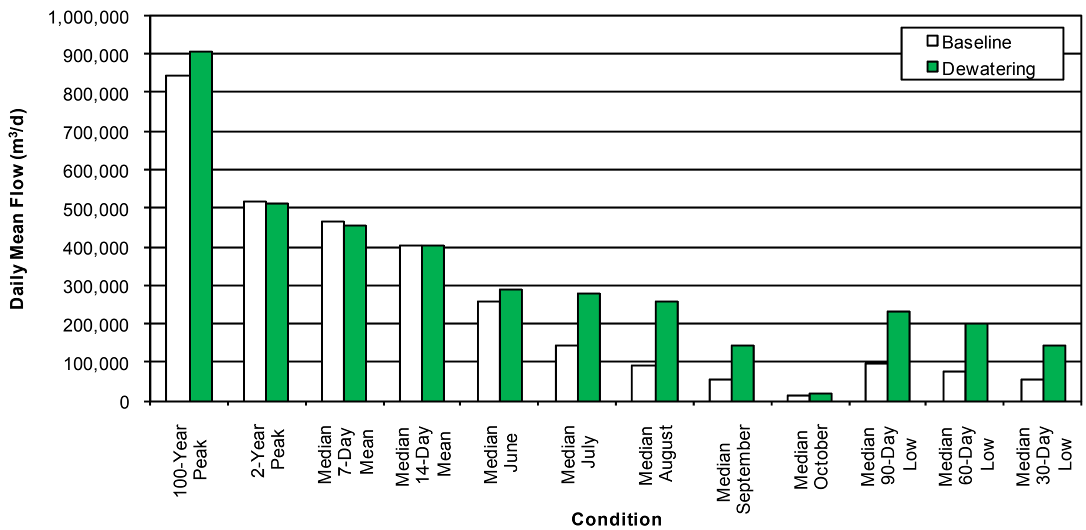
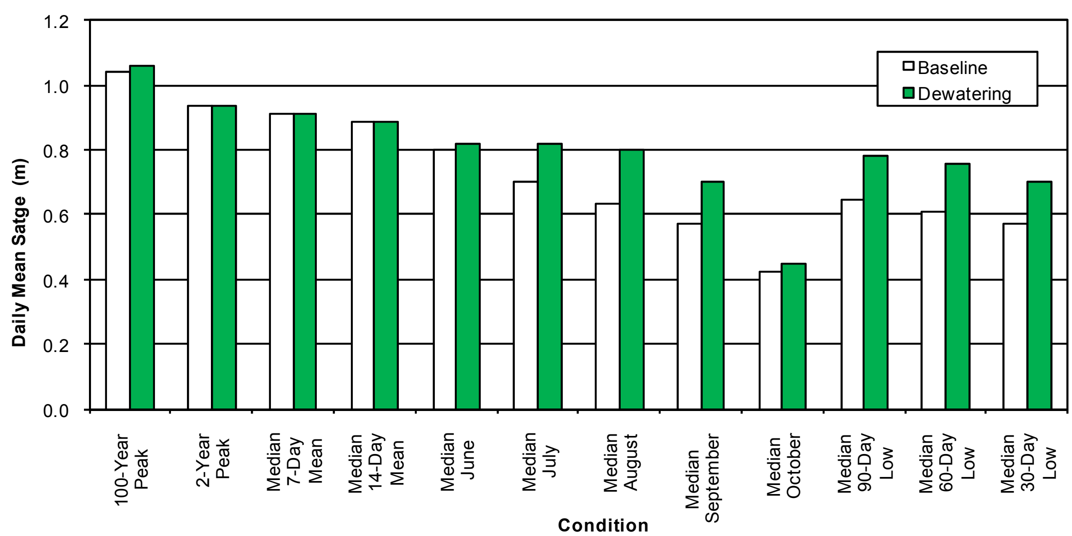
9.7-16. Project effects on Lake N1 during dewatering are summarized in Figures 9.7-10 to 9.7-11 and Tables 9.7-17 to 9.7-20.

Figure 9.7-8 Comparison of Effects on Lake N11 Outlet Discharges – Dewatering



m^3/d = cubic metres per day.

Figure 9.7-9 Comparison of Effects on Lake N11 Stages – Dewatering



m = metres.

Table 9.7-13 Monthly Mean Discharges at the Lake N11 Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	443,000	293,000	221,000	258,000	50,700
		dewatering	478,000	373,000	332,000	370,000	62,900
	10	baseline	359,000	215,000	147,000	123,000	28,200
		dewatering	389,000	324,000	294,000	247,000	35,100
Median	2	baseline	257,000	141,000	91,400	56,800	14,700
		dewatering	288,000	280,000	256,000	142,000	18,600
Dry	10	baseline	155,000	83,600	58,800	33,300	8,740
		dewatering	196,000	248,000	226,000	71,700	11,200
	100	baseline	71,900	46,900	42,600	25,900	6,400
		dewatering	126,000	230,000	207,000	32,400	8,380

m^3/d = cubic metres per day.

Table 9.7-14 Derived Representative Discharges at the Lake N11 Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	9.8	747,000	630,000	179,000	198,000	215,000
		dewatering	10.5	805,000	676,000	326,000	331,000	343,000
	10	baseline	8.22	630,000	538,000	102,000	125,000	152,000
		dewatering	8.27	634,000	543,000	239,000	264,000	284,000
Median	2	baseline	6.00	464,000	404,000	55,500	75,000	98,700
		dewatering	5.92	457,000	405,000	143,000	200,000	229,000
Dry	10	baseline	3.36	269,000	240,000	33,900	48,500	64,200
		dewatering	4.12	321,000	296,000	73,500	152,000	189,000
	100	baseline	0.85	85,300	81,700	25,200	36,500	45,200
		dewatering	3.19	250,000	238,000	43,600	128,000	167,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-15 Monthly Mean Stages at Lake N11 – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.903	0.824	0.774	0.801	0.558
		dewatering	0.919	0.869	0.847	0.868	0.585
	10	baseline	0.862	0.769	0.707	0.680	0.490
		dewatering	0.878	0.843	0.825	0.793	0.514
Median	2	baseline	0.800	0.700	0.636	0.572	0.424
		dewatering	0.821	0.816	0.800	0.702	0.447
Dry	10	baseline	0.715	0.624	0.577	0.508	0.378
		dewatering	0.754	0.794	0.778	0.603	0.399
	100	baseline	0.603	0.548	0.537	0.481	0.352
		dewatering	0.683	0.781	0.763	0.505	0.374

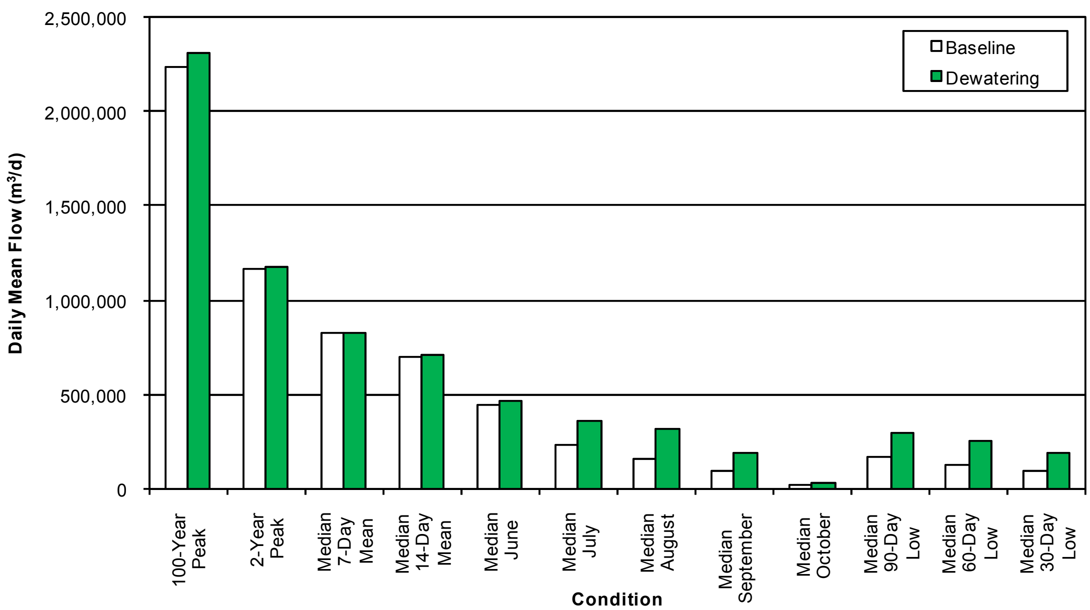
m = metre.

Table 9.7-16 Derived Representative Stages at Lake N11 – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.043	1.015	0.977	0.739	0.755	0.769
		dewatering	1.059	1.032	0.992	0.844	0.847	0.853
	10	baseline	1.003	0.977	0.943	0.652	0.682	0.712
		dewatering	1.005	0.978	0.945	0.788	0.805	0.818
Median	2	baseline	0.935	0.913	0.885	0.569	0.609	0.647
		dewatering	0.933	0.910	0.886	0.703	0.757	0.780
Dry	10	baseline	0.822	0.809	0.788	0.510	0.553	0.588
		dewatering	0.861	0.841	0.826	0.606	0.712	0.748
	100	baseline	0.606	0.626	0.620	0.478	0.519	0.544
		dewatering	0.813	0.796	0.787	0.540	0.686	0.727

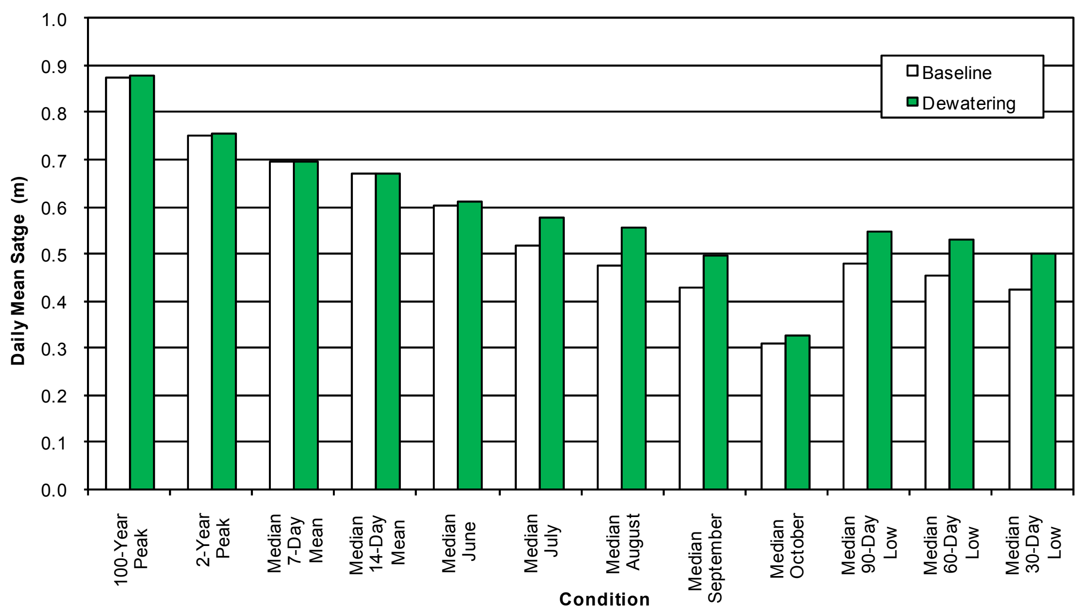
m = metre.

Figure 9.7-10 Comparison of Effects on Lake N1 Outlet Discharges – Dewatering



m^3/d = cubic metres per day.

Figure 9.7-11 Comparison of Effects on Lake N1 Stages – Dewatering



m = metres.

Table 9.7-17 Monthly Mean Discharges at the Lake N1 Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	737,000	470,000	370,000	398,000	84,100
		dewatering	764,000	550,000	499,000	490,000	99,600
	10	baseline	609,000	348,000	248,000	204,000	47,600
		dewatering	632,000	453,000	396,000	326,000	57,400
Median	2	baseline	444,000	229,000	156,000	99,000	25,100
		dewatering	471,000	364,000	317,000	194,000	30,900
Dry	10	baseline	270,000	138,000	102,000	56,600	14,600
		dewatering	312,000	297,000	272,000	111,000	18,400
	100	baseline	121,000	79,300	75,400	41,600	10,300
		dewatering	184,000	256,000	249,000	66,700	13,300

m^3/d = cubic metres per day.

Table 9.7-18 Derived Representative Discharges at the Lake N1 Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	25.9	1,250,000	1,050,000	285,000	333,000	353,000
		dewatering	26.7	1,280,000	1,070,000	417,000	462,000	482,000
	10	baseline	19.9	1,080,000	910,000	171,000	212,000	251,000
		dewatering	19.9	1,080,000	914,000	304,000	351,000	384,000
Median	2	baseline	13.5	827,000	704,000	95,600	128,000	166,000
		dewatering	13.6	826,000	705,000	195,000	257,000	296,000
Dry	10	baseline	8.2	527,000	441,000	57,200	83,800	109,000
		dewatering	8.8	561,000	473,000	112,000	195,000	235,000
	100	baseline	4.5	242,000	174,000	40,500	63,800	77,100
		dewatering	5.8	335,000	264,000	59,400	161,000	199,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-19 Monthly Mean Stages at Lake N1 – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.677	0.610	0.577	0.587	0.411
		dewatering	0.682	0.633	0.619	0.616	0.427
	10	baseline	0.648	0.569	0.527	0.504	0.360
		dewatering	0.653	0.605	0.587	0.561	0.376
Median	2	baseline	0.602	0.517	0.473	0.426	0.311
		dewatering	0.610	0.575	0.557	0.498	0.326
Dry	10	baseline	0.537	0.460	0.429	0.375	0.274
		dewatering	0.555	0.549	0.538	0.438	0.289
	100	baseline	0.446	0.405	0.400	0.349	0.253
		dewatering	0.492	0.531	0.527	0.389	0.269

m = metre.

Table 9.7-20 Derived Representative Stages at Lake N1 – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.874	0.764	0.734	0.544	0.564	0.571
		dewatering	0.880	0.768	0.737	0.594	0.608	0.614
	10	baseline	0.822	0.739	0.710	0.483	0.508	0.528
		dewatering	0.822	0.739	0.711	0.552	0.571	0.582
Median	2	baseline	0.752	0.695	0.670	0.423	0.452	0.480
		dewatering	0.753	0.695	0.670	0.498	0.531	0.549
Dry	10	baseline	0.671	0.626	0.601	0.376	0.410	0.436
		dewatering	0.682	0.636	0.611	0.439	0.498	0.520
	100	baseline	0.584	0.524	0.485	0.347	0.385	0.403
		dewatering	0.620	0.564	0.534	0.379	0.477	0.501

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake N11 Outlet Flows: The water balance results for Lake N11 show that during dewatering, monthly mean flows will increase due to pumping to Lake N11. The 2-year flood discharge during dewatering will be approximately equal to the baseline value, and the 100-year flood discharge will increase by approximately 7%. Low flows will also increase by 132% to 167%.

Lake N11 Water Levels: Lake N11 water levels are also expected to increase during dewatering. The 2-year flood level is expected to decrease by approximately 0.002 m, the 100-year flood level by 0.016 m, and monthly mean stages by 0.021 m (June), 0.116 m (July), 0.164 m (August), 0.130 m (September) and 0.023 m (October), under median conditions.

Lake N11 and Outlet Channel/Bank Stability: No effects on Lake N11 and Outlet channel or bank stability are expected during dewatering, because increases in flood magnitude are small relative to the existing flood regime. Additional information on the Lake N11 Outlet follows this summary.

Lake N1 Outlet Flows: The water balance results for Lake N1 show that during dewatering, monthly mean flows will increase due to pumping to Lake N11. The 2-year flood discharge during dewatering will increase by approximately 1% above the baseline value, and the 100-year flood discharge will increase by approximately 3%. Low flows will also increase by 78% to 104%.

Lake N1 Water Levels: Lake N1 water levels are also expected to increase during dewatering. The 2-year flood level is expected to increase by approximately 0.001 m, the 100-year flood level by 0.006 m, and monthly mean stages by 0.008 m (June), 0.058 m (July), 0.084 m (August), 0.072 m (September) and 0.015 m (October), under median conditions.

Lake N1 and Outlet Channel/Bank Stability: No effects on Lake N1 and Outlet channel or bank stability are expected during dewatering, because increases in flood magnitude are small relative to the existing flood regime.

Additional comment on the Lake N11 Outlet channel: The project description indicates that dewatering discharges to Lake N11 will be limited to 500,000 m^3/d and a prior dewatering plan considered this magnitude of discharge. For that reason, a detailed analysis of hydraulic characteristics and erosion potential at the Lake N11 outlet was performed. The current dewatering plan involves dewatering a reduced quantity of water at a lower rate, such that dewatering discharges to Lake N11 will typically be on the order of 300,000 m^3/d and occur after the freshet peak.

Surveys of the Lake N11 outlet channel indicate that it is naturally armoured with boulders and bedrock and any effects of the higher flows to scour of finer sediment fractions from interstitial areas between boulder and cobble substrates would be temporary and limited. A summary of the flow area, velocity and water surface elevation of each cross-section of the Lake N11 outlet channel during dewatering, is provided in Table 9.7-21 for 2, 10 and 100-year flood conditions.

The locations of these cross-sections are shown superimposed on an oblique aerial photo mosaic in Figure 9.7-12.

A conservative estimate of rock size required to resist local, depth-averaged flow velocities, as presented by TAC (2001), indicates that nominal rock diameters of 0.26 m, 0.54 m, 0.94 m and 1.48 m would be required for stability at flow velocities of 3 metres per second (m/s), 4 m/s, 5 m/s and 6 m/s, respectively. The largest mean channel velocities anticipated for the Lake N11 outflow channel are 1.9 m/s (2-year flood) and 2.3 m/s (100-year flood) at cross-section 6. Applying a conservative factor of 1.5 yields local, depth-averaged flow velocities of approximately 3 m/s (2-year flood) and 3.5 m/s (100-year flood). This indicates that boulders of diameter 0.26 m (2-year flood) and 0.40 m (100-year flood) would be stable at this section.

An evaluation of erosion potential at each section of the Lake N11 outlet is provided in Table 9.7-22. Based on this analysis, no erosion due to dewatering is expected in the outlet channel from Lake N11 outlet (i.e., stream N11).

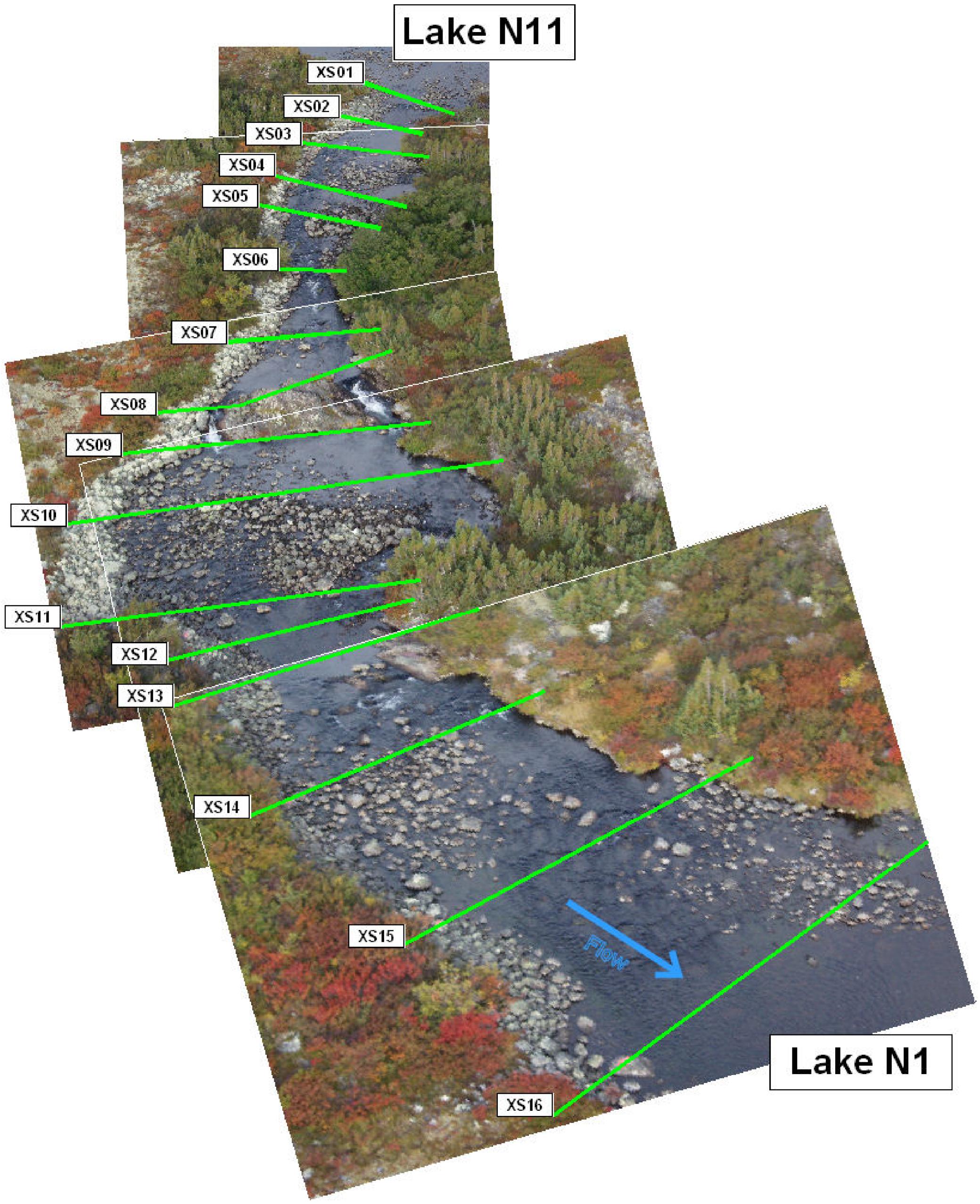
Table 9.7-21 Derived Changes to Discharge, Velocity, Flow Area and Water Surface Elevation at the Lake N11 Outlet during Dewatering

Section	Quantity	2-year Flood Discharge		10-year Flood Discharge		100-year Flood Discharge	
		Baseline	Dewatering	Baseline	Dewatering	Baseline	Dewatering
	Discharge (m^3/s)	**6.00**	**5.92**	**8.22**	**8.27**	**9.77**	**10.5**
XS1	flow area (m^2)	17.87	17.74	21.27	21.34	23.29	24.16
	velocity (m/s)	0.34	0.34	0.39	0.39	0.43	0.44
	max depth (m)	1.02	1.02	1.13	1.14	1.2	1.23
XS2	flow area (m^2)	9.52	9.46	11.30	11.34	12.42	12.9
	velocity (m/s)	0.65	0.64	0.76	0.76	0.82	0.85
	max depth (m)	1.11	1.11	1.22	1.22	1.28	1.31
XS3	flow area (m^2)	3.68	3.64	4.65	4.67	5.25	5.55
	velocity (m/s)	1.67	1.66	1.82	1.82	1.91	1.95
	max depth (m)	0.44	0.44	0.51	0.51	0.55	0.57
XS4	flow area (m^2)	15.52	15.39	18.98	19.06	21.26	22.30
	velocity (m/s)	0.41	0.40	0.46	0.46	0.49	0.50
	max depth (m)	0.92	0.92	1.06	1.06	1.14	1.18
XS5	flow area (m^2)	10.60	10.51	13.03	13.08	14.59	15.29
	velocity (m/s)	0.61	0.61	0.69	0.69	0.74	0.76
	max depth (m)	1.13	1.12	1.25	1.26	1.34	1.37

Table 9.7-21 Derived Changes to Discharge, Velocity, Flow Area and Water Surface Elevation at the Lake N11 Outlet during Dewatering (continued)

Section	Quantity	2-year Flood Discharge		10-year Flood Discharge		100-year Flood Discharge	
		Baseline	Dewatering	Baseline	Dewatering	Baseline	Dewatering
	Discharge (m^3/s)	**6.00**	**5.92**	**8.22**	**8.27**	**9.77**	**10.5**
XS6	flow area (m^2)	3.14	3.1	3.88	3.89	4.35	4.57
	velocity (m/s)	1.91	1.91	2.12	2.12	2.24	2.30
	max depth (m)	0.94	0.94	1.03	1.03	1.08	1.11
XS7	flow area (m^2)	6.68	6.67	8.44	8.47	9.31	9.67
	velocity (m/s)	0.95	0.94	1.03	1.04	1.12	1.16
	max depth (m)	0.93	0.93	1.05	1.05	1.10	1.12
XS8	flow area (m^2)	3.26	3.09	4.52	4.54	5.39	5.68
	velocity (m/s)	1.84	1.91	1.82	1.82	1.81	1.85
	max depth (m)	0.71	0.69	0.82	0.82	0.88	0.90
XS9	flow area (m^2)	8.46	8.42	9.70	9.73	10.54	10.92
	velocity (m/s)	0.71	0.70	0.85	0.85	0.93	0.96
	max depth (m)	0.87	0.87	0.94	0.95	0.99	1.01
XS10	flow area (m^2)	4.73	4.68	5.85	5.88	6.41	6.74
	velocity (m/s)	1.27	1.26	1.40	1.41	1.53	1.56
	max depth (m)	0.46	0.46	0.50	0.50	0.52	0.53
XS11	flow area (m^2)	7.40	7.33	9.38	9.42	10.62	11.17
	velocity (m/s)	0.81	0.81	0.88	0.88	0.92	0.94
	max depth (m)	0.79	0.79	0.89	0.90	0.96	0.98
XS12	flow area (m^2)	7.15	7.1	8.42	8.44	9.21	9.56
	velocity (m/s)	0.84	0.83	0.98	0.98	1.07	1.11
	max depth (m)	0.91	0.91	1.00	1.01	1.06	1.09
XS13	flow area (m^2)	3.94	3.90	4.94	4.96	5.65	6.00
	velocity (m/s)	1.53	1.53	1.69	1.69	1.76	1.78
	max depth (m)	0.60	0.60	0.67	0.67	0.72	0.75
XS14	flow area (m^2)	6.11	6.06	7.32	7.35	8.14	8.56
	velocity (m/s)	0.98	0.98	1.13	1.13	1.21	1.23
	max depth (m)	0.80	0.80	0.87	0.87	0.92	0.94
XS15	flow area (m^2)	3.89	3.85	4.84	4.87	5.48	5.75
	velocity (m/s)	1.54	1.54	1.70	1.70	1.78	1.82
	max depth (m)	0.50	0.50	0.55	0.56	0.59	0.61
XS16	flow area (m^2)	12.47	12.42	12.96	12.98	13.31	13.48
	velocity (m/s)	0.48	0.48	0.63	0.64	0.73	0.78
	max depth (m)	0.87	0.87	0.89	0.89	0.91	0.92

m/s = metres per second; m^3/s = cubic metres per second; m^2 = square metres; m = metres.



GAHCHO KUÉ PROJECT

Aerial Photo Mosaic of the Lake N11 Outlet Channel to Lake N1 Showing the Cross-Section Survey Transects Used to Describe the Channel Morphology

PROJECTION: N/A	DATUM: N/A	DE BEERS CANADA
Scale: N/A		
FILE No: E-Hydro-011-GIS		DATE: December 17, 2010
JOB NO: 09-1365-1004	REVISION NO: 0	**Figure 9.7-12**
OFFICE: GOLD-CAL	DRAWN: SK	CHECK: JF

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Table 9.7-22 Evaluation of Erosion Potential in the Lake N11 Outlet Channel during Dewatering

Section	Quantity	2-year Discharge		10-year Discharge		100-year Discharge	
		Natural	Dewatering	Natural	Dewatering	Natural	Dewatering
	Discharge (m^3/s)	6.00	5.92	8.22	8.27	9.77	10.5
XS1	velocity (m/s)	0.34	0.34	0.39	0.39	0.43	0.44
	materials	boulders with vegetation in low velocity areas of sediment deposition					
	evaluation	transition zone from Lake N11 with low velocities, low erosion potential					
XS2	velocity (m/s)	0.65	0.64	0.76	0.76	0.82	0.85
	materials	boulders embedded in LDB high bank, large boulders at RDB					
	evaluation	low velocities, low erosion potential					
XS3	velocity (m/s)	1.67	1.66	1.82	1.82	1.91	1.95
	materials	boulders embedded in LDB bank, large boulders at RDB					
	evaluation	lake outlet sill; mean flow velocity increased by up to 20%, boulder armour adequate					
XS4	velocity (m/s)	0.41	0.40	0.46	0.46	0.49	0.50
	materials	boulders embedded in LDB bank, large boulders at RDB					
	evaluation	low velocities because channel increases in width, low erosion potential					
XS5	velocity (m/s)	0.61	0.61	0.69	0.69	0.74	0.76
	materials	large boulders at LDB and RDB					
	evaluation	low velocities, low erosion potential					
XS6	velocity (m/s)	1.91	1.91	2.12	2.12	2.24	2.30
	materials	natural rock boulders, D_{50} approximately 600 mm					
	evaluation	constriction causes highest velocities, but still well below stability threshold					
XS7	velocity (m/s)	0.95	0.94	1.03	1.04	1.12	1.16
	materials	large boulders at LDB and RDB					
	evaluation	low velocities, low erosion potential					
XS8	velocity (m/s)	1.84	1.91	1.82	1.82	1.81	1.85
	materials	bedrock control in bed and banks					
	evaluation	this section is resistant to erosion, and insensitive to increase in velocity and discharge					
XS9	velocity (m/s)	0.71	0.70	0.85	0.85	0.93	0.96
	materials	bedrock at LDB, large boulders at RDB					
	evaluation	immediately below bedrock control. Low erosion potential					
XS10	velocity (m/s)	1.27	1.26	1.40	1.41	1.53	1.56
	materials	bedrock in LDB, large boulders at RDB					
	evaluation	this section is insensitive to increase in velocity and discharge					

Table 9.7-22 Evaluation of Erosion Potential in the Lake N11 Outlet Channel during Dewatering (continued)

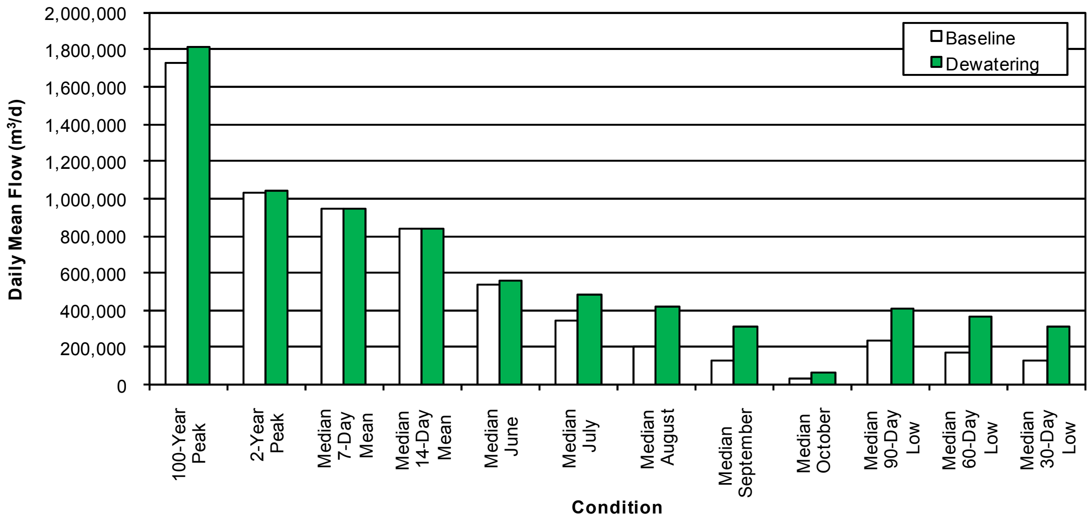
Section	Quantity	2-year Discharge		10-year Discharge		100-year Discharge	
		Natural	Dewatering	Natural	Dewatering	Natural	Dewatering
	Discharge (m^3/s)	6.00	5.92	8.22	8.27	9.77	10.5
XS11	velocity (m/s)	0.81	0.81	0.88	0.88	0.92	0.94
	materials	bedrock in LDB, large boulders at RDB					
	evaluation	this section is insensitive to increase in velocity and discharge					
XS12	velocity (m/s)	0.84	0.83	0.98	0.98	1.07	1.11
	materials	bedrock in LDB, large boulders at RDB					
	evaluation	this section is insensitive to increase in velocity and discharge					
XS13	velocity (m/s)	1.53	1.53	1.69	1.69	1.76	1.78
	materials	bedrock at LDB, large boulders at RDB					
	evaluation	constriction causes relatively high velocities, but still well below stability threshold					
XS14	velocity (m/s)	0.98	0.98	1.13	1.13	1.21	1.23
	materials	boulders embedded in bank on LDB, large boulders at RDB					
	evaluation	this section is insensitive to increase in velocity and discharge					
XS15	velocity (m/s)	1.54	1.54	1.70	1.70	1.78	1.82
	materials	large boulders at LDB and RDB					
	evaluation	this section is insensitive to increase in velocity and discharge					
XS16	velocity (m/s)	0.48	0.48	0.63	0.64	0.73	0.78
	materials	large boulders at LDB and RDB					
	evaluation	transition zone to Lake N1 with low velocities, low erosion potential					

m^3/s =cubic metres per second; m/s = metres per second; RDB – right descending bank; LDB – left descending bank.

