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Department of Soil Science

The University of British Columbia
1956 Main Mall
Vancouver, Canada
V6T 1Y3

Date April 27, 1984
This thesis is concerned with direct interactions between energy transmission facilities and agricultural operations. The objective of this study is to determine to what extent government regulation is advisable where energy transmission facilities occupy agricultural land. The area of electrical transmission line and pipeline rights-of-way within the Agricultural Land Reserve of British Columbia was found to be approximately 174 km² or about 0.37% of the Reserve.

Impacts to farmers were found to vary with the type of agricultural practices and the type of energy transmission facility. On intensively farmed land, electrical transmission lines could increase the cost of irrigation by as much as $1,000 per year, per kilometre of line. Land loss due to transmission line towers was found to reach 345 m² per kilometre of transmission line.

A wide variety of other impacts were also found. In grazing areas, impacts to agriculture were generally positive. The clearing of electrical transmission lines could increase grazing capacities by 10.4 animal unit months per year per kilometre of right-of-way.

Pipelines were found to have less impacts on agriculture than electrical lines. The most serious impact was yield loss along trenchlines on fine textured soils. The maximum value of such losses was $500 per kilometre of pipeline.
The cost of energy transmission facilities avoiding farmland was found to vary greatly with terrain and location. In many situations this cost can exceed $100,000 per kilometre of right-of-way, which is significantly higher than the value of any impact they can have on agriculture.

Federal and Provincial regulation of energy transmission facilities requires the compensation of affected persons and the reduction of negative impacts. Deficiencies in both processes were found. New Federal Legislation will increase the protection of affected persons, but unclear jurisdiction and problems of accurately assessing impacts will persist. Provincial regulation is more discretionary but has been well implemented in some cases.

The conclusion reached by the author is that transmission operators can and should bear the cost of all impacts on agriculture, and that the only way of consistently relieving this cost over the long term is to require compensation in kind.
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I wish to thank the many individuals and organizations who contributed their knowledge and time to the study. The farmers and ranchers in both the case studies not only provided information on the effects of electrical transmission lines and pipelines on their operations but also shared their feelings toward the transmission companies and governmental agencies. I also wish to thank these farmers and ranchers for the generous hospitality they showed me during the study.

The following energy transmission companies provided information on their operations and the effects they have had on agricultural operations; West Coast Transmission Co. Ltd., B.C. Hydro and Power Authority, West Kootenay Power and Light Co. Ltd., Alcan Smelters and Chemicals Ltd., Foothills Pipelines Ltd., Inland Natural Gas Co. Ltd., and Trans Mountain Pipe Line Company Limited. In particular the following individuals gave freely of their time and expertise: Mr. Bernie Guichon, of Westcoast, Mr. John Kelly and Mr. Gary Miller of B.C. Hydro, and Mr. Lorne E. Trickey of West Kootenay.

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My thesis advisors Dr. T.A. Black and Dr. L.M. Lavkulich contributed suggestions on the organization and presentation of this thesis.

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INTRODUCTION

Industrial activities are normally incompatible with agriculture. This study concerns one case where an industrial activity often shares land with agriculture. That activity is energy transmission. Specifically this study addresses the question "Should the government regulate the sharing of land by energy transmission facilities and agricultural activities, and if so, does the present system of regulation satisfy the needs of both the farmer and the energy transmission operator".

This study considers two methods of energy transmission: high voltage electrical transmission lines (over 200 kV) and pipelines (oil and gas). Chapter one, "Inventory", describes the types, operators of and extent of electrical transmission and pipeline rights-of-way, which occupy agricultural land in British Columbia. Both existing and proposed energy transmission projects are considered. In Chapter two, "Costs and Benefits to Farmers of Using Agricultural Land for Energy Transmission Facilities", the costs and benefits which accrue to farmers are estimated. Chapter three reviews costs and benefits from the transmission company's perspective. Chapter four, "Current Regulation", describes Federal and British Columbia legislation which applies to electrical transmission lines and pipelines crossing agricultural land. Chapter five, "Conclusions and Recommendations", addresses the basic question of this thesis: Is regulation of energy transmission facilities on agriculture advisable. This question is answered in the affirmative and recommendations are made to improve the current regulatory structure. The bibliography at the end of the thesis lists literature cited. Government acts and regulations are listed separately following the bibliography.
REVIEW OF LITERATURE

Energy transmission facilities are part of most modern agricultural landscapes. A considerable amount of scientific literature has been published on the effect energy transmission facilities can have on agricultural operations. Unfortunately much of this literature is published in private reports rather than scientific literature.

To meet the objectives of this thesis, a review of related literature was undertaken. This review concentrated on studies, articles, and reports on energy transmission facilities (electrical transmission lines and pipelines) which were either wholly concerned with agriculture or had a section on agricultural aspects. A number of pieces of literature were reviewed on the biological effects of electrostatic and electromagnetic fields associated with electrical transmission lines as these are of concern to all farmers operating near these lines. To allow for better comparisons of results, special emphasis was placed on studies which quantified impacts in dollar or area terms. The apparent concentration on studies located in Canada is not intentional. Canada appears to be responsible for a disproportionately large percentage of scientific studies on agricultural impacts of energy transmission facilities. Canadian studies may also be more available at Canadian libraries than are foreign studies.
The subject of energy transmission facilities affecting agriculture was introduced to the public in *Power Over People* (Young, 1973). This book traces the attempts of the people in a small rural Ohio town to stop a high voltage transmission line. The book is a "call to arms" against large power companies and their power to expropriate land for rights-of-way. The book concentrates on electro-magnetic effects of electrical transmission lines on humans. It chronicles a public review process that was in use in 1973 and finds it inadequate. This book has had the effect of arousing public interest in electrical transmission line impacts and regulations.

The earliest study reviewed which actually measured the impact of energy transmission lines on agricultural operation was "Influence du Type de Pylon Sur Les Performances des Machine Aratoires" (Hydro Quebec; 1974). Full scale models were constructed of both square lattice towers and guyed V towers. The time loss and land loss associated with these towers were then measured. Only one farmer harvesting corn silage was used. The steel lattice tower caused a land loss of 307m² and a time loss of 2.48 minutes per year. The guyed V tower resulted in 40m² of land loss and only 0.33 minutes of time loss per year. Tower position and orientation was found to affect time loss and land loss. One collision happened during misty weather and was considered a good reflection of actual field conditions. Based on this study, Hydro Quebec justified the use of less expensive V towers in agricultural areas.
The first major study that actually measured direct effects of electrical transmission lines on agricultural yields was *A Study of the Projected Effect of Hydro Towers on the Revenues of Farmers in the Ridgetown Area* (Bomford, 1974). This study was initiated by Ontario Hydro in western Ontario. A year later Ontario Hydro initiated a companion study in eastern Ontario entitled *Effects of Electrical Transmission Towers on Farm Field Operation in Eastern Ontario* (Kempville College of Agriculture, 1975).

These two studies became known as the Ridgetown and Kempville studies and were synthesized in *The Effects of Hydro Transmission Towers on Farm Operations in Western and Eastern Ontario* (Ontario Hydro; 1977). The crops studied were corn, soybeans, wheat, buckwheat, and hay. Various tower sizes and locations in fields were studied. Seventy percent of the costs to farmers attributed to electrical transmission lines was due to land not farmed under and adjacent to towers (land loss). The remaining thirty percent was attributed to time loss in avoiding towers, crop damage, and fertilizer and seed loss. The least loss was associated with towers positioned on fences. The total cost of transmission towers with a 7.9m square base ranged from $12.64 per year per tower in wheat to $28.28 per year per tower in corn silage in the Ridgetown study. Similar values in the Kempville study ranged from $2.10 per year per tower in hay to $13.16 per year per tower in corn.
In 1976 the U.S. Department of Agriculture issued a pamphlet titled *Electrostatic and Electromagnetic Effects of Overhead Transmission Lines* (Rural Electrification Administration, 1976). The following is the summary of conclusions reached by this report that is of significance to this thesis:

As transmission line voltages and currents increase, possible problems associated with electrostatic (E/S) and electromagnetic (E/M) coupling between overhead alternating current transmission lines and conductive objects increase. Electrostatically-induced voltages are possible when a conductive object insulated from ground is in the vicinity of over-head lines. If the conductive object is not adequately grounded when a person or animal comes in contact with it, a current flows in the connection to ground through the electrical body resistance. Intervals between grounding points that will reduce the E/S and E/M induction effects are based on the maximum allowable shock current passing through a person or animal when touching the conductive object. For the E/S case, a steady state shock current magnitude of 5 ma is being considered as the maximum "let'go" level in the proposed revision of Part 2 of the National Electrical Safety Code. (Rural Electrification Administration, 1976, 2). The let'go level is a threshold where a person can no longer voluntarily break contact with an electric current. Other practical considerations may dictate that the shock current magnitude be kept below the one milliampere "threshold of perception" level. For the E/M case, recommended object grounding intervals are based on a 50 kilogram (110 pound) person experiencing no more than a 0.5 percent probability of "ventricular fibrillation" (Rural Electrification Administration, 1976, 1).

Using both field trials and surveys, this study concluded the following:

1. The major financial effect on tower was caused by loss of crop followed by weed control, then time loss.

2. Economic loss to peach growers ranged from $30.91 per tower, per year, to $137.43 per tower per year.

3. Economic losses to grape growers ranged from $100.99 per tower per year to $119.72 per tower per year.

4. Economic losses for strawberries ranged from $31.35 to $87.54 per tower per year.

In addition to these losses, growers mentioned the following less measurable losses:

1) larger, more efficient implements could not be used on the farm because of the need for small machinery to fit under towers
2) towers caused damage to machines through accidental collision
3) birds which fed on crops used towers as roosting sites
4) trees located near towers suffered due to the lack of drainlines
5) uncontrolled vegetation around tower bases led to increased pest problems
6) shocks were experienced by some workers.

No attempt was made to assess the above impacts.

A more general publication was issued by the Canadian Committee on Agricultural Engineering entitled *Effects of High Voltage Hazards and Power Lines*, (Morris, R.M.: 1976). While no new data was generated in the paper the following phenomenon was identified as affecting agricultural operations near transmission lines: Corona Effects (including radio noise, audible noise, ozone generation, and television interference), Electromagnetic Radiation, Flashover (electrical discharge to ground), Electrostatic shocks, Magnetic Fields, Subtle Phenomena (biological). None of these phenomena are found to be an obstacle to agricultural production.

*Electrical and Biological Effects of Transmission Lines* (Lee, J.M. et al, 1977) was a similar review of electrical phenomena. The booklet gives the basis for high voltage electrical transmission line construction standards over farmland.

The first major conference on Environmental Concerns in Rights-of-way Management was held at Mississippi State University in 1976. The Proceedings of this conference (Tillman, Robert, ed: 1976) contain ten papers on transmission line siting, ranging from papers on environmental

In 1977 Bonneville Power Administration published a collection of research findings on transmission line impacts on aerial crop dusting and crop yield trials under transmission lines, Farming Around and Under Transmission Lines, (Kulp, K.E.L., 1977). It was found that while electrical conductors did not greatly interfere with crop dusting, towers increased the time it took to dust fields, but farmers were not charged for this time. The report included following results of crop trials. No loss of yield was reported under or near conductors between towers. Two areas of yield loss were noted: losses due to uncropped land immediately under and adjacent to 7.6 m square tower bases and yield loss due to poorer crop growth immediately around the uncropped area. The partial yield losses were attributed to weed spread from weed population under towers and effect of soil compaction and extra cultivation on sensitive soil type. The following data is based on 2 farms for wheat and one farm for both beet and corn.
Wheat

<table>
<thead>
<tr>
<th>Loss under tower</th>
<th>100%</th>
<th>121m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional partial yield loss</td>
<td>10%</td>
<td>930m x 0.10 = 93m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>214m</td>
</tr>
</tbody>
</table>

Sugar Beets

<table>
<thead>
<tr>
<th>Loss under tower</th>
<th>121m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional partial yield loss</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sweet Corn

<table>
<thead>
<tr>
<th>Loss under tower</th>
<th>100%</th>
<th>121m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional partial yield loss</td>
<td>20%</td>
<td>404m x 0.2 = 80m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>201m</td>
</tr>
</tbody>
</table>

Potato data was found to be incomplete.

By 1978, a considerable amount of research on the impact of electrical transmission lines on agriculture became available. One of the most extensive of these studies was An Investigation of Electrical Power Transmission and Agricultural Compatability on the Mapp Region, (Gustofson et al, 1978). The Mapp Report which shared some of the objectives of this thesis, concentrated on the midwestern United States. The Mapp Report reached the following conclusions:
Interaction areas in the midwestern U.S.A. would not imply that significant amounts of land are being lost from agricultural production on a state or regional basis. However, this does not imply that locating a right-of-way on a parcel of land does not have significant effect on the individual parcel. Therefore, future studies on routing and construction procedures should concentrate on minimizing the effect on individual farm units. Quantification should include effects on the total business of a farm, not just the crop-loss aspect. The report found that the use of sprinkler irrigation is rapidly growing in many areas of the Midwest. The amount of land lost from irrigation due to a transmission line R-O-W varies with R-O-W width, orientation, and the type of irrigation system used. The loss in revenue associated with the location of transmission R-O-W on irrigated land is much more significant than that for nonirrigated land. Potentially hazardous situations can be envisioned when an irrigation system is located in close proximity, and, in particular, parallel to a high voltage transmission line. Current published guidelines and recommendations are inadequate for use by irrigation equipment personnel or irrigators to establish a basis for adequate clearances and sufficient grounding. Hypothetical straight line R-O-W's placed on aerial photographs indicate that in most highly productive agricultural areas, a very high percentage, ninety percent or above, of the R-O-W will be in agriculturally productive fields.

Aerial photography of towers of existing lines showed that a large variation in land lost from production exists within any line segment. For the line segments in this study, average losses per structure varied
from 644 ft² (0.015 ac) for a 230 kV line using H-Frame structures to 2,213 ft² (0.051 ac) for 230 kV line using lattice structures.

Another study was produced in Ontario in 1978, this time by a Royal Commission of the Provincial Government, not Ontario Hydro. This study was entitled *The Socio-Economic Impacts of Electrical Transmission Corridors - A Comparative Analysis* (Boyer, J.G.; 1978). The study was set up as a controlled experiment. Biophysically and socio-economically matching corridors were chosen, one with a transmission line, one without. There were few differences between Questionnaire responses from the 500 kV and 230 kV study areas. The impacts of transmission corridors do not appear to be influenced by the age, voltage, or size of the line. Hydro lines were found to meet with the strongest opposition during the planning and construction phases but, once in place, became neutral components of the landscape. Land values were found to be relatively unaffected. While a majority of respondents to the survey in all categories thought electrical transmission lines affect agriculture, significantly more of those living away from the hydro lines than those living by the lines thought agriculture was affected 58.7% rather than 76.7%.

The first major study on interaction between electrical transmission lines and agriculture in Western Canada was published by Calgary Power Ltd. in 1978. The study *The Cost of Farming Around Transmission Line Towers in Central Alberta* (McKinnon, Allen and Associates Western Ltd., 1978) used both survey data and actual field measurements.
Survey data showed that:

1. 33% of surveyed farms had machinery collide with towers which caused an average downtime of 2.6 hrs.

2. 87% of farmers thought yield around towers was reduced. 10% thought they had weed problems around towers.

3. An average of 10.74 machine operations were carried out each year on grain fields and 4.98 on hay fields.

4. Average revenue per hectare in the study area (Alberta) was $99.85/yr.

The field experiment yielded the following results:

**TABLE 1.**

<table>
<thead>
<tr>
<th>COST PER TOWER PER YEAR TO FARM AROUND SINGLE AND DOUBLE TOWERS AS PRESENTLY PLACED</th>
<th>Single Tower</th>
<th>Double Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;Complex&quot;</td>
<td>&quot;Diamond&quot;</td>
</tr>
<tr>
<td>Weed control</td>
<td>$11.00</td>
<td>$11.00</td>
</tr>
<tr>
<td>Herbicide misses</td>
<td>.29</td>
<td>.29</td>
</tr>
<tr>
<td>Harvesting loss</td>
<td>.34</td>
<td>.34</td>
</tr>
<tr>
<td>Double seeding effect</td>
<td>.81</td>
<td>.21</td>
</tr>
<tr>
<td>Extra machine operation</td>
<td>3.47</td>
<td>2.86</td>
</tr>
<tr>
<td>Area lost to production</td>
<td>1.90</td>
<td>2.57</td>
</tr>
<tr>
<td>Risk of Bertha Army Worm</td>
<td>.72</td>
<td>.72</td>
</tr>
<tr>
<td>Time loss due to collision</td>
<td>9.87</td>
<td>9.87</td>
</tr>
<tr>
<td>Collision repair insurance</td>
<td>4.98</td>
<td>4.98</td>
</tr>
<tr>
<td>Annual cost</td>
<td>$33.38</td>
<td>$32.95</td>
</tr>
</tbody>
</table>

The twin line increased the cost slightly per tower.

1 (McKinnon, Allen, and Associates Western Ltd., 1978, pii)
2 circling tower an extra time
3 veering around towers
The farmers interviewed were not united in their opinion, but in the case of a twin line, most preferred the towers opposite each other as opposed to staggered.

There are other operating situations around towers which are variable in nature and occur less frequently. Allowances for the costs of these situations have not been included in the above tabulation. For example, in one case where the tower was too close to the fence to get equipment through, the extra cost was $1.45 per tower for lost crop due to missed areas of herbicide.

Towers would be less of a problem if placed on a fence line. The cost in this situation is estimated to be as follows:

**TABLE 2.**

<table>
<thead>
<tr>
<th>Cost Description</th>
<th>Cost Per Tower Per Year</th>
</tr>
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<tbody>
<tr>
<td>Extra machinery operation</td>
<td>$2.242</td>
</tr>
<tr>
<td>Double seeding</td>
<td>.32</td>
</tr>
<tr>
<td>Weed control</td>
<td>11.00</td>
</tr>
<tr>
<td>Herbicide miss</td>
<td>--</td>
</tr>
<tr>
<td>Area lost to production</td>
<td>2.06</td>
</tr>
<tr>
<td>Harvesting loss</td>
<td>--</td>
</tr>
<tr>
<td>Time loss due to collision</td>
<td>8.002</td>
</tr>
<tr>
<td>Insurance for collision repairs</td>
<td>4.982</td>
</tr>
<tr>
<td>Bertha Army Worm control</td>
<td>.68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$29.28</strong></td>
</tr>
</tbody>
</table>

1 (McKinnon, Allen, and Associates Western Ltd., 1978, piii)

2 Swathing the outside round backwards with a self-propelled swather and combining the round backwards would substantially decrease the extra machine time required and also reduce the risk of collision.
Electrical effects of high voltage transmission lines continued to be a subject of research. *Electrostatic and Electro-magnetic Effects* (Miller, M.W., and G.E. Kaufman; 1978) was an extensive review of research up to that date. They concluded that neither animal and plant experimentation, nor clinical studies, nor 25 years experience with operating extra high voltage transmission lines have to date provided convincing evidence for harmful effect of exposure to electric and magnetic fields associated with transmission lines in spite of numerous attempts to do so. Miller and Kaufman recommend that transmission lines be designed to limit the strength of electrical fields at ground level to 10 kV/m. Above this level, electrostatic shocks and annoying skin sensation have been reported.

Problems with electrical charge building up on sensitive farm machinery was reported in 1978. Ontario Hydro released a study entitled *The Effects of Extra High Voltage Transmission Lines on Laser Beam and Other Electronic Equipoment used in Agricultural Operations*, (Ontario Hydro, 1978). A literature search and contact with manufacturers of agricultural tile laying machinery who use electronic equipment confirmed that problems have been encountered in the past when this machinery was used near EHV transmission lines. This was also partially confirmed by some of the major agricultural implement manufacturers. It was generally agreed, however, that research and new technology have alleviated many of the problems of electromagnetic charge build-up from engines and lines in newer models.
Most of the previously mentioned literature dealt with electrical transmission. In 1980 a Canadian study on pipelines was published entitled: *The Effect of Pipeline Installations on Agricultural Land Values in Alberta* (Deloitte Haskins and Sells Associates; 1980). This study found that pipelines have no effect on agricultural land values regardless of size or soil type.

Also in 1980 more research was published on land loss and time loss around electrical transmission towers. In *Time and Land Lost with Electric Towers*, (Fortine, J.M., 1980), three methods of estimating land loss and time loss for 120, 230 and 735 kV lines were compared: computer simulation, (1) field trials, (2) and farmer survey (3). The range for each of these methods covered a factor of 10. The mean values for different methods of estimation were close. The following table gives the comparison estimates for land and time loss.

<table>
<thead>
<tr>
<th>TOWERS</th>
<th>Land Lost (metre²)</th>
<th>Time Lost (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RANGE</td>
<td>MEAN</td>
</tr>
<tr>
<td>WOOD FRAME</td>
<td>5 to 324</td>
<td>68 (1)</td>
</tr>
<tr>
<td>120 kV</td>
<td>2.4 to 2511</td>
<td>70 (3)</td>
</tr>
</tbody>
</table>

1 (Fortine, J.M., 1980, p14)
2 (Gustafson, J.A. et al, 1978)

This document is significant as it committed the company to recognize and either mitigate or compensate for a wide variety of impacts including impacts on agricultural production. Topics covered are legislation, planning, design, construction, operation, maintenance and abandonment. This manual is regularly updated.

Similar manuals were published by NOVA an Alberta Corporation, 1981 and Foothill Pipelines Ltd.

