STORMWATER MANAGEMENT AND WATER BALANCE UPDATE FOR TSHIPI BORWA WASTE ROCK DUMP EXTENSION PROJECT

Tshipi Borwa

Prepared for: Thsipi E' Ntle Manganese Mining (Pty) Ltd

SLR

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EXECUTIVE SUMMARY

SLR Consulting Africa (Pty) Ltd (SLR) was commissioned by Tshipi E' Ntle Manganese (Pty) Ltd (Tshipi) to update the stormwater management plan and water balance in support of the Environmental Authorisation (EA) amendment for the Thipi Borwa Waste Rock Dump (WRD) extension project.

A baseline characterisation was undertaken and it presents relevant information which has been used to develop the stormwater management and water balance including climate, storm intensities, surface water receptors, topography, waste classification, and current stormwater management. The site is located within a semi-arid climatic region of South Africa characterised by seasonal rainfall, hot temperatures in summer, and colder temperatures in winter. Monthly average rainfall was estimated from a 67 year daily rainfall record from Milner rain gauge, located seven kilometres east of the site (Latitude: -27.375, Longitude: 23.042) were considered and the mean annual precipitation of 372.0mm and a lake evaporation of 1972.0 mm were determined. The records show that annual evaporation is much higher than rainfall in this region.

The nearest watercourse is the Vlermuisleegte, a non-perennial tributary of the Gamagara, which flows from south-east to north-west approximately 1.6 km west of the site and 1km drom the proposed west WRD extension. Given the large distance between the mine and these watercourses, the floodlines have not been mapped.

A conceptual stormwater management plan (SWMP) for the mine was undertaken and presents the design of stormwater management measures as presented in SLR's 2017 -Stormwater Management Report and Water Balance for EMPR Report , furthermore including the proposed extensions of North, East and West WRD Stormwater Measures. The key features of the stormwater management plan include:

- Clean stormwater will be prevented from entering dirty water catchments by creating perimeter berms around dirty water areas and dirty water collection infrastructure (channels and dams).
- Dirty stormwater from the operational areas (crushers, ore stockpiles, load out stations, workshops, stores, contractor's area etc.) will be collected by lined drainage channels and conveyed into dirty water containment facilities, either the dirty water dam or workshop dirty water collection dam.
- During significant storm events, the dirty water dam and workshop dirty water collection dam will spill via new channels into a stormwater dam/ pollution control dam)(PCD), and this stormwater will be pumped back to the dirty water dam for re-use after the storm event.
- Dirty stormwater and any groundwater collecting within the pit will be collected and pumped to the dirty water dam or will be used directly for dust allaying in contaminated areas
- Runoff from the waste rock dumps will be prevented from entering any surface water receptors by creating perimeter stormwater retention berms(10m from the toe of the WRD) to collect runoff and allow it to evaporate and/or infiltrate to ground. Given the waste rock dumps do not pose a significant risk to water resources (Section 2.5), and the low rainfall in this region, this is considered compliant with GN 704.
- Dirty stormwater from the tailings storage facility will be collected within the return water dam and pumped back to the dirty water dam for re-use. Both the tailings storage facility and the return water dam are HDPE lined. Further details of these facilities are presented within SLR's August 2017 Environmental Impact Assessment and Environmental Management Programme report.
- The topsoil stockpile will be revegetated and any runoff from this will be classified as clean.

- Dirty water within the dirty water containment facilities will be re-used at the site for dust suppression, wash down or other non-potable uses where water quality permits.

An update of the existing 2017, site wide water balance was undertaken for the average wet and dry seasons and to include the water abstraction from the boreholes (TBW04 and TBW02) supply in order to inform estimates on re-use rates, makeup water requirements and requirements for discharge (if any). This report presents the summaries for the wet and dry season water balances as modelled in Section 4 in conformance with Department of Water and Sanitation (DWS) template summary tables for wet and dry periods for current year (2018), Year 10 (2028) and the Life of Mine. The water balance shows that currently, groundwater inflows are negligible and the mine is reliant on makeup water from Sedibeng with monthly demand estimated to be between 11 111 – 27 378m^3. The supply options yields 1.5 l/s (1 970 m^3/month) at TBW02 and 1.0 l/s (1 310 m^3/month and these yields are still less that what would be required in the average dry season for the current mining scenario water balance to complement the 16 666 m^3/month water supply limit authorised for withdrawal from the Sedibeng. This leaves an additional water demand from Sedibeng over and above the monthly limit approximately up to 7 400 m^3/month when the mine is water negative.

Groundwater inflow and stormwater collecting within the open pit becomes a very significant source of water for the mine in future years and from year 10 onwards the mine could be expected to be water positive during the wet season, although there is still expected to be a requirement for makeup water through the dry season.

The identification of impacts and qualitative assessment of the impacts of the proposed WRDs and summary of mitigation measures was undertaken. It was therefore identified that the WRD will result in low significance impacts based on the following rationale.

- The proposed WRD will alter natural drainage patterns and reduce runoff potential to the streams and considering that the location of surface infrastructure is informed by the surface topography which is fairly gently sloping thus limited runoff is anticipated and the impact will be low.
- The proposed project could cause pollution of local watercourses through runoff from waste rock dump. However, the location of surface infrastructure is informed by the storm water management plan developed in accordance with GN 704 to ensure that dirty water does not spill into clean water more frequently than once in 50 years.

The recommendations for further work are as detailed below.

It is recommended that the design parameters for the WRD toe paddocks are revisited and updated to reflect closure plans in particular any re-profiling, top-soiling or revegetation of the WRD prior to closure. Often WRDs will be re-profiled and benches removed creating a larger area of the side slopes that will drain into the toe paddocks. The lower gradients and revegetated surface of the WRD is likely to reduce the runoff coefficients..

Considering the limitation for the water balance, to improve certainty on the makeup water requirements, and identify water conservation and water demand management measures, a dynamic simulation water balance model should be undertaken once further water monitoring data become available. In that way the level of detail of the existing daily time step model as well as calibration can be undertaken against actual monitored data from the site, which will greatly improve the accuracy of any modelled results.

Groundwater inflow to the open pit forms a critical part of the mine's water circuit and is the main source of water in later years of mining. Groundwater inflows are based on the available modelled data and it is recommended that measurements of water pumped out of the pit are collected and used to calibrate the water balance model presented.

Once further water monitoring data become available within the mine water circuit, consideration should be given to increasing the level of detail of the model, and calibrating against actual monitored data from the site, which will greatly improve the accuracy of any modelled results. The water balance study should be updated whenever additional information becomes available, and a review of available monitoring or design data should be undertaken on an annual basis.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
BPG	Best Practice Guidelines
DDF	Depth Duration Frequency
DWS	Department of Water and Sanitation
EMPr	Environmental Management Programme
GN 704	Government Notice 704
LOM	Life of Mine
LCTO	Leachable Concentration Threshold Limits
MAR	Mean Annual Runoff
PCD	Pollution Control Dam
ROM	Run Of Mine
SANRAL	South African National Road Agency
SWMP	Stormwater Management Plan
WUL	Water Use Licence
WRD	Waste Rock Dump
WR2005	Water Resources of South Africa 2005 Study

1 INTRODUCTION

1.1 BACKGROUND

SLR Consulting Africa (Pty) Ltd (SLR) was commissioned by Tshipi E’ Ntle Manganese (Pty) Ltd (Tshipi) to update the stormwater management plan and water balance in support of the current Environmental Management Programme amendment (EMPr) process for the Thipi Borwa Waste Rock Dump extension project (refer to in this report as the EMP2 amendment).

1.2 PROJECT DESCRIPTION

Tshipi operates the open pit manganese Tshipi Borwa Mine located approximately 56 km north west of Kuruman, 20 km south of Hotazel, 45 km north of Kathu more specifically on the farms Mamatwan 331 (mining right and surface use areas) and Moab 700 (surface use area), in the John Taolo Gaetsewe District Municipality and Joe Morolong Local Municipality in the Northern Cape Province

The Tshipi Borwa Mine consists of open-pit mining sections, crushing and screening operations, run of mine (“ROM”) stockpiles, Waste Rock Dumps (“WRD”) and product stockpile dumps, and associated support and administrative infrastructure.

The changes to Tshipi’s approved layout to be addressed by the EMP2 amendment include the following:

- The extension of the existing East Waste Rock Dump (WRD) to the mining right boundary and towards the Mamatwan WRD to provide additional overburden storage capacity.
- The extension of the existing West WRD onto Portion 8 of the farm Mamatwan 331, to provide additional overburden storage capacity.
- Extension of the North WRD.
- The erection of an 11kV overhead powerline along the southern boundary onto the existing mining right area.
- The construct of an overland conveyor system from the existing secondary crushing and screening plant to the existing manganese ore product stockpiles.

The proposed West Extension WRD is located to the south west of the existing Tshipi Borwa west WRD as shown in Figure 1-1.

1.3 ENVIRONMENTAL LEGISLATION

Government Notice 704 (Government Gazette 20118 of June 1999) (hereafter referred to as GN 704), was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. The four main principle conditions of GN 704 applicable to this project are:

- *Regulation 4* which defines the area in which, mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.

- *Regulation 5* which indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure which may cause pollution of a water resource.
- *Regulation 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water dams should have a minimum freeboard of 0.8m above full supply level.
- *Regulation 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion etc.) and ensure that water used in any process is recycled as far as practicable.

In addition to GN 704, Department of Water and Sanitation (then Department of Water and Forestry), has developed several Best Practice Guidelines (BPGs) for the mining industry including:

- BPG G1: Stormwater Management.
- BPG G2: Water and Salt Balances

Further guidance is presented in 'Best Practice Guidance for Water Resource protection in the South African Mining Industry (BPG) A4: Pollution Control Dams'. In this document it defines the allowable PCD spillage frequency as being a spill every 50 years on average. This is equivalent to stating that a PCD should be designed such that there is less than a 1 in 50 chance of a spill occurring in any given year

1.4 SCOPE OF WORK

This report is an update of the previous hydrology and storm water management report produced by SLR Consulting Ltd, namely the Tshipi Borwa Mine – Storm water Management Report and Water Balance for EMPR (SLR Consulting, 2017).

The scope of work and report structure is as follows:

- Baseline Characterisation – Section 2 presents relevant information which has been used to develop the stormwater management and water balance including climate, storm intensities, surface water receptors, topography, waste classification, and current stormwater management.
- Conceptual Stormwater Management for the Mine – Section 3 presents the design of stormwater management measures as presented in SLR's 2017 -Stormwater Management Report and Water Balance for EMPR Report , furthermore including the proposed extensions of North, East and West WRD Stormwater Measures for the preparation of typical design details (presented in SLR's 2018 WRD Detailed design for EMP Amendment Report for measures such as: paddocks, channels, berms, silt traps etc. to support WULA.
- Site Wide Water Balance – Section 4 presents the water balance for the operation during average wet and dry seasons and update the water balance to include the water abstraction from the boreholes supply and add summary tables in order to inform estimates on re-use rates, makeup water requirements and requirements for discharge (if any).

- Summary of Water Balance – Section 5 presents the summary of water balance results as requested by the DWS populated into summary template tables.
- Impact Assessment – Section 5 presents the qualitative assessment of the impacts of the proposed WRDs and summary of mitigation measures.

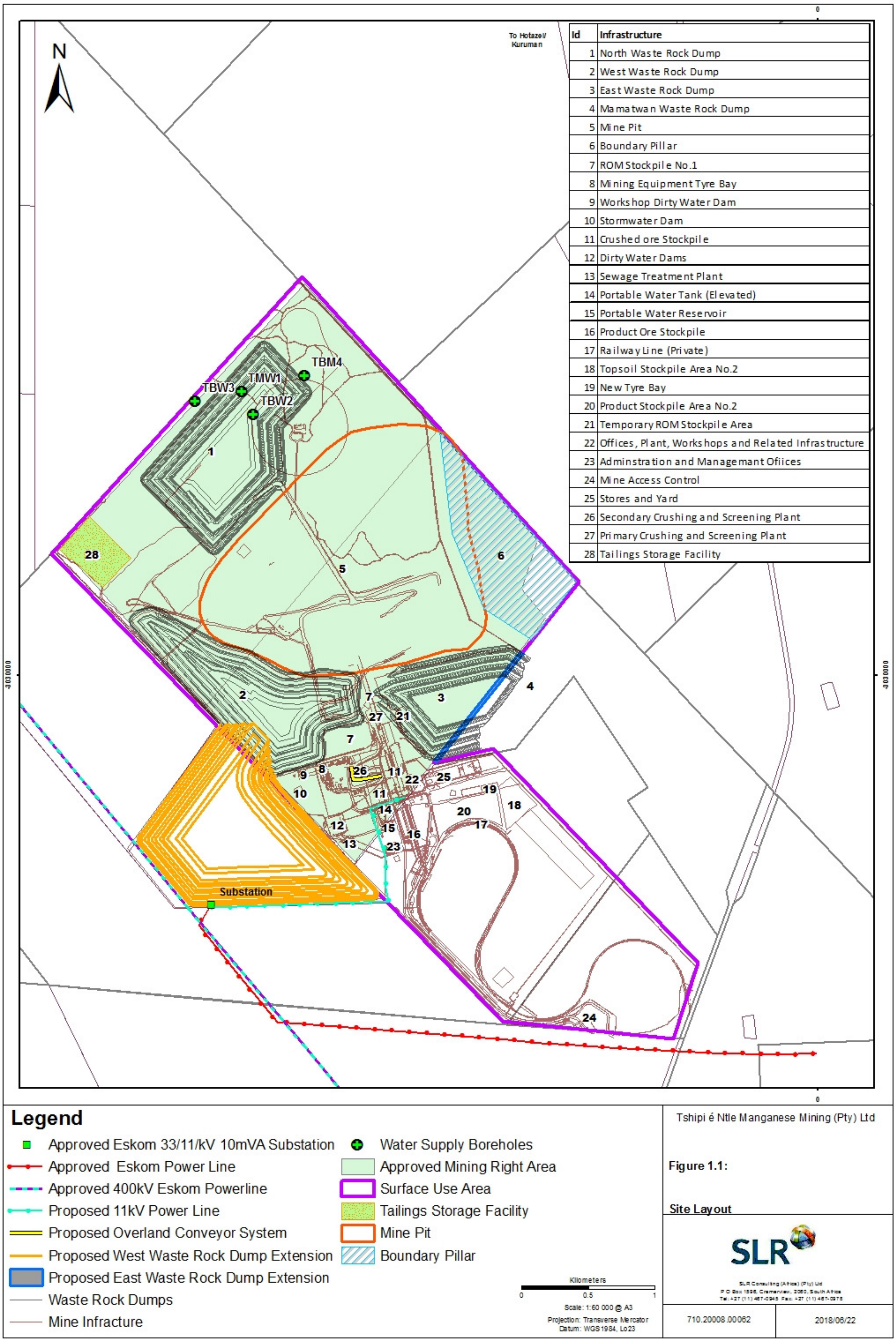

FIGURE 1-1: SITE LAYOUT

2 BASELINE DESCRIPTION

2.1 INTRODUCTION

This section presents a summary of the baseline description including rainfall/evaporation, watercourse network, catchments, topography of the site and surroundings based on review of various information sources.

