8 KEY LINE OF INQUIRY: WATER QUALITY AND FISH IN KENNADY LAKE

8.1 SUMMARY OF SECTION 8 BEFORE UPDATES

Context

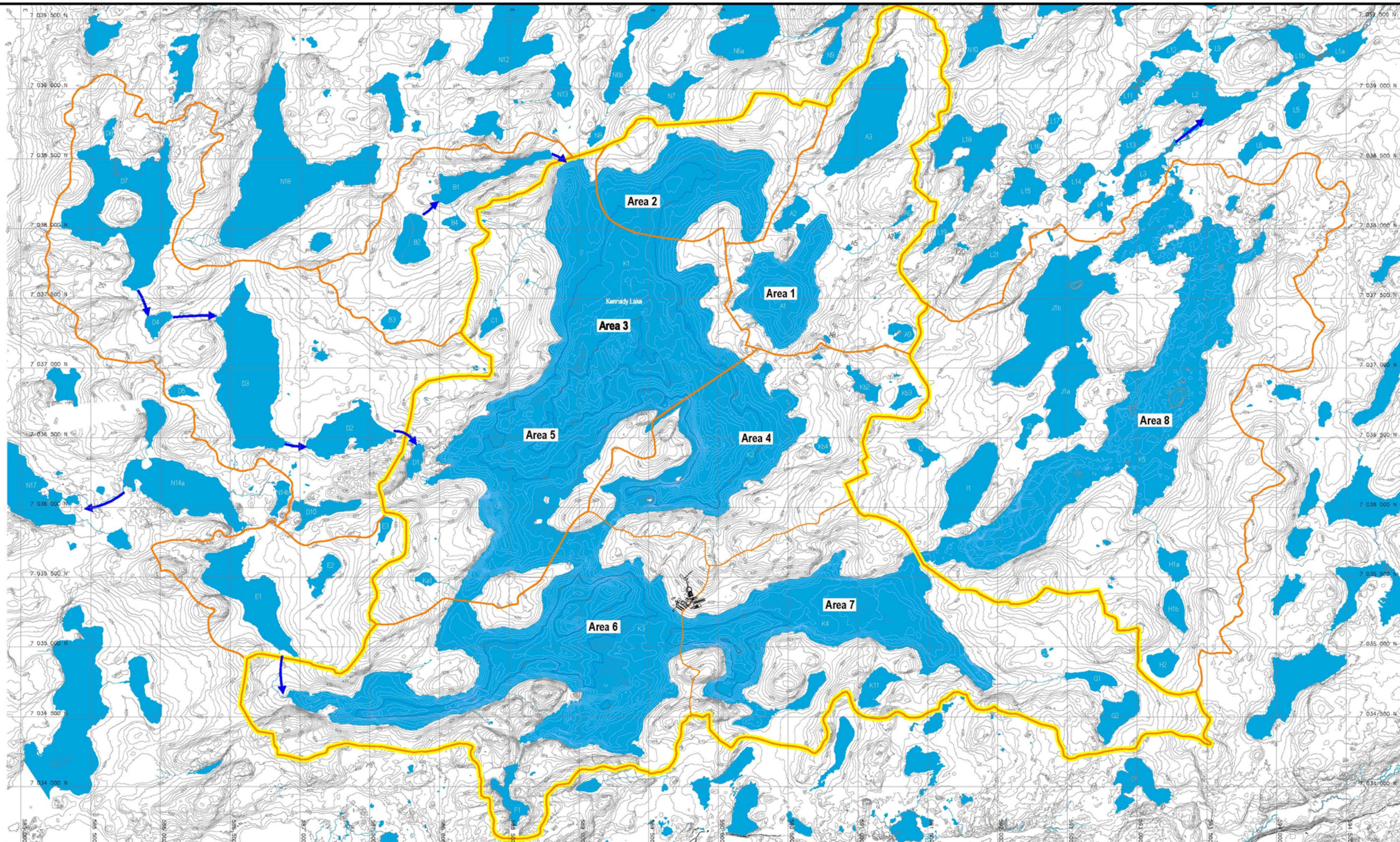
The summary within Section 8.1 is limited to the effects to water quality and fish in Kennady Lake that are relevant to the supplemental mitigation described in Section 3 of this 2012 Environmental Impact Statement (EIS) Supplement. This section is a summary of the predictions made before the supplemental mitigation was incorporated and is based on information provided in the 2011 EIS Update (De Beers 2011), but is limited to information included in the 2011 EIS Update that provides a background for this supplement.

Background

The Key Line of Inquiry: Water Quality and Fish in Kennady Lake includes the specific effects of changes caused by the Gahcho Kué Project (Project) within the seven areas of Kennady Lake (Areas 2, 3, 4, 5, 6, 7, and 8) and the Kennady Lake watershed (Figure 8.1-1). The downstream limit of the study area is the Kennady Lake outflow in Area 8 (i.e., Stream K5). Impacts are included for the construction (i.e., Kennady Lake dewatering), operations, and closure (i.e., refilling and recovery of Kennedy Lake) phases.

Effects to Water Quantity

During construction and operations, the dewatering process was not expected to result in effects to natural channel or bank stability; however, the exposed lake bed within the dewatered Kennady Lake might have been subject to erosion, depending on the bed substrate. The construction of earth-filled diversion dykes was expected to increase water levels and surface areas in a number of the diversion lakes, block the existing outlet of another lake (Lake B1) with no change in water levels, and cause the cessation of flows downstream of the dykes for most of the year. However, as mean annual water level variation in the upper watershed lakes was anticipated to be similar or reduced from pre-diversion conditions, erosion potential and sediment sourcing would be minimized.



LEGEND

- Existing Ground Contours 5m Index - 1m Intermediate
- Bathymetry Contours 5m Index - 1m Intermediate
- Controlled Area Boundary
- Marsh Area
- Scrub
- Sub-watershed Boundary
- Drainage Flow Direction
- Lake/Pond

NOTES
Base data source: EBA Figure 4.5 - Stage 2 - Water Management During Mine Operation Years 1 to 3 (2015 to 2017)
Source: Adapted from Figure 3.2-2 of De Beers 2010.

GAHCHO KUÉ PROJECT

Kennady Lake Study Area

PROJECTION: UTM Zone 12	DATUM: NAD83
SCALE 500 0 500 METRES	DE BEERS CANADA
FILE No: E2011-Fish-001-CAD	DATE: April 20, 2012
JOB No: 11-1365-0001 / REVISION No: 0	Figure 8.1-1
OFFICE: GOLD - SAS / DRAWN: TAH / CHECK: JF	

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Runoff from Project surface infrastructure in watersheds that drain to Areas 2 to 7 was going to be conveyed to the WMP in Areas 3 and 5 by the site water management system. Runoff from watersheds that drain directly to Area 8 would be free-draining. Project surface infrastructure, including the two mine rock piles, the Coarse PK Pile, and the Fine PKC Facility, were to be located almost entirely within the controlled area boundary and all drainage would be managed. No effects on natural channel or bank stability were anticipated.

During dewatering, water from Area 7 was going to be directed to Area 8. The resultant flows downstream of Area 8 would be generally increased from baseline conditions; however, flows would be limited so that discharge would not exceed the 1:2 year flood discharge volume. During operations, flows through Area 8 decreased from baseline conditions because there was to be no flow from the watershed upstream of Dyke A. The alterations in water levels in Area 8 would correspond with the flow changes; no adverse effects to channels or bank stability were anticipated.

During construction and operations phases, dewatering and WMP discharge from Areas 3 and 5 were going to be directed to Lake N11. Pumping to Lake N11 would commence on June 1 of each year, at a pumping rate that limits discharge at the Lake N11 outlet to not exceed 500,000 m^3/d.

At closure, the diverted watersheds, with the exception of the A watershed, would be restored, and pumping from Lake N11 would occur to supplement the refilling of Kennady Lake. No effects on channel or bank stability were expected during refilling, and erosion would be prevented at discharge points by armouring of outfalls and use of diffusers. No water from the refilled areas would be released to Area 8 until the water level was at the naturally armoured shoreline elevation, and water quality met specific requirements. During the refilling of Kennady Lake, flows at the Area 8 outlet (Stream K5) would continue to be reduced similar to operations.

Beyond closure, the water balance would change for the Kennady Lake watershed resulting in the increase of mean annual water yield by 8.9 percent (%). The reduction in the surface area of Kennady Lake of 14.1% means that flood peak discharges would increase post-closure due to less storage in the lake.

Effects to Water Quality

Potential influences to water quality in the main areas of Kennady Lake (Areas 2 to 7) and Area 8 included the following:

- air emissions from the Project (e.g., fugitive dust, vehicle emissions);
- isolation of Areas 2 and 7 from Area 8;
- drainage in the controlled area that comes into contact with the Fine PKC Facility, mine rock piles, and the Coarse PK Pile; and
- the open Hearne and Tuzo pits.

Water quality was modelled under the assumption that permafrost would not establish in the mine rock piles, Coarse PK Pile, and Fine PK Facility. Therefore, simulated concentrations of water quality parameters in Kennady Lake following closure would remain elevated above background levels for the long-term. However, these projections were conservative, as parameter loading to Kennady Lake from the reclaimed mine rock and PK storage facilities is expected to decrease with the establishment of permafrost. With the onset of climate change conditions that reduce or eliminate permafrost conditions at the Project site, parameter concentrations were projected to increase to modelled long-term levels.

The effects of dust and associated metal deposition on water quality from Project air emissions were evaluated for a subset of lakes within the Kennady Lake watershed. Changes to total suspended solids (TSS) and trace metals (e.g., aluminum, cadmium, chromium, copper, iron, mercury, and silver) concentrations resulting from deposition would potentially exceed average baseline concentrations in two or more lakes adjacent to the Project area during construction and operations by greater than 100%. The contribution of deposited dust and metals to lakes were modeled under the assumption that no natural mitigation would be afforded in winter conditions. There is a paucity of available literature that discusses the natural mitigation of fugitive dust generation from haul truck traffic during winter. As a result, winter fugitive dust was not mitigated and was modelled to directly transfer through drainage to receiving waters with the onset of spring melt. Project-related deposition of sulphate and nitrate in the Kennady Lake watershed was not predicted to result in lake acidification.

To estimate the water quality in Kennady Lake (i.e., Areas 2 to 7 and Area 8) through the closure phase (i.e., the refilling period), and post-closure once Kennady Lake was refilled and Dyke A was breached, a dynamic, mass-balance water quality model was developed in GoldSim™. Water quality in Area 8 was expected to remain similar to background conditions during operations and closure, before the removal of Dyke A, because this area would remain isolated from the main areas of Kennady Lake. Water quality in Area 8 during post-closure was anticipated to be driven by the water flowing from Kennady Lake after Dyke A is breached, with additional dilution from the Area 8 sub-watershed.

Concentrations of total dissolved solids (TDS) and major ions in the main areas of Kennady Lake were projected to increase during the operations phase due to the management of water within the controlled area (e.g., runoff, groundwater inflows, process water) and decrease during the closure phase when the lake is refilled. Concentrations of TDS and major ions in Area 8 were predicted to increase when Dyke A is breached; concentrations were expected to peak within five years of Dyke A being removed, as water in Area 8 is replaced with water from the refilled Kennady Lake. Over time, concentrations of TDS and major ions were generally predicted to decline, but for some parameters (e.g., potassium), concentrations were predicted to increase during the post-closure period and reach a long-term steady state concentration within a few decades. TDS and all major ions were predicted to remain above background conditions, but below levels that would affect aquatic health.

Nutrient levels were predicted to increase in Areas 2 through 7 during operations, with nitrogen projected to decrease during the closure phase as nitrogen residue in the stored PK and mine rock from blasting were depleted. By the time Dyke A is removed, modelled nitrate and ammonia concentrations were expected to be below Canadian Council of Ministers of the Environment (CCME) water quality guidelines and decline thereafter to near background levels. In Area 8, all forms of nitrogen were expected to peak in concentration in Area 8 within five years of breaching Dyke A, then return to near-background concentrations.

