Appendix 8 Water Balance Modelling

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Ashton Coal Operations Pty Ltd
PO Box 699
Singleton, NSW
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Attention Phil Fletcher

Dear Sir

Bowmans Creek Diversion Environmental Assessment - Water Balance Modelling

1. INTRODUCTION

WorleyParsons was engaged by Ashton Coal Operations Limited (*ACOL*) to undertake water balance calculations as part of the Bowmans Creek Diversion Environmental Assessment (*EA*). The project comprises Bowmans Creek Diversion works as well as an extension of the existing underground long wall mining operations. The proposed long wall mining areas consists of an additional panel located on the western side of the approved underground. Groundwater modelling has predicted a moderate increase in inflows to the underground workings resulting from the additional panel. However, it is noted that the predicted inflows are less than those predicted and approved in the original EIS. The Director General's Requirements include a requirement to revise the site water balance for the Ashton Coal Project, this document addresses that requirement.

WorleyParsons has recently developed a comprehensive water balance model of the ACOL operation as part of the South Eastern Open Cut (*SEOC*) EA, which is currently under consideration by the NSW Department of Planning. This water balance model was revised to incorporate the additional inflow from the underground operation. As the SEOC project has not yet been approved, this water balance assessment has considered both the existing ACOL operation and the proposed ACOL operation should the SEOC project be approved.

This letter should be read in conjunction with the report titled *South Eastern Open Cut - Surface Water Assessment (Worley Parsons, 2009)*. This report documents the development, calibration and results of the SEOC water balance. **Section 6** of this report discusses the water balance model in detail, and is attached as **Attachment 1** to this document.

2. INFLUENCE OF DEVELOPMENT PROPOSAL ON THE EXISTING WATER BALANCE

Groundwater modelling undertaken by Aquaterra (ref: *Bowmans Creek Diversion: Groundwater Impact Assessment Report, Aquaterra, 2009)* has concluded that the proposed long wall mining panels would result in increased inflow rates into the underground workings. The projected inflows into each panel, as well as the cumulative inflows over the life of the project are presented in **Plate 1**.

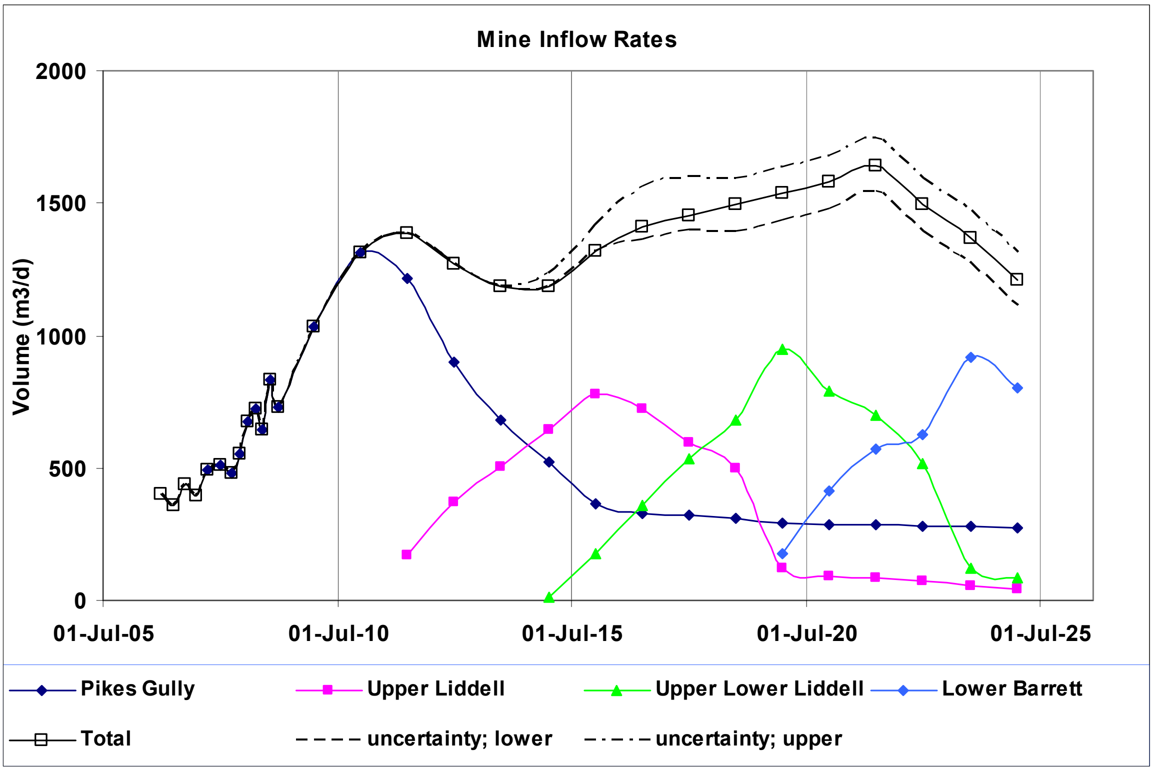

Plate 1 – *Projected mine inflows (source Aquaterra)*

Inflows into the existing underground workings are currently estimated to be 0.4 ML/day. As detailed in **Plate 1**, the projected average daily inflows are expected to increase as mining progresses inline with the original EIS. Predicted inflows (*from all panels*) range from 1.2ML/day in 2014 to 1.6ML/day in 2021. The maximum predicted inflow rate of 1.6ML/day is less than the maximum rate of 1.9ML/day predicted in the original EIS. Hence, the proposed development is not expected to increase inflows above previously approved levels. In addition to inflows from seepage, continuous and long wall miners require water during operation. Data provided by ACOL indicates that on average approximately 0.3ML/day of water is used by the miners.

In order to prevent the mine workings from becoming flooded, all water that accumulates in the underground workings (*including seepage inflow and water used for mining*) is to be pumped into the existing mine water management system. The mine WMP is required to provide sufficient water for mining operations during dry periods, and provide sufficient storage to prevent the release of mine water during periods of heavy rainfall. The water balance model was used to assess the impact of the additional under ground inflow on the capacity of the existing WMP to achieve the above objectives.

3. WATER BALANCE MODEL

As discussed above, the water balance model of the ACOL operation that was developed for the SEOC EA was revised to incorporate the additional inflow from the underground operation. The SEOC water balance methodology, calibration and results are described in **Attachment 1**. The revised water balance model structure is presented in **Figure 1**. A schematic that locates the features detailed in **Figure 1** is also presented in **Figure 2**.

3.1 Modelling Scenarios

As discussed above, this water balance assessment has considered both the existing ACOL operation and the proposed future overall operation, should the SEOC project be approved. For each of these scenarios, the water balance model assessed the WMP for five key years within the proposed mining period. These are detailed in **Table 1**.

Table 1 – *Model Simulations*

Years	2011	2014	2016	2020	2022
SEOC YEAR	1	4	6	Post Mining	
Net water make from underground mine (ML/day)	1.4	1.2	1.4	1.6	1.5

As discussed in **Attachment 1**, each simulation applies the defined model parameters for each scenario over a 105 year simulation period. This simulation period applies the observed rainfall time series between 1904 and 2009. The application of a 105 year modelling period facilitates the assessment of a diverse range of short and long term rainfall trends, as well as numerous flood events.

