City of Nanaimo
BC, Canada

Cost Estimate Peer Review
Final Report

For

Colliery Dams Rehabilitation/Renewal

H343713-0000-00-124-0001
Rev. 0
May 1, 2013

City of Nanaimo
BC, Canada

Cost Estimate Peer Review Final Report

For

Colliery Dams Rehabilitation/Renewal

H343713-0000-00-124-0001
Rev. 0
May 1, 2013

Hatch Ltd.

Suite 400, Oceanic Plaza, 1066 West Hastings Street
Vancouver, British Columbia, Canada V6E 3X2
Tel. (604) 689 5767 • Fax: (604) 689 3918 • www.hatch.ca

May 1, 2013

Bill Sims, AScT Manager, Water Resources
City of Nanaimo
2020 Labieux Road
Nanaimo, BC V9T 6J9

Dear Mr. Sims

Subject: Colliery Dams Rehabilitation/Renewal - Cost Estimate Peer Review Final Report

Hatch is pleased to submit our draft report for the Cost Estimate Peer Review – Colliery Dams Rehabilitation/Renewal. Given that the report is being issued electronically, the fully signed signature page for the report will follow in due course.

Hatch thanks the City of Nanaimo for the opportunity of performing this review. We will be pleased to respond to any comments you may have.

Yours faithfully,

Jim Smith, P. Eng.
js:ig

Safety • Quality • Sustainability • Innovation

Project Report

May 1, 2013

City of Nanaimo
Colliery Dams Rehabilitation/Renewal

Distribution
Bill Sims

Peer Review Final Report

Table of Contents

Safety • Quality • Sustainability • Innovation

Disclaimer

This report, including the comments on the conceptual designs and cost estimates prepared by Klohn Crippen Berger, as documented in their report “Middle and Lower Colliery Dams - Conceptual Costing of Rehabilitation and Replacement Options” dated April 30, 2013, has been prepared by Hatch Ltd (“Hatch”) for the sole and exclusive use of the City of Nanaimo (the “Client”) for the purpose of assisting the management of the Client in making decisions with respect to potential redevelopment of the Middle and Lower Colliery Dams (also known as Chase River Dams); and shall not be (a) used for any other purpose, or (b) provided to, relied upon or used by any third party.

This report contains opinions, conclusions and recommendations made by Hatch, using its professional judgment and reasonable care. Hatch’s peer review of the estimate prepared by Klohn Crippen Berger has been prepared by Hatch, using its professional judgment and exercising due care consistent with the agreed level of accuracy. Any use of or reliance upon this report and estimate by the City is subject to the following conditions:

a) the report being read in the context of and subject to the terms of the contract “Peer Review – Cost Estimates – Colliery Dam’ PO No. 524812 between Hatch and the City dated February 25, 2013 (the “Agreement”), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions that were specified or agreed therein;

b) the report being read as a whole, with sections or parts hereof read or relied upon in context;

c) the conditions of the dams may change over time (or may have already changed) due to natural forces or human intervention, and Hatch takes no responsibility for the impact that such changes may have on the accuracy or validity or the observations, conclusions and recommendations set out in this report;

d) the peer review of Klohn Crippen Berger’s estimate is based on several factors over which Hatch has no control, including without limitation, site conditions, cost and availability of inputs, etc, and Hatch takes no responsibility for the impact that changes to these factors may have on the accuracy or validity of this estimate; and

e) the report is based on information made available to Hatch by the City or by certain third parties, and unless stated otherwise in the Agreement, Hatch has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

1. Introduction and Background

In response to input from stakeholders, the City committed a study for the development of conceptual level cost estimates for rehabilitation and/or replacement of the Middle and Lower Colliery Dams (also known as the Chase River Dams). The objective of the study being the development of cost estimates to compare to those already being developed for the dam removal and re-naturalization option. Subsequently, the City decided to have a peer review undertaken of the cost estimates for the rehabilitation/replacement options to ensure the stakeholders of the validity of the findings.

Hatch Ltd submitted a proposal to the City of Nanaimo on February 8, 2013 in response to the City's RFP 1414. The scope of services requested was the performance of a peer review of a report being prepared by the engineering consulting firm Klohn Crippen Berger (KCB) on the costs to rehabilitate or renew the Middle and Lower Colliery Dams. Hatch was advised of the acceptance of its proposal on February 20, 2013 and commenced assembly of the background data and previous reports on these structures.

The scope of services, as presented in our proposal, included:

- Performance of a peer review of the estimates prepared by KCB to ensure the costs were reasonable, given the level of concept, including preparation of comments on scope, direct and indirect costs, contingency, etc.

- A review of the rehabilitation / re-build options, based on non-financial criteria and viability. This review would not include the performance of any calculations, nor commenting on any of the preliminary design parameters selected by KCB.

Hatch met with KCB's project manager and City staff on February 26 for introductions and a project kick-off meeting. Following review and familiarization of the background information, Hatch met with the citizen's group - Colliery Dams Preservation Society (CDPS) and City staff on March 6. At this meeting the CDPS presented a number of options they considered to be viable for rehabilitation of the dams and to be worthy of review. They also proposed various options to reduce the volume of water stored in the dam's reservoirs in order to reduce the dams' dam safety hazard consequence classification from Extreme to Very High. The objective of lowering the consequence classification being a decrease in the severity of the design seismic and flood events that the rehabilitated or re-built dams would need to be designed to withstand, and subsequently the costs of the associated work. In addition to the various options associated with the retention of the dams, the CDPS presented a one page document summarizing the findings of a study they had undertaken regarding the viability of installing hydro generation facilities at the dams. The study indicated that the installations would be economic and thus potentially offset some of the added costs associated with retention of the dams.

Following the meeting with the CDPS, Hatch met with KCB at their offices on March 12 to undertake a screening review of the options presented by the CDPS, as well as any others that either consultant believed to be viable from both technical as well as financial aspects. At this meeting, a number of the options proposed by the CDPS were deleted from further financial review as they were either deemed to be too costly compared to other acceptable options or unacceptable from a technical perspective. It was also necessary to make an assumption as to the magnitude of decrease in the volume of water stored in the reservoirs that would be required to achieve the desired reduction in the Hazard Consequence Classification. The need to make this assumption was necessitated by the inability of the consultant that had performed the earlier flood inundation study to run the various additional scenarios that would be required to determine this value, within the available time period.