Lake 410 to Kirk Lake Outlet

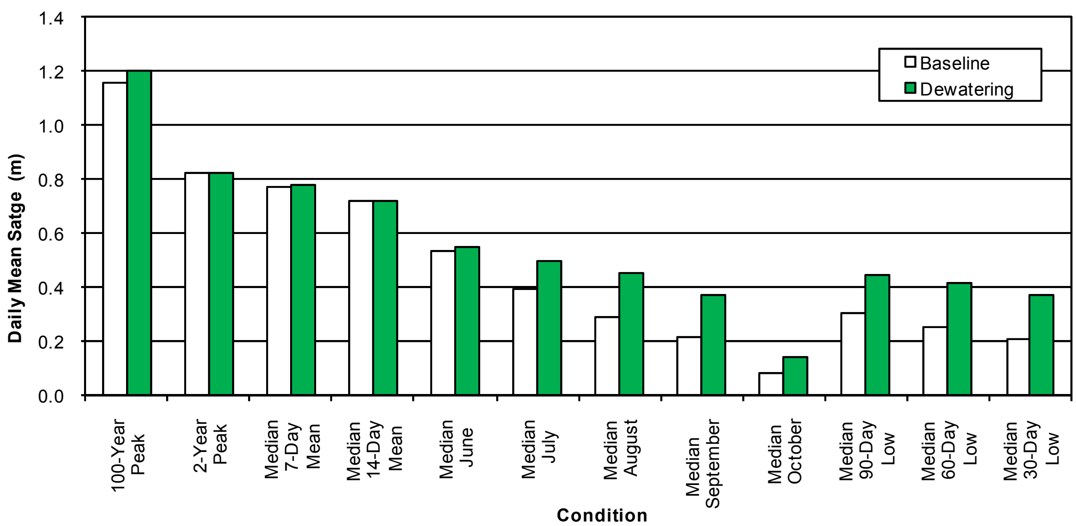
Lake N1 and Lake M1 flow into Lake 410, which then drains through watershed P through to Kirk Lake. The water balance model for the Project examined all downstream waterbodies between Lake 410 and Kirk Lake. Project effects on Lake 410 during dewatering are summarized in Figures 9.7-13 to 9.7-14 and Tables 9.7-23 to 9.7-26. Project effects on Kirk Lake during dewatering are summarized in Figures 9.7-15 to 9.7-16 and Tables 9.7-27 to 9.7-30.

Figure 9.7-13 Comparison of Effects on Lake 410 Outlet Discharges – Dewatering



m^3/d = cubic metres per day.

Figure 9.7-14 Comparison of Effects on Lake 410 Stages – Dewatering



m = metres.

Table 9.7-23 Monthly Mean Discharges at the Lake 410 Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	934,000	678,000	475,000	587,000	135,000
		dewatering	929,000	732,000	640,000	656,000	178,000
	10	baseline	759,000	514,000	329,000	278,000	70,700
		dewatering	762,000	603,000	518,000	460,000	114,000
Median	2	baseline	537,000	344,000	210,000	135,000	32,700
		dewatering	564,000	482,000	423,000	308,000	69,900
Dry	10	baseline	329,000	203,000	132,000	73,900	16,000
		dewatering	374,000	392,000	365,000	217,000	46,400
	100	baseline	190,000	106,000	90,100	49,800	9,660
		dewatering	225,000	337,000	336,000	170,000	35,700

m^3/d = cubic metres per day.

Table 9.7-24 Derived Representative Discharges at the Lake 410 Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	20.00	1,420,000	1,240,000	404,000	443,000	491,000
		dewatering	21.00	1,480,000	1,290,000	546,000	601,000	630,000
	10	baseline	16.50	1,230,000	1,080,000	237,000	287,000	355,000
		dewatering	16.70	1,240,000	1,090,000	426,000	472,000	513,000
Median	2	baseline	11.90	942,000	837,000	128,000	173,000	234,000
		dewatering	12.00	949,000	843,000	309,000	366,000	409,000
Dry	10	baseline	7.11	580,000	523,000	74,200	108,000	150,000
		dewatering	8.08	652,000	588,000	220,000	298,000	338,000
	100	baseline	3.03	219,000	200,000	50,900	77,500	100,000
		dewatering	5.27	407,000	375,000	162,000	260,000	296,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-25 Monthly Mean Stages at Lake 410 – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.769	0.621	0.490	0.564	0.212
		dewatering	0.766	0.653	0.597	0.607	0.255
	10	baseline	0.669	0.516	0.383	0.343	0.138
		dewatering	0.671	0.574	0.519	0.479	0.189
Median	2	baseline	0.531	0.395	0.284	0.212	0.082
		dewatering	0.549	0.495	0.453	0.367	0.136
Dry	10	baseline	0.383	0.278	0.209	0.142	0.051
		dewatering	0.418	0.431	0.411	0.290	0.104
	100	baseline	0.266	0.180	0.162	0.109	0.036
		dewatering	0.298	0.390	0.389	0.247	0.087

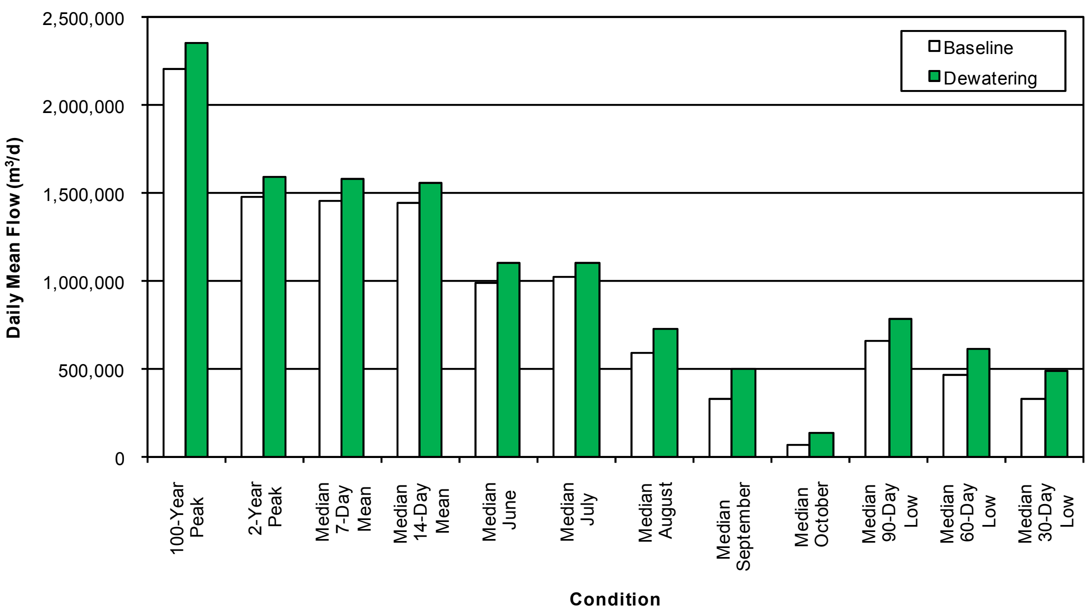
m =metre.

Table 9.7-26 Derived Representative Stages at Lake 410 – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.158	1.016	0.928	0.440	0.467	0.501
		dewatering	1.197	1.045	0.953	0.537	0.573	0.591
	10	baseline	1.019	0.923	0.847	0.308	0.350	0.403
		dewatering	1.027	0.928	0.852	0.455	0.488	0.515
Median	2	baseline	0.819	0.773	0.714	0.204	0.250	0.305
		dewatering	0.824	0.777	0.718	0.368	0.412	0.443
Dry	10	baseline	0.581	0.559	0.522	0.142	0.182	0.227
		dewatering	0.633	0.605	0.565	0.293	0.359	0.390
	100	baseline	0.329	0.292	0.275	0.110	0.146	0.173
		dewatering	0.476	0.442	0.418	0.239	0.328	0.357

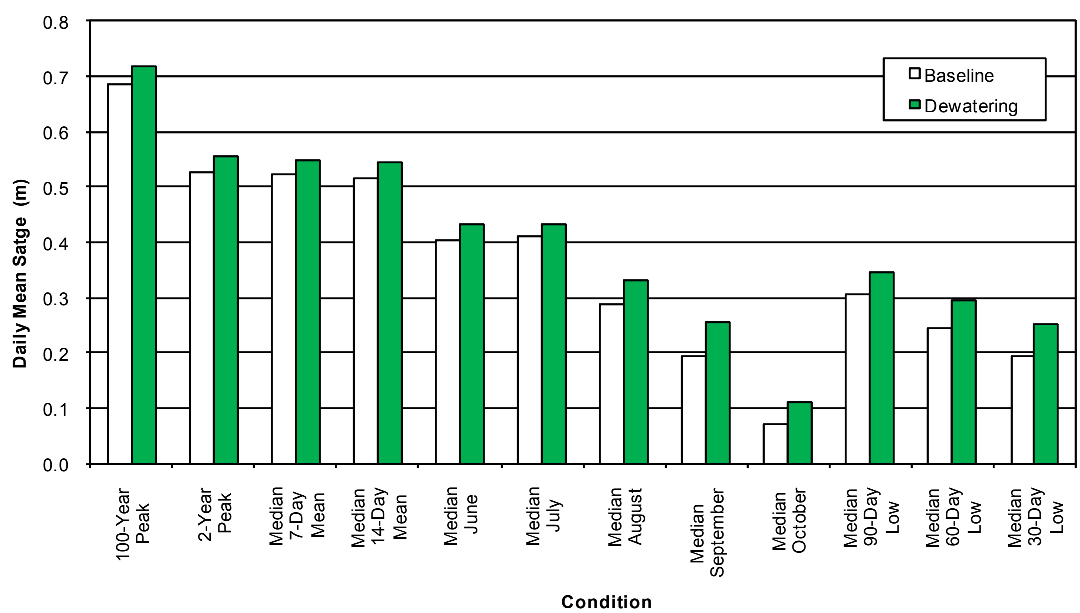
m =metre.

Figure 9.7-15 Comparison of Effects on Kirk Lake Outlet Discharges – Dewatering



m^3/d = cubic metres per day.

Figure 9.7-16 Comparison of Effects on Kirk Lake Stages – Dewatering



m = metres.

Table 9.7-27 Monthly Mean Discharges at the Kirk Lake Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	1,850,000	1,730,000	1,250,000	1,370,000	420,000
		dewatering	1,960,000	1,830,000	1,360,000	1,410,000	454,000
	10	baseline	1,450,000	1,420,000	916,000	676,000	188,000
		dewatering	1,570,000	1,500,000	1,040,000	860,000	266,000
Median	2	baseline	995,000	1,020,000	596,000	332,000	75,700
		dewatering	1,110,000	1,100,000	734,000	500,000	142,000
Dry	10	baseline	562,000	607,000	349,000	161,000	24,500
		dewatering	681,000	710,000	508,000	321,000	79,600
	100	baseline	226,000	255,000	191,000	85,200	4,760
		dewatering	345,000	391,000	366,000	244,000	52,600

m^3/d = cubic metres per day.

Table 9.7-28 Derived Representative Discharges at the Kirk Lake Outlet – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	25.50	2,160,000	2,100,000	1,050,000	1,140,000	1,290,000
		dewatering	27.30	2,360,000	2,260,000	1,200,000	1,260,000	1,410,000
	10	baseline	22.10	1,890,000	1,850,000	636,000	774,000	981,000
		dewatering	23.70	2,030,000	1,980,000	795,000	916,000	1,100,000
Median	2	baseline	17.10	1,460,000	1,440,000	333,000	467,000	660,000
		dewatering	18.50	1,580,000	1,560,000	494,000	619,000	789,000
Dry	10	baseline	10.60	902,000	884,000	163,000	262,000	395,000
		dewatering	12.30	1,060,000	1,030,000	323,000	422,000	540,000
	100	baseline	3.98	321,000	290,000	82,100	148,000	213,000
		dewatering	6.28	576,000	497,000	239,000	311,000	374,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-29 Monthly Mean Stages at Kirk Lake – Dewatering

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.610	0.584	0.470	0.500	0.227
		dewatering	0.634	0.606	0.497	0.509	0.239
	10	baseline	0.519	0.512	0.382	0.312	0.133
		dewatering	0.547	0.531	0.416	0.366	0.168
Median	2	baseline	0.404	0.410	0.287	0.194	0.072
		dewatering	0.434	0.432	0.330	0.255	0.110
Dry	10	baseline	0.276	0.290	0.201	0.120	0.034
		dewatering	0.314	0.322	0.258	0.190	0.075
	100	baseline	0.150	0.163	0.134	0.078	0.011
		dewatering	0.199	0.217	0.207	0.158	0.057

m = metre.

Table 9.7-30 Derived Representative Stages at Kirk Lake – Dewatering

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.686	0.677	0.664	0.418	0.442	0.480
		dewatering	0.718	0.718	0.698	0.457	0.473	0.509
	10	baseline	0.623	0.619	0.610	0.300	0.342	0.400
		dewatering	0.653	0.649	0.639	0.348	0.382	0.432
Median	2	baseline	0.525	0.521	0.517	0.195	0.244	0.307
		dewatering	0.554	0.550	0.545	0.253	0.294	0.346
Dry	10	baseline	0.382	0.378	0.373	0.121	0.166	0.218
		dewatering	0.422	0.421	0.413	0.191	0.228	0.269
	100	baseline	0.199	0.190	0.177	0.077	0.113	0.144
		dewatering	0.269	0.280	0.254	0.156	0.186	0.210

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake 410 Outlet Flows: The water balance results for Lake 410 show that during dewatering, monthly mean flows will increase due to pumping to Lake N11 and Kennady Lake Area 8. The 2-year flood discharge during dewatering will increase by approximately 1% above the baseline value, and the 100-year flood discharge will increase by approximately 5%. Low flows will also increase by 75% to 141%.

Lake 410 Water Levels: Lake 410 water levels are also expected to increase during dewatering. The 2-year flood level is expected to increase by approximately 0.005 m, the 100-year flood level by 0.039 m, and monthly mean stages by 0.018 m (June), 0.100 m (July), 0.169 m (August), 0.155 m (September) and 0.054 m (October), under median conditions.

Lake 410 and Outlet Channel/Bank Stability: No effects on Lake 410 and Outlet channel or bank stability are expected during dewatering, because increases in flood magnitude are small relative to the existing flood regime.

Kirk Lake Outlet Flows: The water balance results for Kirk Lake show that during dewatering, monthly mean flows will increase due to pumping to Lake N11 and Kennady Lake Area 8. The 2-year flood discharge during dewatering will increase by approximately 8% above the baseline value, and the 100-year flood discharge will increase by approximately 7%. This apparent inconsistency with flow increases with Lake 410 is because the Kirk Lake natural flood peak typically occurs in July, later than upstream lakes which tend to peak in June. Therefore, while dewatering discharges to Lake N11 occur after the Lake N11 outlet flood peak and only cause slight increases in the flood peaks at the Lake N1 and Lake 410 outlets, the sustained post-peak flows cause an incremental increase in flood discharge at the later-peaking Kirk Lake outlet. Low flows will also increase by 20% to 48%.

Kirk Lake Water Levels: Kirk Lake water levels are also expected to increase during dewatering. The 2-year flood level is expected to increase by approximately 0.029 m, the 100-year flood level by 0.032 m, and monthly mean stages by 0.030 m (June), 0.022 m (July), 0.043 m (August), 0.061 m (September) and 0.038 m (October), under median conditions.

Kirk Lake and Outlet Channel/Bank Stability: No effects on Kirk Lake and Outlet channel or bank stability are expected during dewatering, because increases in flood magnitude are small relative to the existing flood regime.

9.7.3.2 Effect of Diversion in Watersheds A, B, D, and E to Flows, Water Levels and Channel/Bank Stability in Streams and Lakes in the N lakes Watershed

9.7.3.2.1 Project Activities

To reduce the amount of runoff into the dewatered Kennady Lake Areas 2 to 7, and the amount of water that must be managed by the mine water management system, four tributary watersheds will be diverted to the adjacent N watershed during operations. These diversions will remain in place until the start of

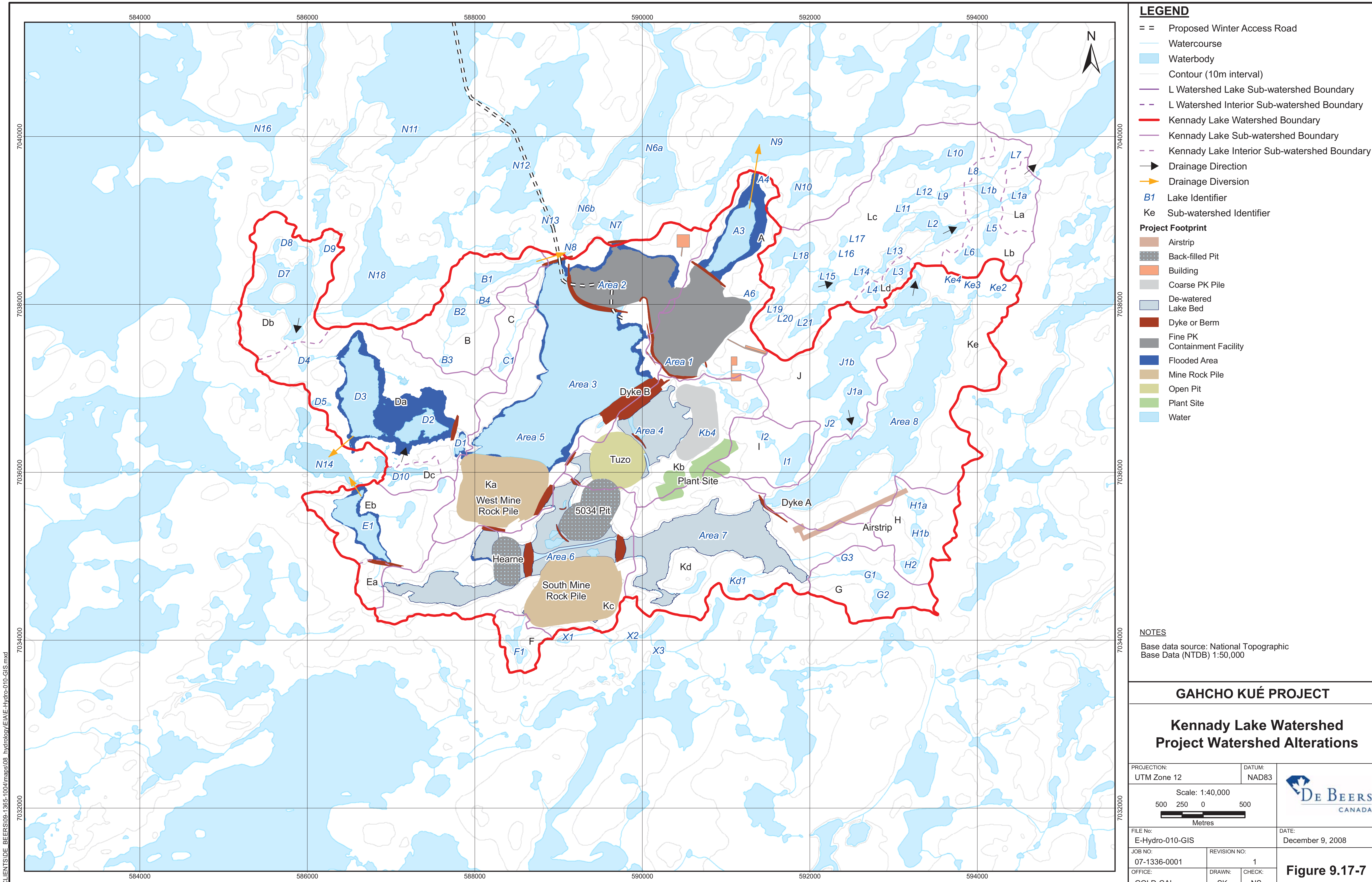
Kennady Lake refilling. The location and layout of these diversions are shown in Figure 9.7-17.

The A watershed above the Lake A3 outlet will be diverted to Lake N9 by constructing a diversion dyke (Dyke C) at the Lake A3 outlet and constructing a diversion channel or pipeline to Lake N9. The ultimate water level of the diverted lake will also inundate Lake A4. This will be a permanent diversion.

The B watershed above the Lake B1 outlet will be diverted to Lake N13 by constructing a diversion dyke (Dyke E) at the Lake B1 outlet and constructing a diversion channel or pipeline from Lake B1 to Lake N13. The dyke will be breached in Year 11 to restore drainage from the B watershed to Kennady Lake.

The D watershed above the Lake D2 outlet will be diverted to Lake N14 by constructing a diversion dyke (Dyke F) at the Lake D2 outlet and constructing a diversion channel or pipeline to Lake N14. The ultimate water level of the diverted lake will also inundate Lake D3. This will be a temporary diversion that is removed during mine closure.

The E watershed above the Lake E1 outlet will be diverted to Lake N14 by constructing a diversion dyke (Dyke G) at the Lake E1 outlet and constructing a diversion channel or pipeline to Lake N14. This will be a temporary diversion that is removed during mine closure.



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9.7.3.2.2 Environmental Design Features

Diversion of the A, B, D and E watersheds into the N watershed will reduce the amount of runoff from undisturbed areas that must be managed by the mine water system. At diversion outlets, a channel or pipeline will be constructed to convey flows. A diversion outlet structure will be designed to approximate the natural hydrograph to the extent possible during operations, to manage the water level regime of the diverted lake. Diversion channels or pipeline foundations will be designed and constructed to prevent erosion and sedimentation and to incorporate lessons learned at the Ekati Diamond Mine (Jones et al. 2003a; see also Sections 9.6.1.1 and 9.10.3.7).

9.7.3.2.3 Effects Analysis

Effects of the Project activities on Kennady Lake tributary A, B, D and E watersheds were described in EIS Section 8.7. Diverted water from the A watershed will be conveyed to Lake N9, and from there will be combined with natural flow to Lake N6, N5, N4, N3 and N2 before reaching Lake N11. Diverted water from the B watershed will be conveyed to Lake N8, and from there will be combined with natural flow to Lake N6, N5, N4, N3 and N2 before reaching Lake N11. Diverted water from the D and E watersheds will be conveyed to Lake N14, and from there will be combined with natural flow to Lake N17, N16 and N15 before reaching Lake N11.

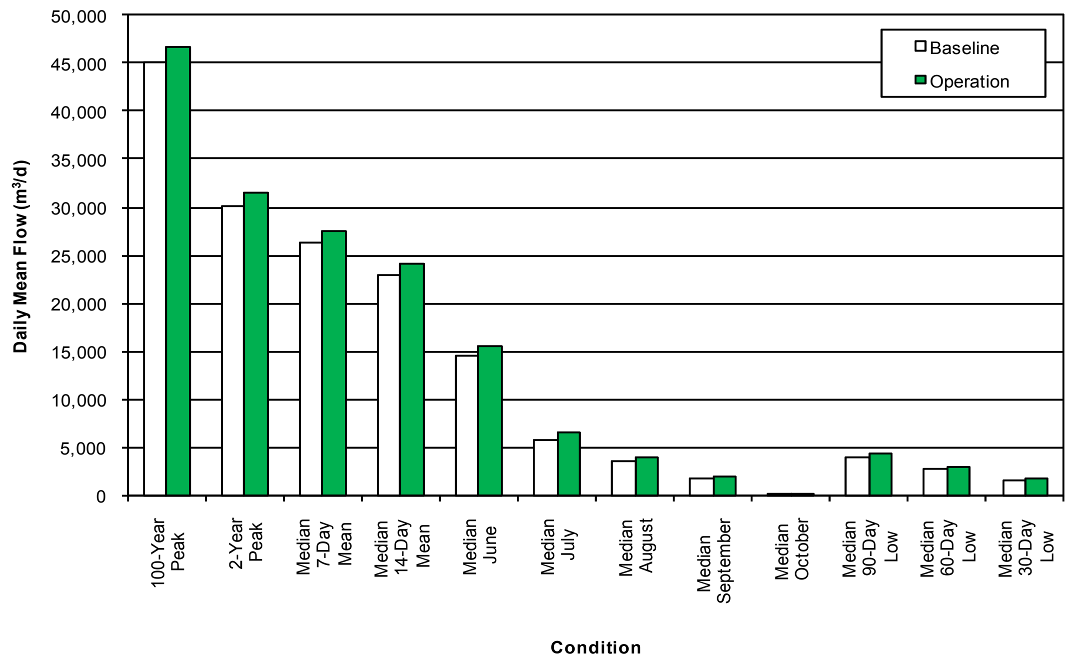
Effects of the Project on Lake N11 and Lake N1 due to the combined diversions are presented in this section. Downstream effects from Lake 410 to Kirk Lake were included in the assessment presented in Section 9.7.3.1.

Lake N8 and Lake N9 to Lake N1 Inflow (A Watershed and B Diversions)

The water balance model for the Project examined this receiving watershed by modeling the flow diverted from the A watershed into Lake N9, a tributary of Lake N6. Lake N8 was not modeled due to its small size and low storage/flow attenuation capacity, but was lumped, along with Lake N6b, as part of the entire Lake N6 watershed. Below Lake N6, Lake N5, Lake N3 (including Lake N4, lumped for the same reasons) and Lake N2 were modelled.

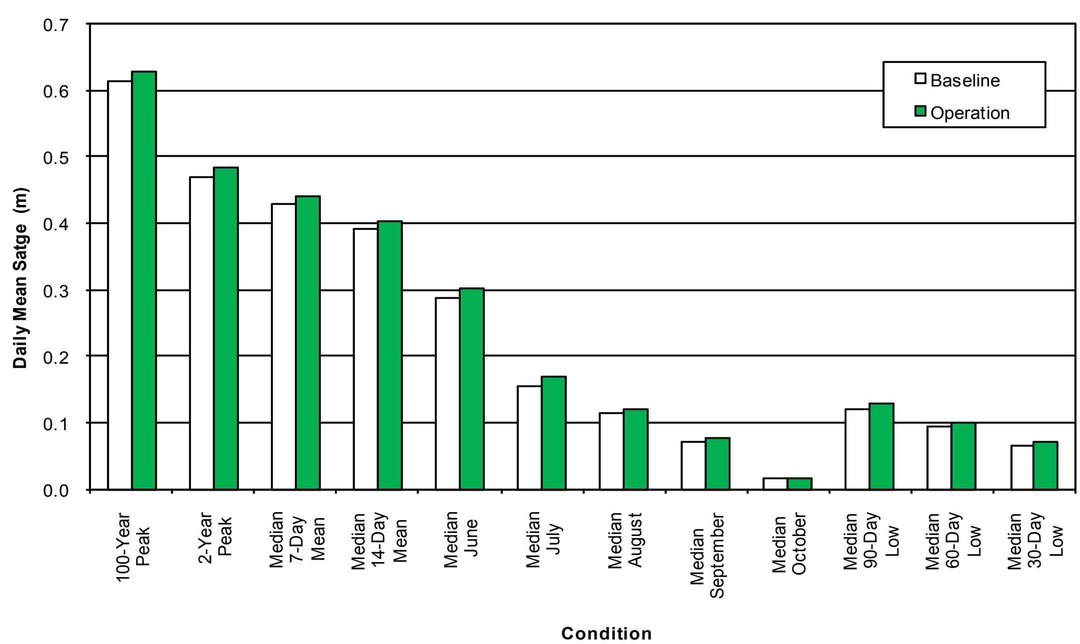
Project effects on Lake N9, which receives the A watershed diversion, are presented in Figures 9.7-18 to 9.7-19 and Tables 9.7-31 to 9.7-34, Project effects on Lake N6, where the two diversions meet, are presented in Figures 9.7-20 to 9.7-21 and Tables 9.7-35 to 9.7-38, and Project effects on Lake N2, upstream of its confluence with Lake N1, are presented in Figures 9.7-22 to 9.7-23 and Tables 9.7-39 to 9.7-42.

