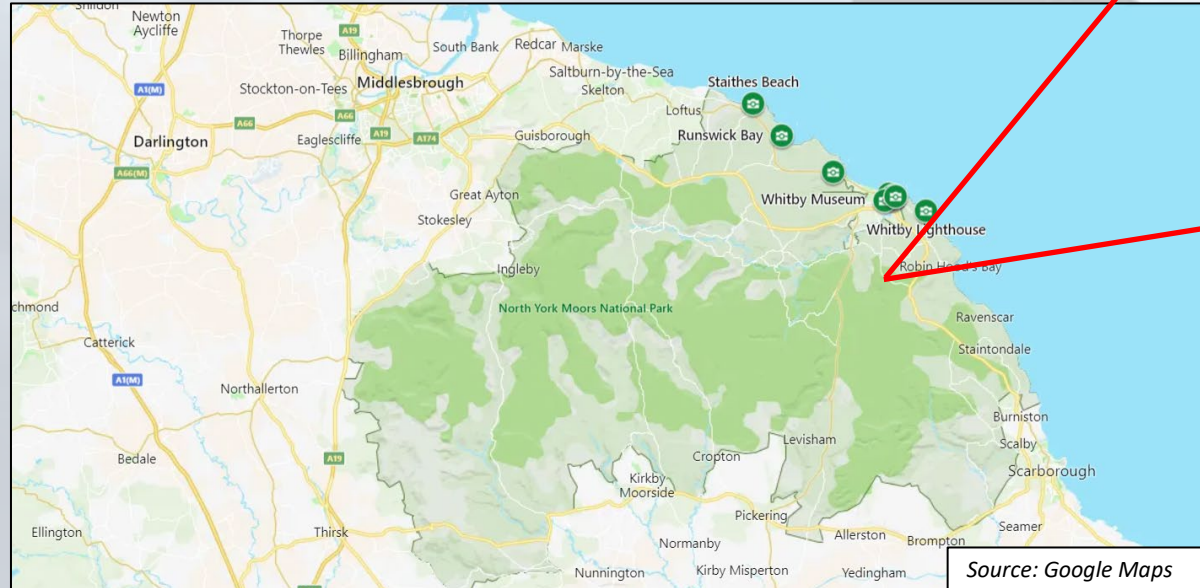
Considerations of each package: quality, environmental, safety