Hatch received preliminary Figures and costing data from KCB on April 8, followed by receipt of Draft 1 of their report on April 9. Following review of this information, Hatch met with KCB and City staff on April 12 to present comments and to make requests for additional details related to certain technical/design issues, as well clarifications related to various cost items and percentage allowances for contingency, design services, etc.

On April 23 Hatch received the Final Draft of KCB's report for review, followed by receipt of the final report on April 30.

The comments in the following sections of our report relate to the contents of KCB's final report, but also take in to account technical details and clarifications provided by KCB that are beyond those presented in their report.

2. Comments on Conceptual Designs

The BC Dam Safety Regulation protects the public from the risk of a dam failure. The greater the potential for loss or damage as a result of dam failure, the more remote must be the possibility that the dam could fail. The Middle and Lower Colliery Dams have been checked specifically to ascertain whether they could be vulnerable to an extreme flood on the Chase River or to an earthquake greater than the dams have ever experienced in the past. The Dam Safety Regulation defines how low the risk of dam failure must be. Both dams have been found deficient in terms of their ability to safely pass a flood of the required magnitude and in terms of their ability to safely withstand an earthquake of the required severity.

2.1 Classification of dams according to the BC Dam Safety Regulation

Table 1 defines the various dam consequence classifications and is taken directly from the BC Dam Safety Regulation.

The dam failure consequences classification of a dam is determined in accordance with the following steps:

a) For each category of consequences of failure in the following table, identify the losses or damages specified in the table that most closely describe the losses or damages that are the worst potential consequences of a failure of the dam;

b) Identify the classification that is specified in the following table for the losses or damages referred to in paragraph (a) for each category;

c) The classification identified under paragraph (b) with the worst potential consequences is the classification of the dam.

Table 1: Definition of Dam Consequence Classifications

Dam failure consequence classification	Population at risk	Consequences of failure		
		Loss of life	Environment and cultural values	Infrastructure and economics
Low	None[1]	There is no possibility of loss of life other than through unforeseeable misadventure.	Minimal short-term loss or deterioration and no long-term loss or deterioration of (a) fisheries habitat or wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance.	Minimal economic losses mostly limited to the dam owner's property, with virtually no pre-existing potential for development within the dam inundation zone.
Significant	Temporary only[2]	Low potential for multiple loss of life.	No significant loss or deterioration of (a) important fisheries habitat or important wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is highly possible.	Low economic losses affecting limited infrastructure and residential buildings, public transportation or services or commercial facilities, or some destruction of or damage to locations used occasionally and irregularly for temporary purposes.
High	Permanent[3]	10 or fewer	Significant loss or deterioration of (a) important fisheries habitat or important wildlife habitat, (b) rare or endangered species, or (c) unique landscapes	High economic losses affecting infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to scattered residential

			or sites of cultural significance, and restoration or compensation in kind is highly possible.	buildings.
Very high	Permanent[3]	100 or fewer	Significant loss or deterioration of (a) critical fisheries habitat or critical wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is possible but impractical.	Very high economic losses affecting important infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas.
Extreme	Permanent[3]	More than 100	Major loss or deterioration of (a) critical fisheries habitat or critical wildlife habitat, (b) rare or endangered species, or (c) unique landscapes or sites of cultural significance, and restoration or compensation in kind is impossible.	Extremely high economic losses affecting critical infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas.

[1] There is no identifiable population at risk.
[2] People are only occasionally and irregularly in the dam-breach inundation zone, for example stopping temporarily, passing through on transportation routes or participating in recreational activities.
[3] The population at risk is ordinarily or regularly located in the dam-breach inundation zone, whether to live, work or recreate.

The consequence classification of a dam is a function of how much loss and damage could be caused as the result of a breach of the dam. This depends in part on the volume of water that could be released in a catastrophic manner if the dam were to fail. Depending on the predicted consequences of dam failure, the Dam Safety Regulation determines the severity of floods and earthquakes that the dam must be able to withstand. Table 2 shows how the application of the Dam Safety Regulation affects the maximum floods and earthquakes that the Colliery Dams must be capable of withstanding.

KCB have considered reducing the volume of stored water that could be released by a catastrophic failure of the Colliery Dams, in order to reduce the loss and damage that could result from dam failure. If the consequences of dam failure were to be reduced, it may not be necessary for the dams to be designed to survive events with extremely low probability of occurrence. The volume of stored water can be reduced in three ways:

a) The maximum water level in the dam(s) could be lowered by lowering the spillway; and/or

b) The reservoir could be partly filled in from the bottom, retaining the original perimeter of the lake; and/or

c) The reservoir could be filled in from the shore, reducing the area of the lake.

Using information provided in the KCB report, the different dam consequence classifications translate into the following design requirements:

Table 2: Design Parameters for the Colliery Dams by Consequence Classification

Classification	Inflow Design Flood	Earthquake
Extreme	Probable maximum flood = 205 m^3/s	1:10,000 year earthquake = 0.7g
Very High	2/3 between 1,000 year flood and PMF = 161 m^3/s	1:5,000 year earthquake = 0.6g
High	1/3 between 1,000 year flood and PMF = 117 m^3/s	1:2,500 year earthquake = 0.5g*

* Earthquake value obtained from Geological Survey of Canada Open File GSC 4459 Table 1.

The report by EBA Engineering Consultants Ltd., entitled “Seismic Hazard Assessment – Middle and Lower Chase Dams”, dated April 14, 2010 contains an instructive discussion of the potential effects of a failure of these dams and the determination of their consequence classifications. That report records on page 21 that:

“Based on the aforementioned observations and considerations, and given the unknown extent of flood inundation, the consequence classification is either at the upper end of High-Low or at the low end of Very High-High. This matter cannot be resolved until the 2010 flood inundation study is completed.”

The KCB report also references the 2012 flood inundation study undertaken by Associated Engineering entitled “Chase River Dam Breach Inundation Study”, which determined that the consequence classifications of the dams to be Extreme. Hatch concurs with the statement in KCB’s report that “a reduction in dam classification based on a reduction in lake volume remains speculative and hypothetical at this stage”, and such “options may not be acceptable to the City or to Dam Safety”.