Environmental Impact Studies were prepared for most electrical transmission projects since the mid 1970's. Early studies did not include discussion of impacts on agriculture. By the early 1980's considerable space was devoted to agricultural impacts. Two recent environmental studies addressed the impacts of electrical transmission lines on ranching as well as cultivated agriculture. Stage I Environmental Studies for the Kelly Lake-Cheekye Transmission Line, (Sigma Resource Consultants Ltd., 1981) included the following table of Agricultural impacts.
<table>
<thead>
<tr>
<th>TRANSMISSION LINE ACTIVITY</th>
<th>AGRICULTURAL IMPACT</th>
<th>MITIGATION OR COMPENSATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right-of-way clearance</td>
<td>Disruption of cropping operations</td>
<td>avoid cropping season, compensation</td>
</tr>
<tr>
<td></td>
<td>Disruption of fencing</td>
<td>repair fences</td>
</tr>
<tr>
<td>Access road construction</td>
<td>Loss of arable land</td>
<td>compensation</td>
</tr>
<tr>
<td></td>
<td>Soil compaction and rutting</td>
<td>renovate soil</td>
</tr>
<tr>
<td></td>
<td>Crop Loss</td>
<td>avoid cropping season, compensation</td>
</tr>
<tr>
<td>Tower construction</td>
<td>Loss of arable land</td>
<td>compensation</td>
</tr>
<tr>
<td></td>
<td>Crop loss</td>
<td>avoid cropping season, compensation</td>
</tr>
<tr>
<td></td>
<td>Interruption of existing irrigation equipment; loss of options for future irrigation system design</td>
<td>compensation</td>
</tr>
<tr>
<td>Vegetation control</td>
<td>Crop and animal loss from use of herbicides to control vegetation on surrounding right-of-way</td>
<td>selective pesticide program adjacent to and on agricultural lands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reseed using grass species suitable for grazing</td>
</tr>
<tr>
<td>Line maintenance</td>
<td>Crop loss</td>
<td>avoid cropping season</td>
</tr>
<tr>
<td></td>
<td>Soil compaction</td>
<td>avoid use of heavy equipment off permanent access routes, renovate soil</td>
</tr>
<tr>
<td>Unexpected events</td>
<td>Crop loss</td>
<td>compensation</td>
</tr>
<tr>
<td>(surface erosion, slides)</td>
<td>Soil loss</td>
<td>renovate soil</td>
</tr>
</tbody>
</table>

1 Sigma Resource Consultants, 1981.
The other environmental study was on the Stikine-Iskut Transmission Project in northwestern B.C.. It included a large agricultural section (Goldstein, 1982), which included a detailed methodology for assessing the impacts of high voltage transmission lines on agriculture as well as a discussion of impacts. The major steps in this methodology are given below:

"Step 1 Determination of highest agricultural capability.

The highest agricultural capability class covering over 10% of the land area within a subsegment was determined visually. To do this the corridor boundaries are placed on 1:125,000 or 1:50,000 Land Capability for Agriculture maps. Where neither of these were available the simplified agricultural capability maps included in this report were used.

Step 2 Determination of maximum developable capability

Economic factors can enhance or limit the development that can be realized on land of a given agricultural capability. For this reason the highest agricultural capability determined above was modified as follows. The capability class was raised to the improved rating with irrigation and/or drainage in areas where such development was judged likely over the next 50 years. Likewise, the capability class was lowered to the class corresponding to the maximum intensity over the next 50 years in areas where economic factors limit agriculture.

Step 3 Assignment of Impact Rating

The potential impacts of transmission line development on agriculture as outlined in Section 2.3 of this report were applied to the type of development indicated by the maximum developable capability. The definitions of levels of impact listed below were used to do this in a consistent and reproducible manner."

The impact ratings used in the agriculture assessments range from 5 to -3, and are defined as follows:

1 (Goldstein, 1982)
## TABLE 5

DEFINITIONS OF IMPACT RATINGS

<table>
<thead>
<tr>
<th>LEVEL OF IMPACT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe impact (5):</td>
<td>Areas of intensive agricultural development, where the area of prime agricultural land (BCLI Class 3 or better) that would be affected by transmission line development is large enough to make agricultural communities less viable. Mitigative measures would be required in these areas.</td>
</tr>
<tr>
<td>High impact (4):</td>
<td>Areas of prime agricultural land, where the amount of land that would be affected by transmission line development is not large enough to greatly discourage agricultural development.</td>
</tr>
<tr>
<td>Moderate impact (3):</td>
<td>Areas capable of growing a narrow range of cultivated crops (BCLI Class 4).</td>
</tr>
<tr>
<td>Low impact (2):</td>
<td>Areas capable only of forage production (BCLI Classes 4 and 5).</td>
</tr>
<tr>
<td>Slight impact (1):</td>
<td>Areas where the overall effect of transmission line development would be an inconvenience.</td>
</tr>
<tr>
<td>No impact</td>
<td>Areas of no agricultural potential or areas in which the impacts and benefits of transmission line development on agriculture would be roughly equal.</td>
</tr>
<tr>
<td>Slight benefit (-1):</td>
<td>Areas where the economic benefit of improved grazing capacity would largely offset the impacts of transmission line development on forage areas.</td>
</tr>
<tr>
<td>Low benefit (-2):</td>
<td>Areas where the economic benefit to ranch operators of improved grazing capacity as a result of transmission line development would be significant.</td>
</tr>
<tr>
<td>Moderate benefit (-3):</td>
<td>Areas where the right-of-way clearing associated with transmission line development could lead to agricultural development in areas which would otherwise not be developed.</td>
</tr>
</tbody>
</table>

1 (Goldstein, 1982)
Another study of methods for assessing the agricultural impacts of transmission lines was issued in 1982, (Grumstrup, P.D. et al, 1982), described how aerial photographs could be used to assess the impact of transmission lines and agricultural crop production.

Similar or different energy transmission systems occupy the same or adjacent rights-of-way in many areas. The advantages and disadvantages of this system were studied by Ian Hayward and Associates in Common Utility Corridor Study, (Ian Hayward and Associates, 1982). This study concluded that while common corridors may, in some instances, reduce agricultural impacts, they may also increase these impacts by restricting less demanding (in terms of terrain) transmission facilities, such as electrical transmission line to routes that can be traversed by pipelines. Rather than suggest a universal common corridor policy, the study suggested a case by case approach be taken. Planning of future common corridors was recommended in narrow, confined mountain passes and in suburban areas where land prices are high.

The author of this thesis completed a study entitled Opportunities and Risks Presented to Agriculture by Linear Developments for the B.C. Ministry of Agriculture and Food (Goldstein; 1983). Some of the material analysed in this thesis has been drawn from this work.
The majority of the literature reviewed concentrated on assessing and mitigating individual impacts of electrical transmission lines and pipelines. Most studies are based on developed agricultural areas and not on ranching areas. While informative, care should be taken in applying cost estimates from non B.C. studies to British Columbia.

In particular, the bibliography is a strong measurement of impacts caused by transmission towers on common cultivated crops, and effects of electrical transmission lines on land values. The largest body of literature was on the electrical effects of electric transmission lines on people, plants, and animals.

Considerably less material was available on all aspects of pipelines. Many utilities publish public information booklets, but these booklets lacked sufficient detail to design irrigation under electrical transmission lines.

Unfortunately, little information was available on the success of government environmental regulation or utility environmental procedures. Such information is badly needed. In particular, no "post mortems" were reviewed which showed the effectiveness of different government regulation strategies.
1.1 Introduction and Background

Two types of energy transmission modes are considered in this report: high voltage electrical transmission lines and pipelines. To set the stage for what is to follow, the following description of each of these energy transmission modes is provided.

1.1.1 High Voltage Transmission Lines

In British Columbia the major source of electric power is hydroelectric dams. These dams often must be located at a distance from load centres (cities and industrial facilities). To tie generation facilities to load centres, a provincial extra high voltage electrical transmission grid has been developed. This grid is also connected to neighboring electrical systems. With the increase in electrical demand, there has been a progression of larger hydro electric projects that are further from load centres. As a result, longer and higher voltage transmission lines have had to be developed. The long term outlook is for this progression to continue.

Transmission lines are normally divided into categories on the basis of their voltages. As longer distances are crossed, higher voltages must be used to avoid excessive electrical losses. Higher voltage lines require larger towers to maintain adequate separation between lines and ground. At the present time 500 and 230 kilovolt transmission lines are the most
common voltages for long range transmission in B.C. If additional generation facilities are developed in northern B.C., 765 and 1000 kV lines may be considered.

Transmission line development begins with a survey of the centre line. This is followed by logging. Access roads developed during logging may be upgraded for construction use. Prior to actual tower construction, the right-of-way is cleared. In areas where agronomic grass species are desired for grazing, the removal of stumps and roots and seeding with appropriate grasses is normally carried out. Placement of foundations and tower erection is the next step, followed by the actual stringing of the conductor(s). In some cases up to three years is needed to complete this process in an area, although the actual working time is a few months.

There are three companies which operate high voltage (over 200kV) electrical transmission lines in B.C.: B.C. Hydro and Power Authority, West Kootenay Power and Light Company Ltd. and Alcan Smelters and Chemicals Ltd. The following are short descriptions of each of these companies.

a) B.C. Hydro and Power Authority

B.C. Hydro is by far the largest electrical transmission project operator in B.C. In 1962 the B.C. Electric company was taken over by the B.C. Power Commission.
B.C. Hydro services over 90% of B.C. with electricity and gas. B.C. Hydro's installed generating capacity is over 8 million kilovolts, based largely on hydro-electric projects. Goldstein, 1982, lists Hydro's integrated transmission system at 31 March, 1981 as the following:

- 500,000 volt lines: 4,017 km
- 360,000 volt lines: 330 km
- 230 volt lines: 2,969 km
- Total: 7,316 km

plus lower voltage lines

b) West Kootenay Power and Light Company Ltd.

West Kootenay Power and Light Company Ltd. provides hydroelectric power for the southeastern corner of the province of B.C. from the east side of Okanagan Lake to Creston. West Kootenay manages five hydro-electric plants for Cominco Ltd.

Most of West Kootenay's transmission system is at voltages below 230 kV. The following is a list of their existing and proposed transmission lines.
<table>
<thead>
<tr>
<th>Line Number</th>
<th>End Points</th>
<th>Voltage</th>
<th>Length R/W with structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-8</td>
<td>Trail to South</td>
<td>8 x 69kV*</td>
<td>40 km single wood poles</td>
</tr>
<tr>
<td></td>
<td>Slocan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Vernon to Hollywood</td>
<td>230 kV</td>
<td>35 km 43m wooden H frame</td>
</tr>
<tr>
<td>Proposed:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oliver to Hollywood</td>
<td>230 kV</td>
<td>80 km 43m wooden H frame</td>
</tr>
</tbody>
</table>

*included due to the number of parallel lines

c) **ALCAN Smelters and Chemicals Ltd.**

The Alcan hydro-electric plant at Kemano came into operation in 1954. Using a dam on the Nechako River, water was impounded in a lake chain extending through Tweedsmuir Park, then diverted through a 16 km tunnel at Kemano. A 50 mile, 287 kV transmission line connects the 812 MW generators at Kemano to the aluminum smelter at Kitimat.
1.1.2 Pipelines

Pipelines can be categorized in several ways. Gas pipelines carry compressible light gas, normally methane, which is propelled by compressor stations along the line. Crude oil pipelines carry an incompressible fluid that is pumped. This distinction is not as clear for pipelines which carry feedstocks such as ethylene to petrochemical plants. Many of these chemicals have properties which fall between gas and oil. Pipelines are often classified by their diameter with 12 inches being the major division point. Gas pipelines may be high or low pressure, the category separation is at 100 psi. Another differentiation is made between gathering lines in producing areas, distribution lines in consuming areas, and the large diameter transmission pipelines that connect them. In spite of these differences, a right-of-way of a single transmission pipeline tends to fall between 12 and 20 m.

Pipelines are normally buried under about 1 m of cover. For this reason rights-of-way normally avoid rocky areas in favor of soil or muskeg. In wet areas, construction generally takes place in winter when the ground is frozen. Normally an 18 m wide right-of-way is cleared and a temporary road is constructed. On farm land the topsoil is removed with a small bulldozer to a depth of 0.2 m for a 7 m width and stockpiled. A trench is then dug, and the trench soil is piled on the area scraped of topsoil. The pipe is then welded into a continuous length, covered with a protective coating, and buried with the trench soil. The stockpiled topsoil is then distributed over the 7 m disturbed area. Revegetation procedures vary with the site and ownership. The entire process can take between 3 and 60 days.
Due to the greater density of oil, oil pipelines are normally routed on flatter land than gas pipelines thus avoiding the need for very high pumping pressures. This means that oil pipelines have much less flexibility with respect to location.

Pumping stations vary greatly in size with an average station occupying about 3 ha. Some additional area is often used as a buffer strip. Metering stations are placed along pipelines at varying intervals and normally require about 0.5 ha of land. Cathodic inspection posts are located at approximately 2 km intervals. These 10cm by 10cm wooden posts are often located along fence lines.

There are five companies which operate pipelines in British Columbia: Westcoast Transmission Company Ltd., Trans Mountain Pipe Lines, Inland Natural Gas Company Ltd., B.C. Hydro Gas Division, and Foothills Pipelines. The following are short descriptions of each of these companies.

a) Westcoast Transmission Company Ltd.

Nearly all of the natural gas from B.C. wells is purchased by the B.C. government through the B.C. Petroleum Corporation. The Petroleum Corporation then sells the gas to Westcoast which is responsible for gathering, processing and selling the gas. Westcoast also buys gas from
Alberta, the Yukon, and Northwest Territories. Westcoast's major customers are B.C. Hydro Gas Division, Inland Natural Gas, and Pacific Northern Gas, which is itself a Westcoast subsidiary. A large fraction of Westcoast's gas is sold to the U.S.

Westcoast operates five natural gas pipelines in B.C. which total 2,824 km. Westcoast also operates an oil pipeline that parallels their main gas line for 127 km.

Westcoast has proposed two major gas transmission pipeline projects. The Dome Gas project consists of an 855 km long gas pipeline with a diameter of 26 inches, to deliver natural gas from Alberta to Dome Petroleum's Liquified Natural Gas exporting facility near Prince Rupert. Westcoast is also proposing a 413 km gas pipeline to bring natural gas from 150 Mile House to Comox on Vancouver Island.

b) Foothills Pipelines (Northern B.C.) Ltd.

Foothills Pipelines is the principal in the proposed Canadian Arctic gas pipeline project. This project would consist of a large diameter natural gas pipeline from Prudhoe Bay in Alaska through the Yukon and western Canada to southern markets. Agreement has been reached between the U.S. and Canadian governments that the preferred route for such a project is the Foothills' Alaska Highway Pipeline Project. The proposed pipeline would include 867 km of right-of-way in B.C.
c) **Inland Natural Gas Company Limited**

Inland is a natural gas transmission and distribution company serving the North Central Cariboo, Okanagan, and Kootenay areas of B.C. Gas is purchased from Westcoast Transmission. Inland's system included about 18 kilometres of transmission pipeline.

Inland Natural Gas Company Limited has 1852 kms of distribution pipe. The pipe diameter varies from 12 inches to 2 inches. It owns three compressor stations in British Columbia. Rights-of-way vary in width from 3 to 18m. Inland occupies common corridors with B.C. Hydro in the Southern Okanagan, and eastern Kootenays.

d) **Trans Mountain Pipe Line Company Ltd.**

Trans Mountain owns and operates a pipeline for transmission of crude oil and natural gas liquids from Edmonton to Burnaby, British Columbia. The length of the system is 1161 km with a capacity of 410,000 bbls/day.

e) **B.C. Hydro Gas Division**

B.C. Hydro and Power Authority's Gas Division distributes natural gas in Vancouver and the Lower Fraser Valley. B.C. Hydro obtains natural gas from Westcoast at Huntington which is close to Chilliwack in the Lower Fraser Valley. Most of its pipeline is small diameter and follows highway and road rights-of-way. B.C. Hydro is proposing a major gas transmission to Vancouver Island.
1.2 Methods of Inventory

How much agricultural land is directly affected by energy transmission facilities? To answer this question the occurrence of electrical transmission lines and pipelines in the B.C. Agricultural Land Reserve was estimated in the following way.

Only a small percentage of British Columbia's 90 million hectare area is fit for agriculture; about 5% or 4.5 million hectares. To preserve the quality of this land base for agriculture, British Columbia has enacted two pieces of legislation; The Agricultural Land Commission Act (B.C.L.S. 1979 RSC9) and the Soil Conservation Act (B.C.L.S. 1977, RSC603). The Agricultural Land Commission Act sets up a land reserve where activities such as industrial development which make land unfit for agriculture are prohibited. The Soil Conservation Act prohibits removal of soil and other practices which seriously harm soil in the Agricultural Land Reserve.

The Agricultural Land Reserve was presumed to be the agricultural land base of the province for the purposes of this chapter. The area of this land shared by energy transmission facilities was calculated as follows: the location of existing and proposed electrical transmission lines with operating voltages over 230 kV and oil and gas transmission pipelines was drafted onto a 1:1,000,000 map of Agricultural Land Reserves of B.C.
Maps of existing and proposed projects were supplied by linear operators. Existing projects were located using the following maps in order of preference: Aeronautical charts, black and white LANDSAT satellite mosaics, and National Topographic Series Maps at scales of 1:250,000, 1:125,000 and 1:50,000. A copy of the energy transmission facilities and Agricultural Land Reserve Map is included in Goldstein, (1983)

Areas of rights-of-way and stations were calculated for comparative purposes. The total length of each electrical transmission line and pipeline and the length within the ALR were measured on the base map with a precision map measuring device. The area affected by linear developments was estimated by multiplying the length of the linear development by the following average rights-of-way widths:

**Electrical transmission lines**

- 300-500 kV: 64m
- 230 - 300 kV: 42m

**Pipelines**

- Transmission: 15m
- Gathering: 10m
Major electrical transformer stations and compressor and pumping stations were drafted onto the base map based solely on the information supplied by linear operators. No information was readily available on the size of individual stations. Low elevation air photographs of two electrical transformer stations, two large gas compressor stations and one oil pumping station were used to estimate the size of such stations. The sizes of these stations ranged between 8 and 16 ha with an average about 10 ha\(^1\). While all linear projects of a single type and size are often very similar, stations along a single project may vary greatly in size and function. In this study, an average size of all major linear development stations of 10 ha was assumed.

The magnitude of agriculture/linear project interaction was assessed by comparing the total land area within the ALR to the portion of this area which is within rights-of-way for electric, gas and oil transmission lines. It should be noted that many impacts are associated with areas much larger or smaller than the right-of-way. Impacts on irrigation can affect much larger areas than the right-of-way. Impacts caused by transmission tower bases affect only a small portion of the rights-of-way. Some impacts such as land clearing and prohibition of building development are closely associated with the size of the right-of-way. It is felt that the area of right-of-way within the ALR is a good relative measure of the magnitude of interaction at the overview level.

\(^1\) The legal size of the land parcel for compressor stations was approximately twice the size of the actual station. Information on land ownership around electrical and oil stations was not available.
1.1 Results of Inventory

Background

The Canadian Agricultural Economic Research Council estimates 23% of B.C. economic activity is directly or indirectly generated by agriculture. [Economics Branch Ministry of Agriculture, 1981(9)] With wholesale sales of $2.6 billion, agriculture ranks third behind forestry and mining. In times of recession, the importance of agriculture relative to forestry and mining increases. The major impetus of agriculture is not its relatively small land base of about 4 million hectares but the readily available markets based on the forestry and mining industries. These industries stimulate the agricultural industry but also compete with it for flat, accessible agriculturally capable land and rangeland.

Results

Table 7 gives the number of hectares of electrical transmission lines and pipelines rights-of-way for each of the 8 Agricultural Reporting Regions in British Columbia. Numbers without parentheses are the current projects and numbers in parentheses are for proposed transmission projects.

Electrical transmission rights-of-way occupy a much larger percentage of the agricultural land reserve than any other energy transmission facility - about 0.3%. Proposed new transmission lines would increase this total to 0.4%. While this is a small percentage, it represents over
### Table 7 Energy Transmission Rights-of-Way Within the B.C. Agricultural Land Reserve in Hectares

Existing (proposed)

<table>
<thead>
<tr>
<th>Agricultural Reporting Region</th>
<th>Electrical Transmission Right-of-Way Within ALR</th>
<th>% of ALR</th>
<th>Pipeline Right-of-Way Within ALR</th>
<th>% of ALR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kootenay</td>
<td>1,324 (569)</td>
<td>0.39% (0.17%)</td>
<td>315 (30)</td>
<td>0.09% (0.01%)</td>
</tr>
<tr>
<td>Okanagan</td>
<td>1,009 (336)</td>
<td>0.33% (0.11%)</td>
<td>165 (0)</td>
<td>0.05% (0.0%)</td>
</tr>
<tr>
<td>Island</td>
<td>680 (0)</td>
<td>0.61% (0.0%)</td>
<td>0 (105)</td>
<td>0.00% (0.09%)</td>
</tr>
<tr>
<td>Mainland</td>
<td>2,428 (416)</td>
<td>1.54% (0.14%)</td>
<td>382 (37)</td>
<td>0.24% (0.02%)</td>
</tr>
<tr>
<td>Thompson</td>
<td>3,365 (768)</td>
<td>0.57% (0.13%)</td>
<td>300 (30)</td>
<td>0.05% (0.01%)</td>
</tr>
<tr>
<td>Cariboo</td>
<td>2,952 (1801)</td>
<td>0.32% (0.20%)</td>
<td>855 (82)</td>
<td>0.09% (0.01%)</td>
</tr>
<tr>
<td>Omineca</td>
<td>2,510 (1,280)</td>
<td>0.32% (0.16%)</td>
<td>495 (195)</td>
<td>0.06% (0.02%)</td>
</tr>
<tr>
<td>Peace</td>
<td>64 (0)</td>
<td>0.004% (0.00%)</td>
<td>557 (225)</td>
<td>0.04% (0.02%)</td>
</tr>
<tr>
<td>B.C.</td>
<td>14,331 (4978)</td>
<td>0.30% (0.11%)</td>
<td>3062 (705)</td>
<td>0.07% (0.02%)</td>
</tr>
</tbody>
</table>

35
19,000 hectares. Pipeline rights-of-way occupy approximately 3,062 ha of the agricultural land reserve or about 0.07% of the reserve. Even if all of the proposed projects were built, this total would only increase by about 23%. Energy transmission rights-of-way occupy about 0.4% of the agricultural reserve. Proposed projects would increase this total of 0.5% of the reserve or about 23,076 ha. Most of this land can still be used for agricultural production (see Chapter Two). This is not true of the land occupied by electrical transmission substations, pumping stations on oil pipelines, and compressor stations on gas pipelines.

