City of Nanaimo

Middle and Lower Colliery Dams

Conceptual Costing of Rehabilitation and Replacement Options

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April 30, 2013

City of Nanaimo
455 Wallace Street
Nanaimo, BC
V9R 5J6

Bill Sims, AScT
Manager, Water Resources

Dear Mr. Sims:

Middle and Lower Colliery Dams
Conceptual Costing of Rehabilitation and Replacement Options

Klohn Crippen Berger Ltd. (KCB) is pleased to submit our final report for the Conceptual Costing of options for the Middle and Lower Colliery Dams.

Yours truly,
KLOHN CRIPPEN BERGER LTD.

Robin J. FitzGerald, P.Eng.
Project Manager

RJF:

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City of Nanaimo

Middle and Lower Colliery Dams

Conceptual Costing of Rehabilitation and Replacement Options

Cover Image: Photo-Rendering of Middle Dam with Spillway and Lake lowered 3m (Option VH1)

EXECUTIVE SUMMARY

Klohn Crippen Berger (KCB) was awarded consulting services to support the removal of two dams in Colliery Dam Park near the City neighbourhood of Harewood. These two dams are located along the Chase River and are known to the public as the Colliery Dams. These dams are also known as the Middle and Lower Chase River Dams. Discussions between the City, CDPS and BC Dam Safety has confirmed that the "Extreme" risk classification, and the risks to the City and downstream population it represents, will pertain until major and imminent action is taken,

In response to input from stakeholders, the City then asked KCB to also develop conceptual cost estimates for the remediation and replacement of the dams, to provide the basis for comparison of all options on a consistent cost, feasibility and safety basis. To demonstrate the consistent technical and cost basis used across all options, this report presents conceptual cost estimates not only for the Rehabilitation and Replacement options, but also for the Dam Removal and Re-naturalization option, with which they share many common project components.

The overall range of ideas and solutions for rehabilitating or replacing the dams in presented in Figure 1 and the feasibility and effectiveness of each is addressed in this report.

Conceptual cost estimates for seven different options for rehabilitation and/or replacement of the dams, are compared in this report to a conceptual cost estimate for removal and re-naturalization of both dams. As presented in Tables 1 and 2, and Figure 8, the eight different combinations of project components and costs lead to project cost estimates ranging from \$5.5 million to \$23.6 million.

A reduction in dam classification based on a reduction in lake volume remains speculative and hypothetical at this stage, and the presentation in this report of options based on a "Very High" classification must not be seen as confirmation that these options are acceptable to the City or to BC Dam Safety. The difference in design criteria between Extreme and Very High classification for these dams can be summarised as a 22% reduction in spillway capacity (205 m^3/s to 161 m3/s) and a 14% reduction in peak Earthquake acceleration (1:10,000 year = 0.7g to 1:,5000 year = 0.6g).

The conceptual cost estimates, presented in Figure 8, fall into three groups:

5 schemes involving Rehabilitation of one or both dams:	\$14.5 million to \$23.5 million.
2 schemes involving replacement of one or both dams:	\$7.9 to \$8.5 million
Removal and Re-naturalization of both dams:	\$5.5 million

These estimates include Engineering and City costs, and contingency allowances related to the unknowns and risks involved in various parts of the work. They do not include the overall budget contingency which may be applied by the City and are initial capital costs only. The City will probably also wish to consider life cycle costs in considering their course of action.

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1 INTRODUCTION

1.1 General

Klohn Crippen Berger (KCB) was awarded consulting services to support the removal of two dams in Colliery Dam Park near the City neighbourhood of Harewood. These two dams are located along the Chase River and are known to the public as the Colliery Dams. These dams are also known as the Middle and Lower Chase River Dams.

In response to input from stakeholders, the City then asked KCB to also develop conceptual cost estimates for the remediation and replacement of the dams, to provide the basis for comparison of all options on a consistent cost, feasibility and safety basis. In accordance with the City's and stakeholders' intent that the cost estimates for remediation or replacement of the dams should be developed independently from the removal option, this task has been carried out under a separate agreement, mostly by a civil/geotechnical/structural team within KCB who are not directly involved in the planning or design of the "removal" option.

However, in order to provide estimates for all three types of options (removal, rehabilitation or replacement) which are on a consistent and directly comparable basis, there has been some cross-over of coordination and review between the two tasks. For instance, the same assumed bedrock surfaces, dam material volumes, design parameters, construction unit rates and environmental considerations are used for all concepts and cost estimates. To demonstrate the consistent technical and cost basis used across all options, this report presents conceptual cost estimates not only for the Rehabilitation and Replacement options, but also for the Dam Removal and Re-naturalization option, with which they share many common project components.

The objective of this report is to provide information to the City and City Council to support a decision on the course of action for 2013 construction. The hydrologic, geotechnical and structural analyses and design which have been carried out to date, to support the conceptual cost estimates, are described in general in this report. They will be reported in detail, in due course, for the project scope which will be implemented.

1.2 Solutions and Options

Initial discussions of alternatives to dam removal, between the City and the Colliery Dams Preservation Society (CDPS) produced an "Options Tree" similar to Figure 1, which explored various solutions and suggestions. After initial evaluation and elimination of some suggestions, as discussed in Section 2.1, the remaining feasible actions for dam rehabilitation and replacement were grouped into nine different combinations for evaluation and cost estimating, as presented in Figures 2 and 3. Two of these (VH3 and VH5), which involved removal of the Lower Dam, were removed from the reporting, on the understanding that they were not favoured by the CDPS.

Therefore, conceptual cost estimates for seven different options for rehabilitation and/or replacement of the dams, are presented in this report along with a conceptual cost estimate for removal and re-naturalization of both dams. As presented in Tables 1 and 2, and Figure 8, the eight different combinations of project components and costs lead to project cost estimates ranging from \$5.5 million to \$23.6 million.

1.3 Dam Classification and Design Parameters

The "Extreme" risk classification for the Colliery Dams has been discussed between City, CDPS and BC Dam Safety. It has been confirmed that this classification, and the risks to the City and downstream population it represents, will pertain until major and urgent action is taken, along the lines of the City's October 2012 decision to proceed with dam removal and Re-naturalization of the two lakes.

Under the 2007 Canadian Dam Association Guidelines (CDA 2007) the Extreme Classification carries a requirement to construct the dams and spillways to withstand the Probable Maximum Flood (PMF) and the 1:10,000 year earthquake.

It has been suggested that a reduction in the volume of stored water by the two dams could reduce the dam breach flood wave such that estimated human life, private property and infrastructure losses would permit a reduction in dam classification from "Extreme" to "Very High". To follow this line of reasoning through dam breach and inundation analysis, and review by BC Dam Safety, leading to confirmation of whether a reduction in in dam classification was justified, would have required more time than has been available.

Scenario SC5 in the "Chase River Dam Breach Flood Inundation Study", Associated Engineering, 2012 (AE 2012) involves a breach of the Lower Dam only in a 1:100 year flood, with a stored volume (at overtopping level) of 165,000 m^3. SC5 was estimated to cause similar downstream economic losses as SC6, the failure of both dams in an earthquake. The Middle Dam (only) at Normal Water Level stores 112,000 m^3 for a sunny-day failure of the Lower Dam in an earthquake event. However warning time and evacuation considerations for an earthquake event are very different from the flood conditions in SC5 in AE 2012.

Therefore, a reduction in dam classification based on a reduction in lake volume remains speculative and hypothetical at this stage, and the presentation in this report of options based on a "Very High" classification must not be seen as confirmation that these options are acceptable to the City or to BC Dam Safety.

Based on a slight simplification of the results of previous reports, the following Inflow Design Flood was used for evaluation of spillway capacities and upgrades for both dams:

Extreme Classification	Probable Maximum Flood	= 205 m^3/s
Very High Classification	2/3 between 1:1000 year flow and PMF	= 161 m^3/s

The following ground accelerations were derived by KCB for this location and used in analysing the extent of seismic upgrading required:

Extreme Classification	1:10,000 year earthquake	= 0.7 g
Very High Classification	1:5,000 year earthquake	= 0.6 g

[g is the acceleration due to gravity, therefore 0.6 g is 60% of the acceleration due to gravity]

2 CONCEPTUAL OPTIONS

2.1 Eliminations from Evaluation

As shown in Figure 1, a number of technical suggestions were initially considered but eliminated for the following reasons:

Piles

A close array of steel pipe piles has been suggested as a way of stiffening the existing dam body and supporting the concrete wall against collapse in a seismic event. KCB has seismically analyzed various pile dimensions and number of rows (with the commercial software L-PILE) and concluded that it was not practical or effective for a number of reasons:

- Smaller-bore piles, even if concrete filled and drilled through the rock fill to bedrock, present far too high a length to width ratio to be stiff and effective in a seismic event.
- Pipe piles which were sufficiently large-diameter to provide lateral stiffness in the design earthquake could probably not be drilled through the rockfill to bedrock.
- The ability of a wall of pipe piles to significantly change the seismic behavior of the existing embankment – i.e. the interaction of the piles with the surrounding existing fill - is very uncertain.

Rock Bolts

Rock bolting has been suggested to strengthen the existing concrete wall and tie it to the bedrock. However, given the cracking and evident condition of the existing concrete, it is very doubtful, even with a closely spaced and comprehensive system of wall support, the existing walls would "hold together" in a large earthquake.

Sheet Pile

Steel sheet pile would be used to provide an impermeable barrier, upstream of the existing concrete wall, to support the concrete wall and prevent leakage if the concrete wall was shattered by an earthquake. However,

- The penetration of sheet pile through the existing rockfill would be very difficult and sealing of the sheet pile to the underlying bedrock very doubtful due to the likely uneven rock profile and inability to drive the sheets into the bedrock.

- The sheet pile wall would rely on the existing dam embankment for lateral support in an earthquake. Therefore, the existing risks of embankment collapse would only be slightly changed.

Downstream Slope Spillways

If the existing dams and lakes are retained as-is, with an Extreme Classification, spillway capacity has to be increased by a factor of 3.3 and 8.2 respectively for the Middle and Lower dams, to accommodate the PMF. A spillway over a lowered and armoured dam crest, with the downstream dam slope armoured with concrete or riprap has been suggested. Incidentally, this would require a long concrete pathway bridge on piers across this crest spillway.

EBA 2010, on the basis of High classification, considered this possible approach and discussed a number of technical hurdles (compaction, settlement, scour etc.) that would have to be addressed. These considerations would be even more stringent at the current Extreme classification.

In addition, KCB's experience is that it would be extremely difficult to design and construct to a degree that would gain the approval of the Dam Safety Branch or provide assurance that the "back-slope spillway" would remain functional in the long term to protect the integrity of the dam body, especially given this "Extreme" risk context.
Or put another way; to deal with the uncertainties in the existing dam structure, the amount of excavation and reinforcement that would be necessary to ensure no settlement or cracking of the spillway on the back slope, would involve a fundamental re-build of the entire dam.

The default position of the BC Dam Safety Guidelines is that the spillway should be "*constructed on undisturbed ground, not on embankment fill*". Only in special cases (such as concrete dams) is that normally waived.

Replacement with New Embankment Dam

Dam rehabilitation options presented in this report show the extent of buttress fill that would be required on the upstream and downstream slopes of existing dams in which a significant zone had been augmented by jet grouting and soil cement. Unless a similar concrete or soil cement core was constructed in a new dam, the dimensions of a conventional earth embankment dam would have to be greater than presented for rehabilitation, to provide the same overall stability. And combined with the need to remove the existing dam completely and construct an expanded spillway, this would be an impractical and costly solution comparable to the most expensive of the options presented in this report.

Alternatively, a Concrete Faced Rockfill Dam (CFRD) could be designed to meet the seismic requirements, with dimensions lying between a compact Roller Compacted Concrete (RCC) dam and a large embankment dam. However, for this project, the RCC option is better in terms of cost, construction logistics, spillway arrangement and reduction in both long-term liabilities and risks to public life safety.

Lake In-Fill

Although not included in the CDPS Options Tree (Figure 1) the possibility of filling in the lake bottoms with rock fill, to reduce the stored water volume, has been suggested as another way to lower the dam classification to Very High. Among the considerations leading to elimination of this idea from further evaluation are:

- This option would simply be the addition of supply and installation of approximately 110,000 cu.m. of infill material to the cost of rehabilitating both dams (to 1:5000 year earthquake) and spillways (to 161 m^3/s). Based on other options costed, the overall project cost would be in the order of $20 million.
- The reduction of lake depth to a uniform 3m (approximately) would fundamentally change the nature and habitat of the lakes and result in a Harmful Alteration, Disruption or Destruction of fish habitat (HADD) of up to 25,000 m^2. Compensation for this HADD, in the form of a habitat development elsewhere, would be required as an additional cost to the project.

Options VH3 and VH5: Removal of Lower Lake and Rehabilitation or Replacement of Middle Dam

Two of the options initially developed, VH3 and VH5, involving retention of the Middle Dam and removal of the Lower Dam, were removed from the reporting, on the understanding that they were not favoured by the CDPS.

2.2 Other Considerations

Long-Term Risks and Liabilities

The retention of the dams, either by rehabilitation or replacement, would carry with it the long-term liability and maintenance costs of Extreme or Very High classification dams. The risks associated with the dams would remain and would never be reduced to zero. The life-cycle costs associated with dam safety obligations for these dams, going forward, have not been included in this conceptual cost comparison, but will be an important consideration for the City in comparing the overall options.

Design, Permitting and Construction Duration

Given the current Extreme classification of the dams, a decision to proceed with Dam rehabilitation or replacement would require a sequence of studies and negotiations with BC Dam Safety Branch to obtain the necessary approvals, followed by detailed design based on the approved parameters.

In the case of dam replacement, dam removal in 2013 will be feasible, but dam construction would probably not commence until the 2014 low-flow season or probably later due to the design and approvals process for new dams. This delay carries with it the need to clean and prepare the natural channel through the lakes to carry the winter river flows without sediment risk to the downstream river. This additional cost has been included in the cost estimates.

Hydro Power

The possibility of adding small hydro generation to the dams, if they were rehabilitated or replaced, has been suggested. The implications and cost/benefit of this side-issue have not been evaluated for this report.

Location of New Dams

Previous discussions and reports have discussed the possibility of building new dams either upstream or downstream of the existing dams, in order to simplify water management during construction. However, KCB has concluded that the extra width of the valley at these locations makes this impractical both in terms of quantities and costs. It also would result in a fundamental change in the topography and use of the area, since the new dams would occupy either current lake area or the valley downstream of the existing dams. Therefore, new RCC dams have been indicated at the same location as the existing dams.

2.3 Options Selected for Costing

As presented in Figures 2, 3 and 8 and in Tables 1 and 2, the following eight options were evaluated at a conceptual level to produce conceptual cost estimates.

Very High Classification

As discussed previously in Section 1.3, the approval of a reduced classification based on a reduction in the volume of stored water is purely speculative at this stage and would require a lengthy sequence of analyses and discussions with BC Dam Safety. The following three options reduce the stored water volume by approximately 50% by lowering both lakes by 3m, or by eliminating the Middle Lake.