3.2 Model Results

Assessment of the simulation scenarios detailed in **Table 1** was undertaken. The following key model results are presented in **Table 2**:

- Average daily demands and losses.
- Average daily controlled water sources such as licensed extraction and water received from the Glennies Creek Underground Mine.
- Averaged daily uncontrolled sources such as runoff and groundwater inflow into both the underground and open cut mines.
- Required average daily source water from controlled water sources to balance inflows and outflows from the ACOL operation.

The model results in **Table 2** have been presented for 10^{th} percentile, average and 90^{th} percentile rainfall years.

Table 2 – *Water Balance Model Results*

Year	2011	2014	2015 / 2017	2020	2023 / 2024	2011 to 2024
SEOC YEAR	**1-3**	**3-4**	**5-7**	**7-9**	**9+**	**No SEOC**
Water Demands (ML/day)						
Dust Suppression	1.3			0.0		0
CPP	4.5			3.0		3.0
Evaporation Losses	0.5			0.3		0.3
Total Demand	**6.3**			**3.3**		**3.3**
Controlled Water Sources (ML/day)						
Water received from Glennies Creek mine	1.2					1.2
Licensed Extraction^	Up to 2.2					Up to 2.2
Total Controlled Water Source	**3.4**					**3.4**
Un-Controlled Water Sources (ML/day)						
Net water make from underground mine	1.4	1.2	1.4	1.6	1.5	1.2 to 1.6
Seepage into SEOC	0.2			0		0
Annual Rainfall	**Surface Runoff (ML/day)**					
10th Percentile	0.7	0.7	0.8	0.3	0.3	0.3
Average	2	2	2.4	0.9	0.9	0.9
90th Percentile	3.6	3.6	4.4	1.5	1.5	1.5
Total Uncontrolled Water Source	**2.3 to 5.2**	**2.1 to 5.0**	**2.4 to 6.0**	**1.9 to 3.1**	**1.8 to 3.0**	**1.5 to 3.1**
Annual Rainfall	**Required Controlled Water Source (ML/day)**					
10th Percentile	**4**	**4.2**	**3.9**	1.4	1.5	1.4 to 1.8
Average	2.7	2.9	2.3	0.8	0.9	0.8 to 1.2
90th Percentile	1.1	1.3	0.3	0.2	0.3	0.2 to 0.6

Note: bold indicates required source water exceeds available source water.

^ licensed extraction volumes subject to annual allocations that can be as low as 0% during dry periods.

3.3 Results Discussion

Water Balance Model Including the SEOC

The anticipated increase in inflow into the proposed underground workings will effectively add an additional 0.8 to 1.2 ML/day of uncontrolled inflow into the existing mine water management system. With reference to **Attachment 1**, the water balance undertaken as part of the SEOC EA indicated that the ACOL operation would face water shortages during low rainfall periods. The additional inflow would moderately reduce the frequency and severity of these water shortages. However, water shortages in excess of 1ML/day are predicted during dry periods, when the SEOC is operational. Following the closure of the SEOC, the probability of water shortages is significantly reduced due to the reduced water demands for dust suppression and coal processing.

During wet periods, when higher rainfall leads to increased surface runoff volumes, controlled water sources such as licensed extraction and inflow from the Glennies Creek Underground mine can be reduced to maintain a balance between water inflows and outflows. As indicated in **Table 2**, water balance modelling predicts only minimal use of the controlled sources would be required during wet years. Importantly, the ability to control inflows provides the flexibility to maintain a balance between inflows and outflows during wet periods.

Water Balance Model excluding the SEOC

The water balance model excluding the SEOC project predicted reasonably steady results over the life of the project. This is because the only variation in the model input and output parameters was variations of up to 0.4ML/day in predicted inflows into the underground workings over the life of the mine. Similarly to the SEOC modelling scenario, the ability to control inflows of up to 3.4ML/day, provides the flexibility to maintain a balance between inflows and outflows during both wet and dry periods.

General

The existing and proposed surface water management plan provides emergency storage in both the proposed SEOC pit and the remnant Barret Pit. During major rainfall events, such as a 100 year ARI design storm, excess water would be pumped into these emergency storages to prevent mine water overflows occurring. With reference to **Table 6-7** in **Attachment 1**, the predicted volumes of runoff during historic major storms range from 280 to 520ML. Therefore, the increase inflow rates from the underground operations are insignificant when compared to the volumes of runoff predicted during major rainfall events. As such, the proposed underground mining project would not adversely affect the capacity of the surface water management system to retain mine water runoff during major rainfall events, provided existing management measures remain in place.

4. CONCLUSION

Water balance modelling was undertaken to assess the revised seepage inflows into the underground workings. The key conclusions from the assessment are:

- The additional groundwater source would increase the drought security of the ACOL operation.

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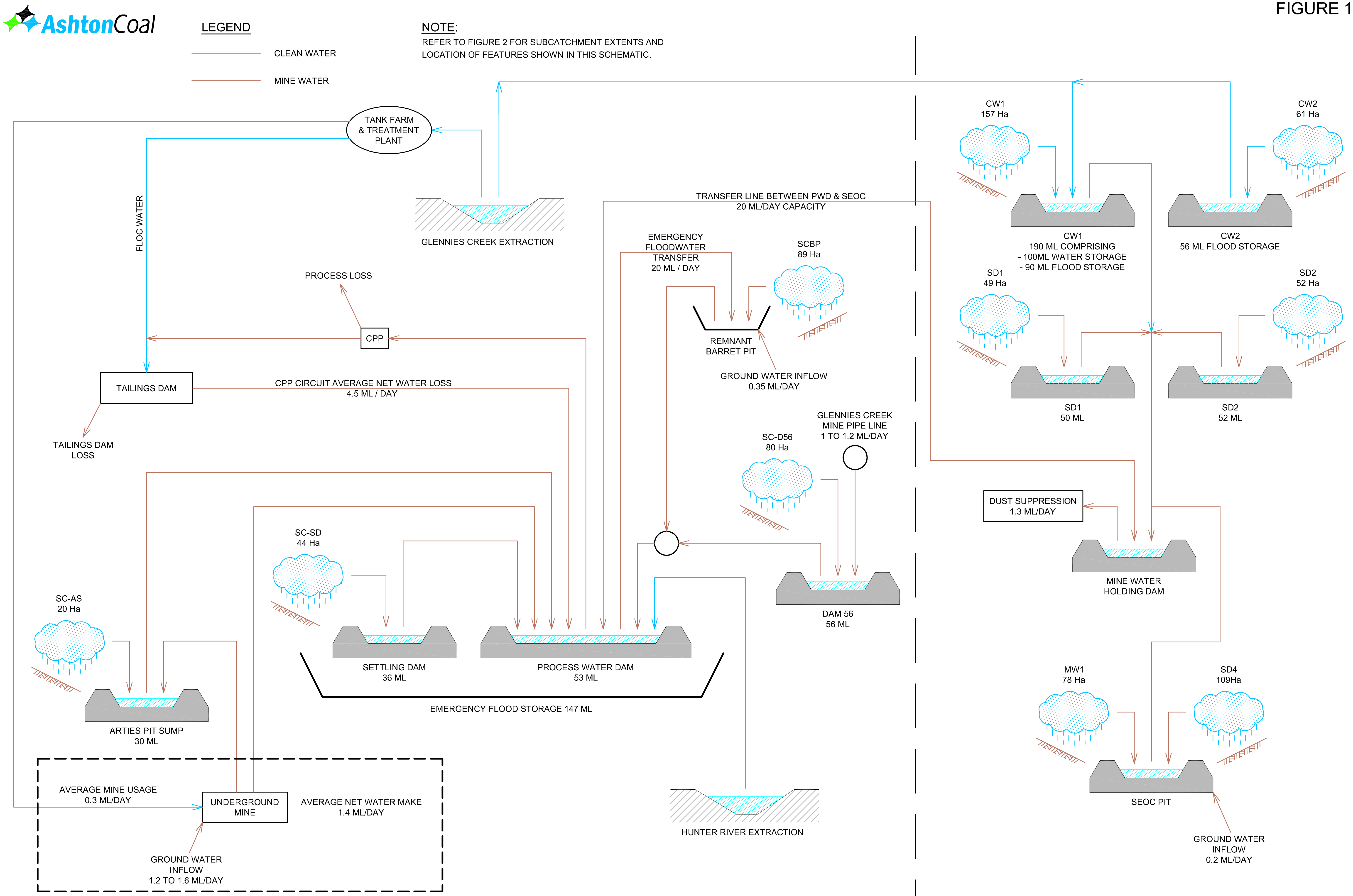
- The increased inflow rates from the underground operations are insignificant when compared to the volumes of surface runoff predicted during major rainfall events. As such, the proposed underground mining project would not adversely affect the capacity of the surface water management system to retain mine water runoff during major rainfall events.
- The ability to control inflows of up to 3.4ML/day provides the flexibility to maintain a balance between inflows and outflows during dry, average and wet periods.