2.2 CLIMATE

The site is located within a semi-arid climatic region of South Africa characterised by seasonal rainfall, hot temperatures in summer, and colder temperatures in winter. Monthly average rainfall was estimated from a 67 year daily rainfall record from Milner rain gauge, located seven kilometres east of the site (Latitude: -27.375, Longitude: 23.042). Monthly S-pan evaporation data was obtained from the Water Resources of South Africa manual, (WR2005, 2009), and converted to open water evaporation as presented in Table 2-1. The records show that annual evaporation is much higher than rainfall in this region.

TABLE 2-1: MONTHLY AVERAGE RAINFALL AND EVAPORATION

Month	Rainfall (mm)	WR2005	WR2005
	Milner (393083 W)	S-Pan Evaporation	Open Water Evaporation
January	59.8	276.9	232.6
February	63.0	209.9	184.8
March	72.3	193.3	170.1
April	39.9	144.1	126.8
May	19.2	114.7	99.8
June	9.1	91.0	77.3
July	1.3	106.0	88.0
August	5.4	153.8	124.5
September	6.4	213.0	172.5
October	19.2	269.7	218.4
November	31.5	248.0	232.9
December	44.5	294.6	244.5
Annual	**372.0**	**2351.0**	**1972.0**

2.3 DESIGN STORM DEPTHS

The design storm data was obtained from the design rainfall software (Smithers and Schulze, 2002), as presented in Table 2-2

TABLE 2-2: RAINFALL DEPTH DURATION FREQUENCY (DDF)

Storm Duration (m/h/d)	Return Period (years)						
	2	5	10	20	50	100	200
15 m	15.0	21.3	25.7	30.2	36.3	41.2	46.2
30 m	19.8	28.1	34.0	40.0	48.0	54.4	61.1
45 m	23.3	33.1	40.1	47.1	56.6	64.1	71.9
1 hr	26.1	37.2	45.0	52.8	63.5	72.0	80.7
1.5 hr	30.8	43.8	53.0	62.2	74.8	84.7	95.1
2 hr	34.6	49.2	59.5	69.9	84.0	95.2	106.8
4 hr	40.0	56.9	68.8	80.7	97.0	110.0	123.4
6 hr	43.5	61.9	74.9	87.9	105.6	119.7	134.3
8 hr	46.2	65.7	79.5	93.3	112.1	127.1	142.6
10 hr	48.4	68.8	83.3	97.8	117.5	133.1	149.4
12 hr	50.3	71.5	86.5	101.5	122.0	138.3	155.2
16 hr	53.4	75.9	91.9	107.8	129.6	146.9	164.8
20 hr	55.9	79.6	96.2	113.0	135.8	153.9	172.6
24 hr	58.1	82.6	100.0	117.3	141.0	159.8	179.3
1 d	46.7	66.5	80.5	94.5	113.5	128.6	144.3
2 d	56.8	80.8	97.7	114.7	137.9	156.2	175.3
3 d	63.6	90.5	109.5	128.5	154.4	175.0	196.3
4 d	68.2	97.1	117.4	137.8	165.7	187.7	210.6
5 d	72.0	102.5	124.0	145.5	174.9	198.2	222.4
6 d	75.3	107.2	129.6	152.1	182.9	207.2	232.5
7 d	78.2	111.3	134.6	158.0	189.9	215.1	241.4

2.4 SURFACE WATER RECEPTORS

The site is located within the D41K quaternary catchment, which has a total catchment area of 4 216km^2, with a net Mean Annual Runoff of 6.53 million m^3.

The nearest watercourse is the Vlermuisleegte, a non-perennial tributary of the Gamagara, which flows from south-east to north-west approximately 1.6 km west of the site. Given the large distance between the mine and these watercourses, the floodlines have not been mapped.

The entire Moloto catchment which includes D41K is classified as endoreic i.e. catchments with large areas which do not contribute to runoff.

2.5 TOPOGRAPHY

Topography in this area is almost flat, with a gentle slope (1:250) towards the north-west. Small undulations mean that stormwater ponds locally, as opposed to forming sheet flow, which runs off towards a watercourse.

2.6 WASTE CLASSIFICATION

A waste classification study was undertaken by Golder[1] on the waste dump / overburden material which concluded the following:

- The waste material classifies as non-hazardous waste.
- The waste material is not potentially acid generating.
- The waste rock is classified as Type 1 waste on the basis of total manganese concentrations.
- The concentration of all constituents of concern in leachate is below the leachable concentration threshold (LCT0), indicating a low risk from seepage, as per Regulation 634 of 2013
- The waste rock dumps do not pose a significant risk to water resources.

The above conclusions are used to inform the design principles for stormwater management at the waste rock dumps, as discussed in Section 3.2.

2.7 CURRENT STORMWATER MANAGEMENT

Current stormwater management at the site is as follows:

- Contaminated stormwater from the processing plant area (ore stockpiling plus crushing and screening plant) is collected by a series of concrete lined channels and conveyed to the PCD / Dirty Water Dam.
- Ground levels at the mining contractor's area are contoured to convey stormwater to the workshop dirty water collection dam as presented in SLR's 2017 [2] and SLR's 2018 [3]Design report
- Stormwater and any groundwater inflows into the pit are collected within one or more drainage sumps.

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[1] Tshipi e' Ntle Mine – Waste Classification Assessment. Report No. 1541973-301423-1 (Golder Associates, February 2016)

[2] Tshipi Borwa Mine – Stormwater Management Report and Water Balance for EMPR (SLR Consulting, July 2017). 710.20029.00011

[3] Integrated Storm Water Management Design for WULA Purposes Report (SLR, January 2018) 710.20008.00043

3 CONCEPTUAL STORMWATER MANAGEMENT PLAN

3.1 INTRODUCTION

Mining operations have the potential to impact upon the baseline water quality of an area and, if not managed correctly, stormwater may pose a risk of flooding to project infrastructure. The aim of stormwater management measures is to mitigate these impacts by fulfilling the requirements of the National Water Act (Act 36 of 1998) and more particularly GN 704.

The design principles for the other stormwater infrastructure measures i.e. the stormwater dam, the northern and southern inlet channels and silt traps are presented in this section as was discussed in detail in the SLR's 2018[4] Report and the SLR's July 2017[5] Storm Water Management Plan (SWMP) Report.

The following definitions from GN 704 are appropriate to the classification of catchments and design of stormwater management measures at the Tshipi Borwa Mine:

- **Clean water system:** includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;
- **Dam:** includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);
- **Dirty area:** means any area at a mine or ***activity*** which causes, has caused or is likely to cause pollution of a water resource;
- **Dirty water system:** This includes any dirty water diversion bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and
- **Activity:** means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

In addition to the above, the Department of Water and Sanitation (then Department of Water and Forestry) developed Best Practice Guidelines for the mining industry, which should inform the design and operation of the Tshipi Borwa project.

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[4] Integrated Storm Water Management Design for WULA Purposes Report (SLR, January 2018) 710.20008.00043

[5] Tshipi Borwa Mine – Stormwater Management Report and Water Balance for EMPR (SLR Consulting, July 2017). 710.20029.00011

3.2 DESIGN PRINCIPLES FOR OVERALL STORMWATER MANAGEMENT

As discussed in Section 1.3, GN 704 requires the following:

- **Capacity:** dirty water systems are to be designed, constructed, maintained and operated so that they are not likely to spill into a clean water system or the environment more frequently than once in 50 years.
- **Conveyance:** all water systems are to be designed, constructed, maintained and operated so that they convey a 1:50 year flood event.
- **Freeboard:** as a minimum, any dirty water dams are to be designed, constructed, maintained and operated to have 0.8m freeboard above full supply level.
- **Collect and Re-Use:** ensure that dirty water is collected and re-used as far as practicable.
- **Diversion:** minimise flow of any surface water or floodwater into mine workings.

Informed by a review of the site setting and existing drainage infrastructure (presented in Section 2), a series of design principles for site wide stormwater management have been developed to ensure compliance with the requirements of GN 704 and BPGs.

The proposed conceptual stormwater management plan for the entire site is presented on Figure 3-1, whilst Figure 3-2 presents more detail around the plant area.

The key features include:

- Clean stormwater will be prevented from entering dirty water catchments by creating perimeter berms around dirty water areas and dirty water collection infrastructure (channels and dams).
- Dirty stormwater from the operational areas (crushers, ore stockpiles, load out stations, workshops, stores, contractor’s area etc.) will be collected by lined drainage channels and conveyed into dirty water containment facilities, either the dirty water dam or workshop dirty water collection dam.
- During significant storm events, the dirty water dam and workshop dirty water collection dam will spill via new channels into a stormwater dam (which acts as a pollution control dam), and this stormwater will be pumped back to the dirty water dam for re-use after the storm event.
- Dirty stormwater and any groundwater collecting within the pit is collected and pumped to the dirty water dam or re-used.
- Runoff from the waste rock dumps will be prevented from entering any surface water receptors by creating perimeter stormwater retention berms to collect runoff and allow it to evaporate and/or infiltrate to ground. Given the waste rock dumps do not pose a significant risk to water resources (Section 2.5), and the low rainfall in this region, this is considered compliant with GN 704.
- Dirty stormwater from the tailings storage facility will be collected within the return water dam and pumped back to the dirty water dam for re-use. Both the tailings storage facility and the return water

dam are HDPE lined. Further details of these facilities are presented within SLR's August 2017[6] Environmental Impact Assessment and Environmental Management Programme report.

- The topsoil stockpile will be revegetated and any runoff from this will be classified as clean.
- Dirty water within the dirty water containment facilities will be re-used at the site for dust suppression, wash down or other non-potable uses where water quality permits.

In order to meet the design principles detailed above, conceptual design details for the proposed stormwater management measures are presented below, along with the specific hydraulic design standards, methodologies, assumptions and input parameters for each measure proposed.

3.3 SIZING OF STORMWATER DAM

The total dirty catchment area draining to the stormwater dam is 0.966km^2. Runoff coefficients have been estimated using Table 3.7 and 3.8 of the SANRAL Drainage Manual[7], and the new stormwater dam is sized to accommodate runoff generated from a 1:50 year design rainfall (24 hour) event **and** the highest monthly rainfall (March) **less** the corresponding monthly evaporation (March) taking place over the surface area of the dam.

The catchment parameters and recommended design capacity for the stormwater dam are presented in Table 3-1 and Table 3-2. For the purposes of the calculations it is assumed that the dirty water dam and workshop dirty water collection dam are both full, and that these facilities will not contribute to the capacity requirements.

TABLE 3-1: STORMWATER DAM – CATCHMENT PARAMETERS

Catchment	Area (km^2)	1:50 year 24 hour Event		Average Wet Month		
		Runoff Coef.	Rainfall (mm)	Runoff Coef.	Rainfall (mm)	Evaporation (mm)
Processing Plant	0.966	0.30	141	0.15	72	170

TABLE 3-2: STORMWATER DAM – RECOMMENDED DESIGN CAPACITY

Facility	1:50yr Storm Runoff (m^3)	Wet Month Runoff (m^3)	Wet Month Evaporation (m^3)	Design Capacity (m^3)	PCD Footprint (m^2)
Stormwater Dam	42 722	11 564	2 211	52 075	13 000

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[6] Environmental Impact Assessment And Environmental Management Programme Amendment Report For The Tshipi Borwa Mine, (SLR Consulting, July 2017) 710.20029.00008

[7] South African National Roads Agency Limited - Drainage Manual, Sixth Edition. (SANRAL, 2013)

A 78Ml (78 000m^3) stormwater dam has already been approved as part of the original EIA for Tshipi. This dam has not been established. It is recommended that this dam be moved to the west of the workshop dirty water collection dam and constructed in stages. The initial compartment sized to take the overflow from the workshop dirty water collection dam and the dirty water dam when these are full, thereby satisfying the above capacity requirements (52Ml or 52 075m^3). A secondary compartment can be constructed later if more detailed analysis demonstrates that the additional capacity is required.

