# WATER RELEASE FACILITY AT KENNEY DAM

## UPDATED CONCEPTUAL LAYOUT AND COST ESTIMATE

**Prepared for:**

**NECHAKO ENVIRONMENTAL ENHANCEMENT FUND MANAGEMENT COMMITTEE**

**by:**

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# Water Release Facility at Kenney Dam
# Updated Conceptual Layout and Cost Estimate

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# 1. INTRODUCTION

## 1.1 TERMS OF REFERENCE

This report presents an updated conceptual layout and cost estimate for a water release facility at Kenney Dam. The study was commissioned by the Management Committee of the Nechako Environmental Enhancement Fund (NEEF) and was undertaken under Provincial Government Contract WMB01-073, pursuant to a proposal submitted by Klohn Crippen in January 2001.

## 1.2 BACKGROUND

In 1995, as part of the deliberations of the joint Province/Alcan Kenney Dam Release Facility (KDRF) Working Group, Klohn Crippen developed conceptual layouts and preliminary cost estimates for nine alternatives for a water release facility at Kenney Dam to meet a wide range of possible discharge requirements and performance objectives. The aim was to indicate the order-of-magnitude cost of achieving the various performance objectives, and an appropriately simple methodology was used. Wherever possible, project components were based on those developed for the KDRF which Klohn Crippen had designed as part of the Kemano Completion Project (KCP), but with the size adjusted as necessary for the increased flow required. The costs of those components were derived from estimates which others had prepared for the KCP KDRF components by pro-rating in proportion to the increase in size, and applying appropriate escalation to convert the costs to 1995 dollars. In some cases, new components had to be developed. In these cases, approximate proportions were developed and quantities of major work and materials were then priced at rates obtained from the KCP KDRF estimates, where rates for comparable work were available. When rates for comparable work were not available, rates were estimated based on experience on other projects. The conceptual alternatives and costs were presented in a joint Province/Alcan report in April 1996(1). The alternatives were referred to by a number, generally in the order in which they were suggested by the Working Group. In some cases, a letter was added to indicate a variant, i.e. Alternative 4A was a variant of Alternative 4.

Subsequent to the publication of the Working Group report, and as a result of the 1997 Agreement between Alcan and the Province, the Nechako Environmental Enhancement Fund (NEEF) was established. The Nechako Watershed Council was also formed. When these organizations requested presentations on the options for a water release facility at Kenney Dam, it was decided to re-arrange the alternatives in a more logical order based generally on the increase in potential benefit provided, although discharge capacity was also a factor. Some additional concepts had also been developed since the Working Group report. Accordingly, a new alpha-numeric reference system was used, Case A representing the simplest facility and Case H representing the largest facility. The budget costs remained at the 1995 level.

The Management Committee of NEEF has been considering the various configurations of a water release facility at Kenney Dam as a possible candidate for the funds committed to NEEF by Alcan and the Province. The Management Committee's consideration of the various options is nearing completion and a preferred basic configuration, now known as Case E (Alternative 4A in the 1995 KDRF Working Group report), has been selected, with some desired modifications. In view of the modifications, and the somewhat rudimentary nature and 1995 dollar level of the previous cost estimates, the Management Committee required an updated layout and cost estimate for the preferred configuration. The updated layout and cost estimate are the subject of this report.

## 1.3 SCOPE OF WORK

The work involved four principal tasks:

- refining of the conceptual layout for Case E to suit the components and the flow and operating regimes identified by the Management Committee, including review of the capacity of the low level outlet;
- measurement of the quantities of major work and materials;
- a pre-feasibility level estimate of the cost of the facility in 2001 Canadian dollars; and
- the preparation of this report.

The Management Committee subsequently requested that Klohn Crippen provide an estimate of the annual operating and maintenance cost of the water release facility.

# 2. CRITERIA

## 2.1 BASIC CONFIGURATION

The basic water release facility (Case E) envisaged by the Management Committee would consist of:

- a surface-water intake channel;
- deep-water intakes and pipelines;
- a high-level outlet regulating structure, capable of releasing water from surface and deep sources either one at a time or together, and a surface spillway equipped with a flip bucket energy dissipator; and
- a low-level outlet with the capability of releasing water from surface and deep sources either one at a time or together, and equipped with one or more hollow-cone valves for energy dissipation and dissolved gas control.

As an option, the Management Committee requested that a facility (mixing chamber) be included in the high-level outlet to mix the water from deep and surface sources as it is released (to avoid the potential temperature shears associated with the release of separate streams of water into the spillway).

## 2.2 OPERATING REGIME

The water release facility is envisaged by the Management Committee to operate in conjunction with the Skins Lake Spillway, which would continue to provide flows to the Murray-Cheslatta system. The hydrograph for the Murray-Cheslatta system would follow a natural form with a maximum annual average flow of 15 $m^3$/s. Assuming that the natural annual inflow to the Murray-Cheslatta system averages about 5 $m^3$/s, this means that the Skins Lake Spillway would release a maximum annual average of 10 $m^3$/s, excluding releases required for the management of excess reservoir inflows.

Assuming that the annual average of base flow releases from the Nechako Reservoir continues to be 36.8 $m^3$/s (as required under the Short Term Water Allocation [STWA] of the 1987 Agreement between Alcan and the federal and provincial governments), base flow releases from a water release facility at Kenney Dam would average 26.8 $m^3$/s. Base flows measured below Cheslatta Falls are envisaged by the Management Committee to follow a similar seasonal variation to those currently used by the Nechako Fisheries Conservation Program (NFCP). The Kenney Dam facility base flow releases would be the base releases from the reservoir required by the STWA minus the flows being released from Skins Lake Spillway, according to the season.

## 2.3 HYDRAULIC CAPACITIES

### 2.3.1 Low-Level Outlet

A low-level outlet capacity of 60 $m^3/s$ was established for the conceptual layouts developed in 1995. This capacity stemmed from two principal assumptions: a) that all the STWA base flows would be released from the facility at Kenney Dam, and b) that it would be preferable for operational reasons and dissolved gas control to release all base flows through the facility's low-level outlet. Consequently, the low-level outlet would need to have a capacity of at least 54.6 $m^3/s$, the maximum of the mean monthly releases (in April) indicated in Column I of Schedule "C" of the 1987 Agreement, the so-called "default" releases for the STWA. A capacity of 60 $m^3/s$ met this requirement and also provided for some release of excess inflows in winter, assuming that Skins Lake Spillway would not be used.

Because Skins Lake Spillway is now envisaged to continue to release a proportion of the STWA base flow, the size of a low-level outlet at Kenney Dam could potentially be reduced by the amount which would be released at Skins Lake Spillway. However, there is another factor to consider, namely, cooling water. We understand from discussions with Triton Environmental Consultants (Clyde Mitchell personal communication), which has been studying various cooling water regimes for NEEF, that the base cooling water release would probably be 60 $m^3/s$, and that the next level of release in response to a forecast increase in downstream water temperatures would probably be in the order of 90 $m^3/s$, a 50% increase. If the low-level outlet does not have the capacity to release the base cooling water release, then this release would have to be made through the high-level outlet and spillway. However, because of other requirements, the high-level outlet gates would be relatively large. Furthermore, they would free discharge to atmosphere under full reservoir head. As a consequence of these conditions, a release of 60 $m^3/s$ would require relatively small gate openings. Also, in most cases, cooling water releases would require a proportion to come from both deep and surface sources, according to the temperature of each source. When the potential range of temperatures of the two sources, and hence the proportion of water from each source to produce a mixed temperature of 10°C, is taken into consideration, the opening of one or other of the high-level outlet gates would become impracticably small from the perspective of accurate temperature regulation of a 60 $m^3/s$ release. For a release of 90 $m^3/s$, this problem would be alleviated.

In contrast to the high-level outlet gates, the low-level outlet gates would not only be smaller, but, more importantly, they would not free discharge to atmosphere; the gates would discharge into a pressurized conduit in which primary flow regulation would be provided by the outlet hollow-cone valve(s). The gates would act simply as restrictions, producing variable head losses, and hence varying the amount of water drawn from each source. In operation, one or other of the gates would generally be fully open, and the other partially open.

Regulation of flow, and hence temperature, would therefore be achieved with relatively large gate openings. Consequently, if base cooling water releases would be 60 $m^3$/s and accurate temperature control is required, then the low-level outlet should have a capacity of 60 $m^3$/s.

It must be noted that although the Management Committee is envisaging seasonal flow variations similar to those currently used by the NFCP, the NWC is understood to be considering a release of 68 $m^3$/s in the second half of May. This release would exceed the capacity of the low-level outlet in the present layout. However, because this is outside the cooling water period, and temperature control would presumably not therefore be required, the May release could be made from the high-level outlet. Even if a hydroelectric generating facility were to be added to the facility, requiring, for example 25 $m^3$/s, then the 43 $m^3$/s balance of the May release could still be made through the high-level outlet. Nevertheless, there are complications associated with the possibility of a 68 $m^3$/s release in May, as discussed in Section 2.6.

### 2.3.2 High Level Outlet

A high-level outlet spillway capacity of 450 $m^3$/s was established for the conceptual layout developed in 1995. This was the capacity estimated to be required to reduce the frequency of operation of Skins Lake Spillway to release excess inflows to no more than once in 200 years on average, and thereby afford an opportunity for the restoration of the Murray-Cheslatta system. The estimate was based on a preliminary evaluation of the combined probabilities of initial reservoir levels and freshet inflows. If releases from Skins Lake Spillway would continue, then the capacity of the spillway at the Kenney Dam facility could theoretically be reduced by the amount permitted from Skins Lake Spillway. However, in view of the preliminary nature of the capacity estimate, the 450 $m^3$/s capacity of the high-level outlet spillway has been retained in the updated layout.

### 2.3.3 Cooling Water Capacity

For the 1995 conceptual layouts with selective withdrawal capability, a cooling water capacity of 170 $m^3$/s at 10ºC from either or both surface and deep-water sources was assumed, based on the requirement for the KCP KDRF. We understand that preliminary studies for the Management Committee by Triton indicate that this capacity could possibly be reduced for the non-KCP flow regime. However, the capacity of 170 $m^3$/s has been retained for the updated layout.

### 2.3.4 Reservoir Levels

The capacities for base and maximum cooling flows are to be available at any reservoir level within the current operating range, plus the additional range that might occur as a result of the dredging of Tahtsa Narrows. The maximum capacity of the spillway (450 $m^3$/s) is to be available at the reservoir levels at which excess inflows would be released, including requirements for pre-spill. Based on routings of large excess inflows, including the Probable Maximum Flood (PMF), a pre-spill reservoir level of El. 851 m was used for the present layout.

## 2.4 SEASONAL OPERATION

The deep and surface water intakes for the low-level outlet, and the low-level outlet itself are to be capable of operating 12 months of the year. The surface water intake for the high-level outlet, and the high-level outlet and spillway are to be capable of operating in ice-free months, deemed to include non-freezing weather conditions.

## 2.5 REDUNDANCY

The Management Committee required that consideration be given to providing sufficient redundancy in the surface spillway design such that maintenance could be carried out on the spillway gates and sufficient water could be released at the same time to meet the requirements of the NFCP. This was deemed to mean that the surface spillway should have the same degree of redundancy as provided in the KCP KDRF, which was previously approved by the NFCP.

## 2.6 TEMPERATURE CONTROL

The Management Committee requested that Klohn Crippen provide guidance as to the degree of temperature control to be provided. We proposed that the target criteria for temperature control be the same as those for the KCP KDRF, namely:

- the controlled mean daily temperature of water releases during the cooling water period should not be less than 10.0ºC nor the instantaneous temperature be less than 9.5ºC; and
- during transitions between the surface and deep sources, and immediately prior to and following the cooling water period, temperatures should decrease no faster than 1ºC/day and increase no faster than 2ºC/day.

The extent to which the second criterion can be met depends upon the relative configuration of the low-level and high-level outlet surface-water intakes, because the greatest potential for short-term temperature variations exceeding those specified occurs when there is a need for cooling water releases to increase beyond the base flow capacity of the low-level outlet, at which time the supply of surface water would be transferred from the low-level intake to the high-level intakes. Because of the constraints of topography, hydraulic requirements and the requirements of dam safety, there is very limited latitude in which to modify the relative configuration of the surface-water intakes of the facility. Nevertheless, the intakes have been set as high and as close to the same level as possible, consistent with other requirements.

The KCP KDRF low-level outlet surface-water intake was also equipped with a retractable skimming weir. The principal function of this weir was to enable the warmest surface water to be withdrawn during the spring and early summer, when the water in the body of the reservoir is still relatively cold. The skimming weir also provided additional temperature control capability during the temperature ramping immediately prior to the cooling water period. A skimming capability has been incorporated in the low-level outlet surface-water intake of the updated conceptual layout. However, hydraulic and structural requirements indicated that it would not be practicable to provide skimming capability for the full 60 $m^3$/s capacity of the low-level outlet. This should not be an issue for the release schedules that we understand are being considered, because releases would not appear to exceed 30 $m^3$/s during the period when warmer water might be desired, with one important exception. If a release of 68 $m^3$/s is required in the last half of May, then the water could be colder during this period than before and after the period, assuming that the skimming weir is deployed, and depending upon the degree of surface warming actually experienced, which would depend upon climatic conditions.

We have assumed that the volume of the cold water "reservoir" required would be the same as for the KCP KDRF, i.e. the deep water intakes would have to be at the same elevation as those for the KCP KDRF. The Management Committee requested sufficient redundancy in the facility to enable maintenance to be carried out, while still meeting the NFCP requirements. Again, this was deemed to mean that the cooling water release components should have the same degree of redundancy as provided in the KCP KDRF, which was previously approved by the NFCP.

## 2.7 TOTAL DISSOLVED GAS (TGP)

The level of total dissolved gas (TGP) required in the discharged water (i.e. in the tailrace) is not known at this time. The spillway is to be equipped with a flip bucket which discharges water into the Nechako canyon efficiently over the normal flow ranges and minimizes erosion and downstream damage. The normal flow range has been deemed to mean up to at least 170 $m^3$/s. It has been assumed that some erosion would be tolerable at the infrequent maximum 450 $m^3$/s discharge.

## 2.8 HYDROELECTRIC GENERATION

The Management Committee did not require a hydroelectric generating facility to be included, but did request that the design and construction of the facility be such as to not preclude the addition of power generation.

Construction of a generating facility after the commissioning of the water release facility would require the construction of a temporary cofferdam adjacent to the portal of the existing dam construction diversion tunnel to permit the excavation of the powerhouse foundations in what would then be a functioning waterway. The powerhouse would have to be located further away from the tunnel portal and probably set back into the right bank to provide space for the cofferdam, which would increase the cost. In addition, based on the observation of substantial boulders in the floor of the canyon around the diversion tunnel portal, difficulties would almost certainly be encountered in sealing the cofferdam and dewatering the powerhouse excavation. In view of these factors, and the possibility that they could preclude the addition of power generation, the Management Committee requested that the conceptual layout include a provision for the future addition of hydroelectric generation.

# 3. CONCEPTUAL LAYOUT

## 3.1 GENERAL

The general arrangement of the water release facility is shown on Figures 1, 2 and 3. The facility would consist of:

- a surface-water intake channel;
- two deep-water intakes, pipelines and culverts;
- a high-level outlet;
- a low-level outlet;
- appropriate instrumentation and controls;
- operator accommodation;
- a skeleton hydro bay; and
- miscellaneous other works.

These components are described in more detail in the following sections.

