Coast Information Team

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Re: Economic Gain Spatial Analysis–Minerals, Oil and Gas Sector Studies

The attached draft document, *CIT Economic Gain Spatial Analysis–Minerals, Oil and Gas Sector study* with components *Queen Charlotte/Hecate Basin Oil and Gas Potential February 2003* and *Minerals Sector Study March 2003*, was commissioned by the Coast Information Team (CIT), a project established by the Provincial Government of British Columbia, First Nations, environmental groups, the forest industry, and communities. The CIT mandate is to provide independent information on the central and north coasts of British Columbia and Haida Gwaii/Queen Charlotte Islands using the best available scientific, technical, traditional and local knowledge.

The CIT is led by a management committee consisting of representatives of these bodies; and is funded by the Provincial Government, the environmental groups and forest products companies, and the Federal Government of Canada. The CIT technical team comprises nine project teams consisting of scientists, practitioners, and traditional and local experts. The CIT information and analyses, which include the EGSA–Minerals, Oil, and Gas Sector report, are intended to assist First Nations and the three subregional land use planning processes in making decisions that will achieve ecosystem-based management (as per the April 4th 2001 Coastal First Nations – Government Protocol and the CCLRMP Interim Agreement).

In keeping with the CIT's commitment to transparent and highly credible independent analysis, the EGSA–Minerals, Oil, and Gas Sector report underwent an internal peer review and the CIT's independent peer review process chaired by University of Victoria Professor Emeritus Rod Dobell. Peer reviews of the report and the authors' response are found at http://www.citbc.org/abostru-comm.html. The authors chose not to revise their report to address peer review comments and questions raised by the CIT. The CIT is, therefore, issuing this document as a Working Paper. While CIT Working Papers contain useful information, readers should consider the analysis, results, and conclusions as provisional.

We encourage all stakeholders involved in land and resource management decision-making to consider CIT products as they seek to implement EBM and develop EBM Land Use Plans. We are confident that the suite of CIT products provides valuable information and guidance on the key tenets of EBM: maintaining ecosystem integrity and improving human wellbeing.

Sincerely,

Robert Prescott-Allen, Executive Director
on behalf of the CIT Management Committee:
Ken Baker, Art Sterritt, Dallas Smith, Jody Holmes, Corby Lamb
Graem Wells, Gary Reay, Hans Granander, Tom Green, Bill Beldessi

Coast Information Team

Queen Charlotte/Hecate Basin Oil and Gas Potential

This paper contains some estimates of the crude oil and natural gas potential of the Queen Charlotte/Hecate Basin that should be considered to be entirely speculative at this time. These estimates are provided only for the purposes of illustrating a methodological approach to estimating potential oil and gas values. They should in no way be interpreted as either accurate or reliable estimates of potential economic value.

Not only are there very large geological uncertainties associated with the conceptual oil and gas plays that might be available should the existing moratorium on oil and gas exploration activity in the B.C. offshore be lifted, these uncertainties are compounded by technological and economic uncertainties. A very large number of possible development scenarios could be modeled, based upon a variety of equally plausible assumptions.

Estimates of potential oil and gas values based upon just one set of assumptions are presented for illustrative purposes only. These estimates should be interpreted to be entirely speculative, and no special significance should be placed upon them.
BriMar Consultants Ltd. bears sole responsibility for the contents of this report.

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BriMar Consultants Ltd. **February, 2003**

Queen Charlotte/Hecate Basin Oil and Gas Potential

The Resource

The table attached as Appendix A provides two sets of estimates for the crude petroleum and natural gas potential of the Queen Charlotte/Hecate Basin, which lies within the *Area of Interest* of the Coast Information Team (CIT). With respect to natural gas, the larger estimates of potential volumes-in-place come from the Geological Survey of Canada (GSC), while the smaller estimates come from the Canadian Gas Potential Committee (CGPC). For both petroleum and natural gas, recoverable volumes would be considerably smaller than volume-in-place estimates. Moreover, if oil and gas discoveries were made in the Queen Charlotte/Hecate Basin, the oil recovery factor (ratio of recoverable oil to oil-in-place) would be smaller than the gas recovery factor (ratio of recoverable gas to gas-in-place), largely due to typical pressure effects.

The table also compares the recoverable resource potential of the Queen Charlotte/Hecate Basin with that of other Canadian offshore basins, notably the Jeanne d'Arc Basin (which contains the Hibernia field), the Nova Scotia Shelf, and the Beaufort Sea. At this time, there continues to be a moratorium on exploratory drilling activity in the Queen Charlotte/Hecate Basin, which would need to be lifted before drilling could proceed.

There are three geological horizons within the Queen Charlotte/Hecate Basin that are expected to be prospective for potential hydrocarbon discoveries, the Cretaceous, Miocene, and Pliocene. These geological horizons (or oil and gas plays) are mapped as irregular stacked polygons in the key GSC report (Hannigan et al., GSC Bulletin 564, 2001). The Cretaceous horizon is both older and, in the main, deeper than the two Tertiary horizons. The Pliocene oil and gas play overlays the Miocene, but is confined to the northern part of the Queen Charlotte/Hecate Basin. One of the more prospective areas (especially for Cretaceous hydrocarbon traps that may contain significant quantities of crude oil) lies off the eastern coast of the Queen Charlotte Islands, roughly parallel to the Sandspit fault system. Natural gas is more likely to be found in the Tertiary hydrocarbon traps of Miocene and Pliocene age.

The potential for significant discoveries of oil and gas within the Queen Charlotte/Hecate Basin is large. However, since one is here dealing with what the geologists call *conceptual resource plays,* rather than resources that are anywhere close to being proven, the risks associated with exploration activity are also large. The CGPC estimates that the probability of exploratory success, that is the probability that an exploration well drilled into a defined prospect will find a natural gas field which is economically viable, is 0.080 for Cretaceous gas, 0.225 for Miocene gas, and 0.136 for Pliocene gas. The estimated probabilities of exploratory success are not large, and numerous unsuccessful wells may be drilled before major discoveries occur. Because of these high risks, the finding costs associated with the potential oil and gas resources of the Queen Charlotte/Hecate Basin will be substantial.

This report proceeds on the following assumptions. First, it uses the GSC estimate of recoverable crude oil volumes from the Queen Charlotte/Hecate Basin of 413 million cubic metres (mcm), or 26.5% of the estimated oil-in-place volume of 1,560 mcm across the Cretaceous, Miocene and Pliocene horizons. Second, it uses an average of the GSC and CGPC estimates of gas-in-place volume, 734 billion cubic metres (bcm) and 213 bcm, respectively, and applies the GSC estimate of the gas recovery factor (567 bcm / 734 bcm, or 77.2%) to this average to obtain an estimate of recoverable natural gas volumes of 366 bcm across the three geological horizons. These two assumptions embody a conservative approach to recoverable petroleum and natural gas volumes.

Methodologies

The gain scenarios for the oil and gas sector should take an economic development perspective. The key measures of economic gain should include the number of full-time equivalent jobs created, the amount of direct income generated, and the flow of hydrocarbon resource rents to governments. (In this context, the federal, provincial, and specific First Nations governments might all be involved.) Since the generation and capture of oil and gas resource rents is of importance to both the public and the private sectors, the construction of economic gain scenarios will also involve a net social benefits approach. To make the economic gain scenarios operational also requires that representative cost-accounting frameworks be developed, using onshore or offshore exploration and production technologies, as appropriate.

The production of crude oil and natural gas from newly discovered pools or fields tends to follow a particular (usually declining) time-profile. A net present value (NPV) approach is required in order to compare net production revenues with initial capital and other up-front costs (for tenure acquisition, exploration activity, well drilling, etc.). Viable private sector activities will have positive NPVs, and thereby command a positive share of available economic rents. Indeed, if private rent (as measured by the private NPV) were expected to be zero or negative, an oil or gas development project would be unlikely to proceed, and there would be no employment created or income generated. Nor would the public sector collect economic rent from the project.

An eight percent real discount rate should be used in the rent calculator that is employed in the estimation of public and private NPVs. If the private NPV is positive, the next step should be to estimate the public share of the available resource rents (as measured by the public NPV), the number of full-time equivalent jobs created, and the amount of direct income generated. Within this step, inter-sectoral spill-over impacts and multiplier effects should be ignored, at least in the first instance, since most of these would in any case percolate outside the CIT *Area of Interest.*

It follows that the initial methodological focus must, of necessity, be on the estimation of probable resource values, as measured by the public and private NPVs that are associated with the development of potential hydrocarbon resources. The NPVs could alternatively be expressed as equivalent annual net values by dividing by the annuity factor for the life of the oil and/or gas field and the assumed 8% discount rate. This approach permits linkages from production and other activity levels to employment creation, income generation, and government revenue flows also to be annualized. Representative ratios of annualized cost and benefit flows to the volume of recoverable resources and/or to the area of productive oil and gas polygons could also be constructed.

The three geological horizons with significant hydrocarbon content, the Pliocene, Miocene and Cretaceous, may be represented by large vertically stacked polygons, drawn within the map footprint of the CIT *Area of Interest.* Ideally, it would be useful to break the CIT *Area of Interest* spatially into zones of high, medium and low hydrocarbon potential. However, the Ministry of Energy and Mines does not have sufficiently detailed information pertaining to the spatial location of potential hydrocarbon resources to allow polygons of high, medium and low potential to be drawn within the larger horizon-specific polygons. Information on potential *hot-spots* either does not exist, or is kept confidential by companies that are in possession of thirty-year-old seismic and exploratory drilling data. As a result, analysis of the oil and gas potential of the Queen Charlotte/Hecate Basin must largely be based on an aggregative approach, without much spatial detail. Major uncertainties with respect to both potential in-place volumes of crude oil and natural gas and recoverability factors in any case pervade the aggregative approach.

The Economic Gain Scenarios

Two economic gain scenarios are identified. The first of these involves the drilling of marine-based exploration wells, and the use of large oil and gas recovery platforms, possibly of the semi-submersible type. Offshore oil and gas resources could be found beneath Queen Charlotte Sound, Hecate Strait, or Dixon Entrance. The second scenario involves the drilling of conventional land-based exploration wells, with subsequent field development if viable quantities of oil and/or gas are found. Onshore oil and gas resources are most likely to be found on Graham Island in the Queen Charlottes. (The GSC horizon maps suggest that only the extreme north-west portion of Graham Island may not be prospective for oil and/or gas.)

Even if the moratorium on drilling activity is lifted, it is possible that exploration and development activity on Graham Island may be postponed until a land title settlement with the Haida First Nation has been concluded. For this reason, this report focuses, for the most part, on offshore oil and gas resources. However, information based upon well-specific drilling records of hydrocarbon showings from more than thirty years ago does not appear to be sufficient to separate the estimated in-place oil and gas volumes for the three geological horizons into the proportions that are likely to be found onshore and offshore. Moreover, dis-aggregation on the basis of the relative areas of each of the stacked horizon polygons that seem to lie beneath land and sea does not appear to be justifiable.

Although it is not possible to apportion potentially recoverable volumes by gain scenarios, the technologies associated with the two economic gain scenarios are clearly different. Other differences relate to the combinations of crude oil, associated gas, unassociated gas and natural gas liquids that are discovered, because the production, gathering, processing and transmission technologies that are necessary to bring these products to the market place differ. Submersible pipelines seem to be required for natural gas transmission, whereas tankers might suffice for the transportation of crude oil.

There are environmental risks associated with any of these technologies and, more generally, with the pursuit of either of the two basic gain scenarios. It will be important to find ways and means to minimize these risks, if the moratorium is to be lifted. Much has been learned about risk minimization through oil and gas developments in other parts of the world. In addition, *best practice technologies* have changed dramatically since the moratorium was first imposed. For example, the frequency of exploration and development well blow-outs in offshore drilling programs in the North Sea (Norway and U.K. combined) was just 0.4% (20 blow-outs for 4,704 wells drilled) during the 1980-92 period, and would be lower if drilling were to occur today.

Specification of the Economic Gain Scenarios

Full-cycle petroleum and natural gas operations involve several phases. These phases include:

(a) exploration, which includes geophysical and seismic activities as well as exploratory drilling activities;

(b) development, which includes the drilling and completion of additional wells to develop the oil and/or gas field;

(c) production, which includes the gathering, processing and transmission of the extracted oil and/or gas; and

(d) decommissioning, which occurs when resource depletion brings the field to the end of its productive life.

Petroleum and natural gas activity is highly capital intensive. Most of the direct labour requirements associated with the two different economic gain scenarios are for skilled operatives. This is especially true of the exploration and decommissioning phases. For these phases, most of the labour requirements would be filled by skilled workers who are brought in from outside the *Area of Interest.* If taken in isolation, these two phases would not generate large economic gains.

The field development phase characteristically involves a short-term burst of intensive activity. Field equipment, drilling rigs and semi-submersible production platforms would generally be acquired from outside the *Area of Interest.* Nevertheless, with advance planning, local communities should be able to corner a reasonable share of the employment and other supply-side opportunities presented at the development phase. These opportunities may, however, be short-lived, unless additional fields are discovered and developed within the *Area of Interest.*

At the production phase, employment and other opportunities would be smaller in scale, but much longer lasting, than at the development phase. Stability is a feature of the production phase, while the development phase may unleash destabilizing forces within local communities, unless the development of separate hydrocarbon pools, or oil and gas fields, follows a staged approach. In sum, although the income generation potential of oil and gas activity in the CIT *Area of Interest* is large, for both the private and the public sector, the employment creation potential could be relatively limited. Training initiatives pertaining to the labour requirements of the development and production phases will be important if regional employment benefits are to be maximized.

Even if the moratorium is lifted within the next couple of years, it will probably be ten years before the first crude oil and/or natural gas production occurs from the Queen Charlotte/Hecate Basin. Environmental assessments must be completed and jurisdictional issues settled before exploration and development activities can commence in earnest, and these activity phases necessarily pre-date production. Considerable progress may be made in the development of *best practice technologies,* especially in relationship to offshore activities, over the decade. As a result, it is difficult to specify today what the production function parameters that underlie a cost-accounting framework would be, if and when the various phases of activity commence.

An alternative approach would be to base the cost-accounting framework on today's technologies. This approach will probably lead to the over-statement of costs. As a result, underlying resource values, as represented by private and public NPVs, will tend to be estimated conservatively, and thereby under-state the *option values* associated with the potential hydrocarbon resources. However, biases introduced by the failure to account for prospective technological change may be small in relationship to the other overwhelming uncertainties associated with the estimation of potential resource values for conceptual hydrocarbon plays.

The Net Present Value Methodology: An Illustration

The estimates provided in this section are hypothetical, speculative, and based upon just one of many plausible development scenarios. No special significance should be placed on these illustrative estimates.