Ina separate study by SLR[8], using the GoldSim simulation software, a daily timestep rainfall runoff model for the dirty stormwater catchments was coupled with a daily timestep water balance model for the SWD. The rainfall runoff model is based on the Soil Conservation Service (SCS) method to estimate the portion of the rainfall which infiltrates or runs off of each catchment type each day of the simulation. The SWD water balance model considers stormwater inflows and direct rainfall against evaporation losses and return water pump out and estimates the volume of water in the SWD each day of the simulation. The model uses the 67 year daily rainfall record taken from SAWS Milner rain gauge described in Section 2. Based on the design parameters discussed above, the recommended capacity of the SWD required to comply with GN 704 and BGPG A1 is approximately 51 000m^3. This excludes the 0.8m freeboard and excludes any permanent water storage below the inlet for the pump.

[8] SLR,2018 ,Note for the Record 1(NR01) – Tshipi Borwa Mine Storm Water Dam Sizing - 2018-04-03 Tshipi SWD Sizing NFTR

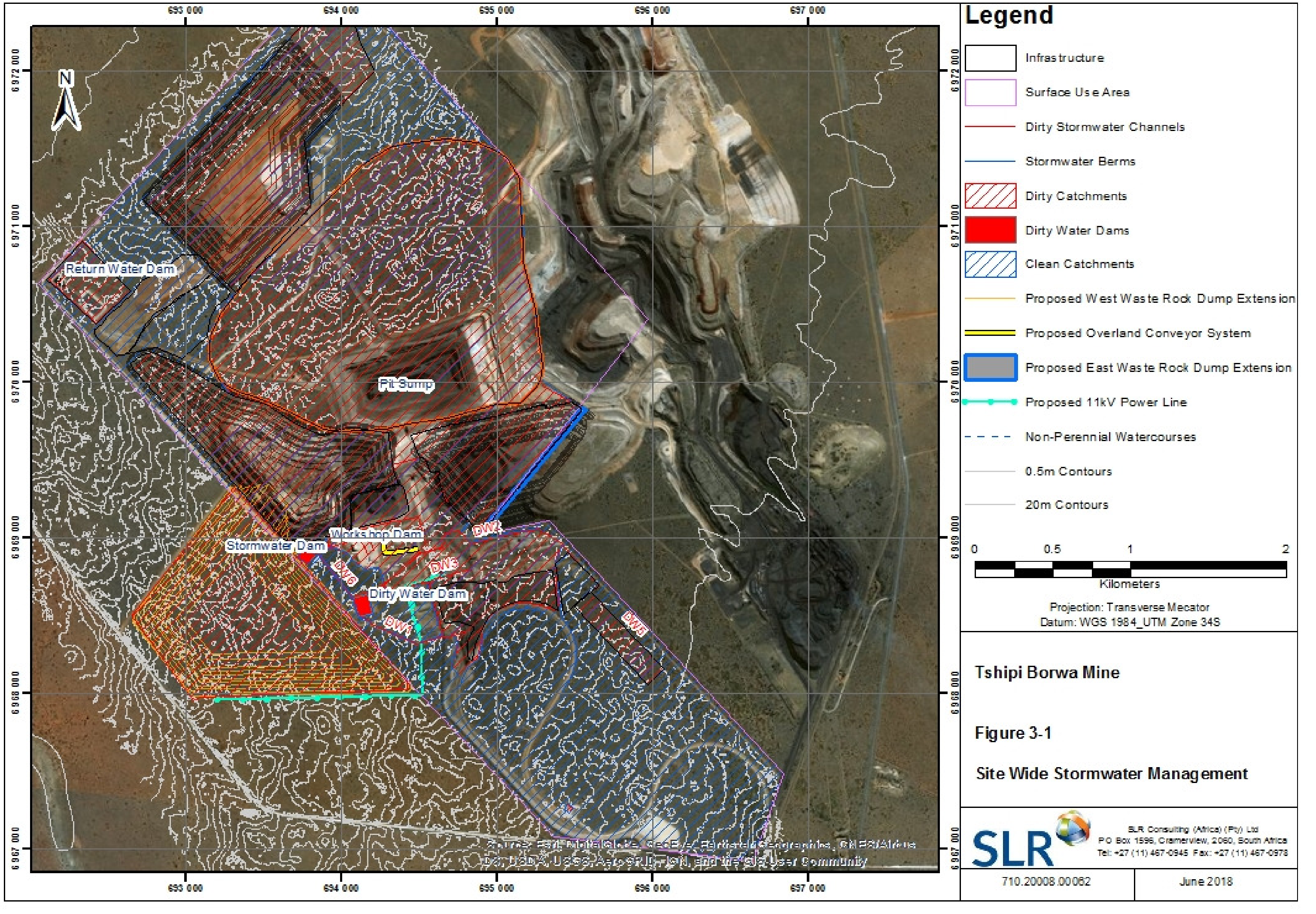

FIGURE 3-1: SITE WIDE STORMWATER MANAGEMENT

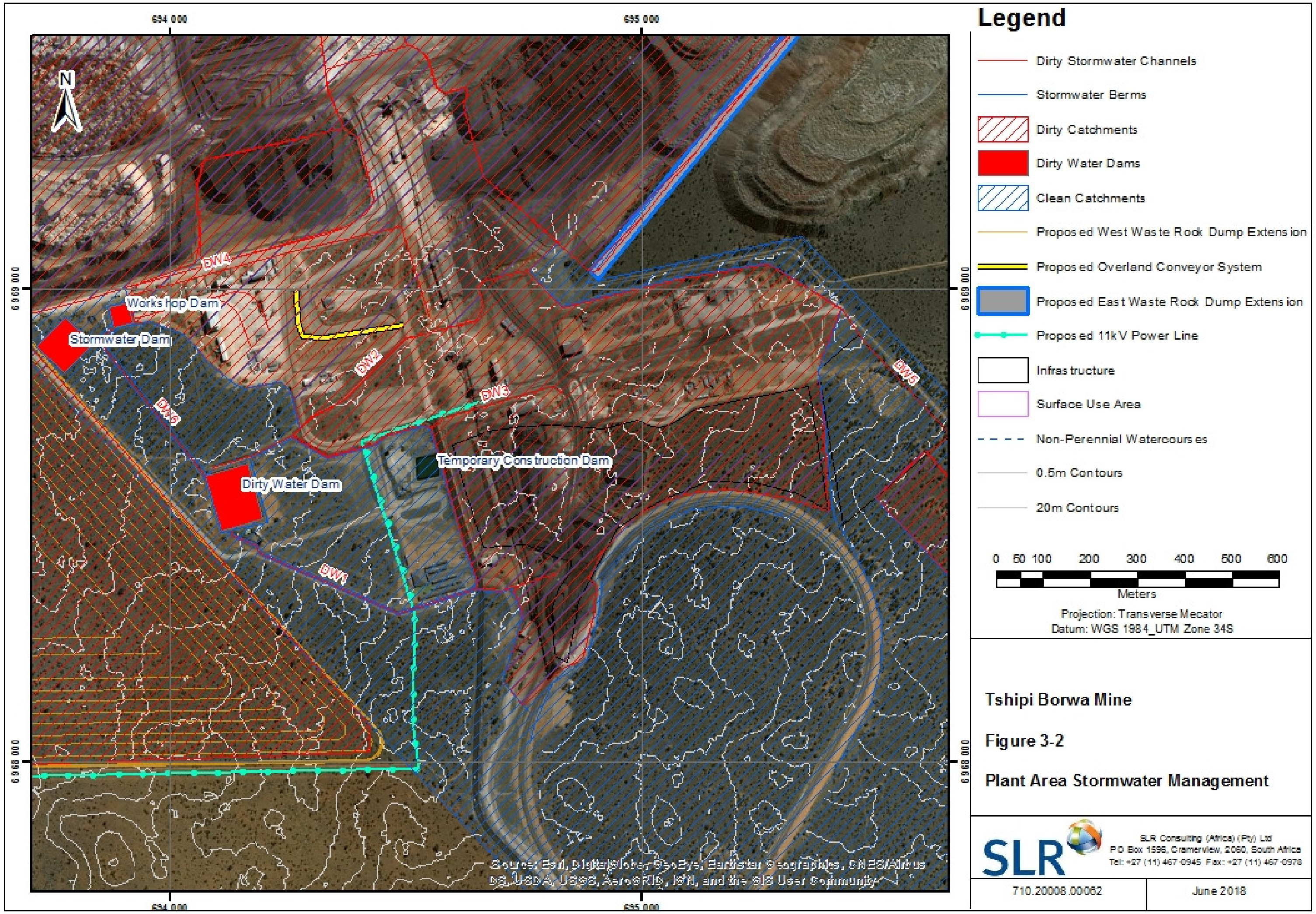

FIGURE 3-2: PLANT STORMWATER MANAGEMENT

3.4 SIZING OF DRAINAGE CHANNELS AND BERMS

The 1:50 year rainfall intensities and peak flow estimates for each of the stormwater diversion channels are presented in Table 3-3.

TABLE 3-3: DESIGN FLOW ESTIMATES

Catchment	Area (km^2)	Runoff Coefficient	Time of Concentration (hours)	Rainfall Intensity (mm/hr)	Flow (m^3/s)
ROM, Crusher & Contractors Yard	0.369	0.300	0.910	67.81	2.09
Plant & Stockpiles	0.497	0.300	1.168	58.92	2.44
Sinter Plant (Future Plan)	0.102	0.300	0.814	72.42	0.62
Plant & Stockpiles & Sinter Plant	0.597	0.300	1.543	49.19	2.45

Based on the design drawings, the existing channels at the site are 1.5m wide and 0.6m deep. Comparing the dimensions against the design flows it is concluded that channel DW3 will need to be deepened by 0.2m to accommodate the flows, which should be relatively easy to achieve. It is not considered necessary to extend the concrete lining to the top of the channel, as water will only contact the unlined upper section of the channel during extreme events, in the region of a 1:10 year event. It should be noted that channel DW2 will need to be deepened before the Sinter Plant is constructed to accommodate the increased design flows from this catchment which will be routed via channel DW5 into channel DW2.

The following assumptions were made during the design of the flow diversion channels:

- The channels are sized to take the maximum flow calculated for the downstream end of the contributing catchment and the channel sizing will be uniform along their entire length.
- The longitudinal gradients are based on 0.5m contours provided by Tshipi.
- Clean water will be kept out of the dirty water channels by constructing and maintaining a linear bund alongside the channel with the material excavated from the channel (as shown on Figure 3-3).

Where practical, the dirty water channels should be lined with a low permeability liner (as is already the case with most of the drainage channels on site) to prevent dirty water from infiltrating through the base of the channels which otherwise might impact upon the quality of the underlying groundwater. Due to the width of the existing channel, this may not be feasible for the existing channel which cross the contractor’s area.

A nominal berm height of 0.5m is considered to be sufficient to prevent runoff from clean areas flowing into dirty areas. Given the flat gradients, low rainfall and high evaporation rates, it is expected that any clean stormwater ponding against the berm will either evaporate or infiltrate within a few days of a storm event.

In order to accommodate the design flows, the recommended channel sizes are presented in Table 3-4. Figure 3-3 presents a typical cross-section through the channel.

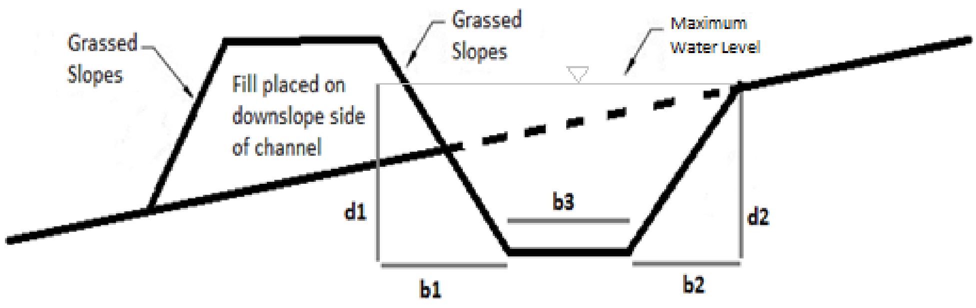

FIGURE 3-3: STORMWATER DIVERSION CHANNEL SIZING

TABLE 3-4: STORMWATER DIVERSION CHANNEL SIZING

Catchment	Total Flow	Drainage Channel	Design Flow		Channel dimension (refer to Fig 3-3)					S	n	A	P	R	V	Q
					b1	d1	b2	d2	b3							
	m^3/s		%	m^3/s	m	m	m	m	m	m/m		m^2	m	m	m/s	m^3/s
Plant & Stockpiles	2.4	DW1	25%	0.6	0.6	0.6	0.6	0.6	0.3	0.004	0.025	0.5	2.0	0.3	1.1	0.6
		DW2	25%	0.6	0.6	0.6	0.6	0.6	0.3	0.004	0.025	0.5	2.0	0.3	1.1	0.6
		DW3 Existing	50%	1.2	0.6	0.6	0.6	0.6	0.3	0.004	0.025	0.5	2.0	0.3	1.1	0.6
		DW3 Upgrade	50%	1.2	0.9	0.9	0.9	0.9	0.3	0.004	0.025	1.0	2.7	0.4	1.3	1.3
ROM, Crusher & Contractors Yard	2.1	DW4	100%	2.1	0.9	0.9	0.9	0.9	0.3	0.009	0.025	1.1	2.8	0.4	1.9	2.1
Sinter Plant	0.6	DW5	100%	0.6	0.6	0.6	0.6	0.6	0.3	0.004	0.025	0.5	2.0	0.3	1.1	0.6
Plant & Stockpiles & Sinter Plant	2.4	DW2 Upgraded	50%	1.2	0.8	0.8	0.8	0.8	0.3	0.004	0.025	0.9	2.6	0.4	1.3	1.2
Dirty Water Dam overflow	2.4	DW6	100%	2.4	0.9	0.6	0.9	0.6	1.2	0.009	0.025	1.3	3.4	0.4	1.9	2.4
Workshop Dam overflow	2.1	DW7	100%	2.1	0.6	0.6	0.6	0.6	1.2	0.010	0.025	1.1	2.9	0.4	2.1	2.2

3.5 SIZING OF WASTE ROCK DUMP (WRD) STORMWATER RETENTION BERM

Runoff from the WRDs will collect at the toe of the WRD, and unless managed could in an extreme rainfall event migrate off site and reach a surface water receptor. Whilst this is considered unlikely due to the topography, it is recommended that stormwater retention berms are constructed around the perimeter of the WRD to collect dirty stormwater from the WRDs and satisfy the requirements of GN 704.

