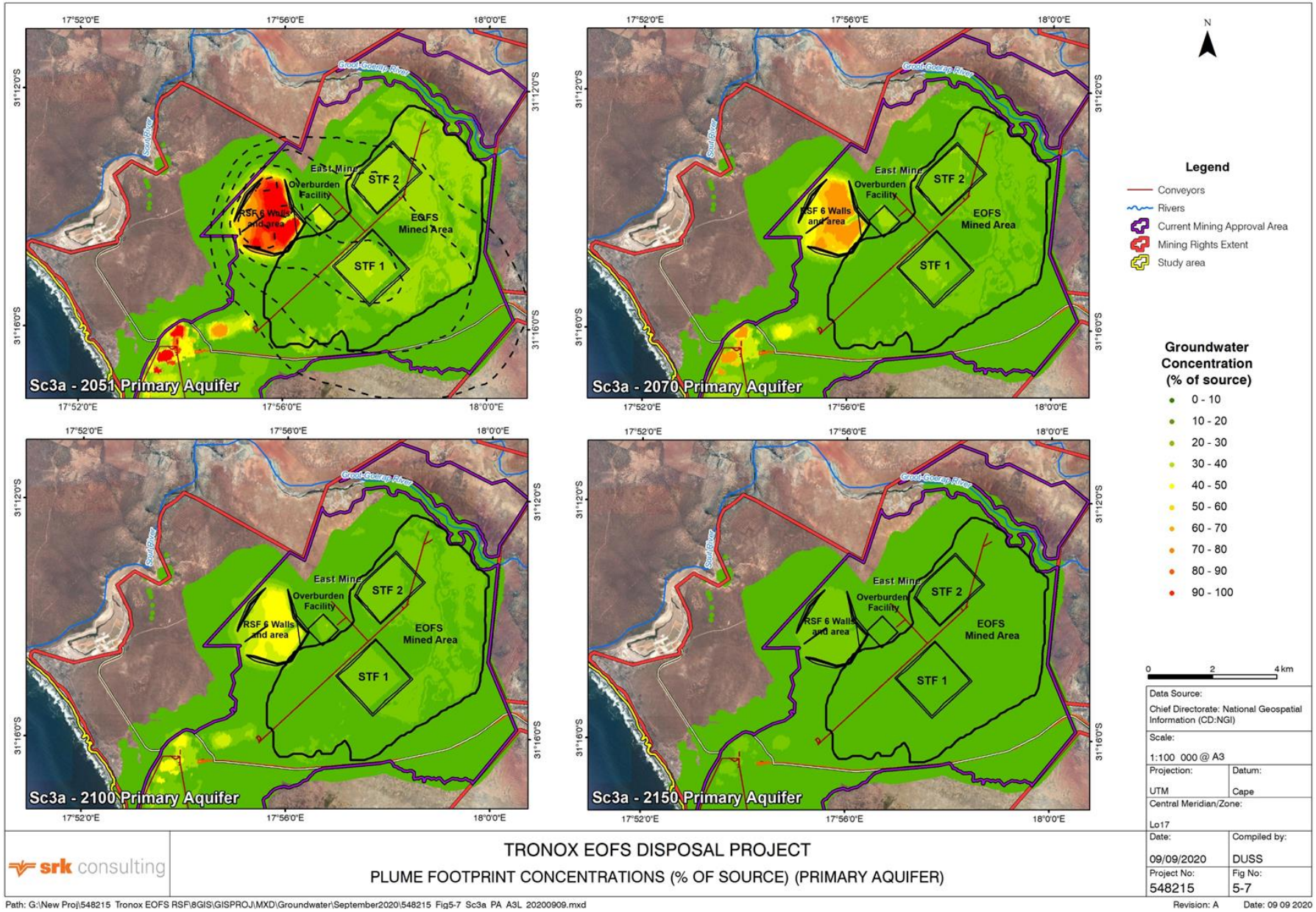


Figure 5-7: Scenario 3a Concentrations (% of source) in the Primary Aquifer

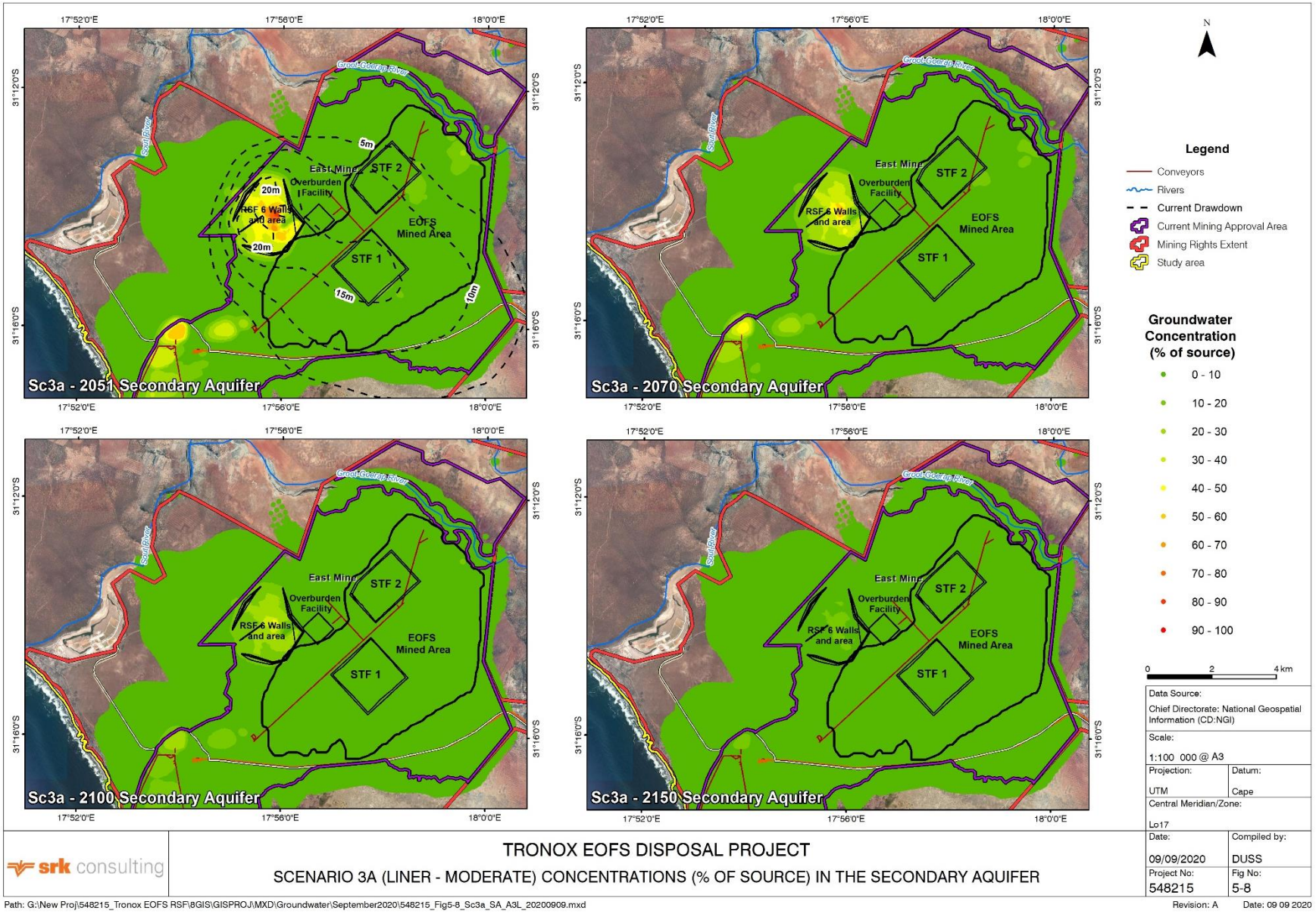


Figure 5-8: Scenario 3a (Liner – Moderate) Concentrations (% of source) in the Secondary Aquifer

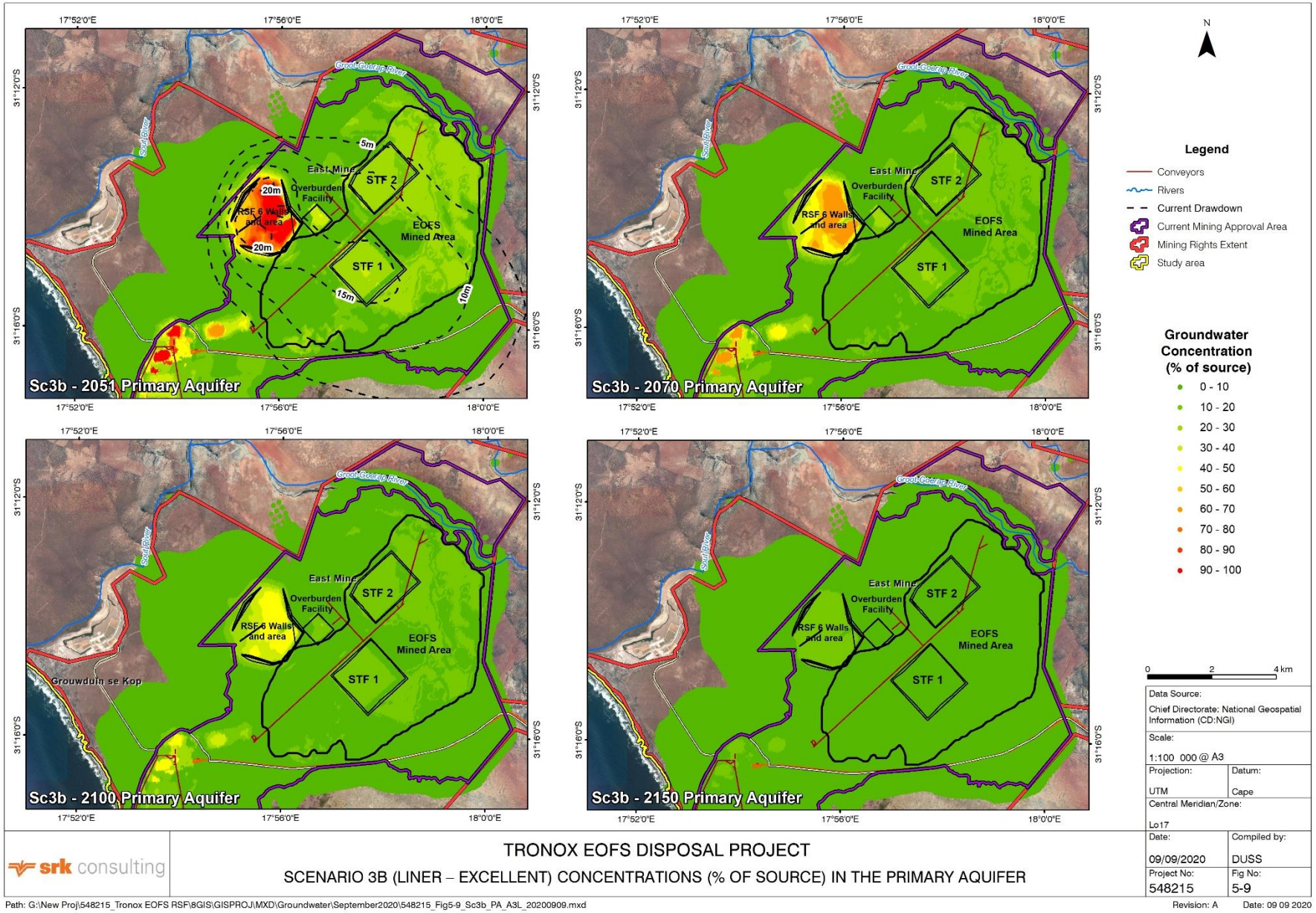


Figure 5-9: Scenario 3b (Liner – Excellent) Concentrations (% of source) in the Primary Aquifer

