HYDROLOGY

1.0 PROJECT METHODOLOGY

Hydrological analyses were conducted to assess the effects of the Project on the surface water flows in tributary streams (see Figure 1) and in the Saskatchewan River. These components were combined to provide an overall assessment of potential Project effects on hydrology.

A water balance model was developed for the life of the Project. The water balance model provides a tool for quantifying the volume of water at various nodes within the mine's water management system at any specific time. Results from the water balance can be used to help determine if there is a risk of having water in excess of what can be managed by the current design and if there is a risk of not having enough water for mine operations. The water balance results were also used to assess the effects of the mining developments on the local study area.

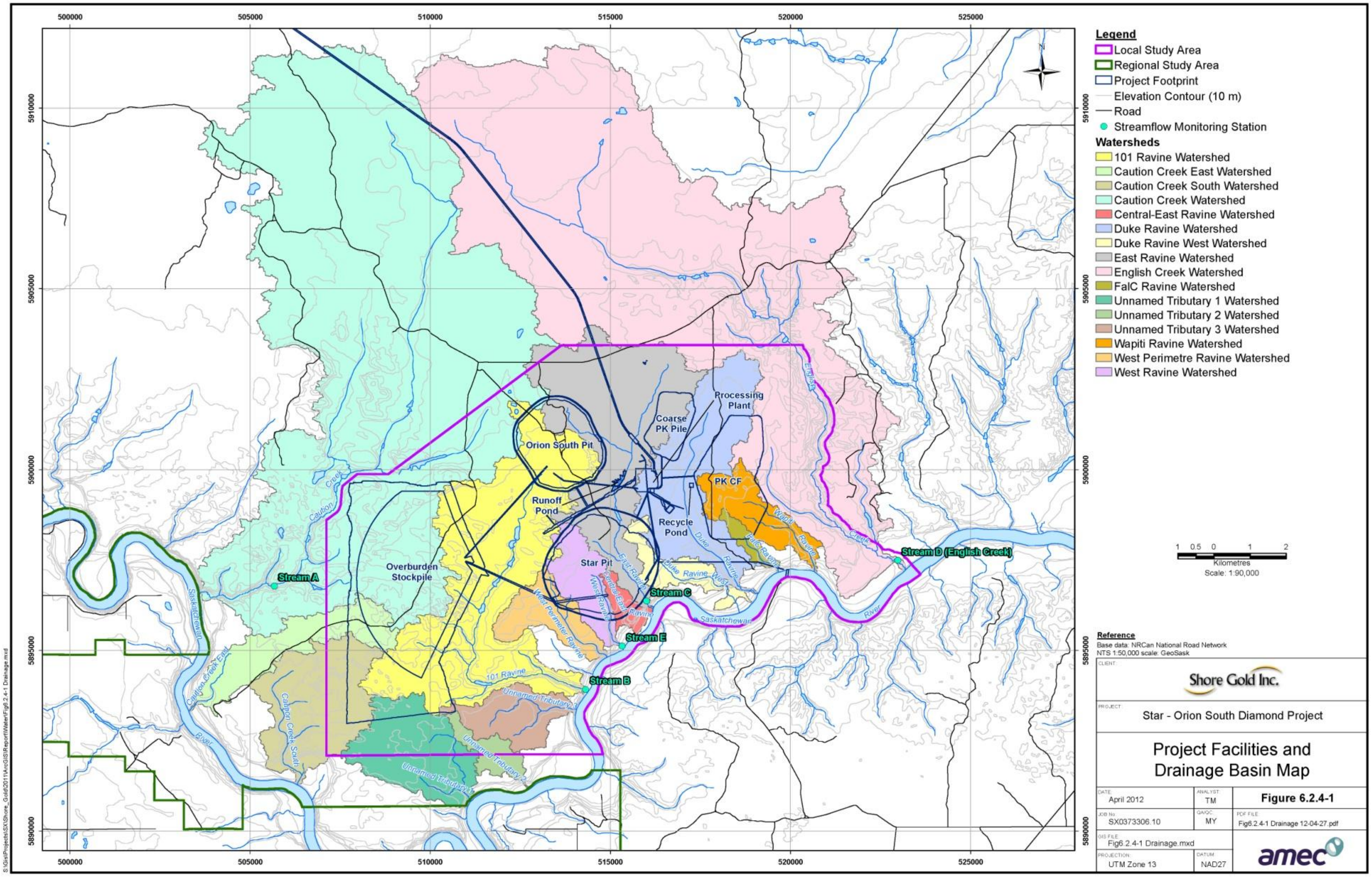
2.0 UPDATED WATER MANAGEMENT PLAN

The water balance was initially developed as described in Appendix 6.2.7-A of the revised EIS. As a result of input and comment received from reviewers, the proposed water management plan and water balance have been updated as described in Appendix 6.2.7-B of the revised EIS. Other than the components listed in Table 1 all other hydrological components in the Water Balance remained unchanged from the 2012 model presented in Appendix 6.2.7-A of the revised EIS.

Table 1: Summary of Changes to Water Balance Compared to 2012 Model

Hydrology Component	Change in Annual Magnitude (Mm^3)	
	Previous Model	Updated Model
Withdrawal from Saskatchewan River	0	23.00 to 23.42
Inflow to PKCF	23.85	23.52
Runoff Pond contribution to Plant	0	1.74 to 2.16
Release directly to Saskatchewan River	36.24 to 36.49	20.99 to 56.83

Figure 1: Project Facilities and Drainage Basin Map



The water balance model developed for the Project tracks the volume of water that is gained and lost on a monthly basis for a period of 24 years. The period modeled begins a year prior to the start of construction to determine the baseline conditions and ends at the stop of operations. The structure of the water balance model is discussed in Appendix 6.2.7-A of the revised EIS. Updates to the water balance are presented in Appendix 6.2.7-B of the revised EIS and key points are summarized below.

The following water sources or inputs were applied in the water balance:

- Star Pit surficial aquifer Residual Passive Inflow (RPI);
- Star Pit deep aquifer (Mannville) RPI;
- Star Pit Mannville pumping well flow;
- Orion South surfical aquifer RPI;
- Orion South Mannville RPI;
- Orion South Mannville pumping well flow;
- Saskatchewan River water to supply all process water in the plant (with options to recycle from 0 to 100% of plant needs);
- surface runoff from:
    - Star Pit (upper and lower pit walls);Orion South Pit (upper and lower pit walls);
    - Overburden Stockpile;
    - Fine PK Containment Facility (PKCF);
    - Coarse PK Pile;
    - Processing Plant and other site facilities;
    - roads;
    - undeveloped area of East Ravine Watershed upstream of Star Pit, which is assumed to be diverted to the Runoff Pond; and
- direct precipitation on ponds.

Water losses for the Project will include:

- evaporation from pond surfaces;
- seepage from ponds;
- discharge from the sewage lagoon; and
- infiltration, including that from the PKCF, Coarse PK and Overburden Piles

The water balance links all the inflows and outflows to determine the water volume for the following nodes each month:

- Processing Plant bypass water/recycle water. For the purposes of the assessment in order to evaluate the worst case scenario, a 0% recycling rate was assumed during mining of Star;
- PKCF water storage;

- Inflow to wetlands around the PKCF from seepage;
- Runoff Pond;
- Star Pit water storage (post operation);
- Discharge to the Saskatchewan River via the diffuser; and
- Discharge to the Saskatchewan River from tributary streams.

Key assumptions made in establishing the water balance model include:

- Water from upstream extents of East Ravine will be used on site or pumped to Duke Ravine beginning during the construction phase of the project;
- The area of East Ravine contributing runoff to the Saskatchewan River will diminish during Star Pit development and at full build out of Star Pit, the area is assumed to be negligible;
- 90% of seepage from the PKCF and runoff from the exterior slopes of the PKCF will be captured in ditches around the toe of the facility and pumped back into the PKCF;
- 10% of seepage from the PKCF will bypass the ditches around the toe of the facility and report to wetlands in Duke Ravine, FalC Ravine and Wapiti Ravine;
- During the Star Mine all operation water for operating the plant will be withdrawn from the Saskatchewan River, with contingency to recycle from the PKCF; during the Orion South Mine operation process water and Fine PK will be discharged to the Star Pit and the PKCF will no longer be used, therefore water for operating the plant will be sourced from recycling, the Mannville dewatering system or the Saskatchewan River as needed;
- The Saskatchewan River intake will be proximate to the diffuser;
- Runoff from the side slopes and floor of the pits and residual groundwater flow into the pits will be collected and pumped to the PKCF;
- Runoff from the Overburden Stockpile and Coarse PK Pile areas were distributed based on the proportion of the watershed overlapped by each pile (i.e., 47% of the Overburden Stockpile is in the Caution Creek watershed, therefore 47% of the runoff from the Overburden Stockpile will runoff to Caution Creek); and
- Catchment areas for the Overburden Stockpile, Coarse PK Pile and PKCF assumed that the facilities would be at full footprint at the start of Operations.

The water balance computes monthly water volumes from a year prior to the start of construction (Year 0) to the end of operations (Year 24). The following years represent years of interest within the Construction and Operations phases of the Project that have been selected for the effects assessment:

- Construction:
  - Year 3 - final year of stripping prior to initiation of mining in Star Pit in Year 4;
- Operations:
  - Year 12 – production in Star Pit prior to stripping for Orion South Pit;
  - Year 16 – production in Star Pit with stripping for Orion South Pit; and

- Year 24 - The last complete year prior to end of mining in Orion South Pit in the summer of Year 24.

Three climatic scenarios were examined:

- Mean Case. Mean annual precipitation (468 mm) in all years;
- Wet Case. Mean annual precipitation in all years, except Year 19, when 1:20 year return period (wet) precipitation (656 mm) occurs; this year was selected as it is the year with the highest groundwater contribution and when the expected diffuser outflow is greatest under normal conditions, hence this year represents the minimum required flows to the water management system;
- Dry Case. Mean annual precipitation in all years, except Year 7, when 1:20 year return period (dry) precipitation (318 mm) occurs; this year was selected as it is the year with the lowest groundwater contribution and when the expected diffuser outflow is lowest under normal conditions, hence this year represents the greatest potential demand for process/make-up water supply over the life of the project.

The operating life of the mine will be approximately 20 years, thus the analysis of the 1:20 year dry and wet conditions were considered to be the most reasonable. The effects of the Project were first assessed for the Mean Case, and then changes to the assessment for the other two cases were determined.