Estimates of the public and private resource rental values that are potentially associated with the recoverable oil and gas resources of the Queen Charlotte/Hecate Basin need to be based upon some reasonably representative profile of exploration, development, production, and decommissioning activities. For purposes of illustration, it is assumed herein that each of these processes is staged over time, and that the whole process takes forty years to complete from the first pool discovery to the final decommissioning of production facilities. Production of either crude petroleum or natural gas is assumed to follow a trajectory that peaks in the second decade. Taken in five-year intervals, the hypothetical production trajectories are as follows.

				Years				
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40
Production percentage	8%	14%	18%	18%	14%	11%	9%	8%
Crude oil (total: 413 mcm)	33	58	74	74	58	46	37	33
Natural gas (total: 366 bcm)	29	51	66	66	51	41	33	29

By way of comparison, the total B.C. production volumes over the five year interval, 1997-2001, inclusive, were 13.2 mcm of crude oil production and 132.4 bcm of natural gas production. Offshore hydrocarbon development could make a huge difference to the annual volume of crude oil produced in B.C., but might only (even at its peak) add 50% to the annual production of natural gas. Of course, this comparison also indicates how gas prone the B.C. segment of the Western Canadian Sedimentary Basin (WCSB) is.

Based upon a number of comparable situations, the following cost-price breakdowns might be assumed to apply to the economic gain scenarios for offshore oil and offshore gas, respectively. However, while these cost-price breakdowns are reasonably representative of the B.C. segment of the WCSB at the present time (and assume the existing B.C. fiscal regime), they may bear no relationship to the cost-price situation that might prevail down the track for the B.C. offshore, should the moratorium be lifted.

	Crude Petroleum Can $ per cubic metre	**Natural Gas** Can $ per 1000 cubic metres
Wellhead price	$170.00	$150.00
Capital costs	$ 59.50	$ 52.50
Operating costs	$ 51.00	$ 45.00
Bonuses, royalties and taxes	$ 42.50	$ 37.50
Net cash flow	$ 17.00	$ 15.00

Using the assumed production profiles and the cost-accounting framework, one may generate the following ***purely illustrative*** NPV estimates. These estimates assume that the cost functions for onshore oil and gas are similar to those for offshore oil and gas. The NPVs for public revenues (bonuses, royalties and taxes) are estimated using both a 5% discount rate and an 8% discount rate. Whereas 8% real is an approximation to the real after tax return on private capital investment, 5% real is a better approximation for the public sector borrowing rate.

	NPV (oil) Can $ millions	**NPV (oil)** Can $ per cubic metre	**NPV (gas)** Can $ millions	**NPV (gas)** Can $ per 1000 cubic metres
Private cash flows @ 8%	$2,106	$ 5.10	$1,644	$ 4.49
Public revenues @ 8%	$5,265	$12.75	$4,110	$11.23
Public revenues @ 5%	$7,708	$18.66	$6,022	$16.45

If any credibility could be placed on these NPV estimates, they would suggest that there may be significant resource rental values, for both the private and the public sectors, associated with the development of the hydrocarbon resources that are projected to exist within the Queen Charlotte/Hecate Basin. By way of comparison, if the average levels for the 1997-2001 period of Crown royalty receipts from oil and gas production were to continue for forty years, then at a 5% discount rate the NPVs of the resulting royalty streams would be $1,600 million for oil (about $24 per cubic metre) and $9,100 million for gas (about $14 per 1000 cubic metres).

The illustrative NPV estimates are, of course, based upon only one of many possible development scenarios for the Queen Charlotte/Hecate Basin. They make no allowance for the huge geological and economic uncertainties involved, and the substantial limitations of the information that is currently available. Different estimates of recoverable volumes, alternative production profiles, re-specified price-cost accounting frameworks, and higher or lower discount rates, would all lead to different estimates for private and public resource rental values. Nevertheless, one might claim that these illustrative estimates are reasonably conservative, partly because they are based upon the assumption of a forty-year time horizon for the full-cycle project. On the other hand, the existing estimates of recoverable oil and gas potential for the Queen Charlotte/Hecate Basin conceptual play could be seriously exaggerated.

Analogies to East Coast Offshore Development

The data provided within Appendices B, C, and D relate to the exploration, development, and production activities that have taken place, or are projected to take place, in the offshore oil and gas plays of Atlantic Canada. The Canada Newfoundland Offshore Petroleum Board (CNOPB) estimates that the proven reserves plus probable resources associated with the oil and gas plays of the Grand Banks region consist of 337.8 mcm of crude oil, 160.1 bcm of natural gas, and 49.1 mcm of natural gas liquids. The Hibernia field is responsible for 42%, 24%, and 47% of these respective volumes, while the Terra Nova field and the Whiterose field are responsible for 19% of the potentially recoverable oil volume and 48% of the potentially recoverable gas volume, respectively. At both Hibernia and Terra Nova, natural gas is currently re-injected into the reservoir to aid in pressure maintenance. Estimates of resource potential are likely to increase as delineation progresses.

The Canada Nova Scotia Offshore Petroleum Board (CNSOPB) estimates that the Sable Island field contains 85 bcm of recoverable natural gas. Oil production from the Cohasset field has already run its course, and the Cohasset facilities have been decommissioned. Additional hydrocarbon resources may be discovered as exploration moves to deeper waters along the Nova Scotia Shelf, the Deep Panuke Project being a prominent example.

As indicated in Appendices B, C, and D, it is estimated that $14.7 billion has been spent on all phases of petroleum and natural gas activity associated with the Newfoundland and Labrador offshore, which includes the Hibernia, Terra Nova and Whiterose Projects. It is also estimated that about $2.6 billion has been spent on Nova Scotia's Sable Offshore Energy Project. For 2003 alone, total projected exploration and development expenditures in Atlantic Canada could be as large as $1.5 billion. In the Appendices, employment (in person-years) and expenditures (in million dollars) at the development stage are measured cumulatively, while employment and expenditures at the production stage are measured on an annual average basis. Where data on cumulative production expenditures are provided, these are projected field life totals.

The activity measures provided in Appendices B, C, and D may be used to provide a comparative framework for assessing the probable employment creation and income generation effects that could be associated with B.C. offshore hydrocarbon development. Essentially, the analysis would proceed by way of analogy, using empirical data drawn from offshore experience in Atlantic Canada. However, since geological, geophysical and other conditions differ between the East and West Coasts, differences in development technologies (and associated crew sizes) would need to be taken into account.

For example, the Terra Nova development uses floating production, storage and off-loading (FPSO) vessels. Other semi-submersible extraction technologies are also available for offshore oil and gas production. In this context, although the well depths at which hydrocarbons may be found in the Queen Charlotte/Hecate Basin are likely to be fairly similar to the Atlantic Canada offshore, the average water depths at drilling rig locations will, for the most part, be larger. Water depths from forty to four hundred metres are likely to be encountered if drilling activity commences in the Queen Charlotte/Hecate Basin.

It can be argued from a geological perspective that the oil and gas fields of Alaska's Cook Inlet provide a closer parallel to the potential fields of the Queen Charlotte/Hecate Basin. However, oil and gas production from the Cook Inlet fields has been underway for much longer than production from the offshore oil and gas fields of Atlantic Canada. Indeed, Cook Inlet production volumes have been in decline since the mid-1990s, falling from 2.5 mcm of crude oil per year in 1994 to about 1.8 mcm in 2002. The potential advantage that could accrue from the use of Cook Inlet data from the perspective of geological analogy is offset by the potential advantage that could accrue from the use of Atlantic Canada data from the perspective of developmental and technological analogy, including project scale.

The Method of Analogy: An Illustration

The estimates provided in this section are hypothetical, speculative, and based upon just one of many plausible development scenarios. No special significance should be placed on these illustrative estimates.

The Queen Charlotte/Hecate Basin is estimated to contain a recoverable crude oil volume that is 55.3% as large as the Jeanne d'Arc Basin. Since the combined oil reserves of the Hibernia and Terra Nova fields represent about 27.5% of the Jeanne d'Arc Basin potential, the Queen Charlotte/Hecate Basin could contain about twice the recoverable oil volume of Hibernia and Terra Nova combined. The Queen Charlotte/Hecate Basin is also estimated to contain a recoverable natural gas volume that is 71.8% as large as the Nova Scotia Shelf. Since the gas reserves of the Sable Offshore Energy Project represent about 16.7% of the Nova Scotia Shelf potential, the Queen Charlotte/Hecate Basin could contain about four times the recoverable gas volume of the Sable Offshore Energy Project.

There is no way of constructing confidence bounds around these estimated recoverable volume ratios, which must therefore be treated as highly speculative. Moreover, the proportionality assumption made below cannot be justified by reference to existing empirical data.

Using these recoverable volume ratios and an assumption of proportionality, the following ***purely illustrative*** estimates may be obtained for the Queen Charlotte/Hecate Basin: cumulative development employment, 83,590 person-years, cumulative development expenditures, $23,630 million, annual production employment, 3,440 person-years, and annual production expenditures, $1,037 million. Although development employment might be confined to a relatively small number of years (for example, ten years), production employment and production expenditures could be spread out over a time period that lasts as long as forty years. The calculations underlying these hypothetical estimates are assembled in the following table.

Annual production employ (person-yrs)

Hibernia:	800 x 2	=	1,600
Terra Nova:	440 x 2	=	880
Sable Project:	240 x 4	=	960
Total		**=**	**3,440**

Cumulative development employ (person-yrs)

Hibernia:	21,000 x 2	=	42,000
Terra Nova:	21,000 x (64.6/140.5) x 2	=	19,310
Sable Project:	5,570 x 4	=	22,280
Total		**=**	**83,590**

Annual production costs ($million)

Hibernia:	$300 x 2	=	$ 600
Terra Nova:	$300 x (25/83) x 2	=	$ 181
Sable Project:	$ 64 x 4	=	$ 256
Total		**=**	**$ 1,037**

Cumulative development costs ($million)

Hibernia plus Terra Nova:	$8,615 x 2	=	$ 17,230
Sable Project:	$1,600 x 4	=	$ 6,400
Total		**=**	**$ 23,630**

The $23,630 million estimate for cumulative development expenditures is, of course, an undiscounted sum, and is not commensurable with the NPV analysis presented earlier. However, assuming a ten year development period and an 8% real discount rate, the undiscounted cumulative sum for capital costs that is implicit in our earlier NPV estimates is $19,560 million. Moreover, the $23,630 million estimate is probably overstated, since some of the cumulative development expenditures in the Newfoundland and Labrador offshore are attributable to Whiterose and various other projects, rather than to Hibernia and Terra Nova. In addition, in the simple addition of the elements generated by the Hibernia, Terra Nova, and Sable Project analogies, no allowance has been made for economies of scope and scale. Nevertheless, overall expenditures per person-year of development employment created are estimated to lie between $234,000 and $283,000. These numbers compare with average payroll expenditures of $70,000 per person-year for the development phase of the Sable Offshore Energy Project.

Similarly, the $1,037 million estimate for annual production expenditures is not directly commensurable with the NPV analysis presented earlier. However, assuming a forty year project life and an 8% real discount rate, the equivalent annual value for operating costs that is implicit in our earlier NPV estimates is $943 million per annum. As a result, overall expenditures per person-year of production employment created are estimated to lie between $274,000 and $301,000. These numbers compare with average payroll expenditures of $83,000 per person-year for the production phase of the Sable Project, and $86,000 per person-year for the Hibernia Project. Clearly, the production and development of crude oil and natural gas are capital-intensive activities.

Employment Creation and Income Generation Effects

The estimates provided in this section are hypothetical, speculative, and based upon just one of many plausible development scenarios. No special significance should be placed on these illustrative estimates.

Even if the previous estimates were credible, not all of the development and production expenditures would be made on goods and services that are produced in B.C. Nor would all of the development and production employment refer to B.C.-based workers. Using the source-related percentages pertaining to the Sable Offshore Energy Project for development, and the source-related percentages pertaining to the Hibernia Project for production, the proportions of direct income-generating and employment-creating expenditures that might stay within B.C. could be estimated. The resulting estimates would likely be conservative, largely because the overall B.C. economy is much larger than both the Newfoundland and Nova Scotia economies, and, as a result, the leakages from the circular flow of provincial income and expenditure should be smaller for B.C. than for the two Atlantic Provinces.

Annual B.C. production employment

83% of 3,440 = 2,850 person-years
Estimated labour income = $245 million/year

Cumulative B.C. development employment

53% of 83,590 = 44,000 person-years
Estimated labour income = $3,080 million

Annual B.C. production expenditures

64% of ($1,037 - $296) = $475 million/year
Income-generating impact in B.C. including direct labour income = $720 million/year

Cumulative B.C. development expenditures

28% of ($23,630 - $5,850) = $5,000 million
Income-generating impact in B.C. including direct labour income = $8,080 million

In addition to these estimated direct impacts for income-generation and employment-creation within the Province of B.C., there would also be impacts for other Canadian Provinces and, in particular, for Alberta. Cumulative development expenditures for Canada as a whole, including B.C., are likely to be about twice those for B.C., and cumulative development employment could be about fifty percent larger, based upon source-related percentages pertaining to the Sable Offshore Energy Project. Smaller, but nevertheless significant, impacts for Provinces other than B.C. are also likely at the production stage.

It is worth remembering that the production-based estimates are annual averages pertaining to an overall project life that could be as long as forty years. The development-based estimates are undiscounted cumulative sums. The overall development stage could last for ten years, and perhaps longer. How much of the income-generating and employment-creating impacts could be harnessed in local communities within the CIT *Area of Interest* would depend upon government policy responses and community initiatives.

In proportional terms, Prince Rupert is likely to experience the most significant income-generating and employment-creating impacts from potential offshore oil and gas activity in the Queen Charlotte/Hecate Basin. Indeed, Prince Rupert would, almost inevitably, become the regional service centre for offshore oil and gas activity. However, drilling platforms are likely to be assembled closer to the Lower Mainland area of B.C., before being towed to the most promising drilling sites.

There would also be indirect and induced income-generating and employment-creating effects of both offshore and onshore oil and gas activity, assuming that onshore activity is permitted on Haida Gwaii. Estimates of these effects would depend upon the sizes of the multipliers that are assumed. In the context of potential oil and gas activity in the Queen Charlotte/Hecate Basin, provincial income and employment multipliers of about two are recommended. These multipliers should be applied to the direct B.C.-based impacts, for which estimates have been provided above. Local multiplier effects would be smaller that these, given the inevitability of major activity spill-overs outside the CIT *Area of Interest.*

Concluding Remarks

This paper has provided a methodological framework for estimating the economic potential of the conceptual hydrocarbon resource plays of the Queen Charlotte/Hecate Basin. The underlying methodology involves the use of a net present value (NPV) approach to the estimation of the expected private and public resource rental values that could be associated with the resource. The private resource rental value takes the form of an *option value* for the resource, while the public resource rental value depends upon the fiscal regime that would apply to potential pools of crude oil and natural gas, if they were discovered and developed.