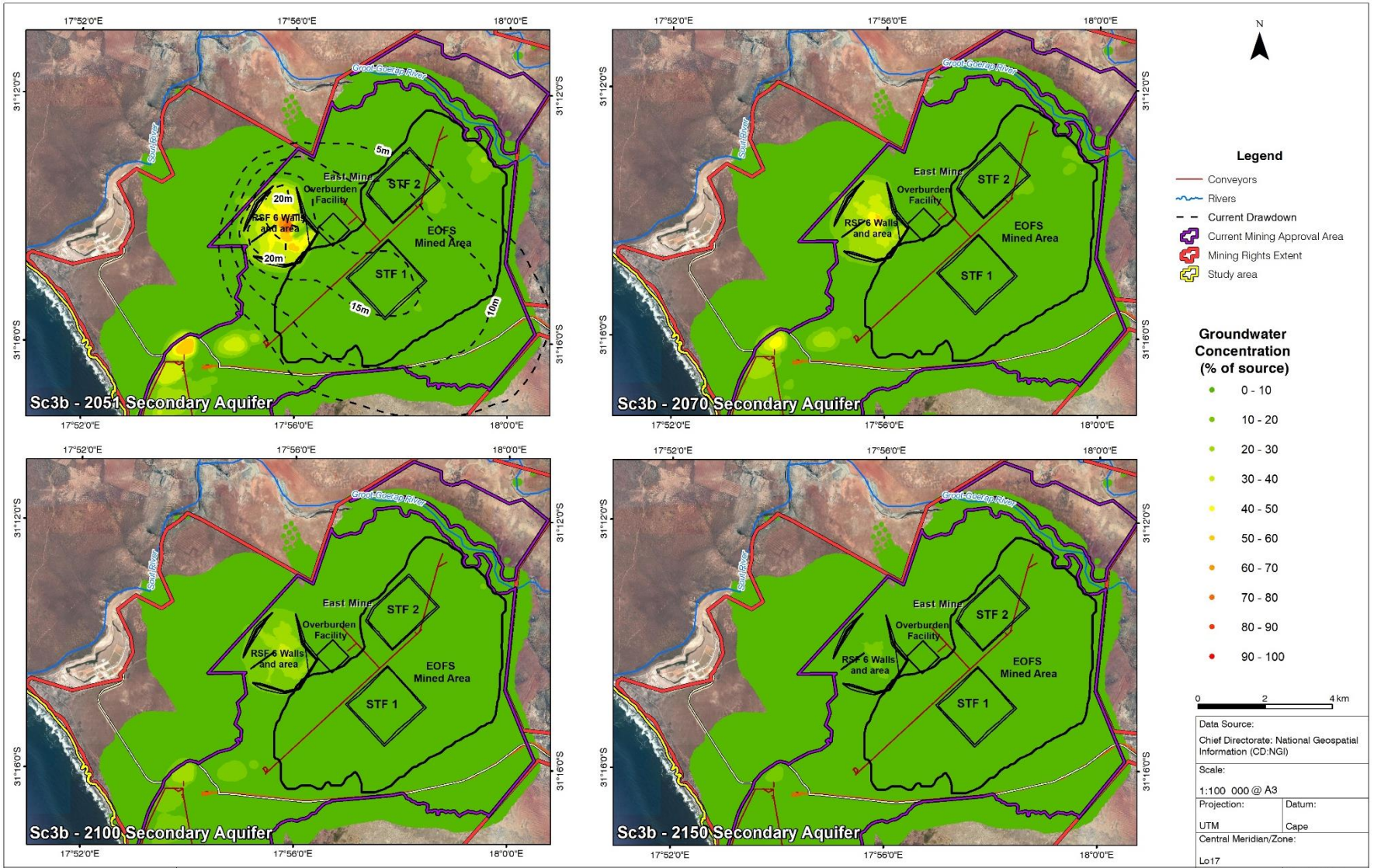


Figure 5-10: Scenario 3b (Liner – Excellent) Concentrations (% of source) in the Secondary Aquifer

5.8.3 Revised RSF Results

There are only negligible differences in plume extent and concentrations for Sc1, Sc3a and Sc3 for the *original RSF* predictive scenarios. The implication is that there would be no benefit in nstalling a Class D containment barrier. The *revised RSF* design assumes an updated groundwater mass balance and additional predictive scenarios were run to ascertain whether the *revised RSF* would have the same impact as the *original RSF*.

The following assumptions (Table 5-7) informed analytical and numerical predictions of seepage to groundwater from the revised RSF, and the associated contaminant plume footprint.

Table 5-7: Scenario Parametisation

Parameter	Units	RSF	RSF (updated)
Years active	years	2020 -2051	2002 - 2040
Duration of years active	years	31	20
Deposition Rate (Mtpa)	Mtpa	4.10	6.35
Density (t/m^3)	t/m3	1.09	1.13
Moisture Content at Disposal (% by mass)	% by mass	85%	85%
Maximum seepage water available	m3/pa	15 500	26 000
Max Height	m above current ground level	25	25
Hydraulic Conductivity of deposited material (m/d)	m/d	8.6 x 10^{-4}	8.6 x 10^{-4}
Percent density reduction in consolidated fines	m/d	40%	40%
Consolidated Fines	%	6.0 x 10^{-9}	6.0 x 10^{-9}
Hydraulic Conductivity of consolidated material (m/d)	m/d	5.2 x 10^{-4}	5.2 x 10^{-4}
Effective porosity of deposited material (-)	m/d	0.01	0.01
Potential Evaporation (mm/a)	mm/a	1190	1190
Evaporation Extinction Depth (m)	m	0 -20 m	0 -20 m
Indicator Element(s)	% source concentration	% source concentration	% source concentration
Source Concentration	%	100	100
Background Concentration	%	0	0

Modelled Seepage from the RSF:

Saturated fines deposited with a moisture content of *c*.85% are deposited from the dual conveyor. Over a period of time, the deposited fines become partially saturated due to evaporation. This cycle continues until the RSF reaches capacity, i.e. 31 years for the *original* RSF design and 20 years for the *revised* RSF design. The depositional period / volume of fines deposited determine the seepage flow rate through the RSF.

The seepage flow rate through the RSF is governed by Darcy's Law which states that the *'total discharge (Q) is equal to the product of the hydraulic permeability (K) of the medium, the cross-*

*sectional area (A) to flow, the total pressure drop (*Δh*), all divided by the length/height (L) over which the pressure drop is taking place'*. This is formulated as Q = K A (Δh / L).

The deposited fines are simulated using the General Head Boundary (GHB) condition, which changes in height (L) according to the volume of fines deposited (Figure 5-11). The saturated fines are the same for both modelled scenarios, thus the hydraulic head / total pressure drop (Δh) remains constant, but the height (L) of the RSF changes continually (with modelled changes updated on an annual basis). According to Darcy's Law (Q = K A (Δh / L), the flow (seepage) rate from the RSF (Q) is inversely proportional to the height of the RSF (L). Thus, the longer the depositional period for the same tonnage of deposited residue (39.6 Mt), the lower the height of the RSF and the higher the seepage. For example, Figure 5-12 shows that the *revised* RSF reaches its capacity over a period of 20 years at its maximum height (L_{20}b), whereas the *original* RSF is only at *c*.60% of its capacity or height (L_{20}a). In other words, the *original* RSF height is lower than the *revised* RSF height, thus the flow is greater.

In conclusion, the *revised* RSF would generate a lower seepage rate due to a greater volume of fines being deposited over a shorter period of time.

Contaminant Plume Footprint

Scenario 1 (fines only) was numerically modelled incorporating the aforementioned RSF assumptions (Table 5-7). This scenario was modelled to the end of mine (20 years) to assess the worst-case contaminant plume (conservative approach).

The changes in contaminant plumes were assessed by comparing the *original* RSF (previously modelled) to the *revised* RSF (Table 5-7) using "simulated points". The locations of these simulated points are as shown on Figure 5-12, and were selected as follows:

a) In the middle of the RSF;
b) On the RSF boundary;
c) 200 m from the RSF;
d) 1 km from the RSF; and
e) In the Sout River.

The modelled concentrations (end of mine) at the simulated points are displayed in Table 5-8 and Table 5-9 below. These results show that the *revised* RSF design will result in lower concentrations to groundwater than those of the *original* RSF design. This is attributed to the lower seepage rate of the *revised* RSF design, limiting groundwater seepage, thus containing a larger contaminant mass within the fines/RSF.

Table 5-8: Primary Aquifer Simulated Point Results

	Primary		
ID	**RSF *original***	**RSF *revised***	**% Difference**
a	100	100	0%
b	60	57	-5%
c	30	28	-7%
d	11	8	-29%
e	5	1	-84%

Table 5-9: Secondary Aquifer Simulated Point Results

	Secondary		
ID	**RSF *original***	**RSF *revised***	**% Difference**
a	92	89	-3%
b	44	42	-5%
c	26	24	-7%
d	9	6	-40%
e	4	1	-75%

Darcy's Law

Q = KAi

i = ΔH / l (length)