Should you have any questions, or wish to discuss this letter further, please do not hesitate to contact Ben Patterson or Chris Kuczera at 4907 5300.

Yours faithfully
WorleyParsons

Ben PATTERSON
Senior Principal Engineer

Figure 1 – Water Balance Schematic
Figure 2 – Water Management Arrangement
Attachment 1 – Section 6 from the report titled *South Eastern Open Cut - Surface Water Assessment (Worley Parsons, 2009)*



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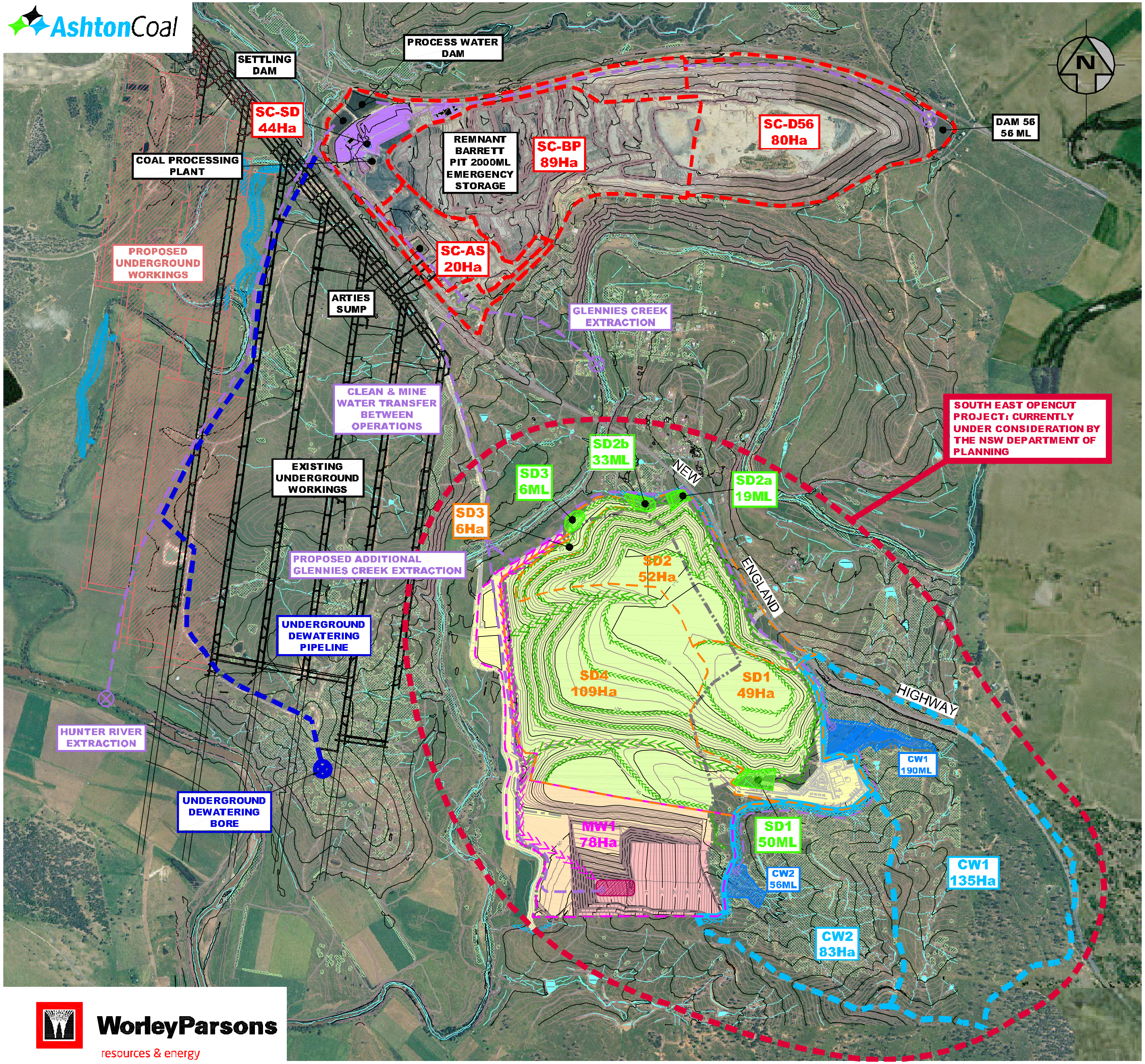
EXISTING ACOL OPERATION

PROPOSED SEOC OPERATION

WATER BALANCE SCHEMATIC

FIGURE 2



LEGEND

- WATER BALANCE CATCHMENT BOUNDARY
- CLEAN WATER CATCHMENT BOUNDARY
- CLEAN WATER DRAIN
- CLEAN WATER DAM
- SEDIMENT WATER CATCHMENT BOUNDARY
- SEDIMENT WATER TRUNK DRAIN
- SEDIMENT WATER MINOR DRAIN
- SEDIMENT WATER BASIN
- MINE WATER CATCHMENT BOUNDARY
- MINE WATER DRAIN
- MINE WATER BASIN
- WATER TRANSFER
- PUMP
- BORE DEWATERING PIPELINE

0 800m
SCALE 1:20000 (A3)

WATER MANAGEMENT ARRANGEMENT

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES BOWMANS CREEK UNDERGROUND\FIGURE 2 ARRANGEMENT.dwg 07/10/2009

Attachment 1 – Section 6 from the report titled *South Eastern Open Cut - Surface Water Assessment (Worley Parsons, 2009*)

6. SITE WATER BALANCE

A site water balance was undertaken to assess both the drought security of the proposed ACOL operation as well as the capacity to manage surface water runoff volumes during periods of high and extreme rainfall. This section discusses the modelling methodologies, model assumptions, calibration techniques as well as the water balance results.

