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# Benefit Cost Analysis of a Toll Highway—British Columbia's Coquihalla

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## ABSTRACT

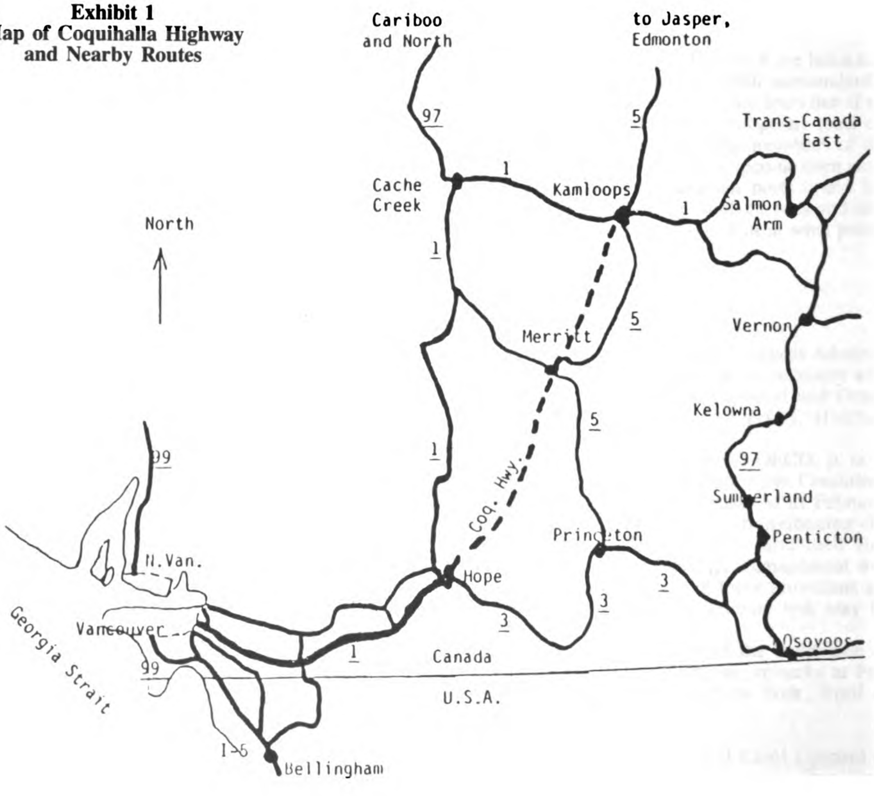
The Coquihalla is a major new toll highway bisecting existing routes to British Columbia's "Interior." This ex ante benefit cost study estimates the user benefits to traffic diverting to the new highway as well as reduced congestion benefits to those remaining on the old routes. Tolls reduce the number diverting to the new highway, therefore reduce the overall net benefits. The benefit cost analysis is conducted both from a global and provincial perspective. The project shows a modest net benefit or loss depending on the perspective adopted, the discount rate used, and other assumptions. Optimal timing is also considered; the highway would have a slightly higher net benefit if construction had been deferred for a few years.


## I. INTRODUCTION

The Coquihalla Highway project involves the construction of 189 kilometres of four-land divided highway through the Cascade mountains in south-eastern British Columbia. The highway connects the town of Hope and the Lower Mainland area of B.C. with interior cities of Kamloops and Merritt. The new highway saves a considerable distance for travellers destined to Kamloops and points north, and those travelling on the Trans Canada highway from or to the Lower Mainland. Exhibit 1 is a map of the surrounding area.

The highway is being constructed in two phases. Phase I, which connects Hope to Merritt, was completed in early 1986. Phase II consists of the remaining link between Merritt and Kamloops; it will open

**Exhibit 1**
**Map of Coquihalla Highway and Nearby Routes**



in 1987. (A third phase which would connect eastward toward Kelowna and the Okanagan area is still in the planning stage and is not considered in this paper).

This paper summarizes a social benefit cost analysis of the Coquihalla highway. Unlike some public projects, there are few externalities and social impacts to be included. Most of the benefits accrue directly to users of the project. There are some interesting features concerning the evaluation of this project. The new highway lies between two existing major highways; hence estimating project benefits require that interaction or network effects of the new highway be considered. Another interesting feature is that this is a toll highway. This case provides a useful illustration of the effect of pricing and finance policies on the economic benefits of a project. Although the project will generate a substantial cash flow from toll revenues, the presence of tolls causes the overall economic benefits of the project to be reduced.

Although the highway is partially open, this analysis is an ex ante rather than ex post study. It uses information and forecasts developed before the highway was built as this is more relevant to assessing the original decision to build the highway. A few issues are addressed which have arisen subsequent to the highway's construction.

The following sections outline the project costs, the benefit categories, the forecasts of traffic levels and diversions among routes, and the estimations of benefits by categories of users. The base case benefits are estimated without tolls. A subsequent section incorporates the impact of tolls on net benefits on the highway. Distinguishing between provincial and non-provincial users provides an alternate calculation of net benefits. From the Province's perspective, toll revenues from non-residents are a benefit, while other benefits which accrue to non-residents are excluded. Nonetheless, the results still show that the imposition of tolls reduces the overall net benefits of the project. The remaining sections of the paper explore the question of optimal timing of the project (was now the right time to build it?) and raise a few benefit and cost considerations which warrant further study.

