FORTISBC

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December 15, 2006

Mr. R. J. Pellatt
Commission Secretary
BC Utilities Commission
Sixth Floor, 900 Howe Street, Box 250
Vancouver, BC V6Z 2N3

Dear Mr. Pellatt:

Re: FortisBC Inc.'s ("FortisBC") Application for a Certificate of Public Convenience and Necessity for the Ellison Project - Project No. 3698442

Please find 20 copies of FortisBC Inc.'s response to information requests from the BC Utilities Commission, Donald and Bette Mushta, Pier Mac Petroleum Installation Ltd. and the Quail Ridge Residents' Association.

Sincerely,

David Bennett
General Counsel and Corporate Secretary

cc: Registered Intervenors

Q1.0 Reference: FortisBC Inc. Application dated October 27, 2006 for Ellison Substation Project (the "Application"), pp. 6, 24

Q1.1 Further to Figure 1 on page 6 and Figure 4 on page 24, please provide a summary of the lines that supply power to the F.A. Lee Substation, and discuss whether this supply meets N-1 reliability criteria.

A1.1 The FA Lee Terminal station is supplied by two 230 kV lines (72 Line and 74 Line) from BC Hydro's Vernon Terminal with capacities identified in the response to Q1.2 below. In addition, a 230 kV interconnection line between FA Lee Terminal station and RG Anderson Terminal station in Penticton (73 Line) can provide approximately 50 MVA backup to FA Lee Terminal station.

This supply scenario does meet N-1 criteria but does not meet N-1-1 criteria for the Kelowna area load approved by the Commission. A proposed Okanagan Transmission Reinforcement ("OTR") project will satisfy N-1-1 criteria when completed in 2009.

Q1.2 With the higher forecast load growth in the area, when will power supply to F.A. Lee Substation need to be reinforced? If reinforcement will be needed within a 20 year planning horizon, what reinforcement option is likely to be chosen?

A1.2 The supply lines identified in the response to BCUC IR1 Q1.1 above use 795 kcmil ACSR conductor with a normal rating of 407 MVA and an emergency rating of 604 MVA. No reinforcement of power supply is foreseen over the current 20 year planning horizon.

Q1.3 Figure 4 shows 72L and 74L going from F.A. Lee Substation to the Duck Lake Substation, and carrying on north from the Duck Lake Substation. What are these lines and how are they connected?

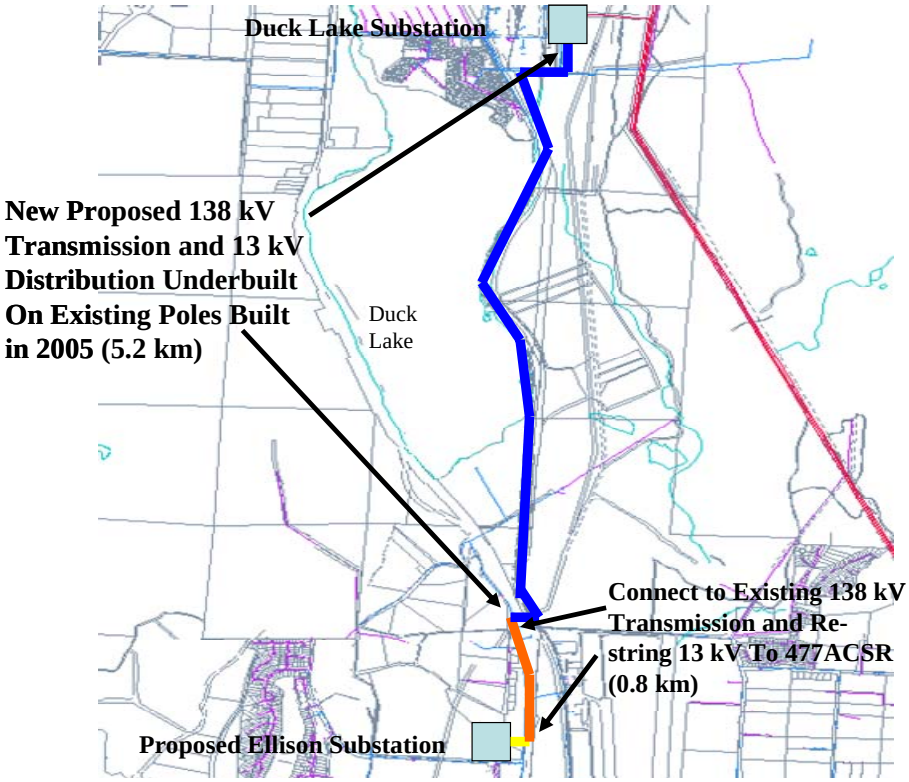
A1.3 Please refer to the response to BCUC IR1 Q1.1 above. Figure 4 merely indicates the transmission corridor which includes 46 Line, 72 Line and 74 Line. Only 46 Line connects to the Duck Lake Substation.

Q2.0 Reference: Application, pp. 9-11, 24, 31, 34, 60

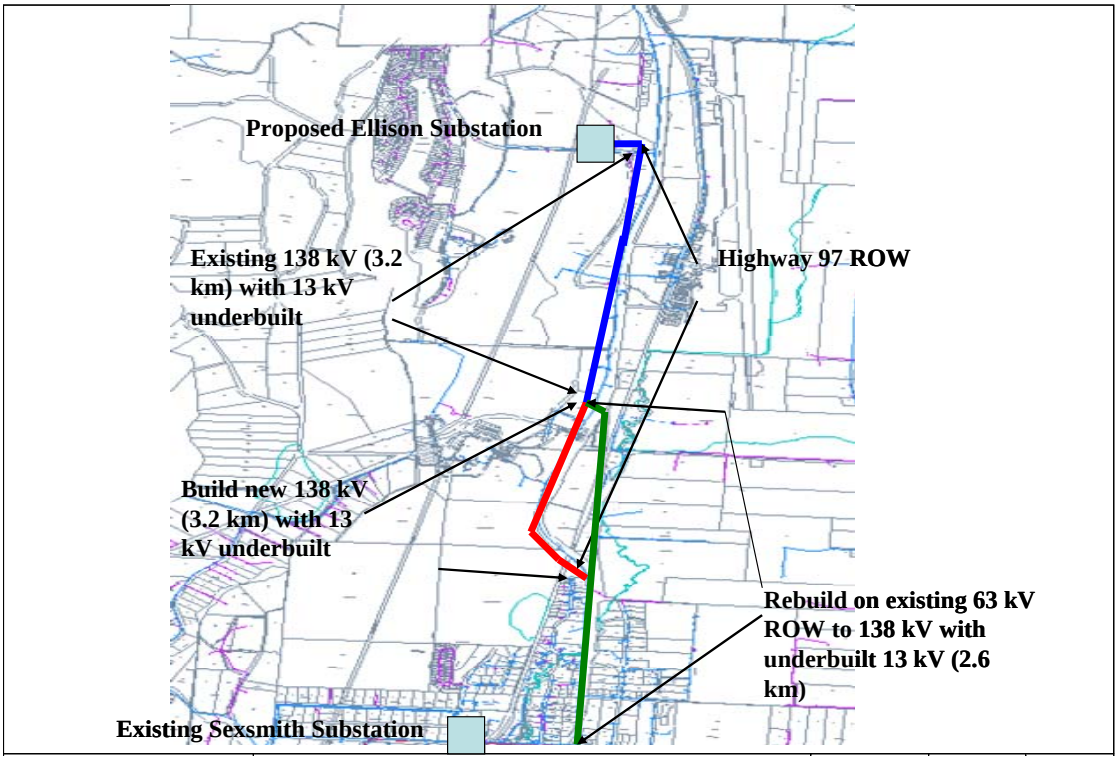
Q2.1 Further to Figure 6 and to the description of the 138 kV connection from Duck Lake to Ellison on page 9 and from Sexsmith to Ellison on page 31, please provide a map or drawing to scale that identifies the portions of the 138 kV lines that will be overbuilt on existing poles, the 0.8 km of existing 138 kV line, the 2.6 km of "existing transmission line" and other.

A2.1 Below is the map from Duck Lake Substation to Ellison Substation. (Map 2.1A) that shows the portion of the 138 kV lines that will be overbuilt on existing poles (5.2 kilometers) and the 0.8 kilometers of existing 138 kV line and the map from Ellison Substation to Sexsmith Substation (Map 2.1B) that shows the 2.6 km of "existing transmission line" (63 kV right of way that supplied Lake Country prior to 138 kV 46 Line installation).

Map 2.1A



Map 2.1B



Q2.2 Please provide a diagram that clarifies the relationship between the conversion section(s), the overbuild section(s), and the section(s) already built to 138 kV standards. Also, please indicate the 5.2 km of 13 kV feeder tie between Duck Lake and Sexsmith that was constructed in 2005.

A2.2 Please refer to the response to BCUC IR1 Q2.1 above.

Q2.3 Please describe each section of the 138 kV connection from Sexsmith to Ellison, explain the current use and status of the right-of-way and outline the line(s) on the right-of-way after this connection is completed.

A2.3 Please refer to the response to BCUC IR1 Q2.1 above.

Q2.4 As Figure 6 shows both a distribution line, and a transmission line built in 2010, between Ellison and Sexsmith, please outline the sequential steps to develop the lines along this right-of-way. Would there be any cost savings if all the construction in this section were done at the same time (for a 2007 in-service date)?

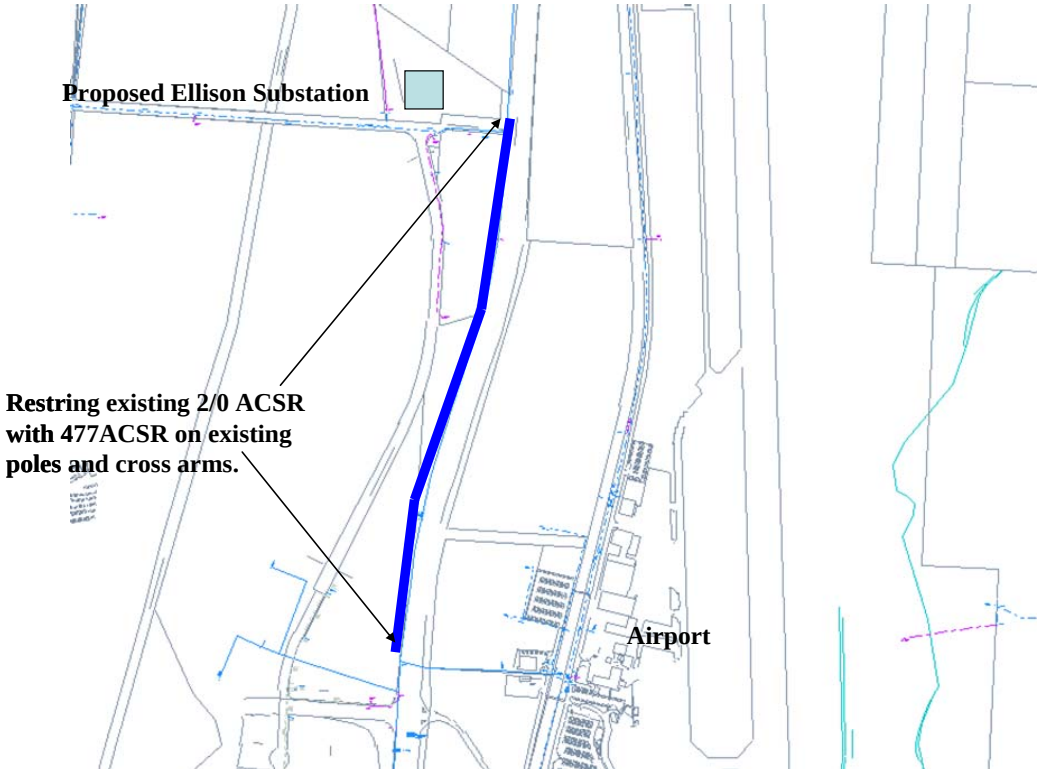
A2.4 The sequential steps to develop the lines along this right of way are:

- re-build a small portion of the 13 kV line (1 kilometer) from Lochrem Road to the tap point to the Airport which is the only area that requires any form of upgrade between 2007 and 2010. The existing distribution infrastructure is sufficient to handle loads beyond 2010 so no other upgrades would be required (please see Map 2.4 below); and

- Construct or rebuild a new transmission line as per Map 2.1B above indicated by the red and/or green lines only.

There would be no cost savings related to construction of the transmission line at the same time because the existing power pole infrastructure is sufficient to carry the short portion of the 13 kV upgrade.

Map 2.4



Q2.5 Please confirm that the 5.2 km section between Duck Lake and Ellison will be built on existing poles.

A2.5 This is confirmed.

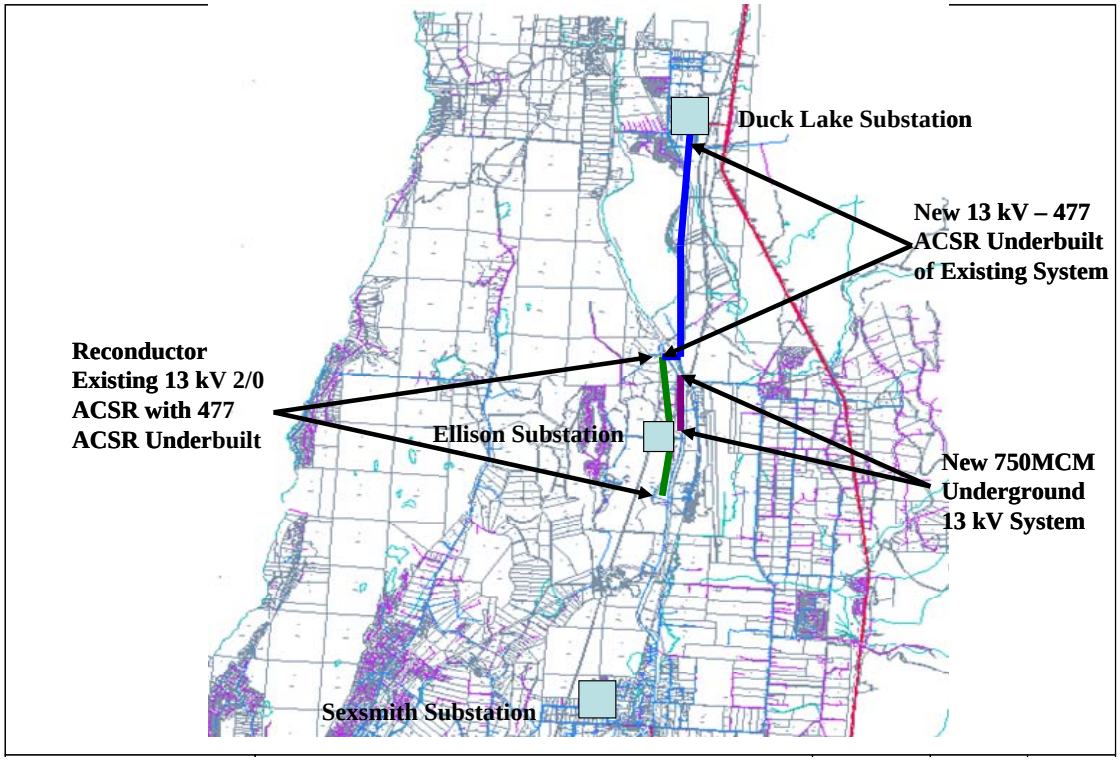
Q2.6 Further to Figure B3 on page 60, please provide a side-by-side to scale schematic that shows a typical pole for the existing distribution line, and the pole with the distribution line and the 138 kV overbuild.

A2.6 Please refer to Appendix A2.6 attached.

Q2.7 Further to Figure 6 on page 34, please provide a to-scale map or diagram that identifies each section of new, rebuilt or double circuit distribution line that is part of this project.

A2.7 The diagram below identifies all of the 13 kV upgrades for this project including the underground system.

Map 2.7



Q2.8 Further to page 31, on the map provided in response to the previous question, please identify all sections of new underground distribution cable.

A2.8 The only other underground cables are standard station egress cables. This is to maintain clearances and safety near the substation. Please also see the response to BCUC IR1 Q2.7 above.

Q2.9 If any underground cable is not being paid for by a customer who has requested undergrounding, please identify the additional cost involved and explain why underground construction is appropriate.

A2.9 Underground cable is proposed for the short section that runs north from the Ellison Substation to Old Vernon Road to avoid a triple overhead circuit between these two points with the existing 138 kV and 13 kV lines. FortisBC would have had to replace all of the structures between these points to maintain an overhead system. Running an underground line is the least cost solution. The underground section would cost in the order of $0.5 million versus the replacement of the overhead system at approximately $1.0 million for a triple overhead circuit.

Q3.0 Reference: Application, pp. 12, 13

The application provides a brief description of each Ellison feeder and the area it will serve.

Q3.1 Please provide a table that shows, for each Ellison, Sexsmith, and Duck Lake feeder, the feeder loading in MVA by year through the planning horizon.

A3.1 Sexsmith load is shared with Glenmore and is therefore included Table 3.1 below.

Table 3.1

Distribution Feeder Loading (KVA)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SEX1	14,200	6,250	7,322	8,394	9,466	10,038	10,610	11,182	11,754	12,326
SEX2	9,000	5,700	5,780	5,860	5,940	6,020	6,100	6,180	6,260	6,340
SEX3	7,100	7,600	7,938	8,276	8,516	8,756	8,996	9,236	9,476	9,716
ELL1	-	6,250	6,450	6,650	6,850	7,050	7,250	7,450	7,650	7,850
ELL2	-	4,000	4,100	4,200	4,300	4,400	4,500	4,600	4,700	4,800
ELL3	-	1,000	1,100	1,200	1,300	1,400	5,500	5,600	5,700	5,800
ELL4	-	3,500	4,700	5,900	7,890	12,700	9,490	10,280	11,070	11,860
DUC1	8,736	5,500	6,667	8,667	10,667	9,667	11,667	13,667	15,667	17,667
DUC2	6,078	7,500	8,493	9,486	10,479	10,922	11,365	11,808	12,251	12,694
GLE5	4,400	4,700	4,780	4,860	4,940	5,020	5,100	5,180	5,260	5,340
GLE6	-	4,900	5,600	6,300	7,000	7,700	8,400	8,500	8,600	8,700

Q3.2 Ellison Feeder 1 will serve the airport, the university, and other developments. Are the airport and university also served by other feeders and, if so, will automatic load transfer schemes be used? Please explain.

A3.2 Ellison Feeder 1 will serve the airport and the university. Sexsmith Feeder 1 would be the backup feeder and load would be transferred manually. Automatic load transfer schemes would be paid for entirely by the customer. Both the airport and the university have installed automatic back up supplies to their facilities for emergency purposes. The Ellison station project would ensure timely responses to outages should they occur. The timelines for outages in this area would be such that the existing customer back up systems would be sufficient to maintain service until the alternate feeder was put into service.

Q3.3 FortisBC proposes to reconductor 3 km of 2/0 underbuild to 477 MCM ACSR and to use the same conductor on Ellison Feeder 4. Please provide the analysis used by FortisBC to conclude that 477 MCM ACSR is the appropriate conductor.

A3.3 The 477MCM ACSR is the standard conductor that is used by FortisBC for 600 amp systems. The reconductoring of the two sections of line is to provide both voltage support and current carrying capacity for both normal and emergency power flow. For the reconductoring of the underbuilt circuit, the load carrying capability of 2/0 ACSR is 318 amps which is insufficient to carry the forecast load of 363 amps for Feeder 1 or to provide back up capacity for the potential loss of Sexsmith Feeder 1 or Duck Lake Feeder

1. Based on this review the next higher capacity conductor used by FortisBC is 477 ACSR which is rated at 600 amps.

Q4.0 Reference: Application, p. 14

The schematic showing the proposed 13 kV feeders shows a number of points at which feeders come together, presumably at normally open points.

Q4.1 Please confirm that there are feeder tie switches at these points.

A4.1 There will be 900 amp gang switches at each of these locations.

Q4.2 Assuming tie switches are present, please state whether (and why) manual or remotely operated switches are proposed.

A4.2 All switches will be manual gang operated 900 amp switches. FortisBC current practice is to use manual switching for distribution loads. Only transmission loads are switched remotely.

Q5.0 Reference: Application, pp. 16, 65-68

Q5.1 Table 1 on page 16 identifies $0.29 million right-of-way cost. Please identify where this right-of-way is located and clarify if this is new right-of-way, or additional rights on an existing right-of-way.

A5.1 This is a new right of way cost for the portion of the future Ellison to Sexsmith transmission line as stated on page 18, section 3.2 of the CPCN Application. The right of way is indicated in green on Map 2.1B.

Q5.2 Further to Tables D1, D2, D3 and D4, please identify the components for which FortisBC has obtained updated cost estimates from a supplier. If the estimate for the Ellison station equipment is not an updated figure, please explain.

A5.2 FortisBC has obtained cost estimates during the course of 2006 for all major equipment, including transformer, breakers, switches, voltage transformers, current transformers, relays, and communication equipment and as noted, current market conditions are creating volatility in both final pricing and equipment deliveries.

Q5.3 Please explain how FortisBC estimated its Engineering and Project Management costs.

A5.3 The engineering and project management costs in the estimate are based on a percentage of the total project cost. This depends on the type of project. For example, on a Greenfield site, the engineering costs are typically 10% of the total project and project management costs are 2%. A project specifically dealing with protection and control would involve more of an engineering effort. However, the total project cost is lower; therefore the percentage of engineering costs would be increased. The estimate percentage would increase as the complexity of the project increases.

Q5.4 What components of the project does FortisBC expect to bid on a fixed price basis? When does FortisBC expect to obtain and finalize the tenders for these components?

A5.4 Material and equipment are expected to be purchased on a fixed price basis and be obtained upon disposition of this CPCN.

Q5.5 Similar to the tables in Appendix D, please provide a breakout of the $3.86 million cost estimate for the transmission line between Ellison and Sexsmith. What is the level of accuracy for this estimate?

A5.5 Please see Table 5.5 shown below. The estimate is presumed to have an accuracy level of ± 10%.

Table 5.5

	Category Description	Estimated Cost ($million)
A	**Station Related**	
A.1	Line Works	0.05
A.2	Civil and Site	0.06
A.3	Structures and Bus Work	0.14
A.4	Station Equipment and Apparatus	0.33
A.5	Protection, Control and Metering	0.13
A.6	Engineering	0.13
A.7	Commissioning	0.05
A.8	Owner's Cost	0.11
A.9	Station Equipment Removal	0.01
A.10	Provincial Tax On Material	0.04
A.11	Project Management	0.04
B	**Transmission Related**	
B.1	Material	0.45
B.2	Labour	0.96
B.3	Contingency	0.14
B.4	Tax On Material	0.03
B.5	Project Management	0.06
B.6	Engineering	0.11
B.7	SCADA Controlled Mod-S	0.37
C	**Distribution Upgrades**	
C.1	Material	0.17
C.2	Labour	0.26
C.3	Contingency	0.03
C.4	Tax On Material	0.01
C.5	Project Management	0.03
C.6	Engineering	0.02
D	**Estimated AFUDC**	0.12
Total Project Cost		**3.86**

Q5.6 Please confirm that the cost estimate in the Application reflects current labour market conditions as discussed in FortisBC's letter dated November 16, 2006 regarding the NK'Mip Project, or provide a cost estimate that does.

A5.6 Yes, the cost estimate in the Application reflects current labour market conditions as discussed in FortisBC's letter dated November 16, 2006 regarding the Nk'Mip Project.

Q6.0 Reference: Application, pp. 10, 16, 46

Q6.1 On page 10, FortisBC states that after the Ellison project is completed, no additional substations are foreseen to the end of the planning horizon to 2015/16, and that it is difficult to predict where the growth will occur. Nevertheless, with currently projected growth rates, would a substation expansion be needed within a 20 year planning horizon? If so, when?

A6.1 Yes, with the currently projected load growth rates a substation expansion is expected within a 20 year planning horizon of 2006-2026.

Assuming reasonable load transfer capability between the regional substations (Duck Lake, Ellison and Sexsmith) it is expected that the nameplate capacity of the Ellison and Sexsmith substation transformers is likely to be exceeded by 2018-2019 while, the 80% load backup criterion of the Ellison Substation will also be violated as early as 2016. Considering the above parameters, it is probable that a substation expansion might be necessary by 2017.

Q6.2 With completion of the Ellison project, FortisBC will have three substations each with a single transformer in the area, rather than two substations with one or two transformers. Please discuss the pros and cons of having three rather than two substations, from the point of view of reliability, efficient expansion of the substations and efficient extension of the distribution system to serve the increased load.

A6.2 The three regional station option is preferable because it reduces the risk associated with the location of future load growth and it has a lower cost than the two regional station option over the next 20 years. More detail on the pros and cons of having three rather than two substations, from the point of view of reliability, efficient expansion of the substations, efficient extension of the distribution system to serve the increased load and also financial impact on rate payers is analyzed in the Table 6.2 below.

Table 6.2

	Parameters Considered	3 Regional Single Transformer Substations (Option 1)	2 Regional Single / Multi Transformer Substations (Options 2 & 3)
	Reliability Perspective		
1	Satisfaction of back up power criterion during the Planning Horizon	Yes-Preferable	No-Not Preferable
2	Large Radial Load (Transmission Perspective)	No-Preferable	Yes-Not Preferable
3	Transmission Tie/Transmission Level Reliability	Yes-Preferable	No-Not Preferable
	Efficient Expansion Of Substation		
4	Substations in emerging load centre	Yes-Preferable	No-Not Preferable
5	Required to build new substation in future in built up area	No-Preferable	Yes-Not Preferable
6	Future stakeholder acceptability for building new substation in built-up areas	Not Applicable-Preferable	Difficult-Not Preferable
	Efficient Expansion Of Distribution		
7	Distance from emerging load centers	Low-Preferable	High-Not Preferable
8	Requirement of Single & Double Circuit Distribution Lines	Low-Preferable	High-Not Preferable
9	Requirement of new Rights of Way (“RoW”) to accommodate growth	Low-Preferable	High-Not Preferable
10	Distribution feeder length / Exposure to elements (natural / accidental)	Low-Preferable	High-Not Preferable
11	Distribution feeder length / Line Loss (function of line length)	Low-Preferable	High-Not Preferable
12	Requirement of Voltage Regulators	Low-Preferable	High-Not Preferable
	Project Capital Cost/Financial Impact On Rate Payers		
13	Project Capital Cost/Customer Rate Impact	Low-Preferable	High-Not Preferable

Q6.3 Please provide an estimate of the cost of adding a second transformer at the Ellison substation at a future date.

A6.3

	($million)
Additional transformer only	2.00
Four distribution breaker bays	1.00
High side buswork	1.25
Project cost loadings	0.97
Total cost	**5.22**

Estimate in 2006 dollars

Q7.0 Reference: Application, p. 16, Appendix D (Cost Tables)

Q7.1 Please provide a single table comparing the cost of the major project components (such as new transformers, new breakers, and feeder egress) across Options 1, 2, and 3. Please explain any material differences between the costs for similar items across projects.

A7.1 The three Options (Option 1, 2 and 3) are schematically different. A common Table of Financial Summary (combination of Tables 5, 6 and 7) incorporating all the three options grouped by similar type of expenditure has been prepared for comparative cost analysis and is provided in the Table 7.1 below.

Table 7.1

	Component Of Project	Option 1 Cost	Option 2 Cost	Option 3 Cost
1.0	**Substation & Station Egress Related**			
1.1	Modifications at Duck Lake Substation to allow proposed 61 Line	**1.85**		
1.2	Ellison Substation	**6.19**		
1.3	Upgrade of the Sexsmith Substation with one 32 MVA 138 kV/13 kV transformer and associated 13 kV station equipment		**8.33**	
1.4	Upgrade of the Sexsmith Substation with one 32 MVA 138 kV/13 kV transformer and associated 13 kV station equipment			**7.92**
1.5	Upgrade of Duck Lake Substation with one 32 MVA 138 kV/13 kV transformer and associated 13 kV station equipment			**9.16**

	Component Of Project	Option 1 Cost	Option 2 Cost	Option 3 Cost
1.6	Duck Lake Substation: Upgrade cost for two additional distribution feeders		**3.98**	
1.7	Feeder reactors at the Sexsmith Substation to reduce fault level at the Sexsmith Substation		**1.27**	
1.8	Feeder reactors at the Sexsmith to reduce fault level at the Sexsmith Substation			**1.19**
1.9	Feeder reactors at the Duck Lake Substation to reduce fault level at the Duck Lake Substation			**0.95**
2.0	**Line Related**			
2.1	61 Line - Construction at 138 kV as double circuit overbuild	**1.36**		
2.2	Building of Greenfield Distribution Lines / Re-conductor of existing distribution lines / Construction of double circuit distribution lines and substation egress	**4.33**		
2.3	Sexsmith Substation: Cost for building new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation.		**8.24**	
2.4	Duck Lake: Cost for building two new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation.		**3.22**	
2.5	Duck Lake Substation: Cost for building new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation.			**9.95**
2.6	Sexsmith Substation: Cost for building new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation.			**7.82**
3.0	**Land / Row / Environmental Related**			
3.1	Land and Environmental Cost for Ellison Substation	**1.17**		
3.2	Transmission ROW Cost	**0.29**		
3.3	ROW / Environment cost for additional distribution feeders		**0.17**	
3.4	ROW / Environment cost for additional distribution feeders			**0.17**
3.5	Additional land and development cost for the Sexsmith Substation			**0.59**
3.6	Additional land and development cost for the Sexsmith Substation (based on estimated value)		**0.62**	
4.0	**Loading**			
4.1	AFUDC	**0.58**	**1.61**	**2.01**
5.0	**Grand Total**	**15.77**	**27.44**	**39.76**
6.0	**NPV Of Revenue Requirements**	**17.72**	**18.84**	**29.94**
7.0	**One Time Equivalent Rate Impact**	**0.61%**	**0.65%**	**1.04%**

Q8.0 Reference: 3.7 Project Schedule; p. 20 and 4.8 Contingency Plan for Project Delays

Q8.1 Please provide a more specific project construction schedule by month, also reflecting the expected dates for other agency permits and approvals. This schedule should also allow for the normal regulatory process required from the January 9, 2007 public hearing leading to the BCUC decision.

A8.1 The original schedule, as submitted in the CPCN Application (page 20) contemplated a completion date of December 1, 2007. However, in an effort to create a schedule that is realistic relative to present day knowledge, several risk factors have been assessed and the schedule extended accordingly. The risk assessment assumes that delay could occur on a number of fronts, all of which are outside of the control of FortisBC. Delays may arise as a result of:

- Transformer delivery. As late as the week of December 4, 2006, FortisBC received vendor information that indicated the delivery will take up to 65 weeks after the receipt of order by the manufacturer;
- Regulatory approvals. This is primarily associated with the anticipated City of Kelowna zoning application for the substation property, in the event that Option 1 is approved; and
- A lack of contract labour. In the past two years, the construction labour market has become increasingly competitive, which in turn causes a delay in the supply of skilled trades people.

The revised schedule has been developed with these risks in mind. Please refer to Appendix A8.1.

Q8.2 What are the riskiest elements in the schedule provided with regard to potential delays?

A8.2 The proposed schedule, as stated in the CPCN Application, assumed that the regulatory approval process and specifically the Commission approval would be complete by January 2007. Given that the oral hearing is occurring in that month, the actual approval

date is uncertain. The zoning application to the City of Kelowna will not occur until the Commission approval is received, since the use of the proposed substation site is contingent on whether Option 1, 2 or 3 is approved.

The schedule also includes a realistic time frame for the delivery of the power transformer and other large equipment such as circuit breakers. However, recent experience indicates that the delivery times can vary, so there is some associated timing risk with material ordering and receipt thereof. Finally, competing market demand has an influence on the availability of contract construction labour, so there is a chance that securing the required labour force is at risk of delay.

The schedule submitted in the Application is tight but achievable. If any of the identified risk categories result in a delay, the project may not be complete until 2008.

Q8.3 What would be the consequences and risks of a six month or one year delay?

A8.3 If the project is delayed beyond the summer of 2008, back-up capabilities will be reduced. If the project is delayed beyond the spring of 2009, there will be voltage instability requiring voltage regulation from Duck Lake Feeder 1 to support load growth in the Highway 97 corridor and there would be rotating outages in the event that the Sexsmith transformer failed during a peak period.

Q9.0 Reference: 4.7 Risks to project Completion

Q9.1 Please describe the nature and degree of the four risk factors identified on page 47 in more detail.

A9.1 (1) "Change to the preferred transmission and/or distribution routes due to permitting / legal issues"

As shown on the included aerial photo and with respect to Option 1, the transmission route from the Duck Lake Substation to the proposed substation location near Lochrem Road passes through land parcels of multiple statuses. In the northerly most section, the corridor is parallel to the Canadian National Railway right of way, which bisects Indian Reserve #7 of the Okanagan Indian Band. Upon leaving the Reserve land it continues along the railway right of way until it connects with the road system controlled by the

Ministry of Transportation ("MoT"). The MoT has jurisdiction over the balance of the route to the Lochrem Road site.

The proposed transmission corridor between Sexsmith Substation and the Lochrem Road site passes along gazetted roadways then onto private land for a short distance. It then emerges onto MoT controlled roadway and continues to the substation location.

On the southerly portion, rights of way have not yet been negotiated pending Project approval. There are also some known changes to the Highway 97 access that are planned which may force a slight relocation of the transmission corridor. While the "unknowns" are not significant in number, they do add a degree of uncertainty and therefore a similar degree of risk.

> (2) "Unforeseen environmental or archaeological discoveries during the construction phase. The risk of such an occurrence is considered to be low, based on the results of environmental and archaeological assessments"

This risk always exists where land excavation is required. As the land on the substation site has been previously disturbed and the Okanagan Indian Band has not expressed concern, the risk remains, albeit very low, until the construction is complete.

> (3) "An unexpected increase in the delivery times of transformers, poles or conductor"

This is an effect of market forces. No specific concerns have been identified to date, but the construction industry in general is very competitive and it is possible that the delivery times could be extended based on low equipment inventory levels or manufacturing capacity.

> (4) "Increases in the cost of labour and/or materials beyond typical inflationary levels"

As described in item 3 above, labour supply is exposed to competitive market forces.

Q9.2 What risk management strategies will FortisBC apply in order to minimize the risks identified?

A9.2 Early and ongoing discussions with equipment and labour suppliers as well as permitting agencies is the preferred way to identify and qualify risks. The mitigation strategies can only be determined once the risks and their impacts are known. Examples of pre-emptive methods are entering into sole source labour contracts to secure resources and ordering larger quantities of material (i.e. poles and conductor) into inventory such that it can be used on a variety of projects.

Q10.0 Reference: Application, pp. 16, 17

The Application sets out the major project components for Option 1.

Q10.1 What are the expected fault current levels at each substation?