Other conceptual options presented by KCB do not seek to change the dam classification.

3. Comment on Eliminated Options

The Middle and Lower Colliery Dams were constructed circa 1911. They are 13 and 24 m high, and 50 and 77 m long, respectively. Both dams are generally comprised of a central concrete core wall buttressed by rock fill slopes constructed upstream and downstream of the concrete wall. Additional fill was placed on the downstream side of each dam in subsequent construction episodes.

The fill and foundation materials within and below the dams are known from borehole logs and test pits made in 1978, and from rehabilitation work in 1980. Historical subsurface information, including logs of the investigatory boreholes drilled in 1978, is presented in Appendix B of a report entitled "Seismic Hazard Assessment – Middle and Lower Chase Dams, by EBA Engineering Consultants Ltd., dated April 14, 2010. According to the EBA report, there are five general material types within the dams:

- Concrete in the vertical core wall and spillway;
- Rock fill on either side of the concrete walls from the original construction work in 1911 (original rock fill);
- Compacted pit run in the downstream shell of the Middle Chase Dam;
- Cinders, ash and sand and gravel on the downstream side of the concrete core wall on top of the original rock fill at the Lower Chase Dam; and
- Timber in the low level conduit.

The original rock fill consisted of waste sedimentary rock from the mine excavation. In 1980, the downstream shell of the Middle Chase Dam was substantially excavated in an unsuccessful attempt to locate a low level conduit within the dam. Photos of the rock fill on the upstream and downstream side of the dam indicate that the maximum rock fill particle size is generally 0.6 m or smaller. The waste rock would also have had appreciable cobble, gravel, sand and silt contents.

3.1 Options to Address the Deficiency of Flood Discharge Capability

KCB have considered various concepts to address the deficiency of flood discharge capability. If the existing dams can be sufficiently rehabilitated, it may be possible to expand the existing spillways or to armour the downstream face of the dams so that overtopping need not cause catastrophic damage. It was concluded that armouring the downstream face of the existing dams to resist scour from overtopping would not be acceptable to Dam Safety Branch and was therefore eliminated as an option. Hatch agrees that it is difficult to ensure that the armouring will be completely effective if subjected to sustained or repeated overtopping, especially in the case of the 24-m high Lower Dam. Severe scour damage from overspilling on an embankment dam could potentially lead to a dam breach. Increasing the capacity of the existing spillway by deepening and widening it, or building a new spillway, are thus the only viable options to address the deficiency of flood discharge capacity, unless the existing embankment dams are to be replaced with concrete dams.

3.2 Options to Address the Deficiency of Seismic Withstand Capability

KCB have considered various alternative means of strengthening the dams against collapse in a seismic event. These options include:

1. Strengthen the body of the existing dam using drilled pipe piles;
2. Strengthen the body of the existing dam using jet grouted piles;
3. Provide a flexible impervious barrier through the existing dam using driven sheet piles;
4. Strengthen the concrete core wall of the existing dam using rock anchors;
5. Buttress the existing dam by adding earth or rock fill berms on the upstream and downstream sides;
6. Remove the existing embankment dam and replace it with a new embankment dam; and
7. Remove the existing embankment dam and replace it with a new dam constructed with Roller Compacted Concrete (RCC).

The piling options (Options 1 and 3) were removed from further consideration because of anticipated difficulties with the installation of suitable piles through rock fill that contains pieces of rock as large as 0.6 m. Cost was also a factor.

Option 4 – anchoring the concrete wall to the bedrock, was eliminated from consideration because the 0.6-m wide concrete core wall, being constructed in 1911, is unlikely to have sufficient strength and integrity to carry the loads that would be imposed by rock anchors.

The remaining Options, namely strengthening with jet grouted piles, adding upstream and downstream stabilizing berms, and replacing the dams, were given further consideration. With Option 2, adding jet grouted piles, Hatch anticipates that some difficulty may be experienced with the installation if rock fill as large as 0.6 m is encountered. Hatch concurs that adding stabilizing berms to the existing dams, or replacing the dams, are the only viable options to address the deficiency of seismic withstand capacity, based on the available records of subsurface information.

We also note that complete removal and replacement of the Middle Colliery Dam will eliminate all concerns that there could be a concealed abandoned timber low level outlet.

4. Comments on KCB's Rehabilitation and Replacement Options

4.1 General

Hatch concurs that it is technically feasible to completely remove the existing Middle and Lower Colliery Dams and to replace them with new dams on the same axis and to the same height as the existing dams. However, there remains a question whether faults believed to be present in the immediate vicinity of the Colliery Dams Park could be seismically active faults. This question would need careful consideration if a rehabilitation or replacement option were to be chosen.

4.2 Replacement with New Embankment Dams

Replacement dams could be earthfill embankments with a central impervious core zone. Alternatively, the replacement dams could be rock fill embankments with a thin upstream face of concrete or asphalt. The footprint of the new dam will be considerably greater than that of the existing dam. Provision would be required to the pass the Chase River during the construction until the service spillways can be used. This could be achieved by first building a gated low level outlet conduit. An enlarged spillway would be required at each dam to achieve the necessary discharge capacity.

4.3 Replacement with RCC Dams

There are no insurmountable geotechnical problems associated with completely removing the existing dams and rebuilding an adequate Roller Compacted Concrete (RCC) dam on the same axis and to the same height as the existing dam. The footprint of the new dam will be considerably smaller than that of the existing dam. A low level outlet conduit could be incorporated into the dam to the pass the Chase River during the construction until the service spillway can be used. Attention would need to be given to foundation preparation for the RCC dam. An overflow spillway could be incorporated into the dam itself. Proportionately, the RCC dam would include a significant volume of enriched or conventional concrete at the upstream face of the dam, in the spillway crest, downstream face, flip bucket, and bridge piers. Consolidation grouting may be required in the foundations, and curtain grouting may be recommended in the case of the Lower Dam.