## II. PROJECT COSTS

There are three broad categories of costs: construction costs, ongoing maintenance and snow removal costs, and environmental costs associated with construction and ongoing use of the highway. In addition, the rerouting of traffic will entail diversion of road-related business (e.g. gasoline sales) from one route to another. As is customary, these transfers of economic activity are not included in the analysis (although, not surprisingly, the secondary effects of diverted spending by highway users have generated controversy in the affected regions).

The total undiscounted costs of the project (in 1984 dollars) are $375 million. In lieu of more precise budgeting figures, it was assumed that the construction outlays over the years were proportional to the published estimates of the number of direct jobs associated with the project:

1984: 2750 jobs—$105,225,000
1985: 4700 jobs—$179,850,000
1986: 2350 jobs—$89,925,000

The present value of the construction costs (at a 7.5 per cent real discount rate) is $338 million.

For this project there was no shadow pricing of construction costs. That is, it is assumed that the amounts paid to contractors reflect the actual opportunity costs of the resources employed on the highway project. This may be an overstatement. The B.C. economy was not healthy during this period, so some of the employment and equipment used may not have had comparable opportunities for employment elsewhere. Therefore, a case could be made to "shadow price" at least part of the inputs used in constructing the highway. (There is a counter argument that, during times of unemployment, the alternative to this public project would be some other public project; in order to accurately evaluate the relative merits of the different projects, it would be appropriate to value the resources used at a consistent price such as their usual market price).

The Coquihalla is a new addition to the road system and will incur costs of routine maintenance and snow removal. The latter is potentially important for this route. Examination of snow removal and maintenance costs for several mountain highway districts revealed annual costs between $2500 and $7500 per kilometre. A conservative figure of about $2600 per kilometre or $500,000 per year was used for this cost category.

Environmental costs are of several types. The construction is through mountainous terrain with many river crossings. The Coquihalla is a valuable river for steelhead, salmon and trout. The impacts of highway construction could have been severe. However, by careful timing of construction activity and special efforts to repair any encroachment on the river (including relocating and reconstructing river habitat for fish), most of these potential environmental impacts have been prevented. That is, the costs of mitigating environmental impacts have been incorporated into the construction cost estimates. There may be ongoing environmental impacts such as the impact of greater surface water runoff and sedimentation of the river, but these effects are unknown at this time.

The other environmental impact is the inevitable encroachment of civilization on this area which was previously largely a wilderness area. There will be impacts on wildlife through greater hunting and fishing pressure as well as animals killed by cars. However, this is the paradox of all such wilderness access. Clearly, there are costs of harming the wilderness, yet it is also clear that people value the opportunity to penetrate these areas. That is, there are both benefits and costs of access to regions with limited previous access. These environmental benefits and costs have not been included in this study.

## III. BENEFIT CATEGORIES

The primary benefits of the project accrue to the users of the highway in the form of savings in operating costs and time. There are also significant safety benefits associated with the project, and there are benefits to road users who remain on other highways but who experience lower congestion levels once the Coquihalla has opened.

The Coquihalla cuts 72 kilometres off the previous Hope-Kamloops route. At a cost of $0.10 per vehicle kilometre, this is a saving of over $7.00 per trip for automobiles. For large trucks, the saving is even greater, about $33.50 per trip.[1]

The reduction in distance and increased average speed means significant time savings to traffic who divert.[2] The valuation of travel time is often contentious in transportation studies. Usually this is because only small time savings are involved. The time savings per vehicle are substantial in the case of the Coquihalla. The value of time for leisure travelers was set at 25 per cent of the gross wage; multiplied by the typical passengers per car on B.C. Highways results on a value of time of $6.68 per vehicle hour, or a time savings worth about $8.00 per trip on average for cars diverting to the Coquihalla. Higher values of time were used for automobile drivers assumed to be traveling on business ($12 per hour) and truck drivers ($14 per hour) (the former based on the average wage in the service sector as reported by the Statistics Canada, and the latter from Trimac Consulting Ltd., 1982).

Building the Coquihalla will relieve traffic volumes on the existing highways Number 1 and Number 3. The effect will be minor during periods of light to moderate traffic, but there will be significant benefits during congested periods. This is a difficult category of benefits to estimate. It requires knowledge of the number of hours of various degrees of congestion, and the impact on operating speeds (hence time and cost savings) of reducing the level of congestion. Only rough approximations of this benefit category were possible; they are described later.

The other major benefit category is safety. Use of the Coquihalla saves substantial distance (thus reduces the chance of accidents). In addition, the Coquihalla is a divided four lane highway with adequate shoulders. Such a highway has a significantly better accident record than regular two lane highways. One set of estimates are as follows:

Effect on Accident Rates of Changing to Divided Highway*
(Accidents per million vehicle kilometres)

| | fatal accident rate | injury accident rate | property damage only | total accident rate |
|---|---|---|---|---|
| two-lane | .0316 | .323 | .472 | .825 |
| divided expressway | .0236 | .273 | .472 | .769 |
| freeway | .0155 | .168 | .304 | .490 |

* For rural highways, partial access control; converted to metric.
*Source:* Pacquette and Wright, (1979) p. 73.