The side slopes of the WRDs feature horizontal benches 10-30m in width with 20m high lifts/raises between the benches, with an assumed angle of repose of 1:3. The width of the side slopes between each bench is typically 30-60m and any runoff from the upper slopes of the WRD will collect on the benches and infiltrate through into the permeable WRD. Runoff from the lowest portion of the side slope will be collected by the perimeter stormwater retention berm which will be created parallel to the toe of WRD as presented in Figure 3-4. Indicative sizing of the stormwater retention berms is as follows:

- Maximum width of WRD side slope (between benches) = 50m.
- Offset of perimeter stormwater retention berm from toe of WRD = 10m.
- 1:50 year 24 hour rainfall depth = 141mm.
- Runoff coefficient = 0.53.

Considering the high evaporation and a conservative estimate of infiltration, it is anticipated that the water contained behind the retention berms will evaporate rather in a short space of time and within a few days considering:

- The lowest basic infiltration rate for clay soils (FAO,1988) of 1 mm/hr (24mm/day).
- Mean annual evaporation (1972mm) gives a daily evaporation of 5 mm/d.

Given the arid climate and the fact that the WRDs rarely generate runoff, the stormwater berms / paddock arrangement are not considered to be dams in the context of GN704, and as such, the application of 0.8m freeboard is not considered appropriate. The benches should either be sloped inwards towards the toe of previous section of the WRD above the bench or small berms constructed on the edges to contain stormwater from each side slope for evaporation or seepage.

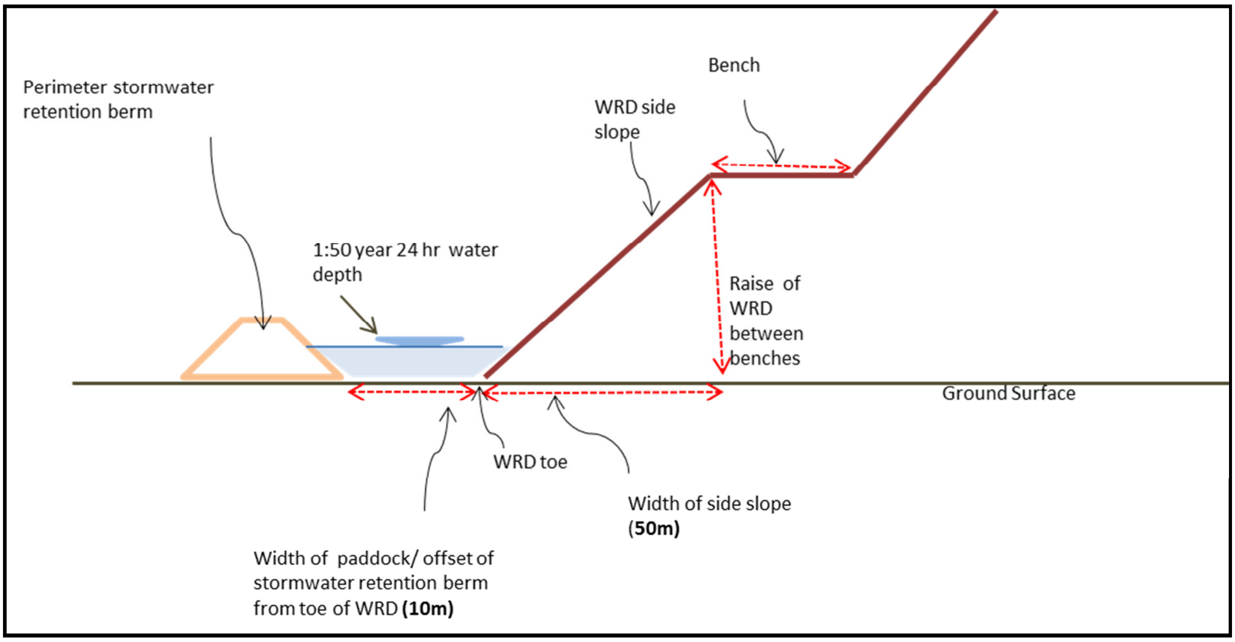

FIGURE 3-4: ILLUSTRATION OF WRD'S STORMWATER MANAGEMENT MEASURES CONCEPTUAL DESIGN RECOMMENDATIONS

3.6 IMPACTS ON MAR

As discussed above, it is proposed that stormwater from the WRD is contained and allowed to evaporate or infiltrate effectively reducing the catchment area draining to the local watercourses. The runoff from the proposed WRD extensions currently drains to the Vlermuisleegte and Ga-Mogara within the D41K quaternary catchment. The existing impacts from the approved infrastructure as part of the approved EMPr (SLR, 2017) would be expected to reduce the run-off to quaternary catchment D41K by 0.152% and the establishment of additional facilities and activities will further reduce the run-off to the quaternary catchment D41K by 0.04%. When considering the loss of run-off to the catchment as a result of proposed WRD extensions containment infrastructure, the significance of the impact is expected to be negligible if any.

3.7 LIMITATIONS AND FURTHER WORK

It is understood that the existing dirty water dam is under capacity when considering the expected runoff volumes from the contributing catchment and a spillway must be constructed so that this facility can convey overflows to the stormwater dam. The invert level of the spillway must be suitable to allow decant from this pond without causing water levels within the dirty water channels to backup and spill upstream of the dirty water dam.

Consideration should be given to incorporating silt traps upstream of the existing dirty water dam and workshop dirty water collection dam, to minimise the silt load to these facilities, which will reduce capacities of the dams and may potentially cause operational problems when re-using water from these facilities (for example silty water may lead to blockages of sprinkler systems at the crushers).

It is recommended that the design parameters for the WRD toe paddocks are revisited and updated to reflect closure plans in particular any re-profiling, top-soiling or revegetation of the WRD prior to closure. Often WRDs will be re-profiled and benches removed creating a larger area of the side slopes that will drain into the toe paddocks. The lower gradients and revegetated surface of the WRD is likely to reduce the runoff coefficients presented above.

4 SITE WIDE WATER BALANCE

4.1 INTRODUCTION

A site wide static water balance was developed in the SLR, 2017[9] Report to understand flows within the Tshipi Borwa Mine's operational water circuit during average dry seasons and average wet seasons during different phases of the project. Following on to this, in 2017, SLR[10] developed a preliminary / high level dynamic daily timestep water balance model for the major water components of the mine for various water management scenarios and tested for a variety of climatic conditions (using 69years of daily rainfall). The model was to endeavour to understand makeup water requirements, likelihoods of water shortages and / or spillage risks for pollution control facilities at Tshipi Borwa Mine.

In this study, the 2017 static water balance remains largely unchanged for the process flow components except for most recent changes as follows:

- The use of water abstracted from proposed boreholes for make-up water thus reducing the need for Sedibeng water.
- Inclusion of the waste rock dumps water circuit in the mine wide water balance, even though runoff from these facilities will be managed separately and will not feed into the mines water circuit.

The water balance is static and no consideration is given to changes in flows resulting from progressive development of infrastructure, variations in climate or changes in production rate, or operational storage.

To demonstrate how variations in groundwater inflows and operational water requirements will impact upon the water balance, the following scenarios were modelled:

- Current average wet and dry seasons.
- Year 10 average wet and dry seasons.
- Life of mine (LOM) average wet and dry seasons.

The water balance reviews all relevant design work by the wider project team, estimates the typical flows, and volumetric requirements of make-up water or discharge of surplus water (where applicable).

The modelled water balance circuit includes water inflows, losses and transfers for the following aspects of the operation as presented in Figure 1-1 which includes:

- Open Pit;

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[9] Tshipi Borwa Mine – Storm water Management Report and Water Balance for EMPR (SLR Consulting, July 2017).

[10] Tshipi Borwa Mine Simulation Water Balance Model (SLR Consulting October 2017). 710.20029.00011

- Stormwater from various dirty water areas defined in Section 3;
- Process Plant(crushing and screening plant);
- Stockpiles; and
- Various Support Services (offices, laboratory, stores and yards, change house, workshops and load out stations).

4.2 WATER RE-USE HIERARCHY

Priority will be given to reusing dirty water from the open pit, treated sewage effluent, and stormwater (collected within the dirty water dam, workshop dirty water collection dam and stormwater dam) for non-potable uses before abstraction of water from clean water sources i.e. makeup water from Sedibeng and potable water from boreholes.

4.3 METHODOLOGY

A Microsoft Excel spreadsheet based model was used to represent the flows within the operational water circuit using information taken from the following sources of information:

- Tshipi Borwa Mine - Stormwater Management And Water Balance For EMPR (SLR,2017) which included the following
  - Information collected during a site visit on 14 March 2017.
  - Process Flow Simulations Report (SET, May 2017)[11].
  - Water Balance – Letter to Dept. Water Affairs (Tshipi, 12 August 2014).
  - Tshipi Borwa Groundwater Study (SLR, July 2017).
  - Environmental Impact Assessment and Environmental Management Programme for the proposed Ntsimbintle Mining Project (Metago, May 2009)
- Information from client on borehole pump testing results

Water sources (inflows) were taken as:

- Groundwater ingress into the open pit;
- Stormwater collected from dirty catchment and conveyed to the stormwater dam, dirty water dam and workshop dirty water collection dam;
- Direct rainfall into the stormwater dam, tailings facility and return water dam, dirty water dam, workshop dirty water collection dam and temporary construction dam; and
- Makeup water abstraction from:

[11] Process flow simulations to complete the construction of the Tshipi mine process plant – Report for Basic Design. (Simulation Engineering Technologies, May 2016)

- Sedibeng pipeline;
- On-site raw water storage facility (filled during the wet season); or
- On-site boreholes (TBW04 and TBW02).

Water sinks (losses) were taken as:

- Evaporation from the dams and tailings facility and waste rock dump paddocks;
- Dust suppression of haul roads, access roads, crushing, screening and conveying installations;
- Potable water consumption;
- Transfer into an on-site raw water storage facility or discharge to environment (to be treated if required).

4.4 ASSUMPTIONS AND INPUT PARAMETERS

The water balance assumes the following:

- The sinter plant and tailings facility will only become operational sometime in the future.
- Rainfall related inflows and evaporation related losses for the wet and dry season scenarios were estimated based on: i) average values during the three driest months of the year; and ii) average values during the three wettest months of the year.
- Runoff and evaporation coefficients for each surface were fixed and not influenced by antecedent climatic conditions, likewise all catchment areas are constant.
- Evaporation from the dams will only occur if there is water in the dam.
- The total / final pit footprint is considered for stormwater calculations into the pit.
- Under normal / average conditions there will be no overflow of stormwater from the dirty water dam or workshop dirty water collection dam into the stormwater dam.
- There will be no inflow of stormwater from the Mamatwan pit in the water balance, and containment arrangements will be in place during mining of the barrier pillar.
- This water balance model is run for only static average wet season and average dry season conditions and no consideration is given to storage of water at any aspect of the infrastructure modelled i.e. flow in = flow out.

The input parameters used for the water balance are presented in Table 4-1

TABLE 4-1: WATER BALANCE INPUT PARAMETERS

Parameter	Description	Source
Climate Data	• Average wet month rainfall = 65mm • Average wet month evaporation = 196mm • Average dry month rainfall = 4mm • Average dry month evaporation = 128mm	• Section 2.1
Pit Inflows	• Current: Zero inflows. • Year 10: 477m^3/day • Life of Mine: 609m^3/day	• SLR Groundwater Model, June 2017
Potable Water	• Demand: 2 628m^3/month • RO Plant Brine: 37% of throughput • Consumption Losses: 36.5m^3/month	• SET, May 2016
Sinter Plant and Tailings Facility	• Water in Tailings: 4 526m^3/month • Water Recovery at Thickener (not shown): 118 729m^3/month • Tailings facility footprint: 20ha • Return to Plant: 0m^3/month • Sinter Plant Losses: moisture losses lumpy (5 258m^3/month) & fines (1 788m^3/month) – moisture in ore (6 000m^3/month) = 1 046m^3/month	• Tshipi, 12 August 2014
Dust Suppression	• Sprinkler System: 7 570m^3/month • Dust Suppression Trucks: 20 x 16kl trucks and 10 x 22kl trucks per day • Wash-down Water: 10l/s for 12hrs, twice per week.	• SET, May 2016 • Information from Site Visit • Information from Site Visit
Make up water	• Monthly water demand = 11 111 – 27 378m^3 • 2 borehole= TBW04 *=1.0 l/sec and TBW02 = 1.5l/s • Sedibeng water : 609m^3/day	• SLR, Stormwater and Water Balance July 2017 • Tue 2018/08/07 email- Pump testing results • SLR Groundwater Model, June 2017

Parameter	Description	Source
Waste Rock Dumps	• North WRD= 94.7 ha • East WRD = 58ha • West WRD = 87.7ha • West WRD Extension =128ha • Runoff coefficient = 53% • Losses = 100 % (interstitial storage and evaporation losses)	• EMP2 Amendment Application Form, SLR. 2018 (710.20008.00041) • EIA and EMP Amendment report final DMR, October 2017 (710.20029.00008) • SLR assumed
Dams	• Dirty Water Dam: o Catchment = 496 800m^2 exc. Sinter Plant or 596 900m^2 inc. Sinter. o Dam Footprint = 10 600m^2 o Runoff Coefficient = Wet Season: 13%, Dry Season = 6% • Workshop Dirty Water Collection Dam: o Catchment = 368 700m^2 o Footprint = 1 900m^2 o Runoff Coefficient = Wet Season: 13%, Dry Season = 6% • Stormwater Dam: o Catchment = N/A (overflow from dirty water dam and workshop dirty water collection dam dams only) o Footprint = 13 000m^2 o Runoff Coefficient = N/A • Pit Stormwater: o Catchment = yr0: 680 541m^2 increasing to 2 437 466m^2 from yr10 onwards. o Pit Sump Footprint = assumed 1% of pit area o Runoff Coefficient = Wet Season: 13%, Dry Season = 6% • Temporary Construction Dam: o Catchment = N/A o Footprint = 2 500m^2	• Stormwater Management Plan – Section 3.