4.4 Specific Comments on KCB's Conceptual Designs

KCB have proposed that the only effective solution that would limit displacement of the concrete cutoff walls within the existing dams during the design seismic event is stiffening of a significant zone of the existing dam fill adjacent to the wall with jet grouting. This entails injecting cement at very high pressure through a rotating drill nozzle to mix with the rockfill and create a column of concrete-like material. It has not been demonstrated that this can be done economically in these dams, which contain pieces of rock 0.6 m in size nor has it been demonstrated that the very high grouting pressures will not damage the concrete wall. However, we understand from verbal conversations with KCB that they have consulted with a contractor who believes that the solution is viable.

For the replacement embankment dams option, KCB do not present embankment zoning details nor material properties. However, we believe that an embankment configuration similar to that shown for the jet grouting rehabilitation option, and containing a central impervious fill core, would be reasonable as a conceptual design.

For the expanded spillway and for the replacement spillway options, details of the discharge energy dissipation are lacking within KCB's report and we therefore cannot comment on the appropriateness of the design concept, other than to comment that there should not be any significant challenges with such a design.

For the dam removal operations, there is no description of how the reservoir will be unwatered and the flow maintained in the Chase River to the downstream so that removal of the existing dams can proceed. However, as this is a common component of both the Removal and the Re-Build options, it does not directly impact on the comparison between these two alternatives.

In regard to the roller compacted concrete (RCC) replacement dam options, a proportion of the dams will be constructed in conventional concrete or enriched concrete (upstream face, overspill crest, downstream face, flip bucket, low level outlet, diversion opening, bridge support piers) which in the case of the Middle Dam will leave a relatively small volume of RCC to be placed. We would note that the some of the economies of RCC construction may be lost if the volume of RCC to be placed is too small. In this regard, it is our understanding, from communications with KCB, that they have considered the volumes of RCC to be placed and have taken this in to account in the unit prices selected for this material.

5. Hydro Development Option

Although not part of Hatch's original scope of work, upon a request from the City, a review of the CDPS's document on hydro development was undertaken and an opinion was offered on the validity of the findings, as well as on the potential for hydro development at the sites.

The study by the CDPS was based on an analysis performed with the software program RETScreen. This is a program that, as its name infers, is used to screen sites at a very basic level to determine whether or not they offer the potential for an economic development, and to allow comparison of various options to home in on the most favourable option.

Our review of the CDPS report concluded that the size of the plants proposed, as well as the annual energy generation and revenue estimates contained therein, were within the range we would anticipate. As we do not believe the costs generated by RETScreen can be relied upon to make financial expenditure decisions, we recommended that it would not be cost effective to have Hatch undertake an independent analysis using the RETScreen software at this time. However, based on our experience at other sites, we can conclude that the capital costs reported by the CDPS appear to be lower than we would anticipate for developments of this size.

In addition to the construction costs, the licensing and engineering costs associated with developments of this nature can be considerable, and the duration to obtain regulatory approval to proceed would typically be in the range of 18 to 24 months, but could in fact be longer.

Details of the energy analysis undertaken by Hatch, along with commentary sent to the City on the potential capital costs and regulatory approval process duration, are contained in **Appendix A**.

Should the City decide to rehabilitate or rebuild the dams, a more detailed study could be undertaken to verify the projects' economics. A redevelopment of the dams undertaken at this time could make an allowance for the possibility of future hydro development by including an intake pipe and valve at each dam, at a relatively low cost.

6. Comments on Cost Estimates

This section of our report discusses the information reviewed and the cost estimating methodology utilized by KCB, as well as the allowances provided for contingency and engineering costs. While there are differences in approach between our normal practice and that employed by KCB, as discussed below, we have concluded that in our opinion the bottom line costs presented within KCB's report are credible for a conceptual level cost estimate.

6.1 Options Estimated

Conceptual level cost estimates were provided by KCB for three (3) types of comparable options (removal, rehabilitation and replacement), with their estimated costs being in the ranges indicated below.

5 schemes involving rehabilitation of one or both dams	$14.6 million to $23.6 million
2 schemes involving replacement of one or both dams	$7.9 to $8.6 million
1 removal and re-naturalization of both dams	$5.5 million

Generally, the estimated options have been organized into three (3) groups:

1. Very High Consequence Classification

VH1: Rehabilitation Both Dams - Lower Both Lakes by 3 m:	$17.8 million
VH2: Remove Middle Dam, Rehabilitate Lower Dam:	$14.6 million
VH4: Remove Middle Dam, Replace Lower Dam:	$7.9 million

2. Extreme Consequence Classification

EXT1: Rehabilitation Both Dams Without Drawdown:	$23.6 million
EXT2: Replace Middle Dam, Rehabilitate Lower Dam:	$16.2 million
EXT3: Replace Lower Dam, Rehabilitate Middle Dam:	$16.1 million
EXT4: Replace Both Dams, without Drawdown:	$8.6 million

3. Remove Both Dams, Re-naturalize Both Lakes: $5.5 million

6.2 Methodology

To ensure consistency of estimating throughout all options, KCB utilized a method of compiling their estimates that employed a "modular pricing" approach, in which consistent unit rates (Table 3 of KCB report) are used in all component cost estimates (Tables 4 to 9 of KCB report). This approach ensures that common items of work between the Removal option and the Rehabilitation and / or Re-Build options are consistently priced.

We would note that estimates of this nature, even at the conceptual level, typically include “brief” explanations related to the following items: method or technique used to develop the estimate, bases for the allowances and assumptions, an estimate exclusions statement, cost basis, and method of deriving the quantities. While we consider this a shortcoming in the report, we have no reason to question the report’s findings on this basis.

6.3 Contingency Allowances and Management Reserve

Hatch considers that the estimates prepared by KCB are conceptual level cost estimates and are at a Class 4 level, as defined by the Association for the Advancement of Cost Engineering) Classification System (AACE). This System provides a uniform basis to assess the level of the confidence that can be placed in the estimate, based on a documented level of the project definition.

Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, preliminary economic evaluation, and preliminary budget approval. Typically, engineering completed at this stage of a project is only 1% to 15% of the total required for final design.

Contingency is routinely included in estimates to cover:

- site conditions changes
- design refinements
- increase in cost in allowances
- incorrect assumptions
- changes in labour and equipment productivity

Based on a Class 4 estimate category, contingency is typically in the range of 20% to 30% of the bottom line cost.

