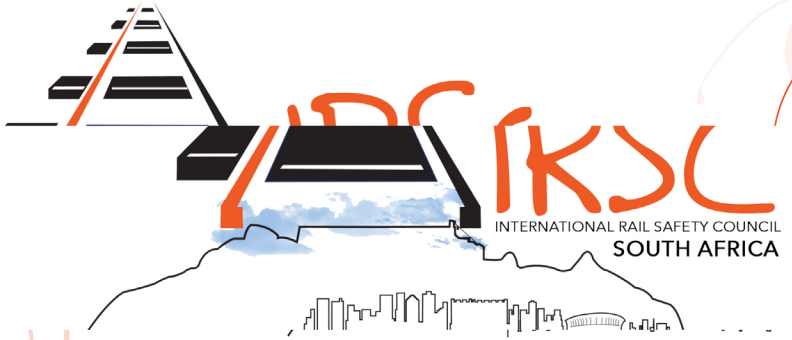

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Gautrain Management Agency

‘WHERE NATURE MEETS RAIL’

GAUTRAIN TUNNEL SAFETY CASE

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INTERNATIONAL RAIL SAFETY COUNCIL SOUTH AFRICA

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CONTENT

1. Overview of Gautrain Tunnel
2. Legislative Requirements
3. Tunnel Geohydrology
4. Tunnel Design
5. Groundwater Management
6. Tunnel Water Monitoring
7. Safety & Emergency Response
8. Conclusion

OVERVIEW OF THE GAUTRAIN TUNNEL

The Gautrain Tunnel is a 15km tunnel between Marlboro Portal and Park Station in central Johannesburg.

The depth of the tunnel varies from twenty meters below the surface, to more than ninety meters underground

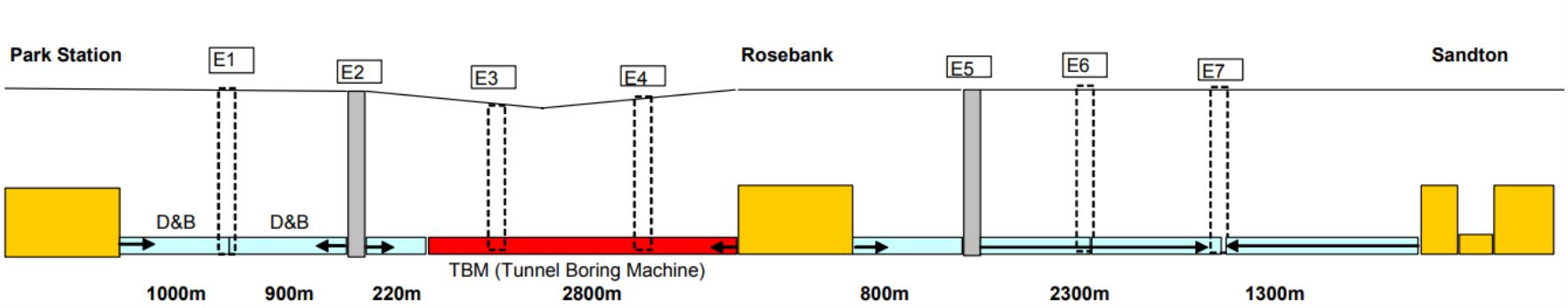
12kms of the tunnel was constructed using drill and blast techniques
3 kms of the tunnel used a Tunnel Boring Machine (TBM)

The tunnel has a slab track instead of ballast which reduces noise and vibration from the train

Three underground stations including Sandton, Rosebank and Park Station
7 emergency shafts (E1 – E7)

Auxiliary Tunnel Systems (head houses, drainage and fire main, ventilation and smoke management station and tunnel management system, fire detection and suppression, tunnel emergency vehicles)

OVERVIEW OF THE GAUTRAIN TUNNEL



LEGISLATIVE REQUIREMENTS

Standards & legislative requirements applicable to the design, construction and operations of the tunnel

- For the Tunnel: European Union Technical Specifications for Interoperability – Safety in Railway Tunnels (TSI-SRT)
- For the Underground Stations: Standard for Safety in Rapid Transit Systems (SFRTS)
- National Environmental Management Act & Regulations
- Occupational Health and Safety Act 85 of 1993
- Railway Safety Regulations
- SANS 10400: Part T – Fire Protection
- Emergency Management Services Regulations