A10.1 Following are the expected fault levels at each of the substations for Option 1:

Ellison Substation 13 kV bus :	~ 195 MVA (8800 amps)
Duck Lake Substation 13 kV bus:	~ 130 MVA (5800 amps)
Sexsmith Substation 13 kV bus:	~ 200 MVA (9050 amps)

Q10.2 Please explain what is meant by "voltage regulation" under the heading "Distribution Upgrade" on page 17, given that the transformer proposed for Ellison will have an OLTC providing ±10 percent regulation.

A10.2 Voltage regulation in this context means distribution line regulators and is not required for the Option 1 project. This was included in the scope to check for voltage deficiencies and studies identified that no additional regulators are required.

Q11.0 Reference: Application, pp. 32, 33, 39, 40, 43, 48

Q11.1 On page 33, FortisBC states that the 138 kV connection between Ellison and Sexsmith "must be constructed to provide backup to the area," but proposes to defer the construction until 2010. FortisBC has not included this connection in the Ellison Project, and intends to seek Commission approval for the expenditure at a future date. Please discuss whether it would be efficient and appropriate to consider the need for this line and the proposed routing in the current proceeding, potentially leading to a form of approval or acceptance for certain aspects of the future connection.

A11.1 The Company believes it would not be preferable or appropriate from the rate payer's perspective to construct the transmission line between the proposed Ellison Substation and Sexsmith Substation prior to 2010 and as such is not within scope of the present CPCN Application.

However, since the need of this transmission loop is being supported by this CPCN Application, a formal approval/acceptance by the Commission for its future implementation in 2010 timeframe will be preferable.

Q11.2 Please compare the likely post-2015 distribution system requirements for each of the three proposed options based on ForitsBC's current long-term forecast.

A11.2 The comparative likely post-2015 distribution system limits/shortfalls that will initiate or trigger actions to ensure adequate system configuration/requirements during 2015-2025 timeframe for each of the three proposed options based on FortisBC's current long-term forecast are indicated in Tables 11.2.1, 11.2.2 and 11.2.3 below.

However, as has already been indicated in page 10 of the CPCN Application, the scenario is hypothetical, since with the aggressive growth rate experienced in this area, it is difficult to know exactly where the loads will actually materialize. This was the primary reason that the project strategy is to employ the principles of flexibility, minimum cost and planning for a shorter period of time.

Table 11.2.1: Option 1 2015-2025 Scenario

Year	Sexsmith Transformer 1		Duck Lake Transformer 1		Ellison Transformer 1		Capacity Available For Backup Of Sexsmith T1 (MVA / %)		Capacity Available For Backup Of Duck Lake T1 (MVA / %)		Capacity Available For Backup Of Proposed Ellison T1 (MVA / %)	
	Transformer Capacity (MVA)	Station Load Actual & Forecast (MVA)	Transformer Capacity (MVA)	Station Load Actual & Forecast (MVA)	Transformer Capacity (MVA)	Station Load Forecast (MVA)						
2015/16	32	31.0	28	17.9	32	31.6	35.5	115 %	27.4	153%	26.2	83%
2016/17	32	31.6	28	18.2	32	32.3	34.5	109 %	26.1	143%	25.2	78%
2017/18	32	32.2	28	18.6	32	32.9	33.5	104 %	24.9	134%	24.2	73%
2018/19	32	32.9	28	19.0	32	33.6	32.5	99%	23.6	124%	23.2	69%
2019/20	32	33.5	28	19.3	32	34.2	31.4	94%	22.2	115%	22.1	65%
2020/21	32	34.2	28	19.7	32	34.9	30.3	89%	20.9	106%	21.1	60%
2021/22	32	34.9	28	20.1	32	35.6	29.3	84%	19.5	97%	20.0	56%
2022/23	32	35.6	28	20.5	32	36.3	28.1	79%	18.1	88%	18.9	52%
2023/24	32	36.3	28	20.9	32	37.1	27.0	74%	16.6	79%	17.8	48%
2024/25	32	37.0	28	21.4	32	37.8	25.8	70%	15.2	71%	16.6	44%
2025/26	32	37.8	28	21.8	32	38.6	24.7	65%	13.7	63%	15.5	40%

Note:
2016 / 2017: 1) Ellison Transformer Capacity will be exceeded 2) Backup Capacity availability for Ellison Transformer will fall below 80%
2017 / 2018: 1) Sexsmith Transformer Capacity will be exceeded 2) Duck Lake Substation Regulator Capacity will be exceeded
2022 / 2023: 1) Backup Capacity availability for Sexsmith Transformer will fall below 80%
2023/ 2024: 1) Backup Capacity availability for Duck Lake will fall below 80%

Table 11.2.2: Option 2 2015-2025 Scenario

Year	Sexsmith Substation		Duck Lake Transformer 1		Capacity Available For Backup Of Sexsmith Substation (MVA / %)		Capacity Available For Backup Of Duck Lake Substation (MVA / %)	
	Substation Capacity (MVA)	Station Load Actual & Forecast (MVA)	Transformer Capacity (MVA)	Station Load Actual & Forecast (MVA)				
2015/16	64	56.0	28	26.3	48.7	87%	34.0	129%
2016/17	64	57.1	28	26.8	48.2	84%	32.9	123%
2017/18	64	58.2	28	27.4	47.6	82%	31.8	116%
2018/19	64	59.4	28	27.9	47.1	79%	30.6	110%
2019/20	64	60.6	28	28.5	46.5	77%	29.4	103%
2020/21	64	61.8	28	29.0	46.0	74%	28.2	97%
2021/22	64	63.0	28	29.6	45.4	72%	27.0	91%
2022/23	64	64.3	28	30.2	44.8	70%	25.7	85%
2023/24	64	65.6	28	30.8	44.2	67%	24.4	79%
2024/25	64	66.9	28	31.4	43.6	65%	23.1	74%
2025/26	64	68.2	28	32.0	43.0	63%	21.8	68%

Note:
2018 / 2019: 1) Backup Capacity availability for Sexsmith Transformer will fall below 80%
2019 / 2020: 1) Duck Lake Transformer Capacity will be exceeded
2022 / 2023: 1) Sexsmith Substation Capacity will be exceeded
2023/ 2024: 1) Backup Capacity availability for Duck Lake will fall below 80%

Table 11.2.2: Option 3 2015-2025 Scenario

Year	Sexsmith Substation		Duck Lake Substation		Capacity Available For Backup Of Sexsmith Substation (MVA / %)		Capacity Available For Backup Of Duck Lake Substation (MVA / %)	
	Substation Capacity (MVA)	Station Load Actual & Forecast (MVA)	Substation Capacity (MVA)	Station Load Actual & Forecast (MVA)				
2015/16	64	45.9	60	36.3	88.7	193%	44.1	121%
2016/17	64	46.9	60	37.0	88.0	188%	43.1	116%
2017/18	64	47.8	60	37.8	87.2	182%	42.2	112%
2018/19	64	48.8	60	38.5	86.5	177%	41.2	107%
2019/20	64	49.7	60	39.3	85.7	172%	40.3	102%
2020/21	64	50.7	60	40.1	84.9	167%	39.3	98%
2021/22	64	51.7	60	40.9	84.1	163%	38.3	94%
2022/23	64	52.8	60	41.7	83.3	158%	37.2	89%
2023/24	64	53.8	60	42.6	82.4	153%	36.2	85%
2024/25	64	54.9	60	43.4	81.6	149%	35.1	81%
2025/26	64	56.0	60	44.3	80.7	144%	34.0	77%

Note: 2025/ 2026: 1) Backup Capacity availability for Duck Lake Substation will fall below 80%

Q11.3 Items 5 and 6 in Table 6 Option 2, both refer to two (additional and new, respectively) distribution feeders at Duck Lake. Please clarify whether a total of four new feeders are included in the cost estimate, and whether that is the correct number.

A11.3 Items 5 and 6 in Table 6 Option 2, both refer to the same two additional distribution feeders at Duck Lake and not a total of four new feeders.

Q11.4 Please provide additional cost detail on the items in this table whose total cost is expected to be $3 million or more.

A11.4 There are four items in Table 6 (Option 2), whose total costs are expected to be more than $3.0 million as indicated below. The cost breakdowns of the individual items are presented below in tabular format:

1. **Table 11.4.1: $8.33 million:** Upgrade of the Sexsmith Substation with one 32 MVA 138 kV/13 kV transformer and associated 13 kV station equipment
2. **Table 11.4.2: $8.24 million:** Sexsmith Substation: Cost for building new 13 kV station equipment, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation
3. **Table 11.4.3: $3.98 million:** Duck Lake Substation: Upgrade cost for two additional distribution feeder bays in the substation
4. **Table 11.4.4: $3.22 million:** Duck Lake: Cost for building two new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation

Table 11.4.1

	Category Description	Estimated Cost ($million)
1	Line Work	0.25
2	Civil and Site	0.55
3	Buildings	0.23
4	Structures and Bus Work	0.03
5	Station Equipment and Bus Work	4.59
6	Communication and SCADA	0.16
7	Protection and Control and Metering	0.25
8	Engineering	0.89
9	Commissioning	0.31
10	Owner's Cost	0.43
11	Station Equipment Removal	0.02
12	Provincial Tax On Material	0.31
13	Project Management	0.31
TOTAL		**8.33**

Table 11.4.2

	Category Description	Estimated Cost ($million)
1	Material	2.50
2	Labour	3.75
3	Salvage Labour	0.37
4	Provincial Tax On Material	0.17
5	Project Management	0.26
6	Engineering	0.53
7	Contingency	0.66
TOTAL		**8.24**

Table 11.4.3

	Category Description	Estimated Cost ($million)
1	New Switchgear Cost	0.91
2	Replacement Of Existing Switchgear For Higher Rating	0.30
3	Upgrading Of Existing Switchgear	0.91
4	Outdoor Regulators	0.24
5	Provincial Tax On Material	0.17
6	Labour	0.50
7	Station Equipment Removal	0.02
8	Engineering	0.38
9	Commissioning	0.13
10	Project Management	0.12
11	Contingency	0.30
TOTAL		**3.98**

Table 11.4.4

	Category Description	Estimated Cost ($million)
1	Material	0.98
2	Labour	1.46
3	Salvage Labour	0.15
4	Provincial Tax On Material	0.07
5	Project Management	0.10
6	Engineering	0.21
7	Contingency	0.26
TOTAL		**3.22**

Q11.5 Please explain why feeder reactors are required at Sexsmith and Duck Lake under Option 3 but not under Option 1.

A11.5 Feeder reactors are not required in Option 1 because the fault level at the Ellison Substation meets the criteria set out in the document "FortisBC Distribution Substation Fault Level Control Guidelines" as filed in Appendix 8 of the FortisBC 2007/08 Capital Expenditure Plan.

Feeder reactors are required in the other options as parallel operation of the transformers is contemplated (please also refer to the response to BCUC IR1 Q11.6).

Q11.6 If the feeder reactors are required because of parallel operation of substation transformers, please indicate whether the low-voltage buses could be split such that fault current is available from one transformer only.

A11.6 It is possible to operate with the substation transformers separated, but this severely limits the operating flexibility of the station as it is difficult to allocate the load between feeders to ensure that each transformer has roughly equal loading. Instead, one transformer will encounter loading constraints before the other transformer will. Operating the transformers in parallel ensures that the load is always evenly split between the two transformers. This usually helps reduce losses as well.

Parallel operation also improves reliability since, following a transformer fault, the remaining transformer can immediately pickup the station load without requiring complicated automatic load-transfer switching.

Q11.7 Please provide additional cost detail on the items in this table 7 Option 3 whose total cost is expected to be $3 million or more.

A11.7 There are four items in Table 7 (Option 3), whose total costs are expected to be more than $3.0 million as indicated below. The cost breakdowns of the individual items are presented below in tabular format:

1. **Table 11.7.1: $7.92 million:** Upgrade of the Sexsmith Substation with one 32 MVA 138 kV/13 kV transformer and associated 13 kV station equipment
2. **Table 11.7.2: $9.16 million:** Upgrade of Duck Lake Substation with one 32 MVA 138 kV/13 kV transformer and associated 13 kV station equipment
3. **Table 11.7.3: $9.95 million:** Duck Lake Substation: Cost for building new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation.
4. **Table 11.7.4: $7.82 million:** Sexsmith Substation: Cost for building new distribution feeders, integration of the new and existing feeders to the distribution network, feeder egress from the substations and voltage regulation.

Table 11.7.1

	Category Description	Estimated Cost ($million)
1	Line Work	0.24
2	Civil and Site	0.52
3	Buildings	0.22
4	Structures and Bus Work	0.03
5	Station Equipment and Bus Work	4.36
6	Communication and SCADA	0.15
7	Protection and Control and Metering	0.24
8	Engineering	0.84
9	Commissioning	0.30
10	Owner's Cost	0.41
11	Station Equipment Removal	0.01
12	Provincial Tax On Material	0.30
13	Project Management	0.29
TOTAL		**7.92**

Table 11.7.2

	Category Description	Estimated Cost ($million)
1	Line Work	0.32
2	Civil and Site	0.60
3	Buildings	0.12
4	Structures and Bus Work	0.31
5	Station Equipment and Bus Work	4.84
6	Communication and SCADA	0.21
7	Protection and Control and Metering	0.34
8	Engineering	0.93
9	Commissioning	0.32
10	Owner's Cost	0.46
11	Station Equipment Removal	0.02
12	Provincial Tax On Material	0.35
13	Project Management	0.34
TOTAL		**9.16**

Table 11.7.3

	Category Description	Estimated Cost ($million)
1	Material	3.01
2	Labour	4.52
3	Salvage Labour	0.45
4	Provincial Tax On Material	0.21
5	Project Management	0.32
6	Engineering	0.64
7	Contingency	0.80
TOTAL		**9.95**

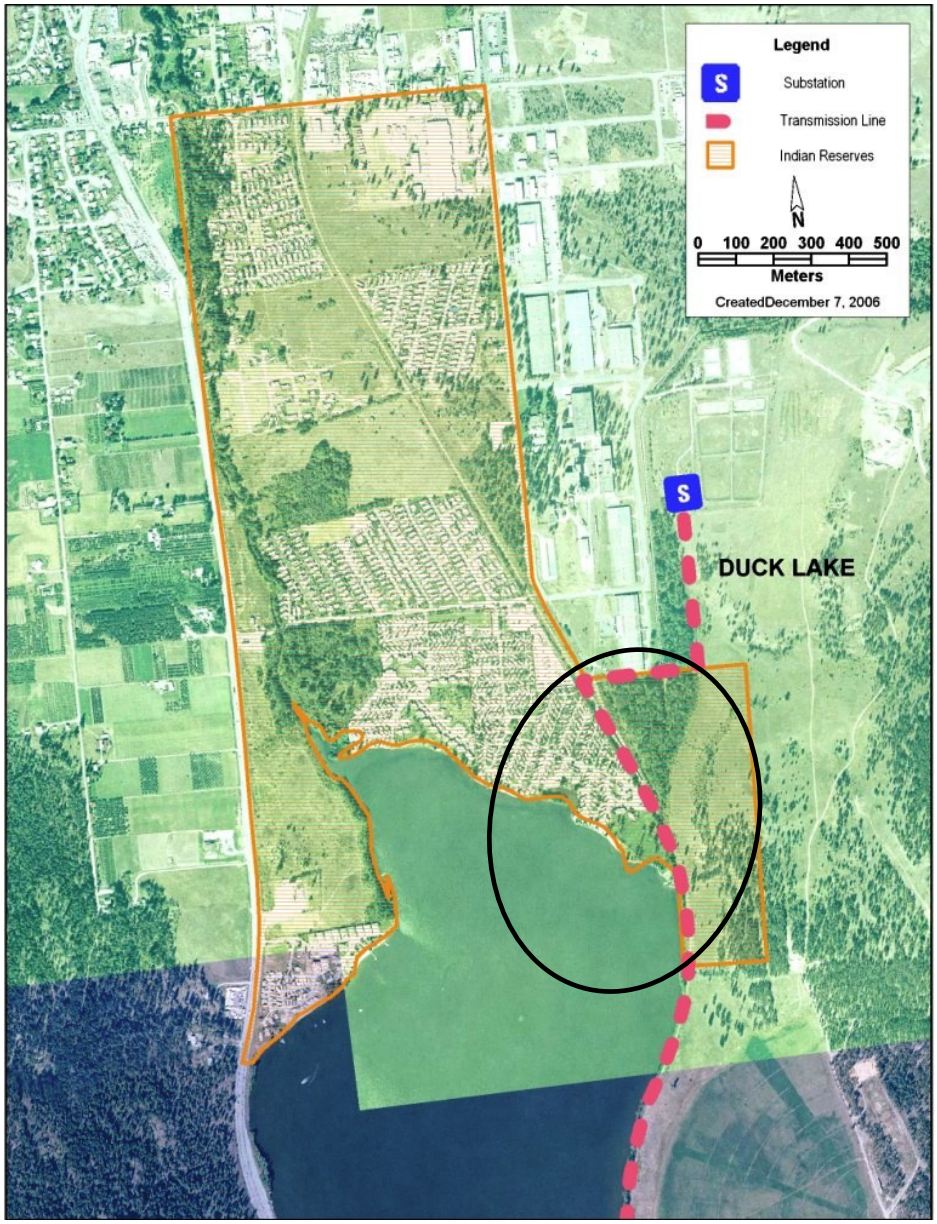
Table 11.7.4

	Category Description	Estimated Cost ($million)
1	Material	2.37
2	Labour	3.55
3	Salvage Labour	0.36
4	Provincial Tax On Material	0.17
5	Project Management	0.25
6	Engineering	0.50
7	Contingency	0.62
TOTAL		**7.82**

Q11.8 The Application at page 48 states that negotiations have been completed with the Okanagan Indian Band for the right-of-way permit for the proposed transmission corridor. Please confirm that the permit covers the entire route from Duck Lake to Sexsmith, or explain.

A11.8 The permit covers an approximate 1 kilometer section of the transmission line (as shown in Figure A11.8 below) that is within the Indian Reserve.

Figure A11.8


Legend
S
Substation
Transmission Line
Indian Reserves
N
0 100 200 300 400 500
Meters
CreatedDecember 7, 2006
S
DUCK LAKE

Q12.0 Reference: Application, pp. 44, 45

Table 8 provides a comparison of the capital costs and NPVs of Options 1, 2, and 3. Table 9 summarizes the revenue requirements for Option 1.

Q12.1 Please provide a table similar to Table 9 for Options 2 and 3.

A12.1 The required tables are shown below:

Table 12.1.1: Summary of Revenue Requirements - Option 2

	Expenditure / Impacts	**2006**	**2007**	**2008**	**2009**	**2010**	**2015**
		($000s)					
1	**Cumulative Capital Expenditure**		1,460	7,660	16,740	27,440	27,440
2a	Annual System Technical Losses		43	46	50	54	77
2b	Annual Operating Expense	16	74	75	77	79	87
2c	Financing and Income Tax		8	(104)	251	725	1,835
2d	Total Revenue Requirement	16	125	18	608	1,359	2,823
3	**Maximum Annual Incremental Rate Impact Over Previous Year**	0.58%					
4	**Net Present Value of Revenue Requirement**	18,841					
5	**One-Time Equivalent Rate Impact**	0.65%					

Table 12.1.2: Summary of Revenue Requirements - Option 3

	Expenditure / Impacts	2006	2007	2008	2009	2010	2015
		($000s)					
1	**Cumulative Capital Expenditure**	2,810	18,620	18,620	20,830	39,760	39,760
2a	Annual System Technical Losses		43	46	50	54	77
2b	Annual Operating Expense	16	74	75	77	79	87
2c	Financing and Income Tax	75	560	1,276	1,339	1,939	2,638
2d	Total Revenue Requirement	91	677	1,956	2,025	2,696	3,995
3	**Maximum Annual Incremental Rate Impact Over Previous Year**	0.54					
4	**Net Present Value of Revenue Requirement**	29,941					
5	**One-Time Equivalent Rate Impact**	1.04%					

Q12.2 What is the effect on the project NPVs of the inclusion of operating costs and distribution losses for the next 20 years?

A12.2 The present Project NPV already takes into consideration the effect of the estimated operating costs and estimated distribution losses for the next 50 years.

For the purpose of clarification a comparative presentation for Project NPVs for the three project options, with and without operating costs and distribution losses are provided in the table below:

Table 12.2

Parameters	Option 1 ($000s)	Option 2 ($000s)	Option 3 ($000s)
Project NPV with Operating Costs Distribution Losses	**17,718**	**18,841**	**29,941**
Project NPV without Operating Costs Distribution Losses	**15,232**	**17,079**	**28,179**

Q13.0 Reference: Application, p. 46

Table 10 provides a non-financial comparison of Options 1, 2, and 3.

Q13.1 Item 1.7 in the table relates to reliability. What is the incremental reliability of Option 1 over Options 2 and 3 due to the looping of the transmission network?

A13.1 The looping of the transmission network with Option 1 will satisfy N-1 criteria for the transmission system thereby providing two transmission sources for Duck Lake, Ellison, and Sexsmith substations.

Q14.0 Reference: Application, pp. 48-51, 62

Q14.1 Please describe the site selection process that FortisBC typically uses to select the site for a new facility such as a substation, outlining the steps from a broad screening process to a short list of sites and finally to the selected site.

A14.1 Prior to specific sites being selected, a general site "zone" is identified. For a substation, there is specific criteria that must be satisfied for any site to be acceptable, including:

- **Proximity to the appropriate transmission line(s).** Access to the necessary bulk power supply is critical. The line itself is also important, in that it must be the correct voltage to ensure the station is not unnecessarily over or underbuilt. If a station site is a significant distance away from the transmission source, a transmission line extension must be constructed to access the station

- **Proximity to load center.** As most new substations are required to meet increasing electrical load created by residential, commercial and industrial development, siting a substation close to this load results in fewer and smaller distribution circuits. If a station is constructed too far away from the load, the power must first be transported from the substation into the load center via a larger conductor, and distance often requires voltage support and often creates additional power losses. The net effect is higher cost and more infrastructure.

- **Access to the distribution network.** When the substation is located such that it is not central to the local distribution system, the electrical load cannot be distributed

equally throughout the area, creating a need for some feeders to be unnecessarily robust as the power is delivered over long distances to the end users

- **Cost.** These are the all inclusive capital project costs as well as the future costs associated with the maintenance and operation of the local power system. As an example, longer lengths of distribution lines have higher future costs associated with inspection, equipment replacement and line losses.
- **Limit direct impact to area residents.** As described in the response to Q21.1, a direct impact has a specific and often negative effect to residents, based on objective assessment as opposed to an indirect impact where the impacts tend to be more subjective in nature. Minimizing the direct impacts of infrastructure occurs through fewer facilities and suitable siting.
- **Limit impact to adjacent land use (ALR, environment, etc.).** Where lands are sensitive to environmental concerns, agricultural sustainability or community use, alternate sites are often investigated. Land parcels are normally 3-5 times larger than the substation footprint to allow for physical separation, visual screening and/or retention of native land to create community value.

Once of the preceding considerations are taken into account, specific sites are investigated. Sites are evaluated based on land availability (i.e. is the owner a willing seller), adjacent land use, price, etc. Depending on the number of potential sites that satisfy the various criteria, a single site may be selected for detailed evaluation or several sites may be considered. As the assessment costs such as geotechnical investigation, environmental assessment and survey are not insignificant, care must be exercised when selecting a site for evaluation.

Once a site or sites have passed each stage of the screening process, consultation with the public at large proceeds in earnest. Commencing this process much earlier, risks either garnering acceptance of or raising local ire over a site that proves to be technically unsound. Community balance is also sought and the Company strives to ensure that the moving to an alternate site does not merely change the group of people that are concerned.

Final site selection is based on a balance of all of these described criteria.

Q14.2 Further to the map on page 62, please provide a map or to-scale diagram that shows all rail and road systems and all residences or commercial establishments within approximately one kilometer of the proposed site on Lochrem Road. On the map (or a map for a larger area if necessary), please identify the location of the other site that was proposed at the July 2006 information session and show current development zoning and future development plans.

A14.2 Please refer to Appendix A14.2.

Q14.3 Please also provide a topographical map for the area that extends for at least approximately one-half kilometer around the proposed site on Lochrem Road.

A14.3 Please refer to Appendix A14.3.

Q14.4 Please provide a table comparing the strengths and weaknesses of the two sites, and any other potential sites that FortisBC evaluated in the area.

A14.4 Please see site comparisons below.

Table A14.4 - Site Comparisons

	Dry Valley Road	Lochrem Road	East of Highway 97
Access	Good	Good	Requires railway crossing, cannot access from Hwy.
ALR Status	In ALR	Not in ALR	Not in ALR
Land Purchase (willing seller)	No	Under negotiations	
Customers near within 500m	Good - less than 10	Good - less than 10	Good - less than 10
Grounding	Good	Good	Poor - requires additional grounding for Railway
Sufficient Land	Good	Good	Requires significant design changes
Elevation	Good	Good	Requires higher structures to access site.
Visual Impact	Moderate	Good - can be placed within 20 ft slopes on three sides.	Moderate
Proximity to Load Center	Good	Moderate	Moderate
Additional Transmission	Good	Good	Moderate - would require two highway crossings
Proximity to Fly zone	Good	Good	Moderate - Not preferred by NavCanada

Q14.5 Please provide an update on the status of the negotiations with the owner of the proposed site on Lochrem Road, and on the Zoning application to the City of Kelowna for the site.

A14.5 Negotiations are ongoing and confidential at this point in time. The zoning application is pending successful negotiation with the landowner.

Q14.6 Please provide a photograph of a similar substation, possibly Duck Lake Substation or Sexsmith Substation, or an artist's sketch of the proposed substation.

A14.6 Please refer to the attached photographs of the Duck Lake Substation. Please note that in the lower portion of Photo14.6B there is a quantity of used equipment stored. This is not typical of most substations and occurs at Duck Lake Substation due to the industrial nature of the area.

Photo 14.6A

Photo 14.6B

Q14.7 On page 62, the Application states that there is a single residence approximately 200 meters from the proposed site. Please discuss how FortisBC proposes to use topography, vegetation or other means to screen the site, and the reaction of the resident to these proposals.

A14.7 The station will be sited in such a way so as to utilize the natural topography of the gravel pit as a physical barrier, limiting visual impacts. In addition, selective planting of natural vegetation will help mitigate any remaining visual impacts. FortisBC has not received any reaction specific to the visual impacts from the resident.

Q15.0 Reference: Application, p. 50

FortisBC states that the distribution feeders all use existing routing, with the exception for a small section of the proposed Ellison Feeder 4, which will be constructed once the City of Kelowna builds a proposed road in the next few years.

Q15.1 Please provide a detailed map of Feeder 4 routing and identify the location and routing of the proposed road mentioned above.

A15.1 Please refer to Appendix A15.1.

Q16.0 Reference: Application, Appendix I

Q16.1 Appendix I at lines 20-26 provides a breakout of incremental Annual Operating Costs for Option 2. Please provide revised spreadsheet for Options 1 and 3 that include similar detailed information.

A16.1 Please refer to Appendix A16.1.

Q16.2 Incremental Total Operating Cost is generally higher for Option 1 than for Options 2 or 3. Please discuss the effect that building a third substation in the area would have on losses, maintenance costs and total operating costs.

A16.2 Total Losses for Option 1 are lower than Option 2 and 3 because the Option 1 puts the substation at the centre of the load. Losses are reduced because the current does not have to travel as far in Option 1 as it does in Option 2 and 3.

There is significantly more equipment required for Option 2 and 3 which is evidenced by the cost comparison between each option. The maintenance costs and operating costs are higher because of the additional infrastructure compared to Option 1.

Note that the total operating cost is higher in Option 1 versus Option 2 and 3 due to the property taxes for the five acres for the station.

Q17.0 Reference: Application, Executive Summary, pp. 3-4

FortisBC states that the cost escalation "is primarily attributable to escalating land cost and higher distribution networking required to match the recent rapid growth in the Duck Lake-Ellison-Sexsmith area".

Q17.1 Please provide a more detailed reconciliation for the cost escalation from $ 9.24 million to $ 11.7 million to $ 15.77 million by identifying separately the impact of escalating land costs, requirement for higher distribution networking and other variables.

A17.1 The tables below provide a detailed stage wise breakdown and reconciliation for the project cost escalation from $9.24 million to $11.7 million to $15.77 million.

Table17.1.1
Project Cost Escalation from $9.24 million to $11.7 million

Project Component	Escalation
Total Project Cost (Loaded) as in 2005 Capital Plan (Table 9, Page 21, Table 9.3)	**9.24**
Correction for Estimated Land Cost escalation	0.05
Correction for Inflation (2%)	0.19
Additional Estimated T&D Cost (Duck Lake-Ellison)	1.10
Estimated Additional Distribution Egress & Additional New Distribution Line	1.10
Total Escalated Cost: 2006 Capital Plan	**11.7**

Table17.1.2
Project Cost Escalation from $11.7 million to $15.77 million

Project Component	Loaded 2005	Inflation (2%)	Total With Inflation	Presently Estimated Project Cost (Without AFUDC)	2006 AFUDC (Prop.)	Loaded Project Cost 2006
	A	B = 0.02 x A	C = A + B	D	E	F = D + E
Land & Right of Way	0.30	0.01	0.31	1.46	0.06	**1.52**
Engineering & Transformer Cost	1.80	0.04	1.84	8.04	0.31	**8.35**
Other Substation Related Equipment	7.40	0.15	7.55			
138 kV Transmission (61 Line) as Double Circuit overbuild	1.10	0.02	1.12	1.36	0.05	**1.41**
Distribution Egress & Additional new Distribution Line	1.10	0.02	1.12	4.33	0.17	**4.50**
Total	**11.70**	**0.23**	**11.93**	**15.19**	**0.58**	**15.77**

Q17.2 Describe the sensitivity of capital cost estimates to further growth. For instance, what would be the cost impact of an additional 20 MVA in load over and above the 2007 Capital Plan forecast?

A17.2 The present cost estimate is based on the forecast load as in the CPCN which has considered all available load data / information at the time of submission of the CPCN Application.

The specific sensitivity is highly dependent on the location of load growth and is somewhat minimized by way of equally spaced substations capable of capacity expansion (addition of new transformers) within their respective boundaries without the need for acquiring any additional land. Hence, the sensitivity of the Project capital cost under the impact of an additional 20 MVA proposed load will be limited to the cost of installation and commissioning of an additional substation power transformer and distribution feeders (number and length of the new distribution feeders will be subject to the specific spatial location of the newly emerged load). The distribution network costs under the implementation of Options 2 and 3 are more sensitive to construction of incremental distribution lines and the introduction of additional voltage regulation equipment to serve

this load. This will not only result in higher capital layout with negative rate payer impact and higher system loss, but also will invoke intensive customer/stakeholder opposition/dissatisfaction due to right of way and aesthetics related issues. Considering these circumstances, Option 1 is less cost sensitive and provides greater flexibility to meet anticipated load growth.

Analysis of Option 1 indicates that in case such a load actually matures in the Ellison-Duck Lake region by 2008, an additional transformer will be required at Ellison Substation around 2011 winter. A capital cost scenario has been has been analyzed based on the following assumptions:

	($million)
1. Cost of new / additional station transformer:	2.16
(Please refer response to BCUC IR1, Q6.3, value escalated @ 2% per year for inflation)	
2. Cost of two distribution circuit breaker bays:	0.54
(Please refer response to BCUC IR1, Q6.3, value escalated @ 2% per year for inflation)	
3. Cost of transformer high side (primary) circuit breaker & bus work:	1.35
(Please refer response to BCUC IR1, Q6.3, value escalated @ 2% per year for inflation)	
4. Estimated line cost for 2 new overhead distribution feeders:	1.73
(Estimated cost only, without detailed engineering analysis)	
5. Estimated Project Loadings:	1.34
(Estimated cost only, without detailed engineering analysis)	
Total Additional Cost expectation in 2011 due to unexpected additional load of 20 MVA in 2008.	**7.12**

The net financial impact on the Project with respect to existing Option 1 is indicated below:

Table 17.2

Financial Parameters	Existing Option 1	Option 1 with Additional 20 MVA Load In 2008
	($000s)	
Capital Cost	15,770	22,893
NPV of Revenue Requirements	17,718	21,611
One Time Equivalent Rate Impact	0.61%	0.75%

Q17.3 Please explain what is meant by "higher distribution networking."

A17.3 The term "higher distribution networking" has been used to explain the fact that more kilometres of electricity distribution lines are now required in the Ellison Project to match and serve the incremental load growth in the Duck Lake-Ellison-Sexsmith area that has developed post submission of the 2006 Capital Plan.

Q17.4 Of the escalating land costs, what portion relates to general increases in property values and what portion relates to the change in proposed substation location from Old Vernon Road to Lochrem Road?

A17.4 The escalating land costs are due to increases in property values only. No portion relates to the change in location.

Q18.0 Reference: Application, Executive Summary, p. 4

FortisBC states that it has consulted and sought feedback from provincial and local governments, First Nations, business owners and representatives, potentially affected landowners and area residents in the development of this Project and, on July 6, 2006, held a public information session for the north Kelowna public and stakeholders to present options and proposed plans for the Ellison Project. This provided an opportunity for the public to comment, ask questions, and view maps of the proposed substation site and new and existing line routes. The session was well attended, with 33 residents taking time to learn about the project and provide their feedback.

Q18.1 Please identify the Option One site that was described in the Public Information Meeting.

A18.1 The Option 1 site that was presented during the July 6 public information session was located west of Dry Valley Road, approximately 200 meters west of Highway 97. Photo A18.1 below shows the Dry Valley Road site in relation to the proposed Lochrem Road location.

Photo A18.1

Q18.2 If the Option One site that was described in the Public Information Meeting is not the site near Highway 97 and Lochrem Road, what public consultation has FortisBC carried out in connection with the Lochrem Road site?

A18.2 The Lochrem Road site has been discussed with the members of the Quail Ridge Residents Association ("QRRA"), as well as the two nearest landowners as well as the City of Kelowna and the Okanagan Indian Band.

Q18.3 Were Quail Ridge residents included in the Flyer Delivery advising of the Public Information Meeting? If not, why not?

A18.3 A specific invitation to the members of the Quail Ridge Residents Association was sent to the president of the QRRA in advance of the July 6, 2006 public meeting. Individual

flyers were not distributed as it was believed that the Quail Ridge subdivision was far enough away from any proposed infrastructure that no impacts would be incurred. Once the substation site was changed, discussions with the QRRA commenced.

Q19.0 Reference: Application, Appendix C1 – Substation Land Location

FortisBC states that the site is located immediately north of the western terminus of Lochrem Road in a vacated gravel pit and that an appraisal of the site has been commissioned.

Q19.1 What is the size of the proposed substation in square feet that will be built on the property to be acquired?

A19.1 The estimated size of the station is 52,000 square feet.

Q19.2 What is the minimum size in square feet, required by regulation and/or common utility practice for a substation of the capacity and service specifications described in this Application?