6.1 Modelling Objectives

The objectives of the water balance are:

- To gain an understanding of the predicted water sources, demands and water movements within the proposed ACOL operation.
- Demonstrate the ability of the proposed stormwater management measures to manage surface water runoff during periods of extended wet weather.
- Assess the drought security of the proposed ACOL operation.
- Estimate the reduction in surface water runoff to receiving waters expected as a result of the SEOC development.
- Assist in the determination of water licensing requirements for the proposed ACOL operation.

6.2 Modelling Methodology

The water balance modelling was undertaken using a scripted water balance model that has been developed over the past 24 months to examine the water management strategy at the existing ACOL operation. This model was calibrated using data collected by ACOL over an 18 month period. Following calibration, the model was expanded to incorporate the SEOC proposal that includes additional catchment areas, storages and water demands. The resulting model facilitates the integrated assessment of the water management strategy for the proposed ACOL operation. This includes the existing underground mine, the Coal Processing Plant (CPP) and the proposed SEOC open cut mine.

6.2.1 Water Balance Model

The water balance model was developed as a continuous simulation model that simulates the various model inputs, outputs and storages on a daily time step. The key features of the water balance model are described below:

- A simplified SIMHYD rainfall runoff model was adopted to model the rainfall runoff relationship of the identified catchments within the mine site. SIMHYD is a conceptual daily rainfall-runoff model which simulates both surface and base flow runoff from a given catchment. When used in continuous simulation, the SIMHYD model tracks the soil moisture content, which is the key variable in determining the volumetric runoff from a particular rainfall event.

- Water demands and sources can be applied at constant rates or through the use of custom functions. Time series data can also be applied when known or observed data is available.

- Water transfers between storages, demands and sources can be controlled using transfer rules that are based on storage levels, demand requirements and/or source availability. This function can be used to ensure elements of the water management strategy, such as maintaining low levels in flood mitigation storages, can be captured in the water balance simulation.

- The water balance runs on a daily time step and requires daily rainfall and evaporation rates as model inputs. The model results are available on a daily timestep, but are reported as monthly averages to simplify the model results.

6.3 Model Structure

Water movements around a mine site are complex and often vary over time as the operation progresses through the mining plan. Accordingly, the water balance model has been simplified to capture the key water sources, water demands and storages. The adopted model structure is presented in **Figure 15**. A schematic, which locates the features detailed in **Figure 15**, is presented in **Figure 16**. The key demands, sources and storages are discussed in detail in the following sections.

6.3.1 Model Inputs

ACOL commenced monitoring key water flows within the existing operation in July 2007. A comprehensive data set is available for the period between 25/9/2007 to 31/3/2009. The observed water movements over this 18 month period were used to gain an understanding of the water movements (*i.e supply and demand*) through the existing operation and subsequently calibrate the water balance model. This period is referred to as the calibration period in the remainder of this report.

Observed rainfall depths during the calibration period were provided by ACOL. This data set was compared to the rainfall data from BoM station at *Jerrys Plains Post Office* (*BoM station 061086*) which is located 16km to the west of the SEOC. Comparison of the rainfall depths indicated that the two sites are very similar. However, the ACOL data did not include data during some of the higher rainfall events. Hence, the rainfall time series from *BoM station 061086* was considered to be the most suitable for use in the water balance model as it was comparable, but also a more complete set.

6.3.2 Water Demands and Losses

The following water demands have been identified.

Coal Processing Plant (CPP)

ROM product is processed on-site prior to exporting the final product off-site. With reference to **Figure 16**, the Coal Processing Plant (CPP) is located adjacent to the Process Water Dam (PWD). ROM product is washed in the CPP, using water sourced from the PWD. The washing process separates the product from the non-product components of the ROM. The non-product component consists of coarse and fine rejects. Fine rejects are pumped as slurry to tailings dams, where a settling agent (*floc*) is added to assist in settlement of the fine reject. Excess water is decanted from the tailings dam and returned to the process water dam to complete the cycle.

The cycle described above results in a net loss of water through various means. ACOL have installed flow meters, which measures the inflow into the CPP, the flow from the CPP to the tailings dam, and the flow decanted from the tailings dam and returned to the PWD. The net loss through the total process was observed to vary from 0.5 to 5.5ML/day, with an average net loss of 3.1ML/day. The variation is the result of varying levels of throughput, variation in the percentage of product in ROM, CPP down time and other factors.

It is proposed to increase the CPP processing capacity from 5.2Mtpa of ROM Coal to a maximum annual rate of 8.6Mtpa. ACOL estimates this will increase the net water loss from the existing 3.1ML/day to 4.5ML/day. As this EA seeks approval for the increased processing rate, the higher net water loss has been adopted for the water balance calculations (*excluding the model calibration which is based on observed data*).

DUST SUPPRESSION

Dust suppression is required on non-rainy days to mitigate the dust levels produced from the operation. The key dust suppression measure is water sprayed from water trucks over the active haul roads. Information supplied by ACOL defines an average daily water demand for dust suppression to be 1.3 ML/day. This is based on a 38KL truck making 2 runs per hour for an equivalent of 18 hours a day (*2 trucks running for 6 hours per day and one truck running for 6 hours*). This calculation assumes there are 12 rainy days per year when dust suppression is not required. ACOL anticipate that the dust suppression requirements for the SEOC would be similar to the existing open cut operation, for which the above water usage rates are sourced from.

Water usage for dust suppression of product stockpiles and conveyors is accounted for in the overall CPP water demand.

EVAPORATION LOSSES

Evaporation/evapotranspiration losses are applied to both the open water bodies as well as the onsite soils for which the average monthly values specified in **Table 3-2** were adopted. The evaporation from the open water bodies is calculated based on the storage levels and estimated surface area (*which is based on survey data*). Evapotranspiration losses from the onsite catchments are integrated into the simplified SIMHYD rainfall runoff model, which is described in **Section 6.4**.

6.3.3 Water Sources

LICENSED EXTRACTION

ACOL currently have access licences to extract surface water from both Glennies Creek and the Hunter River. The licences details are summarised in **Table 6-1**.

Table 6-1– *Existing surface water extraction licences*

Stream	Sub Category	Total Allocation (*ML/year*)
Glennies Creek	High Security	91
	General Security	354
	Supplementary	4
Hunter River	High Security	3
	General Security	335
	Supplementary	15.5

The above licence allocations are administered by DWE, who regulates the extraction volumes based on water availability and stream flows. During extended dry periods, it is likely that the general and supplementary allocations are reduced. ACOL have provided flow meter readings for both Hunter River and Glennies Creek extraction locations from the past 18 months. Over this period, an average 1.4ML/day was extracted collectively from Glennies Creek and the Hunter River. This equates to approximately 64% of ACOL's total allocation.