These figures show that fatal accidents can be reduced by 25 to 50 percent by changing from two-lane undivided to multi-lane divided highways. We use an estimate 33 percent for our calculations. For accidents involving injuries and property damage only accidents, we assume reductions of 33 and 15 percent, respectively.

The safety benefits arise for two reasons: (1) reduced distances travelled; and (2) travel on a safer highway.

In the base year of 1987, approximately 130 million vehicle-kilometres could be saved due to the shorter distances travelled. For a fatality rate of .0316 per million vehicle kilometres, this implies a saving of 4.1 "statistical" lives. (By way of comparison, the B.C. death rate per million vehicle kilometres is .027 from Government of British Columbia, 1984). Similarly, the reduced distances travelled imply a reduction of about 42 accidents involving injuries, and 61 fewer non-injury accidents.

The other safety benefits are due to the use of a safer highway. The base year calculation estimates 313 million kilometres diverted to the new highway. Using the estimated accident reductions noted above, this results in 3.3 additional lives saved, 3.4 fewer accidents involving injuries, and 22 fewer property damage only accidents.

Therefore, total safety benefits for the base year are 7.4 lives saved, 76 fewer accidents involving injuries, and 83 fewer p.d.o. accidents. These benefits can be expected to grow with increases in traffic volumes.

The valuation of safety benefits is a highly controversial subject, but at least some estimate needs to be included for the study. The most contentious figures are those involving loss of life. Arbitrarily using a value of $500,000 per statistical life[3] results in a base year benefit of $3.7 million.

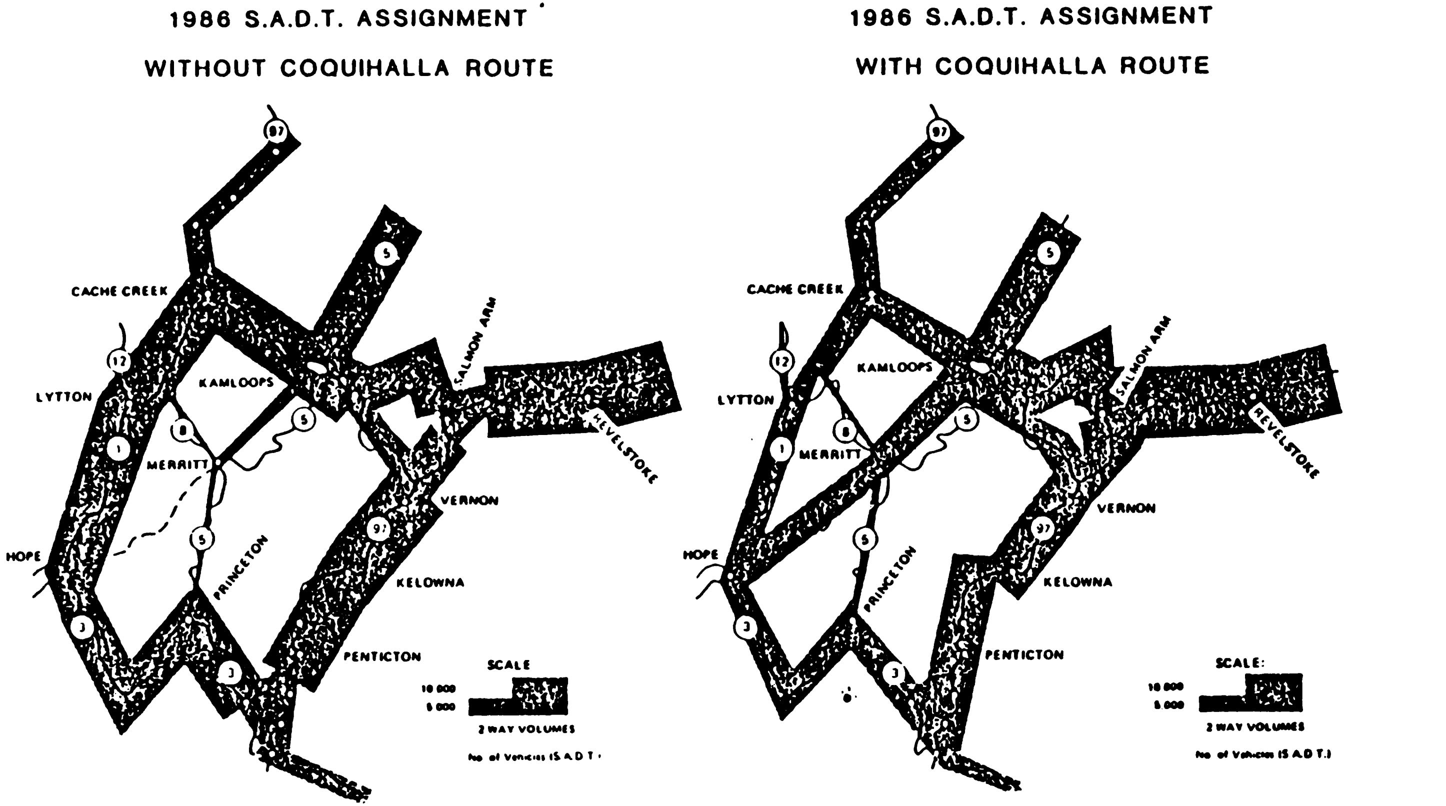
The valuation of non-fatal accidents depends on accident and injury severity. Christofferson (1984), citing several sources including work by Lawson, used $10,780 for the average cost of an accident involving injuries. The more comprehensive study by Miller, Reinhert and Whiting calculated a range from about $2300 to $261,000 depending on accident severity. This study uses a single figure of $11,000 for an accident involving injuries. Property damage only accidents entail lower total costs. Christoferson (1984), citing several Canadian sources, settled on $2000 per such accident. This is the figure used here. The base year accident reduction benefits add about $1.0 million to the benefits of lives saved, for a total annual safety benefit of $4.7 million dollars.