A19.2 The minimum required size to accommodate safe work practice and sound engineering is 52,000 square feet, based on the ultimate arrangement of the substation and latest engineering standards. Similar existing stations are not able to accommodate the latest equipment requirements such as fault limiting reactors (as acknowledged by the Commission in Order G-8-06, 2006 Capital Expenditure Plan "Fault Level Reduction" project).

Q19.3 Are there unique circumstances that require special sizing considerations for the proposed substation?

A19.3 No.

Q19.4 Please provide a copy of the appraisal of the site.

A19.4 The requested appraisal of the site is not complete at this time. Upon completion, it will be filed with the Commission.

Q19.5 Please provide a detailed map of the general area proposed for the substation showing road and rail systems, location of adjacent housing including homes located in the Quail Ridge Development, development zoning and future development plans.

A19.5 Please refer to Appendix A19.5.

Q19.6 What will be the noise level emitted from the proposed substation:

a) At the fence

b) 20 meters from the fence and,

c) 50 meters from the fence

A19.6 The noise level at the substation will be determined by the noise generated by the transformer as dictated by "CSA Standard C88-M90, Power Transformers & Reactors". The Ellison Substation power transformer will have a maximum allowable noise level of 74dBA at 1.0 Meter (3 feet approximately) from the source as per the above CSA Standard.

From Figure B2, page 60 of the Ellison CPCN Application, it is apparent that at the proposed Ellison Substation the east side fence would be the nearest from the source (transformer) at a distance of 18.7 meters.

On the basis of the same, the following Table provides the requested data assuming the presence of no other sound source in the specific environment.

Table 19.6 Noise Level at Different Locations

	Location	Distance From Source (Meters)	Expected Noise Levels (dBA)
1	One meter from transformer (source)	1.0	74.0
2	At the fence (nearest to source)	18.7	48.6
3	20 meters outside of the fence nearest to the source	38.7	42.2
4	50 meters outside of the fence nearest to the source	68.7	37.3

Q19.7 Are there impediments to locating the proposed substation further east, closer to Highway 97, and if so, what are they and can they be overcome?

A19.7 There are impediments to locating the station closer to Highway 97. The proposed land that FortisBC is negotiating for becomes narrow as it gets close to the Highway so the required foot print for the substation is compromised. This would require that FortisBC purchase a second piece of land adjacent to and north of the existing proposed location. The land owner also owns the land to the north and is not willing to sell the land. That land is also in the Agricultural Land Reserve ("ALR") which creates other barriers. The proposed location is not in the ALR. The visual screening of the station becomes more complex and therefore more expensive as it gets moved towards Highway 97. Access to the site from Quail Ridge Boulevard becomes more difficult which would require a road access.

Q20.0 Reference: Application, Section 5, Public and First Nations Consultation, Appendix A, Public Consultation

On October 24, 2006 FortisBC met with the members of the Quail Ridge Residents Association and presented information on the project proposal, benefits, options and public process.

Q20.1 Why did FortisBC not meet with the Quail Ridge Residents Association ("QRRA") until October 24, 2006 even though it was ready to file the Application with BCUC on October 27, 2006?

A20.1 The meeting with the QRRA was pre-scheduled for October 24 some weeks in advance at the request of the Association executive. The QRRA Annual General Meeting ("AGM") had been scheduled for that date and the executive indicated that coinciding the Ellison Project presentation with their AGM would likely maximize the number of people in attendance.

The combined AGM/FortisBC presentation attracted an audience of 118 people, which is exceptional based on other project related information sessions that FortisBC has conducted in the past two years. The opportunity to use the AGM as a gathering spot likely created a larger audience than may have attended were the events done separately.

FortisBC assessed the feedback from this session and concluded that the Company could undertake reasonable measures within the project scope and cost to effectively address identified noise and aesthetic issues. The Company believes that the current location and distance from residences effectively mitigates other concerns raised at the meeting and as such no material changes were made to the scope of this project and subsequent CPCN filing shortly thereafter.

Q20.2 Please provide copy of the materials presented in the Annual General meeting of the QRRA.

A20.2 The materials are provided in Appendix A20.2.

Q20.3 Please provide a Summary Report of the information session with the QRRA, similar to that prepared after the July 6, 2006 Public Information Session on the first site proposed. This report should be similar to that identified in the Table of Contents (Items 1-9) of the July 21, 2006 report. If it is not available, explain why not.

A20.3 The verbatim record of the discussion is included in Appendix A20.3. It is anticipated that this format will offer even greater clarity than a summarized version of the presentation and the discussion.

Q20.4 Does FortisBC believe that another public information session of the type held on July 6, 2006, prior to the January 9, 2007 Public Hearing would be appropriate and/or necessary?

A20.4 No. Approximately 50% of the registered interveners for the oral hearing slated for January 9-10, 2007 were in attendance at the October 24 QRRA meeting. The information presented at both the July 6 Information Session and the October 24 QRRA AGM was very similar with the exception of the proposed substation site moving from Dry Valley Road to Lochrem Road. A subsequent meeting was also held with members of the QRRA on November 10, 2006. Those discussions have been unable to resolve concerns as evidenced by the intervention in this Project and as such further Company sponsored public information sessions are not expected to resolve the outstanding issues.

The vast majority of the Quail Ridge interveners have expressed concern about health issues and property devaluation. It is the contention of FortisBC that the proposed substation site, being at least 800 meters away from the nearest Quail Ridge residence, will not create any material concerns once the issues are identified and properly debated. FortisBC believes that the prescribed Oral Hearing is the proper venue to address these concerns and that an additional public meeting would not necessarily reduce the number of issues arising at the Hearing.

Q20.5 Please provide a simulation of the proposed Ellis Substation with and without the "strategically located vegetation."

A20.5 Please refer to Appendix A20.5.

Q20.6 Please submit photographs of existing other FortisBC substations where vegetation has been successfully planted to address aesthetic concerns.

A20.6 FortisBC's Vaseux Lake Terminal station has a vegetation barrier that has been in place for approximately one year to address aesthetics. Please see Appendix A20.6.

Q21.0 Reference: Comparative Option Evaluation, Table 10, p. 46

Q21.1 Would FortisBC like to adjust the ratings in the "Land & Associated Issues" section of the evaluation after receiving copies of various interventions from the Quail Ridge residents? If yes, please provide the amended table.

A21.1 It would be reasonable to amend the rating results of item 3.3, Expressed Public Concern Local to Site. Given the feedback from the QRRA, the rating of Option 1 should be changed to "L" as opposed to "H" that had been submitted in the CPCN Application. However, further explanation is required.

FortisBC realizes that the addition of electrical infrastructure is likely to cause local concern to those most affected. To reduce the overall community impact, the Company seeks to create power system solutions that serve the community reliably and safely while minimizing the number of residents that are directly affected by the new facilities. "Direct impact" is defined as limiting land use or having a direct invasive effect to a resident. This includes the requirement for easements and rights of way as well as facilities immediately adjacent to residents, such as a new or larger pole on the street in

front of their home. This is in contrast to an "indirect impact", which is where a resident can perhaps see new facilities from a further distance but do not have their property physically impacted.

Option 1 employs existing infrastructure for the most part and the substation site has been selected such that the number of people with a direct impact is very low. As shown in Appendix A1 of the CPCN Application, Options 2 and 3 create a need for significant construction of double circuit distribution lines. This will create a direct impact to many more area residents in the form of taller poles and more wires in front of their homes. This concern was raised at the July 6 Information Session where many of the attendees recognized that the addition of these circuits would create much more community concern that a single new substation.

Considering that the proposed substation site is a significant distance from all homes (one within 200 meters one within 200 meters and the closest one at Quails Ridge being 800 meters) as well as the fact that the site selection follows the philosophy of reducing community impact, FortisBC does not believe that the ratings should change other than the single amendment cited herein.

Q21.2 If not, please explain why the ratings should stand.

A21.2 Please refer to the response to BCUC IR1 Q21.1.

Q21.3 Please also clarify the rating and weight descriptions. What do H,M, and L indicate in the weight column? What do H, M and L indicate in the rating columns?

A21.3 The weighting scale is intended to convey the relative level of importance of that feature to the success of the project. For example, the Ellison project is driven by the increasing electrical load in the area. Therefore, the ability of an option to meet the capacity needs of the area for an extended period of time is obviously an important criterion. Relative to capacity, the number of residents within 0.5 kilometers of a substation is given less weight. The Company will look at each situation in determining weight, however, it is usually better to try and mitigate individual concerns about aesthetics then to design a system which does not meet the long term needs of the community as a whole.

The rating scale compares an individual project feature between options. It does not consider how important the criterion is to the success of the project, as this is considered in weighting. Rather, the rating determines the impact of the criterion relative to the other options. Using Item 1.3 from Table 10 (page 46 of the Application) as an example, satisfying the backup criteria is a moderately important feature (weight M), and Option 1 is able to satisfy that criterion somewhat better (rating M) than Option 2 or 3.

Q21.4 Using the same weighting and rating scales, provide an evaluation of the three options for the criteria shown below. (Alternatively, for some of the criteria ratings from adequate to good to inadequate could be used.)

A21.4 For the sake of consistency, the criteria have been assessed using the same rating scale as offered in the CPCN Application.

Comparative Options Evaluation

Criterion	Weight	Option 1	Option 2	Option 3
Capital Cost	H	H	M	L
Reliability	H	H	M	M
Meeting Planning Criteria	H	H	L	M
Aesthetic Impact	M	H	M	L
Construction Impacts	M	H	M	L
Public Health	H	L	L	L

Weighting Scale Description: H (high) = best relative outcome; M (moderate) = acceptable outcome; L (low) - less than preferred outcome

Q21.5 Please explain in layman's terms the significance of the transmission tie between Sexsmith and Duck Lake substations provided in Option 1 but not provided in Options 2 and 3.

A21.5 Please refer to the response to BCUC IR1 Q13.1. The transmission tie between Duck Lake and Sexsmith substations is a transmission loop which provides two sources to the

Ellison, Duck Lake and Sexsmith substations. In Option 2 and 3, Duck Lake will remain single source ("radial") from the FA Lee Terminal station.

Q21.6 Putting the capital cost comparison aside, are all the benefits identified for Options 2 and 3 overshadowed by the fact that they do not involve a transmission link?

A21.6 As stated in the 'deficiencies' section of Option 2 (page 37) and Option 3 (page 41) the transmission link is only one of many reasons that overshadow the benefits of Option 2 and Option 3.

Q22.0 Reference: Application, p. 20

Fortis BC states that at all locations along the transmission and distribution line right of way, the EMF levels associated with this specific project will be significantly lower than the public exposure guidelines supported by the World Health Organization ("WHO").

Q22.1 Please provide values for EMF levels compared to the WHO Guidelines, for the proposed substation:

a) at the fence

b) 20 meters from the fence and,

c) 50 meters from the fence

A22.1 Magnetic Field simulation was not carried out on the proposed Ellison Substation. However, provided below are actual readings of the Okanagan Mission Substation which is representative of the Ellison Substation.

Table 22.1 below represents the actual readings and the recommended magnetic field levels by ICNIRP / WHO:

Table 22.1

Distance from Station Fence Line (Mts)	Expected Magnetic Field (Milli Gauss)	Comparison with Recommended Levels: WHO / ICNIRP	
		%	Times Lower
0.0 (at fence line)	5.88	0.71%	142
16	1.72	0.21%	484
20	1.56	0.19%	534.
30	1.12	0.13%	744
40	0.96	0.12%	868
50	0.80*	0.10%	1041

* calculated

Q22.2 Please provide values for EMF levels compared to the WHO Guidelines, for proposed transmission and distribution lines or a combination there of:

a) at the closest dwelling

b) at the closest regularly travelled roadway

A22.2 Calculation of estimated magnetic field levels for the Nk'Mip and Big White Projects (now approved by the BC Utilities Commission) indicated that the EMF levels are significantly below the recommended exposure limits for EMF fields developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) which is formally recognized by the World Health Organization ("WHO").

The levels estimated to be generated by the proposed Ellison Project overhead transmission and distribution lines are similar to the EMF levels at Nk'Mip and Big White Projects. For the Ellison Project it is estimated that at the closest dwelling and the closest regularly travelled road the EMF levels will be between 16.7 and 11.9 mGauss. This EMF level is 50 to 70 times lower than the recommended exposure limit of 833 mGauss developed by ICNIRP and WHO (please see Figure A22.2).

A magnetic field is a function of the electric current flowing in a conductor. Considering line load conditions, it can be reasonably assumed that the Ellison Project will have magnetic field levels that will be in a similar range of the Big White and the Nk'Mip

Projects (please refer: Nk'Mip BCUC IR1 Q10.4 and Big White BCUC IR2 Q10.1, Table E) which assumed the following line loading conditions:

Nk'Mip Project: 16 MVA on 63 kV transmission and 2 MVA on 13 kV distribution under built (Please refer Karow IR1 Q2.3 for Nk'Mip Project)

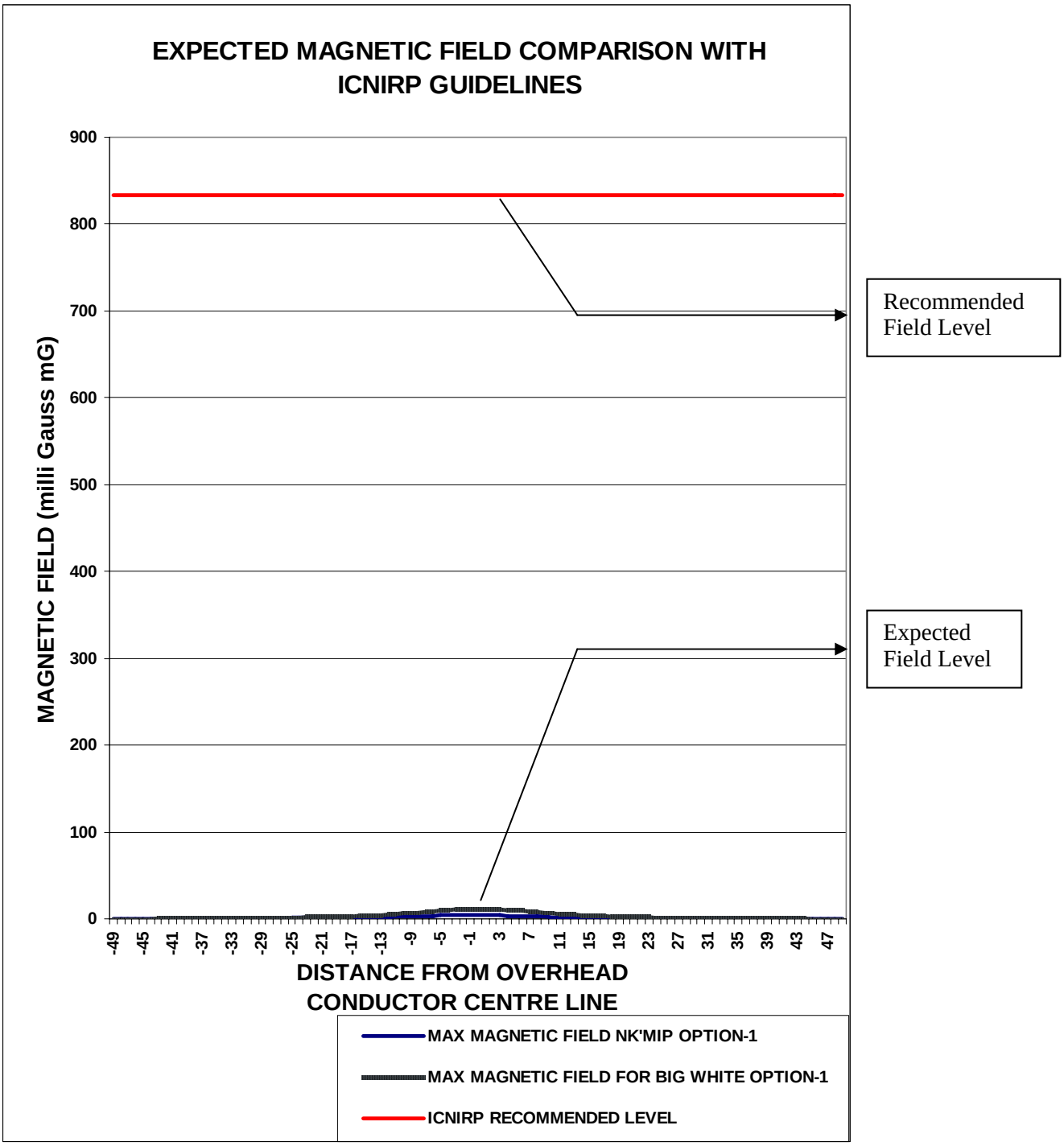
Big White Project: 45 MVA on 138 kV transmission and 5 MVA on 25 kV distribution under built

The presumption that the Ellison Project will have a magnetic field in the similar range of the Nk'Mip / Big White Project arises out of the following load consideration:

Ellison Project: 40 MVA on 138 kV transmission and 10 MVA on 13 kV distribution under built

1

Figure A22.2



Q23.0 Reference: Application, Appendix I – Revenue Requirement Projections

Q23.1 What is the rationale for the use of the 10% discount rate in the NPV calculations?

A23.1 The discount rate is based on a real discount rate of 8% plus inflation of 2%. FortisBC has used a real discount rate of 8% as a base case in evaluating its capital expenditures for a number of years. The use of 8% nominal (6% real) or 12% nominal (10% real) does not affect the ranking of the options considered.

Q23.2 How does that compare to the projected 30 year bond yields?

A23.2 Using projected 30 year bond yields, FortisBC's cost of capital would be 8.70% on any new debt. This rate however would not reflect FortisBC's embedded long term debt, nor would it reflect FortisBC's long term cost of capital. As discussed in the response to BCUC IR1 Q23.1, the discount rate does not affect the project ranking.

Q23.3 Does this rate reflect the income tax effect?

A23.3 Yes, this rate reflects the income tax effect.

Q24.0 Reference: Application, pp. 3, 6, 15

Completion of the transmission line between the proposed Ellison Substation and Sexsmith Substation will link all Kelowna substations in a transmission looped network and will provide N-1 backup.

Q24.1 Please update Figure 3 (page 15) to show the route of the 138 kV line proposed for 2010.

A24.1 The transmission line route is identified in Figure 6 (page 34) of the Application but is reproduced as Appendix A24.1 for convenience.

Q24.2 Please provide a schematic of the transmission system in the Kelowna area.

A24.2 Schematic attached as Appendix 24.2.

Q24.3 Will any single contingency at F. A. Lee Terminal cause a simultaneous outage on 46L and the proposed 138 kV line? Please explain, and provide a circuit diagram for the F. A. Lee area if appropriate.

A24.3 During the recent upgrades at the FA Lee Terminal station, significant effort has been made to reduce the possibility of load loss due to N-1 contingencies. However, due to the limitations resulting from the arrangement of the 138 kV transmission lines leaving the station and the 230 kV/138 kV transformer locations it was not feasible to eliminate all possibilities. As a result, there is a small portion of 138 kV bus between FA Lee Terminal station CB18 and FA Lee Terminal station CB12 (please refer to the drawing "2008 – Kelowna area" in Appendix 24.3) that, if faulted, would result in an outage to both 46 Line and 50 Line. It is important to note however, that the 138 kV transmission system can be remotely reconfigured by the FortisBC System Control Centre to restore supply to 50 Line via one of the other 138 kV transmission lines that are still energized. Thus, while there would be an outage to both Ellison and Duck Lake, it would be short in duration. Bus faults are also considered to be rare events.

The future project to fully mesh the Kelowna transmission system (item 2.1.2.1 of the 2007 SDP Update "Loop Kelowna 138 kV Circuits") would prevent an outage from occurring for the bus fault described above as there would be two sources of supply at all times for the Kelowna area substations. That project is scheduled for the 2011 timeframe.

Q25.0 Reference: Application, p. 9

The Company investigated several options to meet the expected demand out of which three options emerged as technically viable.

Q25.1 Please provide a brief explanation of the other options that were considered.

A25.1 The following options were investigated, but were rejected since they were technically deficient and failed to satisfy the single contingency (N-1) system planning criterion:

a) Rejected Consideration 1:Ellison Substation with Radial Transmission from Duck Lake:

This alternative consideration investigates the construction of the proposed Ellison distribution substation in the north end of Kelowna together with only a radial transmission line to the Duck Lake Substation. This also involves installation of necessary distribution feeders to tie the proposed substation into the existing distribution network.

While providing adequate capacity for loads served by the Duck Lake, Sexsmith and the proposed Ellison substations, it violates the single transformer substation planning criteria. A single transmission contingency (N-1) for 46 Line between FA Lee Terminal station and Duck Lake Substation will result in loss of both the Duck Lake and the proposed Ellison substations. Under such a circumstance, even by loading Sexsmith Transformer 1 (32 MVA) to 125% of its nameplate rating and providing an additional 3 MVA load back up from Glenmore Substation, 80% load back up of both the Duck Lake and the proposed Ellison substations cannot be achieved beyond 2008/09.

This consideration was rejected since it failed to achieve single contingency (N-1) Planning Criterion.

b) Rejected Consideration-2:Expansion of Duck Lake Substation and additional Distribution Backup of Sexsmith Substation from Glenmore Substation by 3.0 MVA during Contingency Situations:

This consideration involves the installation of an additional 138 kV/13 kV, 32 MVA transformer at the Duck Lake Substation to create additional station capacity and make provision for four additional 13 kV feeders to feed the north Kelowna area.

This consideration provides adequate capacity for loads served by the Duck Lake and Sexsmith substations. However, a single transmission contingency (N-1) on 46 Line will result in loss of both transformers at the Duck Lake Substation and adequate backup power cannot be met by the Sexsmith substation even after loading the Sexsmith Transformer to 125% and transferring an additional 3 MVA of load from Glenmore Substation beyond 2007/08 (please refer to Table G.2 at Appendix G of the

CPCN Application). This violates the planning criterion for single transformer substations.

This consideration was rejected since it failed to achieve single contingency (N-1) planning criterion for the proposed Duck Lake Transformer 2.

Q26.0 Reference: Application, Appendix G, p. 78

Q26.1 Please provide an annual load duration curve for the Duck Lake and Sexsmith Substations.

A26.1 It is assumed that "annual load duration" means annual load profile. The Duck Lake and Sexsmith substations are not yet equipped with appropriate metering to provide annual load profiles. New metering systems will be installed at the Duck Lake Substation as part of the Ellison Project and at Sexsmith as part of a Substation Automation project. Peak load data for this Application was obtained from existing metering systems that only produce maximum demand information on a monthly basis. However, a daily profile is shown for Duck Lake Feeder 1 for the summer and winter peak in Appendix A26.1.

Q26.2 Please provide daily load profiles for winter peak day and summer peak day at each substation

A26.2 Please refer to the response to BCUC IR1 Q26.1 above.

Q27.0 Reference: Application, Appendix G, p. 78, 79

The capacity of Sexsmith T1 is currently limited by the secondary cables to 30 MVA. These cables will be upgraded during 2007. Duck Lake T1 has a nameplate capacity of 28 MVA, but circuit capacity is limited by transformer regulators that have a capacity of 9 MVA. These regulators are scheduled to be upgraded during 2006-2007 to 18 MVA.

Q27.1 What is the cost of the secondary cable upgrade, and is it included in the cost estimate for the current project?

A27.1 This project is separate from this application as this load capacity is required in 2007 and is listed in the 2007/2008 Capital Expenditure Plan under the station assessments and minor planned projects. The cost for this project is estimated at $79,000.

Q27.2 Will the capacity of the Duck Lake circuit still be limited by the regulators after the upgrade? Please explain.

A27.2 Yes, the capacity of the Duck Lake transformer will be limited to 18 MVA after the upgrade. However, further upgrades are not necessary as per the proposed Option 1, since Duck Lake transformer capacity will not exceed 17.9 MVA in the present planning horizon of 2015/2016.

Please refer to Table G4, page 80 of the CPCN Application for further reference.

Full utilization of the Duck Lake transformer capacity (28 MVA) will require addition of new distribution feeders and will entail further costs. This has already been considered in Option 2. Please refer to Table G5, page 81 of the CPCN Application for further reference.

Q27.3 How did the situations in which circuit capacity is limited to a value less than transformer capacity arise? Are such non-transformer limitations common on the FortisBC system?

A27.3 The original design for Duck Lake was around 1989. The design did not include “on board” (OLTC) voltage regulation but rather separate, easily changeable “out board” regulators. At that time, the station was designed to match the 20-year load growth. The

prediction for growth was at around 1-2% per year as opposed to 4-5% that the City of Kelowna is now seeing. This load growth was not predicted in 1989, thus the undersized regulators were installed to minimize cost at that time.

This is not a common limitation in the FortisBC system. FortisBC builds the stations such that the distribution systems and the transmission systems attached to the transformer are all the same rating as the transformer. Present standards dictate on board regulation that is factory matched to the transformer size.

Q28.0 Reference: Application, Appendix G, p. 78, 79; Appendix H, p. 83

FortisBC states that the ability of Duck Lake T1 to provide 80 percent backup power to Sexsmith T1 will be violated during the winter of 2006/07. During emergencies, the transformer can be operated at 125 percent nameplate capacity.

Q28.1 Is a transformer's overload capability considered when evaluating its ability to provide back-up power? Please explain.

A28.1 A transformer's overload capability is only considered for emergency back up situations, not for normal planning capacity.

Q28.2 For how long can the transformer be loaded at 125 percent of its nameplate capacity without damage?

A28.2 According to Table 4 of IEEE C57.91 Standard, for an ambient temperature of 8ºC the transformer can be loaded at 125% of its MVA rating with "normal loss of insulation" life. This applies for transformers that are in a Condition 1 (healthy) only, however, at temperatures above 8ºC, loading the transformer at 125% of its nameplate capacity will reduce insulation life.

Q28.3 What is the basis for the figure of 80 percent backup for single-transformer stations and 100 percent backup for multiple-transformer stations? In answering, please describe the factors, other than the number of transformers, that affect the criteria.

A28.3 The figures are based on minimum acceptable customer voltage levels as defined in the distribution planning criteria approved by the Commission in 2005 (Appendix E, Section 3.2.2 of the System Development Plan).

Q28.4 Please explain whether the backup criterion for a multi-transformer substation is any different in the cases where: (a) the transmission system provides N-1 capability to the substation; and (b) the transmission system does not provide N-1 capability.

A28.4 The backup for multi-transformer substations (as stated in Appendix H, page 83 of the CPCN Application) is independent of transmission supply.

Q28.5 Is there a "mandated" response to violations of the backup criteria? If so, what is it?

A28.5 There is no "mandated" response to violations of the backup criteria. The criteria serve as guidelines to the planning function.

Q29.0 Reference: Application, Appendix G, p. 80

Q29.1 Please provide a detailed calculation of each of the Capacity Available for Backup values for 2007/08.

A29.1 Please refer to the response to BCUC IR1 Q31.1 for a detailed clarification.

Q29.2 Please explain what is meant by the comment below Table G4 regarding load transfer between substations.

A29.2 Please refer to the response to BCUC IR1 Q31.2 for a detailed clarification.

Q30.0 Reference: Application, Appendix G, p. 81

Q30.1 Please provide a detailed calculation of each of the Ability to Provide Backup Power values for 2007/08.

A30.1 The detailed calculation philosophy for the capacity available for backup values for 2007/08 for Option 2, as indicated in Table G5, page 81 of the CPCN Application is indicated below in Table 30.1.

Table 30.1

Year	Sexsmith Transformer 1		Duck Lake Transformer 1		Ability of Duck Lake Substation to Provide Back Up Power to Sexsmith Substation		Ability of Sexsmith Substation to Provide Back Up Power to Duck Lake Substation	
	Station Transformer Nameplate Capacity (MVA)	**Station Forecast Load =** 101% Of Previous Year Load And Additional New Loads as Indicated In Table G1, page 77 of CPCN Application in MVA	**Station Transformer Nameplate Capacity (MVA)**	**Station Forecast Load =** 101% Of Previous Year Load And Additional New Loads as Indicated In Table G1, Page 77 Of CPCN Application in MVA	**F =** 125% OF Column D) - (Column E)	**G =** % (Column F / Column C)	**H** = 125% OF Column B) - (Column C)	**I =** % (Column H / Column E)
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
2007/08	**32**	**31.0**	**28**	**15.3**	**19.7**	**64%**	**9.0**	**59%**

Q30.2 Please explain what is meant by the comment, contained in the Notes to the table, that a contingency can only affect a single transformer beyond 2009/10 in the upgraded multi-transformer Sexsmith substation.

A30.2 The above comment in Table G5, page 81 of the CPCN Application refers specifically to the Sexsmith Substation.

The Sexsmith Substation is presently a single transformer substation. So, a station transformer outage will render complete shutdown of the substation.

However, Option 2 proposes to upgrade Sexsmith Substation to a two transformer substation during 2010. So, beyond 2009/10 a single transformer contingency at Sexsmith Substation will still ensure operation of the second station transformer and the substation will continue to remain in operation.

Incidentally, please note that the Sexsmith Substation is fed by a looped 138 kV transmission network and satisfies N-1 transmission criterion (a single transmission fault can only result in an intermittent outage at the most, but will not be able to shut down the substation during the entire duration of the fault).

Q31.0 Reference: Application, Appendix H, p. 83

Q31.1 Please provide a detailed calculation of each of the Capacity Available for Backup values for 2007/08.

A31.1 The detailed calculation philosophy for the capacity available for backup values for 2007/08 for Option 1, as indicated in Table G4, page 80 of the CPCN Application is indicated below in Table 31.1.

Table 31.1

Year	Sexsmith Transformer 1		Duck Lake Transformer 1		Ellison Transformer 1							
	Station Transformer Nameplate Capacity (MVA)	**STATION FORECAST LOAD =** 101% of previous year load and additional new loads as indicated in Table G1, page 77 of the CPCN Application. In MVA. Also in 2007/2008 10 MVA load is to be transferred from Sexsmith to the Proposed Ellison Substation through distribution feeders	**Station Transformer Nameplate Capacity (MVA)**	**STATION FORECAST LOAD =** 101% of previous year load and additional new loads as indicated in Table G1, page 77 of the CPCN Application. In MVA. Also in 2007/2008 5 MVA load is to be transferred from Duck Lake to the Proposed Ellison Substation through distribution feeders	**Proposed Station Transformer Nameplate Capacity (MVA)**	**STATION FORECAST LOAD =** New Loads as indicated in Table G1, page 77 of the CPCN Application. In MVA. Also in 2007/2008 15 MVA load in total is to be transferred from Duck Lake & Sexsmith substations (Refer comments in Column C & E) to the Proposed Ellison Substation through distribution feeders	**H1 = Capacity Available For Backup Of Sexsmith T1=** {125% X Column D - Column E) + (125% of 2nd Stage Cooling Of Ellison Transformer (40 MVA) - Column G} **H2 = % Capacity Availability =** % (Column H / Column C)		**I1 = Capacity Available For Backup Of Duck Lake T1=** {125% X Column B - Column C) + (125% of 2nd Stage Cooling of Ellison Transformer (40 MVA) - Column G} **I2 = % Capacity Availability =** % (Column I1 / Column E)		**J1 = Capacity Available For Backup Of Ellison T1=** {125% X Column B - Column C) + (125% of Column D - Column E} **J2 = % Capacity Availability =** % (Column J1 / Column G)	
A	**B**	**C**	**D**	**E**	**F**	**G**	**H1**	**H2**	**I1**	**I2**	**J1**	**J2**
2007/08	**32**	**19.7**	**28**	**6.8**	**32**	**19.0**	**59.3**	**301%**	**51.4**	**759%**	**48.6**	**256%**

Q31.2 Please explain what is meant by the comment below Table G4 regarding load transfer between substations.

A31.2 The comment below Table G4 regarding load transfer indicates the following:

1. During years 2007/2008, 10 MVA load in the Sexsmith Substation feeding zone/area will be transferred onto the proposed Ellison Substation feeding zone/area through change of isolation point in the relevant distribution feeders in the area.

2. During years 2007/2008, 5 MVA load in the Duck Lake Substation feeding zone/area will be transferred onto the proposed Ellison Substation feeding zone/area through change of isolation point in the relevant distribution feeders in the area.

3. During years 2013/2014, 5 MVA load in the Duck Lake Substation feeding zone/area will be transferred onto the proposed Ellison Substation feeding zone/area through change of isolation point in the relevant distribution feeders in the area.

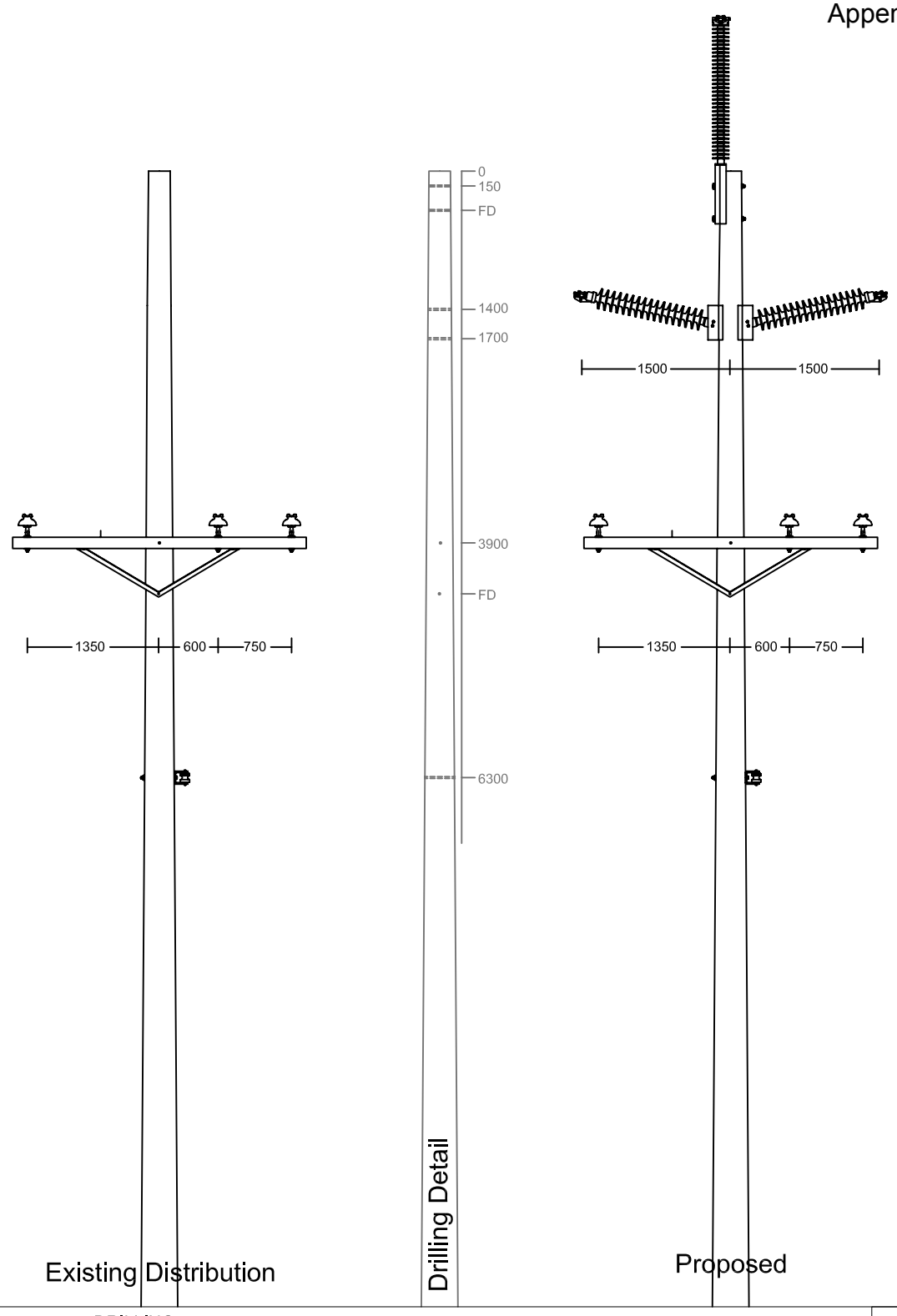
4. During years 2013/2014, 5 MVA load in the Sexsmith Substation feeding zone/area will be transferred onto the proposed Ellison Substation feeding zone/area through change of isolation point in the relevant distribution feeders in the area.