Concentrations of phosphorus were projected to increase in Areas 3 to 7 of Kennady Lake during operations due to loading to the WMP, but to decrease during the closure phase due to the refilling of Kennady Lake. Phosphorus concentrations were projected to gradually increase to steady state concentrations during post-closure due to seepage from materials located in the mine rock piles, Coarse PK Pile, and the Fine PKC Facility. The Fine PKC Facility was the largest contributing source of phosphorus. Using a combination of mitigation strategies, De Beers was committed to incorporating additional mitigation to achieve a long-term maximum steady-state total phosphorus concentration of 0.018 mg/L in Kennady Lake. Although the phosphorus concentrations would be reduced by the additional mitigation, they would remain higher than the baseline concentration range of <0.001 to 0.010 mg/L. As a result of the increase in phosphorus levels, changes in lake trophic status from oligotrophic (low productivity) to mesotrophic (moderate productivity) were expected in the refilled Kennady Lake, including Area 8.

An increase in productivity (e.g., growth of phytoplankton and algae) would result in increased organic carbon remaining in the lake after senescence in the fall. An increased under-ice oxygen demand in Kennady Lake was anticipated as a result of the increased productivity. The winter oxygen depletion rates for surface (under ice to 6 m), middle (7 to 12 m) and deeper (>12 m) depth zones in Kennady Lake and a dissolved oxygen balance for Kennady Lake at the end of winter was estimated. The results indicated that the surface zone of the water column was expected to remain oxygenated over the winter, but the mid-depth and bottom depth zones would likely be subject to lower oxygen levels. The deeper epilimnetic zones of the open Tuzo and Hearne Pits were not expected to be subject to the same winter oxygen demand as other shallower areas of Kennady Lake and were expected to remain well oxygenated.

Of the 23 trace metals that were modelled for the assessment, three patterns were predicted in modelled concentrations of the main areas of Kennady Lake over operations and closure:

- Some metals were predicted to increase in concentration during the operations phase, then steadily decline in concentration as the lake is flushed during post-closure. Of these metals, chromium and iron were projected to be higher than CCME water quality guidelines in post-closure.
- Some metals were predicted to increase in concentration relatively steadily throughout the operations phase, rise or fall during closure, and then remain fairly constant throughout post-closure. Of these metals, cadmium and copper were expected to be higher than CCME water quality guidelines in post-closure.
- Some metals were predicted to increase after closure, and reach steady state conditions in Kennady Lake within about 40 years. These metals included barium, beryllium, boron, molybdenum and strontium; none of these five metals were projected to be higher than CCME water quality guidelines in post-closure.

As groundwater and geochemical sources were the primary contributors of these metals**,** the dissolved fraction of these metals was predicted to comprise the majority of the total concentrations.

Concentrations of trace metals in Area 8 were predicted to remain similar to background concentrations until Dyke A is breached, after which it would take approximately five years for metals concentrations to peak and then follow the general trends described for Kennady Lake in post-closure. Of the 23 modelled trace metals, cadmium, chromium, and copper were projected to be higher than CCME water quality guidelines during post-closure in Area 8.

Effects to Aquatic Health

Potential effects to aquatic health were assessed based on the changes to water quality from Project emissions, and Project activities. During construction and operations, predicted maximum concentrations of suspended solids and some metals from Project air emissions were predicted to increase concentrations above water quality guidelines in some lakes close to the Project boundary; some of these lakes are fish-bearing. Given the conservatism in the predicted concentrations, and the short length of the exposure to elevated concentrations, the potential for adverse effects from dust and metals deposition was considered to be low. At the end of operations, the Project was not projected to be a notable source of dust and metal deposition and, therefore, a return to existing conditions was anticipated.

As a result of Project activities, changes to water quality in Kennady Lake during closure and post-closure were expected. For direct waterborne exposure, predicted maximum concentrations for most substances of potential concern (SOPCs) were lower than the corresponding chronic effects benchmark (CEB), with the exception of total copper, iron, and strontium. Despite the predicted exceedances of the CEB, the potential for copper, iron, and strontium to cause adverse effects to aquatic life in Kennady Lake was considered to be low. Follow-up monitoring would be undertaken to confirm this evaluation. For the indirect exposure pathway, predicted fish tissue concentrations were expected to be below toxicological benchmarks for all substances considered in the assessment, except silver. Given the modest predicted increase, and that both baseline and predicted tissue concentrations only marginally exceeded the available no-effect concentration, the potential for predicted silver concentrations to cause effects to fish was concluded to be low. Based on the above results, changes to concentrations of all substances considered in this assessment were predicted to result in negligible effects to aquatic health in Kennady Lake.

Effects to Fish and Fish Habitat

Changes to fish habitat were predicted to occur from the footprint of the Project (e.g., excavation of the mine pits, placement of mine rock, placement of PK, dykes, and other construction activities). The affected habitat areas included the following:

- portions of Kennady Lake and adjacent lakes within the Kennady Lake watershed that would be permanently lost (194.56 ha of lake area and 0.51 ha of watercourse area in tributaries to Kennady Lake);
- portions that would be physically altered after dewatering and later submerged in the refilled Kennady Lake (83.32 ha of lake area); and

- portions that would be dewatered (or partially dewatered) but not otherwise physically altered before being submerged in the refilled Kennady Lake (435.90 ha of lake area and 0.23 ha of watercourse area in tributaries to Kennady Lake).

The affected habitat areas were quantified in the Conceptual Compensation Plan, which also described the various options considered for providing compensation, and presented a proposed plan to achieve no net loss of fish habitat. The options for compensation included: construction of impounding dykes to raise lake levels; construction of finger reefs in Kennady Lake; construction of habitat structures on the decommissioned mine pits/dykes; and widening the top bench of pits to create shelf areas where they extend onto land. The compensation ratio provided by the proposed compensation plan (gains:losses calculated based on total area of permanently lost habitat and physically altered and re-submerged habitat) was 0.65 for operations and 1.37 for closure.

To minimize the waste of fish caused by dewatering activities, fish salvage would be conducted to remove fish from Areas 2 to 7 before and during dewatering. Dewatering would result in the temporary loss of fish habitat within Areas 2 to 7 of Kennady Lake; however, it was expected that a self-sustaining fish population would be present in Kennady Lake post-closure.

In the diversion watersheds, fish habitat downstream of the dykes would be dewatered and lost to fish residing in upstream lakes; the loss of habitat resulting from the placement of the dykes and the dewatering of downstream stream segments and lakes was included in the Conceptual Compensation Plan. Raising water levels in Lakes A3, D2, D3, and E1 within the Kennady Lake watershed would result in increased lake habitat area, which was likely to benefit fish residing in these lakes. Negligible effects on fish and fish habitat would be expected from shoreline erosion. Although the dykes would isolate fish populations within the B, D, and E watersheds for the duration of mine operations (and permanently in Lake A3), it was expected that the diversion watersheds would support self-sustaining populations of fish species, such as Arctic grayling (*Thymallus arcticus*), northern pike (*Esox lucius*), burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), and ninespine stickleback (*Pungitius pungitius*).

Isolation of Area 8 from the remainder of Kennady Lake during operations and closure was predicted to result in a small increase in nutrient concentrations, which was expected to result in a slight increase in productivity of plankton and benthic invertebrate communities. The residual fish community in Area 8 of Kennady Lake was anticipated to consist of small-bodied fish species (i.e., lake chub [*Couesius plumbeus*], ninespine stickleback, and slimy sculpin), as well as

Arctic grayling, northern pike, and burbot. As a result of the existing overwintering limitations in Area 8 and the elimination of alternative overwintering refugia in Areas 2 through 7, lake trout (*Salvelinus namaycush*) and round whitefish (*Prosopium cylindraceum*) might not continue to persist in Area 8 throughout the operational period, as they are less tolerant of low dissolved oxygen concentrations.

At closure, the water levels in the raised lakes were expected to return to baseline levels and the fish and lower trophic communities would adjust to the new lake levels. Habitat conditions for spawning, rearing, and overwintering would be similar to pre-Project conditions.

During post-closure, the concentration of phosphorus was predicted to reach a long-term steady-state concentration of 0.018 mg/L, which is higher than the pre-development concentration range of <0.001 to 0.010 mg/L. The predicted change in the trophic status was expected to result in increased primary and secondary productivity in Kennady Lake, resulting in a change in trophic status from oligotrophic to mesotrophic. Due to the increases in the food base for fish (zooplankton and benthic invertebrates), and likely in the small-bodied forage fish community, there might also be increased growth and production in the large-bodied fish species of Kennady Lake. It was expected that due to the change in trophic status, overwintering habitat in Kennady Lake at post-closure would become more limited for cold-water fish species than under baseline conditions. The surface waters of Kennady Lake (i.e., under ice to 6 m depth) would be expected to retain sufficient levels of dissolved oxygen during winter to support fish; however, there might be reduced suitability and availability of overwintering habitat for cold-water fish species, such as lake trout.

Recovery of Kennady Lake

An aquatic ecosystem was projected to develop within Kennady Lake after refilling and reconnection of its basins. The physical and chemical environment in Kennady Lake was expected to be in a state that would allow re-establishment of an aquatic ecosystem, although projected nutrient concentrations indicated the re-established communities might differ from pre-development communities.

The expected timeframe for recovery of the phytoplankton community was estimated to be approximately five years after refilling was complete, taking into account that the community would begin to develop during the refilling period. Zooplankton community development was predicted to follow recovery of the phytoplankton community (i.e., likely within five to ten years of Kennady Lake being completely refilled). The increased nutrient levels in the refilled Kennady Lake would facilitate community re-establishment and result in a more productive plankton community. Recovery of the benthic invertebrate community in

Kennady Lake was expected to be slower than that of the plankton communities, with an estimated time for recovery of about ten years after refilling is complete. The benthic invertebrate community was expected to be different from the community that currently exists in Kennady Lake and in surrounding lakes; the community would be of higher abundance and biomass, reflecting the more productive nature of the lake, and would likely be dominated by midges and aquatic worms.

Re-establishment of the fish community within Kennady Lake, and the speed at which it would occur, would depend on the ability of fish to re-colonize the refilled lake, the habitat conditions within the lake, and how succession takes place within the refilled system after it has been fully connected to the surrounding environment. It was expected that a fish community would become re-established in Kennady Lake; however, due to changes in trophic status and associated habitat conditions, the fish community structure might be different than exists currently.

The B, D, and E watersheds were projected to be the primary source of initial migrants into the refilled lake. As conditions improve, and water depths increase, the early migrants would become permanently established. During refilling, exclusion measures would be used to limit the initial migration of large-bodied fish into the lake. Following the removal of Dyke A, fish would also enter from Area 8. The final fish community of Kennady Lake would likely continue to be characterized by low species richness (less than 10 species) consisting of a small-bodied forage fish community (e.g., lake chub, slimy sculpin, ninespine stickleback) and large-bodied species, (e.g., Arctic grayling, northern pike, burbot, round whitefish, lake trout, and possibly longnose sucker [*Catostomus catostomus*]). Total lake standing stock and annual production might be increased over what currently exists in the lake. It was expected that the fish species assemblage (i.e., fish species present) within Kennady Lake would be similar to pre-Project conditions, but the community structure (i.e., relative abundances of the species) might differ. Mesotrophic conditions were likely to be more favourable to northern pike, burbot, and Arctic grayling, than cold-water species, such as lake trout and round whitefish. As such, the relative abundances of the large-bodied fish species were anticipated to change from baseline conditions.

Overall, the life history attributes of the large-bodied fish species would ultimately determine the duration of the complete recovery of the Kennady Lake aquatic ecosystem. Northern pike was expected to re-establish a stable, self-sustaining population in Kennady Lake later than Arctic grayling or burbot (i.e., approximately 50 to 60 years following the complete refilling of Kennady Lake). Lake trout would also require a long time to re-establish a stable, self-sustaining population (i.e., approximately 60 to 75 years following the complete refilling of Kennady Lake).

Residual Impact Classification

The projected impacts of the Project on the suitability of water within the Kennady Lake watershed to support a viable and self-sustaining aquatic ecosystem were considered to be not environmentally significant. Water quality was predicted to change, but was expected to result in negligible effects to aquatic health in Kennady Lake. Phosphorus was projected to increase to a level that would shift the trophic status of Kennady Lake from oligotrophic to mesotrophic conditions.