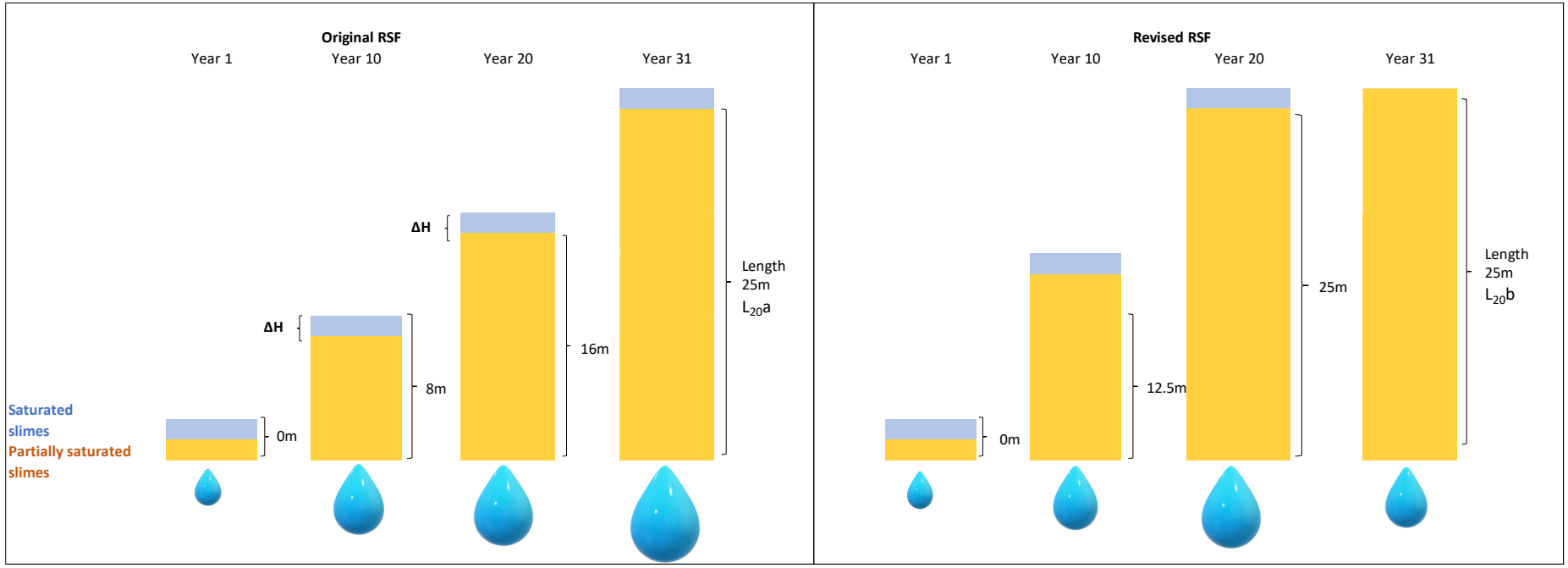


Figure 5-11: Flow from the RSFs – Darcy's Law

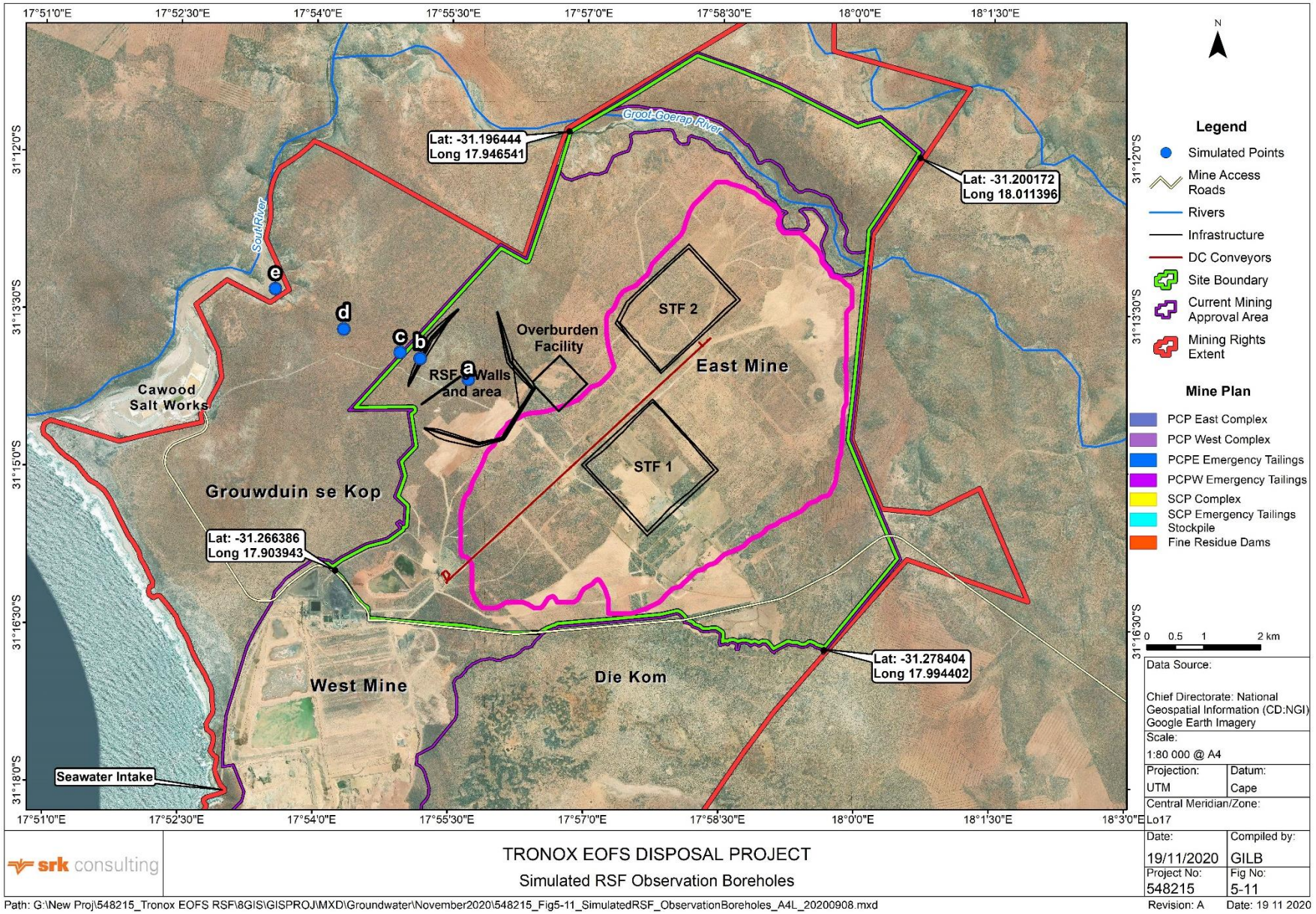


Figure 5-12: Simulated Points

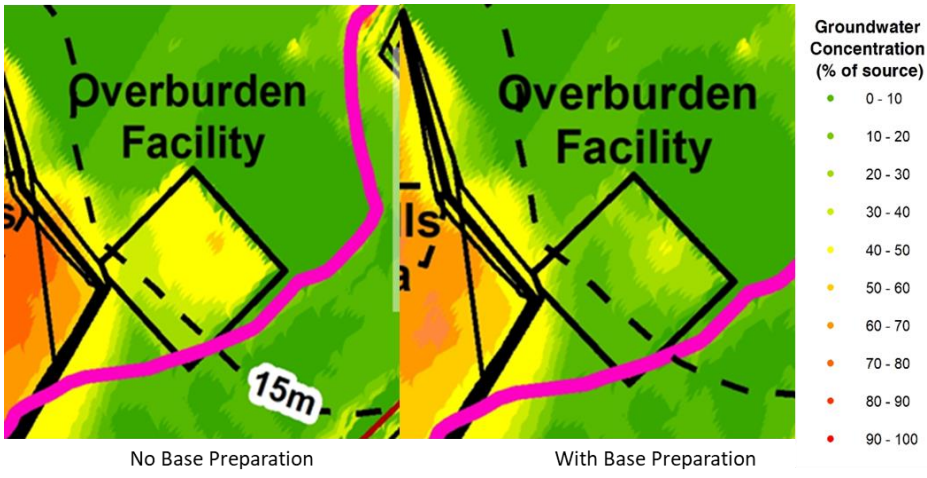
5.8.4 Overburden Stockpile Base Preparation Scenarios

The majority of the EOFS area is located in previously mined out areas. These voids were backfilled with RAS tailings as per requirements of the current mining authorisation. Therefore, to exploit the EOFS, this material (referred to as overburden) must be removed. As there is no void in which this overburden be placed, it is necessary to stockpile the first three years of excavated material in an Overburden Stockpile (total stockpile volume of *c.*3.15 Mm^3). At the end of the LoM, the stockpiled material will be used to cap/rehabilitate the RSF and/or STFs. The Overburden Stockpile is modelled in a conservative manner using a maximum moisture content of 5% - as specified by the design engineers (Epoch). However, it is unlikely that the stockpile will have freely available (liberated) water which might seep into the groundwater table.

A comparative assessment was conducted which assessed the effect with and without base preparation. The simulated results for the end of LoM are as follows:

- No base preparation/ “as is” Overburden Stockpile produces a maximum groundwater concentration of *c.*60% of source, with a mean of *c.*35% of source in the overburden facility footprint area;
- With base preparation, the facility produces a maximum groundwater concentration of *c.*40% of source, with a mean of *c.*20% of source in the overburden facility footprint area; and
- The contaminant plume does not migrate beyond 200 m from the facility in both (no base and) base preparation options.

Both base preparation options generate fairly low groundwater concentrations under the Overburden Stockpile, attributable to the low moisture content (5%) of the overburden (previously placed RAS tailings) as well as the short (three year) duration of RAS tailings disposal. Although lining the facility may reduce local concentrations by c.20%, lining is deemed unnecessary as the contaminant plume does not migrate further than 200 m from the facility.



srk consulting	**East OFS Project Residue Disposal Plan - Groundwater Specialist Study** Overburden Stockpile with and without base preparation	Project No. 548215

Figure 5-13: Overburden Stockpile with and without Base Preparation

6 Impact Assessment

6.1 Assessment of Impacts: Operational Phase

The following potential direct and indirect construction phase impacts on groundwater were identified:

- G1: Reduction in Groundwater Quality from Seepage
- G2: Groundwater Mounding from Seepage
- G3: Cumulative Reduction in Groundwater Quality

6.1.1 Potential Impact G1: Reduction in Groundwater Quality from Seepage

The RSF, tailings backfill (shallow areas and STFs) and Overburden Stockpile are the potential groundwater contaminant sources of the EOFS Project. The RSF base preparation design options include:1) "as is"/no base preparation, 2) engineered base preparation and 3) liner. The tailings will be backfilled into the void in shallow areas and deeper depositional STFs. The maximum volume of water deposited at the RSF, tailings (shallow areas and STFs) and Overburden Stockpile are *c.*17 000, *c.*40 000 and *c.*3 500 m^3/d respectively, with the majority evaporating or returned to the process, though some seeps to groundwater.

Seawater will be used to process East OFS ore; thus, the leachate quality is assumed to be primarily that of seawater (EC of *c.*5 000 mS/m). Natural background water quality in the area has a mean EC of *c.*1000 mS/m indicating poor water quality. Monitoring data and previous modelling have shown an existing contaminant plume in the area with a mean of *c.*1 050 mS/m and a range of *c.*1 000 to *c.*4 900 mS/m. For example, borehole GNS 5 located in the centre of the EOFS proposed mining area (-3456692.34S, 93114.84E), increased by *c.*600 mS/m and *c.*1 000 mS/m for years 2005 and years 2007.

Groundwater flows *c.*10 m below the Groot-Goeraap in the north-east and towards the Sout River in the north-west. There are a few groundwater users within *c.*4 km of the site, which include neighbouring farmers and the Cawood Salt Works.

Predictive numerical groundwater scenarios simulated the additional impacts of the EOFS Project on groundwater, including the RSF base preparation design options. Seepage of the EOFS Project process water, through the deposited material, infiltrates to groundwater resulting in a localised increase in concentrations in the vicinity of the East Mine. To assess the RSF base preparation design options, Layer 3 of the model (representing the RSF base layer) was assigned K values of 1×10^{-8} m/s (material K of RSF) for "as is" (Sc1), and 2.6×10^{-9} m/s and 7.4×10^{-11} m/s over a thickness of 0.3 m for a 'moderate' installed liner (Sc3a) and an 'excellent' installed liner (Sc3b) respectively. The calculations of K for the engineered base preparation (Sc2) are higher than the material K of the RSF (as modelled in Sc1), thus it was not deemed necessary to model as the impact would be greater than that of Sc1.

The modelled results show that the contaminant footprint areas and concentrations are very similar for Sc1 and Sc3 (a and b): i.e. there is little difference/impact between the various RSF base preparation design options.

The key findings of the model results are:

- The plume largely mimics the shape of the seepage areas;
- The contaminant plume migrates from the EOFS mining area in a north-west direction towards the Sout River as well as a north-east direction towards the Groot Goeraap;

- The majority *(c.*70%) of the contaminant plume footprint at LoM is <5% of source concentration;
- Average groundwater concentrations in 2051 in the local area directly underlying the RSF decrease by *c.*7% and *c.*13% for Sc3a and Sc3b respectively, in comparison to Sc1 (Table 5-5), whereas concentrations more than 200m beyond the RSF footprint are very similar across scenarios;
- The maximum concentrations in the Primary Aquifer are *c.*8% higher than the Secondary Aquifer; and
- The Secondary Aquifer contaminant plume extends further *(c.*500 m) than the Primary Aquifer.

Three main local receptors were identified in this study, which include: groundwater, surface water and surrounding private borehole users (including the Cawood Salt Works Mine). The following modelled impacts on these receptors are as follows:

- Surrounding private farming boreholes will not be affected by the EOFS mining as the contaminant plume does not migrate far beyond the MRA;
- The contaminant plume is unlikely to impact the Groot Goeraap River as the plume migrates below the river channel (*c.*10 mbgl) with a maximum concentration of *c.*10% of source. However, surface water seepage may occur during tailings backfill within *c.*300 m of the channel; and
- The contaminant plume may reach up to 5% of the source concentration within a stretch of *c.*50 m along the southern banks of the Sout River (see Figure 5-4). This stretch forms *c.*5% of the baseflow of the Sout River in the study area. Thus, the Sout River concentrations could increase by a maximum of 0.0025% of source concentration. Assuming leachate to be *c.*99% seawater in constitution (with an EC of *c.*5000 mS/m,) this contribution to the Sout River baseflow would equate to an insignificant (and undetectable) maximum EC increase of *c.*12.5 mS/m. The main downstream receptor in the Sout River is the Cawood Salt Works. This maximum predicted increase in salt load of the Sout River would be within the natural salt load variations of the Sout River water and is thus considered to have an insignificant impact to Cawood Salt Works.

In terms of total impact to groundwater on the site, this difference in water quality is considered insignificant, thus the unlined option (Sc1) is supported as a preferred option and is used for the following impact assessment.

The impact to local receptors is assessed to be of ***medium*** significance and with the implementation of mitigation is reduced to ***low*** (Table 7-5).

Table 6-1: Reduction in Groundwater Quality from Seepage

Criteria	*Extent*	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Medium 2	Long-term 3	**Medium** **6**	Possible	**MEDIUM**	**- ve**	High
Essential Mitigation Measures • Continue to monitor boreholes in the existing monitoring network for water quality parameters on a quarterly basis. • Drill an additional three boreholes in the following approximate locations: 1)-31.221185°S,18.000656°E; 2)-31.224872°S;17.895495°E and 3)-31.234620°S;17.892371°E. Monitor these boreholes on a quarterly basis to monitor/detect groundwater concentrations towards the Groot Goerap and Sout River. • Drill an additional monitoring borehole into preferential pathways to monitor plume migration if these are found to intercept the STFs or RSF through geotechnical analysis. • Conduct surface water sampling in the Sout River every six months to monitor the influence of the RSF on river salinity. • If monitoring data shows a significant variation in groundwater levels, (>6 m) compared to the modelling outputs, implement appropriate mitigation measures, such as actively pumping from a strategically placed wellfield(s) to minimise mounding and limit the migration of groundwater in unintended directions (such as towards private boreholes, the shoreline and/or rivers).								
With mitigation	Local 1	Low 1	Long-term 3	**Low** **5**	Improbable	**LOW**	**- ve**	High

6.1.2 Potential Impact G2: Groundwater Mounding from Seepage

Water levels prior to the EOFS Project were already slightly mounded, based on decant observations in the Groot Goeraap River whilst RAS tailings backfill took place in close proximity (*c.*1 km). The extent of mounding and dissipation varies according to the seepage rate and operational period of sources - RSF, mine void backfill (deep areas and STFs) and interim Overburden Stockpile (as discussed in Section 6.1.1).

In addition to contaminant plumes, seepage to groundwater from the RSF, Tailings (shallow areas and STFs) and the Overburden Stockpile also result in temporary, local increases in groundwater levels (mounding).

Model results show that:

- The largest increases (up to *c.*20 m) in local groundwater levels occur below the RSF. Natural local groundwater levels are deep (*c.*60 mbgl) and thus these increased water levels did not show an increase in likelihood of local decant;
- There is little difference (<5 m) between the modelled scenarios in terms of the water level increases for the various RSF base preparation design options;
- The effect of groundwater level mounding is very localised (within *c.*300 m from the source); and
- Temporary seepage may occur in the Groot Goeraap River during backfill in the north of the EOFS mine area.
- The long-term impact of groundwater mounding is insignificant as it is very localised and unlikely to seep as the groundwater levels are deep.

The impact to receptors (groundwater, groundwater users and local rivers) is assessed to be of ***medium*** significance and with the implementation of mitigation is reduced to ***low*** (Table 7-3).