3.0 POTENTIAL EFFECTS

Effects of the Project Tributary streams

Tributaries to the Saskatchewan River can be affected by the following Project activities:

- Clearing of vegetation;
- Construction of roads and plant site facilities that have compacted surfaces;
- Release of excess Mannville groundwater;
- Capture of groundwater from dewatering wells that would otherwise provide interflow to local streams;
- Excavation of pits;
- Creation of overburden stockpiles; and
- Impoundment of channels to create the Runoff Pond.

The results from the water balance model were used to quantitatively assess the effects of mine development and operations activities on the tributary channels.

Table 2 presents changes in the drainage areas reporting to the mouths of tributary streams for Baseline, Construction and Operations phases of the Project.

Table 2: Effects of the Project on Drainage Areas for Selected Tributary Streams to the Saskatchewan River

Stream	Drainage Areas at the Mouth of Creek (ha) and Percent Change from Baseline (%)								
	Baseline	***Construction***		***Operations***					
	Year 0	**Year 3**		**Year 12**		**Year 16**		**Year 23**	
Caution Creek	9,319	8,611	-8%	8,358	-10%	8,358	-10%	8,358	-10%
Caution Creek South	916	810	-12%	766	-16%	766	-16%	766	-16%
UT-2*	163	163	0%	163	0%	163	0%	163	0%
101 Ravine	2,431	1,919	-21%	1,419	-42%	1,419	-42%	1,419	-42%
West Perimeter Ravine	344	334	-3%	315	-9%	315	-9%	315	-9%
West Ravine	345	208	-40%	86	-75%	86	-75%	86	-75%
East Ravine	1,687	-	-100%	-	-100%	-	-100%	-	-100%
Duke Ravine	1,169	1,169	0%	874	-25%	874	-25%	874	-25%
FalC Ravine	81	81	0%	45	-44%	45	-44%	45	-44%
Wapiti Ravine	375	375	0%	154	-59%	154	-59%	154	-59%
English Creek	8,124	8,124	0%	8,011	-1%	8,011	-1%	8,011	-1%

*UT-2 – Unnamed Tributary

As a result of the construction of the Star Pit, the drainage area of East Ravine is reduced from 1,687 ha to 10 ha; for the purposes of the assessment this has been deemed a 100% loss Other watersheds are impacted by construction to a lesser extent with the reduction of the drainage area ranging from under 1% to 59%. The drainage area of Wapiti Ravine is reduced by 59% due to the development of the PKCF. However, negligible development in the area of Unnamed Tributary 2 results in the reduction of the drainage area being less than 1%.

Table 3 indicates the mean annual flows for each of the tributary channels that were assessed for the Baseline, Construction and Operations phases.

Table 3: Effects of the Project on Annual Mean Surface Water Discharges in Streams Tributary to the Saskatchewan River for the Mean Climatic Case

Stream	Annual Mean Discharge at the Mouth of Creek (m^3/s) and Percent Change from Baseline (%)								
	Baseline	*Construction*		*Operations*					
	Year 0	Year 3		Year 12		Year 16		Year 23	
Caution Creek	0.08	0.11	34%	0.12	44%	0.11	40%	0.11	32%
Caution Creek South	0.01	0.01	48%	0.01	46%	0.01	42%	0.01	39%
UT-2	0.00	0.00	0%	0.00	-37%	0.00	-46%	0.00	-52%
101 Ravine	0.03	0.05	70%	0.05	86%	0.05	82%	0.05	76%
West Perimeter Ravine	0.02	0.02	0%	0.02	-3%	0.01	-9%	0.01	-25%
West Ravine	0.02	0.02	-5%	0.01	-11%	0.01	-18%	0.01	-33%
East Ravine	0.02	-	-100%	-	-100%	-	-100%	-	-100%
Duke Ravine	0.02	0.03	33%	0.10	365%	0.10	360%	0.10	348%
FalC Ravine	0.01	0.01	0%	0.01	-3%	0.01	-11%	0.01	-27%
Wapiti Ravine	0.02	0.02	0%	0.02	-8%	0.01	-15%	0.01	-30%
English Creek	0.11	0.11	0%	0.11	-1%	0.11	-4%	0.10	-12%

The baseflow in each steam discussed above will be reduced over the life of the mine as a result of the Manville aquifer dewatering. The baseflow reduction due to dewatering is taken from groundwater modelling carried out by SRK (SRK, 2011). However, the discharges from Caution Creek, Caution Creek South and 101 Ravine increase, as a result of the increased runoff and reduced evapotranspiration following the development of the Overburden and Rock Storage pile.

The PKCF will capture and store runoff from areas of the Duke Ravine, FalC Ravine, Wapiti Ravine and English Creek watersheds, which will act to reduce the contributing catchment areas. Water collected in the PKCF perimeter ditch from seepage and exterior slope runoff will be released into the English Creek, Wapiti Ravine and Duke Ravine wetlands, based on the relative lengths of the perimeter ditch in each catchment (as was apportioned in the previous water balance model) or pumped back to the PKCF if it is determined that the wetlands do not have the capacity to achieve applicable water quality. For modeling, all seepage was considered appropriate for wetland treatment. Approximately 29% will flow to English Creek wetland, 17% will flow to Wapiti Ravine wetland and 54% will flow to Duke Ravine wetland. The reduction in contributing catchment areas for the reduction in groundwater baseflow account for the changes in the stream discharges reported in Table 3.

Flows from East Ravine are virtually eliminated due to the development of the Star Pit in the lower reach of the watershed. Runoff from the upper reach of the East Ravine watershed will be collected in the Runoff Pond and used for processing or flow supplementation of area water courses as needed to mitigate effects on fish habitat diverted to Duke Ravine. This diversion accounts for a portion of the almost 3-fold increase in the annual mean discharge from Duke Ravine from the baseline rate during operations.

The percentage of plant demand met by water from the runoff pond per month is presented in Table 4.

Table 4: Plant Demand Met by Runoff Pond

Month	% Plant Demand Met by Runoff Pond
January	4
February	4
March	4
April	27
May	9
June	6
July	6
August	8
September	4
October	4
November	4
December	4
Annual	7

Overall, the runoff pond provides approximately 7% of the plant demand.

The maximum monthly discharges in tributaries are expected to change in a manner similar to those for the mean annual flows. Table 5 lists the maximum monthly mean discharges computed for the years of interest.

Table 5: Effects of the Project on Maximum Monthly Mean Surface Water Discharges in Selected Streams Tributary to the Saskatchewan River for the Mean Case

Stream	Maximum Monthly Mean Discharge at the Mouth of Creek (m^3/s) and Percent Change from Baseline (%)								
	Baseline	***Construction***		***Operations***					
	Year 0	**Year 3**		**Year 12**		**Year 16**		**Year 23**	
Caution Creek	1.04	1.53	46%	1.68	61%	1.67	60%	1.66	59%
Caution Creek South	0.10	0.18	69%	0.19	88%	0.19	87%	0.19	86%
UT-2	0.02	0.02	0%	0.02	-16%	0.02	-19%	0.02	-21%
101 Ravine	0.29	0.64	120%	0.72	148%	0.72	147%	0.71	146%
West Perimeter Ravine	0.07	0.07	-1%	0.07	-5%	0.07	-9%	0.06	-18%
West Ravine	0.07	0.06	-20%	0.05	-38%	0.04	-42%	0.04	-51%
East Ravine	0.21	-	-100%	-	-100%	-	-100%	-	-100%
Duke Ravine	0.16	0.28	78%	0.83	419%	0.83	417%	0.82	413%
FalC Ravine	0.05	0.05	0%	0.04	-10%	0.04	-16%	0.03	-30%
Wapiti Ravine	0.08	0.08	0%	0.05	-30%	0.05	-33%	0.04	-42%
English Creek	1.02	1.02	0%	1.01	-1%	1.00	-2%	0.98	-4%

Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11 illustrate the computed monthly discharge hydrographs for Caution Creek, Caution Creek South, Unnamed Tributary 2, 101 Ravine, West Ravine, Duke Ravine, Wapiti Ravine and English Creek, respectively for Baseline, Construction and Operations conditions.

White Fox Creek is a stream located north of the LSA and Stream F and Stream G (Peonan Creek) are two streams south of the Saskatchewan River and south of the LSA that are not directly affected by physical disturbance resulting from the construction and operation of the Project. It is predicted that the effects of groundwater pumping will extend to these streams, resulting in a reduction in baseflow. Streams such as English Creek, Stream F and Stream G (Peonan Creek), which have little or no physical disturbance occurring in their watersheds, the effects are expected to be greatest approximately 45 to 60 years after the start of Project construction. After this point in time the groundwater discharge begins to increase towards pre-development levels (SRK, 2011). The effect of groundwater pumping in these streams is most significant in the winter months when there is little to no surface runoff to supplement the flow in the streams. Figure 12, Figure 13 and Figure 14 illustrate the computed monthly hydrographs for White Fox Creek, Steam F and Stream G (Peonan Creek). The total discharge from these streams in the baseline year was based on streamflow monitoring in the region. There were no monitoring data available for the months of November through March; thus, it was assumed that the winter baseflow would be equal to the groundwater discharge.

In summary, for tributary basins not directly affected by physical disturbance resulting from the construction and operation of the Project, the effects on stream discharges are expected to result solely from groundwater pumping.

A 90-10 approach is applied to water withdrawals from tributary streams supporting fish habitat. This means that:

- Withdrawals could conceptually be as much as 10% of the weekly average flow: and,
- Withdrawals can be limited by ensuring that the 90% of the weekly average discharge remains in the steam, meaning that if the natural flow falls below 90% of average, then no withdrawal would be allowed.

The groundwater pumping results in reductions in baseflow to the tributary streams locally and regionally. Results show that in the post freshet period the percentage reduction in baseflow will be less than 10% of the average baseline values for large streams (watersheds greater than about 500 km^2), but could exceed the 10% withdrawal limit for small streams (watersheds less than about 500 km^2) during the post freshet period. Effects are expected to be greater than 10% of the average baseline values during the winter ice-cover period for those streams that normally have sustained flow during the winter. Such an effect would not be observable on streams that normally cease to flow during the winter. However there are little to no streamflow data available for this period.