*1) Borehole TWB04 test data indicate a hydraulic barrier at approximately 70 mbgl; recovery data recorded indicate severe dewatering,

2) Pumping of borehole TWB04 must be monitored continuously, and if the water level drawdown reaches below 65 mbgl., the pumping yield should be reduced.

4.5 RESULTS

The water balances for the wet and dry seasons for the modelled scenarios are presented in Figure 4-1 to Figure 4-6 below.

The water balance shows that currently, groundwater inflows are negligible and the mine is reliant on makeup water from Sedibeng with monthly demand estimated to be between 11 111 – 27 378m^3.

Currently, Tshipi is exploring the inclusion of an option to abstract water from two boreholes (TBW02 &TBW04) which would reduce reliance on Sedibeng water. This supply option yields 1.5 l/s (1 970 m^3/month) at TBW02 and 1.0 l/s (1 310 m^3/month and these yields are still less that what would be required in the average dry season for the current mining scenario water balance to complement the 16 666 m^3/month water supply limit authorised for withdrawal from the Sedibeng. This leaves an additional water demand from Sedibeng over and above the monthly limit approximately up to 7 400 m^3/month when the mine is water negative.

Groundwater inflow and stormwater collecting within the open pit becomes a very significant source of water for the mine in future years and from year 10 onwards the mine could be expected to be water positive during the wet season, although there is still expected to be a requirement for makeup water through the dry season.

Consideration should be given to storage of the excess stormwater and groundwater expected during the wet season, to reduce makeup water requirements during the dry season. An option for storage of this water would be to utilise another compartment of the 78Ml stormwater dam not required for stormwater from the plant area, or storage within a suitably designed sump within the base of the pit which is a cost effective solution.

The temporary construction dam has been retained throughout the life of the mine and will be used to store raw water from the Sedibeng water from time to time, due to the unreliability of this water source.

4.6 LIMITATIONS

As discussed in Section 4.3, this water balance is run on a static basis and no consideration is given to storage of water at any aspect of the infrastructure modelled. Furthermore the daily time step model in the SLR[12] , 2017, was based on high level information and several assumptions. Therefore, to improve certainty on the makeup water requirements, and identify water conservation and water demand management measures, a dynamic simulation water balance model should be undertaken once further water monitoring data become available. In that way the level of detail of the existing daily time step model as well as calibration can be undertaken against actual monitored data from the site, which will greatly improve the accuracy of any modelled results.

Groundwater inflow to the open pit forms a critical part of the mine's water circuit and is the main source of water in later years of mining. Groundwater inflows are based on the available modelled data and it is recommended that measurements of water pumped out of the pit are collected and used to calibrate the water balance model presented herewith.

Once further water monitoring data become available, consideration should be given to increasing the level of detail of the model, and calibrating against actual monitored data from the site, which will greatly improve the

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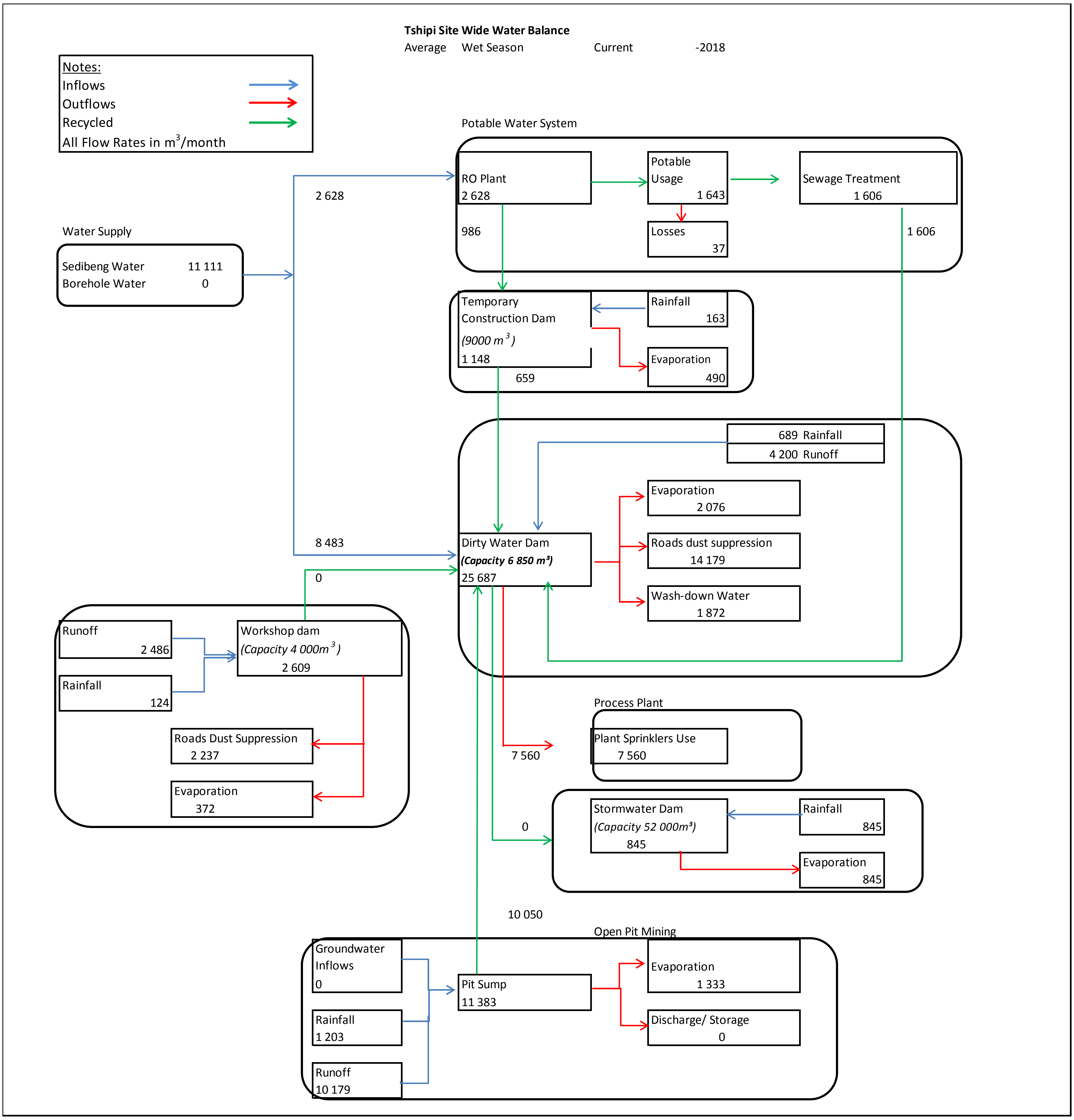
[12] Tshipi Borwa Mine Simulation Water Balance Model,(SLR Consulting , October 2017) 710.20029.00011

accuracy of any modelled results. This study should be updated whenever additional information becomes available, and a review of available monitoring or design data should be undertaken on an annual basis.