The projected impacts on the abundance and persistence of Arctic grayling, lake trout, and northern pike were considered to be not environmentally significant. Arctic grayling, lake trout, and northern pike would be affected by the loss of habitat in Kennady Lake during the life of the mine; however, it was expected that self-sustaining populations would become established in the refilled lake.

8.2 UPDATES TO SECTION 8

8.2.1 Overview of Changes

Supplemental mitigation of the Fine Processed Kimberlite Containment (PKC) Facility is a minor but necessary change intended to reduce the phosphorus release associated with long-term storage of processed kimberlite (PK). This mitigation will result in a reduction in the Fine PKC Facility’s footprint and minor changes to mine waste and water management.

The purpose of Section 8.2 is to assess the effects of the supplemental mitigation on aquatic components (e.g., hydrology, water quality, aquatic health, and fish and fish habitat) in Kennady Lake. Table 8.2-1 identifies the subsections from Section 8 of the 2011 EIS Update (De Beers 2011) and specifies whether they are unchanged or updated within this 2012 EIS Supplement. If they are unchanged, the reader is directed to the 2011 EIS Update. If the text in the subsection required updates, the changes are provided in the text that follows.

Table 8.2-1 Updated and Unchanged Subsections from Section 8 of the 2011 Environmental Impact Statement Update

Section 8 from the 2011 EIS Update	Updated in 2012	Reason for Update[(a)]
8.1 Introduction	no	-
8.2 Summary	no	updates are included in the subsections indicated by "yes"
8.3 Existing Environment	no	-
8.4 Water Management Plan Summary	yes	reduction in Project footprint
8.5 Assessment Approach	no	-
8.6 Pathway Analysis	yes	minor updates to pathways
8.7 Effects to Water Quantity	yes	revised Project footprint and diversion from the A watershed
8.8 Effects to Water Quality	yes	reduction in Project footprint and revised model inputs from on-going geochemical testing
8.9 Effects to Aquatic Health	yes	updated results from water quality modelling
8.10 Effects to Fish and Fish Habitat	yes	reduced Project footprint and updated water quality results
8.11 Recovery of Kennady Lake and Its Watershed	yes	change in nutrient status
8.12 Related Effects to Wildlife and Human Use	yes	increase in amount of wildlife habitat (i.e., decrease in disturbance)
8.13 Residual Effects Summary	yes	updates for reasons described above; now included as Section 8.2.12 Conclusions
8.14 Residual Impact Classification	yes	details in the rationale and classification have changed; now included as Section 8.2.12 Conclusions
8.15 Uncertainty	yes	updates to water quality modelling and geochemical testing
8.16 Monitoring and Follow-up	yes	minor correction of details

[(a)] - = Subsection is unchanged and available in the 2011 EIS Update (De Beers 2011).

8.2.2 Water Management Plan Summary

The primary purpose of the Water Management Plan is to reduce the effect of the Project on the aquatic ecosystem of Kennady Lake and downstream environments during construction, operations, and closure phases. The key objectives of the Water Management Plan are to:

- dewater Kennady Lake to the maximum extent possible to safely access and mine the ore bodies;
- utilize passive treatment in the controlled area and discharge water when the water quality meets discharge requirements;
- utilize available containment volumes within the controlled area for water management as required, e.g., the mined-out pits for water storage;
- minimize environmental impacts to adjacent and downstream waters during construction, operations, and closure phases of the Project; and
- re-establish a flow regime and self-sustaining ecosystem in the refilled Kennady Lake after closure.

The following section provides a brief summary of the main changes to the Water Management Plan presented in Section 8.4 of the 2011 EIS Update (De Beers 2011) given the supplemental mitigation presented within this document. The reader is directed to Section 3.9 (Water Management) of this supplement for specific Project description details on how the Water Management Plan has changed as a result of the supplemental mitigation.

Construction Phase

As outlined in Section 8.4.2 of the 2011 EIS Update (De Beers 2011), the following key water-related activities will take place during the construction phase of the Project:

- the majority of the upper Kennady Lake watershed (sub-watersheds A, B, D, and E) will be diverted through the construction of dykes to facilitate the dewatering of Kennady Lake, and to isolate the WMP during operations;
- Dyke A will be constructed to separate Area 8 from Area 7 of Kennady Lake;
- Kennady Lake will be dewatered to allow access to the lake-bed and the underlying kimberlite pipes; and
- a WMP will be established in Areas 3 and 5 to collect mine water, process water, groundwater inflow, and drainage from the mine site and surrounding area.

The following text outlines the main water-related construction changes associated with the supplemental mitigation. Further details are provided in the following sections of this supplement: Section 3.9.2 (Diversion of A, B, D, and E Watersheds); Section 3.9.3 (Dykes for Water Management); Section 3.9.4 (Dewatering of Kennady Lake); and Section 3.9.5 (Fresh Water Supply and Distribution).

In the 2010 EIS (De Beers 2010), the Fine PKC Facility involved storage of fine PK in both Area 1 and Area 2. The Fine PKC Facility's footprint has been reduced by omitting Area 1, which included Lakes A1 and A2 in the 2010 EIS. This decrease in size allowed for a reduction in the long-term phosphorus loadings from the facility. To identify this supplemental mitigation, the term "Fine PKC Facility (mitigated)" has been used herein. With the footprint of the facility reduced to Area 2, the fine PK that was to be stored in Area 1 has been relocated to the 5034 and Hearne Pits. As a result of the supplemental mitigation of the Fine PKC Facility (mitigated), the size of the Project footprint has decreased by about 83 ha compared to the footprint associated with the Project Description in the 2010 EIS.

The reduction in the size of the Fine PKC Facility (mitigated) involves a change in the diversion of water in Area 1. In the 2010 EIS (De Beers 2010), a permanent dam (Dyke C) would have been constructed to contain the fine PK in Area 1 (Lakes A1 and A2), raising the water level of Lake A3 and causing the water to flow northeast to the N watershed. However, as a result of the supplemental mitigation, Dyke C will no longer be constructed. Instead, Area 1, which now includes Lakes A1, A2, A3, and A9, will be isolated from the Fine PKC Facility (mitigated) during operations and closure phases by construction of three low till berms and a permanent saddle dam (Dyke A1) between Areas 1 and 2. Table 8.2-2 provides a summary of the dykes for the Project given the supplemental mitigation. Surface runoff into the A watershed will be managed by a discharge pipeline into Lake J1b, allowing water to flow to Area 8 of the Kennady Lake watershed.

Table 8.2-2 Summary of Project Dykes

Dyke	Description
Dyke A	Isolates Kennady Lake from Area 8.
Dyke A1	Permanently diverts runoff water from the catchment area of Area 1 and isolates the A watershed from the Fine PKC Facility (mitigated).
Dyke F	Diverts water from the D watershed (Lakes D2 and D3) to the N lakes during mine operations.
Dyke G	Diverts runoff water from the catchment of Lakes E1 to E3 to the N lakes during mine operations.
Dyke L	Filter dyke used to minimize suspended solids load from the Fine PKC Facility (mitigated) to the WMP.
Dyke E	Diverts runoff from the B Lakes watershed into the N Lake system.
Dyke D	Separates the Fine PKC Facility (mitigated) from Lake N7.
Dykes H, I and J	Internal dykes used to separate Areas 4 and 5 from Area 6 to allow complete dewatering of Area 6.
Dykes B, J, and M	Dykes located between Area 4 and the WMP. Permits dewatering of Area 4 in preparation for mining the Tuzo open pit.
Dyke K	Isolates Area 6 from Area 7. Permits refilling of Area 7.
Dyke N	Located east of the Hearne Pit. Permits refilling of Hearne Pit and Area 6.

Source: adapted from Table 8.4-4 of De Beers 2011. See also Table 3.9-1 of the 2012 EIS Supplement.

PKC = Processed Kimberlite Containment; WMP = Water Management Pond.

Operations Phase

One of the key objectives for the Water Management Plan during operations is to use the mined-out open pits (e.g. 5034 and Hearne) for additional mine rock, PK, and mine water storage. Water management during operations was detailed in Section 8.4.3 of the 2011 EIS Update (De Beers 2011). The reader is now directed to Section 3.9.6 (Water Management During Operations) of this supplement for further information.

Closure Phase

Water management during the closure phase was presented in Section 8.4.4 of the 2011 EIS Update (De Beers 2011). This section described the following key water-related activities that are to take place during the closure phase of the Project:

- restoration of Kennady Lake;
- site-wide drainage; and
- linkages to surrounding watersheds.

The reader is now referred to Section 3.9.7 of this supplement for details on these topics.

Water Balance

Section 8.4.5 of the 2011 EIS Update (De Beers 2011) provided information on the water balance for the Project. Current details on the water balance for the Project are presented in Section 3.9.8 of this EIS Supplement. The reader is directed to this section for changes to the water balance as a result of the supplemental mitigation.

Potential Sources of Change to Site Water Quality

Section 8.4.6 of the 2011 EIS Update (De Beers 2011) listed the potential sources of change to water quality at the Project site as follows:

- the use of a landfill for disposal of solid waste;
- the storage and handling of explosives, petroleum products, and other chemicals; and
- disposal of mine rock and PK from mining.

For information relating to the landfill, the reader is directed to Section 3.8.3 Waste Facilities of this supplement. Sections 3.10.2.5 and 3.10.2.6 of this supplement provide details on the storage and handling of explosives, petroleum products, and other chemicals.

Disposal of mine rock and PK from mining has changed given the supplemental mitigation. For example, as part of the supplemental mitigation of the Fine PKC Facility (mitigated), the coarse PK and mine rock that was to be used in reclamation of Area 1 will be transferred to the West Mine Rock Pile (mitigated); this will result in an increase in the height of the West Mine Rock Pile (mitigated) by 24 m (i.e., from 70 to 94 m) compared to the height given in the 2010 EIS (De Beers 2010). The reader is directed to Section 3.7 (Mine Waste Management) of this supplement for further information on the current plans for mine rock and PK disposal.

Potential Accidents and Malfunctions Relevant to Water Management

Section 8.4.7 of the 2011 EIS Update (De Beers 2011) contains information on potential accidents and malfunctions relevant to water management. The reader is asked to refer to this section of the 2011 EIS Update for details on this topic, as this text is unchanged given the supplemental mitigation.

8.2.3 Pathway Analysis

There are no changes to the identification and classification of effects pathways from the pathway analysis section of the 2011 EIS Update (i.e. Section 8.6.2; De Beers 2011); i.e., the classification of pathways into No Linkage, Secondary, or Primary pathway is unchanged from the 2011 EIS Update.

However, due to the implementation of the supplemental mitigation associated with the Fine PKC Facility, there are minor revisions to the project description. Only those pathways affected by these project details have been included below; other pathways are as described in the 2011 EIS Update (De Beers 2011).

8.2.3.1 Potential Pathways during Construction and Operations

8.2.3.1.1 Pathways with No Linkage

Seepage and Runoff from the Mine Rock Piles, Coarse PK Pile, and Fine PKC Facility (Mitigated) May Change Water Quality in the Kennady Lake Watershed, and Affect Aquatic Health and Fish

As a result of the mitigation associated with the Fine PKC Facility, Area 1 will no longer be used for deposition of fine PK. However, Fine PK will still be deposited into Area 2 of Kennady Lake, and the filter dyke (Dyke L) will be constructed to separate this area from Area 3. As described in the 2011 EIS Update (De Beers 2011), runoff and seepage from the Fine PKC Facility (mitigated) will report to Area 3 via filter Dyke L. The initial deposition of the fine PK will be in Area 2 of the Fine PKC Facility (mitigated) and later into the mined-out 5034 and Hearne pits. Starting in Year 6 of operations, the Fine PKC Facility (mitigated) will be progressively reclaimed as terrestrial landscape. Subsequently, runoff and seepage from the Fine PKC Facility (mitigated) resulting from precipitation will continue to report to Area 3 via filter Dyke L. The mitigation associated with the Fine PKC Facility (mitigated) will not change the conclusions of the pathway.