## 3.2 SURFACE-WATER INTAKE CHANNEL

An open rock cut channel excavated in the left abutment of the dam would draw water from the surface source. The size and curved alignment of the channel are necessary to convey the water at low velocity around the left end of the dam to the high-level outlet regulating structure, where it would be released at high velocity into the spillway chute. A tunnel is considered to be impracticable because of the size required to accommodate the deep-water conduits as well as the maximum discharge of the facility.

The majority of the channel would have an excavated invert width of 10.5 m and stepped vertical sides. The first step would occur 6 m above the invert and thereafter at 10 m intervals. The first step or berm would be 6 m wide and thereafter the berms would be 3 m wide. The relatively shallow overburden would be excavated with a set back from the top of the rock cut.

The majority of the channel would be excavated in the dry behind a temporary rock plug at the entrance. The temporary rock plug and overlying overburden would be excavated underwater. The sides of the channel excavated in the dry would be bolted and protected with shotcrete, as necessary. The sides excavated underwater would be unsupported and loose rock would be removed. The width of the channel would generally be increased in this section to protect the deep-water pipelines from any rock falls. At the entrance to the channel, where the height of the cuts is least, the width would be reduced to discourage the intrusion of deeper, colder, water into the channel.

## 3.3 DEEP-WATER INTAKES, PIPELINES AND CULVERTS

Water would be withdrawn from depth in the reservoir by two steel bellmouth intakes and would be conveyed to the bottom of the surface-water channel by two 4.17-m-diameter rigid steel pipelines. The intakes would be equipped with coarse trashracks to exclude large submerged debris. The pipelines would be externally stiffened to withstand the differential pressure and would be supported at two points on the left abutment of the dam and at a third point within the surface-water channel. The pipelines would end just beyond the location of the temporary rock plug and water would be conveyed from there to the regulating structure by twin reinforced concrete culverts. A short section of the pipes would be constructed in the dry integrally with the concrete culverts to facilitate subsequent connection of the pipelines after removal of the temporary plug.

Each pipeline would have a capacity of 85 $m^3/s$ at any reservoir level within the foreseeable operating range, including allowances for increased hydraulic losses due to partial trashrack blockage and deterioration of the pipe surface condition.

## 3.4 HIGH-LEVEL OUTLET

### 3.4.1 General

The high-level outlet would be used to release large cooling flows up to a maximum of 170 $m^3/s$, and to make releases necessary to manage excess inflows to the reservoir, up to a maximum of 450 $m^3/s$. The outlet would consist of the regulating structure and the chute spillway.

### 3.4.2 Regulating Structure

The regulating structure would be constructed of reinforced concrete and would have a maximum height above the foundation of 28 m and a maximum width of 28.5 m. The structure would contain two 3.7-m-wide by 3.9-m-high surface-water passages and two 2.5-m-wide by 4.3-m-high deep-water passages. Each passage would be equipped with an electrically-operated bonneted fixed-wheel regulating gate and each pair of passages would share a fixed-wheel bulkhead/emergency closure gate. The surface-water passages would be angled towards the deep-water passages (5° in the current layout) to cause the jets to impinge upon one another to initiate mixing.

The structure would also contain a control room, a light workshop, and storage and toilet facilities. The structure would be provided with electrical power by diesel generators housed in a separate adjacent building. A gantry crane would be provided to install and remove the bulkhead gates, and to maintain all the gates.

The situation of the structure in a through-going open cut between the reservoir and the canyon downstream, requires that the structure be designed as a dam, and meet the safety requirements of a dam. These requirements include adequate watertightness and stability. Adequate stability, in turn, requires that the structure have sufficient mass to provide an adequate factor of safety against sliding under the imposed hydrostatic, hydrodynamic, seismic and uplift forces, and that the line of action of that mass be sufficiently far upstream that tensile stresses do not occur at the upstream edge of the foundation. Bearing pressures must also be within allowable limits everywhere within the foundations.

For watertightness, and to reduce uplift pressures, the structure would be provided with a grout curtain, which would extend to the existing grout curtain of the dam. Adequate mass would be provided by flooded ballast compartments upstream of the central gate block and by rock-filled ballast compartments downstream of the gate block. The sides of the facility would also converge in the downstream direction to take advantage of the resistance provided by the surrounding rock mass. Additional stability could be provided, if necessary, by connecting the structure to the anchors provided in the walls of the rock cut during excavation.

### 3.4.3 Spillway

The regulating structure would discharge into a chute spillway. The spillway would initially be approximately 20 m wide, the outside walls converging to a constant width of 12 m in approximately 69 m (based on a wall convergence angle of 4° to the centre line). A central wall in the upstream portion of the converging section would provide two separate bays each capable of discharging both surface and deep water, thereby providing for emergency maintenance/repair of one set of outlets without interrupting the operation of the other set. The total length of the spillway would be approximately 274 m. The spillway would have an initial slope of 15H:1V, followed by the major portion of the chute at 6.5H:1V, and would end with a vertical circular curve of 130 m radius, and a short section at 1.5H:1V.

The spillway would be equipped with a flip bucket energy dissipator with a radius of 15 m and a lip angle of 25°. The invert of the bucket would be set 2.5 m above the maximum tailwater level at a discharge of 450 $m^3$/s estimated to be approximately El. 769.9 m. The relatively shallow lip angle is necessary both to restrict the throw of the jet and to afford an appropriately shallow entry angle into the plunge pool, and thereby restrict the depth of plunge and the associated increase in dissolved gas. The flip bucket would also flare in the downstream direction to spread the jet, thereby increasing the energy dissipation and reducing the impact into the plunge pool. The narrow nature of the canyon and the oblique angle of the spillway to the canyon wall restrict the amount of spread that can be achieved. Dentations could be added to the bucket if a model test indicates that this would be beneficial in fraying the jet without excessive spread.

Despite the shallow lip angle and the low setting of the bucket relative to the tailwater level, the maximum throw of the jet is estimated to be in the order of 90 m. To minimize subsequent erosion, a plunge pool would be pre-excavated.

## 3.5 LOW-LEVEL OUTLET

### 3.5.1 Basis of Layout

There has been extensive discussion of the need or otherwise for a low-level outlet at a water release facility, primarily because of the substantial cost involved. However, a low-level outlet serves several functions, namely:

- assuming an appropriate means and location for the discharge, it provides a means of releasing water during the winter, when substantially below zero freezing temperatures occur at Kenney Dam;
- it provides an alternative means of releasing water to allow maintenance of the high-level outlet;
- if appropriately sized and equipped, it allows almost all base releases to be discharged with control of dissolved gas;
- if appropriately equipped, it provides better temperature control, both prior to and during the cooling water period; and
- it provides the opportunity to add hydroelectric generation.

The first two functions are considered essential if the facility is required to release water continuously year round. The remaining three functions could be regarded as essential, desirable or discretionary, depending upon point of view. All but the first function could be provided equally by an outlet constructed predominantly on the surface. However, when the topography and arrangement of the structures are considered, a surface outlet would itself involve a substantial amount of excavation and steel pipe penstock to provide an outlet at the foot of the spillway near the diversion tunnel portal. Even if the opportunity for hydroelectric generation is foregone and the penstock is replaced with a second, smaller, spillway chute, the amount of reinforced concrete would be substantial.

However there are other factors which argue against a predominantly surface outlet, even one which could ultimately enter the diversion tunnel near its downstream end and thereby conceivably be equipped for winter operation. These factors concern the siting of the intake for the outlet. To provide a surface outlet, and avoid tunnelling, the intake would have to be situated immediately adjacent to the main regulating structure. In the present concept, the regulating structure has been set as far downstream as possible, based on the estimated subsurface rock contours. Adding another intake structure adjacent to the regulating structure would require that both be moved substantially further upstream, requiring a reduction of the radius of the surface-water channel and forcing it further into the dam abutment, with associated increase in cost. In addition, the intake would now be at the end, rather than the beginning of the surface-water channel. Eddies resulting from the curved geometry of the channel would probably have mixed the water and produced an essentially isothermal condition by the time the water reached the intake, thereby probably precluding any possibility of "skimming" warmer surface water in the spring.

Although a cost estimate for a predominantly surface outlet has not been prepared, it is our opinion that the cost would be at least comparable to that of the proposed underground layout.

The proposed underground layout would consist of an inlet and regulating structure, an upper and lower tunnel and connecting inclined shaft, and two pressure pipelines and hooded hollow-cone valves, with butterfly guard valves.

### 3.5.2 Inlet/Regulating Structure

The inlet/regulating structure would be situated as close to the entrance of the surface water approach as possible while leaving sufficient distance between it and the temporary rock plug to enable the plug to be removed without damaging the structure. The structure would contain the surface-water intake, equipped with an adjustable skimming weir and trashrack, the surface water passage, and the deep-water passage, which would draw water either from the side of the deep-water culverts or from a gallery excavated below them. Each of the passages would be equipped with an electrically-operated bonneted fixed-wheel regulating gate, and a bulkhead gate.

The primary function of the regulating gates would be to control the outflow temperature because flow regulation would be provided by the outlet hollow-cone valves.

Currently it is envisaged that each bulkhead gate would be installed and removed with a dedicated cable hoist, and that all the gates would be maintained using a mobile crane. However, the rails for the regulating structure gantry crane could probably be arranged to enable the gantry crane to be used. Alternatively the gantry crane could be equipped with steered rubber-tired wheels similar to those used on boatyard travel hoists.

### 3.5.3 Tunnels and Shaft

The surface and deep-water passages would discharge via a concrete-lined transition into a short upper tunnel, an inclined shaft and a lower tunnel. The shaft would be inclined at 55° and would be concrete lined. The shaft would be circular in cross section with a lined diameter of 3.4 m. The lower tunnel would be driven to an inverted U section but would have a circular concrete lining the same diameter as shaft. The downstream section of the lower tunnel adjacent to the dam construction diversion tunnel would be steel lined. The steel lining would extend into the diversion tunnel as a pressure pipeline.

Contact, consolidation and curtain grouting would be undertaken, as necessary.

### 3.5.4 Pressure Pipelines and Valves

Soon after entering the diversion tunnel and after a 60° bend, the 3.4-m-diameter pipeline would bifurcate into two 2.2-m-diameter pipelines. One pipeline would be relatively short and the other pipeline would extend to the downstream portal of the diversion tunnel. The pipelines would be provided with appropriate steel ring stiffeners, and concrete anchor blocks, and the pipeline to the portal would be surrounded in concrete.

Each pipeline would be equipped with a 1.2-m-diameter hollow-cone valve to dissipate energy and control dissolved gas. Each valve would be equipped with a separately mounted bell-shaped hood. Air supply to the valve would be provided through an annular space between the valve and the upstream end of the hood. The valve and hood would be anchored with a thrust block and a small control cubicle would be provided on the top of the block to house local operation controls. To enable independent maintenance/repair of the hollow-cone valves, a butterfly guard valve would be provided upstream of each valve.

The pipeline arrangement within the diversion tunnel is somewhat awkward, and a portion of the right wall of the tunnel has to be excavated to make room. However, this is necessary to provide a symmetrical discharge channel for the first, interior, valve. The staggered valve arrangement was selected rather than positioning both valves side by side inside the tunnel for two reasons:

- access could not otherwise be provided to the valves except by suspending an enclosed walkway from the roof of the tunnel or driving a separate tunnel, both of which were deemed to be impractical, whereas the concrete surround to the second pipeline provides the base for a walkway along the wall of the tunnel, the same as that included in the KCP KDRF; and
- the arrangement provides for the possible addition of hydroelectric generation with minimal disruption to the use of the interior valve, and the disruption has been further reduced, if not avoided, by providing a blind bifurcation in the pipeline upstream of the exterior valves, to which a future turbine branch could be connected.

The exterior hollow-cone valve is envisaged to be provided with a hood to limit the extent of erosion protection measures, and the interference with the powerhouse tailrace if a hydroelectric generating facility is added in the future.

### 3.5.5 Diversion Tunnel

A section of the floor of the existing diversion tunnel would be concrete lined to resist the impact of the interior valve jet. Access to the valve would be provided by a walkway on top of the concrete pipe surround on the right wall of the tunnel. The section of the walkway closest to the valve would be enclosed to provide protection against spray from the valve.

The downstream portal of the diversion tunnel would be equipped with a flexible curtain wall to reduce the inflow of sub-zero air and to encourage the re-circulation of air within the tunnel to prevent icing in winter. Separate ventilation would be provided for the control cubicle.

## 3.6 INSTRUMENTATION AND CONTROLS

Instrumentation would include:

- sensors to monitor the reservoir level, and the water level in the low-level outlet surface-water intake downstream of the skimming weir (to warn of excessive differential water levels);
- sensors to monitor the temperature of the water in each of the four high-level outlet water passages and the two low-level outlet water passages;
- a sensor in the Nechako River downstream of the facility to monitor release temperatures;
- sensors to measure the internal pressure in the deep-water pipelines, to determine the head on the gates, and to monitor the differential external pressure on the pipelines to warn of partial obstruction of the intake trashracks;
- gate and valve position indicators and limit switches; and
- intrusion sensors and alarms.

The regulating gates and hollow-cone valves would be equipped with controls to enable them to be operated locally, or remotely from the control room in the regulating structure.

## 3.7 OPERATOR ACCOMMODATION

The facility would require a full-time operator/attendant and domestic family accommodation would be provided adjacent to the structure, together with accommodation for a maintenance crew.

## 3.8 SKELETON HYDRO BAY

The provision for the future addition of a hydroelectric generating facility has been based on a study for the NWC which indicated that such a facility would probably consist of a single Francis-type turbine generator unit, with an adjacent erection/maintenance bay. The powerhouse would be situated adjacent to the diversion tunnel portal and such that the tailrace from the turbine draft tube would not extend into the path of the jet from the hollow-cone valve at the tunnel portal.

The work would include:

- the excavation of all overburden, boulders and bedrock for the foundation of the sub-structure of the unit and erection bays, including the tailrace excavation;
- the excavation of overburden and bedrock around the sub-structure, and the approaches above the level of the sub-structure to a sufficient distance to permit future excavation for the superstructure and permanent access to be undertaken using controlled blasting techniques;
- the construction of the reinforced concrete downstream wall of the sub-structure of the unit and erection bays and a portion of the draft tube deck (to provide access to the diversion tunnel), and a portion of the side walls of the unit bay;
- the provision of an opening in the downstream wall of the unit bay equipped with slots and embedded metalwork to accommodate the future installation of a draft tube bulkhead gate;
- the provision of an opening in the unit bay side wall to accommodate a future access gallery within the sub-structure; and
- post-tensioned anchoring of the side walls, and tensioned rock anchors and consolidation and curtain grouting beneath the perimeter footing of the downstream sub-structure wall.

The opening in the downstream wall for the draft tube gate would allow drainage from the catchment formed by the dam and the canyon walls. If the generating facility is constructed this drainage path would be closed off. Consequently, to avoid water ponding behind the powerhouse, two small circular openings would also be provided in the downstream wall at each end to accommodate future drainage culverts. These would be plugged temporarily to dewater the skeleton bay and construct the sub-structure.

## 3.9 MISCELLANEOUS WORKS

The road leading to the crest of the dam would have to be temporarily diverted around the work during construction, and would then be relocated on a bridge on the downstream side of the regulating structure.

The Nechako River channel downstream of the dam would be improved to convey discharges without erosion, particularly in the vicinity of the dam construction disposal area on the left bank. The toe of the disposal area would be protected with rock from excavations.