Q32.0 Reference: Application, Appendix I, pp. 85-87

Q32.1 Reference is made to lines in the tables that appear to have been left out of the Application. Please provide the missing parts of the tables.

A32.1 Please refer to the response to BCUC IR1 Q16.1.

Appendix A2.6



DRILLING

Notes:
1) Dimensions are in millimetres.
2) Drilling dimensions are for distribution separation of 2.4m (8').

REVISIONS

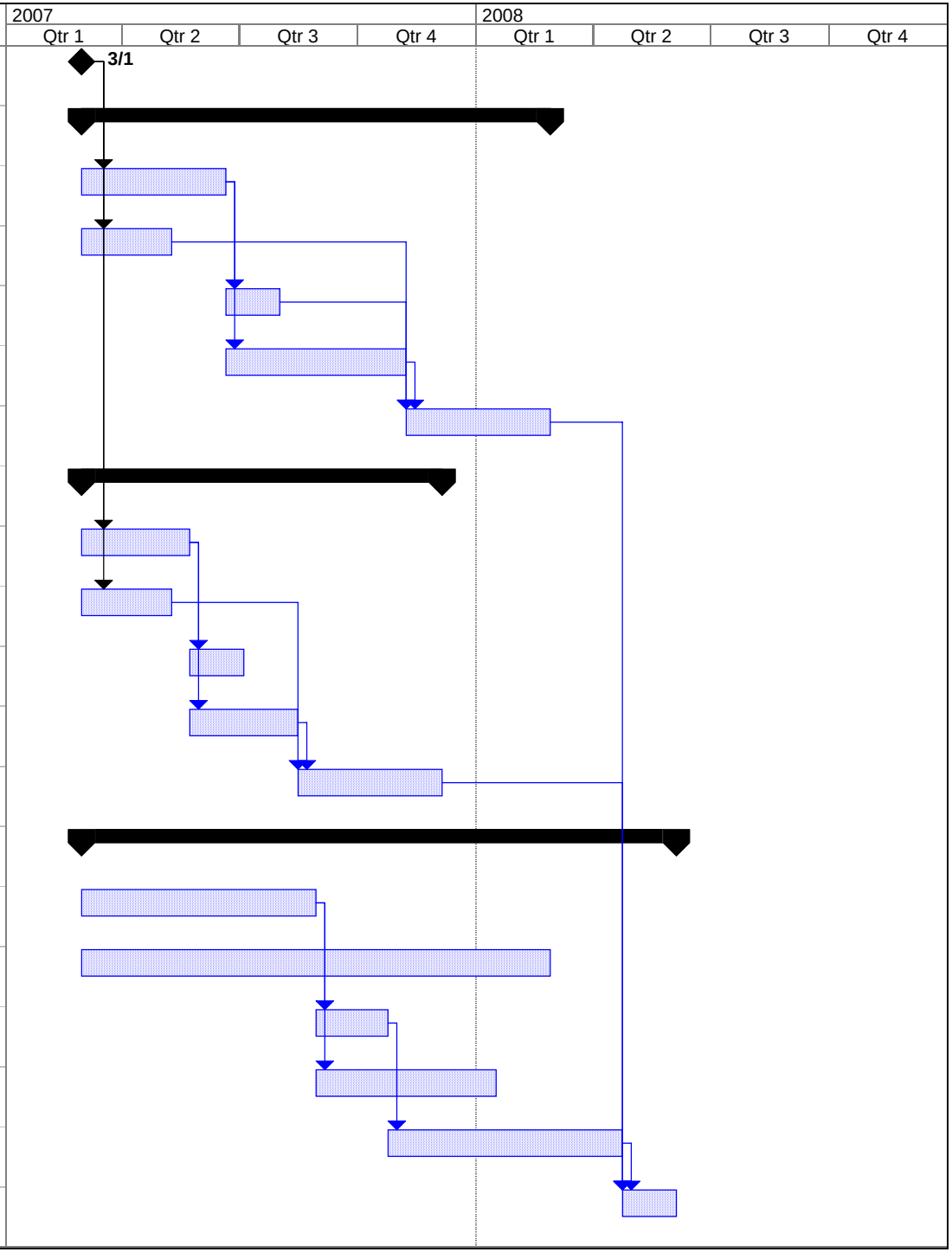
No.	BY	DATE	DESRIPTION	APP.
1	JMD	06/12/07	Added existing Distribution for comparison	
0	JMD	06/05/12	NEW DRAWING	

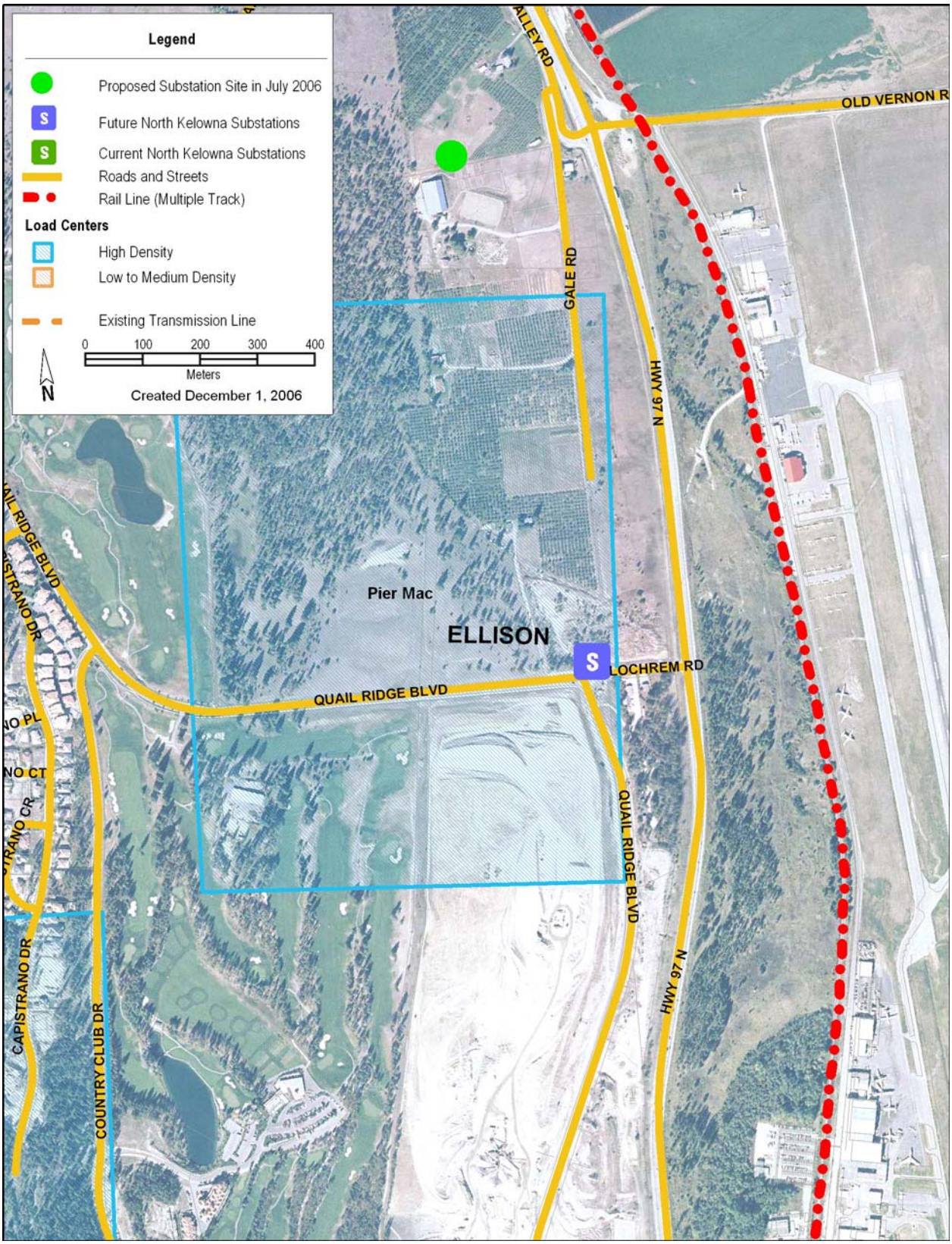
TYPICAL TANGENT STRUCTURE
North Kelowna Support Project

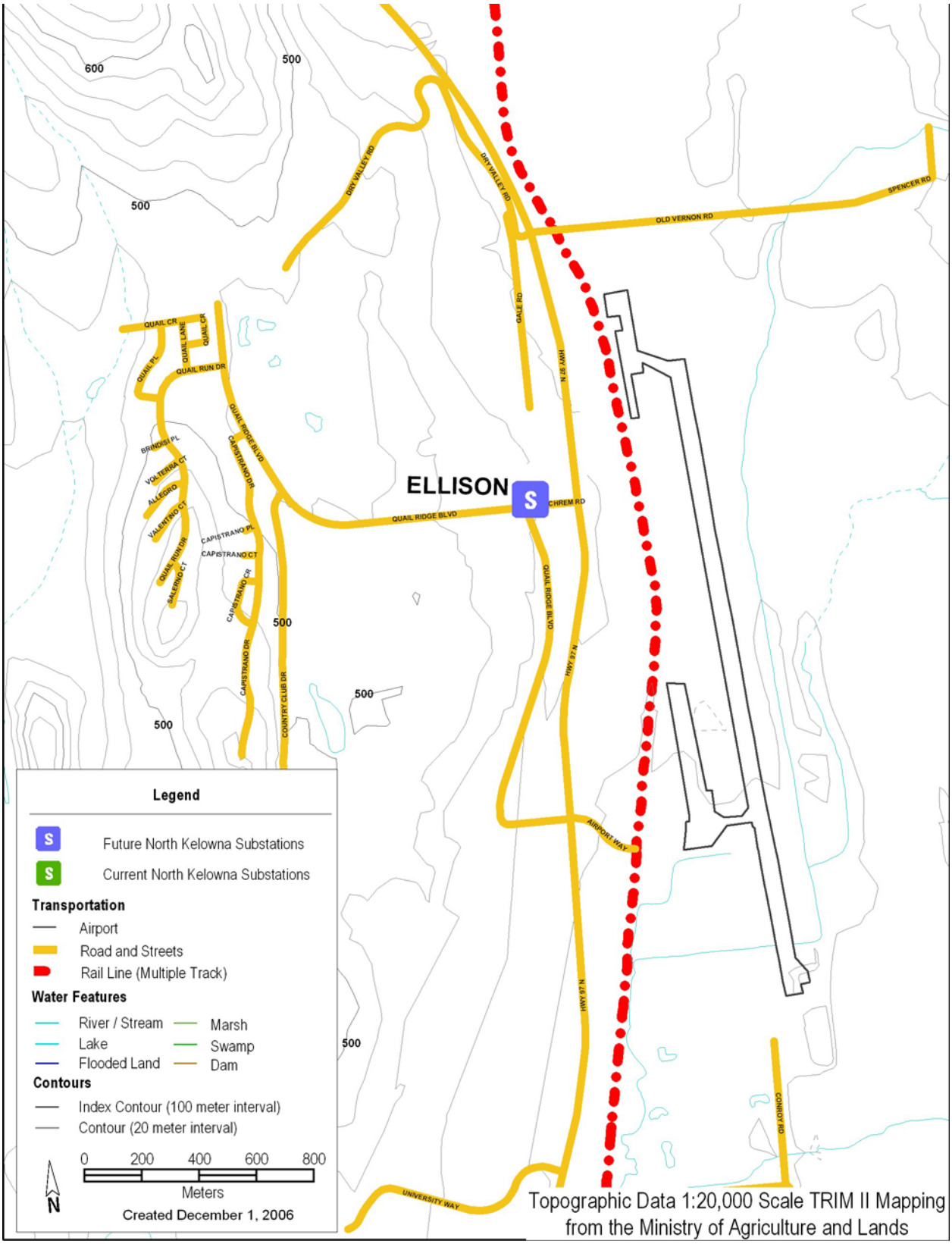
Detmold Consulting Ltd.

DRAWING No.	REV.
3176-1145	1

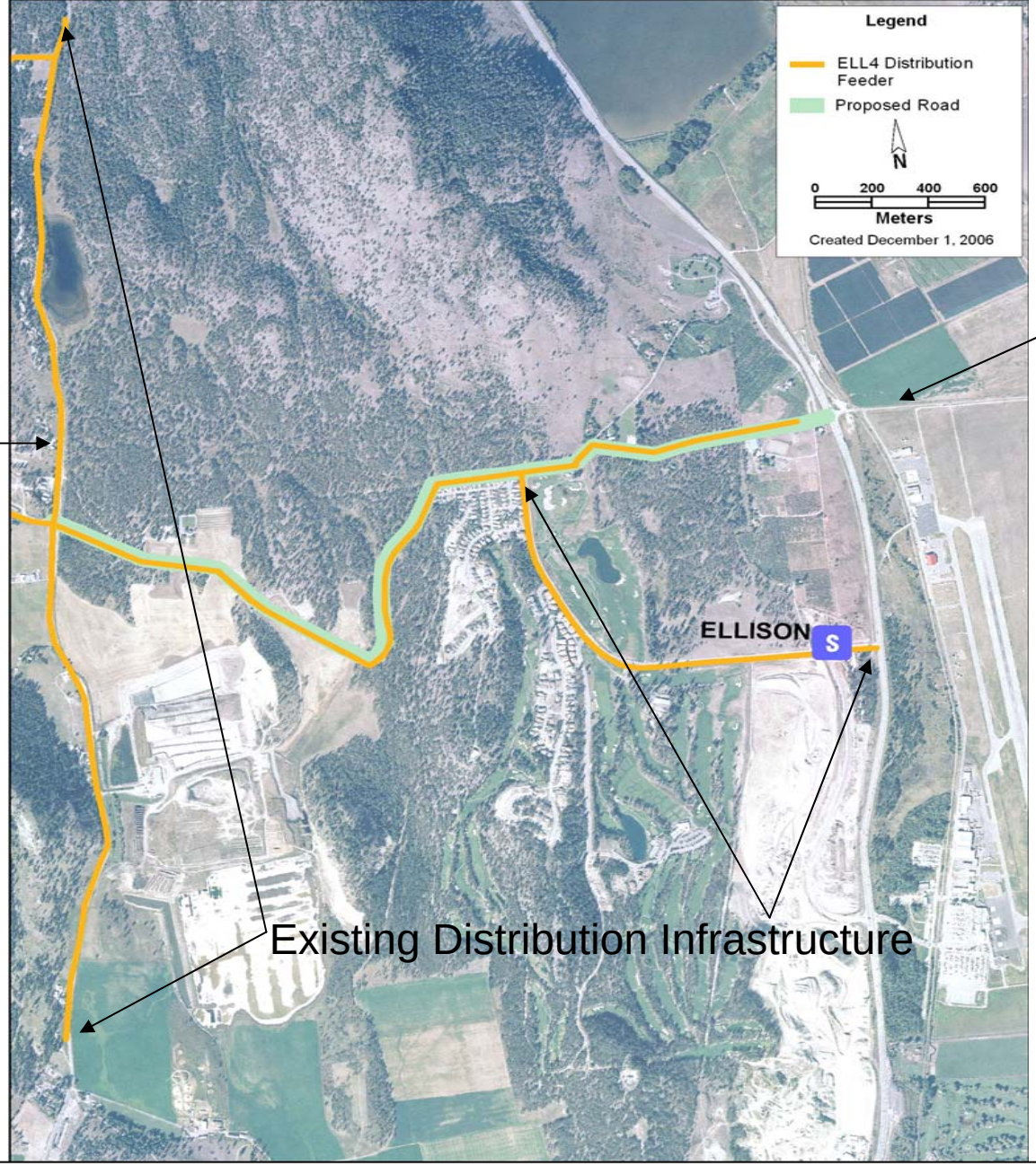
ID	Task Name
1	Expected CPCN Approval
2	**Transmission Line Construction (Duck Lake-Ellison)**
3	Engineering
4	ROW & Permitting
5	Tender
6	Procurement
7	Construction
8	**Ellison Distribution Upgrades**
9	Engineering
10	ROW & Permitting
11	Tender
12	Procurement
13	Construction
14	**Ellison Substation**
15	Engineering
16	Major Equipment Procurement
17	Tender
18	Procurement
19	Construuction
20	Commissioning




Legend
Proposed Substation Site in July 2006
Future North Kelowna Substations
Current North Kelowna Substations
Roads and Streets
Rail Line (Multiple Track)
Load Centers
High Density
Low to Medium Density
Existing Transmission Line
0 100 200 300 400
Meters
N
Created December 1, 2006
OLD VERNON R
GALE RD
HWY 97 N
Pier Mac
ELLISON
S
LOCHREM RD
QUAIL RIDGE BLVD
CAPISTRANO DR
COUNTRY CLUB DR


ELLISON
S
QUAIL RIDGE BLVD
CHREM RD
OLD VERNON RD
SPENCER RD
DRY VALLEY RD
GALE RD
HWY 97 N
QUAIL CR
QUAIL LANE
QUAIL RUN DR
QUAIL PL
BRINDISI PL
VOLTERRA CT
ALLEGRO
VALENTINO CT
SALERNO CT
CAPISTRANO PL
CAPISTRANO CT
CAPISTRANO CR
CAPISTRANO DR
COUNTRY CLUB DR
AIRPORT WAY
UNIVERSITY WAY
CONROY RD
600
500
Legend
Future North Kelowna Substations
Current North Kelowna Substations
Transportation
Airport
Road and Streets
Rail Line (Multiple Track)
Water Features
River / Stream
Lake
Flooded Land
Marsh
Swamp
Dam
Contours
Index Contour (100 meter interval)
Contour (20 meter interval)
0 200 400 600 800
Meters
N
Created December 1, 2006
Topographic Data 1:20,000 Scale TRIM II Mapping
from the Ministry of Agriculture and Lands

Appendix A15.1



Ellison 13 kV Feeder 4 – New Extension

Option 1

Option1: Ellison Substation & ROW Cost for Future Transmission Interconnection

Line No.		Reference	Dec-04	Dec-05	Year: Dec-06	0 Dec-07	1 Dec-08	2 Dec-09	3 Dec-10	4 Dec-11	5 Dec-12	6 Dec-13	7 Dec-14	8 Dec-15
	Summary													
	Revenue Requirements													
1	Operating Expense (Incremental)	Line 31	0	0	11	176	182	188	200	207	214	222	230	238
2	Depreciation Expense	Line 36	0	0	0	0	473	473	473	589	589	589	589	589
3	Carrying Costs	Line 43	0	0	93	679	1,158	1,123	1,232	1,337	1,293	1,249	1,205	1,161
4	Income Tax	Line 60	0	0	(27)	(203)	(78)	(39)	(46)	4	40	73	102	128
5	Total Revenue Requirement for Project		0	0	76	653	1,736	1,746	1,859	2,136	2,136	2,132	2,126	2,116
6	**Net Present Value of Revenue Requirement**	10.00%			**17,718**									
	Rate Impact													
7	**Forecast Revenue Requirements**		178,818	182,394	**197,404**	206,758	225,193	241,458	246,287	251,213	256,237	261,362	266,589	271,921
8	Rate Impact		0.00%	0.00%	0.04%	0.32%	0.77%	0.72%	0.76%	0.85%	0.83%	0.82%	0.80%	0.78%
	Annual Incremental Rate Impact over previous year			0.00%	0.04%	**0.28%**	0.46%	-0.05%	0.03%	0.10%	-0.02%	-0.02%	-0.02%	-0.02%
9	**NPV of Project / Total Revenue Requirements**				**0.61%**									
	Regulatory Assumptions													
10	Equity Component		40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
11	Debt Component		60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%
12	Equity Return		8.69%	9.88%	9.20%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%
13	Debt Return		6.53%	6.49%	6.51%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%
	Capital Cost													
14	61 Line New Construction at 138kv as Double Circuit Overbuild				480	880								
15	Modification of Duck Lake Substation to Emanate Proposed 61L					1,850								
16	Ellison Substation					5,990			1,093					
17	Land / ROW / Environmental Cost				1,170	290								
18	Transmission Line from Ellison to 50L Tap Point								1,743					
19	Fibre Optic & Motor Operated Disconnect Switches at 50L Tap					200								
20	Distribution Upgrades				700	3,630			530					
21	SCADA Controlled MODs								379					
22	AFUDC				90	490			120					
23														
24	Total Cash Outlay in Year		0	0	**2,440**	**13,330**	0	0	**3,865**	0	0	0	0	0
25	Cumulative Cash Outlay		0	0	2,440	15,770	15,770	15,770	19,635	19,635	19,635	19,635	19,635	19,635
26			0			0	0	0	0	0	0	0	0	0
27	Cumulative Project Cost		0	0	2,440	15,770	15,770	15,770	19,635	19,635	19,635	19,635	19,635	19,635
	Annual Operating Costs / (Savings)													
28	Line Losses					41	45	48	52	56	60	64	69	75
29	Maintenance				10	14	14	15	20	20	21	21	22	22
30	Property Taxes		0	0	1	121	123	126	128	131	134	136	139	142
31	Total Incremental Operating Costs (Savings)		0	0	11	176	182	188	200	207	214	222	230	238
	(Forecast inflation rate 2%)													
	Depreciation Expense													
32	Opening Cash Outlay		0	0	0	2,440	15,770	15,770	15,770	19,635	19,635	19,635	19,635	19,635
33	Additions in Year	Line 24	0	0	2,440	13,330	0	0	3,865	0	0	0	0	0
34	Cumulative Total		0	0	2,440	15,770	15,770	15,770	19,635	19,635	19,635	19,635	19,635	19,635
35	Depreciation Rate - composite average		3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
36	Depreciation Expense		0	0	0	0	473	473	473	589	589	589	589	589
	Net Book Value													
37	Gross Property	Line 25	0	0	2,440	15,770	15,770	15,770	19,635	19,635	19,635	19,635	19,635	19,635
38	Accumulated Depreciation		0	0	0	0	(473)	(946)	(1,419)	(2,008)	(2,597)	(3,186)	(3,776)	(4,365)
39	Net Book Value		0	0	2,440	15,770	15,297	14,824	18,216	17,627	17,038	16,449	15,860	15,270
	Carrying Costs on Average NBV													
40	Return on Equity		0	0	45	329	561	544	597	647	626	605	583	562
41	Interest Expense		0	0	48	350	597	579	635	689	667	644	621	599
42	AFUDC	Line 23	0	0	0	0	0	0	0	0	0	0	0	0
43	**Total Carrying Costs**		0	0	93	679	1,158	1,123	1,232	1,337	1,293	1,249	1,205	1,161
	Income Tax Expense													
44	Combined Income Tax Rate		34.12%	34.12%	34.12%	34.12%	32.50%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%
	Income Tax on Equity Return													
45	Return on Equity	Line 40	0	0	45	329	561	544	597	647	626	605	583	562
46	Gross up for revenue (Return / (1- tax rate)		0	0	68	499	831	800	877	952	921	889	858	827
47	Less: Income tax on Equity Return		0	0	23	170	270	256	281	305	295	285	275	265
48	Net Income (equal return on equity)		0	0	45	329	561	544	597	647	626	605	583	562
	Income Tax on Timing Differences													
49	Depreciation Expense		0	0	0	0	473	473	473	589	589	589	589	589
50	Less: Capital Cost Allowance	Line 67	0	0	98	721	1,196	1,100	1,167	1,228	1,130	1,040	956	880
51	Total Timing Differences		0	0	(98)	(721)	(723)	(627)	(694)	(639)	(541)	(451)	(367)	(291)
52	Income Tax on Timing Differences		0	0	(33)	(246)	(235)	(201)	(222)	(205)	(173)	(144)	(118)	(93)
53	Before Tax Revenue Requirement [=Line 52/(1-tax)]		0	0	(51)	(373)	(348)	(295)	(327)	(301)	(255)	(212)	(173)	(137)
60	**Total Income Tax**	Lines 47 + 53	0	0	(27)	(203)	(78)	(39)	(46)	4	40	73	102	128
	Capital Cost Allowance													
61	Opening Balance - UCC		0	0	0	2,342	14,952	13,756	12,655	15,353	14,125	12,995	11,955	10,999
62	Total Cash Outlay		0	0	2,440	13,330	0	0	3,865	0	0	0	0	0
63	Subtotal UCC		0	0	2,440	15,672	14,952	13,756	16,520	15,353	14,125	12,995	11,955	10,999
64	Capital Cost Allowance Rate		8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
65	CCA on Opening Balance		0	0	0	187	1,196	1,100	1,012	1,228	1,130	1,040	956	880
66	CCA on Capital Expenditures (1/2 yr rule)		0	0	98	533	0	0	155	0	0	0	0	0
67	Total CCA		0	0	98	721	1,196	1,100	1,167	1,228	1,130	1,040	956	880
68	Ending Balance UCC		0	0	2,342	14,952	13,756	12,655	15,353	14,125	12,995	11,955	10,999	10,119

Option 2

Option 2: Expansion of Existing Sexsmith Substation

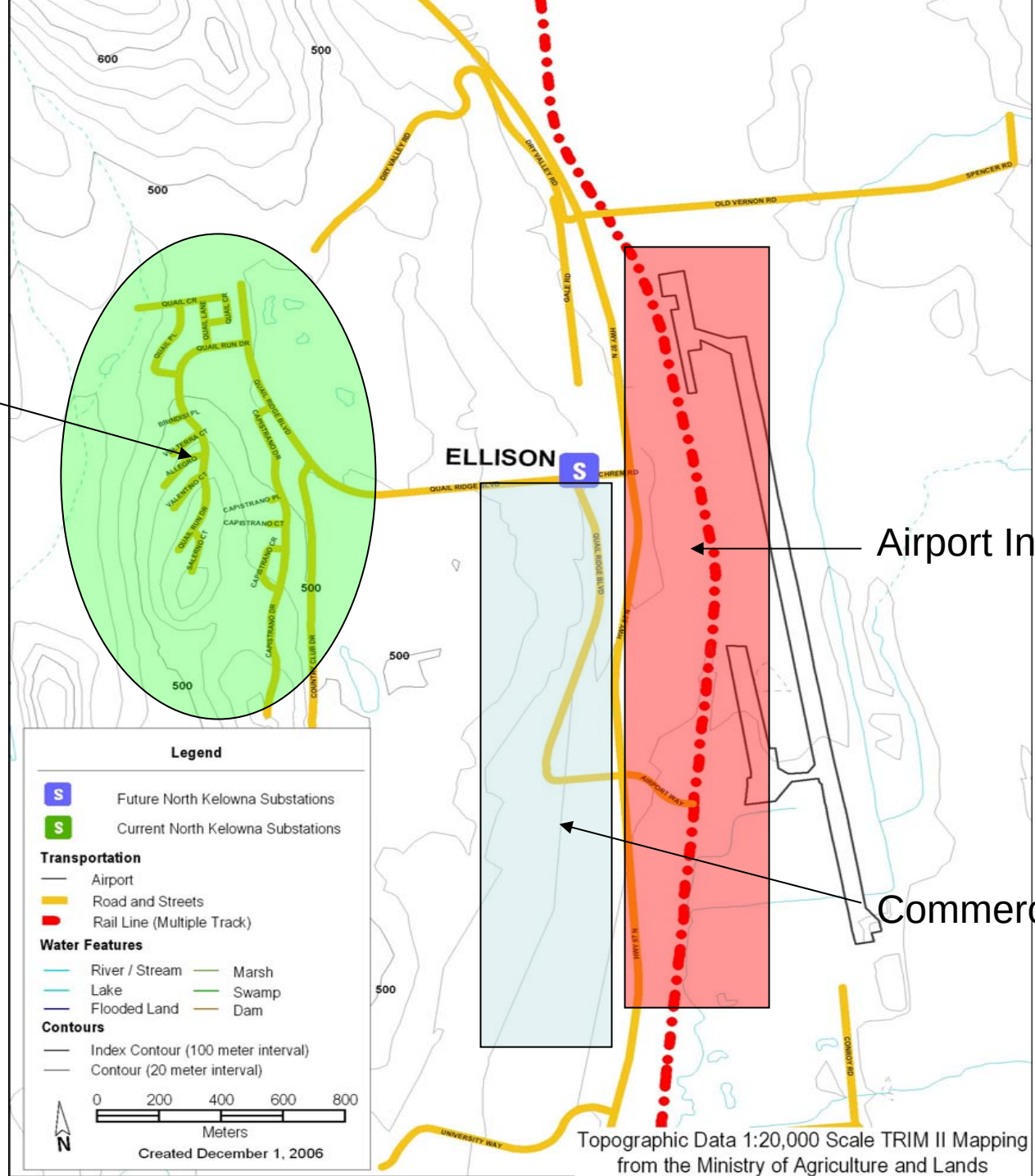
Line No.		Reference	Dec-04	Dec-05	Year: Dec-06	0 Dec-07	1 Dec-08	2 Dec-09	3 Dec-10	4 Dec-11	5 Dec-12	6 Dec-13	7 Dec-14	8 Dec-15
	Summary													
	Revenue Requirements													
1	Operating Expense (Incremental)	Line 29	0	0	16	117	122	127	132	138	144	150	157	164
2	Depreciation Expense	Line 34	0	0	0	0	0	230	502	823	823	823	823	823
3	Carrying Costs	Line 41	0	0	0	24	(10)	381	902	1,961	1,900	1,838	1,777	1,716
4	Income Tax	Line 60	0	0	0	(17)	(94)	(130)	(177)	(85)	(25)	28	76	120
5	Total Revenue Requirement for Project		0	0	16	125	18	608	1,359	2,837	2,841	2,840	2,834	2,823
6	**Net Present Value of Revenue Requirement**	10.00%			**18,841**									
	Rate Impact													
7	**Forecast Revenue Requirements**		178,818	182,394	**197,404**	206,758	225,193	241,458	246,287	251,213	256,237	261,362	266,589	271,921
8	Rate Impact		0.00%	0.00%	0.01%	0.06%	0.01%	0.25%	0.55%	1.13%	1.11%	1.09%	1.06%	1.04%
	Annual Incremental Rate Impact over previous year			0.00%	0.01%	**0.05%**	-0.05%	0.24%	0.30%	0.58%	-0.02%	-0.02%	-0.02%	-0.02%
9	**NPV of Project / Total Revenue Requirements**				**0.65%**									
	Regulatory Assumptions													
10	Equity Component		40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
11	Debt Component		60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%
12	Equity Return		8.69%	9.88%	9.20%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%
13	Debt Return		6.53%	6.49%	6.51%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%
	Capital Cost													
14	Upgradation of Sexsmith Substation & Feeder Reactor Installation							4,030	4,300					
15	Feeder Reactors at Sexsmith to reduce Fault Level								1,270					
16	Additional Land Development Cost for Sexsmith							620						
17	Distribution Upgrade--Sexsmith							3,870	4,370					
18	ROW / Environmental Cost					40	40	40	50					
19	Duck Lake Sub: Egress of 2 additional Feeders					920	3,060							
20	Duck Lake : 2 additional Distribution Feeder Upgrade / Integration					470	2,750							
21	AFUDC					30	350	520	710					
22	Total Cash Outlay in Year		0	0	0	1,460	6,200	9,080	10,700	0	0	0	0	0
23	Cumulative Cash Outlay		0	0	0	1,460	7,660	16,740	27,440	27,440	27,440	27,440	27,440	27,440
25	Cumulative Project Cost		0	0	0	1,460	7,660	16,740	27,440	27,440	27,440	27,440	27,440	27,440
	Annual Operating Costs / (Savings)													
26	Line Losses					43	46	50	54	58	62	67	72	77
27	Maintenance				15	24	24	25	25	26	26	27	28	28
28	Property Taxes (At Sexsmith)		0	0	1	50	51	52	53	54	55	56	57	59
29	Total Incremental Operating Costs (Savings)		0	0	16	117	122	127	132	138	144	150	157	164
	(Forecast inflation rate 2%)													
	Depreciation Expense													
30	Opening Cash Outlay		0	0	0	0	1,460	7,660	16,740	27,440	27,440	27,440	27,440	27,440
31	Additions in Year	Line 22	0	0	0	1,460	6,200	9,080	10,700	0	0	0	0	0
32	Cumulative Total		0	0	0	1,460	7,660	16,740	27,440	27,440	27,440	27,440	27,440	27,440
33	Depreciation Rate - composite average		3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
34	Depreciation Expense		0	0	0	0	0	230	502	823	823	823	823	823
	Net Book Value													
35	Gross Property	Line 23	0	0	0	1,460	7,660	16,740	27,440	27,440	27,440	27,440	27,440	27,440
36	Accumulated Depreciation		0	0	0	0	0	(230)	(732)	(1,555)	(2,378)	(3,202)	(4,025)	(4,848)
37	Net Book Value		0	0	0	1,460	7,660	16,510	26,708	25,885	25,062	24,238	23,415	22,592
	Carrying Costs on Average NBV													
38	Return on Equity		0	0	0	26	165	437	781	950	920	890	861	831
39	Interest Expense		0	0	0	28	175	465	831	1,011	980	948	916	885
40	AFUDC	Line 21	0	0	0	(30)	(350)	(520)	(710)	0	0	0	0	0
41	**Total Carrying Costs**		0	0	0	24	(10)	381	902	1,961	1,900	1,838	1,777	1,716
	Income Tax Expense													
42	Combined Income Tax Rate		34.12%	34.12%	34.12%	34.12%	32.50%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%
	Income Tax on Equity Return													
43	Return on Equity	Line 38	0	0	0	26	165	437	781	950	920	890	861	831
44	Gross up for revenue (Return / (1- tax rate)		0	0	0	40	244	642	1,148	1,397	1,353	1,309	1,266	1,222
45	Less: Income tax on Equity Return		0	0	0	14	79	205	367	447	433	419	405	391
46	Net Income (equal return on equity)		0	0	0	26	165	437	781	950	920	890	861	831
	Income Tax on Timing Differences													
47	Depreciation Expense		0	0	0	0	0	230	502	823	823	823	823	823
48	Less: Capital Cost Allowance	Line 67	0	0	0	58	360	943	1,658	1,954	1,797	1,654	1,521	1,400
49	Total Timing Differences		0	0	0	(58)	(360)	(713)	(1,156)	(1,130)	(974)	(830)	(698)	(576)
50	Income Tax on Timing Differences		0	0	0	(20)	(117)	(228)	(370)	(362)	(312)	(266)	(223)	(184)
51	Before Tax Revenue Requirement [=Line 52/(1-tax)]		0	0	0	(30)	(173)	(335)	(544)	(532)	(458)	(391)	(329)	(271)
60	**Total Income Tax**	Lines 45 + 51	0	0	0	(17)	(94)	(130)	(177)	(85)	(25)	28	76	120
	Capital Cost Allowance													
61	Opening Balance - UCC		0	0	0	0	1,402	7,241	15,379	24,421	22,467	20,670	19,016	17,495
62	Total Cash Outlay		0	0	0	1,460	6,200	9,080	10,700	0	0	0	0	0
63	Subtotal UCC		0	0	0	1,460	7,602	16,321	26,079	24,421	22,467	20,670	19,016	17,495
64	Capital Cost Allowance Rate		8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
65	CCA on Opening Balance		0	0	0	0	112	579	1,230	1,954	1,797	1,654	1,521	1,400
66	CCA on Capital Expenditures (1/2 yr rule)		0	0	0	58	248	363	428	0	0	0	0	0
67	Total CCA		0	0	0	58	360	943	1,658	1,954	1,797	1,654	1,521	1,400
68	Ending Balance UCC		0	0	0	1,402	7,241	15,379	24,421	22,467	20,670	19,016	17,495	16,095