Figure 9.7-18 Comparison of Effects on Lake N9 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-19 Comparison of Effects on Lake N9 Stages – Operation



m = metres.

Table 9.7-31 Monthly Mean Discharges at the Lake N9 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	22,600	13,900	10,700	12,000	1,340
		operation	24,800	15,800	12,300	13,500	1,570
	10	baseline	19,300	9,540	6,580	5,280	677
		operation	20,900	11,000	7,390	5,800	767
Median	2	baseline	14,500	5,670	3,580	1,810	195
		operation	15,500	6,580	3,970	1,970	215
Dry	10	baseline	8,690	2,960	1,920	507	0
		operation	9,260	3,420	2,150	570	0
	100	baseline	3,010	1,370	1,120	73	0
		operation	3,390	1,510	1,310	118	0

m^3/d = cubic metres per day.

Table 9.7-32 Derived Representative Discharges at the Lake N9 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	0.52	38,100	32,300	7,810	9,920	9,650
		operation	0.54	40,300	34,600	8,980	11,300	11,000
	10	baseline	0.45	33,400	28,800	3,980	5,390	6,440
		operation	0.47	35,300	30,600	4,490	6,050	7,340
Median	2	baseline	0.35	26,300	22,900	1,610	2,670	3,860
		operation	0.36	27,500	24,100	1,800	2,950	4,360
Dry	10	baseline	0.23	17,100	14,800	506	1,440	2,230
		operation	0.23	17,700	15,300	576	1,590	2,490
	100	baseline	0.11	7,830	5,810	58	951	1,370
		operation	0.10	7,590	5,860	97	1,060	1,500

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-33 Monthly Mean Stages at Lake N9 – Operation

Conditions	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.387	0.280	0.235	0.254	0.059
		operation	0.412	0.305	0.258	0.275	0.065
	10	baseline	0.348	0.218	0.170	0.147	0.037
		operation	0.367	0.240	0.184	0.156	0.041
Median	2	baseline	0.288	0.154	0.113	0.072	0.016
		operation	0.301	0.170	0.121	0.076	0.017
Dry	10	baseline	0.205	0.100	0.075	0.031	-
		operation	0.214	0.110	0.081	0.033	-
	100	baseline	0.101	0.060	0.052	0.008	-
		operation	0.109	0.064	0.058	0.012	-

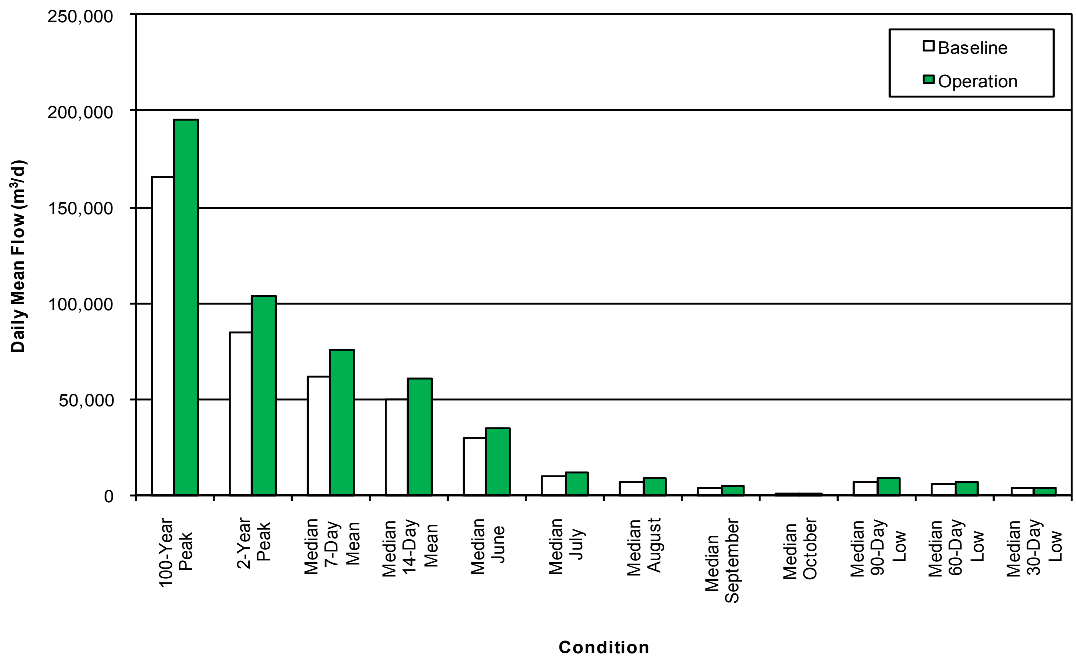
m = metre.

Table 9.7-34 Derived Representative Stages at Lake N9 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.613	0.548	0.491	0.191	0.224	0.220
		operation	0.628	0.569	0.514	0.209	0.244	0.240
	10	baseline	0.557	0.502	0.455	0.122	0.149	0.168
		operation	0.572	0.521	0.474	0.132	0.161	0.183
Median	2	baseline	0.469	0.428	0.391	0.067	0.093	0.119
		operation	0.483	0.441	0.404	0.072	0.100	0.129
Dry	10	baseline	0.352	0.321	0.292	0.031	0.062	0.083
		operation	0.358	0.329	0.298	0.034	0.066	0.089
	100	baseline	0.217	0.191	0.157	0.007	0.047	0.060
		operation	0.207	0.187	0.157	0.010	0.050	0.063

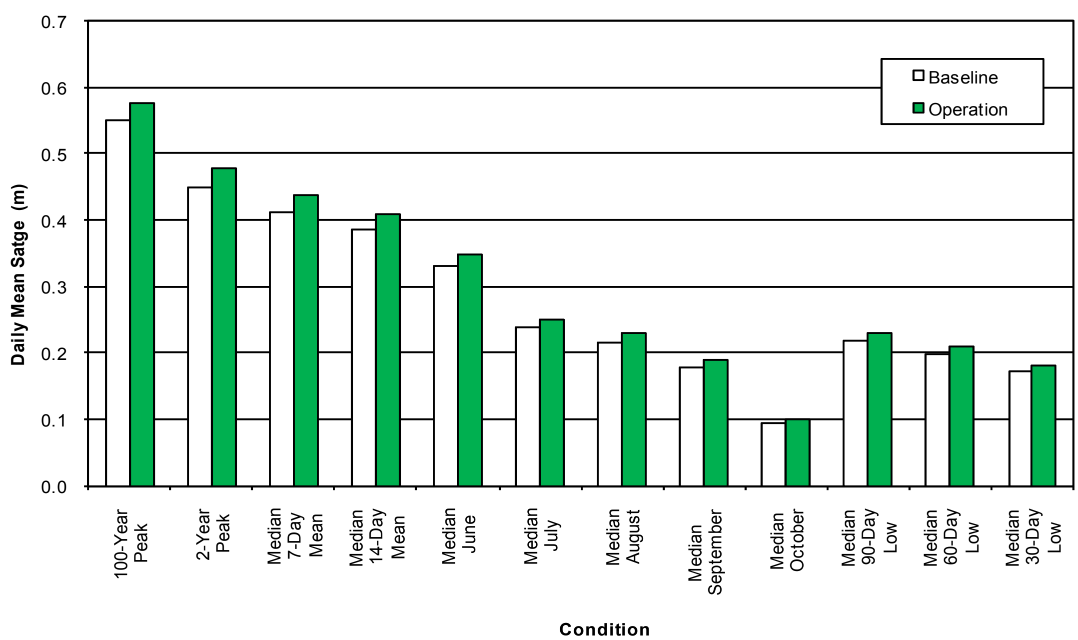
m = metre.

Figure 9.7-20 Comparison of Effects on Lake N6 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-21 Comparison of Effects on Lake N6 Stages – Operation



m = metres.

Table 9.7-35 Monthly Mean Discharges at the Lake N6 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	44,300	25,100	22,200	22,200	3,600
		operation	53,000	29,900	27,100	26,500	4,220
	10	baseline	38,800	16,700	13,100	9,900	1,430
		operation	46,500	20,000	16,000	11,900	1,670
Median	2	baseline	29,400	9,740	6,980	3,650	431
		operation	35,100	11,600	8,530	4,390	505
Dry	10	baseline	15,800	5,140	3,860	1,330	102
		operation	18,300	6,020	4,740	1,580	121
	100	baseline	329	2,590	2,500	576	5
		operation	0	2,910	3,080	656	9

m^3/d = cubic metres per day.

Table 9.7-36 Derived Representative Discharges at the Lake N6 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	1.91	91,800	70,600	13,400	19,300	18,200
		operation	2.26	113,000	86,000	15,900	23,200	22,000
	10	baseline	1.44	79,600	63,000	7,180	10,400	11,900
		operation	1.74	97,400	76,600	8,550	12,500	14,400
Median	2	baseline	0.98	61,800	50,000	3,220	5,240	7,140
		operation	1.20	75,700	60,800	3,860	6,380	8,570
Dry	10	baseline	0.60	40,400	31,500	1,330	3,040	4,290
		operation	0.75	50,300	38,500	1,580	3,730	5,170
	100	baseline	0.35	19,700	10,500	547	2,220	2,840
		operation	0.44	26,300	13,500	622	2,740	3,470

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-37 Monthly Mean Stages at Lake N6 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.373	0.315	0.304	0.304	0.178
		operation	0.393	0.332	0.322	0.320	0.186
	10	baseline	0.358	0.279	0.260	0.239	0.135
		operation	0.378	0.295	0.276	0.253	0.142
Median	2	baseline	0.330	0.238	0.216	0.178	0.095
		operation	0.348	0.251	0.229	0.188	0.100
Dry	10	baseline	0.275	0.197	0.181	0.132	0.062
		operation	0.287	0.207	0.193	0.139	0.065
	100	baseline	0.088	0.161	0.160	0.103	0.025
		operation	-	0.167	0.170	0.108	0.030

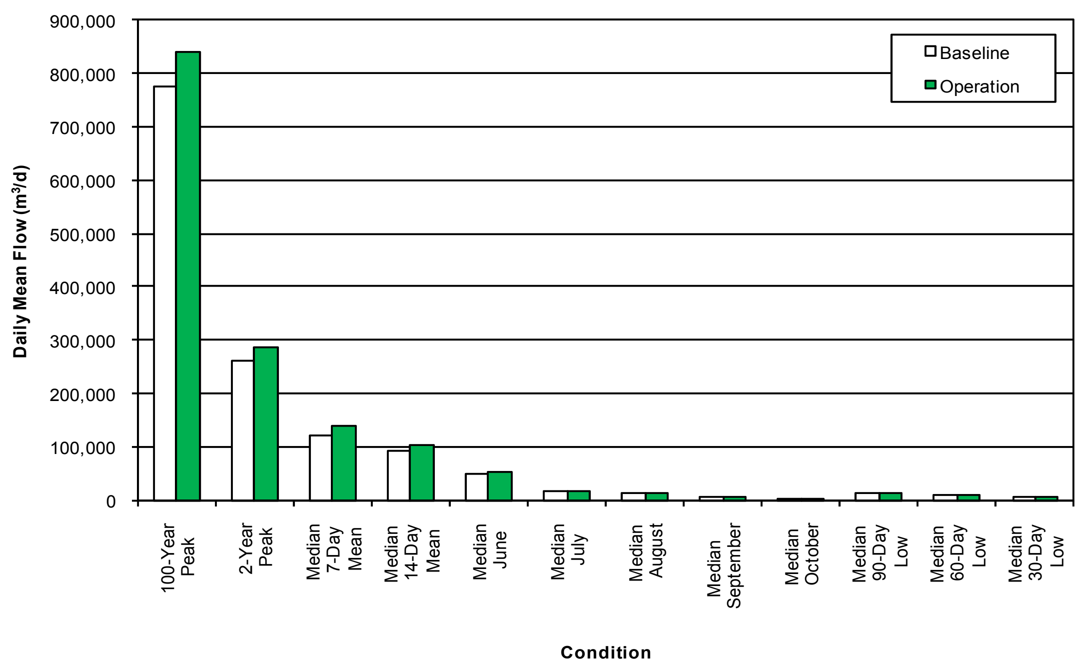
m = metre.

Table 9.7-38 Derived Representative Stages at Lake N6 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.549	0.462	0.427	0.262	0.292	0.287
		operation	0.577	0.491	0.453	0.275	0.308	0.303
	10	baseline	0.505	0.443	0.413	0.218	0.243	0.253
		operation	0.534	0.470	0.438	0.229	0.256	0.267
Median	2	baseline	0.450	0.411	0.386	0.172	0.198	0.217
		operation	0.479	0.436	0.409	0.181	0.210	0.229
Dry	10	baseline	0.391	0.363	0.337	0.132	0.169	0.187
		operation	0.417	0.387	0.357	0.139	0.180	0.198
	100	baseline	0.334	0.293	0.244	0.102	0.154	0.166
		operation	0.355	0.319	0.262	0.106	0.164	0.176

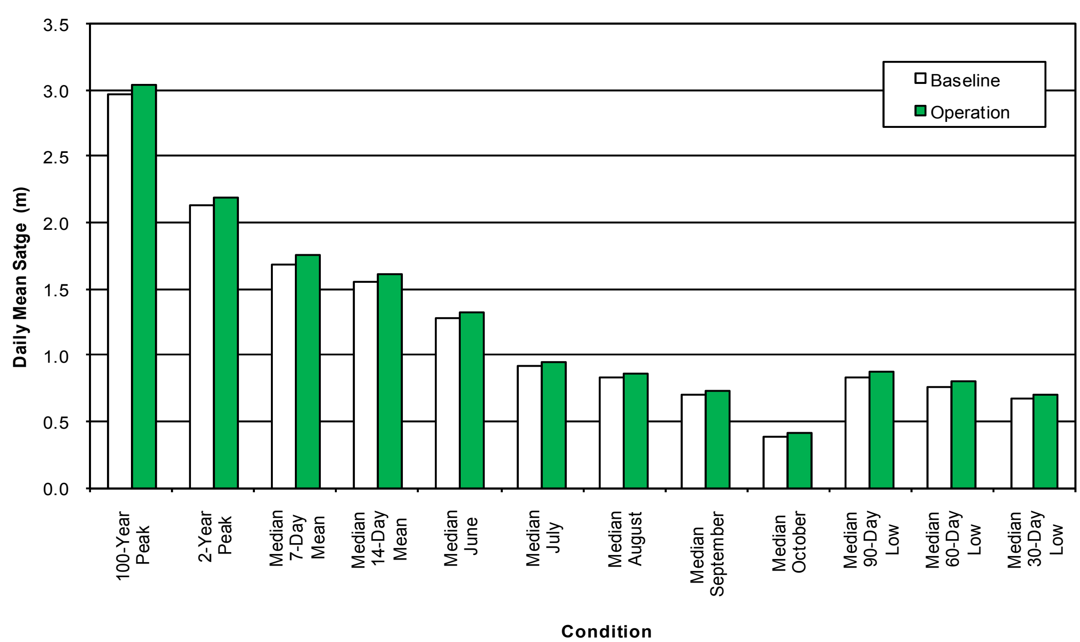
m = metre.

Figure 9.7-22 Comparison of Effects on Lake N2 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-23 Comparison of Effects on Lake N2 Stages – Operation



m = metres.

Table 9.7-39 Monthly Mean Discharges at the Lake N2 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	74,000	40,000	33,500	36,300	6,640
		operation	82,800	44,500	38,100	41,000	7,360
	10	baseline	63,800	27,200	20,700	17,000	2,840
		operation	71,500	30,400	23,600	19,300	3,230
Median	2	baseline	47,900	16,200	11,600	6,710	964
		operation	53,700	18,100	13,300	7,710	1,120
Dry	10	baseline	27,100	8,800	6,590	2,710	282
		operation	30,200	9,790	7,550	3,160	332
	100	baseline	5,550	4,580	4,230	1,330	63
		operation	5,630	4,990	4,850	1,580	70

m^3/d = cubic metres per day.

Table 9.7-40 Derived Representative Discharges at the Lake N2 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	8.96	159,000	123,000	22,300	30,700	29,400
		operation	9.74	180,000	138,000	25,300	34,500	33,300
	10	baseline	5.62	146,000	112,000	12,400	17,100	19,700
		operation	6.13	165,000	126,000	14,000	19,400	22,200
Median	2	baseline	3.03	121,000	91,700	5,890	8,960	12,000
		operation	3.33	138,000	103,000	6,720	10,300	13,600
Dry	10	baseline	1.49	81,300	60,200	2,680	5,350	7,360
		operation	1.65	92,800	68,000	3,110	6,160	8,350
	100	baseline	0.70	30,400	21,800	1,310	3,950	4,960
		operation	0.78	35,200	25,500	1,570	4,550	5,640

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-41 Monthly Mean Stages at Lake N2 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	1.454	1.206	1.143	1.171	0.700
		operation	1.504	1.246	1.189	1.215	0.722
	10	baseline	1.390	1.073	0.988	0.931	0.541
		operation	1.439	1.110	1.028	0.967	0.563
Median	2	baseline	1.274	0.917	0.829	0.702	0.390
		operation	1.319	0.949	0.864	0.732	0.408
Dry	10	baseline	1.072	0.762	0.698	0.534	0.269
		operation	1.108	0.787	0.728	0.559	0.282
	100	baseline	0.663	0.625	0.611	0.430	0.171
		operation	0.666	0.642	0.636	0.453	0.176

m = metre.

Table 9.7-42 Derived Representative Stages at Lake N2 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.372	2.962	1.833	1.696	1.011	1.113
		operation	0.372	3.037	1.903	1.756	1.050	1.154
	10	baseline	0.322	2.571	1.786	1.648	0.846	0.932
		operation	0.321	2.640	1.854	1.708	0.878	0.969
Median	2	baseline	0.257	2.132	1.687	1.551	0.675	0.767
		operation	0.257	2.194	1.756	1.607	0.703	0.800
Dry	10	baseline	0.189	1.719	1.496	1.366	0.532	0.656
		operation	0.189	1.773	1.557	1.417	0.556	0.684
	100	baseline	0.124	1.367	1.110	1.004	0.428	0.598
		operation	0.124	1.414	1.161	1.053	0.452	0.624

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Conveyance from Lake A3 to Lake N9 was discussed in Section 8.7. Because this will be a permanent diversion, an engineered channel will be constructed at this location.

Conveyance from Lake B1 to Lake N8 was also discussed in Section 8.7. This temporary diversion will comprise an engineered channel or pipeline, to prevent erosion by flowing water. Because Lake N8 is small, it provides little storage or flow attenuation, and diverted flows in the Lake N8 outlet channel to Lake N6 will greatly exceed baseline values, particularly during spring freshet. Alternatives for flow conveyance from Lake N8 to Lake N6 include improving the existing outlet channel to ensure that it is resistant to erosion, or constructing a parallel engineered channel or pipeline to handle excess discharge. Any of these will allow flows and water levels to be managed to prevent adverse effects on Lake N8 and Outlet channel and bank stability.

Note that these values represent changes that will occur after Lake A3 fills to its spill elevation, which would take 11 years under median conditions. Changes to Lake N6 and downstream waterbodies due to the Lake B1 diversion only, which would occur in the first year of operation, would be lower.

Lake N9 Outlet Flows: The water balance results for Lake N9 show that during operation, monthly mean flows will increase in proportion to the additional flow from the diverted A watershed. The 2-year flood discharge during operation will increase by approximately 3% above the baseline value, and the 100-year flood discharge will increase by approximately 4%. Low flows will also increase by 10% to 13%.

Lake N9 Water Levels: Lake N9 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.014 m, the 100-year flood level by 0.015 m, and monthly mean stages by 0.013 m (June), 0.016 m (July), 0.008 m (August), 0.004 m (September) and 0.001 m (October), under median conditions.

Lake N9 and Outlet Channel/Bank Stability: No effects on Lake N9 and Outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime.

Lake N6 Outlet Flows: The water balance results for Lake N6 show that during operation, monthly mean flows will increase in proportion to the additional flow from the diverted A and B watersheds. The 2-year flood discharge during operation will increase by approximately 22% above the baseline value, and the 100-year flood discharge will increase by approximately 18%. Low flows will also increase by 20% to 22%.

Lake N6 Water Levels: Lake N6 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.029 m, the 100-year flood level by 0.028 m, and monthly mean stages by 0.018 m (June), 0.013 m (July), 0.013 m (August), 0.010 m (September) and 0.005 m (October), under median conditions.

Lake N6 and Outlet Channel/Bank Stability: No effects on Lake N6 and Outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime.

Lake N2 Outlet Flows: The water balance results for Lake N2 show that during operation, monthly mean flows will increase in proportion to the additional flow from the diverted A and B watersheds. The 2-year flood discharge during operation will increase by approximately 10% above the baseline value, and the 100-year flood discharge will increase by approximately 9%. Low flows will also increase by 13% to 15%.

Lake N2 Water Levels: Lake N2 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.062 m, the 100-year flood level by 0.075 m, and monthly mean stages by 0.045 m (June), 0.032 m (July), 0.035 m (August), 0.030 m (September) and 0.018 m (October), under median conditions.

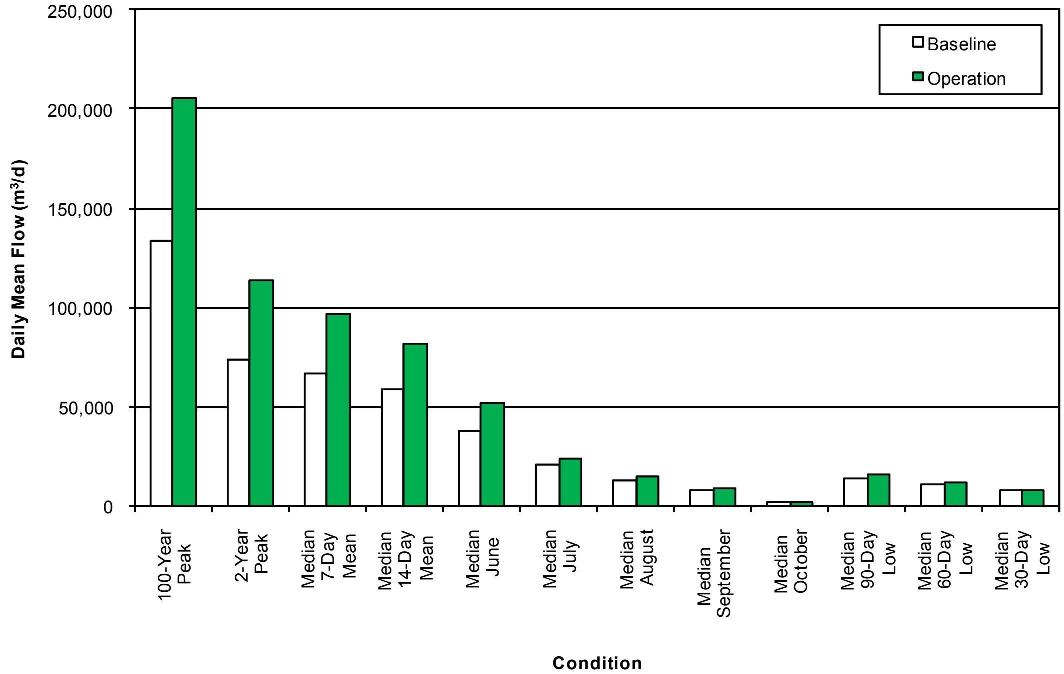
Lake N2 and Outlet Channel/Bank Stability: No effects on Lake N2 and outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime.

Lake N14 to Lake N11 Inflow (Watershed D and E Diversions)

The water balance model for the Project examined this receiving watershed by modeling the flow diverted from the D and E watersheds into Lake N17, with Lake N14 being lumped into the N17 watershed due to its small size and low storage/flow attenuation capacity. Lake N16, located below Lake N17, was modeled, and Lake N15 was not, due to its small size and low storage.

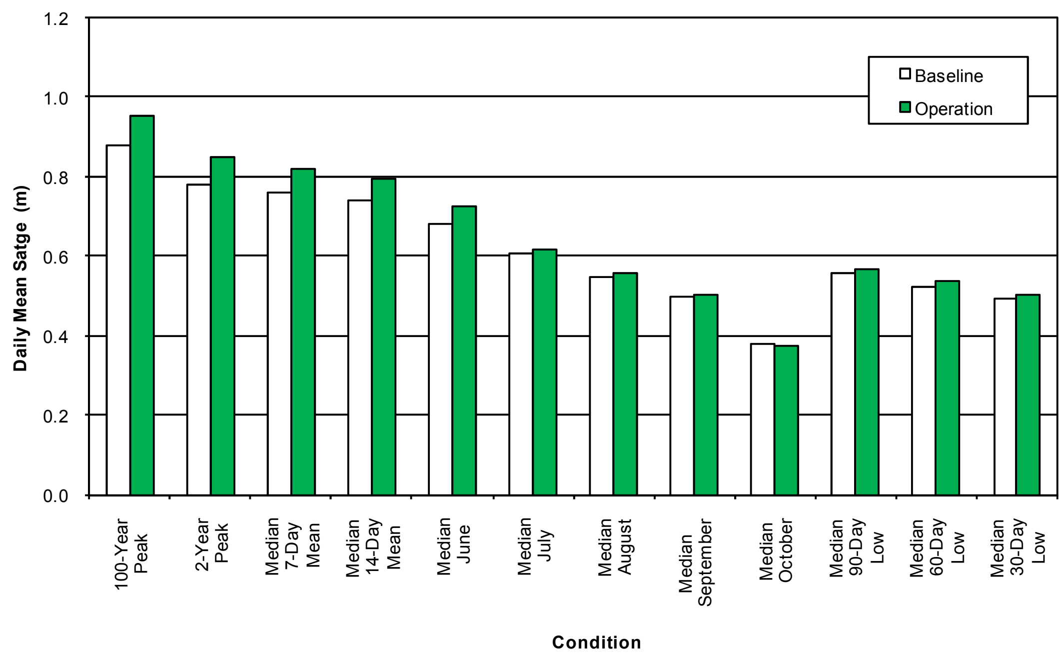
Project effects on Lake N17 are presented in Figures 9.7-24 to 9.7-25 and Tables 9.7-43 to 9.7-46, and Project effects on Lake N16 are presented in Figures 9.7-26 to 9.7-27 and Tables 9.7-47 to 9.7-50.

Figure 9.7-24 Comparison of Effects on Lake N17 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-25 Comparison of Effects on Lake N17 Stages – Operation



m = metres.

Table 9.7-43 Monthly Mean Discharges at the Lake N17 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	66,800	44,200	31,800	36,800	7,720
		operation	88,000	52,900	39,600	47,800	8,340
	10	baseline	54,000	32,400	20,900	17,300	4,100
		operation	72,300	37,300	24,700	20,400	4,210
Median	2	baseline	38,000	21,100	12,800	7,830	2,040
		operation	51,500	23,400	14,200	8,220	1,910
Dry	10	baseline	21,800	12,400	8,050	4,500	1,160
		operation	29,000	13,500	8,550	4,370	963
	100	baseline	8,350	6,980	5,720	3,460	835
		operation	9,180	7,620	5,920	3,270	620

m^3/d = cubic metres per day.

Table 9.7-44 Derived Representative Discharges at the Lake N17 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	1.55	115,000	95,800	26,300	30,300	35,000
		operation	2.38	168,000	133,000	30,800	36,500	42,200
	10	baseline	1.28	96,700	82,100	14,300	17,800	22,400
		operation	1.98	141,000	115,000	16,000	20,600	25,700
Median	2	baseline	0.85	66,500	58,300	7,690	10,300	13,900
		operation	1.32	96,900	81,900	8,130	11,400	15,400
Dry	10	baseline	0.42	34,700	32,300	4,340	6,590	9,200
		operation	0.64	50,400	45,200	4,160	6,940	9,990
	100	baseline	0.09	8,900	10,300	3,530	5,780	7,880
		operation	0.10	12,800	13,500	3,240	6,090	8,680

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-45 Monthly Mean Stages at Lake N17 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.762	0.702	0.657	0.677	0.495
		operation	0.806	0.728	0.687	0.713	0.503
	10	baseline	0.731	0.660	0.604	0.582	0.436
		operation	0.775	0.679	0.625	0.601	0.439
Median	2	baseline	0.681	0.606	0.548	0.497	0.379
		operation	0.724	0.618	0.559	0.501	0.375
Dry	10	baseline	0.609	0.544	0.499	0.445	0.339
		operation	0.645	0.554	0.505	0.442	0.327
	100	baseline	0.503	0.485	0.466	0.422	0.317
		operation	0.513	0.494	0.470	0.417	0.299

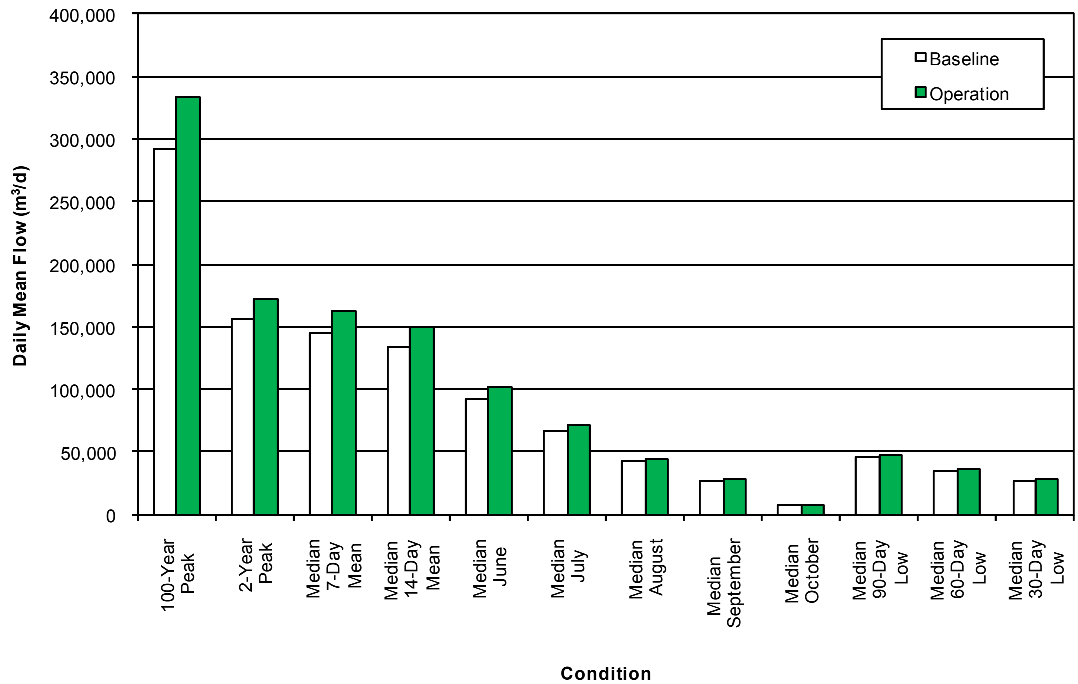
m = metre.