Dewatering Of Area 7 and Pumping To Area 8 May Change Water Quality, and Affect Aquatic Health and Fish

Water from Area 7 will be pumped to Area 8 while it meets specific water quality requirements. Based on the revision to the water balance, the projected maximum water pumped to Area 8 will be such that the pumped and natural flow at the Area 8 outlet (Stream K5) will not exceed the two-year (median) maximum daily flow rate of 135,000 m^3/d. However, this will not change the conclusions of the pathway.

Seepage of Pore Water Through, or Underneath, Dykes to Adjacent Watersheds May Change Water and Sediment Quality in the Kennady Lake Watershed, and Affect Fish Habitat, Aquatic Health and Fish

As a result of the supplemental mitigation associated with the Fine PKC Facility, the diversion of the A watershed has changed from the 2011 EIS Update (De Beers 2011). Dyke C, which was included in the 2010 Project Description (De Beers 2010), is no longer going to be constructed. Instead, a permanent dyke in the A watershed will be constructed:

- Dyke A1 – this is a permanent water diversion dyke constructed before Year -1 to divert runoff water from the A watershed and to isolate the A watershed from the Fine PKC Facility (mitigated).

Seepage volumes through the perimeter dykes, including Dyke A1, were explicitly considered in the water balance model. Seepage volumes are expected to be small because these dykes will be constructed with seepage control, which for dykes A1, D, E, F, and G includes a liner keyed into competent frozen ground (i.e., saturated inorganic permafrost) or bedrock. The mitigation associated with the Fine PKC Facility (mitigated) will not change the conclusions of the pathway.

8.2.3.1.2 Secondary Pathways

Impingement and Entrainment of Fish in Intake Pumps during Dewatering May Cause Injury and Mortality to Fish

In the 2011 EIS Update (De Beers 2011), it is indicated that fish salvage will also occur in Lake A1 prior to it being partially dewatered to accommodate the Fine PKC Facility. Due to the supplemental mitigation associated with the Fine PKC Facility, this lake is no longer being dewatered; as a result, fish salvage will not occur. All other aspects of the pathway, including the conclusions, remain unchanged.

Reduction in Upper Watershed Flow to Area 8 May Change Surface Water Levels, and Affect Surface Water Quality, Fish Habitat and Fish

Due to the supplemental mitigation associated with the Fine PKC Facility, the water balance for the Project was updated. After the cessation of discharge from Area 7, the reduction of inflows to Area 8 associated with the short-circuiting of the Kennady Lake watershed will result in an estimated annual average water level drop within Area 8 of 0.085 m during open water conditions (approximately 0.7% of the surface area of Area 8), which will remain through the operations and closure phases of the Project. This is less than the 0.11 m water level reduction that was predicted in the 2011 EIS Update (De Beers 2011).

The predicted average annual reduction in water level of approximately 0.085 m (during open water conditions), represents approximately 24% of the modelled average annual variation in water level under normal flow conditions. The predicted decrease in under-ice water levels in Area 8 relative to baseline is approximately 0.070 m, even under dry conditions.

The conclusions of the pathway remain unchanged.

Changes to Permafrost Conditions in the Flooded Shoreline Zone of the Raised Lakes Due To Increased Water Levels May Lead To Erosion and Affect Fish Habitat

Due to the supplemental mitigation associated with the Fine PKC Facility, the A watershed diversion has been redesigned. Dyke A1 will be constructed in the A watershed, and Dyke C will no longer be constructed. Towards the end of operations, lake levels will gradually be raised in Lake A1 to allow for the flow to Area 3 of Kennady Lake at closure. Lakes A1 and A2 will become one raised lake. However, similar to the description for Lakes D2, D3, and E1, Lakes A1 and A2 will fill gradually; therefore, changes to the inundated shoreline are also expected to be gradual. Surveys prior to the raising of the lakes will identify shoreline habitat that will be more prone to erosional processes when permafrost is lost (e.g., soils types, slope, bedrock) so that shoreline stabilization can be implemented where necessary.

Release or Generation of Nutrients, Mercury, or Other Substances into Lakes A1/A2, D2, D3 and E1 from Flooded Sediments and Vegetation May Change Water Quality, and Affect Aquatic Health and Fish

In the 2011 EIS Update (De Beers 2011), this pathway was *Release or generation of nutrients, mercury, or other substances into Lakes A3, D2, D3 and E1 from flooded sediments and vegetation may change water quality, and affect aquatic health and fish*. The assessment for Lakes D2, D3, and E1 is as described in the 2011 EIS Update. However, due to the supplemental mitigation associated with the Fine PKC Facility, the A watershed diversion has been redesigned. Towards the end of operations, and into closure and post-closure, Lakes A1 and A2 will become one raised lake; approximately 16.2 ha of riparian habitat around Lakes A1 and A2 will be inundated.

The effects relating to nutrients and mercury methylation in Lakes A1 and A2 are as described for the other raised lakes in this pathway. The mitigation associated with the Fine PKC Facility (mitigated) will not change the conclusions of the pathway.

Extraction of Potable Water Requirements for the Project May Change Surface Water Levels in Area 8, and Affect Fish Habitat

Due to the supplemental mitigation associated with the Fine PKC Facility, the water balance for the project has been updated. As per the 2011 EIS Update (De Beers 2011), about 60,000 m^3/y of fresh water will be required for potable water during construction and about 27,000 m^3/y during operations. The changes in Area 8 water depth and lake area under open-water conditions associated with potable water withdrawals compared to baseline are shown in Table 8.2-3. Note that the results presented in the table also take into account the reduction in flow from the upper watershed as a result of the operational diversions. The largest changes are predicted to occur in operations during July, with decreases in lake depth of 0.13 m, which corresponds to a 1% change in lake area. The reductions in depth are attenuated throughout the summer, with smaller changes predicted for other months.

The changes in Area 8 water depth and lake area under ice-covered conditions compared to baseline are shown in Table 8.2-4. The reduction in water levels under the ice are small, with a maximum decrease of 0.12 m in depth and 2.9% in under-ice wetted area predicted during construction; in operations, the changes are less, with a maximum decrease in depth of 0.05 m and under-ice wetted area of 1.3%.

Although the changes in water levels remain small, the conclusions of the pathway are unchanged from the 2011 EIS Update (De Beers 2011).

Close-Circuiting of Areas 2 to 7 May Change Water Quality in Area 8, and Affect Aquatic Health and Fish

Although the water balance has been updated, the overall effects assessment of this pathway has not changed for the 2011 EIS Update (De Beers 2011).

Table 8.2-3 Projected Changes in Area 8 Water Depth and Lake Area under Open Water Conditions

	Open Water											
	May		June		July		August		September		October	
	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)
Dewatering	-0.005	-0.04	0.018	0.14%	0.124	0.95	0.181	1.39	0.149	1.15	-0.027	-0.20
Operations	-0.014	-0.10	-0.108	-0.83%	-0.131	-1.01	-0.106	-0.82	-0.095	-0.73	-0.074	-0.57

Note: Takes into account close-circuiting of Areas 2 to 7 of Kennady Lake and potable water withdrawals.
m = metres; % = percent.

Table 8.2-4 Projected Changes in Area 8 Water Depth and Under-Ice Wetted Area under Ice-Covered Conditions

	Ice-Covered													
	November		December		January		February		March		April		May	
	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)	Change in Depth (m)	Change in Area (%)
Dewatering	-0.016	-0.41%	-0.033	-0.83	-0.050	-1.25	-0.066	-1.65	-0.083	-2.07	-0.100	-2.47	-0.117	-2.90
Operations	-0.007	-0.18%	-0.015	-0.37	-0.023	-0.56	-0.030	-0.74	-0.037	-0.93	-0.045	-1.11	-0.052	-1.30

Notes: Takes into account close-circuiting of Areas 2 to 7 of Kennady Lake and potable water withdrawals. Assumes uniform 2 m thick ice cover from Nov 1st to May 31st, to be conservative.
m = metres; % = percent.

8.2.3.2 Potential Pathways during Closure

8.2.3.2.1 No Linkage Pathways

Alteration of Drainage Patterns to Kennady Lake due to the Mine Rock and Coarse PK Piles May Change Water Flows, Water Levels, and Channel/Bank Stability in Streams and Small Lakes, and Affect Water and Sediment Quality, Fish Habitat and Fish

As part of the supplemental mitigation of the Fine PKC Facility, the coarse PK and mine rock that was to be used in reclamation of Area 1 will be transferred to the West Mine Rock Pile; this will result in an increase in the height of the West Mine Rock Pile (mitigated). The South Mine Rock Pile final pile crest will be at a surface elevation of approximately 490 masl, giving the pile a maximum height of about 80 m, and the West Mine Rock Pile (mitigated) will have a final crest elevation of 510 masl and a height of 94 m. All other aspects of the pathway, including the conclusions, remain unchanged.

Alteration of Drainage Patterns to Kennady Lake from the Fine PKC Facility (Mitigated) May Change Water Flows, Water Levels, and Channel/Bank Stability in Streams and Small Lakes, and Affect Water Quality, Fish Habitat and Fish

As part of the supplemental mitigation of the Fine PKC Facility, the Fine PKC Facility's footprint has been reduced by omitting Area 1. Therefore, the discussion regarding the progressive reclamation of Area 1 is no longer relevant. All other aspects of the pathway, including the conclusions, remain unchanged.

8.2.3.3 Secondary Pathways

Removal of the Temporary Dykes for the Realignment of Diverted B, D and E Watersheds to Kennady Lake May Release Sediment and Change Water and Sediment Quality, and Affect Fish Habitat and Fish

At the end of operations, Lakes A1 and A2 will be reconnected to Kennady Lake through the removal of one of the perimeter berms between Lake A1 and Area 3 of Kennady Lake. All other aspects of the pathway, including the conclusions, remain unchanged.

Pumping Water from Lake N11 to Kennady Lake to Supplement Refilling May Change Water and Sediment Quality in Kennady Lake, and Affect Aquatic Health, and Fish

As Area 1 is no longer under the footprint of the Fine PKC Facility, the discussion regarding water levels should refer to Areas 2 to 7, as opposed to Areas 1 to 7. All other aspects of the pathway remain unchanged.

Reconnection of Areas 3 to 7 With Area 8 May Change Water Flows and Water Levels In Area 8, and Affect Fish Habitat and Fish

Due to the supplemental mitigation associated with the Fine PKC Facility, the water balance for the Project was updated. When Kennady Lake and Area 8 are reconnected, water levels in Area 8 will increase slightly from the operations and closure period (annual average water level increase of approximately 0.09 m). This predicted water level in the post-closure phase is similar to baseline conditions (i.e., approximately 0.006 m above baseline). The conclusions of the pathway remain unchanged.

8.2.4 Effects to Water Quantity

A summary of changes to the analysis and assessment of flows, water levels, and channel and bank stability, associated with the supplemental mitigation associated with the Fine PKC Facility (mitigated) are presented below. As required, additional detail of these analyses is provided in Appendix 8.I.

8.2.4.1 Effects Analysis Methods – Construction and Operations

8.2.4.1.1 Water Balance Model

Changes to the water balance model presented in Section 8.7.1.1 of the 2011 EIS Update (De Beers 2011) are required to reflect the revised Project footprint and the diversion of surface water from the A watershed via pipeline to Lake J1b in the J watershed, as summarized in Table 8.2-5.

Table 8.2-5 Updates to Water Balance Model – Construction and Operations

2011 EIS Update	2012 EIS Supplement	Reason for Change
Runoff from the A watershed was diverted from the Kennedy Lake watershed due to the presence of Dyke C	Runoff from the A watershed is diverted to Lake J1b via pipeline during operations	Dyke C will not be constructed and the A watershed is no longer diverted through Lake N9, and is now diverted through the J watershed into Area 8 of Kennady Lake
The A watershed in Area 1 downstream of the Lake A3 outlet, was treated as land due to the establishment of the Fine PK Facility during operations	Area 1 is removed from the Fine PKC Facility	The revised Project footprint does not extend onto lake areas of the A watershed

8.2.4.1.2 Analysis

There are no changes to Section 8.7.1.2 in the 2011 EIS Update (De Beers 2011).