Option 3

Option 3: Expansion of Existing Duck Lake & Sexsmith Substations

Line No.		Reference	Dec-04	Dec-05	Year: Dec-06	0 Dec-07	1 Dec-08	2 Dec-09	3 Dec-10	4 Dec-11	5 Dec-12	6 Dec-13	7 Dec-14	8 Dec-15
	Summary													
	Revenue Requirements													
1	Operating Expense (Incremental)	Line 31	0	0	16	117	122	127	132	138	144	150	157	164
2	Depreciation Expense	Line 36	0	0	0	0	559	559	625	1,193	1,193	1,193	1,193	1,193
3	Carrying Costs	Line 43	0	0	107	799	1,368	1,409	2,153	2,791	2,702	2,613	2,524	2,435
4	Income Tax	Line 60	0	0	(31)	(239)	(92)	(69)	(214)	(78)	4	77	143	203
5	Total Revenue Requirement for Project		0	0	91	677	1,956	2,025	2,696	4,044	4,042	4,033	4,017	3,995
6	**Net Present Value of Revenue Requirement**	10.00%			**29,941**									
	Rate Impact													
7	**Forecast Revenue Requirements**		178,818	182,394	**197,404**	206,758	225,193	241,458	246,287	251,213	256,237	261,362	266,589	271,921
8	Rate Impact		0.00%	0.00%	0.05%	0.33%	0.87%	0.84%	1.09%	1.61%	1.58%	1.54%	1.51%	1.47%
	Annual Incremental Rate Impact over previous year			0.00%	0.05%	**0.28%**	0.54%	-0.03%	0.26%	0.52%	-0.03%	-0.03%	-0.04%	-0.04%
9	**NPV of Project / Total Revenue Requirements**				**1.04%**									
	Regulatory Assumptions													
10	Equity Component		40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%
11	Debt Component		60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%	60.00%
12	Equity Return		8.69%	9.88%	9.20%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%	9.03%
13	Debt Return		6.53%	6.49%	6.51%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%	6.41%
	Capital Cost													
14	Upgradation of Sexsmith Substation & Feeder Reactor Installation				880	7,040								
15	Feeder Reactors at Sexsmith to reduce Fault Level					1,190								
16	Upgradation of Duck Lake Substation & Feeder Reactor Installation							810	8,350					
17	Feeder Reactors at Duck Lake to reduce Fault Level								950					
18	Additional Land Development Cost for Sexsmith				590									
19	Distribution Upgrade--Duck Lake							1,300	8,650					
20	Distribution Upgrade--Sexsmith				1,230	6,590								
21	ROW / Environmental Cost				40	40		40	50					
22	AFUDC				70	950		60	930					
23														
24	Total Cash Outlay in Year		0	0	2,810	15,810	0	2,210	18,930	0	0	0	0	0
25	Cumulative Cash Outlay		0	0	2,810	18,620	18,620	20,830	39,760	39,760	39,760	39,760	39,760	39,760
26			0			0	0	0	0	0	0	0	0	0
27	Cumulative Project Cost		0	0	2,810	18,620	18,620	20,830	39,760	39,760	39,760	39,760	39,760	39,760
	Annual Operating Costs / (Savings)													
28	Line Losses					43	46	50	54	58	62	67	72	77
29	Maintenance				15	24	24	25	25	26	26	27	28	28
30	Property Taxes (At Sexsmith)		0	0	1	50	51	52	53	54	55	56	57	59
31	Total Incremental Operating Costs (Savings)		0	0	16	117	122	127	132	138	144	150	157	164
	(Forecast inflation rate 2%)													
	Depreciation Expense													
32	Opening Cash Outlay		0	0	0	2,810	18,620	18,620	20,830	39,760	39,760	39,760	39,760	39,760
33	Additions in Year	Line 24	0	0	2,810	15,810	0	2,210	18,930	0	0	0	0	0
34	Cumulative Total		0	0	2,810	18,620	18,620	20,830	39,760	39,760	39,760	39,760	39,760	39,760
35	Depreciation Rate - composite average		3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
36	Depreciation Expense		0	0	0	0	559	559	625	1,193	1,193	1,193	1,193	1,193
	Net Book Value													
37	Gross Property	Line 25	0	0	2,810	18,620	18,620	20,830	39,760	39,760	39,760	39,760	39,760	39,760
38	Accumulated Depreciation		0	0	0	0	(559)	(1,117)	(1,742)	(2,935)	(4,128)	(5,321)	(6,513)	(7,706)
39	Net Book Value		0	0	2,810	18,620	18,061	19,713	38,018	36,825	35,632	34,440	33,247	32,054
	Carrying Costs on Average NBV													
40	Return on Equity		0	0	52	387	662	682	1,043	1,352	1,309	1,265	1,222	1,179
41	Interest Expense		0	0	55	412	705	726	1,110	1,439	1,393	1,347	1,302	1,256
42	AFUDC	Line 23	0	0	0	0	0	0	0	0	0	0	0	0
43	**Total Carrying Costs**		0	0	107	799	1,368	1,409	2,153	2,791	2,702	2,613	2,524	2,435
	Income Tax Expense													
44	Combined Income Tax Rate		34.12%	34.12%	34.12%	34.12%	32.50%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%	32.00%
	Income Tax on Equity Return													
45	Return on Equity	Line 40	0	0	52	387	662	682	1,043	1,352	1,309	1,265	1,222	1,179
46	Gross up for revenue (Return / (1- tax rate)		0	0	78	587	981	1,003	1,533	1,988	1,924	1,861	1,798	1,734
47	Less: Income tax on Equity Return		0	0	27	200	319	321	491	636	616	596	575	555
48	Net Income (equal return on equity)		0	0	52	387	662	682	1,043	1,352	1,309	1,265	1,222	1,179
	Income Tax on Timing Differences													
49	Depreciation Expense		0	0	0	0	559	559	625	1,193	1,193	1,193	1,193	1,193
50	Less: Capital Cost Allowance	Line 67	0	0	112	848	1,413	1,388	2,123	2,710	2,493	2,294	2,110	1,941
51	Total Timing Differences		0	0	(112)	(848)	(854)	(830)	(1,498)	(1,517)	(1,300)	(1,101)	(917)	(749)
52	Income Tax on Timing Differences		0	0	(38)	(289)	(278)	(265)	(479)	(486)	(416)	(352)	(294)	(240)
53	Before Tax Revenue Requirement [=Line 52/(1-tax)]		0	0	(58)	(439)	(411)	(390)	(705)	(714)	(612)	(518)	(432)	(352)
60	**Total Income Tax**	Lines 47 + 53	0	0	(31)	(239)	(92)	(69)	(214)	(78)	4	77	143	203
	Capital Cost Allowance													
61	Opening Balance - UCC		0	0	0	2,698	17,659	16,247	17,069	33,876	31,166	28,673	26,379	24,268
62	Total Cash Outlay		0	0	2,810	15,810	0	2,210	18,930	0	0	0	0	0
63	Subtotal UCC		0	0	2,810	18,508	17,659	18,457	35,999	33,876	31,166	28,673	26,379	24,268
64	Capital Cost Allowance Rate		8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%	8.00%
65	CCA on Opening Balance		0	0	0	216	1,413	1,300	1,365	2,710	2,493	2,294	2,110	1,941
66	CCA on Capital Expenditures (1/2 yr rule)		0	0	112	632	0	88	757	0	0	0	0	0
67	Total CCA		0	0	112	848	1,413	1,388	2,123	2,710	2,493	2,294	2,110	1,941
68	Ending Balance UCC		0	0	2,698	17,659	16,247	17,069	33,876	31,166	28,673	26,379	24,268	22,327

Appendix A19.5



FORTISBC

Ellison Project

Quail Ridge Residents Association
October 24, 2006
Kelowna, BC

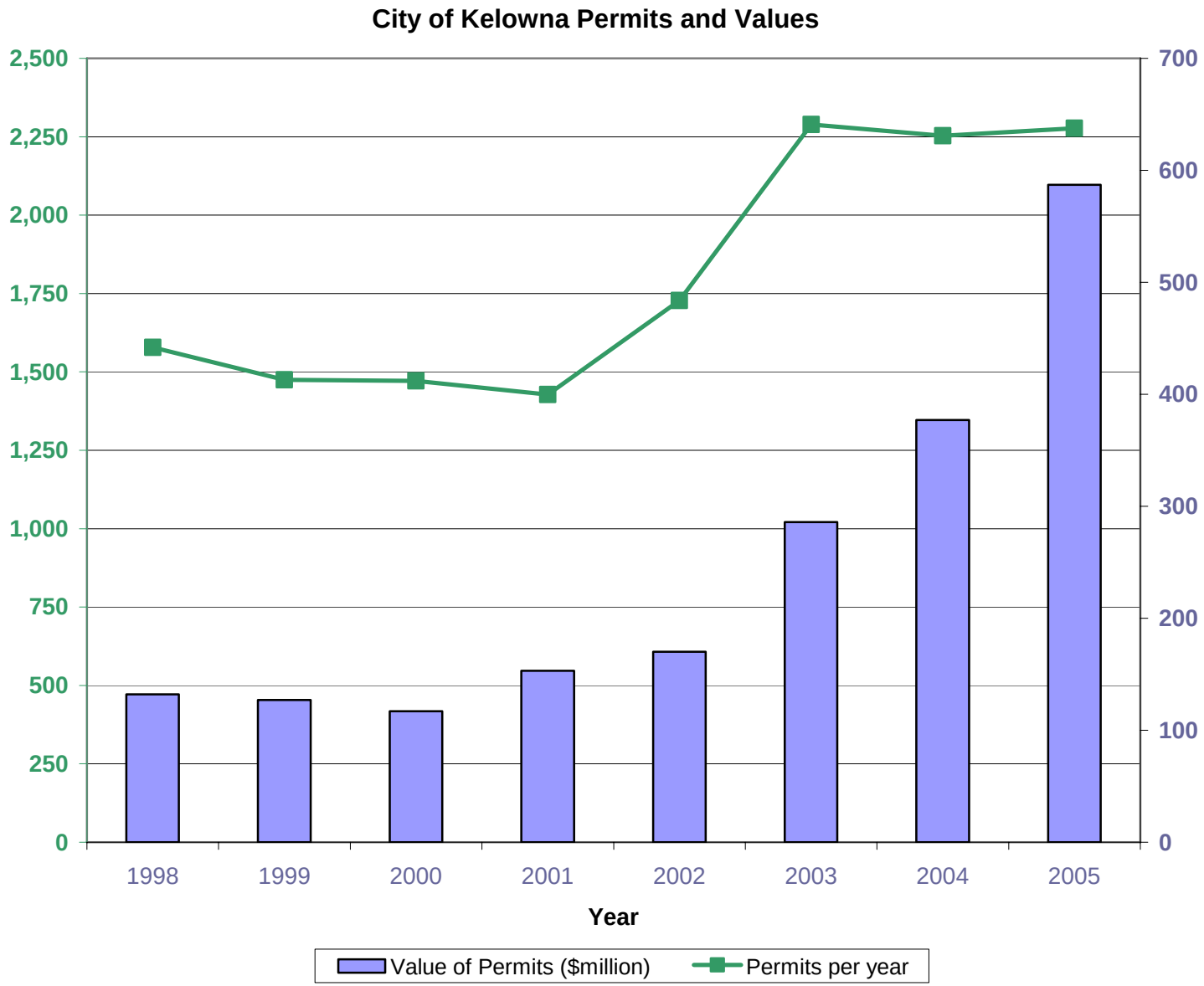
Agenda

Overview of Ellison Project

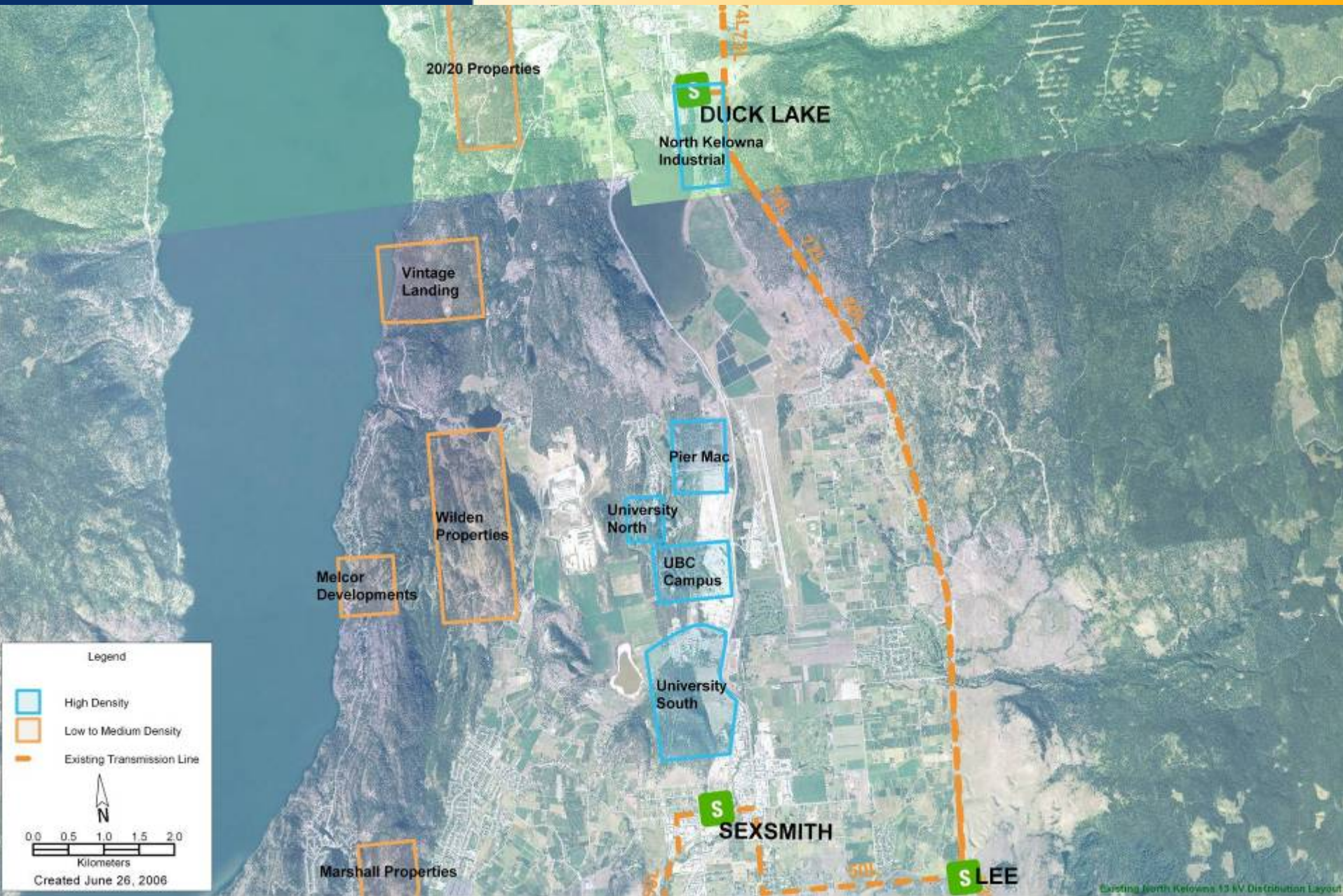
- Need
- Location and View

Question and Answers

The Construction Story



North Kelowna Development



Growth

- Rapid development in the north Kelowna area creating an electrical load increase equivalent to **800 to 1,000 additional homes per year**

- Existing lines and substations will soon be inadequate

System Capacity

Development = Greater Demand for Electricity

- FortisBC has an obligation to serve customers with safe, reliable and cost effective electricity.
- Existing system is at or near capacity.
- New lines and substation equipment are ***required to keep the lights on***.

Reliability

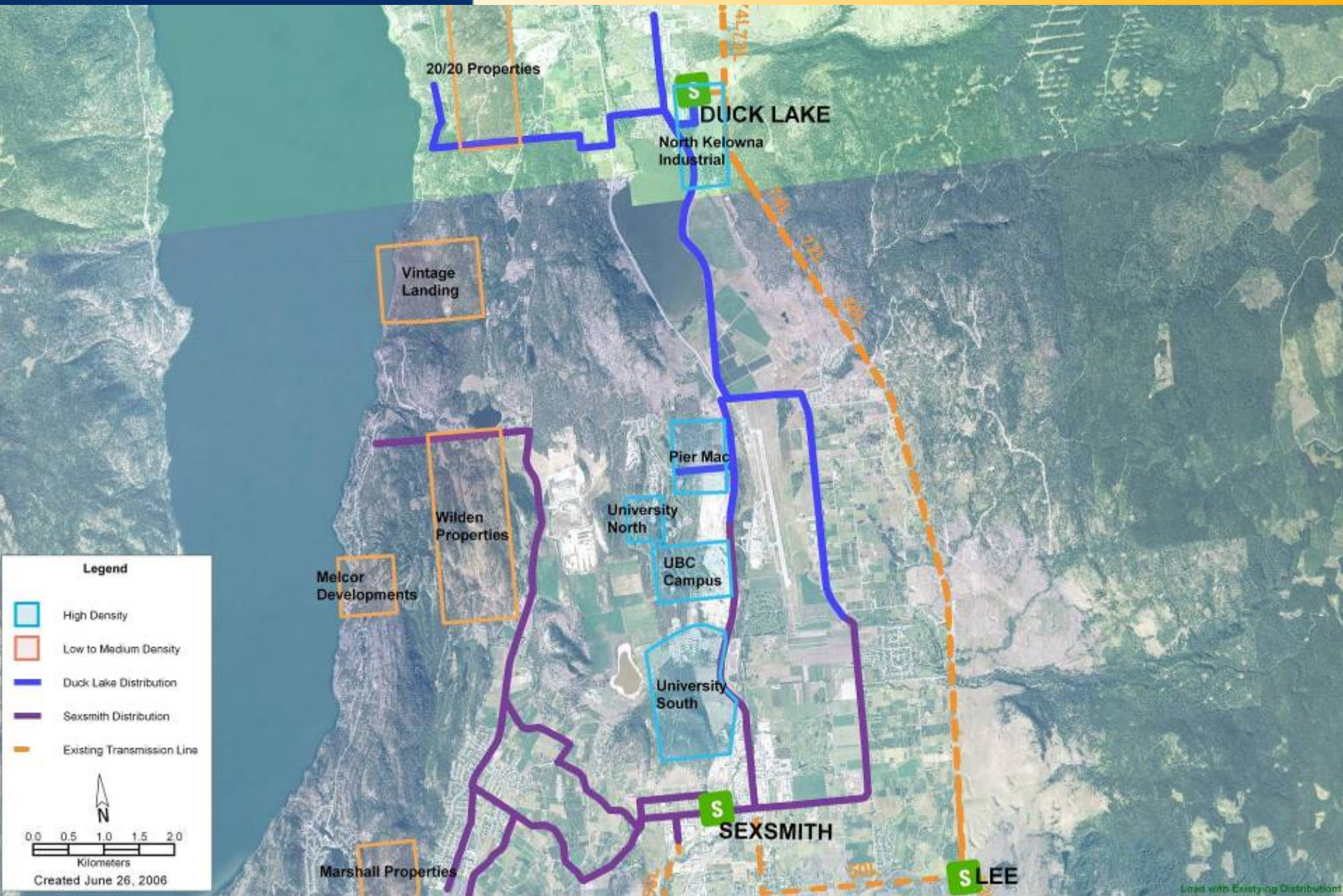
Three criteria for reliable power:

1. Substations should be backed up.
2. Distribution networks should be backed up.
3. Back up should be in place for a single transmission line failure (N-1) in urban areas.

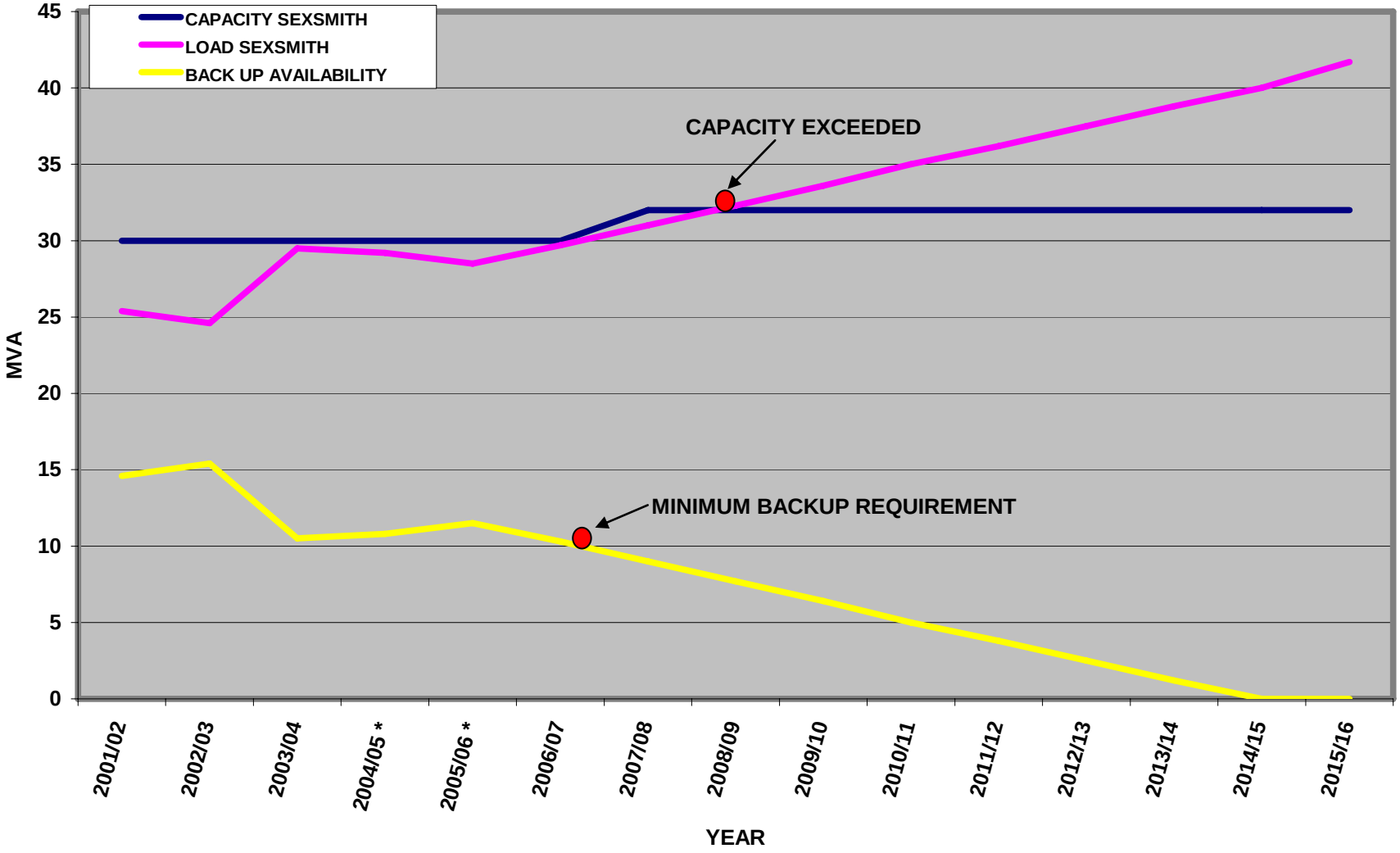
Cost

- as an area monopoly, all of our costs are reviewed by the BC Utilities Commission
- efforts must be made to keep project costs reasonable to ensure that electricity rates are kept reasonable
- FortisBC is allowed a specific rate of return on capital investment

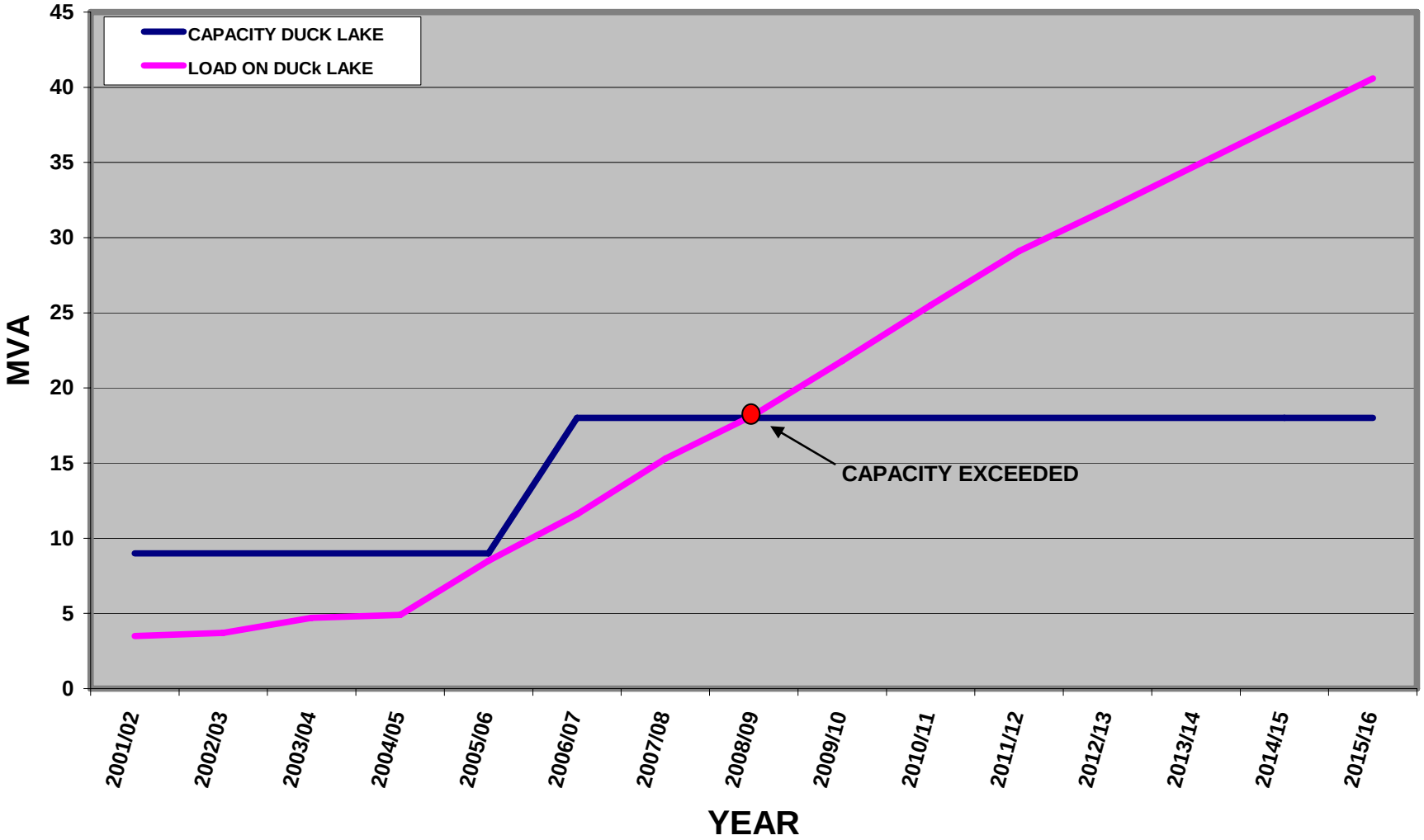
Existing North Kelowna System



Load Growth - Sexsmith



Load Growth – Duck Lake



Ellison Project Options

SAFETY RELIABILITY STAKEHOLDER INPUT COST

Option 1 - (preferred)

- New substation
- Construct 4 distribution lines
- Construct transmission line

Option 2

- Expand existing Sexsmith substation
- Construct 6 distribution lines (from Sexsmith and Duck Lake)

Option 3

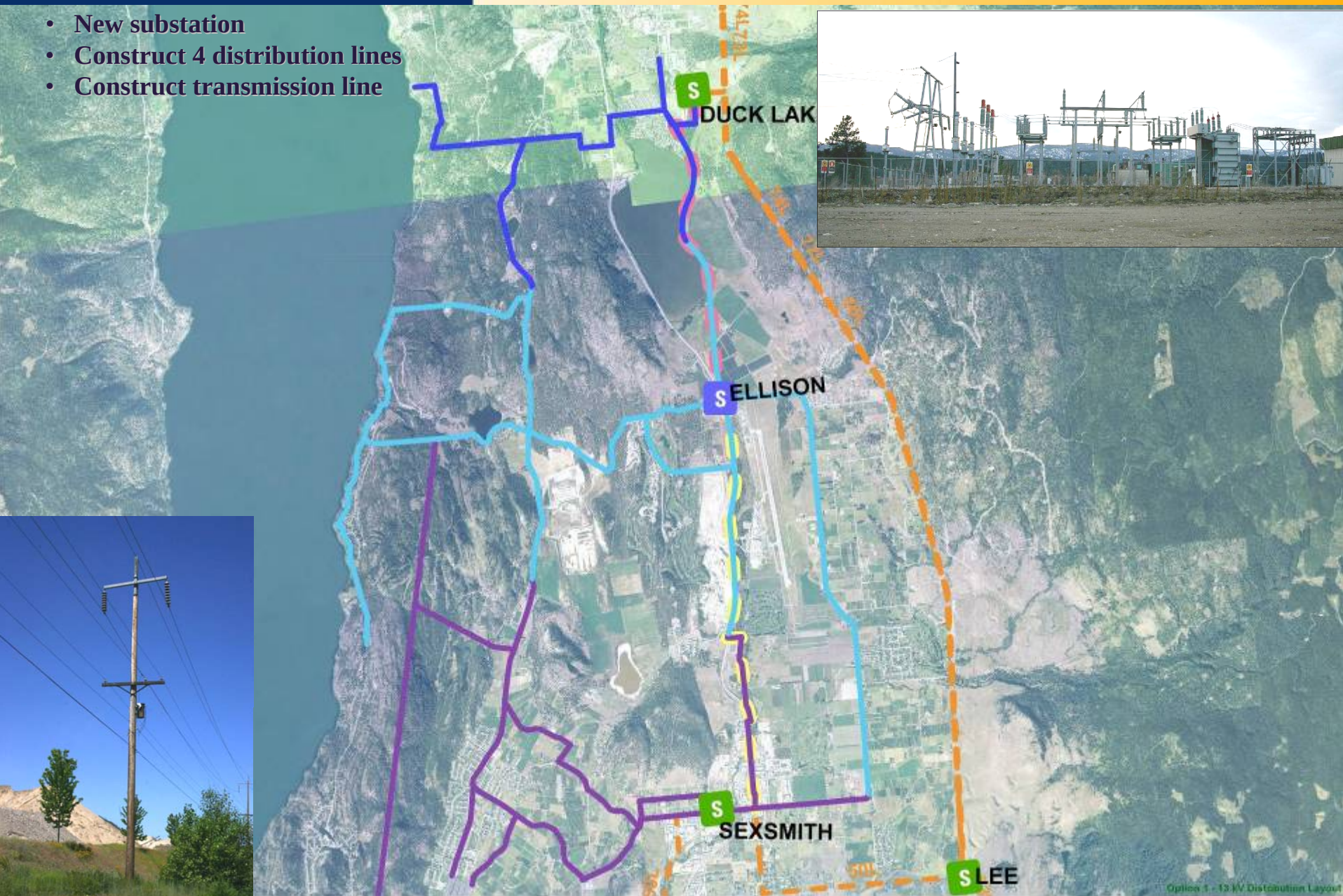
- Expand existing Sexsmith and Duck Lake substations
- Construct 8 distribution lines

Option Comparison

	Option 1 (Preferred)	Option 2	Option 3
Safety	High	High	High
• Right of Way	Existing	New	New
Cost	$15 million	$30 million	$38 million
Stakeholder Impacts			
▪ Environmental Impact	Low	Low	Low
▪ Archaeological Impact	None	None	None
▪ Distribution Lines ▪ Transmission Lines	4 1 (2 in future)	6 0	8 0
▪ Visual and direct land impact	Low	Moderate	Moderate
Reliability	Moderate (High in future)	Moderate	Moderate
• Capacity	Long term solution	More facilities needed in 2016	Long term solution