KCB assigned contingency allowances, as a percentage of the estimated cost, for the following construction cost components. The contingencies are attributed to current unknowns, either related to site conditions or to the conceptual design level:

Rehabilitation works	30%
Spillway upgrade	20%
Dam Removals	10%
Re-naturalization	10%
New Concrete Dam	30%
New Footbridge	20%

Hatch reformatted the data in KCB’s costing Tables and determined that the total contingency percentage on the 7 Rehabilitation / Re-Build options varies from 9% to 17% of the total construction cost + engineering, while it equalled 8% for the Removal option. This is somewhat below the anticipated range of 20% to 30% anticipated for a Class 4 estimate, as indicated above. However, it is our understanding, based on discussions with KCB, that some of the unit rates they utilized carry some "buried contingencies", ie the rates are slightly higher than normal to allow for a number potential variations relative to the base case assumptions. This is consistent with our review of the unit rates, as presented.

Hatch's understanding is that the contingencies included by KCB are those considered to be necessary to bring the estimates to a probability level of 50% of not being over-run, although this is not clearly stated in their report.

In addition to the contingencies discussed above, KCB have suggesting adding a "Project Budget Contingency Allowance" varying between 15% for the Removal option to 20% to 30% for the Rehabilitation and Re-Build options. While not clearly defined in KCB's report, Hatch believes that this is what frequently is referred to as a "Management Reserve", an allowance that is designed to take the estimate from a level of confidence of 50% of not being over-run, to some other predetermined probability level, frequently in the range of 80% or 90%, dependent upon the client's requirements.

As stated above, KCB's report does not indicate the level of accuracy assigned to bottom line costs. However, it is typical for a Class 4 estimate, with an indicative probability of 90% of not being exceeded, to carry an expected accuracy range of "-15% to -30% on the lower side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination)". Thus, the +20% to +30% range assigned by KCB for the "Management Reserve" / "Project Budget Contingency Allowance", to reach the high side cost, appears reasonable for projects of this nature.

6.4 Engineering Costs

Hatch believes that the Engineering costs contained in the KCB estimates vary between 5% and 9% of the total construction cost, including engineering. Hatch considers that engineering cost is typically between 10% and 15% for an Engineering, Procurement, Construction Management (EPCM) delivery method,. KCB explained that their rationale for these lower than normal costs was that the designs did not involve a high level of complex details and Hatch is in agreement with the explanation and the utilization of the lower than normal percentage allowances presented by KCB.

6.5 Summary / Conclusions on Cost Estimates

Some of the unit rates utilized by KCB appear to include "buried" contingency and thus their use of percentage contingency rates that are lower than suggested by a Class 4 AACE estimate are justified in our opinion. While Hatch would normally take a different approach than KCB in developing cost estimates of this nature, including the individual allowances contained therein, it is our opinion that the bottom line cost estimates presented by KCB are consistent with the current conceptual level of design.

7. Conclusions

As requested by the City, Hatch has undertaken a peer review of the final draft of KCB's report "Middle and Lower Colliery Dams – Conceptual Costing of Rehabilitation and Replacement Options". We are in agreement with the report's findings with respect to the identification and evaluation of the various possible options that are available for the rehabilitation or replacement of the dams. However, the question of whether faults believed to be present in the immediate vicinity of the Colliery Dams Park could be seismically active faults would need careful consideration if a rehabilitation or replacement option were to be chosen.

We are also in broad agreement with the technical evaluations and cost estimates presented in the report. We would have liked to have seen more details or discussion contained within the report on the assumptions made in relation to construction methodology as well as on the allowances provided for engineering, contingency and management reserve. However, based on communications with KCB throughout the course of the study, we believe that a commensurate level of thought has been applied by KCB to these aspects, given the conceptual level of these studies. Our review of the costing aspects concluded that while we would have taken a slightly different approach to the unit rate structure utilized for various cost items, as well as for the contingency allocation, the bottom line costs presented by KCB are appropriate for the various alternatives reviewed.

The City also requested that Hatch review and comment on a document provided by the CDPS related to inclusion of hydro generation at the dam sites. It was our conclusion that while developments of the size proposed were feasible, the level of detail contained within screening level studies of this type are insufficient upon which to base an economic decision. Allowances for the incorporation of hydro facilities could be incorporated in any Rehabilitation or Re-Build options at reasonably low costs, should further detailed evaluation indicate favourable project economics.

Jim Smith, P. Eng.
Project Manager

David Rupay, P. Eng.
Senior Reviewer

Appendix A:
Review of Hydro Generation Option

From: Smith, Jim
Sent: Monday, April 15, 2013 8:51 AM
To: 'Bill Sims'
Cc: 343713
Subject: FW: Colliery Dam Lakes - Energy Estimation from Hydro Plants

Hi Bill,

Please find attached the spreadsheet that I mentioned at our Apr 12th meeting. Please also note the caution at the bottom of the email below that the energy estimations should be lowered by approx 10% , based on experience when using the average monthly flow data as the only source of flow data.

Using the info in the attached spreadsheet, and the Citizen's sized plants we would expect the following scenario:

Middle Dam - at the 100KW capacity selected by the Citizens, it would generate the income they forecast with a value of energy of approx $90 / MWH (this is after factoring in the 10% reduction relative to the values in the spreadsheet)

Lower Dam – at 325 KW capacity, it would generate the income forecast by the Citizens with a value of energy of approx $70/MWH or, conversely, it would be expected to generate approx $122,000 in energy at a value of $90/MWH

I have been advised by senior staff in our office that while RETScreen is a good tool for evaluating and ranking various development options relative to each other. However, the Capital Cost estimates obtained from the program cannot really be relied upon to make investment decisions, this would require considerable additional site specific analysis. I have been advised that, based on our recent experience, a plant in the 100KW size range might be expected to cost approx $700,000 per 100 KW. For a larger plant in the size range of 325 KW, the capital cost is more likely in the range of $500,000/100KW. Thus, the anticipated capital costs for the 2 plants proposed by the Citizens is likely to be in the range of approximately $2,325,000 vs their estimated cost of approximately $1,720,000.

I have gotten the sense from the Hatch staff that I have discussed this with that a study to refine the optimum plant sizes and the corresponding estimated capital costs and economic case for the developments is a sizeable undertaking. Perhaps we should discuss further whether a discussion similar to the above would be satisfactory for presentation in our report or if you believe it worthy of further study.