It is notable that, even if classification were lowered from Extreme to Very High, the dam safety criteria for design flow (spillway capacity) only reduces by approximately 22% (205 m^3/s to 161 m^3/s) and the seismic acceleration reduces by only 14% (0.7g to 0.6g).

VH1: Lower Both Lakes by 3m

The existing spillways on both dams are on bedrock and would be lowered (with rock blasting) by 3m and the crest area re-profiled to improve hydraulic performance, to handle the Inflow Design Flood (IDF) of 161 m^3/s. The deepened spillways would fit within the width of the existing spillways, with new sidewalls and pathway bridge.

As discussed in section 3.1, the selected solution for seismic upgrade of the dams to the 1:5000 year level would involve jet grouting the existing dam adjacent to the concrete cut-off wall and constructing a RCC section or similar above existing fill, to stiffen the dam and concrete wall zone. Significant buttress rock fill is then needed to stabilize the outer shell of the existing dam (see Figures 4 and 6).

The perimeter of the lake bottom, exposed by a 3 m reduction in water level, would be landscaped. A conceptual view of Option VH1, for the Middle Dam, is shown on the cover of this report, and a plan view is shown in Drawing 01.

VH2: Remove Middle Dam, Rehabilitate Lower Dam

The assumption is that, with the 50% reduction in water volume resulting from the removal of the Middle Dam, the objective would be to retain the Lower Dam at its existing level. This results in the need to greatly expand the width of the Lower Dam spillway (from approximately 12 m to 48 m) to accommodate 161 m^3/s, and construct a pathway causeway across the wide spillway. See Drawing 02 for plan view.

Seismic upgrading of the Lower Dam would be the same as in Option VH1 (see Figure 6). Conceptual design and cost derivation for dam removal and re-naturalization of the Middle Dam is the same as developed for the overall Dam Removal scheme.

VH4: Remove Middle Dam, Replace Lower Dam

The main difference between Option VH4 and VH2 is the substitution of dam removal and a new RCC dam (and pathway causeway across the crest spillway) in place of the dam rehabilitation and spillway expansion at the Lower Dam. See Drawing 03 for plan view.

<u>**Extreme Classification**</u>

The following four options result in the retention of both dams at their current water levels, and therefore the need to design the work according to the current Extreme dam classification.

EXT1: Rehabilitate Both Dams Without Drawdown

Both dams would be upgraded to the 1:10000 year criteria, with ground improvement of the core (jet grouting and RCC or similar) and rockfill buttressing, as described in Section 3.1.

Spillway capacities need to be increased as described in Section 3.2, to handle the 205 m^3/s PMF.

See Drawing 04.

EXT2: Replace Middle Dam, Rehabilitate Lower Dam
EXT3: Replace Lower Dam, Rehabilitate Middle Dam

These two options were evaluated to check the interplay of dam size on the relative costs, as well as other considerations such as the different location of an expanded spillway. See Drawings 05 and 06. Note that, in each case, construction of the new RCC dam would be preceded by complete removal (to bare rock foundation) of the existing dam.

EXT4: Replace Both Dams, Without Drawdown

Both dams would be removed and replaced by new RCC dams, as illustrated in Drawing 07.

3 CONCEPTUAL DESIGN

3.1 Seismic Rehabilitation

Seismic analysis of various suggested options (piles, ground improvement etc.) resulted in the conclusion that, to limit displacements of the concrete cut-off wall to an acceptable level, the only effective solution was the stiffening of a significant zone of the existing dam fill adjacent to the wall with jet grouting (cement is injected at very high pressure through a rotating drill nozzle, to mix with the soil or rockfill and create a column of concrete-like material), with RCC or similar strong fill added at higher elevations. In effect, the objective is to transform the rockfill of the dam into a stronger mass, and add buttress fill and flatten slopes to form a stable shell.

As shown in Figures 4 to 7 (and in Table 4), the seismic analysis (Slope-W and Sigma-W) lead to the conclusion that the main difference between the 1:5000 year and 1:10000 year rehabilitation would be a small increase in ground improvement zone dimensions rather than a large difference in buttress dimensions and dam footprint. Therefore the overall dam dimensions and quantities for buttress fill are the same for both 1:5000 year and 1:10000 year level of rehabilitation.

For the Lower Dam, both seismic analysis and cost estimates assume that all of the coal waste layer will be removed from the crest and downstream slope, as illustrated in Figures 6 and 7. For the Middle Dam, only a shallow layer of topsoil and fill would be removed to prepare the surface for additional buttress rockfill.

Detailed design of dam rehabilitation would probably involve a somewhat more complex cross-section with, for instance, a filter layer between existing fill and buttress fill. However, the conceptual quantities and cost estimates make allowance for these potential design developments.

3.2 Spillway Expansion

Both existing spillways feature a flat entrance and crest apron which limit their hydraulic performance. The conceptual design of spillway improvements in this report, to accommodate IDFs of 161 m^3/s or 205 m^3/s, includes rock excavation to produce a more sharp-crested weir and sloped downstream chute to optimize the hydraulic performance and spillway dimensions.

In the case of Option VH1, the lowering of the lake normal water levels allows a much deeper spillway section which will fit within the existing spillway widths, although involving a complete rebuilding of the deepened spillway with new concrete sidewalls and pathway bridge.

Note that, unlike the existing Lower Dam spillway, it is assumed that the floor of both deepened and steepened spillways will be exposed bedrock, to save costs.

For Options VH2, EXT1, EXT2 and EXT3, the assumption is that the spillway crest and dam crest elevations (and therefore freeboard) remain as-is. The additional spillway capacity must result from improved weir (crest) performance (through rock excavation and shaping) and additional spillway width. In the case of Option VH2, the improved weir hydraulics mean that, although the IDF is approximately 6 times the current capacity, the proposed spillway width (weir length) is about 4 times the existing width.

Lateral spillway expansion would involve removal of a significant area of existing park woodland and excavation up to 5 m deep into the current side-hill bordering the existing spillways. It is assumed that this excavation would be partly in overburden, but would reach bedrock over the full spillway area to avoid the need for a concrete slab for the spillway chute.

3.3 Dam Removal

The dam removal assumptions, design and quantities which are used, where applicable, in these conceptual cost estimates, are the same as developed for the Dam Removal option.

Dam removal estimates assume that excavation will be limited to what is needed to expose the natural streambed, the bedrock sides of the original valley and bedrock outcrops for the proposed footbridge abutments. Slopes of 1:1 are assumed for the volume calculations (with contingency amounts) but the actual slopes will depend on the exposed rock surface.

3.4 Re-naturalization

The Re-naturalization and landscaping assumptions, for both lakes, include sediment removal and channel rehabilitation along the watercourse, and various proportions of planting, seeding and pathways. The assumptions, design and quantities which are used, where applicable, in these conceptual cost estimates, are the same as developed for the Dam Removal option.

3.5 New Structures

Roller Compacted Concrete (RCC) was selected as the most cost-effective option for dam replacement, since the crest can serve as the spillway. An RCC dam also permits various options for water management that would allow construction to stretch beyond the low-flow season.

At a conceptual level, the RCC cross-section is 4m at the crest and has a vertical upstream face and a 1V:1H stepped downstream face accommodating a stepped spillway chute. A grout curtain would be installed to seal the foundation bedrock. Cost estimates in this report include an allowance for facing of the upstream face, crest spillway and downstream spillway with conventional concrete.

In addition to new Roller Compacted Concrete dams and spillway side-walls, various combinations of new structures are required for the options:

- Footbridges (where dams are removed). These have been designed and costed to a preliminary level as part of the Dam Removal option.
- Spillway bridges and pathway causeways. These are costed at a conceptual level as a concrete deck and metal railings crossing the spillways on concrete piers. As seen on the drawings, these pathway causeways could be up to 50m in length and are included in the appropriate spillway expansion and RCC dam cost estimates.

4 COST ESTIMATES

4.1 Methodology

As illustrated in Figures 2 and 3, and in Tables 1 and 2, there are many common elements and work components between various overall schemes for dam removal, replacement and rehabilitation. In an effort to ensure consistency, a "modular pricing" approach was used, in which consistent unit rates (Table 3) are used in all component cost estimates (Tables 4 to 9), which in turn are used as needed in the compilation of overall Option Cost estimates in Tables 1 and 2.

However, some minor variations are incorporated to recognize differences in construction requirements. For instance, the work scope and quantities for removal of the Middle Dam in Options VH2, VH4, EXT2, EXT4 and "REMOVAL" are essentially the same. However, as shown in Table 1, it is assumed that, in options EXT2 and EXT4, all clean excavated material and demolished concrete can be disposed of into the lake, which is retained. In Options VH2, VH4, and "REMOVAL", in which the lake is emptied and the lakebed is re-naturalized, it is assumed that most of the clean excavated material can be utilized in the lakebed for pathway construction and beneficial contouring, but all concrete and some unsuitable fill will need to be disposed of off-site. A cost difference of approximately $25,000 recognizes this issue.

The quantities, cost estimates and contingency allowances in this report are based on the conceptual design nature of this assignment, information available at this time and on engineering judgment. The City may choose to add a "level of confidence" budget allowance to the estimates presented in this report (i.e. Tables 1 and 2). Table 2 includes a suggested additional budget allowance based on the level of confidence in ground conditions and other assumptions.

4.2 Contingency Allowances

Table 1 shows the contingency allowances that have been added to the estimated amounts derived in Tables 3 to 9. These contingency allowances reflect not only the current unknowns, either related to site conditions or to the conceptual level of design, but also the fact that some project elements could be scaled back slightly to suit budget, since the end result does not carry a dam safety implication, whereas others may need to be scaled up to suit ground conditions and meet dam safety requirement.

For instance, the final dam removal slopes and the extent and complexity of Re-naturalization efforts could be scaled back slightly to meet budget since there is no dam safety implication. Whereas there are significant unknowns with the dimensions and logistics of dam rehabilitation options which must meet the strict requirements for either Extreme or Very High dam safety classification requirements, and costs may increase as more information is obtained.

The quantities, cost estimates and contingency allowances in this report are based on the conceptual design nature of this assignment, information available at this time and on engineering judgment.

The City may choose to add a “level of confidence” budget allowance to the estimates presented in this report (i.e. Tables 1 and 2). Table 2 includes a suggested budget allowance for consideration.

4.3 Cost Estimate Tables

Table 1 Option Cost Component Summary

Component costs developed in Tables 4 to 9 are adjusted by the noted contingency allowance and utilised as needed in the compilation of each Option estimate.

Table 2 Option Cost Summary

The cost estimate amounts from Table 1 are compiled in somewhat less detail under the cost headings that are illustrated in Figure 8.

Table 3 Unit Rates Used in Cost Estimates

This shows the unit rates which are used consistently (and automatically) across all cost estimates in Tables 4 to 9.

Table 4 Seismic Rehabilitation Costs

The cost difference between 1:5000 year and 1:10000 year seismic rehabilitation for each dam is related to the dimensions of core ground improvement (jet grouting and soil cement) and is relatively small for each dam.

Table 5 Spillway Upgrade Costs

The costs of spillway expansion to accommodate IDFs ranging from 2.6 to 8 times existing spillway capacity represent large components of the overall cost of options which require dam rehabilitation. Not included in these costs, but an important consideration in the comparison of options, is the area of woodland and usable park which is replaced with an open spillway.

Table 6 Dam Removal Costs

The dam removal quantities and cost estimates summarized in Table 6 have been developed for the Dam Removal scope of work. They are used consistently for all options which require removal of one or more dams, either permanently or to prepare for a new RCC dam.

As shown, allowances are made for various requirements and costs for on-site and off-site disposal.

Table 7 Re-naturalization Costs

The design and quantities for Re-naturalization were developed (for the Dam Removal scope of work), based on a set of assumptions and landscaping approaches which will be applied (or modified) as appropriate once the lakes are drained and the lake bottom and channel conditions are revealed. For this exercise, the same assumptions and quantities and costs are used consistently for all options which require permanent removal of one or more dams.

Re-naturalization costs include restoration of construction laydown areas, which vary depending on the scope of construction work, and for off-site provision of habitat compensatory works.

Table 8 New Structure Costs

Table 8 details cost estimates for new RCC dams, including the pathway causeways which would cross the crest spillways. The unit rate for RCC (Table 3) recognises the relatively small quantity and the logistics of placing between natural bedrock faces. The quantity (and the contingency added in Table 1) recognises the uncertainty of bedrock location which will dictate the length and volume of the dam.

Cost estimates for a number of footbridge types have been developed, to a Conceptual Design level, under the Dam Removal scope of work, and are applied here consistently to all options involving permanent dam removal.

Table 9 Other Costs

A diversion scheme for summer river flow is being developed under the Dam Removal scope of work and is utilized here for all options. It is possible that some options may stretch to a second construction season, but it is assumed that the extra costs related to duration of operation will be minor, once the diversion is in place.

Engineering cost estimates are conceptual, but recognize the differences in design requirements, complexity and duration related to the various options.

5 CONCLUSIONS

With reference to Table 8, the cost estimates confirm earlier forecasts that the cost of dam rehabilitation would be very high. Options involving seismic rehabilitation and spillway upgrading, to either Very High or Extreme dam safety classification are estimated in the $15 million to $24 million range.

This study identifies a scheme for dam replacement with Roller Compacted Concrete dams at the same location as the existing dams. The cost differential, compared to dam removal, is reduced by the offsetting saving in re-naturalization/landscaping costs when lakes are retained. Because of this offset, the costs for retaining either the Lower or both lakes, with new RCC dam(s), are only 10% different ($7.9 million or $8.6 million, capital cost, respectively).

This study confirms that removal of both dams and re-naturalization of both lakes is the lowest cost option overall, with a conceptual cost estimate of $5.5 million (not including overall budget contingency). Factors not addressed in the cost estimate include the lower level of risk to public life safety, reduced life-cycle costs (including maintenance, dam safety-related monitoring and assessment), and lower implications of unknowns such as bedrock profile and subsurface geology.

In addition to the 45% additional cost for retaining the Lower Lake, compared to dam removal and Re-naturalization, there are significant issues and impacts related to lake and dam retention which the City must consider, including:

- construction impacts;
- life-cycle costs including long-term dam safety costs and liabilities, including monitoring, maintenance and future upgrades;
- Public safety issues, including swimming, spillways and downstream neighbourhoods;
- loss of opportunity to re-establish natural stream habitat above the Lower Dam

On the other hand, retention of one or both lakes and dams allows current recreational activities, including swimming and fishing, to continue.