Table 9.7-46 Derived Representative Stages at Lake N17 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.876	0.850	0.819	0.633	0.651	0.670
		operation	0.955	0.917	0.875	0.653	0.676	0.696
	10	baseline	0.843	0.821	0.795	0.560	0.585	0.613
		operation	0.920	0.885	0.850	0.573	0.603	0.630
Median	2	baseline	0.778	0.762	0.742	0.495	0.525	0.557
		operation	0.849	0.821	0.794	0.500	0.535	0.569
Dry	10	baseline	0.675	0.669	0.659	0.441	0.480	0.513
		operation	0.735	0.721	0.705	0.438	0.485	0.521
	100	baseline	0.491	0.510	0.525	0.423	0.467	0.497
		operation	0.510	0.548	0.554	0.416	0.472	0.507

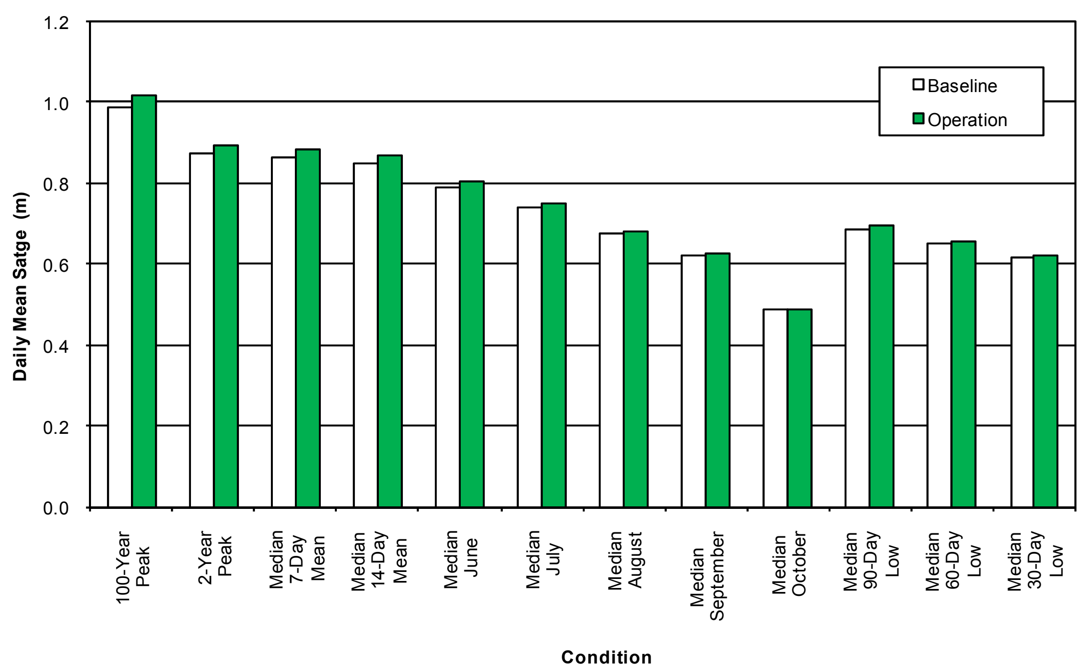
m = metre.

Figure 9.7-26 Comparison of Effects on Lake N16 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-27 Comparison of Effects on Lake N16 Stages – Operation



m = metres.

Table 9.7-47 Monthly Mean Discharges at the Lake N16 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	171,000	127,000	92,300	93,600	23,800
		operation	190,000	138,000	98,700	101,000	25,400
	10	baseline	134,000	97,800	64,700	51,400	14,100
		operation	149,000	105,000	68,500	54,400	14,700
Median	2	baseline	91,900	66,900	42,400	27,300	7,910
		operation	102,000	71,600	44,300	28,300	8,140
Dry	10	baseline	53,200	40,900	28,200	17,000	4,960
		operation	57,800	43,400	29,300	17,500	5,060
	100	baseline	23,900	22,600	20,500	13,200	3,740
		operation	24,600	23,900	21,300	13,600	3,820

m^3/d = cubic metres per day.

Table 9.7-48 Derived Representative Discharges at the Lake N16 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	3.37	257,000	228,000	79,300	89,800	100,000
		operation	3.86	295,000	258,000	84,700	96,100	108,000
	10	baseline	2.71	212,000	190,000	45,800	55,800	69,400
		operation	3.07	242,000	215,000	48,200	58,800	73,900
Median	2	baseline	1.80	145,000	133,000	26,700	34,500	45,500
		operation	2.00	163,000	149,000	27,700	36,000	48,000
Dry	10	baseline	0.94	78,200	74,600	16,700	23,300	30,500
		operation	1.00	84,500	81,300	17,200	24,200	32,100
	100	baseline	0.31	26,400	29,000	14,300	20,700	25,500
		operation	0.30	25,100	28,500	14,600	21,400	26,900

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-49 Monthly Mean Stages at Lake N16 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.891	0.840	0.789	0.791	0.604
		operation	0.910	0.854	0.799	0.803	0.612
	10	baseline	0.849	0.798	0.736	0.703	0.545
		operation	0.867	0.809	0.744	0.711	0.549
Median	2	baseline	0.788	0.740	0.677	0.621	0.486
		operation	0.805	0.750	0.683	0.625	0.489
Dry	10	baseline	0.708	0.672	0.624	0.565	0.443
		operation	0.719	0.680	0.629	0.568	0.445
	100	baseline	0.604	0.598	0.586	0.538	0.419
		operation	0.608	0.604	0.591	0.541	0.421

m = metre.

Table 9.7-50 Derived Representative Stages at Lake N16 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.989	0.965	0.943	0.766	0.785	0.801
		operation	1.016	0.992	0.966	0.776	0.795	0.814
	10	baseline	0.948	0.929	0.910	0.687	0.714	0.746
		operation	0.971	0.954	0.932	0.694	0.722	0.755
Median	2	baseline	0.874	0.862	0.848	0.618	0.650	0.686
		operation	0.893	0.883	0.867	0.622	0.655	0.694
Dry	10	baseline	0.769	0.764	0.757	0.563	0.601	0.634
		operation	0.779	0.775	0.769	0.566	0.606	0.641
	100	baseline	0.619	0.616	0.628	0.546	0.588	0.612
		operation	0.612	0.610	0.626	0.548	0.591	0.619

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Conveyance from Lake D2/D3 and Lake E1 to Lake N14 was discussed in Section 8.7. These temporary diversion flows will be conveyed by engineered channel or pipeline to manage flows and water levels and prevent any adverse effects on diversion channel and bank stability.

Because the existing Lake N14 watershed is small relative to the upstream diverted area, diverted flows will greatly exceed baseline values, particularly during spring freshet. Alternatives for flow conveyance from Lake N14 to Lake N17 include improving the existing outlet channel to ensure that it is resistant to erosion, or constructing a parallel engineered channel or pipeline to handle excess discharge. Any of these will allow flows and water levels to be managed to prevent adverse effects on Lake N14 and Outlet channel and bank stability.

Note that these values presented here represent changes that will occur after Lake D2/D3 fills to its spill elevation, which will take 3 years under median conditions. Changes due to only the Lake E1 diversion, which would occur in the first year of operation, would be lower.

Lake N17 Outlet Flows: The water balance results for Lake N17 show that during operation, monthly mean flows will increase in proportion to the additional flow from the diverted D and E watersheds. The 2-year flood discharge during operation will increase by approximately 54% above the baseline value, and the 100-year flood discharge will increase by approximately 55%. Low flows will also increase by 6% to 11%.

Lake N17 Water Levels: Lake N17 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.071 m, the 100-year flood level by 0.079 m, and monthly mean stages by 0.043 m (June), 0.012 m (July), 0.011 m (August), 0.004 m (September) and -0.004 m (October), under median conditions.

Lake N17 and Outlet Channel/Bank Stability: No effects on Lake N17 and Outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime. Water level increases of 50 to 80 mm are unlikely to affect lake shorelines, but increased flood magnitudes are large enough to warrant more intensive monitoring on this lake outlet channel. It is expected that bouldery substrates, along with frozen bank conditions during spring freshet, will prevent any adverse effects to the outlet channel.

Lake N16 Outlet Flows: The water balance results for Lake N16 show that during operation, monthly mean flows will increase in proportion to the additional flow from the diverted D and E watersheds. The 2-year flood discharge during operation will increase by approximately 11% above the baseline value, and the 100-year flood discharge will increase by approximately 15%. Low flows will also increase by 4% to 5%.

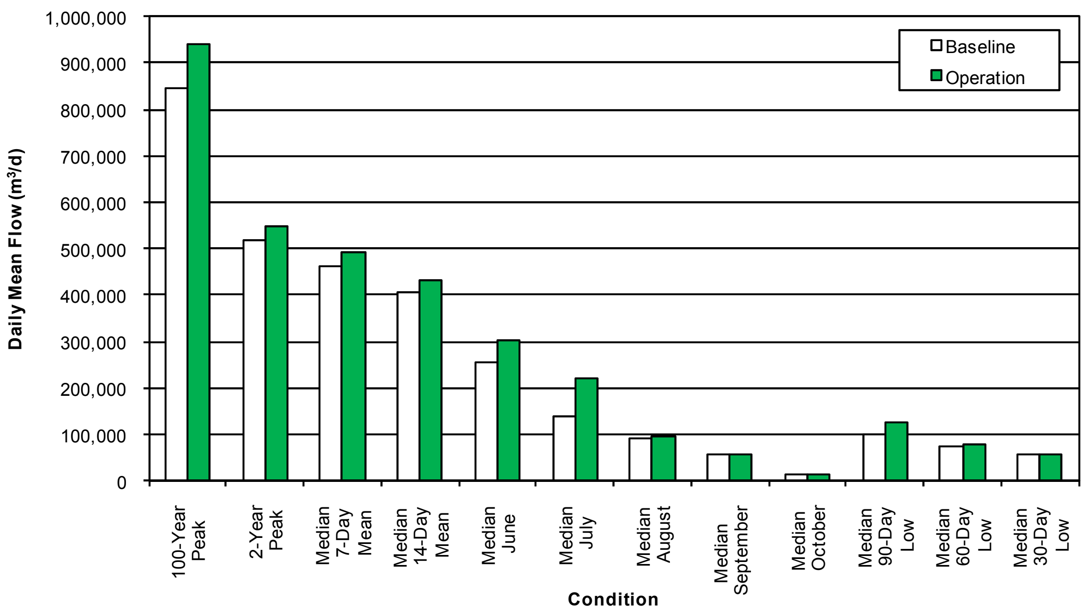
Lake N16 Water Levels: Lake N16 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.019 m, the 100-year flood level by 0.027 m, and monthly mean stages by 0.017 m (June), 0.010 m (July), 0.006 m (August), 0.004 m (September) and 0.003 m (October), under median conditions.

Lake N16 and Outlet Channel/Bank Stability: No effects on Lake N16 and Outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime.

Lake N11 to Lake N1 (Combined Diversion)

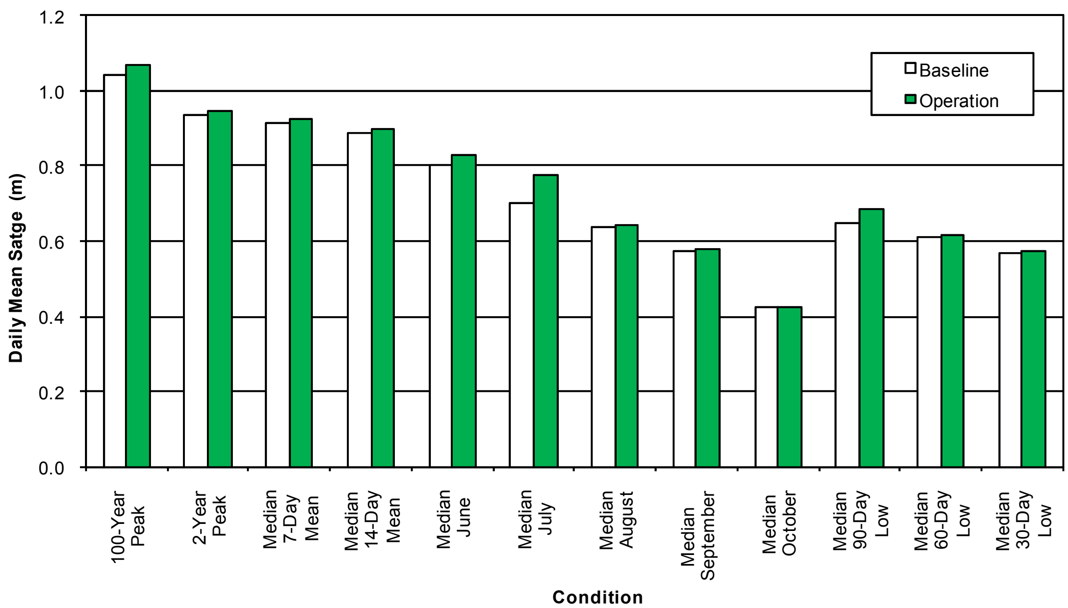
The water balance model for the Project examined flows and water levels at Lake N11 and Lake N1. Project effects on Lake N11 are presented in Figures 9.7-28 to 9.7-29 and Tables 9.7-69 to 9.7-72, and Project effects on Lake N1 are presented in Figures 9.7-30 to 9.7-31 and Tables 9.7-73 to 9.7-76.

Figure 9.7-28 Comparison of Effects on Lake N11 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-29 Comparison of Effects on Lake N11 Stages – Operation



m = metres.

Table 9.7-51 Monthly Mean Discharges at the Lake N11 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	443,000	293,000	221,000	258,000	50,700
		operation	508,000	388,000	243,000	267,000	53,300
	10	baseline	359,000	215,000	147,000	123,000	28,200
		operation	413,000	311,000	158,000	127,000	29,200
Median	2	baseline	257,000	141,000	91,400	56,800	14,700
		operation	304,000	221,000	96,600	58,700	15,100
Dry	10	baseline	155,000	83,600	58,800	33,300	8,740
		operation	202,000	132,000	62,200	34,400	8,880
	100	baseline	71,900	46,900	42,600	25,900	6,400
		operation	123,000	62,600	45,700	26,700	6,510

m^3/d = cubic metres per day.

Table 9.7-52 Derived Representative Discharges at the Lake N11 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	9.77	747,000	630,000	179,000	198,000	215,000
		operation	10.90	838,000	702,000	196,000	222,000	259,000
	10	baseline	8.22	630,000	538,000	102,000	125,000	152,000
		operation	8.86	680,000	580,000	109,000	135,000	189,000
Median	2	baseline	6.00	464,000	404,000	55,500	75,000	98,700
		operation	6.37	493,000	433,000	57,900	78,800	127,000
Dry	10	baseline	3.36	269,000	240,000	33,900	48,500	64,200
		operation	3.87	311,000	288,000	34,900	50,700	83,000
	100	baseline	0.85	85,300	81,700	25,200	36,500	45,200
		operation	1.82	167,000	172,000	25,900	38,600	57,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-53 Monthly Mean Stages at Lake N11 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.903	0.824	0.774	0.801	0.558
		operation	0.931	0.877	0.791	0.807	0.564
	10	baseline	0.862	0.769	0.707	0.680	0.490
		operation	0.889	0.835	0.718	0.684	0.494
Median	2	baseline	0.800	0.700	0.636	0.572	0.424
		operation	0.831	0.774	0.644	0.577	0.426
Dry	10	baseline	0.715	0.624	0.577	0.508	0.378
		operation	0.759	0.690	0.584	0.512	0.379
	100	baseline	0.603	0.548	0.537	0.481	0.352
		operation	0.680	0.585	0.545	0.484	0.354

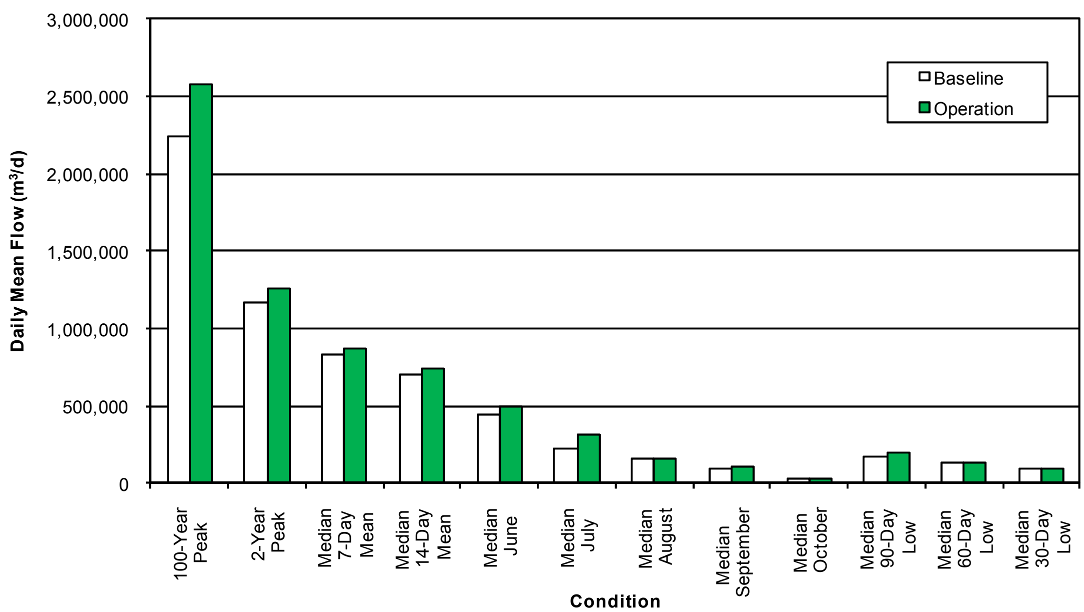
m = metre.

Table 9.7-54 Derived Representative Stages at Lake N11 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.043	1.015	0.977	0.739	0.755	0.769
		operation	1.068	1.041	1.001	0.754	0.775	0.802
	10	baseline	1.003	0.977	0.943	0.652	0.682	0.712
		operation	1.020	0.994	0.959	0.662	0.694	0.748
Median	2	baseline	0.935	0.913	0.885	0.569	0.609	0.647
		operation	0.948	0.925	0.899	0.575	0.616	0.684
Dry	10	baseline	0.822	0.809	0.788	0.510	0.553	0.588
		operation	0.849	0.835	0.821	0.514	0.558	0.623
	100	baseline	0.606	0.626	0.620	0.478	0.519	0.544
		operation	0.718	0.727	0.732	0.481	0.525	0.573

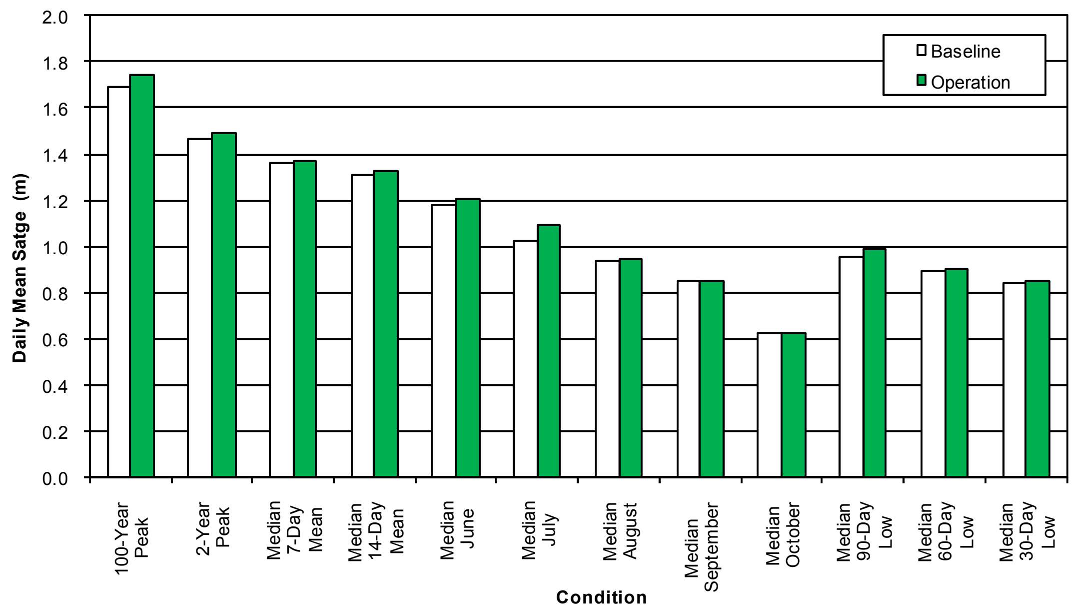
m = metre.

Figure 9.7-30 Comparison of Effects on Lake N1 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-31 Comparison of Effects on Lake N1 Stages – Operation



m = metres.

Table 9.7-55 Monthly Mean Discharges at the Lake N1 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	737,000	470,000	370,000	398,000	84,100
		operation	801,000	569,000	401,000	418,000	87,900
	10	baseline	609,000	348,000	248,000	204,000	47,600
		operation	660,000	448,000	265,000	213,000	49,300
Median	2	baseline	444,000	229,000	156,000	99,000	25,100
		operation	489,000	315,000	164,000	102,000	25,700
Dry	10	baseline	270,000	138,000	102,000	56,600	14,600
		operation	319,000	197,000	107,000	58,300	14,900
	100	baseline	121,000	79,300	75,400	41,600	10,300
		operation	183,000	111,000	79,700	43,000	10,500

m^3/d = cubic metres per day.

Table 9.7-56 Derived Representative Discharges at the Lake N1 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	25.90	1,250,000	1,050,000	285,000	333,000	353,000
		operation	29.80	1,350,000	1,110,000	312,000	368,000	404,000
	10	baseline	19.90	1,080,000	910,000	171,000	212,000	251,000
		operation	22.10	1,150,000	962,000	183,000	227,000	293,000
Median	2	baseline	13.50	827,000	704,000	95,600	128,000	166,000
		operation	14.60	872,000	740,000	100,000	134,000	197,000
Dry	10	baseline	8.22	527,000	441,000	57,200	83,800	109,000
		operation	8.68	557,000	472,000	59,100	87,500	132,000
	100	baseline	4.51	242,000	174,000	40,500	63,800	77,100
		operation	4.84	270,000	211,000	41,600	67,200	95,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-57 Monthly Mean Stages at Lake N1 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	1.323	1.197	1.135	1.154	0.817
		operation	1.348	1.249	1.156	1.166	0.825
	10	baseline	1.268	1.120	1.039	0.995	0.720
		operation	1.291	1.185	1.054	1.004	0.725
Median	2	baseline	1.182	1.020	0.937	0.847	0.624
		operation	1.208	1.095	0.947	0.853	0.628
Dry	10	baseline	1.058	0.912	0.853	0.748	0.553
		operation	1.098	0.987	0.862	0.753	0.556
	100	baseline	0.886	0.806	0.797	0.698	0.512
		operation	0.971	0.869	0.807	0.704	0.514

m = metre.

Table 9.7-58 Derived Representative Stages at Lake N1 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.693	1.488	1.431	1.071	1.109	1.123
		operation	1.747	1.514	1.449	1.093	1.134	1.158
	10	baseline	1.597	1.440	1.387	0.956	1.003	1.041
		operation	1.635	1.461	1.404	0.971	1.018	1.078
Median	2	baseline	1.465	1.357	1.310	0.840	0.897	0.950
		operation	1.491	1.373	1.324	0.849	0.906	0.987
Dry	10	baseline	1.312	1.228	1.180	0.750	0.816	0.865
		operation	1.328	1.243	1.198	0.755	0.824	0.903
	100	baseline	1.148	1.033	0.960	0.694	0.768	0.801
		operation	1.167	1.058	1.002	0.698	0.777	0.839

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake N11 Outlet Flows: The water balance results for Lake N11 show that during operations, monthly mean flows will increase due to the upstream diversion of the D and E watersheds. The peak daily discharges will increase by 6% (2-year flood) and 12% (100-year flood). Low flows will increase by up to 29% because of the increased upstream storage and flow area.

Lake N11 Water Levels: Lake N11 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.013 m, the 100-year flood level by 0.025 m, and monthly mean stages by 0.031 m (June), 0.074 m (July), 0.008 m (August), 0.005 m (September) and 0.002 m (October), under median conditions.

Lake N11 and Outlet Channel/Bank Stability: No effects on Lake N11 and Outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime, and the channel is naturally well armoured.

Lake N1 Outlet Flows: The water balance results for Lake N1 show that during operations, monthly mean flows will increase due to the upstream diversion of the A, B, D and E watersheds. The peak daily discharges will increase by 8% (2-year flood) and 15% (100-year flood). Low flows will increase by up to 19% because of the increased upstream storage and flow area.

Lake N1 Water Levels: Lake N1 water levels are also expected to increase during operation. The 2-year flood level is expected to increase by approximately 0.026 m, the 100-year flood level by 0.054 m, and monthly mean stages by 0.026 m (June), 0.075 m (July), 0.010 m (August), 0.006 m (September) and 0.004 m (October), under median conditions.

Lake N1 and Outlet Channel/Bank Stability: No effects on Lake N1 and Outlet channel or bank stability are expected during operation, because increases in flood magnitude are small relative to the existing flood regime, and the channel is naturally well armoured.

9.7.3.3 Effect of Project Infrastructure in Kennady Lake Watershed to Flows, Water Levels, and Channel/Bank Stability in Streams and Lakes in Downstream Waters

9.7.3.3.1 Project Activities

Effects of the Project activities on the water balance of Kennady Lake Area 8 during operation were described in EIS Section 8.7. Water management activities that affect the water balance of Area 8 during operation (i.e., after Dyke A is constructed and dewatering is complete) include:

- Dewatered Areas 2 to 7 will be isolated from Area 8 of Kennady Lake.
- A reduction of inflow to dewatered Areas 2 to 7 will result from diversion of the A, B, D and E watersheds.

The effects of these activities on the water balance and water levels in Area 8 were assessed in Section 8.7 (Effects to Water Quality and Fish in Kennady Lake; Effects to Water Quantity). The effects of changes in the discharge from Area 8 on flows, water levels and channel/bank stability in the Area 8 outlet channel and downstream waterbodies is assessed herein. The assessment below includes mainstem lakes within the L and M watersheds, Lake 410, mainstem lakes within the P watershed, Kirk Lake and watersheds further downstream. The downstream watersheds and flow paths from Kennady Lake to Lake 410 (Figure 9.7-1), and the downstream watersheds and flow paths from Lake 410 to Kirk Lake (Figure 9.7-2).

The operational diversion of the A, B, D and E watersheds into watershed N is discussed further in Section 9.7.3.3. The effects of these diversions are included in modelling of effects on Lake 410 and downstream watersheds.

9.7.3.3.2 Environmental Design Features and Mitigation

During operation, all contact water, including Project site contact water and inflows to the dewatered lake bed will be collected in the WMP (Areas 3 and 5). In general, this will reduce flows in Kennady Lake Area 8 during spring runoff, due to closed-circuiting of Areas 2 to 7. The relative magnitude of these effects on each waterbody will diminish with downstream distance.

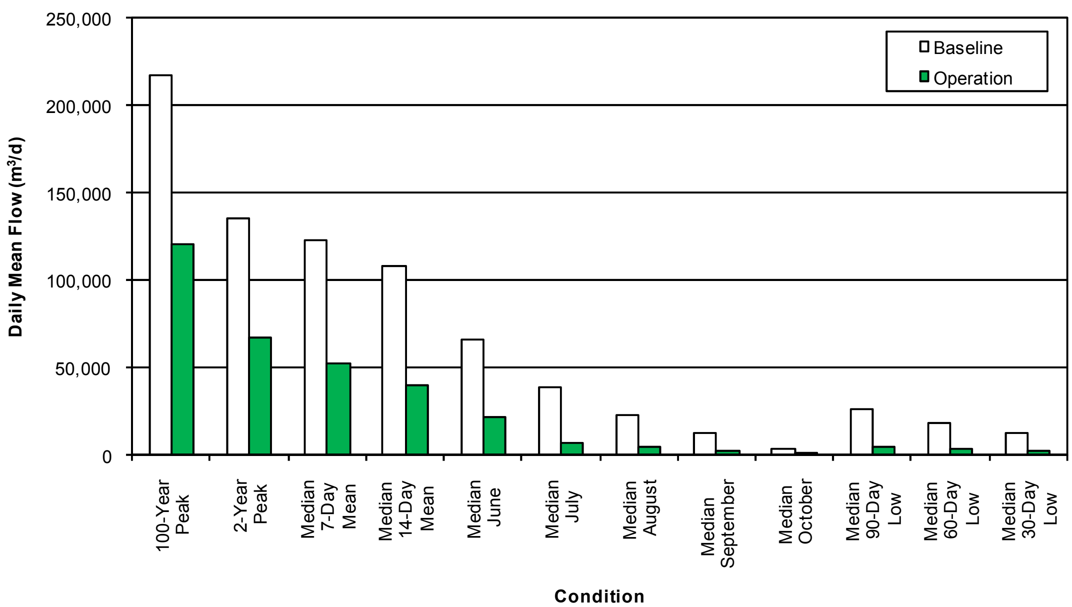
9.7.3.3.3 Effects Analysis

Kennady Lake (Area 8) Outlet (Stream K5) to Lake M1 Outlet

Dyke A will prevent water from flowing from Area 8 into Areas 2 to 7 during dewatering and operation. Area 8 will be preserved as a free-draining waterbody throughout this period, though its hydrological regime will be changed.