Table 8 gives the area within the agricultural land reserve occupied by electrical substations, pipeline pumping stations, and gas pipeline compressor stations. These stations are exclusive land uses. Electrical substations excluded agricultural use of 140 ha of the Agricultural Land reserve. This is about the size of a moderately large dairy farm. Proposed electrical stations would add 30 ha to this amount. The total potential alienation by electrical stations is 170 ha or about 0.001% of the agricultural reserve. Land alienated by pipeline pumping and compressor stations is somewhat less than that alienated by electrical stations; about 120 ha or about 0.002% of the agricultural land reserve. Proposed pipeline stations would increase this value by less than 10%. Energy transmission stations now occupy only 260 ha of the land reserve, about 1% as much as is occupied by the rights-of-way.

Table 7 and 8 show a great deal of disparity between agricultural reporting regions. For example, the highest percentage of Land Reserve land occupied by electrical rights-of-way is in the Mainland Region at
<table>
<thead>
<tr>
<th>Agricultural Reporting Region</th>
<th>Electrical Substations</th>
<th>% of ALR</th>
<th>Pipeline Pumping and Compressor Stations</th>
<th>% of ALR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kootenay</td>
<td>20 (0)</td>
<td>0.006% (0%)</td>
<td>0 (0)</td>
<td>0% (0%)</td>
</tr>
<tr>
<td>Okanagan</td>
<td>20 (10)</td>
<td>0.007% (0.003%)</td>
<td>0 (0)</td>
<td>0% (0%)</td>
</tr>
<tr>
<td>Island</td>
<td>20 (0)</td>
<td>0.018% (0%)</td>
<td>0 (0)</td>
<td>0% (0%)</td>
</tr>
<tr>
<td>Mainland</td>
<td>20 (10)</td>
<td>0.013% (0.006%)</td>
<td>10 (0)</td>
<td>0.006% (0%)</td>
</tr>
<tr>
<td>Thompson</td>
<td>20 (0)</td>
<td>0.003% (0%)</td>
<td>30 (0)</td>
<td>0.005% (0%)</td>
</tr>
<tr>
<td>Cariboo</td>
<td>0 (10)</td>
<td>0% (0.001%)</td>
<td>30 (10)</td>
<td>0.003% (0.001%)</td>
</tr>
<tr>
<td>Omineca</td>
<td>40 (0)</td>
<td>0.005% (0%)</td>
<td>20 (0)</td>
<td>0.003% (0%)</td>
</tr>
<tr>
<td>Peace</td>
<td>0 (0)</td>
<td>0% (0%)</td>
<td>30 (0)</td>
<td>0.002% (0%)</td>
</tr>
<tr>
<td><strong>B.C.</strong></td>
<td><strong>140 (30)</strong></td>
<td><strong>0.003% (0.001%)</strong></td>
<td><strong>120 (10)</strong></td>
<td><strong>0.002% (0.0002%)</strong></td>
</tr>
</tbody>
</table>
1.54%. The lowest percentage is in the Peace Region where only 0.004% of the right-of-way is occupied by high voltage rights-of-way. This disparity is more significant when agricultural production is taken into account. The Peace Region accounts for about 7% of the Province's gross farm sales. The Mainland Region generates 53% of the Province's gross farm sales. Table 9 presents some agricultural statistics for each of the eight agricultural reporting regions to help put the figures in Tables 7 and 8 in perspective.

Pipeline rights-of-way follow a pattern similar to that of electrical transmission lines. The highest percentage of the land reserve is occupied in the highly developed Mainland Region and the lowest percentage in the sparsely developed Peace Region.

1.4 Conclusions to the Inventory

On a provincial level, energy transmission facilities cannot in themselves be considered a threat to the agricultural land base of British Columbia. A more realistic assessment is that energy transmission facilities are part of the pattern of development in western society which competes for land with agriculture. In some areas such as the Lower Mainland, this competition for land is much keener than Provincial averages suggest. While the amount of land occupied by energy transmission facilities may be small provincially, its importance can
Table 9. Regional Agricultural Statistics.

<table>
<thead>
<tr>
<th>Agricultural Reporting Region</th>
<th>Population 000's</th>
<th>Farms with sales over $2500.</th>
<th>Farm Sales $000</th>
<th>Agricultural Land Reserve 000's ha</th>
<th>Improved Farmland 000's ha</th>
<th>Land Irrigated 000's ha</th>
<th>Crown Range Land 000's ha</th>
<th>Major Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kootenay</td>
<td>105</td>
<td>643</td>
<td>21,947</td>
<td>338</td>
<td>36</td>
<td>9</td>
<td>840</td>
<td>beef, grain</td>
</tr>
<tr>
<td>Okanagan</td>
<td>270</td>
<td>3620</td>
<td>137,207</td>
<td>303</td>
<td>104</td>
<td>35</td>
<td>440</td>
<td>fruit, beef</td>
</tr>
<tr>
<td>Island</td>
<td>1494</td>
<td>1191</td>
<td>62,111</td>
<td>111</td>
<td>25</td>
<td>4</td>
<td>0</td>
<td>dairy, beef</td>
</tr>
<tr>
<td>Mainland</td>
<td>1438</td>
<td>4256</td>
<td>423,864</td>
<td>158</td>
<td>81</td>
<td>8</td>
<td>2</td>
<td>dairy vegetables</td>
</tr>
<tr>
<td>Thompson</td>
<td>112</td>
<td>718</td>
<td>37,567</td>
<td>594</td>
<td>102</td>
<td>26</td>
<td>889</td>
<td>beef, grain</td>
</tr>
<tr>
<td>Cariboo</td>
<td>62</td>
<td>1018</td>
<td>26,649</td>
<td>919</td>
<td>90</td>
<td>15</td>
<td>4770</td>
<td>beef, grain</td>
</tr>
<tr>
<td>Omineca</td>
<td>196</td>
<td>1001</td>
<td>29,900</td>
<td>777</td>
<td>128</td>
<td>1</td>
<td>3000</td>
<td>beef, grain</td>
</tr>
<tr>
<td>Peace</td>
<td>55</td>
<td>1441</td>
<td>59,632</td>
<td>1498</td>
<td>377</td>
<td>0</td>
<td>1000</td>
<td>beef, seed</td>
</tr>
<tr>
<td>B.C. Total</td>
<td>2,744</td>
<td>13,597</td>
<td>798,877</td>
<td>4,700</td>
<td>946</td>
<td>900</td>
<td>11,015</td>
<td></td>
</tr>
</tbody>
</table>

1 Economics Branch Ministry of Agriculture, 1981(9)

2 Agricultural Land Commission, 1981.
increase several fold when viewed regionally. The proportion of agricultural land occupied by energy transmission facilities may be very significant on a local level. For example; electrical transmission lines running the length of a narrow valley could occupy a significant portion of the best agricultural land. On a single farm basis, transmission facilities could cover over half the farm area and affect all aspects of farm management.

The inventory pointed out several important aspects of the structure of energy transmission in British Columbia. Each type of energy transmission forms part of a system or "grid". All oil pipelines in B.C. are joined together as are all gas pipelines (some are connected through Alberta). All electrical transmission lines in B.C. are also joined together. New transmission projects are extensions of these grids and normally connect to one or more existing nodes. The existing grid systems affect the routing of future transmission lines.

The Mainland Region has a heavy concentration of electrical, gas and oil lines because Vancouver is a centre of energy consumption. The Thompson and Cariboo Regions have a considerable concentration of electrical transmission lines and pipelines because of their central location in the Provincial grid. The Island Region has an average concentration of electrical lines in proportion to its population but as yet lacks pipelines as Vancouver Island has not been connected to the national gas grid. The Peace Region has a concentration of pipelines because it is an area of production for oil and gas but has few high voltage transmission lines at the present time. The Kootenays, Okanagan and Omineca Regions
have close to the Provincial average for transmission rights-of-way occupying the agricultural land reserve.

The inventory also showed that while different types of energy transmission rights-of-way almost never run adjacent to each other, there is a very strong tendency for transmission lines carrying the same type of energy to share a right-of-way. Once a grid for a particular commodity has been set up in a region, most increasing capacity is met by utilizing the existing rights-of-way rather than construction on new routes. This basic pattern of development has several causes. Rights-of-way are the single most valuable asset of transmission companies. Different types of energy transmission have different requirements for terrain security and may have different destinations. Ownership of each type of energy transmission is extremely concentrated in British Columbia. Developing new rights-of-way is normally more expensive and less acceptable to the public than enlarging existing ones.

Both energy transmission and agricultural production are necessary to modern industrial society. Therefore, there is sufficient reason to seek improvements in the way agriculture and energy transmission facilities share land. Electrical transmission and pipeline rights-of-way occupy over 17,000 ha of the B.C. Agricultural land reserve. The present market value of this land is in the range of $5000 per hectare or about 85 million dollars. Chapter two examines the costs and benefits of using land for energy transmission rights-of-way and agriculture simultaneously.
CHAPTER 2 - COSTS AND BENEFITS TO FARMERS OF USING AGRICULTURAL LAND FOR ENERGY TRANSMISSION

2.1 Introduction and Methods

In the last chapter it was learned that about 14,000 ha of B.C. Agricultural land reserve is occupied by electrical transmission rights-of-way and that about 3,000 ha of the reserve is occupied by pipeline rights-of-way. This chapter investigates the costs and benefits of using farmland for energy transmission.

Transmission lines and pipelines have positive and negative impacts on the environment they cross, and the people who earn their living and make their life within this environment. Even people who live a distance from the right-of-way but are still connected to transmission facilities by economic or social ties may experience impacts. Impacts on agriculture can be direct, such as the removal of arable land from production, or indirect such as the growth of market population for agricultural products. Some impacts occur only during construction or during the first few years after construction of a linear project. Others have a long term effects that might not be felt until long after a project is completed.

The relationship between an energy transmission and agriculture becomes more complex if more than one right-of-way is involved. For example, two electrical transmission lines close together but not adjacent may have a different effect on a farm than if they were adjacent to each other.
Similarly, a pipeline and a highway will affect a farm in a different manner than a pipeline only. To further add to this complex relationship, different farms and even different portions of the same farm vary greatly in the crops grown and the techniques used to grow these crops. For example, a given area of a field crop such as peas is much more valuable than the same area of hay. The size of farm machinery also affects the impact of a transmission line on a farm. A large harvester will require more clearance around an electrical transmission tower than a small mower.

Over the past twenty years a method of analysis has been developing to systematize the interactions between agriculture and linear development. This system of analysis is especially well developed for electrical transmission lines. The system divides the overall interaction into a series of direct individual impacts to farmers. For example, the loss to a farmer due to weed spread along a linear project is separated from the direct land lost to production. Each individual impact is then analysed as to its cause and value in a wide variety of agricultural situations. This analysis of individual impacts is used in most of the research reviewed in this thesis.

Several terms which recur in the literature need to be defined. A **mitigation measure** is defined as practice which makes a negative impact less severe. An **enhancement measure** is a practice which raises the value of a positive impact. A **compensation measure** is a practice which confers a benefit to offset a negative impact. Compensation does not lessen the negative impact's direct effect.
An aspect of costs and benefits which needs to be kept clear is to whom do the costs and benefits evolve. Four distinct parties are considered by this thesis: the transmission company which operates the right-of-way, the landowner who grants (sells) an easement to a transmission company; the farmer who practices agriculture on or adjacent to the transmission facility, and the public who are assumed to be consumers of both the energy transmitted by the right-of-way and the products of the farmer's labour.

The first source of information used in this analysis are published scientific papers and technical reports. The major findings of these studies are presented in the Review of Literature.

The second source of information used in the analysis are two case studies prepared by the author in British Columbia.

The case studies were undertaken by the author as part of the Opportunities and Risks Presented to Agriculture by Linear Development Study, Goldstein, (1983). These case studies are analysed in this section to obtain B.C. values for the costs and benefits of using agricultural land for energy transmission.

The data was obtained by the following means. Four agricultural operators were interviewed in each study area. Local District Agriculturalists and range agrologists were also interviewed. Land loss was measured with a measuring tape at 3 consecutive towers for each crop type and soil type cited. Visual inspections were made for crop cover, weed populations, and wheel ruts while walking along the lines.
Two widely varying situations were chosen for the case studies. The first study (see Section 2.2) was in the Lower Fraser Valley. The first study area consisted of a 7 kilometre long by 2 kilometre wide strip between Sumas and Chilliwack. This strip contains two gas pipelines in a shared right-of-way, three electrical transmission lines in one shared right-of-way, the B.C. Electric Railway, and a short section of the Trans Mountain Pipe Lines Ltd. crude oil pipeline.

The area is primarily used for dairy production. Impacts are assessed quantitatively where possible. The effectiveness of mitigation measures is evaluated as is the potential effectiveness of mitigation measures that could have been, but were not used. The use of common corridors in this area is also evaluated.

The second case study (see Section 2.3) was located in a ranching area just north of Williams Lake. The area is a 2 kilometre wide strip 10 kilometres long, following the Williston-Kelly Lake Transmission Lines between Williams Lake Creek and Hawks Creek. This area is used by several ranches for grazing.

The first case study approximates a worst case situation. A prime agricultural valley adjacent to a major market which is confined by mountains through which a number of linear developments pass. The second case study represents a much more positive situation. It is an extensive plateau which would be used for improved pasture for beef production were it not for the high cost of land clearing. Taken together these two case studies represent a wide range of interaction that takes place between agriculture and transmission projects. The evaluations made in these
case studies is applicable to a wide range of the linear projects proposed for British Columbia. Section 2.4 gives conclusions that can be drawn from these case studies and the scientific literature reviewed in the Review of Literature section.

2.2 Case Study 1 - Sumas Valley

2.2.1 Background

Physiography

The first case study was located in the Sumas Valley of the Lower Mainland. This valley is bounded on the north by Sumas Mountain and on the south by Vedder Mountain. Both of these mountains rise from near sea level at their base to over 900 metres in elevation in a horizontal distance of 2 kilometres. Thus these steeply sloping mountains force most transmission lines onto the flat valley bottom. This extremely flat valley bottom is 6 kilometres wide and is the floor of a glacial lake (Luttmerding, 1980). Figure 1 is a location map of the Sumas Valley, showing the study area and the location of the transmission projects that follow the Sumas Valley. The study area is a 2 kilometre wide strip, 7 kilometres long that follows both the B.C. Hydro and Westcoast Transmission rights-of-way.

The Vedder Canal crosses the study area and forms the divide of two major soil types. West of the Vedder Canal are sandy loams of the Sumas Soil Series (Luttmerding, 1980) which are derived from glacial lacustrine parent material. These soils are saturated for much of the growing
Case Study Site #1 Location Map

Scale 1:125,000
season if not drained. If drained, the low moisture holding capacity of these soils causes them to become droughty. Most of the area is drained and subirrigated. A portion of it receives surface sprinkler irrigation. If both drained and irrigated, the Sumas Soils have an agricultural capability rating of class 1. To the east of the Vedder Canal, the coarse textured lacustrine deposits have been overlain by recent fine textured stream deposits such as the Bates and McElvie Soil Series (Luttmerding, 1980). These soils are harder to drain than the Sumas soil and have much higher water retention values. These soils are seldom irrigated. In general, these soils cannot grow as wide a range of crops as the Sumas soil and have an improved agricultural capability rating of class 2 or 3. The height of the groundwater table during the growing season depends, to a large extent, on proximity to the mountain. The southeast corner of the study area is close to Vedder mountain. The high watertables in this area have given rise to organic soils such as the Annis Soil Series. The Annis soils are rated as class 4 for agricultural capability without drainage and class 3 with drainage.

All of the study area is within the Agricultural Land Reserve. The continued agricultural use of the area is supported by both Central Fraser Valley and Fraser Cheam Regional Districts.

Energy Transmission Facilities

There are four separate rights-of-way in the study area. Each is operated by a separate company and follows a separate route through the Sumas Valley.
Westcoast Transmission operates a double or "looped" gas pipeline through the study area. The right-of-way is 60 feet (18.2m) wide. The northern pipe is 30 inches in diameter and was installed in 1956. The second pipeline is 36 inches in diameter and was installed in 1971. The only station along this line is a control valve just west of the Vedder Canal that occupies about 0.1 ha.

B.C. Hydro and Power Authority operates three adjacent high voltage transmission lines in a single 450 foot (137m) wide right-of-way through the study area. The northernmost line is the Kelly Lake to Ingledow 500 kV line. All of the tower structures along this line are standard steel lattice design with 8.0 m by 8.0 m bases. The second line is the Nicola Lake-Ingledow 500 kV line. The tower structures of this line are identical to those of the previous line and are match-stepped to them. Matchstepping is the practice of aligning towers of adjacent electric transmission lines so that the towers of adjacent lines are as close as possible to each other. In theory this practice leaves as much of the field untouched by towers as possible and is also more aesthetic. The third line is the Atchelitz to Ingledow 360 kV line. The major tower type on this line is a steel lattice H-frame tower. Each tower has two 2m x 2m bases. These towers are also match-stepped with those of the other two lines. Only the 360 kV line is attached to the Atchelitz Substation which occupies about 2.5 ha on the eastern edge of the study area. B.C. Hydro also operates the B.C. Hydro Electric Railway which
crosses the southeast corner of the study area. This railway consists of a single set of tracks on a 30m wide gravel pad.

Trans Mountain Pipe Lines Co. Ltd. operates a single 24 inch diameter crude oil pipeline that crosses the southeast corner of the study area.

Agricultural Development

Agriculture has long been a dominant force in the study area. George Winter in *The Lower Fraser Valley: Evolution of a Cultural Landscape* (Siemens, 1968) states that "except at Langley and on small plots along the Cariboo Road, the earliest systematic attempts at farming were at Chilliwack and in the Sumas Valley". In the early 1860's early settlers, including the Vedders and Millers, established farms on the open prairie. Using the 1858 gold rush as a market and the Fraser River and numerous sloughs for transportation, agriculture flourished in the study area, and by the time B.C. joined Confederation in 1871, nearly all of the Sumas prairie had been pre-empted. Production included dairy products, poultry, grain, and vegetables.

As the gold rush dwindled and Vancouver and New Westminster grew, attention was focussed on the city markets. Prior to the development of the B.C. Electric Railway to Chilliwack in 1909, milk for Vancouver was derived from Sea and Lulu Islands. Since the introduction of the
railway, milk has been the most valuable product of the study area. The railway was instrumental in giving Sumas farmers access to the Vancouver market.

Over-production of milk and chaotic price fluctuations prompted the Milk Industry Act of 1956. Under this Act, each farmer received a quota for the percentage of fluid milk which could be sold, to his total production, times his average lowest four months of production. The price for non quota milk is low in relation to the high production costs in the valley. This system makes milk quota itself a valuable commodity.

Another factor in dairy farming in the study area is the immigration of Dutch farmers after World War II. This influx brought a progressive attitude toward modern farming methods, and new capital and ideas to the dairy industry. In 1966 Margaret Ginn (Siemens, 1968) estimated that 25% of the dairy farmers in Sumas were Dutch. A major change that was encouraged by the Dutch has been to use land intensively to produce a harvested feed such as hay or silage rather than relying on pasturing of animals. Improved drainage systems is another major technical advance encouraged by the Dutch.

With the increase in the size of the Vancouver market, the fixed land base and the use of larger labour saving machinery, the minimum size of an economic dairy farm has grown from 20 cows in 1957 to 36 cows in 1968 to around 60 cows today.
The following statistics from the 1971 and 1981 census, (Table 10) show the increased emphasis on improved farmland, silage and small fruit production, a decrease in the number of farms and the large increase in population that is largely related to urban and industrial endeavours.

2.2.2 Results of Case Study 1 - Sumas Valley

Information on the interaction between agriculture and linear developments was gathered in several ways. Field inspections were made of the rights-of-way within the study areas. Measurements were made of the uncropped areas around transmission tower bases and the general level of weeds was noted. Yield samples were not taken along the pipeline and electrical transmission lines. Such yield sampling is necessary to accurately evaluate the level of impact. Interviews were held with Don Bates, the Provincial Forage Management Specialist for the Ministry of Agriculture and Food in Chilliwack, and four dairy farmers who farm land that is within one or more rights-of-way. Black and white air photographs were examined stereoscopically. The photos were taken in 1979 and are at a scale of 1:10,000.

This information was assembled and analysed by type of interaction. Mitigation measures are discussed under each section. For each type of interaction, electrical transmission lines and pipelines are discussed independently and in their relationships with each other.
Table 10. Agricultural Statistics for Case Study 1.

<table>
<thead>
<tr>
<th></th>
<th>B.C.</th>
<th>Central Fraser Valley Census District</th>
<th>Fraser-Cheam Census District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population:</td>
<td>2,184,621</td>
<td>2,744,467</td>
<td>58,063 115,012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46,119 56,934</td>
<td></td>
</tr>
<tr>
<td># of Farms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18,400 20,012</td>
<td>2,167 2,814</td>
<td>1,248 1,109</td>
</tr>
<tr>
<td>Sales over $2500.</td>
<td>8,625. 13,597</td>
<td>1,374 2,002</td>
<td>692 810</td>
</tr>
<tr>
<td>Dairy</td>
<td>1,633 1,345</td>
<td>485 328</td>
<td>420 306</td>
</tr>
<tr>
<td>Land Area(ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>89,310,362 89,310,362</td>
<td>70,191 70,191</td>
<td>1,080,322 1,080,322</td>
</tr>
<tr>
<td>In Farms</td>
<td>2,356,661 2,178,673</td>
<td>36,904 38,274</td>
<td>23,398 24,219</td>
</tr>
<tr>
<td>Improved Farmland</td>
<td>710,348 946,363</td>
<td>29,046 32,088</td>
<td>18,397 19,876</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>5,242 11,729</td>
<td>1,056 2,506</td>
<td>1,192 3,346</td>
</tr>
<tr>
<td>Hay</td>
<td>207,574 290,238</td>
<td>9,701 10,805</td>
<td>5,662 6,360</td>
</tr>
<tr>
<td>Vegetables</td>
<td>7,250 7,867</td>
<td>1,949 1,635</td>
<td>1,414 1,952</td>
</tr>
<tr>
<td>Small Fruits</td>
<td>3,983 5,580</td>
<td>1,226 2,250</td>
<td>321 231</td>
</tr>
<tr>
<td>Livestock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All cattle</td>
<td>573,171 789,840</td>
<td>54,513 65,074</td>
<td>32,830 45,326</td>
</tr>
<tr>
<td>Dairy cows</td>
<td>80,485 89,279</td>
<td>22,274 22,836</td>
<td>17,117 20,289</td>
</tr>
<tr>
<td>Beef cows</td>
<td>184,308 233,911</td>
<td>4,775 5,543</td>
<td>1,740 2,895</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture and Food (Sept. 1982)
Census of Agriculture Statistics British Columbia 1971 and 1981, Victoria, B.C.