8.2.4.2 Effects Analysis Methods – Closure

8.2.4.2.1 Water Balance Model

Updates to the water balance model presented in Section 8.7.2.1 of the 2011 EIS Update (De Beers 2011) were required to reflect the revised Project footprint and the diversion of surface water from the A watershed back into Kennady Lake, as summarized in Table 8.2-6.

Table 8.2-6 Updates to Water Balance Model - Closure

2011 EIS Update	2012 EIS Supplement	Reason for Change
All statements featured in the 2011 EIS Update (De Beers 2011) are applicable to the 2012 EIS Supplement	Runoff from Lake A1 remains diverted to Lake J1b via pipeline during closure	The A watershed is no longer diverted through Lake N9, and is now diverted through the J watershed into Area 8 of Kennady Lake
All statements featured in the 2011 EIS Update (De Beers 2011) are applicable to the 2012 EIS Supplement	Lake to land ratio was updated in Areas 1 to 7 to reflect the effects of the reduced Project footprint on runoff	The revised Project footprint does not extend onto lake areas of the A watershed

8.2.4.2.2 Monte Carlo Simulation

There are no changes to Section 8.7.2.2 in the 2011 EIS Update (De Beers 2011).

8.2.4.2.3 Analysis

There are no changes to Section 8.7.2.3 in the 2011 EIS Update (De Beers 2011).

8.2.4.3 Effects Analysis Results – Construction and Operations

8.2.4.3.1 Effect of Project Footprint on Flows, Water Levels, and Channel/Bank Stability in Streams and Smaller Lakes in the Kennady Lake Watershed

Project Activities

As part of the supplemental mitigation, Area 1 will no longer be part of the Fine PKC Facility (mitigated). The area of the Fine PKC Facility (mitigated) will be reduced from 1.554 km^2 to 0.710 km^2. For other activities, the reader is referred to Section 8.7.3.1.1 of the 2011 EIS Update (De Beers 2011).

Residual Effects

The effects of the Fine PKC Facility in Section 8.7.3.1.2, including Table 8.7-5, of the 2011 EIS Update (De Beers 2011), does not reflect the change in Project activities described above. The effect of the Fine PKC Facility on Watershed A is no longer applicable.

8.2.4.3.2 Effects of Dewatering of Kennady Lake to Flows, Water Levels and Channel/Bank Stability in Area 8

Project Activities

There are no changes in Section 8.7.3.2.1 from the 2011 EIS Update (De Beers 2011).

Residual Effects

The diversion of the A watershed by pipeline to Lake J1b, which flows into Area 8 of Kennady Lake, has slightly modified predicted flows and water levels presented in Section 8.7.3.2.2 of the 2011 EIS Update (De Beers 2011) for the outlet of Area 8. A summary of flows is presented in Table 8.2-7, with a comparison to results of the 2011 EIS Update. Conclusions on flows, water levels, and channel and bank stability remain similar. Supporting tables and figures summarizing discharge and water level statistics are available in Appendix 8.I.

Table 8.2-7 Predicted Flow Increases from the Outlet of Area 8 during Construction and Operations, Compared to Baseline Conditions

Project Phase	2-Year Flood Discharge (%)	100-Year Flood Discharge (%)	Low Flows (Median Conditions)	
			Minimum (%)	Maximum (%)
Construction	-4 (-10)	-11 (-20)	231 (200)	337 (500)
Operations	-43 (-50)	-40 (-45)	-74 (-81)	-76 (-84)

Note: Results presented in the 2011 EIS Update (De Beers 2011) are shown in parentheses after the results of the new modelling.

8.2.4.3.3 Effect of Watershed Diversion in Watersheds A, B, D, and E on Flows, Water Levels and Channel/Bank Stability in Streams and Smaller Lakes in the Kennady Lake Watershed

Project Activities

As explained in the Project Description (Section 3), Area 1 is no longer part of the Fine PKC Facility (mitigated) and its footprint no longer includes Lakes A1 and A2. The reduction in the size of the Fine PKC Facility (mitigated) involves a change in the diversion of water in Area 1. In the 2010 EIS (De Beers 2010), a permanent dam (Dyke C) would have been constructed to contain the fine PK in Area 1, raising the water level of Lake A3 and causing the water to flow northeast to the N watershed. Dyke C is not included in the current plan. Surface runoff into the A watershed will be managed by a discharge pipeline from Lake A1 to Lake J1b, allowing water to flow to Area 8 of the Kennady Lake watershed.

Residual Effects

Updates to Table 8.7-11 in Section 8.7.3.3.2 of the 2011 EIS Update (De Beers 2011) are required to reflect the diversion of surface runoff from the A watershed by pipeline to the J watershed and are presented in Table 8.2-8. Table 8.7-11 includes Lake A3, but Lake A3 is no longer affected by the Project. Supporting tables are available in Appendix 8.I.

Table 8.2-8 Hydrological Effects on the Outflows from the A, B, D, and E Watersheds during Operations

Lake	Condition	Local Lake Parameters			Watershed Parameters				
		Surface Area	Perimeter	Maximum Depth	Watershed Area	Lake Surface Area		Mean Annual Water Yield	
		(ha)	(m)	(m)	(km^2)	(km^2)	(%)	(mm)	(m^3)
A1[(a)]	Baseline	26.73[(a)]	3,894[(a)]	7.3[(a)]	2.236	0.639	28.6	161	361,000
	Diverted	54.2	3,842	9.0	2.236	0.806	36.0	[(b)]	[(b)]

(a) Includes Lake A2

(b) Controlled by pipeline.

8.2.4.4 Effects Analysis Results – Closure

8.2.4.4.1 Effect of Refilling Activities on Flows, Water Levels and Channel/Bank Stability in Areas 3, 4, 5, 6, and 7

Activity Description

There are no changes in Section 8.7.4.1.1 from the 2011 EIS Update (De Beers 2011).

Residual Effects

Updates to Table 8.7-13 in Section 8.7.4.1.2 of the 2011 EIS Update (De Beers 2011) were required to reflect the change in Project footprint, and the diversion of the A watershed back to Kennady Lake. Updates are presented in Table 8.2-9 and compared to results from the 2011 EIS Update. Conclusions on the refilling time of Kennady Lake remain similar to those from the 2011 EIS Update.

Table 8.2-9 Kennady Lake Refilling Time Frequency and Cumulative Probability after the Supplemental Mitigation

Range (years)	Frequency (%)	Cumulative Probability (%)
5 to 6	0.00	0.00
6 to 7	2.84 (0.00)	2.84 (0.00)
7 to 8	20.40 (1.40)	23.24 (1.40)
8 to 9	33.04 (16.92)	56.28 (18.32)
9 to 10	26.92 (32.24)	83.20 (50.56)
10 to 11	12.00 (29.00)	95.20 (79.56)
11 to 12	4.12 (14.68)	99.32 (94.24)
12 to 13	0.68 (5.00)	100.00 (99.24)
13 to 14	0.00 (0.76)	100.00
14 to 15	0.00	100.00

Note: Results presented in the 2011 EIS Update (De Beers 2011) are shown in parentheses after the results of the new modelling.

8.2.4.4.2 Effect of Diversion on Flows, Water Levels and Channel/Bank Stability in Area 8

Activity Description

There are no changes in Section 8.7.4.2.1 from the 2011 EIS Update (De Beers 2011).

Residual Effects

There are no changes in Section 8.7.4.2.2 from the 2011 EIS Update (De Beers 2011).

8.2.4.4.3 Effects of Temporary Dyke Removal to Flows, Water Levels and Channel/Bank Stability in Kennady Lake

Activity Description

There are no changes in Section 8.7.4.3.1 from the 2011 EIS Update (De Beers 2011).

Residual Effects

There are no changes in Section 8.7.4.3.2 from the 2011 EIS Update (De Beers 2011).

8.2.4.4.4 Long-term Effects of Mine Development on Hydrology of Kennady Lake

Activity Description

There are no changes in Section 8.7.4.4.1 from the 2011 EIS Update (De Beers 2011).

Residual Effects

Updates to Table 8.7-15 in Section 8.7.4.4.2 of the 2011 EIS Update (De Beers 2011) were required because the area of the Project footprint will be reduced and the water management updated. After closure, the pipeline to Lake J1b will be removed and surface runoff from the A watershed will be redirected to Kennady Lake. The permanent diversion of Lake A3 to the N watershed described in the Project Description in the 2010 EIS (De Beers 2010) will no longer occur (i.e., permanent Dyke C will not be constructed). A summary of changes to the areas of Kennady Lake is provided in Table 8.2-10, with a comparison of results from the 2011 EIS Update. A supporting table is provided in Appendix 8.I. Conclusions on long-term potential effects remain similar to those from the 2011 EIS Update, as indicated in Table 8.2-11.

Table 8.2-10 Post-closure Changes to Kennady Lake Watershed Land and Lake Areas

Area Description	Total Watershed (km^2)	Total Land (km^2)	Total Lake (km^2)	Kennady Lake (km^2)	Tributary Lake (km^2)	Lake Proportion (%)
Kennady Lake Watershed Pre-development Condition	32.463	21.170	11.293	8.149	3.144	34.8
Kennady Lake Post-Closure Condition	32.463 (31.624)	22.034 (21.922)	10.429 (9.703)	7.136 (7.190)	3.126 (2.513)	32.1 (30.7)
Change from Pre-development Conditions	0.000 (0.839)	0.864 (0.752)	-0.864 (-1.590)	-1.013 (-0.959)	0.149 (-0.631)	-2.7 (-4.1)

Note: Results presented in the 2011 EIS Update (De Beers 2011) are shown in parentheses after the results of the new modelling.

Table 8.2-11 Updates to Concluding Statements of Residual Effects

2011 EIS Update	2012 EIS Supplement	Reason for Change
....the mean annual water yield will increase by 5.1% at post-closure, from approximately 147 mm to 160 mm. Mean annual discharge from Kennady Lake will increase by only 6.1%, from 4,760 cubic decametres (dam^3) to 5,050 dam^3. Due to the post-closure decrease in water surface area in Kennady Lake by 11.8%, the runoff of a given quantity of water into the lake will result in a proportionally greater increase in lake water level.	....the mean annual water yield will increase by 5.1% at post-closure, from approximately 147 mm to 154 mm. Mean annual discharge from Kennady Lake will increase from 4,760 cubic decametres (dam^3) to 5,000 dam^3. Due to the post-closure decrease in water surface area in Kennady Lake by 12.4%, the runoff of a given quantity of water into the lake will result in a proportionally greater increase in lake water level.	Change in mine footprint. Change in diversion of the A watershed.

8.2.5 Effects to Water Quality

Changes to surface water quality will depend on sources and the water balance within the Kennady Lake watershed throughout the different phases of the mine. Since the submission of the 2011 EIS Update (De Beers 2011), the mine plan has been updated to reflect supplemental mitigation associated with the deposition of fine PK to reduce potential loading of water quality constituents, including phosphorus. This change has resulted in a lower volume of fine PK that will be deposited to the Fine PKC Facility (mitigated) (Section 3). Therefore, the footprint of the Fine PKC Facility (mitigated) has been limited to Area 2, which reduces its surface area by approximately half as it no longer includes Area 1. In addition, on-going geochemical testing of site-specific PK material (Appendix 8.III) has also identified that the leachate concentrations for many of the geochemical constituents loading from fine PK material is not as high as reported in the 2011 EIS Update. A combination of the reduction in footprint area and revised source term inputs alter the projected long-term loading of water quality constituents to Kennady Lake, and therefore, an update on the water quality modelling was required.

The following section provides an overview of the anticipated major changes in water quality projections from the earlier assessment (De Beers 2011) due to additional mitigation measures.