The underlying methodology also proceeds by way of analogy to convert resource values into estimates of employment creation and income generation effects. The method of analogy depends upon finding a comparable operating regime somewhere else in the world, and is limited by the closeness of comparability. In this paper, East Coast offshore developments are used as a benchmark for estimating the possible employment and income consequences of potential oil and gas development in the Queen Charlotte/Hecate Basin, should the existing moratorium on exploration activity be lifted. It is conceivable that a better benchmark may be available, elsewhere in the world, for possible method of analogy application to the estimation of the potential employment and income effects associated with the development of the Queen Charlotte/Hecate Basin.

Direct employment creation and income generation effects need to be truncated in order to separate provincial and local impacts from those that percolate elsewhere in the world. The provincial and local impacts may then be augmented by suitable multipliers, if estimates of indirect and induced effects are required. The extent to which employment creation and income generation effects can be captured locally will depend upon local initiatives and provincial policies, including the availability of appropriate skills-training spaces. The nature of petroleum technologies is such that major activity spill-overs outside the local economy are inevitable.

This paper has also provided illustrative estimates of private and public resource rental values, and of employment creation and income generation effects. ***These estimates are provided only as illustrations of the underlying methodologies, and no special significance should be attributed to these hypothetical values. Major geological and economic uncertainties, and other data limitations, make it impossible to generate accurate or reliable estimates at this time.***

It is nevertheless the case that the conceptual hydrocarbon resource plays of the Queen Charlotte/Hecate Basin could have enormous economic potential. Given appropriate environmental safeguards, this potential could be realized, thereby generating important socio-economic benefits for the provincial and local economies.

Appendix A

Crude Petroleum and Natural Gas Potential: Queen Charlotte/Hecate Basin

Geological Survey of Canada Data

Crude Oil Potential (resource volume in place in million cubic metres)

	Expected No. of fields	Median play potential	Mean play potential	Median of largest field size
Pliocene Oil	13	398	652	233
Miocene Oil	28	574	668	165
Cretaceous Oil	62	392	478	96
Total Oil	103	1560		

Natural Gas Potential (resource volume in place in billion cubic metres)

	Expected No. of fields	Median play potential	Mean play potential	Median of largest field size
Pliocene Gas	30	322	390	96
Miocene Gas	40	286	317	71
Cretaceous Gas	50	75	94	21
Total Gas	120	734		

Canadian Gas Potential Committee Data

Natural Gas Potential (resource volume in place in billion cubic metres)

	Expected No. of fields	Total risk	Mean play potential	Mean size of largest field if field exists
Pliocene Gas	5	0.136	62	83
Miocene Gas	17	0.225	137	92
Cretaceous Gas	7	0.080	14	26
Total Gas	29		213	

Geological Survey of Canada Data

Median Recoverable Resource Volume Comparisons

	Queen Charlotte Basin	Newfound-land Jeanne d'Arc Basin	Nova Scotia Shelf Basin	Beaufort-Mackenzie Basin
Total Oil (mcm)	413	747	159	1,113
Total Gas (bcm)	567	368	510	1,926

Appendix B

Crude Oil and Natural Gas Statistics: Jeanne d'Arc Basin and Nova Scotia Shelf

	Newfoundland & Labrador				Nova Scotia Shelf	
	Hibernia & Avalon	Terra Nova	White Rose	Hebron	Sable Island	Cohasset
Crude oil						
Disc. reserves (mcm)	140.5	64.6				7.2
Est. resources (mcm)			45.0	51.6		
Production (mcm/yr)	9.5	5.5				
Natural gas						
Disc. reserves (bcm)	38.7	7.6			85.0	
Est. resources (bcm)			76.7			
Production (bcm/yr)					5.5	
Natural gas liquids						
Disc. reserves (mcm)	23.0	2.2				
Est. resources (mcm)			15.3			
Misc. statistics						
Wells drilled	10	9	4	1		
Water depth (m)	80	93	119	94	22-76	
Well depth (1000 m)	2.3-3.8	3.3	3.0-3.8			
Est. field life (years)	18				25	6

Sources: Canada Newfoundland Offshore Petroleum Board (www.cnopb.nfnet.com), and Canada Nova Scotia Offshore Petroleum Board (www.cnsopb.ns.ca)

Appendix C

Measures of Oil and Gas Activity Levels: Newfoundland and Labrador

Cumulative Newfoundland Offshore Area Program Expenditures (million Can$)

	Exploration 1966-2001	Pre-devel. 1984-2001	Development 1990-2001	Production 1997-2001	Total
Expenditures	4,343.9	324.0	8,615.1	1,372.20	14,655.20
Person-years	4,000				

	Devel. Employment Person-years	Prod. Employment Person-years Annual	Prod. Employment Person-years Cumulative	Prod. Expenditures Million Can$ Annual	Prod. Expenditures Million Can$ Payroll	Prod. Expenditures Million Can$ Cumulative
Hibernia	21,000	800	13,300	300	69	8,300
Terra Nova		440	6,000			2,500

Notes: $191 million (64%) of production expenditures and 662 person-years (83%) of production employment occurred in Newfoundland. *Sources:* ExxonMobil Canada (www.hibernia.ca), and Canada Newfoundland Offshore Petroleum Board (www.cnopb.nfnet.com)

Appendix D

Measures of Oil and Gas Activity Levels: Nova Scotia Sable Island Project

Development Phase Cumulative	Direct Outlays $1995 million	Materials Requirements $1995 million	Labour Requirements Wages/salaries	Person-years
Engineering	152	38	114	1,630
Drilling	540	459	81	1,160
Platforms	288	216	72	1,030
Pipelines	396	339	57	820
Gas Plant	144	101	43	610
NGL Facilities	80	56	24	320
Sub-total	1,600	1,209	391	5,570
Other development costs	400			
Grand total	2,000			

Production Phase Annual	Direct Outlays $1995 million	Materials Requirements $1995 million	Labour Requirements Wages/salaries	Person-years
Platforms	20	14	6	75
Pipeline & Marine	20	14	6	69
Gas Plant & NGL Facilities	12	8	4	40
Shore Base & Office	8	5	3	40
Well Servicing	4	3	1	16
Sub-total	64	44	20	240
Other production costs	16			
Grand total	80	Cumulative total over 25 year project life: $2 billion		

Breakdown of Costs by Source of Materials or Labour ($1995 million)

	Development			Production		
	Total	Materials	Labour	Total	Materials	Labour
Nova Scotia	547	341	206	47.0	28.0	19.0
Rest of Canada	473	355	118	11.5	11.0	0.5
Non-Canadian	580	513	67	5.5	5.0	0.5
Total	1,600	1,209	391	64.0	44.0	20.0

Notes: Cumulative expenditures on the Sable Offshore Energy Project to June 30, 2001, totaled $2,557 million, or which $870.3 m (34%) occurred in Nova Scotia, $402.4 m (16%) in the Rest of Canada, and $1,284.3 m (50%) in other countries. Cumulative employment to the same date totaled 8,000 person-years, of which 4,400 person-years (55%) was Nova Scotian, 900 person-years (11%) was Other Canadian, and 2,700 person-years (34%) was non-Canadian. Similar data pertaining to the Cohasset Project, from which production started in 1992, are also available from the Canada Nova Scotia Offshore Petroleum Board web-site. Cumulative expenditures and employment for the Cohasset Project totaled $1,454 million and 4,776 person-years, respectively.

Sources: Sable Offshore Energy Project (www.soep.com), and Canada Nova Scotia Offshore Petroleum Board (www.cnsopb.ns.ca)

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CIT-EGSA Minerals Sector Study

Section 1.
Economic Gain Scenarios

Background

The Coast Information Team

The Coast Information Team (CIT) is an independent, multi-disciplinary group set up to provide locally and internationally credible information and develop decision-making tools for the Central and North Coast, and Queen Charlotte/Haida Gwaii, land and resource management planning tables and First Nations' land use plans in the region. The CIT is not a decision-making body. Its mandate is to bring together the best available scientific, traditional and local knowledge, environmental expertise and community experience to develop information and analyses to present to the three planning tables. The team will conduct regional and sub-regional analyses to provide ecological and socio-economic context for planning.

To fulfill its mandate, the CIT has been tasked with:

- developing a framework for consistent decision-making based on Ecosystem-Based Management (EBM),
- undertaking assessments and spatial analyses of ecological, social, or economic conditions, trends, potentials, and values in the CIT region,
- providing technical support to EBM pilot projects in the CIT region, and
- developing EBM tools such as a hydro-riparian decision tool.
- All of these tasks are to be completed by June, 2003.

The CIT Area

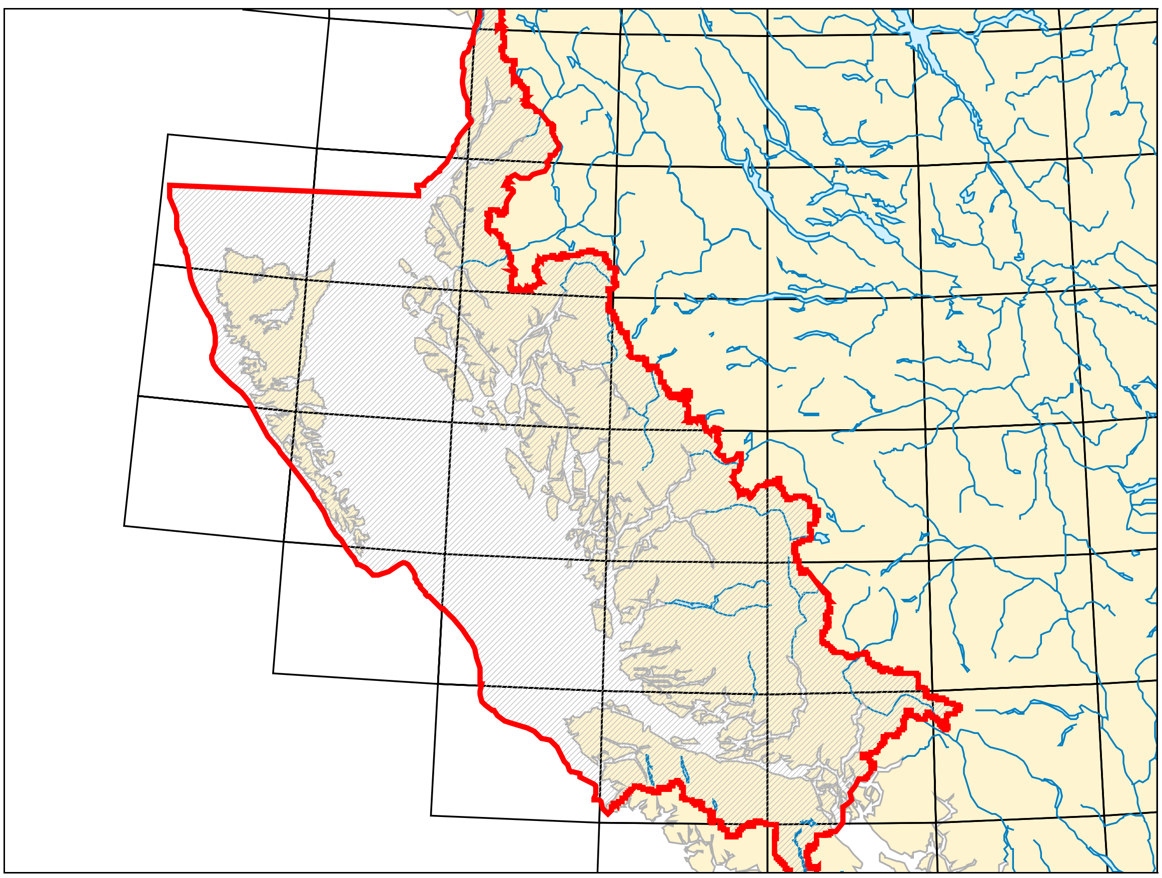
The core CIT region consists of 8 million hectares comprising the Haida Gwaii/Queen Charlotte Islands, the areas covered by the North Coast and Central Coast Land and Resource Management Plans (LRMPs), and the coastal portion of the area covered by the Kalum South LRMP. A 2 million hectare supplementary region includes northeast Vancouver Island. The core CIT region corresponds roughly to the Skeena-Queen Charlotte Regional District and part of the Stikine Regional District Subdivision A (drainages into Portland Canal, Observatory Inlet, and Portland Inlet, except the Nass), part of the Kitimat-Stikine Regional District Subdivision D, the Central Coast Regional District, Mount Waddington Regional District Subdivision A, and part of the Comox-Strathcona Regional District Subdivision A.

Table 1: CIT Area

CIT Subregion	Approximate Area (hectares)
Queen Charlotte Islands/Haida Gwaii	1.0 million
North Coast LRMP	2.0 million
Central Coast LRMP	4.8 million
Supplemental (North Vancouver Island)	2.0 million
Total	9.8 million

The supplementary region includes Mount Waddington Regional District Subdivision B, the rest of Comox-Strathcona Regional District Subdivision A, and Comox-Strathcona Regional District Subdivisions B and C.

Figure 1 CIT Area



CIT Economic Gain Spatial Analysis

The Economic Gain Spatial Analysis (EGSA) project will cover the core CIT region and may also cover the supplementary region, depending on the cost and time required. The EGSA project will develop alternative "portfolios" of land to be allocated to economic development that will subsequently be used by the CIT and the planning tables to explore options and scenarios around alternative combinations of biodiversity conservation, maintenance of cultural values, and economic development. Nine economic sector studies will contribute to the EGSA project. For each economic sector, consultants will:

1. Identify and map sites of current or potential economic gain. "Sites" may be points, lines, or polygons, depending on the sector.

2. Estimate the value of each site or group of sites (megasites), based on a defined economic gain scenario. Economic value will be expressed as dollars, jobs, or subsistence (e.g., nutrients). Where appropriate, separate scenarios will be required to estimate commercial and traditional/subsistence values.

3. Rate sites or megasites for irreplaceability and vulnerability.

Economic Gain Scenarios

Each sector consultant is required to define a number of Economic Gain Scenarios (EGS), and will describe the scenarios according to various factors, as outlined in the Table below.