53
Building Development

Virtually all easement agreements forbid construction of buildings and foundations in the right-of-way. On highways, railways and electrical transmission lines this prohibition is fairly complete. Vehicle storage and temporary crop storage has been allowed on pipeline rights-of-way although no such use was made of the pipeline rights-of-way in the study area. Zoning and the Agricultural Land Commission Act do not permit commercial and residential development of the entire study area. There are areas closer to Vancouver where an electrical transmission right-of-way is used for pasture while the surrounding land was developed into residential subdivision. Farmers faced with a single right-of-way found little trouble finding alternate building sites. A more serious problem arose where a dairy barn and house were caught between the pipeline and a transmission line. One such case was found in the study area. In this instance, farm buildings spanned the entire distance between the Westcoast gas pipeline and the B.C. Hydro Electrical Transmission line. This situation would increase the cost and decrease the efficiency of expansion of this dairy operation. A similar situation could exist at the far west side of the study area where a farm is between a road and the Westcoast pipeline. The impact of restriction of farm development could have been largely eliminated by the use of a carefully planned common corridor. Such a corridor could have contained both the pipeline and electrical transmission line and could have been planned so as not to isolate farms between it and the roadway or
railway. If the rights-of-way had been located along farm and natural boundaries, most of the problem of restricting farm development could have been avoided. Now that the situation of two close-by but not adjacent rights-of-way exists in the study area, development of milking parlors etc. between them will be discouraged for the foreseeable future. Another minor problem of development restriction was brought up by a farmer. The prohibition restricts the way a farm can be subdivided and so reduces his potential profit should he be able to subdivide. This problem is felt to be small within the ALR where such subdivisions are restricted and since it does not directly affect agricultural income.

Land Fractionation

Modern farm machines such as tractors pulling cultivating and harvesting equipment require minimum areas of land to operate efficiently. Gas pipeline compressor stations, oil pipeline pumping stations and electrical substations are exclusive uses of land. If these exclusive land uses are close together but not adjacent, they can cut off a parcel of land so that it is too small to be used efficiently. This situation occurred in the study area where the Atchelitz Substation has increased the number of turns the farm equipment must make to cover a given area of land. This is a minor impact, the only result of which is an inconvenience to the farmer. This minor inconvenience could have been reduced by locating the substation on a field boundary as is the gas control valve.
Land Loss

Lost land occurs as a result of areas not being cultivated because of an energy transmission facility. The pipelines, (the two Westcoast gas pipelines and the Trans Mountain crude oil pipeline), cause the least land loss. All of the pipeline rights-of-way are cultivated except for the control valve and scentiing station just west of the Vedder Canal. The only other land losses are small areas around posts located at sharp bends in the Westcoast pipeline. Over 15 kilometres of pipeline in the study area have resulted in the loss of only about 0.1 ha of land.

The three electrical transmission lines have resulted in considerably more land loss. Three major crops are grown on the electrical transmission right-of-way in the study area. These are pasture, hay, and corn grown for silage. The land lost around towers was found to depend more on the crop grown than on the individual farmer. The least land loss was found with improved pasture. Dairy and beef cattle grazed right up to the concrete block on which each leg of each tower sat. The area inside the steel lattice towers of the 500 kV towers was completely grazed. Land loss in the pasture area amounted to about 1m² per 500 kV tower and 8m² for the steel lattice H-frame tower of the 360 kV line. The reason for the lower loss with the 500 kV towers was the fact that cows grazed under the 500 kV towers but not within the bases of the 360 kV towers. Since all of the towers are matchstepped at a frequency of 3 towers/kilometre, the land loss on improved pasture was 3m²/kilometre for the steel lattice tower and 24m²/km for steel lattice H-frame towers.
Land loss increased dramatically on hayland. Hay could not be mowed mechanically within an average of 0.5m from the tower base. This translates into a land loss of 81m²/tower or 243m²/km for the 500 kV lines and 60m²/km for the 360 kV lines. This amount of land loss was found not to vary greatly if the towers were matchstepped, or located a distance from each other. Some of this land loss could have been recovered by cutting the hay under the 500 kV tower by hand and moving to where it could be picked up by machine but this is not viewed as economic by farmers at this time. While 50% of the farmers interviewed cut the grass under the towers on a regular basis for weed control, none thought it was worthwhile to harvest it.

The largest land losses occur on land used for corn silage production. The limiting factor to how close to a tower a field could be cropped was the width of the multi-row planters that were used. Six row planters are 12 feet wide and difficult, if not impossible, to back up because they are pulled by tractor. The result is a 9m by 17m oval around the 8m square bases of the 500 kV towers that is not cropped. The 115m² per tower of land lost varied about 10% depending on the individual farmer and orientation of the field. This translates into 345m² or 0.035ha of land loss per kilometre. Land loss along the 360 kV line depended on the orientation of the H-frame in the field. If the tower was parallel to the direction of cultivation, the area between the towers was not cropped. This resulted in a land loss of 76m² per tower. If the tower was perpendicular to the direction of cultivation, the area between the two tower bases was cultivated and land loss was lessened to 68m² per
tower. An average of about 216m² per kilometre of 360 kV transmission line was lost to cultivation.

The most common mitigation measure for land loss along electrical lines is to locate the tower along farm, field and fence boundaries. Unfortunately this was not done regularly in the study area. The transmission lines cross the fields diagonally. Several cases where towers were located along fence lines were studied. Where a transmission line straddled a fence line, the land loss caused by the tower was reduced by the normally uncropped area along the fence. This would be a metre wide strip for a savings of 17m² per tower. Where a tower did not straddle a fence but was close enough to prevent machinery from passing between the tower and the fence, land loss was increased from 115 to 205m² per tower. This is based on the tower being located 3m from a fence, which is the maximum distance to restrict cultivation.

Another mitigation measure that is employed to reduce land loss is tower design. The study area did not afford a good chance to compare different tower types used for a given voltage. The dead-end three-base towers that are used on turns in the 360 kV line increase land loss from 50 to 100% compared to the normal 2-base towers.

Loss of Yields on Cropped Land

Three sources of yield loss on cultivated land were found within the study area. The first was loss due to weeds which occurred around electrical transmission towers but not on pipelines. The second was
changes in drainage patterns and soil organic matter that was noticed above pipelines. The third was soil compaction which was found in the immediate vicinity of transmission towers.

Weed concentration around transmission towers was found to depend greatly on the crops grown and on the weed control methods used. Farmers felt weeds were a real obstacle to corn production. One farmer uses "Round-up" a post emergent herbicide under towers in corn fields to cut down weed spread. Several farmers regularly cut grass and weeds by hand under towers. Normally towers in hay fields received less treatment for weeds than towers in corn fields. Towers in pastures received little or no weed control. Weed control measures were estimated by the farmers interviewed to cost roughly $20 per tower per year. Farmers receive only a single lump sum payment for a transmission line and no annual compensation for weed control. Where corn was grown, and no herbicide used, the loss of yield due to increased weed populations around a tower was estimated by farmers at 2-3 tons (equivalent to 0.1 ac). At a price of $40/ton this would be about $80 to $120 per tower per year. The yield loss without weed control for hay would be about 0.6 tons or about $54 per tower per year if hay is valued at $90/ton. These figures should be viewed as general levels because factors such as background weed levels, individual farming methods, weather and many other factors would affect them. The loss of yield on improved pasture due to weeds around towers is significantly less than the loss for cultivated fields. The above figures represent losses which would be caused by a single 500 kV line similar to those in the study area. If no control measures are taken for weed spread around towers, loss can exceed $400 per year per kilometre. For this reason, weed control measures are advisable.
Match-stepping of towers of three lines had several beneficial effects. The cost of applying weed control spray was reduced by 20 to 30% based on farmers' experience. The area affected by weeds per tower is lowered by grouping towers in the same immediate area. Any measures which lower land loss will also lower weed loss by restricting the nurse area for weeds under towers. In this regard, most successful mitigation measures for land loss will also be a mitigation measure for loss of yield caused by weeds. Planting non invasive plants under towers might also be tried to lessen weed spread.

Another source of loss of yield was reported by three out of four farmers who cultivated over the Westcoast Transmission gas pipeline in the study area. They report that while the grass or corn over the pipelines starts growing earlier in the season, the final harvested yield was as low as half that of the rest of the field. The fourth farmer stated that there was no discernable difference in yield. The affected area was reported to be about a 1 to 2m wide area over the pipeline itself and not across the 18 m right-of-way. Inspection of air photographs showed a possible reason for this discrepancy. The farmer who reported no continuing yield difference was on the Sumas Soil. The pipeline would make little difference in the coarse-textured Sumas soils. The farmers who reported the highest yield loss are located on the fine-textured Bates and McElvie soils. The pipeline trench can be seen to have a higher hydraulic conductivity than surrounding areas on the Bates and McElvie soils. This difference gives the pipeline trench better drainage in spring but less available water in mid-summer.
All farmers reported temporary loss of yield along pipelines for a few years after construction. The cost of purchasing replacement feed for this period is paid as compensation. A worst case for continuing loss along a single pipeline through a fine-textured, poorly-drained area would be 50% of the value of corn crop over a 2m wide strip, or 0.2 ha/km x 62 tons corn silage per ha x $40/ton of corn, or about $500/km of pipeline. On most soils yield loss would be much less than this. Hay and pasture would have lower values per ha. The use of drain lines would, in most cases, eliminate most of the yield loss if subirrigation was also practiced during the summer.

The third source of yield loss was noticed immediately around electrical transmission towers. The area within 3m of the tower often had tire ruts and more bare spots than the surrounding field. This problem was much more pronounced on fine textured soils. The area around transmission towers has increased traffic from two sources. The major one is caused when two or three passes have to be made by a tractor around a tower. A minor source of increased traffic is caused if machinery is used for specialized weed control measures around towers. No quantitative measurements were made. The area subject to this kind of yield loss is about 132 m² for a 500 kV steel lattice tower. Assuming a 20% reduction in yield of hay, the loss would be approximately 0.04 tons, or about $3.50 per tower per year. Half of this area is not cultivated for corn due to the problems of getting a 12 foot wide planter near the tower (see land loss). The loss in corn yields would be about the same as hay. The problem with compaction in fields normally used for pasture was found to be considerably less.
Time Loss

No time trials were made to determine the time lost due to avoiding transmission towers. All farmers interviewed stated that a few minutes were lost during each operation due to avoiding towers. Fortin (1980) measured average time losses for guyed towers of between 2 and 3 minutes per operation. The actual amount of time loss experienced by a farmer will depend on such factors as size of machinery used and the number of field operations undertaken each year. Farmers reported that equipment pulled behind a tractor was harder to manoeuvre around towers than self-propelled equipment. If operator time is valued at $25.00 per hour and seven operations are completed a year with a 2.5 minute time loss for each tower, the total annual loss would be $7.29 per tower per year or $21.87 per kilometre of 500 kV line per year.

Since time loss is caused by going around the land that is lost to cultivation, the mitigation measures that reduce land loss around towers will also reduce time loss. Locating towers along field, farm and natural boundaries can greatly reduce time loss. Towers with smaller bases will also reduce both land and time loss. Match-stepping of towers would have little effect on time loss.

No time loss was reported along pipelines.
Increased Costs Immediately Around Towers

All farmers report that field operations including cultivating, planting, spraying, fertilizing and harvesting are repeated twice in the area immediately around a tower. The time loss for avoiding the tower was discussed in the previous section. The extra fertilizer, herbicide and machine costs added to the area immediately around towers contributed little or no yield to the farmer. The area which received double treatment was approximately 132 m² for corn. Affected areas for other crops grown in the study area would be slightly lower. Using Financial Statement for a 60 cow Dairy Herd published by the Economics Branch of the Ministry of Agriculture and Food (1981), the following increased annual costs for the area immediately around towers were estimated:

A. Corn

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>$ 56./ha</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>222./ha</td>
</tr>
<tr>
<td>Herbicide</td>
<td>18./ha</td>
</tr>
<tr>
<td>Machine cost</td>
<td>264./ha</td>
</tr>
</tbody>
</table>

Total = $560./ha x 0.0132 ha/tower = $ 7.4/tower per year
B. Hay

Seed (1 seeding each 5th year, i.e. $106./5) $ 21./ha
Fertilizer 109./ha
Baling twine 6./ha
Machine costs 189./ha
Total $325./ha yr x 0.01 ha/tower =
$ 3.25 per tower per year

C. Pasture

Seed $ 21./ha
Fertilizer 109./ha
Machine Costs 170./ha
$300./ha yr x 0.1 ha/tower =
$ 3.00 per tower per year

These figures are only very rough approximations. They are intended merely to show the magnitude of impact. Mitigation measures for these impacts are the same as for land loss and time loss. These measures include the use of towers with smaller bases and positioning of towers along farms, fields and natural boundaries. No similar impacts were encountered for pipelines roads or railways.

Increased Access

None of the farmers interviewed reported any problems with increased access. Maintenance crews for both B.C. Hydro and Westcoast Transmission were said to be considerate and always request permission before entering
a property. The only incident reported was that of a replaced metal spacer used on a B.C. Hydro high voltage transmission line that was inadvertently left in a hay field by a maintenance crew and caused substantial damage to a piece of farm machinery.

Irrigation and Drainage

The Lower Fraser undergoes a period of heavy rainfall from November to April. During this period, excess water must be removed from the field. This is especially true in pastures and hay fields where excess water will lead to winter-kill of palatable grasses and encroachment of sedge type grasses which have little forage value. In order for many low lying areas to be farmed, extensive ditch and pumping facilities must be installed on a regional level. This is true of the entire study area. On fine textured soils, such as those east of the Vedder Canal, subsurface drain lines are necessary to carry the water from the field to the regional ditches. The hydraulic conductivity of these soils is insufficient to remove all of the excess water. The problem is compounded near the mountains where the discharge from large groundwater systems must also be removed. This is the case in the Annis and neighbouring soils in the southeast corner of the study area. During July and August the Lower Fraser valley experiences a severe drought. The water deficit is often made up in part by natural and artificial subirrigation, Goldstein (1980). In coarse-textured soils such as this Sumas soil, surface irrigation is also required.
The electrical transmission lines did not appear to affect drainage on either a farm or regional level but did affect irrigation. One farmer located on the Sumas soil who wished to use his wheel-move irrigation equipment on a field containing three transmission towers had not done so because of the transmission towers. He now uses hand-moved pipes to irrigate this field.

Automated irrigation equipment falls into two categories. The first employs long moving pipes with sprinklers attached. In the Lower Fraser Valley, the most common of these are wheel-move systems with long pipes that move back and forth on large wheels. To irrigate under transmission lines, the pipes have to be shorter than the distance between towers or more separate pipes perpendicular to the right-of-way have to be used. Both of these techniques would add both capital and labour costs to a system. Another pipe type irrigation system is the centre pivot. In this system a pipe swings around a central water source. A real advantage of the centre pivot system is that an operator is not needed to connect the pipe to a separate hydrant each time the pipe is moved. The specialization of hay production, increase in farm size and development of centre pivots with legs that work on square fields might bring centre pivots into common use in the Fraser Valley. Centre pivots can be located near transmission lines if towers are located in unused corners. Another solution is the "windshield wiper" pivot that changes direction each time it encounters a tower. Both of these methods increase the
capital cost of an irrigation system and lessen the uniformity of water distribution.

The second type of automated irrigation system relies on high speed water jets to distribute the water. The two types of this system operating in the vicinity of the study area are small manually moved or permanently mounted water cannons and the reel type irrigators which automatically are constantly reeled back to a hydrant. The small water cannon system is generally compatible with transmission lines. The large reel systems produce a spray which, under pressures up to 100 psi, are capable of crossing a transmission line and conducting current to ground. This is called "flashover". For this reason, such systems are not used in fields crossed by transmission lines. Many farmers consider this reel type irrigator the most suitable type for the Lower Fraser Valley.

Several mitigation measures are of potential benefit where the electrical transmission lines cross fields which require irrigation. Positioning of towers along farm, field, and natural boundaries is not always possible but would substantially reduce impacts on irrigation. Match-stepping reduced the number of fields that had towers in the study area. Matchstepping could make designing an irrigation system around towers easier. The most appropriate mitigation measure seemed to be the use of smaller lower pressure reel type irrigators. Although not suitable for all fields and crops, such systems combine fairly low (but not as low as centre pivot and high pressure reel systems) labour costs with compatibility with electrical transmission lines. It is difficult to place a value on the impact of electrical transmission lines on
One farmer in the study area reported he spent 3 hours per week for a 3 month period moving hand lines which would have been unnecessary with a wheel move irrigator in use in an adjacent field. At $25 per hour a season cost would be over $1000 for the 10 hectare field. This scale of costs could mean that the time lost through interference with irrigation equipment is the highest impact on farming areas that require irrigation. On a kilometer basis, costs of over $3000 per kilometre per year are possible. The above estimates do not take into consideration many variables, such as the higher capital costs of the automated irrigation system that would be needed to avoid the time used on hand-move systems. Interference with irrigation by transmission towers can adversely affect areas much larger than the right-of-way. If transmission lines are located on soils such as most of those to the east of the Vedder Canal where irrigation is not practiced or practical, then no impact on irrigation will occur.

Pipelines do not affect surface irrigation but can affect drainage and subirrigation. This affect is based on the fact that the hydraulic conductivity and soil water retention characteristics of the pipeline trenches are different from those in the surrounding soil. The effect may be beneficial, detrimental, or both at different times of the year. In coarse-textured soils, the difference in the characteristics of the trench and surrounding soil would be much less than in fine-textured soils. Farmers on fine-textured soils reported that grass and corn crops started earlier but provide a smaller harvest (see yield loss section) over trench lines. The farmer interviewed on the Sumas soil reported
earlier growth and no difference in harvested yield. Many of the fields in the study area have some type of drain lines. The alignment of drainlines had to be modified around the pipeline. Drainlines would reduce the difference in hydraulic conductivity characteristics of the trenches as compared with the rest of the field. Pipeline companies may pay the increase in cost of drainlines due to the presence of pipelines. In all cases, the pipeline company should be informed before any trenching is done on the right-of-way.

Electrostatic and Electromagnetic Effects

Energized electrical transmission lines give rise to electric and electro-magnetic fields. Effects of these fields were of concern to all of the farmers interviewed. Two distinct phenomena were consistently reported by farmers along with several concerns that were viewed as inconveniences.

The most important phenomenon was "tingle voltage". If a milking parlor has stray voltages, there is a possibility that a cow being milked and a milking machine will be at different voltages. These voltages can be in the range of 1 to 5 volts. The electrical shock thus generated can cause a cow not to "let down" her milk temporarily. A milking machine operating on a dry teat often causes irritation and inflammation which may lead to a mastitis infection. These infections, which have many other causes, increase bacteria counts in milk and can necessitate the culling of a cow. The B.C. Department of Agricultural Engineers Note 324.5-1 (undated) describes a system of grounding a milking parlor to prevent this problem.
This system costs approximately $3000 in an existing parlor but less than half this amount in a new parlor. The same publication blames the problem on "electrical pollution". Chris Dyble, a Professional Agrologist with B.C. Hydro, stated that he provides free advice to dairy farmers on the causes and cures of tingle voltage on specific farms. Both Mr. Dyble and the preponderance of material on the subject available from the B.C. Ministry of Agriculture state the usual cause is improper wiring or grounding of farm machinery. Another possible cause is imbalances on 3-phase lines. Two of four farmers interviewed reported serious tingle voltage problems. One had lost a cow. Both had spent thousands of dollars to reground milking parlors. A third farmer reported a minor problem that was easily solved. One of the causes of tingle voltage on one of the farms appears to be induction of electricity from the B.C. Hydro transmission lines into an electrical fence which was in turn connected to a circuit inside the milking barn. Mr. Dyble supplied the farmer with a filter meant to diminish or eliminate this problem. The battle against tingle voltage on this farm had been long and expensive. Since transmission lines can act as a contributory effect to stray voltage, dairy farming areas should be avoided during the route selection process. Where transmission lines are developed near milking parlors, special efforts should be taken to protect the farmer from stray voltages.

The other major complaint is that of electrical shocks received due to the electrical transmission lines. The major type is transient electric shock. This occurs when a person or animal touches an object that is at different electrical potential. These shocks last only a small fraction of a second during which time the current is quite high. All farmers
interviewed report this type of shock when operating farm machinery directly underneath the line. Some farms had over twenty percent of their fields within the B.C. Hydro right-of-way. These farmers spend considerable time under the lines. One farmer reported a greater incidence of shocks when pulling a plough through the soil. These shocks are reported to be unpleasant. Full compliance with B.C. Hydro and CSA clearance standards would ensure that there was no potential for dangerous shock no matter what combination of weather conditions and electrical load occur. Steady state shocks were also reported but occurred rarely. The only instances were related to electrical fences that passed under the power lines. These electrical fences are frequently moved to new locations. A clear set of grounding and moving instructions is needed for electrical fences used under electrical transmission lines. Ungrounded metal fences (both non-electric and electric), buildings, roofs, gutters and storage tanks should therefore be grounded before transmission lines are energized in their vicinity. A worst-case current of 5 ma, approximately one half the "let go" threshold for adult men, is taken as the maximum safe level by the Canadian Safety Association (Morris, 1976). The "let-go" threshold is the point where a hand could no longer be voluntarily removed from a conductor due to the amount of current flowing through the body. It is B.C. Hydro's policy to investigate all complaints and ground all metal objects that show induced voltages from transmission lines.