8.2.5.1 Site Water Quality

To project the site water chemistry in Kennady Lake during construction, operations, closure and post-closure, a mass-balance water quality model was developed using GoldSim™ version 10.5. The model approach used for the 2012 EIS Supplement is similar to the methods used in the 2011 EIS Update (De Beers 2011), with the following changes:

- The water balance within the Kennady Lake watershed was revised as a result of the smaller Fine PKC Facility (mitigated) and management of the Area 1 watershed. During construction and operations, watershed runoff from Area 1 will be directed via pipeline from Lake A1 to Area 8, via Lake J1b. At closure, flow from Lake A1 will be reconnected to Area 3 of Kennady Lake.
- Geochemical source terms for each of the geochemical constituents were revised for mine rock, coarse PK and fine PK material to reflect on-going geochemical testing results, which included supplemental site-specific rock and kimberlite material.
- Baseline chemistry data were updated based on supplemental baseline monitoring conducted in 2011.
- Hydrodynamic modelling of Hearne Pit was included, which was not modelled in the 2011 EIS Update (De Beers 2011).
- Lake water recharging the groundwater draining towards the open pits was updated to include contributions from the WMP and Kennady Lake Areas 4, 6, and 7.
- The GoldSim™ water quality model was refined to incorporate the updated water balance, include updated seepage modelling results through the Fine PKC Facility, and include updated source term inputs.

For this section, consistent with the 2011 EIS Update (De Beers 2011), the model simulates concentrations for a range of water quality parameters at the following key nodes, for specific Project phases:

- Kennady Lake (Areas 3 to 7):
  - For construction and operations, the results reflect the water chemistry in Areas 3 and 5 (WMP), because this water will be discharged to Lake N11; and
  - For closure (refilling and long-term closure), the results reflect the average water quality in Areas 3 to 7.
- Area 8 (all phases).

Also consistent with the 2011 EIS Update (De Beers 2011), water quality projections in Kennady Lake 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, resulting in lower rates of seepage through the facilities and geochemical loading to Kennady Lake than simulated within this assessment. The assessment is conservative as it has been designed to represent potential future climatic conditions where there may be no permafrost.

A detailed description of the site water quality model, including inputs and assumptions, is provided in Appendix 8.II. Projected water chemistry results on a time series basis are presented in Appendix 8.IV.

8.2.5.1.1 Results

Since Area 8 will be isolated from Kennady Lake during operations, model results for Kennady Lake and Area 8 are discussed separately. Water quality modelling in Kennady Lake takes into account Project activities within Areas 3 and 5, Area 4, Area 6, and Area 7 during all phases and resulting water chemistry changes, and in Tuzo and Hearne pits above the pycnocline (the layer of water with the highest density gradient between two waters of varying density).

Effects to Water Quality in Kennady Lake at Post-closure

Concentrations of each of the water quality parameters after the refilling of Kennady Lake and breaching of Dyke A (i.e., during post-closure) are presented in Table 8.2-12. Data from the 2011 EIS Update (De Beers 2011) are provided for comparison.

Two snap shots were selected to bracket the range of water quality in Kennady Lake during post-closure:

- immediately after refilling, when Dyke A is breached and the lake is reconnected to Area 8; and
- one hundred years after the start of mining operations, to represent long-term, steady-state conditions.

A brief discussion of the water quality modelling results is provided below, which includes time series plots for selected water quality parameters. Time series plots are provided for each of the modelled water quality parameters in Appendix 8.IV. Table 8.2-12 includes a comparison to the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 1999) for reference;

however, the assessment of effects of changes in water quality to aquatic life is presented in the following section.

Consistent with the 2011 EIS Update (De Beers 2011), the modelled water quality results have been grouped into three categories:

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

Table 8.2-12 Predicted Water Quality in Kennady Lake During Post-closure

Regulated Parameter	Units	CCME Water Quality Guidelines [a]	Kennady Lake Baseline Water Quality	Projected Concentrations in Kennady Lake			
				Maximum Post-closure Concentration [b]		Long-term Steady State Concentration [b]	
				2012	2011	2012	2011
Conventional Parameter							
TDS	mg/L	-	13	145	162	37	83
Hardness [c]	mg/L	-	-	85	97	19	47
Major Ions							
Calcium	mg/L	-	1.2	27	30	5	13
Chloride	mg/L	120	0.55	64	69	3	21
Fluoride	mg/L	0.12	0.03	0.13	-	0.13	-
Magnesium	mg/L	-	0.52	4.6	5.6	1.6	3.4
Potassium	mg/L	-	0.48	2.8	5.8	1.9	5.7
Sodium	mg/L	-	0.71	15	17	2.4	9.5
Sulphate	mg/L	-	0.83	20	22	10	22
Nutrients							
Nitrate	mg N/L	13	-	2.0	2.9	0.024	0.037
Ammonia	mg N/L	5.55 [d]	0.032	1.9	3.1	0.03	0.021
Total Nitrogen	mg N/L	-	0.35	2.3	9.3	0.35	0.84
Dissolved P	mg/L	-	0.0057	0.011	0.021	0.009	0.016
Total Phosphorus	mg/L	-	0.0033	0.011	0.023	0.009	0.016
Total Metals							
Aluminum	mg/L	0.005 to 0.1 [e]	0.0098	0.092	0.071	0.057	0.07
Antimony	mg/L	-	0.0001	0.0008	0.0021	0.0005	0.0019
Arsenic	mg/L	0.005	0.00014	0.0024	0.0025	0.0006	0.0024
Barium	mg/L	-	0.0027	0.03	0.19	0.02	0.19
Beryllium	mg/L	-	0.000041	0.00014	0.00014	0.00012	0.00014
Boron	mg/L	1.5	0.0031	0.11	0.59	0.09	0.59
Cadmium	mg/L	0.000017 [f]	0.00002	**0.000045**	**0.000042**	**0.000041**	**0.00004**
Chromium	mg/L	0.001	0.0002	0.001	**0.005**	0.0005	**0.0013**
Cobalt	mg/L	-	0.000135	0.00136	0.00048	0.00105	0.00027
Copper	mg/L	0.002-0.004 [f]	0.0012	**0.0023**	**0.0028**	**0.002**	**0.0027**
Iron	mg/L	0.3	0.065	0.19	**0.44**	0.1	0.14
Lead	mg/L	0.001-0.007 [f]	0.000049	0.00034	0.00038	0.00026	0.00022
Manganese	mg/L	-	0.0122	0.043	0.056	0.033	0.015
Mercury	mg/L	0.000026	0.0000102	0.00001	0.000017	0.00001	0.000011
Molybdenum	mg/L	0.073	0.000074	0.007	0.012	0.003	0.012
Nickel	mg/L	0.025-0.15 [f]	0.00032	0.0048	0.0031	0.0029	0.0031
Selenium	mg/L	0.001	0.00019	0.00017	0.00084	0.00014	0.00025
Silver	mg/L	0.0001	0.00008	0.000061	0.000076	0.000056	0.000059
Strontium	mg/L	0.049	0.0082	0.03	0.19	0.02	0.19
Thallium	mg/L	0.0008	0.000021	0.00005	0.00019	0.000029	0.000038
Uranium	mg/L	-	0.000026	0.0016	0.0022	0.00121	0.00085
Vanadium	mg/L	-	0.00024	0.0027	0.003	0.0024	0.0029
Zinc	mg/L	0.03	0.0028	0.008	0.012	0.0067	0.0045

Table 8.2-12 Predicted Water Quality in Kennady Lake During Post-closure (continued)

Regulated Parameter	Units	CCME Water Quality Guidelines [a]	Kennady Lake Baseline Water Quality	Projected Concentrations in Kennady Lake: Maximum Post-closure Concentration [b]		Projected Concentrations in Kennady Lake: Long-term Steady State Concentration [b]	
				2012	2011	2012	2011
Dissolved Metals							
Aluminum	mg/L	0.005 to 0.1 [e]	0.0055	0.063	0.042	0.054	0.042
Antimony	mg/L	-	0.000082	0.0007	0.0021	0.0005	0.0019
Arsenic	mg/L	0.005	0.00012	0.0024	0.0025	0.0006	0.0024
Barium	mg/L	-	0.0027	0.03	0.19	0.02	0.19
Beryllium	mg/L	-	0.000038	0.00014	0.00014	0.00012	0.00014
Boron	mg/L	-	0.0023	0.11	0.59	0.09	0.59
Cadmium	mg/L	0.000017 [f]	0.000022	**0.000035**	**0.000032**	**0.000032**	**0.000031**
Chromium	mg/L	0.001	0.00016	0.0005	**0.0045**	0.00044	0.00078
Cobalt	mg/L	-	0.000135	0.00129	0.0004	0.00105	0.00019
Copper	mg/L	0.002-0.004 [f]	0.00069	**0.0017**	**0.0022**	**0.0015**	**0.0021**
Iron	mg/L	0.3	0.021	0.11	**0.36**	0.079	0.061
Lead	mg/L	0.001-0.007 [f]	0.00003	0.00031	0.00035	0.00025	0.0002
Manganese	mg/L	-	0.0122	0.042	0.055	0.033	0.014
Mercury	mg/L	0.000026	0.0000077	0.000009	0.000015	0.0000081	0.0000092
Molybdenum	mg/L	0.073	0.000058	0.007	0.012	0.003	0.012
Nickel	mg/L	0.025-0.15 [f]	0.00032	0.0034	0.0017	0.0028	0.0016
Selenium	mg/L	0.001	0.00004	0.00017	0.00084	0.00014	0.00025
Silver	mg/L	0.0001	0.000051	0.000061	0.000076	0.000056	0.000059
Strontium	mg/L	-	0.0082	0.06	0.19	0.05	0.19
Thallium	mg/L	0.0008	0.000017	0.00005	0.00018	0.000023	0.000032
Uranium	mg/L	-	0.000019	0.0015	0.0022	0.00121	0.00085
Vanadium	mg/L	-	0.000134	0.0025	0.0027	0.0022	0.0026
Zinc	mg/L	0.03	0.0023	0.008	0.012	0.0067	0.0045

[a] Chronic Aquatic Health Guidelines from Canadian Environmental Quality Guidelines (CCME 1999).

[b] Bold font indicates concentration is higher than the CCME water quality guideline.

[c] Theoretical hardness calculated based on observed calcium and magnesium concentrations; measured as mg $CaCO_3$/L.

[d] Dependent on pH and temperature (assumed 15ºC, to give most conservative guideline).

[e] Dependent on pH.

[f] Dependent on hardness.

mg/L = milligrams per litre; mg/L as $CaCO_3$ = milligrams per litre as calcium carbonate; mg N/L = milligrams per litre as nitrogen; - = not available or not applicable.

Total Dissolved Solids (TDS) and Major Ions

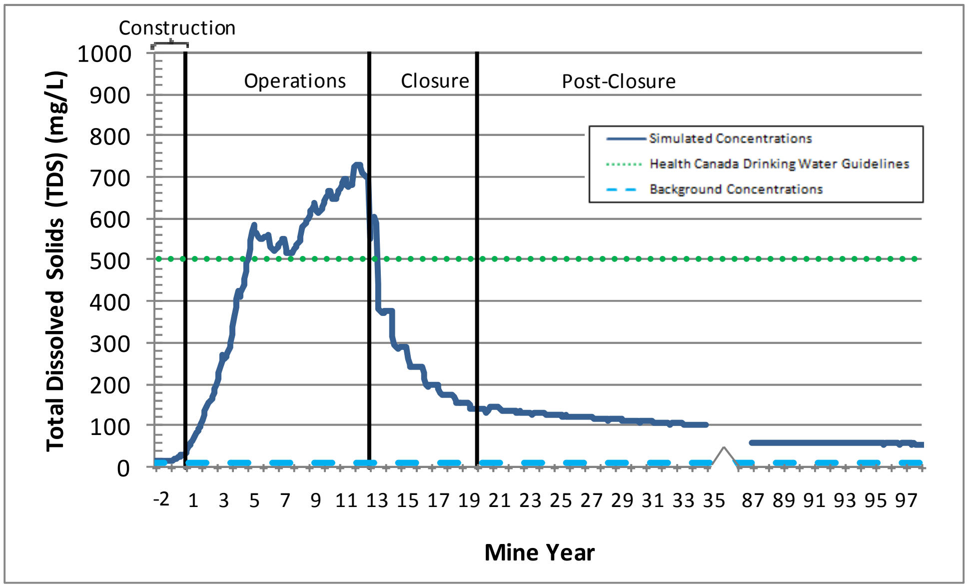
As described in the 2011 EIS Update (De Beers 2011), TDS concentrations increase in Kennady Lake (primarily areas 3 and 5) during the operations as a result of the management of saline groundwater inflows from the mining pits, natural runoff, and process water cycling within the WMP. During the closure phase, TDS concentrations are projected to decrease rapidly as a large proportion of high TDS water in the WMP is siphoned to Tuzo Pit and the lake is filled with low TDS waters from natural drainage through the reconnected upper watersheds A, B, D and E, and supplemental inflows from Lake N11 (Table 8.2-12; Figure 8.2-1). As a result of the smaller Fine PKC Facility (mitigated) and updated geochemistry testing, the maximum projected post-closure TDS concentration (145 mg/L) is lower than the maximum projected TDS concentration in the 2011 EIS Update (165 mg/L).