6 LIMITATIONS OF REPORT

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of the City of Nanaimo (Client) for the specific application to the Middle and Lower Chase River Dams, Rehabilitation/Replacement Options. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

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REFERENCES

WMC 2002: "Middle and Lower Chase River Dams. Spillway Hydrology Study", Water Management Consultants, April 2002

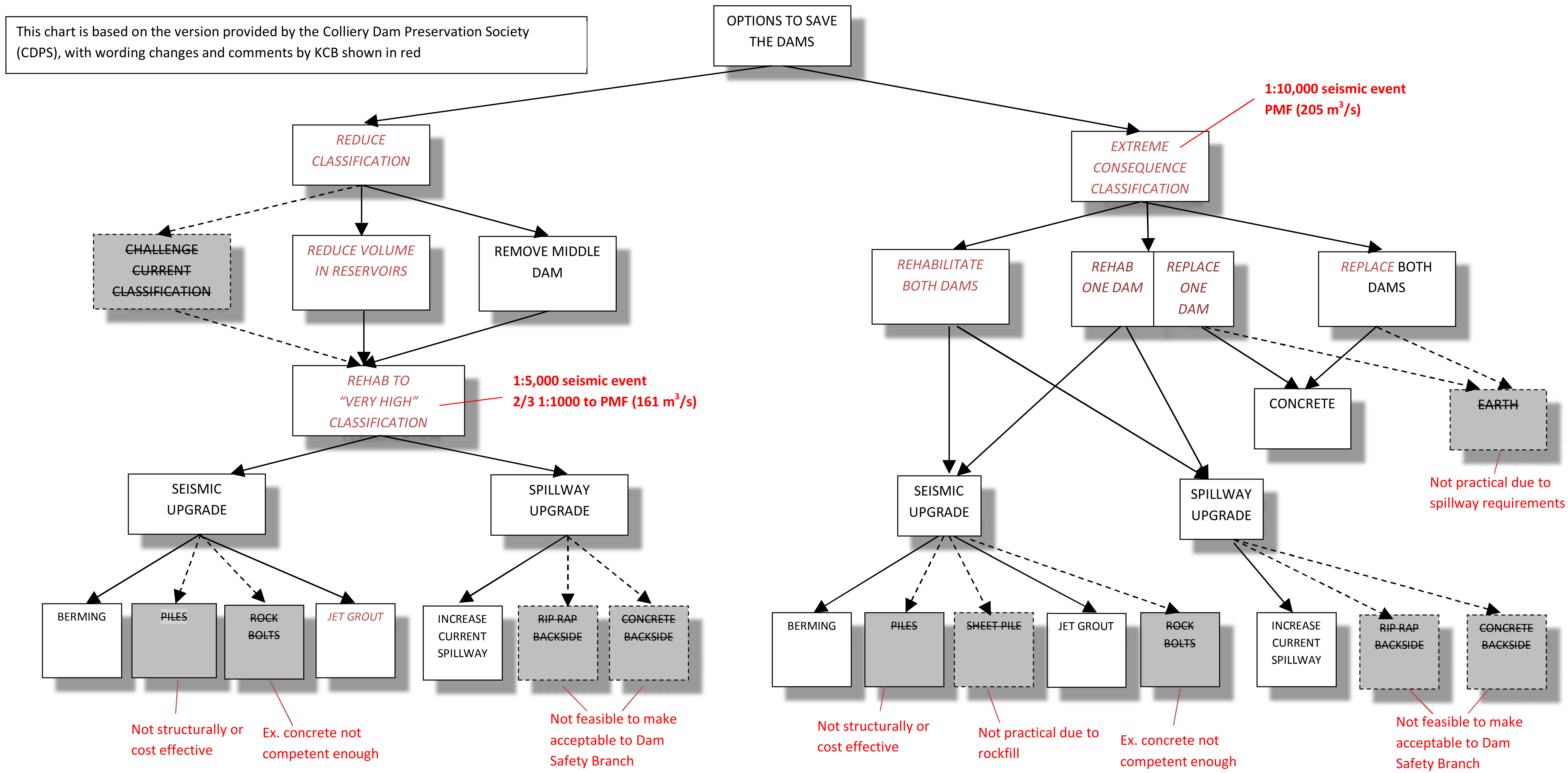
WMC 2003: "Upper Chase River Dam. Spillway Hydrology Study", Water Management Consultants, April 2002

EBA 2010: "Middle and Lower Chase Dams, Seismic Hazard Assessment", EBA,

AE 2012: "Chase River Dam Breach Flood Inundation Study", Associated Engineering, September 2012

FIGURES

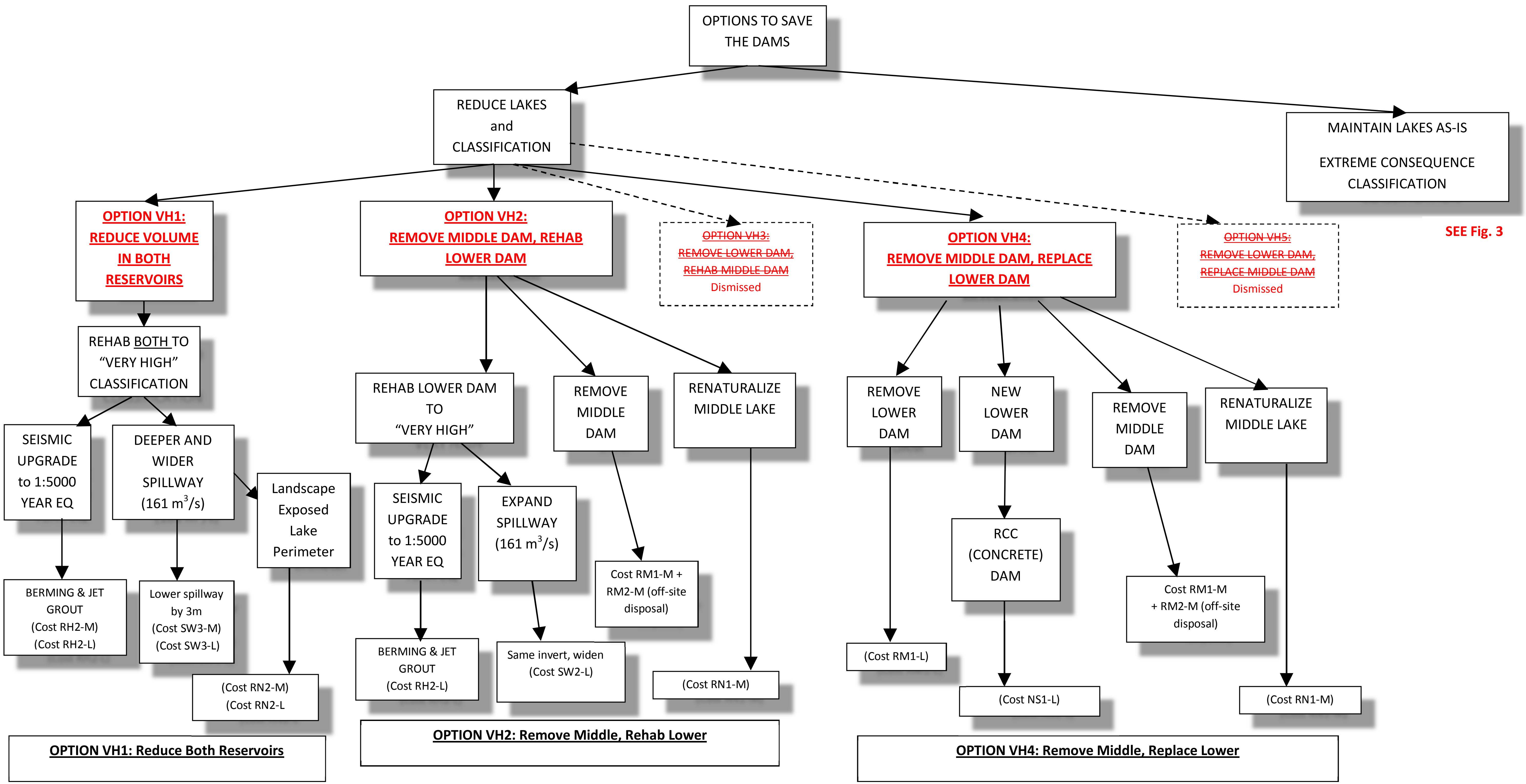
CITY OF NANAIMO
CHASE DAMS REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES



Klohn Crippen Berger Ltd.
Project P09849A01

FIGURE 1
INITIAL SCREENING OF REHAB/REPLACE OPTIONS

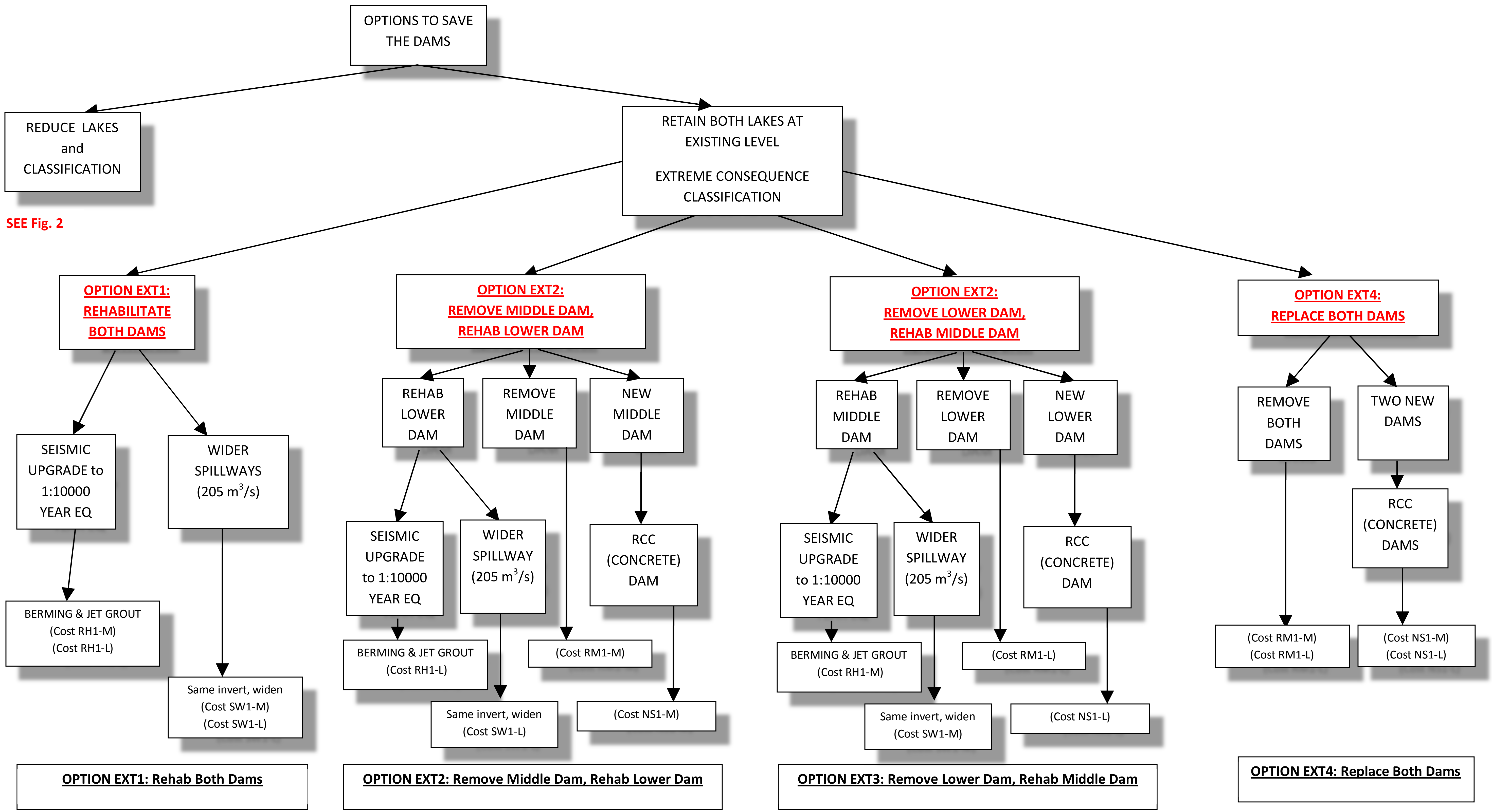
CITY OF NANAIMO
CHASE DAMS REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES



Klohn Crippen Berger Ltd.
Project A09849A01

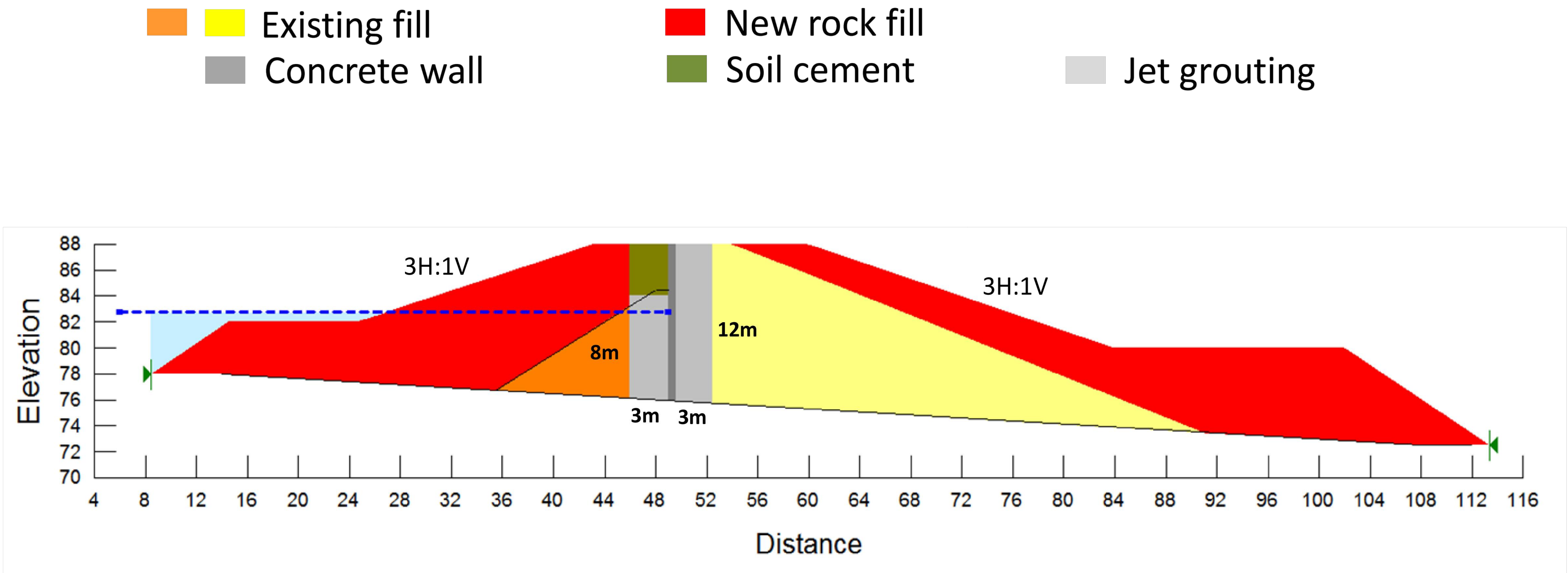
FIGURE 2
OPTIONS WITH LOWER CLASSIFICATION

CITY OF NANAIMO
CHASE DAMS REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES



Klohn Crippen Berger Ltd.
Project P09849A01

FIGURE 3
OPTIONS FOR RETAINING BOTH LAKES



Jet grouting dimensions:
Upstream = 3m wide x 8m high
Downstream = 3m wide x 12m high