ACOL advised that during the dry period observed during 2005, 2006 and 2007, the general and supplementary licence allocations were reduced to as low as 0% (*i.e no extraction allowed*). Accordingly, the potential for reductions in licence allocations has been captured in the water balance model by tracking the total rainfall depths over a 24 month period prior to each model timestep. In order to develop this algorithm, the storage level in Glenbawn and Glennies Creek Dams was compared to the total annual rainfall depths and the average annual allocation of General Security Licences. Both the dam storage levels and the General Security allocations were sourced from DWE's website. The resulting information from June 2004 to June 2008 is plotted in **Plate 6-1**.

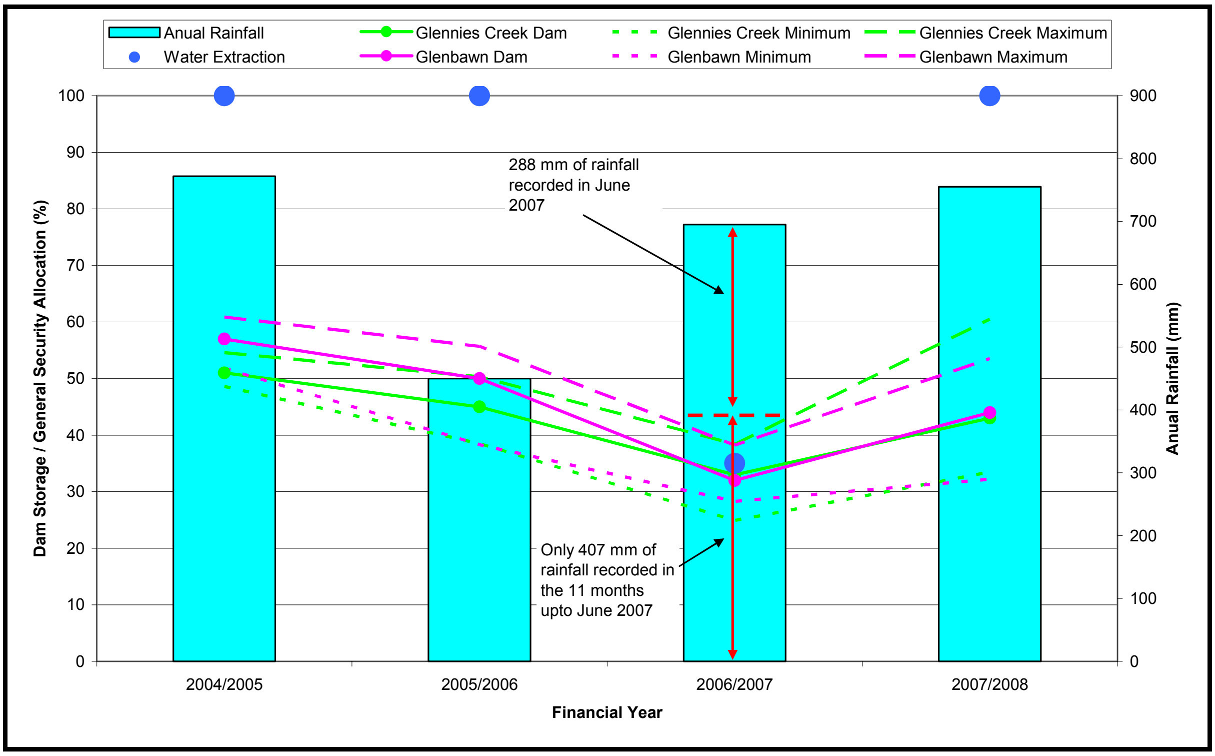


Plate 6-1 – *is a plot comparing Glennies Creek and Glenbawn Dam storage levels, observed rainfall and General Security licensed allocations.*

As indicated in **Plate 6-1**, the General Security allocation was only reduced during the 2006/2007 Financial Year. As indicated on the diagram, rainfall total during the 2006/2007 was significantly increased by the June 2007 long weekend storms. Rainfall for the month of June totalled 288mm, which effectively broke the drought. Prior to June, 2007, there were approximately 2 consecutive years of 10th percentile rainfall. This resulted in the dam levels in both Glennies Creek and Glenbawn Dam dropping below 30%. As a result the General Security license allocation was reduced to an average of 30% during the 2006/2007 Financial Year. As discussed above, ACOL advised that it was reduced to 0% for a short period of time.

As indicated in **Table 6-1**, ACOL currently has an 689 ML/year allocation under a General Security licences. Hence, the risk of this licence allocations being reduced must be captured in the water balance calculations. Accordingly, license allocations in the SEOC water balance model are weighted based on the 24 month cumulative rainfall totals adopting the algorithm outlined in **Table 6-2**.

Table 6-2 – *24 month rainfall to General Security Allocation*

24 month cumulative rainfall Total	Assumed General Security Allocation	Assumed Permissible ACOL extraction (ML/year)
Greater than 1100mm	100%	689 ML/year
Less than 1100mm	75%	517 ML/year
Less than 1000mm	50%	345 ML/year
Less than 900mm	30%	207 ML/year

It is noted that, the algorithm recalculates the allocation on a daily basis. Hence, it assumes the allocation would quickly be adjusted following significant rainfall events, such as the storms observed in June 2007.

CATCHMENT RUNOFF

Surface water runoff volumes are dependent of rainfall patterns and can be highly variable. During dry periods, it is expected that next to no surface runoff would occur. Conversely, during wet periods significant volumes of surface runoff are likely. The key soil variable defining rainfall runoff relationships for water balance calculations is the Soil Moisture Storage Capacity (*SMSC*). If dry, soils can absorb relatively large volumes of water prior to generating runoff. As the soil becomes partially saturated, the ratio of runoff to rainfall increases. This soil absorption capacity is referred to as the Soil Moisture Storage Capacity (*SMSC*). SMSC is generally higher in cohesive soils, with moderate to high organic components and lower in soils which are either compacted and/or barren and contain little cohesive material. Accordingly, the following soil types have been identified in the ACOL study area:

- **Undisturbed Soils –** refers to areas which are relatively undisturbed such as the clean water catchment upstream of the SEOC. The native soils in the area generally have a moderate clay component, which would result in moderate to high SMSC.

- **Rehabilitated Overburden Soils –** refers to areas of the overburdened which are fully rehabilitated. The rehabilitation would have resulted in the development of healthy topsoil encompassing moderate organic components, and therefore moderate SMSC.

- **Barren Overburden Soils** – refers to areas of active pit or unshaped and/or untreated overburden. The associated soil is basically the parent rock, which generally has a limited SMSC. The uncompacted nature of the overburden would facilitate the deep infiltration of the majority of excess runoff.

- **Compacted Mine Working Areas**. – refers to areas of the mining operation where machinery frequently operates. Generally, this refers to haul roads, stockpile areas and other general working areas. The continual compaction of machinery would substantially reduce the SMSC, resulting in increase runoff to rainfall ratios similar to impervious surfaces. In addition, infrastructure areas also generally incorporate impervious areas such as car parks, hardstand areas and large structures.

As discussed above, a SIMHYD rainfall runoff model has been used to estimate the rainfall runoff relationship of the above soil types. This is further discussed in **Section 6.4**.