A final category on the benefit side is the residual value of the project. The highway will last much longer than the 20 year life used for the analysis of benefits and costs. In principle, the residual value for such a project would be the capitalized value of benefit accruing after 20 years, less all reconstruction costs which would be necessary to keep the road in operation, all discountered back to the present. A simple procedure often done is to include all or part of the initial construction costs as a terminal value, on the assumption that much of the initial road investment will still be useful at the end of the assumed project life. The latter practice was used here. A residual value of 75 per cent of initial construction cost was included as a terminal value.

## IV. FORECASTS OF TRAFFIC DIVISION

There are two forecasting tasks: first is forecasting the overall volume of traffic, and second, their assignment among alternate routes. B.C. Highway Officials had made such forecasts as part of the original environmental impact study of the project. The B.C. Highway's forecast were for a base year (1986) with and without the Coquihalla Highway. These forecasts are illustrated in Exhibit 2. In order to calculate a net present value, it was necessary to extend the

Exhibit 2
Traffic Assignment




SOURCE: GOVERNMENT OF BRITISH COLUMBIA

forecast 20 or more years into the future. Projection methods were used based on recent traffic growth but with a "EXPO bulge" for traffic in 1986. Sensitivity analysis was used to assess the significance of the results to the forecasts; variations in the forecasted growth rates did not change the results significantly.

It was necessary to construct price-sensitive diversion rates to the Coquihalla because tolls will be charged on the new highway. To do this effectively required that total traffic forecasts be disaggregated into different categories. Separating cars and trucks was done on the bases of existing data on the mix of vehicles travelling on the highways. It was also important to disaggregate traffic into different origin-destination categories. For example, Highway 1 north of Hope (the Fraser and Thompson River canyons) includes local traffic and traffic going on north at Cache Creek. This traffic is not candidate for diversion to the new road. Of the traffic going on to Kamloops, some traffic either originates or terminates here. The time saving of the Coquihalla is a more significant portion of total journey time and cost for this "Kamloops-determined" traffic than it is for traffic continuing on the Trans-Canada highway or turning north up to the Yellowhead highway (Jasper Park and Edmonton). Typically, one would expect higher diversion rates for Kamloops-determined traffic than traffic travelling greater distances because the time (and operating costs) savings represent a larger share of total journey costs for the Kamloops-determined traffic.

Similar arguments apply to traffic previously taking the southern route, Highway 3. Traffic destined along this route or continuing to the Southeast are not likely to divert to the Coquihalla, whereas traffic which rejoins the Trans-Canada highway east of Kamloops would be candidates for diversion.

Predicting the precise diversion rates for different toll charges is very difficult. Ideally it would require extensive surveys or other investigative techniques, and even there would be considerable uncertainty concerning the reliability of forecasts. A simpler approach was adopted.

Aggregate traffic forecasts were disaggregated into various origin-destination groups. These were based on an origin-destination survey by B.C. Highways. The various origin-destination pairs were reviewed to identify those most affected by opening of the new highway. In the absence of tolls, it was assumed that 100 per cent of traffic would divert for those O-D pairs able to use the full distance saving of the Coquihalla. This traffic was then disaggregated by truck, commercial auto travel, and general or leisure auto travel, and grouped into broad origin-destination categories. Two of the categories, traffic travelling on north and traffic destined to the southeast, were assumed not to divert to the new highway at all. Local traffic was also excluded from estimates of diverted traffic. For the remaining traffic, they must be separated into diverted, undiverted and generated traffic. The latter refers to new traffic attracted to the roads because of the improved travel conditions. Because the time and operating costs of travelling is only a part of the total costs of travel, generated traffic is not likely to be important except on the Coquihalla route itself, and this will primarily be for the "Kamloops-determined" traffic (ignoring tolls, the time and operating costs savings via the Coquihalla rather than via Highway 1 represent a 28 percent saving in total trip cost; this is sufficient to stimulate some response in the total amount of travel by this traffic category).