# 4. DISCUSSION OF LAYOUT

## 4.1 MIXING FACILITY

The layout does not include a facility specifically to mix surface and deep water from the high-level outlet prior to its discharge into the Nechako Canyon, which the Management Committee requested be included. This is because we have been unable to develop a hydraulic concept that we are confident would function satisfactorily. However, we believe that the desire for a mixing facility stemmed from our caveat that temperature shears could occur with the original Case E because of inadequate mixing of the water in the spillway chute. However, there are significant differences between the original Case E and the present concept. In the original layout, the water was released through three outlets in separate chutes which merged gradually, and only after the separate flows had gathered momentum. In the present concept, there would be four outlets (two surface and two deep-water), and a surface and a deep-water outlet would discharge side by side into each of two converging bays before they enter the chute. The surface-water outlets are angled towards the deep-water outlets to cause the jets to impinge upon and mingle with the deep-water jets. Model tests would be required to show how effective this simple method is in beginning the mixing process which would continue in the main chute. If the mixing is insufficient, then several relatively inexpensive options could be used to improve the mixing, such as: adding curved fillets to the chute sides to rotate the flow initially or adding angled ramps to the floor of the chute.

It has been suggested(2) that mixing could be accomplished by creating a pool at the head of the spillway chute. The pool would be created by an ogee-crested weir, which would, in effect, create a hydraulic jump stilling basin. However, our calculations suggest that a weir of fixed height is unlikely to work satisfactorily at all discharges and under all reservoir levels, although model tests would be required to confirm this because the circumstances not being readily amenable to reliable calculation. The stilling basin approach would also require a wider spillway with higher walls a) because the height of a hydraulic jump for 450 $m^3$/s is in the range of 8.5 to 10.5 m and would require walls 11.25 to 13.25 m high to provide freeboard, and b) because a substantial amount of energy is dissipated in a properly formed hydraulic jump, and the loss in energy results in lower velocities, which would require a greater flow area, i.e. a wider chute, higher walls or a combination of the two.

However, we have a more fundamental concern with creating hydraulic jumps of any appreciable depth, and that is the potential increase in dissolved gas levels. Strong hydraulic jumps are invariably accompanied by a roller at the leading edge and considerable turbulence, which entrain large quantities of air into the jump. The sequent water depths which would result for flows in the range of 170 $m^3$/s to 450 $m^3$/s envisaged for this facility are in the range of 5.5 to 10 m, i.e.

producing maximum hydrostatic pressures of approximately 0.5 to 1.0 atmosphere, pressures readily capable of causing air to be absorbed into the water.

Ideally, one would want flows up to 170 $m^3$/s, the maximum cooling flow, to be mixed, and flows in excess of this, which would be predominantly, if not entirely, surface water, to be discharged without interference. In this context, it may be possible to develop a relatively low sill on the floor of the chute which will encourage mixing through a riffle, but which would not produce a hydraulic jump, at least not at discharges beyond, for example, 100 to 120 $m^3$/s. This could be model tested in the current concept.

## 4.2 VORTICITY

There is a strong possibility that the curved alignment of the surface-water intake channel would produce rotational eddies in the flow. These eddies could lead to vortices occurring at the surface-water intakes, which, if they are severe enough, could reduce the capacity of the intakes, unless preventative measures are taken. At low reservoir levels and maximum discharge, neither the high-level outlet intakes nor the low-level outlet intake provide the depth of submergence recommended in the literature to avoid vortices. Providing sufficient submergence would have required the regulating structure and low-level outlet intake structure, and the surface-water intake channel and deep-water culverts to have been set up to 4 m deeper than in the current layout, resulting in a substantial increase in cost. Increasing the width of the intake gates, the other means of achieving the recommended submergence was investigated but found to be impractical.

However, in addition to the increase in cost, we were not satisfied that increasing the submergence would actually overcome the potential for vortices. Our experience, as a result of model testing the KCP KDRF low-level outlet intake, indicates that vortices resulting from rotational eddies would tend to occur at high reservoir levels, when the depth of submergence substantially exceeds the recommended amount. This is because the flow is relatively tranquil and minor disturbances have the opportunity to develop into strong coherent patterns. At low reservoir levels, the velocities increase and the flow becomes turbulent and eddies do not have an opportunity to develop into coherent patterns. If model tests do indicate a vortex problem, then a vortex raft, a floating grillage of timber beams, could be provided. A vortex raft was successful at the KCP KDRF intake and was included in the final design. A vortex raft has also been used successfully at the West Tahtsa power intake to the Kemano tunnel.

## 4.3 OTHER CONCEPTS

The possibility of developing a facility with a regulating structure and high level tunnel arrangement similar to that developed for the KCP KDRF should not be ruled out. Review of the data suggests that a facility with a capacity of 450 $m^3/s$ could probably be developed. However, the hydraulics of such a structure are complex and are not readily amenable to reliable study by calculation. Gate sizes and other hydraulic data for the KCP KDRF were largely determined empirically from model tests.

# 5. CONSTRUCTION PLANNING

## 5.1 SITE ACCESS

Principal access to the site, for construction equipment, personnel and materials, would be from Highway 16 via the existing Holy Cross Forest Service Road from Fraser Lake and the Kenney Dam Road from Vanderhoof. These roads provide access to the left (south west) and right (north east) abutments of Kenney Dam, respectively. Although Alcan owns the dam and the land around it, Alcan allows public use of the dam crest road which links the Holy Cross Road and the Kenney Dam Road. The dam provides the only crossing of the Nechako River in the area, and is relatively heavily used by logging and other traffic. Consequently, it has been assumed that pubic access would have to be maintained during construction of the water release facility. The manner and sequence of construction would have to accommodate this requirement, as described later.

It has been assumed that the principal area for disposal of excavated material would be the borrow area for the original dam construction situated on the right side of the Nechako Canyon just downstream of the dam. Access to this area would be by original dam construction haul roads from the Kenney Dam Road. Excavated material would also be used for construction of bank protection and other channel improvements in the old Nechako River channel downstream of the spillway, and access to this area would also be primarily by original haul roads.

The original dam construction quarry upstream of the dam on the left bank would serve as the area for lay down, and for assembly and launching of the deep-water pipelines. There is existing access to the quarry, and this would be maintained until removal of the temporary rock plug at the entrance to the surface-water channel.

Some upgrading of the original haul roads and some short sections of new temporary roads would be required.

## 5.2 TEMPORARY WORKS

The site work areas would include a lay down area, site offices, an aggregate process plant, a concrete batching plant and a construction camp. It has been assumed that the offices and camp would be located at the site already prepared for the construction of the KCP KDRF, just downstream of the dam on the right bank. The location of the aggregate process plant would depend on the final location of the borrow areas. The batch plant would be installed close to the job site in order to keep transportation costs to a minimum. The principal lay down area would be in the vicinity of the launching area for the deep water intake pipes in the quarry.

The camp would accommodate approximately 110 people and would consist of bedrooms, kitchen, dining, recreation and washroom facilities. An appropriate sewage system would be required to deal with all sanitary waste.

The Kenney Dam area does not have mains electricity, and generators would therefore be required to provide power to the offices , camp, and other facilities.

Water would be pumped from the reservoir, and a small water filtration/treatment plant could be required to provide potable water.

A telephone communication system would be installed to serve both offices and the camp.

## 5.3 CONSTRUCTION PLANNING

### 5.3.1 General

For planning purposes, the project has been divided into the five major areas of work, namely:

- surface-water intake channel;
- regulating structure;
- spillway and flip bucket;
- low-level outlet and skeleton hydro bay; and
- deep-water intakes and pipelines.

### 5.3.2 Surface Water Intake Channel

Because of the requirement to maintain public access, the surface-water intake channel would be constructed in three stages.

Stage 1 would be limited to bulk excavation of the overburden and rock down to the general site formation level, approximately El. 860 m, and would include the excavation to this level for the regulating structure and spillway. Stage 1 would also include the excavation necessary to relocate the public access to the dam crest road around the site to the south and east of the regulating structure. Traffic would then be diverted and further work on the surface-water intake channel would be delayed until the regulating structure construction is sufficiently advanced to allow the public traffic to be relocated over this structure. The overburden and rock would be hauled across the dam to the designated disposal area.

Stage 2 would start as soon as the public traffic has been relocated over the regulating structure. This stage would include rock excavation down to final grade, excluding the temporary rock plug at the entrance, and would include the low-level outlet intake, and the construction of the concrete deep-water culverts and the low-level outlet intake structure. The rock would be hauled up a series of ramps within the excavation and to the designated disposal area. Some double handling would be required when the excavation reaches the lower elevations. The structures would be constructed using a combination of cranes and concrete pumps.

Stage 3 would be the removal of the rock plug, most of which is underwater. Drilling of the rock would be done from the existing ground, and with drills mounted on the Flexifloats provided for the deep-water pipeline construction, which would be modified to accommodate the drills. Underwater explosives would be used and would be loaded through temporary casing pipes.

On land disposal, rather than underwater disposal has been assumed for the present estimate. Rock and overburden material would be excavated using clamshell equipment mounted on the reconfigured Flexifloats and would be loaded onto flat scows made up of Flexifloats. The scows would be towed to the right (north east) end of the dam and unloaded using front end loaders onto trucks which would haul the materials to the designated disposal area.

### 5.3.3 Regulating Structure

After the public traffic has been diverted to the south and east of the regulating structure, the excavation of the regulating structure and the spillway would continue below El. 860 m. The excavated material would be hauled down hill, within the confines of the structures, to the designated disposal area.

The structure would be constructed using a combination of cranes and concrete pumps. The gates and gantry crane would be installed, tested and commissioned prior to the removal of the surface-water intake channel rock plug.

### 5.3.4 Spillway and Flip Bucket

The excavation of the spillway and flip bucket would be done simultaneously with the excavation for the regulating structure.

The structure would be constructed using a combination of cranes and concrete pumps. Rock anchors would be installed through the spillway chute slab and in the flip bucket.

### 5.3.5 Low-Level Outlet and Skeleton Hydro Bay

The intake would be constructed simultaneously with the deep-water culverts. The intake gates would be installed, tested and commissioned prior to the removal of the rock plug at the entrance to the surface-water channel.

The short section of upper tunnel would be excavated from the surface-water intake channel when that work has reached grade.

The lower tunnel would be driven from the existing dam construction diversion tunnel with access from the existing portal near the toe of the dam on the left bank. Prior to the start of the lower tunnel excavation, rock support would be installed in the diversion tunnel around the "portal" of the new tunnel. The tunnel would be excavated using controlled drill and blast techniques. The tunnel has been located at a safe minimum distance from the existing diversion tunnel plug. The short stub tunnel at the right side of the diversion tunnel near the downstream end, which would permit the future addition of a hydroelectric facility, would also be excavated.

The inclined shaft section would be excavated using an Alimak System. Firstly a pilot shaft raise would be excavated from the lower tunnel to the upper tunnel and this would then be slashed to size. All excavated material would be dropped to the lower tunnel and transported to the designated disposal area through the diversion tunnel.

The concrete lining would begin with the concreting of the lower bend and then working outwards towards the portal. The steel lining would then be installed in sections and concrete backfill placed behind the lining as each section is installed. The pipeline extensions of the steel lining and the valves would be installed, including the bifurcation and stub penstock for a future hydroelectric facility, followed by the remaining concrete work in the diversion tunnel.

The shaft concrete lining would commence after the lower bend is complete and would progress up the shaft using a climbing form system. Concrete would be delivered and placed by pump and tremie pipes.

Excavation of overburden and bedrock for the skeleton hydro bay would interrupt access to the diversion tunnel unless an alternative access is provided. Providing an alternative access could be relatively costly due to the steep rock walls of the canyon in the vicinity. Consequently, it has been assumed that excavation and construction of the skeleton hydro bay would be undertaken after the completion of the work in the diversion tunnel.

### 5.3.6 Deep-Water Intake and Pipelines

The construction of the deep-water pipelines is by far the most challenging aspect of the project. For the purpose of the estimate, it has been assumed the contractor would elect to site weld the pipelines into sections on shore and side launch them into the lake ready to be towed out and placed. The launching area for the pipes would be similar to a ship construction side launching yard with rails set to slope down to and into the lake.

The deep-water intake pipes could be partially fabricated off site and transported to the site in short half-barrel lengths, where they would be welded up to form two sets of three major pieces, or they could be fabricated completely on site from flat plate. The three major pieces consist of a bottom sloping section complete with the bellmouth intake and trashrack, a curved mid section, and an upper near horizontal section.

Prior to launching, each section would be fitted with inflatable bulkheads at each end for initial floatation. The sections would be launched and further floatation devices would be fitted to the outside of the pipes and the inflatable bulkheads would be removed. A system of Flexifloats would be used for transporting the pieces from the launching area to the dam. The Flexifloats would be joined together in pairs by a pipe lifting/lowering yoke structure. The pipes would then be suspended from the yoke between the Flexifloats. A service boat will be used to tow and position the Flexifloats.

The lower pipeline support has to be constructed underwater in water depths of approximately 60 m. The original KCP KDRF design called for a steel platform with cylindrical steel casing legs supported by a grillage of steel beams to be custom-fabricated to suit the bedrock profile. The platform would be lowered to the bottom of the reservoir and pile anchor holes would be drilled into the bed rock through the steel casings using off-shore oil drilling techniques either from a spud-equipped barge or, if climatic conditions and the schedule permit, from the ice in winter, artificially thickened if necessary. The same principal has been retained in the current concept, but a simpler steel structure, which would be filled with tremied concrete for support and ballast, has been assumed. The underwater work would inevitably involve human intervention, either in the form of divers or manned submersibles. The water depth and altitude would permit unaided divers to stay underwater for only very short periods. It is therefore envisaged that a contractor employing divers would elect to use aided systems, such as the Newtsuit, or the Exo-suit currently being developed by Nuytco Research of North Vancouver, or to use saturation diving techniques. (A number of difficult underwater construction projects have been completed in recent years using divers and remotely operated vehicles [ROV], including the construction of an intake structure in Lake Mead, USA, under 80 m of water.) When the supporting platform and anchors have been installed, the pipeline support from would be lowered and attached to the platform.

Because of the length and shape of the assembled main spans of the pipelines, it is envisaged that the straight lower sections and the arched upper sections would be joined whilst in the floating position. It is doubtful that the connection could be accomplished successfully by welding. Consequently, for the present concept, it has been assumed that a bolted flanged connection would be provided to facilitate the work.

The upper mid support would be in shallower water at a maximum depth of approximately 20 m and therefore does not present the same problem as the lower support. The upper mid support would be constructed after removal of the channel rock plug. Once the this support is in place the pipelines would be installed.

The second upper support would be constructed in the dry behind the channel rock plug.

The pipes would be towed into position and lowered using the Flexifloat yokes and by adjusting the pressures in the buoyancy devices. Divers or a manned submersible would do the final bolting up of the pieces. A specially designed bolting machine could also be used if this is found to be cost effective.

# 6. COST ESTIMATE AND SCHEDULE

## 6.1 CONSTRUCTION SCHEDULE

To enable the variable indirect costs and other components of the construction cost to be estimated, a preliminary construction schedule was prepared using the Primavera P3 Version 3 Project Management software.

Most of the major operations, which are critical, were based on working single 10 hour shifts for 6 days per week.

The schedule Work Breakdown Structure (WBS) was divided into four major elements: General, Civil, Structures, and Mechanical and Electrical.

The General section includes mobilization, site set up, camp, temporary access roads and erection of the aggregate processing and concrete batch plants.

The Civil and Structures sections are divided into the Surface-Water Intake Channel, Regulating Structure, Spillway and Flip Bucket, Low-Level Outlet, Skeleton Hydro Bay, and Deep-Water Intake and Pipes.

The Mechanical and Electrical section is divided into the Regulating Structure and Low Level Outlet.

The preliminary schedule is shown in Figure 4.