LEGISLATIVE REQUIREMENTS

Environmental Impact Assessment Process

- The EIA process was undertaken for the Gautrain System prior to final design
- Several alterations to the design of the tunnel were undertaken which subsequently led to EIA amendments
- Environmental Approvals (ROD's) were eventuality obtained for the various sections of the System
- Construction Environmental Management Plan
- Operations & Maintenance Environmental Management Programme

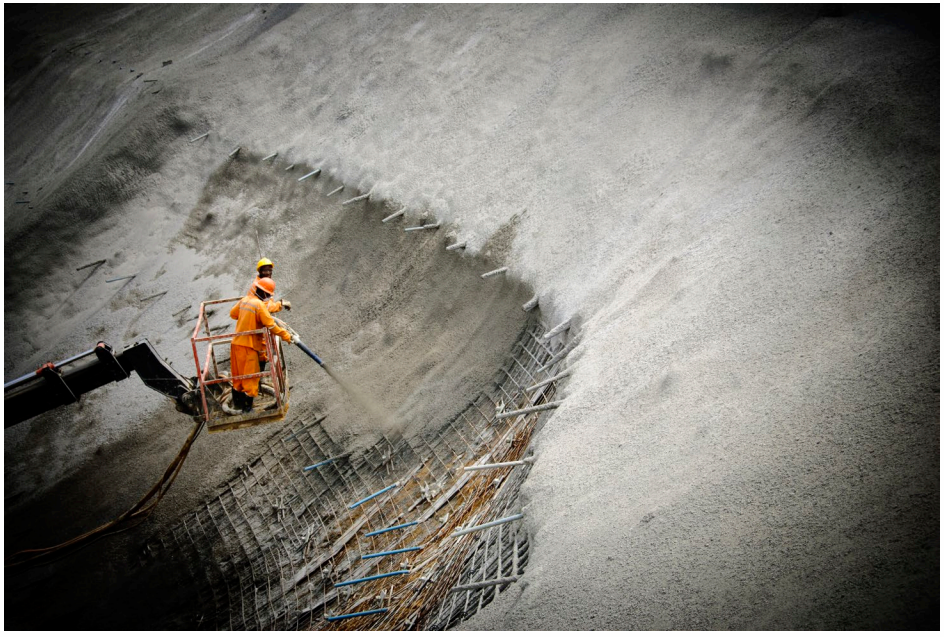
TUNNEL GEOHYDROLOGY

- The hydrology of most of the tunnel section was severely affected by tectonics.
- Rocks encountered were massive and abrasive.
- Highly permeable rocks due to cracking which meant there was water ingress into the tunnel.
- Choice of construction methods therefore had to take the geological and geotechnical considerations to ensure safe train operations.
- DRILL & BLAST – strong, hard, poorly fractured rock conditions
- TUNNEL BORING MACHINE (TBM) – soft and soil like ground conditions, focused on areas

TUNNEL DESIGN – DRILL & BLAST

Marlboro Portal – Sandton Station

- Consists of a 4.8km tunnel
- Single bore twin track tunnel separated by a full height fire wall.
- The fire wall, has a walkway located on both sides, with eight bi-parting sliding fire doors for emergency evacuation purposes
- The tunnel was constructed using "drill and blast" methods.
- Shotcrete was used to line the tunnel to alleviate the rough surface and to waterproof