The water balance model for the Project examined all downstream waterbodies between the Kennady Lake Area 8 outlet channel and the Lake M1 outlet channel. Project effects on the Area 8 outlet channel during dewatering are summarized in Figure 9.7-32 and Tables 9.7-59 to 9.7-60. Project effects on Lake L1 during dewatering are summarized in Figure 9.7-33 to 9.7-34 and Tables 9.7-61 to 9.7-64. Project effects on Lake M1 during dewatering are summarized in Figures 9.7-35 to 9.7-36 and Tables 9.7-65 to 9.7-68.

Figure 9.7-32 Comparison of Effects on Area 8 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Table 9.7-59 Monthly Mean Discharges at the Area 8 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	121,000	86,500	59,600	68,600	13,500
		operation	35,500	19,600	14,700	16,900	2,030
	10	baseline	97,600	61,900	38,100	29,200	6,640
		operation	30,700	12,000	8,680	6,620	967
Median	2	baseline	65,900	39,300	22,800	13,200	3,070
		operation	21,900	6,670	4,580	2,460	371
Dry	10	baseline	36,900	23,100	13,900	6,880	1,430
		operation	12,000	3,570	2,310	892	91
	100	baseline	12,900	12,000	9,420	4,910	878
		operation	2,380	1,880	1,390	496	18

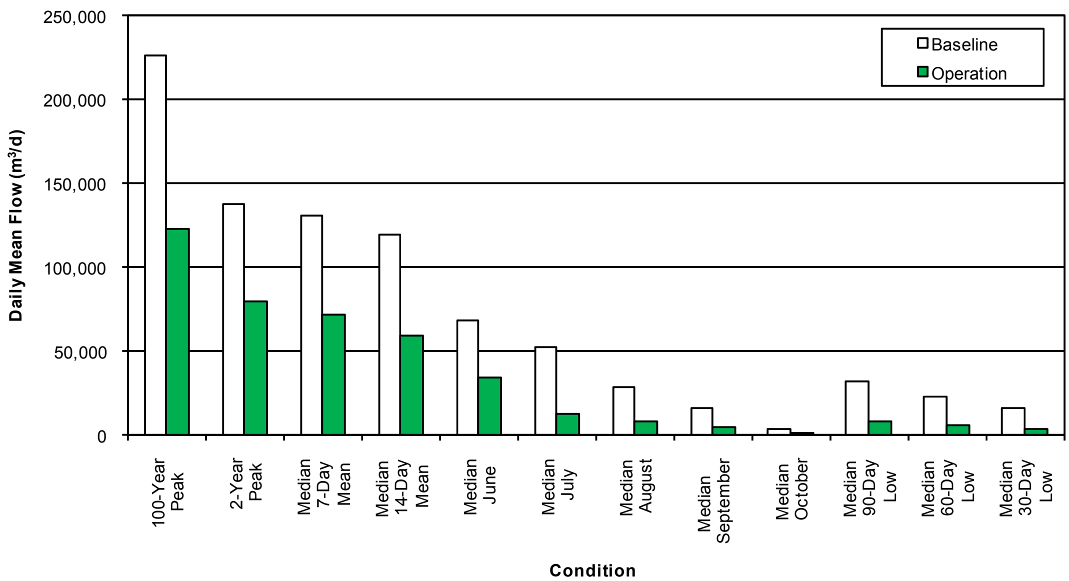
m^3/d = cubic metres per day.

Table 9.7-60 Derived Representative Discharges at the Area 8 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	2.51	192,000	167,000	48,900	52,500	59,000
		operation	1.39	85,200	61,000	10,500	14,100	13,300
	10	baseline	2.14	166,000	145,000	26,200	32,300	41,000
		operation	1.11	71,700	52,600	5,070	7,200	8,450
Median	2	baseline	1.56	123,000	108,000	12,800	18,300	26,000
		operation	0.78	52,900	39,900	2,100	3,390	4,830
Dry	10	baseline	0.80	65,100	60,000	6,560	10,900	16,100
		operation	0.46	31,100	23,700	900	1,820	2,720
	100	baseline	0.15	14,900	17,300	5,000	9,340	13,200
		operation	0.21	10,800	7,400	473	1,260	1,680

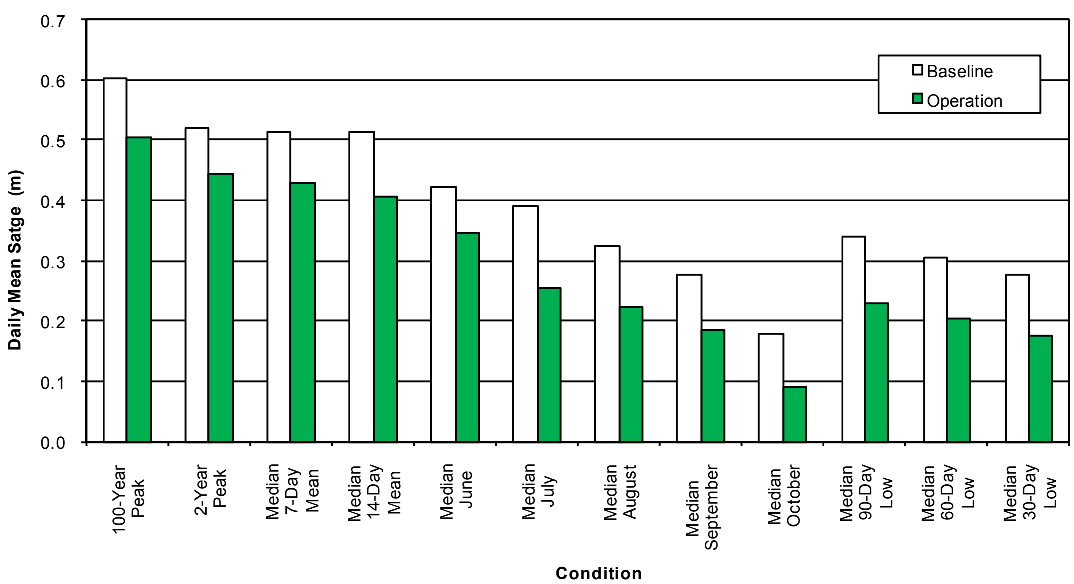
Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Figure 9.7-33 Comparison of Effects on Lake L1 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-34 Comparison of Effects on Lake L1 Stages – Operation



m = metres.

Table 9.7-61 Monthly Mean Discharges at the Lake L1 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	130,000	111,000	67,700	85,000	20,600
		operation	57,000	36,100	23,600	31,300	8,690
	10	baseline	102,000	81,400	45,700	38,900	9,240
		operation	47,200	22,700	14,400	12,800	2,140
Median	2	baseline	67,800	52,300	28,100	16,400	3,630
		operation	34,300	12,300	7,690	4,190	376
Dry	10	baseline	35,700	29,300	17,100	8,310	1,620
		operation	20,500	6,140	3,940	1,310	57
	100	baseline	10,700	14,200	11,300	5,750	976
		operation	8,500	2,980	2,130	448	4

m^3/d = cubic metres per day.

Table 9.7-62 Derived Representative Discharges at the Lake L1 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	2.62	214,000	189,000	57,000	63,400	76,800
		operation	1.42	112,000	89,500	17,000	23,300	23,000
	10	baseline	2.25	185,000	164,000	31,300	38,900	51,900
		operation	1.23	96,200	77,900	8,570	12,100	14,800
Median	2	baseline	1.59	131,000	119,000	16,100	22,400	32,500
		operation	0.93	72,200	59,700	3,540	5,780	8,520
Dry	10	baseline	0.86	71,700	66,800	7,980	13,000	19,900
		operation	0.54	42,100	35,500	1,300	3,100	4,770
	100	baseline	0.23	20,000	21,000	5,770	9,970	15,000
		operation	0.13	12,000	10,200	427	2,120	2,860

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-63 Monthly Mean Stages at Lake L1 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.512	0.488	0.422	0.451	0.297
		operation	0.401	0.351	0.309	0.336	0.230
	10	baseline	0.476	0.446	0.376	0.358	0.235
		operation	0.380	0.306	0.267	0.258	0.152
Median	2	baseline	0.422	0.391	0.326	0.278	0.178
		operation	0.345	0.255	0.222	0.186	0.091
Dry	10	baseline	0.350	0.330	0.281	0.227	0.140
		operation	0.297	0.208	0.182	0.132	0.052
	100	baseline	0.245	0.266	0.249	0.204	0.121
		operation	0.229	0.168	0.152	0.096	0.023

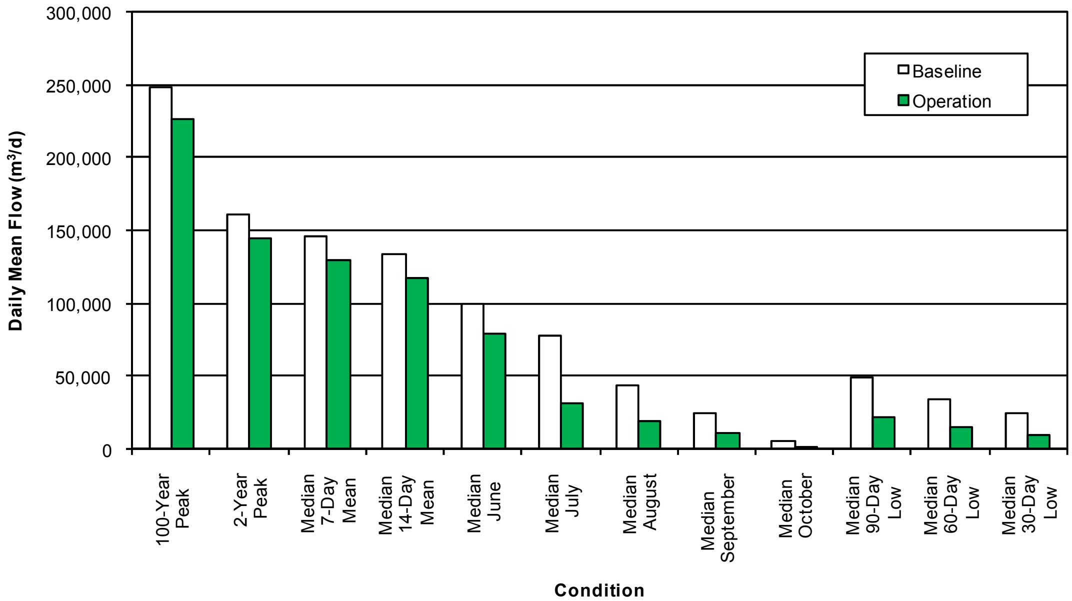
m = metre.

Table 9.7-64 Derived Representative Stages at Lake L1 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.603	0.593	0.571	0.401	0.414	0.438
		operation	0.503	0.490	0.458	0.281	0.308	0.307
	10	baseline	0.576	0.568	0.548	0.336	0.358	0.390
		operation	0.482	0.468	0.440	0.229	0.254	0.270
Median	2	baseline	0.520	0.513	0.499	0.276	0.305	0.340
		operation	0.443	0.430	0.407	0.177	0.204	0.229
Dry	10	baseline	0.433	0.429	0.420	0.225	0.259	0.294
		operation	0.377	0.367	0.349	0.132	0.170	0.193
	100	baseline	0.292	0.295	0.299	0.204	0.240	0.271
		operation	0.250	0.253	0.242	0.095	0.152	0.166

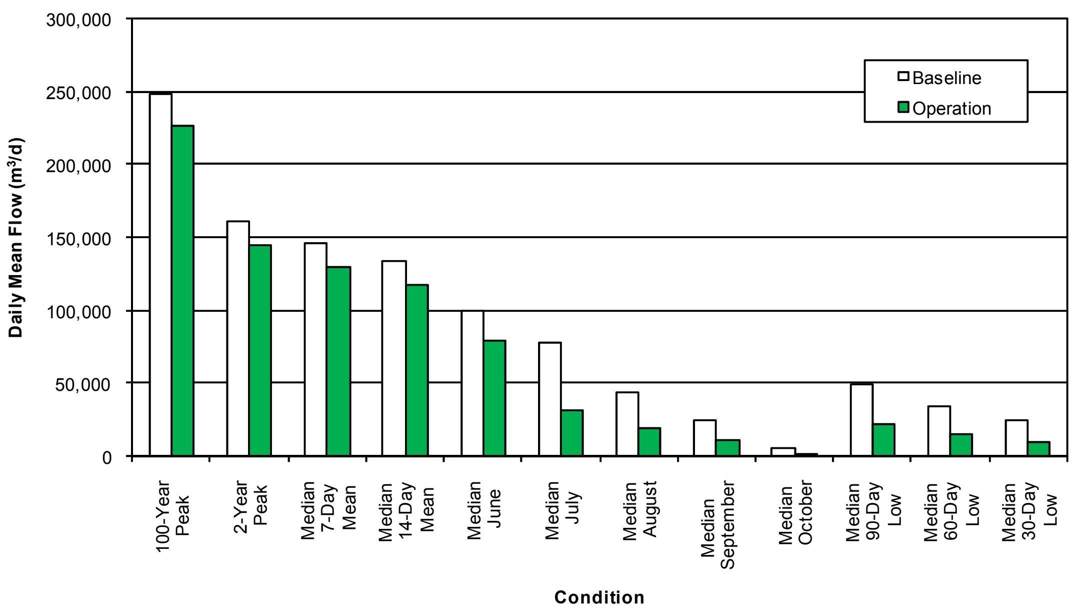
m = metre.

Figure 9.7-35 Comparison of Effects on Lake M1 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-36 Comparison of Effects on Lake M1 Stages – Operation



m = metres.

Table 9.7-65 Monthly Mean Discharges at the Lake M1 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	178,000	152,000	102,000	116,000	29,300
		operation	126,000	83,900	57,800	70,300	8,410
	10	baseline	142,000	116,000	69,100	56,400	13,500
		operation	106,000	55,600	35,800	30,500	4,450
Median	2	baseline	100,000	77,600	43,200	25,100	5,140
		operation	78,800	31,900	19,600	11,000	1,500
Dry	10	baseline	61,000	43,900	27,300	12,900	1,880
		operation	48,000	16,300	10,600	3,890	0
	100	baseline	30,800	19,800	19,100	8,800	762
		operation	20,100	7,750	6,180	1,640	0

m^3/d = cubic metres per day.

Table 9.7-66 Derived Representative Discharges at the Lake M1 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	2.88	220,000	205,000	84,900	92,300	105,000
		operation	2.62	187,000	169,000	44,200	57,600	54,800
	10	baseline	2.45	189,000	176,000	48,200	58,500	75,700
		operation	2.22	165,000	149,000	22,400	30,200	36,400
Median	2	baseline	1.87	146,000	134,000	24,700	34,400	49,700
		operation	1.68	130,000	117,000	9,470	14,800	21,800
Dry	10	baseline	1.26	96,400	85,100	13,200	21,300	31,200
		operation	1.09	83,500	73,600	3,790	8,480	12,800
	100	baseline	0.73	50,300	38,600	8,380	15,200	20,200
		operation	0.56	34,300	28,300	1,600	6,170	8,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-67 Monthly Mean Stages at Lake M1 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.626	0.563	0.432	0.470	0.188
		operation	0.497	0.379	0.296	0.337	0.082
	10	baseline	0.538	0.470	0.333	0.291	0.112
		operation	0.443	0.288	0.215	0.193	0.053
Median	2	baseline	0.426	0.360	0.243	0.170	0.059
		operation	0.363	0.199	0.144	0.098	0.026
Dry	10	baseline	0.306	0.246	0.179	0.109	0.030
		operation	0.261	0.127	0.095	0.049	-
	100	baseline	0.194	0.145	0.141	0.084	0.016
		operation	0.146	0.077	0.067	0.027	-

m = metre.

Table 9.7-68 Derived Representative Stages at Lake M1 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.782	0.721	0.687	0.382	0.404	0.440
		operation	0.734	0.647	0.604	0.247	0.295	0.285
	10	baseline	0.702	0.651	0.621	0.262	0.298	0.354
		operation	0.658	0.595	0.556	0.157	0.192	0.217
Median	2	baseline	0.587	0.548	0.518	0.168	0.209	0.267
		operation	0.546	0.507	0.473	0.089	0.119	0.154
Dry	10	baseline	0.451	0.416	0.383	0.110	0.152	0.196
		operation	0.409	0.378	0.347	0.048	0.082	0.108
	100	baseline	0.314	0.269	0.226	0.082	0.121	0.147
		operation	0.263	0.209	0.184	0.027	0.067	0.079

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Area 8 Outlet Flows: The water balance results for Area 8 show that during operations, monthly mean flows will decrease due to the upstream closed-circuiting. The peak daily discharges will decrease by 50% (2-year flood) and 45% (100-year flood). Low flows will decrease by up to 84% because of the reduction of upstream storage and flow area. A flow mitigation plan is being developed to mitigate any fish habitat losses due to reduced flows. The specifics of the mitigation plan have not been developed, but would focus on providing suitable spawning and rearing habitat for Arctic grayling (*Thymallus arcticus*).

Area 8 Outlet Channel/Bank Stability: No effects on Area 8 outlet channel or bank stability are expected, because flows and water levels will decrease during operation.

Lake L1 Outlet Flows: The water balance results for Lake L1 show that during operations, monthly mean flows will decrease due to the upstream closed-circuiting. The peak daily discharges will decrease by 42% (2-year flood) and 46% (100-year flood). Low flows will decrease by up to 78% because of the reduction of upstream storage and flow area. A flow mitigation plan is being developed to mitigate any fish habitat losses due to reduced flows. The specifics of the mitigation plan have not been developed, but would focus on providing suitable spawning and rearing habitat for Arctic grayling (*Thymallus arcticus*).

Lake L1 Water Levels: Lake L1 water levels are also expected to decrease during operation. The 2-year flood level is expected to decrease by approximately 0.077 m, and monthly mean stages are expected to decrease by 0.077 m (June), 0.136 m (July), 0.104 m (August), 0.092 m (September) and 0.087 m (October), under median conditions.

Lake L1 and Outlet Channel/Bank Stability: No effects on Lake L1 and outlet channel or bank stability are expected, because flows and water levels will decrease during operation.

Lake M1 Outlet Flows: The water balance results for Lake M1 show that during operations, monthly mean flows will decrease due to the upstream closed-circuiting. The peak daily discharges will decrease by 10% (2-year flood) and 9% (100-year flood). Low flows will decrease by up to 62% because of the reduction of upstream storage and flow area. A flow mitigation plan is being developed to mitigate any fish habitat losses due to reduced flows. The specifics of the mitigation plan have not been developed, but would focus on providing suitable spawning and rearing habitat for Arctic grayling (*Thymallus arcticus*).

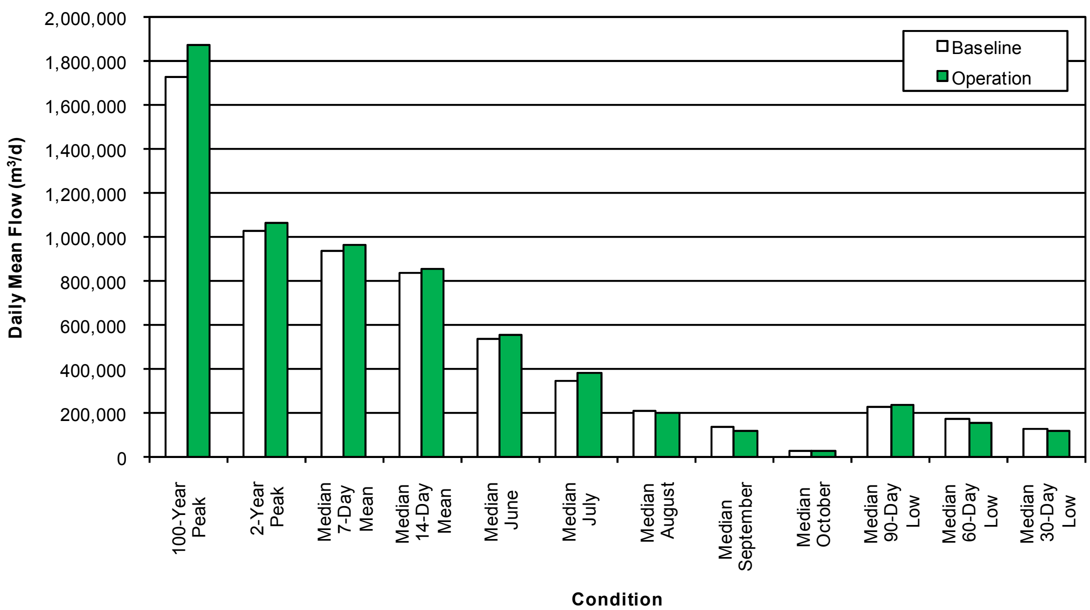
Lake M1 Water Levels: Lake M1 water levels are also expected to decrease during operation. The 2-year flood level is expected to decrease by approximately 0.041 m, and monthly mean stages are expected to decrease by 0.063 m (June), 0.161 m (July), 0.099 m (August), 0.072 m (September) and 0.033 m (October), under median conditions.

Lake M1 and Outlet Channel/Bank Stability: No effects on Lake M1 and outlet channel or bank stability are expected, because flows and water levels will decrease during operation.

Lake 410 to Kirk Lake Outlet

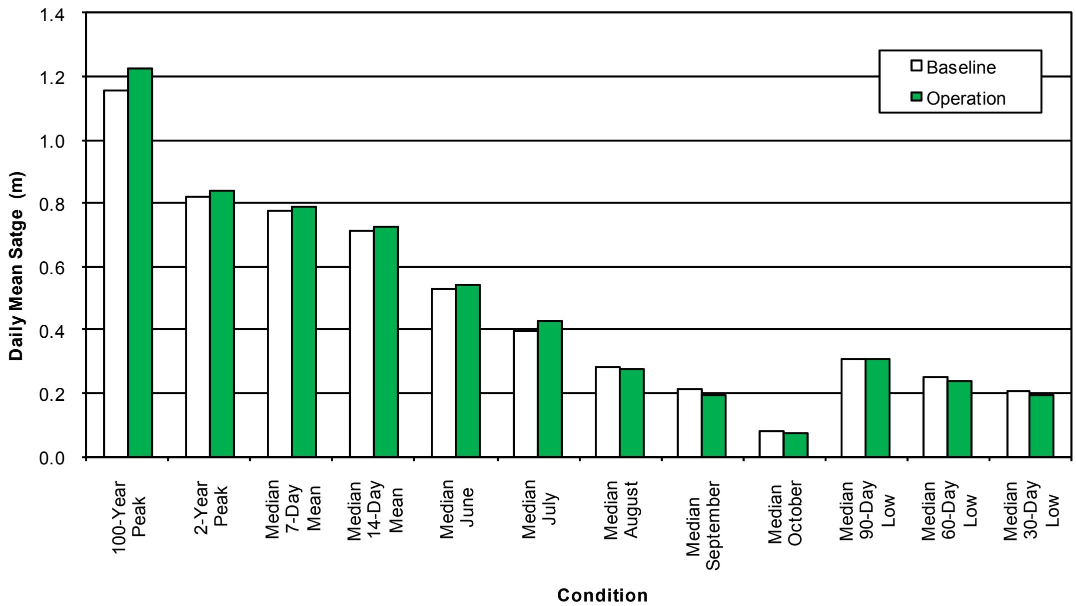
Lake M1 flows into Lake 410, which also receives inflow from Lake N1. Lake 410 then drains through watershed P to Kirk Lake. The water balance model for the Project examined all downstream waterbodies between Lake 410 and Kirk Lake. Project effects on Lake 410 during dewatering are summarized in Figures 9.7-37 to 9.7-38 and Tables 9.7-69 to 9.7-72. Project effects on Kirk Lake during dewatering are summarized in Figures 9.7-39 to 9.7-40 and Tables 9.7-73 to 9.7-76.

Figure 9.7-37 Comparison of Effects on Lake 410 Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-38 Comparison of Effects on Lake 410 Stages – Operation



m = metres.

Table 9.7-69 Monthly Mean Discharges at the Lake 410 Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	934,000	678,000	475,000	587,000	135,000
		operation	935,000	710,000	467,000	534,000	123,000
	10	baseline	759,000	514,000	329,000	278,000	70,700
		operation	762,000	553,000	317,000	264,000	63,400
Median	2	baseline	537,000	344,000	210,000	135,000	32,700
		operation	555,000	388,000	198,000	121,000	28,900
Dry	10	baseline	329,000	203,000	132,000	73,900	16,000
		operation	353,000	248,000	123,000	65,400	14,000
	100	baseline	190,000	106,000	90,100	49,800	9,660
		operation	193,000	149,000	82,800	46,100	8,420

m^3/d = cubic metres per day.

Table 9.7-70 Derived Representative Discharges at the Lake 410 Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	20.00	1,420,000	1,240,000	404,000	443,000	491,000
		operation	21.70	1,490,000	1,280,000	388,000	441,000	495,000
	10	baseline	16.50	1,230,000	1,080,000	237,000	287,000	355,000
		operation	17.40	1,280,000	1,110,000	224,000	276,000	358,000
Median	2	baseline	11.90	942,000	837,000	128,000	173,000	234,000
		operation	12.30	966,000	859,000	118,000	161,000	240,000
Dry	10	baseline	7.11	580,000	523,000	74,200	108,000	150,000
		operation	7.33	596,000	539,000	66,300	100,000	159,000
	100	baseline	3.03	219,000	200,000	50,900	77,500	100,000
		operation	3.44	241,000	218,000	44,500	72,300	113,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day

Table 9.7-71 Monthly Mean Stages at Lake 410 – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.769	0.621	0.490	0.564	0.212
		operation	0.769	0.640	0.484	0.529	0.199
	10	baseline	0.669	0.516	0.383	0.343	0.138
		operation	0.671	0.542	0.374	0.331	0.128
Median	2	baseline	0.531	0.395	0.284	0.212	0.082
		operation	0.543	0.428	0.273	0.197	0.076
Dry	10	baseline	0.383	0.278	0.209	0.142	0.051
		operation	0.402	0.318	0.199	0.131	0.047
	100	baseline	0.266	0.180	0.162	0.109	0.036
		operation	0.269	0.226	0.153	0.103	0.033

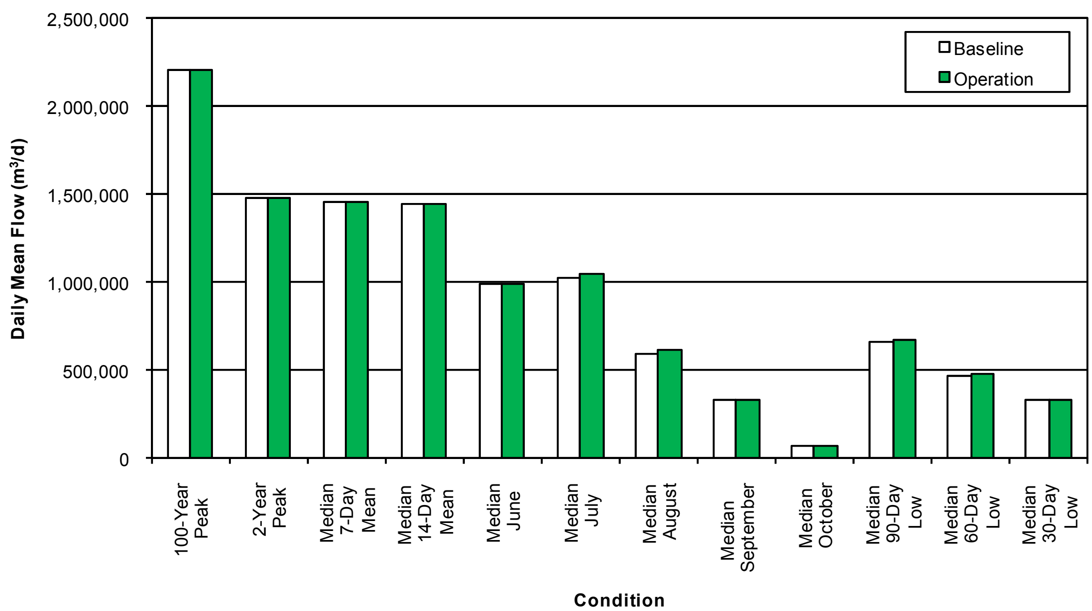
m = metre.