Regards, Jim

From: Alavi, Amir
Sent: Thursday, April 11, 2013 3:12 PM
To: Smith, Jim
Cc: Murray, Don; Rupay, David; Saiedi, Saied
Subject: Colliery Dam Lakes - Energy Estimation

Hi Jim,

Please find attached a spread sheet including Hydrology and energy calculation tabs for Colliery Dams project.

Attached tables are included all assumptions which was provided through the string of e-mails.

For the hydrology I averaged the KCB and Golder estimates and used it as monthly inflows.

Tables also showing energy calculation for Middle Dam and Lower Dam separately following with a table showing the summation of the two sites. Fourth table is an option to combine Middle and Lower sites and locate the intake at Middle Lake and Powerhouse at downstream of the Lower Lake with taking advantage of having 40 meters of gross head. Tables are including of 10 different scenarios based on a range of possible design discharges. The monthly energy production has been calculated based on the initial assumptions and average monthly inflows into the lakes. The plant availability of 90% as been applied in calculations. Following the monthly energy estimates, the capacity factor for all scenarios has been shown in the table. Then, the annual revenue has been calculated based on total annual energy estimation and BCHydro possible range of average price. At the end, the scenario that has the most reasonable capacity factor has been recommended and highlighted by red color.

At the end, it should be noted that, based on experience, in this situation, because of using the monthly average inflows for the energy calculations, a 10% reduction adjustment to the output energy should be considered. Although, this factor is not included into the attached tables.

Please let me know if you need more information.

Regards,

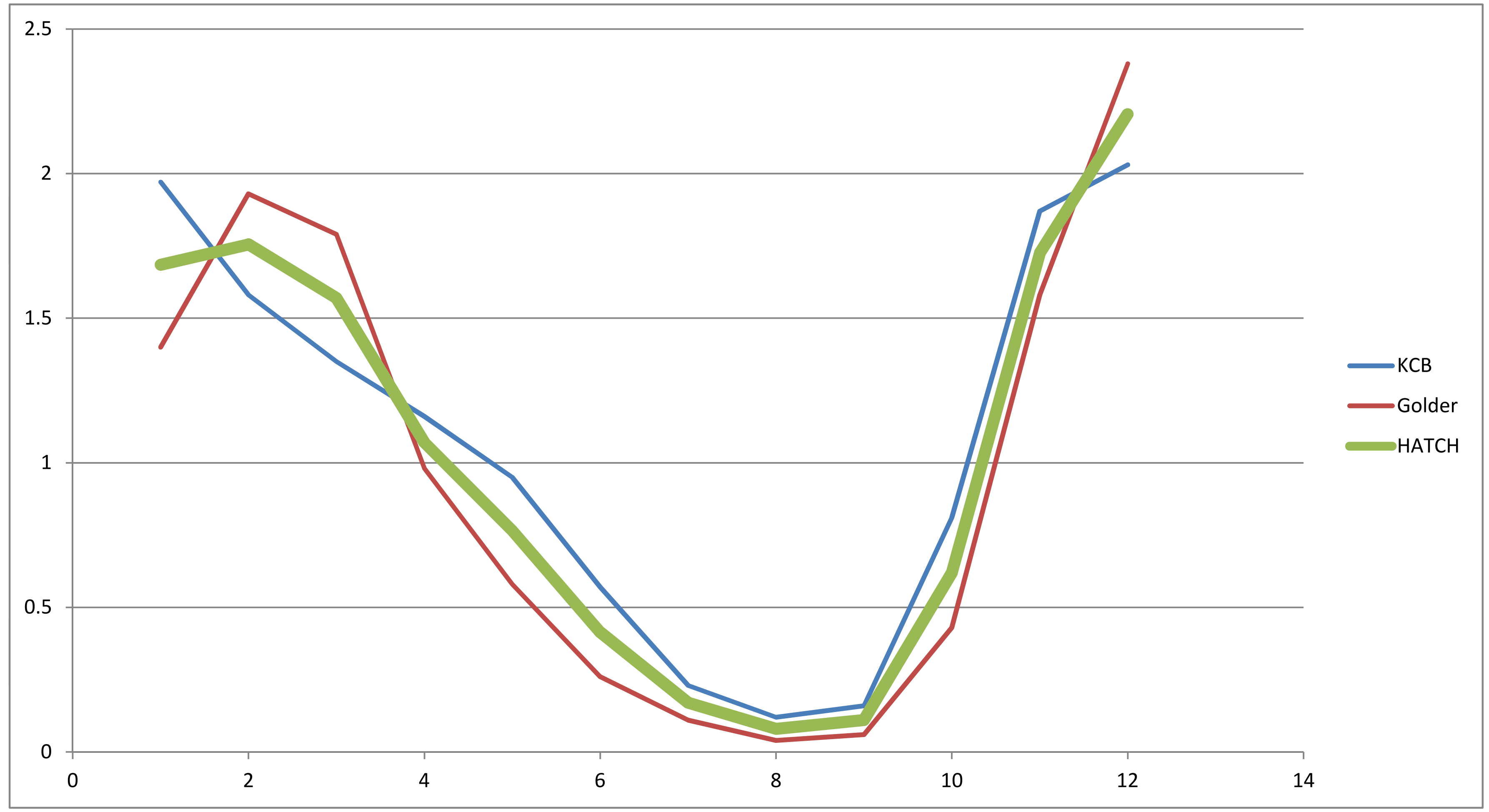
Amir Alavi, M.A.Sc., P.Eng.
Senior Water Resources/Hydrotechnical Engineer

HATCH™

400 - 1066 W. Hastings Street
Vancouver, BC V6E 3X2
Tel 604-630-7350
Fax 604-689-3918
aalavi@hatch.ca

21	km^2

Month	KCB	Golder	HATCH
Jan	1.97	*1.4*	**1.7**
Feb	1.58	*1.93*	**1.8**
Mar	1.35	*1.79*	**1.6**
Apr	1.16	*0.98*	**1.1**
May	0.95	*0.58*	**0.8**
June	0.57	*0.26*	**0.4**
July	0.23	*0.11*	**0.2**
Aug	0.12	*0.04*	**0.1**
Sept	0.16	*0.06*	**0.1**
Oct	0.81	*0.43*	**0.6**
Nov	1.87	*1.58*	**1.7**
Dec	2.03	*2.38*	**2.2**
MAD	1.07	*0.96*	**1.0**