The proportion of traffic diverting to the new highway—and the potential amount of generated traffic—will be influenced by the level of tolls. Estimating price and time elasticities of demand is a difficult task. For this study some approximations were used. First of all, for each traffic group affected by the Coquihalla, the potential time and operating cost savings were calculated. It was assumed that if the toll charged was exactly equal to the average time and costs saved, that the traffic group would split 50/50 between the two routes. If there were no tolls, then a much higher percent of traffic divert, 100 percent for traffic which realize significant savings via the Coquihalla. Interpolating between these two diversion rates and toll charges (zero tolls and tolls equal to total time and cost savings) for each group gave predictions of diversion rates for each traffic category for different toll charges.

Our forecasts of traffic volumes on the three highways appear to be very close to B.C. Highways' forecasts. With tolls, our estimates of the traffic allocation among Highways 1, 3, and the Coquihalla are 34, 35, and 31 percent, respectively. B.C. Highways' figures are 32, 34, and 34 percent, respectively (Kasianchuk and Warburton, 1986). Without tolls, we estimate that about 50 percent of through-traffic would use the Coquihalla.

For generated traffic, the size of time and cost savings were compared to total costs and travel (adding estimates of food and lodging costs) to get an idea of the percentage change in "trip price" which faced travellers. For commercial vehicles, this percentage change in price would be multiplied by a derived elasticity of demand for freight transport, typically a fairly low elasticity (for example, if the elasticity of demand for final products was unity, and the transportation costs represent 10 percent of the delivered price of goods, then the derived elasticity of demand for freight transport would be $-.1$). The only significant amounts of generated traffic were for Kamloops-determined traffic, and levels of generated traffic were modest in comparison to other traffic volumes already on the road. Therefore, the overall results are not very sensitive to generated traffic estimates.

The remaining traffic estimates of potential importance are the total volumes of traffic on the old highways. During congested periods, the presence of the Coquihalla means that traffic congestion on other highways will be reduced, and all undiverted traffic (including local traffic) realize a benefit. To calculate this benefit to undiverted users requires a comparison of the traffic volumes relative to the rated road capacity, and relating this to speed-flow conditions to estimate any time and operating cost savings to undiverted traffic. Surveys of highway use by time of day had been projected by B.C. Highways. An estimate was made of the local annual time the existing highways would encounter congested conditions ("Level D" and "Level E" service, unstable vehicular flow at 55-70 kph and 55 kph, respectively, Government of B.C., 1978, p. 17) Traffic diverting to the Coquihalla will greatly reduce congestion levels for traffic which remain on the old routes. A 20 minute saving was estimated for through-vehicles on the old routes (traffic figures were based on volumes away from settled areas, this tends to exclude traffic which realize smaller benefits from reduced congestion). The benefits to undiverted traffic were proportional to the number of cars diverting to the Coquihalla, and the latter is a function of the tolls charged.

## V. BASE CASE EVALUATION

The base case consists of the Coquihalla highway with no tolls. Exhibit 3 summarizes the benefit and cost categories using a 7.5 percent real discount rate and an arbitrary project life of 20 years.[4] A positive terminal value for the project was assumed at the end of the calculation period.

The "bottom line" shows a positive net benefit for the project although not a very large one. The internal rate of return (IRR) of the base case is about 11 percent.

Exhibit 3 also lists the benefits (and costs) with current toll charges of $40.00 maximum for trucks ($35. used as an average) and $8.00 for cars. The project costs are largely unaffected by tolls (there are the annual costs of toll collection), but the project benefits are smaller because fewer travellers divert when tolls are levied. There are also costs and time delays imposed while collecting tolls (this cost is not included). The toll revenue itself represents a transfer of benefits from users to the government or tax payers, therefore toll revenues are not included in calculations because it would be double counting (but see the discussion from a "Provincial perspective," below).

The overall project with tolls are positive but small at a 7.5 percent discount rate. Exhibit 4 plots the IRR's for the project with and without toll charges. This exhibit is also useful for illustrating the sensitivity of project benefits to the discount rate.

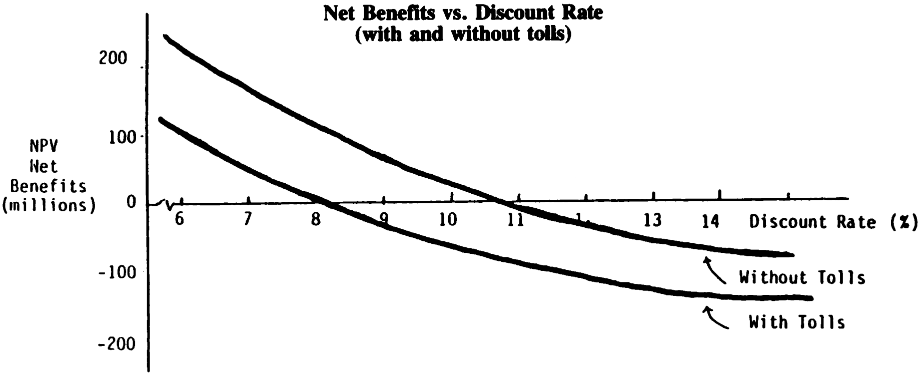
Traffic diversion rate for other toll levels were interpolated between the base case (zero toll) and the currently-imposed tolls. Therefore, the sensitivity of net benefits to different toll charges are estimated as a straight forward proportion of the difference between the two net benefit calculations and any proportionate change in the overall level of tolls charged. Different categories of users were assumed to have different elasticities of demand, for example, truck and commercial automobile travel are expected to be less sensitive to tolls than are leisure travellers. It would be difficult to discriminate among the two types of auto traffic, but a shift of tolls charged to increase those on commercial automobiles and decrease them on leisure travellers could generate the same toll revenue but with less reduction in project net benefits (up to a point). The same argument could apply to toll charges for commercial trucks relative to leisure cars, but additional information on their respective demand elasticities would be needed to settle this.