The farmers interviewed were aware of "flashover", a large electrical discharge that could occur if a grounded conducting object is brought close to an energized transmission line. Farmers were careful in
handling long pipes under the lines but did not view the lines as a major risk. Corona effects such as radio and television interference and audible noise were reported by all farmers. These were viewed as inconveniences and nuisances and did not appear to have significant effects on agriculture.

Compensation

During the interviews with farmers, several deficiencies with the present system of compensation were noted.

1. Compensation was given to the owner, but not to the farmer who often rents the land.
2. Compensation represented the value of the impact on the land when the project was constructed. Since the 1950's and 60's when the electrical lines and first pipelines were constructed, land use has gone from poorly drained pastures to intensive production of silage corn. The impacts on silage corn production are far greater than for pasture.
3. Compensation is normally given on a one time basis. The present operator has to absorb the costs even though the sale price of the land does not take impacts into consideration.
4. Farmers are unfamiliar with impacts of linear development during negotiations for easement.
5. Impacts due to the combined effects of two or more projects are usually not considered.
6. Farmers were not consulted during the route selection process.
7. Farmers are not aware of their options when approached for right-of-way easements.

8. Compensation paid to an individual does little to replace the losses to the agricultural industry or the consumer. Compensation in kind, such as developing alternate agricultural land, could compensate both owner and the general public.

Summary of Results Case Study 1 - Sumas Valley

Electrical transmission lines were found to have few benefits and several negative impacts on agriculture in the study area. These impacts included restrictions on building development and impacts directly associated with transmission towers, including land loss, time loss, increased field costs, yield losses, and interference with irrigation equipment. These impacts were found to be affected by tower type, tower size and location in the field. The crop grown was a major factor in determining actual costs to the farmer. On land used for silage corn, land loss was approximately 115 m² per tower, land loss to pasture was only about 1 m² while land loss in hay fields was 81 m² per tower. Time loss and related impacts also follow this pattern. The use of mitigation measures such as the use of towers with smaller bases and location of towers on field boundaries would have reduced impacts in the study area.

Match-stepping, which was practiced, was of some benefit. Location of multiple electrical transmission lines in the same right-of-way probably
reduced these impacts slightly overall but intensified impacts on the combined right-of-way. Interference with automated irrigation systems was found to depend on soil and groundwater conditions. On coarse-textured soils where irrigation is practiced, interference with automated systems could represent the highest impact as it affects a larger area than the right-of-way. On soils where no irrigation will be practiced, there would be no impact of this nature. Match-stepping and use of multi-line rights-of-way reduced interference with irrigation systems. Location of towers on field, farm, and natural boundaries, and use of towers more compatible with automated irrigation systems would further reduce these impacts. The most important electrical effect was the contributory effect that induced voltages on fences and buildings can have on tingle voltages in milking parlors. Electrical effects of transmission lines were also found to include nuisances such as shocks, audible noise, and radio interference. Increased access and line maintenance were not important impacts in the study area.

Pipelines in the study area were found to have few beneficial impacts on the study area. The negative impacts of pipelines on the study area were confined to restrictions on building development, temporary yield loss, the first few years after construction, and continuing loss of yield above trenches on fine-textured soils. Continuing yield loss is the most serious of these impacts. A worst case of $500 per kilometre per year was estimated. Route selection, the use of drainlines for drainage and subirrigation, and importation of topsoil are possible mitigation
measures for this problem. Additional costs for installation of drainlines occurred along the pipeline. In some cases this increased cost would be born by the pipeline company. Land loss, time loss, increased field cropping costs, increased access, and interference with irrigation were found not to be significant impacts on the pipeline right-of-way in the study area.

2.3 Case Study #2 - The Fraser Plateau

2.3.1 Background

Physiography

The second case study was located on the Fraser Plateau, just north of Williams Lake, in the central interior of B.C. The study area is within the Bull Mountain Range unit. This unit lies between the Fraser River to the west and Highway 97 to the east and between Williams Lake Creek in the south and Hawks Creek in the north. Most of the area is an extensive, gently undulating plateau at an elevation of about 900m. Hawks Creek, Whiskey Creek and Williams Lake Creek have cut through the Plateau from east to west. The level bedrock of the area is covered by a blanket of drumlinized till. Glaciofluvial terraces are found along Hawks Creek, Williams Lake Creek and the Fraser River. Three B.C. Hydro high voltage transmission lines cross the area from north to south.

Figure 2 is a location map of the Williams Lake area showing the study area and the electrical transmission line. The study area is a two
kilometre wide strip which follows the B.C. Hydro transmission lines for 10 kilometres through the Bull Mountain Range Unit.

The soils in the study area can be divided into two basic types; those derived from glaciofluvial terraces and those derived from extensive morainal deposits. Two soil associations are located on glaciofluvial terraces. The Hawks soils are sloping areas of gravelly sand without much agricultural capability (classes 5, 6, and 7). The Hargreaves soils are developed on flat terraces with aeolian capping of fine sand and silt. Without irrigation these soils support natural grasslands that support important spring and fall rangeland. With irrigation, these soils are a major source of forage for winter feeding of beef cattle. With irrigation the Hargreaves soils are rated as class 2 agricultural capability but only class 5 without irrigation. The Tyee soil association is the most extensive of the morainal soils. Like the Williams Lake soils, the Tyee soils are drumlinized with dry, water-shedding ridges and wetter troughs. This uneven drainage characteristic is compounded by a clay enriched Bt horizon at 30 cm depth in the soil and compact till at 80 cm depth. Although with irrigation some areas could produce grains such as barley and oats, yield levels would be low and cultivation would be difficult. For this reason the morainal areas will tend to be used for hay land if irrigated and for pasture or

Soil associations are based on the soils and landforms map 93B.1 by the B.C. Ministry of Environment. Agricultural capability units are also shown on the study area map, based on a 1:50,000 manuscript map produced by the B.C. Ministry of Environment.
rangeland without irrigation. The poorer drainage of the morainal plateau soils and the need to pump water up to them make it likely that these soils will not be irrigated for a long time if at all. No cases were found in the area around Williams Lake where the Tyee or similar soils were used for anything other than forage, pasture, or range purposes. For this reason the unimproved class 5 agricultural capability rating likely represents the developable capability for the next several decades. If development pressures increase rapidly, this situation could change.

**Energy Transmission Facilities**

The only transmission facility in the study area is a B.C. Hydro multiple high voltage transmission line right-of-way. At present this right-of-way includes the following:

<table>
<thead>
<tr>
<th>B.C. Hydro #</th>
<th>Terminal substations</th>
<th>Voltage</th>
<th>Tower Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>5L11</td>
<td>Williston to Kelly Lake</td>
<td>500 kV</td>
<td>guyed-V</td>
</tr>
<tr>
<td>5L12</td>
<td>Williston to Kelly Lake</td>
<td>500 kV</td>
<td>guyed-V</td>
</tr>
<tr>
<td>2L94</td>
<td>Kelly Lake to Soda Creek</td>
<td>230 kV</td>
<td>wooden H-frame</td>
</tr>
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</table>

An additional 500 kV transmission line is proposed for the right-of-way. The proposed line would have guyed-V towers and be located immediately east of the existing lines. At present the cleared right-of-way width is approximately 130m. The additional line would require clearing an
additional 54 m for a total of 184 m. Easements for most of this additional right-of-way have already been obtained.

Agricultural Development

The Fraser Plateau is often referred to as the Chilcotin-Cariboo. Its long history of ranching is an important part of B.C. history. The Chilcotin Indians were grazing horses in the region in the early 1700's. The first ranches in the area were set up in the 1860's. The most rapid period of settlement was in the 1870's with pre-emption under the Land Ordinance of 1870. Overgrazing had significantly reduced the capacity of much of the rangelands by the 1930's. Tighter government control in the 1950's and 1960's resulted in the return of much of the rangeland to a useful state.

The pattern of ranching in the region greatly affects the impacts that transmission line can have. There are approximately 130,000 head of cattle in the region on about 1,165 farms and ranches. Before 1950 most of the cattle were fattened for markets around Vancouver. More recently, operations have been geared to supply calves to Alberta feed lots. Table 11 gives agricultural statistics for the Cariboo District.

The cycle of ranching in the Chilcotin begins with the first flush of growth in spring when cattle are turned out onto the range. Spring range areas are comprised of low elevation grasslands, clearcuts, and organic meadows. Spring range is a major limiting factor to beef production. As more abundant natural vegetation becomes available, the cattle move to
### Table 11: Agricultural Statistics for Case Study 2

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population:</td>
<td>2,184,621</td>
<td>2,744,467</td>
<td>39,357</td>
<td>59,252</td>
</tr>
<tr>
<td># of Farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18,400</td>
<td>20,012</td>
<td>762</td>
<td>996</td>
</tr>
<tr>
<td>Sales over $2500</td>
<td>8,625</td>
<td>13,597</td>
<td>386</td>
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<tr>
<td>Beef</td>
<td>2,501</td>
<td>4,558</td>
<td>313</td>
<td>517</td>
</tr>
<tr>
<td>Land Area (ha)</td>
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<tr>
<td>Total</td>
<td>89,310,362</td>
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<tr>
<td>In Farms</td>
<td>2,356,661</td>
<td>2,179,673</td>
<td>322,139</td>
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<tr>
<td>Improved Farmland</td>
<td>710,348</td>
<td>946,046</td>
<td>54,577</td>
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<tr>
<td>Oats, barley</td>
<td>115,440</td>
<td>121,342</td>
<td>919</td>
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<tr>
<td>Corn silage</td>
<td>5,244</td>
<td>11,729</td>
<td>291</td>
<td>313</td>
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<tr>
<td>Hay</td>
<td>207,574</td>
<td>290,238</td>
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<tr>
<td>Irrigated Land</td>
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<td>100,477</td>
<td>14,737</td>
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<tr>
<td>Sprinkler Systems</td>
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<tr>
<td>Livestock</td>
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<tr>
<td>All cattle</td>
<td>573,171</td>
<td>789,841</td>
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<tr>
<td>Beef Cows</td>
<td>184,304</td>
<td>233,911</td>
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</tbody>
</table>

higher elevations. These areas are comprised primarily of meadows and clear cuts which are used under Crown grazing permits. The grazing permits regulate animal numbers and season of use by range unit. These units have been determined by a combination of natural barriers, fencing, and historic use. Unlike most of the rest of the province, Chilcotin range units are often used by several ranches. In September and October, the cattle drift back to the home ranch areas for over-wintering. Recently, with the introduction of 3-phase power to many ranches, large irrigation systems have been developed to increase production of hay and alfalfa for winter forage. These irrigation systems have usually been developed on glaciofluvial terraces with aeolian cappings, which are found along most of the rivers in the region.

Coordinated Resource Management Planning (CRMP) is expanding through the Chilcotin-Cariboo. Many range units have projects under CRMP's that seek to improve grazing capabilities while also increasing opportunities in forestry, recreation, and wildlife industries. Recently, funds for CRMP projects have come from the Agricultural and Rural Development Subsidiary Agreement (A.R.D.S.A.). Projects such as range seeding and improvement and cross fencing for cattle stocking control could be affected by transmission line development.

2.3.2 Results of Case Study 2 - Fraser Plateau

Information on the interaction of agriculture and the electrical transmission lines in the study area was gathered in the following ways.
Field inspections were made in December of 1982 of the right-of-way in the study area. These inspections were difficult because of a light covering of snow in the area. Interviews were held with Ross Fredell, the range agrologist for the Ministry of Forests, Mr. Peter Fofonoff, District Agriculturist, Ministry of Agriculture and Food, and several of the ranchers active in the study area. Black and white aerial photography was examined stereoscopically. These photos were taken in 1973 and are at a scale of 1:16,000. Inventory information, including soil type and agricultural capability, was taken from B.C. Government maps and modified on the basis of field inspection. This information was assembled and analysed by the type of interaction. Mitigation measures are discussed for each interaction type.

Cattle Grazing

The most dramatic effect of the B.C. Hydro right-of-way is on cattle grazing. The majority of the right-of-way is located on Tyee soil association. For the foreseeable future these soils will be used for grazing and improved pasture. The Tyee soils on the right-of-way were found to support a healthy stand of Crested wheat grass. The present yield of this area was estimated at approximately 1.2 animal unit months (AUM) per ha per year. (The Animal Unit is a standard livestock unit and is defined as one mature 1000 lb cow with or without unweaned calf at side or equivalent.) The surrounding area of Tyee soils consists of conifer forest with thinned and cleared areas. The pinegrass vegetation of this area is estimated to yield about 0.4 AUM per hectare per year.
This increased level of production is due to the clearing and seeding of the right-of-way which was done at B.C. Hydro expense.

The current cleared right-of-way is about 130 m wide. This gives the local rancher an additional 10.4 AUM per kilometre of right-of-way. This would increase to 14.7 AUM per kilometre if the third 500 kV line is installed. Not all of the right-of-way can or should be used for grazing. Steeply sloping land adjacent to Hawks and Williams Lake Creek is not useful for grazing. Portions of the prime agricultural land on the glaciofluvial terraces (Hargreaves soil association) are used for hay production. About 77% of the right-of-way is used for range. The benefits to agriculture can be assessed by looking at the dollar value of the increased grazing, but this would not take into consideration the cost included with utilizing the increased grazing potential. To realize the full benefit of the increased grazing capacity, ranchers have to increase their level of range management accordingly.

The Springfield Ranch which utilizes most of the range in the study area uses a repeated seasonal grazing pattern. Several techniques are used to distribute the animals on the range to ensure that the total available forage is used.

Fencing is an important method of cattle control. The north boundary of the Bull Mountain range is Hawks Creek which functions as an effective natural barrier to cattle movement within or without the right-of-way. Williams Lake Creek is the southern boundary of the Bull Mountain range unit. A cross fence is located north of Williams Lake Creek and is
effective in controlling cattle movements. One problem that was reported with cattle management along the right-of-way was abuse of gates on right-of-way maintenance roads. A rancher may lose cattle or spend considerable time retrieving them if a gate is left open. The closing of a gate that a rancher has purposely left open also causes problems. A few incidents of this nature were reported.

Salting and water development are also very important methods used to control cattle distribution. Salting procedures are modified both to prevent over-concentration of cattle on the right-of-way and over-grazing. Such over-concentration on an electrical transmission right-of-way could lead to poor utilization of the pinegrass and over-grazing of the crested wheatgrass with resultant poor regrowth and weed infestation where overgrazing has occurred.

Riding and herding are practiced in the study area although fencing, salting and water development are more important. Development of cattle trails, fertilization, and supplemental feeding are other cattle management methods used on the Fraser plateau. Although these cattle distribution methods had to be altered due to the effect of the right-of-way, the ranchers interviewed did not believe these costs increased on a per AUM basis because of the right-of-way.

Weed control followed a similar pattern. The right-of-way had annual weeds such as bull thistle and Canada thistle. These weeds are selectively sprayed both by the rancher and the Forest Service when conditions warrant and equipment is available. Since clipping is not used as a method of weed control over most of the rights-of-way,
increased weed population was not found around tower and guy wire bases. The conifer/pinegrass areas surrounding the right-of-way are normally not sprayed.

The costs of range utilization apply equally to the right-of-way and to the rest of the range. There are several ways of evaluating the increased grazing on the cleared right-of-way. If a rancher were to clear and seed himself, the cost in 1983 would be approximately $1000 per hectare. [Economic Branch, Ministry of Agriculture, 1981(9)]. A rancher could also lease privately owned improved pasture for about $10 to $12 per AUM if it was available. A single 500 kV transmission line has a cleared right-of-way of 64m or 6.4 hectares per kilometre. This type of line would give the rancher an additional 5 AUM per kilometre, or about $50 per year per kilometre. The present cleared right-of-way yields approximately $100 per year per kilometre based on the above assumptions. The key to realizing this level of gross benefits is the skill of the rancher. There may be a need to train ranchers in right-of-way utilization, and a year or two may be needed to change cattle management plans sufficiently to realize the full benefit of the right-of-way.

Land Loss

The largest amount of land loss in the study area was due to a 4m wide maintenance road which follows most of the B.C. Hydro right-of-way. This road is in fair to good condition and is used by ranchers, B.C. Hydro, loggers, and the general population. The negative impact of this road is the 0.4 ha of range land that is removed from production per km and
possible weed spread from the disturbed areas to either side of the road.

The positive impact of this road is the improved access it gives all its users. Similar logging and access roads are found throughout the study area. In general, there is a lack of planning of minor roads in the study area. The right-of-way road may not greatly increase the negative effect of an inefficient road system. It might even improve this system.

The small areas lost at the tower bases and guywire bases was much smaller than the land loss to trees in the surrounding area. Each guyed-V tower only removed about 8 m² from grazing. The land loss due to the Soda Creek Substation is about 1 ha. The substation is located on Williams Creek Soil on a glaciofluvial terrace. The topography and soil of this area limited its agricultural capability to class 5 and the land loss did not affect an area which could be used as an irrigated hayfield.

A more significant land loss occurred where the electrical lines crossed hayfields. Judging from air photographs, land loss on the hayfield 3 km north of Williams Lake Creek was about 100 m² per 500 kV tower and about 34 m² for each 230 kV tower. The greatest amount of land loss on the hayfield just north of Williams Lake Creek was caused not by the major transmission line but by a low voltage distribution line. No actual measurements were made of this land loss.

The rancher reported that interference with irrigation equipment was more important than the land loss in this area. Match-stepping did not appear
to be a benefit for land loss. Matchstepping could be a disbenefit because guy wires of adjacent towers were close enough to form an obstacle to field operations.

**Weed Control**

Three distinct areas of interaction of transmission lines and weed populations were found. The most serious is the sharp increase in weed populations immediately following construction. Ranchers noticed increased weed population along the right-of-way and in the area adjacent to it for about 2 years after construction. Early reseeding and a good take helped to reduce this problem after construction of the two 500 kV lines in the study area. In addition to the timely re-seeding, a selective spraying program should be undertaken about 2 years after construction. In most areas the range seeder from the B.C. Ministry of Agriculture and Food would provide the best reseeding from a weed control point of view.

Construction practices themselves can be modified to reduce invasion of weeds. Soil disturbance should be minimized during construction. Temporary construction roads should be reclaimed immediately after construction is over.

The second weed problem is on haylands where mowing is an important method of weed control. This situation did not occur within the study area on either the 500 kV lines or the 230 kV line. It did occur along a distribution power line extending west from the Soda Creek Substation.
This line runs through an irrigated hay field. Small weed populations occur around the wooden poles in areas where the mower cannot reach. The problem of weeds around tower bases could also occur 3 km north of Williams Lake Creek where the major transmission lines cross a meadow used for hay and pasture. The major problem with weed population around tower and guy wire bases is that they produce seed and act as nurse areas which increase weed populations in the surrounding area. This problem occurs only where mowing is practiced. The ranchers in the study area did not take the time to spray herbicide on the patches of weeds at tower bases, even though such procedures may be cost effective. No value can be placed on yield loss due to weed concentrations around towers without analysing yield samples. The author estimates that special spraying would cost in the neighbourhood of $20 per tower per year.

The third problem is endemic weed population along the right-of-way used for rangeland. Other cleared areas, such as logged-off areas, have similar weed densities as the right-of-way. Both the B.C. Ministry of Forests and the ranchers do some selective spraying of all of these areas. This spraying is viewed by this author as one of the management procedures necessary to take advantage of the increased grazing capacity of the right-of-way.

Irrigation and Drainage

Irrigation is necessary to bring areas with large climatic moisture deficits into full, or in some cases, up to economic levels of production.
Three major factors determine the need for irrigation. These are the climatic moisture deficit, the capacity of a soil to retain water, and the availability of groundwater near the surface. The cultivatable portions of the study area (class 1 through 5) can be divided into three categories by the need for irrigation. The first category is the plateau which has predominantly luvisolic soils. These soils have a clay enriched Bt horizon and can retain significant amounts of water. The plateau is also slightly colder than lower elevations, giving it a slightly lower climatic moisture deficit. Irrigation of this area is not widely practiced at the present time even though it would increase yields. The second type is the glacial fluvial terraces. These terraces are made up of very coarse rocks with thin cappings of fine sand and coarse silt. These areas have little water retention and without irrigation are often sparse grasslands. With irrigation these areas improve from class 5 to class 2 agricultural capability. Most of the hay production in the Williams Lake area comes from irrigated hayfields on these terraces. The third type of cultivatable land in the study area is organic meadows such as the one on the right-of-way 3km north of Williams Lake Creek. These meadows have developed where groundwater gathers in depressions. Normally this groundwater meets most of the climatic moisture deficit. Organic meadows are an important source of hayland and pasture in the Chilcotin-Cariboo.

Interference with irrigation by electrical transmission towers is mainly a problem for automated sprinkler systems and high pressure reel irrigators. These types of systems are rapidly replacing less water efficient systems such as flood irrigation and more labour intensive systems such as hand move sprinklers. As can be seen from Table 11, the
amount of irrigated land in the Cariboo census district increased by 7% between 1971 and 1981. During this same period the area of land under sprinkler systems increased by 422% [Economics Branch Ministry of Agriculture, 1981(b)]. While no irrigated hayfields are crossed by the major transmission lines, the distribution line, west of the Soda Creek Substation interfered with irrigation. The rancher who operates this field wishes to use a wheel move system throughout the field. Such a system would be effectively blocked by the closely placed wooden poles of the distribution line. He has approached the local B.C. Hydro office about having the line moved. Although B.C. Hydro is willing to move the line, it insists on B.C. Hydro doing the work themselves. This policy adds several thousand dollars over the cost of a private contractor doing the work with the rancher using his own equipment to clear the right-of-way. The distribution line is over 10 years old but B.C. Hydro is reported to require the complete cost of replacement instead of depreciated value of the current line. The high labour cost of irrigating around the distributor will probably cause the rancher to eventually pay B.C. Hydro's price.