Middle Dam

MAD	1.0

									31	28	31	30	31	30	31	31	30	31	30	31									
									Monthly Energy Generation															Annual Revenue ($)					
Scenario	% of MAD	Design Q	Gross Head	Design Head Loss	Head Loss Factor	eff	Plant Capacity	Min q	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Plant Availability	Total	capacity Factor	BCHydro Average Rate ($/MWH)					
									1.7	1.8	1.6	1.1	0.8	0.4	0.2	0.1	0.1	0.6	1.7	2.2									
	%	m³/s	m	m			kW	m³/s	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	%	MWHr		70	80	90	100	110	120
1	300%	3.00	12.0	1.0	0.1111	0.85	275	0.15	122094	114597	114166	76239	56620	29839	12647	0	0	45974	120804	156700	90%	765	0.32	53,530	61,177	68,824	76,471	84,118	91,765
2	250%	2.50	12.0	1.0	0.1600	0.85	229	0.13	120644	113117	112993	75880	56484	29818	12646	0	0	45901	119298	153450	90%	756	0.38	52,934	60,497	68,059	75,621	83,183	90,745
3	240%	2.40	12.0	1.0	0.1736	0.85	220	0.12	120240	112705	112666	75780	56446	29812	12645	0	0	45881	118878	152545	90%	754	0.39	52,769	60,307	67,845	75,384	82,922	90,461
4	220%	2.20	12.0	1.0	0.2066	0.85	202	0.11	119261	111705	111874	75537	56354	29798	12644	0	7920	45832	117862	150072	90%	755	0.43	52,848	60,398	67,948	75,497	83,047	90,597
5	200%	2.00	12.0	1.0	0.2500	0.85	183	0.10	117974	110392	110833	75218	56234	29779	12643	0	7920	45768	116525	136429	90%	738	0.46	51,642	59,020	66,397	73,774	81,152	88,529
6	175%	1.75	12.0	1.0	0.3265	0.85	160	0.09	115703	107823	108997	74656	56022	29746	12641	0	7919	45655	114168	119375	90%	713	0.51	49,940	57,075	64,209	71,343	78,478	85,612
7	150%	1.50	12.0	1.0	0.4444	0.85	138	0.08	102322	92420	102322	73789	55694	29696	12637	5952	7918	45481	99021	102322	90%	657	0.55	45,963	52,529	59,095	65,662	72,228	78,794
8	125%	1.25	12.0	1.0	0.6400	0.85	115	0.06	85268	77016	85268	72351	55151	29612	12631	5951	7917	45192	82517	85268	90%	580	0.58	40,581	46,378	52,176	57,973	63,770	69,567
9	100%	1.00	12.0	1.0	1.0000	0.85	92	0.05	68214	61613	68214	66014	54152	29457	12620	5950	7914	44660	66014	68214	90%	498	0.62	34,841	39,819	44,796	49,773	54,751	59,728
10	90%	0.90	12.0	1.0	1.2346	0.85	83	0.05	61393	55452	61393	59413	53501	29357	12613	5949	7912	44313	59413	61393	90%	461	0.64	32,262	36,871	41,480	46,089	50,698	55,307

Lower Dam

									Monthly Energy Generation															Annual Revenue ($)					
Scenario	% of MAD	Design Q	Gross Head	Design Head Loss	Head Loss Factor	eff	Plant Capacity	Min q	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Plant Availability	Total	capacity Factor	BCHydro Average Rate ($/MWH)					
									1.7	1.8	1.6	1.1	0.8	0.4	0.2	0.1	0.1	0.6	1.7	2.2									
	%	m³/s	m	m			kW	m³/s	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	%	MWHr		70	80	90	100	110	120
1	300%	3.00	26.0	1.7	0.1889	0.85	608	0.15	266076	249863	248605	165567	122820	64673	27404	0	0	99686	263338	342963	90%	1666	0.31	116,613	133,272	149,931	166,590	183,248	199,907
2	250%	2.50	26.0	1.7	0.2720	0.85	506	0.13	263610	247347	246610	164956	122589	64637	27402	0	0	99563	260778	337438	90%	1651	0.37	115,601	132,115	148,629	165,144	181,658	198,172
3	240%	2.40	26.0	1.7	0.2951	0.85	486	0.12	262924	246646	246055	164786	122525	64627	27401	0	0	99529	260066	335900	90%	1647	0.39	115,319	131,793	148,267	164,741	181,215	197,689
4	220%	2.20	26.0	1.7	0.3512	0.85	446	0.11	261259	244948	244708	164373	122369	64603	27399	0	17161	99446	258337	331522	90%	1653	0.42	115,676	132,201	148,726	165,251	181,776	198,302
5	200%	2.00	26.0	1.7	0.4250	0.85	405	0.10	259071	242714	242938	163831	122164	64571	27397	0	17160	99337	256065	301384	90%	1617	0.46	113,188	129,358	145,527	161,697	177,867	194,036
6	175%	1.75	26.0	1.7	0.5551	0.85	354	0.09	255211	238190	239816	162874	121803	64516	27393	0	17159	99145	252058	263711	90%	1568	0.50	109,738	125,415	141,092	156,769	172,446	188,123
7	150%	1.50	26.0	1.7	0.7556	0.85	304	0.08	226038	204163	226038	161401	121246	64430	27387	12896	17158	98849	218746	226038	90%	1444	0.54	101,077	115,516	129,956	144,395	158,835	173,274
8	125%	1.25	26.0	1.7	1.0880	0.85	253	0.06	188365	170136	188365	158957	120324	64287	27377	12895	17155	98357	182289	188365	90%	1275	0.57	89,263	102,015	114,767	127,518	140,270	153,022
9	100%	1.00	26.0	1.7	1.7000	0.85	203	0.05	150692	136109	150692	145831	118624	64025	27358	12893	17150	97453	145831	150692	90%	1096	0.62	76,693	87,649	98,605	109,561	120,518	131,474
10	90%	0.90	26.0	1.7	2.0988	0.85	182	0.05	135623	122498	135623	131248	117517	63853	27346	12892	17147	96863	131248	135623	90%	1015	0.64	71,031	81,179	91,326	101,473	111,621	121,768