Figure 2: Caution Creek Hydrography

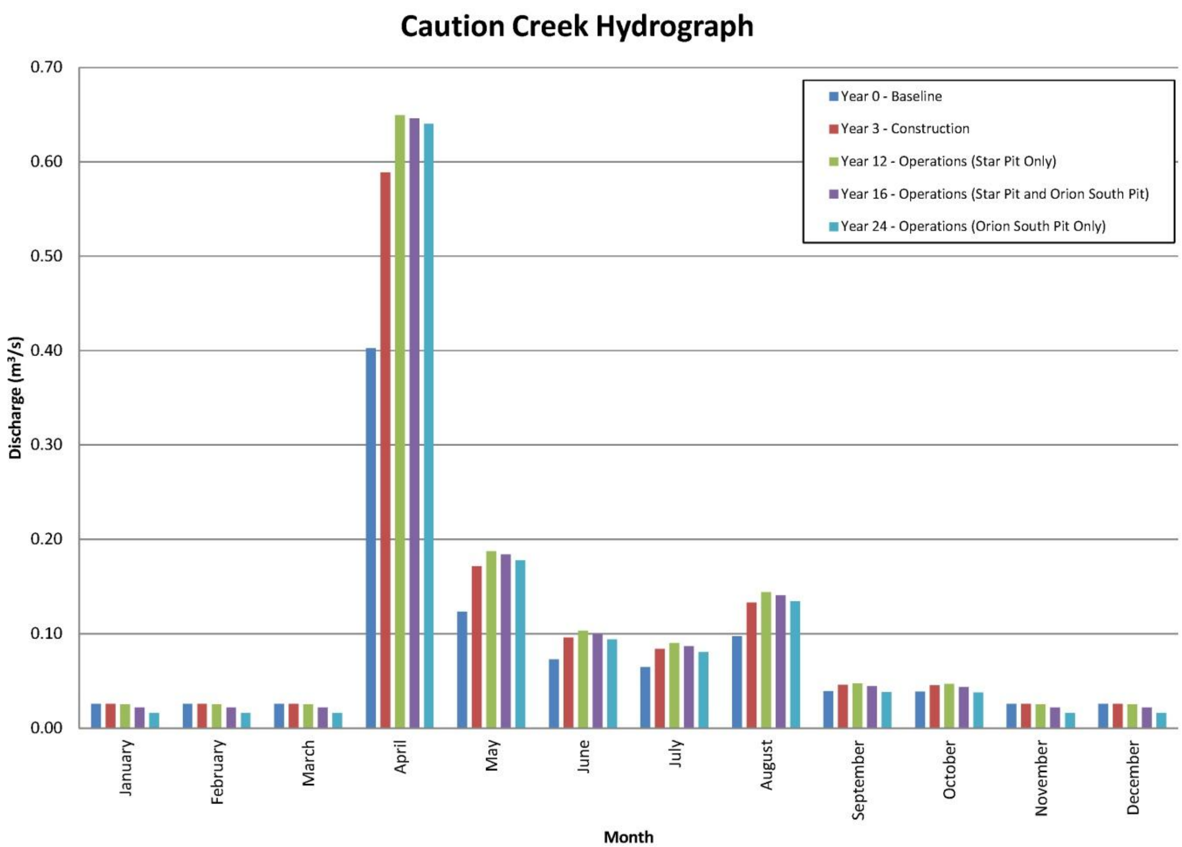


Figure 6.2.4-2

Figure 3: Caution Creek South Hydrography

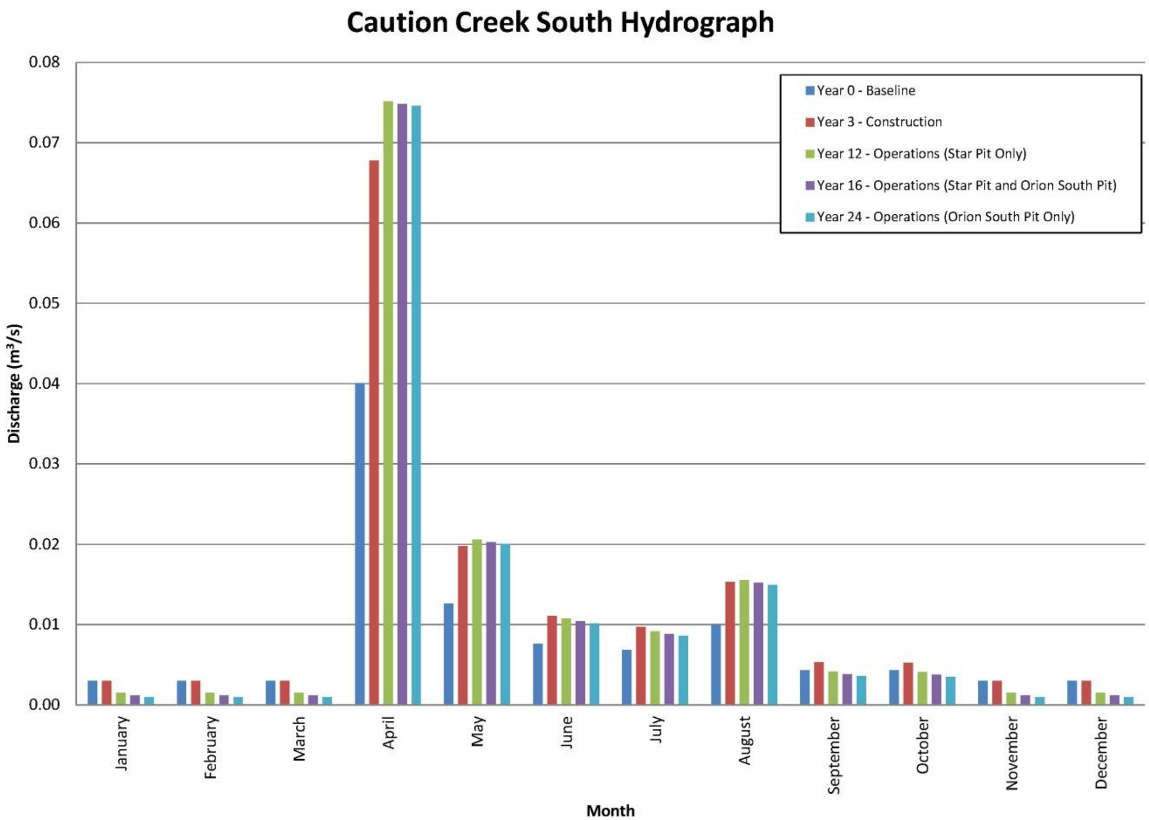
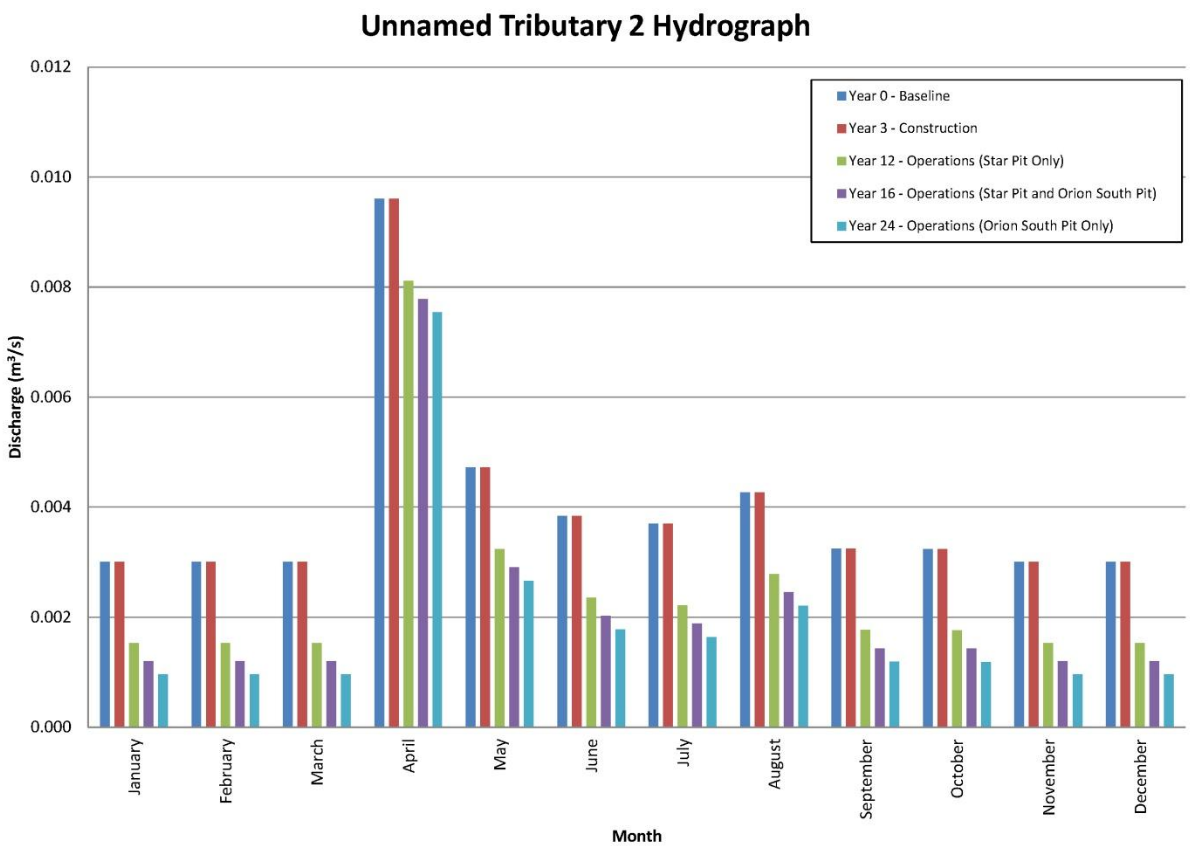