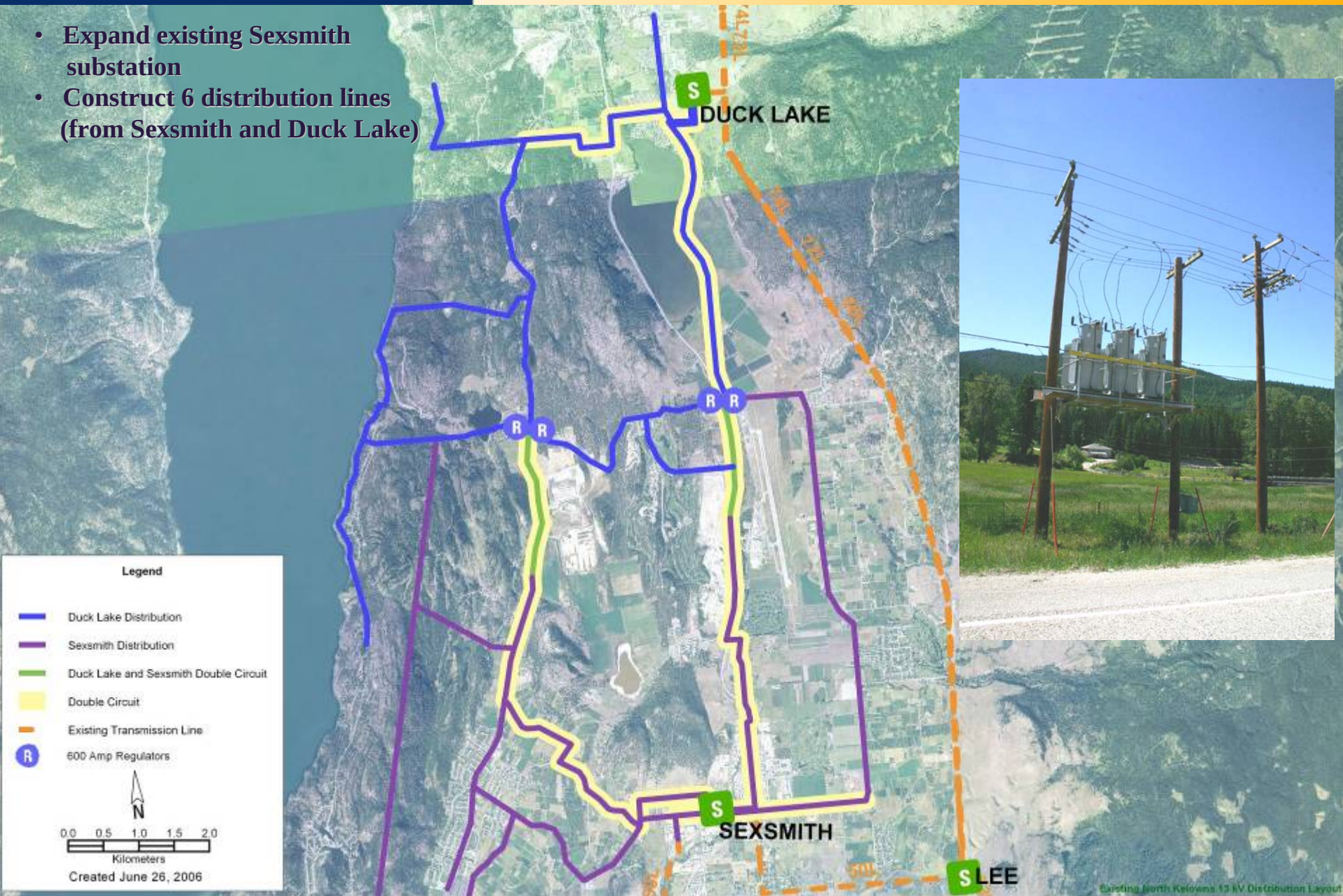
Option 1 (preferred)

- New substation
- Construct 4 distribution lines
- Construct transmission line



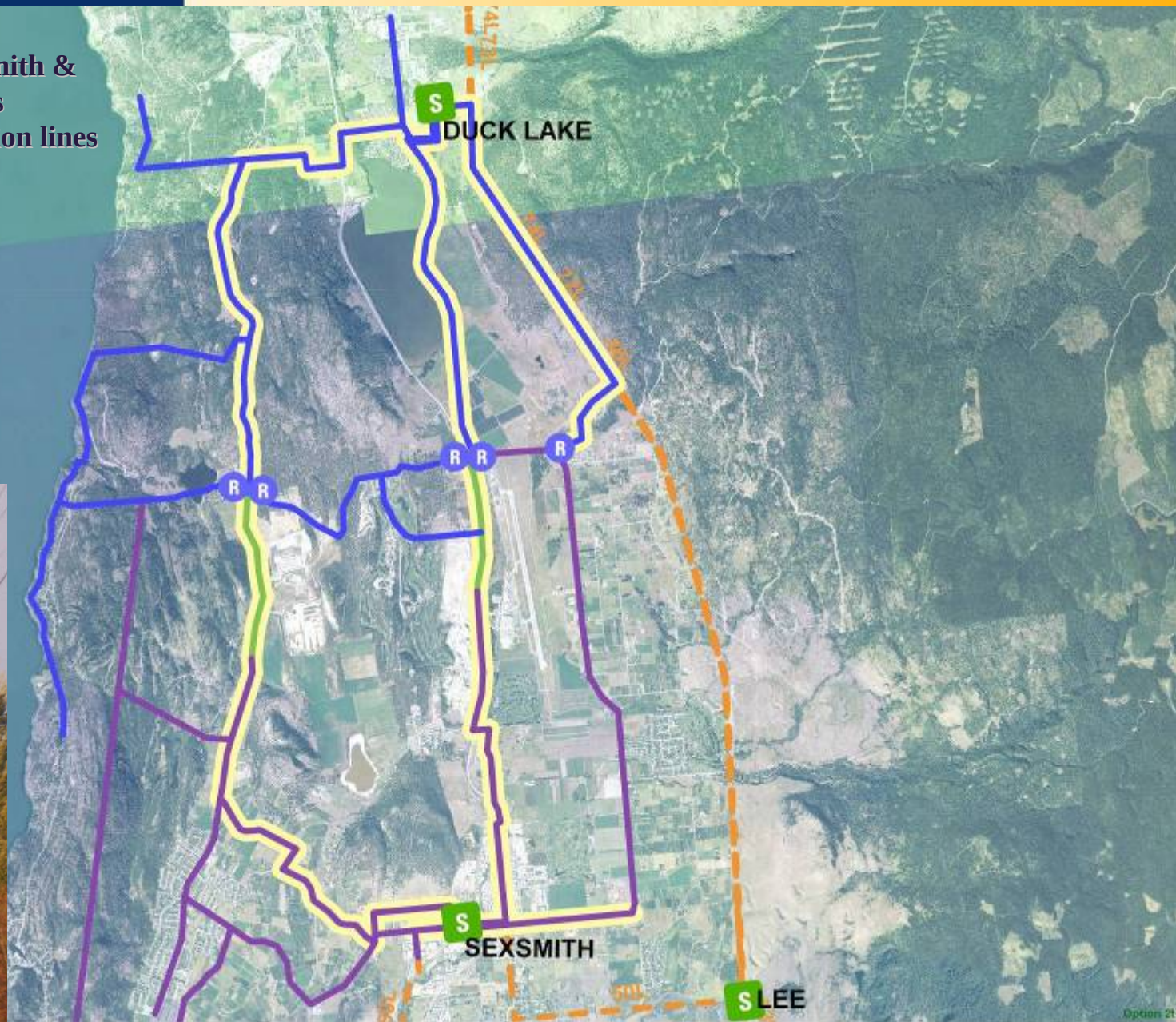
Option 2

- Expand existing Sexsmith substation
- Construct 6 distribution lines (from Sexsmith and Duck Lake)



Option 3

- Expand existing Sexsmith & Duck Lake substations
- Construct 8 distribution lines



Transmission Structure

Double Circuit Structure

Regulator Bank

Duck Lake Substation

Duck Lake Substation Aerial View

Proposed Ellison Substation

View from Quail Ridge Blvd

Regulatory Process

- FortisBC is regulated by the BC Utilities Commission
- Public consultation continues
- Certificate of Public Convenience and Necessity (CPCN)
- BC Utilities Commission and public review
- Written or oral hearing

Project Schedule

• BCUC approval	Winter 2006/07
• Ellison distribution upgrades	Spring 2007
• 138 kV line construction	Spring 2007
• Substation construction	Spring 2007
• Energize system	December 2007

Construction Impacts

- Safety is FortisBC's priority
- Minimize disruptions to customers
- Advertise planned power outages in advance and keep outages as brief as possible
- Ongoing communication with public

Next Steps

- Proceed with regulatory and public process
- Follow-up on individual concerns of residents

Project Contact Information

Planning Project Manager: Keith Sones

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FortisBC website:	**www.fortisbc.com**
BCUC website:	**www.bcuc.com**

Quail Ridge
October 24, 2006

Meeting commenced at 7:35pm.

Keith Sones

Just a couple of things before we get started. I've been noted in the past, and I'm going to make a conscious effort tonight to slow it down a bit. I have been accused of speaking too fast before. The first time I met Mac, he gave me the deer in the headlights look. I will try and speak slower tonight.

As Mac mentioned, our mission here tonight is multiple. The most important thing we are going to do here tonight is convey the growth in the area; it's the reason we are proposing the project in the Ellison area in the first place. We'd certainly like to invite any and all questions, comments, and suggestions as we go through. As we go through some of this material, hopefully we will answer all of the questions that come up, if you have anything that doesn't seem to make sense, and you want more information on, I'm not sure about you, but my memory sometimes lasts about 30 seconds. They say to hold questions until the end of the presentation, but I often forget my question by the time we get there. So if you can just raise your hand and stand up so that everyone can hear, we'll try and get to it right away. Troy has offered to serve as Vanna White tonight, to deal with the overhead projection. Troy is also our Regional Engineer, and he's our technical expert, so if you have questions of a technical nature, I may call him to answer some of them.

I'm also not great at talking in the mike, so I may at some point in time arbitrarily walk away from it, we'll see how it goes. In fact, I think I'll do that right now. Can everybody hear me ok?

Yes

Alright, great. So, tonight we want to make sure that everybody understands the overview of the project, and why it is needed. What we're hoping to do, and there are some options involved here. And it's really important that we get some of your feedback on some of those options. We want to try and lay it out as clear as we can. What those options look like, the impacts of each and then how we're supposed to move forward with this whole thing. As I mentioned, we will have a formal time for questions and answers and the end, but by all means, if you have something as we're going through, just yell it out.

I don't think it's going to come as a shock to anybody that there is growth in Kelowna, and the Kelowna area. So, as you can see right here, the trend in the year has gone like this: these values in blue bars represent the amount of dollars we've spent in building permits. So, this is more than just planned, it's where we're starting planning to spend money. This is the number of building permits that we have applied for. Now, from the

utility point of view, we can take a look at this top bit and say, "Well, in the last few years, it has flattened out a bit. Does that mean that growth is going away?". Well, not really because although the number of permits is perhaps flattening at least for now, this is for the end of 2005, because the value is going up, one permit may represent an apartment block, or a condominium complex as opposed to a single dwelling. So, the value keeps going up, and as you can probably appreciate, an apartment complex takes a lot more electricity, or a building such as this for example than a home. So suffice to say that along with this rise in building, goes a corresponding need in power.

Now, I'll try to get some landmarks on these maps because they are a little bit small. This is our Duck Lake station, which is in the industrial area of what used to be know as Wheatfield, now it's lake country. We have our substation there feeds this general area. And this is our Sexsmith substation, which is on Sexsmith Road, right near Reeds corner, so just off of Highway 97 and Sexsmith Road, just a bit south of here. There is the airport runway, just to give you a little bit of perspective, and there's Piermac. In these blue boxes, which are very difficult to see, primarily represent industrial and commercial growth. So, to our planners, that really represents a more concentrated need for power. Now these other areas; Vintage Landing, Melford Developments, these new areas along the lake as well as over here, is primarily, not exclusively are targeted for growth. All of this translates into a zone in the middle that currently is being served in the north and south and very soon we won't be able to be served with just the current infrastructure we have. In fact, what this translates into as we look forward, it's between 800 and 1000 new homes, just in that zone that we just looked every year for the next several years. And that really means that the existing lines and substations and infrastructures that we have in place right now is taxed, and it's getting more and more taxed, and we have to come up with a solution to make sure that we can serve.

We on a regular basis, Troy has gone out several times and talked to various developers, Kelowna Airport, UBC; we need to get a pulse on the community to find out what's happening for growth so we can plan for it. And these are based on our best and latest projections.

Now there are a few things that prior to myself entering into the electrical industry, as a bit of a side, when I started working with another electrical utility about 16 or 17 years ago now, all I knew was two things about electricity:

1) I flick on the switch, the lights went on
2) Every month I get a bill

That's what I knew. And what I didn't know is that FortisBC in this case, we have an obligation to serve new customers. We can't by law say no. So, if you or somebody else comes up and knocks on our door and says, "I'm building a house and I need more power, we have to find a way to give you power. Now there's also cost involved in that. But we can't say no. That's one of the facts of being an area monopoly. You can't buy your power from somewhere else, or somebody else in this area. The existing system, as I have mentioned is at or near capacity. In certain cases, as we'll see a little bit later on, it's very, very close to not being able to serve the load. So, we have some very tight timelines in front of us. And this substation and lines, is really required to keep lights on.

So, it's not necessarily saying, "This is only to serve a new development. This is sort of the effect of seeing previous development and it's sort of rising into the future. Just so that you're aware, the Kelowna area as a whole is growing at a rate of 4% on an annual basis. Throughout our service territory, we might be looking at one or one and a half, typically, the numbers don't sound big, but what that really means is, it's three to four times as high in Kelowna as it is in the other areas. So, it's very aggressive. I'd like to talk to you about why we do these things. With respect to reliability, if these lights went out right now, you'd think that there was a problem with the line feeding this building.

Why do we need another substation? Reliability. As the utility, we want to make sure we have another source, because if we don't, and the lights go out, they stay out until we fix the pole that is broken or the wire that needs fixed, or what have you. So, part of our plan is to make sure that when we build something, we have an adjacent something. A line or substation that can sort of keep the power going. If there's a problem here, we can bring it in from somewhere else. It takes a little time, but not nearly as much. That substation side, the distribution side, those are the poles that you see in front of your house, or adjacent to the area, and also on the transmission side, the big lines that you see on the mountain side. Now, once again, sort of giving you the Fortis 101 version of how we operate – this is how we make money. As the monopoly, all of our costs are reviewed by the BC Utilities Commission. So, we can't just spend money – your money. We can't just go spend it indiscriminately. We have lots of plans in place, all of them have to be looked at by the Utilities Commission, and then we have to get approval for them. This project is no exception. We have an obligation, therefore, to keep the costs reasonable, because if I say, I want to go and spend $15 million dollars. And you say, that sounds like a lot of money, and I say, well, I'm going to go to the other guy and ask him to spend $30 million dollars. Now, the next question might be, "Who's paying for this?" We have one answer. Everybody in this room, and everybody else in the service territory, we all pay for it. Now, there becomes a third point, because FortisBC is allowed to make a specific rate of return, our capital investors, I know this is sounding like an economics course, but there's a point to be made here – if I go back to Mac and say, "you know Mac, I really like my $30 million option better than my $15 million option. Well then I get twice as much money in my back pocket. So we go back to point number two and point number one says, well, hang on Fortis, we understand you need to serve, and you need to build stuff and you have standards you need to abide by, but don't let things go crazy because we know how you make the money, and the more money you spend, the more money you make. So, although we have to build things that are reasonable, we can't build things that are extravagant. And there has to be a balance point too.

So the existing system at Duck Lake, these lines that you see represent what we call feeders and distribution networks, it's those poles that come to your house it's the stuff that actually let you use electricity. So, you see it come from here and here, and most of the growth is right in here. So, we need to find a way to do something about that. And that's what we're here to talk about tonight. So, once again, without getting too technical here, there's a couple of important pieces on this graph. It's where this purple line crosses the black line. The black line is how much power we have, and the purple line is how much power we need. That's for the Sexsmith substation, the south end territory.

This one, when this line is going down, we have less and less ability if the lights go out, to serve from somewhere else, because they're overloaded too. So, if it's difficult to see these numbers, this represents the winter of 2007/2008. By the end of next year, we need to have something in place. Or getting things together to get in place. Once again at north end, at Duck Lake, where the purple line crosses the black, it's about 2008/2009, so we have a little bit more time there. This adjustment right here is basically an adjustment to make the substation maximize the use and the equipment that we have right there. It's still not going to do us a whole lot of good, but it buys us a bit of time, but not a whole lot.

So, we have three options. And when I say options, these are things that will work. They are technically viable, it will work for a very long period of time, they all have pros and cons, and one thing that is really critical is now I can go talk to our engineers and say, "Look, why don't you put down something that is going to work? Put some designs on paper and show us what they are and give us some options. So we know we have the ability in three different ways that your power is reliable, it's going to be cost effective, within scope of course, and it will be that way for several years. But it's crucial that we understand what you want. You're paying for it. So, I'm going to go through these options in a little bit of detail, primarily focusing on the benefit and the impact that you will see in either one. And I'm really curious to see what you like.

So, with respect to option one, it's marked as preferred, and I'll make a couple of points about that.

<u>Option One, marked as "preferred"</u>:
Involves a New Substation
Four new feeder lines
A new set of transmission lines

<u>Option Two</u>:
South end
We'll build some new lines that will connect, going north, into the territory

<u>Option Three</u>:
Expand both substations
Lines to come backing the centre of the territory. This substation we will be talking about in great detail in just a second. This is close to Quail Ridge, it would be (Mac, can you help me out with the geography here) you would turn off Quail Ridge Blvd,

*Mac – (hard to hear)*go down the road that takes you down south, looking across the airport, Walkin Road, and it's closed off, you'll see rocks, so you'd turn and go down towards the airport and turn right. Do you have a diagram there?

Yes I sure do.

Mac – The area that's being considered is north of the closed off section of Laughlin Road.

Q: McMacaken road – just North of closed off road (gravel road) – is this the only area for the substation site being considered?

A: I can give you a bit of history about that. About two or three months ago, it was one of the sites that was on our list of options. I'm really glad you asked that question. Just in case you didn't hear that question, it was "Is that the only site that we are considering?" In order to properly select a site that's going to work, we have a number of criteria that we have to satisfy. Two of the really important ones are that they are close to a load centre. Which really means where are the people are and where all the growth is happening. Ideally, put it right in the middle, so that it's nice and close, less infrastructure to build, more reliable, etc. It also needs to be close to the transmission lines, and that's the bigger line you see going along Highway 97, like the taller pole here. We did look at a site near Old Vernon Road, north of the airport. Where Highway 97 goes like this and Old Vernon – if you keep going straight, there is an orchard back there, and it's small, but as you go over the rise, you look at that. Now that land was our originally preferred option because it's very close to the centre of the substations, and it's reasonably close to the transmission line. No, we went to an open house in July, and one of the things that was impacted was that it is in agricultural land. So it's in the Agricultural Land Reserve. So, when we have options, that's obviously one of the things that we don't have there, we would prefer to, but it's not a show stopper there. Now based on the feedback we got back from those residents, and from the Agricultural Land Reserve, and they said, no, we would really like you to go look at something else. So we did. We did look, and evaluated a site sort of across a lot of developments, we looked at, although it proved to be not satisfactory, across the road on the Airport side, and I'm trying to think if there's any other sites.

Q: Anything closer to the highway?

A: Yes. We actually looked at purchasing, a parcel. When we talk about this, we'll talk about the actual parcel of land footprint here. Yes, we did look at parcels that extend right up to the highway, we would sort of build right on the highway, and we'll talk about what this could look like. We'll extend that conversation. But right now this is our preferred option for a bunch of reasons. But no, it's not the only one we did consider or have evaluated.

Q: Just to take that one step further, have you ruled out all other options?

A: No. No we haven't. One of the things I think everybody needs to be very clear on is that this consultation process, in this case, is in advance of the submission to the BC Utilities Commission. Now they weigh all of the various factors. One of the things they take a look at is what the public says. And they weight that with increasingly with greater weight, we've noticed that in our last several applications, in fact we've had a

couple where they've directed us to do something different, strictly because of public feedback.

Q: So, is this forum the only one we're going to have? Is the Association going to have feedback from the BC Utilities Commission?

A: No it's not. And we'll get into what the process looks like. I just want to make sure everyone has a chance to understand what our plans look like so that after the Commission gets a hold of the application, and then in several months you feel that you look in your rearview mirror and say, well we never had a chance to hear about it. So that's why we're here tonight.

Q: Your process of notifying people. You had a public hearing, there seems to be a little bit of a problem with the terminology. It's called Ellison substation. This is not Ellison. Ellison is across the way. It's my understanding that people in Ellison were notified, but people that are directly involved with the proposed site, have not been, and to this day have not been notified.

A: You're right about the Ellison thing. The actual name – that's the second time I've actually been corrected by someone. And consider it more north. We actually call Ellison the general area of Ellison

Q: Now, they were notified by mail.

A: That's right. There were flyers dropped through the mail. There are two types of forums, I guess you could say. On the one hand, and we've got one in the Black Mountain area. We took a look and said, OK, let's draw a line around who we think would probably be impacted. Now in this case…

Q: This did not happen. The people that are directly involved have not heard this case. They've heard through secondary sources.
A: Right. One of the things that is unfortunate, is that people do get missed.

Q: And why wouldn't that be rectified? We had a conversation, and it was an oversight.

A: Yes, and I apologize. First of all for the original oversight, and secondly, we're trying to refine our methodology of contacting people. Now when I first talked to Mac, I thought it was a great opportunity to express a single avenue to a much larger group of people. So, given that everyone in this particular community received the flyer in the newsletter they got that sounded like a great opportunity to get the word out. But, people did get missed, and I apologize for that. We are trying to refine this process. We tried to direct flyers, radio, newspaper, postal code delivery. So, hopefully we're getting better at this process, but I'm not going to try and say it's perfect. We're trying to get better. So, my apologies for any one who did get missed. We want to make sure that if there's somebody you do know that did get missed, either tonight, or you feel that should have

the information, by all means, spread the word, and we can sit down with them and try to answer their concerns.

Q: Real Estate. Stations do impact value. Nobody wants to be impacted. If we are really concerned about this, where can we register our concerns?

A: There are actually two ways of doing that. Tonight this is your first opportunity to hear in detail of the project, and we would love to hear your feedback and take it back and then once we hear all the various views, we would then sit down and say, Ok, what are we going to do about that? But it doesn't stop with just us, and as I mentioned before, we are regulated by the BC Utilities Commission and they're third party communicators, that takes all the input from the various parties and takes the input from groups that represent rate increases, for example. They will also take into consideration your view on property value for example and health concerns. We've got that piece coming up as well. So, all of these various views, their job is then to balance the solution. Then they will come back to us and say, "Here's what we've heard, but you may heard from other groups as well and they've communicated to me that we'll talk about what that process involves, and how you can get involved, either now or in the future as well.

Q: N*ot able to hear question. Someone from the floor is commenting that they are not able to hear.*
Mac – Sorry. Keith, are you able to repeat each question, so that everyone can hear?

A: Yes. The question was, and I'll paraphrase it. What about property value? And is the only opportunity to provide feedback and views on the project? Or is there some other avenue that we can expect as well? And the answer to that is no, it is not the only avenue, although it is one of them. And there will be further processes as we will talk about here in a bit.

Q: I understand there has been a meeting like a formal intervention, and people had to be registered by a certain date, which has already passed.

A: The answer to that is no. We originally anticipated on submitting our application… Sorry, the question was I understand that the date for sort of a formal intervention was already passed? The answer to that is no. When we submitted our application which we hope to be doing reasonably soon, because we wanted to get together with this group prior to doing that. The BC Utilities Commission will be the ones doing that - set the dates. Now it will be on our website and their website, and certainly it will be widely available. Now I would suspect, just for the sake of argument, that if we were to submit our application by the end of this month, the Utilities Commission would usually take three to six weeks, which is the average, to come up with what they call a Regulatory Timetable, and it will say, ok, on December 1st, that's your deadline for registering what they call an intervener, someone that's from an interested party. But it will spell out, sort of all of the land things as well. So, no, that time can actually happen prior to the application being submitted, which hasn't happened yet.

Q: Can we use the Association to communicate, and not do this as an individual?

A: Oh yes absolutely, absolutely. And in fact, quite honestly, for me it makes it a lot easier for…

Q: *Mac* – Can you repeat the question please?

A: Yes, sorry. The question was, does it have to be just an individual that requests feedback, or cand we use the Association as an avenue to get established as a two way communication link. And the answer is yes, you can do it both ways, either or, or both. Whichever. Certainly using the Association is a great way to spread the word. But if people want to have an individual conversation, they can do that as well.

Q: The Application – when does the City get involved?

A: The application itself, what's termed as certificate, and Application of Public Convenience and Necessity. So the Utilities Commission has to assess whether, A, we need the project, did we define it clearly enough, and is it what they call the public interest? The City, their role, if they so choose, would be to act as an intervener. So they would have the same status as anybody in this room. They would apply to the BC Utilities Commission and then depending on how the Utilities Commission decides to hear the process, and they have different ways of doing that, the City would then send their submission, their views on that process.

Q: Does one intervener have more weight than another intervener?

A: The question was, "Does one intervener have more weight than another intervener?" The practical answer is, theoretically, no but practically yes. If I Keith Sones have a particular view on something, and I make it known. I make it myself. If the City, their elected officials have a particular view, then they are representing the city as a whole, or their association would be representing more than just one person, they would be representing that particular group of constituents. So, quite honestly, the Utilities Commission won't discriminate, they'll say we accept any and all intervener applications. Nobody is denied. They will certainly take, I would say, or would apply greater weight to the Residence Association, the City of Kelowna, as opposed to you or I as individuals. Now, having said that, now once again, this is speaking from past history, they do tend to pay particular attention to individuals that are directly impacted. So, if we're proposing to put something in your back yard for example, they're going to listen to you a lot louder than if I say, you know what, I can see it across the valley and I don't really like it. They're going to listen to you and put more weight on that particular thing. OK, so we've got a chart, and I'll try to define the important bits on here. The other thing I should let you know is that we've got copies up here, just a few, of this overhead presentation and we can certainly make them widely available, Mac, to yourself, or….

Q: Can you put them on e-mail?

A: Oh absolutely, yes. Not a problem at all.

So when we look at the three options, and once again, this is the substation. This is expanding the secondary substation, adding more lines, and this is expanding the old substation, adding more lines. This is something that we might use to look at the various heating. Quite often heating priorities or interests, are not necessarily coming up with an answer, but putting it all in one piece.

So for example, in Option One, safety, and this is public and employee safety, is a priority, and we will not negotiate on. We have certain standards, and they will be adhered to. With respect to right of way, for example, we have to acquire new land for lines and space. For Option One, we would be using existing lines, where they are already, for the most part. Options two and three require some new lines. With respect to cost:.

Option One is around$50 million
Option Two is $30 million
Option Three is about $38 million

And you can certainly go down this list and take a look at the look at the various impacts. The impact is really going to depend on your point of view. So, if you live in Creston for example, and the only one you're really going to be impacted on is cost, that's probably the only one they're really interested in. However, if you live in Portal Ridge, you might be more interested in well, am I going to get new lines, and what is the substation going to look like? So once again, it really depends on your perspective. So, that's why this Utilities Commission process is so important, because it allows all the views to be taken in.

Q: Do they have any restriction on position?

A: Utilities Commission does not. We would have to apply through zoning, for example, so if we have to change it from industrial from residential for example, we would have to go through the zoning application in order to do that. And of course, the zoning applications are also public processes.

Q: Has the site at the Airport been dismissed?

A: The question was, "Has the site at the Airport been dismissed?" Which site specifically?

Q: Um, you mentioned something about the opposite side of the highway.

A: Yes it has. And that's for technical reasons, the slope of the land is close to airport operations. Nap Canada has mandatories. The biggest thing is the slope down there. We need flat land to build a substation.

Q: What is the size of the substation?

A: That's a very good question. The question was, "What's the size of the substation we're talking about?" It is slightly less than an acre, actual fenced area. What we're talking about in terms of and acquisition is five acres. And the reason for that is not because we want to use five acres, but when we construct the substation, we want to have a buffer zone around the substation for visual screening or just physical separation from us and the rest of humanity. Primarily because people don't want to be directly looking at the fence.

Q: Now are you saying that they're won't be expansion then on those five acres?

A: There would be no reason to. Troy can probably better answer this. Sorry, the question was, "Would there be any need to expand that substation down the road?".

Troy – The existing footprint that we have on paper, that Keith has identified, right now we're going to have one transformer, a transformer, and then there will be a second transformer in there, I would predict in about 10 years, and four distribution breakers that were identified in Option One there, with the expectation that there would be four more again, around more in 10 maybe 15 years at this point. The fenced area will not change.

Q: Keith, can I make a suggestion? Can you please acknowledge the sequence of hands?

A: Yes, yes, that's my fault. I think it was your turn to speak.

Q: Can you tell us a little bit about what the visual impact of the distribution lines, etc. would be?

A: I sure can. I actually have some pictures…. Sorry, the question was, "Can you see the visual impact of the lines and whatnot?" I've got some pictures of what you can expect to see, a little bit later. So we will address that.

Q: As the crow flies, how close is the closest home to the substation?

A: The question was, "How close is the closest home to the substation?" Now, would you be referring to the substation itself, or the lines? And you're talking in Quail Ridge, right? Troy, you can probably help me out better here.

A: *Troy* - Whatever the road is at the "T", as you drive into the area. It would be those roads there.

Mac – can I just add….

Q: How far from my home?

A: Yes. From one home, now that's the closest residence. Within Quail Ridge itself, what's the closest part of the subdivision, if you will.

Mac – Keith, I'm just wondering, you've been getting a lot of questions, and you still have a lot of information, right?

A: Yes I do.

Mac - Yes, and a lot of these things will be portrayed?

A: Hopefully if the questions don't get answered within the next few minutes, we will certainly have time at the end. Maybe we'll take one more before we move on. Yes?

Q: There are a whole bunch of residents that already have their homes here. Why entertain the idea in a residential area when there are already homes there? Why wouldn't you consider putting the substation where there is nobody right now?

A: Now, we'll talk a little bit about that selection process itself, but, I'll hang on to that question.

Q: I have an additional comment.

A: Oh sorry. Go ahead.

Q: Is the purpose to have more lines to service more area? Right? Now, you have mentioned that you have four distribution lines on that chart, but then there you have eight. Right? Does that mean it's got twice the capacity if they were to upgrade the _____

A: *Troy* - Electrically speaking, what we'd need to do is we'd need to build four new lines from one existing station, and then for this particular option, we've got two, we'd have to build two additional lines from the Duck Lake station. So what ends up happening, is that I've got to build five to six kilometers more line for each of those four coming out of the Sexsmith station, and then I have to build five more kilometers for each line coming out of the Duck Lake station. Whereas for the Ellison station, putting it right at the centre, I can connect it very quickly with very few lines to the existing distribution structure that is already here. Now also, you'll notice the transmission line, right? So, we already have a distribution line that can be rebuilt, so the transmission line coming down from Duck Lake down to Ellison, and then everybody sees the transmission line that runs along Highway 97. That's pretty much just outside our doors here.

Q: Is Option One, four lines?

A: Yes.

Q: And then, ten years down the road, area just keeps growing. What's it going to cost down the road?

A: *Troy* – So, economically, you are going to see these kind of costs are down the road somewhere. Now with the Ellison station, – I don't need to build these lines as far, because I already have the lines here, so I'm only going to stretch them out maybe two or three kilometers, going into the centers of the loads. Not only that though, but I won't have to stretch – I will probably only need two lines here coming from here if I have Ellison here, because I don't have to stretch them out as far.

Q: When you say stretch them out, what does that mean?

A: *Troy* – For example, the college is going to double, almost triple in size as far as load is concerned. I need one single line just to feed them. The residences that are going to occur just north of the university, we are going to need some lines for there, and then of course, there are two roads that are going from the highway across over to the Glenmore area, one is kind of going through the university, and the other one is really going to connect up with Old Vernon Road. That one is a fair distance, and in time, the one through the university is, and I'm hearing as soon as the next couple of years, so we're going to see some lines coming across.

Q: Are those those high transmission lines?

A: *Troy* – No they're not. No. Those are distribution lines.

Q: Can I ask one question? You said the Airport issue? Is this not close to the Dry Valley site?

A: *Troy* - The question was, "Is this site that we're looking at, at the end of Rockford Road not much closer than the Dry Valley site?" It is closer to the Airport. Now there are two considerations, the fly zone that is at the end of the road – so you could arguably say, look, we want to build a substation there. But the biggest consideration there is the slope of the land is more of the issue. From a civil engineering point of view, I think they've basically picked a side, because it was as useful to construct. So, there's one other point I'd like to add, with the other side of the road, it is also on the other side of the rail road tracks that are on that side. So, first of all, access to that substation makes it very difficult, and take that access from the highway, so we'd be having to come across from the airport road there, and then coming through a controlled intersection on the rail road tracks itself. So that also adds costs. The other thing is, whenever you build a substation, near a rail road track, what is happening is if there is a potential failure, and we understand that there are failures once in a while, what happens is a fault occurs, sends a lot of current back to the substation through the grounding system, so when you attach near a rail road track, you can actually raise the level of voltage on the rail road tracks. So what I would have to do is I would have to build a much bigger grounding system, and again, that adds costs.

Q: Isn't the Sexsmith site near a railroad station?

A: *Troy* - It is, yes.

Perhaps we can get through a couple of these pictures. Just so that people have a better understanding of what we are talking about, for example, Option One has the four lines if not equivalent to the lines to Option Three, as an example. But I promise to get to everyone's questions here, let me just continue.

So, this is the Duck Lake station that we've talked about before in Sexsmith. The proposal for Ellison of course is just about half way between those two. Now these lighter blue lines that you see, the ones that we were just talking about, would be the lines that would actually eliminate _____ substation. Really what they have to do is just connect to the existing distribution network, that's primarily already there. They would grow over time.

Q: Are the lines above ground, or below ground.

A: All above. That's right.

We'll get into that, with respect to that in just a minute here. In fact…. (Keith and Troy looking for a particular slide.) For those of you that haven't seen – we have a larger picture here. This is the transmission structure that we are talking about, and these are actually on Highway 97 right now.

Q: Are there any plans to build over houses?

A: *Troy* – No.

A: No, there are no plans, for any of the transmission, there are no plans to have them anywhere right along the highway; in the southern section, there's a small section which we refer to as the new territory, 200 metres and it's along agricultural land. (Duck Lake photograph showed.)

Q: Is this what it will look like?

A: Ok. That's the Duck Lank station that's in the industrial part of Duck Lake. Just for a perspective. This substation would be about the same size. Now when we get to the actually renderings of what it would look like, this one is – when the photographer took this, it was a relatively low shot, and it does look elevated. Although they would put that in the new substation if that were the case.

Q: Can you enlarge that picture?

A: Yes. In fact, I have a larger version of that right here. I will show that to you in just a minute.

Q: Where each of these lines goes, does it effect residences?

A: No. These for the most part, are what will exist in the future. This right here would have to be new. The rest are pretty much existing.

A: So, when I say for the most part, for this particular option, this line doesn't exist right now, but it would in the future. If you take a look at the Old Vernon Road, as you go along the north end of the airport, if you go west toward the lake, ultimately the city is planning on developing a road along there. This is not intended to go in until that road is constructed. So, whenever the city puts the road in, as going to plan, we would just construct that line, and I can't tell you when that might be because the city has its guidelines.

Q: Isn't the logical area along the dump area or the Wildon construction area, rather than our area?