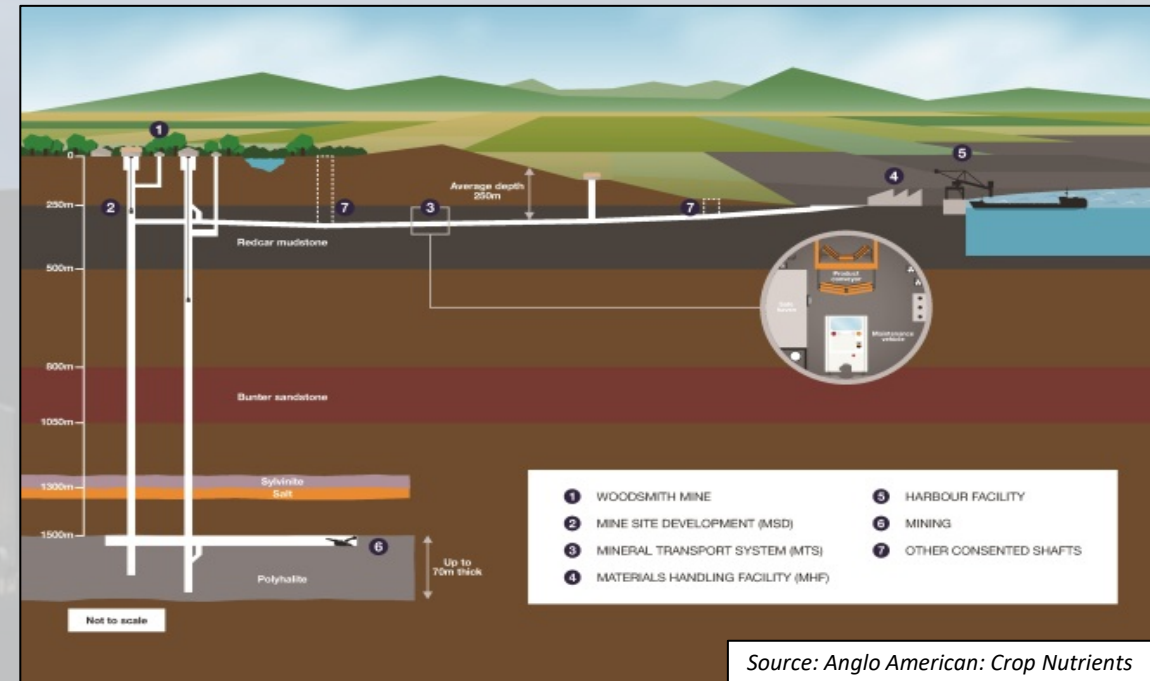
Discussion points

Project Overview

Location/ Background



Source: Google Maps



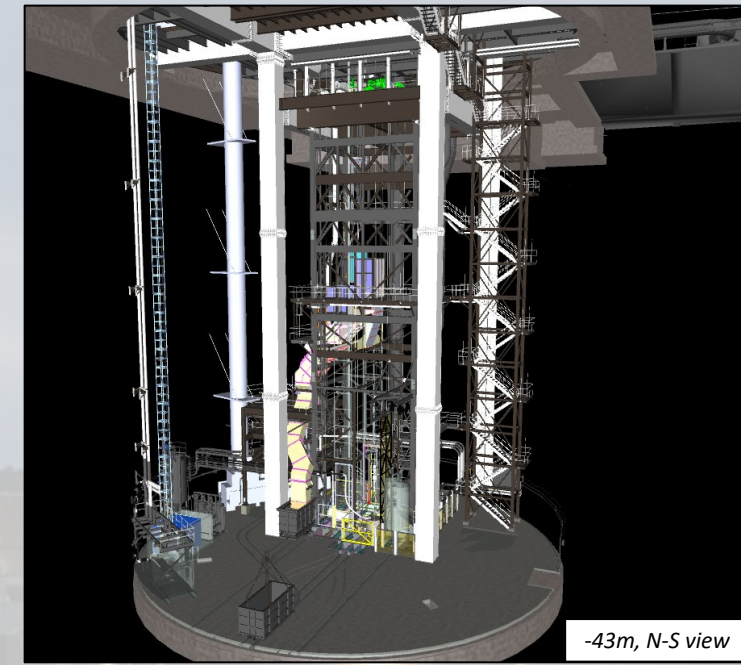
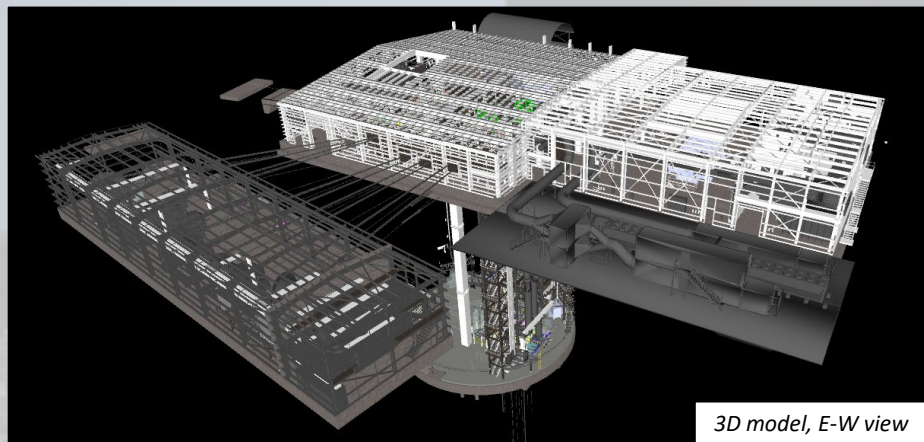
Source: Anglo American: Crop Nutrients

- Polyhalite deposit (late Permian deposition). POLY4 – Anglo American Crop Nutrients.
- Proven 7% of deposit - 2.69 billion metric tonnes (JORC).
- Service Shaft, **SS**, (1600m – Shaft Boring Roadheader – **SBR**), Production Shaft, **PS** (1600m - SBR), Mineral Transport Shaft, **MTS**, (360m - Galloway). SS fore shaft (-43m, 35m D), PS fore shaft (-43m, 32m D).

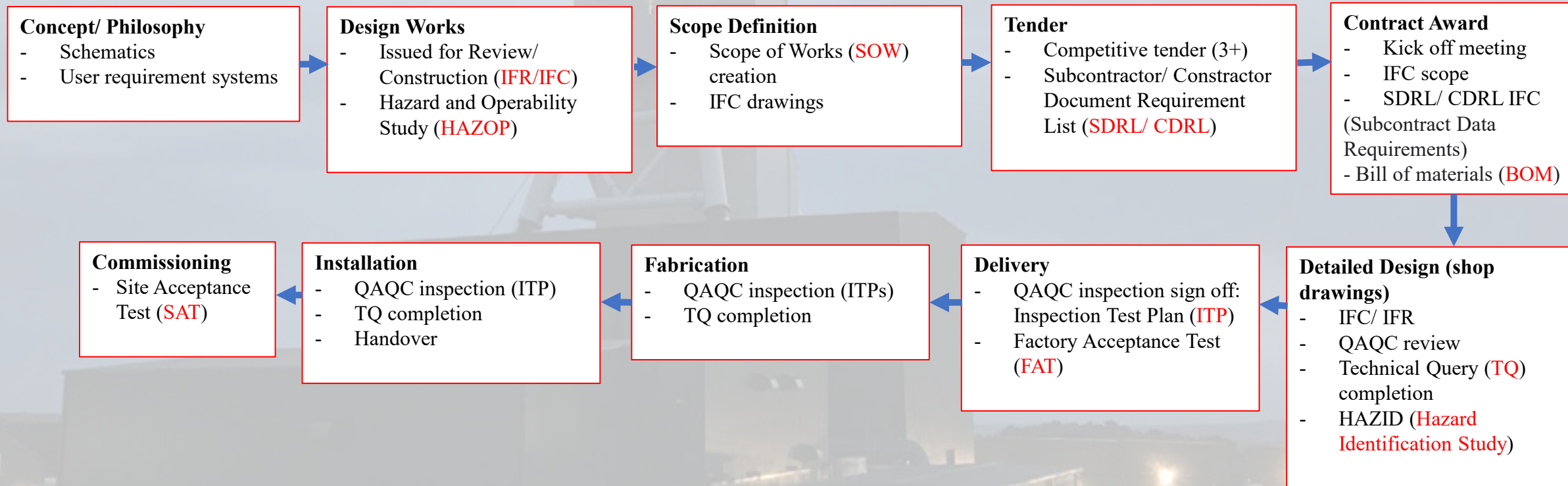
Project Involvement

Service Shaft

- Package manager (engineering, budget, schedule, construction).
- Mechanical, electrical, instrumentation and structural scopes (vendor install/ free issue).
- 3rd party GA design/ space proofing - self performed concept/ philosophy/ user requirement specification, self performed calculation checks, self performed installation/ management.
- Constructability, QAQC, technical queries.
- Operational engineering/ useability.