TUNNEL DESIGN – DRILL & BLAST

Sandton Station - Rosebank Station

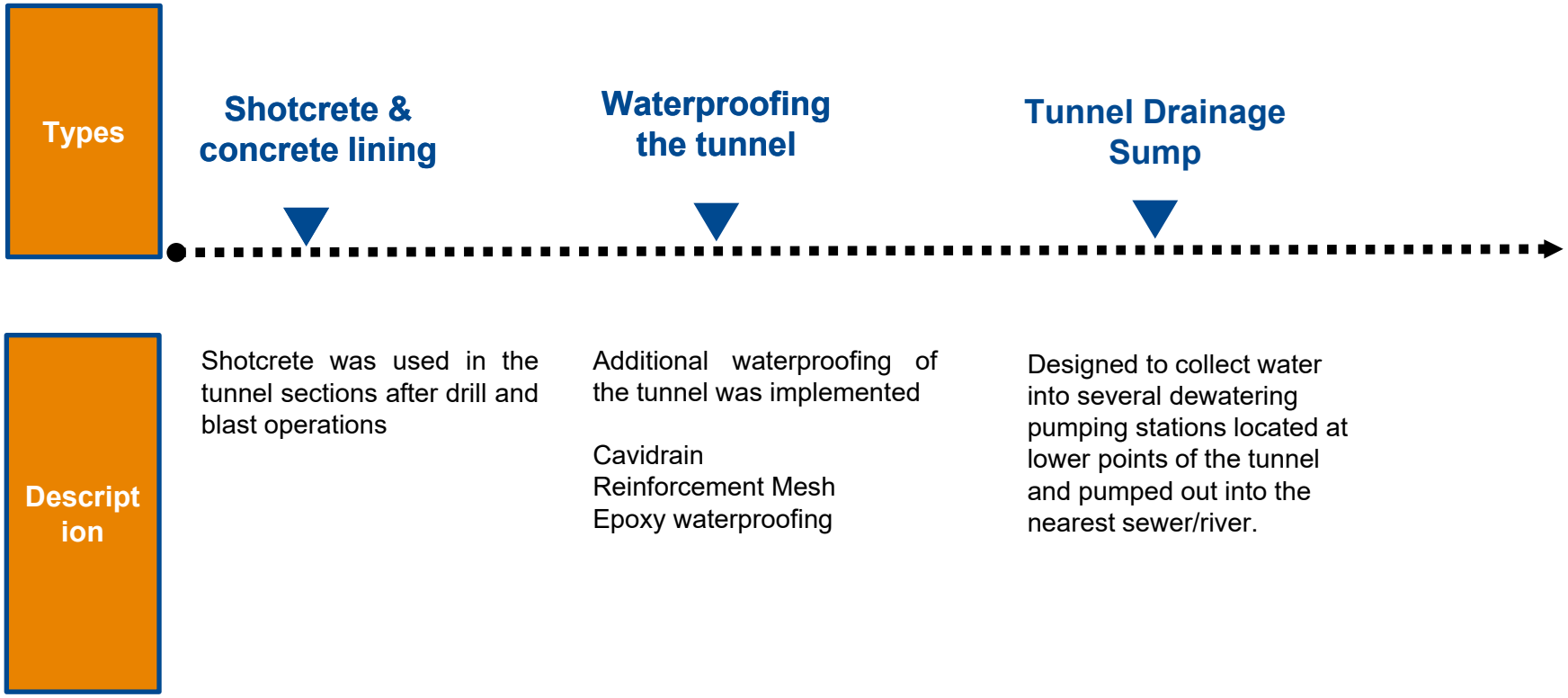
- 4.5km single bore single track tunnel
- This section was also constructed using a drill and blast technique
- The Sandton - Rosebank tunnel section has three emergency shafts (E7, E6 & E5) which serve as refuge chambers

TUNNEL DESIGN

Rosebank Station - Park Station

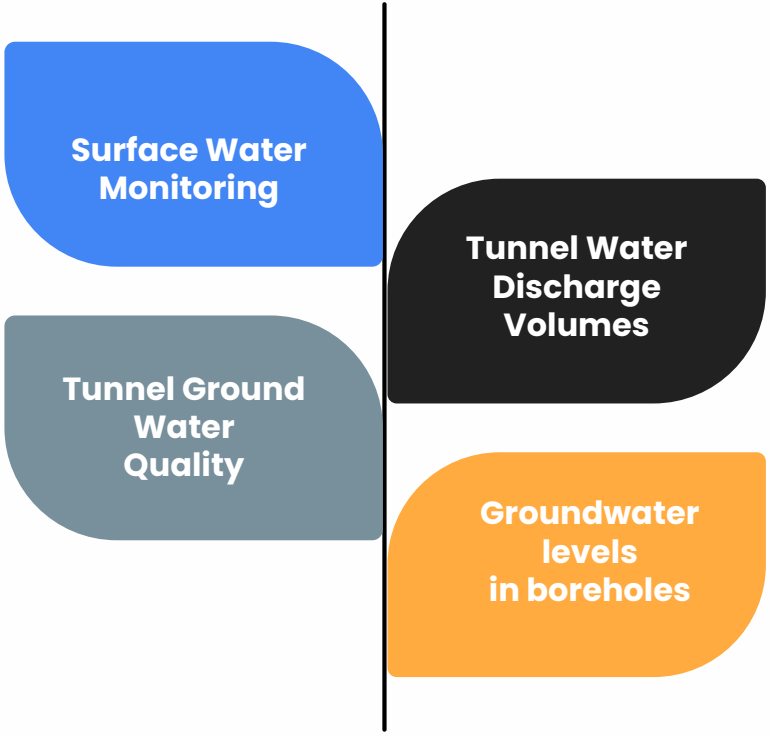
- 5.4km single bore single track tunnel
- Signalled for bi-directional train movements
- This tunnel section includes shafts which provide access between ground level and the running tunnel (E1, E2, E3 and E4)
- Parts of this section were constructed using a Tunnel Boring Machine