**Exhibit 3**
**Summary of Project Benefits and Costs**
**With and Without Tolls**

(7.5% discount rate)
(Million 1984 dollars)

| Project Costs: | No Tolls | | With Tolls | |
|---|---|---|---|---|
| Construction | 338.1 | | 338.1 | |
| Maintenance | 7.6 | | 7.6 | |
| Toll Collection | - | | 8.4 | |
| Toll Booth Const. | - | | .3 | |
| | 345.7 | | 354.4 | |
| **Project Benefits:** | **No Tolls** | **%** | **With Tolls** | **%** |
| Coquihalla Traffic | 389.8 | 75.3 | 290.4 | 73.6 |
| Residual Value of Coq. | 53.3 | 10.3 | 53.3 | 13.5 |
| Safety Benefits | 52.1 | 10.1 | 36.5 | 9.3 |
| Traffic decongestion (#1 & #3) | 21.9 | 4.2 | 14.1 | 3.6 |
| Generated Traffic | .8 | .2 | .3 | .1 |
| Total Benefits | 517.9 | | 394.5 | |
| Net Benefits | 172.2 | | 40.1 | |

**Exhibit 4**
**Net Benefits vs. Discount Rate**
**(with and without tolls)**




## VI. PROJECT FINANCE AND BENEFITS FROM A PROVINCIAL PERSPECTIVE

The relationship between project benefits and project pricing is an illustration of basic economic principles which date back to Dupuit, 1844. The Coquihalla is a classic example of a public project with largely fixed costs and low variable costs with use. Such a project gives rise to a paradox because financial and economic criteria diverge. The optimal policy from an economic point of view is to keep the price low in order to encourage use of the project because the incremental costs of additional use are very low. But then the project runs a financial deficit. A better method of finance for such a project is to levy a fixed charge such as via general taxation rather than specific tax (toll) which discourages use of the facility.

However, there is still the necessity to finance the project. The usual illustration of the foregoing principle applies to "first best" world where prices equal marginal costs everywhere and there are few or no taxes. If taxation is discussed at all in textbook illustrations of the problem, taxes are limited to a head tax or some other non-distorting tax. But in practice, a variety of taxes are imposed, so the decision to add another public project such as the Coquihalla may not necessarily leave total taxation unaffected. Whatever form of taxation is used to finance the project will have some resource allocation effects. The estimate of the reductions in net benefits due to tolls is an over-estimate of the actual loss because it ignores any economic costs (resource allocation effects) of the ultimate forms of taxation used to finance the project. But the basic principles are still valid: levying a specific tax (toll) on a particular group (users) causes reductions in project benefits not compensated for by reductions in project costs.[5]

The other interesting facet of project benefits, costs and finance is to focus on the project from a purely provincial perspective. The project is financed by B.C. residents, yet many of the benefits accrue to non-residents. Without a toll, the residents of B.C. would be incurring costs for the benefit of non-residents. The tolls are a way of capturing some of the benefits for B.C. and non-B.C. residents. This is shown in Exhibit 5.

Surveys in the 1970's showed that out-of-province license plates constitute over 30 percent of traffic on Highways 1 and 3, especially the former. However, the proportion of out-of-province vehicles is less during winter months than it is during the rest of the year. We used an arbitrary figure of 25 percent of traffic on the Coquihalla as out-of-province vehicles. The provincial benefits are defined as the time savings and operating costs savings to provincial car users, and toll revenues from non provincial vehicles. From the purely provincial perspective, net benefits of the project without tolls are reduced compared to the base case calculations; this is because a provincial perspective does not count benefits to non-B.C. users. Counting the toll revenues from non-B.C. residents as a benefit still results in even lower overall net benefits. That is, the impact of tolls causes a sufficient number of B.C. drivers not to use Coquihalla thereby reducing the benefits to B.C. users, and the reduction in benefits to B.C. users because of tolls is not offset by the toll revenues collected from non-B.C. travellers. The Provincial net benefit without tolls are positive whereas the net benefits with tolls are slightly negative at the 7.5 percent discount rate. Sensitivity analysis showed that assuming a higher proportion of non-B.C. travellers made little change to this basic result.