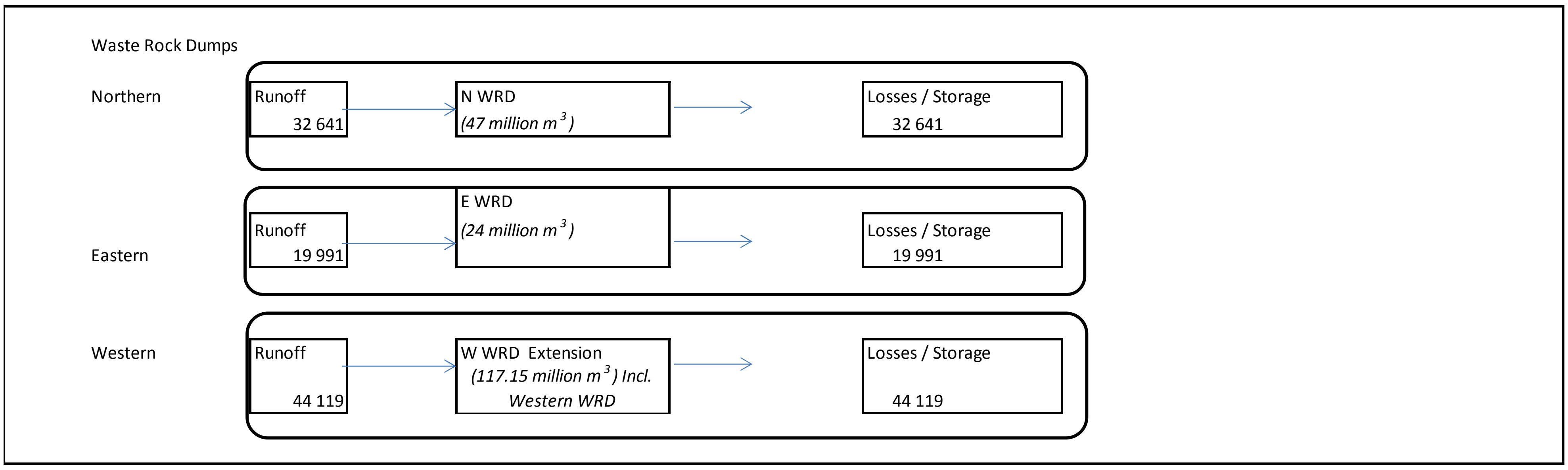


FIGURE 4-1: WATER BALANCE - CURRENT WET SEASON

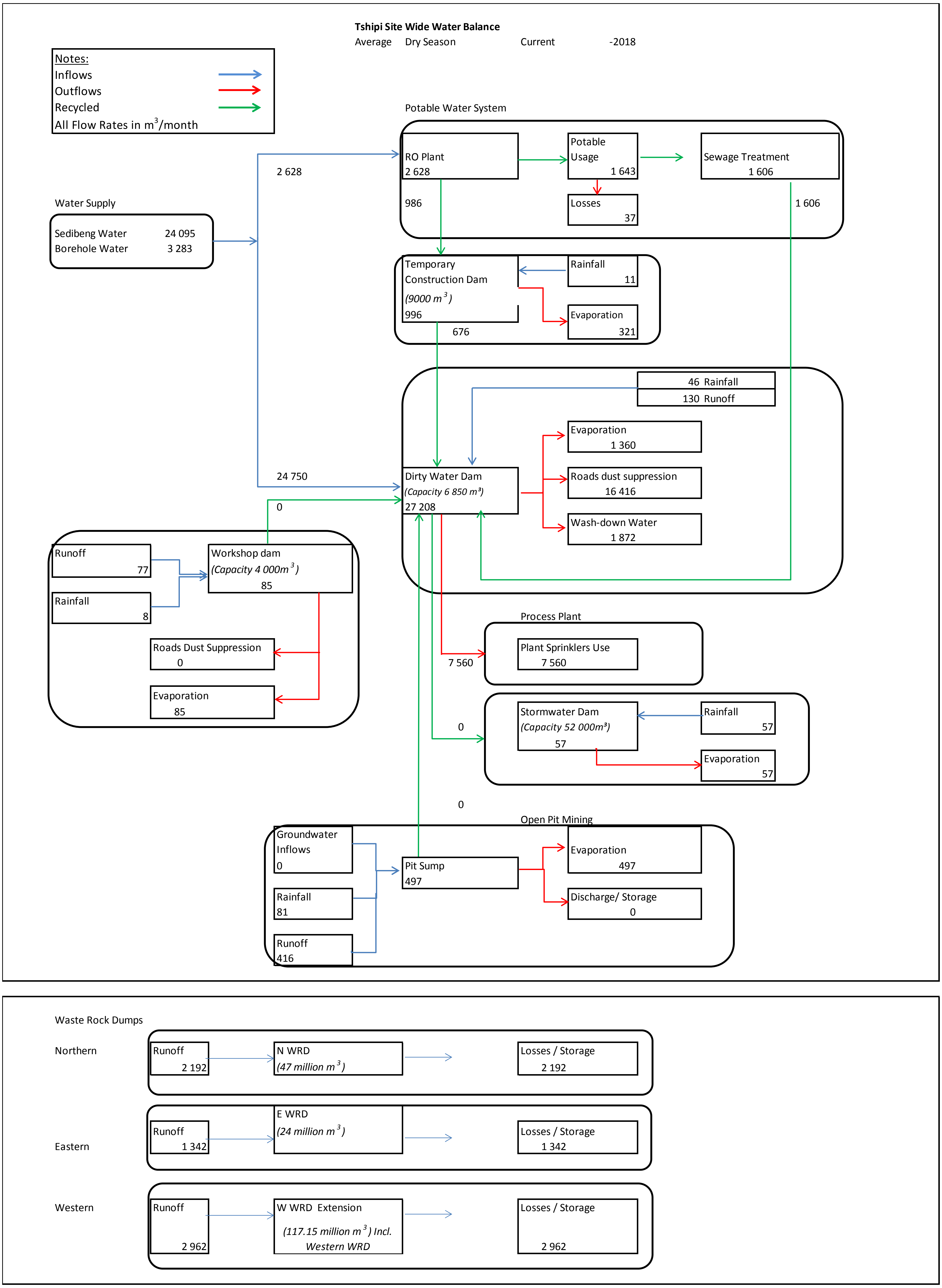


FIGURE 4-2: WATER BALANCE - CURRENT DRY SEASON

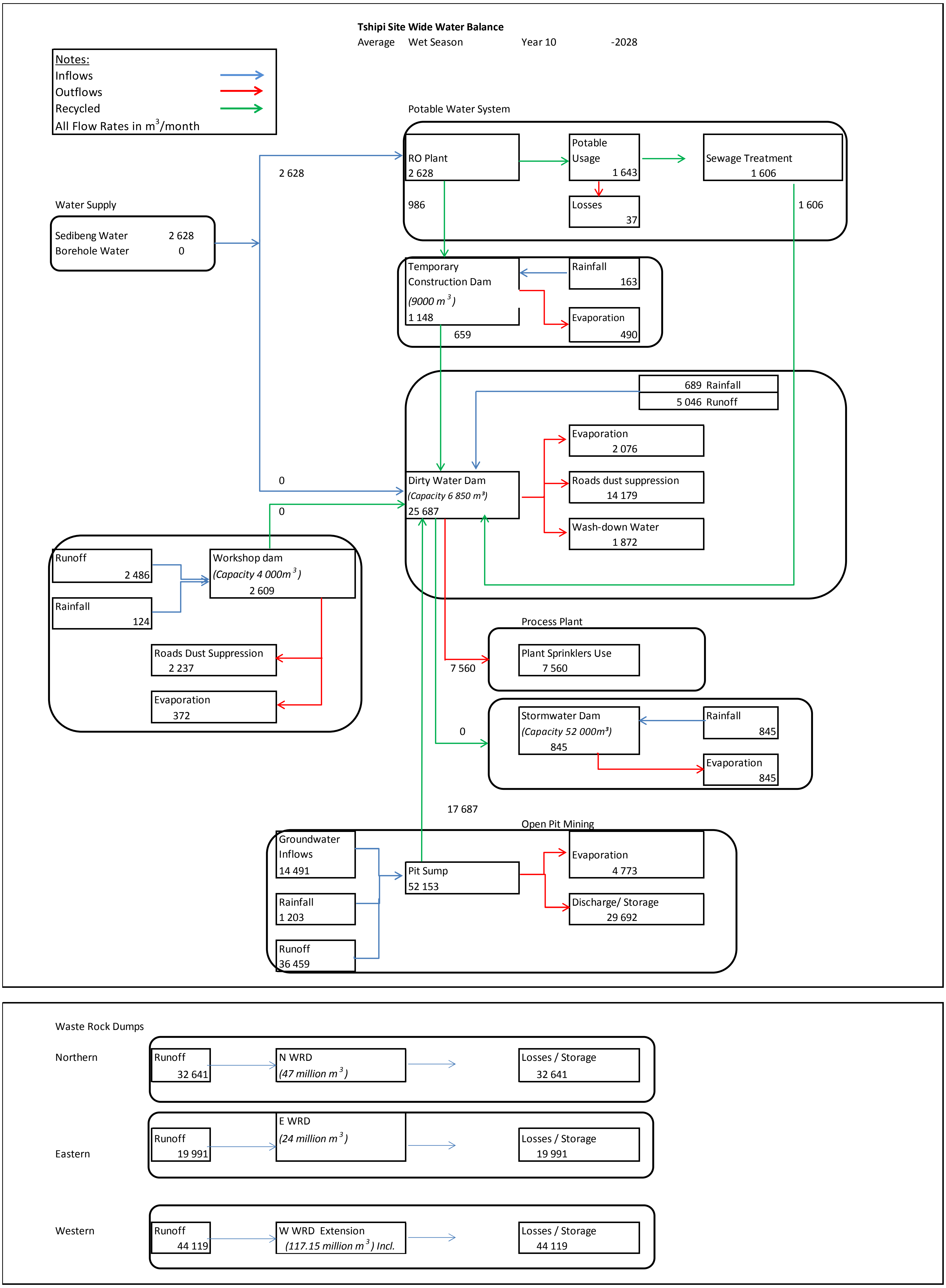
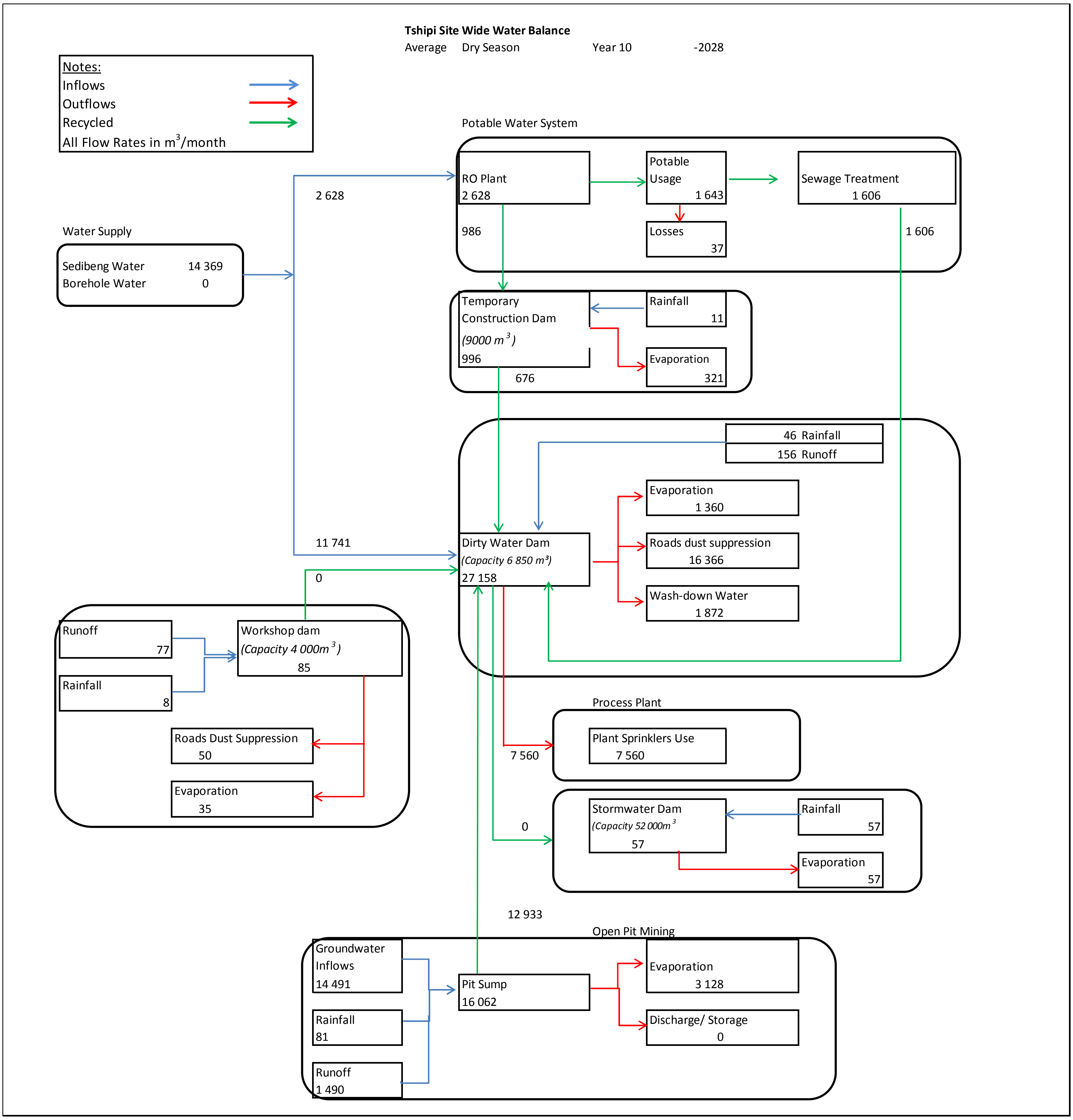