CLIENT

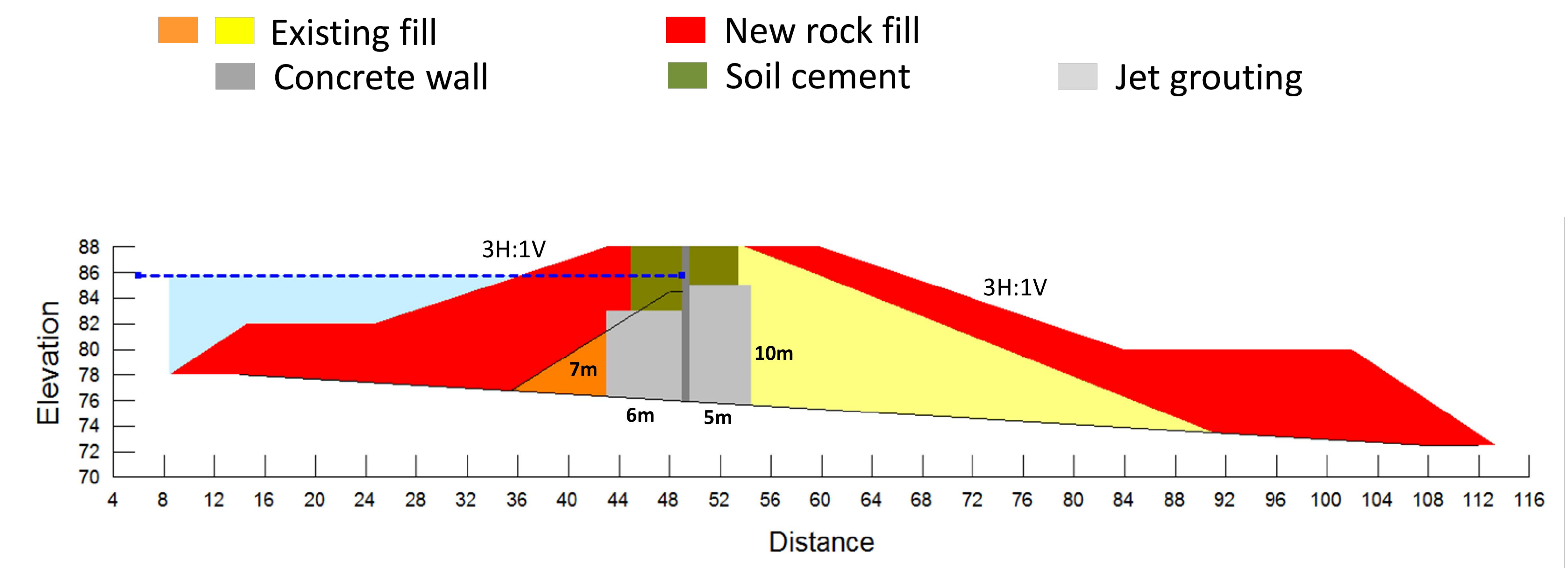
Klohn Crippen Berger

PROJECT
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE
Rehabilitation of Middle Dam for the 5,000-year return period earthquake

PROJECT NO. P09849 A01

FIGURE NO. Figure 4



Jet grouting dimensions:

Upstream = 6m wide x 7m high

Downstream = 5m wide x 10m high

CLIENT

Klohn Crippen Berger

PROJECT

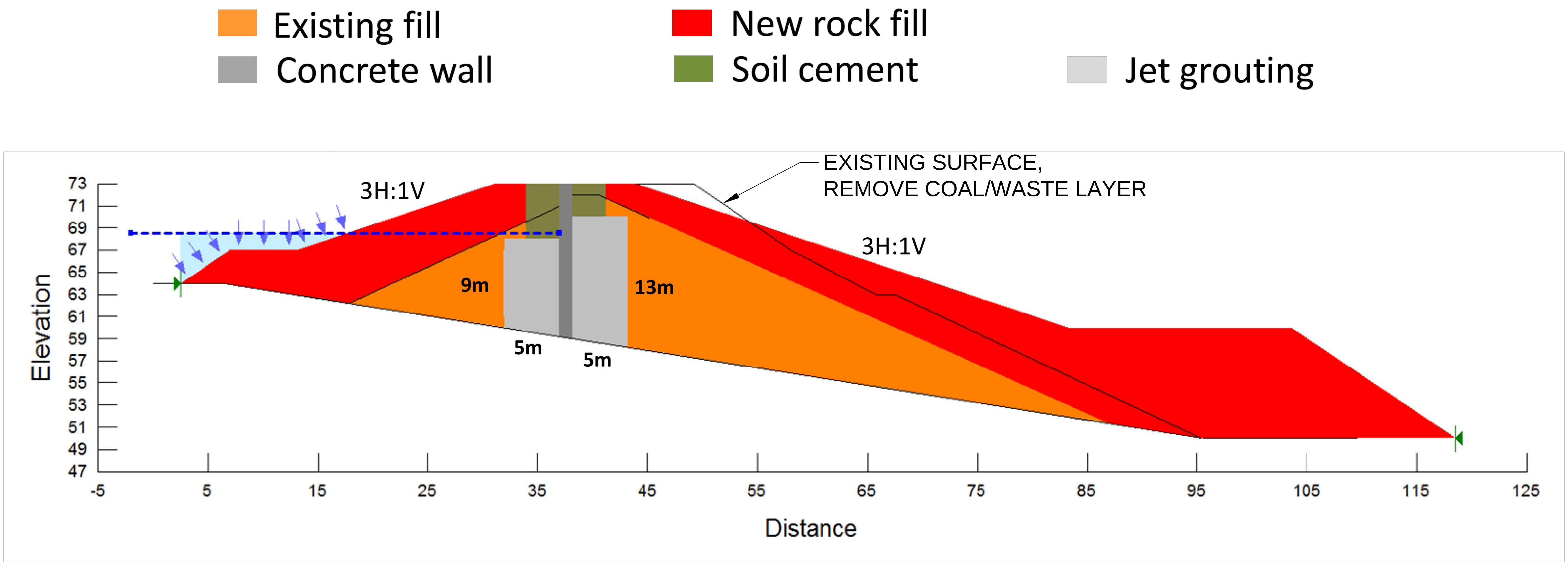
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE

Rehabilitation of Middle Dam for the 10,000-year return period earthquake

PROJECT NO. P09849 A01

FIGURE NO. Figure 5



Jet grouting dimensions:

Upstream = 5m wide x 9m high

Downstream = 5m wide x 13m high

CLIENT

Klohn Crippen Berger

PROJECT

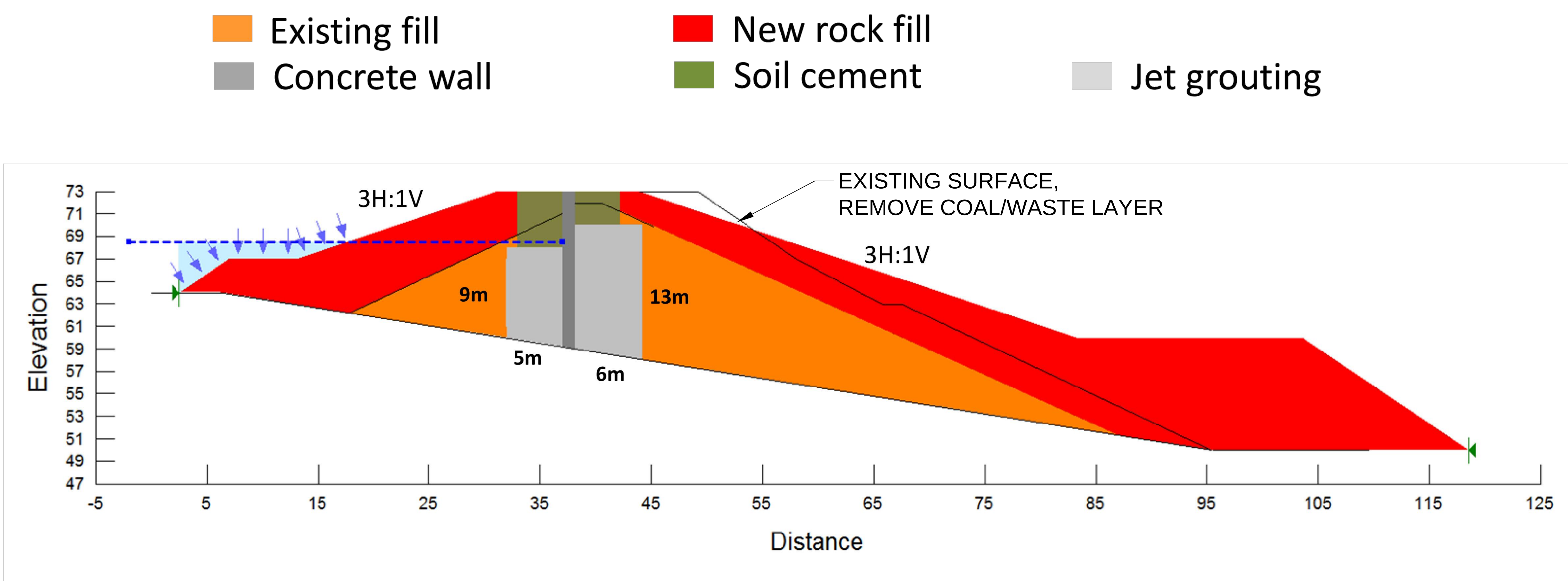
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE

Rehabilitation of Lower Dam for the 5,000-year return period earthquake

PROJECT NO. P09849 A01

FIGURE NO. Figure 6



Jet grouting dimensions:

Upstream = 5m wide x 9m high

Downstream = 6m wide x 13m high

CLIENT

Klohn Crippen Berger

PROJECT

CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE

Rehabilitation of Lower Dam for the 10,000-year return period earthquake

PROJECT NO. P09849 A01

FIGURE NO. Figure 7

CITY OF NANAIMO
CHASE RIVER DAMS - OPTIONS
Conceptual Cost Estimates

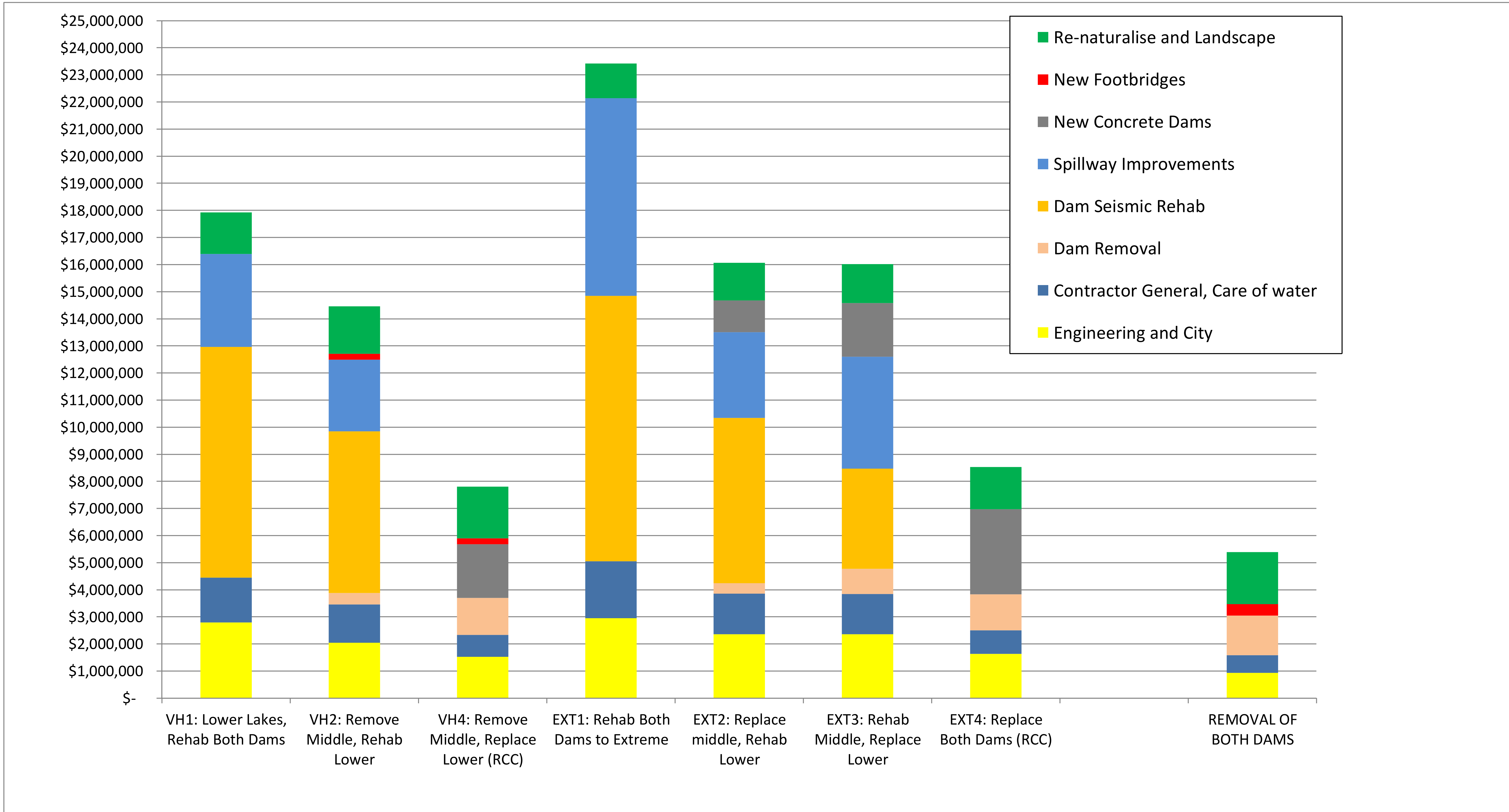


FIGURE 8
COST ESTIMATE SUMMARY CHART

TABLES

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

				VH1	VH2	VH4	EXT1	EXT2	EXT3	EXT4		REMOVAL
Cost Code	**Cost Component**	**Remarks**	**Risk Contingency allowance added to base estimate**	Reduce Level of Both Reservoirs	Remove Middle, Rehab Lower	Remove Middle, Replace Lower	Rehab Both Dams	Replace Middle, Rehab Lower	Rehab Middle, Replace Lower	Replace Both Dams		Remove both Dams, Renaturalize both Lakes
				Lower both lakes	Remove Middle Lake, keep Lower Lake		Retain Both Lakes at existing water Level					Remove Both Dams
	MIDDLE DAM											
RH1-M	Rehab (Extreme)	Rehab Middle Dam to "Extreme" Classification	30%				$ 3,694,600		$ 3,694,600			
RH2-M	Rehab(Very High)	Rehab Middle Dam to "Very High" Classification	30%	$ 2,550,600								
SW1-M	Expand Spillway at Ex WL (205 m3/s)	Widen Spillway for 205 m^3/s at existing level	20%				$ 4,128,000		$ 4,128,000			
SW2-M	Expand Spillway at Ex WL (161 m3/s)	Widen Spillway for 161 m^3/s at existing level	20%									
SW3-M	Expand Spillway -3m (161 m^3/s)	Reduce Spillway Level (-3m) and widen for 161 m^3/s	20%	$ 1,530,000								
RM1-M + RM2-M	Remove Middle Dam	clean material to lakebed, concrete offsite	10%		$ 426,800	$ 426,800						$ 426,800
RM1-M	Remove Middle Dam (lake disposal)	dispose "clean material" in lake	10%					$ 390,500		$ 390,500		
RN1-M	Renaturalise Lakebed and dam areas	Establish river channel and landscape	10%		$ 911,900	$ 911,900						$ 911,900
RN2-M	Topsoil and seed lake perimeter	exposed by 3m drop	10%	$ 123,750								
RN4-M	Compensation Works for HADD	additional footprint and construction disturbance	10%	$ 440,000			$ 440,000	$ 440,000	$ 440,000	$ 440,000		
RN5-M	Clean and Armour Channel	for over-winter after dam removal	10%					$ 110,000		$ 110,000		
NS1-M	New Concrete Dam Middle	RCC dam with crest spillway and pathway bridge	30%					$ 1,168,700		$ 1,168,700		
NS2-M	New Footbridge (Middle)	incl. abutments	20%		$ 217,200	$ 217,200						$ 217,200
	LOWER DAM											
RH1-L	Rehab Lower (Extreme)	Rehab Lower Dam to "Extreme" Classification	30%				$ 6,099,600	$ 6,099,600				
RH2-L	Rehab Lower (Very High)	Rehab Lower Dam to "Very High" Classification	30%	$ 5,969,600	$ 5,969,600							
SW1-L	Expand Spillway at Ex WL (205 m3/s)	Widen Spillway for 205 m^3/s at existing level	20%				$ 3,168,000	$ 3,168,000				
SW2-L	Expand Spillway at Ex WL (161 m3/s)	Widen Spillway for 161 m^3/s at existing level	20%		$ 2,635,200							
SW3-L	Expand Spillway -3m (161 m^3/s)	Reduce Spillway Level (-3m) and widen for 161 m^3/s	20%	$ 1,897,200								
RM1-L + RM2-L	Remove Lower Dam	clean material to lakebed, concrete offsite	10%									$ 1,025,200
RM1-L	Remove Lower Dam (lake disposal)	dispose "clean material" into lake	10%			$ 936,100			$ 936,100	$ 936,100		
RN1-L	Renaturalise Lower Lake and dam area	establish river channel and landscape	10%									$ 957,000
RN2-L	Topsoil and seed lake perimeter	exposed by 3m drop	10%	$ 123,750								
RN4-L	Compensation Works for HADD	additional footprint and construction disturbance	10%	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000	$ 660,000		
RN5-L	Clean and Armour Channel	for over-winter after dam removal, for replacement	10%			$ 165,000			$ 165,000	$ 165,000		
NS1-L	New Concrete Dam Lower	RCC dam with crest spillway and pathway bridge	30%			$ 1,973,400			$ 1,973,400	$ 1,973,400		
NS2-L	New Footbridge (Lower)	incl. abutments	20%									$ 213,600
	COMMON											
	Drain Lakes			$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000		$ 50,000
OH1	River Flow Diversion		20%	$ 249,600	$ 249,600	$ 208,000	$ 208,000	$ 208,000	$ 208,000	$ 208,000		$ 208,000
	Mob/demob/General Conditions	10% of above total		$ 1,359,450	$ 1,112,030	$ 554,840	$ 1,844,820	$ 1,229,480	$ 1,225,510	$ 610,170		$ 400,970
RN3	Restore and Landscape Laydown Areas		20%	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000		$ 45,000
OH2	Engineering	Design and Construction Phases	20%	$ 984,000	$ 789,600	$ 808,800	$ 984,000	$ 1,003,200	$ 1,003,200	$ 894,400		$ 538,400
OH3	Engineering	Dam Breach Analysis update	10%	$ 92,400	$ 92,400	$ 92,400						
OH4	City Admin Costs	10% of above total		$ 1,611,795	$ 1,320,193	$ 709,204	$ 2,145,702	$ 1,470,748	$ 1,466,381	$ 778,627		$ 499,407
				$ 17,822,145	$ 14,614,523	$ 7,893,644	$ 23,602,722	$16,178,228	$16,130,191	$ 8,564,897		$ 5,493,477

Klohn Crippen Berger ltd.
Project A05130B01
Date: 4/23/2013

TABLE 1
OPTIONS COST COMPONENT SUMMARY

City of Nanaimo

CHASE RIVER DAMS - REHABILITATION/REPLACEMENT CONCEPTUAL COST ESTIMATES

	VH1	VH2	VH4	EXT1	EXT2	EXT3	EXT4	REMOVAL
Cost Component	Reduce Level of Both Reservoirs	Remove Middle, Rehab Lower	Remove Middle, Replace Lower	Rehab Both Dams	Replace Middle, Rehab Lower	Rehab Middle, Replace Lower	Replace Both Dams	
Note: These estimates include the contingency allowances shown in Table 1.	Lower both lakes	Remove Middle Lake, Retain Lower Lake		Retain Both Lakes at existing water Level				Remove Both Dams
MIDDLE DAM								
Dam Rehabilitation	$ 2,550,600	$ -	$ -	$ 3,694,600	$ -	$ 3,694,600	$ -	$ -
Spillway Upgrades	$ 1,530,000	$ -	$ -	$ 4,128,000	$ -	$ 4,128,000	$ -	$ -
Dam Removal	$ -	$ 426,800	$ 426,800	$ -	$ 390,500	$ -	$ 390,500	$ 426,800
Renaturalise Lakebed and dam areas	$ 563,750	$ 911,900	$ 911,900	$ 440,000	$ 550,000	$ 440,000	$ 550,000	$ 911,900
New Concrete Dam	$ -	$ -	$ -	$ -	$ 1,168,700	$ -	$ 1,168,700	$ -
New Footbridge	$ -	$ 217,200	$ 217,200	$ -	$ -	$ -	$ -	$ 217,200
LOWER DAM								
Rehab Lower (Extreme)	$ 5,969,600	$ 5,969,600	$ -	$ 6,099,600	$ 6,099,600	$ -	$ -	$ -
Spillway Upgrades	$ 1,897,200	$ 2,635,200	$ -	$ 3,168,000	$ 3,168,000	$ -	$ -	$ -
Dam Removal	$ -	$ -	$ 936,100	$ -	$ -	$ 936,100	$ 936,100	$ 1,025,200
Renaturalise Lakebed and dam areas	$ 783,750	$ 660,000	$ 825,000	$ 660,000	$ 660,000	$ 825,000	$ 825,000	$ 957,000
New Concrete Dam Lower	$ -	$ -	$ 1,973,400	$ -	$ -	$ 1,973,400	$ 1,973,400	$ -
New Footbridge (Lower)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 213,600
OTHER								
Contractor General/Water	$ 1,659,050	$ 1,411,630	$ 812,840	$ 2,102,820	$ 1,487,480	$ 1,483,510	$ 868,170	$ 658,970
Engineering and City Costs	$ 2,688,195	$ 2,202,193	$ 1,610,404	$ 3,129,702	$ 2,473,948	$ 2,469,581	$ 1,673,027	$ 1,037,807
Restore and Landscape Laydown Areas	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 180,000	$ 45,000
	$ 17,822,145	**$ 14,614,523**	**$ 7,893,644**	**$ 23,602,722**	**$ 16,178,228**	**$ 16,130,191**	**$ 8,564,897**	**$ 5,493,477**

Suggested Project Budget Contingency Allowance	30%	20%	20%	30%	30%	30%	30%	15%

Klohn Crippen Berger ltd.
Project A05130B01
Date: 4/23/2013

TABLE 2
OPTIONS COST SUMMARY

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

Remove Misc. items within Dam extents (Demolish and Dispose off-site)

Existing Asphalt Surfaced Trail on Dam	sq.m.	$ 20
Catchbasin	LS	$ 1,000
V-Notch Seepage Monitoring Weir and Structure	LS	$ 5,000
Wooden Fence	lin.m.	$ 20
Chain Link Fence	lin.m.	$ 20
Metal Railing and concrete bags	LS	$ 1,000
100 dia PVC drain	LS	$ 500
Park Benches	each	$ 500
Signs	each	$ 100
Concrete Picnic tables	each	$ 500
SCADA pole	LS	$ 3,000

Demolition, Excavation

Clear and Grub,	sq.m.	$ 10
Demolish and Dispose of Concrete Dam Face, walls, spillways etc.*	cu.m.	$ 300
Original Rockfill *	cu.m.	$ 50
Compacted Sand and Gravel, overburden *	cu.m.	$ 50
Coal Waste (1918) - dispose off-site	cu.m.	$ 50
Existing Woodstave Offtake Pipe	lin.m.	$ 500
Rock Excavation	cu.m.	$ 120

Seismic Rehab

Soil Improvement (Jet Grouting)	cu.m.	$ 1,000
Buttress Fill	cu.m.	$ 50

* assumes local disposal of clean excavated materials in existing lake area.

Construction, Structures

Prepare Bedrock Surface	sq. m.	$ 50
Roller Compacted Concrete	cu.m.	$ 300
Conventional Concrete, dam facing	cu.m.	$ 1,500
Grout Curtain	cu.m.	$ 500
Low Level Outlet and Valve	lin.m.	$ 500
Steel Truss Footbridge, 2.0m wide	lin.m.	$ 1,600
Steel Truss Footbridge, 3.0m wide	lin.m.	$ 1,700
Bridge shipping and installation	LS	$ 90,000
In-situ Concrete, walls and decks, total	cu.m.	$ 2,000
Spillway piers and bridge deck, 3m wide	lin.m.	$ 4,000
Spillway piers and bridge deck, 2m wide	lin.m.	$ 3,000
Railings	lin.m.	$ 250

Landscaping

Prepare and landscape excavated slopes	sq.m.	$ 10	
Place and compact fill from stockpile (spillways)	cu.m.	$ 25	
Remove sediment within channel extents.	cu.m.	$ 50	
Wood-chip pathways	lin.m.	$ 20	
Asphalt pathways (incl. base)	sq.m.	$ 30	
Topsoil and hydroseed	sq.m.	$ 15	includes grading, landscaping, planting
Plantings	sq.m.	$ 20	
Full River Channel Renaturalization	lin.m.	$ 2,000	
River Channel zone clean and armour only	lin.m.	$ 1,000	
Habitat Compensation	sq.m.	$ 200	

Offsite Disposal		
Concrete	cub. metre	$ 100
"Clean" material - gravel, sediment	cub. metre	$ 20

TABLE 3
UNIT RATES USED IN COST ESTIMATES

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

					MIDDLE DAM			LOWER DAM	
ITEM NO.	**DESCRIPTION**	**UNIT OF MEASURE**	**UNIT RATE**		**ESTIMATED QUANTITY**	**TOTAL PRICE**		**ESTIMATED QUANTITY**	**TOTAL PRICE**
RH1	**Rehabilitate Existing Dam to 1:10,000 EQ**								
	Demolish and Dispose miscellaneous items	see item RM1.1				$ 14,000			$ 7,000
	Clear and Grub, topsoil removal , stockpile	sq. m.	$ 10		1800	$ 18,000		4,120	$ 41,200
	Remove Coal Waste, Sand and Gravel (Circa 1918) offsite	cu.m.	$ 50					3480	$ 174,000
	Remove existing fill as prep for buttress	cu.m.	$ 50		300	$ 15,000			
	Soil Improvement (Jet Grouting and Soild Cement)	cu.m.	$ 1,000		2280	$ 2,280,000		3600	$ 3,600,000
	Buttress Fill	cu.m.	$ 50		8500	$ 425,000		15000	$ 750,000
	Topsoil and re-landscape	sq. m.	$ 15		6000	$ 90,000		8000	$ 120,000
RH1	**TOTALS**					**$ 2,842,000**			**$ 4,692,000**
RH2	**Rehabilitate Existing Dam to 1:5,000 EQ**								
	Demolish and Dispose existing surfacing	see item RM1.1				$ 14,000			$ 7,000
	Clear and Grub, topsoil removal , stockpile	sq. m.	$ 10		1800	$ 18,000		4,120	$ 41,200
	Remove Coal Waste, Sand and Gravel (Circa 1918) offsite	cu.m.	$ 50					3480	$ 174,000
	Remove existing fill as prep for buttress	cu.m.	$ 50		300	$ 15,000			
	Soil Improvement (Jet Grouting and Soil Cement)	cu.m.	$ 1,000		1400	$ 1,400,000		3500	$ 3,500,000
	Buttress Fill	cu.m.	$ 50		8500	$ 425,000		15000	$ 750,000
	Topsoil and re-landscape	sq. m.	$ 15		6000	$ 90,000		8000	$ 120,000
RH2	**TOTALS**					**$ 1,962,000**			**$ 4,592,000**

Totals carried to Table 1

Klohn Crippen Berger ltd.
Project A05130B01
Date: 4/23/2013

TABLE 4
SEISMIC REHABILITATION COSTS

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		MIDDLE DAM ESTIMATED QUANTITY	MIDDLE DAM TOTAL PRICE		LOWER DAM ESTIMATED QUANTITY	LOWER DAM TOTAL PRICE
SW1	**Widen Spillway at Existing WL for 205 m3/s**								
	Remove existing spillway and Bridge (RR1.3)					$ 30,000			$ 90,000
	Clearing and grubbing	sq.m.	$ 10		4500	$ 45,000		6000	$ 60,000
	Topsoil/Overburden Excavation	cu.m.	$ 50		4500	$ 225,000		6000	$ 300,000
	Rock Excavation	cu.m.	$ 120		20000	$ 2,400,000		11000	$ 1,320,000
	Construct Concrete Spillway Walls	cu.m.	$ 2,000		300	$ 600,000		300	$ 600,000
	Spillway piers and bridge deck, 3m wide	lin.m.	$ 4,000					60	$ 240,000
	Spillway piers and bridge deck, 2m wide	lin.m.	$ 3,000		40	$ 120,000			
	Railings	lin.m.	$ 250		80	$ 20,000		120	$ 30,000
SW1	**TOTAL**					**$ 3,440,000**			**$ 2,640,000**
SW2	**Widen Spillway at Existing WL for 161 m3/s**								
	Remove existing spillway and Bridge (RR1.3)					$ 30,000			$ 90,000
	Clearing and grubbing	sq.m.	$ 10		3000	$ 30,000		4500	$ 45,000
	Topsoil/Overburden Excavation	cu.m.	$ 50		3000	$ 150,000		4500	$ 225,000
	Rock Excavation	cu.m.	$ 120		17000	$ 2,040,000		8500	$ 1,020,000
	Concrete Walls	cu.m.	$ 2,000		300	$ 600,000		300	$ 600,000
	Spillway piers and bridge deck, 3m wide	lin.m.	$ 4,000					48	$ 192,000
	Spillway piers and bridge deck, 2m wide	lin.m.	$ 3,000		32	$ 96,000			
	Railings	lin.m.	$ 250		64	$ 16,000		96	$ 24,000
SW2	**TOTAL**					**$ 2,962,000**			**$ 2,196,000**
SW3	**Deepen Spillway (-3m) for 161 m3/s**								
	Remove existing spillway and Bridge (RR1.3)					$ 30,000			$ 90,000
	Clearing and grubbing	sq.m.	$ 10		500	$ 5,000		1000	$ 10,000
	Topsoil/Overburden Excavation	cu.m.	$ 50		500	$ 25,000		500	$ 25,000
	Rock Excavation	cu.m.	$ 120		1350	$ 162,000		3240	$ 388,800
	Concrete Walls	cu.m.	$ 2,000		500	$ 1,000,000		500	$ 1,000,000
	Spillway piers and bridge deck, 3m wide	lin.m.	$ 4,000					15	$ 60,000
	Spillway piers and bridge deck, 2m wide	lin.m.	$ 3,000		15	$ 45,000			
	Railings	lin.m.	$ 250		30	$ 7,500		30	$ 7,500
SW3	**TOTAL**					**$ 1,275,000**			**$ 1,581,000**