Table 2

Factor	**Example**
The type of gain	Revenue, jobs, food
How the gain would be obtained	Export of raw logs, local millwork and joinery plant, local food supply, tourist lodge
The potential size and structure of the gain	Total revenue and the breakdown of revenue into employment income (labour costs), cost of other inputs, and profit
The distribution of the gain	The expected local/non-local share of the gain
Minimum and maximum levels of the activity concerned	Minimum levels required for the activity to be economically viable. Maximum levels at which the activity would be sustainable
What is required to realize the gain	In terms of resource ownership or tenure, product development, market development, infrastructure, human resources, and cost assumptions
Vulnerability to external change	Changes in market, policy, or environment
Compatibility with other uses of the area (or other values associated with the area)	What sectors, if any, would impair or enhance the activity or be impaired or enhanced by it?
Anticipated impacts on the ecosystem and how they could be reduced or mitigated	Impacts on biodiversity, and the quality of land, water, and air

The Minerals Sector

Minerals Industry Fundamentals

The minerals industry is characterized by a number of factors which distinguish it from other resource industry sectors such forestry, hydropower, fishing and hunting:

- Minerals are resources that are largely hidden from the view of those wishing to exploit them. The definition of an economic mineral deposit is time-consuming, costly, and high risk, and requires the use of advanced technologies such as remote sensing and geophysical methods. By some accounts, the likelihood of an individual mineral occurrence eventually being developed as a mine is considered to be perhaps 0.1%, or 1 in 1,000. These figures should be used with caution. Some of these occurrences may be small showings which are simply indications that the geology in the area is amenable to the formation of such minerals. Mineral deposits of measurable size (i.e. tonnage and grades are calculable) are fewer in number, but have a greater likelihood of development.

- Because individual economic mineral deposits are rare, exploration requires that large tracts of land be available for exploration to maximize the chances for locating significant occurrences. Although mineral exploration may encompass large tracts of land, the impacts are relatively limited in terms of duration and severity (eg. disturbances to the surface and environmental effects). The relatively few mining operations that emerge occupy only small areas, by some measures disturbing only 0.1% of the B.C. land mass on a cumulative basis.

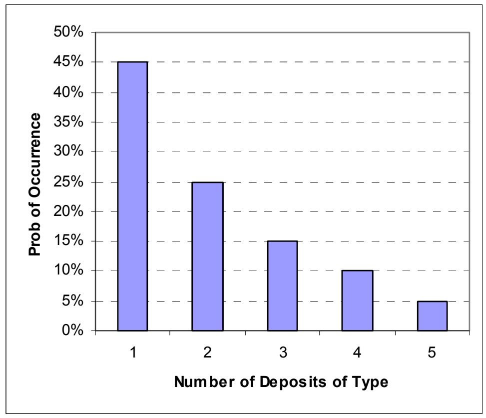
- Mines, once developed, typically produce high values for employment, income and economic rent in relation to the land area disturbed by such activities. According to some reports, B.C. mining activities generate annual direct revenues of about $150,000 per hectare, compared with approximately $5,700 for forestry and $1,400 for agriculture.

- Under-explored Crown lands and mineral deposits that are non-economic under current economic conditions have significant potential values to the Crown as forms of development "call options". New extraction technologies, new uses for metals and market shifts can improve the development prospects for marginal mineral deposits and provide the impetus for renewed exploration.

Geological Survey Branch Mineral Potential Assessments

The B.C. Government through the Geological Survey Branch (GSB) has extensively studied the mineral potential of the province in a spatial sense by assigning relative rankings to defined tracts covering the entire province. These mineral potential tracts, which can range from under 10,000 to over 400,000 hectares in area, were established on the basis of similar geological and potential characteristics. An expert opinion process involving knowledgeable scientists and experts was used to define the types of mineral deposits, and to estimate the numbers of deposits of each type which can be found, within certain confidence limits, in each tract (Figure 2).

Figure 2. Example of Expert-Determined Distribution of Mineral Deposits within a Tract

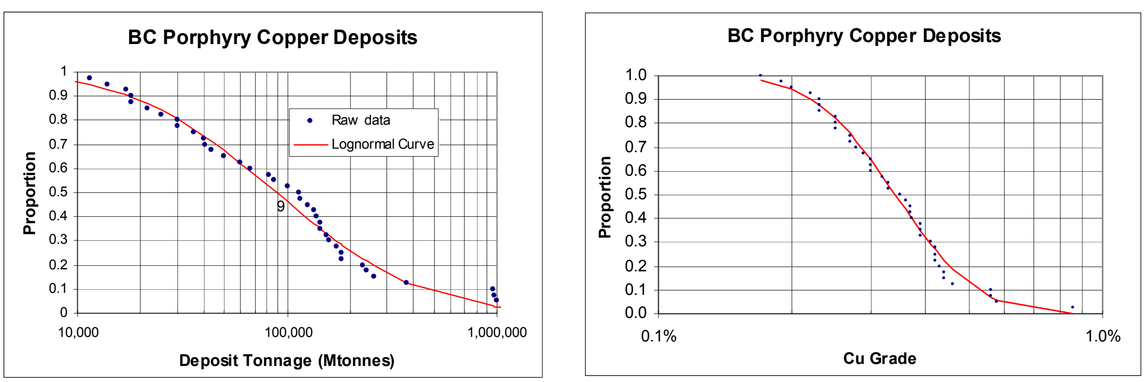


From this process, a relative ranking of the mineral potential of each tract was developed. The results also allow explorationists to determine which tracts are more likely to contain mineral deposits of the desired type.

<u>Deposit Types</u>

Worldwide, there are hundreds of different types of mineral deposits. These are defined by type of metal or mineral associations, the chemistry of the deposit, the style of emplacement and numerous other factors. Within the CIT area, approximately 26 types of metal deposits (gold, copper, zinc, etc.) and 40 types of industrial minerals deposits (eg. aggregate, limestone, granite, gemstones, etc.) are considered relevant (Appendix B). Worldwide tonnage and grade information for each deposit model is widely available.

Figure 3 Examples of Cumulative Probability Curves of Deposit Tonnage and Grade



Minerals Industry Employment

Operating Mines

Operating mines are large generators of employment. According to B.C. government statistics, the full-time employment at nine operating metal mines during 2002 is estimated to be 3,012, an average of 335 direct employees per operation. Historically, employment has averaged about 325 employees per operating metal mine. This corresponds with national figures from Statistics Canada. During 1999, there were 28,527 employees at 82 metal mines, or 348 per mine. Large mining operations such as Highland Valley Copper can employ 1,000 people or more, while smaller operations generally employ around 150 to 250 people.

Employment figures for coal mines are roughly in line with metal mines, averaging nationally 356 employees per coal mine (7,117 employees in 20 operations). In 2001, B.C. coal operations employed 2,869 people in 7 operations, or 410 per coal mine.

In employment terms, non-metallic minerals operations, such as aggregate pits, are typically much smaller than metal mines. In this sector nationally, employment per operation averages 25 people (17,781 employees in 706 operations). B.C. statistics report employment of 3,300 persons in the aggregate sector, implying roughly 130 individual aggregate operations.

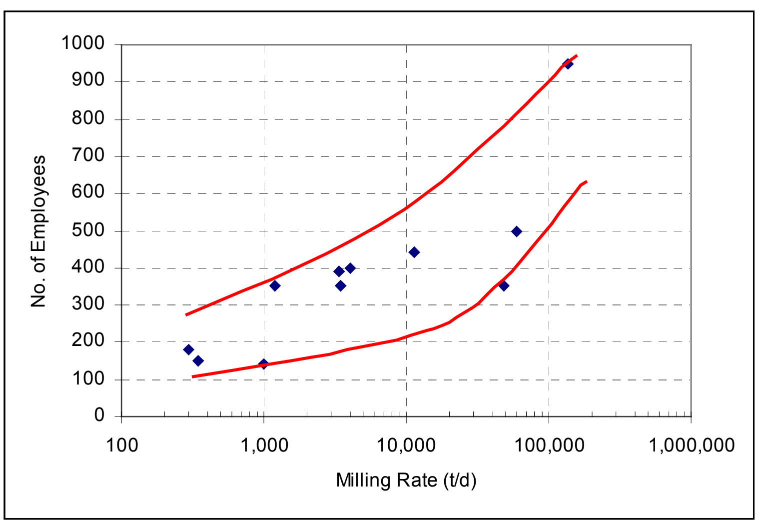
Minerals Exploration

Annual employment in the B.C. mineral exploration sector is estimated at 700 persons, based on B.C. statistics.

Minerals Industry Wages

Average annual wages for the minerals sector are amongst the highest of any sector. Annual wages and benefits in the minerals sector are estimated to range from $75-80,000 per employee based on Statistics Canada and industry figures.

Figure 4. Mine Employees vs Mine Size



Government Taxation of the Minerals Industry

The minerals industry pays direct taxes to governments principally in the form of corporate income tax, mining taxes, provincial sales tax, federal GST, and capital taxes. Provincially, in B.C., companies pay income taxes, mining taxes and sales tax. Capital taxes have been phased out in B.C. Income taxes are profit based, while mining taxes combine a profit-based tax with a minimum annual amount payable based on operating profits. Sales taxes are paid on certain supplies consumed in mining operations such as fuel, tires, etc. No BC sales tax is payable on most mining equipment purchases and leases.

Based on typical operating scenarios, combined B.C. income and mining taxes will take up roughly 18-25% of projected pre-tax project cashflows, net of capital cost allowances.

The B.C. income tax rate is currently 15%. The calculations generally follow federal tax rules with the exception of the federal resource allowance, which is excluded as a deduction, and the B.C. mining tax, which is included as a deduction. The percentage take of the B.C. government increases with mine profitability, because the effective rate of mining tax rate increases beyond the minimum rate of 2% of net current proceeds.

B.C. sales taxes are also payable at a rate of 7.5% on such inputs as tires, explosives, power and supplies. As a percentage of total operating costs, these inputs can vary greatly from perhaps 30-60% of operating costs depending on factors such as mine location and mining methods.

Minerals Sector Economic Gain Scenarios

Due to the wide range and large numbers of deposits types, deposit sizes, commodity outputs, and mining methods, BriMar and Finisterre decided to restrict the scenarios to a select number that are representative of the range of possible types of mineral developments in the CIT study area.

Scenario Development Approach

Scenario development is a process that, for each scenario, requires:

1. selection of a representative deposit type, tonnage and grade;
2. selection of a mine development method, generally underground or open pit;
3. selection of an extraction rate appropriate to the size of the deposit;
4. estimation of capital and operating costs appropriate to the scale and type of operation; and
5. estimation of the economic impacts of the scenario.

Deposit Type and Size

With approximately 60 different deposits types (metal and industrial minerals) occurring in the CIT area, it was not possible to develop individual scenarios for each deposit type. A "generic" approach was used, whereby the possible range of deposit outcomes is narrowed to six types that are representative of the various commodities, scales of operation, and mining methods.

Metal Prices

For the purpose of developing representative economic gain scenarios, a gold price of US$300 per ounce and a copper price of US$1.00 per pound were used. The gold price assumed is currently less than the current spot price of approximately US$330 per ounce (March 24th, 2002). The copper price assumed is higher that the current spot price of US$0.65 per pound, which is depressed by oversupply and lagging demand.

Mine Capital and Operating Costs

The capital investment for a new mineral project is determined by several factors:

1. Project Location. Mining projects that are remotely located, and far from infrastructure, will be more expensive to construct. The cost of construction at a remote site is high, and the project investment may have to include provisions for road access, power lines or a power plant, and employee accommodations.

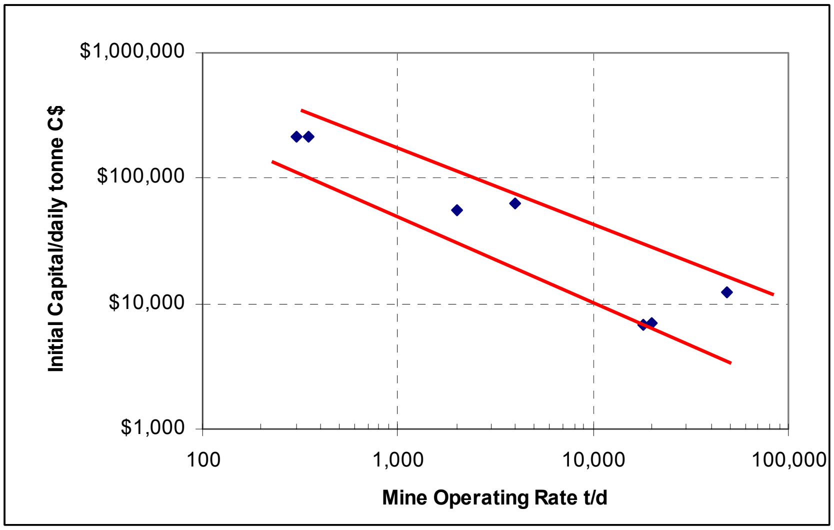
2. Project Scale of Operations. A large mining operation that extracts and processes several million tonnes of ore and waste rock per year will have higher construction costs than a small mine which processes a fraction of that tonnage. The equipment requirements are larger, more numerous, and more expensive. Larger operations will typically have lower unit operating costs, reflective of larger, more efficient equipment and general economies of scale.

3. Type of Mining. There are two basic types of mines: open pit and underground. Open pit mines extract and process ore from surface pits using drilling and blasting techniques, whereas underground mines access the ore via vertical shafts, or via horizontal (adits) or inclined tunnels (declines). The mining method selected is largely a function of the spatial location of an ore body. Ore bodies that are closer to the surface are more likely to be mined via open pit methods.

   Underground mines are generally smaller than open pit mines in terms of extraction rates, but are more expensive to build and operate than open pit mines. As a consequence, underground mines tend to mine ore bodies with higher unit values.

4. Type of Metal Extraction. Mined ore is transported to a processing facility where the ore is usually crushed and milled to reduce its size in order to liberate the metal of interest from the other minerals that surround it. The metal is then recovered using a variety of processes that employ the physical or chemical properties of the metal or mineral of economic interest to separate it from the remaining material. The required capital investment can vary widely depending upon the selected processing method.

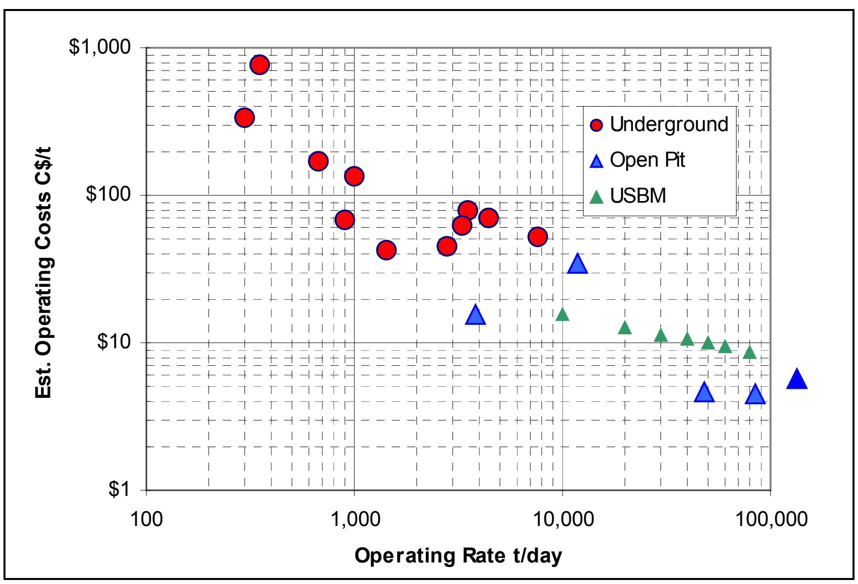
Figure 5. Mine Capital Costs vs Scale of Operations



Mine Operating Costs

Unit operating costs for mining operations vary widely (Figure 6). This wide variance is caused by a variety of factors, primarily differing mine locations, mining methods (including strip ratio for open pit mines), and metal extraction methods employed.