Table 6-2: Groundwater Mounding from Seepage

Criteria	*Extent*	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Medium 2	Long-term 3	**Medium** **6**	Probable	**MEDUIM**	**- ve**	High
Essential mitigation measures: • Continue to monitor boreholes in the existing monitoring network for water levels on a quarterly basis. • Monitor for surface seepages within a 1 km radius of the RSF on a six-monthly basis in potential discharge areas (e.g. topographically low-lying areas and riverbanks). • Monitor potential seepage discharge areas (e.g. topographically low-lying areas and riverbanks) within 50 m of the river on a quarterly basis for a year, if mining or backfilling occurs within 1 km of the Groot Goerap River. • Monitor for surface seepages within a 500 m radius of the Overburden Stockpile biannually; and • If monitoring data shows a significant variation in groundwater levels, (>6 m) compared to the modelling outputs, implement appropriate mitigation measures, such as actively pumping from a strategically placed wellfield(s) to minimise mounding and limit the migration of groundwater in unintended directions (such as towards private boreholes, the shoreline and/or rivers)..								
With mitigation	Local 1	Low 1	Long-term 3	**Low** **5**	Probable	**LOW**	**- ve**	High

6.1.3 Potential Impact G3: Groundwater Contamination from Cumulative Seepage

Natural background water quality (mean *c.*1000 mS/m) exceeds potable drinking water standards with active RAS mining (that has been taking place at the East Mine from 1994) contributing to increased salinity. Thus, the groundwater pre-mining the EOFS is of a generally poor water quality (*c.*1 050 mS/m). To assess the impact of groundwater contamination of the mine as an entirety, all continued and approved operations of the mine (West Mine, East Mine, processing plants, satellite sites etc.) are assumed to be active. Future potential Tronox operations, for which licensing is still underway (such as the Grouwduin se Kop and Die Kom mine expansion areas), were not included in the model scenarios, but are included in this assessment of potential cumulative impacts.

Additional contributors to the degradation of groundwater include:

- Neighbouring farmers that partake in agricultural activities may irrigate and fertilize their land. Fertilizer is a source of nitrogen which is highly soluble, thus has the potential to leach into groundwater; and
- The Cawood Salt Works Mine (the only other mine in the area) may enhance salinization in the Sout River an enable additional saline intrusion. The increase in salinity is inferred by the pumping of groundwater to the evaporation ponds, which then evaporate and precipitate concentrated salts. Potential saline intrusion is inferred from the increase in hydraulic gradient towards abstraction boreholes, potentially allowing for seawater to extend further inland.

The cumulative impact of all local sources on local receptors is assessed to be of ***medium*** significance and with the implementation of mitigation is reduced to ***low*** (Table 6-3)

Table 6-3: Groundwater Contamination from Cumulative Seepage

Criteria	*Extent*	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Medium 2	Long-term 3	**Medium** **6**	Definite	**MEDIUM**	**- ve**	High
Essential mitigation measures: • Continue to monitor boreholes in the existing monitoring network for water quality parameters and water levels on a quarterly basis. • If monitoring data shows a significant variation in groundwater levels, (>6 m) compared to the modelling outputs, implement appropriate mitigation measures, such as actively pumping from a strategically placed wellfield(s) to minimise mounding and limit the migration of groundwater in unintended directions (such as towards private boreholes, the shoreline and/or rivers)..								
With mitigation	Local 1	Medium 2	Medium-term 2	**Low** **5**	Definite	**LOW**	**- ve**	High

6.2 Decommissioning Phase and Post Closure

The following potential direct and indirect construction phase impacts on groundwater were identified:

- G4: Groundwater Contamination from Seepage

6.2.1 Potential Impact G4: Groundwater Contamination from Seepage

Post-closure model simulations cover a period of 100 years, with outputs at 20, 50- and 100-years post-closure (2070, 2100 and 2150). Post-mining groundwater levels are expected to recover very rapidly (a few years), however, the saline contamination plume is expected to take much longer (> 100 years) to return to the natural water quality of the area. The model results show that the contaminant plume concentrations decrease by an average c.30%, 50% and 80% for 2070, 2100 and 2150 respectively. This is due to natural attenuation through dilution and dispersion, with eventual discharge into the ocean.

The impact to receptors is assessed to be of ***low*** significance and with the implementation of mitigation remains ***low*** (Table 7-9).

Table 6-4: Groundwater Contamination from Seepage

Criteria	*Extent*	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Medium 2	Medium-term 2	**Low** **5**	Definite	**LOW**	**- ve**	High
Essential mitigation measures: • Continue to monitor boreholes in the existing monitoring network for water quality parameters and water levels on a quarterly basis for a period of 5 years post-closure. • If contaminated surface seepage is evident within the site boundary at discharge zones, e.g. topographically low-lying areas and riverbanks, monitor these areas on a quarterly basis for a period of 5 years post-closure.								
With mitigation	Local 1	Medium 2	Medium-term 2	**Low** **5**	Definite	**LOW**	**- ve**	High

6.3 Recommended Borehole Network

TNS has an active and extensive groundwater monitoring programme which samples the depths, yield, water levels and water quality since the start of mine (1993 to present). To monitor potential groundwater impacts from the East OFS project the following borehole network recommendations are proposed:

- Continue to monitor boreholes in the existing monitoring network for water quality and quantity parameters on a quarterly basis;

- Add an additional new borehole (in the approximate location of -31.221185°S and 18.000656°E) to the quarterly monitoring network near the northern boundary of the Groot Goeraap River to monitor groundwater concentrations within this river channel;
- Add two new boreholes (in the approximate locations of -31.224872°S;17.895495°E and -31.234620°S;17.892371°E) to the quarterly monitoring network near the north-west boundary (towards the Sout River);
- Drill an additional monitoring borehole into preferential pathways to monitor plume migration if these are found to intercept the STFs or RSF through geotechnical analysis; and
- Move or replace boreholes GNS5, GNS12 and GNS13 (part of the WUL) within the same vicinity, if they are destroyed during mining operations.

7 Conclusions

Based on the data and information discussed in this report, the principal conclusions of the hydrogeological assessment for the EOFS Project (including the RSF, tailings deposition in shallow areas and STFs in the mine void and Overburden Stockpile facilities) are as follows:

- The contaminant plume migrates from the EOFS mining area in a north-west direction towards the Sout River as well as a north-east direction towards the Groot Goeraap;
- The majority *(c.*70%) of the plume footprint is under 5% of source concentration *(c.*3 km radial extent);
- The Primary Aquifer has higher concentrations (*c.*8%) than the Secondary Aquifer.
- The Secondary Aquifers plume extends *c.*500 m further than that of the Primary Aquifer;
- The Overburden Stockpile is unlikely to produce a significant impact as it has a low moisture content (5%) and RAS tailings disposal ceases after a period of 3 years;
- Average groundwater concentrations in 2051 in the local area directly underlying the RSF decrease by *c.*7% and *c.*13% for Sc3a (lined – moderate) and Sc3b (lined-excellent) respectively, in comparison to Sc1, whereas concentrations more than 200m beyond the RSF footprint are very similar across scenarios;
- The contaminant footprint areas and concentrations are very similar between Sc1 and Sc3(a&b), thus there is little difference between the various RSF base preparation design options.
- The largest increases (up to *c.*20 m) in local groundwater levels occur below the RSF. Natural local groundwater levels are deep (*c.*60 mbgl) and thus these increased water levels did not increase the likelihood of local decant;
- There is little difference (<5 m) between the modelled scenarios in terms of the water level increases for the various RSF base preparation design options;
- Temporary seepage may occur in the Groot Goeraap River during backfill in the north of the EOFS mine area;
- Surrounding private farming boreholes will not be affected by the EOFS mining as the contaminant plume does not migrate far beyond the MRA;
- The contaminant plume is unlikely to impact the Groot Goeraap River as the plume migrates below the river channel (*c.*10 mbgl) with a maximum concentration of *c.*10% of source. However, surface water seepage may occur during tailings backfill within *c.*300 m of the channel;
- The contaminant plume may reach up to 5% of the source concentration within a stretch of *c.*50 m along the southern banks of the Sout River. This maximum predicted increase in salt load of the Sout River would be within the natural salt load variations of the Sout River water and is thus considered to have an insignificant impact to Cawood Salt Works;
- The contaminant plume dissipates/decreases by an average *c.*30%, 50% and 80% for 2070, 2100 and 2150 respectively for all scenarios. This is due to natural attenuation through dilution and dispersion, with eventually discharges into the ocean; and
- The impact assessment on ground water resources indicate that the overall significance of impact is assessed as ‘medium to low’ without mitigation measures and ‘low to very low’ with mitigation measures.

The use of an HDPE 'liner' below the RSF (representative of 'Class C' design, due to the permeability of fine material being very similar to that of engineered clay) does not provide significant gain in terms of groundwater protection. With no barrier (nor base preparation) of the RSF, seepage to groundwater is naturally controlled to acceptably low levels by the extremely low permeability of the fines material. The model scenarios (simulations of both with and without a liner) show that the potential contaminant plume from the RSF (defined where concentrations >5% of source) does not migrate further than *c*.200 m from the RSF.

Any base preparation of the Overburden Stockpile is also shown to have negligible improvement to the potential for groundwater contamination.

Thus, Tronox motivates and SRK concurs that the additional capital expenditure required for any form of barrier ('Class C' or 'Class D' / base preparation) of the RSF and Overburden Stockpile is not justified.

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Chris Dalgliesh
Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

8 References

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SRK Consulting (Pty) Ltd (2017). Tronox Namakwa Sands: West Mine Slimes Dam 6 Design – Rev 2.Report Number SRK278/495100.

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Appendices

Appendix A: Specialists Curriculum Vitae

Chris Dalgliesh

Principal Consultant

Profession	Environmental Practitioner
Education	MPhil (EnvSci) with Distinction, Cape Town, 1994 BBusSc (Hons), Cape Town, 1985
Registrations/ Affiliations	Registered Environmental Assessment Practitioner (South Africa) Member International Association of Impact Assessment Director SRK South Africa 2018 - Director SRK Australia 2019 - Director SRK Investments 2011 - Director SRK Global 2013 - 2017 SRK Cape Town Managing Partner 2007 – 2015

Specialisation

Environmental management consulting.

Expertise

Chris Dalgliesh has been involved in management and environmental projects for the past 33 years. His expertise includes:

- EIA and ESIA (EMPR);
- environmental and social due diligence;
- socio-economic impact assessments;
- stakeholder engagement;
- strategic environment assessments and management plans;
- state of environment reporting;
- environmental management frameworks;
- site safety reports for the nuclear industry;
- natural resource management;
- waste management.

Employment

2000 – present	SRK Consulting (Pty) Ltd, Director, Partner and Principal Environmental Consultant
1999 – 2000	Arcus Gibb (Pty) Ltd, Associate, Cape Town, South Africa
1996 – 1998	African Environmental Solutions (Pty) Ltd, Senior Environmental Consultant
1994 – 1996	Environmental Evaluation Unit, Environmental Consultant, UCT
1991 – 1993	Novello Music Publishers, Marketing Manager, London, UK
1988 – 1990	JR Phillips, Product Manager, Wokingham, UK
1986 – 1988	Unilever, Trade and Assistant Brand Manager, Durban, South Africa

Publications

I have been interviewed and quoted in numerous environmental and sustainability articles published in the press and sector specific journals, including *Engineering News, Mining News, Business Report and Cape Times,* and am a frequent guest lecturer.

Languages

English – read, write, speak

Afrikaans – read, write, speak

Dutch - read

Chris Dalgliesh
Principal Consultant

Environmental and Social Impact Assessment (ESIA) and Environmental Management Programmes (EMP)

- Tronox Mineral Sands, EIA for East Mine In-Pit Residue Storage Facility, Namakwa Sands Mine, Brand se Baai, South Africa, 2019 – ongoing, R900 000
- N.V. Energiebedrijven Suriname, ESIA for Tout lui Faut Kanaalweg Power Plant, Wanica District, Suriname, 2019, US$115 000
- Eskom, EIA for Kappa-Sterrekus Powerline, Western Cape Province, South Africa, 2019 - ongoing, R3 000, 000
- Staatsolie Maatschappij Suriname, ESIA for Cyclic Steam Stimulation Enhanced Oil Recovery Project, Saramacca District, Suriname, 2019, US$50 000
- Staatsolie Maatschappij Suriname, ESIA for Polymer Flood Enhanced Oil Recovery Project, Saramacca District, Suriname, 2019, US$85 000
- Maritieme Autoriteit Suriname, ESIA for Suriname River Dredging Project, Suriname, 2019, US$185 000
- Staatsolie Maatschappij Suriname, ESIA for Saramacca Power Plant, Saramacca District, Suriname, 2018 - 2019, US$125 000
- Tronox Mineral Sands, EIA for coastal setback prospecting, Namakwa Sands Mine, Brand se Baai, South Africa, 2018 – ongoing, R800 000
- Motaengil Africa, IFC compliant EIA for Patriota Hospital, Luanda, Angola, 2018 – ongoing, R640 000
- Ricocure (Pty) Ltd, EIA for Exploration Right application for Offshore Block 3B, West Coast, South Africa, 2018-2019, R150 000
- Sezigyn (Pty) Ltd, EIA for Exploration Right application for Offshore Mid-Orange Basin, West Coast, South Africa, 2018-2019, R150 000
- Rheinmetall Denel, Multi Purpose Nitration Plant EIA, Wellington, Western Cape Province, South Africa, 2018 - ongoing, R650, 000
- Impact Oil and Gas, Orange Deep Basin Seismic Survey EIA, Offshore West Coast, South Africa, 2017, R600,000
- AES, Bengo Landfill EIA, Angola, 2017 - ongoing, US$80,000
- Sungu Sungu Oil (Pty) Ltd, Pletmos Basin EIA, Offshore Southern Cape, South Africa, 2017, R525,000
- City of Cape Town, Vissershok North Landfill Waste Management Licence, Cape Town, Western Cape Province, 2016 – ongoing, R1 250,000
- Mineral Sand Resources, Tormin Mine EIA, Lutzville, Western Cape Province, 2016 – ongoing R1,250,000
- Department of Agriculture, Forestry and Fisheries, Project Definition and EIA for a proposed Aquaculture Development Zone in Saldanha Bay, Western Cape, 2016 – 2018, R1,000,000
- Easigas, EIA for LNG Plant, Mossel Bay, Western Cape Province, South Africa, 2016 – 2017, R600,000
- Gyproc St Gobain, EMPr for gypsum mine, Vanrhynsdorp, Western Cape Province, South Africa, 2016, R125,000
- Tronox Namakwa Sands, EIA for new slimes dam, Brand se Baai, Western Cape Province, South Africa, 2015 – ongoing, R900,000
- The River Club, EIA for redevelopment of the property, Cape Town, Western Cape Province, South Africa, 2015 – ongoing, R1 900,000
- SIMO Petroleum Ltd, ESIA for fuel supply project, Guinea, 2015, US$200,000