Table 9.7-72 Derived Representative Stages at Lake 410 – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.158	1.016	0.928	0.440	0.467	0.501
		operation	1.223	1.049	0.948	0.428	0.466	0.503
	10	baseline	1.019	0.923	0.847	0.308	0.350	0.403
		operation	1.056	0.948	0.862	0.297	0.341	0.406
Median	2	baseline	0.819	0.773	0.714	0.204	0.250	0.305
		operation	0.838	0.786	0.727	0.194	0.238	0.311
Dry	10	baseline	0.581	0.559	0.522	0.142	0.182	0.227
		operation	0.593	0.570	0.533	0.132	0.173	0.236
	100	baseline	0.329	0.292	0.275	0.110	0.146	0.173
		operation	0.358	0.312	0.291	0.101	0.140	0.188

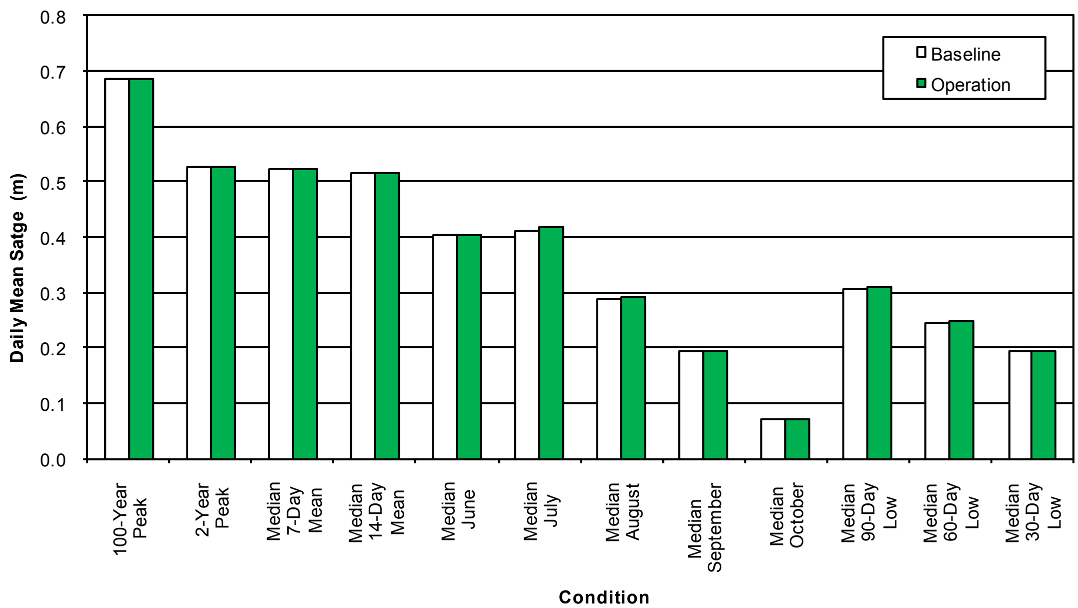
m = metre.

Figure 9.7-39 Comparison of Effects on Kirk Lake Outlet Discharges – Operation



m^3/d = cubic metres per day.

Figure 9.7-40 Comparison of Effects on Kirk Lake Stages – Operation



m = metres.

Table 9.7-73 Monthly Mean Discharges at the Kirk Lake Outlet – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	1,850,000	1,730,000	1,250,000	1,370,000	420,000
		operation	1,840,000	1,750,000	1,270,000	1,220,000	390,000
	10	baseline	1,450,000	1,420,000	916,000	676,000	188,000
		operation	1,450,000	1,440,000	937,000	683,000	190,000
Median	2	baseline	995,000	1,020,000	596,000	332,000	75,700
		operation	993,000	1,050,000	615,000	335,000	73,900
Dry	10	baseline	562,000	607,000	349,000	161,000	24,500
		operation	560,000	637,000	368,000	164,000	24,100
	100	baseline	226,000	255,000	191,000	85,200	4,760
		operation	224,000	292,000	210,000	90,900	5,370

m^3/d = cubic metres per day.

Table 9.7-74 Derived Representative Discharges at the Kirk Lake Outlet – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	25.50	2,160,000	2,100,000	1,050,000	1,140,000	1,290,000
		operation	25.50	2,170,000	2,110,000	1,070,000	1,150,000	1,300,000
	10	baseline	22.10	1,890,000	1,850,000	636,000	774,000	981,000
		operation	22.20	1,890,000	1,850,000	638,000	784,000	992,000
Median	2	baseline	17.10	1,460,000	1,440,000	333,000	467,000	660,000
		operation	17.10	1,460,000	1,440,000	333,000	476,000	674,000
Dry	10	baseline	10.60	902,000	884,000	163,000	262,000	395,000
		operation	10.60	906,000	889,000	166,000	274,000	413,000
	100	baseline	3.98	321,000	290,000	82,100	148,000	213,000
		operation	4.14	335,000	303,000	88,200	161,000	235,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-75 Monthly Mean Stages at Kirk Lake – Operation

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.610	0.584	0.470	0.500	0.227
		operation	0.608	0.588	0.475	0.463	0.216
	10	baseline	0.519	0.512	0.382	0.312	0.133
		operation	0.519	0.517	0.388	0.314	0.134
Median	2	baseline	0.404	0.410	0.287	0.194	0.072
		operation	0.403	0.418	0.293	0.195	0.071
Dry	10	baseline	0.276	0.290	0.201	0.120	0.034
		operation	0.275	0.300	0.208	0.121	0.034
	100	baseline	0.150	0.163	0.134	0.078	0.011
		operation	0.149	0.178	0.143	0.082	0.012

m = metre.

Table 9.7-76 Derived Representative Stages at Kirk Lake – Operation

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.686	0.677	0.664	0.418	0.442	0.480
		operation	0.686	0.679	0.666	0.424	0.445	0.483
	10	baseline	0.623	0.619	0.610	0.300	0.342	0.400
		operation	0.625	0.619	0.610	0.300	0.344	0.403
Median	2	baseline	0.525	0.521	0.517	0.195	0.244	0.307
		operation	0.525	0.521	0.517	0.195	0.247	0.311
Dry	10	baseline	0.382	0.378	0.373	0.121	0.166	0.218
		operation	0.382	0.379	0.375	0.122	0.171	0.225
	100	baseline	0.199	0.190	0.177	0.077	0.113	0.144
		operation	0.204	0.195	0.183	0.080	0.120	0.154

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake 410 Outlet Flows: The water balance results for Lake 410 show that during operations, monthly mean flows will increase slightly in the early open water season and decrease slightly in the late open water season, due to the upstream closed-circuiting and diversions. The peak daily discharges will increase by 3% (2-year flood) and 9% (100-year flood). Low flows will decrease by up to 8% because of the reduction of upstream storage and flow area.

Lake 410 Water Levels: Lake 410 water levels are also expected to decrease during operation. The 2-year flood level is expected to increase by approximately 0.019 m, and monthly mean stages are expected to increase by 0.012 m (June) and 0.033 m (July), and decrease by 0.011 m (August), 0.015 m (September) and 0.006 m (October), under median conditions.

Lake 410 and Outlet Channel/Bank Stability: No effects on Lake 410 and Outlet channel or bank stability are expected during operation, because flow and water level increases will be small.

The water balance results for Kirk Lake show that during operations, changes to floods and mean flows will be negligible, as will corresponding changes to water levels. No adverse effects on downstream channel/bank stability are anticipated.

9.7.4 Effects Analysis Results – Closure

9.7.4.1 Effect of Pumping Supplemental Flows from Lake N11 to Kennady Lake during Refilling to Flows, Water Levels, and Channel/Bank Stability in Streams and Lakes in the N Watershed

9.7.4.1.1 Activity Description

To expedite the refilling of Kennady Lake Areas 2 to 7, water will be pumped from Lake N11. Pumping will typically begin in June and end in July, although it may extend into August. The conceptual layout of the refilling system is shown in Figure 9.7-41. In wet years, flow forecasts, based on snow pack conditions and seasonal precipitation trends, will be used to estimate annual water yields from Lake N11. Planned pumping rates will be set accordingly to ensure that the total annual discharge from Lake N11 does not drop below the 1-in-5 year dry condition. During the pumping season, pumping rates will be adjusted as required to meet this objective. In years where the Lake N11 discharge is forecast to naturally fall below the 5-year dry condition, no pumping will occur.

The total annual average diversion from Lake N11 will be on the order of 3.7 million cubic metres per year (Mm^3/y), which represents no more than 20% of the normal annual flow to Lake N1. The 20% cut-off will be used to ensure that sufficient water remains in Lake N11 to support downstream aquatic systems in the N watershed. The value of 3.7 Mm^3/y represents the difference between the flow reporting to Lake N11 under median/normal flow conditions, and that which occurs under 1-in-5 year dry conditions. Based on a six-week pumping period, the average pumping rate will be in the order of 88,100 m^3/d. It is anticipated that more water will be withdrawn during wet years, i.e., up to a maximum of 175,200 m^3/d. In drier years, less water will be withdrawn. At no time will the diversion cause discharge from Lake N11 to drop below that which occurs under a 1-in-5 year dry condition.

During closure, the permanent diversion of Lake A3 to Lake N9, as described in Section 9.7.3.2.1, will continue.

LEGEND

- Gahcho Kué Project
- Watercourse
- Waterbody
- Contour (10m interval)
- Water Pipeline
- Kennady Lake Diverted Watershed Boundary
- L Watershed Lake Sub-watershed Boundary
- L Watershed Interior Sub-watershed Boundary
- Kennady Lake Watershed Boundary
- Sub-watershed Boundary
- Interior Sub-watershed Boundary
- Brush
- Fen
- Tree
- Drainage Diversion
- *K1* Lake Identifier
- Ke Sub-watershed Identifier

NOTES

Base data source: National Topographic Base Data (NTDB) 1:50,000

GAHCHO KUÉ PROJECT

Conceptual Layout of Kennady Lake Refilling Pipeline System

PROJECTION: UTM Zone 12	DATUM: NAD83		
Scale: 1:30,000 (500 250 0 500 Metres)			DE BEERS CANADA
FILE No: B-Hydro-012-GIS		DATE: December 17, 2010	
JOB NO: 09-1365-1004	REVISION NO: 1		
OFFICE: GOLD-CAL	DRAWN: SK	CHECK: JF	Figure 9.7-41

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9.7.4.1.2 Environmental Design Features and Mitigation

Pumping water from Lake N11 to reduce the time required to refill Kennady Lake will be done to accelerate the recovery of the aquatic ecosystem in Kennady Lake. Pumping rates will be managed to minimize effects in Lake N11 and downstream waterbodies.

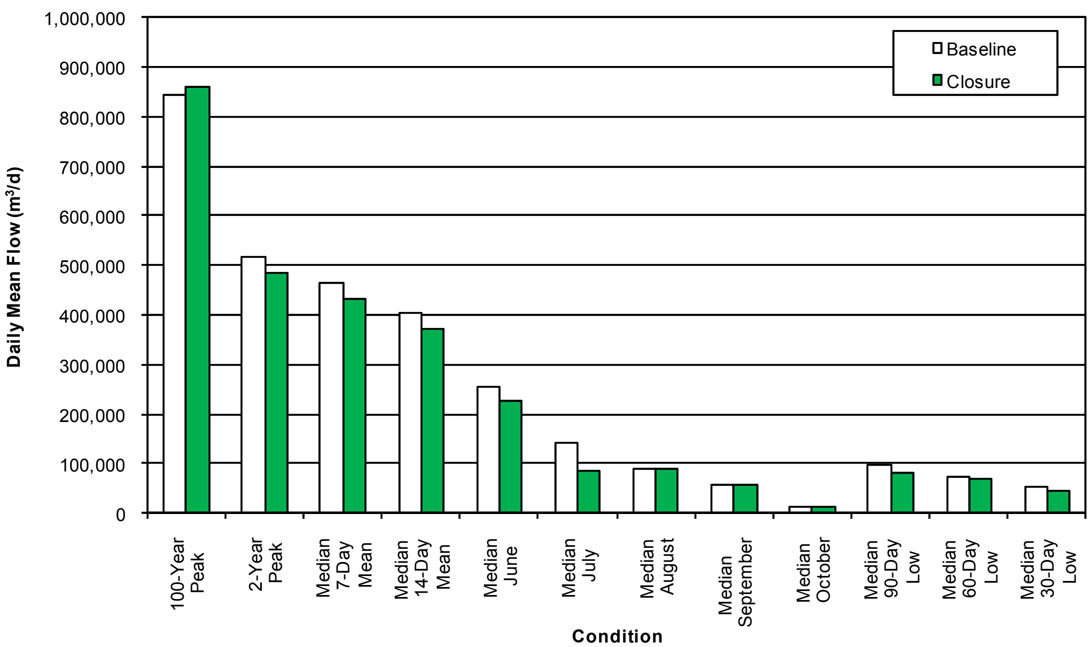
9.7.4.1.3 Effects and Mitigation

Lake N11 to Lake N1 Outlet

Effects to Lake N11 and downstream waterbodies to the Lake N1 outlet are due to the abstraction of flow for Kennady Lake refilling. Pumping will be limited to mitigate downstream effects of the water pumped from Lake N11. Additional effects to the N1 outlet will occur due to the permanent diversion of Lake A3. The operational diversions of the B, D and E watersheds will be removed so that their flow has been rerouted back to Kennady Lake.

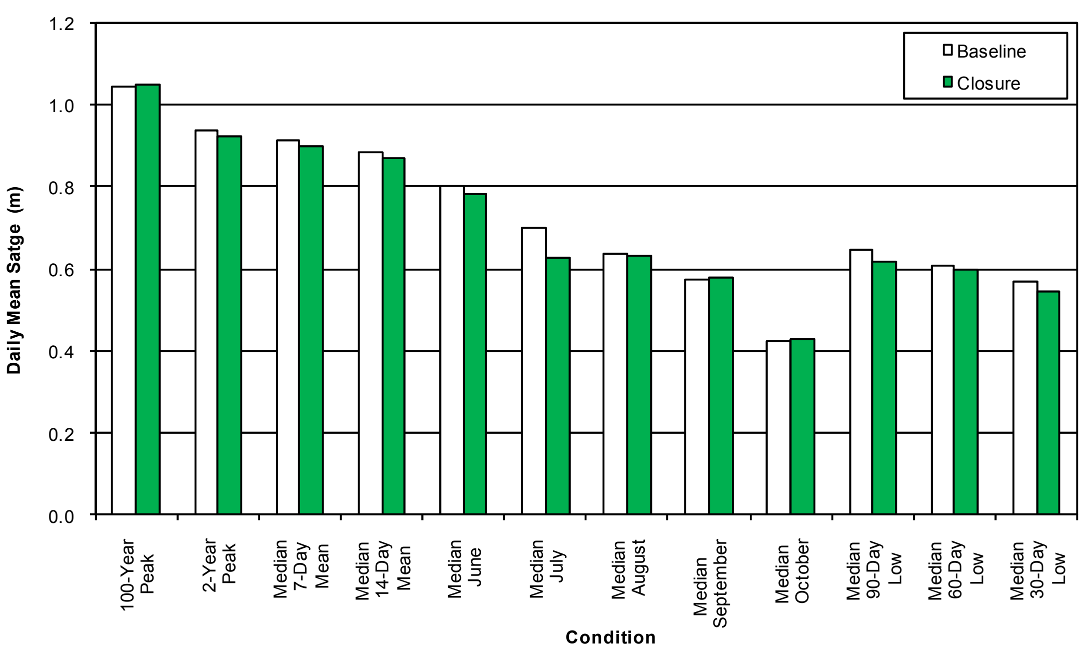
The water balance model for the Project examined all downstream waterbodies between Lake N11 and the Lake N1 outlet channel. Project effects on Lake N11 and outlet during refilling are shown in Figures 9.7-42 and 9.7-43 and summarized in Tables 9.7-77 to 9.7-80. Project effects on Lake N1 during refilling are shown in Figures 9.7-44 and 9.7-45 and summarized in Tables 9.7-81 to 9.7-84.

Figure 9.7-42 Comparison of Effects on Lake N11 Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-43 Comparison of Effects on Lake N11 Stages – Closure



m = metres

Table 9.7-77 Monthly Mean Discharges at the Lake N11 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			June	July	August	September	October
Wet	100	baseline	443,000	293,000	221,000	258,000	50,700
		closure	395,000	201,000	221,000	268,000	53,600
	10	baseline	359,000	215,000	147,000	123,000	28,200
		closure	320,000	144,000	146,000	127,000	29,300
Median	2	baseline	257,000	141,000	91,400	56,800	14,700
		closure	228,000	85,100	88,800	58,600	15,100
Dry	10	baseline	155,000	83,600	58,800	33,300	8,740
		closure	138,000	37,400	54,400	34,300	8,890
	100	baseline	71,900	46,900	42,600	25,900	6,400
		closure	65,000	5,180	36,800	26,700	6,520

m^3/d = cubic metres per day.

Table 9.7-78 Representative Discharges at the Basin N11 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	9.77	747,000	630,000	179,000	198,000	215,000
		closure	9.93	751,000	600,000	106,000	145,000	175,000
	10	baseline	8.22	630,000	538,000	102,000	125,000	152,000
		closure	7.96	607,000	501,000	75,000	106,000	122,000
Median	2	baseline	6.00	464,000	404,000	55,500	75,000	98,700
		closure	5.62	434,000	373,000	46,200	69,700	80,500
Dry	10	baseline	3.36	269,000	240,000	33,900	48,500	64,200
		closure	3.38	266,000	237,000	25,100	42,800	54,700
	100	baseline	0.85	85,300	81,700	25,200	36,500	45,200
		closure	1.61	132,000	119,000	12,100	26,300	41,200

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-79 Monthly Mean Stages at the Lake N11 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			June	July	August	September	October
Wet	100	baseline	0.903	0.824	0.774	0.801	0.558
		closure	0.881	0.758	0.774	0.808	0.565
	10	baseline	0.862	0.769	0.707	0.680	0.490
		closure	0.840	0.704	0.706	0.684	0.494
Median	2	baseline	0.800	0.700	0.636	0.572	0.424
		closure	0.779	0.626	0.632	0.576	0.426
Dry	10	baseline	0.715	0.624	0.577	0.508	0.378
		closure	0.697	0.522	0.567	0.512	0.379
	100	baseline	0.603	0.548	0.537	0.481	0.352
		closure	0.590	0.336	0.520	0.484	0.354

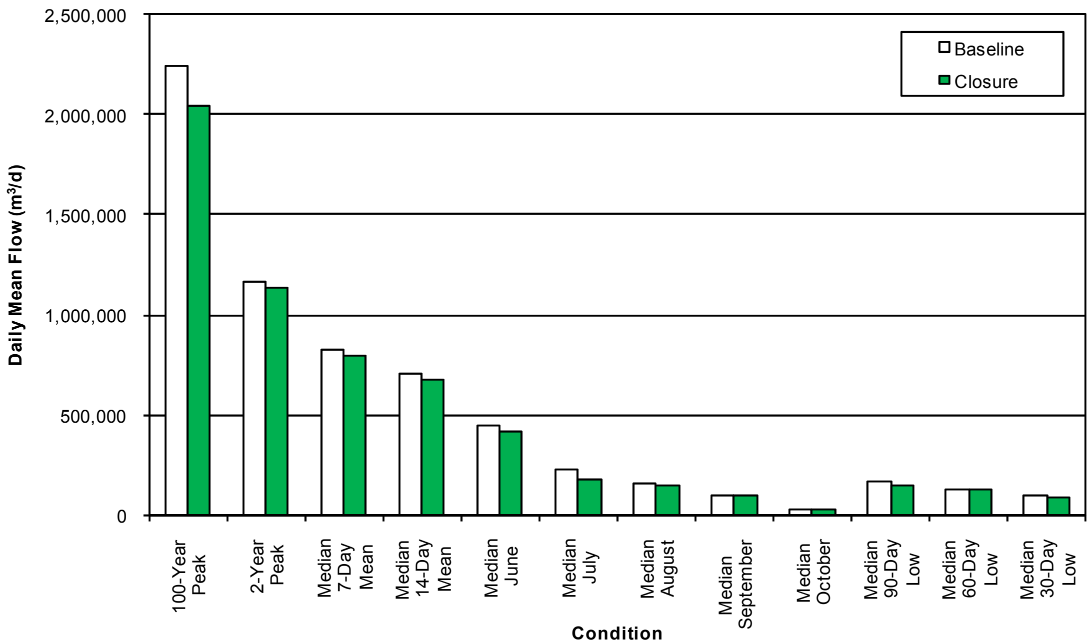
m = metre.

Table 9.7-80 Representative Stages at the Basin N11 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.043	1.015	0.977	0.739	0.755	0.769
		closure	1.046	1.016	0.966	0.657	0.705	0.735
	10	baseline	1.003	0.977	0.943	0.652	0.682	0.712
		closure	0.996	0.969	0.928	0.609	0.657	0.678
Median	2	baseline	0.935	0.913	0.885	0.569	0.609	0.647
		closure	0.922	0.899	0.869	0.547	0.599	0.618
Dry	10	baseline	0.822	0.809	0.788	0.510	0.553	0.588
		closure	0.823	0.807	0.786	0.477	0.537	0.568
	100	baseline	0.606	0.626	0.620	0.478	0.519	0.544
		closure	0.698	0.690	0.675	0.406	0.482	0.533

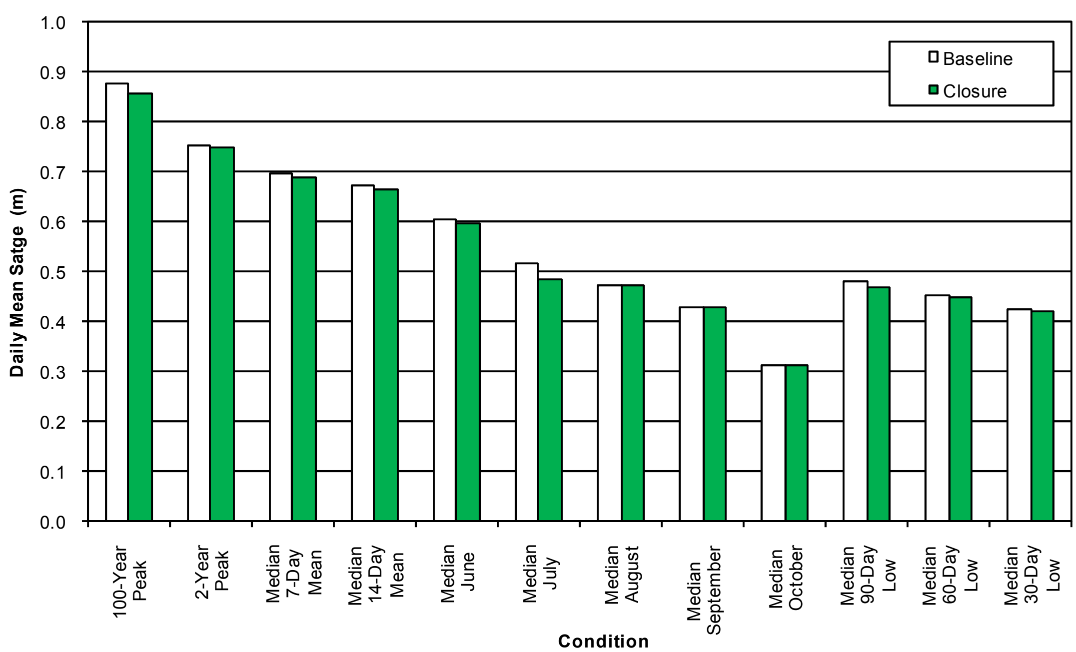
m = metre.

Figure 9.7-44 Comparison of Effects on Lake N1 Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-45 Comparison of Effects on Lake N1 Stages – Closure



m = metres.

Table 9.7-81 Monthly Mean Discharges at the Lake N1 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			June	July	August	September	October
Wet	100	baseline	737,000	470,000	370,000	398,000	84,100
		closure	691,000	375,000	375,000	415,000	87,700
	10	baseline	609,000	348,000	248,000	204,000	47,600
		closure	570,000	265,000	247,000	211,000	49,200
Median	2	baseline	444,000	229,000	156,000	99,000	25,100
		closure	417,000	172,000	151,000	101,000	25,600
Dry	10	baseline	270,000	138,000	102,000	56,600	14,600
		closure	259,000	110,000	97,300	57,800	14,800
	100	baseline	121,000	79,300	75,400	41,600	10,300
		closure	127,000	75,100	70,900	42,700	10,500

m^3/d = cubic metres per day.

Table 9.7-82 Representative Discharges at the Lake N1 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	25.90	1,250,000	1,050,000	285,000	333,000	353,000
		closure	23.60	1,250,000	1,020,000	229,000	294,000	305,000
	10	baseline	19.90	1,080,000	910,000	171,000	212,000	251,000
		closure	18.60	1,050,000	878,000	149,000	195,000	219,000
Median	2	baseline	13.50	827,000	704,000	95,600	128,000	166,000
		closure	13.10	797,000	676,000	90,800	124,000	148,000
Dry	10	baseline	8.22	527,000	441,000	57,200	83,800	109,000
		closure	8.27	527,000	443,000	57,700	83,600	102,000
	100	baseline	4.51	242,000	174,000	40,500	63,800	77,100
		closure	4.74	294,000	226,000	41,800	64,500	77,500

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-83 Monthly Mean Stages at the Lake N1 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			June	July	August	September	October
Wet	100	baseline	0.677	0.610	0.577	0.587	0.411
		closure	0.667	0.579	0.579	0.593	0.415
	10	baseline	0.648	0.569	0.527	0.504	0.360
		closure	0.638	0.535	0.526	0.507	0.363
Median	2	baseline	0.602	0.517	0.473	0.426	0.311
		closure	0.594	0.484	0.470	0.428	0.312
Dry	10	baseline	0.537	0.460	0.429	0.375	0.274
		closure	0.532	0.437	0.425	0.377	0.275
	100	baseline	0.446	0.405	0.400	0.349	0.253
		closure	0.451	0.400	0.395	0.351	0.254

m = metre.

Table 9.7-84 Representative Stages at the Basin N1 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.874	0.764	0.734	0.544	0.564	0.571
		closure	0.855	0.764	0.729	0.517	0.548	0.552
	10	baseline	0.822	0.739	0.710	0.483	0.508	0.528
		closure	0.810	0.734	0.705	0.468	0.498	0.512
Median	2	baseline	0.752	0.695	0.670	0.423	0.452	0.480
		closure	0.747	0.689	0.663	0.418	0.449	0.468
Dry	10	baseline	0.671	0.626	0.601	0.376	0.410	0.436
		closure	0.672	0.626	0.602	0.377	0.410	0.429
	100	baseline	0.584	0.524	0.485	0.347	0.385	0.403
		closure	0.591	0.548	0.516	0.350	0.386	0.403

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake N11 Outlet Flows: The water balance results for Lake N11 show that during closure, monthly mean flows will decrease in proportion to the flow diverted to refill Kennady Lake. The 2-year flood discharge during operation will decrease by approximately 6% above the baseline value, and the 100-year flood discharge will be approximately equal to baseline. Low flows will also decrease by 7% to 18%.

Lake N11 Water Levels: Lake N11 water levels are also expected to decrease during closure. The 2-year flood level is expected to decrease by approximately 0.013 m, the 100-year flood level remain approximately the same as for baseline, and monthly mean stages to decrease by 0.021 m (June), 0.074 m (July), 0.004 m (August), under median conditions, with smaller increases in September and October.

Lake N11 and Outlet Channel/Bank Stability: No effects on Lake N11 and outlet channel or bank stability are expected during closure, because flood discharges and water levels will be equal to or reduced from baseline.

Lake N1 Outlet Flows: The water balance results for Lake N1 show that during closure, monthly mean flows will decrease in proportion to the flow diverted to refill Kennady Lake. The 2-year flood discharge during closure will decrease by approximately 3% below the baseline value, and the 100-year flood discharge will decrease by approximately 9%. Low flows will also increase by 3% to 11%.

Lake N1 Water Levels: Lake N1 water levels are also expected to decrease during closure. The 2-year flood level is expected to decrease by approximately 0.005 m, the 100-year flood level by 0.019 m, and monthly mean stages by 0.008 m (June), 0.033 m (July), 0.003 m (August), under median conditions, with smaller increases in September and October.

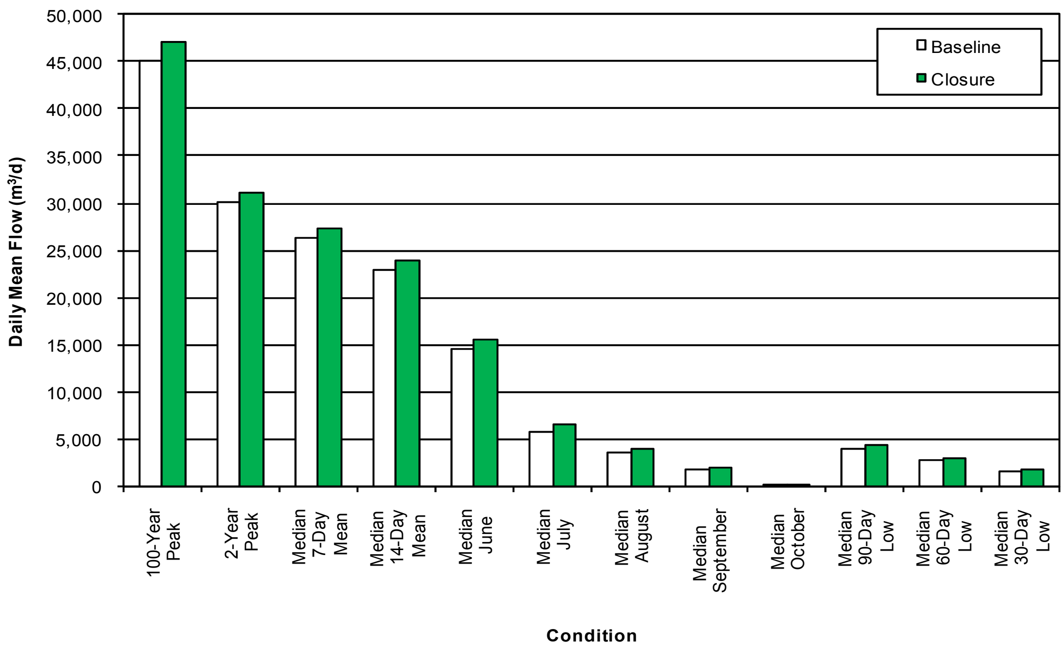
Lake N1 and Outlet Channel/Bank Stability: No effects on Lake N1 and Outlet channel or bank stability are expected during closure, because flood discharges and water levels will be equal to or reduced from baseline.

Lake N9 to Lake N1 Inflow (Watershed A Diversion)

The water balance model for the Project examined this receiving watershed by modeling the flow diverted from Watershed A into Lake N9, a tributary of Lake N6. Below Lake N6, Lake N5, Lake N3 (including Lake N4, lumped for the same reasons) and Lake N2 were modeled.