Figure 6.2.4-3

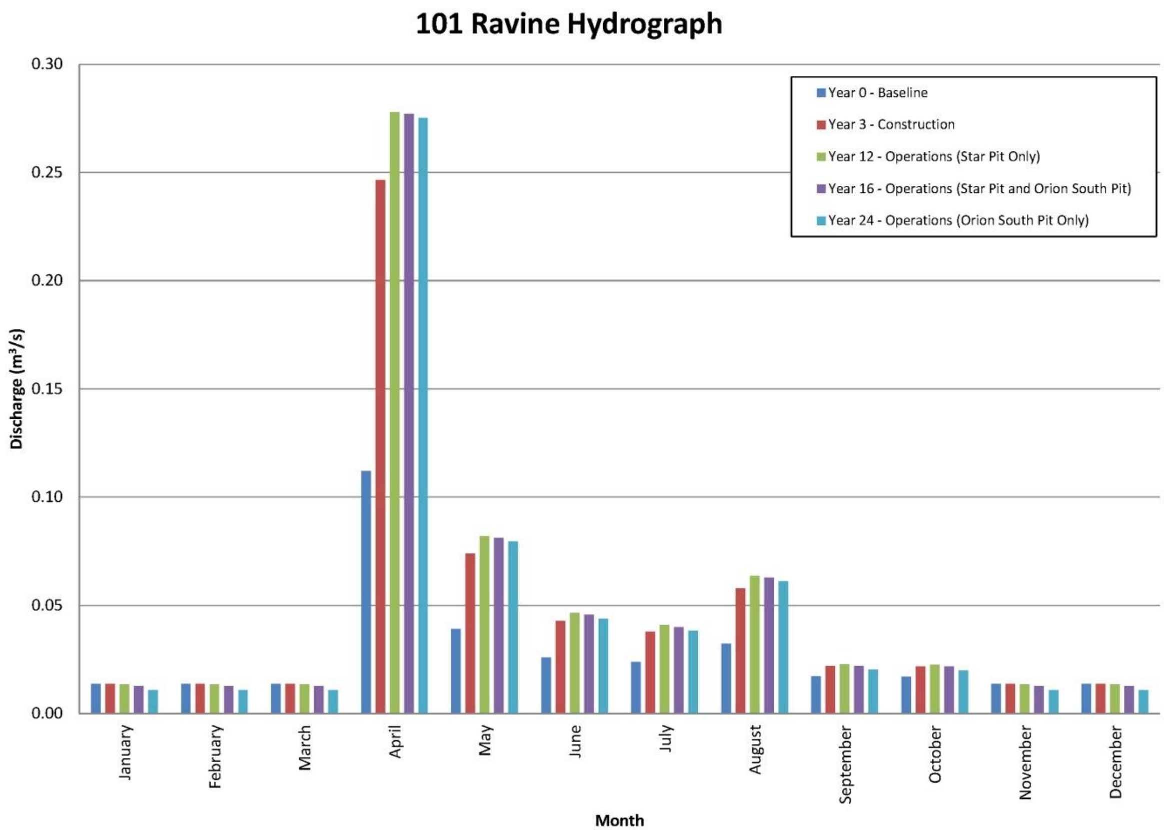
Figure 4: Unnamed Tributary 2 Hydrography



R:\Water Resources\General\PROJECT\SX\0373306 EIA\Water Balance\WaterBalance2011_r9.xlsx\UT-2Hydrograph
6/5/2012 10:50 AM

Figure 6.2.4-4

Figure 5: 101 Ravine Hydrography



R:\Water Resources\General\PROJECT\SX\0373306 EIA\Water Balance\WaterBalance2011_r9.xlsx\101Hydrograph
6/5/201210:50 AM

Figure 6.2.4-5

Figure 6: West Perimeter Ravine Hydrography

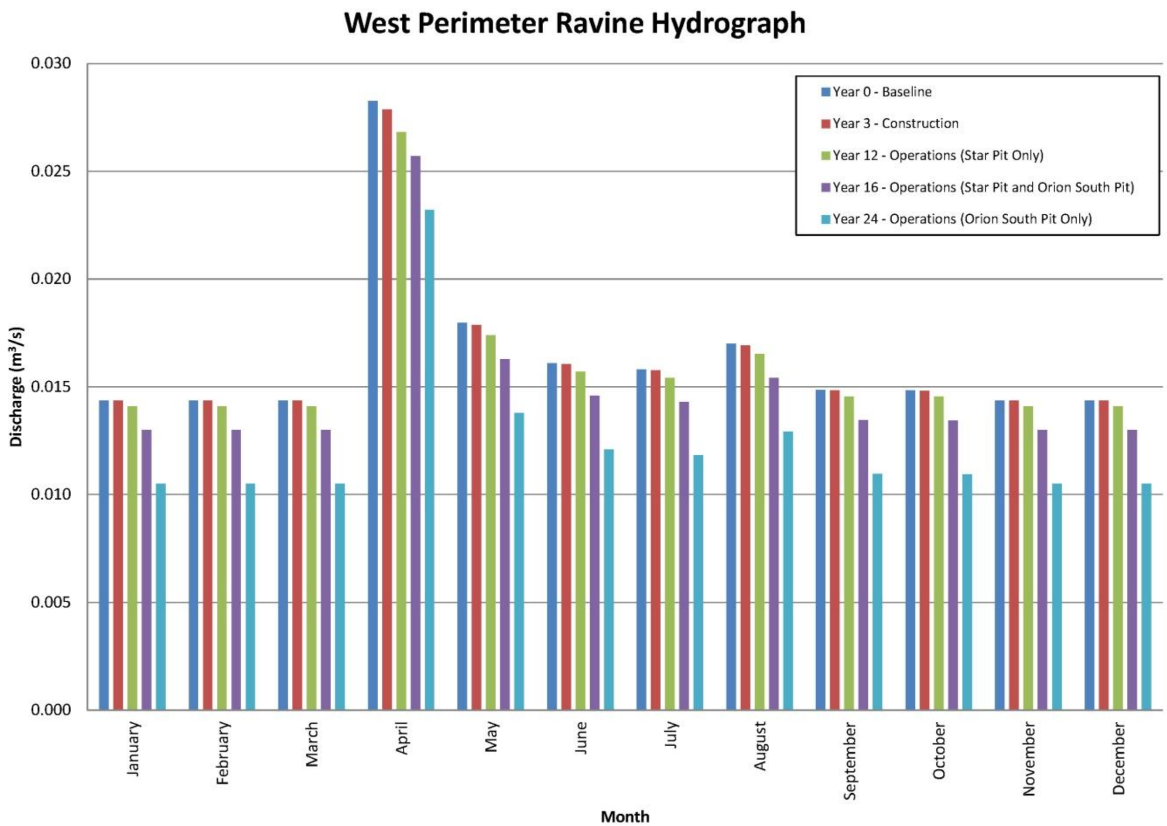
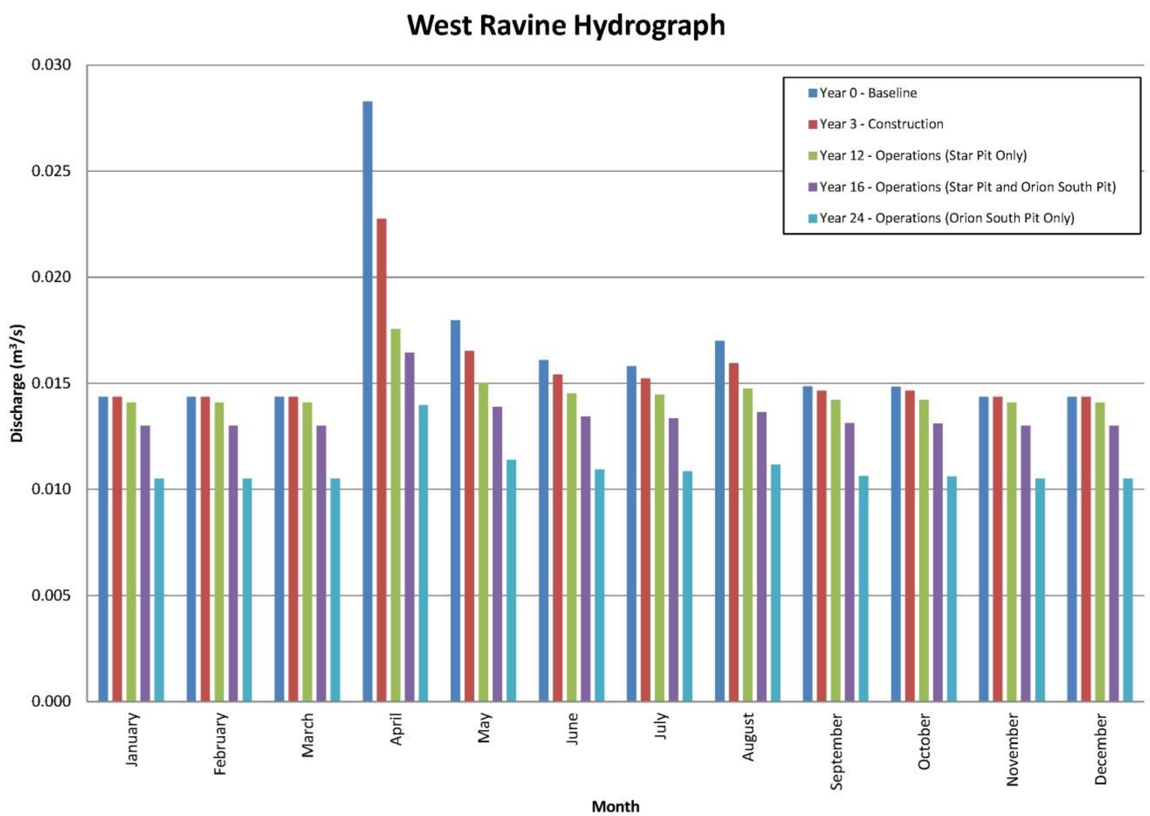


Figure 6.2.4-6

Figure 7: West Ravine Hydrography



R:\Water Resources\General\PROJECT\SX0373306 EIA\Water Balance\WaterBalance2011_r9.xlsx\WestHydrograph
6/5/2012 10:51 AM