GROUNDWATER MANAGEMENT



TUNNEL WATER MONITORING

- Water monitoring is done in accordance with the Integrated Water Use Licenses (IWUL)
- The IWUL outlines the prescribed volumes and quality thresholds that may not be exceeded across multiple discharge points
- Monthly Water Monitoring Reports are submitted to the Department of Water and Sanitation
- An Independent Environmental Consultant (IEC) is appointed to monitor and assure compliance

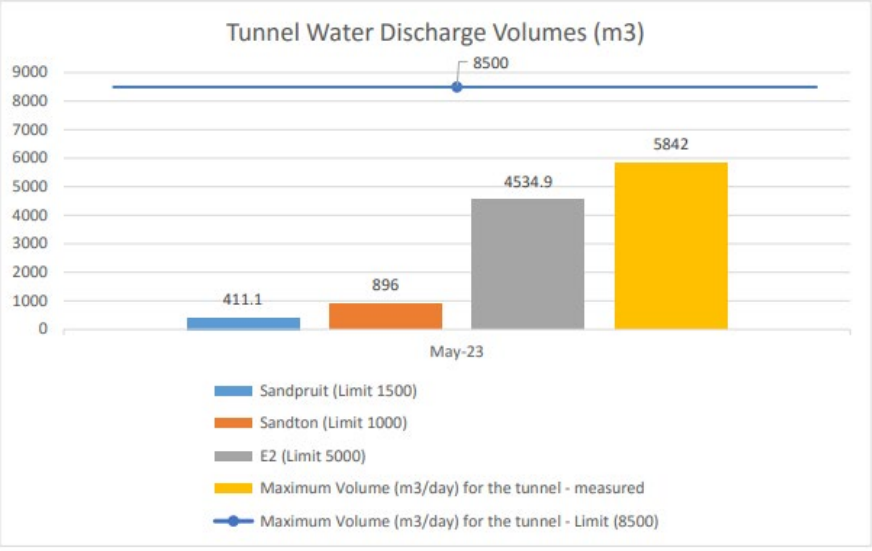


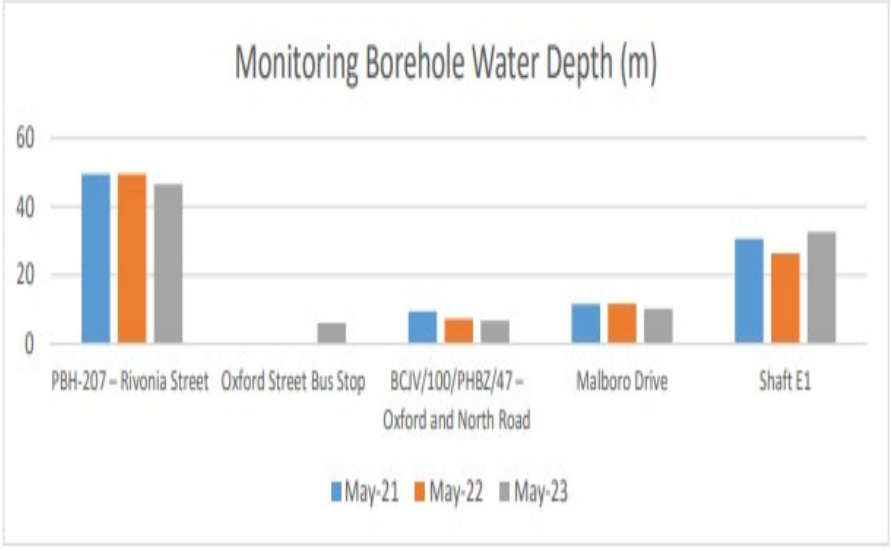
TUNNEL WATER MONITORING

Surface Water Monitoring – Sandspruit River

- Water is extracted from the tunnel sections and brought to the surface, where it is discharged into the Sandspruit watercourse.
- Discharged water is subjected to chemical analysis in accordance with the specifications outlined in the Water Monitoring Programme.
- These analyses are performed to assess the Present Ecological State (PES) of the river and potential influence of the discharged water on the surrounding environment
- Water quality assessments are conducted both upstream and downstream of the water discharge location, spanning a distance of 100 meters in each direction