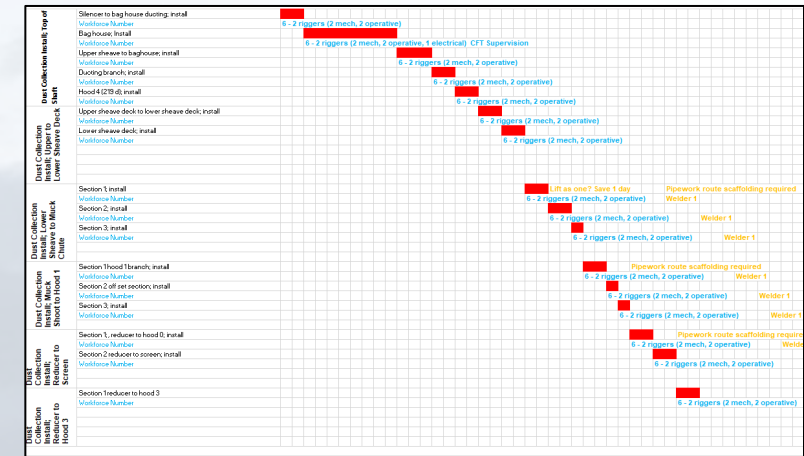


Engineering Basis - Phase I (Pre Construction) Process

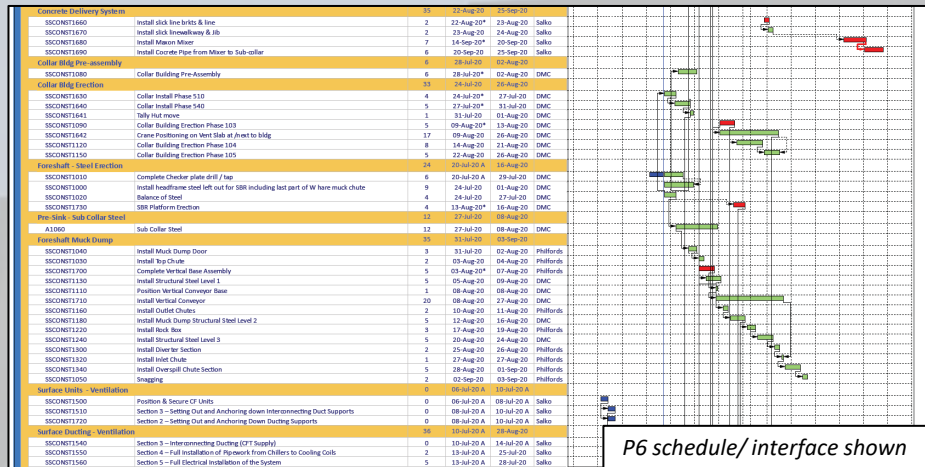


Foreshaft Steel - Phase II (Construction) Engineering Scope

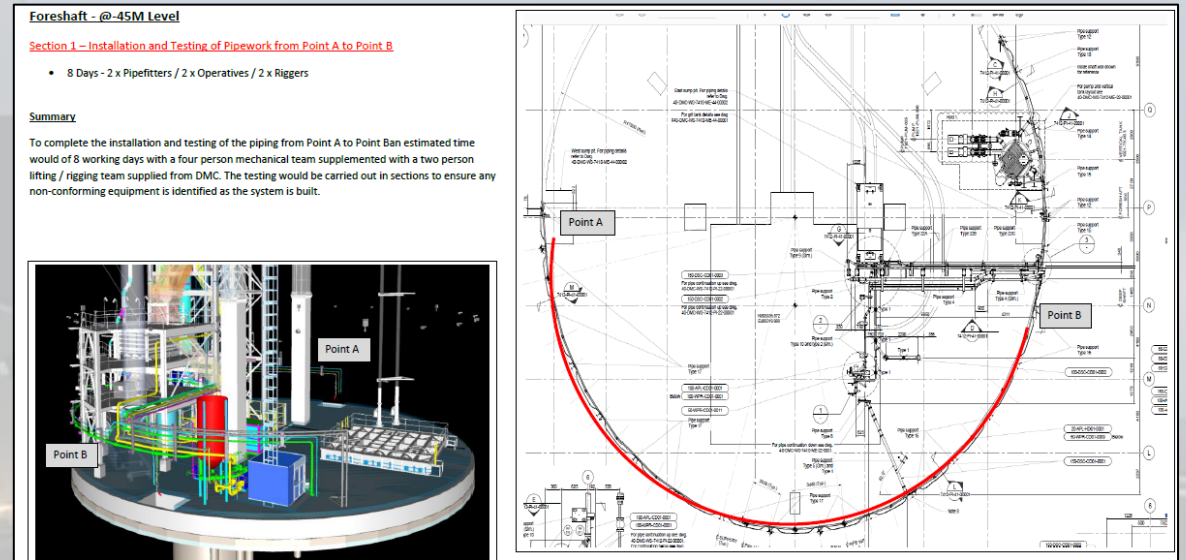
- Delivery/ constructability. Design 3rd party. 800t of steel (base).
- Back chargeable claims (clashes/ lost time/ reworks). Float 18 days.
- Simultaneous operations scheduled based on scope and available resource. Bottom-up construction. Interface and personnel number considered.
- Factor of Safety in shaft 10:1, General 5:1.