Water from Other Mines

ACOL have an ongoing arrangement with the operators of Glennies Creek Underground Mine to receive mine water from the underground operation. ACOL have indicated that received flows are in the order of 1 to 1.2 ML/day. ACOL is not required to receive water during wet weather periods.

Underground Operation

The existing underground operation produces a net surplus of water. Clean source water is required to assist in the mining operation. This water is collected within the mine, along with seepage from the local groundwater storages and returned to either Arties Sump or the PWD. The flow rates into and out of the underground mining operation have been metered for approximately 18 months. Over this period, a net water surplus ranging from less than 0.1 ML/day to over 0.6 ML/day was observed. The average daily surplus was 0.4ML/day.

Seepage into Pit

ACOL have monitored the pump out volumes from the existing open cut pit for approximately 18 months. The pump out volume represents the combined inflow from surface runoff (*i.e from rainfall over the pit*), as well as seepage inflow from external sources. Observed pump out rates range from 0.3 to 1.4 ML/day, with an average volume of 0.6ML/day. ACOL estimate that 0.35 ML/day of this inflow is attributed to seepage, or subsurface flow into the pit.

With reference to the Hydrological Impact Assessment (*Aquaterra, 2009*), the anticipated average seepage inflow into the SEOC pit is estimated to range from 0.15ML/day to 0.23 ML/day.

6.3.4 Onsite Storages

Figure 16 locates the numerous storages, and associated capacities, located within the existing and proposed SEOC operation. ACOL has provided detailed survey information for all existing dams allowing the stage/storage relationship to be accurately modelled. The proposed stage/storage relationships for the proposed dams at the SEOC were indicatively determined based on standard mine dams.

6.4 Model Calibration

The data collected during the calibration period was used to define average daily water movement time series for the following flows:

- Water pumped out of the Barrett pit.
- Water movements through the CPP and tailings storage facilities.
- Extraction from both Glennies Creek and the Hunter River.
- Water flows into and out of the underground operation.
- Water movements between the various storages.

These water flow time series were integrated into the water balance model as known data. Other unmetered water movements, such as flows received from the Glennies Creek Mine and the water usage for dust suppression were applied to the model based on information provide by ACOL (*as documented in **Section 6.3***). In addition, ACOL provided survey dam levels (*for which the dam storage volumes can be estimated*) at four dates within the calibration periods. Additional survey dam levels were also available at the start of the calibration period and were adopted as initial conditions in the water balance model.

All of the above information was integrated into the water balance model. Using the known and assumed data, the water balance model was calibrated by adjusting the SIMHYD model parameters to achieve a reasonable correlation between the simulated water storages and the surveyed dam levels. The resulting model results are summarised in **Plate 6-2** that graphs the observed water used and sourced, the simulated storage and runoff volumes and the survey dam storage levels on a monthly scale over the calibration period.

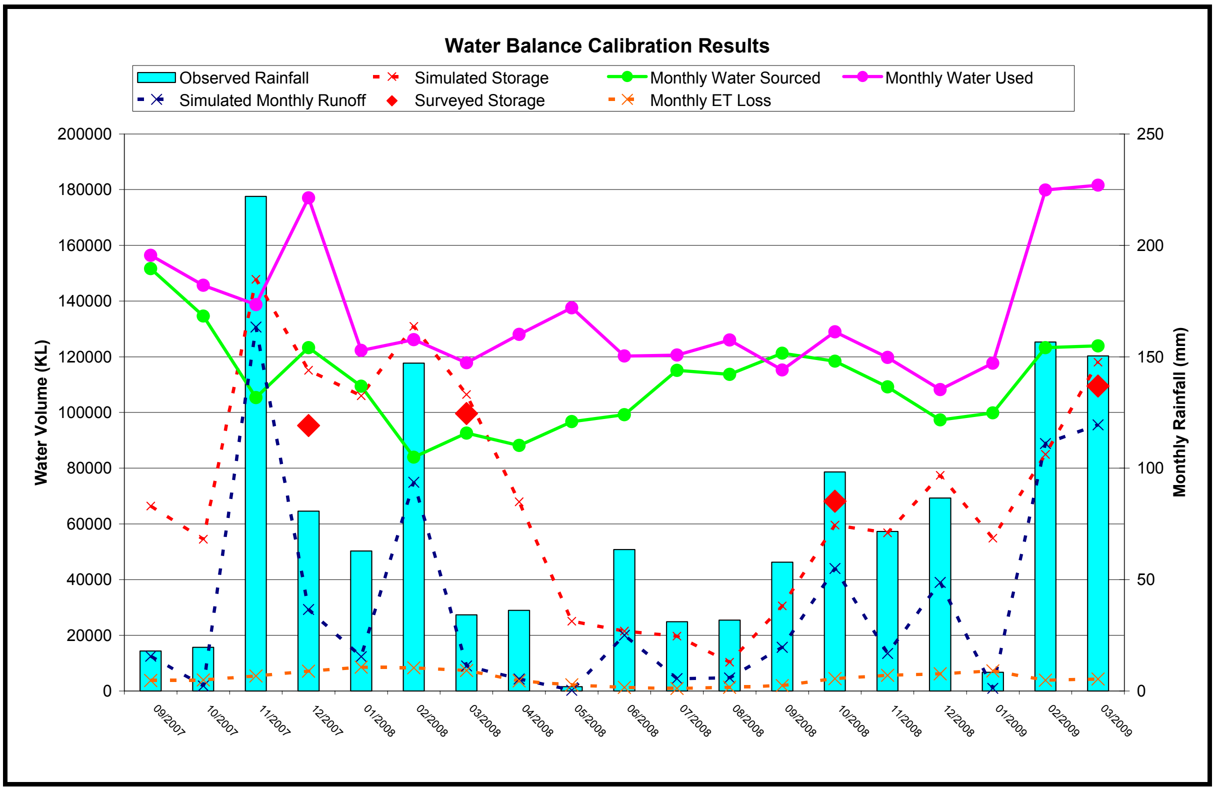


Plate 6-2 – *Water balance model calibration results*

As demonstrated in **Plate 6-2**, the simulated storage levels are reasonably well correlated with the survey dam storage levels indicating the model calibration is reasonably accurate. The calibration periods included periods of high rainfall in November 2007, February 2008 and February and March 2009. During each of these months, the estimated surface water runoff volumes ranged between 80ML to 130ML. During moderate rainfall months (*i.e total rainfall depths between 50mm and 100mm*), the monthly surface water volumes ranged between 15 and 50ML. There was negligible runoff during months with minimal rainfall.

As indicated in **Plate 6-2**, the storage levels were high during the initial month of the calibration period. This is the result of above average rainfall over this period. The storage levels were progressively reduced between March and May of 2008. This resulted in an increased requirement for source water to meet demand.

In summary, the key water movements during the calibration periods are presented in **Table 6-3**.