TUNNEL WATER MONITORING





TUNNEL WATER MONITORING

Groundwater quality monitoring

Analyses in mg/ℓ (Unless specified otherwise)	Sample Identification – Discharge Positions				
	E2	E4	Sandton Station	Sandspruit	Limits
pH – Value at 25°C	7.3	7.2	7.6	8.0	5.5 – 9.5
Electrical Conductivity in mS/m at 25°C	28.4	42.1	52.5	33.0	150
Suspended Solids at 105°C	1.3	2.0	4.7	4.7	<25
Free Residual Chloride as Cl_2	<0.1	<0.1	<0.1	<0.1	<0.25
Fluoride as F	<0.2	<0.2	<0.2	<0.2	<1
Nitrate as N	5.3	5.5	8.6	3.7	15
Nitrite as N	<0.05	<0.05	0.08	<0.05	15
Ortho Phosphate as P	<0.1	<0.1	<0.1	<0.1	<1
Free Cyanide	<0.01	<0.01	<0.01	<0.01	<0.02
Chemical Oxygen Demand O_2	<10	<10	<10	16	<75
Oil & Grease *	<1	<1	<1	2	2.5
Faecal Coliform Bacteria (MPN/100ml)	<1	<1	32	96	<1000
Free and Saline Ammonia as N	0.1	0.1	0.1	<0.1	<6
Arsenic as As	0.001	<0.001	<0.001	0.001	<0.02
Boron as B	<0.025	<0.025	<0.025	<0.055	<1
Cadmium as Cd	<0.001	<0.001	<0.001	<0.001	<0.005
Hexavalent Chromium as Cr	<0.01	<0.01	<0.01	<0.01	<0.05
Copper as Cu	0.001	0.004	0.004	<0.001	<0.01
Iron as Fe	<0.025	<0.025	<0.025	0.055	<0.3
Lead as Pb	<0.001	<0.001	<0.001	<0.001	<0.01
Manganese as Mn	<0.025	0.025	<0.025	<0.025	0.1
Mercury as Hg	<0.001	<0.001	<0.001	<0.001	<0.005
Selenium as Se	0.001	<0.001	0.001	<0.001	<0.02
Zink as Zn	<0.025	0.631	<0.025	<0.025	<0.1

TUNNEL SAFETY & EMERGENCY MANAGEMENT

Tunnel Management

Auxiliary Tunnel Systems

1.Refuge Shelters
2.Head Houses
3.Drainage and Fire Main
4.Ventilation and Smoke management (fans and ducting)
5.Station and Tunnel Management System (STMS)
6.Fire walls and doors
7.Fire Detection and Suppression
8.Underground water reservoir
9.11kV ring main power supply

Access & Evacuation

1.Walkways with handrails
2.Fireman's lifts
3.Cat ladders
4.Escape route signage and lighting
5.Stretchers

Communication Systems

1.Operational Control Centre
2.CCTV Camera's
3.Emergency Telephones (ETELs)
4.Fireman's Microphones
5.Two-way radios
6.Passenger Announcement (PA) System
7.3G

Safety Health Environment Quality

1.Safety Management System
2.Maintenance Plans
3.Emergency Preparedness Procedures
4.Emergency Response Plans
5.Incident Investigation Procedures
6.ISO Certification
7.Environmental & Safety Assurance
8.Rail Safety Regulator inspections

Emergency Management Services

1.Monthly meetings with local EMS and Disaster Management
2.Inspection of the Gautrain system by EMS personnel
3.Emergency drills conducted in conjunction with EMS
4.Contracts with Medical Services
5.Inhouse First Response Team
6.Knowledge and lessons learnt through debriefing

Trained Employees

1.Competency and skills training
2.Safety and Incident Management Training
3.Simulation exercises

Vehicles and Equipment

1.Tunnel Emergency Vehicles
- EMU-EMU
- Steel wheel locomotive – EMU
- RRV -EMU

2.Fire hydrants & extinguishers

Security Management

1.On board security on each train
2.Conductor or train driver assistance on each train set.

CONCLUSION

- Geohydrological and environmental considerations in tunnel design play a critical role in ensuring safe train operations
- Delays in geotechnical studies may result in the delay of obtaining environmental approvals and subsequently delay project commencement
- An important consideration is that an EIA should commence once the design has been finalised
- Prior to the design being finalised it is recommended that a Strategic Environmental Assessment be considered to identify all issues that can be ringfenced into the EIA

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