A: *Troy –* I've looked at that option. What you have is an existing transmission corridor right between these two substations, right now. You need to understand that we need to build a root transmission system, so, somehow, I would have to come along here, along and back, and still have to tie into this substation. Transmission systems cost about five times more than distribution systems. So, if I were to be putting a transmission system around the dump, it's going to cost me, probably $10 million more, just for the transmission structure to bring it all the way out. Not only that, but, we have an obligation to our public as a whole to try and minimize the number and length of our lines, and all the rest of that. So, if I have an existing corridor, and existing right of way, and existing lines, I would use that first, and that's why we've chosen the Ellison substation because of where it is. But really, it's about half way between Sexsmith and Duck Lake.

I'll give you an idea of what's going on. You've got about 17,000 lots up in what's called the 20 20 properties. So they are actually bigger than the Wildon properties are. You've got 1,100 units here. In the course of the next 20 years there is, in this area, is about 7,000 units. We're going to be seeing municipal sport complex over in this area. This area here, all along Highway 97, really isn't a whole lot different here than what you're seeing along Highway 97 now where the WalMart and that whole stretch of commercial complex. So, along Highway 97, my prediction is that you're going to see a lot of that tight, tight commercial development happen, and you've seen that with the Piermac there, so 17 commercial units, and of course, further south, the university are going to see it's fair amount of growth.. Also a sports complex, and along Highway 97 there will be tight commercial building, as well as the University area for the residents that are living in that area.

I'm not quite sure what's happened to our visual presentation here.

Q: I'm just wondering about location again. What about the location at the corner of University Way and Highway 97?

A: *Troy* – So, what I've done is looked at that. Electrically I need to put the thing right in the centre for the sake of losses. So, electrically, every wire has some heating losses, and that sort of thing, so, the further away I put the substation from the centre of the load, the more the costs in power for me.

Q: Where's the centre of the load?

A: *Troy* - Right where I put the substation. So, you're seeing a high concentration in that area, but I'm seeing a whole bunch of units over in the residential part of the Glenmore area.

Q: I want to get back to the location. Why can't it be in the new area that they haven't developed yet?

A: So, I've chosen the location to be most preferable where Old Vernon Road comes right across, because of where the road is going to go. Over to the Glenmore area, because in the long run, I'm going to see you double circuit like two circuits going across that road, over into the Glenmore Valley area. Really what happens, what it looks like is you've got lines that all converge down to one point, all at one intersection. So, my preferred site is electrically speaking, is right at that intersection. So, this is the next closest location. Now that you have to understand that I am obligated to bring the least cost option also, and the Utility Commission will ask me, very specifically, what is the least cost option that will reasonably work? Now you guys have the opportunity to come back and intervene with us and identify why you don't think this is the best location.

Q: So I guess my point of view is if you lived up in this area, would you be comfortable?

A: *Troy* – Absolutely. I live across from transmission lines. I do appreciate everyone's concerns from the value of their property. But electrically speaking, I'm not concerned about living near something that's got power in it.

I'm going to suggest that we move to some of the more graphic pictures of the presentation, just so we can make the point. And just to be quite honest, I'm a little bit worried about this electrical device that I brought along. Also, hopefully I can identify some of these other concerns.

Let's see. Duck Lake here and Sexsmith right here. So this is what is referred to as a regulator bank. And what it does – for those of you that don't know, I found this helpful when I first got involved in the electrical side. Electricity and water are very similar in how they function. And I'm not sure if anyone has a sprinkler system in your yard, but if you've fought with a sprinkler that's on the end of a long, long hose. You crank that thing on you house for all she's worth, and you get a little coming out. Voltage, electrical voltage is much the same. So, as you get a long section of line, if you go to the end of the line, the lights are going to do what that projector was doing just a minutes ago. It does down, and it doesn't have the proper voltage, so what we have to do is identify the points in the power system where you can put equipment that looks like this, and it's designated

with these bars, so that we can boost the voltage and get it to where it's needed. And that's one of the challenges of having remote substations. What we've heard quite often is, "Can you take this station and put it somewhere else?" Well, electrically speaking, you can do that up to a point. But it's not without it's downsides, and one of them is you have to put these along the way so that you can actually get the power to the people at the end of the line. Now, in this particular case, a lot of those people, including this community and others, are sort of in the centre of the zone. There a little bit more remote stations which makes it more challenging, and as I mentioned, more expensive to get the power in the middle. These thicker indicate what is referred to as a double circuit structure. And that's got two circuits on the same pole, and I think we've got a picture here, in just a minute. This is out in the valley along Highway 33; it would be very representative of the kind of structure you've been seeing along these thicker lines. Simply because you have to have two electrical circuits in order to get power once again to where your supplier is. So, if you are in the central zone, you can see these R's mounting up, this is where the growth is, so to get the power from here or here, you have to have more of these circuits, more of these lines, and more of what we call booster stations to regulate stations to get it on the final leg of it's journey. So, these poles exist on these thicker lines, right here. Right now for the most part they are single circuits. This circuit is a single circuit, it would be double, this would be double, and I think there's one section in the transmission corridor that would be triple. So, you'd actually take another one of these and put it up higher. So, this is what Option Three looks like. So, if we expand the station and put more capacity at either end, we'd build sort of into the middle. Here's a few shots. So, this is near Highway 97, very close to some developments. That's transmission on the top, and this distribution circuit is on the bottom.

Q: Has Option Three got more capacity?

A: A bigger shot – the two circuits, you've got one, two and they're both distribution there, at 13,000 volts – the kind of thing you'd see going through a community. This is a bigger shot of the regulator bank. Once again, along Highway 33, and we would have multiple units. That's the Duck Lake substation itself. It's a bit of an elevated shot, so I actually included this in there, when people take a look at it, myself included, saying it actually looks bigger than what it is. But I want this for a point of reference so that you can see some of the other shots actually minimizes this a bit, not that I'm trying to say that this is pretty, but. I still think other things are prettier than this. so this is an arial view of the same thing, so this would be about the same size, this fenced area is what we're talking about. We've got all the storage material right here. So what you just saw was this. And this space over here, that is for our expansion in the future. This remains empty until that point in time, when we have to build another set of infrastructure. So this wouldn't increase, you'd just have another line like this, just over here.

Q: Is this one acre?

A: Right, this is one. So this other zone, this fenced area, will remain fenced for far into the future. That's one acre. What we would do is we would have a bigger zone around it

for physical separation, so that nobody could actually build there. So this is a graphic rendering. This is the actual site looking from the north end, south. This pole exists right now, this of course doesn't. And this is generally what it would look like, and this is without any attempt to dress it up. We've left these in their sort of natural state, it's one of the things that, irrespective of what we do with expansion is, the Sexsmith or creation of the substation here, and we hear people say, "Well, what can we do to make it look prettier?" If you drive through Kelowna or Penticition, you will see a substation right in the heart of town, and they've got a wall around it, so you'll see some stuff around it, anything we can do to reduce the overall visual.

Q: Did you level out a spot?

A: This is sort of a natural drop. There's a bit of a depression right here. It dips down a little, a bit of leveling was needed. It doesn't go like this, it actually dips down. This is the block, and the end of it is here. Highway 97 is down this direction, and Quail Ridge is up this way. So, you're looking south.

Q: Maybe I missed something, but what are the size of towers that feed the substation?

A: Yes, I think I did mention it. The question was, "Did we mention the size of the towers that would be feeding the substation?" The highest pole that you would see on Highway 97 right now, anything in the substation would be shorter than that. So, if you want to use a reference, it probably would be, the point where it comes into the station would be right about here, is 10 feet lower.

Q: So, we're not looking at big metal towers?

A: No, I think it's important that everybody understands that when we say transmission, I think it's a natural tendency for all of us to leave it to our imagination and say, I've seen those big BC Hydro towers, but we're not talking about that. We're talking about wood poles, concrete, or whatever the cosmetic value but generally, single pole construction, similar to what you see on Highway 97 today.

This is another look as you come up the boulevard, once again, without any attempt to dress it up. This is what it would look similarly like, in the future. So, basically you can see how it might exist by the artists rendering – we've knocked out a tree here. So we come up here, and Quail Ridge is up this way.

Q: Is this what it would look like today?

A: No. What's been added are these structures right here. Everything else is as you see it right now. In fact, that pole is the pole as you go down that road. So this is new, a couple of these pine trees have been taken out of the picture. This is just a photograph so you can get a better idea of what it would look like.

Q: Now, where is that line going?

A: This one would be going down to Highway 97, just to connect to the existing transmission line. As I mentioned before, one thing about a substation is that it has to be served by it's transmission line, which is why we have to build as close to this transmission line as we can. So, this one will go down about ". probably three or four of these structures down this way, and then to the transmission line on Highway 97. And then connect to the existing lines on the infrastructure.

Q: The concrete block – is it further north?

A: Just for reference, this corner, as you come up the turnoff by the airport, you come up Quail Ridge Blvd, and you turn and you go up, its right there. This is right at that corner. Perhaps you can see the existing flagpoles.

Q: How much North of the water pumping station is it?

A: I'm trying to actually think of where that water pumping station is.

A: *Troy* – The road you're not supposed to go down. The road that you're not supposed to go on to get on the highway? That's right here. I know because I took it.

Q: How far up from the road is the substation going to be?

A: It's right there. It will be sort of just down from that draw. It's a natural draw. As I did mention before, within that five acre zone, we would have the flexibility of shuffling it a little bit. There are limitations of course, because of the nature of the land itself, but where you have a natural draw actually comes up a little right here. I do have some, but they're not part of this presentation, but I can find them quite quickly, what the shot from the highway looks like.

Q: The transmission lines along the highway, can't they be closer to the highway, away from all our houses?

A: We actually did look at that, there are a few people that were adverse to that primarily because of the high volumes, the land that's along there is parcel. This was the same fellow that looked at this parcel right here. He had a strong, strong preference was, "I want to keep that for future development. You'd take a five acre parcel for that. We initially looked at getting it right down to the highway, but quite honestly, we thought that the City, the Regional District wouldn't like it in plain site. It's also about that balance, right?

A: *Troy* - The land also is, the land where we are putting the substation is not in the ALR. Whereas the land down below, in the strip there, is in the ALR. If you take a look at the new ALR map, you will see, and I've got an older map that shows where the station is and there's a little pocket in there, and it's a piece of land that's excluded from the ALR. We looked at that. There is a high traffic volume and the land owner is going

to use that area for future development. There is an existing pole here. Now, as I mentioned before.

Q: Conceptions – if the homeowner is 200 metres from the site. Health and property values haven't been considered. Have you considered these things?

A: Now, as I mentioned before, So, this is once again sort of in a natural basin here. This is sort of, pretty much at the end where the property line is. This is without any attempt to put up a visual screen. Now this particular site is not something we find all that often because it does have natural screening around it, sort of a natural draw. We like to fill substations with gravel, clean gravel. This is in a gravel pit already, which helps. But when we talk about the visual screening here, I'm not going to say its non existent, but it will certainly be minimized. Now getting back to the consideration of the land owner, or any landowner along that line, we want to work as closely as we can with them. We certainly try to minimize the number of people that are directly impacted. We also recognize that as an area grows, there will always be a need for new lines and I guess that's just the nature of it.

Q: How can this be advantageous?

A: Actually, if you drive through Kelowna and Penticition you can identify a number of substations in urban areas that are immediately in residential areas. There's not much separation at all. So, I'm not going to say that putting it adjacent to your neighbourhood is the best plan, but ideally, if money weren't an object, you could take these and put them somewhere else, and put them underground, at a huge cost, of course. That would solve the visual impact. But we can't do that. We'd have to spend some money, and it would have to be your money. It may not be the BEST solution, but it makes the most sense cost wise.

Q: Can you show the rest of the presentation, please?!

Yes, yes we will. People have asked what the regulatory process is, and what voice do you have in terms of support, opposition, whatever the case may be. As I mentioned, we are regulated by the BC Utilities Commission, if we want to spend money, they tell us whether we can or we can't, and for the large part, how we can. The public consultation will continue. This is the first crack for this particular group of people to make sure that people are aware of the plans and what the various options looked like. I've heard the term "done deal", and you'll notice that there are three options. Just to give you a little bit of history – probably 18 months ago, a project, we formulated one of these applications, and it's very different that what we were considering from Ellison. And that was, "We want to build this". What happened then was the public got involved and said, "We don't like that", and the Utilities Commission took in their point of view and said, "You know what? We're going to force you to do this option. So, we went back and said, oh, ok. It was our fault. So, in this particular case, where we are right now, so that everybody is fully aware is that you have options. Your perspective is, how to get our

perspective on the table with respect to the Utilities Commission, and that is important. They hear those voices, and listen.
Regulatory process:

Q: Could this be forced into option two or three?

A: Well, it's not a matter of one particular group forcing anything. Because as I mentioned, they take the balance of everything. They are very, very serious about that. As far as the cost goes they will ask what does the long term view look like? Are you building this to last for a little while and then you're just going to go back in five or six years? So all those things they really take a look at. So, can you force us to do one particular option? Categorically, I would have to say no just as we can't force any particular option on anybody. We have to go through a process.

Q: Can you force us?

A: That is a significant part of it. The impacts are more than just us. By virtual impact, there would be overall less infrastructure. I think I showed you those lines on the map, we don't have to build double circuits – that kind of thing. No, we can't force anything on you.

Q: Option One, is cost a factor?

A: Yes it costs money, but they also have impact. So, if I go to somebody that's going to have one of those new circuits in front of their house, you can pretty much guarantee that they are not going to like it. It's reducing infrastructure, therefore, it's reducing cost.

Q: Is the cost shared over time – spread out? Do we pay now, or do we pay later?

A: If you think about the current configuration where you have a current substation in the north end and the south end to get to the other properties, you would still have to build those other lines. It's actually a little closer if you come through the central area. So, yes, there is in the future, but it depends on where it goes, develops we have to get there, the infrastructure and when Troy and I go through this exercise, we'll take a look at that and say what's the best solution for the long term.

Q: Option Three. You said it was a cost of $38 million, versus $15 million now, If you spent $38 million in today's dollars, and built Option number Three, as opposed to if you spent the $15 million today, and then you and added 10 years or 15 years. Have you cost it out, or projected what the cost of that future expansion? My question is wouldn't it be better to spend the money today, and build what you need, there's Option Three which is going to cost you $38 million today, as opposed to spending $15 million dollars today, and then in another five, or another 10 or 15 years, you have those accelerated costs we're all familiar with what happens with swimming pools. Have you costed that out, and might it not be better to build at today's costs, as opposed to building half today and the another quarter, and then another quarter at all accelerating costs?

A: *Troy* – So, electrical utilities in a general sense, don't just look at just tomorrow. For this particular project, we have looked all the way out 10 years, because at the 10 year mark, we are gong to have other decisions about voltage, where things are, all that is going to change. The Option Three will limit out in 10 years, and I'm going to have to go and restudy it again, and make new decisions about what is going to happen with this area. So, we've taken, and we've talked it out, all of the work, the time value, money, and have costed it out for the next 10 years and brought it all back to today's dollars. So, we've done the next present value calculation of both Option One and Two and three. And Option on still very much comes out on top.

Q: What about the transmission lines in Glenmore?

A: If I put a transmission line over in the Glenmore landfill area, I did not even include that as one of the options. That would be another option. We've looked at numerous other transmissions, corridors, and I've really just talked them out because compared to these three options, they were significantly more that the ones we've presented.

Q: In Europe, they have insulated lines.

A: Sorry, the question was, "In Europe, they have a lot of insulated lines". It's no different than here.

Q: Do you have some visuals?

A: We do have some visuals, yes. I will get to the insulated line question here in a minute.

We're going to continue with the public consultation, the immediate land owners, and once again, I've recognized that there are some people that we've missed in the past and we'll try and fix that going forward and into the future.

We will file this application to the Utilities Commission, it will have our preference and our good reasons listed for it, and will have summaries of this meeting and the one in July and then that will be put forward with each of those three options. One of the things we don't want to do is put in something that you will be unsatisfied down the road, we understand that we need to balance, and the Commission will also make that decision. They will publish a timetable. A regulatory timetable that I would suspect would probably start, the registration, in late November or early December. I'm just guessing. And I would suspect that whatever process unfolds, would be over the next four to six months. And it would likely resolve in a written process, an oral process, and that where a panel is brought in.

Q: You mentioned a second site of the ALRN. For the substation?

A: Yes. We will be having a discussion in our application. That all becomes part of the application. We don't make the final decision. We put forward out best proposal, and the reasons for it, and we balance it the best that we can. That's not to say that the Commission is going to have the same views though.

Q: Will the process change from Ellison to Quail?

A: No. I'm not sure if it was actually called Ellison. Ellison sort of describes the general area.

Q: Substation for Option One – will there be more lines through the community?

A: The question was, "If the substation was build where Option One indicates, where there be more lines going through the community". And the answer is no. Troy, can you actually back that up?

A: Actually, the way that the lines have been planned whether it's Option One, Two or Three, the lines that go across from Highway 97 across to Glenmore – I only have two choices. One is sort of along where the University is, and the other one is going to be where Old Vernon Road intersects with Highway 97.

Q: You don't have a very good track record of letting people know about new poles and lines, etc.

A: *Troy –* So, the question was there, "There have been some new lines going in at the north end of Quail, this year, and pople have kind of been told after the fact. Are there going to be any more built?" So, the short answer is no, we are not going to build that line any further than we are right now, until we see the road go through. It would be along what would be the existing road right here. So, we would be five feet off of the property line. I planned the lines roads to be where the new roads are going to be. We have worked this out with the city.

So, with respect to the schedule, we're looking for the application with subsequent approval, this schedule might be a little bit optimistic, especially in the early stages. By winter, this really needs – sometime between now and next spring. I don't know, I can't tell you what the regulatory schedule will be. We need to get something in place by the end of next year; whatever the option is only because we start to run out of capacity by the end of next year. And really what that means is, it would get a slight increase. Now these forecasts are based on planned roads, you know, if that's accelerated, like we've seen in other areas, or decelerated, like in certain cases, that will then dictated if the load is going to go as much as we thought, or more or less? It is also very weather dependant. And Murphy's law, being what it is, and it's also the nature of power systems.

Power goes out on the coldest day of the year. That's when people use it the most. So, when you want your heater or your air conditioner on, that's when the power system is working the hardest to keep it there. We are trying to avoid that, and this brings us to the

end of next year. So, we need to work fairly aggressively in terms of schedule, but the Commission, once again will dictate when that process actually gets done. So, just a little bit in respect to construction; this is really irrespective to what Option looks like, sort of generic.

Once again, Fortis employees are the top priority, sometimes it's the crews on the side of the road seeming to perhaps take longer than they should, a lot of discussion goes on, there has to be a lot of communication, especially when they work with energized wires, which they do. It's absolutely critical that they get it right, and sometimes that does take a bit of time. Having said that, the reason they work energized conductors in their hands, or the orange sticks sometimes, is to make sure that you don't see an interruption in your power. That's becoming more and more common. We'll advertise when we do have power outages, we'll try to keep it as short as we can, and that communication is to and from, needs to happen throughout the entire process.

So, what happens next is the process, but we also want to follow up on concerns. This is, as I mentioned, an information secession tonight. But now that we've got some information, some knowledge, either now or sometime in the near future, please feel free to get in touch with us, let us know your views, your thoughts. If there are individual things we can address, we'd love to. If there are groups of things, we have to work with the about the process, we would certainly discuss that as well.

Q: If the budget is $30 million, does that come out of the taxpayers' money?

A: The question was, "The $30 million, or I guess it would be whatever option it would be, what ever the final cost is. Is that coming out of taxpayers' money?" Years ago, FortisBC, as well as other Utilities; i.e.: BC Hydro, an others, they used to have what they call a rate rider, or a regional rate. Certain people, perhaps more remote, paid more. And about 15 years ago, the Utilities Commission said, "you know, this is too confusing, it's not fair. Everybody pays the same. So, when we build something in Creston, a portion of your rate, your power bill, goes to that. And vise versa. So the rate payers pay for everything. The cost increases you are going to see are generally related to these new projects. The power that you consume, is pretty much flowthrough, we don't make any money on that.

Q: How much do I pay of the $38 million?

A: The question was, "If we take the $38 million option, how much would that cost the individual person"? On an average basis, and this is sort of a round figure, you would be looking at about 1.2% every month on your bill. So, 1.2 would be the one time rate impact for this project. And then it would be the same for all of the other projects.

Q: So, it's pretty insignificant for the customer?

A: The question was, "That's pretty insignificant for the individual customer". And you're right. You certainly take a look at it and say, "1.2% that doesn't sound like a lot

of money. But we have to develop a process that you're also paying for anything that we do in Oosoyos, Princeton, Castlegar, all of these other projects, and sometimes its it's two, three, five, seven percent, and you know, I guess it depends on personal circumstances, it may seem like a lot, or it may seem like a little bit.

There's just one more point I want to make, and then we'll open up a general questions and answers.

I really urge anyone that has an interest to seek more information. What you would find tremendously handy, as I do myself, is go to the website, either ourselves, or BCUC at bcuc.com. Surf around, get the information. We've got information on what we call our System Developing Plan, which talks about all of our upcoming projects for the next several years, in all of the areas, and when you can expect them – including this one. So, make yourself as educated as possible, ask us lots of questions, if we're not getting back to you in what you consider a timely basis, demand it. There's my phone number right there, e-mail addresses, etc. My e-mail address, I'll leave some cards here after – it's Keith.Sones@FortisBC.com. And I'll leave some cards up here, and Mac, I think you've got it as well. So yes,

Q: Is Quail the only place in Option One for the substation?

A: Option One discusses the preferences for that site. That's what our preference is, for various reasons – close to transmission lines, etc.

Q: No, other locations being considered at all?

A: Not actively at this point, no. We have looked at others, but that where it stands right now.

Q: Mac, what position is the Association going to take?

A: *Mac –* I think there may be other questions, and I've heard the presentation for the first time as well. Did you show an overhead of the satellite of the location. I just want to sum up a little bit, and then come back to that. Because I think there's several things that we're not clear on.

Mac - This gal was stating that we've heard the presentation, normally we have a presentation, and then the members formulate what their view is, probably either with or without the presenters. And then give direction to The Associatis on; I'd like to in turn give direction to the individuals. So, it's a two sided situation.

Mac - Here's Highway 97, we come up through, up to the lights, up through to this road, and there are three or four legs throughout here, and this is the old lock, the old way out. This is the little cement building.

In categories like this, there's a strip here, along the highway, and it kind of carves up like this, in a irregular shape.

Q: When we've talked about questions being asked and recorded, I would like to ask as well. The Quail community - are all of our lines underground? Piermac is developing north, and they are forced by regulation to put all of the services underground. Why do you not put your services adjoining areas where businesses are at, similarly out of sight?

A: Excellent question. This comes back to the financing, and how we are regulated by the Utilities Commission. That question has come up more than any other question than I can remember, "Why don't we put lines underground, instead of building them overhead?" The practical answer is when you move into a subdivision that has underground services, so all of the lines are underground, the incremental cost between what it would cost to put it in overhead, and what it actually costs to put it underground is absorbed by the development. So, for the sake of argument, they are three to five times more expensive for underground as it is for overhead. So it costs, for the sake of argument, $100,000 to build overhead, $500,000 to put it underground, the developer would pay the $400,000, and puts it in the price of the lots. That's why you will see some areas that are underground. Now, the Utilities Commission has told us very clearly that unless we have a compelling, environmentally or safety engineering reason to put it underground, we won't. We would build it overhead. They specifically told us that in a meeting. The only reason they say that is cost. Now, we did a quick study….

Q: Even though the standard is to…the irrigation is underground?

A: That's correct. We did a quick study – so if you take a look at this next several year plan we've got, and you take a look at all the overhead lines, that we're proposing, in our service territory, and put them all underground, it would be in the order of $1.1 billion dollars. And getting back to the rate question, that would be somewhere in the order of 100% rate increase. And, I think the main reason the Commission stands to that line, and has for quite some time, is that if it goes underground in Castlegar, or somewhere, the only recipients of that are local. But everybody pays, and that's the equity part of the "everybody pays the same rate".

Q: Can I ask another question? Two years ago, at the AGM, we had the Piermac personnel come in with PowerPoint. They had design guidelines, and therefore they have to have a very standard look to the shopping centre that they are developing. Would you be looking at a facid, maybe extend that visual?

A: Yes. And when it comes down to it, irrespectively…..

Q: IF it was to go in.

A: Absolutely. I think one of the point that bears to take specific note of is that the public, even if we had a project that didn't follow the criteria of the CPCN Application, now, there are kind of two things the Commission does; they sort of look at our overall

plans, and they say, certain projects, whether they are big enough, they're expensive enough, they're controversial, whatever – to meet criteria for a separate application. What that means is they want a lot more information so they can make the best possible decision. We have a number of smaller projects that just get reviewed on a mass basis every year. The Commission says, "alright, lets see these other blocks of projects, don't worry about those we will approve them as you state they may be a short work such as a power line in Kaslo, or something like that. They just approve them. But what our go forward position is, and this is quite honestly a result of getting slapped around a bit, if we want to make sure that, irrespective of whether we have a CPCN, a type of project of something else, the public consultation goes ahead. Part of that is saying, how can we best work with the community? So even if the Commission came back and said, "Alright, put the substation right here." That doesn't stop our obligation or desire to carry on with consultations. So, alright, it's going here. We don't want to just build a chain link fence around it, and try to make it look as ugly as possible; we want to make sure that it is as publicly acceptable as possible, and that includes façades, and that can be anything from vegetation screens, walls, there are a variety of setbacks. So, a longwinded answer to your very short question is, yes.

Q: Once again, can you tell me why can't you go closer to the highway or on the other side of the road?

A: The question was, "Is there any possible way to get the substation in here or perhaps, on this side of the rail road, somewhere close to this intersection, but just not here?" We had another group of people wanting us to take this from here and put it up here. Including the fellow that owns this block of land. That's as I mentioned before, this area is problematic because of slope and also because you've got the rail road tracks along there causing some, some – it's not good when you tie electricity and lines around rail road tracks. So,

Q: Are financials a factor for the other side of the road?

A: *Troy* - It's financial and technical, because you're having to do a whole lot more engineering around that. And also, you've got rail road crossing there so you need permits with CNR and you'd need a controlled rail road crossing because there just isn't any access across that rail road track, or that area

Q: So, why do you have to cross a railway?

A: *Troy* – Because I have to be able to bring trucks, vehicles, mobiles and substations in there, and that sort of thing.

A: There's another issue, and it doesn't sound like a big one, but when it come to it, our transmission line is on this side of the road, and it just adds a layer of complexity.

Q: What about where your arrow is right there, right where your red line is? Go south. Right there, in that corner.

A: Yes. We talked to Piermac about that, and they said no. We do have, as I did mention several times that the cost is not the only factor, but I would be remiss in saying it's not a significant one. And, you know, the price of land in this zone is what we would consider to be very expensive.

Q: What is the cost of the five acres?

A: We're not sure yet. We're in a zone in terms of negotiating with the land owner, so the final process hasn't been nailed down yet. But, all I can say is……

Mac – Arman, Arman, just wait a minute, I want to get a summation opinion of this group. And maybe the decision will sway it. We might start heading out. Let me… I appreciate them coming. We heard of this, we said you need to talk to our community. You're the community, and you're all represented, and we appreciate that. I actually had to go to the washroom, and I said to someone as I went by, now, if they finish before I get back, can you make sure you thank them. He said, "Where are the tomatoes"? And that's not a reflection on them, the people, it's a reflection on the proposal. In my sense, listening, because I've listened t the questions, I didn't hear too many accommodations, maybe I didn't expect them, but my sense is that this community is saying, "We really don't it here, or here or here, we want it elsewhere. Is that correct then? *<APPLAUSE>*

Mac – Let me also be clear. Let me talk about the intervener role, and the intervener status. If one organization, namely the Resident Association, indicates no concern, that is not effective. Let me go one step further. On the airport's master plan, I'm really upset that they're tolerance of another 10 year delay before they handle lights. I'm asking you as individuals of recipients of that letter, to also, at least do one of two things: take the letter and say I agree. And I wonder how many of you did, or are you silent on the issue. The presence tonight is conveying your thoughts, your impressions; your mild applause is saying you agree that you don't want it there. But these gentlemen know that. Their eyes, their ears, they sense that. They are not the ones that make the decisions. The decision is made by the commission. And the decision is made on the based on the communication they receive. So, I may have heard it elsewhere, and I may have communicated that, if you don't communicate it, I've always said that "Silence is perceived as consent." So, I'm kind of challenging you to look at what you start as communications. There may be people here who are saying, "Sounds great. What we need is more power, what we need is a confidence in the power system we have", and that is what these gentlemen indeed are trying to provide in part. It's just that we sense as residents in a residential community one is committed to a standard as no visuals of Hydro, we're staying beyond the residential community. But, you need to be communicating that as individuals as well. Question? Comment on my comment?

Q: Parachute this into an already developed area! Who can make the most noise? Do we need a Lawyer working on this?

Mac – We need to entertain a motion.

Q: The group of "people" to push it back up, who are they? Are there many of them?

A: The question was, just in case anybody didn't hear it, "Who are these people that are complaining about it – this section right here". Primarily it's the City of Kelowna and the landowner that said, "Well, I'll sell this area here, but I want to keep this area down here". I don't want to leave you with the wrong impression here tonight. Our obligation here tonight is so that everyone in this entire area has got an adequate power source going in to the future. We really want to make this as good as we can for you, we understand that it is ugly, you don't want it there, and we accept that. So, as Mac said, I fully expect that anytime something is proposed to be built near you, you're not going to like it.

Q: What about health issues? Are EMF's harmful? There's no documentation to explain this.

A: We align ourselves with the World Health Organization and Health Canada. No, I think you're right in terms that the World Health Organization would not say that EMF's will not harm you – full stop – period. What they do say is that EMF's at a very low level are not considered a risk. And the other thing I can say is by the time we get to this road, this station; they've dropped off to such a point, that they are difficult to even measure. And by the time you get to about here, you won't measure. I'll give you an example. We were asked to look through a very exhaustive process this year, and we went down and took some measurements, and what we found was at the fence line, we had, I'm just going to throw some numbers at you, don't worry about what they mean, I think every body would agree, a low of .3 millidose you wouldn't even have to worry about, it's as simple as that. Anything below one or two is almost _____. We were at the fence line, leaning right up against the fence of the substatiaon, we were at about 5-1/2. And as soon as you went back about 20 feet, you were at about one. And as soon as you went back another ten feet, you're into that zone - .5. It falls off very very quickly. And that's not to say that it's good, bad or indifferent.

It's just the fundamentals of electricity. Now, you turn to the question, "is it harmful"? The reason we call upon the World Health Organization is because they go back to the large group of scientists around the world that come together and set the standards. What they have said is that if you have a pacemaker, you shouldn't be subjected 24 hours a day, anything more than 833 millidose on a continuous basis. What we are proposing here, right under the transmission lines, is probably be more around 15. So, the numbers as put out by the World Health Organization and it's affiliates, we're talking about magnitude, we're talking about _____ times less than the minimum values. And you're right, you can find stuff on the internet, but we really don't have the resources internally to say what we thought, so we go to a large reputable company, The World Health Organization, Health Canada, The Cancer Society and we have to default on what they have to say.

Q: Emissions – what is the electricity in this room? There's electricity all around us, what are the level of emissions that we've been exposed to tonight?

A: Probably very little unless you're sitting next to an electrical socket.

A: *Troy* – Can I take this one? I've done my own personal studies. I've worked out the power for cleaner ovens, ranges, under power lines, and then I've walked around my own office, and I've found the measurements that I took while I was sitting at my computer are higher than those while I was under the transmission lines. You know, there's EMF's in everything. A current runs through a wire, and creates an electric field. We deal with this every single day.

Q: Will the substation make noise?

A: *Troy* – A low level hum, yes.

Q: I have a concern. I've heard a lot of negativity here tonight. I want to have enough electricity. We all want it in somebody else's back yard. I looked at the visibility, and it's actually going to be less visible than what is in the picture, am I correct?

A: Yes, that was no attempt to dress it up.

Q: *(continued)* I can appreciate that everyone has concerns, but I also think that we might be subject to a bit of mass hysteria here. I overheard a comment that property value is going to drop $30,000 a unit. Well, what's the evidence to say that that's going to happen? The residents need to look at this. There are many communities that have electrical substations, and as far as this subdivision goes, I don't think that driving through the gravel pit has hurt our property value at all. It's been there for awhile; nobody has seen much change since this subdivision has started. So, I would just suggest that when the Residence Association does make their decision, then the residents look at this from a rational perspective, and eliminate some of the hysteria that I've heard here tonight. The other thing is that I would certainly back Mac in his comment about the value of the Residence Association's decision to the Utilities Commission. If you are serious about this, then you as an individual have to take action. You can not hide behind your Residence Association. Politicians look at numbers, and they don't evaluate group numbers with nearly the impact they do from individual numbers. And I stick to that from political experience through several years, and see the results of individual action compared to group action. So, whatever you want to do, it's in your hands to do it as individual property owners, and don't think you can hide behind your Residence Association and then blame the Association for not building a strong enough case. You can't do that. And we stand here tonight, we listened to a problem about speeding in our neighbourhood, and I would suggest that probably the majority of us sitting here in this room are guilty of what we are complaining about. So, let's just use a little common sense in dealing with this thing tonight.

Q: What about the University site?

A: *Troy* – It's too far away.

Q: What about East, above Ellison?

A: Now you are starting to talk about the flight zone. It's probably strongly discouraged.

Q: We were the third choice – how come?

A: With respect to the first choice, that was a significant part of it. We also heard back from the Agricultural Land Commission.

Mac – We should be wrapping it up

Just so that you know, certain democratic process require appeal, and others don't. We don't have any route of appeal with the Land Commissions. Once they make their decision, it's final. We don't have any way to go back.

Mac - So, what may happen with the process is – I guess people are starting to head home. And I really feel we should get close to wrapping it up. And it doesn't mean that you wouldn't be here to intervene, and answer questions and clarifications. I really think that in terms of the group, we should be close to closing it down. If your comment is in relation to – we have a motion??

Motion read

Overruled

Motion read a second time.

Mac - I would like you to join me though, in thanking this team for coming. Maybe it wasn't the message you wanted to hear, but I think they're commitment to come and share information is very detailed, and be very patient with questions is something that we can appreciate and acknowledge. Do you agree? <*APPLAUSE*> We weren't too far into this discussion when my wife said to me, "I don't think I'd want his job". But that is his job, and his job is to provide information, and interact with the community.

Let me ask you one other question. If there is a chance to manufacture a better outcome, is that also something that you would want the Association to do, or do you want us to be stagnant in our opposition? I really want you people to register as well, so you get knowledge and communications as readily as we do as an Association. It does come out on e-mail. So, it would come back to you that same as we do. We could look at that. I mentioned and there's commitment, there's just intent to make sure there is a façade if it was to go somewhere to minimize the visual. We can derive, add money to enhance the visuals that we encounter. I would like to look at that. Whatever else we are able to do. If we're going down the road, we can offset that. That's a fairly, fairly rigid position. And you can state that, that sometimes you want to go beyond that and work out an outcome for all.