Transmission lines at present do not interfere with irrigation on either of the other cultivatable land types. Problems may occur if the luvisolic soils of the plateau such as the Tyee soils are eventually irrigated. Organic meadows will continue to be only subirrigated for the foreseeable future.

Several mitigation measures are available for the irrigated terraces. The best measure is to route transmission lines around areas where irrigation would increase the agricultural capability of land by several
classes. Where this cannot be done, tower structures should be placed in such a way that standard wheel-move systems can be used. Matchstepping of towers on multiple transmission line routes would often help in this regard. Matchstepping would probably be a wasted expense over areas where irrigation would not be practiced. It is interesting to note from this case study that it is harder to develop a compatible irrigation system for electric distribution lines than for the major transmission lines. This is due to the lower conductors and closer spacing of poles of the distribution lines. Distribution lines are considerably cheaper to move and route around fields than major transmission lines. The transmission lines were not found to alter drainage patterns or practices in the study area. Care should be taken to insure adequate culverts along construction and maintenance roads.

Soil Compaction and Erosion

Several locations in the study area show appreciable erosion. The most severe of these is along the terraces adjacent to Williams Lake Creek and Hawks Creek. In both of these cases, the good take by seed along the B.C. Hydro right-of-way appears to have reduced erosion on the right-of-way compared with the same slopes outside of the right-of-way. Clearing may have led to some small scale erosion, however no significant loss due to erosion was noted by ranchers or on airphoto inspection. Rapid reseeding and contouring where necessary were effective mitigation measures for erosion.

Some loss of yield due to soil compaction around towers is evident from the air photos. The snow cover during the inspection of the study area
prevented an estimate of this loss of yield. The loss on the rangeland such as on the Tyee soils is thought to be minor and out-weighed by the greater palatability of crested wheat grass on the right-of-way than the pinegrass off the right-of-way. The Hargreaves soil association is coarse-textured and unlike the Tyee would not be subject to easy compaction. The major potential problem with the Hargreaves and similar soils is that the thin aeolian cap could be disturbed during construction. Soil compaction and disturbance around the wooden poles of the distribution line did not appear to adversely affect the growing capability of the soil.

Increased Access

The removal of trees and construction of access roads along major transmission lines is known to increase access into remote areas. The study area is not a remote area. The entire area is used by resource users including range users, forestry companies and woodlot operators. The residents of the region use rangelands for a variety of recreational uses; hiking, all-terrain vehicles, snowmobiling etc. As long as the range is used only seasonally for grazing, the presence of the B.C. Hydro right-of-way does not appear to greatly increase conflicts between agricultural and other land uses. The major complaint is that gates are left open. This is a serious problem as it can result in loss of cattle and time. Cattle guards help to prevent this impact. When a major right-of-way is used as an access road by many users, a cattle guard should be installed. The $1500 to $2000 cost of such a cattle guard is an expensive outlay for most ranchers, especially if the rancher is
only one of several users of the access road. The responsibility for deciding the location of guards and who is responsible for their cost and maintenance should be part of a coordinated management plan for the area.

An entirely different situation exists where the right-of-way is intensively used for agriculture, such as the hayfield 3 km north of Williams Lake Creek on the B.C. Hydro right-of-way. In such a situation the level of conflict between agricultural and non-agricultural users is more intense. Cattle are present for a large portion of the year and recreational traffic could lower production. Field equipment is often left out and vandalism and theft may become a problem. Such areas would benefit from controlled access. The right-of-way may increase the cost of controlling access in these situations. Increased fencing and lockable gates are needed. If recreational or forestry traffic is utilizing a right-of-way, alternate routes may have to be developed. Ranching in the study area is expected to grow in intensity over time. Pressure from the local population for access will also grow over time.

Although increased access into the study area is viewed by ranchers as a minor problem at the present time it may well grow into a major problem in twenty years. Several mitigation measures exist to lessen the impacts of improved access. The first is access planning. B.C. Hydro now produces plans for its own access for new rights-of-way. A general access plan is needed for all range units where access by different users creates conflicts. This is viewed as a continuing task because the need for control of access will change over time. Although B.C. Hydro needs
emergency access to every tower site, this does not have to take the form of a maintenance road. There is little opposition to allowing a utility operator to have keys to locked gates and permission to drive over fields if there is just compensation for crop damage. This controlled access system is relatively easy to set up where a new right-of-way crosses an existing field. Methods should be set up so that non-controlled access can become controlled access should the need arise. In the short term, mitigation measures such as cattle guards and reclamation of construction roads will alleviate most impacts. No mitigation method can replace courtesy on the part of all range resource users. Public education on correct uses of Crown land would be of great benefit.

Electrostatic and Electromagnetic Effects

Few shocks or other electrical effects were reported by ranchers in the area. Interference with TV signals was reported by one rancher. Other possible sources of TV interference such as distribution lines occur in the immediate area. In ranching areas, signal strengths are often weak. Satellite dishes are coming into use in the area and do not appear to be affected by transmission lines. Fences in the study area are reported to be sufficiently grounded. Some shocks are reported from vehicles operated under transmission lines.

The major impact of the electric field appears to be psychological. There is an undercurrent of worry. The ranching community is concerned that the fields around the transmission lines are somehow harmful to
their cattle, themselves or their crops. They are unfamiliar with the preponderance of research that suggests that any such effects are negligible. Public education would probably help to alleviate their fears. No economically significant electrical effects were found in the study area except where distributor lines limited the use of reel irrigators.

Summary of Results for Case Study #2 - Fraser Plateau

The presence of a major electrical transmission right-of-way was found to have a beneficial effect in the second case study. The major reason for this was the improvement to rangeland values provided by clearing of the right-of-way and seeding it with desirable range grasses. This provided ranchers with 10.4 Animal Unit Months (AUM's) of forage per year per kilometre of right-of-way. The crested wheat grass on the right-of-way was considered by ranchers to be preferable to the pinegrass off of the right-of-way in terms of its palatability, season of use and potential for weight gains. Several formidable obstacles were found to the utilization of this benefit. The first was the lack of skill on the part of the rancher in using techniques such as salting, fencing, and range riding to control cattle distribution. Other range management techniques had to be modified to optimize the use of the right-of-way. These included selective spraying of weeds. These management techniques would be required if the conifer cover was cleared for purposes other than a right-of-way and their cost does not outweigh the benefits of the increased forage. Several factors reduced the amount of range yields
that could be realized from the right-of-way. These included a small amount of land loss, weed spread and yield loss due to soil compaction.

This positive picture changed abruptly on hayland. Since clipping is used to control weeds, tower bases become potential nurse areas for weeds. Land loss around tower bases increased with the use of farm machinery. There is little land loss if cattle graze around towers but if large mowers are used, the area lost around a tower could increase from 8m² to over 100m².

On areas which require irrigation, the negative impacts of electrical transmission lines increase another major step. The high labour cost of hand-move systems would far outweigh any benefits derived from clearing and seeding of the right-of-way.

Prompt reseeding of the right-of-way was reported by ranchers and was a successful mitigation measure in reducing weed spread and soil erosion. Other mitigation measures such as matchstepping and avoiding the ALR south of Hawks Creek were not undertaken but could have reduced the potential for impacts on irrigation of this benchland.

Another conclusion that could be drawn from the case study is that small electrical distribution lines can result in significant negative impacts to ranchers while not providing increased range values. Education was identified as a need in the study area. Special range management techniques were needed along the right-of-way. Providing information to farmers and ranchers on electric field effects is needed to allay fears
and information on irrigation design around transmission lines is also necessary.

The stage of development of an agricultural area was shown to affect both the types and intensities of interactions with the electric transmission lines. Public education on proper recreational use of all rangelands is needed. On cultivated land, controlled access may be necessary. The energy transmission can be viewed as a joint user of the land it crosses. The fact of the right-of-way and its opportunities and requirements should be considered in Co-ordinated Resource Management Plans (CRMP's). Right-of-way operators should be included in CRMP's and other planning exercises.

It is important to note that the majority of ranchers interviewed would welcome the addition of the third 500 kV line because of the increased grazing. The addition of a third line would not require much more right-of-way as B.C. Hydro purchased enough right-of-way for the third line in most areas.

2.4 Conclusions to Chapter 2

Based on the case studies and review of literature, several conclusions can be drawn as to the costs and benefits felt by the farmers when energy transmission facilities cross their fields.
The first conclusion is that the method of dividing impacts into separate components aided assessment. This technique developed out of scientific research including (Hydro Quebec, 1974), (Rural Electrification Administration, 1976), (Bomford, P.H.; 1974), (Ontario Hydro; 1977), and later studies which focused on individual aspects of the interaction between energy transmission and farm operations. Environmental impact assessments then could use this research to total all of these impacts to arrive at an impact rating (Sigma; 1981) (Goldstein, 1982). This technique of analysing individual impacts worked well in both case studies. Case study one was cultivated land similar to that considered by (Ontario Hydro, 1977). Case study two was rangeland which had not been considered by any published report reviewed. A new impact category, cattle grazing, was added for case study two but the basic technique of analysing impacts separately worked. Both the case studies and review of literature showed that the actual costs and benefits experienced by a farmer or rancher are very site and time specific. The costs and benefits of joint land use by agriculture and energy transmission was found to depend on the following factors:

1. Biophysical Factors

   the climate capability for agriculture of the area
   the ability of the soil to store water
   the ability of the soil to resist compaction
   the availability of irrigation water
2. Energy Transmission Factors

the type and size of development
the form and location of structures
the relative position of different linear developments

3. Cultural Factors

the availability of markets for specific agricultural products
the attitude of the agricultural community toward industrial developments
the size and type of machinery and technology used
the agricultural products grown
the skill of the farmer or rancher

Due to these differences, each transmission project must be viewed as an individual case. While previous studies can be used as a guide in conducting specific studies; values from the literature should not be directly applied to new situations. For example, the electrical transmission lines in the two B.C. case studies had quantitatively and qualitatively different impacts on the agricultural operations they crossed.

Having said that the actual cost and benefits of locating energy transmission facilities on farmland are site specific, some general patterns can be seen. First, the impacts of electrical transmission lines on agriculture appear to be in direct proportion to the level of
agricultural development. This is summarized below:

<table>
<thead>
<tr>
<th>General Level of Development</th>
<th>General Level of Impact1 (per kilometer per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large automated irrigation systems</td>
<td>$1,000</td>
</tr>
<tr>
<td>Orchards and vineyards</td>
<td>500</td>
</tr>
<tr>
<td>Cultivated dryland field crops</td>
<td>200</td>
</tr>
<tr>
<td>Grains</td>
<td>100</td>
</tr>
<tr>
<td>Hay lands</td>
<td>- 50</td>
</tr>
<tr>
<td>Forested range</td>
<td>10</td>
</tr>
<tr>
<td>Open range</td>
<td></td>
</tr>
</tbody>
</table>

Both negative and positive impacts were less with pipelines than with high voltage transmission lines.

The case studies and literature demonstrated the fact that the design of an energy transmission facility can be altered to reduce the impact that it has on agriculture. Such practices are normally called mitigation measures. Some of these practices such as using guyed-V electrical transmission towers and placing towers along natural boundaries, farm boundaries or fence lines may not add to the total cost of a project. Other mitigation measures such as major route alternatives, may add significantly to the cost of energy transmission.

The following are the conclusions about individual impacts that can be drawn from the two case studies. Care should be taken in applying these figures to new situations. Electrical transmission lines are considered first, then pipelines.

1 Rounded averages obtained from the literature reviewed and case studies.
2.4.1 Electrical Transmission

Interference with automated irrigation equipment was found to be the most costly impact of electrical transmission on agriculture. Impacts are greatest where the irrigation requirement is the highest, such as on coarse-textured soils without high groundwater tables. On the Interior Plateau (Case Study #2) the majority of irrigation impacts occur on terraces along rivers. These findings are consistent with those in the Mapp Report (Gustafson, R.J. et al, 1978).

Irrigation impacts are minimized if transmission lines avoid areas which show the greatest potential for irrigation. Impacts in the range of thousands of dollars per year per kilometre are possible. Mitigation measures such as route modification, tower location, match-stepping and modification of irrigation systems should be used in all areas of the province with large irrigation requirements. With these mitigation methods, the level of impacts can be greatly reduced. Electrical distribution lines were also found to cause serious interference with irrigation.

The presence of towers in a field led to several major negative impacts. Land loss of uncropped areas, time loss in avoiding towers, yield loss due to increased compaction around towers, yield loss due to increased weed populations, increased costs such as extra seed and fertilizer around towers, and possible damage of farm equipment from collisions with towers were all associated with the bases of transmission towers. These impacts were greatly influenced by the crops grown or the crops that
could be grown. The crops which are grown are determined by the agricultural capabilities of the land, distance to markets and historical agricultural patterns. Land loss and related impacts were also influenced by tower type. Table 12 summarizes the case studies' findings of land loss. Other related impacts followed a similar pattern. The values found were within the range reported by Gustafson, R.J., 1978, (McKinnon, Allen, and Associates Western Ltd., 1978 and Fortine, J.M., 1980. Unfortunately these measures were not followed in Case Study 1.

Land loss due to substations is considerable. In both case studies, land lost to substations equalled or exceeded that lost to towers. Land loss and related impacts occur wherever towers cross cultivated land. Most of the area of the ALR crossed by electrical transmission lines would experience these types of impacts.

Three problems were noted with weed control. The most important was the nurse areas created for weeds under towers where mowers cannot reach. On intensively cropped land it cost $20 per tower per year to spray these areas. On less intensively cropped land weed populations are often left to invade surrounding areas, thus decreasing yields. The mitigation measures for this problem are similar to land loss. Kulp, (1970) found similar levels of impacts to those found in case study one. The second problem is the temporary population of weeds just after construction. Farmers receive compensation for this. A major impact develops if new
### TABLE 12.

**Summary of Land Loss Along Electrical Transmission Lines**

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Crop type</th>
<th>Linear structure</th>
<th>Land Loss$^1$ m$^2$ per kilometre of transmission line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>corn silage</td>
<td>500 kV lattice tower</td>
<td>345</td>
</tr>
<tr>
<td>1</td>
<td>corn silage</td>
<td>360 kV Metal H-frame tower</td>
<td>216</td>
</tr>
<tr>
<td>1</td>
<td>hay</td>
<td>500 kV Lattice tower</td>
<td>243</td>
</tr>
<tr>
<td>1</td>
<td>hay</td>
<td>360 Metal H-frame tower</td>
<td>60</td>
</tr>
<tr>
<td>1</td>
<td>pasture</td>
<td>500 kV Lattice tower</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>pasture</td>
<td>360 kV Metal H-frame tower</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>range forage</td>
<td>500 kV guyed V-tower</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>hay</td>
<td>500 kV guyed V-tower</td>
<td>300</td>
</tr>
</tbody>
</table>

Mitigation measures for land loss and related concerns can be grouped in order of preference:

1. - avoid high capability lands
2. - avoid areas where crops will be grown which require either frequent cultivation, large equipment or automated irrigation
3. - locate transmission towers along farm, field or natural boundaries
4. - minimize the base area of transmission tower
5. - change crops grown to those which are compatible with transmission lines yet which yield high returns

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$^1$ Mean of 3 towers in each case.
weed species are introduced into an area by transmission line development. Expansion of both knapweed and Canada thistle is a potential problem in northern, central and eastern B.C. along proposed transmission routes. The third problem was continued weed population along rights-of-way in rangeland. This is a problem on all cleared pastures and does not appear to be consistently worse along rights-of-way.

Electrostatic and electromagnetic effects were significant concerns in Case Study 1 due to the possible contributory effect of transmission lines to tingle voltages and shocks. Other effects such as noise and radio interference were only inconveniences. In the Williams Lake case study, only inconveniences such as TV interference were reported but some uneasiness about possible biological effects was expressed.

Increased access was not viewed as a problem in the Lower Fraser Valley. In the Williams Lake area conflicts between resource users occurred throughout the study area. Although problems such as cattle gates being left open occurred along the right-of-way, it was hard to separate effects of the right-of-way from background effects. Control of access is needed in cultivated areas. In developed areas of the province such as the Lower Fraser Valley, such control is taken for granted while in remote areas access is often taken for granted. More public education on considerate use of Crown Range is needed. Some additional use of cattle guards and controlled access gates may be needed.

Soil compaction along transmission lines was noted near towers on fine-textured soils in Case Study 1 and along paths following the
right-of-way on luvisolic soils in Case Study 2. Such soil compaction probably lowered yields in both cases.

The largest positive impact of transmission lines was noted in the Crown Range areas of Case Study 2. In these areas the right-of-way saved ranchers $1000/ha in clearing costs and added grazing of 0.8 AUM per hectare per year of cleared right-of-way.

2.4.2 Pipelines

Pipelines were found to have less interaction with agriculture than electrical transmission lines. The most serious impact is continuing yield loss on fine textured soils along the trenchlines. Such losses can amount to $500 per kilometre per year for corn silage. Drainlines could lower this loss in some situations. The cost of installing drainlines may be greater adjacent to pipelines. Since the impacts of pipelines are closely related to fine soils, the Peace Region with its fine-textured soils and large number of existing and proposed pipelines may be an area to study in greater detail. Vancouver Island and the Lower Fraser Valley may also be areas of concern.

2.4.3 Common Corridor Concerns

While land fractionation can occur between two exclusive use rights-of-way, a similar problem can occur between shared use rights-of-way such as a pipeline and transmission line as in Case Study 1. In this case, a farmer could not expand barns because of building
restrictions on rights-of-way to either side of an existing barn. Placement of linear developments together could substantially minimize such impacts. Another situation of planning rights-of-way together was found in case study 2. By using a wide right-of-way for several electrical lines, cattle management problems were reduced. Group rights-of-way also decrease the cost of weed control measures. Interference with irrigation can be lessened in some situations by common corridors. Another advantage to common corridors is the increased efficiency of managing a farm crossed by several rights-of-way if only one route is used. In valleys such as the Sumas Valley where several linear developments are forced to follow similar routes, the use of a common corridor should always be investigated.

In general, common corridors will intensify the impact on one area while reducing the total impact. This is advantageous only where the proposed common corridor has a lower agricultural capability than the non common alternative corridors. Common corridors may greatly increase the negative impacts of linear development if they force linear developments onto higher capability land.
3.1 The Route Selection Process

Many factors influence a linear operator's decision on a preferred route for an electrical transmission line or pipeline. The basic objective of a new line may be to move energy between two well defined points. More often at least one of the end points has several alternatives. A recent example of this is the new electrical transmission line that was constructed to the coal mining town of Tumbler Ridge. The end point, Tumbler Ridge, was defined, but the power could come from anywhere on the main B.C. Hydro electrical grid. Even if there are only two end points, many route and transmission line designs usually can be found. In order to consider alternatives in sufficient detail, a stepwise approach is normally used. First technically feasible (possible) corridors are chosen in an overview study. These corridors are often about 10 km wide. These corridors are often judged on the following basis:

1. Cost (based on length and difficulty of terrain)
2. Cost of developing access
3. Reliability
4. Security
5. Cost and difficulty of obtaining land rights
6. Social and environmental aspects
These studies are referred to as stage 1 or preliminary assessment. They result in the choice of one or two preferred corridors. Within these corridors several routes are chosen. The route closest to a straight line is normally the least expensive. Other routes are designed which vary from this base route in order to meet specific objectives. An example of this can be seen in B.C. Hydro's policy toward Indian Reserves. A decade ago, rights-of-way on Indian Reserves were easy to obtain. At this time the base route was not modified to avoid Indian Reserves. Recently the Department of Indian Affairs has generally upheld the native people's right to refuse an easement to a transmission operator. The result is that B.C. Hydro normally modifies their base "least expensive" route to avoid Indian Reserves. The transmission operator chooses a route that is closest to the base or preferred route while not causing a major threat to settlement, the environment or the security of the line.

Pipeline routing follows a similar pattern. Pipelines are much less visual so normally face less objections from local land holders and Native people. Pipelines are often constructed very close to the base route.

The next two sections review the basic costs and benefits a linear operator faces when making the decision to cross or not to cross agricultural land.
3.2 Electrical Transmission Lines

If an engineer described the perfect place to build a high voltage electrical transmission line it would sound something like this. A long expanse of flat, well drained land which is protected from high winds and icing; which has vegetation that does not grow over 10 feet, which can be driven to without building new roads, and where other resource users such as forestry and wildlife users would not be affected. A transmission line engineer's paradise is a cultivated field! This is even more true when the alternative to agricultural land is urban or suburban land. Compared with residential and commercial land, agricultural land is almost free. Often compensation for a transmission line easement is close to or over the market price of the land within the right-of-way. Agricultural land at $2,000 - $10,000 per hectare looks good when compared to suburban land at $200,000 - $500,000 per hectare.

Table 13 reviews the major costs and benefits faced by an electrical transmission operator using farm land. Different levels of agricultural intensity and different stages of transmission line development are broken out.

Little information on the cost of developing electrical transmission facilities has been published. The following is an analysis based on the few transmission company cost estimates available to the author. The costs of developing access were estimated by The Northern Transmission Overview Study (Ian Hayward and Associates Ltd., 1979). This study divided the terrain types in British Columbia into five categories (codes
Table 13 Electrical Transmission Lines - Agricultural Interactions from Transmission Operator's Viewpoint.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
<th>Cultivated Fields</th>
<th>Improved Pasture</th>
<th>Range Land</th>
<th>Potential Farmland</th>
</tr>
</thead>
<tbody>
<tr>
<td>access</td>
<td>saved expense</td>
<td>VP</td>
<td>VP</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>less impact on other resources</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>compensation for crop damage</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>NS</td>
</tr>
<tr>
<td>Clearing</td>
<td>saved expense</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>less impact on other resources</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Construction</td>
<td>lower costs</td>
<td>VP</td>
<td>VP</td>
<td>NS</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>better access</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>P</td>
</tr>
<tr>
<td>Towers</td>
<td>less obstacles to go around</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>P</td>
</tr>
<tr>
<td>Operation</td>
<td>little or no vegetation maintenance expense</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>lower operating cost</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>P</td>
</tr>
</tbody>
</table>

VP - Very Positive  
P - Positive  
NS - Not Significant  
N - Negative
A to E) and assigned probable access road construction costs to each of these codes as follows:

A - $10,000* - $20,000 per km
B - $20,000 - $30,000 per km
C - $30,000 - $40,000 per km
D - $40,000 - $50,000 per km
E - over $50,000 per km

* 1979 dollars

Code A is described as "reconstruction of existing access roads which are below standard". Based on this definition, almost all cultivated farmland would be Code A. Code B is described as "Construction of new...access road in favorable terrain" and would include almost all potential farmland.