Totals carried to Table 1

TABLE 5
SPILLWAY UPGRADE COSTS

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

					MIDDLE DAM			LOWER DAM		
ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		ESTIMATED QUANTITY	TOTAL PRICE		ESTIMATED QUANTITY	TOTAL PRICE	
RM1	**Demolish Dam**									
RM1.1	**Misc. items within Dam extents (Demolish and Dispose off-site)**									
	Existing Asphalt Surfaced Trail on Dam	sq.m.	$ 20		200	$ 4,000				
	Catchbasin	LS	$ 1,000		1	$ 1,000				
	V-Notch Seepage Monitoring Weir and Structure	LS	$ 5,000		1	$ 5,000				
	Wooden Fence	lin.m.	$ 20		42	$ 840				
	Chain Link Fence	lin.m.	$ 20					75	$ 1,500	
	Metal Railing and concrete bags	LS	$ 1,000		1	$ 1,000		1	$ 1,000	
	100 dia PVC drain	LS	$ 500		1	$ 500		1	$ 500	
	Park Benches	each	$ 500					3	$ 1,500	
	Signs	each	$ 100					1	$ 100	
	Concrete Picnic tables	each	$ 500					1	$ 500	
	SCADA pole	LS	$ 2,000		1	$ 2,000		1	$ 2,000	
	RM1.1 Subtotal					**$ 14,000**			**$ 7,000**	
RM1.2	**Remove and Dispose of Dam Fill Materials (*in-lake, on-site)**									
	Clear and Grub, topsoil removal , stockpile	sq.m.	$ 10		1800	$ 18,000		4,120	$ 41,200	
	Demolish and Dispose of Concrete Dam Face and walls*	cu.m.	$ 200		130	$ 26,000		340	$ 68,000	incl intake tower
	Excavate and dispose of Original Rockfill *	cu.m.	$ 50		2720	$ 136,000		6720	$ 336,000	
	Excavate and dispose of Compacted Sand and Gravel *	cu.m.	$ 50		2280	$ 114,000		1800	$ 90,000	
	Remove Coal Waste (Circa 1918) offsite	cu.m.	$ 50					3480	$ 174,000	
	Existing Woodstave Offtake Pipe	lin.m.	$ 500		33	$ 16,500		90	$ 45,000	
	RR1.2 Subtotal					**$ 311,000**			**$ 754,000**	
RM1.3	**Remove and Dispose of Spillway/Bridge concrete (*in-lake, on-site)**	cub. metre	$ 300		100	**$ 30,000**		300	**$ 90,000**	
RM1	**TOTALS (ROUNDED)**					**$ 355,000**			**$ 851,000**	
RM2	**Offsite Disposal**									
	Concrete	cub. metre	$ 100		230	$ 23,000		640	$ 64,000	
	"Clean" material - gravel, sediment (assume 10% of exc.)	cub. metre	$ 20		500	$ 10,000		852	$ 17,040	
RM2	**TOTALS (ROUNDED)**					**$ 33,000**			**$ 81,000**	

Total carried to Table 1

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		MIDDLE DAM ESTIMATED QUANTITY	MIDDLE DAM TOTAL PRICE		LOWER DAM ESTIMATED QUANTITY	LOWER DAM TOTAL PRICE
RN1	**Renaturalization of Lake and dam area**								
RN1.1	**Within former dam footprint**								
	River Channel Treatment	lin.m.	$ 2,000		70	$ 140,000		100	$ 200,000
	Prepare and landscape excavated slopes	sq.m.	$ 10		1400	$ 14,000		500	$ 5,000
RN1.2	**Exposed Lake Bottom**								
	Remove sediment within channel extents	cu.m.	$ 50		210	$ 10,500		300	$ 15,000
	Wood-chip Pathways	lin.m.	$ 20		200	$ 4,000		200	$ 4,000
	Topsoil and hydroseed above 1:100 year flood limit	sq.m.	$ 15		3000	$ 45,000		3000	$ 45,000
	Plantings (50% area)	sq.m.	$ 20		6900	$ 138,000		7550	$ 151,000
	River Channel Treatment	lin.m.	$ 2,000		230	$ 460,000		220	$ 440,000
RN1.3	**Re-Landscape Removed Spillways**								
	Place excavated fill on exposed bedrock	cu.m.	$ 25		600	$ 15,000		100	$ 2,500
	Topsoil and hydroseed	sq.m.	$ 15		180	$ 2,700		200	$ 3,000
	Reinstate asphalt pathways	sq.m.	$ 30					150	$ 4,500
RN1	**TOTALS (ROUNDED)**					**$ 829,000**			**$ 870,000**

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		MIDDLE DAM ESTIMATED QUANTITY	MIDDLE DAM TOTAL PRICE		LOWER DAM ESTIMATED QUANTITY	LOWER DAM TOTAL PRICE
RN2	**Landscape Lake Perimeter (3m drop)**								
	Topsoil and hydroseed (ave 5m width)	sq.m.	$ 15		7500	$ 112,500		7500	$ 112,500

either dam

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		ESTIMATED QUANTITY	TOTAL PRICE
RN3	**Restore and Re-landscape Laydown areas**					
RN3.1	For Rehab or replace works	sq.m.	$ 25		6000	$ 150,000
RN3.2	For removal Only	sq.m.	$ 15		3000	$ 45,000

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		MIDDLE DAM ESTIMATED QUANTITY	MIDDLE DAM TOTAL PRICE		LOWER DAM ESTIMATED QUANTITY	LOWER DAM TOTAL PRICE
RN4	**Habitat Compensation for HADD**								
	For Rehab or replace works	sq.m.	$ 200		2000	$ 400,000		3000	$ 600,000
RN5	**Clean and Prepare River Channel (for over-winter operation)**								
	For replacement works	lin.m.	$ 1,000		100	$ 100,000		150	$ 150,000

Totals carried to Table 1

Klohn Crippen Berger ltd.
Project A05130B01
Date: 4/23/2013

TABLE 7
RENATURALIZATION COSTS

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

					MIDDLE DAM			LOWER DAM	
ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE		ESTIMATED QUANTITY	TOTAL PRICE		ESTIMATED QUANTITY	TOTAL PRICE
NS1	**Construct New Concrete Dam and Spillways**								
	Prepare Bedrock Surface	sq. m.	$ 50		380	$ 19,000		500	$ 25,000
	Roller Compacted Concrete	cu.m.	$ 300		1340	$ 402,000		2700	$ 810,000
	Conventional Facing Concrete (assume 300mm thick)	cu.m.	$ 1,500		210	$ 315,000		300	$ 450,000
	Grout Curtain	cu.m.	$ 500		60	$ 30,000		80	$ 40,000
	Low-Level Outlet Pipe and Valve	lin.m.	$ 500		20	$ 10,000		25	$ 12,500
	Spillway piers and bridge deck, 3m wide	lin.m.	$ 4,000					40	$ 160,000
	Spillway piers and bridge deck, 2m wide	lin.m.	$ 3,000		35	$ 105,000			
	MOT Standard Bicycle Railing	lin.m.	$ 250		70	$ 17,500		80	$ 20,000
NS1	**TOTAL**					**$ 899,000**			**$ 1,518,000**
NS2	**Construct Pathway Bridge**								
	Cast-in-Place Concrete Abutments	cu.m.	$ 2,000		32	$ 64,000		20	$ 40,000
	Precast Prestressed Concrete, 2.0m wide	lin.m.	$ 1,600		32	$ 51,200			
	Precast Prestressed Concrete, 3.0m wide	lin.m.	$ 1,700					40	$ 68,000
	MOT Standard Bicycle Railing	lin.m.	$ 250		64	$ 16,000		80	$ 20,000
	Shipping and installation	LS	$ 90,000			$ 50,000			$ 50,000
NS2	**TOTAL**					**$ 181,000**			**$ 178,000**

Totals carried to Table 1

City of Nanaimo
CHASE RIVER DAMS - REHABILITATION/REPLACEMENT
CONCEPTUAL COST ESTIMATES

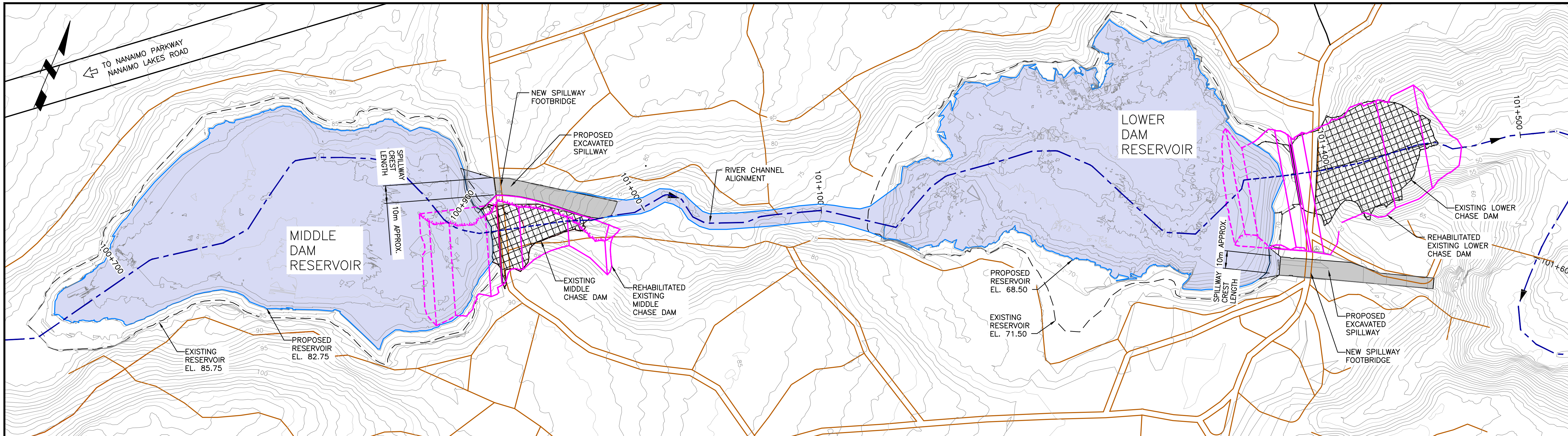
ITEM NO.	DESCRIPTION	UNIT OF MEASURE	UNIT RATE	ESTIMATED QUANTITY	TOTAL PRICE
OH1	**Water Diversion**				
	Prep route	LS	$ 20	400	$ 8,000
	Coffer Dam	cu.m.	$ 50	1000	$ 50,000
	900mm HDPE PIPE, surface	lin.m.	$ 200	750	$ 150,000
	TOTAL				**$ 208,000**
OH2	**Engineering Costs - Removal - per dam**				
	Geotech				$ -
	Design-Tender				$ 50,000
	Construction Phase	man-month	$ 7,000	8	$ 56,000
	TOTAL - per dam				**$ 106,000**
OH2	**Engineering Costs - Replace - per dam**				
	Additional Geotechnical Investigations				$ 30,000
	Design-Tender				$ 150,000
	Construction Phase	man-month	$ 7,000	20	$ 140,000
	TOTAL - per dam				**$ 320,000**
OH2	**Engineering Costs - Rehab - per dam**				
	Additional Geotechnical Investigations				$ 50,000
	Design-Tender				$ 150,000
	Construction Phase	man-month	$ 7,000	30	$ 210,000
	TOTAL - per dam				**$ 410,000**
OH2	**Engineering Costs -Renaturalise - per lake**				
	Additional Geotechnical Investigations				$ -
	Design-Tender				$ 70,000
	Construction Phase	man-month	$ 6,000	12	$ 72,000
	TOTAL - per lake				**$ 142,000**

OH3	**Engineering Costs - Dam Breach Analysis etc.**				
	Dam Breach and Inundation Report				$ 50,000
	Re-Assess Downstream Impacts				$ 10,000
	Reporting and Permit Negotiations	man-month	$ 6,000	4	$ 24,000
	TOTAL - per lake				**$ 84,000**

TABLE 9
OTHER COSTS

DRAWINGS

Drawing 01	**Option VH1, Reduce Level of Both Reservoirs, Rehabilitate Both Dams**
Drawing 02	**Option VH2, Remove Middle Dam, Rehabilitate Lower Dam**
Drawing 03	**Option VH2, Remove Lower Dam, Rehabilitate Middle Dam**
Drawing 04	**Option EXT1, Rehabilitate Both Dams Without Drawdown**
Drawing 05	**Option EXT2, Replace Middle Dam, Rehabilitate Lower Dam**
Drawing 06	**Option EXT3, Replace Lower Dam, Rehabilitate Middle Dam**
Drawing 07	**Option EXT4, Replace Both Dams, Without Drawdown**



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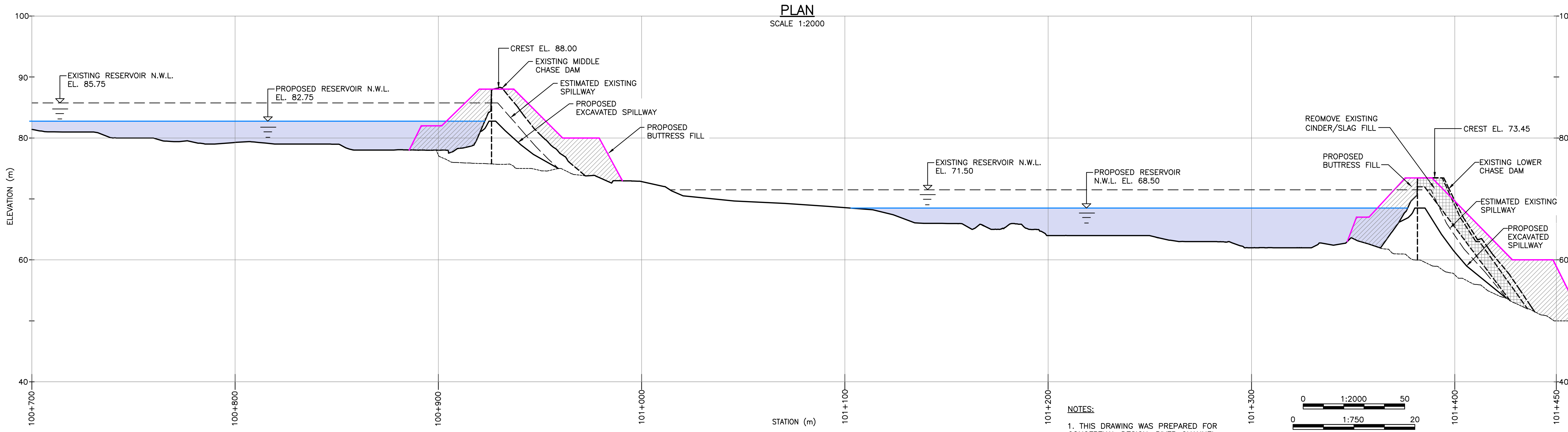

PROFILE ALONG RIVER CHANNEL
SCALE 1:2000 HORIZ
1:750 VERT

NOTES:

1. THIS DRAWING WAS PREPARED FOR CONCEPTUAL DESIGN. RIVER CHANNEL PROFILE SHOWS MOST RELEVANT SECTIONS OF DAMS AND DOES NOT MATCH PLAN VIEW ALIGNMENT.