FIGURE 4-3: WATER BALANCE - YEAR 10 WET SEASON

SLR



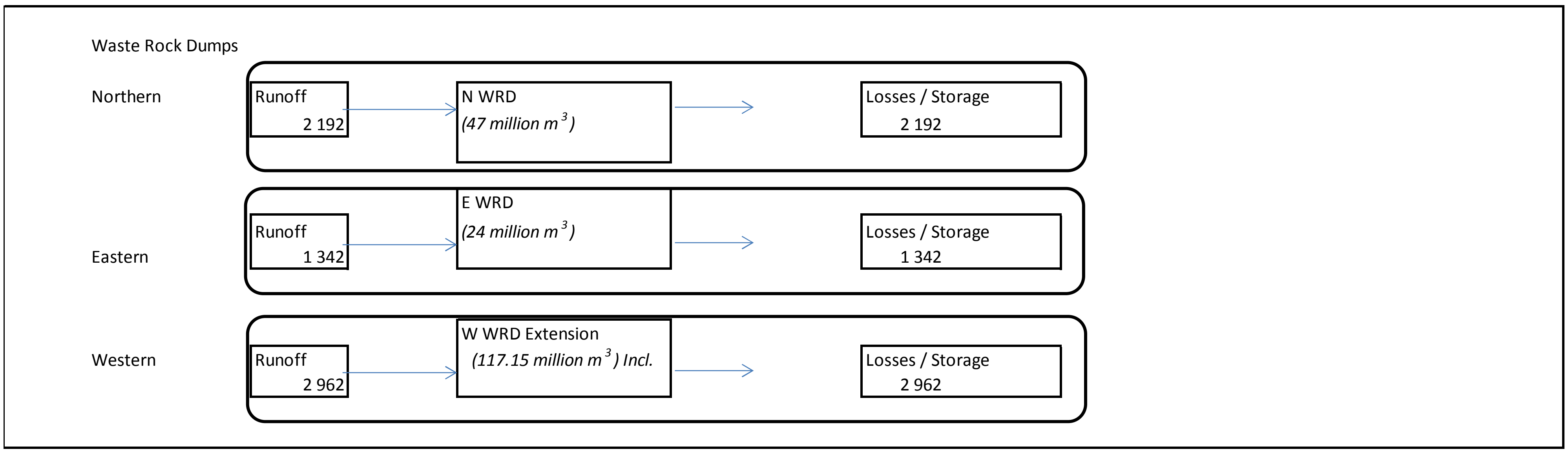


FIGURE 4-4: WATER BALANCE - YEAR 10 DRY SEASON

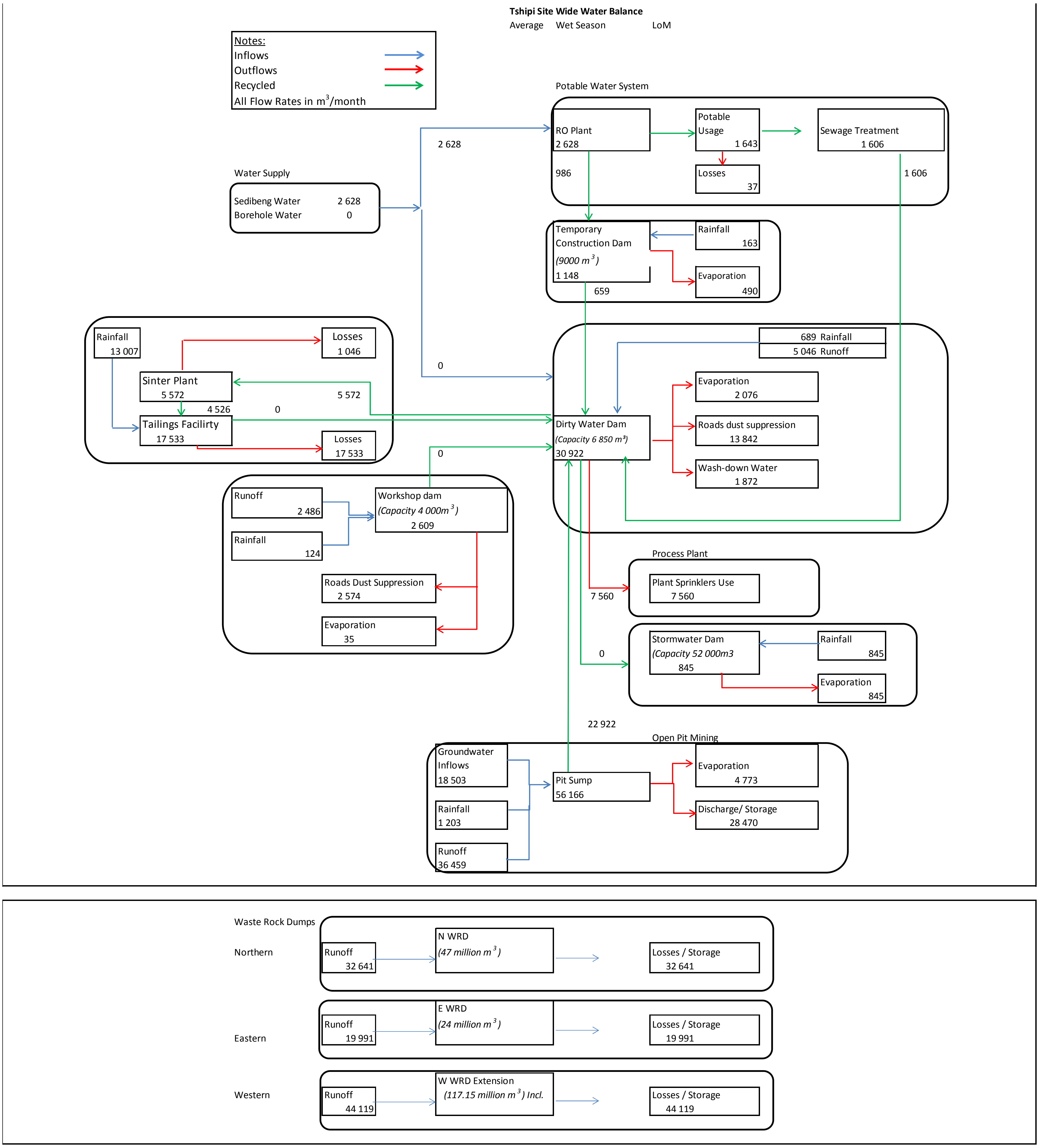
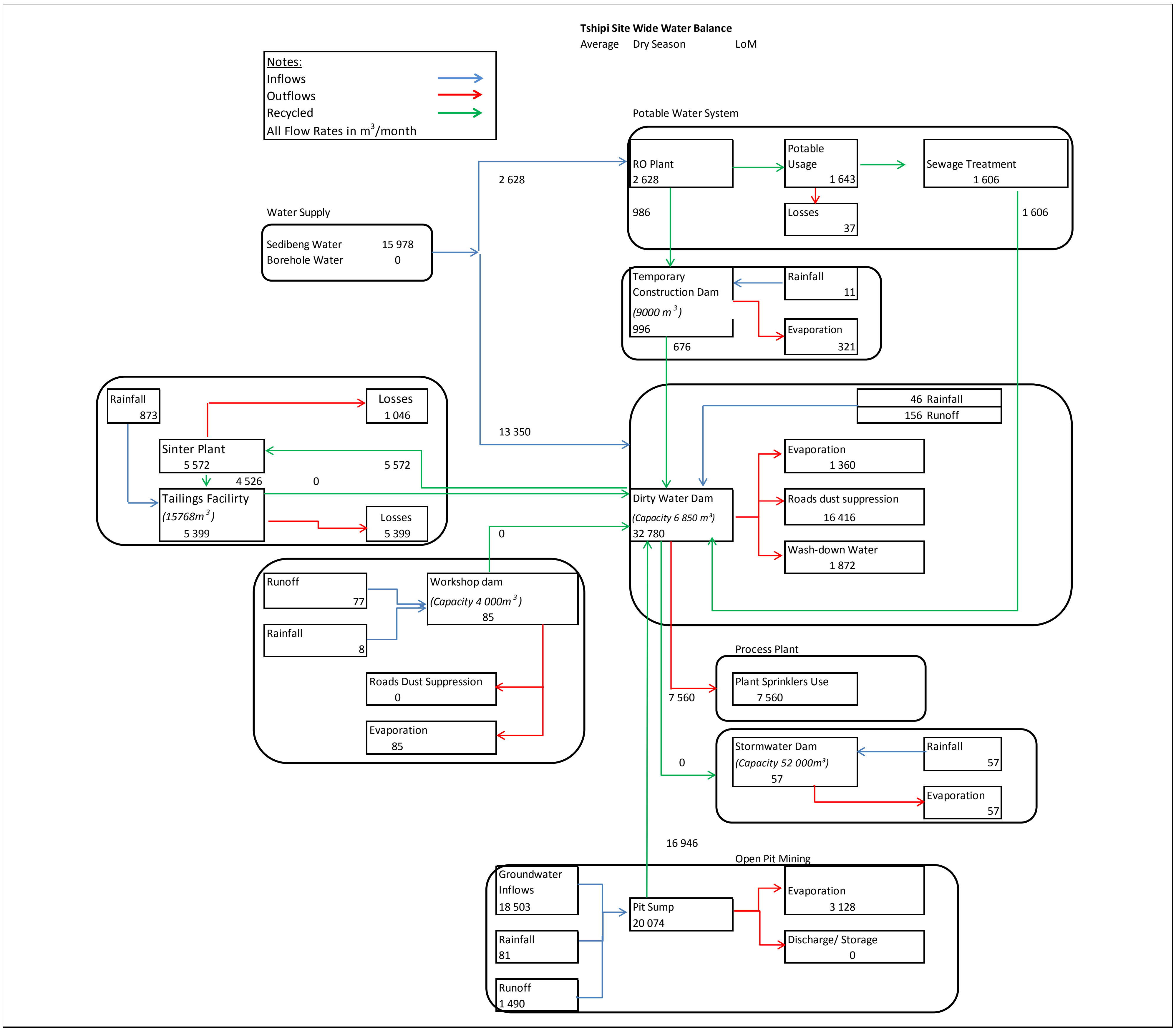


FIGURE 4-5: WATER BALANCE – LIFE OF MINE WET SEASON



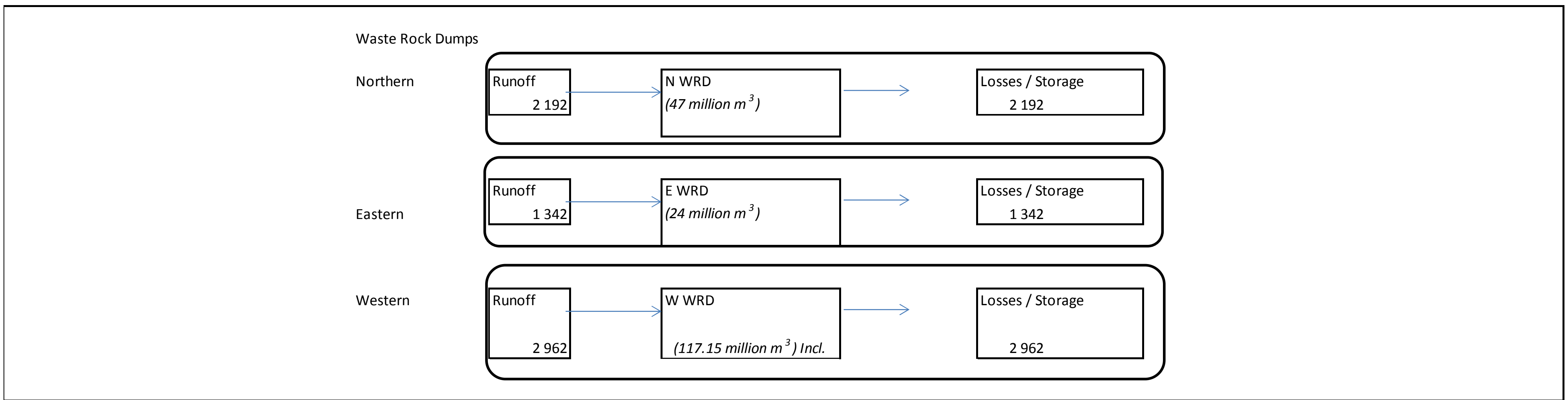


FIGURE 4-6: WATER BALANCE – LIFE OF MINE DRY SEASON

5 SUMMARY OF WATER BALANCE

This section presents the summaries for the wet and dry season water balances as modelled in Section 4 in conformance with Department of Water and Sanitation (DWS) template summary tables for wet and dry periods for current year (2018), Year 10 (2028) and the Life of Mine presented in from Table 5-1 through to Table 5-6.

In the current scenario, the mine is water negative, requiring some make up water from Sedibeng in both the wet and dry season presented in Table 5-1 and Table 5-2.

TABLE 5-1: SUMMARY WATER BALANCE – CURRENT WET SEASON - 2018

Facility		Water in		Water Out
	Water Circuit/stream	Quantity (m^3/month)	Water Circuit/stream	Quantity (m^3/month)
Offices and Plant Workshops	Sedibeng Water	2 628	Water Uses	37
	Boreholes Water	-	Dirty Water Dam from STP Effluent	1 606
			RO Plant effluent	986
Totals		2 628		2 629
Pit (Sump)	Groundwater Inflows	-	Dirty Water Dam	10 050
	Runoff	10 179	Evaporation	1 333
	Rainfall	1 203	Discharge/ Storage	-
Totals		11 383		11 383
Temporary Construction Dam	Rainfall	163	Dirty Water Dam	659
	RO Plant Effluent	986	Evaporation	490
Totals		1 149		1 148
Workshop Dam	Rainfall	124	Dust supression roads	2 237
	Runoff	2 486	Evaporation	372
			Dirty Water Dam	-
Totals		2 609		2 609
Dirty Water Dam	Sedibeng Water or Boreholes	8 483	Washdown Water	1 872
	Boreholes Water	-	Dust supression roads	14 179
	Runoff	4 200	Plant	7 560
	Rainfall	689	Evaporation	2 076
	STP effluent	1 606		
	Pit Sump	10 050		
	Temporary Construction Dam	659		
	Workshop dam	-		
Totals		25 687		25 687
Plant	Dirty Water Dam	7 560	Plant Sprinklers	7 560
Totals		7 560		7 560
Waste Rock Dumps	Runoff- N WRD	32 641	Interstitial lock up, Storage & evap	32 641
	Runoff- E WRD	19 991		19 991
	Runoff- W WRD Extension	44 119		44 119
Totals		96 751		96 751
Balance				**0**

TABLE 5-2: SUMMARY WATER BALANCE – CURRENT DRY SEASON - 2018

Facility		Water in		Water Out
	Water Circuit/stream	**Quantity (m^3/month)**	**Water Circuit/stream**	**Quantity (m^3/month)**
Offices and Plant Workshops	Sedibeng Water	2 628	Water Uses	37
	Boreholes Water	-	Dirty Water Dam from STP Effluent	1 606
			RO Plant effluent	986
Totals		2 628		2 629
Pit (Sump)	Groundwater Inflows	-	Dirty Water Dam	0
	Runoff	416	Evaporation	497
	Rainfall	81	Discharge/ Storage	-
Totals		497		497
Temporary Construction Dam	Rainfall	11	Dirty Water Dam	676
	RO Plant Effluent	986	Evaporation	321
Totals		997		996
Workshop Dam	Rainfall	8	Dust supression roads	0
	Runoff	77	Evaporation	85
			Dirty Water Dam	-
Totals		85		85
Dirty Water Dam	Sedibeng Water or Storage	21 467	Washdown Water	1 872
	Boreholes Water	3 283	Dust supression roads	16 416
	Runoff	130	Plant	7 560
	Rainfall	46	Evaporation	1 360
	STP effluent	1 606		
	Pit Sump	0		
	Temporary Construction Dam	676		
	Workshop dam	-		
Totals		27 208		27 208
Plant	Dirty Water Dam	7 560	Plant Sprinklers	7 560
Totals		7 560		7 560
Waste Rock Dumps	Runoff- N WRD	2 192	Interstitial lock up, Storage & evapora	2 192
	Runoff- E WRD	1 342		1 342
	Runoff- W WRD Extension	2 962		2 962
Totals		6 496		6 496
Balance				**-1**

Groundwater inflow and stormwater collecting within the open pit becomes a very significant source of water for the mine in future years and from year 10 onwards the mine could be expected to be water positive during the wet season, although there is still expected to be a requirement for makeup water through the dry season as presented in Table 5-3 to Table 5-6.

TABLE 5-3: SUMMARY WATER BALANCE – YEAR 10 WET SEASON - 2028

Facility		Water in		Water Out
	Water Circuit/stream	**Quantity (m^3/month)**	**Water Circuit/stream**	**Quantity (m^3/month)**
Offices and Plant Workshops	Sedibeng Water	2 628	Water Uses	37
	Boreholes Water	-	Dirty Water Dam from STP Effluent	1 606
			RO Plant effluent	986
Totals		2 628		2 629
Pit (Sump)	Groundwater Inflows	14 491	Dirty Water Dam	17 687
	Runoff	36 459	Evaporation	4 773
	Rainfall	1 203	Discharge/ Storage	29 692
Totals		52 153		52 152
Temporary Construction Dam	Rainfall	163	Dirty Water Dam	659
	RO Plant Effluent	986	Evaporation	490
Totals		1 149		1 148
Workshop Dam	Rainfall	124	Dust supression roads	2 237
	Runoff	2 486	Evaporation	372
			Dirty Water Dam	-
Totals		2 609		2 609
Dirty Water Dam	Sedibeng Water or Storage	-	Washdown Water	1 872
	Boreholes Water	-	Dust supression roads	14 179
	Runoff	5 046	Plant	7 560
	Rainfall	689	Evaporation	2 076
	STP effluent	1 606		
	Pit Sump	17 687		
	Temporary Construction Dam	659		
	Workshop dam	-		
Totals		25 687		25 687
Plant	Dirty Water Dam	7 560	Plant Sprinklers	7 560
Totals		7 560		7 560
Waste Rock Dumps	Runoff- N WRD	32 641	Interstitial lock up, Storage & evaporat	32 641
	Runoff- E WRD	19 991		19 991
	Runoff- W WRD Extension	44 119		44 119
Totals		96 751		96 751
Balance				**0**

TABLE 5-4: SUMMARY WATER BALANCE – YEAR 10 DRY SEASON - 2028

Facility		Water in		Water Out
	Water Circuit/stream	**Quantity (m^3/month)**	**Water Circuit/stream**	**Quantity (m^3/month)**
Offices and Plant Workshops	Sedibeng Water	2 628	Water Uses	37
	Boreholes Water	-	Dirty Water Dam from STP Effluent	1 606
			RO Plant effluent	986
Totals		2 628		2 629
Pit (Sump)	Groundwater Inflows	14 491	Dirty Water Dam	12 933
	Runoff	1 490	Evaporation	3 128
	Rainfall	81	Discharge/ Storage	-
Totals		16 062		16 061
Temporary Construction Dam	Rainfall	11	Dirty Water Dam	676
	RO Plant Effluent	986	Evaporation	321
Totals		997		996
Workshop Dam	Rainfall	8	Dust supression roads	50
	Runoff	77	Evaporation	35
			Dirty Water Dam	-
Totals		85		85
Dirty Water Dam	Sedibeng Water or Storage	11 741	Washdown Water	1 872
	Boreholes Water	-	Dust supression roads	16 366
	Runoff	156	Plant	7 560
	Rainfall	46	Evaporation	1 360
	STP effluent	1 606		
	Pit Sump	12 933		
	Temporary Construction Dam	676		
	Workshop dam	-		
Totals		27 158		27 158
Plant	Dirty Water Dam	7 560	Plant Sprinklers	7 560
Totals		7 560		7 560
Waste Rock Dumps	Runoff- N WRD	2 192	Interstitial lock up, Storage & evapora	2 192
	Runoff- E WRD	1 342		1 342
	Runoff- W WRD Extension	2 962		2 962
Totals		6 496		6 496
Balance				**0**