Most non-urban, non-agricultural land in B.C. belongs to Codes B, C and D. If avoiding agricultural land means building access over more difficult terrain, access costs to the transmission companies will rise by $10,000 to $40,000 per kilometre. If the total length of a transmission line is lengthened by avoiding agricultural land, about $20,000 can be added to access cost per kilometre of additional length.

The following case is used to show the other costs involved in routing an electrical transmission line around an agricultural area. The Kelly Lake to Cheekye 500kV Double Circuit Transmission Line Route Location Report (B.C. Hydro and Power Authority, 1981) gave cost estimates for several
cost estimates for several alternative routes. Segment F went through the ranching area of Pavilion, B.C., and segment D was an alternative which avoided this agricultural land. Table 14 compares the cost estimates of these two routes.

Table 14 Costs per km of Avoiding the Pavilion Agricultural Area

<table>
<thead>
<tr>
<th>Activity</th>
<th>Segment F agricultural</th>
<th>Segment D non agricultural</th>
<th>Per Cent increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>$23,000$</td>
<td>$29,000</td>
<td>20.6%</td>
</tr>
<tr>
<td>Acquisition</td>
<td>8,800</td>
<td>9,200</td>
<td>4.3%</td>
</tr>
<tr>
<td>Clearing</td>
<td>1,000</td>
<td>21,000</td>
<td>95.2%</td>
</tr>
<tr>
<td>Materials</td>
<td>314,776</td>
<td>356,757</td>
<td>11.8%</td>
</tr>
<tr>
<td>Construction</td>
<td>303,736</td>
<td>487,842</td>
<td>37.7%</td>
</tr>
<tr>
<td>Contingency</td>
<td>130,144</td>
<td>180,643</td>
<td>27.9%</td>
</tr>
<tr>
<td>Total</td>
<td>$781,456/km</td>
<td>$1,084,442/km</td>
<td>27.9%</td>
</tr>
</tbody>
</table>

1 data from (B.C. Hydro, 1981)
2 given in 1981 dollars, not including interest, overhead or inflation

It is not surprising that transmission companies, as B.C. Hydro did in this case, pick routes which cross agricultural land. In this case electrical transmission lines costs are $303,000/km less over agricultural land. Using a 10% per annum amortization rate, this is a saving of about $30,000 per year per kilometre.
An electrical transmission line company can also face annual costs if agricultural land is avoided. Any lengthening of a transmission line to go around a field increases the electrical loss (resistance) of the line which is an annual cost. Maintenance costs also increase with increasing length.

Chapter 2, Costs and Benefits to Farmers, showed that the net value of impacts to farmers of electrical transmission lines occupying farmland seldom exceeds a cost of $1,000 per year per kilometre of right-of-way. Compared to the costs faced by a transmission company of avoiding farmland, this cost is small. In B.C. with our rugged topography, cost to the transmission company of avoiding farmland can often exceed $30,000 per year per kilometre of right-of-way. This does not take into consideration impacts of other resources such as forestry.

3.3 Pipelines

Pipelines are categorized in several ways. For the purposes of this discussion, two types of pipelines are differentiated; gas pipelines and oil pipelines. Gas lines carry a low density compressible gas. For this reason they can be built over much steeper grades than oil pipelines. The high density and high pumping pressures of oil lines limit their practical application to gentle slopes. Gas pipelines can be economically operated over steeper land. Maximum slope is a major routing constraint of all linear developments. Another constraint is the need to bury pipeline in soil. The soil not only serves as an anchor for the pipeline but also protects it from sunlight and weather.
Blasting through rock is an extremely expensive way of building pipelines. An engineer's ideal route pipeline development would be a long straight expanse of well drained soil at least 2 m deep which has good access. In short, a cultivated field is prime real estate for pipelines.

As with electrical transmission lines, other economic factors add to the attractiveness of farmland for pipeline construction. Building construction is prohibited on pipeline rights-of-way as it is with electrical transmission lines. For this reason, the cost of pipeline easements is close to the market price for the land within the right-of-way. Suburban land is therefore 10 times more expensive to pipeline operators than farmland.

Table 15 reviews the major costs and benefits faced by pipeline operators using farmland. Table 15 is set up similarly to Table 13.

Not as much published material on pipeline costs was found as for electrical transmission lines. In a hypothetical example (section 9.4.2) The Common Utility Corridor Study (Ian Hayward and Associates, 1982) the average cost of pipelines was estimated as $250,000/km (1982 dollars). This report also states that construction costs can increase fivefold if rocky terrain rather than level soil is crossed. Assuming avoiding agricultural land in B.C. could double the cost of developing a pipeline is reasonable, given B.C.'s rough topography. This would imply an increase of cost of $250,000 per kilometre to avoid agricultural land if total pipeline length is not increased. If the length of pipeline is
Table 15 Pipeline-Agriculture Interactions from the Linear Operator's Viewpoint

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
<th>Cultivated Land</th>
<th>Improved Pasture</th>
<th>Range Land</th>
<th>Potential Farmland</th>
</tr>
</thead>
<tbody>
<tr>
<td>access</td>
<td>saved expense</td>
<td>VP</td>
<td>VP</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>less impact on other resources</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>compensation for crop damage</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>NS</td>
</tr>
<tr>
<td>Clearing</td>
<td>saved expense</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>less impact on other resources</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Construction</td>
<td>lower costs</td>
<td>VP</td>
<td>VP</td>
<td>NS</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>better access</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>P</td>
</tr>
<tr>
<td>Pipeline</td>
<td>better material to bury it in</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>P</td>
</tr>
<tr>
<td>Operation</td>
<td>easy inspection and maintenance</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>lower operating costs</td>
<td>P</td>
<td>P</td>
<td>NS</td>
<td>P</td>
</tr>
</tbody>
</table>

VP - Very Positive
P - Positive
NS - Not Significant
N - Negative
increased, the increased costs would double.

Increasing length also leads to annual costs. Ian Hayward and Associates (1982) estimates the cost of energy needed to counteract friction on a 12 inch gas pipeline carrying approximately 2 million cubic feet per day of gas at $12,000 per kilometre on discounted present value basis. Maintenance costs also increase with length.

3.4 Conclusions to Chapter 3.

It can be concluded from this that the magnitude of costs of avoiding agricultural land facing both electrical and pipeline transmission companies in B.C. is in the order of $30,000 per year per kilometre of right-of-way. This is roughly 30 times as much as the costs faced by the farmer who owns the farmland to be crossed. This figure does not take into consideration the impacts on other resources such as forestry, wildlife etc. if farmland is avoided by energy transmission facilities.
CHAPTER 4. CURRENT REGULATION OF ENERGY TRANSMISSION FACILITIES ON AGRICULTURAL LAND.

4.1 INTRODUCTION

Many different laws with different objectives have been passed which include provisions that pertain to energy transmission facilities on agricultural land. This chapter reviews statutes and regulations that directly address problems that arise when electrical transmission lines and pipelines cross agricultural land in B.C. Federal and Provincial jurisdictions are discussed separately.

The major piece of federal legislation is the National Energy Board Act. This act is discussed in greater detail under pipelines where it has been most active. The major piece of British Columbia Legislation is the Utilities Commission Act. The Energy Review Process that takes place under this act is reviewed using an example of an electrical transmission line as this is where the Utilities Act has been most active.

Chapter five first answers the question as to whether government regulation of energy transmission facilities is needed and then goes on to recommend changes to the existing regulation.

Special purpose acts which can affect energy transmission facilities on agricultural land are also reviewed. The most important of these is British Columbia's Agricultural Land Commission Act. This act regulated all energy transmission facilities that are within the Agricultural Land Reserve.
A list of the Government Acts and Regulations is given after the Bibliography.

4.2 Regulation of Electrical Transmission Lines

4.2.1 Federal Regulation

There is currently little federal regulation of electrical transmission projects in B.C. and only one regulatory agency directly responsible for reviewing proposals: The National Energy Board (NEB). The NEB was established in 1959 by the National Energy Board Act and was given the authority to review energy projects. Federally regulated electrical transmission lines are defined by the NEB as only those individual power lines leading to or crossing an international border. The B.C. electrical grid system as a whole is not regulated by the NEB. The following are considered by the NEB to be international power lines in B.C.:

B.C. Hydro

o Ingledow Substation (Vancouver) to Custer Substation (Washington State). Two 500 kV circuits.

Cominco (operated by West Kootenay Power and Light).


For these power lines the NEB follows a simple review process covering only new lines between existing substations and an international border. An application to construct a new line includes general information on land capabilities and uses, including agriculture. After a public hearing the NEB assesses the application and, if approved, grants a Certificate of Public Convenience and Necessity. Terms and Conditions can be added to this certificate by the NEB to satisfy concerns for impact mitigation and compensation. Normally, the line is inspected once after construction to ensure that the Terms and Conditions have been met.

The NEB process and federal jurisdiction in general takes precedence over provincial acts. No recent applications for international power lines have been made in B.C.; there are no examples of what roles would be played by provincial acts such as the Utilities Commission Act and the Agricultural Land Commission Act in such a situation. The NEB operates in Ottawa and, according to NEB personnel contacted in this study, has only a sketchy knowledge of the Provincial Utilities Commission and little knowledge of the Agricultural Land Reserve or agricultural issues in British Columbia.
4.2.2 Provincial Regulation

Regulation of new high voltage (over 500 kV) electrical transmission lines is evolving rapidly in B.C. under the Utilities Commission Act. Little regulatory activity is evident dealing with smaller transmission and distribution lines. Little remedial action is being taken to address impacts caused by older transmission lines constructed prior to environmental regulation.

Provincial regulation of electrical transmission projects falls into two categories. The first includes the environmental review processes discussed below. The second category comprises the special purpose legislation which is described in the following section.

There are three basic environmental review processes followed in British Columbia. Large energy projects deemed to be significant for the province are regulated by the Utilities Commission Act through the Energy Project Review Process. Projects of moderate size that cross regional boundaries can be reviewed by the Ministry of Environment under the Guidelines for Linear Development. Smaller projects of mostly regional significance were reviewed by Regional Resource Management Committees before these committees were discontinued. Both the Guidelines for Linear Development and the Regional Resource Management Committees were established by the Environment and Land Use Act (RS 110, 1979). The following is a synopsis of each of these review mechanisms.
Energy Project Review Process. The B.C. Energy Project Review Process (EPRP) forms the basis for most regulation of electrical transmission projects in the Province. Under the Utilities Commission Act (RS 60, 1980), transmission lines are regulated projects if they involve operating voltages of 500 kV or more. Smaller lines are also regulated if they connect to new power plants of 20 MW or higher, or involve electrical use of 3PJ (95 MW of continual use). An energy project of any kind can be regulated if directed by the Lieutenant Governor in Council.

The Energy Project Review Process normally begins with a prospectus, prepared by the project proponent, giving a general project description and schedule, project rationale and a description of proposed studies. The prospectus is reviewed by the Energy Project Coordinating Committee and appropriate working committees.

There are three working committees: the Environment, Resources and Land Use Committee, the Social and Economic Committee, and the Energy, Economics and Finance Committee. The B.C. Ministry of Agriculture and Food, is represented by the Farmland Resources Branch on the Environment, Resources and Land Use Committee. It is through this working committee that agricultural concerns are first communicated to the project proponent. The Farmland Resources Branch usually informs the Agricultural Land Commission and regional field staff of the project at this time.

The next step is the Preparation of a Preliminary Planning Report by the proponent. A key component is an analysis of alternative routes and
locations. Also included in this report are the following: a preliminary procurement plan, terms of reference for detailed environmental, socio-economic and project justification studies, a description of a public consultation program, and a list of approvals, licences and permits required. The preliminary planning report is reviewed by the Energy Project Coordinating Committee and Working Committees. This review is more formal than that of the prospectus. A working committee could identify areas where either the inventory or analysis is in their opinion deficient for route selection purposes. They could ask that additional studies be undertaken to cover areas of dispute. Agencies, in particular, the B.C Agricultural Land Commission may also make known their preferences for a most desired route or corridor. Normally at this stage a route is a corridor several kilometres wide and, as such, often contains land of widely varied agricultural capability and development. As the company has not made application at this time, recommendations for choosing a particular corridor are only recommendations to the company.

Usually the next step is to use the preliminary planning report as a basis for public consultation, which is conducted on a project-wide basis. All aspects of a project are discussed throughout the project area. Local residents may form impact committees and/or municipal governments may represent local views. Ideally, the public consultation continues until a project is satisfactorily completed and operating. Objections to a line can be voiced by individual farmers at public meetings.
The first formal and legally necessary portion of the Energy Project Review Process is the Application. B.C. Regulation 388/80 pursuant to Section 18 of the Utilities Act states that an application should contain:

"...identification and preliminary assessment of any impacts by the project on the physical, biological or social environments, and proposals for reducing negative impacts and obtaining the maximum benefits from positive impacts."

The application documents are formally reviewed for compliance with the regulations. Once this is done and the proponent clears up any deficiencies, the application is forwarded to the Minister of Energy, Mines and Petroleum Resources. This Minister, with the concurrence of the Minister of Environment, may proceed with the application in any one of three ways. Under Section 19(1)(a), the application can be referred to the Utilities Commission with the ultimate decision being made by Cabinet. Under Section 19(1)(b), the application can be dealt with by the Commission as an application for a Certificate of Public Convenience and Necessity. Under Section 19(1)(c), a project can be exempted from provisions of the Utilities Commission Act. In any case, terms and conditions may be included in the Energy Project Certificate, Certificate of Public Convenience and Necessity, Energy Operation Certificate, or Exemption Order.

Since it would be unlikely that an agricultural concern along a transmission line would be sufficient to cause the failure of an application, the types and implementation of terms and conditions...
accompanying a project's approval are a key to agricultural impact management.

The following is a short review of the development and implementation of Terms and Conditions for Kelly Lake Substation to Nicola Substation 500 Kv Transmission Line. This review is provided because the implementation section of the Energy Project Review Process is determined more by precedent than by documentation.

On May 6, 1981, B.C. Hydro and Power Authority made application to build the Kelly Lake-Nicola 500kV line.

The application was reviewed under the Energy Project Review Process and it was determined that the project would have minimal environmental and socio-economic impacts which could be managed through terms and conditions (a clear statement of the impact management philosophy).

On September 8, 1981, the Agricultural Land Commission approved the proposed route subject to a list of conditions. This approval came under the Agricultural Land Commission Act after a lengthy process described in the following section.

On October 29, 1981, the Minister of Energy, Mines and Petroleum Resources, with the concurrence of the Minister of Environment, granted an exemption to the project under Section 19(1)(c) subject to terms and conditions.

For the Kelly Lake-to-Nicola line, the terms and conditions were instrumental in improving agricultural and linear project interactions. The key terms are summarized below:

1) A project steering committee was established to ensure compliance, including representatives from the Ministry of Agriculture and the Thompson-Okanagan Regional Resource Management Committee.
2) This committee had the authority to set clearing specifications, subject to the approval of the Ministry of Energy, Mines and Petroleum Resources.

3) B.C. Hydro was instructed to implement measures necessary for soil conservation, revegetation and noxious weed control. Such measures are outlined in the Guidelines for Linear Development on Agricultural Land (Ministry of Agriculture and Food) and the Weed Control Act (RS 432, 1979).

In February, 1983, a route modification was granted to B.C. Hydro which added the following conditions:

1) The project steering committee was empowered to impose additional conditions on the construction and operation phases to ensure protection of environmental and social resources.

2) The land use mitigation measures identified in the B.C. Hydro's environmental review were incorporated into the condition of the order.

3) The route modifications were also approved by the Agricultural Land Commission.

Large scale airphoto mosaic maps were included in B.C. Hydro's environmental report and clearly showed the position of sensitive areas and the location of proposed mitigation measures along the entire route. These "index" maps were to act as a guide for the Environmental Officer supervising the construction of the line. In addition to working with the Project Steering Committee, the Environmental Officer will also report to the Surveillance and Monitoring section of the Planning and Assessment Branch of the Ministry of Environment.

In general, the persons directly involved with the Energy Project Review Process felt that it is rapidly maturing and will be successful in
Guidelines for Linear Development. Moderately sized electrical transmission projects such as transmission lines operating below 500 kV may be reviewed under the B.C. Guidelines for Linear Development (Victoria, 1977). An Order in Council is necessary to start such a review. These guidelines predate and set down the basic steps for the Energy Project Review Process. Figure 4-1 shows the assessment and planning review procedure under these guidelines.

Regional Resource Management Committees. Electrical transmission lines that are not regulated under the EPRP or the Guidelines often require various local permits to cross the Agriculture Land Reserve, Crown land, streams or municipal properties. If significant concerns were raised by local farmers or others, the Regional Resource Management Committee (RRMC) were asked to review the development. RRMCs were formed under the Environment and Land Use Act. These committees have been recently disbanded in favour of a system of interagency referral at the regional level. Due to a lack of documentation on these committees, little investigation was made of the referral process for this study.

Special Purpose Legislation

In addition to the three basic review mechanisms discussed above, the Provincial Government has passed a number of special acts that address the preservation of the agriculture industry. Special purpose acts such as the Agricultural Land Commission Act, the Water Act, and the Waste
Management Act are often superimposed on these review processes to deal with specific concerns. In addition, authority to deal with any concern not met by the legislation can be reviewed by the Ministry of Environment under the Environment Management Act (RS 14, 1981).

Agricultural Land Commission Act. The Agricultural Land Commission is charged under this Act to set up and monitor the Agricultural Land Reserve (ALR). Section 15(2) of the act states:

No person shall use agricultural land for any purpose other than farm use, except as permitted by this Act, the regulations or an order of the [Agricultural Land] Commission, on terms the Commissioner may impose.

Regulation 313/78 defines electrical transmission lines as a special use and sets out the form to be used in applying for a special use permit. Unlike the Utilities Commission Act, the Agricultural Land Commission Act does not state any minimum voltage and all new rights-of-way are reviewed regardless of site. No clear guidelines exist for the resolution of interagency conflicts.

Except for the Interpretation Act, the Environment and Land Use Act, and the Pollution Control Act; the Agricultural Land Commission Act takes precedence over other Provincial statutes. Application form (Schedule F) is unsuited for energy transmission projects. No guidelines exist for the information to be supplied to the ALC.
For larger transmission lines, the ALC prepares a statement of a preferred corridor if a preliminary planning report has been released. Normally the ALC concerns are represented on the Environment Resources Land Use Committee by the Farmland Resources Branch of the Ministry of Agriculture and Food. Formal application to the ALC is normally made late in the approval process, after a Certificate of Public Convenience or equivalent document has been granted. If the ALC believes the proposed project is compatible with agricultural purposes, an approval will be granted.

The Agricultural Land Commission had considerable input into the Kelly Lake to Nicola transmission. This input was primarily made directly between the Agricultural Land Commission and B.C. Hydro, not through the Utilities Commission.

After being informed of the proposed Kelly Lake-Nicola transmission line, the ALC contacted the following ranching associations:

Nicola Stock Breeders Association
Ashcroft Ranchers Association
Upper Hat Creek Stockbreeders Association

After reviewing the Stage I and II environmental reports and receiving recommendations of the ranching associations, the ALC recommended a realignment of the proposed transmission route. The new route was acceptable to both B.C. Hydro and the ranchers. The new route avoided the higher capability agricultural lands near Nicola Lake where hay was
grown. Subject to this realignment and the following conditions, the proposed transmission line was approved by the Agricultural Land Commission.

(1) the new line paralleling existing lines wherever possible;

(2) the eastern end of the line area Nicola Lake should comply with what was agreed to between B.C. Hydro and the Nicola Valley Ranches as it avoids much of the irrigated and cultivated fields in the area;

(3) line should be kept in scrub timber or timbered areas, wherever possible, as this would be less damaging to grazing areas and would provide increased grazing once the R/W was cleared;

(4) transmission towers are not to be located in any irrigated or cultivated fields;

(5) line should follow property boundaries through private cultivated lands;

(6) construction roads should be kept to a minimum. Furthermore, prior to construction, a plan of all roads and staging areas, their use, standard of construction and eventual disposition should be prepared and made available to the B.C. Forest Service and ranchers holding grazing permits in the area. In this way, Hydro's activities could be co-ordinated with possible range improvement projects;

(7) access road construction should be kept to a minimum and maximum use should be made of existing access roads. These roads should be carefully selected and upgraded for multi-purpose use. A continuous multi-purpose road is not recommended. The Commission would also encourage the use of helicopters wherever possible;
(8) B.C. Hydro or contractor to secure permission from appropriate crown agencies and/or property owners for permission to use existing roads or to build new roads;

(9) B.C. Hydro to ensure any damage to fences, gates, cattle guards, culverts and bridges is avoided or promptly repaired. B.C. Hydro should also be responsible for the activities of its contractors in assuring all facilities are kept in good condition;

(10) B.C. Hydro to maintain control of noxious weeds such as knapweed on its R/W;

(11) B.C. Hydro to ensure that revegetation of disturbed areas takes place immediately, otherwise the rapid invasion of the disturbed area by noxious weeds could take place. Hydro should also endeavour to improve the grazing capability of the cleared R/W by soil preparation and seeding;

(12) drift fences should be installed to prevent the drift of cattle from one range unit to another.