Middle Dam + Lower Dam

									Monthly Energy Generation															Annual Revenue ($)					
Scenario	% of MAD	Design Q	Gross Head	Design Head Loss	Head Loss Factor	eff	Plant Capacity	Min q	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Plant Availability	Total	capacity Factor	BCHydro Average Rate ($/MWH)					
									1.7	1.8	1.6	1.1	0.8	0.4	0.2	0.1	0.1	0.6	1.7	2.2									
	%	m³/s	m	m			kW	m³/s	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	%	MWHr		70	80	90	100	110	120
1	300%						883		388170	364460	362771	241806	179439	94511	40051	0	0	145660	384142	499663	90%	2431		170,142	194,449	218,755	243,061	267,367	291,673
2	250%						736		384254	360464	359603	240836	179073	94455	40047	0	0	145464	380076	490888	90%	2408		168,535	192,611	216,688	240,764	264,841	288,917
3	240%						706		383163	359351	358721	240566	178971	94439	40046	0	0	145410	378944	488444	90%	2401		168,087	192,100	216,112	240,125	264,137	288,150
4	220%						647		380520	356653	356583	239910	178723	94401	40043	0	25081	145278	376199	481594	90%	2407		168,524	192,599	216,674	240,749	264,824	288,899
5	200%						588		377044	353106	353771	239049	178398	94351	40040	0	25080	145105	372591	437813	90%	2355		164,830	188,377	211,924	235,471	259,019	282,566
6	175%						515		370914	346013	348813	237530	177825	94262	40034	0	25078	144800	366225	383086	90%	2281		159,679	182,490	205,301	228,112	250,923	273,735
7	150%						441		328360	296583	328360	235190	176941	94125	40024	18848	25076	144329	317767	328360	90%	2101		147,040	168,045	189,051	210,057	231,062	252,068
8	125%						368		273633	247152	273633	231308	175475	93899	40008	18847	25072	143549	264806	273633	90%	1855		129,844	148,393	166,942	185,491	204,040	222,589
9	100%						294		218906	197722	218906	211845	172776	93482	39978	18843	25064	142113	211845	218906	90%	1593		111,534	127,468	143,401	159,335	175,268	191,202
10	90%						265		197016	177950	197016	190660	171018	93210	39959	18841	25059	141176	190660	197016	90%	1476		103,294	118,050	132,806	147,562	162,319	177,075

Combination of Middle Dam and Lower Dam

									Monthly Energy Generation															Annual Revenue ($)					
Scenario	% of MAD	Design Q	Gross Head	Design Head Loss	Head Loss Factor	eff	Plant Capacity	Min q	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Plant Availability	Total	capacity Factor	BCHydro Average Rate ($/MWH)					
									1.7	1.8	1.6	1.1	0.8	0.4	0.2	0.1	0.1	0.6	1.7	2.2									
	%	m³/s	m	m			kW	m³/s	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	%	MWHr		70	80	90	100	110	120
1	300%	3.00	40.0	2.5	0.2778	0.85	938	0.15	409728	384793	382776	254812	188989	99502	42160	0	0	153382	405531	528488	90%	2565	0.31	179,560	205,212	230,863	256,515	282,166	307,818
2	250%	2.50	40.0	2.5	0.4000	0.85	781	0.13	406102	381093	379843	253914	188650	99450	42157	0	0	153201	401766	520363	90%	2544	0.37	178,072	203,511	228,950	254,388	279,827	305,266
3	240%	2.40	40.0	2.5	0.4340	0.85	750	0.12	405092	380062	379027	253664	188555	99435	42156	0	0	153151	400718	518101	90%	2538	0.39	177,657	203,037	228,417	253,796	279,176	304,556
4	**220%**	**2.20**	**40.0**	**2.5**	**0.5165**	**0.85**	**688**	**0.11**	**402644**	**377564**	**377047**	**253057**	**188326**	**99400**	**42153**	**0**	**26401**	**153029**	**398176**	**511608**	**90%**	**2546**	**0.42**	**178,253**	**203,717**	**229,182**	**254,647**	**280,111**	**305,576**
5	200%	2.00	40.0	2.5	0.6250	0.85	625	0.10	399426	374280	374444	252260	188025	99353	42150	0	26401	152869	394835	465099	90%	2492	0.46	174,456	199,378	224,300	249,223	274,145	299,067
6	175%	1.75	40.0	2.5	0.8163	0.85	547	0.09	393750	367578	369852	250853	187494	99271	42144	0	26399	152586	388941	406961	90%	2417	0.50	169,207	193,380	217,552	241,725	265,897	290,070
7	150%	1.50	40.0	2.5	1.1111	0.85	469	0.08	348824	315067	348824	248686	186675	99145	42135	19841	26397	152150	337572	348824	90%	2227	0.54	155,871	178,138	200,405	222,672	244,940	267,207
8	125%	1.25	40.0	2.5	1.6000	0.85	391	0.06	290687	262556	290687	245092	185318	98935	42120	19839	26393	151428	281310	290687	90%	1967	0.57	137,658	157,324	176,989	196,654	216,320	235,985
9	100%	1.00	40.0	2.5	2.5000	0.85	313	0.05	232549	210045	232549	225048	182819	98549	42093	19836	26386	150098	225048	232549	90%	1690	0.62	118,287	135,185	152,083	168,981	185,879	202,777
10	90%	0.90	40.0	2.5	3.0864	0.85	281	0.05	209294	189040	209294	202543	181191	98297	42075	19834	26381	149231	202543	209294	90%	1565	0.64	109,558	125,209	140,861	156,512	172,163	187,814

Suite 400, Oceanic Plaza, 1066 West Hastings Street
Vancouver, British Columbia, Canada V6E 3X2
Tel (604) 689 5767 ◆ Fax (604) 689 3918

Suite 400, Oceanic Plaza, 1066 West Hastings Street
Vancouver, British Columbia, Canada V6E 3X2
Tel (604) 689 5767 ◆ Fax (604) 689 3918