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TABLE 5-5: SUMMARY WATER BALANCE – LOM WET SEASON

Facility		Water in		Water Out
	Water Circuit/stream	**Quantity (m^3/month)**	**Water Circuit/stream**	**Quantity (m^3/month)**
Offices and Plant Workshops	Sedibeng Water	2 628	Water Uses	37
	Boreholes Water	-	Dirty Water Dam from STP Effluent	1 606
			RO Plant effluent	986
Totals		2 628		2 629
Pit (Sump)	Groundwater Inflows	18 503	Dirty Water Dam	22 922
	Runoff	36 459	Evaporation	4 773
	Rainfall	1 203	Discharge/ Storage	28 470
Totals		56 166		56 165
Temporary Construction Dam	Rainfall	163	Dirty Water Dam	659
	RO Plant Effluent	986	Evaporation	490
Totals		1 149		1 148
Workshop Dam	Rainfall	124	Dust supression roads	2 574
	Runoff	2 486	Evaporation	35
			Dirty Water Dam	-
Totals		2 609		2 609
Dirty Water Dam	Sedibeng Water or Storage	-	Washdown Water	1 872
	Boreholes Water	-	Dust supression roads	13 842
	Runoff	5 046	Plant	7 560
	Rainfall	689	Evaporation	2 076
	STP effluent	1 606	Sinter Plant	5 572
	Pit Sump	22 922	Stormwater Dam	-
	Temporary Construction Dam	659		
	Workshop dam	-		
	TSF	-		
Totals		30 922		30 922
SWD	Dirty Water Dam	0	Evaporation	845
	Rainfall	845		
Totals		0		845
Plant	Dirty Water Dam	7 560	Plant Sprinklers	7 560
Totals		7 560		7 560
Waste Rock Dumps	Runoff- N WRD	32 641	Interstitial lock up, Storage & evaporat	32 641
	Runoff- E WRD	19 991	Interstitial lock up, Storage & evaporat	19 991
	Runoff- W WRD Extension	44 119	Interstitial lock up, Storage & evaporat	44 119
Totals		52 632		52 632
Sinter Plant	Dirty Water Dam	5 572	Losses	1 046
			TSF	4 526
Totals		5 572		5 572
TSF	Sinter Plant	4 526	Losses	17 533
	Rainfall	13 007	Dirty Water Dam	-
Totals		17 533		17 533
Balance				**0**

TABLE 5-6: SUMMARY WATER BALANCE – LOM DRY SEASON

Facility		Water in		Water Out
	Water Circuit/stream	Quantity (m^3/month)	Water Circuit/stream	Quantity (m^3/month)
Offices and Plant Workshops	Sedibeng Water	2 628	Water Uses	37
	Boreholes Water	-	Dirty Water Dam from STP Effluent	1 606
			RO Plant effluent	986
Totals		2 628		2 629
Pit (Sump)	Groundwater Inflows	18 503	Dirty Water Dam	16 946
	Runoff	1 490	Evaporation	3 128
	Rainfall	81	Discharge/ Storage	-
Totals		20 074		20 074
Temporary Construction Dam	Rainfall	11	Dirty Water Dam	676
	RO Plant Effluent	986	Evaporation	321
Totals		997		996
Workshop Dam	Rainfall	8	Dust supression roads	0
	Runoff	77	Evaporation	85
			Dirty Water Dam	-
Totals		85		85
Dirty Water Dam	Sedibeng Water or Storage	13 350	Washdown Water	1 872
	Boreholes Water	-	Dust supression roads	16 416
	Runoff	156	Plant	7 560
	Rainfall	46	Evaporation	1 360
	STP effluent	1 606	Sinter Plant	5 572
	Pit Sump	16 946		
	Temporary Construction Dam	676		
	Workshop dam	-		
	TSF	-		
Totals		32 780		32 780
SWD	Dirty Water Dam	0	Evaporation	57
	Rainfall	57		
Totals		57		57
Plant	Dirty Water Dam	7 560	Plant Sprinklers	7 560
Totals		7 560		7 560
Waste Rock Dumps	Runoff- N WRD	2 192	Interstitial lock up, Storage & evaporati	2 192
	Runoff- E WRD	1 342	Interstitial lock up, Storage & evaporati	1 342
	Runoff- W WRD	2 962	Interstitial lock up, Storage & evaporati	2 962
Totals		3 534		3 534
Sinter Plant	Dirty Water Dam	5 572	Losses	1 046
			TSF	4 526
Totals		5 572		5 572
TSF	Sinter Plant	4 526	Losses	5 399
	Rainfall	873	Dirty Water Dam	-
Totals		5 399		5 399
Balance				**0**

6 IMPACT ASSESSMENTS AND MITIGATION

Informed by the baseline hydrology, design specifications for the storm water management measures, and the water balance, the potential impacts of the proposed activities on surface water receptors are discussed in this section.

6.1 IMPACT ASSESSMENTS

This study determined that surface water receptor nearby is the Vlermuisleegte which is almost 1km from the perimeter of the West WRD and at low risk of impacts from any contaminated runoff.

The proposed project design includes various mitigation measures embedded in design principles presented in Section (3 and 4). Theoretically without these measures the impacts on the environment would be much higher, although the proposed WRD extensions would almost certainly not be allowed to proceed without compliance with current best practice and relevant industry guidelines.

The potential unmitigated impacts and residual impacts of the project after considering the design mitigation measures proposed within this report are qualitatively assessed in this section and presented in Table 6-1

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TABLE 6-1: SUMMARY OF SURFACE WATER IMPACT ASSESSMENTS

Issue	Description	Severity	Duration	Extent	Consequence	Probability	Significance
Impact on/from Natural Drainage Patterns – Unmitigated	The proposed WRD will alter natural drainage patterns and reduce runoff potential to the streams.	Considering the topography and drainage patterns, the WRD or parts thereof will have minor alteration of the natural drainage patterns and reduction of runoff volumes reporting to the D41K being 0.04%.< (L)	The alteration of drainage patterns will extend beyond closure as the WRDs are likely to remain in perpetuity. (H)	Impacts could stretch downstream within the Vlermuisleegte catchment. (M)	Medium	The probability of the alteration of drainage patterns is definite, but the magnitude of the reduced flows is unlikely to result in substantial deterioration and related flow impacts downstream due to the relatively flat topography and high infiltration rates, therefore the probability is low. (L)	Low
Impact on/from Natural Drainage Patterns – Mitigated	The location of surface infrastructure is informed by the surface topography which is fairly gently sloping thus limited runoff is anticipated.	Surface infrastructure is located far from the stream, and the impact of the infrastructure on the mean annual runoff of catchments including the quaternary catchment D41K will be 0.04%. (L)	The alteration of drainage patterns will extend beyond closure as the WRDs are likely to remain in perpetuity. (H)	Impacts could stretch downstream within the Vlermuisleegte catchment. (M)	Medium	Probabilities of impacts are Low. (L)	Low
Impact on Baseline Surface Water Quality – Unmitigated	The proposed project could cause pollution of local watercourses through runoff from waste rock dump.	The establishment of the proposed WRD extensions, powerline and conveyor will present additional pollution sources albeit similar in nature to what has already been assessed for the mine. Severity expected to be low. (L)	Impacts could be for the lifetime of the project after rainfall events. (M)	The spatial scale is limited to the mining area given that the nearest river is located nearly 2 km west of the mine and is ephemeral in nature (L)	Low	When considering the nature and location of the mine in proximity to the Vlermuisleegte River, the unmitigated probability is low	Low
Impact on Baseline Surface Water Quality - Mitigated	The location of surface infrastructure is informed by the storm water management plan developed in accordance with GN 704 to ensure that dirty water does not spill into clean water more frequently than once in 50 years.	Considering the mitigation measures discussed within this report, the mine will have a low severity impact on the quality of surface water resources. (L)	With management actions, pollution can be prevented and/or managed and as such the impacts can be reduced to less than the mine life. (L)	The impacts could be confined to the stormwater structures on site. (L)	Low	Probability of impacts is unlikely. (L)	Low.

6.2 MITIGATION MEASURES

Several studies have been undertaken for the mine, and have been covered in this report (in summary and in detail), and these include mitigation measures embedded in design principles and recommendations.

A summary of these measures that when implemented reducing any potential impacts on both surface water drainage quality and quantity is presented below.

- Stormwater management as detailed in Section 3 which includes the following:
  - prevention of clean water from entering dirty catchments by perimeter berms,
  - collection and conveyance of dirty storm water by concrete lined drainage channels
  - containment of dirty runoff water into the various dirty water dams,
  - containment of runoff from the RWD and side slopes within containment berms and allowed to evaporate.
- Water balance as detailed in Section 4 where the it included the following:
  - project's water circuit has been defined and a collection and water management strategy defined where the reuse of dirty water will be prioritised as much as is practical
  - planning for discharge of excess mine water and storing for use in low water supply periods
- Design standards should be followed as presented in the two design reports:
  - Waste Rock Dumps detailed design for EMP 2 Amendment, SLR June 2018.
  - Integrated Storm Water Management Design for WULA Purposes, SLR January 2018.

In addition to the measures presented and discussed above, the following management measures should be implemented:

- Good housekeeping practices should be maintained by clean-up of dislodged or any slope failures material that accumulate and reduce the capacity of containment berms and compartments for runoff collection
- Good housekeeping practices should be maintained by clean-up of spillages of chemical and hazardous material ensuring that the clean-up material and materials safety data sheets are kept on site for immediate clean-up of accidental spillages of pollutants.
- Water management facilities inspection and maintenance should be undertaken throughout the life of mine, and should include the following:
  - include inspection of drainage structures, liners for any in channel erosion or cracks;
  - de-silting of silt traps/sumps and PCDs; and
  - any pumps and pipelines should be maintained according to manufacturer's specifications.
- Vehicles or plant equipment servicing should be undertaken within suitably equipped facilities, either within workshops, or within bunded areas, from which any storm water is conveyed to a stormwater management structures nearby, preferably after passing through and oil and silt interceptor.

All measures implemented for the mitigation of impacts, should be regularly reviewed as best practice and as compliance with various licences issued on site by authorities i.e Water Use Licences (WULs).

7 CONCLUSIONS AND RECOMMENDATIONS

This study was undertaken to complement several other SLR's 2017 reports and the conclusions and recommendations from the study are detailed in this section:

The site is located within a semi-arid climatic region of South Africa characterised by seasonal rainfall, hot temperatures in summer, and colder temperatures in winter. The nearest watercourse is the Vlermuisleegte, a non-perennial tributary of the Gamagara, which flows from south-east to north-west approximately 1 km west of the site and at low risk of impacts from the WRD runoff.

The existing impacts from the approved infrastructure as part of the approved EMPr (SLR, 2017) will reduce the run-off to quaternary catchment D41K by 0.152% and the establishment of additional facilities and activities will further reduce the run-off to the quaternary catchment D41K by 0.04%.

It is a legislative requirement that potentially contaminated surface water runoff from the dumps and stockpiles is prevented from leaving the site and that uncontaminated water from the surrounding areas is diverted around the deposits. It is recommended that perimeter stormwater containment berms are created at a nominal 10m from the toe of the WRD to contain stormwater.

The considerations of using two boreholes (TBW02 &TBW04) as alternative sources of make-up water have been explored. The combined yield from the boreholes (3280m^3/month)assuming they both operating at their maximum 12 hours do not significantly reduce the Sedibeng water demand in the dry water negative (current-dry season scenario). The Sedibeng water demand in the current dry season average water balance will still be higher than the 16 666m^3 monthly supply limit by up to 7 400 m^3/month when the mine is water negative.

An impact assessment was undertaken and the potential identified impact for the proposed waste rock dump extensions on the drainage patterns and water quality were assessed qualitatively. It was determined that these identified impacts will be of low significance on the water resources if mitigation measures embedded in the storm water and water balance are implemented.

The recommendations for further work are as detailed below.

It is recommended that the design parameters for the WRD toe paddocks are revisited and updated to reflect closure plans in particular any re-profiling, top-soiling or revegetation of the WRD prior to closure. Often WRDs will be re-profiled and benches removed creating a larger area of the side slopes that will drain into the toe paddocks. The lower gradients and revegetated surface of the WRD is likely to reduce the runoff coefficients..

Considering the limitation for the water balance, to improve certainty on the makeup water requirements, and identify water conservation and water demand management measures, a dynamic simulation water balance model should be undertaken once further water monitoring data become available. In that way the level of detail of the existing daily time step model as well as calibration can be undertaken against actual monitored data from the site, which will greatly improve the accuracy of any modelled results.

Groundwater inflow to the open pit forms a critical part of the mine's water circuit and is the main source of water in later years of mining. Groundwater inflows are based on the available modelled data and it is recommended that measurements of water pumped out of the pit are collected and used to calibrate the water balance model presented.

Once further water monitoring data become available within the mine water circuit, consideration should be given to increasing the level of detail of the model, and calibrating against actual monitored data from the site, which will greatly improve the accuracy of any modelled results. The water balance study should be updated whenever additional information becomes available, and a review of available monitoring or design data should be undertaken on an annual basis.

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