Planning docs/ personnel numbers



P6 schedule/ interface shown



Space proofing and constructability

Foreshaft Steel

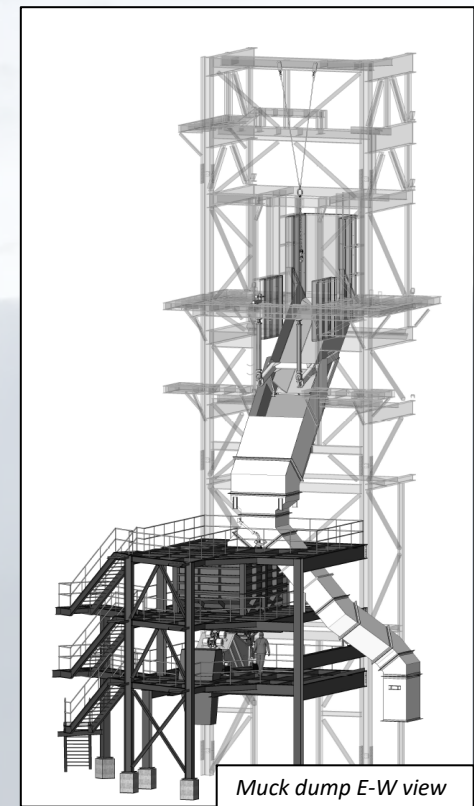
Considerations

- **Procurement** - Phased procurement and delivery (based on storage areas). Back chargeable claims for issues.
- **Quality** - ITP for manufacture and install, surface protection/ painting for exposed surfaces.
- **Environmental** - Headframe sub surface. IP rated equipment (>55). Lighting angled downwards.
- **Regulation**
 - *Mines Regulations 2014*: Regulation 38 – Safety Features of Winding Equipment
 - *Anglo American Technical Standards*: AA TS 108 (Structural integrity), AA Spec 114001 (steel structures), AA spec 114002 (construction of steel structures), AA spec 114008 (design of shaft steel work).
 - *British Standards*: BS 1090 – Structural steel and aluminium

Muck Handling – Phase III

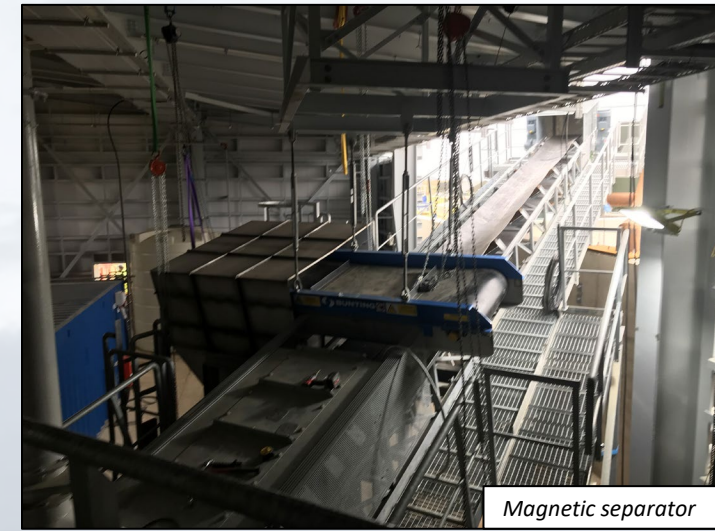
Engineering Scope

- Concept/ philosophy, design, manufacture, (self perform and contractor install). Structural system, mechanical system, hydraulic system.
 - Dump door, diverter gate, diverter chute, rock box, vibrating feeder, dewatering screen, discharge chute, overspill muck cart, grit tank, central HPU, 3x muck dump rams, 6x collar door rams, 6x collar door latches.
 - Phased deliveries – 3 stage delivery – shop painting of selected items (rock box).
 - Initial HAZOP (design), 3x HAZID for operations.
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- Fire suppression system for conveyor – low pressure mist deluge system (590L/min).
 - Dump door retaining lugs – lack of access to install (welded connection designed).
 - Hydraulic system rerouting – hard pipe and flexi hosing. Bracketry to support the lines.
 - Collar door ram supports repositioned to ensure plumb collar doors (prevent fall back if hydraulic leak)

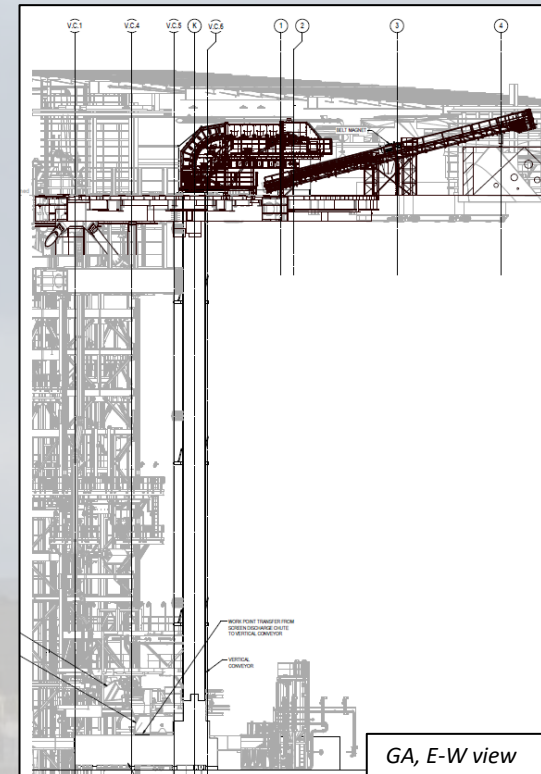


Muck Handling Conveyor System

- Free issue supplied system supplied (vertical bucket conveyor, discharge conveyor, magnetic separator).
- Guarding study and PUWER assessment completed (additional scope).
- Fire resistant belt, exposed nip points, inaccessible areas for maintenance. Study completion showed the need for: fire suppression, bearing temperature monitoring, belt replacement (Din Y changed to Din S type).
- Belt investigation into the manufacture of a compliant belt.
- Additional access control for restricted access of the area.
- Conveyor modifications – plough scraper, deflector pulley, structural cross member beams all moved due to clashes on install.
- Head end structure to support discharge conveyor tail end, including fixing of structure into collar steel/ concrete.
- Discharge conveyor support frame and concrete wall – muck bunker redesign (fit for purpose).