The effect of these conditions was to greatly reduce the potential negative impacts on agriculture of the proposed transmission line, both within the Agricultural Land Reserves and on the rangelands outside of the Reserve. The Commission also acted as a substantial link between the ranchers' associations and B.C. Hydro. The ALC has no normal inspection procedures and relies on complaints by the ranchers and Regional District for follow-up.
Other Special Purpose Acts. The following is a short review of the many provincial statutes that may affect the interaction between electrical transmission projects and agriculture. The Soil Conservation Act forbids the removal of soil or the placement of fill in the Agricultural Land Reserve without permission from the Agricultural Land Commission. The Weed Control Act requires the control and eradication of noxious weeds growing in the Province. The Water Act requires permits for the use, diversion, and storage of water, the alteration of streams or channels, and the operation of works in and around waterbodies. The Range Act includes provision for the use of Crown range, such as control of livestock and revegetation. The Waste Management Act controls the emission or discharge of effluents and contaminants onto the land or into water or air. The Pesticide Control Act requires permits for the use of pesticides and herbicides, including those used along electrical transmission rights-of-way.

4.3 Regulation of Transmission Pipelines

While few existing or proposed electrical transmission lines are regulated by the National Energy Board (NEB), most of the existing and proposed pipelines in B.C. are actively regulated by the NEB. The NEB Act regulates all pipelines connecting a province with any other and includes all branches and auxiliary facilities. Under this definition the NEB Pipelines Branch regulates the Trans Mountain Pipe Line system, the Westcoast Gas Pipeline system including gathering lines, and the Alberta Natural Gas Company pipeline in the Kootenays. The only
pipelines not regulated are the distribution systems operated by B.C. Hydro and Inland Natural Gas Company Ltd.

The **B.C. Utilities Commission Act** creates an overlapping jurisdiction between the Federal and Provincial governments. The proposed natural gas pipeline to Prince Rupert to supply Dome Petroleum's liquified natural gas (LNG) plant could come under both Federal and Provincial regulation. It is unlikely that the federal government would grant the power to expropriate provincially-owned Crown land as long as the national interest was not at stake. A more significant dispute is possible with the transmission of gas to Vancouver Island. If Westcoast Transmission undertakes the job it will be regulated by NEB; if B.C. Hydro supplies the gas it probably will not be regulated by the NEB. Both the NEB Act and **B.C. Utilities Commission Act** contain procedures for choosing between competing energy proposals. Neither Act provides for joint hearings or procedures with the other body.

The following is a summary of the current regulatory structure of the NEB for pipelines. The **Utilities Commission Act** provides for pipeline regulations that are identical to those for electric transmission lines (outlined in Section 4.2.1).

### 4.3.1 Federal Regulation

The National Energy Board Act (C-46, 1959) established the NEB as the basic federal agency responsible for protecting national interests with
regard to energy supply, including safety and environmental protection. An amendment was passed in 1983 that detailed a new procedure for regulating pipelines under the NEB jurisdiction.

Any proposed project or minor extension of a regulated system is discussed informally until a formal application is made. During formal discussion agriculture and environmental concerns are normally handled by NEB staff without referral to other federal or provincial agencies. Part IV of the National Energy Board Rules of Practice and Procedure include a detailed description of environmental information required to be filed by the applicant including the following:

- An evaluation of environmental factors with respect to alternate routes considered and the reasons for selecting the proposed route.
- A proposed description.
- A description of the project area including CLI information and description of current and proposed land use in agricultural areas.
- A description of the natural environment including a mapped and narrative description of soil types and capability classes of agricultural lands.
- A qualitative and, where feasible, quantitative assessment of the probable impact on the environment or land and resource uses including agriculture.
- A description of mitigation plans including topsoil preservation and compatibility with agriculture.
- An assessment of the residual impacts.
Once a formal application is submitted, all communications from the NEB to the proponent are made through its lawyer. The environmental information included with the application is received by the NEB environmental staff and a formal deficiency letter is sent to the proponent if any omissions are found. The NEB then sets the date of the first of two hearings. NEB hearings are held as formal Courts of Inquiry. Any member of the public or group can intervene in these proceedings. The NEB then meets and reaches a decision and a public document is released giving the reasons for the discussion. If approved, the project is issued a Certificate of Public Convenience which can be subject to any terms and conditions set by the NEB.

Up to this point the NEB procedure is fairly similar to the B.C. Utilities Commission. One major difference is the protection of land owners. The NEB Act includes several protections for the land owner not found in the B.C. legislation. Section 74 of the NEB Act, includes regulations controlling the acquisition of land for a pipeline. These are given below:

Section 74, subsection 2 of the NEB Act includes the requirement:

(2) A company may not acquire lands for a pipeline under a land acquisition agreement unless the agreement includes provision for:

(a) compensation for the acquisition of lands to be made, at the option of the owner of the lands, by one lump sum payment or by annual or periodic payments of equal or different amounts over a period of time;

(b) review every five years of the amount of any compensation payable in respect of which annual or other periodic payments have been selected;
(c) compensation for all damages suffered as a result of the operations of the company;

(d) indemnification from all liabilities, damages, claims, suits and actions arising out of the operation of the company other than liabilities, damages, claims, suits and actions resulting from gross negligence or wilful misconduct of the owner of the lands;

(e) restricting the use of the lands to the line of pipe or other facility for which the lands are, by the agreement, specified to be required unless the owner of the lands consents to any proposed additional use at the time of the proposed additional use; and

(f) such additional matters as are, at the time the agreement is entered into, required to be included in a land acquisition agreement by any regulations made under paragraph 75.29(a).

Owners considered in this section include all persons having an interest which could be damaged by the pipeline (Section 64). Section 75 details the method of notice to land owners along a proposed line and a procedure for arbitration where negotiation has not produced a settlement. Once landowners have been identified, the NEB holds a second hearing. This is a land owner hearing where details of the right-of-way alignment and site specific mitigation measures are discussed. Changes in route and additional terms and conditions can be made based on these hearings. A detailed line list is made in the form of an air photo mosaic. This line list is similar to the Environmental index maps used by the B.C. Utilities Commission Steering Committee for the Kelly Lake to Nicola electrical transmission line. It includes all complaints, problems with drainage, fence lines and access routes.

In general, the above system of regulation and enforcement has never been used in B.C. Many of the requirements have only been incorporated as law since 1980. So, to some extent the NEB is as new a system as the
Utilities Commission. Another major problem is the fact that the NEB works out of Ottawa. None of the farmers interviewed along the Westcoast Pipeline knew what the NEB was or how it was intended to protect their rights. Since the NEB has no B.C. staff and no one makes inspections after completion of a project it relies on owner complaints for most of its ongoing enforcement. Problems similar to those found along the pipeline in Case Study 1 have been addressed by the NEB in Ontario for years. NEB pipeline environmental staff did not know that similar problems exist in B.C. The NEB pipeline environmental staff had not heard of Agricultural Land Reserve or the Utilities Commission Act.

One of the documents reviewed by this study was a Landowner's Handbook for the proposed North Bay Shortcut Pipeline proposed for Northern Ontario. This booklet is informative but carefully avoids any mention of an owner's right to annual or periodic payments, (with a review every five years of the payment amount). It did make clear that compensation would be paid for continuing loss of yields in addition to the original payment. Farmers in B.C. are relatively unaware of either of these provisions of the NEB Act.

4.3.2 Provincial Regulation

In theory Provincial regulation of pipelines is the same as a provincial regulation of electrical transmission. Pipelines capable of transporting 16 PJ of energy per year (equivalent to 2,570,000 barrels of crude oil) are regulated projects under the Utilities Commission Act. Smaller pipelines can be regulated under the Guidelines for Linear Developments
if so directed by Cabinet. In practice, most small pipelines are handled by inter-agency referral at the local level. Regulated pipeline projects would follow the same procedures as electrical transmission lines. The Agricultural Land Commission reviews all new pipeline routes that cross the Agricultural Land Reserve in the same manner as electrical transmission lines.
CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The objective of this thesis was to determine if and to what extent the government should regulate the use of agricultural land for energy transmission. The following is a series of conclusions based on this study which lead to the answering of our basic question.

An inventory of electrical transmission lines and pipelines located within the B.C. Agricultural Land Reserve was presented in Chapter One. This inventory showed that existing and proposed energy transmission rights-of-way occupy only about 0.5% of the Agricultural Land Reserve or about 23,000 ha. Eighty percent of this figure is accounted for by electrical transmission rights-of-way which can be farmed to some extent. Based on this inventory it is concluded that energy transmission facilities in British Columbia do not in themselves constitute a major threat or depletion of the Agricultural Land Reserve.

What happens to the 23,000 ha of land in the agricultural reserve that is or could be affected by energy transmission facilities? Chapter two examined the costs and benefits from the farmer's perspective of agriculture and energy transmission sharing the same land. Two B.C. case studies were examined. The first was in a dairy farming area in the Lower Fraser Valley. The direct effects of electrical transmission on cultivated fields found in this case study were similar to those reported in the Review of Literature. The interference of electrical towers with
automated irrigation equipment was found to be the highest cost impact in case study 1 as it was by the Mapp Report (Gustafson, R.J. et al 1978). Land loss, time loss, and weed control impacts found in case study 1 were similar to those reported by the Ridgetown and Kempville Studies, Ontario Hydro, 1977) and Farming Around and Under Transmission Lines (Kulp, E.L., 1977). In addition to well documented impacts, several impacts of the energy transmission facilities were found in case study 1 which do not have counterparts in the literature. The problems of "tingle" or stray voltages on dairy barns, land fractionation between several developments and continuing yield loss over pipelines on fine textured soils, were not reported in the literature reviewed.

Case study 2 showed that on forested rangeland, electrical transmission lines could have a net positive impact on ranching. On forested rangeland, electrical transmission line rights-of-way can save ranchers $6,400 per kilometre in land clearing costs and thereby provide an additional 5 animal unit months (AUM's) per year per kilometre of right-of-way. (5 AUM is valued at $50 based on 1982 rangeland leases). Based on the findings reported in chapter two and the Review of Literature, the following conclusions can be drawn:

1. The costs and benefits to the farmers of large energy transmission lines located on farmland are closely related to the intensity of development.
2. On land requiring automated irrigation equipment and large machinery, electrical transmission lines can impose costs exceeding $1000 per year per kilometre of right-of-way. These costs are sufficient to discourage intensive agriculture.

3. Impacts on improved pasture are often less than $50 per year per kilometre of right-of-way for electrical transmission lines. Impacts of this level would not be expected to inhibit low intensity agricultural use of rights-of-way.

4. Clearing rights-of-way through forested grazing land can provide ranchers with a net financial benefit and encourage use of the right-of-way for cattle grazing.

5. Buried pipelines have less impact, both positive and negative, on agriculture than electrical transmission lines but can lower yields on some soils in both the long and short term.

Chapter three reviewed the costs and benefits to transmission companies of locating energy transmission facilities on agricultural land. Agricultural land was often found to be the most economical location for either electrical transmission lines or pipelines. If farmland is avoided either by locating a right-of-way on steeper, rockier land or by lengthening the right-of-way, increased costs to transmission companies would be in the magnitude of $30,000 per year per kilometre of land.
The interests of farmers are often opposite those of transmission companies. Often the most economical route from the transmission company's perspective is over farmland. To the farmer, energy transmission rights-of-way are an asset as long as they are on his neighbour's land, not his. The public stands in the middle of this dispute. The public is the consumer of both energy and food. The public will have to pay for any increased costs of either due to a lack of compatibility between transmission facilities and agriculture. If transmission companies are forced up off of prime agricultural land, their construction and operating costs will rise and these costs will be passed to consumers. If farm yields go down through land loss around towers, yield loss around towers and over pipelines, the public will have to pay more for food.

One thing is clear; it is not in the public's interest to forbid outright energy transmission rights-of-way on agricultural land. Then is any government regulation advisable? The case studies and some of the literature examined showed areas where avoidable mistakes had been made. In case study 1, mitigation measures such as locating towers along field boundaries and not positioning pipelines and transmission lines in such a way as to restrict agricultural development between them were not taken. How much mitigation is justified? Is a more compatible transmission tower justified if it adds $10,000 to the cost of line? What if it costs $50,000? Can industry be left to make these decisions on its own or is the hand of government needed?

It is a generally recognized economic principle that only when all costs are taken into account are optimum economic decisions made. This is the
policy of the Province of British Columbia. In "Environmental and Social Impact Compensation/Mitigation Guidelines" (Environment and Land Use Committee Secretariat, 1980), this principle is applied to publicly owned resources as Guidelines for Benefit Cost Analysis (ELUC, 1979) had applied it to private resources. Alternate routes for energy transmission can present choices between publicly and privately owned resources. All review processes and reports reviewed have attempted to use a common methodology to assess possible damage to public and private resources.

The government is forced to wear many hats. It is charged with protecting the public's best interests. It may also be an owner of affected resources, i.e. Crown Land, and it may even be the owner of the transmission company involved. The government has to assess the effect of a proposed transmission project on all resources then change this cost to production, i.e. energy prices. This process is referred to as "internalizing" external costs. While adopted in principle, this policy is elusive in practice.

In theory, the transmission company would conduct studies to determine the least total cost design for a transmission project. This least cost design would include mitigation measures wherever the cost of mitigation is less than the cost of compensation to offset the impact. For example, a pipeline company would be expected to mitigate a forestry impact by locating a pipeline on agricultural land in areas where the compensation for forestry impacts exceeds the compensation required for crossing agricultural land.
In practice, a transmission company will attempt to lower its cost in order to further its self interest. It is unlikely that a transmission company would admit to an impact and pay compensation unless it was required to do so. In case study 1, compensation was not paid for the cost of transmission line towers interfering with irrigation equipment because this impact was not widely recognized at the time the right-of-way easements were granted. The role of a government agency such as a Utilities Commission, to review transmission company assessments of impacts appears to be necessary. Specifically the author concludes, Government regulation of energy transmission facilities is needed both on and off of agricultural land to insure that all of the costs of resource impacts are charged to the energy transmission project (internalized) and to insure these costs are considered in the design, construction and operation of energy transmission facilities.

Two problems with implementation of a policy of internalizing the costs of agricultural impacts emerge from the case studies. The first is reconciling the difference between the estimate of value of impacts made before a project is constructed and the measured value of these impacts 10 years or 40 years later after a transmission project is completed. The second problem is deciding what form this internalization should take. Owners were compensated to some extent for rights-of-way in both case studies but the tenant farmers who suffered the impacts were not compensated in case study 1. The food buying public was not taken into consideration by compensation policies although it is they who ultimately must bear any increased cost of production.
The first problem is basically one of uncertainty. All estimates of the future value of impacts are subject to large errors. Maybe in 50 years new techniques will reduce the area of land needed to supply food; or maybe new automated farm equipment that will be in common use in 50 years will be completely incompatible with transmission lines. Who can tell for sure? Both of these may be extreme examples but uncertainty is the only certainty. This problem of uncertainty of future value of agricultural or other resource impacts can be solved by government regulation. The direct costs (construction costs) of the transmission project are not paid before a line is constructed. The majority of the costs of transmission projects are paid while the line is in use. Under the present system of regulation, energy transmission companies are charged the estimated cost of future resource impacts before a transmission project is completed. If these impacts were charged to the transmission line as they were being felt and could therefore be measured, the transmission company would bear the uncertainty, not the farmer. There would be an incentive for transmission companies to purchase more expensive mitigation methods as insurance against future claims. Under this "pay as you go" policy, if an electrical transmission line interfered with an irrigation system for only part of the transmission line's life, compensation would be paid for this impact only during this period of time. Such a policy would also address the question of improving old transmission projects. If the periodic charges made against a transmission company ever got greater than the cost of mitigating the damage, the transmission company would, of its own accord, undertake the mitigation measure even of an old project.
This appears to be the direction taken by the recent amendment to section 74 of the National Energy Board Act, (see chapter 4). This section allows for annual or periodic compensation and a review of this compensation every five years. Disputes over compensation are referred to compulsory arbitration.

Based on the previous analysis, the author concludes that the costs to agriculture created by energy transmission facilities should be charged on a regular periodic basis to the transmission company. This compensation should be based on actual measurement of the impact, not on estimates of impact made prior to construction and operation of the transmission facility.

The last question we have to answer is "What form should internalizing resource opportunity costs take?" Two forms are defined by E.L.U.C., 1980; mitigation and compensation, as follows:

"Mitigation refers to measures taken in the planning, construction or operation of a project with the specific objective of avoiding or reducing adverse environmental or social impacts.

Compensation refers to payments (in cash or kind) which are made by the developer (or party responsible for the impacts) with the objective of redressing or offsetting the losses which occur despite or in lieu of mitigation measures."

Mitigation is obviously preferable to compensation, but there are several situations where mitigation will either not be attempted or will not be
effective. In the past the value of agricultural impacts and the level of compensation was estimated at the time a transmission project was constructed. In some cases (as in case study 1), the value of agricultural impacts was underestimated due to the rapid change in agricultural technology and in the intensity of cultivation. If periodic compensation is required, transmission companies will try to anticipate future impacts and plan some mitigation strategy for them. At best these anticipated impacts will prove to be as good as other economic forecasts. The tendency to underestimate future agricultural impacts can be expected to continue even with periodic compensation.

A transmission company may wish to postpone mitigation costs to make a proposed project more acceptable to the public. Another reason why impacts might be underestimated is the difficulty in predicting the demand for agricultural products or the changes in agricultural technology in the future.

Some known agricultural impacts may not be mitigated. If the cost of mitigating an impact is far more than compensating for it, the public will rightly insist in the lower cost alternative of compensation. In many cases, economics may lead to partial mitigation/partial compensation of an impact. Another case where mitigation may not be economically viable is where the mitigation measures available have environmental or resource impacts of their own. For example, if routing an electrical transmission line around a farm removes forest land and increases energy
losses due to increased line length, the annual impacts of the mitigation (avoiding farmland) may increase rather than decrease the total impact of the line. In cases such as the above, compensation will be the only available method of charging the cost of agricultural impacts to the energy user.

Two kinds of compensation can be differentiated; the first is compensation in cash, the second is compensation in kind. Compensation in kind is viewed by the author as "a measure which increases the capacity of the impacted resource enough to offset the loss in capacity caused by the impacting development." There are several problems with cash compensation: how much is enough? and who should receive it? - the resource owner, the resource user (the farmer), or the resource consumer? The federal legislation (section 74 of the National Energy Board Act) includes provision for both the resource owner and resource user (leasee) to claim compensation for the energy transmission company. The provincial legislation (the Utilities Commission Act) does not make a clear statement of this although it could be included in the terms and conditions for a given project. Neither would benefit the agricultural consumers unless compensation is reinvested in agriculture.

Probably the best yardstick to use to value impacts to agriculture is the cost of replacing the lost productive capacity. In theory, compensation-in-kind is always possible. Compensation-in-kind would compensate both the user of the resource and the consumer of the resource. The owner of the resource who is now compensated directly would be compensated indirectly by compensation-in-kind via the rent
charged to tenant farmers. The leasee would rent the farmland with an energy transmission line crossing it at full market value, knowing that the transmission company would make compensation-in-kind for any non-mitigated impacts to farming. This compensation would be reviewed periodically and would therefore cover impacts not recognized at the time the line was built or at the time the lease was signed. Such a system of compensation-in-kind would maintain the productive capacity of B.C.'s agricultural land base while not making unreasonable demands on energy transmission companies or energy users.

This policy of periodic compensation-in-kind could be applied to energy transmission projects already in operation.

The conclusion reached by this author on the question of the need for government regulation of energy transmission projects on agricultural land is, there is a need for government to establish procedures for the periodic compensation-in-kind of negative impacts to agriculture caused by energy transmission projects.

Such a compensation system would reduce the need for detailed reviews by government of predicted agricultural impacts. Careful consideration of mitigation measures would be made by transmission companies pursuing their own best interest. The cost of acceptable mitigation would be based on the cost of compensation-in-kind of existing projects and estimates of future impacts. Periodic compensation-in-kind is seen as the best means of compensating all affected parties while not placing undue costs on energy transmission companies or their consumers. The
following are recommendations for implementing the basic conclusions of this thesis.

5.2 Recommendations

Requiring periodic compensation-in-kind would entail legislative changes at both the Federal and Provincial levels. The concept that some transmission systems, such as gas pipelines of Westcoast Transmission Co. Ltd., are of national importance, while others, such as B.C. Hydro's main grid, is only of Provincial importance, is absurd. All energy transmission projects reviewed as part of this study were part of international grid systems. While B.C.'s electrical grid was not built with the objective of selling electrical power on a continuing basis to the U.S., contracts for "firm" deliveries were made in 1984. Even if firm export contracts were not made, B.C.'s electrical grid is inseparable from the national wellbeing.

A national approach to energy legislation is also needed so that provinces do not compete for development capital by offering the most lax environmental legislation.

The following are recommendations needed to apply the conclusion of this study on a national level.

Recommendation 1. Amend the National Energy Board Act to cover all energy transmission projects over a given threshold level, not just transprovincial and international electrical transmission lines and pipelines.

Recommendation 3. Specify in the N.E.B. Act that compensation paid under the previous recommendation be made "in kind", that is, that the compensation would bring the level of resource capability up to what it would be if the energy transmission project were not present.

Recommendation 4. That existing projects be covered by periodic compensation-in-kind, not just new ones, so that transmission companies would have an incentive to mitigate the impacts of existing facilities.

The role of the Provincial Government would change if legislation such as that in recommendations 1 to 4 were made. The B.C. Utilities Commission would still be needed in its present role of making recommendations to the cabinet based on the public good.

The role of the B.C. Agricultural Land Commission is to preserve British Columbia's agricultural land base. This type of body is well suited to oversee the implementation of a compensation-in-kind policy for B.C. agriculture. This function would fall within its basic objectives and the Agricultural Land Commission has no conflicting objectives. A provincial body would probably be more in touch with local agricultural communities than a federal department.

Recommendation 5. That the B.C. Agricultural Land Commission or a body with similar objectives be appointed to oversee the required compensation-in-kind by energy transmission companies to agriculture.
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