Table 6-3 – *Key water movements during calibration periods*

	Average Annual Flow (ML)	Average Daily Flow (ML/day)
Water Demands		
CPP (net Demand)	1123	3.1
Dust Suppression	474	1.3
Evaporation Loss	71	0.2
Total Demand	**1668**	**4.6**
Water Sources		
Flow from underground mine (Net)	147	0.4
Flow from Glennies Creek mine	438	1.2
Glennies Creek Extraction	224	0.6
Hunter River Extraction	267	0.7
Pump out from Barrett pit	224	0.6
Surface Runoff (Estimate)	402	1.1
Total Source	**1702**	**4.6**
Balance^	**34**	**0.0**

^ Difference between Storage levels at the first and last model time step

6.4.1 Calibration of SIMHYD Parameters

As discussed above, the calibration of the water balance required adjustment of the SIMHYD rainfall runoff parameters. The calibration model incorporated three of the four soil types discussed in **Section 6.3**. However, the bare overburden soil type was excluded from the calibration model as the pump out from the open cut pit was a known water movement. In addition, there are insufficient areas of natural catchment in the existing operation to facilitate the accurate calibration of the undisturbed soil type. Hence, the following methodology was used to calibrate these soil types:

- **Barren Overburden –** the observed pumpout rates from the existing pit were used to calibrate the SIMHYD model. However, some of the pump out volume is attributed to seepage into the pit from external sources, and must be considered in the calibration. ACOL estimates that seepage into the Barrett Pit is 0.35ML/day. This volume was subtracted from the total pumpout volume to achieve a volume for calibration. It is noted that this calibration volume would incorporate the evaporation losses occurring from any standing water in the pit.

- **Undisturbed Catchments** – in the absence of any calibration data, the SIMHYD parameters were calibrated to achieve a runoff coefficient of 0.125, which is equivalent to 80mm of runoff in an average year. This figure is commonly used in Hunter Valley for undisturbed catchments.

The resulting key adopted SIMHYD model parameters and results are presented in **Table 6-4**.

Table 6-4 – *SIMHYD rainfall runoff parameters.*

Soil type	SIMHYD Parameters					Rainfall Runoff Results		
	Initial Loss	SMSC	Maximum Infiltration Rate	Surface Runoff exponent	Base flow exponent	Runoff Coefficient	Surface Runoff	Base Flow
	mm	mm	mm\day	Unit-less		% of total Rainfall	% of total runoff	
Undisturbed Soils	5	200	50	0.7	0.10	0.12	88%	12%
Rehabilitated Overburden Soils	5	150	50	0.6	0.15	0.15	17%	83%
Barren Overburden Soils	5	120	100	0.4	1.00	0.14	85%	15%
Compacted Mine Working Areas	5	70	25	1.0	0.00	0.60	100%	0%

The SIMHYD parameters listed in **Table 6-4** were applied to the water balance model used to assess the proposed water management strategy for the SEOC.

6.5 SEOC- Water Balance

The calibrated water balance model developed for the existing operation was expanded to include the SEOC proposal. This required the inclusion of the additional water sources, water demands, catchment areas, storages and transfer systems associated with the SEOC development proposal.

Refer to **Figure 15** for the adopted water balance schematic and **Figure 16** for a plan view of the water balance framework.

6.5.1 Assessment Method

In order to facilitate a comprehensive assessment, a 105 year simulation period was used to assess the site water balance. This simulation period applied the observed rainfall time series recorded at *BoM Station 061086* between 1904 and 2009. The recorded data prior to 1904 was incomplete, and therefore was not considered suitable for continuous simulation. The application of a 105 year modelling period facilitates the assessment of a diverse range of short and long term rainfall trends.

6.5.2 Model Scenarios

The water balance model was applied to the Year 3, Year 7 and the post SEOC surface water management plans. The key difference between Year 3 and Year 7 is the increase in catchment area as the mining operation progresses to the south (*refer to life of mine SWMPs*). This will effectively add more surface runoff to the system. When the SEOC operation concludes, the water usage requirements would be reduced as dust suppression will no longer be required and the CPP would be operating on lower throughput as a result of reduced ROM production. The adopted water balance input parameters for each of the above scenarios are presented in **Table 6-5**.

It is noted that the Year 1 and Year 5 SWMPs are very similar to the respective Year 3 and Year 7 SWMPs and as such have not been included in the water balance assessment.

Table 6-5 – *Adopted Water Balance Input Parameters*

	SEOC Year 3	SEOC Year 7	Post SEOC (Year 9)^
Water Demands			
Dust Suppression	1.3 ML/day		0 ML/day^^
CPP	4.5 ML/day		3.0 ML/day
Total Demand	5.8 ML/day		3.0 ML/day
Water Sources			
Net water make from underground mine	0.4 ML/day		
Water received from Glennies Creek mine	1.2 ML/day		
Licensed Extraction	Up to 802 ML/year		
Seepage into SEOC^^	Approximately 0.2ML/day over the life of the mine.		
Total Water Sources	1.8 ML/day and up to 712 ML/year	1.8 ML/day and up to 712 ML/year	
Surface Runoff – Contributing Catchment Areas			
Existing operation	233ha (*refer to **Figure 16***)		
SEOC	378 ha (*refer to **Figure 18***)	512 ha (*refer to **Figure 20***)	
Total Contributing Catchment Area	611ha	745 ha	

^ Post SEOC refers to the period between the finalisation of open cut mining at the SEOC operation (2017) and the finalisation of the underground operation (2023).

^^ Dust suppression for the conveyor and stockpile areas is included in the CPP demands.

^^^Predicted pit inflows provided by Aquaterra

Each of the scenarios detailed in **Table 6-5** was applied to the water balance model from which the key results are presented in the following sections.

6.5.3 Drought Security

It is anticipated that the total ACOL operation will have an average daily water demand of approximately 5.8 ML/day. As detailed in **Table 6-5** approximately 1.8ML/day of water is received from sources such as pit seepage, water received from Glennies Creek Mine and surplus water from the underground. The remaining 4ML/day is to be sourced from rainfall dependant sources, such as harvesting surface water runoff and licensed extraction from Glennies Creek and the Hunter River. The water balance model was used to determine the drought security of the proposed ACOL over the 105 year simulation period. The adopted rainfall runoff parameters and methodology for accounting for reduced licensed extraction availability during dry periods is detailed in **Section 6.3**.

The drought security for each of the scenarios detailed in **Table 6-5** was assessed using the water balance model. For each scenario, the percentage of months where demand is fully satisfied, as well as the 50th, 70th and 90th percentile demand deficits (*i.e the volume of demand not met*) are reported in **Table 6-6**.

Table 6-6 – *Drought Security Assessment*

Year of Mining Operation	Year 3		Year 7		Post SEOC - Year 9	
Percentage of months demand is fully satisfied	35%		41%		97%	
Monthly Demand (*ML/month*)	180		180		93	
Estimated Demand Deficit	Demand Deficit (*ML/month*)	Percentage of Total Demand	Demand Deficit (*ML/month*)	Percentage of Total Demand	Demand Deficit (*ML/month*)	Percentage of Total Demand
50th Percentile	14	7%	5	3%	0	0%
70th Percentile	58	32%	44	25%	0	0%
90th Percentile	104	58%	99	55%	0	0%

With reference to **Table 6-6**, the water balance model estimates that the ACOL operation would have sufficient water to fully meet the estimated monthly demand in approximately 35% of months in the Year 3 scenario and 41% of months in the Year 7 scenario. The increase is the result of an increased catchment area as the SEOC pit progresses to the south (*refer to life of mine SWMP's*). In the post SEOC scenario, the water demand is reduced and the estimated percentage of months where demand is fully satisfied increases to 97%. The estimated magnitude of the predicted water deficits ranges from 58% of total demand in the 90th percentile case to 7% of total demand in the 50th percentile case.