## 6.2 COST ESTIMATE

### 6.2.1 Basis of Estimate

The estimate is based on a preliminary quantity take-off, the construction sequence outlined in Section 5, the preliminary construction schedule, and the construction methods and equipment generally associated with this type of work. However, potential contractors would base their tenders on the equipment and personnel available to them at the time of tender, and on their own construction methods, providing these meet all of the requirements of the Contract.

The estimate was prepared using the G2 Estimating System, which is a database system containing cost data on labour, equipment, and materials.

**Labour**

The labour costs are based on unionized labour rates and conditions. The average hourly rates used include, where applicable, all fringe benefits, trade costs, overtime pay and shift differentials.

The costs for camp, travel and small tools are included in the indirect costs.

**Equipment**

The equipment rates include depreciation, insurance, spare parts and fuel/oil/grease. The equipment operators are included as labour and the mechanics are included in the indirect costs.

The equipment depreciation rates are those calculated from average current capital costs and normal average industry running costs.

**Materials**

All permanent materials and job supplies are based on current average budget prices.

### 6.2.2 Work Breakdown Structure (WBS)

The cost estimate utilizes a work breakdown structure (WBS) as follows:-

**Direct Costs**

These are costs of the hands on labour, equipment and materials required to perform the work.

**Fixed Indirect Cost - Mobilize**

This cost includes the mobilization of the equipment to the job site and the set up of the site infrastructure. The site infrastructure costs include temporary roads, offices, camp, lay down areas, and process and batch plant set up.

**Variable Indirect Costs**

These are the costs of all on-going non-direct work items and are normally spread back into the direct unit cost items. The costs include, but are not limited to, monthly maintenance and operating expenses, contractors on-site management staff, first aid, travel expenses, warehouse operation, small tools and supplies, mechanics, camp running cost, transportation and miscellaneous equipment, other miscellaneous items, performance bonds and insurances, head office administration and contractor's profit.

**Fixed Indirect Cost Demobilize**

This cost includes the demobilization of the equipment from the job site, and the clearing and restoration of the site.

**Taxes**

The provincial sales tax (PST) of 7% is included in the estimated costs, where applicable, and applies to equipment and materials costs. The goods and services tax (GST) is not included but should be applied at 7% to all costs.

**Contingency**

In view of the conceptual nature of the layout and structures, and the fact that the structures would occupy some areas outside those previously investigated for the KCP KDRF, contingencies of 30% of the estimated cost of the marine works and 20% of the estimated cost of the other facilities have been included for changes due to final design and for the conditions encountered.

**Engineering/Project Management**

A percentage allowance has been included for investigations, final design, engineering assistance to the owner during the tendering process, construction and environmental monitoring, and the production of a construction report and record drawings.

**Owner's Costs**

The estimate does not include Owner's costs and financing costs, including interest during construction. The estimate also does not include any costs associated with federal and provincial environmental review and permitting.

**Escalation**

The estimate has been prepared using costs at the April 2001 level. The Management Committee must add an amount for escalation, depending upon the anticipated date of construction.

### 6.2.3 Estimated Construction Cost

The total estimated construction cost, including engineering, is $96 million. The cost estimate is summarized in Table 6-1, and the details of the cost estimate are presented in Appendix A.

## 6.3 OPERATING AND MAINTENANCE COSTS

The operator of an existing water release facility would be the best source of information on the annual operating and maintenance cost of such a facility. The federal Department of Fisheries and Oceans operates a water release facility at Fulton River, and could be approached by the Management Committee to provide information on its annual operating and maintenance costs. However, to our knowledge, the Fulton River facility is not as complex as the facility contemplated for Kenney Dam. We are not aware of a water release facility of the complexity of that contemplated for Kenney Dam. Hence, we have no firm basis for an estimate of the annual cost of operating and maintaining such a facility. Nevertheless, we have made an estimate based on the data available in the literature for utilities operating and maintaining hydraulic structures and hydroelectric generating stations.

BC Hydro and other utilities typically allow 0.7% to 0.75% of the capital cost for annual operation and maintenance costs in budget estimates for hydroelectric generating stations. According to studies by Ontario Hydro[(3)], engineering represented approximately 10% of the annual O&M cost for hydroelectric stations, dams and reservoirs represented a further 20 to 30%, and mechanical and electrical equipment represented approximately 40 to 50%. Assuming that the entity which would operate the water release facility would not have a permanent engineering staff, that a water release facility would represent no more than half the annual cost for dams and reservoirs, and that, in the absence of hydroelectric turbines and generators, the gates and other equipment at the water release facility would cost no more than a third of the annual mechanical and electrical equipment cost, then the annual operation and maintenance cost of a water release facility could be expected to be about 47.5% of the cost of a hydroelectric generating station. Assuming the typical utility allowance of 0.7% of the capital cost, then the annual operation and maintenance cost of a water release facility could be expected to be about 0.33% of the capital cost, i.e. about $320,000 p.a.

From another perspective, the largest components of the annual cost are likely to be the salaries, wages and associated costs for the resident operator, an annual visit by a service crew, and a shift operator during the cooling water period, including transportation, housing, and power. We estimate these to be in the order of $135,000 p.a. An allowance of $25,000 for facility power costs, and minor repairs and spare parts, would bring the annual cost to about $160,000. A reserve fund for future major repairs and maintenance would also be required. Assuming a discount rate of 8%, an allowance for a reserve fund could amount to about $70,000 p.a., bringing the total annual cost to $230,000.

Hence, the annual cost of operating and maintaining a water release facility could be in the range of $230,000 to $320,000 p.a.

## REFERENCES

1. KDRF Working Group. "Conceptual Alternatives for a Release Facility at Kenney Dam". An Interim Report of the KDRF Working Group, April 1996.

2. SNC-Lavalin Inc. "Kenney Dam Water Release Facility - Review of Conceptual Design - Final Report", October 2000.

3. Wong, C.T. "Determining O&M Costs Over the Life of a Hydro Station", Hydro Review, December 1990.

# LIST OF TABLES

**Table No.**

## Table 6-1

## Summary of Estimated Construction Cost

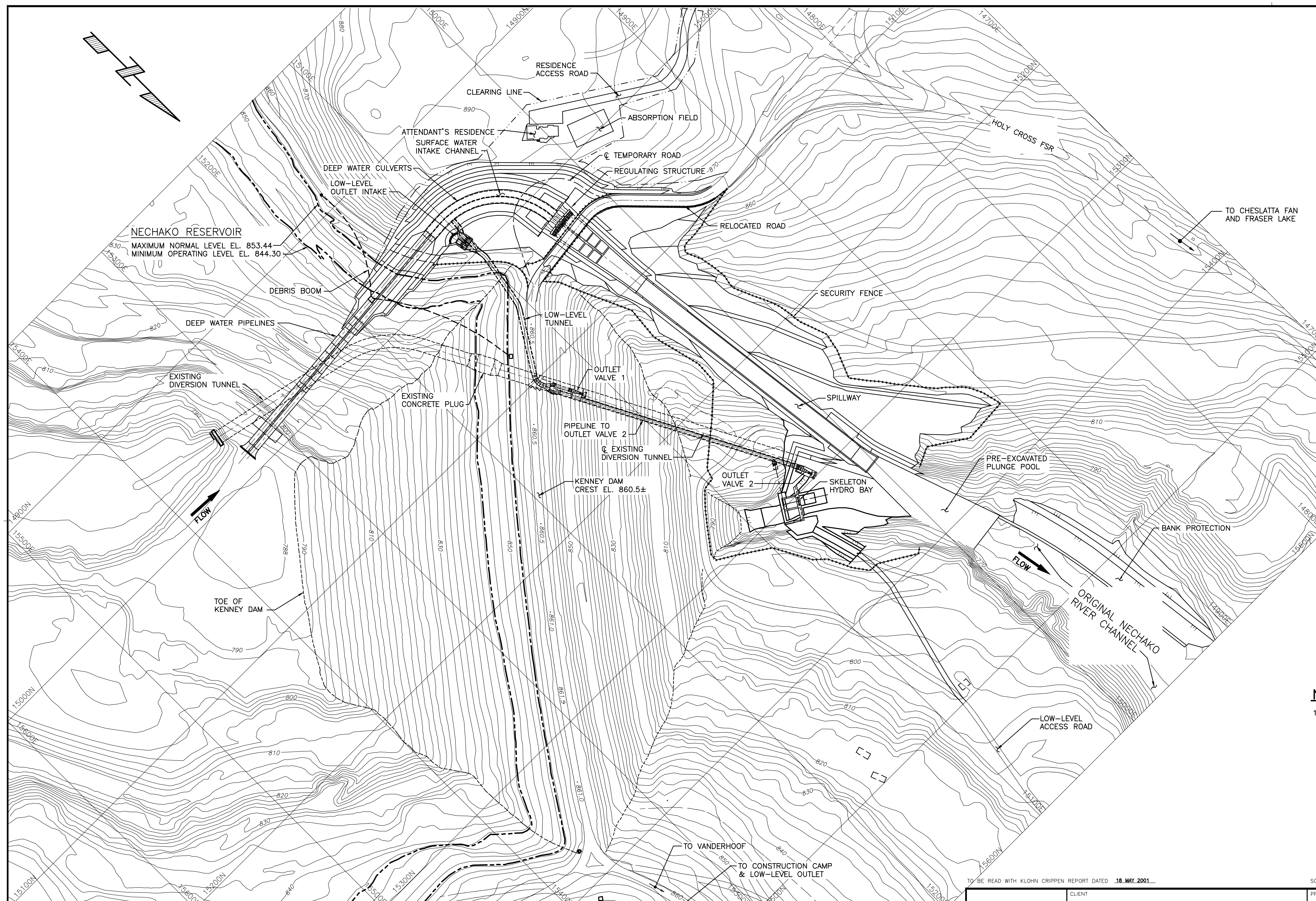
| ITEM | DESCRIPTION | ESTIMATED COST ($1,000) |
|---|---|---|
| 01 | Deep-Water Intakes and Pipelines | 10,876 |
| 02 | Deep-Water Culverts | 1,171 |
| 03 | Surface-Water Intake Channel | 3,342 |
| 04 | Regulating Structure | 6,461 |
| 05 | Spillway and Flip Bucket | 7,478 |
| 06 | Low-Level Outlet | 8,884 |
| 07 | General Site Works | 2,454 |
| 08 | Skeleton Bay Future Hydro | 762 |
| 09 | Fixed Indirect Costs (Mobilize) | 1,388 |
| 10 | Variable Indirect Costs | 25,885 |
| 11 | Fixed Indirect Costs (Demobilize) | 573 |
| 12 | Marine Mobilize and Demobilize | 1,522 |
| 13 | Contingency for Design/Conditions Variations | 17,000 |
| 14 | **Sub-Total Estimated Construction Costs** | **87,797** |
| 15 | Investigations and Preliminary Engineering | 1,250 |
| 16 | Detailed Engineering (4%) | 3,600 |
| 17 | Construction Services (3.75%) | 3,300 |
| 18 | **Total Estimated Project Cost** | **95,947** |

Note:

The above estimated costs are in April 2001 dollars and include PST, but do not include Owner's costs, including financing and any costs associated with federal and provincial environmental review and permitting, and also do not include escalation and GST.

# LIST OF FIGURES

**Figure No.**




## NOTES:

1. TOPOGRAPHY BASED ON McELHANNEY GEOSURVEYS LTD. TOPOGRAPHIC PLAN DATED SEPTEMBER 1988 AND ON McELHANNEY ENGINEERING SERVICES LTD. SOUNDINGS PLAN DATED OCTOBER 1988.

SCALE 0 — 100m

TO BE READ WITH KLOHN CRIPPEN REPORT DATED 18 MAY 2001



CLIENT: NECHAKO ENVIRONMENTAL ENHANCEMENT FUND

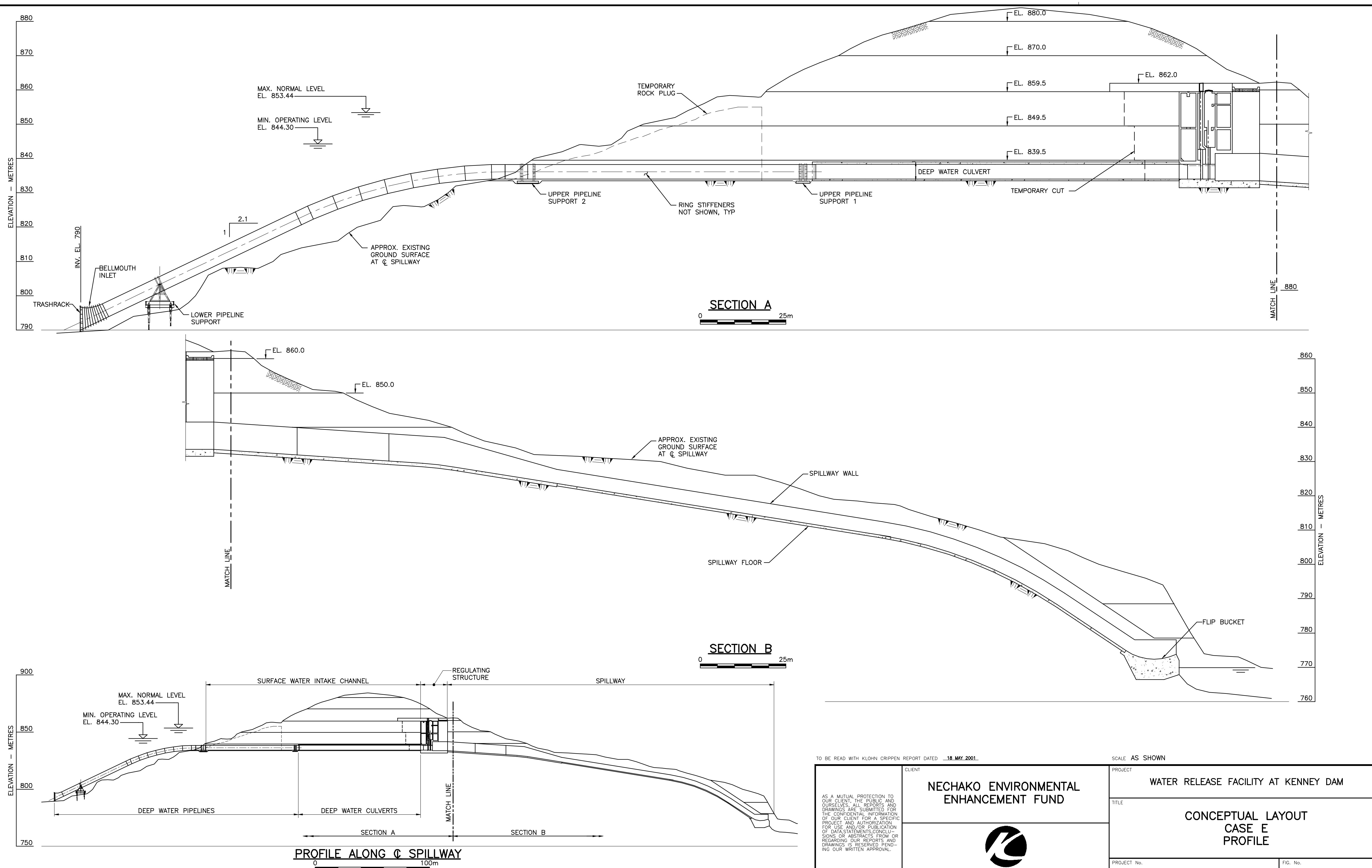
KLOHN CRIPPEN

PROJECT: WATER RELEASE FACILITY AT KENNEY DAM

TITLE: CONCEPTUAL LAYOUT
CASE E
PLAN

PROJECT No. PP1229 03

FIG. No. FIGURE 1




TO BE READ WITH KLOHN CRIPPEN REPORT DATED 18 MAY 2001

SCALE AS SHOWN

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

| | |
|---|---|
| CLIENT | NECHAKO ENVIRONMENTAL ENHANCEMENT FUND |
| | KLOHN CRIPPEN |
| PROJECT | WATER RELEASE FACILITY AT KENNEY DAM |
| TITLE | CONCEPTUAL LAYOUT<br>CASE E<br>PROFILE |
| PROJECT No. | PP1229 03 |
| FIG. No. | FIGURE 2 |