Figure 6.2.4-7

Figure 8: Duke Ravine Hydrography

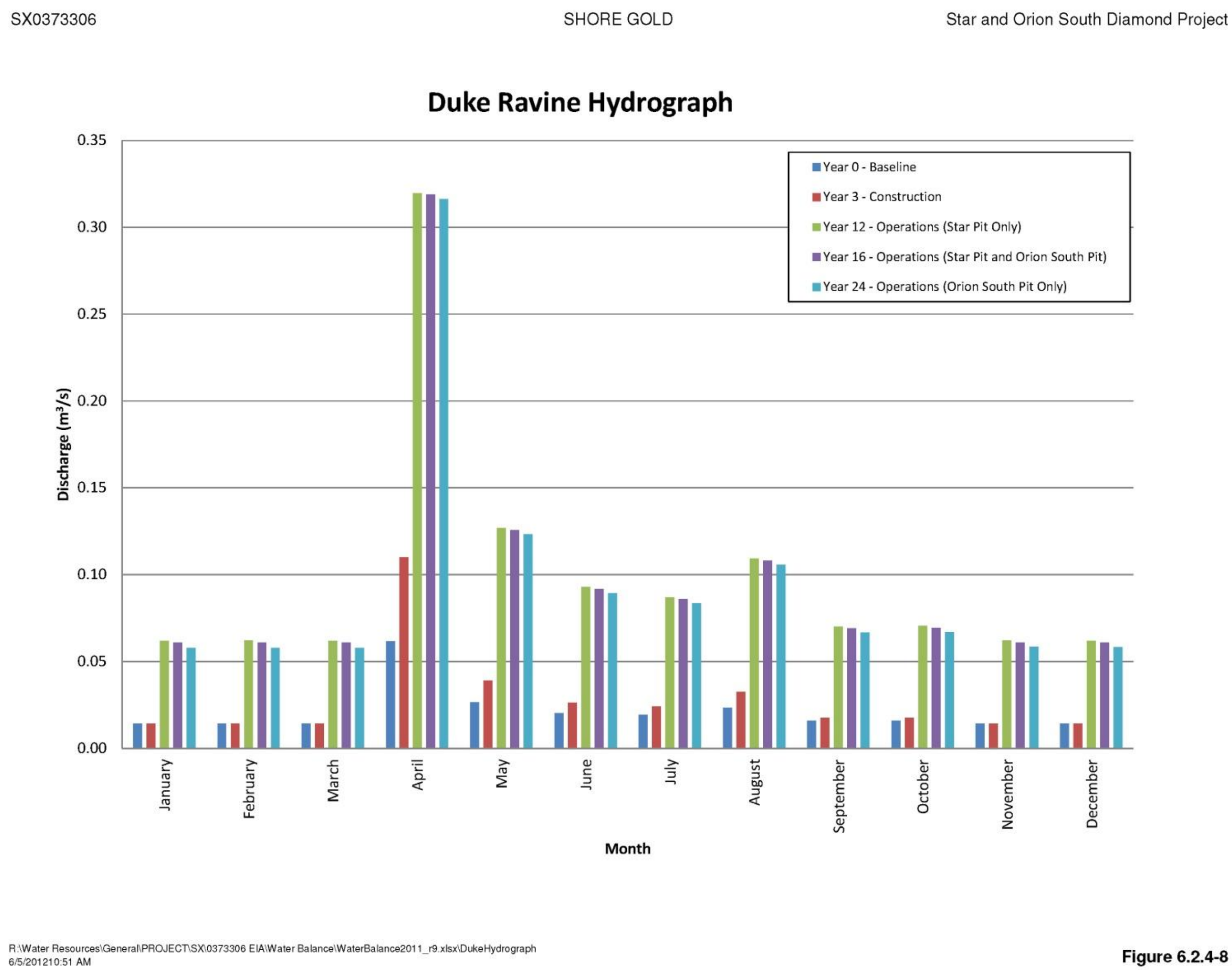
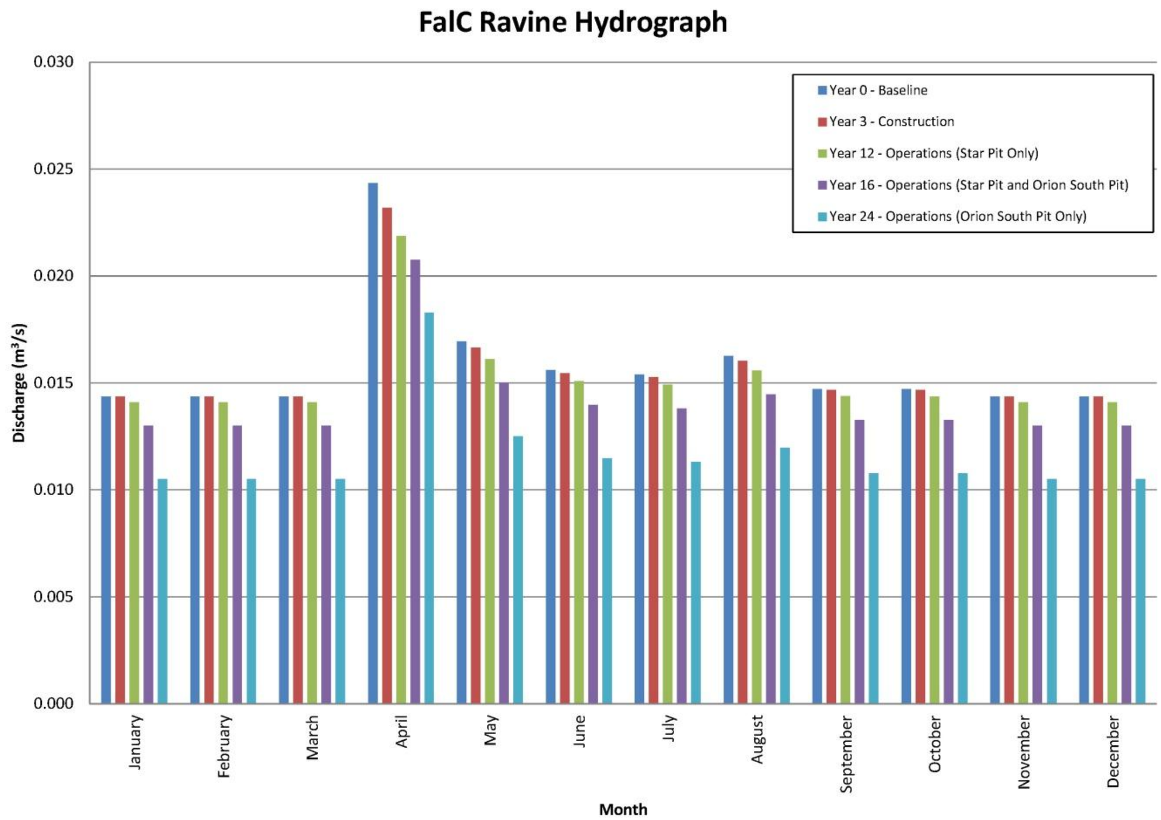


Figure 9: FalC Ravine Hydrography

SX0373306 SHORE GOLD Star and Orion South Diamond Project



R:\Water Resources\General\PROJECT\SX0373306 EIA\Water Balance\WaterBalance2011_r9.xlsx\FalCHydrograph
6/5/201210:51 AM