Periods of water deficit are generally associated with extended dry spells, where the license extraction allocations are reduced and no significant surface runoff is collected. As such, the water availability over the 7 year SEOC mining period would be governed by the rainfall patterns over the life of the mine, and could potentially vary to the results presented in **Table 6-6** that are based on 105 years of rainfall data. In conclusion, the ACOL operation is likely to have sufficient water during above average rainfall years, possible minor water shortages during average rainfall years and is likely to experience shortages of varying levels of severity during below average rainfall years.

In the event of operational water shortages, ACOL could implement the following measures:

- Reduce the throughput through the CPP, which accounts for approximately 70% of the water usage.
- Obtain additional water extraction licenses.

6.5.4 Mine Water Containment

As discussed in **Section 5.4**, it is proposed to direct all mine water from the SEOC area into the operation pit. As the pit will provide a very large storage volume, there is no risk that there would be insufficient capacity to capture mine water during any conceivable rainfall event. Water accumulated in the SEOC pit would be pumped to the final Barrett Pit void (*existing open cut operation*) that would store the water until it can be used in the mining operation. The mine closure plans for the existing open cut operation indicate the final Barrett Pit void would have a storage volume in excess of 2,000 ML.

The key risk with the mine water containment strategy is an operational risk, as large volumes of water in the pit could possibly impact the mining operation. Over the past 100 years, there were four major storm events which would have caused significant flooding in the SEOC pit. These events and the estimated volume of pit flooding are summarised in **Table 6-7**.

Table 6-7 – *SEOC flooding during major storm events*

Date	Monthly Rainfall	Estimated runoff into SEOC Pit^
May 1913	310mm with 200mm in 2 days	520 ML
June 1930	271mm with 250mm in 3 days	400 ML
February 1955	340mm with 244mm in 3 days	400 ML
June 2007	286mm with 222mm in 3 days	280 ML

^ The estimated pit runoff was calculated using the Year 7 Scenario, which has the greatest contributing catchment area. Accordingly, runoff volumes would be reduced in the Year 3 scenario.

A 100 year 72 hour design storm at the SEOC has a total rainfall depth of 239mm over a 3 day period. Hence, each of the storm events presented in **Table 6-7** are similar to a 100 year ARI design storm event. The estimated volume of runoff into the pit is sensitive to the antecedent conditions, which governs the initial *Soil Moisture Storage Capacity* (*SMSC*) as well as the stored volume of water in the clean water dams (*CW 1 and CW 2*) that overflow into the SEOC pit. For example, approximately 80mm of rain was recorded in the week prior to the May 1913 storm. While the June 2007 storm proceeded an extended dry period, whereby the clean water dams upstream of pit would have been empty.

The depth and extent of inundation would depend on the pit geometry at the time of the flooding. Accumulated mine water would be transferred to the final Barrett Pit void at a rate of approximately 20ML/day. Therefore, it is expected that the SEOC pit floor would be inundated for approximately 15 to 25 days following a major storm event.

Water balance modelling indicates that the final Barrett Pit void has sufficient storage volume to contain all runoff during a major storm event. The peak simulated storage was slightly less than 1,000ML which occurred in June 1913, following the May 1913 storm event (*note: excess water from both the SEOC and the existing operations would be pumped into the Barrett Pit*). As the final Barrett Pit void provides over 2,000 ML of storage, it is highly unlikely that there would be insufficient mine water storage capacity.

It is noted that during wet periods, ACOL have the capacity to significantly reduce source water through temporarily suspending licensed extractions and the receipt of water from the Glennies Creek Mine. This would facilitate a drawn down rate of up to 5ML/day minus any additional runoff from continuing rainfall. Water balance modelling indicated that the water accumulated during the May 1913 storm would have taken approximately 8 months to drawdown.

6.5.5 Predicted Changes to Stream Flow

They key impact on stream flows would arise from the temporary reduction in runoff from the SEOC project area during the operational and rehabilitation phases of the project. The SEOC project will have an estimated ultimate footprint of approximately 294 ha. Runoff from the project area will collected in sediment and mine water holding dams and re-used within the ACOL operation. In addition, it is proposed to harvest runoff from the upstream catchment areas which are not to be disturbed by the SEOC project. These upstream catchment areas (*designated as CW 1 and CW 2*) have a collective area of 218ha (*refer to **Figure 20***). Runoff from catchments CW 1 and CW 2 would be stored in clean water dams and used in the mining operation. During and after periods of heavy rain, some clean water would be pumped directly into Glennies Creek to maintain the flood retention capacity in the clean water dams.

During the initial mining period from Year 1 to Year 4, the southern portion of the project area would remain undisturbed, and the collective harvesting and disturbance areas would be approximately 378ha (*refer to **Figure 18***). From Year 5 to the final rehabilitation phase (*Year 13 or 2023*), the collective harvesting and disturbance areas would be approximately 512ha. The resulting estimated changes to annual flows in average, 10th, 50th and 90th percentile rainfall years are presented in **Table 6-8**. These values are compared to the Glennies Creek stream gauging data collected at Middle Fal Brook. It is noted that the Middle Fal Brook stream gauge is approximately 9km upstream of the site. Accordingly, the contributing Glennies Creek catchment area at the SEOC is approximately 15% larger than the catchment contributing to the Middle Fal Brook stream gauge.

Table 6-8 – *Predicted changes to stream flows*

Annual Rainfall Depth		Estimated Annual Flows Existing Conditions	Estimated Reduction in Annual Flows			Observed Glennies Creek Flows	
			Years 1 to 4	Years 5 to 13	Final Landform	Annual Flows	Maximum Reduction
		ML/Year	ML/Year	ML/Year	ML/Year	ML/Year	%
Average		451	331	451	33	55,240	0.8%
Percentile	10th	117	86	117	8	30,570	0.4%
	50th	352	258	352	25	46,670	0.8%
	90th	909	667	909	65	85,990	1.1%

With reference to **Table 6-8**, the predicted average annual loss in Glennies Creek stream flow will be approximately 330 ML/year during the initial 4 years of mining and 450 ML/year during the final 3 years of mining and the 6 year rehabilitation period. A reduction of 450 ML/year is equivalent to 0.8% of the average annual Glennies Creek flow at the subject site. The reduction is stream flow as a percentage is lower in dry years and higher in wet years as a result of the moderating effect of Glennies Creek Dam on the Glennies Creek flow regime.

As indicated in **Figure 22**, the final void would encompass an estimated 37ha area that would not be free draining, and therefore result in a minor permanent loss in stream flow. It is estimated that this would be 33ML/year in an average year and is not considered to be significant considering the Glennies Creek average annual discharge is over 55,000 ML/year.

It is noted that the estimated loss in stream flow only considers surface runoff. The estimated loss of subsurface discharge is documented separately in the *Hydrological Impact Assessment* (*Aquaterra, 2009*).