Chris Dalgliesh
Principal Consultant

- SIMO Petroleum Ltd, EIA for fuel supply project, Liberia, 2015, US$200,000
- Eskom, EIA for Transient Interim Storage Facility, Western Cape, South Africa, 2015 – ongoing, R900,000
- Falcon Oil & Gas, Environment Management Programme Report (EMPr) update and engagement, Western, Northern and Eastern Cape, South Africa, 2014 – 2015, US$90,000
- Department of Environmental Affairs (DEA), Waste Management Licence applications and Basic Assessment for 20 waste facilities, Western Cape, South Africa, 2014 – 2015, R2,600,000
- Sable Mining / West Africa Explorations (WAE), Cumulative Impact Assessment (CIA) for WAE's Nimba iron ore mine, Guinea, May 2014 – on hold, US$90,000
- De Beers Buffalo Camp, Basic Assessment and EMPr Amendment, Kimberley, Northern Cape, 2014, R260,000
- EFG Engineers, EIA for Hermanus bypass road, Western Cape Province, South Africa, 2014 – 2017, R1,200,000
- SRK Turkey, CIA of Copler gold mine, Turkey, 2014, US$30,000
- Sable Mining Africa Ltd, ESIA for railway line and port expansion, Liberia, 2014, US$480,000
- Tronox Namakwa Sands, EIA for abalone farm, Brand se Baai, Western Cape Province, South Africa, 2014 – ongoing, R1,050,000
- Matzikamma Municipality, EIAs for three abalone farms, Doringbaai, Western Cape Province, South Africa, 2014 – ongoing, R1,100,000
- De Beers, EMPr amendment for fine residue pond, Kimberley, South Africa, 2013, R120,000
- AES, ESIA of landfill, Soyo, Angola, 2013, US$70,000
- PetroSA, EIA of offshore gasfield, Southern Cape, South Africa, 2013 – ongoing, R500,000
- EnergieBedrijven Suriname, ESIA for new power plant, Suriname, 2013, US$135,000
- AES, ESIA of Thermal Desorption Unit, Soyo, Angola, 2013, US$65,000
- Staatsolie Maatschappij Suriname, Rapid EIA of power plant expansion, Suriname, September 2012 – 2014, US$100,000
- BP, ESIA of Blocks 18 & 31 Drilling and Seismic Survey, Angola, 2012, US$40,000
- Frontier, EIA for desalination plant and water pipeline, Abraham Villiers Bay, Northern Cape, South Africa, August 2012 – ongoing, R1,250,000
- Tronox Namakwa Sands, EIA /EMPr for two mining application areas, Namakwaland, Western Cape Province, South Africa, 2012 – ongoing, R1,250,000
- Airports Company South Africa, EIA of realignment of runway, Cape Town International Airport, Western Cape, South Africa, R3,175,000
- Grindrod Mauritius, EIA of Matola Coal Terminal Phase 4 Expansion, Maputo, Mozambique, 2012 - 2013, US$425,000
- Maersk, ESIA of Block 16 Seismic Survey, Angola, 2010 – 2011, US$25,000
- Staatsolie Maatschappij Suriname, EIA for diesel, gasoline and LGP pipelines, Suriname, October 2011 – 2013, US$120,000
- Premier Fishing, EIA for re-establishment of fishmeal plant, Saldanha Bay, South Africa, May 2011 – 2015, R1,200,000
- Eni Angola BV, ESIA of development of Block 15/06 West Hub oil fields, Angola, 2011 - 2013, US$110,000

Chris Dalgliesh
Principal Consultant

- Falcon Oil & Gas, EMPr, Western, Northern and Eastern Cape, South Africa, 2010 – 2011, US$100,000
- Great Western Minerals Group, EIA and EMPr of rare earth mine, Vanrhynsdorp, Western Cape, South Africa, 2010 – 2012, R1,760,000
- Vale, ESIA of phosphate mine, Nampula Province, Mozambique, 2010 – 2013, US$630,000
- Sonangol Lda, EIA (x6) of onshore hydrocarbon facilities, Luanda, Malange and Lubango, Angola, March – November 2010, US$280,000
- Empresa Moçambicana de hidrocarbonetos and Buzi Hydrocarbons Pty Ltd, ESIA for seismic surveys and exploration drilling in Buzi Block, Sofala Province, Mozambique, 2009 – 2010, US$200,000
- Staatsolie, ESIA of refinery expansion, Paramaribo, South America, 2009 – 2010, US$400,000
- Sasol Technology, EIA for proposed new gas pipeline from Ressano Garcia to Moamba, Mozambique, Moamba, Mozambique, 2009 – 2010, R1,000,000
- Anglo American, State of Environment Report, Strategic Environment Assessment, and ESIA of Gamsberg zinc mine, Aggeneys, South Africa, 2008 – 2010, R13,000,000
- CIC Energy, Environmental screening and fatal flaw assessment of Trans Kalahari Railroad and port, Botswana and Namibia, 2008 – present, R1,300,000
- BHP Billiton, ESIA of Corantijn River dredging, Suriname, 2007 – 2008, US$750,000
- BHP Billiton, ESIA of Bakhuis transport project, Suriname, 2006 – 2008, US$1,600,000
- Altona Developments, EIA of mixed development, Worcester, Western Cape Province, South Africa, 2006 – 2010, R750,000
- BHP Billiton, ESIA of Bakhuis bauxite mine, Suriname, 2005 – 2008, US$3,200,000
- Levendal Developments (Pty) Ltd, EIA of mixed development, Suider-Paarl, Western Cape Province, South Africa, 2005 – 2008, R450,000
- Bevcan, Angola, EIA of canning facility, Viana, Angola, 2005 -2010, US$75,000
- Chevron Texaco, EIA of landifll, Cabinda, Angola, 2004 – 2005, US$90,000
- Attpower Developments (Pty) Ltd, EIA of mixed coastal development, Mossel Bay, Western Cape Province, South Africa, 2004, R600,000
- Intels Services Luanda, EIA of landifll, Cacuaco, Angola, 2004, US$65,000
- Kwezi V3, EIA of waste water treatment works, Gansbaai, Western Cape Province, South Africa, 2003 – 2005, R350,000
- City of Cape Town, EIA of Fisantekraal waste water treatment works, Cape Town, Western Cape Province, South Africa, 2003 – 2004, R450,000
- St Francis Bay Municipality, EIA of beach remediation, St. Francis Bay, Eastern Cape Province, South Africa, 2002 – 2003, R300,000
- City of Cape Town, Environmental Impact Control Report of Vissershok North landfill, Western Cape Province, South Africa, 2001 – 2004, R175,000
- NDC, EMPr for NDC diamond mine, Vredendal district, Western Cape Province, South Africa, 2001 – 2003, R800,000
- Coega Development Corporation, EIA for rezoning, Eastern Cape Province, South Africa, 1999, R85,000
- BHP Billiton, EIA (Scoping) of Alusaf Hillside smelter, Richards Bay, KwaZulu-Natal Province, South Africa, 1999, R150,000

Chris Dalgliesh
Principal Consultant

- Gencor, EIA of zinc refinery and phosphoric acid plant, Port Elizabeth, Eastern Cape Province, South Africa, 1995 – 1998, R800,000
- Duferco, EIA of steel rolling mini-mill, Saldanha, Western Cape Province, South Africa, 1997, R90,000
- Hoechst, EIA of polymer extension, Durban, KwaZulu-Natal Province, South Africa, 1993 – 1994, R280,000

Environmental Planning and Natural Resource Management

- Tronox Mineral Sands (Pty) Ltd, renewal of the Atmospheric Emission Licence for the Namakwa Sands UMM Plant, Brand-se-Baai, Western Cape, 2018-ongoing, R320 000
- Tronox Mineral Sands (Pty) Ltd, renewal of the Atmospheric Emission Licence for the Namakwa Sands Mineral Separation Plant, Koekenaap, Western Cape, 2018-ongoing, R290 000
- Tronox Mineral Sands (Pty) Ltd, renewal and variation of the Atmospheric Emission Licence for the Namakwa Sands Smelter Plant, Saldanha, Western Cape, 2018-ongoing, R300 000
- Kudumane Manganese Resources, EMP Amendment for KMR Manganeese Mine, Hotazel, Northern Cape, 2017 – ongoing, R170 000
- Eskom, Ecological Reports, Duynefontyn and Thyspunt, Nuclear Site Safety Reports Update, South Africa, 2017 – present, R800,000
- DEA&DP, Western Cape State of Environmental Report, 2017, R1,700,000
- Tronox Namakwa Sands, Development of Closure Commitments and Rehabilitation Monitoring Plan Namakwaland, Western Cape Province, South Africa, 2015 – ongoing, R600,000
- West Coast District Municipality, Integrated Coastal Management Plan, West Coast, South Africa, 2012 – 2013, R700,000
- City of Cape Town, Environmental Management Framework and control zones, Cape Town, Western Cape Province, South Africa, 2008 – 2009, R600,000
- Eskom, Ecological Reports, Koeberg, Bantamsklip and Thyspunt, South Africa, 2008 – 2013, R900,000
- City of Cape Town, Environmental Management Framework and control zones, Cape Town, Western Cape Province, South Africa, 2008, R500,000
- Knysna Municipality, State of Environmental Report, Western Cape Province, South Africa, 2004 – 2005, R130,000
- DEA&DP, Western Cape State of Environmental Report, 2004 – 2005, R1,400,000

Environmental and Social Review and Due Diligence

- Eramet Comilog Manganese, Environmental Regulatory Due Diligence of Heavy Minerals Mine, Alexander Bay, South Africa, 2020, €11 000
- HSBC, Environmental and Social Compliance Monitoring of Fertilizer Plant and Railway Line, Ghorashal, Bangladesh, 2020 – 2032, $670 000
- BNP Paribas, Environmental and Social Due Diligence of Elandsfontein mine Expansion, Langebaan, South Africa, 2020, R115 000
- Euler Hermes/ UniCredit / Voith, Environmental and Social Due Diligence and Action Plan of Caculo Cabaca Hydropower Dam, Angola, 2020, €30 000
- Vedanta - Black Mountain Mining (Pty) Ltd, BMM and Gamsberg EMPr Performance Assessment, Northern Cape Province, South Africa, 2019, R125,000
- Easigas, ESDD of Avedia LPG terminal, Saldanha Bay, South Africa, 2018, R90 000

Chris Dalgliesh
Principal Consultant

- Kropz, Environmental and Social Due Diligence for Competent Persons' Report, Elandsfontein mine, Langebaan, South Africa, 2018, R130 000
- Standard Bank South Africa Limited, Environmental and Social Due Diligence and Environmental and Social Action Plan (ESAP) for Caculo Cabaca Hydropower Dam, Angola, 2017, $23 000
- Voith Hydro, Zenzo Hydroelectric Project Gap Analysis and Environmental and Social Action Plan, Angola, 2017, €30 000
- Voith Hydro, Koysha Hydroelectric Project Gap Analysis, Ethiopia, 2017, €15 000
- AES, Cacuaco Landfill Environmental Compliance Audit, Luanda, Angola, 2017, US$17,500
- Industrial and Commercial Bank of China, Environmental and Social Due Diligence and Environmental and Social Action Plan (ESAP), and Annual Compliance Audits for Caculo Cabaca Hydropower Dam, Angola, 2016-2017, $31 000
- Deutsche Bank, Environmental and Social Due Diligence and Annual Review of Be'er Tuvia Combined Cycle Gas Turbine Power Plant, Israel, 2016 – 2022, €150 000
- Confidential, Environmental and Social Gap Analysis of Caculo Cabaca Hydropower Dam, Angola, 2016, €20 000
- BNP Paribas, Environmental and Social Due Diligence of Elandsfontein mine, Langebaan, South Africa, 2015, R60,000
- Tronox Namakwa Sands, Water Use Licence Audit(s), Namakwaland, Western Cape Province, South Africa, 2015 and 2014, R175,000 (x2)
- Tronox Namakwa Sands, EMPr Performance Assessment, Namakwaland, Western Cape Province, South Africa, 2014, R175,000
- Deutsche Bank, Environmental and Social Due Diligence and Annual Review of Lauca Hydropower Dam, Angola, 2014 – 2018, €300 000
- West Africa Exploration Ltd, Environment and social gap analysis of Nimba iron ore mine, Guinea, 2014, US$80,000
- HSBC, Environmental and Social Due Diligence and Annual Review, Cambambe Hydropower Dam, Angola, 2013 – 2017, €255,000
- Tronox Namakwa Sands, EMPr Performance Assessment, Namakwaland, Western Cape Province, South Africa, 2012 – 2013, R150,000
- Biovac, Environmental due diligence audit of pharmaceutical plant, Cape Town, Western Cape Province, South Africa, 2012, R100,000
- SRK UK, Environmental Due Diligence of phosphate mine, Brazil, 2010, US$15,000
- SRK Russia, Environmental Due Diligence of Rossing South uranium mine, Namibia, 2009, US$12,000
- SonaGas, EIA external review of LNG plant EIA, Soyo, Angola, 2006, US$50,000
- Confidential, Environmental Due Diligence, Cape Town, Western Cape Province, South Africa, 2004, R80,000
- Netherlands Commission for EIA, External EIA review of Mavoco hazardous landfill EIA, Maputo, Mozambique, 2002, R30,000