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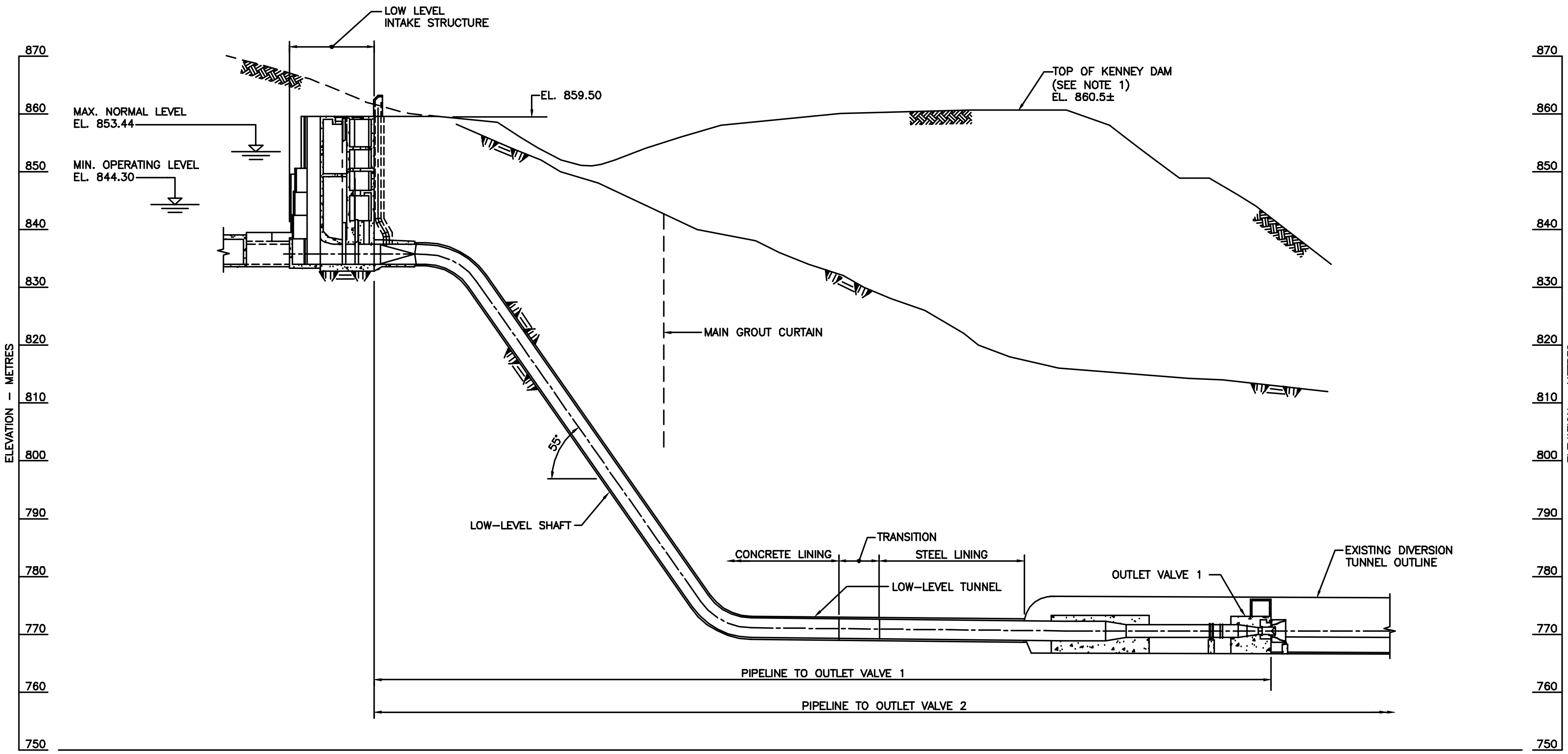
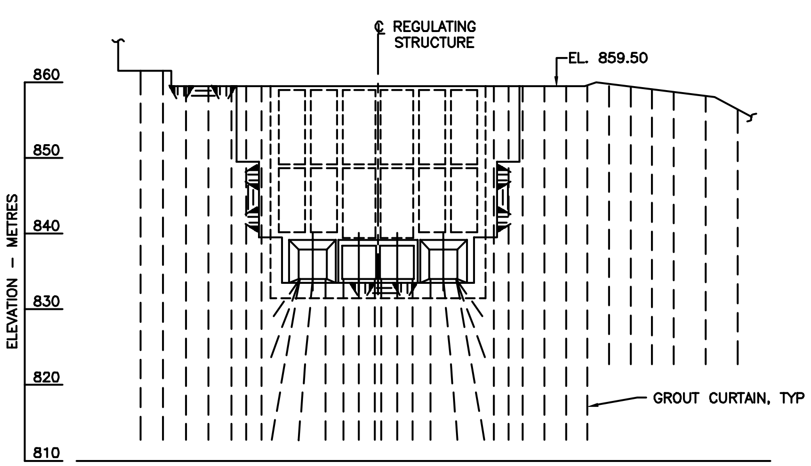


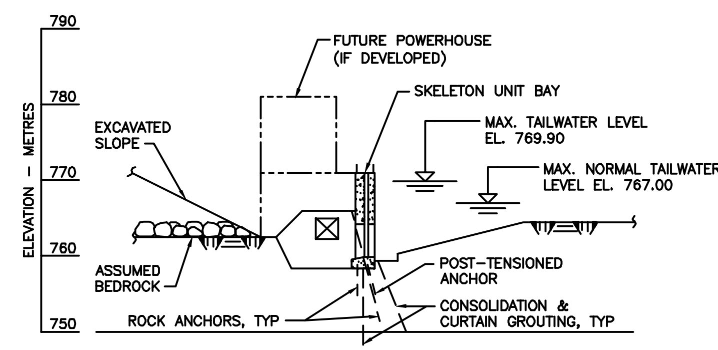

DEVELOPED PROFILE ALONG ℄ WATER PASSAGE

0 25m




UPSTREAM ELEVATION - REGULATING STRUCTURE

0 25m




SKELETON BAY CROSS SECTION

0 25m

## NOTES:

1. DUE TO THE DEVELOPED NATURE OF THE PROFILE ALONG THE CENTRELINE OF THE WATER PASSAGE, KENNEY DAM IS NOT SHOWN IN TRUE SECTION.

TO BE READ WITH KLOHN CRIPPEN REPORT DATED 18 MAY 2001

SCALE AS SHOWN



CLIENT: NECHAKO ENVIRONMENTAL ENHANCEMENT FUND

KLOHN CRIPPEN

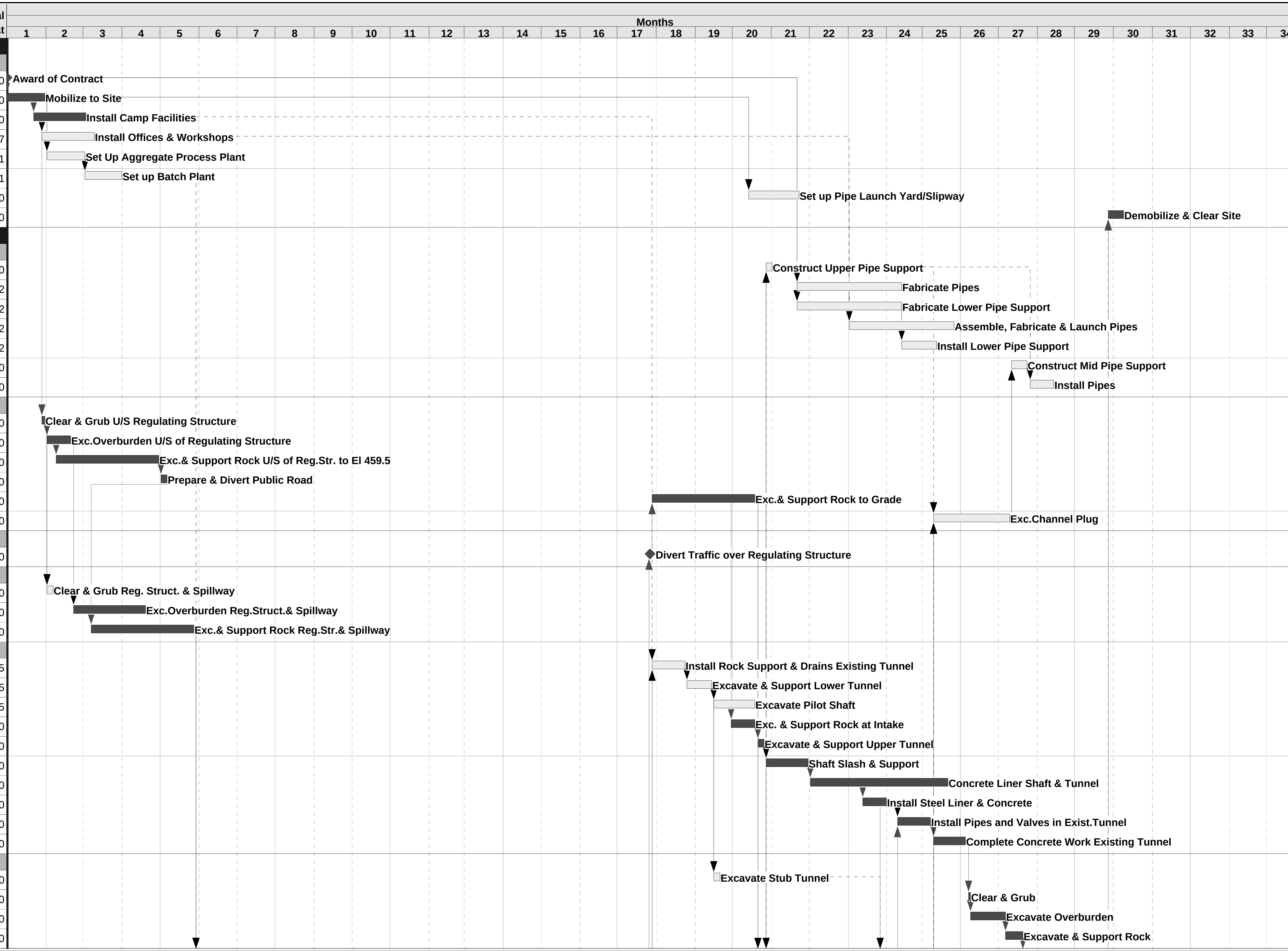
PROJECT: WATER RELEASE FACILITY AT KENNEY DAM

TITLE: CONCEPTUAL LAYOUT
CASE E
LOW-LEVEL OUTLET, REGULATING STRUCTURE AND SKELETON HYDRO BAY

PROJECT No. PP1229 03

FIG. No. FIGURE 3

| Activity ID | Activity Description | Orig Dur | Total Float |
|---|---|---|---|
| **GENERAL** | | | |
| **General** | | | |
| 01.01.001 | Award of Contract | 0 | 0 |
| 01.01.002 | Mobilize to Site | 22 | 0 |
| 01.01.003 | Install Camp Facilities | 30 | 0 |
| 01.01.004 | Install Offices & Workshops | 30 | 17 |
| 01.01.006 | Set Up Aggregate Process Plant | 22 | 41 |
| 01.01.007 | Set up Batch Plant | 22 | 41 |
| 01.01.005 | Set up Pipe Launch Yard/Slipway | 30 | 100 |
| 01.01.011 | Demobilize & Clear Site | 10 | 0 |
| **CIVIL** | | | |
| **Deep Water Intake & Pipes** | | | |
| 02.02.005 | Construct Upper Pipe Support | 5 | 120 |
| 02.02.001 | Fabricate Pipes | 60 | 72 |
| 02.02.002 | Fabricate Lower Pipe Support | 60 | 82 |
| 02.02.003 | Assemble, Fabricate & Launch Pipes | 60 | 72 |
| 02.02.004 | Install Lower Pipe Support | 20 | 82 |
| 02.02.006 | Construct Mid Pipe Support | 10 | 30 |
| 02.02.007 | Install Pipes | 15 | 30 |
| **Surface Water Intake Channel** | | | |
| 02.04.001 | Clear & Grub U/S Regulating Structure | 2 | 0 |
| 02.04.002 | Exc.Overburden U/S of Regulating Structure | 15 | 0 |
| 02.04.003 | Exc.& Support Rock U/S of Reg.Str. to El | 60 | 0 |
| 02.04.004 | Prepare & Divert Public Road | 5 | 0 |
| 02.04.005 | Exc.& Support Rock to Grade | 60 | 0 |
| 02.04.006 | Exc.Channel Plug | 45 | 30 |
| **Regulating Structure** | | | |
| 02.05.001 | Divert Traffic over Regulating Structure | 0 | 0 |
| **Spillway & Flip Bucket** | | | |
| 02.06.001 | Clear & Grub Reg. Struct. & Spillway | 5 | 10 |
| 02.06.002 | Exc.Overburden Reg.Struct.& Spillway | 42 | 0 |
| 02.06.003 | Exc.& Support Rock Reg.Str.& Spillway | 60 | 0 |
| **Low Level Outlet** | | | |
| 02.07.003 | Install Rock Support & Drains Existing | 20 | 5 |
| 02.07.004 | Excavate & Support Lower Tunnel | 15 | 5 |
| 02.07.005 | Excavate Pilot Shaft | 25 | 5 |
| 02.07.001 | Exc. & Support Rock at Intake | 15 | 0 |
| 02.07.002 | Excavate & Support Upper Tunnel | 5 | 0 |
| 02.07.006 | Shaft Slash & Support | 25 | 0 |
| 02.07.007 | Concrete Liner Shaft & Tunnel | 80 | 0 |
| 02.07.008 | Install Steel Liner & Concrete | 15 | 0 |
| 02.07.009 | Install Pipes and Valves in Exist.Tunnel | 20 | 0 |
| 02.07.010 | Complete Concrete Work Existing Tunnel | 20 | 0 |
| **Skeleton Bay Future Hydro** | | | |
| 02.08.004 | Excavate Stub Tunnel | 5 | 90 |
| 02.08.001 | Clear & Grub | 2 | 0 |
| 02.08.002 | Excavate Overburden | 20 | 0 |
| 02.08.003 | Excavate & Support Rock | 10 | 0 |




| | |
|---|---|
| Start Date | 01MAR01 |
| Finish Date | 08AUG03 |
| Data Date | 01MAR01 |
| Run Date | 10MAY01 16:34 |