Figure 6.2.4-9

Figure 10: Wapiti Ravine Hydrography

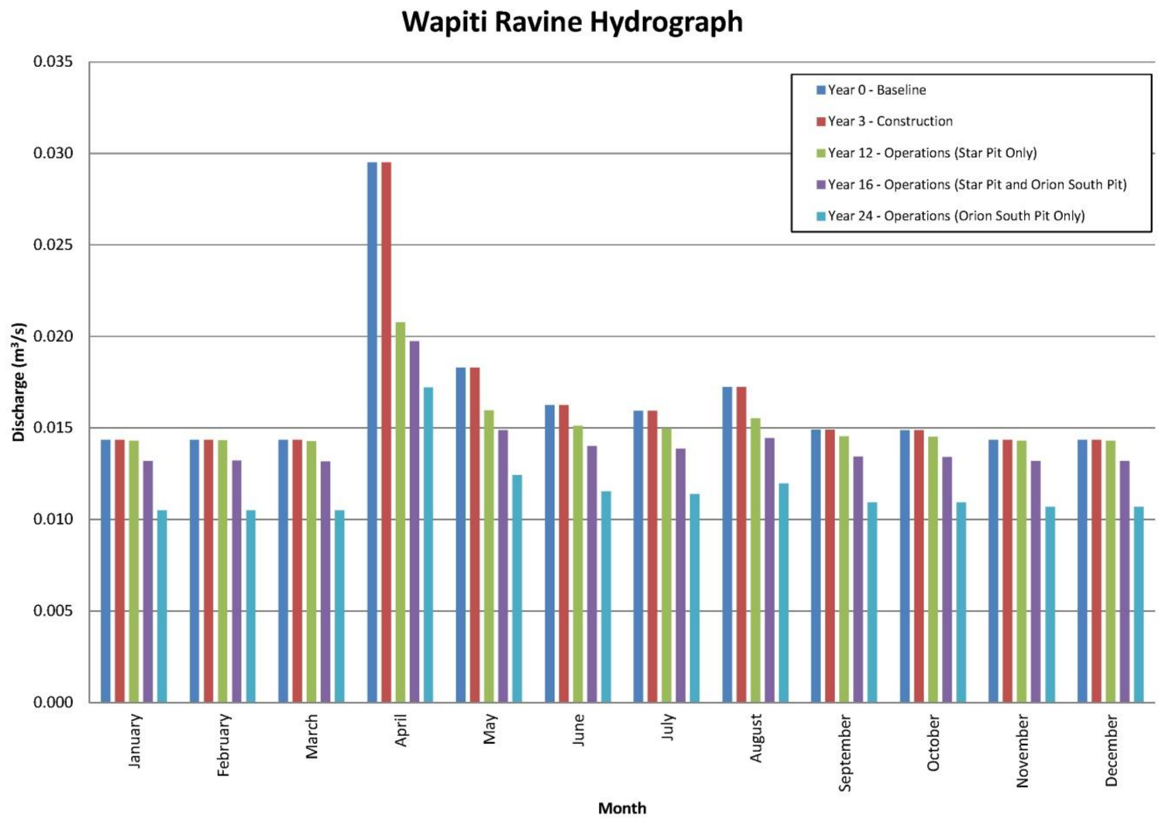


Figure 11: English Creek Hydrography

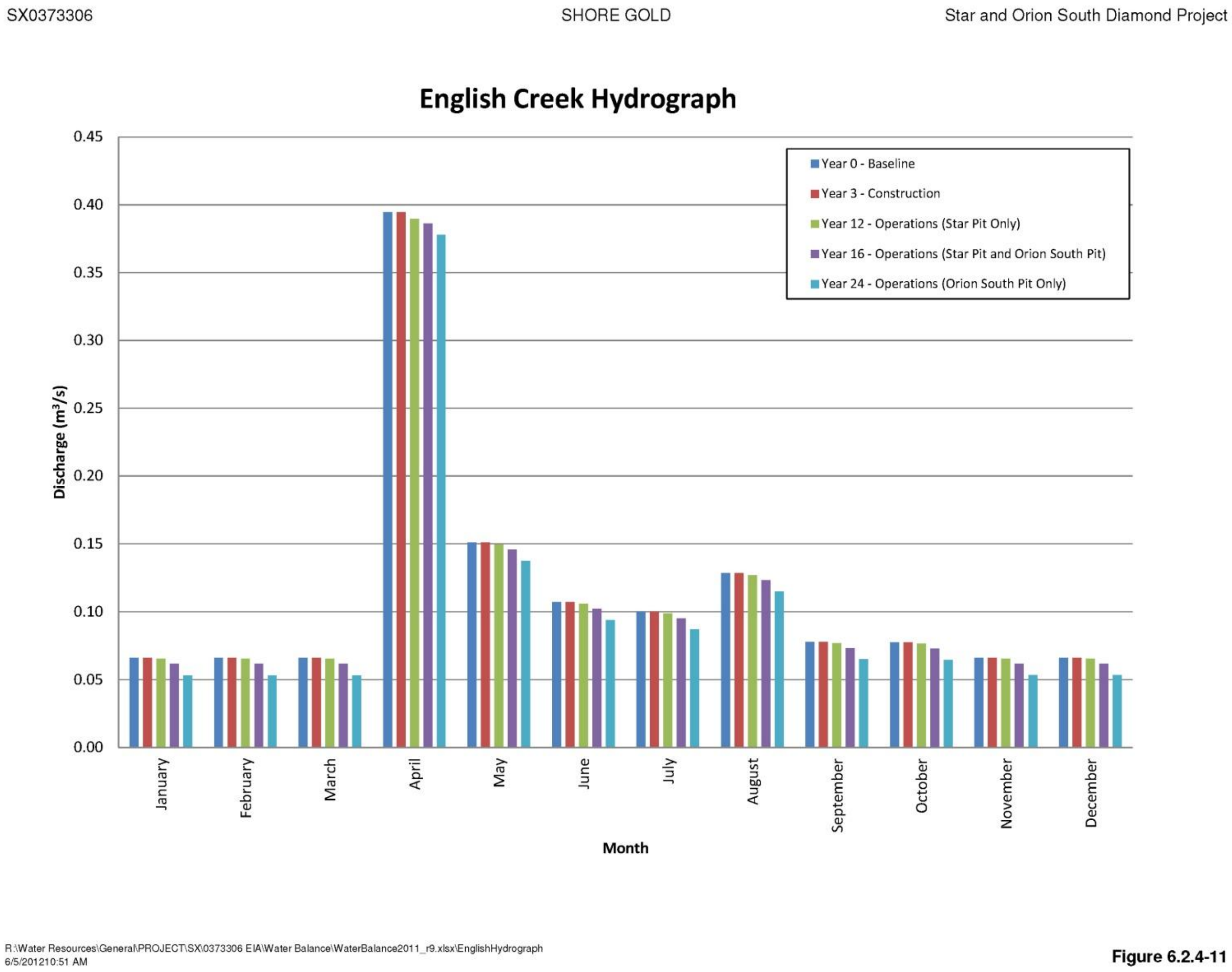


Figure 12: White Fox Creek Hydrography

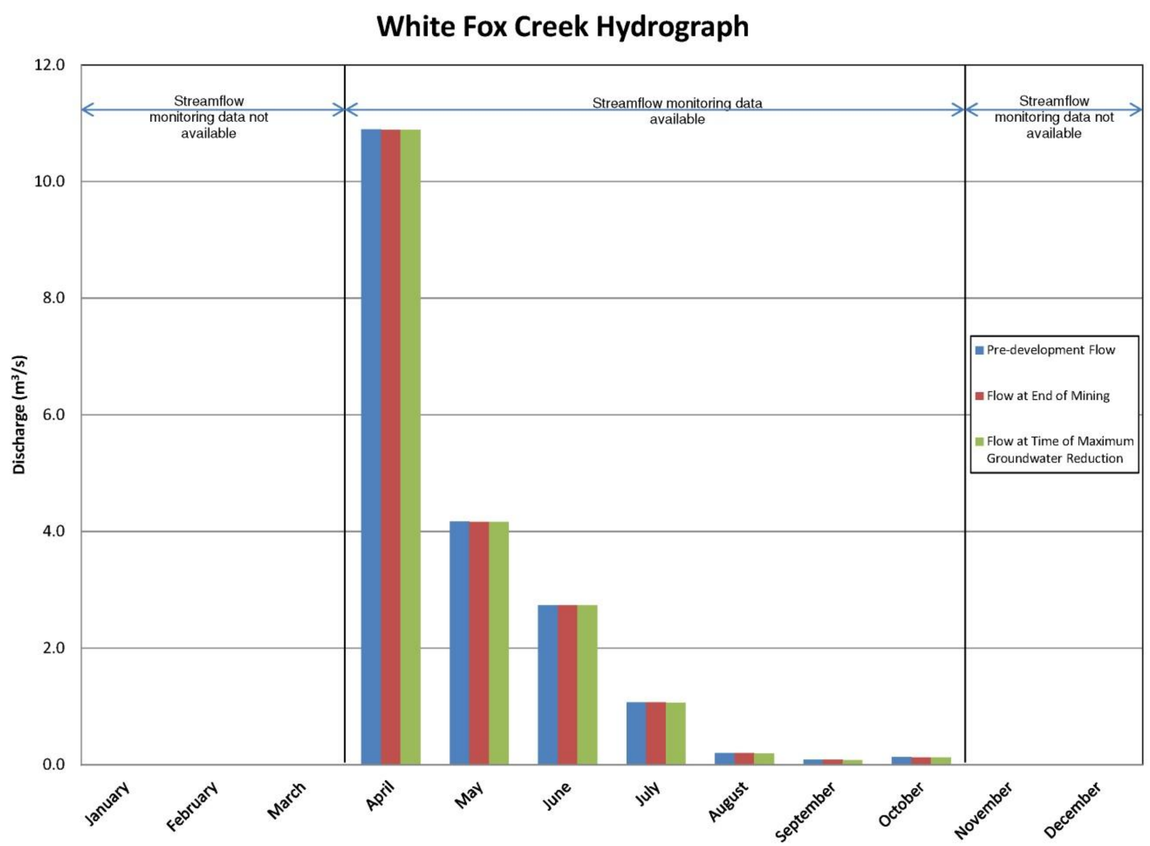


Figure 13: Stream F Hydrography

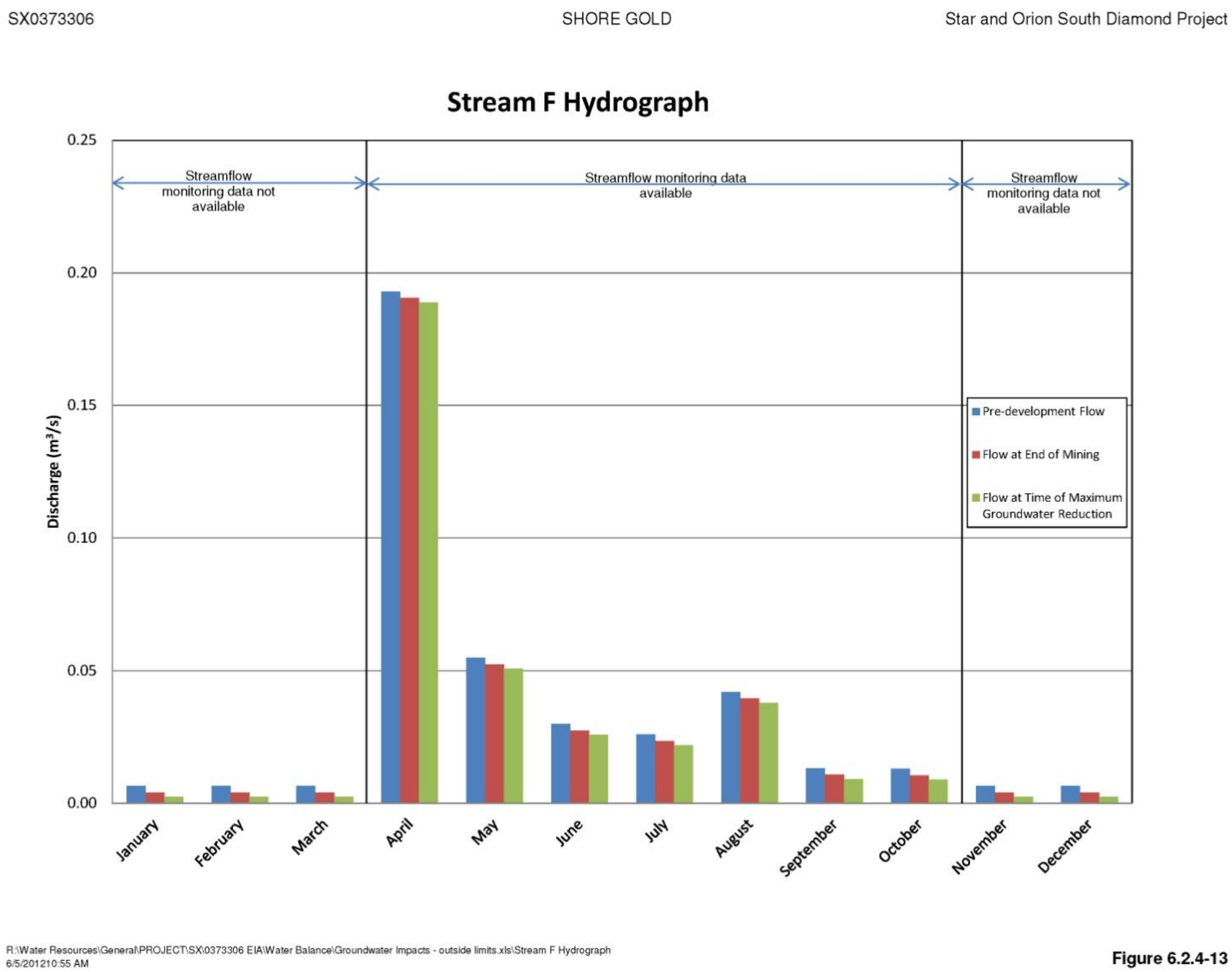


Figure 14: Stream G (Peonan Creek) Hydrography

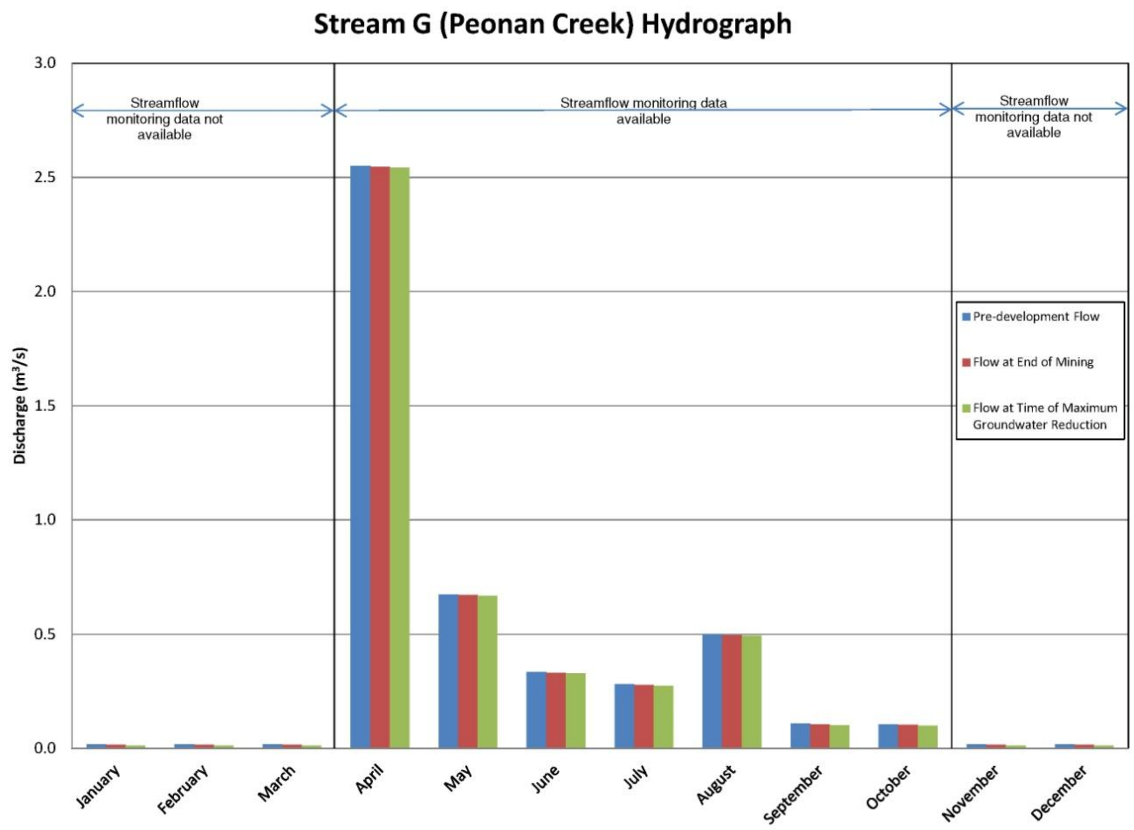


Figure 6.2.4-14

Effects of the Project: Saskatchewan River

The effect of the Project on surface water flows in the Saskatchewan River is the combined effect of:

- Withdrawl of process water
- Changes in the baseflow due to groundwater pumping;
- Changes in runoff discharges from tributary basins; and
- Addition of water from the PKCF and site operations to the River through the diffuser.

The water balance indicates volumes ranging from 23 Mm^3 to 24 Mm^3 annually being withdrawn from the Saskatchewan River. However, all of this volume is discharged back into the River. There is no discharge in the first 3 years, and in Year 4 between 1.61 Mm^3 and 1.78 Mm^3 of PKCF decant water is discharged through the diffuser. In subsequent years, discharge ranges from 4.36 Mm^3 to 4.82 Mm^3 per month. However when considering that approximately 2 Mm^3 originates from the River, net discharge is about 2.36 to 2.82 Mm^3 per month. As such, water withdrawal and process water discharge do not contribute to net changes in Saskatchewan River flows. Note that the proposed intake and diffuser are located proximately, so that no sections of the River are expected to have decreased flows as a result of withdrawal. Throughout the assessment, net diffuser flow refers to the actual change in flow, rather than the absolute value of flow being discharged through the diffuser.

The maximum reduction in groundwater discharge to the Saskatchewan River would be approximately 0.028 m^3/s, which is equivalent to 0.006% of the baseline annual mean discharge. Based on this information it can be concluded that groundwater pumping for the Project has a negligible direct effect on the Saskatchewan River discharge. This small reduction is offset by small net increases in tributary inputs and net diffuser input.

The effects of the Project on runoff discharges to the Saskatchewan River from tributary streams and net outfall discharges are presented in Table 6. Considering the outflow volumes from the diffuser to the River, there is a net inflow to the River during mining at Star accounting for a maximum increase of 0.5% of the mean annual flow.

Table 6: Computed Net Changes to Inflow to the Saskatchewan River

Source of Inflow	Annual Mean Discharge (m^3/s) and Percent Change from Baseline (%)										
	Baseline	***Construction***		***Operations***							
	Year 0	**Year 3**		**Year 6**		**Year 12**		**Year 16**		**Year 23**	