Following refilling, TDS concentrations are predicted to continue to decline as Dyke A is breached and water stored in Kennady Lake is replaced by additional fresh water inflows (i.e., natural drainage) from the upstream lakes and streams. The long-term steady state TDS concentration in Kennady Lake is projected to be 37 mg/L TDS (Table 8.2-12; Figure 8.2-1), compared to 83 mg/L as presented in the 2011 EIS Update (De Beers 2011).

The time series trends for the major ions, sodium, potassium, calcium, magnesium, chloride and sulphate, are projected to be similar to the trend presented for TDS. Maximum concentrations and long-term steady state concentrations for these ions are all lower than projected in the 2011 EIS Update (De Beers 2011) (Table 8.2-12). A representative time series plot is provided for sulphate (Figure 8.2-2).

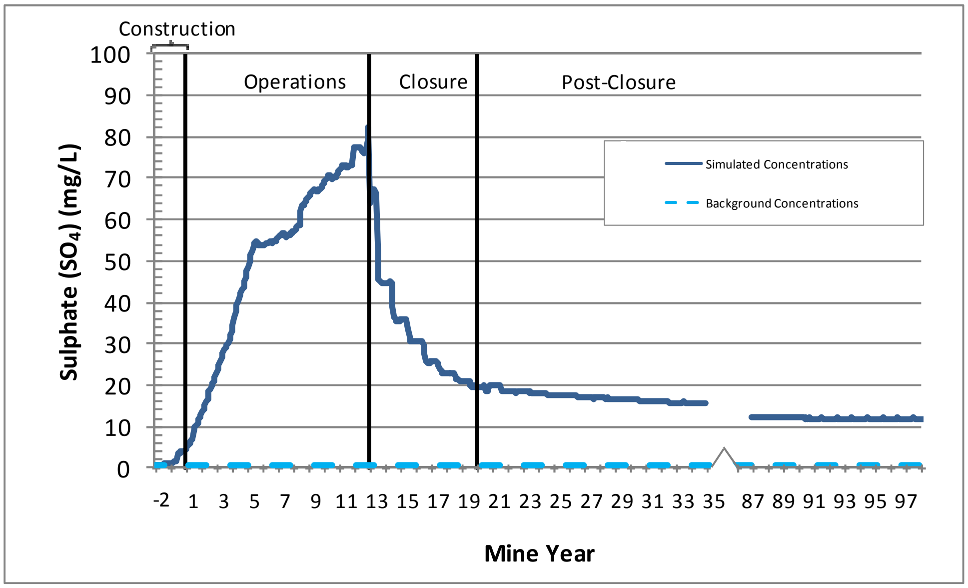
Fluoride was added to the list of modelled water chemistry sources in this supplemental assessment. Similar to the other major ions, fluoride concentrations increase in the WMP during operations and decrease during closure, as a large proportion of water from the WMP is transferred to the Tuzo pit (Figure 8.2-3). However, concentrations increase slightly into the long-term with the steady state concentration just above the CCME guideline (0.12 mg/L). The long-term trend is a result of fluoride being sourced primarily from fine PK than other sources (e.g., groundwater).

Figure 8.2-1 Trends of Predicted Total Dissolved Solids Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



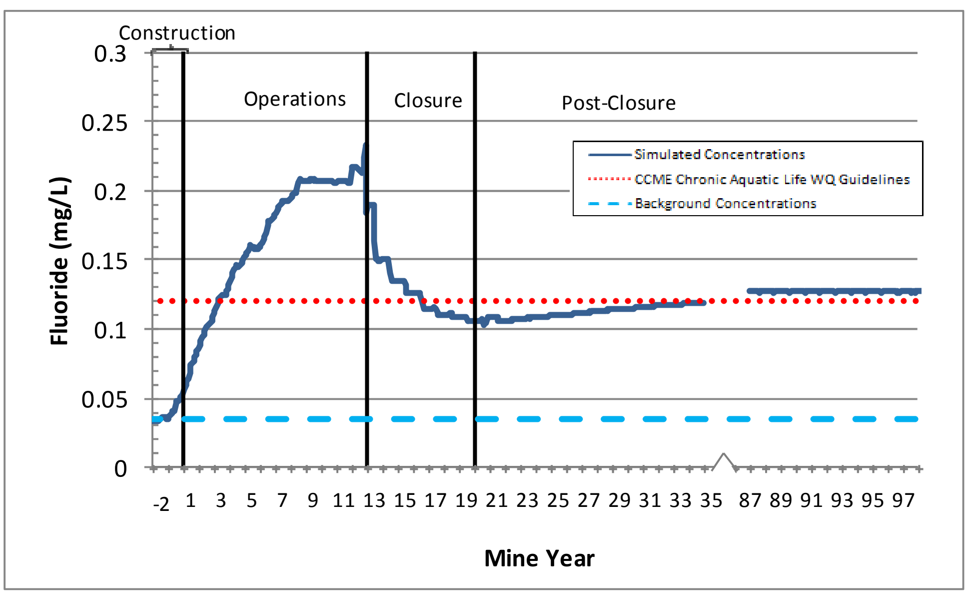
mg/L = milligrams per litre.

Figure 8.2-2 Trends of Predicted Sulphate Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



mg/L = milligrams per litre.

Figure 8.2-3 Trends of Predicted Fluoride Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



mg/L = milligrams per litre.

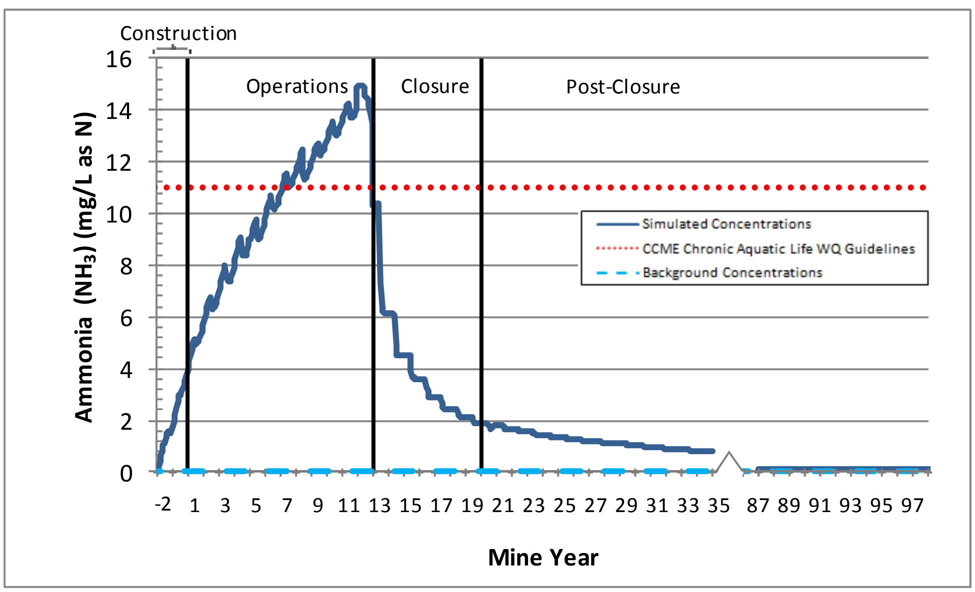
Nutrients

Nitrogen

Consistent with the 2011 EIS Update (De Beers 2011), concentrations of ammonia and nitrate are predicted to increase in the WMP, as a result of blasting activities. Projected concentrations were developed based on a proposed blasting plan, which was prorated evenly over the life of the mine. There is some conservatism associated with these projections as residual nitrogen is assumed to be released immediately to the WMP. In reality, a portion of the residual nitrogen will be incorporated into the mine rock and PK storage facilities, effectively reducing the loading rate to the WMP. In addition, emulsion, which accounts for approximately 30% of the total explosives (Appendix 8.II), was considered to have the same solubility as ammonium nitrate. Maximum concentrations of ammonia and nitrate in the WMP during operations, however, are projected to be lower than presented in the 2011 EIS Update.

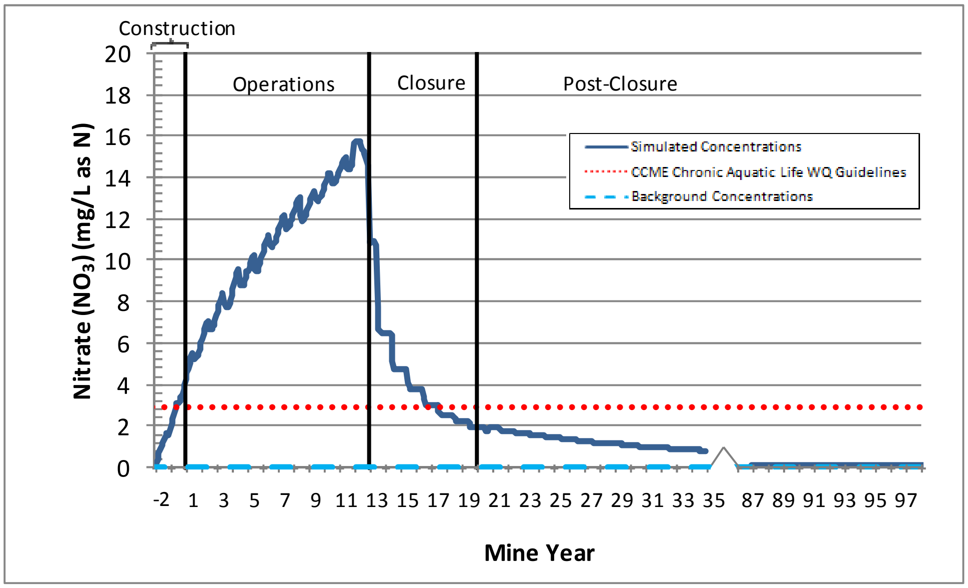
Following closure, projected nitrate and ammonia concentrations decrease to steady state concentrations that are below CCME water quality guidelines (Table 8.2-12) and near background levels (Figures 8.2-4 and 8.2-5).

Figure 8.2-4 Trends of Predicted Ammonia Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



mg/L as N = milligrams per litre as nitrogen.

Figure 8.2-5 Trends of Predicted Nitrate Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



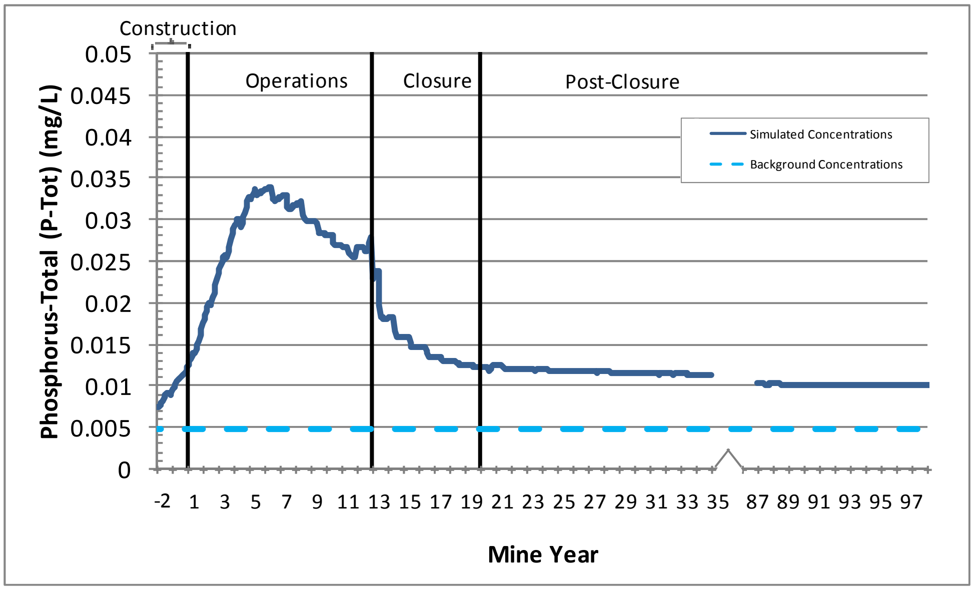
mg/L as N = milligrams per litre as nitrogen.