Early Bar
Progress Bar
Critical Activity

KDR1

Sheet 1 of 2

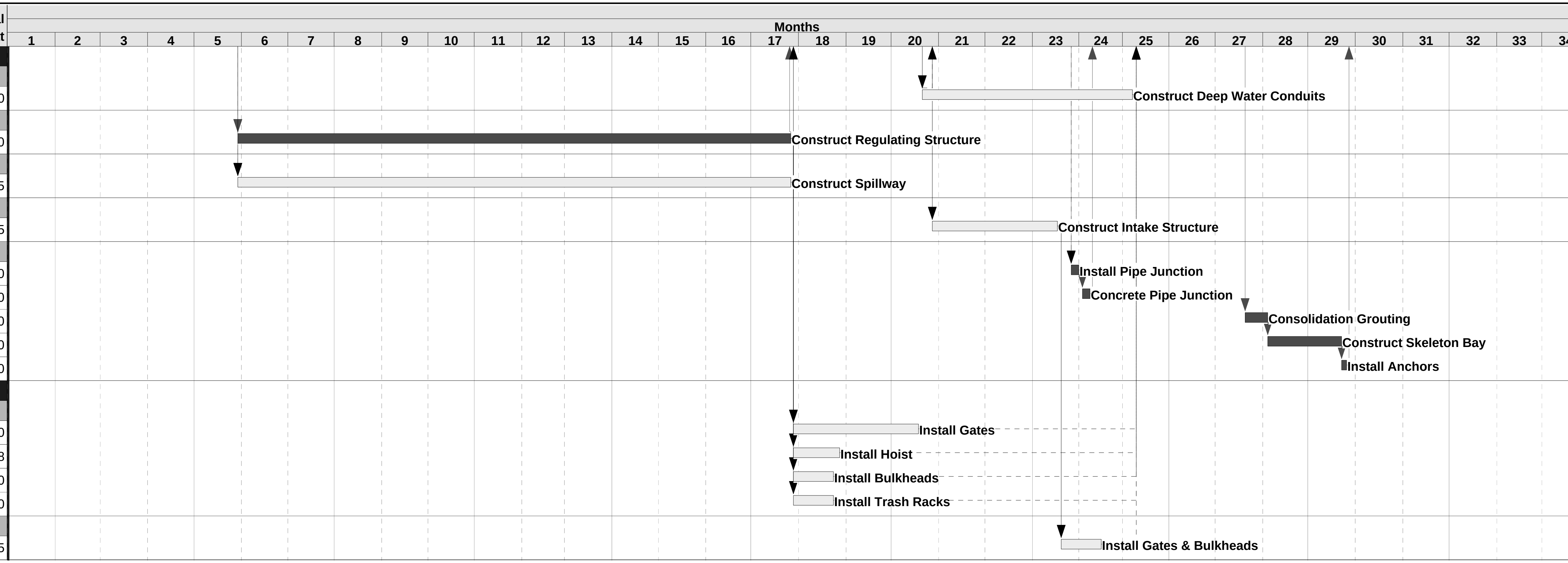
**WATER RELEASE FACILITY AT KENNEY DAM**

**PRELIMINARY CONSTRUCTION SCHEDULE**

KLOHN CRIPPEN

FIGURE 4

| Activity ID | Activity Description | Orig Dur | Total Float |
|---|---|---|---|
| **STRUCTURES** | | | |
| **Deep Water Conduits** | | | |
| 03.03.001 | Construct Deep Water Conduits | 100 | 30 |
| **Regulating Structure** | | | |
| 03.05.001 | Construct Regulating Structure | 260 | 0 |
| **Spillway & Flip Bucket** | | | |
| 03.06.001 | Construct Spillway | 260 | 5 |
| **Low Level Outlet** | | | |
| 03.07.001 | Construct Intake Structure | 60 | 45 |
| **Skeleton Bay Future Hydro** | | | |
| 03.08.004 | Install Pipe Junction | 5 | 0 |
| 03.08.005 | Concrete Pipe Junction | 5 | 0 |
| 03.08.003 | Consolidation Grouting | 10 | 0 |
| 03.08.001 | Construct Skeleton Bay | 35 | 0 |
| 03.08.002 | Install Anchors | 3 | 0 |
| **MECHANICAL & ELECTRICAL** | | | |
| **Regulating Structure** | | | |
| 04.05.001 | Install Gates | 60 | 130 |
| 04.05.004 | Install Hoist | 22 | 168 |
| 04.05.002 | Install Bulkheads | 20 | 170 |
| 04.05.003 | Install Trash Racks | 20 | 170 |
| **Low Level Outlet** | | | |
| 04.07.001 | Install Gates & Bulkheads | 20 | 45 |




| | |
|---|---|
| Start Date | 01MAR01 |
| Finish Date | 08AUG03 |
| Data Date | 01MAR01 |
| Run Date | 10MAY01 16:34 |



Early Bar
Progress Bar
Critical Activity

KDR1

Sheet 2 of 2

**WATER RELEASE FACILITY AT KENNEY DAM**

**PRELIMINARY CONSTRUCTION SCHEDULE**

KLOHN CRIPPEN

FIGURE 4

# APPENDIX A

## DETAILS OF COST ESTIMATE

# KENNEY DAM 1 (WRF1)
# 01 - COST SUMMARY



| WorkCode.01.00.01 | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | DEEP WATER INTAKES & PIPELINES | | | 5,190 | 260,876 | 29,386 | 480,275 | 55,514 | 10,050,000 | | | | | | 10,876,051 |
| 02 | DEEP WATER CONDUITS | | | 14,726 | 560,308 | 38,602 | 499,018 | 73,370 | | | | | | | 1,171,298 |
| 03 | SURFACE WATER INTAKE CHANNEL | | | 21,238 | 780,662 | 638,202 | 634,273 | 1,288,745 | | | | | | | 3,341,882 |
| 04 | REGULATING STRUCTURE | | | 36,575 | 1,389,946 | 105,501 | 1,217,947 | 146,393 | 3,601,500 | | | | | | 6,461,286 |
| 05 | SPILLWAY & FLIP BUCKET | | | 71,304 | 2,681,428 | 665,785 | 3,068,108 | 1,037,088 | 26,000 | | | | | | 7,478,410 |
| 06 | LOW LEVEL OUTLET | | | 46,216 | 1,791,059 | 173,418 | 3,397,676 | 420,631 | 3,101,400 | | | | | | 8,884,184 |
| 07 | GENERAL | | | 425 | 15,776 | 18,123 | | 20,372 | 2,399,250 | | | | | | 2,453,520 |
| 08 | SKELETON BAY FUTURE HYDRO | | | 7,295 | 276,237 | 78,856 | 273,680 | 129,002 | 3,850 | | | | | | 761,625 |
| 11 | FIXED INDIRECT COSTS(MOBILIZE) | | | 11,106 | 421,350 | 76,979 | | 484,928 | 405,000 | | | | | | 1,388,257 |
| 12 | VARIABLE INDIRECT COSTS | | | 27,003 | 6,800,631 | 1,062,023 | | 11,921,136 | 6,101,600 | | | | | | 25,885,390 |
| 13 | CONTINGENCY | | | | | | | 17,000,000 | | | | | | | 17,000,000 |
| 14 | FIXED INDIRECT COSTS(DEMOBILIZE) | | | 4,200 | 159,679 | 20,785 | | 37,732 | 355,000 | | | | | | 573,196 |
| 15 | MARINE MOBILIZE/DEMOBILIZE | | | 3,600 | 137,390 | 1,048,002 | | 261,334 | 75,000 | | | | | | 1,521,726 |
| **Grand Total** | | | | 248,879 | 15,275,343 | 3,955,660 | 9,570,977 | 32,876,246 | 26,118,600 | | | | | | 87,796,826 |

# KENNEY DAM 1 (WRF1)
# 01 - COST SUMMARY



## WorkCode.01.00.01 01 DEEP WATER INTAKES & PIPELINES

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01.01.001 | Supply Pipelines and Fittings | 1,000.00 | TNE | | | | | | 10,000,000 | | | | | | 10,000,000 |
| 01.01.003 | Prepare and launch pipes | 1.00 | LS | 400 | 14,489 | 6,647 | | 5,123 | | | | | | | 26,259 |
| 01.01.004 | Lower Support Prepare Bed | 1.00 | LS | 140 | 8,045 | 477 | | 1,623 | | | | | | | 10,145 |
| 01.01.005 | Fabricate Lower Base Support Frames | 1.00 | EA | | | | 375,000 | | | | | | | | 375,000 |
| 01.01.006 | Install Lower Support Frame Base | 1.00 | EA | 650 | 31,375 | 7,109 | 75,000 | 18,244 | | | | | | | 131,727 |
| 01.01.007 | Install Anchors in base | 1.00 | LS | 450 | 16,241 | 7,962 | 11,650 | 13,925 | | | | | | | 49,778 |
| 01.01.008 | Install Lower Support Trunnion Frame | 1.00 | EA | 130 | 6,275 | 1,422 | | 1,249 | | | | | | | 8,945 |
| 01.01.009 | Middle Support Prepare Bed | 1.00 | LS | 70 | 4,022 | 239 | | 812 | | | | | | | 5,073 |
| 01.01.010 | Middle Support Frame Base | 1.00 | EA | 260 | 12,550 | 2,844 | 10,500 | 4,997 | | | | | | | 30,891 |
| 01.01.011 | Upper Dry Support Base | 1.00 | LS | 210 | 7,877 | 442 | 8,125 | 1,151 | | | | | | | 17,594 |
| 01.01.012 | Install Pipes | 1.00 | LS | 2,880 | 160,002 | 2,245 | | 8,393 | | | | | | | 170,639 |
| 01.01.013 | Underwater Surveys | 1.00 | LS | | | | | | 50,000 | | | | | | 50,000 |
| **01 DEEP WATER INTAKES & PIPELINES** | | | | 5,190 | 260,876 | 29,386 | 480,275 | 55,514 | 10,050,000 | | | | | | 10,876,051 |

## WorkCode.01.00.01 02 DEEP WATER CONDUITS

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02.02.001 | Fabricate Formwork | 470.00 | M2 | 1,689 | 64,080 | 2,335 | | 36,855 | | | | | | | 103,270 |
| 02.02.002 | Erect & Strip Formwork | 2,800.00 | M2 | 8,750 | 334,547 | 22,162 | 238 | 20,861 | | | | | | | 377,808 |
| 02.02.003 | Reinforcement | 157,000.00 | KG | 2,896 | 109,458 | 6,627 | 133,450 | 5,466 | | | | | | | 255,002 |
| 02.02.004 | Concrete Placing | 2,100.00 | M3 | 1,016 | 37,223 | 7,477 | 330,330 | 5,188 | | | | | | | 380,218 |
| 02.02.005 | Concrete Sundries not Measured | 1.00 | LS | 375 | 15,000 | | 35,000 | 5,000 | | | | | | | 55,000 |
| **02 DEEP WATER CONDUITS** | | | | 14,726 | 560,308 | 38,602 | 499,018 | 73,370 | | | | | | | 1,171,298 |