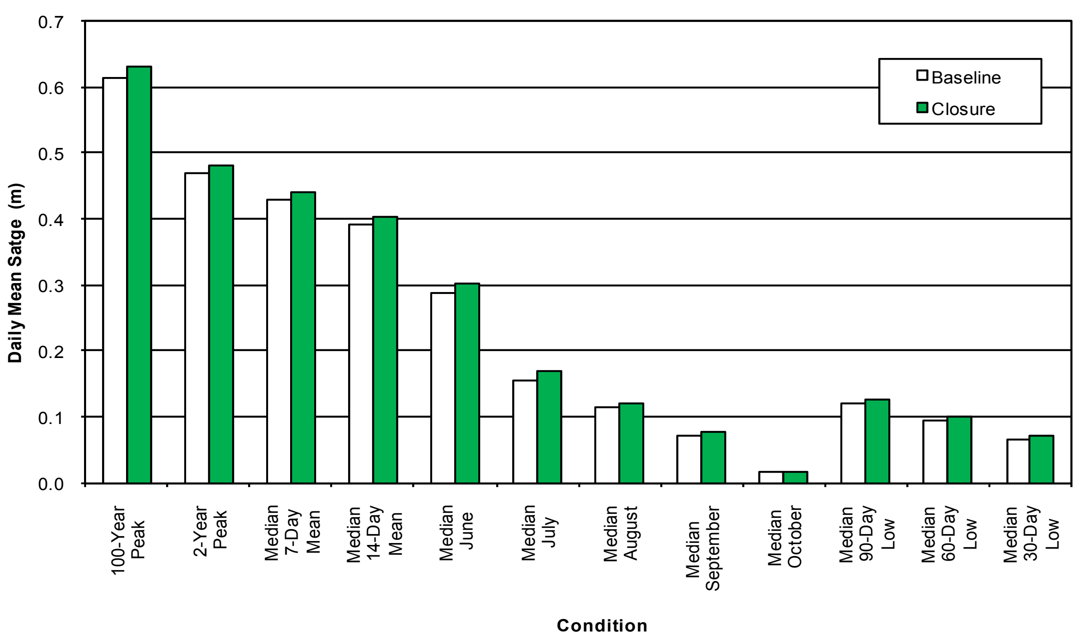
Project effects on Lake N9, which receives the A watershed diversion, are presented in Figures 9.7-46 to 9.7-47 and Tables 9.7-85 to 9.7-88, Project effects on Lake N6 are presented in Figures 9.7-48 to 9.7-49 and Tables 9.7-89 to 9.7-92, and Project effects on Lake N2, upstream of its confluence with Lake N1, are presented in Figures 9.7-50 to 9.7-51 and Tables 9.7-93 to 9.7-96.

Figure 9.7-46 Comparison of Effects on Lake N9 Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-47 Comparison of Effects on Lake N9 Stages – Closure



m = metres.

Table 9.7-85 Monthly Mean Discharges at the Lake N9 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	22,600	13,900	10,700	12,000	1,340
		closure	24,800	15,800	12,300	13,500	1,570
	10	baseline	19,300	9,540	6,580	5,280	677
		closure	20,900	11,000	7,390	5,800	767
Median	2	baseline	14,500	5,670	3,580	1,810	195
		closure	15,500	6,580	3,970	1,970	215
Dry	10	baseline	8,690	2,960	1,920	507	0
		closure	9,260	3,420	2,150	570	0
	100	baseline	3,010	1,370	1,120	73	0
		closure	3,390	1,520	1,310	118	0

m^3/d = cubic metres per day.

Table 9.7-86 Derived Representative Discharges at the Lake N9 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	0.52	38,100	32,300	7,810	9,920	9,650
		closure	0.55	40,600	35,000	8,980	11,300	12,000
	10	baseline	0.45	33,400	28,800	3,980	5,390	6,440
		closure	0.48	35,900	31,200	4,490	6,050	7,350
Median	2	baseline	0.35	26,300	22,900	1,610	2,670	3,860
		closure	0.36	27,300	23,900	1,800	2,950	4,260
Dry	10	baseline	0.23	17,100	14,800	506	1,440	2,230
		closure	0.23	17,600	15,300	576	1,590	2,540
	100	baseline	0.11	7,830	5,810	58	951	1,370
		closure	0.11	8,340	6,930	97	1,060	2,080

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-87 Monthly Mean Stages at Lake N9 – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.387	0.280	0.235	0.254	0.059
		closure	0.412	0.305	0.258	0.275	0.065
	10	baseline	0.348	0.218	0.170	0.147	0.037
		closure	0.367	0.240	0.184	0.156	0.041
Median	2	baseline	0.288	0.154	0.113	0.072	0.016
		closure	0.301	0.170	0.121	0.076	0.017
Dry	10	baseline	0.205	0.100	0.075	0.031	-
		closure	0.214	0.110	0.081	0.033	-
	100	baseline	0.101	0.060	0.052	0.008	-
		closure	0.109	0.064	0.058	0.012	-

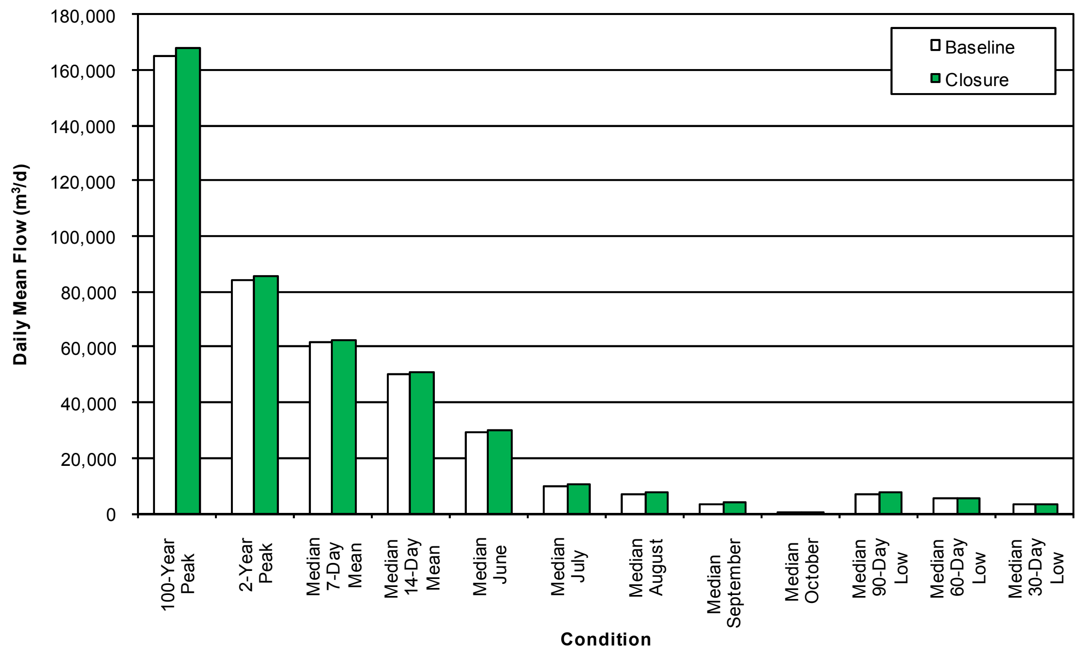
m = metre.

Table 9.7-88 Derived Representative Stages at Lake N9 – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.613	0.548	0.491	0.191	0.224	0.220
		closure	0.632	0.572	0.518	0.209	0.244	0.254
	10	baseline	0.557	0.502	0.455	0.122	0.149	0.168
		closure	0.579	0.527	0.480	0.132	0.161	0.183
Median	2	baseline	0.469	0.428	0.391	0.067	0.093	0.119
		closure	0.480	0.439	0.402	0.072	0.100	0.127
Dry	10	baseline	0.352	0.321	0.292	0.031	0.062	0.083
		closure	0.357	0.328	0.298	0.034	0.066	0.090
	100	baseline	0.217	0.191	0.157	0.007	0.047	0.060
		closure	0.221	0.199	0.176	0.010	0.050	0.079

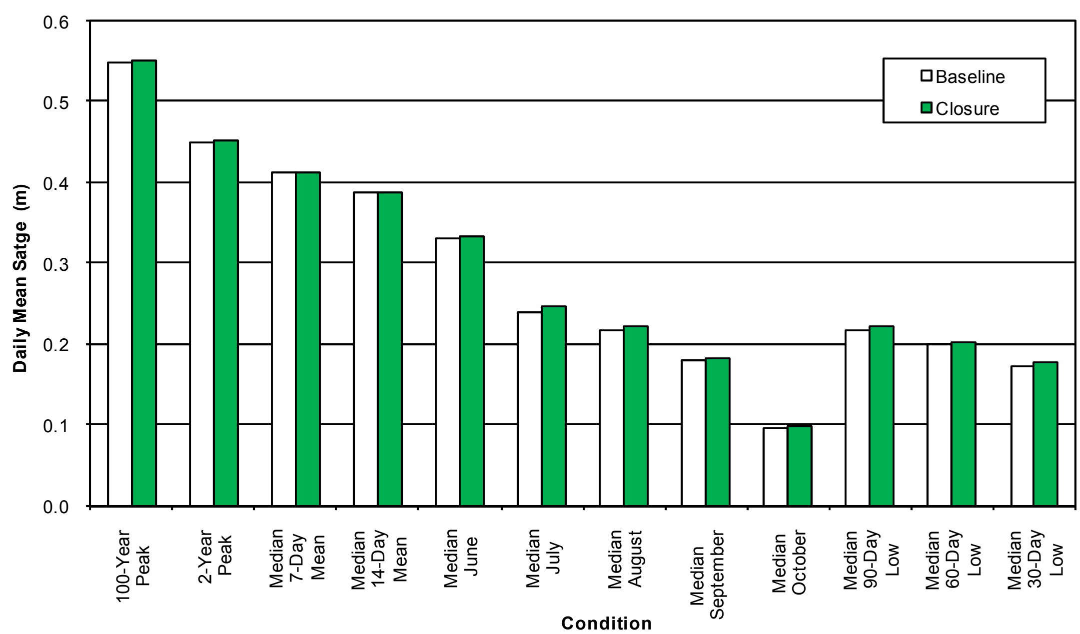
m = metre.

Figure 9.7-48 Comparison of Effects on Lake N6 Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-49 Comparison of Effects on Lake N6 Stages – Closure



m = metres.

Table 9.7-89 Monthly Mean Discharges at the Lake N6 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	44,300	25,100	22,200	22,200	3,600
		closure	46,200	26,900	23,900	23,500	3,830
	10	baseline	38,800	16,700	13,100	9,900	1,430
		closure	40,200	18,200	14,000	10,500	1,520
Median	2	baseline	29,400	9,740	6,980	3,650	431
		closure	30,300	10,700	7,480	3,870	465
Dry	10	baseline	15,800	5,140	3,860	1,330	102
		closure	16,500	5,680	4,200	1,440	112
	100	baseline	329	2,590	2,500	576	5
		closure	1,320	2,810	2,780	644	8

m^3/d = cubic metres per day.

Table 9.7-90 Derived Representative Discharges at the Lake N6 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	1.91	91,800	70,600	13,400	19,300	18,200
		closure	1.94	92,700	72,000	14,600	20,700	19,500
	10	baseline	1.44	79,600	63,000	7,180	10,400	11,900
		closure	1.46	80,500	64,100	7,790	11,100	12,900
Median	2	baseline	0.98	61,800	50,000	3,220	5,240	7,140
		closure	0.99	62,600	50,900	3,490	5,630	7,730
Dry	10	baseline	0.60	40,400	31,500	1,330	3,040	4,290
		closure	0.61	40,900	31,900	1,440	3,280	4,630
	100	baseline	0.35	19,700	10,500	547	2,220	2,840
		closure	0.36	19,800	10,700	601	2,400	3,040

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-91 Monthly Mean Stages at Lake N6 – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	0.373	0.315	0.304	0.304	0.178
		closure	0.377	0.322	0.311	0.309	0.181
	10	baseline	0.358	0.279	0.260	0.239	0.135
		closure	0.362	0.287	0.265	0.244	0.138
Median	2	baseline	0.330	0.238	0.216	0.178	0.095
		closure	0.333	0.245	0.220	0.181	0.097
Dry	10	baseline	0.275	0.197	0.181	0.132	0.062
		closure	0.278	0.203	0.186	0.136	0.064
	100	baseline	0.088	0.161	0.160	0.103	0.025
		closure	0.132	0.165	0.165	0.107	0.029

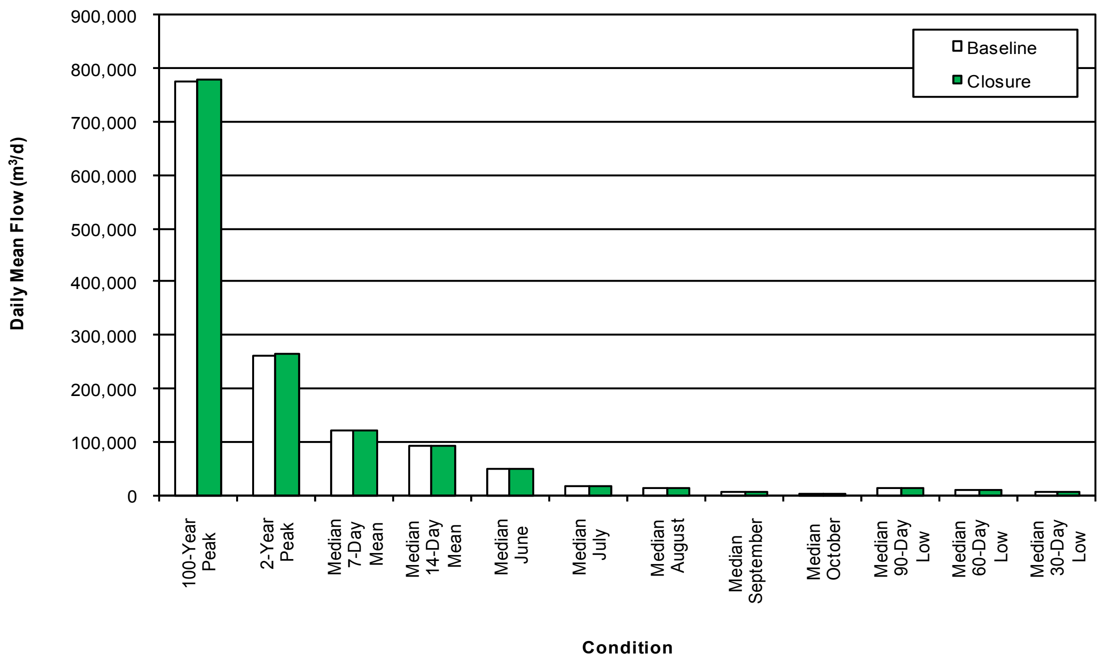
m = metre.

Table 9.7-92 Derived Representative Stages at Lake N6 – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.549	0.462	0.427	0.262	0.292	0.287
		closure	0.552	0.463	0.430	0.269	0.298	0.292
	10	baseline	0.505	0.443	0.413	0.218	0.243	0.253
		closure	0.507	0.444	0.415	0.223	0.248	0.259
Median	2	baseline	0.450	0.411	0.386	0.172	0.198	0.217
		closure	0.452	0.413	0.388	0.176	0.203	0.223
Dry	10	baseline	0.391	0.363	0.337	0.132	0.169	0.187
		closure	0.392	0.364	0.338	0.136	0.173	0.191
	100	baseline	0.334	0.293	0.244	0.102	0.154	0.166
		closure	0.334	0.294	0.245	0.105	0.158	0.169

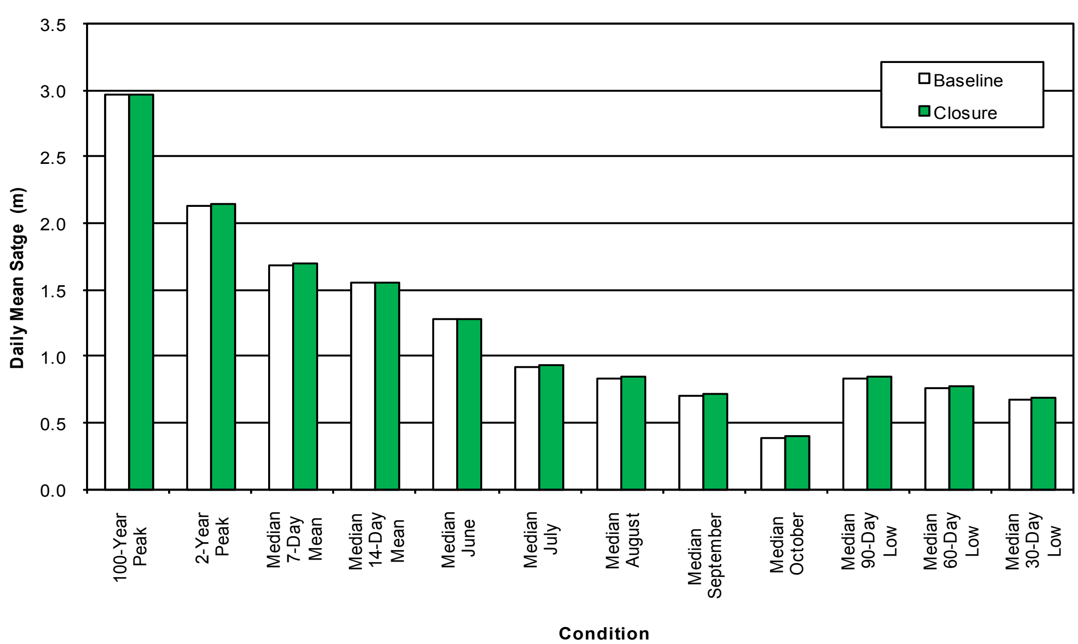
m = metre.

Figure 9.7-50 Comparison of Effects on Lake N2 Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-51 Comparison of Effects on Lake N2 Stages – Closure



m = metres.

Table 9.7-93 Monthly Mean Discharges at the Lake N2 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	74,000	40,000	33,500	36,300	6,640
		closure	75,700	41,800	35,200	37,600	6,890
	10	baseline	63,800	27,200	20,700	17,000	2,840
		closure	65,000	28,700	21,800	17,600	2,990
Median	2	baseline	47,900	16,200	11,600	6,710	964
		closure	48,600	17,300	12,300	7,040	1,030
Dry	10	baseline	27,100	8,800	6,590	2,710	282
		closure	27,700	9,430	7,070	2,880	304
	100	baseline	5,550	4,580	4,230	1,330	63
		closure	6,350	4,860	4,630	1,440	69

m^3/d = cubic metres per day.

Table 9.7-94 Derived Representative Discharges at the Lake N2 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	8.96	159,000	123,000	22,300	30,700	29,400
		closure	9.00	160,000	124,000	23,600	32,000	30,900
	10	baseline	5.62	146,000	112,000	12,400	17,100	19,700
		closure	5.67	147,000	113,000	13,100	17,900	20,700
Median	2	baseline	3.03	121,000	91,700	5,890	8,960	12,000
		closure	3.07	122,000	92,600	6,270	9,490	12,700
Dry	10	baseline	1.49	81,300	60,200	2,680	5,350	7,360
		closure	1.51	82,000	60,800	2,870	5,690	7,800
	100	baseline	0.70	30,400	21,800	1,310	3,950	4,960
		closure	0.71	30,900	22,300	1,410	4,200	5,240

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-95 Monthly Mean Stages at Lake N2 – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			Jun	Jul	Aug	Sep	Oct
Wet	100	baseline	1.454	1.206	1.143	1.171	0.700
		closure	1.464	1.223	1.161	1.184	0.708
	10	baseline	1.390	1.073	0.988	0.931	0.541
		closure	1.398	1.091	1.004	0.941	0.550
Median	2	baseline	1.274	0.917	0.829	0.702	0.390
		closure	1.280	0.936	0.844	0.713	0.398
Dry	10	baseline	1.072	0.762	0.698	0.534	0.269
		closure	1.079	0.779	0.713	0.543	0.275
	100	baseline	0.663	0.625	0.611	0.430	0.171
		closure	0.691	0.637	0.628	0.440	0.176

m = metre.

Table 9.7-96 Derived Representative Stages at Lake N2 – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	2.962	1.833	1.696	1.011	1.113	1.099
		closure	2.966	1.836	1.700	1.028	1.128	1.116
	10	baseline	2.571	1.786	1.648	0.846	0.932	0.973
		closure	2.578	1.790	1.653	0.860	0.945	0.988
Median	2	baseline	2.132	1.687	1.551	0.675	0.767	0.838
		closure	2.141	1.692	1.556	0.688	0.780	0.852
Dry	10	baseline	1.719	1.496	1.366	0.532	0.656	0.722
		closure	1.726	1.500	1.370	0.543	0.668	0.735
	100	baseline	1.367	1.110	1.004	0.428	0.598	0.641
		closure	1.372	1.116	1.011	0.438	0.609	0.652

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake N9 Outlet Flows: The water balance results for Lake N9 show that during closure, monthly mean flows will increase in proportion to the additional flow from the diverted A watershed. The 2-year flood discharge during closure will increase by approximately 3% above the baseline value, and the 100-year flood discharge will increase by approximately 6%. Low flows will also increase by 10% to 12%.

Lake N9 Water Levels: Lake N9 water levels are also expected to increase during closure. The 2-year flood level is expected to increase by approximately 0.011 m, the 100-year flood level by 0.019 m, and monthly mean stages by 0.013 m (June), 0.016 m (July), 0.008 m (August), 0.004 m (September) and 0.001 m (October), under median conditions.

Lake N9 and Outlet Channel/Bank Stability: No effects on Lake N9 and outlet channel or bank stability are expected during closure, because increases in flood magnitude are small relative to the existing flood regime.

Lake N6 Outlet Flows: The water balance results for Lake N6 show that during closure, monthly mean flows will increase in proportion to the additional flow from the diverted A watershed. The 2-year flood discharge during closure will increase by approximately 1% above the baseline value, and the 100-year flood discharge will increase by approximately 2%. Low flows will also increase by 7% to 8%.

Lake N6 Water Levels: Lake N6 water levels are also expected to increase during closure. The 2-year flood level is expected to increase by approximately 0.002 m, the 100-year flood level by 0.003 m, and monthly mean stages by 0.003 m (June), 0.007 m (July), 0.004 m (August), 0.003 m (September) and 0.002 m (October), under median conditions.

Lake N6 and Outlet Channel/Bank Stability: No effects on Lake N6 and outlet channel or bank stability are expected during closure, because increases in flood magnitude are small relative to the existing flood regime.

Lake N2 Outlet Flows: The water balance results for Lake N2 show that during closure, monthly mean flows will increase in proportion to the additional flow from the diverted A watershed. The 2-year flood discharge during closure will increase by approximately 1% above the baseline value, and the 100-year flood discharge by less than 1%. Low flows will also increase by 6%.

Lake N2 Water Levels: Lake N2 water levels are also expected to increase during closure. The 2-year flood level is expected to increase by approximately 0.009 m, the 100-year flood level by 0.004 m, and monthly mean stages by 0.006 m (June), 0.019 m (July), 0.015 m (August), 0.011 m (September) and 0.008 m (October), under median conditions.

Lake N2 and Outlet Channel/Bank Stability: No effects on Lake N2 and outlet channel or bank stability are expected during closure, because increases in flood magnitude are small relative to the existing flood regime.

Kennady Lake Area 8 Outlet to Lake M1 Outlet

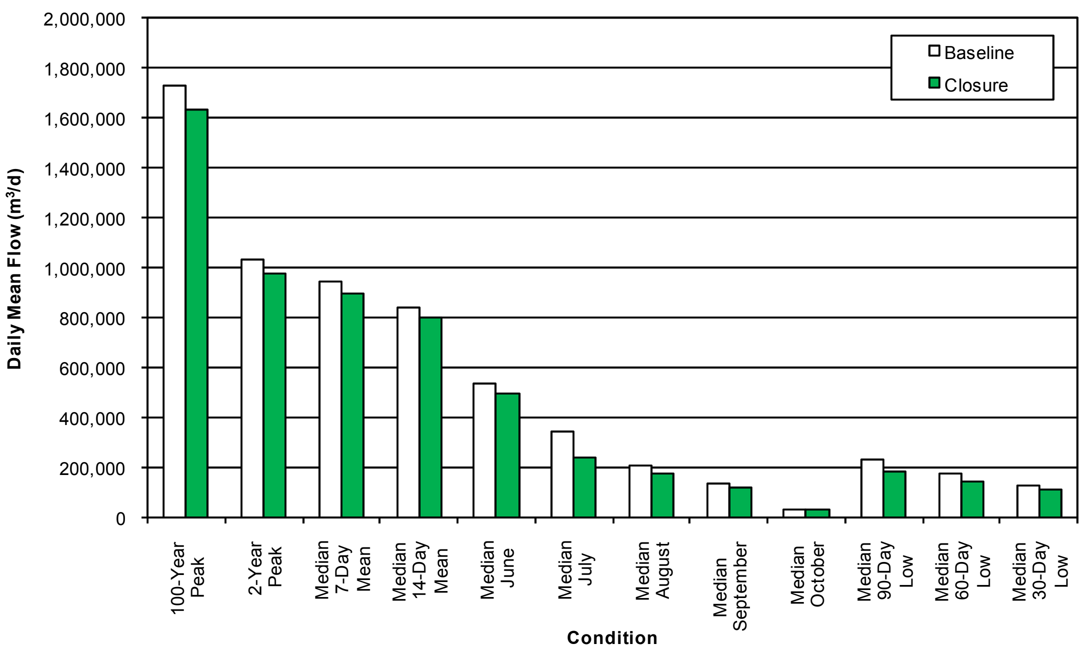
Effects of the Project on the reach from the Area 8 outlet to the Lake M1 outlet during closure are identical to the effects during operation, as presented in Section 9.7.3.3.

Lake 410 to Kirk Lake Outlet

Effects on the reach from Lake 410 to the Kirk Lake outlet during closure are due to the abstraction of flow from Lake N11 for Kennady Lake refilling and the removal of flow from 77% of the natural drainage area (Areas 2 to 7) during the refilling period of Kennady Lake.

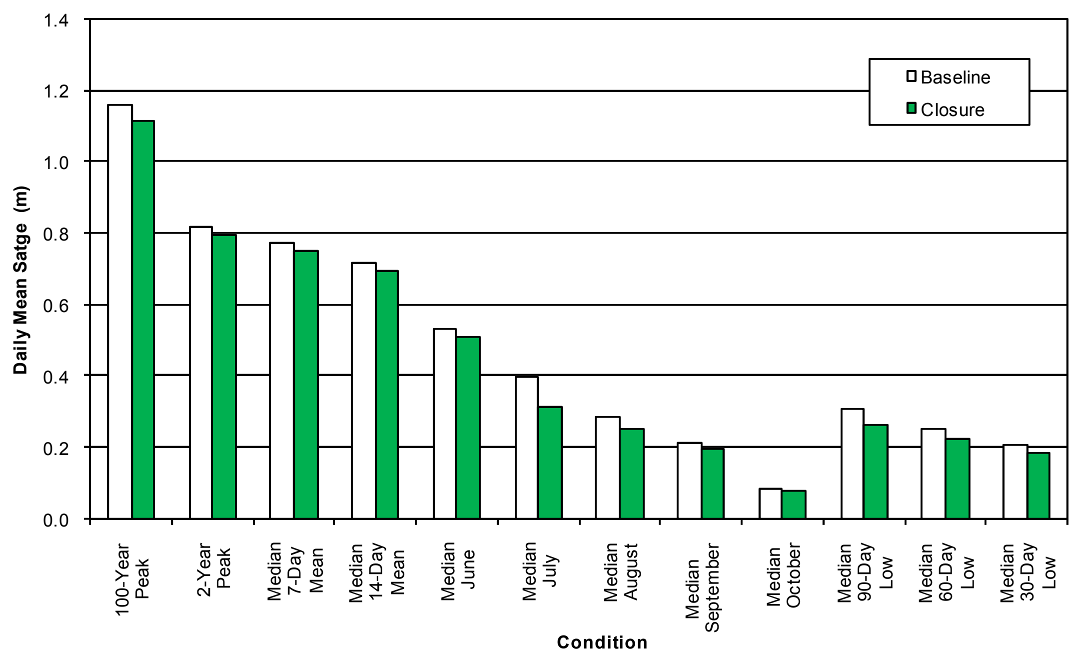
The water balance model for the Project examined all downstream waterbodies between Lake 410 and the Kirk Lake outlet channel. Project effects on Lake 410 and outlet during refilling are shown in Figures 9.7-52 and 9.7-53, and summarized in Tables 9.7-97 to 9.7-100. Project effects on Kirk Lake during refilling are shown in Figures 9.7-54 and 9.7-55, and summarized in Tables 9.7-101 to 9.7-104.

Figure 9.7-52 Comparison of Effects on Lake 410 Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-53 Comparison of Effects on Lake 410 Stages – Closure



m = metres.

Table 9.7-97 Monthly Mean Discharges at the Lake 410 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			June	July	August	September	October
Wet	100	baseline	934,000	678,000	475,000	587,000	135,000
		closure	852,000	518,000	427,000	531,000	123,000
	10	baseline	759,000	514,000	329,000	278,000	70,700
		closure	691,000	371,000	283,000	262,000	63,200
Median	2	baseline	537,000	344,000	210,000	135,000	32,700
		closure	499,000	240,000	172,000	120,000	28,800
Dry	10	baseline	329,000	203,000	132,000	73,900	16,000
		closure	313,000	148,000	105,000	64,600	13,900
	100	baseline	190,000	106,000	90,100	49,800	9,660
		closure	164,000	94,600	71,200	45,700	8,400

m^3/d = cubic metres per day.