Tributary Streams[1]	0.39	0.43	9.9%	0.52	31.2%	0.51	28.8%	0.49	24.4%	0.45	15.5%
Facility Runoff	-	0.24	N/A	0.39	N/A	0.38	N/A	0.36	N/A	0.33	N/A
Net Diffuser[2]	-	0.02	N/A	1.15	N/A	1.19	N/A	1.23	N/A	0.69	N/A
Saskatchewan River	439.00	439.68	0.2%	441.06	0.5%	441.08	0.5%	441.09	0.5%	440.47	0.3%

Notes: 1. Tributary streams includes only the streams within the LSA on the north side of the Saskatchewan River without supplemental flows added to mitigate stream flow reduction due to groundwater pumping. Any supplemental flow added to tributary streams would reduce flows due to runoff or through the diffuser in direct proportion.

2. Net Diffuser inflow is the flow above that withdrawn and returned to the Saskatchewan River.

Reductions in discharge in some catchments are compensated for by increased runoff in other catchments, such that the total inflow to the river from tributary streams is always greater than for Baseline. For example, reductions in baseflow in the tributary streams as a result of groundwater pumping are offset by net diffuser flow to the Saskatchewan River. Net diffuser outflows average near 1 m^3/s to 2 m^3/s. This input together with the small increase in local runoff, amounts to a maximum change of about 2.27 m^3/s in the Saskatchewan River discharge. A change of this small magnitude (0.5%) would not be measurable in the river.

Dry and wet scenarios were also modeled. For the dry scenario, the depth of precipitation was reduced to the 1:20 dry precipitation in Year 7, as this is the year (after the start of operations) with the lowest expected groundwater contribution. Effects on the tributary stream baseflows from groundwater contributions are similar to those for the mean case. However, as precipitation is less, runoff in Year 7 is less than under mean conditions.

Net diffuser discharges are directly related to surface water runoff volumes for the contributing watersheds. For Year 7, the reduction in net diffuser flow volume due to reduced surface runoff is 1%. On a monthly basis the greatest net change to the diffuser discharge occurs in April of Year 7, with a 5% decrease compared to the mean case. These changes are illustrated on Figure 15.

For the wet scenario, the depth of precipitation was increased to the 1:20 year wet precipitation in year Year 19, as this is the year with the highest groundwater contribution and when the expected net diffuser outflow is greatest under normal conditions. Effects on the tributary stream baseflows are similar to those for the mean case. However, as precipitation is greater, runoff in Year 19 is more than under mean conditions.

The increase in net diffuser flow volume in Year 19 is approximately 3% compared to the mean case. On a monthly basis the greatest change in the net diffuser discharge occurs in April of Year 19, with a 14% increase compared to the mean case. These changes are illustrated on Figure 16.