Management Plans

- Black Mountain Mining (Pty) Ltd, Gamsberg Mine IWWMP Update, Aggenys, Northern Cape Province, South Africa, 2018 – ongoing, R185 000

Chris Dalgliesh
Principal Consultant

- West Africa Exploration Ltd, Stakeholder Engagement Plan, Guinea, 2014, US$15,000
- West Africa Exploration Ltd, Biodiversity Action Plan, Guinea, 2014, US$20,000
- Tronox Namakwa Sands, Integrated Water and Waste Management Plan for Namakwa Sands mine, Namakwaland, Western Cape Province, South Africa, 2013 – 2014, R125,000
- Tronox Namakwa Sands, Integrated Water and Waste Management Plan for Namakwa Sands Smelter, Saldanha Bay, Western Cape Province, South Africa, 2013, R110,000
- BHP Billiton, Conceptual Closure and Rehabilitation Plan, Suriname, 2007 – 2013, US$210,000
- Namakwa Sands, Closure Plan, Namakwaland, Northern Cape Province, South Africa, 2003, R170,000

Socio Economic Impact Assessments

- Allied Gold Corp, Economic specialist study for the Dish Mountain Gold Project, Ethiopia, 2018 – ongoing, $11 000
- Joule Africa, Initial Environmental and Social Assessment of the KPEP Hydropower Project, Cameroon, 2018 – ongoing, $10,800
- Anglo Gold Ashanti, Economic Baseline Report for Siguiri Gold Mine, Guinea, 2018, R130 000
- Pam Golding / Pennyroyal (Gibraltar) Ltd., Economics benefits analysis of Amber Resort Development, Zanzibar, Tanzania, 2017, R300 000
- RSK, EACOP Pipeline Economic Study, Uganda and Tanzania, 2017, $ 40,000
- SRK UK, Sintoukola Potash Mine Economic Impact Assessment, Republic of Congo, 2012, $30,000
- Staatsolie Maatschappij Suriname, Refinery Expansion Community Relations Plan, Suriname, 2011, $120,000
- SRK UK, Reko Diq Phosphate Mine Review of Economic Impact Assessment, Pakistan, 2010, $7,500
- DEADP, Western Cape State of the Environment Report Economic Study, 2004, R40,000

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Profession	Hydrogeologist / Groundwater Modeller
Education	MSc, Hydrogeology (distinction), University of Birmingham, UK, 2006 BSc (Hons) (cum laude), University of Kwa-Zulu Natal, Computer Science, 1997 BSc (summa cum laude), University of Kwa-Zulu Natal, Applied Maths and Computer Science, 1996
Registrations/ Affiliations	Pr Sci Nat (South Africa), 400263/09 (Water Resources and Mathematical Science) Member, GSSA (Groundwater Division) Prince 2 (Project Management) Practitioner
Awards	SRK Chairman's Award 2019 ESI Top MSc Project Award NERC (Natural Environment Research Council) Scholarship Award

Specialisation

Groundwater numerical flow and transport modelling, groundwater resource evaluation, pumping test analysis, groundwater monitoring, wellfield development and management, project management, disaster risk reduction, software and database development

Expertise

Sheila has 21 years of experience, with 8 years in IT software development, mathematics and project management, followed by 13 years specialising in water related projects and groundwater numerical modelling. Her expertise includes:

- tailings seepage modeling;
- numerical flow and transport modeling;
- regional groundwater resource assessment;
- applied mathematics and statistics;
- pumping test analysis;
- municipal groundwater supply, groundwater resource evaluation and wellfield development, groundwater management;
- waste disposal site investigations;
- groundwater monitoring;
- database development;
- process development and implementation; and
- project management.

Employment

2012 – present	SRK Consulting (Pty) Ltd, Principal Hydrogeologist, Cape Town
2009 – 2012	Umvoto Africa, Senior Hydrogeologist, Cape Town
2006 – 2009	Entec UK, Hydrogeologist, Shrewsbury (UK)
1998 – 2005	Unilever, IT Software Developer and Project Manager, Durban (SA) and St David's Park (UK)

Publications

Publications on groundwater, tailings facilities and disaster risk reduction

Languages

English – read, write, speak

Afrikaans – read, write (fair)

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Publications

1. W Rouncivell, S Imrie, GC Howell and HAC Meintjes. (2020). 3D Seepage Modelling in Tailings Storage Facility Analysis and Design for Low Permeability Lined Basins. Tailings Storage Conference 2020. The Southern African Institute of Mining and Metallurgy.

2. S. Imrie and D. Visser. (2015). Best Practice' and Value Adding Approach to Undertaking Detailed Groundwater Impact Assessment Studies for Solar Energy Projects. Biennial Groundwater Conference, Muldersdrift, Gauteng, South Africa.

3. S Imrie, ER Hay, A Mlisa, L Hackland & G Tomren. (2011). Namibian Disaster Risk Reduction School Manual and System Strengthening Initiative. Disaster Management Institute of South Africa Conference, Somerset West, 2011.

4. S. Imrie and LV. Sherenberg. (2012). Case Study of Groundwater Supply to the Small Western Cape Coastal Town of Stanford. The Water Institute of Southern Africa Conference, Cape Town, 2012.

5. S. Imrie, K. Riemann, ER. Hay, K. Goldberg, S. Law, D. Laidler and G. Isaacs. (2010). Monitoring and Evaluation System for the Western Cape Climate Change Response Strategy and Action Plan, Disaster Management Institute of South Africa Conference. Jeffrey's Bay, South Africa, 2010

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Mexico
Project duration & year:	Apr 2020 - Dec 2020
Client:	Torex Gold Resources Inc.
Name of Project:	Media Luna Stage 2-Geotechnical / Hydrogeology FS
Project Description:	Regional groundwater modelling to inform feasibility study (mine and tunnel)
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	USD 15 000

Location:	Kazakhstan
Project duration & year:	Jun 2020 - Oct 2020
Client:	KAZ minerals
Name of Project:	Aktogay Groundwater Contaminant Transport Modelling
Project Description:	Assess the potential impact to groundwater from mining contaminant sources
Job Title and Duties:	Contaminant Transport Numerical Modeller
Value of Project:	GBP 20 000

Location:	Crown Mountain Project, British Columbia, Canada
Project duration & year:	Nov 2019 - May 2020
Client:	NWP Coal Canada
Name of Project:	Groundwater Assessment
Project Description:	Regional groundwater modelling to inform impact assessment
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	CAD 20 000

Location:	Harare, Zimbabwe
Project duration & year:	March 2020 - April 2020
Client:	Zimbabwe Platinum Mines (Pvt) Ltd
Name of Project:	Selous Metallurgical Complex Preliminary Design of the TSF Extension
Project Description:	Assessing the tailings seepage stability design
Job Title and Duties:	Tailings Seepage Numerical Modeller.
Value of Project:	R 1 000 000

Location:	North-Western, Zambia
Project duration & year:	February 2020 - April 2020
Client:	First Quantum Minerals (Ltd)
Name of Project:	Enterprise Nickel Deposit Hydrogeological Study
Project Description:	Construct the groundwater numerical model and assess dewatering strategies
Job Title and Duties:	Hydrogeologist/Groundwater Numerical Modeller.
Value of Project:	R 300 000

Location:	Glenwood, Kwa-Zulu Natal, South Africa
Project duration & year:	Dec 2019- Jan 2020
Client:	Da Gama Textiles
Name of Project:	Groundwater Impact Assessment Study – Da Gama Textiles, King Williams Town, Eastern Cape
Project Description:	Construct the groundwater numerical model and assess groundwater impacts associated with Da Gama Textile factory.
Job Title and Duties:	Hydrogeologist/Groundwater Numerical Modeller.
Value of Project:	R 150 000

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience:	**Hydrogeology & numerical groundwater flow and transport modelling**
Location:	Suriname
Project duration & year:	Intermittent: Feb 2019 to Nov 2019
Client:	Staatsolie
Name of Project:	Environmental Impact Assessment - Groundwater Specialist Study
Project Description:	Numerical modelling for groundwater impact assessment from polymer flooding and steam injection for enhanced oil recovery.
Job Title and Duties:	Density, viscosity and thermal dependent numerical modelling
Value of Project:	USD 60 000
Location:	Zambia
Project duration & year:	8 Months: Jun 2019 to Feb 2020
Client:	First Quantam Minerals
Name of Project:	Trident Project
Project Description:	Numerical modelling of the potential pit inflows and dewatering requirements for Enterprise pit.
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R 120 000
Location:	Umbogintwini, Kwazulu Natal
Project duration & year:	April 2019 to Ongoing
Client:	AECI
Name of Project:	AECI EISB Cycle 4
Project Description:	Hydrogeological study: Assess groundwater flow, potential contamination migration, remediation options and assessment of source, pathway, receptors
Job Title and Duties:	Groundwater Numerical Modelling (Flow & Transport) Reviewer
Value of Project:	R 400 000
Location:	Lutzville, Western Cape, South Africa
Project duration & year:	Nov 2019- February 2020
Client:	Tronox Mineral Sands (Pty) Ltd
Name of Project:	Environmental Impact Assessment for East Mine In-Pit RSF - Namakwa Sands Mine
Project Description:	Groundwater impact assessment.
Job Title and Duties:	Hydrogeologist. Specialist input towards the groundwater impact.
Value of Project:	R 1 300 000
Location:	Mareesburg, South Africa
Project duration & year:	Ongoing: Sept 2018 to June 2019
Client:	AngloAmerican Platinum
Name of Project:	Numerical 3D modelling of tailings storage facility (TSF)
Project Description:	Detailed Feflow 3D numerical modelling of the tailings facility. Calibration to pre pressures of uCPTs and piezometric levels. Conceptual modelling to meet understanding of geotechnical team and 2D slide modelling. 3D predictive scenarios to inform the design and management of future elevated drains.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Mexico
Project duration & year:	3 Months: Jul 2018 to Sep 2018
Client:	Ixtaca
Name of Project:	Groundwater Model Review
Project Description:	Numerical modelling of the potential pit inflows and dewatering requirements, as well as detailed modelling of the pit lake rebound at the proposed Ixtaca mine site. Working in conjunction with the SRK Denver office.