Table 9.7-98 Representative Discharges at the Lake 410 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	20.00	1,420,000	1,240,000	404,000	443,000	491,000
		closure	18.90	1,400,000	1,190,000	298,000	364,000	388,000
	10	baseline	16.50	1,230,000	1,080,000	237,000	287,000	355,000
		closure	15.60	1,190,000	1,030,000	187,000	237,000	277,000
Median	2	baseline	11.90	942,000	837,000	128,000	173,000	234,000
		closure	11.30	897,000	796,000	108,000	144,000	184,000
Dry	10	baseline	7.11	580,000	523,000	74,200	108,000	150,000
		closure	7.00	572,000	515,000	64,600	92,700	122,000
	100	baseline	3.03	219,000	200,000	50,900	77,500	100,000
		closure	3.37	276,000	246,000	44,600	68,100	87,900

Q =discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-99 Monthly Mean Stages at the Lake 410 Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			June	July	August	September	October
Wet	100	baseline	0.769	0.621	0.490	0.564	0.212
		closure	0.723	0.519	0.456	0.527	0.199
	10	baseline	0.669	0.516	0.383	0.343	0.138
		closure	0.629	0.415	0.347	0.329	0.128
Median	2	baseline	0.531	0.395	0.284	0.212	0.082
		closure	0.506	0.311	0.249	0.196	0.076
Dry	10	baseline	0.383	0.278	0.209	0.142	0.051
		closure	0.371	0.225	0.179	0.130	0.047
	100	baseline	0.266	0.180	0.162	0.109	0.036
		closure	0.241	0.167	0.138	0.103	0.033

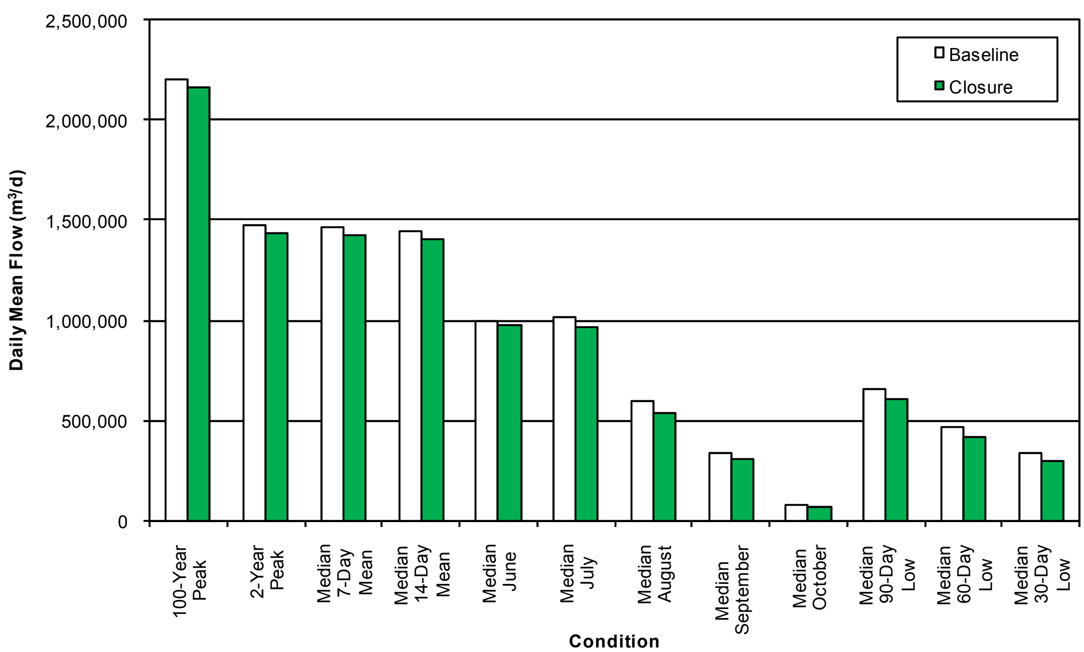
m = metre.

Table 9.7-100 Representative Stages at the Lake 410 Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	1.158	1.016	0.928	0.440	0.467	0.501
		closure	1.115	1.007	0.903	0.359	0.410	0.428
	10	baseline	1.019	0.923	0.847	0.308	0.350	0.403
		closure	0.982	0.903	0.820	0.263	0.308	0.342
Median	2	baseline	0.819	0.773	0.714	0.204	0.250	0.305
		closure	0.792	0.748	0.691	0.182	0.221	0.260
Dry	10	baseline	0.581	0.559	0.522	0.142	0.182	0.227
		closure	0.575	0.554	0.517	0.130	0.165	0.198
	100	baseline	0.329	0.292	0.275	0.110	0.146	0.173
		closure	0.353	0.341	0.316	0.101	0.134	0.159

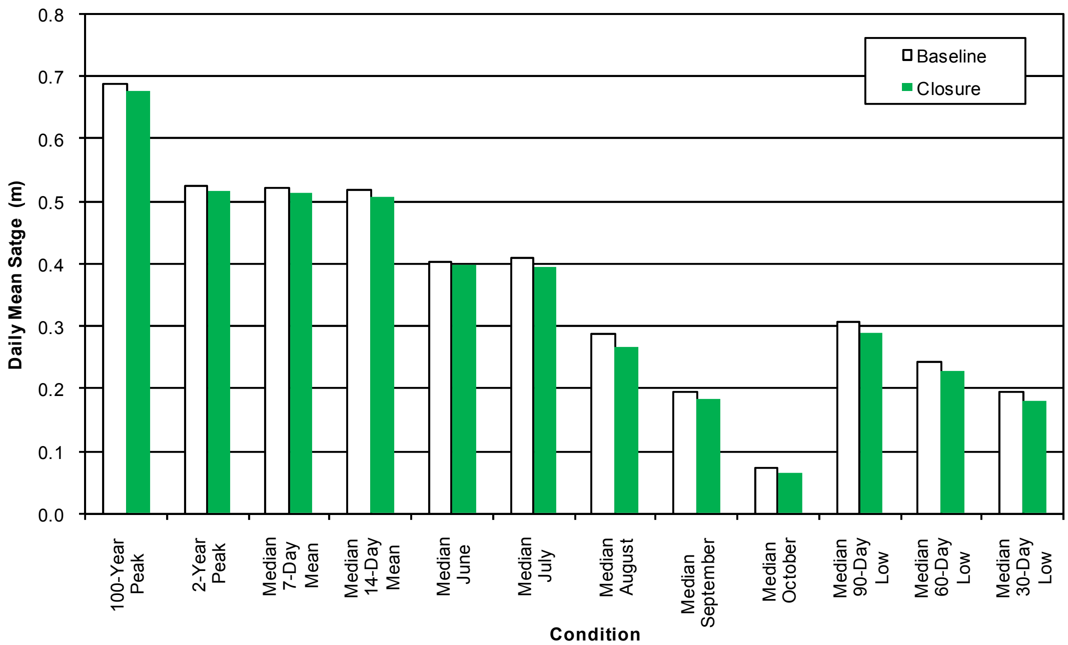
m = metre.

Figure 9.7-54 Comparison of Effects on Kirk Lake Outlet Discharges – Closure



m^3/d = cubic metres per day.

Figure 9.7-55 Comparison of Effects on Kirk Lake Stages – Closure



m = metres.

Table 9.7-101 Monthly Mean Discharges at the Kirk Lake Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Discharge (m^3/d)				
			June	July	August	September	October
Wet	100	baseline	1,850,000	1,730,000	1,250,000	1,370,000	420,000
		closure	1,820,000	1,600,000	1,110,000	1,140,000	382,000
	10	baseline	1,450,000	1,420,000	916,000	676,000	188,000
		closure	1,430,000	1,330,000	812,000	632,000	180,000
Median	2	baseline	995,000	1,020,000	596,000	332,000	75,700
		closure	975,000	964,000	533,000	304,000	66,800
Dry	10	baseline	562,000	607,000	349,000	161,000	24,500
		closure	546,000	582,000	321,000	144,000	20,200
	100	baseline	226,000	255,000	191,000	85,200	4,760
		closure	216,000	254,000	188,000	77,200	3,290

m^3/d = cubic metres per day.

Table 9.7-102 Representative Discharges at the Kirk Lake Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Q (m^3/s)	7-Day Mean Peak Q (m^3/d)	14-Day Mean Peak Q (m^3/d)	30-Day Low Flow Q (m^3/d)	60-Day Low Flow Q (m^3/d)	90-Day Low Flow Q (m^3/d)
Wet	100	baseline	25.50	2,160,000	2,100,000	1,050,000	1,140,000	1,290,000
		closure	25.00	2,130,000	2,070,000	950,000	1,020,000	1,170,000
	10	baseline	22.10	1,890,000	1,850,000	636,000	774,000	981,000
		closure	21.70	1,850,000	1,810,000	573,000	693,000	894,000
Median	2	baseline	17.10	1,460,000	1,440,000	333,000	467,000	660,000
		closure	16.60	1,420,000	1,400,000	299,000	420,000	608,000
Dry	10	baseline	10.60	902,000	884,000	163,000	262,000	395,000
		closure	10.40	886,000	868,000	147,000	240,000	373,000
	100	baseline	3.98	321,000	290,000	82,100	148,000	213,000
		closure	4.24	343,000	310,000	74,400	140,000	213,000

Q = discharge; m^3/s = cubic metres per second; m^3/d = cubic metres per day.

Table 9.7-103 Monthly Mean Stages at the Kirk Lake Outlet – Closure

Condition	Return Period (years)	Snapshot	Monthly Mean Stage (m)				
			June	July	August	September	October
Wet	100	baseline	0.610	0.584	0.470	0.500	0.227
		closure	0.604	0.554	0.434	0.442	0.213
	10	baseline	0.519	0.512	0.382	0.312	0.133
		closure	0.514	0.490	0.353	0.298	0.129
Median	2	baseline	0.404	0.410	0.287	0.194	0.072
		closure	0.398	0.395	0.266	0.183	0.067
Dry	10	baseline	0.276	0.290	0.201	0.120	0.034
		closure	0.271	0.282	0.190	0.111	0.030
	100	baseline	0.150	0.163	0.134	0.078	0.011
		closure	0.146	0.162	0.133	0.073	0.009

m = metre.

Table 9.7-104 Representative Stages at the Kirk Lake Outlet – Closure

Condition	Return Period (years)	Snapshot	Peak Daily Stage (m)	7-Day Mean Peak Stage (m)	14-Day Mean Peak Stage (m)	30-Day Low Flow Stage (m)	60-Day Low Flow Stage (m)	90-Day Low Flow Stage (m)
Wet	100	baseline	0.686	0.677	0.664	0.418	0.442	0.480
		closure	0.677	0.671	0.658	0.391	0.410	0.450
	10	baseline	0.623	0.619	0.610	0.300	0.342	0.400
		closure	0.616	0.610	0.602	0.279	0.317	0.376
Median	2	baseline	0.525	0.521	0.517	0.195	0.244	0.307
		closure	0.515	0.512	0.507	0.181	0.227	0.291
Dry	10	baseline	0.382	0.378	0.373	0.121	0.166	0.218
		closure	0.377	0.374	0.369	0.113	0.156	0.210
	100	baseline	0.199	0.190	0.177	0.077	0.113	0.144
		closure	0.207	0.198	0.186	0.072	0.109	0.144

m = metre.

Summary of Effects on Flows, Water Levels and Channel/Bank Stability

Lake 410 Outlet Flows: The water balance results for Lake 410 show that during closure, monthly mean flows will decrease, as withdrawals from Lake N11 for Kennady Lake refilling combined with the continued closed-circuiting of Kennady Lake upstream of Area 8, are greater than increased inflow to Lake N1 due to the Lake A3 diversion. The 2-year flood discharge during closure will decrease by approximately 5% from the baseline value, and the 100-year flood discharge will decrease by approximately 6%. Low flows will also decrease by 16% to 21%.

Lake 410 Water Levels: Lake 410 water levels are also expected to decrease during closure. The 2-year flood level is expected to decrease by approximately 0.027 m, the 100-year flood level by 0.043 m, and monthly mean stages by 0.025 m (June), 0.084 m (July), 0.035 m (August), 0.016 m (September) and 0.006 m (October), under median conditions.

Lake 410 and Outlet Channel/Bank Stability: No effects on Lake 410 and Outlet channel or bank stability are expected during operation, because flood discharges and water levels will be reduced from baseline.

Kirk Lake Outlet Flows: The water balance results for Kirk Lake show that during closure, monthly mean flows will decrease, as withdrawals from Lake N11 for Kennady Lake refilling combined with the continued closed-circuiting of Kennady Lake upstream of Area 8, are greater than increased inflow to Lake N1 due to the Lake A3 diversion. The 2-year flood discharge during closure will decrease by approximately 3% from the baseline value, and the 100-year flood discharge will decrease by approximately 2%. Low flows will also decrease by 8% to 10%.

Kirk Lake Water Levels: Kirk Lake water levels are also expected to decrease during closure. The 2-year flood level is expected to decrease by approximately 0.010 m, the 100-year flood level by 0.009 m, and monthly mean stages by 0.006 m (June), 0.015 m (July), 0.021 m (August), 0.011 m (September) and 0.005 m (October), under median conditions.

Kirk Lake and Outlet Channel/Bank Stability: No effects on Kirk Lake and Outlet channel or bank stability are expected during operation, because flood discharges and water levels will be reduced from baseline.

9.7.4.2 Effect of Permanent Diversion in the A Watershed

The effects of the permanent diversion of Lake A3 to Lake N9 during and beyond closure will be identical to those presented in Section 9.7.4.1.3 for downstream lakes N9, N6 and N2. Because effects on Lake N2 are negligible, effects on further downstream lakes are not presented.

9.7.4.3 Effects of the Project to Long-Term Hydrology Downstream of Area 8

Changes to the post closure hydrological regime of the Kennady Lake watershed were discussed in Section 8.7.4.4. Expected changes are minor and include a 3.8% increase in mean annual water yield and a slight increase in flood peak discharges. Because the changes are so small, effects to watersheds downstream of Kennady Lake will be proportionately small at Lake L1 and diminish with distance downstream.

The post-closure hydrological regimes of the N11 and upstream watersheds will be identical to the baseline regimes. The post-closure regimes of the N2 and upstream watersheds will be as discussed in Section 9.7.4.2, with negligible changes due to the permanent diversion of Lake A3 into Lake N9. Changes to the post-closure regime of the N1 watershed will similarly be negligible.

9.8 EFFECTS TO SURFACE WATER QUALITY

The pathway analysis presented in Section 9.6 considered potential effects to water quality downstream of Kennady Lake and in Lake N11. The implementation of the Gahcho Kué Project (Project) environmental design features and mitigation reduced the number of potential effects that were carried forward to the detailed effect analysis. A summary of the primary pathways by which changes to downstream water quality could occur during construction and operation is presented in Table 9.8-1.

Table 9.8-1 Valid Pathways and Effect Statements for Effects to Water Quality Downstream of Kennady Lake – Construction and Operation

Project Component	Pathway	Effects Statement	Effects Addressed
Dewatering of Kennady Lake to downstream waterbodies	dewatering of Kennady Lake to Lake N11 may change water quality (i.e., suspended sediments, major ions, metals, and nutrients concentrations) in downstream waterbodies	Effects of dewatering Kennady Lake to Lake N11 to water quality in downstream waters	Section 9.8.2.1

A summary of the primary pathways by which changes to downstream water quality could occur during closure is presented in Table 9.8-2.

Table 9.8-2 Valid Pathways and Effect Statements for Effects to Water Quality Downstream of Kennady Lake – Closure

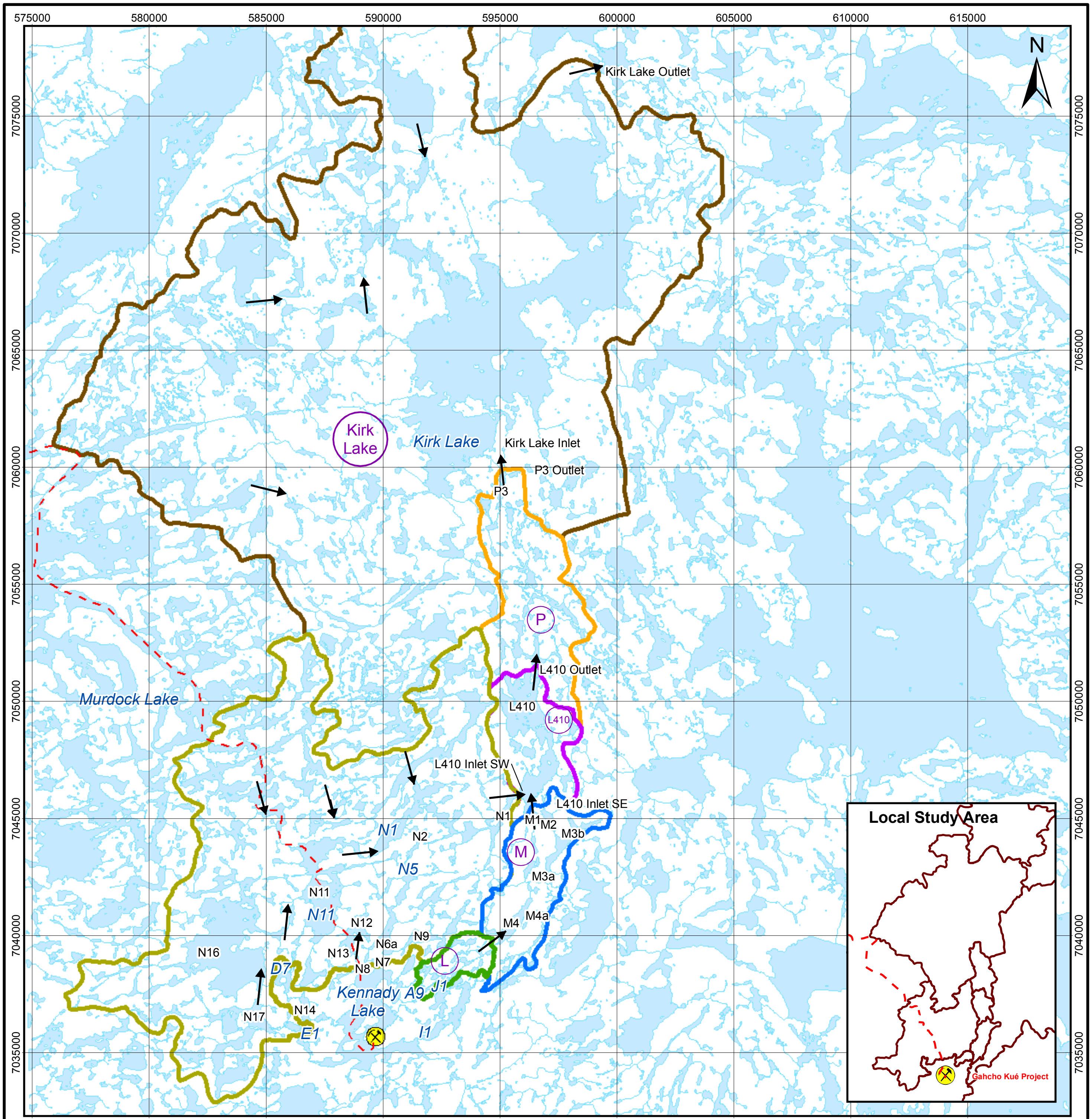
Project Component	Pathway	Effects Statement	Effects Addressed
Removal and reclamation of Project infrastructure	seepage from mine rock and processed kimberlite storage repositories, and the open Tuzo Pit may change water quality in Kennady Lake, and affect water quality in downstream waterbodies	Effects of Project activities to water quality in downstream waters	Section 9.8.2.2 and 9.8.2.3
	reclaimed project area may result in long-term changes to water quality in downstream watersheds		
Breaching and Removal of Dyke A to reconnect Kennady Lake with downstream watersheds	reconnection of Kennady Lake with Area 8 may change the water quality of downstream waterbodies		

Section 9.8.1 provides an overview of the methodology used to analyze the effects to water quality downstream of Kennady Lake during construction operations, and closure. The discussion of analysis results for construction and operation, and closure is provided in Section 9.8.2.

During the mine operation phase of the Project there will be discharges from the Water Management Pond (WMP) to Lake N11. Details regarding water management during all phases of the project are included in Section 9.4. From the N watershed, water drains into Lake 410. The effect to water quality in this system during the construction and operation phases is assessed by downstream mass balance modelling using GoldSim™.

During the initial dewatering in the construction phase, there will be discharges from Area 7 to Area 8. This water will continue to flow through the downstream lake system. This discharge will be comprised of natural, background waters, so there is no primary pathway for effects to water quality during this period. During the closure phase, the refilled Kennady Lake will be reconnected to Area 8, and mine-affected waters will flow through Area 8 (see Section 8.8) and continue through to the downstream lake system. The downstream lake system consists of a number of small and medium interconnected lakes (Figure 9.8-1), which includes lakes in the L watershed, and a chain of lakes in the M watershed. The lakes modelled in the L and M watershed are referred to as the Interlakes system. From the M watershed, water drains into Lake 410. The effect to water quality in this system at during the closure phase is assessed by downstream mass balance modelling using GoldSim™.

The assessment of potential effects of water releases from the WMP and the refilled Kennady Lake to the water quality in the downstream lake systems will include a comparison of modelled water quality results to background natural levels and applicable guidelines for water quality constituents.



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LEGEND

- Gahcho Kué Project
- Winter Access Road
- Watercourse
- Waterbody
- Flow Direction

Watershed Boundary

- Watershed L
- Watershed M
- Watershed N
- Lake 410 Watershed
- Watershed P
- Kirk Lake Watershed
- M Watershed Identifier

NOTES

Base data source: National Topographic Base Data (NTDB) 1:50,000

GAHCHO KUÉ PROJECT

Watershed Boundaries and Lakes Downstream of Kennady Lake

PROJECTION: UTM Zone 12	DATUM: NAD83
Scale: 1:240,000 (4 2 0 4 Kilometres)	
FILE No: KLOI-09-005-GIS	DATE: December 17, 2010
JOB NO: 09-1365-1004	REVISION NO: 2
OFFICE: GOLD-CAL	DRAWN: SK / CHECK: JF

DE BEERS CANADA

Figure 9.8-1

Another potential source of effects to the downstream lakes is atmospheric deposition of Project emissions, such as dust and metals, as well as effects from acidifying emissions. These effects are associated with the transport of Project emissions through the airshed and their deposition onto watersheds and/or waterbodies. The level of effects depends on the distance from emission sources as well as downstream transport through lakes and streams. The effects analysis within Kennady Lake watershed (Section 8.8.3) shows that measurable effects from dust and metal depositions onto lakes water quality are projected to occur within the immediate vicinity to the Project (i.e., within 2 kilometres [km] of the Project); however, these effects are anticipated to be primarily limited to the freshet period when accumulated winter deposition to the watershed is transported through the lakes with the snow melt at a time that peak total suspended sediment (TSS) and metals concentrations naturally occur for short peak flow periods. Therefore, it is expected that there will be negligible effects to water quality from dust or metals deposition outside of the Kennady Lake watershed, and as a result this assessment was not carried through to the downstream lakes system.

Potential acidification analysis outside of the Kennady Lake watershed, including the Lockhart River and Hoarfrost River watersheds, is also expected to be a No Linkage pathway (Section 9.6). The effects analysis within Kennady Lake watershed (Section 8.8.3) shows that non-measurable effects from potentially acidifying deposition onto lakes are projected within the Kennady Lake watershed.

Effects of changes in water quality on the health of aquatic life in Area 8 during closure and post-closure was assessed in Section 8.9.3.1, considering fish tissue accumulation, and direct exposure. During all phases of the Project, including closure and post-closure, predicted changes to water quality in Area 8 were projected to result in negligible effects to fish tissue quality and, by association, aquatic health, because fish tissue concentrations were projected to be below toxicological benchmarks for all parameters considered in the assessment. Predicted peak concentrations for all substances of potential concern (SOPCs) resulting from direct exposure during closure and post-closure phases were lower than the corresponding chronic effects benchmark (CEB). Potential effects to fish tissue quality and aquatic health for Lake 410 during closure and post-closure are assessed in Section 9.9.

9.8.1 Effects Analysis Methods

9.8.1.1 Effect of Water Releases on Water Quality in Downstream Waterbodies – Construction, Operations and Closure Phases

9.8.1.1.1 Introduction

Water quality and quantity in Kennady Lake will vary over time as the Project proceeds through the construction and operations, and closure phases. As water from the WMP is discharged to Lake N11, water quality in Lake N11 and downstream waterbodies may be affected by loading inputs from this discharge. Following the refilling of Kennady Lake and reconnection to Area 8, mine-affected water will flow through Area 8 and continue downstream through the interlakes watersheds and into Lake 410.

During the construction and operations phases, water quality within Kennady Lake was modelled throughout these phases to determine the quality of water that would be discharged to Lake N11, and to determine the quality of water in Kennady Lake when it becomes reconnected to Area 8. Details of this modelling are provided in Appendix 8.I and Section 8.8.2.1.1. The water quality parameter concentration time series plots predicted by the Kennady Lake model were used as inputs to the downstream water quality model, which includes Area 8, the L, M and N watersheds and Lake 410. Inputs from the Kennady Lake model included a discharge to Lake N11 during the construction and operational phase and an outflow to Area 8 during post-closure. The downstream water quality model, developed in GoldSim™, is detailed briefly below and fully described in Appendix 8.I.

The hydrology model (see Section 9.7.1) formed the basis of the downstream water quality model. Within each watershed, water quality profiles were assigned as baseline or background chemistry. Throughout the construction, operations, and closure phases of the project, the downstream watershed was assumed to behave according to baseline conditions, with the following exceptions, which are included in the model:

- inflow to Kennady Lake from its immediate watershed will be diverted to the N watershed;
- water will be discharged from the WMP to Lake N11 during the construction and operations phases;
- water will be drawn from Lake N11 to refill Kennady Lake during the closure phase;

- the flow path from Area 7 to Area 8 will be disconnected during the operations and closure phases; and
- the flow path from Area 7 to Area 8 will be reconnected after Kennady Lake has refilled (i.e., post-closure).

The water quality model simulated concentrations for a range of water quality parameters at all downstream nodes during the construction and operations, and closure phases. The model assumed fully mixed conditions within each waterbody at each daily timestep.

Projections of water quality in the downstream waterbodies did not include the development and persistence of permafrost conditions within the mine rock piles, the Coarse PK Pile, and the Fine PKC Facility. It was assumed that seepage quantities from these facilities would be representative of no permafrost conditions, and provide seasonal geochemical loading to Kennady Lake after closure. It is recognized that frozen layers may establish during the development of these facilities and that permafrost will likely continue to develop following closure, which will result in lower rates of seepage through the facilities and geochemical loading to Kennady Lake than simulated in this assessment. However, as the assessment of impacts to the suitability of the water quality to support aquatic life includes time periods that extend into the long-term (200 years), the assessment was designed to represent potential future climatic conditions where there would be no permafrost.

A median climate scenario (i.e., 1-in-2 year wet climate condition) was used to assess likely changes in water quality in the downstream watersheds. This scenario represents an average climate condition.

9.8.1.1.2 Data Sources

Background water quality data in the L, M and N watersheds and Lake 410 were collected between 1995 and 2010. The data were collected by various consultants during open water and under-ice conditions (Section 9.3). For the purposes of the downstream lakes water quality assessment, data collected from the sources presented in Table 9.8-3 were used.

Table 9.8-3 Water Quality Studies Used in the Assessment of Kennady Lake, 1995 to 2010

Report Author(s)	Publication Date	Report Title
JWEL	July 1998	Water Quality Assessment of Kennady Lake, 1998 Final Report. Project No. BCV50016. Submitted to Monopros Limited, Yellowknife, NWT (Jacques Whitford 1998)
JWEL	October 14, 1999	Results of Water Sampling Program for Kennady Lake July 1999 Survey. Project No. 50091. Submitted to Monopros Limited, Yellowknife, NWT (Jacques Whitford 1999a)
EBA & JWEL	2001	Gahcho Kué (Kennady Lake) Environmental Baseline Investigations (2000) Submitted to De Beers Canada Exploration Ltd., Yellowknife, NWT (EBA and Jacques Whitford 2001)
JWEL	April 29, 2002	Data Compilation (1995-2001) and Trends Analysis Gahcho Kué (Kennady Lake). Project No. ABC50310. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT (Jacques Whitford 2002b)
JWEL	June 4, 2003	Gahcho Kué (Kennady Lake) Limnological Survey of Potentially Affected Bodies of Water (2002). Project No. NTY71008. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT (Jacques Whitford 2003a)
JWEL	January 20, 2004	Baseline Limnology Program (2003) Gahcho Kué (Kennady Lake). Project No. NTY71037. Submitted to De Beers Canada Exploration Inc., Yellowknife, NWT (Jacques Whitford 2004)
EBA	2004	Faraday Lake Winter 2003 Water Quality Sampling Program. Submitted to DeBeers Canada Exploration Inc., Yellowknife, NWT (EBA 2004a)
EBA	2004	Kelvin Lake Winter 2003 Water Quality Sampling Program. Submitted to DeBeers Canada Exploration Inc., Yellowknife, NWT (EBA 2004b)
AMEC	2004-2005	Unpublished water chemistry and field data collected in Kennady Lake and surrounding watersheds (AMEC 2004 and 2005)
Section 9.3	2010	Additional baseline data collected in support of this application

JWEL = Jacques Whitford Environment Ltd.; EBA = EBA Environmental Consultants Ltd.; AMEC = AMEC Earth & Environmental.

9.8.2 Effects Analysis Results

9.8.2.1 Effect of Project Activities on Water Quality in Lake N11 during Construction and Operations, and Closure Phases

During the construction and operations phases of the project, Kennady Lake will be segmented by dykes into separate areas to allow for the creation of a WMP and to allow dewatering in the areas with active mine pits (Section 8.4). Initially, clean water will be withdrawn from the lake to increase the water storage capacity during mining operations. This water will be pumped from the WMP to Lake N11 and from Area 7 to Area 8. Throughout the operations phase, water will continue to be discharged from the WMP to Lake N11.

Because the WMP will receive runoff and direct discharge from mine-related sources, discharge of this water to Lake N11 may potentially affect water quality in Lake N11 and downstream waterbodies. Therefore, water quality was assessed in Lake N11, which represents the node of maximum potential impact in the N watershed, and in Lake 410 (see Section 9.8), which represents far-field effects.

Maximum concentrations of each of the water quality parameters in Lake N11 during all phases are presented in Table 9.8-4. Results for phosphorus, which include supplemental mitigation strategies (described below), are provided in Table 9.8-5. Maximum concentrations for all parameters are attained either early in the operations phase, when discharges to Lake N11 are highest, or at the end of the operations phase, when concentrations in the WMP are highest.

Concentrations of parameters in Lake N11 were predicted to return to background levels during the closure or post-closure phases within five years after discharges to Lake N11 cease.

A discussion of the water quality modelling results is provided below, which includes time series plots for selected water quality parameters. Time series plots for each water quality parameter listed in Tables 9.8-4 and 9.8-5 are provided in Appendix 9.I.

Table 9.8-4 includes a comparison to the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007) for reference; however, the assessment of effects of changes in water quality to aquatic life is presented in Section 9.9, and a summary of the assessment of potential effects to human and wildlife health is presented in Section 9.11.

Within each assessment, the water quality modelling results have been grouped into three categories:

- total dissolved solids (TDS) and major ions;
- nutrients; and
- trace metals.