Magnetic separator



GA, E-W view

Muck Handling Crane System

- Concept, design, manufacture, installation, commissioning.
- Crane steel installation and sliding collar door installation (mechanical system with electrical motors) for fall protection. Sliding collar door concept, design, manufacture, install.
- Lifting frame (integration with 13ft Iso container), with 2 hook lifting points attached.
- Integrated crane safety system (*see shaft protection*).
- Dual remote operation – top person/ bottom person.
- Requirement for edge protection – collapsible barrier solution.
- 12 month lead time – crane steel interface.



Muck Handling

Considerations

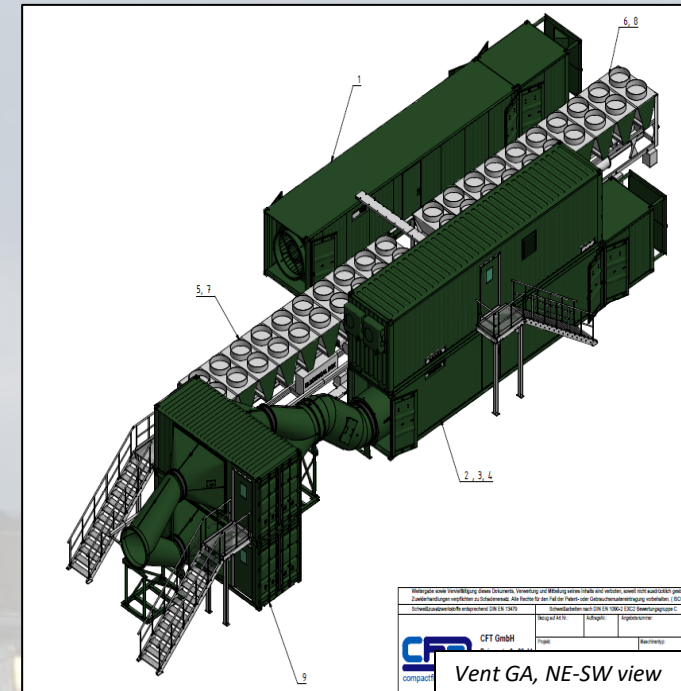
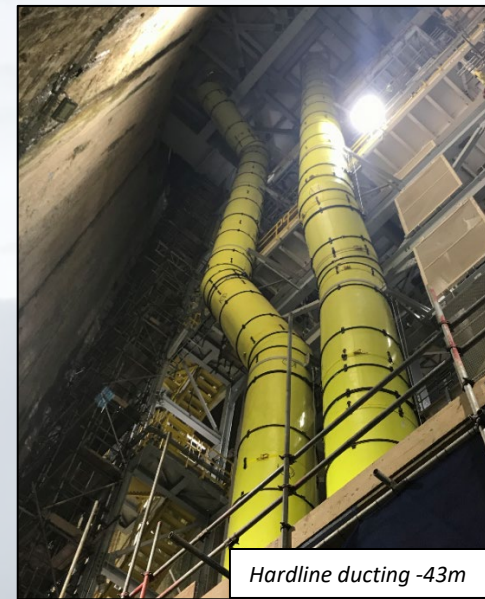
- **Procurement** - Free issue of equipment, one contractor for structural, mechanical and hydraulics.
- **Quality** - ITP for manufacture and install, shop painting of chutes (fitness for purpose), CE marks and modifications, technical queries raised.
- **Environmental** - Monitoring of material/ water in the muck dump area (water control on site), white noise pre-starts and light beacons, vibration analysis.
- **Regulation**
 - *Mines Regulations 2014*: Regulation 38 – Safety Features of Winding Equipment, Regulation 41 – Transport Systems, Regulation 60 – General Duty to Ensure Safety of Tips.
 - *Anglo American Technical Standards*: AA TS 109 (Guarding of belt conveyors), AA 114001 Steel structures, AA 114002 Construction of steel structures, AA 248002 Material handling equipment, AA TS 105 (Shaft Management), AA TS 108 (Plant Structures).
 - *British Standards*: **BS EN 14120** - Safety of machinery. Guards. **BS EN 12100** - Safety of machinery. General principles for design. **BS EN 12882** - Conveyor belts for general purpose use. **BS EN 14973** - Conveyor belts for use in underground installations. **BS EN 13001** - Cranes. General design. **BS EN 15011** - Cranes. Bridge and gantry cranes
 - *UK Coal: CR13*, Codes and Rules for under ground conveyors, 2006

Ventilation – Phase IV

Engineering Scope

- Installation of system and modification, design/ supply of ducting.
 - Fan system (force and exhaust) with chillers, 11kV feed to transformer, hard line ducting to collar, plastic ducting to -43m, transition piece and bagging to SBR. Phased deliveries – equipment, ducting in 3 phases to optimise lead time (hard line long lead time).
 - System to provide a minimum of 26m³ air supply at 4 degrees (surface).
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- Hardline ducting used to -43m – reduced friction, increased leakage. No lagging.
 - Exhaust duct collapse during commissioning – stiffening sections used.
 - Transition piece (GRP) from steel to hardline at 0m and hardline to lay flat at -48m.
 - ‘Sweetener’ fan to provide airflow at -43m, lay flat bagging used and routing changed – steel elbow at -40m to provide secure connection.
 - ATEX exhaust fan (M2 zone in airflow).