Another possible approach would be to only levy tolls on non-B.C. users. Setting aside the probable negative reaction by travellers and the possible harm to B.C.'s tourist reputation, such an approach would probably yield a small net benefit, although it would be less than the base case net benefits without tolls (it is less because compared to the base case without tolls, the benefits to non-B.C. users are replaced by toll charges paid by this group and the tolls are less than the savings realized by this group).

## VII. OPTIMAL TIMING OF THE PROJECT

Most project evaluations concentrate solely on the question of whether or not to build a project, that is, are the discounted net benefits positive? An often neglected question concerns the optimal timing of a project, viz, is it appropriate to undertake the project immediately or would the net benefits be even larger if the project were deferred for a few years? Setting

**Exhibit 5**
**Benefits and Costs from a Provincial Perspective**
**(excludes benefits to non-residents but**
**includes their toll revenues paid)**
**7.5% discount rate**
**(Millions 1984 dollars)**

| Project Costs: | No Tolls | With Tolls |
|---|---|---|
| Constructions | 338.1 | 338.1 |
| Maintenance | 7.6 | 7.6 |
| Toll Collection | - | 8.4 |
| Toll booth Const. | - | .3 |
| | 345.7 | 354.4 |

| Provincial Benefits: | No Tolls | % | With Tolls | % |
|---|---|---|---|---|
| Toll Revenues | - | - | 37.0 | 10.7 |
| Coquihalla Traffic | 292.3 | 76.1 | 217.8 | 62.9 |
| Residual Value | 53.3 | 13.3 | 53.3 | 15.4 |
| Safety Benefits | 39.1 | 9.7 | 27.4 | 7.9 |
| Benefits to Traffic (#1 & #3) | 16.4 | 4.1 | 10.6 | 3.1 |
| Generated Traffic | .6 | .1 | .2 | .1 |
| | 401.7 | | 346.3 | |
| Net Provincial Benefits | 56.0 | | (-8.1) | |

aside the short term macroeconomic concerns of employment generation during an economic downturn (which were a consideration in the Coquihalla construction), the net benefit calculation can be carried out for different years' construction and all results discounted back to the same base year. The optimal year for construction is the year for which the NPV is largest.

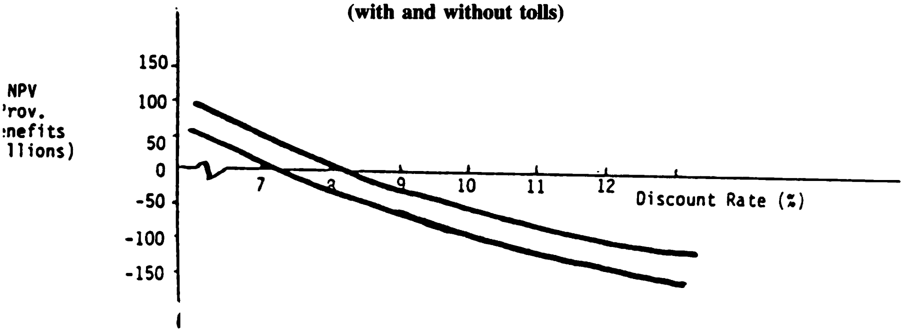
Most transportation projects will realize a larger undiscounted benefit stream by postponing the project. Traffic is usually growing over time, therefore larger user benefits (and reduced congestion effects) will arise if a project is built later. The key point for determining the optimal timing of a project is to compare the change in benefits (discounted to a common year) by postponing a project, with the opportunity cost of capital. The costs of postponing the project are the foregone benefits which are primarily those of the first year; the benefits of postponement are the opportunity costs or use of the capital for the postponed period, and the present value of the increased benefits that would result from the higher traffic volumes over the life of the project.

Exhibit 7 plots the net benefits of the project for various years' opening. The optimal year appears to be about 1990, i.e., the economic analysis based on existing forecasts suggests that the highway was built a few years early. However, because the NPV curve in Exhibit 7 is fairly flat, this indicates that there is very little loss by premature construction. The question of optimal timing is sensitive to assumed growth rates, which are somewhat uncertain, therefore not too much confidence can be placed on precise dates for the optimal timing of this project. If one then considers the need for employment stimulation and the enthusiasm for facilitating EXPO 86, the earlier construction to open in 1986 may be understandable.

## VIII. CAVEATS AND QUESTIONS FOR FURTHER ANALYSIS

This paper was prepared during construction of the Coquihalla, but following the opening of Phase I there are a few developments which warrant comment. First, there is a general caveat which must accompany nearly all benefit cost studies. Finding a positive NPV is not a guarantee that there might not be alternate projects with even higher social returns. This study has also been confined to examining the given scale of the project. The Coquihalla is a four lane divided highway for most of its length. This paper has not inquired into whether or not a phased construction might generate higher net benefits. For example, this study did not consider building a two lane highway and later expanding it as traffic grew. The Ministry of Highways reportedly did consider this but found that the cost savings of two construction periods were very small (Kasianchuk and Warburton, 1986).