Figure 15: Diffuser Outflows Year 7

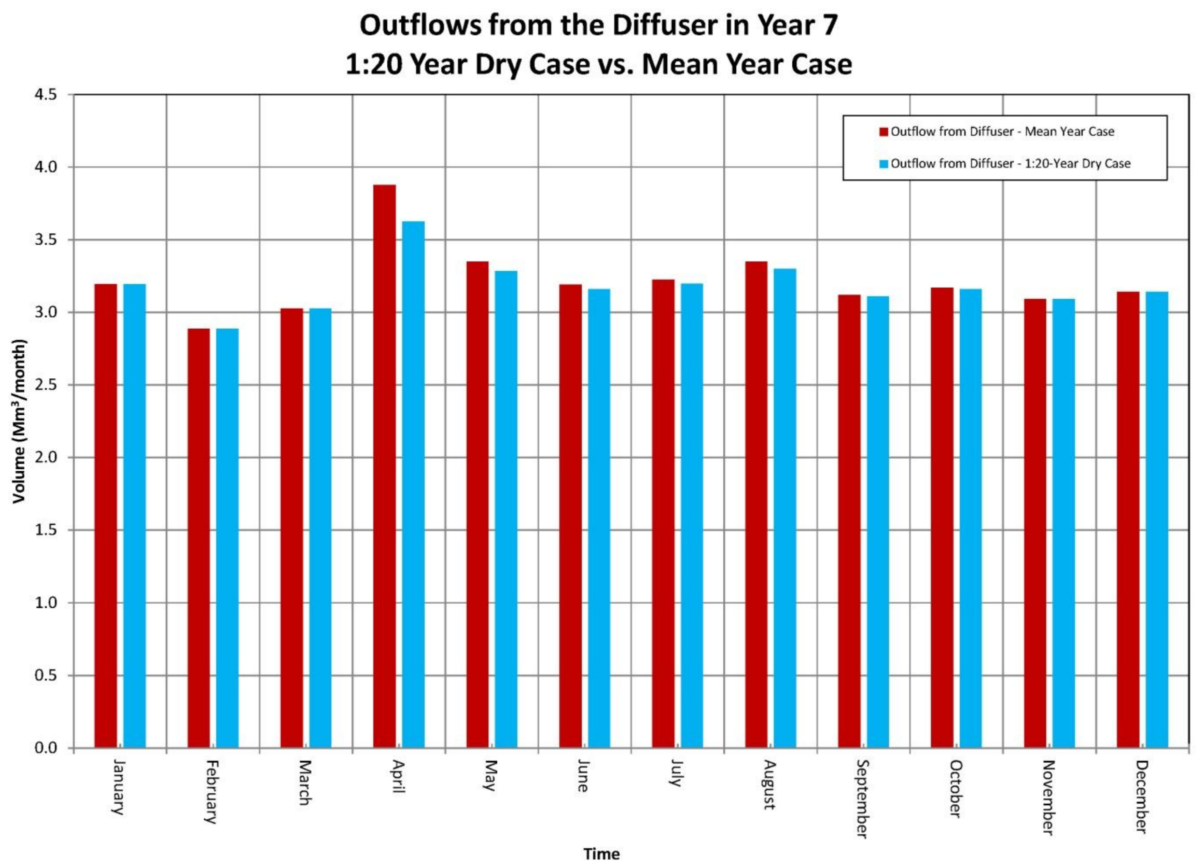


Figure 16: Diffuser Outflows Year 19

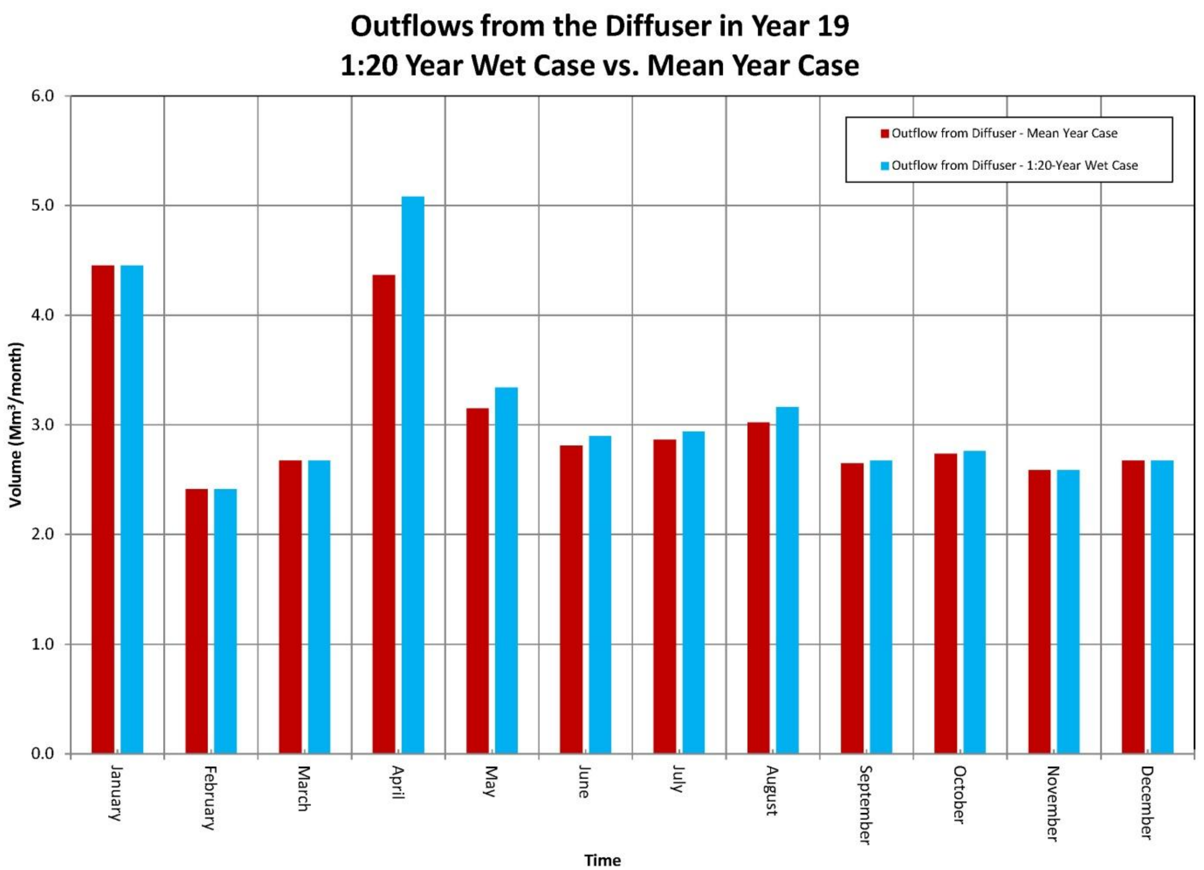


Figure 6.2.4-16

4.0 MITIGATION

Development of the Project includes the following mitigative measures to reduce the effects of the Project on surface water hydrology:

- Water is re-used within the plant site and there is a contingency to recycle up to 100% of process water requirements from the PKCF. Note modeling assumed a worst case of 0% recycling;
- Supplemental flows will be provided from the East Ravine runoff pond to mitigate reductions in low flow conditions for English Creek, Duke Ravine, and 101 Ravine and other streams as warranted; and
- Erosion and sediment control will be installed where necessary and practical to control surface flows and limit transport of parameters of concern into watercourses, including Duke Ravine.

5.0 RESIDUAL EFFECTS

The residual effects of the Project on surface water hydrology have been assessed by considering the mitigative measures discussed above for each phase of the Project. For the Construction and commissioning phase, the following activities could affect surface water hydrology:

- Clearing and Stripping;
- Surface infrastructure installations;
- Water source and wastewater management;
- Pit excavation and development;
- Construction of overburden & rock storage and processed Kimberlite containment facilities;
- Construction of Processing Plant and facilities;

During Operations, the following activities were assessed for surface water hydrology;

- Surface water management;
- Water supply and distribution;
- Mine dewatering;
- Erosion control and soils/till stockpiles management;
- Overburden & rock storage management;
- Fine and coarse processed Kimberlite management;
- Waste water management and drainage control; and
- Processing Plant water consumption.

Table 7 summarizes the assessment of potential effects of the Project for hydrological components (tributaries and the Saskatchewan River) at the selected Project phases. Note that closure is discussed in Section 7.

For construction, flow in tributary streams increases by less than 10%, resulting in a positive direction, moderate magnitude effect. The effect occurs continuously within the LSA, and is reversible. For the Saskatchewan River, the magnitude of increases in flow is negligible, and at a regional scale, with other attributes the same as for tributaries (Table 7).

For operations, magnitude of flow increases is high for site tributaries (with an overall increase in flow of up to 31.2%) and is long term. The effect occurs continuously within the LSA, and is reversible. For the Saskatchewan River, the magnitude of flow increases is negligible (less than 1% and within natural variability), long term, regional, continuous and reversible.

Overall effects on hydrology are not significant (Table 8), as the total magnitude of changes to the hydrological systems is low, although specific streams will have substantial changes in discharge; (e.g., substantial decreases in flow in East Ravine, and increases in flow in Duke Ravine). These changes are mitigated where possible through flow supplementation in fish bearing tributaries with reduced flow. Groundwater contribution to the streams within the Project area, including the Saskatchewan River, will be reduced over time as a result of groundwater pumping. Cumulatively, however, the net change in flow from all local catchments draining to the Saskatchewan River is near zero and will not likely be measurable. Effects on hydrology are considered not significant.

Table 7: Assessment of Surface Water Hydrology Components

Project Phase	Component	Direction	Magnitude	Duration	Geographic Extent	Frequency	Reversibility
Construction	Tributary Streams	Positive	Moderate	Short-term	Local	Continuous	Reversible
	Saskatchewan River	Positive	Negligible	Short-term	Regional	Continuous	Reversible
Operations	Tributary Streams	Positive	High	Long-term	Local	Continuous	Reversible
	Saskatchewan River	Positive	Negligible	Long-term	Regional	Continuous	Reversible

Table 8: Significance of Residual Effects of the Project on Surface Water Hydrology

Project Phase	Direction	Magnitude	Duration	Geographic Extent	Frequency	Reversibility	Significance
Construction	Positive	Low	Short-term	Regional	Continuous	Reversible	Not Significant
Operation	Positive	Low	Long-term	Regional	Continuous	Reversible	Not Significant

6.0 CUMULATIVE EFFECTS

The residual effects of the Project on surface water hydrology at the RSA level (Saskatchewan River) have been determined to be not measurable and not significant as a result. As the effects of this project cannot be detected as a part of cumulative effects of other projects, this project does not add measurably to the effects of the other projects.

7.0 CLOSURE

To assess the hydrologic impacts of the Project beyond the Operations phase a water balance was developed for Closure. Analysis in Appendix 6.2.4-A of the revised EIS has not changed as a result of the updated water management plan and is therefore accurate. The water balance focuses on mine pit infilling and on the changes to local streamflow. Closure was defined as the period commencing at the end of mining (approximately Year 24) during which reclamation is established. The analysis for closure included:

- changes to local streamflow as a result of changes in the reclaimed landscape;
- changes in groundwater baseflow as it recovers; and
- water balance simulation of in-pit lake filling.

The water balance model developed for Closure tracks the volume of water that is gained and lost on an annual basis starting at the end of a period 20 to 25 years after the operations phase. The assumption was made that the vegetation of the reclaimed areas would be fully established and relatively stable after this period.

It was assumed that the PKCF, Course PK Pile, Overburden Pile and all Site Facilities will be reclaimed to the appropriate land use categories, as per provincial regulations, upon mine closure as described in Section 7.5 of the revised EIS. With the exception of the PKCF, it is assumed that the natural watershed boundaries will be restored as close to the natural conditions (i.e., pre-development conditions) as possible. The PKCF will remain bermed and the runoff from within this area will be discharged into Duke Ravine. The runoff from the outer slopes of the PKCF berms will be directed to the natural watersheds in which they are located (English Creek, Wapiti Ravine and FalC Ravine).

The Orion South Pit is contained within the upstream portions of 101 Ravine and East Ravine. Modeling (SRK 2011) shows that the water level within the Orion South Pit will not reach an elevation of 436 mamsl, and therefore, will not overflow into East Ravine. The Closure plan for Star Pit directs overflow into the downstream reach of East Ravine and subsequently the Saskatchewan River when the water level reaches 378 mamsl. The structure of the water balance model is discussed in Appendix 6.2.7-A of the revised EIS.

The following water sources or inputs were applied in the water balance:

- surface water runoff;
- direct precipitation (pond surface and pit walls);
- groundwater seepage;

- evaporation; and
- groundwater infiltration.
-

Key assumptions made in the creation of the water balance for Closure include the following:

- landscape is fully reclaimed (i.e., selection of runoff coefficients is based on fully reclaimed conditions);
- runoff coefficients for adjacent basins and pit walls were invariant with time;
- groundwater flows into and out of the pits were varied, based on information provided in the groundwater model (SRK, 2011); and,
- extreme events, such as extreme precipitation, droughts and wild fires, were not considered.
-

The findings of the Closure water balance study are presented in Appendix 6.4.2-A of the revised EIS. A high level summary of the water balance findings are listed below:

- As per GW modeling by SRK, the maximum reduction in groundwater contribution to stream flow occurs 25 years after end of mining.
- The maximum reduction in groundwater discharge to the Saskatchewan River would be approximately 0.16 m^3/s. This is equivalent to 0.34% of the baseline annual mean discharge
- Creek flows return to between 68% and 92% of baseline at the end of the SRK modeling period which is 350 years after the end of mining.
- Star Pit will spill into East Ravine 326 years after mining ends. The average annual spill volume into East Ravine will be approximately 1.22 Mm^3
- Orion South Pit does not spill during the modeling period (1000 years). After 326 years when Star Pit starts to overflow, the water level in Orion reaches 406 mamsl.

Assessment of closure hydrology is summarized in Table 9. Overall, effects of closure on hydrology are not significant and neutral to positive direction.

Table 9: Residual Effects of the Project on Surface Water Hydrology for Closure

Component	Direction	Magnitude	Duration	Geographic Extent	Frequency	Reversibility	Significance
Tributary Streams	Neutral	Low	Long-term	Local	Continuous	Reversible	n/a
Saskatchewan River	Positive	Low	Long-term	Regional	Continuous	Reversible	n/a
Overall hydrology	Neutral	Low	Long-term	Regional	Continuous	Reversible	Not significant