Exhaust Fan (1x110 kW), Supply Fan 2x (2x90 kW), Supply Fan 1x(1x90 kW), Sinking Chiller 2x - (I) 1x164 kW, (II) 1x234 kW



Ventilation

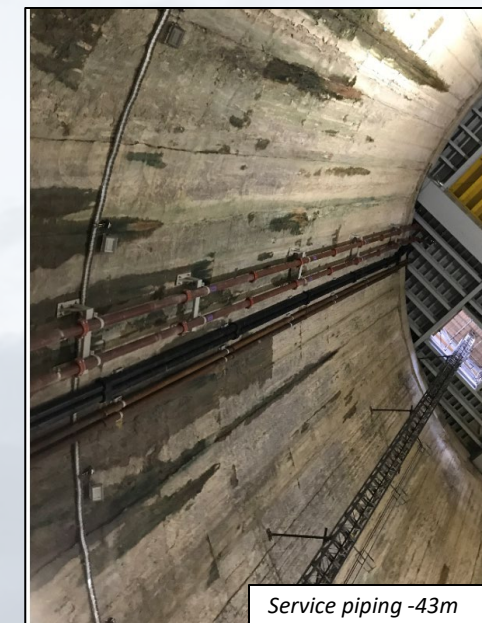
Considerations

- **Procurement** - Free issue of equipment, one contractor for mechanical and electrical. Ducting design, supply (single supply vendor for ducting on site). Commissioning complete by supplier.
- **Quality** - ITP for manufacture and install. FAT for equipment (UK based chiller vendor). Planned preventative maintenance in place.
- **Environmental** - Noise and dust – silencer baffle units on fans. Netting of area to protect from nesting (emphasis during swallow nesting season). Temporary containerised equipment – juniper green (RAL 140 20 20). Plume protection – collar house enclosure/ dust collection system.
- **Regulation**
 - *Mines Regulations 2014*: Regulation 43 – Ventilation, Regulation 59 – Working Plans, Sections, Vent Plans and Geological Map
 - *Anglo American Technical Standards*: Site standard/ Managers Rules, AA TS 105 (Shaft Management), AA standard being developed by site vent engineer.
 - *British Standards*: BS 5885 – Automatic Gas Burners, BS EN 14120 - Safety of machinery. Guards.

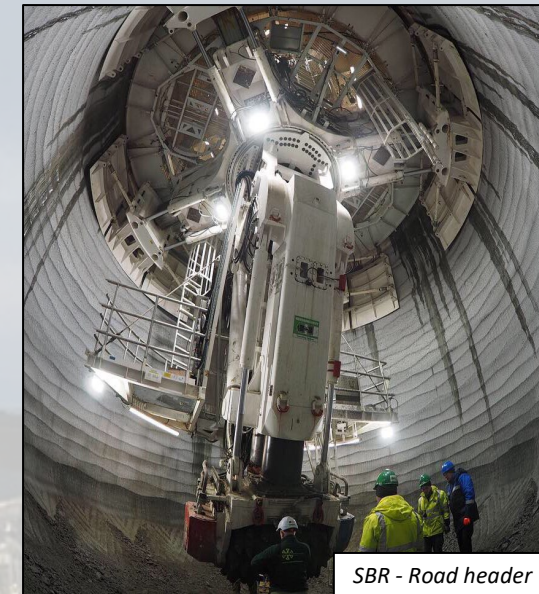
SBR Sinking- Phase V

System Description

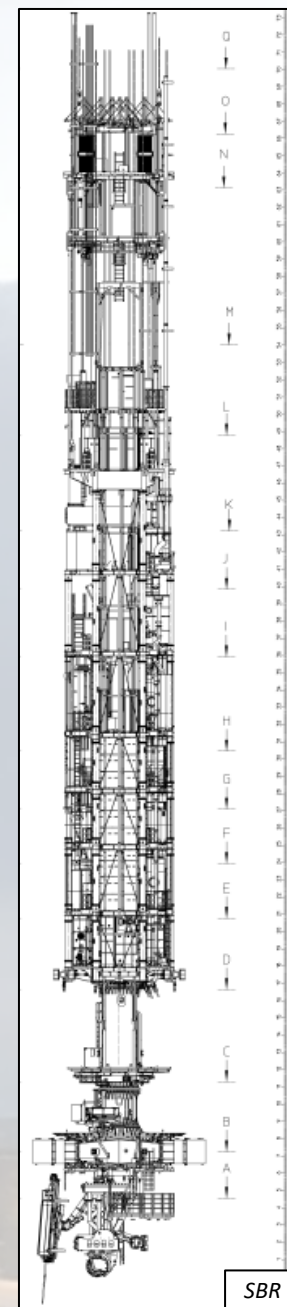
- **Foreshaft:** 6” compressed air line, 4” water line, 6” dewatering line, 2 x 8” concrete lines, 2 x 8” grout lines, 2 x 8” additional lines (for cooling).
 - **Pre sink:** 1 slick line down shaft 8”, 1 drain line (water rings) 4”, 1 process water 4”, 1 dewatering 6”, 1 compressed air 6”
 - SBR #3 and #4: 69m length, 2x movable utility platforms. 7.25m shaft -7.25m shaft.
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- ATEX modifications to machine: M2 zone at face – deck 4.
 - Ventilation ducting modification (hardline to bagging with cassette).
 - Stabiliser modifications to allow for access during inset works.