Figure 6. North American Mine Operating Costs



Mine operating costs include a significant component of mine reclamation costs either as direct ongoing reclamation expenses, bonding expenses, or the cost of funding a closure and reclamation plan. This is a regulatory requirement of any new mining project.

Reclamation costs vary substantially depending on the type of mining operation. Large open-pit mines have greater impacts and can naturally be expected to have greater reclamation costs than small underground operations. A rough rule of thumb is that reclamation costs range from 5-15% of initial capital costs, with these costs spread out over the life of the mining operation. Part of the final reclamation costs is often assumed to be offset by the salvage value of mine and processing equipment.

In selecting unit mining costs for the development of economic gain scenarios, BriMar and Finisterre respected the actual mining costs of similar known deposits while allowing the net economic value of the ore deposits to be sufficient to provide reasonable project economics. It would make little sense to develop economic gain scenarios that provided no direct economic benefits.

Mineral Project Economics

The vast majority of mineral deposits in B.C. are owned by the Crown. The Province, in right of the Crown, grants the private sector rights to explore for and develop mineral deposits subject to the mining and environmental laws governing such development. No private company will initiate development of a mineral deposit without the expectation of future returns/profits on its investment. These future profits must be high enough to at least repay the capital investment and provide sufficient returns to compensate the developer for the anticipated project risks.

While many known mineral deposits in B.C. are not large or rich enough to justify development under present conditions, future developments can often render these deposits to be economic. Examples of such developments might be higher metal prices, exploration resulting in increased deposit size, new mining incentives, or better, lower cost extraction technologies. Additionally, remote deposits can become economically more attractive as infrastructure development (e.g. better roads, power lines, etc.) moves closer.

Output Factors

1. Construction Employment

While large capital projects in the minerals sector have a significant labour cost component, it is a relatively low percentage compared with the cost of equipment, steel, concrete, transportation and other elements of the total construction budget. The USBM costing model suggests that typical capital projects in the mining sector have a 10-15% labour component. For the economic gain scenarios, this percentage was applied to the assumed total construction costs. The resulting dollar figure for labour costs was divided by $80,000 per employee (the average annual wages and benefits assumed) to yield an estimate of direct person-years of construction employment.

For example, a $100 million capital project with a direct labour cost component of 15% yields labour costs of $15 million, equivalent to 187 person-years of construction employment.

2. Operating Employment

The labour cost component of mine operating costs varies widely depending on the type of mining method and the size of operation. For example, large-scale open pit mines will generally be less labour intensive than small underground mines. Labour productivity at Highland Valley Copper (which processes over 100,000 tonnes of ore per day) is equal to about 48,000 tonnes of ore per employee per year, whereas it is around 3,000 tonnes annually per employee at Boliden's Myra Falls underground mine (which processes 3,500 tonnes per day). Labour productivity is smaller still (under 1,000 tonnes annually per employee) at some smaller underground mines.

Labour costs can account for 60% or more of operating costs at some smaller labour-intensive underground mines. For each scenario, BriMar and Finisterre selected a labour cost factor (as a percentage of total operating costs) appropriate for the type of operation being considered. The labour cost portion was divided by the average annual wage to give predicted annual employment. Life-of-mine employment in person-years was obtained by multiplying annual employment numbers by mine life.

For example, a 1,000 tonne per day underground mine with a 10 year mine life has projected operating costs of $100/tonne, and annual total operating costs of $36.5 million. Labour accounts for, say, 50% of these costs, or $18.25 million. Using $80,000 in annual wages and benefits per employee, this equates to 228 employees per year over a 10 year mine life, or 2280 person-years of direct employment in total.

3. Direct Tax Revenues

Combined direct B.C. corporate income and mining tax revenues were estimated using a 20% combined rate applied to project pre-tax net cashflows (ie. revenue less operating and capital costs). B.C. sales tax was estimated by applying the 7.5% sales tax rate to a portion (30%) of mine operating costs.

4. Private Sector Income

The private sector income or project net cashflow is equal to revenues less operating costs, capital costs and taxes on either an annual or life-of-mine basis.

Discounting

Future revenue streams were discounted annually using an eight percent real discount rate. Using this discount rate, an annuity factor was calculated corresponding to the mine life for each scenario, and then applied to future annual revenue and cost streams. The resulting net present values (NPVs) were further discounted to reflect an assumed three-year construction period.

Economic Gain Scenarios for the Minerals Sector

The economic gain scenarios for the minerals sector are detailed in this section. Further descriptions and outputs of the six individual scenarios are provided in Appendix A.

Type of Gain

In the minerals extraction sector, the economic gains are:

- the production and sale of minerals and metals that are useful to society,
- direct minerals sector employment,
- private sector profits, and
- tax revenues accruing to the governments that own these minerals and metals.

How the Economic Gain is Obtained

Economic gains in the minerals sector involve the construction of mineral extraction and processing operations, and the subsequent production of minerals or metals for sale to markets that are, primarily, offshore. This sales revenue returns to the Province to pay for the costs of production, including interest, wages, salaries, fuel, power, supplies, services, taxes and, hopefully, profits. Operating mines, and especially the larger ones, employ substantial numbers of skilled and semi-skilled labourers with relatively high wage levels, and contribute substantial amounts of direct and indirect tax revenue to regional and provincial governments.

Potential Size and Structure

The size and structure of the potential economic gains are illustrated in the detailed gain scenarios in Appendix A. There are wide variations in economic impacts among the scenarios. Large mining operations are huge generators of employment and income, creating hundreds of jobs and hundreds of millions in annual revenue. In contrast, individual prospectors (say, for gemstones such as jade) can start small-scale mining with a pick and shovel, generating annual revenues in the thousands of dollars and only enough income to sustain themselves.

Table 3. Summary of Gain Scenarios

Economic Gain Scenario--->		Large Scale Base Metals Open pit		Small Scale Base Metals Open pit		Small-scale Underground Precious Metals		Large Underground Polymetallic Mine		Low Unit-value Industrial Minerals Operation		Artisanal Mining Operation		Coal	
Economic effects		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Annual Revenues	$millions	$137.9	$183.9	$46.0	$61.3	$43.8	$237.3	$54.8	$109.5	$1.1	$9.1	$0.2	$0.4	$6.4	$27.4
Construction Employment	man-yrs	350	950	150	400	50	100	150	200	9	16	N/A	N/A	19	31
Lif-of-Mine Employment	man-yrs	6,750	15,000	2,250	3,750	800	2,520	1,610	6,150	45	420	3	20	140	1,860
Direct BC taxes	Undis	$118.1	$284.6	$38.9	$101.9	$25.9	$189.3	$19.5	$124.8	$19.5	$124.8	$0.0	$0.7	$7	$70
Direct BC taxes	Disc 8%	$53.5	$96.5	$17.6	$34.6	$16.4	$111.8	$11.5	$56.5	$0.5	$8.7	$0.0	$0.3	$4	$21
Investment	Undis	$275.0	$500.0	$125.0	$200.0	$50.0	$100.0	$100.0	$250.0	$5.0	$30.0	$0.1	$0.5	$10	$30
Investment	Disc 8%	$236.2	$429.5	$107.4	$171.8	$43.0	$85.9	$85.9	$214.8	$4.3	$25.8	$0.1	$0.4	$9	$26
Life of Mine Cashflow	Undis	$449.2	$1,109.4	$150.9	$413.1	$59.5	$564.3	$53.3	$571.3	$4.9	$134.3	$0.2	$3.2	$35	$299
Life of Mine Cashflow	Disc 8%	$91.8	$116.0	$17.6	$36.0	$26.5	$306.3	$4.6	$157.3	$0.2	$23.2	$0.1	$1.0	$15	$72

Distribution of the Economic Gains

The distribution of economic gains between the local and non-local community will vary widely depending on the location of the mining operation in relationship to existing communities and infrastructure. Those mining operations that are located relatively close to communities can expect to have a great impact on the local economy, stimulated by increased demands for goods and services generated by the mine and by its employees, most of who will choose to live nearby. Mines that are located far from community infrastructure often develop fly-in fly-out operations, with employees living in communities far from the mine-site and transported into the site on a scheduled basis. This second situation tends to distribute the economic benefits of a mining operation more widely due to the dispersal of its employees far from the location of the mine itself.

The ability of the existing members of the local community to obtain employment at a new mining operation will depend on the type and mix of their available skills and the extent of any training programs made available by the project sponsors.

The non-labour components of mine costs include fuel, supplies, and services. The economic benefits of these purchases are widely dispersed.

Minimum and Maximum Levels of Mining Activities

Apart from artisanal operations and the smaller industrial minerals operations, mines generally operate at extraction rates in excess of 300 tonnes per day. Open pit mines typically operate at extraction rates of 1,000 tonnes per day to 100,000 tonnes per day or more for the very largest mines. Underground mines are generally much smaller than surface operations, with daily extraction rates ranging from 300 tonnes per day for small mines to 10,000 tonnes per day for large-scale underground operations.

Elements Required to Realize the Gain

Minerals exploration involves long time periods leading from exploration and discovery to development (perhaps 10 years or more in some cases). The industry is characterized by high risks and high capital intensity. With such high technical risk, the industry looks for:

- a stable political environment;
- access to land for exploration purposes;
- stable and predictable mineral tenure systems;
- policy regimes that do not discourage or prohibit project development once an economic discovery has been made; and
- a reasonable sharing of available project profits between the project developer and the government that is commensurate with the risks.

For an individual mineral project development to proceed, a sponsoring company requires:

- a technically feasible project, typically demonstrated in an engineering Feasibility Study that examines all aspects of a project including its economic viability under current and expected product prices.
- the ability to transport the product to market;
- the ability to obtain the required development and operating permits from government;
- sufficient expected future profits to attract investment capital;
- a sales contract, in the case of industrial minerals or coal, with a contract term long enough to repay all, or a substantial portion, of the required capital investment; and
- a skilled labour force.

Vulnerability to External Changes

Minerals production involves the sale of diverse products to markets that are often quite different. For example, gold is a fungible product. Gold markets are well established, and spot and forward prices are readily available through a simple scan of the financial pages. Buyers are always available. At the other extreme, the sales prospects for an industrial mineral can be quite specific to an individual market, or to just a few consumers. Markets are not well established and must be pursued vigorously. Volumes and prices for industrial minerals (and coal) are most often negotiated by contract with a purchaser for a defined length of time.

Producers of many metals and minerals are vulnerable to product price movements that are driven by such external factors as the world economic outlook, and the supply and demand for individual metals. For producers of metal concentrates, an additional factor is introduced -- the need to find a smelter with the capacity to take the concentrate and the ability to handle the various impurities that may be found in the concentrate. A metal concentrate that has no smelters able to process it implies a non-viable mining project.

Compatibility with Other Uses of the Area

Mines are industrial operations that are incompatible with some other land uses in the immediate vicinity of the operation during the period of active mining. The industrial character and visual aspects of mining operations will generally rule out tourism-related activities. To the extent that mining activities diminish the local abundance of wildlife, hunting opportunities may also be impacted during the period of active mining.

According to some figures, mining activities have directly affected only 0.1% of the surface land area of B.C. The relatively small areal footprint of individual mining operations, compared with, say, forestry, tends to limit the extent of impacts on other potential land uses.

Anticipated Impacts on the Ecosystem

Minerals extraction can affect the ecosystem in a number of ways, both short term and medium term. Mining operations require access via road, water, air or some other form of transportation for the movement of supplies and finished products. Some of the materials moving along these routes may be harmful to the environment should an accident introduce these substances into local airsheds or watersheds. These access routes may traverse sensitive areas and cause surface disturbance, impact wildlife, flora and wilderness values, at least for the period of mining operations. Additionally, construction of an access route into a mine-site may open up a wilderness area to other users, thus generating other impacts, both positive and negative.

Mining operations, particularly larger open pit operations, have a surface footprint totaling hundreds of hectares, including the pit itself, the tailings storage areas, and the associated mill buildings. Mining operations have obvious visual impacts. Underground operations generally lead to a smaller area of surface disturbance. Reclamation planning and reclamation bonding is required of mining companies to ensure that, after closure, mine-sites are returned to a safe state, as close to the pre-development state as possible.

Many types of mines use water in their processing operations. This process water, combined with surface water runoff, can occasionally lead to the accidental discharge of contaminated water to the environment. Mines and other industrial operations (and cities and towns for that matter) are required by regulation to manage and, if required, treat discharge water to avoid or minimize damaging effects when this water is returned to the environment.

Mines also employ equipment such as trucks, shovels and, in some cases, diesel power generators that generate noise and air emissions. These emissions can affect local air quality. Exhaust emissions can be mitigated by employing new cleaner-burning technologies, as they emerge. In some cases, it is feasible to develop local hydroelectric power sources, and thus reduce, or even eliminate, the reliance on diesel generators.

Mitigation of Environmental Impacts

Minimizing the effects of mining operations starts with careful engineering designs that both limit surface disturbances, and incorporates technologies that keep environmental impacts to a minimum. For those impacts that are unavoidable, mitigation efforts can include control of surface water, discharge water monitoring and treatment if necessary (including assessment of ARD potential), reclamation and re-vegetation of waste dumps during and after mining activities, habitat enhancement or replacement, and after mining cessation, the removal of structures, re-contouring, re-vegetation and ongoing monitoring of waste dumps and tailings disposal areas. Depending on the circumstance mine access roads can also be reclaimed or gated to control public access.

Sample Potential Impacts of a Mining Operation

Impact	**Open pits**	**Under ground**	**Waste Dumps**	**Tailings Storage**	**Process Plant**	**Ancillary Facilities**	**Access Roads**
Topography/Landscape appearance	P	N	P	P	N	N	P
Hydrology	P	N	P	P	N	N	N
Surface Water Quality	T	N	T	T	N	N	N
Groundwater Quality	T	T	T	T	N	N	N
Fisheries	T	N	T	T	N	N	N
Wildlife	T	T	T	T	T	T	T
Vegetation	T	T	T	T	T	T	T

P=Permanent Effect T=Temporary Effect N=No Material Effect

Section 2.
Subtract Valuation Methodology

Minerals Sector Economic Gain Scenarios

Six economic gain scenarios *(EGSs)* were previously developed to be generally representative of the types of mineral developments and their likely economic effects. A seventh scenario was later added to represent a typical coal development. The table below summarizes these scenarios.