## WorkCode.01.00.01 03 SURFACE WATER INTAKE CHANNEL

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03.01.001 | Medium Clear & Grub | 1.30 | HA | 91 | 3,351 | 1,302 | | 1,281 | | | | | | | 5,934 |
| 03.01.002 | Overburden Excavation | 19,300.00 | M3 | 1,061 | 39,363 | 47,984 | | 57,309 | | | | | | | 144,656 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03.01.003 | Drill & Blast Rock Stage 1 to El 859.5 | 106,300.00 | M3 | 2,430 | 89,161 | 33,041 | | 201,982 | | | | | | | 324,184 |
| 03.01.004 | Excavate Rock Stage 1 to El | 106,300.00 | M3 | 3,697 | 137,959 | 208,935 | | 261,129 | | | | | | | 608,023 |
| 03.01.005 | Drill & Blast Rock Stage 2 to grade | 67,000.00 | M3 | 2,436 | 89,405 | 33,132 | | 177,061 | | | | | | | 299,598 |
| 03.01.006 | Excavate Rock Stage 2 to grade | 67,000.00 | M3 | 3,076 | 114,746 | 177,959 | | 226,455 | | | | | | | 519,160 |
| 03.01.007 | Rock Bolts 25mm dia.* 4m lg. to El.859.5 | 635.00 | EA | 900 | 32,417 | 6,356 | 37,846 | 15,649 | | | | | | | 92,269 |
| 03.01.008 | 50mm dia.*6m lg. Relief Drains to El 859.5 | 147.00 | EA | 239 | 8,636 | 2,207 | 7,056 | 5,434 | | | | | | | 23,333 |
| 03.01.009 | F.R.Shotcrete 50mm Thick to El.859.5 | 1,265.00 | M2 | 206 | 7,442 | 1,009 | 51,802 | 1,417 | | | | | | | 61,669 |
| 03.01.010 | F.R.Shotcrete 100mm Thick to El 859.5 | 926.00 | M2 | 301 | 10,895 | 1,478 | 70,422 | 2,074 | | | | | | | 84,869 |
| 03.01.011 | W.W.Fabric to El 859.5 | 926.00 | M2 | 208 | 7,498 | 592 | 3,816 | 1,569 | | | | | | | 13,475 |
| 03.01.012 | Rock Bolts 25mm dia.* 4m lg. to Grade | 799.00 | EA | 1,132 | 40,790 | 7,998 | 47,620 | 19,691 | | | | | | | 116,099 |
| 03.01.013 | 50mm dia.*6m lg. Relief Drains to Grade | 96.00 | EA | 156 | 5,640 | 1,441 | 4,608 | 3,549 | | | | | | | 15,238 |
| 03.01.014 | F.R.Shotcrete 50mm Thick to Grade | 2,414.00 | M2 | 392 | 14,201 | 1,926 | 98,853 | 2,703 | | | | | | | 117,684 |
| 03.01.015 | F.R.Shotcrete 100mm Thick to Grade | 1,064.00 | M2 | 346 | 12,518 | 1,698 | 80,917 | 2,383 | | | | | | | 97,517 |
| 03.01.016 | W.W.Fabric to Grade | 1,064.00 | M2 | 239 | 8,615 | 680 | 4,385 | 1,803 | | | | | | | 15,483 |
| 03.01.017 | Rock Anch. 32mm dia.* 4m lg. Grade | 338.00 | EA | 718 | 25,883 | 5,075 | 210,777 | 14,362 | | | | | | | 256,096 |
| 03.01.018 | Rock Bolts 25mm dia.* 4m lg. to Plug | 154.00 | EA | 218 | 7,862 | 1,542 | 9,178 | 3,795 | | | | | | | 22,377 |
| 03.01.019 | 50mm dia.*6m lg. Relief Drains to Plug | 16.00 | EA | 26 | 940 | 240 | 768 | 591 | | | | | | | 2,540 |
| 03.01.020 | F.R.Shotcrete 50mm Thick to Plug | 152.00 | M2 | 25 | 894 | 121 | 6,224 | 170 | | | | | | | 7,410 |
| 03.01.021 | Plug Rock Drill & Blast (WET) | 22,900.00 | M3 | 1,145 | 41,987 | 20,207 | | 198,619 | | | | | | | 260,814 |
| 03.01.022 | Plug Rock & Overburden Excavation (WET) | 24,700.00 | M3 | 2,196 | 80,459 | 83,277 | | 89,717 | | | | | | | 253,453 |
| **03 SURFACE WATER INTAKE CHANNEL** | | | | 21,238 | 780,662 | 638,202 | 634,273 | 1,288,745 | | | | | | | 3,341,882 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WorkCode.01.00.01 04 REGULATING STRUCTURE** | | | | | | | | | | | | | | | |
| 04.01.001 | Rockfill | 1,700.00 | M3 | 51 | 1,985 | 1,305 | | 1,324 | | | | | | | 4,615 |
| 04.01.002 | Curtain Grouting Drilling | 1,500.00 | M | 450 | 17,412 | 7,356 | | 7,259 | | | | | | | 32,027 |
| 04.01.003 | Curtain Grouting - Grouting | 225,000.00 | KG | 900 | 32,193 | 3,582 | 48,263 | 8,286 | | | | | | | 92,324 |
| 04.02.001 | Fabricate Formwork | 888.00 | M2 | 3,191 | 121,070 | 4,412 | | 36,347 | | | | | | | 161,829 |
| 04.02.002 | Erect & Strip Formwork | 7,100.00 | M2 | 22,188 | 848,317 | 56,197 | 1,569 | 56,518 | | | | | | | 962,601 |
| 04.02.003 | Reinforcement | 352,000.00 | KG | 6,492 | 245,409 | 14,859 | 299,200 | 12,255 | | | | | | | 571,723 |
| 04.02.004 | Concrete Placing | 5,650.00 | M3 | 2,418 | 88,559 | 17,789 | 785,915 | 12,404 | | | | | | | 904,668 |
| 04.02.005 | Concrete Sundries not Measured | 1.00 | LS | 885 | 35,000 | | 83,000 | 12,000 | | | | | | | 130,000 |
| 04.02.006 | Misc.Metal Regulating Structure | 33,500.00 | KG | | | | | | 201,000 | | | | | | 201,000 |
| 04.03.001 | Deep Water Regulating Gates incl.Embeds | 42.00 | TNE | | | | | | 630,000 | | | | | | 630,000 |
| 04.03.002 | Surface Water Regulating Gates incl.Embeds | 56.00 | TNE | | | | | | 840,000 | | | | | | 840,000 |
| 04.03.003 | Deep Water Bulkheads incl.Embeds | 22.00 | TNE | | | | | | 286,000 | | | | | | 286,000 |
| 04.03.004 | Surface Water Bulkheads incl.Embeds | 26.50 | TNE | | | | | | 344,500 | | | | | | 344,500 |
| 04.03.006 | Supply & Install Rotork Hoists | 4.00 | EA | | | | | | 1,000,000 | | | | | | 1,000,000 |
| 04.03.007 | Supply & Install Gantry Crane | 1.00 | EA | | | | | | 300,000 | | | | | | 300,000 |
| **04 REGULATING STRUCTURE** | | | | 36,575 | 1,389,946 | 105,501 | 1,217,947 | 146,393 | 3,601,500 | | | | | | 6,461,286 |
| **WorkCode.01.00.01 05 SPILLWAY & FLIP BUCKET** | | | | | | | | | | | | | | | |
| 05.01.001 | Medium Clear & Grub | 4.40 | HA | 308 | 11,343 | 4,407 | | 4,335 | | | | | | | 20,085 |
| 05.01.002 | Overburden Excavation | 59,700.00 | M3 | 2,289 | 84,946 | 104,607 | | 118,089 | | | | | | | 307,642 |
| 05.01.003 | Drill & Blast Rock | 76,800.00 | M3 | 3,072 | 112,731 | 41,775 | | 182,525 | | | | | | | 337,031 |
| 05.01.004 | Excavate Rock to Grade | 76,800.00 | M3 | 3,072 | 114,624 | 173,595 | | 216,961 | | | | | | | 505,180 |
| 05.01.005 | Rock Bolts 25mm dia.* 4m lg. to Grade | 1,022.00 | EA | 1,448 | 52,174 | 10,230 | 60,911 | 25,187 | | | | | | | 148,502 |
| 05.01.006 | 50mm dia.*6m lg. Relief Drains to Grade | 158.00 | EA | 257 | 9,282 | 2,372 | 7,584 | 5,841 | | | | | | | 25,079 |
| 05.01.007 | F.R.Shotcrete 50mm Thick to Grade | 5,221.00 | M2 | 848 | 30,713 | 4,166 | 213,800 | 5,847 | | | | | | | 254,526 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05.01.008 | F.R.Shotcrete 100mm Thick to Grade | 1,421.00 | M2 | 462 | 16,718 | 2,268 | 108,067 | 3,183 | | | | | | | 130,236 |
| 05.01.009 | W.W.Fabric to Grade | 1,421.00 | M2 | 320 | 11,506 | 908 | 5,856 | 2,408 | | | | | | | 20,678 |
| 05.01.010 | Rock Anch. 32mm dia.* 4m lg. Grade | 820.00 | EA | 1,743 | 62,793 | 12,312 | 511,352 | 34,842 | | | | | | | 621,299 |
| 05.01.020 | Hydroseeding | 13,000.00 | M2 | | | | | | 26,000 | | | | | | 26,000 |
| 05.01.021 | Medium Clear & Grub Plunge Pool | 0.40 | HA | 28 | 1,031 | 401 | | 394 | | | | | | | 1,826 |
| 05.01.022 | Overburden Excavation Plunge Pool | 7,000.00 | M3 | 268 | 9,960 | 12,265 | | 13,846 | | | | | | | 36,072 |
| 05.01.023 | Drill & Blast Rock Plunge Pool | 28,000.00 | M3 | 560 | 20,639 | 6,692 | | 51,286 | | | | | | | 78,617 |
| 05.01.024 | Excavate Rock to Grade Plunge Pool | 28,000.00 | M3 | 980 | 36,583 | 54,685 | | 67,215 | | | | | | | 158,484 |
| 05.01.025 | Place Rockfill to Left Bank Protection | 12,500.00 | M3 | 375 | 13,846 | 14,309 | | 13,058 | | | | | | | 41,213 |
| 05.02.001 | Fabricate Formwork | 1,031.00 | M2 | 3,705 | 140,567 | 5,123 | | 42,200 | | | | | | | 187,890 |
| 05.02.002 | Erect & Strip Formwork | 8,235.00 | M2 | 25,734 | 983,928 | 65,180 | 1,820 | 65,553 | | | | | | | 1,116,481 |
| 05.02.003 | Reinforcement | 652,000.00 | KG | 12,026 | 454,564 | 27,523 | 554,200 | 22,700 | | | | | | | 1,058,988 |
| 05.02.004 | Erect & Strip Chute & Apron Screeds | 1.00 | LS | 1,800 | 68,266 | | | 10,000 | | | | | | | 78,266 |
| 05.02.005 | Concrete Placing | 8,725.00 | M3 | 3,874 | 141,870 | 28,498 | 1,259,018 | 19,841 | | | | | | | 1,449,227 |
| 05.02.006 | 36mm*5m long Rock Anchors | 530.00 | EA | 4,240 | 155,099 | 56,712 | 142,835 | 76,256 | | | | | | | 430,903 |
| 05.02.007 | 36mm*7m long Rock Anchors | 235.00 | EA | 2,686 | 98,243 | 37,756 | 88,666 | 39,520 | | | | | | | 264,185 |
| 05.02.008 | Concrete Sundries not Measured | 1.00 | LS | 1,210 | 50,000 | | 114,000 | 16,000 | | | | | | | 180,000 |
| **05 SPILLWAY & FLIP BUCKET** | | | | 71,304 | 2,681,428 | 665,785 | 3,068,108 | 1,037,088 | 26,000 | | | | | | 7,478,410 |

**WorkCode.01.00.01 06 LOW LEVEL OUTLET**

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06.01.001 | Tunnel Excavation | 62.00 | M | 1,653 | 78,110 | 26,591 | | 112,373 | | | | | | | 217,074 |
| 06.01.002 | Pilot Shaft Excavation | 79.00 | M | 1,717 | 81,109 | 24,051 | | 37,305 | | | | | | | 142,465 |
| 06.01.003 | Shaft Slash Excavation | 79.00 | M | 1,580 | 74,226 | 18,439 | | 30,320 | | | | | | | 122,985 |
| 06.01.004 | Muck from Portal Area to Dumpsite | 2,170.00 | M3 | 98 | 3,632 | 4,026 | | 5,002 | | | | | | | 12,660 |
| 06.01.005 | Rock Support | 1.00 | LS | | | | 17,876 | | | | | | | | 17,876 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06.01.006 | Drill & Blast Rock at Intake | 3,960.00 | M3 | 352 | 12,917 | 4,787 | | 23,401 | | | | | | | 41,105 |
| 06.01.007 | Excavate Rock Intake | 3,960.00 | M3 | 138 | 5,139 | 7,783 | | 9,728 | | | | | | | 22,651 |
| 06.01.008 | F.R.Shotcrete 50mm Thick to Intake | 580.00 | M2 | 94 | 3,412 | 463 | 23,751 | 650 | | | | | | | 28,275 |
| 06.01.009 | F.R.Shotcrete 100mm Thick to Intake | 580.00 | M2 | 189 | 6,824 | 926 | 44,109 | 1,299 | | | | | | | 53,158 |
| 06.01.010 | W.W.Fabric to Intake | 580.00 | M2 | 131 | 4,696 | 371 | 2,390 | 983 | | | | | | | 8,440 |
| 06.01.011 | Rock Anch. 32mm dia.* 4m lg. to Intake | 290.00 | EA | 616 | 22,207 | 4,354 | 180,844 | 12,322 | | | | | | | 219,728 |
| 06.01.021 | Exist.Tunnel Rock Anchors | 175.00 | EA | 263 | 9,566 | 3,028 | 8,260 | 3,405 | | | | | | | 24,259 |
| 06.01.022 | Exist.Tunnel Fibre Reinf.Shotcrete | 70.00 | M3 | 140 | 5,131 | 1,217 | 53,235 | 716 | | | | | | | 60,300 |
| 06.01.023 | Exist.Tunnel Relief Drains | 15.00 | EA | 5 | 188 | 197 | | 278 | | | | | | | 663 |
| 06.02.001 | Fabricate Formwork Intake | 323.00 | M2 | 1,161 | 44,038 | 1,605 | | 15,961 | | | | | | | 61,604 |
| 06.02.002 | Erect & Strip Formwork Intake | 2,580.00 | M2 | 8,063 | 308,262 | 20,421 | 921 | 22,834 | | | | | | | 352,438 |
| 06.02.003 | Reinforcement Intake | 142,000.00 | KG | 2,619 | 99,000 | 5,994 | 120,700 | 4,944 | | | | | | | 230,638 |
| 06.02.004 | Concrete Placing Intake | 1,990.00 | M3 | 907 | 33,232 | 6,676 | 294,918 | 4,643 | | | | | | | 339,469 |
| 06.02.005 | Concrete Sundries not Measured Intake | 1.00 | LS | 340 | 14,000 | | 31,000 | 5,000 | | | | | | | 50,000 |
| 06.02.006 | Fabricate Formwork | 185.00 | M2 | 1,773 | 67,315 | 2,913 | | 11,779 | | | | | | | 82,006 |
| 06.02.007 | E & S Formwork | 1,265.00 | M2 | 6,958 | 263,860 | | | 10,391 | | | | | | | 274,251 |
| 06.02.008 | Reinforcement | 5,000.00 | KG | 200 | 7,577 | | 4,250 | | | | | | | | 11,827 |
| 06.02.009 | Steel Liner | 52.00 | TNE | 555 | 20,888 | 2,132 | 260,000 | 13,383 | | | | | | | 296,403 |
| 06.02.010 | Concrete Liner | 875.00 | M3 | 875 | 31,817 | 1,825 | 114,844 | 7,822 | | | | | | | 156,308 |
| 06.02.011 | Contact Grouting | 1.00 | LS | 200 | 7,290 | 1,365 | 2,500 | 6,120 | | | | | | | 17,276 |
| 06.02.012 | Consolidation Grouting | 1.00 | LS | 400 | 14,581 | 2,673 | 5,000 | 2,282 | | | | | | | 24,536 |
| 06.02.013 | Concrete Sundries Low Level Outlet | 1.00 | LS | 296 | 12,000 | | 27,000 | 4,000 | | | | | | | 43,000 |
| 06.02.021 | Steel Pipe in Exist.Tunnel | 280.00 | TNE | 4,978 | 187,457 | 19,130 | 1,680,000 | 37,170 | | | | | | | 1,923,757 |
| 06.02.022 | Fabricate Formwork Exist.Tunnel | 335.00 | M2 | 1,204 | 45,674 | 1,665 | | 14,773 | | | | | | | 62,112 |
| 06.02.023 | Erect & Strip Formwork Exist.Tunnel | 1,340.00 | M2 | 4,188 | 159,859 | 5,327 | | 8,059 | | | | | | | 173,244 |
| 06.02.024 | Reinforcement Exist.Tunnel | 119,000.00 | KG | 2,195 | 82,848 | 2,523 | 101,150 | 2,876 | | | | | | | 189,397 |
| 06.02.025 | Concrete Placing Exist.Tunnel | 2,820.00 | M3 | 2,030 | 74,203 | 2,938 | 395,928 | 4,814 | | | | | | | 477,883 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06.02.026 | Concrete Sundries not Measured Exist Tunnel | 1.00 | LS | 300 | 10,000 | | 29,000 | 6,000 | | | | | | | 45,000 |
| 06.02.027 | Misc. Metal LLO | 5,000.00 | KG | | | | | | 30,000 | | | | | | 30,000 |
| 06.03.001 | Surface Water Gate incl.Embeds | 20.10 | TNE | | | | | | 301,500 | | | | | | 301,500 |
| 06.03.002 | Surface Water Bulkhead incl.Embeds | 7.30 | TNE | | | | | | 94,900 | | | | | | 94,900 |
| 06.03.003 | Deep Water Gate incl.Embeds | 20.10 | TNE | | | | | | 301,500 | | | | | | 301,500 |
| 06.03.004 | Deep Water Bulkhead incl.Embeds | 7.30 | TNE | | | | | | 94,900 | | | | | | 94,900 |
| 06.03.005 | Skimming Bulkhead incl.Embeds | 22.20 | TNE | | | | | | 288,600 | | | | | | 288,600 |
| 06.03.006 | LLO Heating & Ventilation | 1.00 | LS | | | | | | 130,000 | | | | | | 130,000 |
| 06.03.007 | LLO Hollow Cone Valves | 2.00 | EA | | | | | | 700,000 | | | | | | 700,000 |
| 06.03.008 | LLO Butterfly Valves | 2.00 | EA | | | | | | 340,000 | | | | | | 340,000 |
| 06.03.009 | LLO Dresser Couplings | 2.00 | EA | | | | | | 20,000 | | | | | | 20,000 |
| 06.03.010 | LLO Trashrack | 10.00 | TNE | | | | | | 100,000 | | | | | | 100,000 |
| 06.03.011 | LLO Rotork Hoists | 2.00 | EA | | | | | | 500,000 | | | | | | 500,000 |
| 06.03.012 | LLO Winch Hoists | 2.00 | EA | | | | | | 200,000 | | | | | | 200,000 |
| **06 LOW LEVEL OUTLET** | | | | 46,216 | 1,791,059 | 173,418 | 3,397,676 | 420,631 | 3,101,400 | | | | | | 8,884,184 |