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience:	**Hydrogeology & numerical groundwater flow and transport modelling**
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	USD 20 000
Location:	Near Ndolo, border of Zambia and DRC
Project duration & year:	6 Months: Jun 2018 to Nov 2018
Client:	Frontier Mine
Name of Project:	Groundwater Model Update for pit dewatering
Project Description:	Site visit and assessment. Review of previous modelling. Updates to model including model boundary, altering the recharge conceptual & numerical modelling approach, updating geology and mine plans and running of predictive scenarios for dewatering management.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R 200 000
Location:	Ghana
Project duration & year:	Ongoing: March 2018 to current
Client:	Iduapriem, AngloGold Ashanti
Name of Project:	Numerical 3D modelling of lined tailings facility (GTSF)
Project Description:	Detailed Feflow 3D numerical modelling of the tailings facility. Calibration to pre pressures of uCPTs and piezometric levels. Conceptual modelling to meet understanding of geotechnical team and 2D slide modelling. 3D predictive scenarios to inform the design and management of future elevated drains.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Greater Cape Town area, Western Cape
Project duration & year:	2 months: May 2018 to Jun 2018
Client:	Firelec Telkom
Name of Project:	Water Supply and Feasibility Study
Project Description:	Desktop hydrogeological feasibility assessment of multiple Telkom sites to inform the next phase of siting and drilling boreholes for water supply.
Job Title and Duties:	Principal Hydrogeologist
Value of Project:	R 57 000
Location:	Saldanha Bay, Western Cape
Project duration & year:	1 Year: Sept 2017 to Sept 2018
Client:	Tronox Namakwa Sands Smelter
Name of Project:	Water Supply
Project Description:	Hydrogeological survey with an emphasis on evaluating the deep groundwater resource and the feasibility and subsequent recommended wellfield setup for water supply. Included hydrocensus, geophysics, siting, drilling, pump testing and numerical modelling.
Job Title and Duties:	Principal Hydrogeologist
Value of Project:	R 630 000
Location:	Husab Mine, Namibia
Project duration & year:	4 Months: November 2017 to February 2018
Client:	Swakop Uranium Mine
Name of Project:	Groundwater Model Review
Project Description:	Numerical modelling of the potential pit inflows and dewatering requirements of the Zone 1 and Zone 2 pits at Husab mine.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Minnesota, United State of America
Project duration & year:	3 Months: October 2017 to December 2017
Client:	Twin Metals Mine
Name of Project:	Groundwater Model Update and Code Conversion
Project Description:	Update and code conversion of the regional numerical groundwater model, for us in simulating pit inflows and slope stability (pore pressures) at the pit.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	USD 10 000
Location:	Katanga Province, Democratic Republic of Congo
Project duration & year:	4 Months: May 2017 to August 2017
Client:	Tenke Fungurume Mine
Name of Project:	Groundwater Model Review
Project Description:	To assess the current analytical methods and numerical models for planning and management of the pit-dewatering programme, and to define practical solutions for increasing the robustness and reliability of those tools.
Job Title and Duties:	External Reviewer/Advisor - Groundwater Analytical and Numerical Modelling
Value of Project:	USD 17 000
Location:	Aurizona, Brazil
Project duration & year:	3 months: May to July 2017
Client:	Trek Mining Inc.
Name of Project:	Hydrogeological Assessment for Feasibility Study
Project Description:	To provide technical input to the Feasibility Study for assessing the viability of reopening the mine, including hydrogeological evaluation of the site groundwater system (in particular the impacts on open pit geotechnical stability studies), site scale groundwater movement for operations, and closure assessment of potential impacts on the local hydrogeological system.
Job Title and Duties:	Data Analysis, Conceptual Modelling and Unsaturated Flow Seepage Modelling
Value of Project:	USD 10 000
Location:	MSP
Project duration & year:	4 months: June to September 2017
Client:	Tronox, Namakwa Sands
Name of Project:	Geohydrological Review
Project Description:	Review of all monitoring data between 2013 and 2016 and subsequent update to the numerical groundwater model and development of recommendations for future groundwater management at the site.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Sasol De Bron
Project duration & year:	2 months: July to August 2017
Client:	Sasol
Name of Project:	Dewatering Modelling
Project Description:	Development and calibration of a local flow model to simulate multiple dewatering scenarios and thus define the most appropriate locations and rates to dewater shallow aquifer water at the site so as to contain the spread of contaminants.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R 65 000

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Ryst Kuil, Western Cape
Project duration & year:	1 Year: Aug 2016 to July 2017
Client:	Tasman Lukisa JV Company (Pty) Ltd
Name of Project:	Karoo Uranium Project Groundwater Investigation
Project Description:	Construct calibrated numerical flow models of the mine application areas and then us flow and contaminant transport scenarios of the multiple (>40) small pits and underground mining areas to inform the assessment of potential mine impacts and water supply.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Phalaborwa, Limpopo, South Africa
Project duration & year:	12 Months: January 2016 to December 2016
Client:	Palabora Copper Mine (Pty) Ltd
Name of Project:	Groundwater Transport Conceptual and Numerical Modelling to Inform Remediation Programme
Project Description:	Detailed hydrogeological and hydrological (GW/SW) re-assessment of conceptual model on site. Detailed update of numerical model. Model simulations and analysis to inform site remediation programme.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Brand-se-Baai, West Coast, Western Cape
Project duration & year:	2 Months: September 2016 to November 2016
Client:	Tronox Mineral Sands (Pty) Ltd
Name of Project:	Tronox Slimes Dam Seepage Modelling
Project Description:	Groundwater to surface water interaction coastal seepage flow modelling for groundwater specialist study input to environmental impact assessment.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Elandsfontein, Hopefield, South Africa
Project duration & year:	2 Years: August 2015 to June 2016
Client:	Elandsfontein Exploration & Mining (Pty) Ltd
Name of Project:	Elandsfontein Phosphate Mine Pit Dewatering Wellfield Design
Project Description:	Hydrogeological flow modelling and scenario simulation for design and continued management of a pit dewatering wellfield.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential
Location:	Gauteng, South Africa
Project duration & year:	2014 - 2015
Client:	Lonmin Plc
Name of Project:	Lonmin Mine: Hydrogeological Specialist Study
Project Description:	Detailed hydrogeological assessment and numerical flow and transport model, required as one of the specialist studies for input to the Environmental Impact Assessment (EIA), Environmental Management Plan (EMP) and Water Use Licence (WUL) amendment.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Gauteng, South Africa
Project duration & year:	2014 - 2015
Client:	Royal Bafokeng Platinum (Pty) Ltd
Name of Project:	Styldrift L-Shape Tailings Disposal Site: Hydrogeological Specialist Study
Project Description:	Detailed hydrogeological assessment and numerical flow and transport model, required as one of the specialist studies for input to the Environmental Impact Assessment (EIA), Environmental Management Plan (EMP) and Water Use Licence (WUL) amendment documentation for the Styldrift Mine Complex with specific reference to the proposed L-shaped TSF facility. The site assessment was focused on the L-TSF area which is located adjacent to the existing TSF but makes reference to the regional Study Area which encompasses both the Styldrift and BRPM operations.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R 130 000

Location:	Limpopo, South Africa
Project duration & year:	2014 - 2015
Client:	Marula Platinum
Name of Project:	Numerical Groundwater Flow and Transport Model for Marula Platinum Mine
Project Description:	Groundwater Numerical Flow and Transport Modelling for the Marula Platinum Mine (phase 1) in support of both the EMP and the WUL and in order to provide a tool to manage the groundwater impacts for the mine.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R 150 000

Location:	Brand-se-Baai, West Coast, Western Cape
Project duration & year:	10 months, 2014
Client:	Tronox, Namakwa Sands
Name of Project:	Geohydrological Assessment and Numerical Modelling (Mine Site at BsB)
Project Description:	Three phase project covering the geohydrological assessment and numerical groundwater flow and contaminant transport modelling at the Namakwa Sands mine, along with multiple future scenarios, analysis and groundwater management recommendations
Job Title and Duties:	Project Manager, Principal Groundwater Numerical Modeller
Value of Project:	R 300 000

Location:	Namibia
Project duration & year:	1 year: 2013 to 2014
Client:	Skorpion Zinc
Name of Project:	Gergarub Feasibility Study
Project Description:	Hydrogeology Specialist study and Groundwater Numerical Flow and Transport Modelling in support of the Gergarub Mine Feasibility study, geotechnical design and EIA.
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R 200 000 (groundwater modelling task, fees)

Location:	Farm Kalkaar 389, Jacobsdal, Free State Province, South Africa
Project duration & year:	7 Months: October 2013 to June 2014
Client:	SLR Consulting (Africa) (Pty) Ltd
Name of Project:	Kalkaar Solar Thermal and PV Energy Power Plant EIA
Project Description:	Specialist Hydrogeological Impact Assessment
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	Confidential

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Rooipunt, Upington, Northern Cape Province, South Africa
Project duration & year:	3 Months: October 2013 to December 2013
Client:	WorleyParsons RSA Pty Ltd
Name of Project:	Rooipunt Solar Thermal Energy Power Plant EIA
Project Description:	Development of numerical groundwater flow and transport model, the results of which were required for input to the project Hydrogeological Scoping and Impact Assessment for the EIA
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R 70 000 (groundwater modelling task)

Location:	Atlantis, West Coast, South Africa
Project duration & year:	5 months, June 2013 to October 2013
Client:	Wellcore / Atlantis Foundries
Name of Project:	Groundwater Modelling for Atlantis Foundries Sand Mining Site
Project Description:	Development of a numerical groundwater model to simulate the 'jetted wellpoint' wellfield expansion programme at the Atlantis Foundries Sand Mining Site for abstraction of water for sand washing. The groundwater model purpose was to facilitate appropriate siting, design and management of the wellfields.
Job Title and Duties:	Project Manager, Groundwater Numerical Modeller
Value of Project:	R 180 000

Location:	Ndlambe Local Municipality, Eastern Cape, South Africa
Project duration & year:	5 months, June 2013 to October 2013
Client:	Aurecon Engineers
Name of Project:	Ndlambe Bulk Water Supply
Project Description:	Development of groundwater numerical flow models for the Cannon Rocks and Port Alfred municipal supply wellfields to assess impact and sustainability of proposed abstraction scenarios. Development of a saline intrusion density-dependant flow and transport model for Cannon Rocks to assess the risk and potential impact from saline intrusion.
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R 200 000 (groundwater modelling task)

Location:	Jansenville, Eastern Cape, South Africa
Project duration & year:	4 months, May 2013 to August 2013
Client:	Cacadu District Municipality
Name of Project:	Jansenville Bulk Water Supply
Project Description:	Development of a groundwater numerical flow model for the Jansenville municipal supply wellfield to assess impact and sustainability of proposed abstraction scenarios.
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R 50 000 (groundwater modelling task)

Location:	South Africa
Project duration & year:	2 years: 2012 to 2014
Client:	Shell
Name of Project:	Karoo Aquifers Study
Project Description:	Compilation of Karoo Aquifers Atlas and other maps and models for the west, central and east Karoo, hydrogeological data collation and analysis, and methodology development
Job Title and Duties:	Data analysis and development of methodologies
Value of Project:	Confidential

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Koekenaap, West Coast, Western Cape
Project duration & year:	2 months, 2012
Client:	Tronox, Namakwa Sands
Name of Project:	Geohydrological Assessment and Numerical Modelling (MSP-Koekenaap)
Project Description:	Phase 1 geohydrological assessment and numerical groundwater flow and contaminant transport modelling at the Mineral Separation Plant at Koekenaap
Job Title and Duties:	Project Manager, Groundwater Numerical Modeller
Value of Project:	R 160 000

Location:	John Taolo Gaetsewe District Municipality, Northern Cape
Project duration & year:	2012
Client:	John Taolo Gaetsewe District Municipality
Name of Project:	John Taolo Gaetsewe DM Groundwater Assessment
Project Description:	Groundwater assessment and GIS layered groundwater classification maps of the study area (representing location of potential mining sites) and the possible impacts on local Aquifer Dependent Ecosystems
Job Title and Duties:	Technical Author
Value of Project:	R150 000

Location:	Gauteng
Project duration & year:	12 months, 2012
Client:	Rand Water
Name of Project:	Analysis of effects of Acid Mine Drainage on Rand Water Pipelines
Project Description:	Data gathering, mapping, modelling, risk analysis and mitigation recommendations for areas of likely corrosion of pipelines for public water supply, caused by AMD.
Job Title and Duties:	Project Manager (start-up phase)
Value of Project:	R 800 000

Location:	Hermanus Gateway and Hemel en Aarde Wellfields
Project duration & year:	2011 - 2012
Client:	Overstrand Municipality
Name of Project:	Water Source Development and Management Plan for the Hermanus Area
Project Description:	Wellfield development and management
Job Title and Duties:	Groundwater Numerical Modeller, Liaison for Infrastructure Installation, Monitoring Team Leader
Value of Project:	R 2 million

Location:	Western Cape
Project duration & year:	18 months, 2010 - 2011
Client:	Department of Environmental Affairs & Development Planning
Name of Project:	Sea Level Rise and Flood Risk Assessment
Project Description:	Literature review, data collection, development of modelling and risk assessment methodology for study into the effect of sea level rise in vulnerable areas on the Western Cape coastline, and assessment of flood risk (West Coast, Cape Town area, Overstrand)
Job Title and Duties:	Project Manager; Reviewer
Value of Project:	R 900 000

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Durban
Project duration & year:	3 months, 2010
Client:	Department of Science and Technology
Name of Project:	SADC Workshop on Women in Science & Technology
Project Description:	Planning and facilitation support of his large workshop event (50+ attendees from 10 different SADC countries), held in Durban, with many dignitaries including the Minister of Science and Technology.
Job Title and Duties:	Workshop programme, planning and facilitation
Value of Project:	R 200 000

Location:	Namibia
Project duration & year:	6 months, 2010
Client:	United Nations Educations, Scientific and Cultural Organisation (UNESCO)
Name of Project:	Development and Implementation of a Schools Disaster Risk Reduction Manual and Systems Strengthening Processes
Project Description:	Develop and implement a Disaster Risk Reduction School Manual, associated guidelines, and System Strengthening processes. This project included desk- top study, field mission, stakeholder review and implementation of capacity building through a training workshop.
Job Title and Duties:	Project Manager, technical author and ICT specialist
Value of Project:	R 300 000

Location:	Oudtshoorn
Project duration & year:	2009 – 2012
Client:	Oudtshoorn Municipality
Name of Project:	Deep Artesian Groundwater Exploration for Oudtshoorn Supply
Project Description:	Feasibility, exploration and pilot study into the use of a groundwater wellfield for the augmentation of the Oudtshoorn public water supply.
Job Title and Duties:	Monitoring Team Leader, Groundwater Numerical Modeller
Value of Project:	R 10 million

Location:	Stanford
Project duration & year:	2009 - 2012
Client:	Overstrand Municipality
Name of Project:	Water Source Development and Management Plan for the Stanford Area
Project Description:	Wellfield development and management
Job Title and Duties:	Groundwater Numerical Modeller, Task Leader for Pipeline Installation
Value of Project:	R 2 million