Table 4. Summary of Gain Scenarios

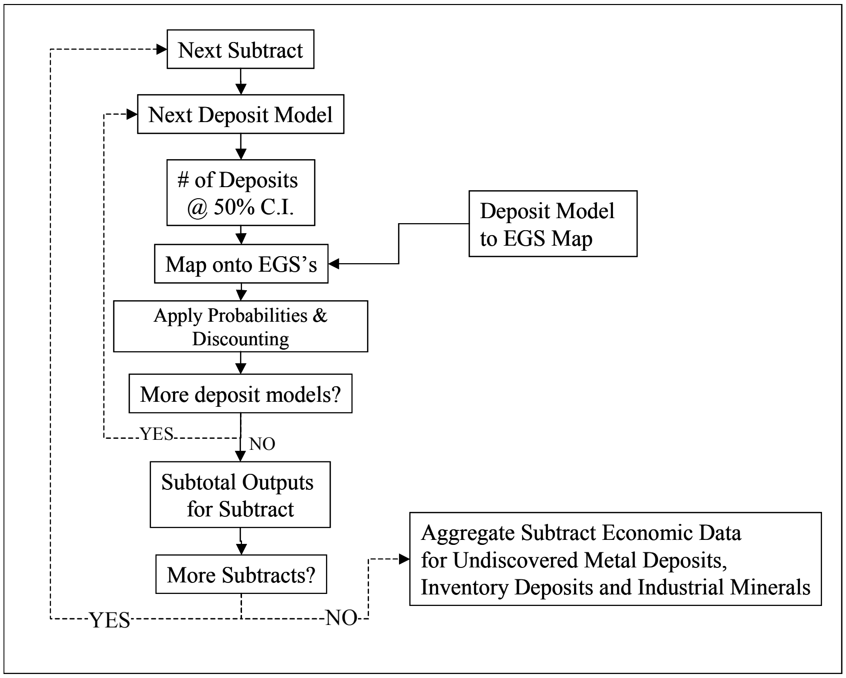
Economic Gain Scenario--->		Large Scale Base Metals Open pit		Small Scale Base Metals Open pit		Small-scale Underground Precious Metals		Large Underground Polymetallic Mine		Low Unit-value Industrial Minerals Operation		Artisanal Mining Operation		Coal	
Economic effects		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Annual Revenues	$millions	$137.9	$183.9	$46.0	$61.3	$43.8	$237.3	$54.8	$109.5	$1.1	$9.1	$0.2	$0.4	$6.4	$27.4
Construction Employment	man-yrs	350	950	150	400	50	100	150	200	9	16	N/A	N/A	19	31
Lif-of-Mine Employment	man-yrs	6,750	15,000	2,250	3,750	800	2,520	1,610	6,150	45	420	3	20	140	1,860
Direct BC taxes	Undis	$118.1	$284.6	$38.9	$101.9	$25.9	$189.3	$19.5	$124.8	$19.5	$124.8	$0.0	$0.7	$7	$70
Direct BC taxes	Disc 8%	$53.5	$96.5	$17.6	$34.6	$16.4	$111.8	$11.5	$56.5	$0.5	$8.7	$0.0	$0.3	$4	$21
Investment	Undis	$275.0	$500.0	$125.0	$200.0	$50.0	$100.0	$100.0	$250.0	$5.0	$30.0	$0.1	$0.5	$10	$30
Investment	Disc 8%	$236.2	$429.5	$107.4	$171.8	$43.0	$85.9	$85.9	$214.8	$4.3	$25.8	$0.1	$0.4	$9	$26
Life of Mine Cashflow	Undis	$449.2	$1,109.4	$150.9	$413.1	$59.5	$564.3	$53.3	$571.3	$4.9	$134.3	$0.2	$3.2	$35	$299
Life of Mine Cashflow	Disc 8%	$91.8	$116.0	$17.6	$36.0	$26.5	$306.3	$4.6	$157.3	$0.2	$23.2	$0.1	$1.0	$15	$72

Each of these scenarios presents a range of effects for several economic variables. For subtract valuation purposes, the mid-point of the range for each EGS variable was used to make the data manipulation more tractable. Consideration was given to employing a Monte Carlo analysis to select from the range of possible outcomes for each EGS variable. Given the nature of the analysis and the size of the project budget, this approach was considered to be both unworkable and unnecessary.

Subtract Valuation Process: Summary

In order to develop economic values by subtract, a valuation process (Figure 7) was developed. This procedure mapped the undiscovered mineral potential and mineral inventory information obtained from the B.C. Ministry of Energy and Mines (MEM) onto the Economic Gain Scenarios. Probability factors representing the likelihood of discovery, and the likelihood of development given discovery, were applied. For some EGS outcomes, a discount factor (8% real) was applied in order to capture the time value of money. For each EGS variable, the resulting impacts were aggregated by subtract for all deposit models. Often several deposit models applied to a given subtract. In total, 226 subtracts were analyzed within the CIT area of interest.

Figure 7 Summary of Subtract Valuation Process



This process required the development of large data spreadsheets and considerable data manipulation to aggregate across mineral deposit types for each subtract. The process was then repeated for each of the following categories of MEM mineral potential information:

1. Undiscovered Metal Deposits
2. Undiscovered Industrial Mineral Deposits
3. Known Mineral Inventories

These results were then aggregated by subtract into a Grand Summary *spreadsheet*.

Mineral Potential by Subtract

Expert-determined Deposits

The B.C. Ministry of Energy and Mines has developed mineral potential maps for many areas of the Province. As part of this mapping process, the potential for undiscovered mineral deposits within each geological tract is developed using a team of mineral deposit experts to assess the likelihood of each mineral deposit type in each subtract, given the geology of the subtract and other factors. The output from this exercise is a probability distribution of the number of undiscovered mineral deposits for each deposit type within the subtract. For example, there may be 1.5 deposits of the epithermal gold type at the 50% confidence level, 0.2 deposits at the 90% confidence level, and 4.0 deposits at the 10% confidence level.

Deposit Characteristics

Deposit types for various metals and minerals have been developed by the international geological community. The establishment of these common types is based upon a number of geological factors such as depositional environments, mineral assemblages, etc. Deposit information including types of metal, size (tonnage), and metal tenor (grades) for each deposit type, is collected worldwide and expressed as a distribution of tonnages and grades.

<u>Gross In-place Metal Values (GIPV)</u>

Utilizing representative metals price forecasts, the tonnage-grade distributions for each deposit type can be used to calculate a gross in-place metal value for the mean deposit size, or even a distribution of GIPV's for that deposit type. GIPV values can be combined for the undiscovered deposits (based upon the expert-determination process) and the known inventory of mineral deposits for each subtract. When normalized on a per hectare basis, the GIPV values for each subtract can be used to rank subtracts with respect to mineral potential.

<u>Economic Implications of Undiscovered and Inventory Deposits</u>

The conversion of information on the levels of occurrence of undiscovered mineral deposits and mineral inventories into EGS variables can only be undertaken using probabilistic methods for the following reasons.

1. The occurrence of undiscovered deposits is itself provided in terms of a probability distribution, as mentioned previously.

2. Even if the number of mineral deposits in a subtract were known with certainty, there is significant uncertainty associated with the size of the deposits.

3. Even if the size of the deposit were known, there is uncertainty with respect to the location and depth of the deposit. This affects the type of mining method and metal recovery process used, the capital and operating costs of a mine development, and the cut-off grade (which is based on operating costs). Hence, the size of the economically exploitable portion of the deposit is also uncertain.

4. Even if the locations of all deposits, and all of the engineering and development cost parameters of these deposits, were known at a given point in time, the economic impacts would still be uncertain due to the variability of metal prices, and to shifts in future metal markets. Changes in metal markets over time will change the potential revenue streams and cut-off grades of the deposits. This will impact the economics of any future mine developments.

5. Even if all information relating to potential mineral deposits and their development were known with certainty based on our current understandings, changes in future uses for metals and minerals, or new technologies, could create new demand for minerals which are currently beyond the scope of our knowledge at present. In addition, future research may change our understanding of mineral deposit occurrences, and this could change our concept of the potential numbers, types or locations of mineral deposits.

<u>Methodology Employed</u>

The types and scales of mineral project developments are numerous and varied. There is no feasible way (within the scope and budget of this project) to represent this wide scope of possibilities completely with only a limited number of Economic Gain Scenarios. A decision was, therefore, made to attempt to "map" the types of potential mineral project developments, for each deposit type, onto the most likely set of EGSs. The Ministry of Energy and Mines provided inputs for this "map" (Table 5) for each deposit type. Note that this is a relatively unsophisticated method of translating potential mineral deposits into economic outcomes but, given the large uncertainties inherent in predicting mineral discoveries and forecasting future developments, it was determined that the method employed would give useful results.

The method employed involves the following steps.

1. For each subtract and each deposit type within that subtract, use the number of undiscovered mineral deposits at the 50% confidence level (CL).

2. Depending on the type of deposit, map the number of deposits onto the Economic Gain Scenarios (Table 5). For example, if the expected number of deposits at the 50% CL is 1.5 and that type of deposit is typically mined as a small open pit EGS or as a small underground EGS with equal likelihood based upon expert opinion, then 50% of the economic results associated with these expected deposits is attributed to each EGS. One, therefore, captures 0.75 times the full outcome of each EGS. The mid-point of the range of economic outcomes for each EGS is assumed in this mapping process.

3. Repeat item 2 for all deposit types for each subtract.

4. Apply probabilities of discovery and development. For undiscovered metals and industrial mineral deposits, the probability of discovery $P_{disc.}$ within a 50 year time frame was assumed to be 50%. The conditional probability of development given a discovery $P_{dev:disc}$ (also within a 50 year time frame) was assumed to be 50%. The combined probability of 25% was then applied to the economic outcomes for each EGS variable within each subtract. For known mineral deposits, P_{disc} was assumed to be 100% and P_{dev} 25%. The results for undiscovered metallic and industrial mineral potential were then aggregated with the results for known mineral inventories.

   Consideration was given to linking the probability of discovery within a subtract to the expected number of deposits or some other measure of geological potential of that subtract. However, there appeared to be no solid basis for establishing such a relationship within the time and budget allowed. Similarly, if tonnage and grade data were available for each deposit a Monte Carlo approach may have been possible. This would involve sampling from a tonnage-grade distribution, and applying economic decision-making rules to each sample to determine the likelihood and type of any project development. While the tonnage and grade data exist, the level of effort required to employ this technique would exceed the time and budget available for this CIT exercise.

   It is of obvious note that the numbers of the EGSA's for each tract, and values associated with them, will be highly dependent on the probabilities of discovery and development that are used. These are subjective figures. Whatever probabilities are assumed should, however, be reflective of the time period for discovery. In this case, a 50 year time period was selected. If a longer or shorter period is assumed, the probabilities of discovery and development should be correspondingly higher or lower.

5. Discount the outcomes for monetary variables. The EGS monetary variables were discounted to start of an assuming project development. For this purpose a construction period of three years was assumed and thereafter the future revenues and costs were discounted to the start of the project development period using the project life assumed for that EGS (these were previously given for each EGS). Thus the economic variables for each EGS were all discounted to the start of assumed mine construction. However, the start of a project development is assumed to occur somewhere within a 50 year time

horizon. Thus the dollar values for each monetary EGS variable must again be discounted (at 8%) to allow for this unknown time delay. We have assumed an average mid-period (25 year) time of development. This essentially applies a 0.146 discount factor (1/(1.08)^25) to the resultant expected monetary EGS variables to account for the delay in project development and the resultant time value of money.

6. For each subtract, aggregate the economic outcomes for each EGS variable across deposit types.

Analysis and Presentation

The summarized economic data by subtract were reviewed in a number of ways. The results were correlated against the raw GIPV data by subtract. This correlation (discounted life of mine cash-flow or private NPV/hectare vs GIPV/hectare) produced a relatively weak, but clearly positive, correlation coefficient (0.53). Given the uncertainties involved in the determination of GIPV/hectare, and the aggregation process involved in estimating private NPV/hectare, the absence of a strongly positive correlation was not unexpected. The individual subtract outcomes variables were also correlated against other. As expected, this produced strong positive correlations among EGS variables across the subtracts.

Three of the six output variables, Direct B.C. Taxes discounted, Capital Investment discounted, and Life of Mine Cash-Flow discounted (or private NPV), were normalized on a per hectare basis for each subtract before subtract rankings were prepared. The other variables, Annual Project Revenue, Construction Employment, and Life of Mine Operating Employment, were not normalized. Employment variables should be related to working age population within the sub-regional area, rather than to subtract areas, and Annual Project Revenue has not been normalized so that it can be used as an economic size variable for each subtract.