Service piping -43m



SBR - Road header



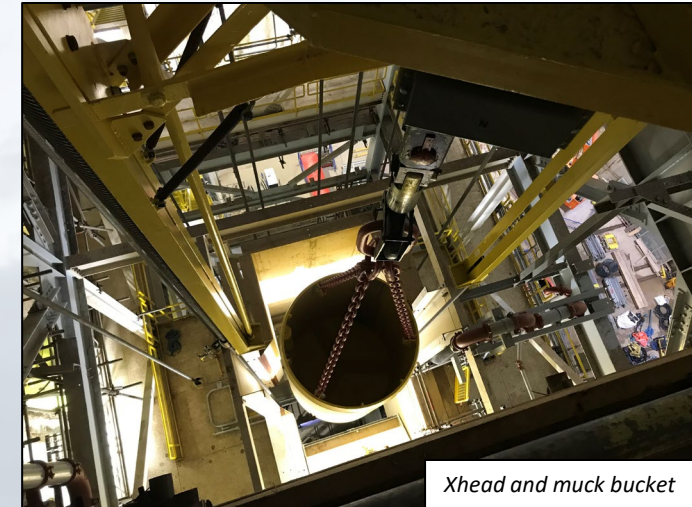
SBR

Compressed air sitewide system (10bar working pressure), process water sitewide water (max 350L/min), dewatering system (max 980L/min) mixer and concrete pump at -43m.

SBR Sinking

Shaft Equipment/ Pre Start Installation

- SBR movement using self propelled movement transportation machines (SPMT's). Lifted onto hydraulic skating system in the fore shaft (-43m).
- Module 6 used as a lifting frame (roped up), SBR modules lifted into pre sink. 7 modules making up the SBR.
- Structural strands installed (providing rigidity).
- Ropes for guiding conveyances. Xheads 1.9m/ 1.5m (OLKO winder for mucking and emergency egress, sinking hoist for general access/ slinging).
- Hoist speeds max 9m/s, creep 0.6m/s, super creep 0.3m/s.
- Concrete buckets for back-up to slick line.
- Probe drilling – initial 17.2m excavation – cyclic mining.
- 7.25m former for concrete pours (curb – E ring), 3.6m height).



SBR Sinking

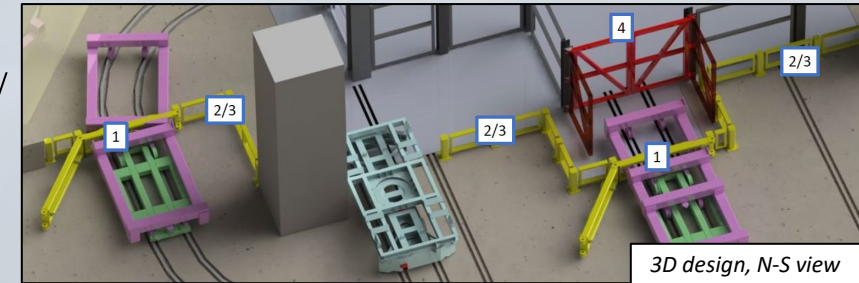
Considerations

- **Procurement** - Phased delivery – service lengths of first 100m, followed by 300m spans. Piping and lagging separate – wrap/ Velcro-similar strapped lagging. SBR module construction at surface prior to installing in shaft.
- **Quality** - ITP for manufacture and install. Pressure/ leak testing for handover. Planned preventative maintenance in place. ATEX register for sign off.
- **Environment** - Usage: access for maintenance, environmental discharge controls on the bench.
- **Regulation**
 - *Mines Regulations 2014*: Regulation 36 – Shaft Construction, Regulation 37 Equipment relevant shafts and outlets
 - *Anglo American Standards*: AA TS 105 (Shaft Management), AA 282003 (Design of Conveyances), AA 2820004 (Fabrication of Conveyances), AA 282005 (Use of Conveyances)
 - *British Standards*: **BS 1090** – Structural/construction steel and aluminium products (Class 2 install)

Shaft Protection – Phase VI

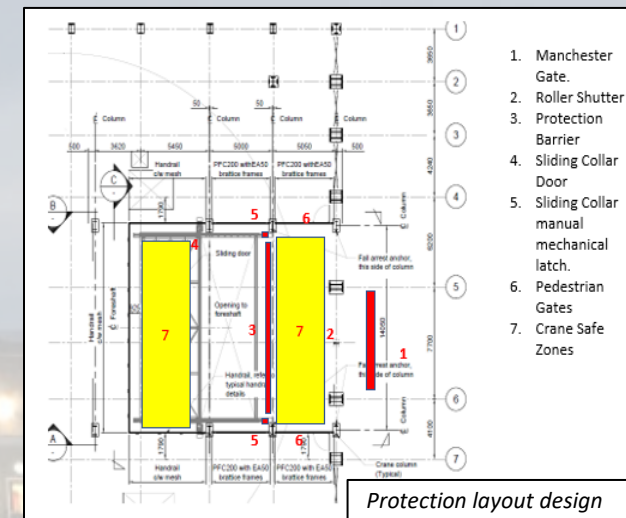
Engineering Scope

- Protection systems concept, design, supply. Self perform install.
- Protection system to create a multi-layer system surrounding the shaft environment – philosophy created,
- Risk: Surface: haul trucks, telehandlers, loaders. -43m: telehandler/ forklift, rail carts.
- Safety integrity level (SIL) rated systems – SIL 2. PILZ switches, DOLD solenoid switches.