NOT FOR CONSTRUCTION

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DRAWING REVISIONS						
REVISION	DESCRIPTION OF REVISION	DATE (YYYY-MM-DD)	DRAWN	DESIGNED	CHECKED	APPROVED
0	ISSUED FOR REVIEW	2013-04-	J.NG/PM			

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PROJECT
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE
OPTION VH1
REDUCE LEVEL OF BOTH RESERVOIRS, REHABILITATE BOTH DAMS

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	01	0

CANCEL PRINTS BEARING PREVIOUS REVISION

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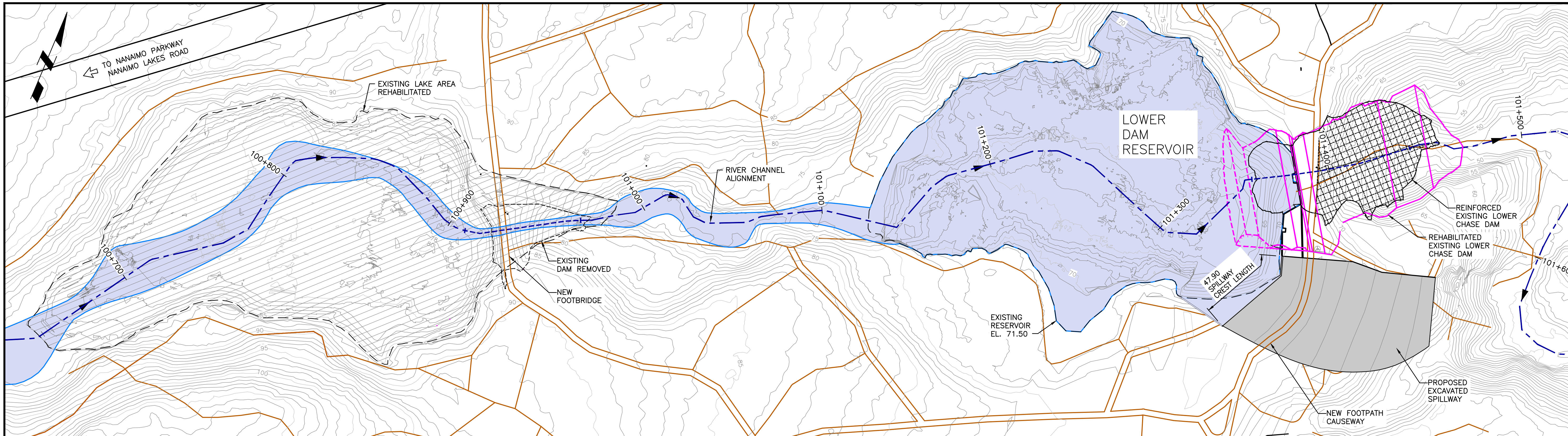

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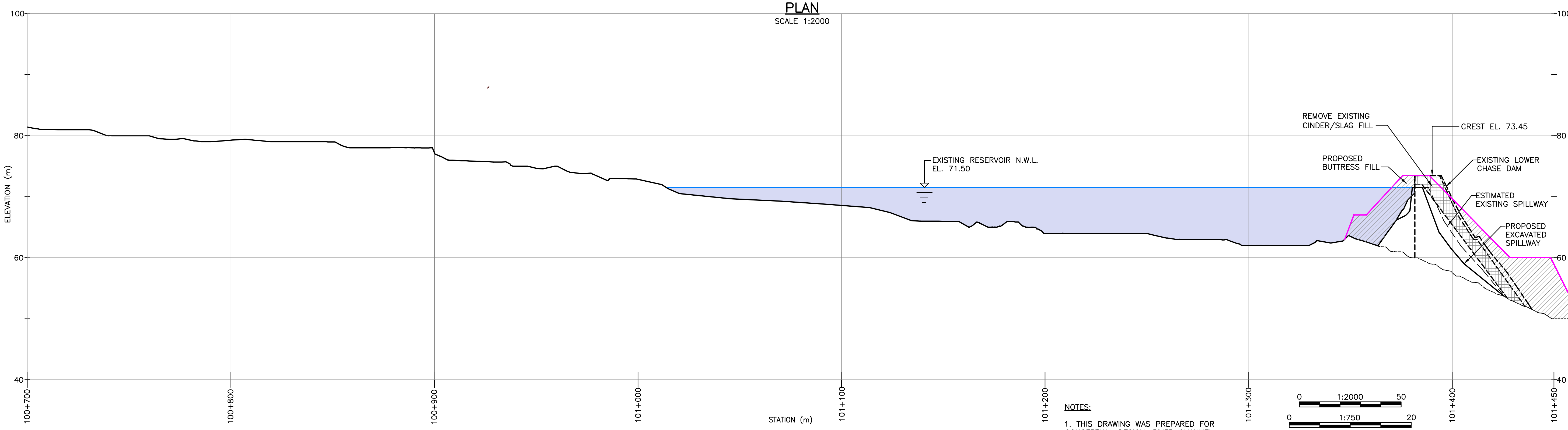

PROFILE ALONG RIVER CHANNEL

SCALE 1:2000 HORIZ
1:750 VERT

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0	ISSUED FOR REVIEW	2013-04	J.NG/PM			

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PROJECT
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE
OPTION VH2
REMOVE MIDDLE DAM,
REHABILITATE LOWER DAM

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	02	0

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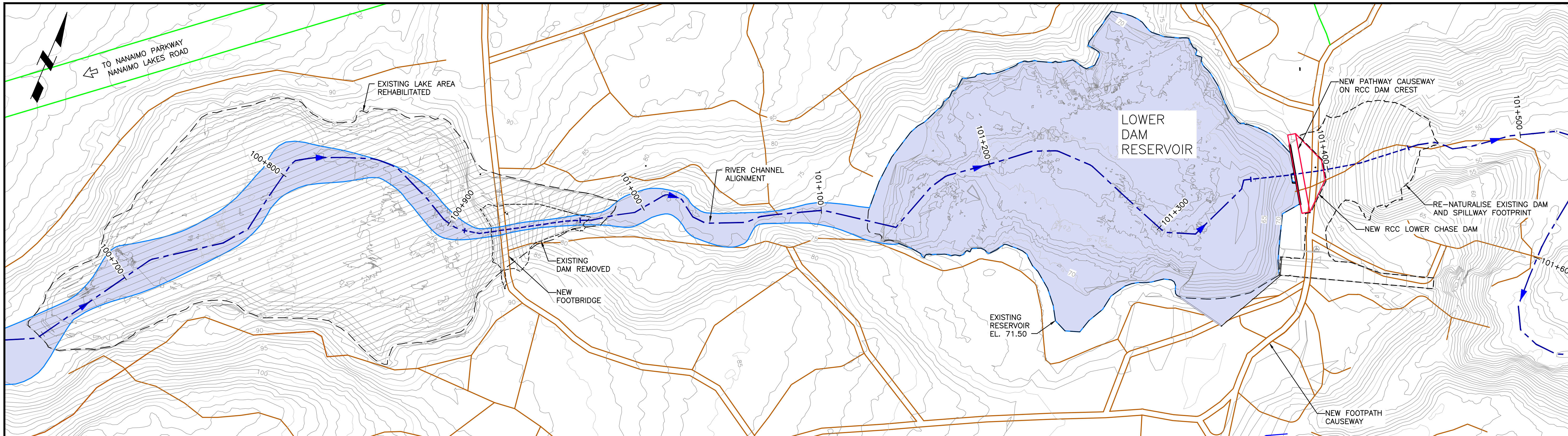

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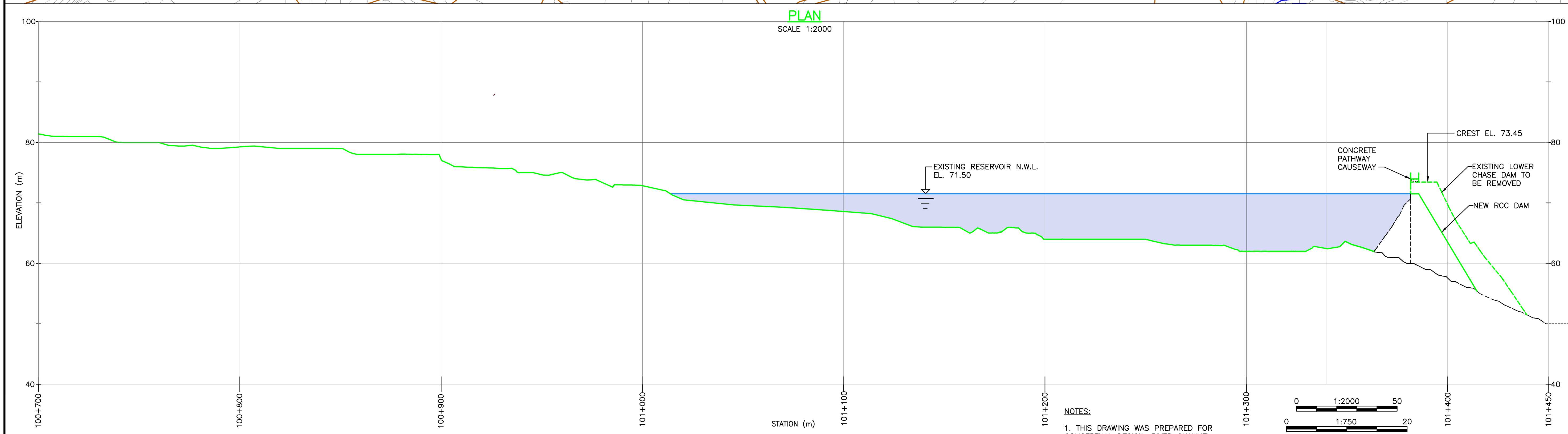

PROFILE ALONG RIVER CHANNEL

SCALE 1:2000 HORIZ
1:750 VERT

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0	ISSUED FOR REVIEW	2013-04	J.NG/PM			

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PROJECT

CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE

OPTION VH4
REMOVE MIDDLE DAM,
REPLACE LOWER DAM

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	03	0

CANCEL PRINTS BEARING PREVIOUS REVISION

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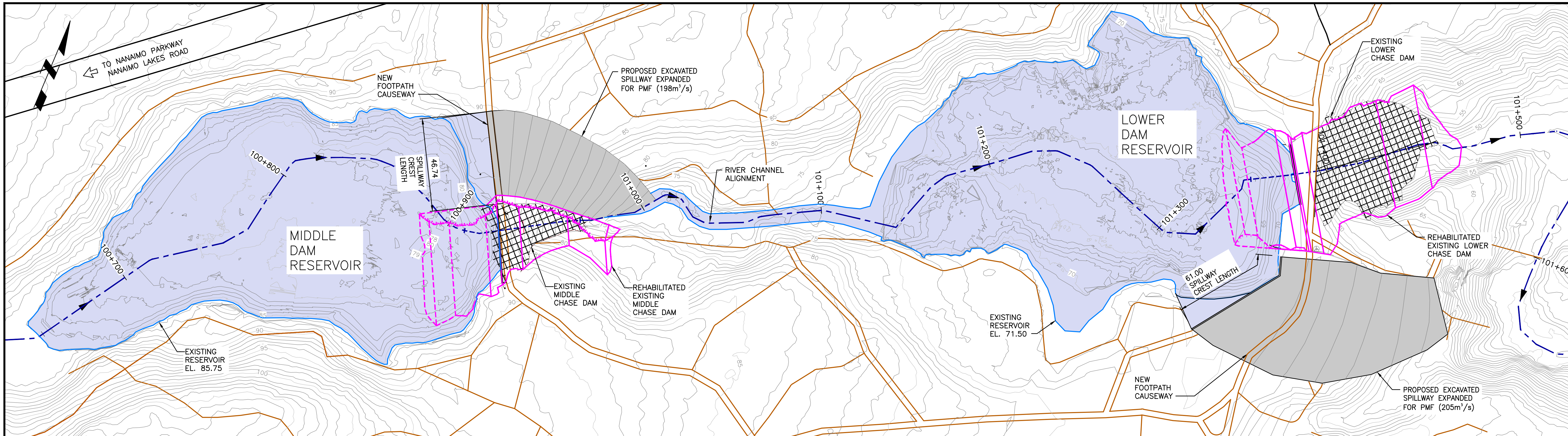

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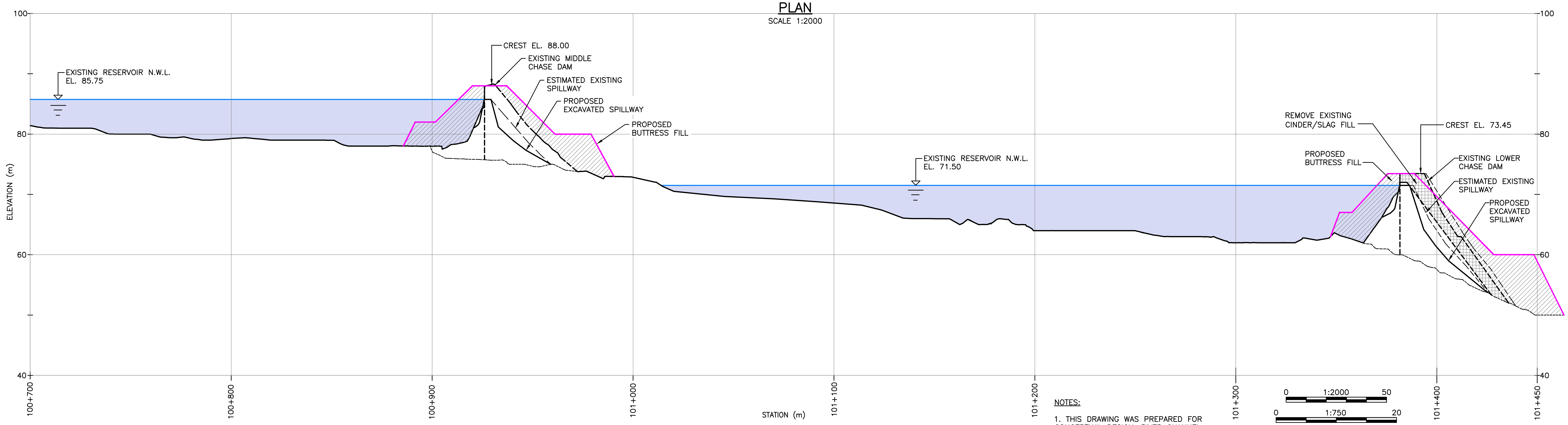