Table 5. Deposit Model to EGS Mapping Matrix

		Economic Gain Scenario Map					
		Large BM OP	Small BM OP	Small UG Au	Large UG Poly	Low value IM	Artisanal
		1	2	3	4	5	6
Code	Description	Mapping percentage to each EGSA					
C1	Placer Au	0%	0%	0%	0%	100%	0%
C2	Paleoplacer (Garnet)	0%	0%	0%	0%	100%	0%
C3	Marine Placer	0%	0%	0%	0%	100%	0%
D1	Volc. Redbed Cu	100%	0%	0%	0%	0%	0%
D2	Sedimaentary Hosted Cu	100%	0%	0%	0%	0%	0%
EC	Eskay Creek	0%	20%	80%	0%	0%	0%
F1	Sedimentary Mn	0%	0%	0%	0%	100%	0%
H2a	Sedex Zn/Pb/Ag	0%	20%	0%	80%	0%	0%
H4/H6	Beshi/Cyprus	0%	20%	0%	80%	0%	0%
H5	Noranda/Kuroko	0%	20%	0%	80%	0%	0%
I4	Hot-Spring Au/Ag	0%	0%	100%	0%	0%	0%
I5	Epithermal Au-Ag Hi	0%	0%	100%	0%	0%	0%
I6	Epithermal Au-Ag Low	0%	0%	100%	0%	0%	0%
J13	Silica-Hg Carbonate	0%	50%	0%	50%	0%	0%
J2	Stibnite Veins/Disseminations (Combined)	0%	100%	0%	0%	0%	0%
J3	Sub. Volc. Shear Au	0%	0%	100%	0%	0%	0%
J4	Au-Quartz Vein	0%	0%	100%	0%	0%	0%
J5	Fe-Formation Au	0%	0%	100%	0%	0%	0%
K1	Mn Veins and Replacements	0%	100%	0%	0%	0%	0%
K5	Poly. Metal. Vein	0%	10%	90%	0%	0%	0%
N1	Cu Skarn	0%	50%	50%	0%	0%	0%
N3	Zn-Pb Skarn	0%	100%	0%	0%	0%	0%
N4	Fe Skarn	100%	0%	0%	0%	0%	0%
N5	Au Skarn	0%	100%	0%	0%	0%	0%
N6	W Skarn	100%	0%	0%	0%	0%	0%
N8	Mo Skarn	0%	100%	0%	0%	0%	0%
O1	Subvolcanic Cu-Ag-Au (As-Sb)	0%	20%	0%	80%	0%	0%
O2	Porphyry Cu-Mo-Au	100%	0%	0%	0%	0%	0%
O4	Alkalic porphyry Cu-Au	100%	0%	0%	0%	0%	0%
O5	Porphyry Related Au	80%	0%	0%	20%	0%	0%
O8	Porphyry Mo (Low F- type)	100%	0%	0%	0%	0%	0%
P2	Tholeiitic intrusion-hosted Ni-Cu	0%	50%	0%	50%	0%	0%
P3	Podiform Chromite	0%	100%	0%	0%	0%	0%
P5	Alaskan PGE	0%	10%	90%	0%	0%	0%

Table 6. Correlation Table Between Output Variables

Correlation Matrix									
	Annual Revenues	Construction Employment	Life-of-Mine Employment	Direct BC taxes	Direct BC taxes Disc	Investment	Investment Disc	Life of Mine Cashflow	Life of Mine Cashflow Disc
Annual Revenues	1.00000	0.88190	0.89660	0.93681	0.99942	0.91930	0.90991	0.96329	0.96249
Construction Employment		1.00000	0.99999	0.99942	0.99931	0.99994	0.99998	0.99978	0.99849
Life-of-Mine Employment			1.00000	0.99949	0.99942	0.99997	0.99999	0.99984	0.99869
Direct BC taxes				1.00000	0.99973	0.99966	0.99954	0.99985	0.99946
Direct BC taxes Disc					1.00000	0.99961	0.99951	0.99985	0.99980
Investment						1.00000	0.99997	0.99994	0.99909
Investment Disc							1.00000	0.99989	0.99888
Life of Mine Cashflow								1.00000	0.99946
Life of Mine Cashflow Disc									1.00000

<u>Subtract Ranking for Mapping</u>

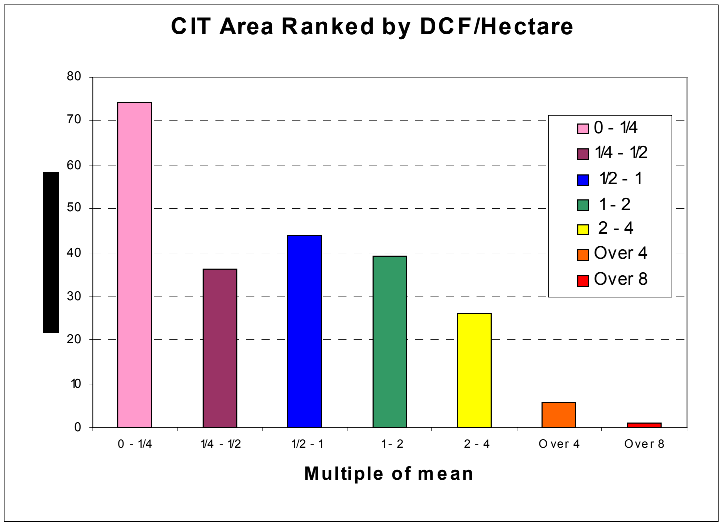
In order to rank subtracts for mapping purposes, the economic outcomes by EGS variable were classified into bins, with the bin boundaries related to the subtract mean for each subtract variable distribution. (Table 7). Given the approximate log-normality of the distribution of mineral potential across subtracts, the selected bin-sorting algorithm was a multiplicative one.

Table 7. Subtract Variable Classification

Bin Boundaries (Fraction of Mean)	Colour Code
0 to ¼	
¼ to ½	
½ to 1	
1 to 2	
2 to 4	
Over 4 times mean	

The bins were colour-coded and a colour assigned to each subtract based upon its ranking for each variable. The results were then organized into a data transfer spreadsheet which displayed the classified results by subtract.

Figure 8. Distribution of Results by Bin for One Variable



A small portion of the data transfer spreadsheet is displayed below.

Figure 9. Mapping Data Transfer Format

	mean	$5.3	$152.1	Bins					
		Direct BC taxes Disc	Direct BC taxes Disc	0 - 1/4	1/4 - 1/2	1/2 - 1	1 - 2	2 - 4	Over 4
Subtract	Area ha	M$	$/ha	< $38	$38 to $76	$76 to $152	$152 to $304	$304 to $609	Over $609
1_____QCIS-1	103,218	$8.6	$83			¦			
1_____QCIS-2	77,530	$13.9	$180				¦		
10____QCIS	26,410	$15.3	$580					¦	
11____QCIS	42,785	$14.7	$343					¦	
12____QCIS	37,257	$28.0	$752						¦
13____QCIS	31,098	$3.6	$115			¦			
14____QCIS	40,338	$9.7	$239				¦		
15____QCIS	9,273	$6.8	$736						¦
16____QCIS	4,729	$7.0	$1,480						¦
17____QCIS	18,710	$7.5	$400					¦	
18____QCIS	28,315	$8.1	$286				¦		
19____QCIS	63,178	$10.3	$163				¦		

Summary of Key Results

Of the 226 subtracts in the CIT area, 33 subtracts totaling approximately 830,000 hectares are considered to have relatively high values based on Discounted NPV per hectare using the EGS methodology. These are subtracts for which the Discounted NPV/hectare variable exceeds twice the mean value for all subtracts. Of these high value subtracts, eight are in the Queen Charlotte/Haida Gwaii LRMP, thirteen are with the North Coast LRMP, six are within the Central Coast LRMP, five with Vancouver Island LRMP and one within the Kalum LRMP. The highest value subtracts within the 33 are identified in orange. These seven subtracts have a Discounted NPV/hectare variable exceeding four times the mean value for all subtracts.

Table 8 High Value Subtracts within CIT Area

Subtract	Area Hectares	LRMP	Subtract	Area Hectares	LRMP
10____QCIS	26,410	qci	CP7___SKEE-1a	9,993	ncoast
11____QCIS	42,785	qci	CP7___SKEE-1b	8,876	ncoast
12____QCIS	37,257	qci	CP7___SKEE-1c	17,584	ncoast
15____QCIS	9,273	qci	CPC-11SKEE-2	24,667	ccoast
16____QCIS	4,729	qci	CPC-11SKEE-3	33,795	ccoast
3_____QCIS	13,672	qci	CPC-12SKEE-1	16,393	ccoast
6_____QCIS	15,140	qci	CPC-14SKEE-1	41,562	ccoast
8_____QCIS	16,019	qci	CPC-27SKEE-1	13,886	ccoast
CP1___SKEE-1	46,125	ccoast	JH25__SKEE-1	28,038	ncoast
CP10__SKEE-1	14,832	ncoast	JH26__SKEE-3	26,732	ncoast
CP10__SKEE-4	5,525	ncoast	JH29__SKEE	82,909	ncoast
CP11__SKEE-1	17,840	ncoast	KJ11__VANI	27,111	van_isl
CP11__SKEE-4	3,235	ncoast	KJ23__VANI-1	34,260	van_isl
CP18__SKEE	84,827	kalum	KJ28__VANI	45,430	van_isl
CP20__SKEE-1	8,154	ncoast	KJ32__VANI	2,148	van_isl
CP20__SKEE-2	14,742	ncoast	S4____VANI	45,951	van_isl
CP20__SKEE-4	9,089	ncoast			

With the strong correlation between EGS variables, the other EGS output variables will also display similarly high values for those subtracts identified above.

The quantitative results for each of the 226 subtracts are presented in spreadsheet form in Appendix C. Results for each of the six gain scenario variables are provided. Three of these variables have not been normalized by subtract size and are expressed in C$ millions, while the other three have been normalized and expressed in net present values per hectare (C$/ha). Although the absolute dollar values presented are subject to a substantial number if caveats and uncertainties, the qualitative rankings of these EGSA values across the 226 subtracts are much more reliable. This implies that the bin-sorting and colour-coded mapping process will provide useful overlays to compare with the EGSA results for other sectors, and with the results from other elements in the CIT exercise. Land use compatibilities, conflicts, and vulnerabilities can then be addressed from a spatial perspective.

When all the subtracts are considered in aggregate, the following table may be constructed. Although the values presented may be over-estimates, perhaps because of the probabilities of (a) discovery; and (b) development, given discovery, may be overly optimistic, a considerable number of subtracts possess substantial mineral values, even after a great deal of discounting has occurred. The most promising subtracts within the CIT Area of Interest have been identified in an earlier table. With the possible exception of oil and gas potential (which is, in large part, an offshore rather than a land-based potential), mineral values could well be the most significant EGSA values within the entire CIT Area of Interest.

Table 9. Mineral Estimates over 226 Subtracts

	Aggregate Value $ millions	Sub-tract mean $ millions	Normalized $ per hectare
Annual Revenues	$2,543.2	$11.3	
Construction Employment	42,919 person-yrs	190 person-yrs	
Life-of-mine employment	728,107 person-yrs	3,222 person-yrs	
Disc. Direct BC taxes	$1,190.4	$5.3	$152.1
Investment discounted	$3,380.2	$15.0	$459.3
Life-of-Mine cashflow discounted	$2,626.0	$11.7	$326.5

Appendix D displays the results in map form.

APPENDIX A

Economic Gain Scenarios

Large Scale Base Metals Open pit

Parameter	Units	Range of Values	
Mining Method		Open Pit	
Scale of Operations	tpd	30,000	60,000
Mine Life	years	15	25
Disc Factors		0.4530	0.3390
Equiv Grade	%	0.6	0.4
Gross value/t	US$1.00	$21	$14
Payable metal factor	60%	60%	60%
Net Ore Value	NSR $/t	$12.60	$8.40
Capital Investment	M$	$275	$500
Capital Investment/daily ton		$9,167	$8,333
Annual Net Revenue	M$	$138	$184
Op costs %		65%	65%
Annual Op Costs	M$	$89.7	$119.6
Annual Op Costs	$/t	$8.19	$5.46
Annual Profit	M$	$48.3	$64.4
Profit Life of Mine	M$ LOM	$724.2	$1,609.4
Capex		$275.0	$500.0
Project Net Cashflow	M$ LOM	$449.2	$1,109.4
Employment			
Construction	man yrs	350	950
Operations (Annual)	employees	450	600
Operations (Life of Mine)	man yrs	6,750	15,000
B.C. Income & Mining Taxes	M$ LOM	$90	$222
B.C. Sales Tax	M$ LOM	$28	$63
Total BC taxes		$118	$285

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$328	$546
Discounted Project Capital Costs	$236	$430
Discounted Project NCF pre-tax	$92	$116
Discounted BC Income Tax Stream	$53	$96

Small Scale Base Metals Open pit

Parameter	Units	Range of Values	
Mining Method		Open Pit	Open Pit
Scale of Operations	tpd	10,000	20,000
Mine Life	years	15	25
Disc Factors		0.4530	0.3390
Equiv Grade	%	0.6	0.4
Gross value/t	US$1.00	$21	$14
Payable metal factor	60%	60%	60%
Net Ore Value	NSR $/t	$12.60	$8.40
Capital Investment	M$	$125	$200
Capital Investment/daily ton		$12,500	$10,000
Annual Net Revenue	M$	$46	$61
Op costs %		60%	60%
Annual Op Costs	M$	$27.6	$36.8
Annual Op Costs	$/t	$7.56	$5.04
Annual Profit	M$	$18.4	$24.5
Profit Life of Mine	M$ LOM	$275.9	$613.1
Capex		$125.0	$200.0
Project L-O-M NCF	M$ LOM	$150.9	$413.1
Employment			
Construction	man yrs	150	400
Operations (Annual)	employees	150	150
Operations (Life of Mine)	man yrs	2,250	3,750
B.C. Income & Mining Taxes	M$ LOM	$30	$83
B.C. Sales Tax	M$ LOM	$9	$19
Total BC taxes		$39	$102

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$125	$208
Discounted Project Capital Costs	$107	$172
Discounted Project NCF pre-tax	$18	$36
Discounted BC Income Tax Stream	$18	$35

Small-scale Underground Precious Metals

Parameter	Units	Range of Values	
Mining Method		Underground	
Scale of Operations	tpd	300	500
Mine Life	years	5	7
Disc Factors		0.6339	0.5904
Grade	g/t	30.00	100.00
Gross value/t	US$300	$459	$1,531
Metal Recovery	90%	$413	$1,378
Net Ore Value	NSR $/t	$400	$1,300
Capital Investment	M$	$50	$100
Capital Investment	$/daily tonne	$166,667	$200,000
Annual Net Revenue	M$	$44	$237
Op costs %		50%	60%
Annual Op Costs	M$	$21.9	$142.4
Annual Op Costs	$/t	$200.0	$780.0
Annual Profit		$21.9	$94.9
LOM Profit		$109.5	$664.3
Capex		$50.0	$100.0
Project L-O-M NCF		$59.5	$564.3
Employment			
Construction	man yrs	50	100
Operations (Annual)	employees	160	360
Operations (Life of Mine)	man yrs	800	2,520
Direct taxes			
B.C. Income & Mining Taxes	M$ LOM	$12	$113
B.C. Sales Tax	M$ LOM	$14	$76
Total		$26	$189

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$69	$392
Discounted Project Capital Costs	$43	$86
Discounted Project NCF pre-tax	$26	$306
Discounted BC Income Tax Stream	$16	$112

Large Underground Polymetallic Mine

Parameter	Units	Range of Values	
Mining Method		Underground	
Scale of Operations	tpd	1,000	3,000
Mine Life	years	7	15
Disc Factors		0.5904	0.4530
Net Ore Value	NSR $/t	$150	$100
Capital Investment	M$	$100	$250
Capital Investment	$/daily tonne	$100,000	$83,333
Annual Net Revenue	M$	$55	$110
Op costs %		60%	50%
Annual Op Costs	M$	$32.9	$54.8
Annual Op Costs	$/t	$90	$50
Annual Profit	M$	$21.9	$54.8
Profit Life of Mine	M$ LOM	$153.3	$821.3
Capex		$100	$250
Project L-O-M NCF	M$ LOM	$53.3	$571.3
Employment			
Construction	man yrs	150	200
Operations (Annual)	employees	230	410
Operations (Life of Mine)	man yrs	1,610	6,150
Direct taxes			
B.C. Income & Mining Taxes	M$ LOM	$11	$114
B.C. Sales Tax	M$ LOM	$9	$11
Total		$19	$125