- Rail cart track gauge accuracy – carts poor running on tracks. Install of bolt-down track for ease of usage.
- Collapsing barrier instrumentation locations – crank arm location.
- Collapsing barrier backing pin distorting – addition of 10mm plate for strength and further retaining pin to assist the lowering/ gravity feed.
- Welded connection for collar door latch due to access.

Exterior Manchester gate – 32t at 20mph, Roller shutter door – access control, Interior barrier – edge protection, Sliding collar door latch – 32t at 5mph, Sliding collar door – motor gear system, Interlocked pedestrian gates – DOLD switches, -43m Manchester gate and rail buffer stop – 20t at 5mph



Shaft Protection

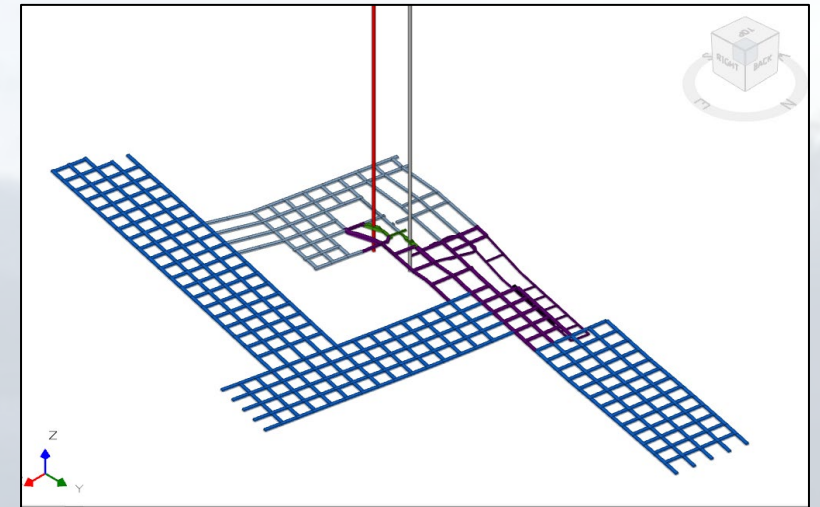
Considerations

- **Procurement** - Separate suppliers based upon lead times and design. Usage of Anglo structural engineer to assist with 3rd party load design checks. Staggered installation/ delivery.
- **Quality** - ITP for manufacture and install (safety critical equipment). Planned preventative maintenance in place.
- **Environmental** – Usage: ergonomics, design life, function. Rail buffer stops for compression. Additional rated barriers for full protection of the shaft brattice area. Colouration – traffic yellow and 3M strips for increased visibility.
- **Regulation**
 - *Mines Regulations 2014*: Regulation 41 – Transport Systems, Regulation 42 – Transport Rules
 - *Anglo American Technical Standards*: AA TS 105 (Shaft Management), AA TS 108 (Plant Structures), AA 114001 (Steel Structures)
 - *British Standards*: BS 1090 – Structural/construction steel and aluminium products (Class 2 install). PAS 69 – Guidance for the selection, installation and use of vehicle security barrier systems

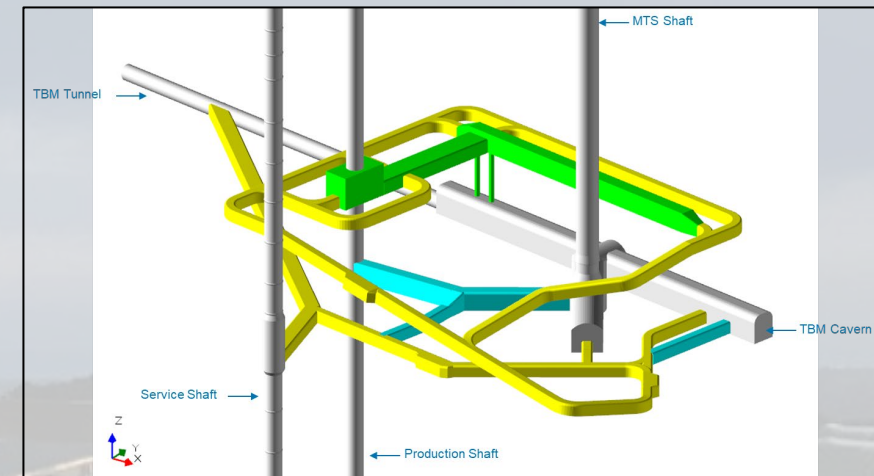
Summary/ Progression

Personal Outcomes and Development

- **Process implementation** – philosophy, design, tender, detailed design, manufacture, install, QA, commissioning.
- **Working relationships** – optimisation/ development of designs – new concepts/ technology (collapsing protective fence/ vertical conveyor).
- **Service shaft “Completions Team” involvement** – schedule/ construction efficiency and drive for completion.
- Engineering change notices for any scope change/ remedial works.
- Commissioning snagging works/ operational requirement modifications. **Fitness for purpose.**
- Shaft inset development (-360m) and lateral development, tubbing transition, shaft bottom development.
- **Constructability** – schedule/ cost – Production shaft lessons learnt – value engineering (UK based, local companies/ solutions); usage of different muck handling system – mechanical chain bucket system/ larger bunker.



Production level plans



-360m level plans

Questions?



Thank you.

Jwheslington@gmail.com

James.heslington@angloamerican.com

07949 896607