Location:	Cape Town
Project duration & year:	2009 – 2012
Client:	City of Cape Town
Name of Project:	Table Mountain Group Aquifer Feasibility Study & Pilot Project
Project Description:	Feasibility, exploration and pilot study into the use of a groundwater wellfield for the augmentation of the City of Cape Town public water supply.
Job Title and Duties:	Groundwater Numerical Modeller. Developed a regional numerical groundwater models, in order to assist in defining recommendations for the siting of a pilot wellfield.
Value of Project:	R 5 million

Sheila Imrie

Principal Hydrogeologist / Groundwater Modeller

Key Experience: Hydrogeology & numerical groundwater flow and transport modelling

Location:	Western Cape
Project duration & year:	12 months, 2009 - 2010
Client:	Department of Environmental Affairs and Development Planning
Name of Project:	Climate Change Monitoring and Evaluation System
Project Description:	Development of a Monitoring and Evaluation system to assess provincial and municipal departments and the private sector on their involvement as it pertains to environmental issues (i.e. conservation, standards, climate change, and sustainability).
Job Title and Duties:	Project Manager, Principal technical author and facilitator of stakeholder workshops
Value of Project:	R 350 000

Location:	North West Norfolk, East Anglia, UK
Project duration & year:	2006 - 2009
Client:	Environment Agency, UK
Name of Project:	North West Norfolk Aquifer Model
Project Description:	Part of the Anglian Framework Contract with the Environment Agency to develop and manage complex numerical models to aid in reserve determination, issuing of water use licences, mapping contamination plumes, quarry dewatering etc. This is a complex, 11-layer model, including both chalk and sandstone aquifers, and covering an area of 2400km2 in East Anglia.
Job Title and Duties:	Project Manager and groundwater modeller (Modflow, 4R, Surfer, Scripter, ArcGIS)
Value of Project:	R 5 million

Location:	Ely Ouse, East Anglia, UK
Project duration & year:	2006 - 2009
Client:	Environment Agency, UK
Name of Project:	North West Norfolk Aquifer Model
Project Description:	Part of the Anglian Framework Contract with the Environment Agency to develop and manage complex numerical models to aid in reserve determination, issuing of water use licences, mapping contamination plumes, quarry dewatering etc. This is a complex, 11-layer model, including both chalk and sandstone aquifers, and covering an area of 2400km2 in East Anglia.
Job Title and Duties:	Project Manager and groundwater modeller (Modflow, 4R, Surfer, Scripter, ArcGIS)
Value of Project:	R 5 million

Location:	Southern Region, UK
Project duration & year:	2006 – 2009
Client:	Environment Agency, Southern Region, UK
Name of Project:	Seaford and Eastbourne Groundwater Quality Project
Project Description:	Study into groundwater quality in Seaford and Eastbourne presenting results of detailed water quality data analysis over the region.
Job Title and Duties:	Hydrogeological groundwater quality analysis and reporting
Value of Project:	R 500 000

Location:	UK
Project duration & year:	2006 - 2009
Client:	Environment Agency, UK
Name of Project:	Assessment of landfill site applications
Project Description:	Assessment of landfill site applications
Job Title and Duties:	Assigned Hydrogeologist for preforming risk assessments for various landfill site licence applications.
Value of Project:	R 500 000

Annalisa Vicente

Hydrogeologist / Groundwater Modeller

Profession	Hydrogeologist / Groundwater Modeller
Education	MSc. Environmental and Water Science, University of the Western Cape, 2020
Registrations/Affiliations	GSSA (Groundwater Division) Golden Key International Honours Society
Awards	Best Presentation Award at the Groundwater Division Conference 2019

Specialisation

Groundwater numerical flow and transport modelling, groundwater resource evaluation, groundwater monitoring, hydrocensus, borehole logging, borehole drilling supervision, aquifer pump test analysis and borehole sampling.

Expertise

Annalisa has been involved in the field of hydrogeology and groundwater modelling, with special focus on:

- Numerical flow and transport modelling;
- Identification, location, assessment and development of groundwater resources for agricultural, industrial and mining industries;
- Water supply borehole siting and drilling supervision;
- Aquifer pumping test design, control and data analyses;
- Groundwater monitoring;
- Groundwater monitoring scheme designs;
- Specialist hydrogeological impact assessments; and
- Specialist hydrogeological reporting.

Employment

2019 – Present SRK Consulting (Pty) Ltd, Hydrogeologist, Cape Town

Publications

Publications and conference papers on groundwater protection and water resource management

Languages

English – read, write, speak

Afrikaans – read, write (fair)

Annalisa Vicente

Hydrogeologist / Groundwater Modeller

Publications

1. Johnson, A., Nel, J and Vicente, A. (2018). Generating hydrogeological modelling input data from laboratory and field tests for fly ash monolith deposition in coal mine backfilling, Mpumalanga, South Africa
2. Nel, J., Vicente, A and Johnson, A. (2018). Challenges with integrated flow and geochemical modelling considering uncertainties in backfilling
3. Vicente, A., Nel, J and Johnson, A. (2017) *Conference Proceeding at 9th International Congress on Environmental Modeling and Software (iEMSs).* Modeling under environmental uncertainties to assess favourable coal combustion residue backfill scenarios
4. Ridell et. al., (2018). Hydrologic process definition of transmission losses along the Letaba River for improved delivery of environmental water requirements
5. Vicente, A., Nel, J and Johnson, A. (2017) *Conference Proceeding at Groundwater Division* Assessing the flow and transport properties of fly ash backfill in opencast coal mine, Mpumalanga, South Africa

Annalisa Vicente

Hydrogeologist / Groundwater Modeller

Key Experience:	**Hydrogeology & numerical groundwater flow and transport modelling**
Location:	Lutzville, Western Cape, South Africa
Project duration & year:	March 2020 - September 2020
Client:	Tronox Mineral Sands (Pty) Ltd
Name of Project:	East OFS Project Residue Disposal Plan - Groundwater Specialist Study
Project Description:	Describe the hydrogeological baseline environment, assess the groundwater impacts and provide recommendations for the mine rehabilitation and closure.
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R100 000
Location:	North-Western, Zambia
Project duration & year:	January 2020 – September 2020
Client:	First Quantum Minerals Limited
Name of Project:	Enterprise Nickel Deposit Hydrogeological Study
Project Description:	Assessing the groundwater flow and contaminant transport from the proposed ENDP mine pit to recommend an effective groundwater dewatering scheme.
Job Title and Duties:	Groundwater Numerical Modeller
Value of Project:	R140 000
Project duration & year:	December 2019 – February 2020
Client:	AngloGold Ashanti
Name of Project:	Surface and Groundwater Study for the Environmental and Social Impact Assessment for Block 2 at Siguiri Mine
Project Description:	Identify potential impacts of mining on the water resources in the study area and to recommend mitigation measures to minimise the impact.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R120 000
Location:	Glenwood, Kwa-Zulu Natal, South Africa
Project duration & year:	Dec 2019- Jan 2020
Client:	Da Gama Textiles
Name of Project:	Groundwater Impact Assessment Study – Da Gama Textiles, King Williams Town, Eastern Cape
Project Description:	Construct the groundwater numerical model and assess groundwater impacts associated with Da Gama Textile factory.
Job Title and Duties:	Hydrogeologist/Groundwater Numerical Modeller.
Value of Project:	R150 000
Location:	Farm Kamiebees, Northern Cape, South Africa
Project duration & year:	Sept 2019- Jan 2020
Client:	S.J.R. Boerdery BK
Name of Project:	Kamiebees Hydrogeological Assessment and Water Use Licence Application (WULA)
Project Description:	Undertaking the hydrogeological Assessment and Water Use Licence Application
Job Title and Duties:	Hydrogeologist. Compiling a hydrogeological report and conducting the WULA
Value of Project:	R100 000
Location:	Lutzville, Western Cape, South Africa
Project duration & year:	Nov 2019- February 2020
Client:	Tronox Mineral Sands (Pty) Ltd
Name of Project:	Environmental Impact Assessment for East Mine In-Pit RSF - Namakwa Sands Mine
Project Description:	Groundwater impact assessment.

Annalisa Vicente

Hydrogeologist / Groundwater Modeller

Job Title and Duties:	Hydrogeologist. Specialist input towards the groundwater impact.
Value of Project:	R1 300 000
Project duration & year:	Sept 2019 - October 2019
Client:	Shirley Hayes IPK (Pty) Ltd
Name of Project:	Proposal for a Hydrogeological Impact Assessment Report Required in Support of a Water Use Licence Application for Rietberg, Jubilee and Homeep Copper Mines
Project Description:	Water Use Licence Application for Rietberg, Jubilee and Homeep Copper Mines.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R140 000
Location:	Komaggas,Northern Cape, South Africa
Project duration & year:	Sept 2019 - Sept 2019
Client:	BVI Consulting Engineering
Name of Project:	Proposal for borehole yield testing and hydrogeological services at Komaggas
Project Description:	Municipal water supply.
Job Title and Duties:	Hydrogeologist. Borehole siting and borehole drilling supervision
Value of Project:	R200 000
Location:	Lutzville, Western Cape, South Africa
Project duration & year:	Aug 2019 - Sept 2019
Client:	Tronox Mineral Sands (Pty) Ltd
Name of Project:	Effluent Treatment Expnsion Project Hydrogeological Study
Project Description:	Update the groundwater numerical model and assess groundwater impacts associated with Tronox's proposed effluent treatment expansion.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R260 000
Location:	Lutzville, Western Cape, South Africa
Project duration & year:	June 2019 - July 2019
Client:	Tronox Mineral Sands (Pty) Ltd
Name of Project:	Groundwater model update and hydrogeological assessment
Project Description:	Update the groundwater numerical model and assess groundwater impacts associated with Tronox's proposed expansion areas.
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R390 000
Location:	Welkom, Free State, South Africa
Project duration & year:	April 2019 - May 2019
Client:	Sibanye Stillwater
Name of Project:	Groundwater modelling for a hydrogeological study
Project Description:	Construct a numerical groundwater model to conduct a hydrogeological study for a new Integrated Water Use Application (IWULA).
Job Title and Duties:	Hydrogeologist / Groundwater Numerical Modeller
Value of Project:	R240 000
Location:	Witbank, Mpumalanga, South Africa
Project duration & year:	2 years 2017 – 2018
Client:	Eskom
Name of Project:	Assessment of coal combustion residue backfill scenarios in opencast coal mines
Project Description:	Construct a groundwater model to conduct a hydrogeological assessment and determine feasible coal combustion residue backfill scenarios
Job Title and Duties:	Masters student

Annalisa Vicente

Hydrogeologist / Groundwater Modeller

Value of Project:	N/A
Key Experience:	Hydrogeology & numerical groundwater flow and transport modelling
Project duration & year:	3 months: May 2017 - July 2018
Client:	Water Research Commission
Name of Project:	Quantification of transmission loss processes along the Letaba River
Project Description:	Construct a numerical model to evaluate river flows and transmission losses under different conditions associated to the natural environment and anthropogenic inputs.
Job Title and Duties:	Intern hydrogeologist
Value of Project:	N/A

Appendix B: Recharge Rates

Recharge rates for the EOFS mine voids for the LoM

Year	Mtpa (deposition rate)	Moisture content (%)	Density (Mt/m^3)	Area (m^2)	Recharge (m/d)
1	8.76	20%	1.3E-06	1017500	3.63E-03
2	8.76	20%	1.3E-06	797500	4.63E-03
3	8.76	20%	1.3E-06	473125	7.80E-03
4	8.76	20%	1.3E-06	197500	1.87E-02
5	8.76	20%	1.3E-06	407500	9.06E-03
6	8.76	20%	1.3E-06	280000	1.32E-02
7	8.76	20%	1.3E-06	93750	3.94E-02
8	8.76	20%	1.3E-06	285625	1.29E-02
9	8.76	20%	1.3E-06	194375	1.90E-02
10	8.76	20%	1.3E-06	396875	9.30E-03
11	8.76	20%	1.3E-06	312500	1.18E-02
12	8.76	20%	1.3E-06	270625	1.36E-02
13	8.76	20%	1.3E-06	485000	7.61E-03
14	8.76	20%	1.3E-06	708125	5.21E-03
15	8.76	20%	1.3E-06	384375	9.61E-03
16	8.76	20%	1.3E-06	321250	1.15E-02
17	8.76	20%	1.3E-06	511875	7.21E-03
18	8.76	20%	1.3E-06	840625	4.39E-03
19	8.76	20%	1.3E-06	785000	4.70E-03
20	8.76	20%	1.3E-06	551875	6.69E-03
21	8.76	20%	1.3E-06	886875	4.16E-03
22	8.76	20%	1.3E-06	715000	5.16E-03
23	8.76	20%	1.3E-06	897500	4.11E-03
24	8.76	20%	1.3E-06	587500	6.28E-03
25	8.76	20%	1.3E-06	2848125	1.30E-03
26	8.76	20%	1.3E-06	2601250	1.42E-03
27	8.76	20%	1.3E-06	2818125	1.31E-03
28	8.76	20%	1.3E-06	2839375	1.30E-03
29	8.76	20%	1.3E-06	3458125	1.07E-03
30	8.76	20%	1.3E-06	596250	6.19E-03
31	8.76	20%	1.3E-06	1017500	3.63E-03