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$91	$372
Discounted Project Capital Costs	$86	$215
Discounted Project NCF pre-tax	$5	$157
Discounted BC Income Tax Stream	$12	$57

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Low Unit-value Industrial Minerals Operation

Parameter	Units	Range	
Mining Method		Open Pit	
Scale of Operations	tpd	1,000	5,000
	tonnes/yr	365,000	1,825,000
Mine Life	years	15	30
Disc Factors		0.4530	0.2979
Unit Minegate Value of Production	$/t	$3.00	$5.00
Annual Net Revenue	M$	$1.1	$9.1
Capital Investment	M$	$5.0	$30.0
Operating costs	%of rev	40%	40%
Annual Op Costs	M$	$0.4	$3.7
Annual Op Costs	$/t	$1.20	$2.00
Annual Profit		$0.7	$5.5
Profit (Life-of-Mine)	M$ LOM	$9.9	$164.3
Capex		$5.0	$30.0
Project Net Cashflow	M$ LOM	$4.9	$134.3
Employment			
Construction	man yrs	9	16
Operations (Annual)	employees	3	14
Operations (Life of Mine)	man yrs	45	420
B.C. Income & Mining Taxes	M$ LOM	$1.0	$26.9
B.C. Sales Tax	M$ LOM	$0.1	$2.3
Total		$1.1	$29.1

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$4	$49
Discounted Project Capital Costs	$4	$26
Discounted Project NCF pre-tax	$0.2	$23
Discounted BC Income Tax Stream	$1	$9

Artisanal Mining Operation

Parameter	Units	Range	
Mining Method		Small Pitting	
Scale of Operations	tpd	1	10
	tonnes/yr	365	3,650
Mine Life	years	3	20
Disc Factors		0.6819	0.3897
Unit Value of Production	$/t	$500	$100
Annual Net Revenue	M$	$0.2	$0.4
Capital Investment	M$	$0.1	$0.5
Operating costs	%of rev	50%	50%
Annual Op Costs	M$	$0.1	$0.2
Annual Op Costs	$/t	$250	$50
Annual Profit		$0.1	$0.2
Profit (Life-of-Mine)	M$ LOM	$0.3	$3.7
Capex		$0.1	$0.5
Project Net Cashflow	M$ LOM	$0.2	$3.2
Employment			
Construction	man yrs	N/A	N/A
Operations (Annual)	employees	1	1
Operations (Life of Mine)	man yrs	3	20
B.C. Income & Mining Taxes	M$ LOM	$0.03	$0.6
B.C. Sales Tax	M$ LOM	$0.01	$0.1
Total Direct BC Taxes		$0.04	$0.69

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$0.2	$1.4
Discounted Project Capital Costs	$0.1	$0.4
Discounted Project NCF pre-tax	$0.1	$1.0
Discounted BC Income Tax Stream	$0.0	$0.3

Small Coal Operation

Parameter	Units	Range	
Mining Method		O/P or UG	
Scale of Operations	tpd	500	1,500
	tonnes/yr	182,500	547,500
Mine Life	years	10	30
Disc Factors		0.5327	0.2979
Unit Minegate Value of Production	$/t	$35.00	$50.00
Annual Net Revenue	M$	$6.4	$27.4
Capital Investment	M$	$10.0	$30.0
Operating costs	% of rev	30%	60%
Annual Op Costs	M$	$1.9	$16.4
Annual Op Costs	$/t	$10.50	$30.00
Annual Profit		$4.5	$11.0
Profit (Life-of-Mine)	M$ LOM	$44.7	$328.5
Capex		$10.0	$30.0
Project Net Cashflow	M$ LOM	$34.7	$298.5
Employment			
Construction	man yrs	19	31
Operations (Annual)	employees	14	62
Operations (Life of Mine)	man yrs	140	1,860
B.C. Income & Mining Taxes	M$ LOM	$6.9	$59.7
B.C. Sales Tax	M$ LOM	$0.4	$10.3
Total		$7.3	$70.0

	Disc Rate 8%	Disc Rate 8%
Discounted Project Operating profit	$24	$98
Discounted Project Capital Costs	$9	$26
Discounted Project NCF pre-tax	$15	$72
Discounted BC Income Tax Stream	$4	$21

APPENDIX B

B.C. Mineral Deposit Models

Metallic Minerals		Industrial Minerals	
Model Code	**Description**	**Model Code**	**Description**
C1	Placer Au	13i	U-Th Pegmatite
C3	Marine Placer	37k	Garnet
D1	Volc. Redbed Cu	B6	Residual Kaolin
D2	Sedimentary Hosted Cu	B7	Fireclay
EC	Eskay Creek	D6	Zeolites
F1	Sedimentary Mn	D7	Zeolites
H4/H6	Beshi/Cyprus	E10	Sedimentary Kaolin
H5	Noranda/Kuroko	E10a	Sedimentary Kaolin
I5	Epithermal Au-Ag Hi	E6b	Carbonate hosted talc
I6	Epithermal Au-Ag Low	E9	Bentonite
J13	Silica-Hg Carbonate	F4a	Bedded Gypsum/Anhydrite
J4	Au-Quartz Vein	F6	Bedded Celestite
J5	Fe-Formation Au	F8b	Diatomite
K1	Mn Veins and Replace	Granite	Granite
K5	Poly. Metal. Vein	Gypsum	Gypsum
N1	Cu Skarn	I11	Hydrothermal Clays
N3	Zn-Pb Skarn	K7	Silica Vein
N4	Fe Skarn	N10	Woll Skarn
N5	Au Skarn	N9	Garnet Skarn
N6	W Skarn	P6	Asbestos
N8	Mo Skarn	PERIDOT	Peridote
O1	Cu-Ag-Au Porph	Q1	Carbonatite hosted
O2	CU-Mo-Au Porph	R2	Kyanite Family
O8	Mo Porph	R4	Talc
P2	Gabbroid Ni-Cu-PGE	R5	Microcrystalline Graphite
P5	Alaskan PGE	R6	Crystalline Flake Graphite
		S1a	Opal
		S2b	Rhodonite
		T1	Cement Shale
		T10	Pumice
		T11	Perlite
		T13	Alaskite
		T14	Crushed Rock
		T2	Expanding Shale
		T4	Dimension Stone Marble
		T5	Dimension Stone Andesite
		T6	Dimension Stone Sandstone
		T8	Flagstone
		T9	Limestone/Dolostone
		T9a	Limestone/Dolostone (WHITE)

APPENDIX C

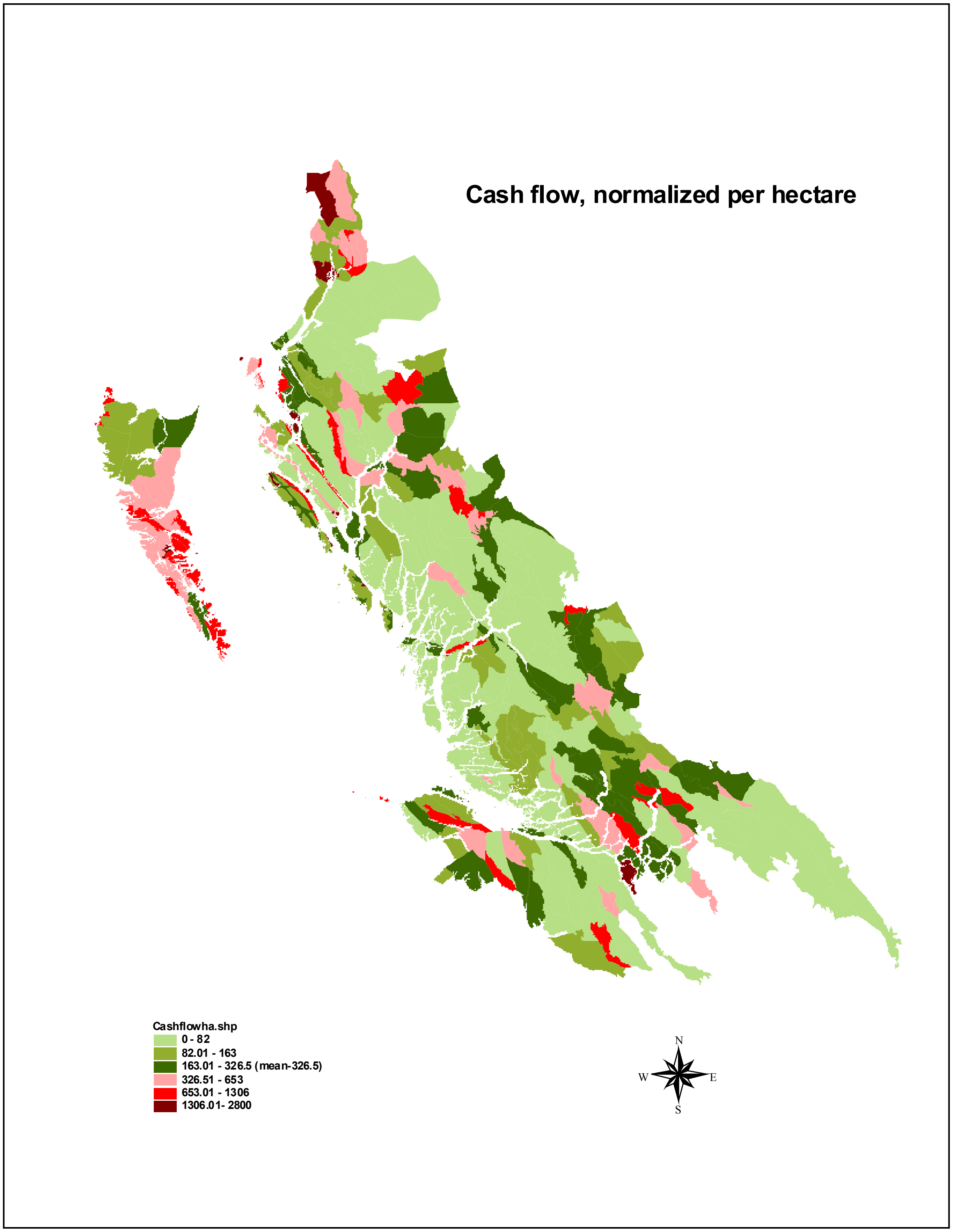
Tract Data Results

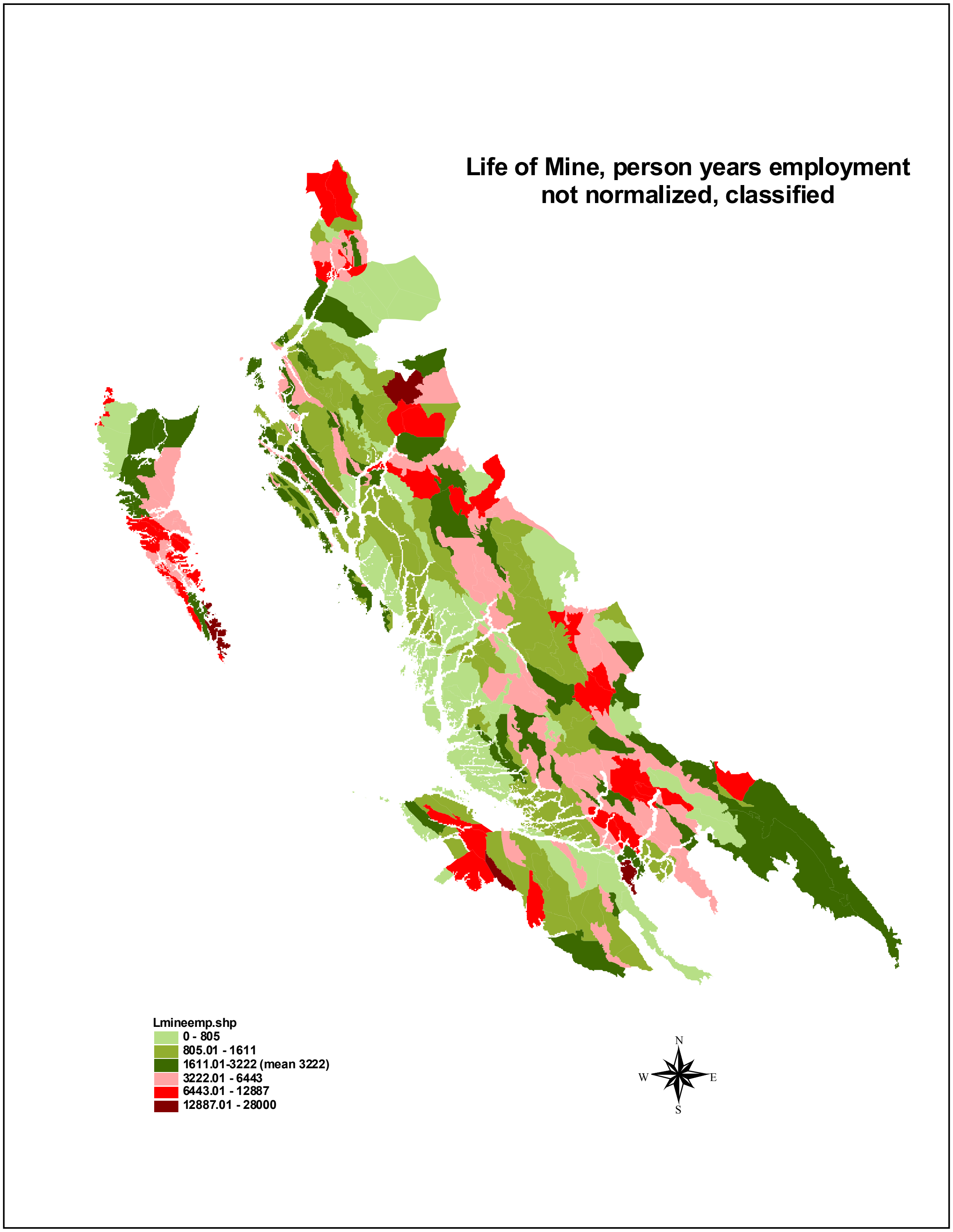
[Transmitted separately as Excel Spreadsheets:

1. Grand Summary.xls
2. CIT Subtract Values MM.xls
3. CIT Subtract Values IM.xls
4. CIT Subtract Values Min; Inventory.xls
5. data transfer.xls

APPENDIX D

Results Maps




Life of Mine, person years employment
not normalized, classified
Lmineemp.shp
0 - 805
805.01 - 1611
1611.01-3222 (mean 3222)
3222.01 - 6443
6443.01 - 12887
12887.01 - 28000
N
W
E
S