## WorkCode.01.00.01 07 GENERAL

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07.01.001 | Medium Clear & Grub | 0.60 | HA | 42 | 1,547 | 601 | | 591 | | | | | | | 2,739 |
| 07.01.002 | Overburden Excavation | 10,000.00 | M3 | 383 | 14,229 | 17,522 | | 19,780 | | | | | | | 51,531 |
| 07.01.003 | Fencing & Gates | 1.00 | LS | | | | | | 73,250 | | | | | | 73,250 |
| 07.01.004 | Operators House Incl.Furnishings | 1.00 | LS | | | | | | 425,000 | | | | | | 425,000 |
| 07.01.005 | Roads & Yards | 1.00 | LS | | | | | | 50,000 | | | | | | 50,000 |
| 07.01.006 | Septic Disposal System | 1.00 | LS | | | | | | 43,000 | | | | | | 43,000 |
| 07.03.001 | Plumbing | 1.00 | LS | | | | | | 10,000 | | | | | | 10,000 |
| 07.03.002 | Domestic Water System | 1.00 | LS | | | | | | 11,000 | | | | | | 11,000 |
| 07.03.003 | Station Drainage | 1.00 | LS | | | | | | 11,000 | | | | | | 11,000 |
| 07.03.004 | Heating & Ventilation | 1.00 | LS | | | | | | 19,000 | | | | | | 19,000 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07.04.001 | Coating, Cable & Trays | 1.00 | LS | | | | | | 25,000 | | | | | | 25,000 |
| 07.04.002 | Diesel Generating System | 1.00 | LS | | | | | | 107,000 | | | | | | 107,000 |
| 07.04.003 | Power Distribution System | 1.00 | LS | | | | | | 404,000 | | | | | | 404,000 |
| 07.04.004 | Data Collection System | 1.00 | LS | | | | | | 43,000 | | | | | | 43,000 |
| 07.04.005 | Telephone System | 1.00 | LS | | | | | | 381,000 | | | | | | 381,000 |
| 07.04.006 | Instrumentation | 1.00 | LS | | | | | | 387,000 | | | | | | 387,000 |
| 07.04.007 | Lighting & 120v Power Distribution | 1.00 | LS | | | | | | 207,000 | | | | | | 207,000 |
| 07.04.008 | Grounding System | 1.00 | LS | | | | | | 144,000 | | | | | | 144,000 |
| 07.04.009 | Fire Alarm System | 1.00 | LS | | | | | | 38,000 | | | | | | 38,000 |
| 07.04.010 | Security Alarm System | 1.00 | LS | | | | | | 21,000 | | | | | | 21,000 |
| **07 GENERAL** | | | | 425 | 15,776 | 18,123 | | 20,372 | 2,399,250 | | | | | | 2,453,520 |
| **WorkCode.01.00.01** | **08 SKELETON BAY FUTURE HYDRO** | | | | | | | | | | | | | | |
| 08.01.001 | Medium Clear & Grub | 0.20 | HA | 14 | 516 | 200 | | 197 | | | | | | | 913 |
| 08.01.002 | Overburden Excavation | 18,000.00 | M3 | 690 | 25,612 | 31,540 | | 35,605 | | | | | | | 92,756 |
| 08.01.003 | Drill & Blast Rock | 3,400.00 | M3 | 272 | 9,981 | 3,699 | | 12,423 | | | | | | | 26,103 |
| 08.01.004 | Excavate Rock to Grade | 3,400.00 | M3 | 272 | 10,149 | 13,281 | | 16,324 | | | | | | | 39,753 |
| 08.01.005 | Rock Bolts 25mm dia.* 4m lg. to Grade | 60.00 | EA | 85 | 3,063 | 601 | 3,576 | 1,479 | | | | | | | 8,718 |
| 08.01.006 | Rock Anch. 32mm dia.* 4m lg. Grade | 55.00 | EA | 117 | 4,212 | 826 | 5,038 | 2,014 | | | | | | | 12,090 |
| 08.01.007 | F.R.Shotcrete 50mm Thick to Grade | 200.00 | M2 | 33 | 1,177 | 160 | 8,190 | 224 | | | | | | | 9,750 |
| 08.01.009 | W.W.Fabric to Grade | 200.00 | M2 | 45 | 1,619 | 128 | 824 | 339 | | | | | | | 2,910 |
| 08.01.011 | Stub Tunnel Excavation | 7.00 | M | 165 | 7,781 | 2,649 | | 11,646 | | | | | | | 22,076 |
| 08.01.012 | Stub Tunnel Rock Support | 1.00 | LS | | | | 1,698 | | | | | | | | 1,698 |
| 08.01.013 | Muck from Portal Area to Dumpsite | 76.00 | M3 | 3 | 127 | 141 | | 175 | | | | | | | 443 |
| 08.01.021 | Consolidation Grouting Drilling | 280.00 | M | 120 | 4,643 | 1,962 | | 1,812 | | | | | | | 8,416 |
| 08.01.022 | Consolidation Grouting - Grouting | 42,000.00 | KG | 240 | 8,585 | 955 | 8,190 | 3,672 | | | | | | | 21,402 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08.02.001 | Fabricate Formwork | 138.00 | M2 | 496 | 18,815 | 686 | | 5,648 | | | | | | | 25,149 |
| 08.02.002 | Erect & Strip Formwork | 825.00 | M2 | 2,578 | 98,572 | 6,530 | 182 | 6,567 | | | | | | | 111,852 |
| 08.02.003 | Reinforcement | 57,000.00 | KG | 1,051 | 39,740 | 2,406 | 48,450 | 1,985 | | | | | | | 92,580 |
| 08.02.004 | Concrete Placing | 750.00 | M3 | 321 | 11,756 | 2,361 | 110,175 | 1,647 | | | | | | | 125,939 |
| 08.02.005 | Concrete Sundries not Measured | 1.00 | LS | | | | | 18,000 | | | | | | | 18,000 |
| 08.02.006 | 36mm*15m long Rock Anchors | 4.00 | EA | 128 | 4,682 | 6,561 | 3,850 | 1,790 | | | | | | | 16,883 |
| 08.02.010 | Steel Liner/Blind Flange | 9.00 | TNE | 313 | 11,789 | 1,203 | 63,000 | 3,755 | | | | | | | 79,747 |
| 08.02.011 | Concrete Liner | 14.00 | M3 | 22 | 840 | 29 | 1,838 | 1,125 | | | | | | | 3,832 |
| 08.02.021 | Supply and Install Stoplog Guides | 3.60 | TNE | 240 | 9,229 | 2,533 | 18,000 | 2,089 | | | | | | | 31,851 |
| 08.02.022 | Fabricate Formwork Guides | 4.00 | M2 | 5 | 197 | 4 | | 146 | | | | | | | 347 |
| 08.02.023 | Erect & Strip Formwork Guides | 10.00 | M2 | 31 | 1,189 | 63 | | 61 | | | | | | | 1,314 |
| 08.02.025 | Concrete Placing | 5.00 | M3 | 53 | 1,963 | 339 | 670 | 280 | | | | | | | 3,251 |
| 08.02.026 | S & I Handrails | 550.00 | KG | | | | | | 3,850 | | | | | | 3,850 |
| **08 SKELETON BAY FUTURE HYDRO** | | | | 7,295 | 276,237 | 78,856 | 273,680 | 129,002 | 3,850 | | | | | | 761,625 |

**WorkCode.01.00.01 11 FIXED INDIRECT COSTS(MOBILIZE)**

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11.11.001 | Freight equipment to site. | 1.00 | LS | | | | | | 280,000 | | | | | | 280,000 |
| 11.11.002 | Assemble equipment at site | 1.00 | LS | 1,600 | 60,464 | 7,558 | | 6,448 | | | | | | | 74,470 |
| 11.11.003 | Medium Clear & Grub Temp.Facilities | 2.40 | HA | 168 | 6,187 | 2,404 | | 2,365 | | | | | | | 10,955 |
| 11.11.004 | Level & Compact Temp.Facilitiy Area | 2.40 | HA | 288 | 10,668 | 9,169 | | 97,393 | | | | | | | 117,230 |
| 11.11.005 | Install Temp.Utilities & Services | 1.00 | LS | 2,800 | 102,799 | 9,396 | | 158,098 | | | | | | | 270,293 |
| 11.11.006 | Erect Offices & Workshops | 1.00 | LS | 2,800 | 107,504 | 15,116 | | 22,896 | | | | | | | 145,516 |
| 11.11.007 | Office Furnishings | 1.00 | LS | | | | | 70,000 | | | | | | | 70,000 |
| 11.11.008 | Install Camp | 1.00 | LS | | | | | | 125,000 | | | | | | 125,000 |
| 11.11.009 | Erect Process Plant | 1.00 | LS | 750 | 28,362 | 1,890 | | 16,612 | | | | | | | 46,864 |
| 11.11.010 | Erect Batch Plant | 1.00 | LS | 1,500 | 56,725 | 3,779 | | 18,224 | | | | | | | 78,728 |
| 11.11.011 | Temporary Access Roads | 1.00 | LS | 1,200 | 44,640 | 27,668 | | 90,893 | | | | | | | 163,201 |
| 11.11.012 | Fuel Storage Facility | 1.00 | LS | 0 | 4,000 | | | 2,000 | | | | | | | 6,000 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11 FIXED INDIRECT COSTS(MOBILIZE)** | | | | 11,106 | 421,350 | 76,979 | | 484,928 | 405,000 | | | | | | 1,388,257 |
| **WorkCode.01.00.01** | **12 VARIABLE INDIRECT COSTS** | | | | | | | | | | | | | | |
| 12.12.001 | Maintain General Facilities | 30.00 | MON | | 15,000 | 9,000 | | 6,000 | | | | | | | 30,000 |
| 12.12.002 | Operating Expense | 30.00 | MON | | | 102,854 | | 53,803 | 246,000 | | | | | | 402,658 |
| 12.12.003 | On site staff Management | 1.00 | LS | 4,944 | 4,968,028 | | | | | | | | | | 4,968,028 |
| 12.12.004 | Engineering Equip.& Supplies | 1.00 | LS | | | | | 100,000 | | | | | | | 100,000 |
| 12.12.005 | First Aid & Safety | 1.00 | LS | | | 6,917 | | 68,590 | | | | | | | 75,507 |
| 12.12.006 | Site Photos | 1.00 | LS | | | | | | 6,000 | | | | | | 6,000 |
| 12.12.007 | Business Travel | 30.00 | MON | | | | | | 30,000 | | | | | | 30,000 |
| 12.12.008 | Warehouse Operation | 1.00 | LS | 4,944 | 187,921 | 15,629 | | 506,019 | 100,000 | | | | | | 809,569 |
| 12.12.009 | Equipment Shop | 1.00 | LS | 10,000 | 371,100 | 71,400 | | 136,900 | 300,000 | | | | | | 879,400 |
| 12.12.010 | Explosive Magazines | 1.00 | LS | | | | | 5,000 | | | | | | | 5,000 |
| 12.12.011 | Blasting Consultant | 3.00 | MON | | | | | | 20,600 | | | | | | 20,600 |
| 12.12.012 | Winter Work Costs | 1.00 | LS | 1,400 | 52,213 | 39,179 | | 152,846 | | | | | | | 244,238 |
| 12.12.013 | Camp running cost | 1.00 | LS | | | | | | 2,152,000 | | | | | | 2,152,000 |
| 12.12.014 | Lube & Fuel | 1.00 | LS | 2,000 | 72,220 | 19,900 | | 53,510 | | | | | | | 145,630 |
| 12.12.015 | Proj.Transport & Misc.Equipment | 1.00 | LS | 3,715 | 134,149 | 297,144 | | 338,467 | | | | | | | 769,760 |
| 12.12.016 | Travel Expenses | 1.00 | LS | | | | | | 1,379,000 | | | | | | 1,379,000 |
| 12.12.017 | Misc.Overtime | 1.00 | LS | | 1,000,000 | | | | | | | | | | 1,000,000 |
| 12.12.018 | Equipment Balance | 1.00 | LS | | | 500,000 | | | | | | | | | 500,000 |
| 12.12.019 | H.O.Administration Fee | 1.00 | LS | | | | | 1,500,000 | | | | | | | 1,500,000 |
| 12.12.020 | Bonds | 1.00 | LS | | | | | | 840,000 | | | | | | 840,000 |
| 12.12.021 | Insurances | 1.00 | LS | | | | | | 968,000 | | | | | | 968,000 |
| 12.12.022 | Construction Water Treatment | 1.00 | LS | | | | | | 60,000 | | | | | | 60,000 |
| 13.13.001 | Contractors Profit | 1.00 | LS | | | | | 9,000,000 | | | | | | | 9,000,000 |
| **12 VARIABLE INDIRECT COSTS** | | | | 27,003 | 6,800,631 | 1,062,023 | | 11,921,136 | 6,101,600 | | | | | | 25,885,390 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WorkCode.01.00.01 13 CONTINGENCY** | | | | | | | | | | | | | | | |
| 13.13.002 | Civil Contingency | 1.00 | LS | | | | | 11,000,000 | | | | | | | 11,000,000 |
| 13.13.003 | Marine Contingency | 1.00 | LS | | | | | 6,000,000 | | | | | | | 6,000,000 |
| **13 CONTINGENCY** | | 2.000 | LS | | | | | 17,000,000 | | | | | | | 17,000,000 |
| **WorkCode.01.00.01 14 FIXED INDIRECT COSTS(DEMOBILIZE)** | | | | | | | | | | | | | | | |
| 14.11.001 | Dismantle Offices & Workshops | 1.00 | LS | 1,400 | 53,752 | 7,558 | | 6,448 | | | | | | | 67,758 |
| 14.11.002 | Dismantle & Remove Camp | 1.00 | LS | | | | | | 65,000 | | | | | | 65,000 |
| 14.11.003 | Dismantle Process Plant | 1.00 | LS | 400 | 15,154 | 1,890 | | 1,612 | | | | | | | 18,656 |
| 14.11.004 | Dismantle Batch Plant | 1.00 | LS | 800 | 30,309 | 3,779 | | 3,224 | | | | | | | 37,312 |
| 14.11.005 | Demob & Tidy Site | 1.00 | LS | | | | | 20,000 | 10,000 | | | | | | 30,000 |
| 14.11.006 | Dismantle & Assemble equipment at site | 1.00 | LS | 1,600 | 60,464 | 7,558 | | 6,448 | | | | | | | 74,470 |
| 14.11.007 | Freight equipment from site. | 1.00 | LS | | | | | | 280,000 | | | | | | 280,000 |
| **14 FIXED INDIRECT COSTS(DEMOBILIZE)** | | 7.000 | LS | 4,200 | 159,679 | 20,785 | | 37,732 | 355,000 | | | | | | 573,196 |
| **WorkCode.01.00.01 15 MARINE MOBILIZE/DEMOBILIZE** | | | | | | | | | | | | | | | |
| 15.11.100 | Excavate & Grade Area Launching Site | 1.00 | LS | 480 | 17,974 | 20,104 | | 22,874 | | | | | | | 60,951 |
| 15.11.101 | Place & Compact Granular Base | 1.00 | LS | 360 | 13,420 | 12,701 | | 73,879 | | | | | | | 100,001 |
| 15.11.102 | Lay Launching Rails | 1.00 | LS | 440 | 17,200 | 5,066 | | 47,428 | | | | | | | 69,693 |
| 15.11.103 | Install winches and anchor pads | 1.00 | LS | 400 | 16,000 | 10,000 | | 14,000 | | | | | | | 40,000 |
| 15.11.104 | Supply of Marine Equipment | 1.00 | LS | | | 990,000 | | 94,797 | | | | | | | 1,084,797 |
| 15.11.105 | Supply and Erect Covered Welding Workshop | 1.00 | LS | | | | | | 75,000 | | | | | | 75,000 |
| 15.11.106 | Erection of Flexifloats for crane platform | 1.00 | LS | 320 | 12,118 | 2,533 | | 2,089 | | | | | | | 16,739 |
| 15.11.107 | Modify Flexifloats for Winch platforms | 1.00 | LS | 1,040 | 39,517 | 5,066 | | 4,178 | | | | | | | 48,760 |

| WorkSheet Number | Description | Quantity | Unit | Manhours | Labor | Equipment | Materials | Supplies | Subcontracts | (Not Used) | (Not Used) | (Not Used) | (Not Used) | (Not Used) | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15.11.108 | Modify Flexifloats for Plug Drill Platform | 1.00 | LS | 240 | 9,045 | | | | | | | | | | 9,045 |
| 15.11.109 | Modify Flexifloats for crane platform | 1.00 | LS | 320 | 12,118 | 2,533 | | 2,089 | | | | | | | 16,739 |
| **15 MARINE MOBILIZE/DEMOBILIZE** | | 10.000LS | | 3,600 | 137,390 | 1,048,002 | | 261,334 | 75,000 | | | | | | 1,521,726 |
| **Grand Total** | | | | 248,879 | 15,275,343 | 3,955,660 | 9,570,977 | 32,876,246 | 26,118,600 | | | | | | 87,796,826 |