PROFILE ALONG RIVER CHANNEL

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PROJECT

CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE

OPTION EXT 1
REHABILITATE BOTH DAMS
WITHOUT DRAW DOWN

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	04	0

CANCEL PRINTS BEARING PREVIOUS REVISION

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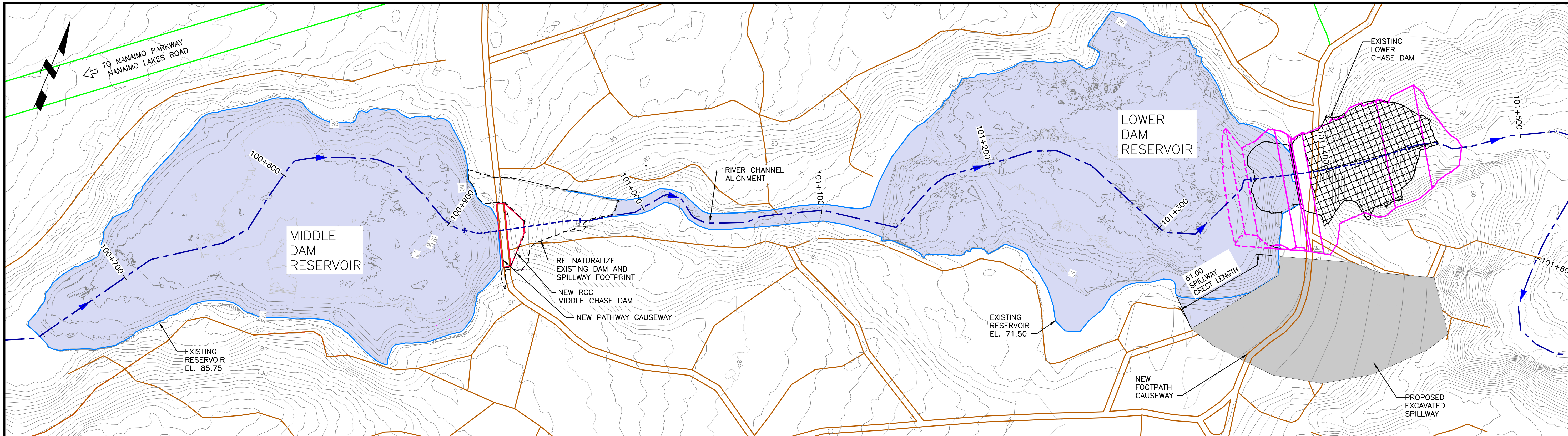

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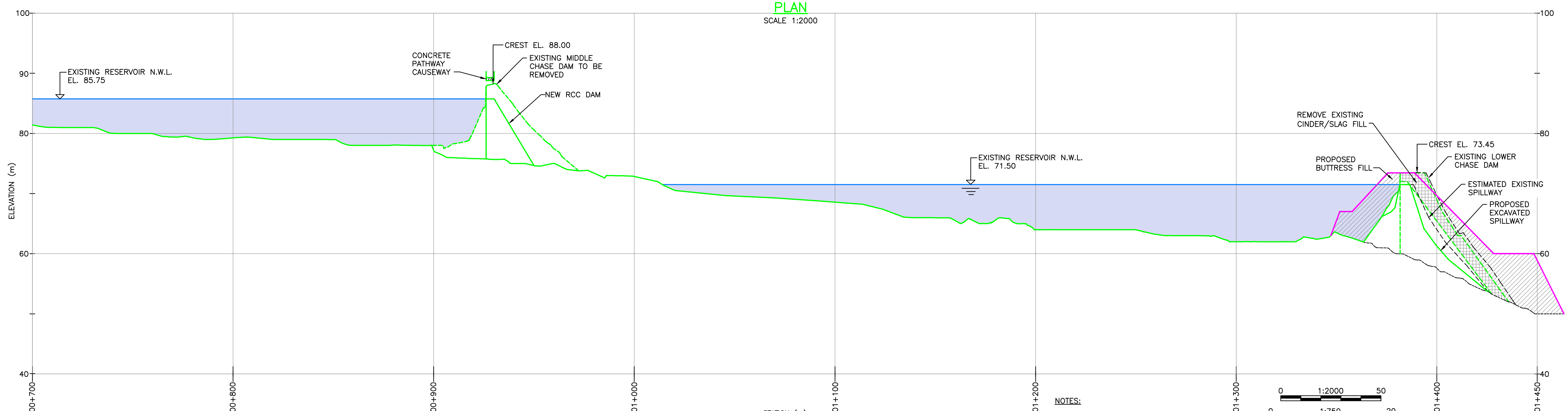

PROFILE ALONG RIVER CHANNEL

SCALE 1:2000 HORIZ
1:750 VERT

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0	ISSUED FOR REVIEW	2013-04	J.NG/PM			

ORIGINAL ISSUE	
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PROJECT
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE
OPTION EXT 2
REPLACE MIDDLE DAM
REHABILITATE LOWER DAM

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	05	0

CANCEL PRINTS BEARING PREVIOUS REVISION

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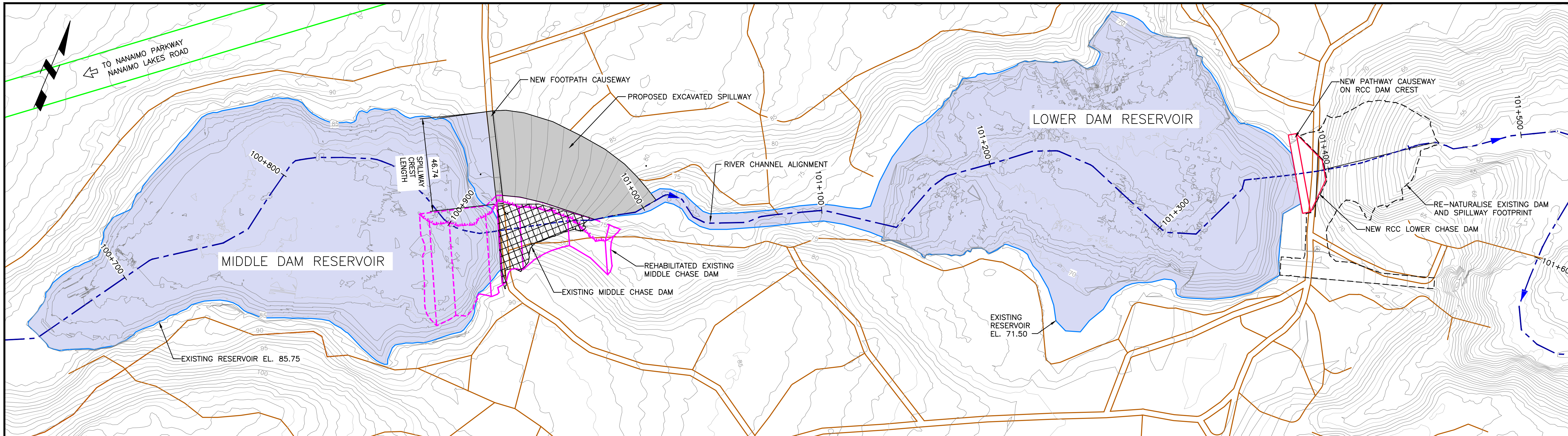

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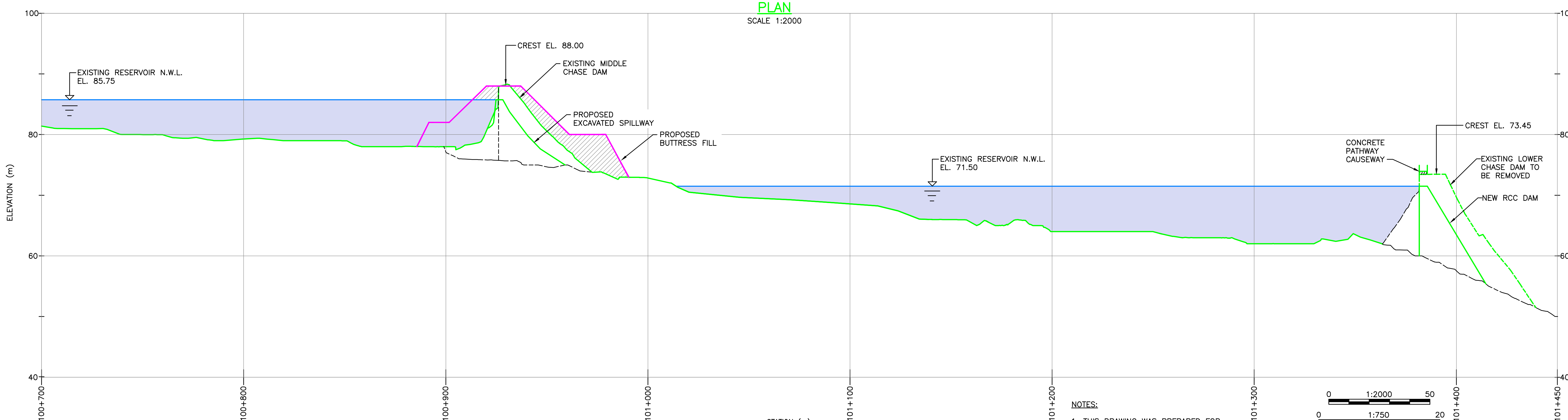

PROFILE ALONG RIVER CHANNEL

SCALE 1:2000 HORIZ
1:750 VERT

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PROJECT

CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE

OPTION EXT 3
REPLACE LOWER DAM
REHABILITATE MIDDLE DAM

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	06	0

CANCEL PRINTS BEARING PREVIOUS REVISION

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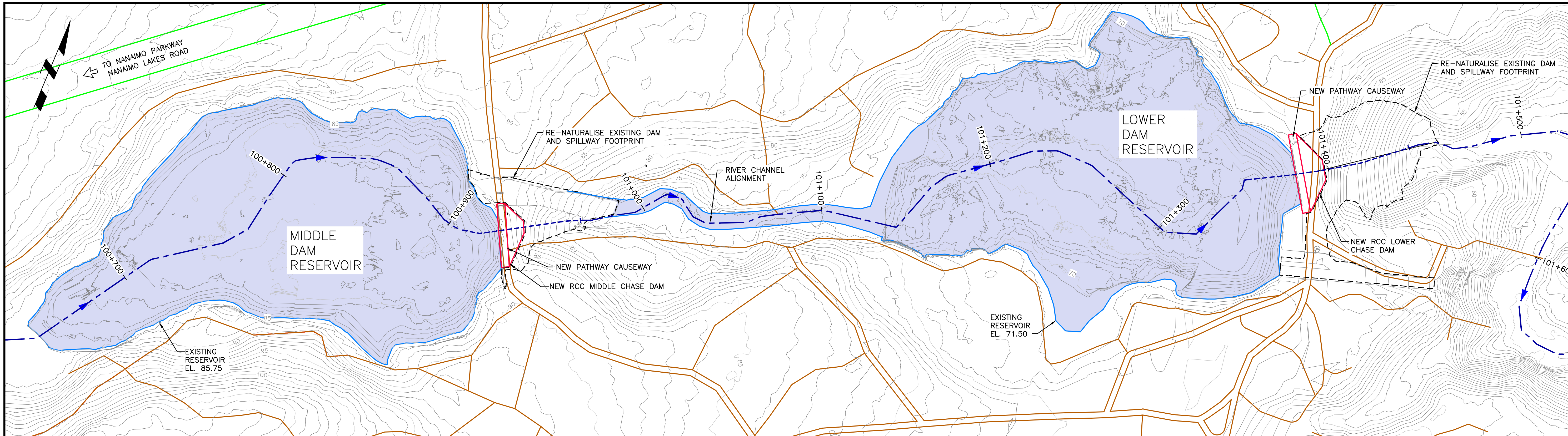

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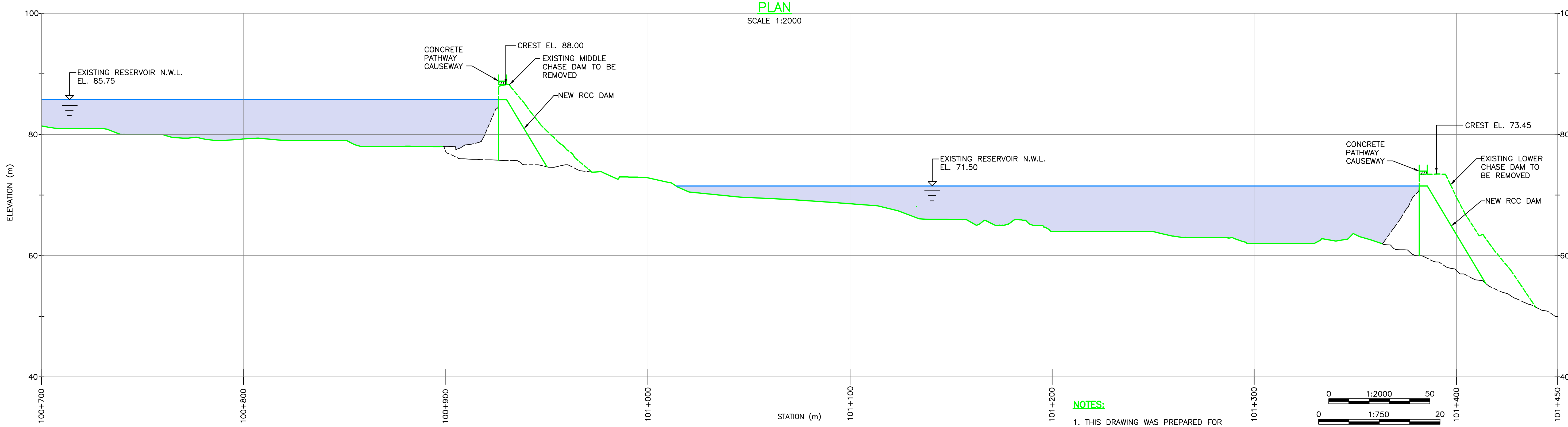

PROFILE ALONG RIVER CHANNEL

SCALE 1:2000 HORIZ
1:750 VERT

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DRAWING REVISIONS						
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PROJECT
CHASE RIVER DAMS
CONCEPTUAL REHABILITATION

TITLE
OPTION EXT 4
REPLACE BOTH DAMS
WITHOUT DRAW DOWN

SCALE	PROJECT NO.	DWG. NO.	REV.
AS SHOWN	P09849A01	07	0

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

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