Phosphorus

Consistent with the 2011 EIS Update (De Beers 2011), concentrations of phosphorus are projected to increase in the WMP during operations due to the incremental loading from process water, runoff and seepage inputs from Project facilities, and groundwater inputs. The supplemental mitigation associated with the deposition of fine PK was developed to address the potential for elevated phosphorus loading from fine PK material. As a consequence of the smaller Fine PKC Facility, and updated geochemistry testing that identified that phosphorus concentrations in leachate is not as high as reported in the 2011 EIS Update, modelled phosphorus concentrations in Kennady Lake during operations and closure phases are lower than presented in the 2011 EIS Update.

During the closure phase, total phosphorus concentrations in Kennady Lake are projected to decrease as a large portion of the water in the WMP is pumped to Tuzo Pit, and Kennady Lake is replaced by freshwater inflows (Figure 8.2-6). Subsequently, concentrations continue to decrease during the post-closure phase to a long-term steady state concentration of 0.009 mg/L (Table 8.2-12). As a consequence, the trophic status of Kennady Lake is projected to return to oligotrophic status (CCME 2004; Environment Canada 2004).

Figure 8.2-6 Trends of Projected Total Phosphorus Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



mg/L = milligrams per litre.

The environmental relevance of the projected total phosphorus levels is discussed below, with reference to dissolved oxygen levels in Kennady Lake, and again in Section 8.2.7.2 with respect to primary productivity, and fish and fish habitat.

Potential Effects of Nutrient Enrichment

Phosphorus is generally a limiting nutrient in freshwater ecosystems, so its concentration can determine trophic status of a waterbody. Currently, Kennady Lake can be classified as an oligotrophic lake, based on the average baseline TP concentration of 0.006 mg/L (CCME 2004; Environment Canada 2004). The projected maximum total phosphorus (TP) concentration during closure (0.011 mg/L) and long-term steady state TP concentration during post-closure (0.009 mg/L) are lower than the concentrations presented in the 2011 EIS Update (De Beers 2011) (0.023 mg/L and 0.018 mg/L, respectively). As a result, the trophic status of Kennady lake will transition from low bounds of mesotrophic following closure to oligotrophic during post-closure (CCME 2004; Environment Canada 2004), remaining oligotrophic in the long-term.

It is anticipated that there will be an increase in productivity in Kennady Lake as a result in the increase in total phosphorus; however, the extent of change will be lower than predicted in the 2011 EIS Update (De Beers 2011). It would be expected that plankton and algal growth would increase, compared to baseline, resulting in a larger amount of total organic carbon remaining in the lake after senescence each fall. The increase in productivity is expected to modify the winter dissolved oxygen concentrations in Kennady Lake. In the 2011 EIS Update, empirical models (i.e., Babin and Prepas 1985, Mathias and Barica 1980, Vollenweider 1979) were used to predict the implications of the higher total phosphorus concentrations in Kennady Lake on winter dissolved oxygen concentrations. For the supplemental assessment, a three-dimensional (3-D) hydrodynamic nutrient model was developed to determine the winter dissolved oxygen profiles in Kennady Lake. This is discussed in Section 8.2.5.3.

Trace Metals

Concentrations of trace metals are expected to change in Kennady Lake during operations due to potential loading sources to Areas 3 and 7, which include mine rock and PK drainage, groundwater and pit wall exposure. As a result of the smaller footprint of the Fine PKC Facility (mitigated) and updated geochemistry testing, the long-term steady state concentrations of 17 of the 23 metals assessed are projected to be lower than presented in the 2011 EIS Update (De Beers 2011). However, long-term steady state concentrations of cadmium, cobalt, lead, manganese, uranium, and zinc are predicted to increase slightly from the previous results presented in 2011 EIS Update (Table 8.2-12).

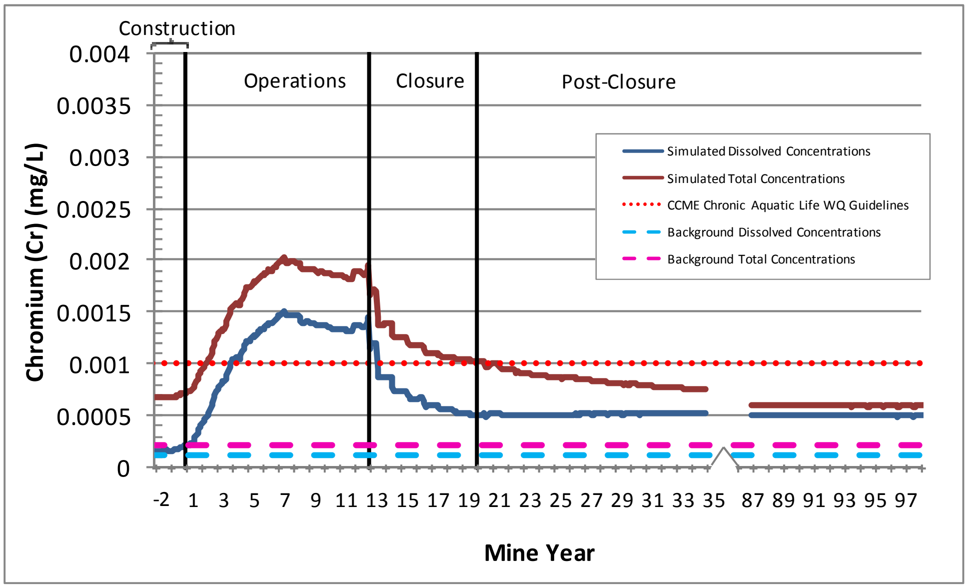
Based on the time-series trends for trace metals, two patterns are evident:

A. Trace Metals that are Projected to Decline Following Closure

Of the 23 modelled trace metals, 11 are predicted to increase in concentration during the operations phase, and then steadily decline in concentration as the lake is flushed during post-closure. These metals are chromium, cobalt, iron, lead, manganese, mercury, selenium, silver, thallium, uranium, and zinc. None of these 11 metals are projected to be higher than CCME guidelines following closure; in the 2011 EIS Update (De Beers 2011), chromium and iron were predicted to be higher than guidelines. Representative time series plots of chromium and iron to illustrate this pattern are presented in Figures 8.2-7 and 8.2-8, respectively.

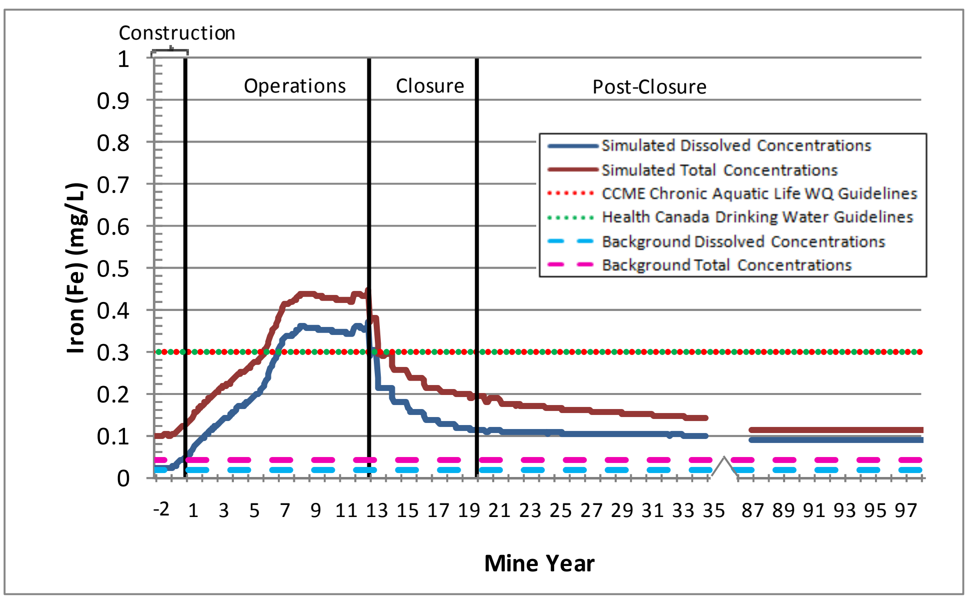
With the exception of thallium, the primary loading source of the listed metals to Kennady Lake is groundwater inflows to the active mine pits, which is pumped to the WMP. Following closure, when a large proportion of the water in the WMP is transferred to Tuzo Pit, the concentrations of these metals decrease once refilling of the lake begins. Thallium has two primary loading sources, namely, groundwater and mine rock runoff.

Figure 8.2-7 Trends of Projected Chromium Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



mg/L = milligrams per litre.

Figure 8.2-8 Trends of Projected Iron Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



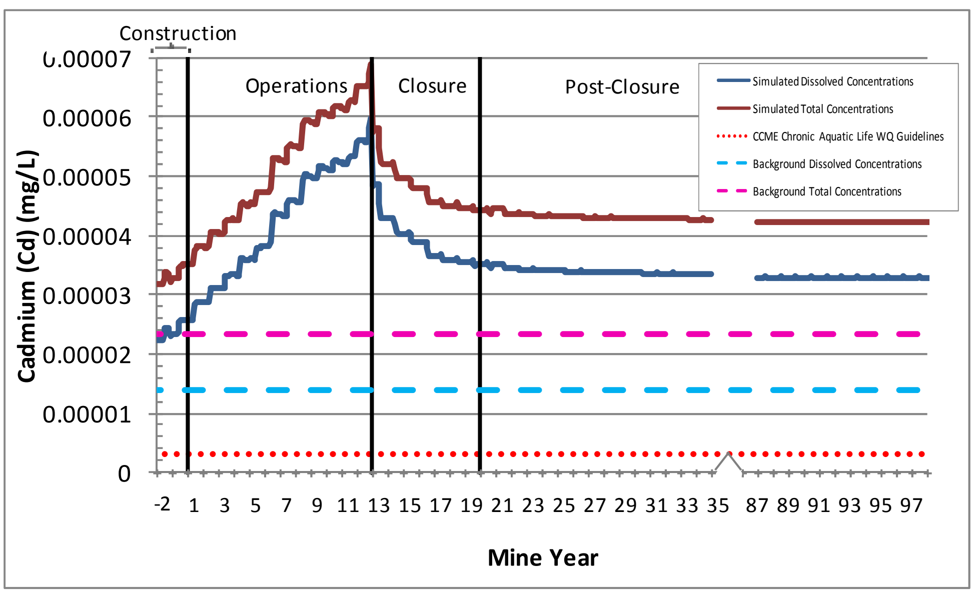
mg/L = milligrams per litre.

B. Trace Metals that are Projected to Reach Steady State Shortly after Closure

The remaining 12 metals are projected to increase during operations due to primary inputs from groundwater and seepage from mine rock and PK storage facilities; however, they are projected to decrease during closure, and reach a steady state condition soon after closure that continues through post-closure. The lack of a further decrease in the post-closure concentrations of these metals is attributed to the predominant geochemical loading from the remaining mine rock and PK facilities under the assumption of permafrost-free conditions. Additionally, because the primary loading sources of these metals are groundwater and geochemical reactions, the majority of these metals are assumed to be in dissolved form.

Of these 12 metals, cadmium and copper are predicted to be higher than CCME guidelines during post-closure. However, these metals have also been measured above guideline concentrations in baseline conditions. Representative time series plots are shown for cadmium (Figure 8.2-9) and copper (Figure 8.2-10) to illustrate the general trends of this group of metals.

Figure 8.2-9 Trends of Projected Cadmium Concentrations in Kennady Lake (Areas 3 and 5 – Construction and Operations, and Areas 3 to 7 – Closure and Post-closure)



mg/L = milligrams per litre.