**Exhibit 6**
**Provincial Benefits vs. Discount Rate**
**(with and without tolls)**




Since the opening of Phase I, there have been some comments about construction and vehicle operations which warrant mention. A high priority was placed on opening at least part of the highway (Phase I) in time to handle expected traffic for EXPO 86. The accelerated construction required greater use of overtime and weekend construction, which raised costs. Because bids for construction work on the highway were reportedly less than in previous years, the project has remained largely on budget. Nonetheless, the greater amounts of overtime and higher cost working hours suggests that the project could have been built at a lower total cost if construction was spread over a longer period.

A related problem are allegations that some paving was done without adequate time for the road base to stabilize. If so, this may require additional maintenance and/or premature reconstruction at some time in the future. However, it has not been possible to substantiate or estimate these possible costs.

In the use of the Coquihalla, there have been complaints, especially from truckers, concerning the very long grades on the highway (Vancouver Sun, June 14, 1986). The grades are no steeper than on other major mountain highways; however, allegedly the grades are so long that cars and trucks are more prone to overheating and similar mechanical problems. If so, the expected operating cost benefits may not be as high as forecast.

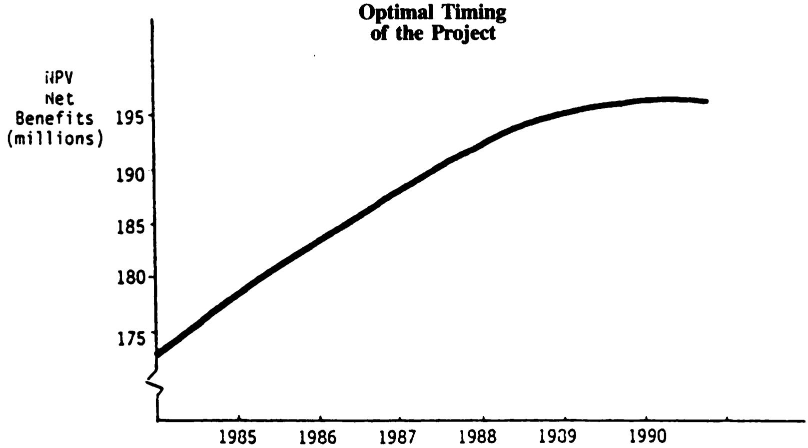
## IX. CONCLUSION

The Coquihalla makes an interesting case study of the economic evaluation of highway projects. It is a largely scale project with significant effects on traffic flows on the highway network. Substantial time and cost savings accrue to users. While there is always some debate over the valuation of these savings, the amounts of time and costs saved by individual vehicles using the Coquihalla are much larger than the magnitude of these benefits on most other road projects. Therefore, there is more confidence in the economic significance of these benefits than comparable figures for many other road projects.

The project has a modest net present value at a 7.5 per cent discount rate without tolls. Tolls reduce the level of benefits (although the net benefits are still positive at a 7.5 per cent discount rate) because tolls reduce the amount of traffic diverting to the highway.

The highway construction was rushed for at least partial completion in time for EXPO 86. The hasty

**Exhibit 7**
**Optimal Timing**
**of the Project**



construction suggests that the project costs could have been less if construction had been spread over a long period. Based purely on the user benefits and construction costs, the highway may have been constructed a few years earlier than warranted by projected traffic growth. However, given the uncertainty of growth forecasts, the need for employment stimulation in the B.C. economy in the mid 1980's, and the concern for facilitating EXPO 86, the actual project timing is not surprising.

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## END NOTES


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1. The vehicle operating cost figure was selected following perusal of figures estimated by the Canadian Automobile Association. The figures for truck operating costs were based on Trimac Consulting LTD. (1982) figures.
2. The time savings are based on design speeds of the new and old highways, taking into account traffic volumes. If people exceed the speed limit on the new highway, the time savings would be greater than calculated.
3. This figure is slightly below the figure (in current dollars) cited by the Insurance Corporation of British Columbia as the social costs of a fatal accident (Rockerbie, 1980).

   Bailey (1980) surveyed a number of studies estimating the valuation of life for decision making purposes. He found a range of figures, from about $170,000 to $584,000 per life saved (1978$). Studies based on direct interviews often produce higher estimates, e.g. see Jones-Lee, Hammerton and Phillips, 1985.
4. The standard discount rate recommended by the Treasury Board Guide (Government of Canada, 1976) is 10 per cent. However, it has been argued that the appropriate social discount rate for Canada is closer to 7.5 per cent (e.g. Burgess, 1981; Jenkins, 1981; Summer, 1980). The latter discount rate is used here; however, the sensitivity of results to the choice of discount rate can be seen in the plots of internal rates of return (Exhibits 4 and 6).
5. For projects with substantial external benefits such as most urban transit projects, where most of the benefits accrue to non users via reductions in congestion, the folly of trying to pay for projects by increasing user charges (therefore, decreasing use and losing the external benefits) is fairly clear. In the case of the Coquihalla, the vast majority of benefits are those which accrue directly to users' via time and operating costs savings. Therefore, the loss of benefits from toll charges is far less of a loss (reduced net benefits relative to total benefits without tolls of only 23 percent) than for many other public projects with greater non-user benefits. Therefore, given the practical necessity to finance large projects by a government facing financial constraints, the toll policy may be an understandable approach.