When this team leaves tonight, and they haven't heard that a well represented community is saying no. They've clearly heard that. It's even written down, right? So, I'm going to formally adjourn the meeting. They will stay and answer questions. We should do that out of respect for you folks.

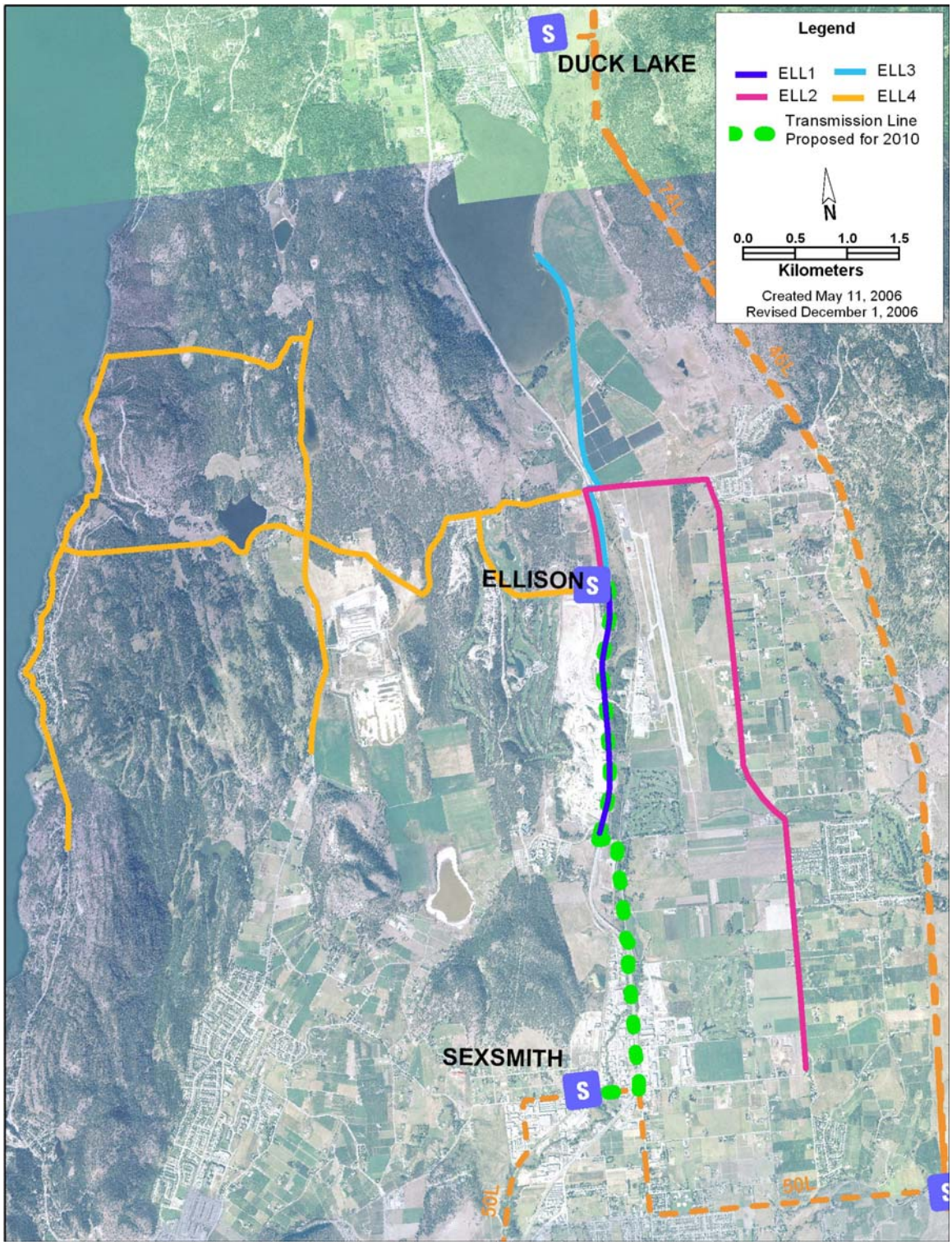
Meeting adjourned at 9:47pm.

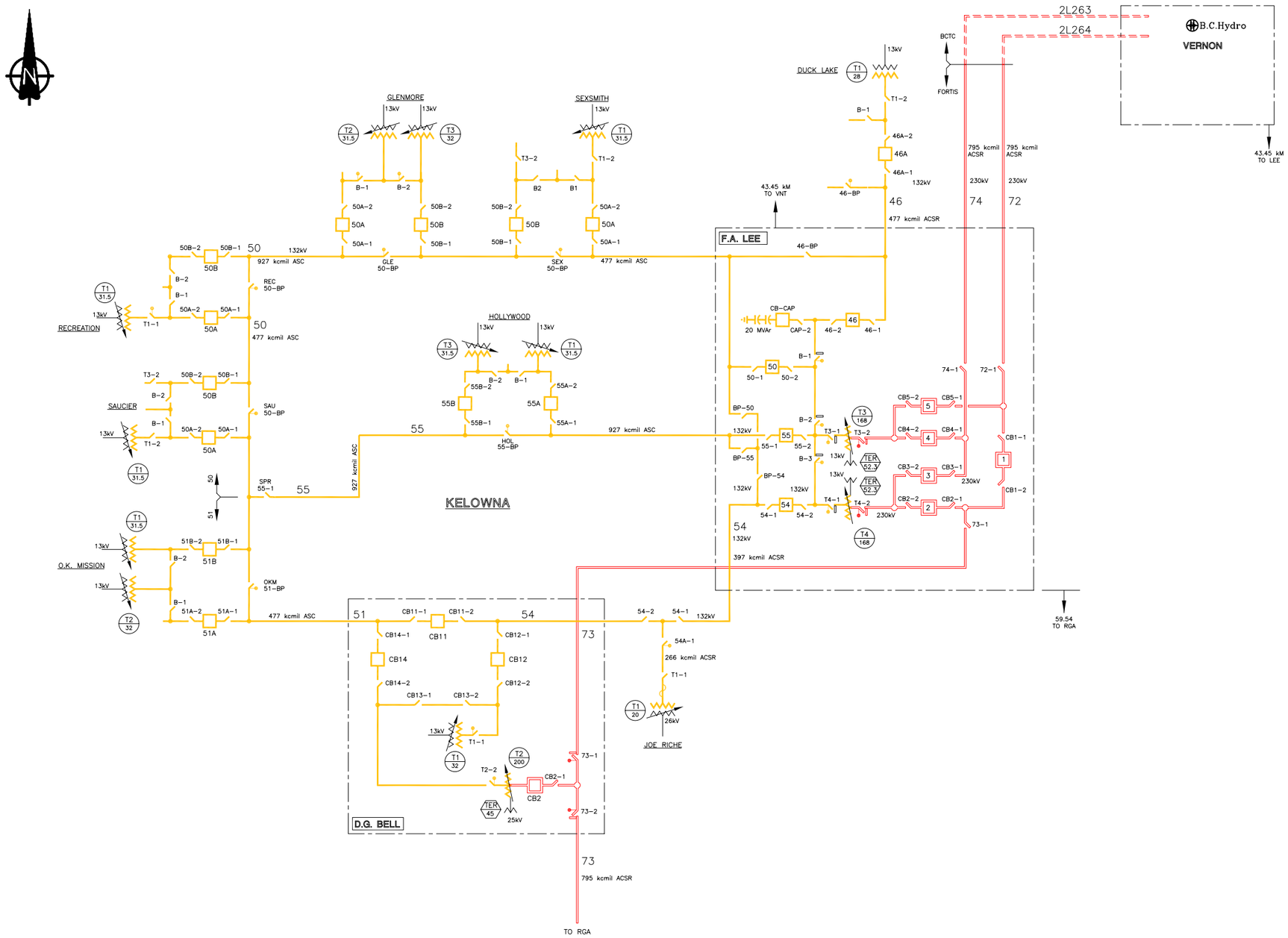
Ellison Substation (Artist Rendering)

Substation without vegetation improvements

Substation with vegetation improvements

Appendix 24.1 (Figure 3 Revised)





REVISIONS							
4							
3							
2							
1	JUL/05	PFE		REDRAWN WITH CHANGES TO DG BELL			
REV	DATE	BY	CHECKED	DESCRIPTION	REVISION APPROVAL	DATE	

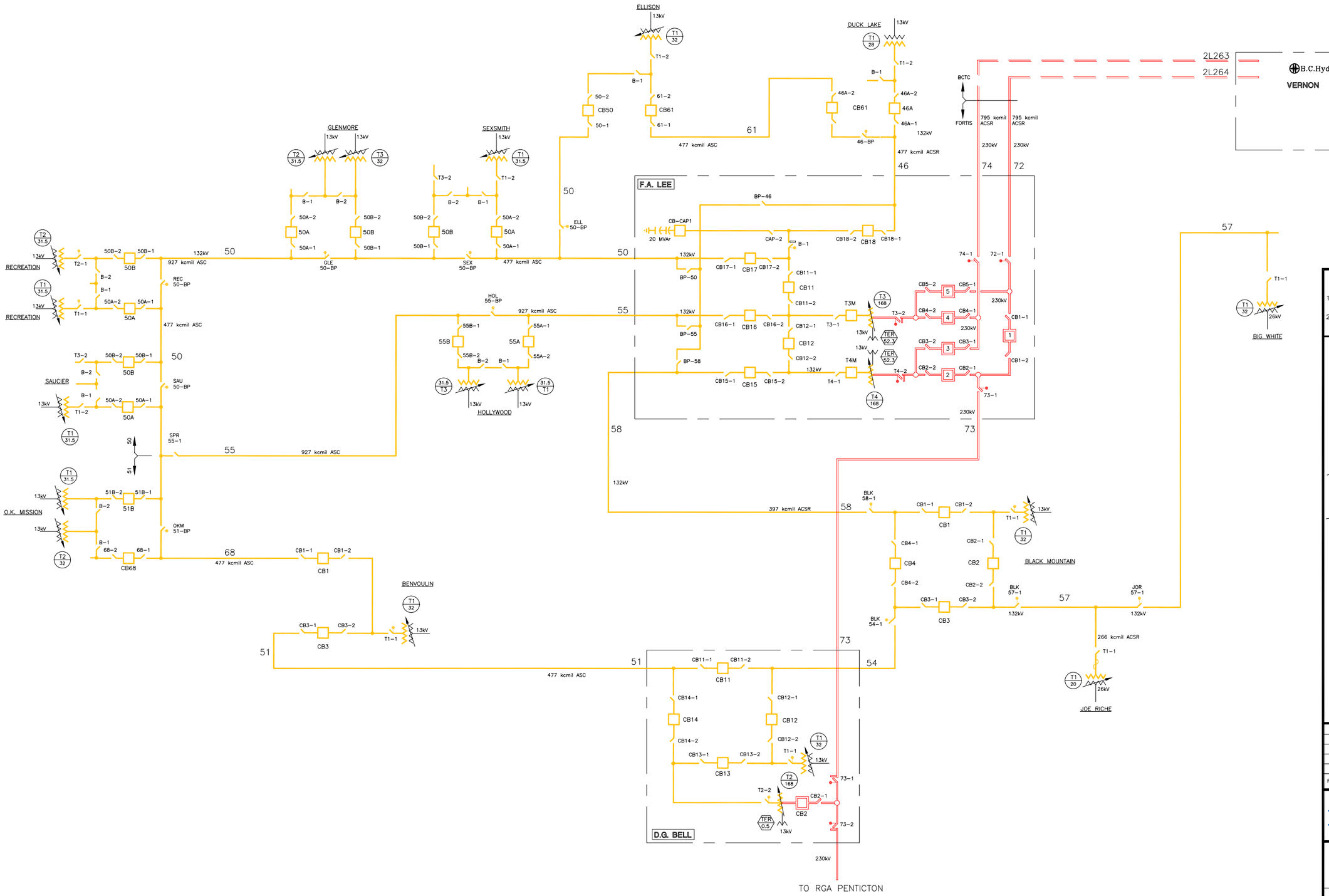
DRAWN BY: P.F. EDWARDS		JUL/05
DESIGNED BY:		
CHECKED BY:		
APPROVALS		
ELEC	CIVIL	MANAGEMENT

FORTISBC

DIVISION	OKANAGAN
DEPARTMENT	PROTECTION-CONTROL
LOCATION	CITY OF KELOWNA
TITLE	SYSTEM SINGLE LINE

SCALE: NONE SCALE FACTOR: 1

DRAWING NUMBER	REVISION
4-000-0403	1



GENERAL NOTES

1. ALL TRANSFORMER RATINGS ARE MAX. NAMEPLATE RATINGS AT 30°C. AMBIENT.
2. ALL TRANSFORMER AND GENERATOR RATINGS ARE IN MVA.

LEGEND

- GENERATOR IDENTIFICATION
- MVA RATING
- TRANSFORMER IDENTIFICATION
- MVA RATING
- TERTIARY
- MVA RATING
- TRANSFORMER c/w ON-LOAD TAP CHANGER
- AUTO-TRANSFORMER c/w ON-LOAD TAP CHANGER
- TRANSFORMER c/w GROUNDED WYE WINDING
- 230kV
- 132kV & 161kV
- 63kV
- OTHER UTILITIES
- VACUUM INTERRUPTER
- HIGH VELOCITY INTERRUPTER
- SCADA CONTROLLED MOTOR OPERATED DISCONNECT
- CIRCUIT SWITCHER

REV	DATE	MADE BY	DESCRIPTION
5			
4			
3			
2			
1	NOV/06	PFE	UPDATED SLD

FORTISBC

2008 KELOWNA AREA

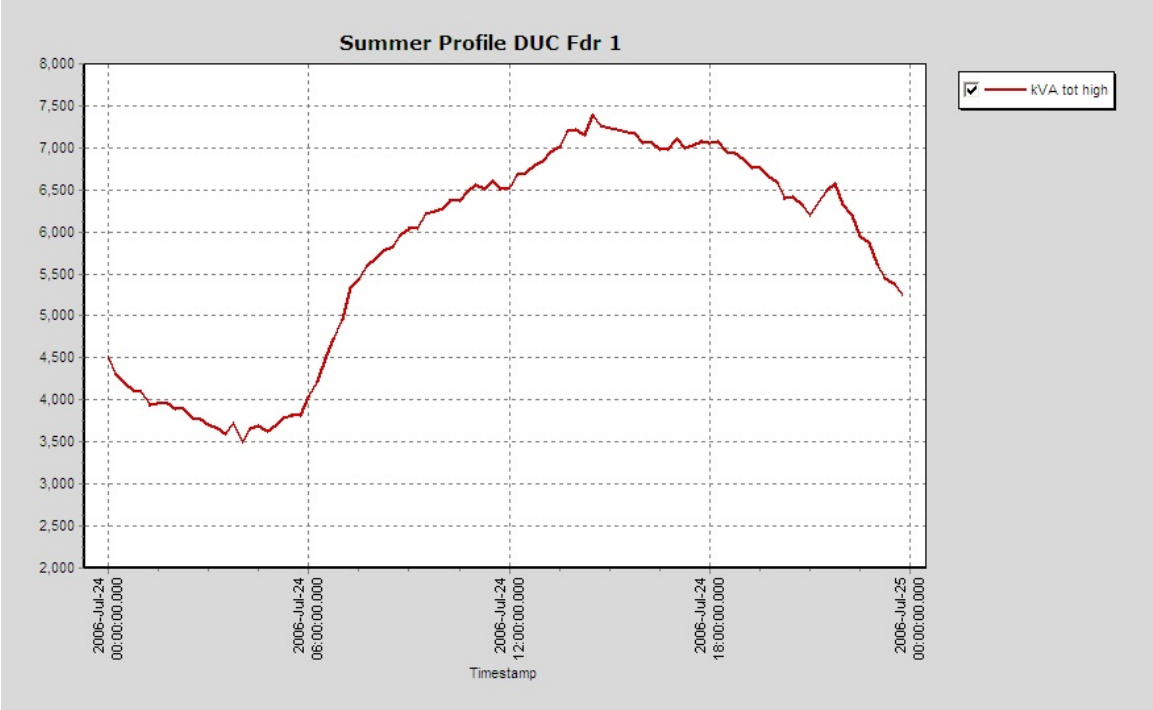
DRAWN BY:

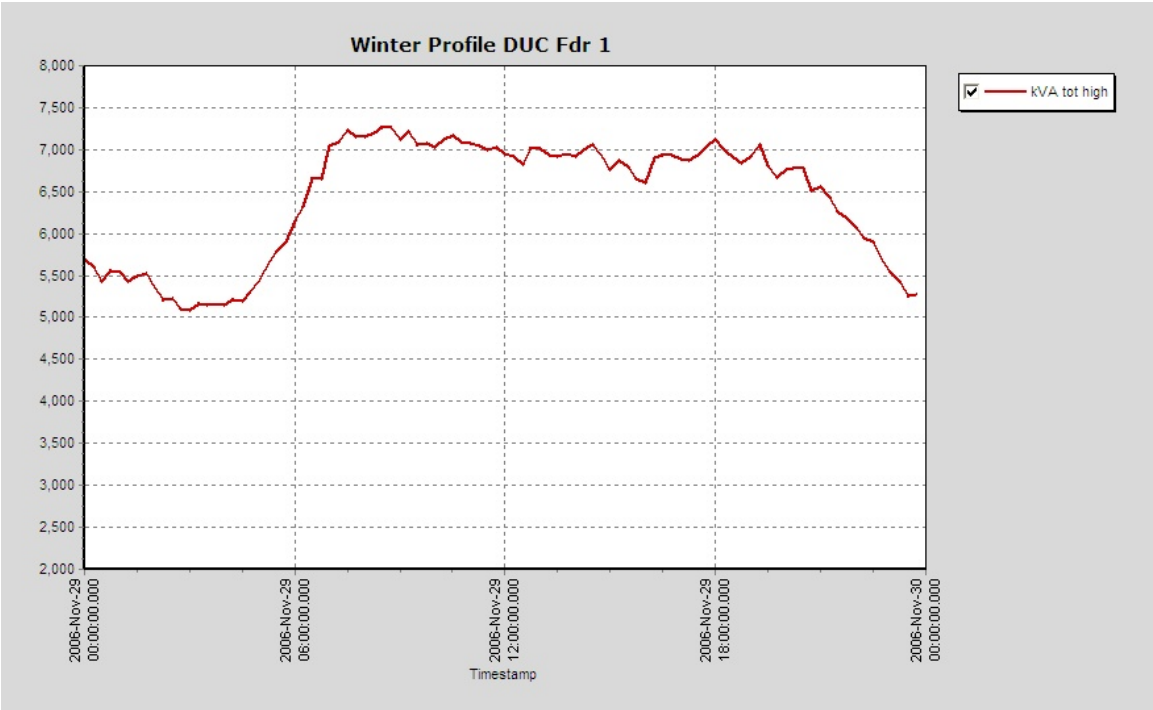
APPROVED BY:

DRAWING NUMBER: 4-000-0408

REVISION: 1

Duck Lake Feeder 1 Load Profiles





We are registered intervenors and part owners of 115 acres bordering on the proposed Ellison substation site.

Q1. We would like to know from Fortis why we have not been formally notified about the proposed substation at either the current Lochrem Rd. site or the previous Dry Valley Rd. site.

A1. The Company's records indicate that the proposed location of the substation was discussed with approximately 25 residents including Mr. Don Mushta on August 30, 2006 at the Gale Road Association meeting. At this meeting the Company acknowledged that it had inadvertently not distributed copies of the proposal to all residents in the neighborhood of the Dry Valley Site and it apologized for this oversight. The formal proposal was also reviewed at the QRRA AGM on October 24, 2006 that Mr. Mushta also attended. However, FortisBC will continue to review its notification process to ensure that residents adjacent proposed facility sites will receive some form of formal notification.

Our property directly borders on both of these sites.

We pasture cattle on this property and we have concerns about the effect of the substation on our cattle. We have a corral situated less than 100 feet from the property line of the proposed site. It is our understanding that a substation gives off a loud humming sound. It is possible that this noise would "spook" the cattle and they would not be willing to come near the corral. If this should be the case, we would not be able to use the corral to transport our animals and it would have to be relocated at significant expense.

A2 Please refer to the response to BCUC IR1 Q19.6. The corral is estimated to be approximately 150 feet from the proposed transformer location and at that distance, the Company estimates that the noise level from the transformer would be approximately 40 dBA. This is equivalent to the noise level in a typical living room of 40 bBA and less than the noise level of 52 dBA from a forced air heating system. Based on these comparisons, FortisBC does not believe the transformer noise level should be a concern for cattle on the property.

Further to the Regulatory Timetable contained in Appendix A to BCUC Order No. G-140-06, this is Pier Mac Petroleum Installation Ltd.'s Request for Information Dated December 8, 2006:

Preamble:

Pier Mac recognizes FortisBC's need to address capacity requirements and accepts that expanded/new substations are required but we have concerns about the CPCN application dated October 27, 2006.

We take issue with Reference Application pp. 4 Lines 15 to 20, which, in our view, inaccurately implies that communications had taken place between FortisBC and Pier Mac, as a "potentially affected property owner", regarding Option 1 or any of the three options.

We are concerned that Option 1 location was identified and added-on as a potential site too late in the process and is being put forward without full consideration and without due process.

We are concerned about the lack of visual impact analysis and mitigation in the application. The area comprising the Airport, Pier Mac and UBC is of key importance as the City's "Gateway"'. Much effort has been made since the August 2000 formation of the Gateway Group composed of the City of Kelowna, EDC, OUC (now UBCO campus), the Kelowna International Airport, Pier Mac and laterally MoT, to ensure the Gateway area's improvement and success. FortisBC's proposals, particularly Option 1, seem to constitute a backward step in this effort.

Substation Site

Although we have not reviewed substation site plans, we believe the substation siteworks under all 3 Options can be adequately sited and screened to mitigate impacts and we expect that this is FortisBC's intention. We ask for confirmation that if Option 1 is chosen, it will be subject to a full rezoning and development permit process.

Ellison Feeder 1:

Reference Application, pp. 12, lines 13-20

and

Reference Application pp. 3 lines 4-8

We are very concerned about the lack of consideration of the visual impact of the overhead lines, and perpetuation and worsening of the existing condition along Highway 97. Option 1 in particular seems to ensure that the existing condition can not be remedied and will be made worse.

The Highway 97 frontage fronting the Pier Mac lands and the Airport lands are the Gateway to the City of Kelowna and create the first impression of the City for hundreds of thousands of road and air travellers each year. The existing overhead 6 line structures on the west side of Highway 97 constitute a visual eyesore.

Our information is that, of the six existing strands, one is used for local distribution and the others five are not being used for either transmission or distribution.

The Pier Mac gravel pit lands are currently being redeveloped as the "Airport Business Park". Phase I underground electrical works were installed in 2005/06. We were advised by FortisBC staff, who did the electrical design, that the electrical ducting and related works were oversized to provide for loop feeds but also to allow for the removal of the Highway 97 overhead lines in the future.

So, in October 2006 after reviewing project materials received from third parties, Pier Mac asked FortisBC how the proposals would affect the future of the existing Highway 97 overheads and received the following November 1 / 2006 email response from Keith Sones, FortisBC's Project Manager:

> **"...the Ellison project contemplates the use of the existing lines along Highway 97 in all of the three possible options. If a new substation is sited near Lochrem Road, the lines would remain and be used as a 138,000 volt transmission circuit.**
>
> **If either of the other two options is implemented, which consists of expansion of one or both of our existing substations, the lines would remain but be**

energized as two 13,000 volt circuits. In all options the lines are intended to remain in place along the highway;"

This is at odds with what we were previously informed by FortisBC staff.

As adjacent lands are serviced, we suspect removal of the existing transmission distribution poles from Lochrem Road southward along Highway 97 can be realized if Option 2 or 3 is chosen, but only at a much greater cost if Option 1 is selected, because of the vastly different voltage.

Please provide responses to following

Q1. Please confirm and commit that none of Options will result in additional overhead transmission and/or distribution structures being built along Highway 97 in locations southward of the existing southernmost transmission & distribution structure (similar to Reference Application pp. 60 Figure 83) at approximately 700 meters south of the Highway 97 - Airport Way intersection.

A1. None of these options will require additional overhead distribution or transmission structures.

Q2. Please confirm and commit that, under all of the Options, FortisBC will remove the existing transmission distribution structures (similar to Reference Application pp. 60 Figure 83) southbound from the location of the proposed Ellison substation at Lochrem Road to and including the southernmost existing tangent structure approximately 700 meters south of the Highway 97 - Airport Way intersection, a total length of approximately 1700 meters. If removal has to be deferred, please confirm a time frame or preconditions for removal to occur.

A2. FortisBC will not be removing the existing transmission and distribution infrastructure nor will the existing line right of way be removed. The existing line will be upgraded to maintain the existing 138 kV circuit as well as an upgrade of the bottom circuit 13 kV which will be changed from 2/0 ACSR to a heavier 477 ACSR which may require replacement of a few poles.

The drawings in the response to BCUC IR1 Q2.7, Figure 2.7 identify the location of the upgrade along Highway 97.

Q3. Please provide for the above commitments in the budgets of all 3 options.

A3. These commitments are not in the budget because they were not a part of the project.

Q4. Please confirm that FortisBC, regardless of any legislative exemptions, will submit the selected substation location to the City of Kelowna for rezoning and development permit approvals and will follow the resulting decisions and conditions.

A4. FortisBC will submit a request for a change in zoning for this station with the City of Kelowna.

1.0 Reference: FortisBC Inc. Application dated October 27, 2006 for Ellison Substation Project (the "Application"),

Q1.1 When was the prominent location that is frequently referred to in this document as the site of the Ellison Substation (Old Vernon Road and Gale Road) abandoned for the current site north of Lochrem Road?

A1.1 Following the July 6 Public Information Session at the Ellison Community Center, FortisBC again met with the owner of the property at which time he advised that he had decided not to sell the portion needed for a substation to FortisBC. FortisBC then had to consider the next suitable site at Lochrem Road.

Q1.2 Why would the extensive documentation in Appendix C1 that refers to a site that is not under consideration be featured as the supporting documentation on Public Consultation?

A1.2 The documentation in Appendix C1 refers to the Lochrem Road site which FortisBC chose as a second option to the previous Dry Valley Road site. The public consultation was for the initial land selection at Dry Valley Road. This consultation was completed on July 6, 2006 and the choice to move to the Lochrem Road site was in August 2006. FortisBC has an obligation to include site documentation relevant to the application even if a particular site does not become part of the final project plan.

Q1.3 What importance do you place on reflecting the needs and interests of the stakeholders adjacent to the new Lochrem Road site in your documentation under the heading Public Consultation? How is your interest in our situation reflected in this application?

A1.3 FortisBC considers it important to receive public feedback and the input received will be considered in the Company's final plans. This is reflected on page 49 of the CPCN Application.

Q1.4 Is there an expectation from the BCUC that the applicant will consult with stakeholders in close proximity to a proposed power station? Do you conclude that you have met or exceeded the standard expected of the applicant by the BCUC?

A1.4 The Company believes there is an expectation from the BCUC to undertake a public consultation process focusing on effected stakeholders in this particular project including those in close proximity to the planned substation. FortisBC has had two public information sessions and numerous one-on-one consultations with the stakeholders of this project and believes that it has appropriately consulted with the stakeholders in proximity to the proposed substation.

Q1.5 Whereas documentation is extensive (55+ pages) for the Public Consultation Process at the initial Ellison site at Old Vernon Road, kindly provide the following information for the process used for the Lochrem Road site:

A1.5 FortisBC utilized the opportunity to meet with the QRRA at its Annual General meeting and received the invitation to come to the AGM for a formal presentation of the proposal.

Q1.5.1 Number of radio advertisements, newspaper advertisements and flyers used?

A1.5.1 There were no media advertisements placed by the Company with regard to its presentation at the QRRA AGM. The Company relied on the normal notification process used by QRRA for its AGM.

Q1.5.2 Number of Information and Poster Board Displays utilized?

A1.5.2 There were three boards used.

Q1.5.3 A scripting of Questions and Comments.

A1.5.3 Please see the response to BCUC IR1 Q20.2 and Q20.3 for all of the dialogue that occurred at the meeting.

Q1.5.4 A sample of the Exit Questionnaire used?

A1.5.4 An exit questionnaire was not used for this meeting.

Q1.5.5 A copy of the Agenda used?

A1.5.5 The agenda was included in the QRRA agenda with one line item. "*FortisBC shall present its proposal for the Ellison Substation.*"

Q1.5.6 A comparison of budget expenditure for Public Consultation for both sites!

A1.5.6 The Company spent approximately $10,000 for consultants, flyer design and delivery, $5,858 for print and radio advertising costs plus 150 hours of internal labour on the public consultation process for the Dry Valley site. The FortisBC Communications Department has since discontinued the use of external consultants for public consultation and has started completing this function in-house and advertising has also been brought in-house.

The public consultation for the second site differed in nature. Upon consultation with the QRRA president, it was determined that the best venue for a presentation was the resident's association annual general meeting. As a result, advertising was completed by the QRRA to promote the AGM at no cost to FortisBC. The presentation at the QRRA AGM was altered to reflect the new site, but no additional costs were incurred to promote the event. FortisBC held discussions with residents most closely located to the site starting in August.

Q1.6 In contrast to the extensive documentation and seemingly thorough process for the abandoned site, there was only an 8 lines ref. Page 49 regarding a meeting on October 24th, 2006.

Q1.6.1 Why would the description not make mention of the Motion at this meeting that clearly stated that there was STRONG opposition to Option 1?

A1.6.1 The Company believed that there was both opposition and support in the meeting.

Q1.6.2 One of the Fortis team members (4 in total) scripted the questions and answers. Where is this documentation? Had you considered including a Session Description which would have shown patience and mannerly demeanour by the 118 attendees but apparent frustration with their inability to follow the presentation and hear the question/answer segment of the

evening? The room where the meeting was held is 48 by 60 feet in dimensions and there were some of the attendees seated on the perimeters of the room.

A1.6.2 Please refer to the response BCUC IR1 Q20.3.

Q1.7 You appeared to have been thorough in contacting the potential residents and property owners in relation to the first site. How and when did you notify the following residents and property owners in proximity to the new site? What level of communication has taken place with the following residents and property owners in proximity to the new site?

1.7.1 T C Ranch ~ large land holdings immediately adjacent to the new site

1.7.2 Pier Mac Inc. ~ Developers of the Airport Business Park

1.7.3 Okanagan Golf Club

1.7.4 The owner(s) of the property 200 meters from the site?

1.7.5 Residents of the Quail Community?

A1.7 Efforts were made to discuss the concerns of each person and/or group since the proposed substation site had changed after project inception. FortisBC has been in contact with all of the aforementioned parties. Direct discussions have been held with each at various stages of the project development.

2.0 Reference: Application, pp. 3 lines 16-17

"community feedback following a public information session encouraged FortisBC to identify other suitable locations"

Q2.1 What does feedback look like? … sound like? that convinced you to identify other suitable locations?

A2.1 FortisBC considers all feedback as relevant to identify alternative locations. FortisBC considers feedback related to land usage (Agricultural Land Commission), location of customer density, visible aesthetics, traffic, noise and cost. Based on customer input, the Company tries to minimize the impact of its facilities with respect to the factors noted

above while placing new infrastructure near its existing plant and the customers that will have to be served.

Q2.2 Where were the other locations?

A2.2 FortisBC considered available locations within an approximate 750 meter radius of Old Vernon Road and Highway 97. The two sites in the application and the area to the east of Highway 97 and south of Old Vernon Road were identified as possible sites for the substation.

3.0 Reference Application, pp. 4, lines 19-20

"most stakeholders have been supportive of the Option 1 concept"

Q3.1 A Fortis Team attended the QRRA AGM and received the Minutes from the QRRA AGM where strong opposition to Option 1 was recorded. Can you direct us to the location(s) in the documentation where this strong opposition is recorded? Why is it omitted from the documentation presented to the BCUC?

A3.1 Please see the responses to BCUC IR1 Q20.3 and Q20.4. FortisBC encouraged the QRRA to register as an intervener for the pending regulatory process. A motion for the QRRA to register as an intervener was forwarded and accepted in the meeting. FortisBC acknowledged that the QRRA would register as an intervener and would express their opposition in a formal manner.

4.0 Reference Application, pp. 12, lines 13-20

Ellison Feeder 1

The Highway 97 frontage adjacent the City of Kelowna Airport and fronting the Pier Mac development lands is the Gateway to the City of Kelowna and forms the first impression of the City for hundreds of thousands of visitor each year. Presently this Gateway frontage is visually blighted by the presence of FortisBC's overhead lines along the west side of the Highway extending past UBCO towards the City.

The Pier Mac property has operated as a large sand and gravel pit since the 1980's but is now transitioning to a Business Park. The Quail Community is accessed by a

single entry road through the Pier Mac lands. The access is shared by residents and visitors including thousands of patrons to the Okanagan Golf Club. Our QRRA hosted a presentation from Pier Mac in 2003 where we learned that, like the Quail Community, the Business Park will have underground services. This is a welcome and expected enhancement.

Pier Mac advises it was told that the Phase I underground electrical works, designed by FortisBC and installed during 2005/06 were overbuilt in part to accommodate the removal of the overhead wires fronting Hwy. 97 at some point in the future. It is assumed that the same overbuild would be incorporated into utility works installed on UBCO and other lands along the Highway 97 route.

The existing lines fronting Highway 97 are not being used for transmission (present voltage use not known) but FortsBC's intent now appears to be to retain the overhead lines permanently.

This intention is demonstrated by October 27, 2006 CPCN application Reference Page 3 lines 4 to 8:

If a new substation is sited near Lochrem Road, FortisBC intends that the lines would remain and be used as a 138,000 volt transmission circuit. If either of the other two options is implemented, which consists of expansion of one or both of our existing substations, the lines would remain but be energized as two 13,000 volt circuits

Q4.1 It is not acceptable that while the City of Kelowna and other utilities providers are moving forward to making Kelowna a more liveable City by moving utilities underground, FortisBC is moving in the other direction. Are you prepared to include the cost of moving the Highway 97 overhead lines underground in the capital cost budgets of all 3 options? If not, why not?

A4.1 No, converting Highway 97 overhead lines underground is not part of this Project and therefore is not part of the current capital cost budget.

Q4.2 In that Option 1 changes the conditions and cost of taking the Highway 97 lines underground, and appears to make it considerably more costly to take the lines underground we request that you choose either of the other Options or include at least, the differential capital cost of doing this in Option 1. Which of these two choices will you choose?

A4.2 FortisBC will recommend Option 1 as it is the most cost effective and flexible option to meet customer needs.

Q4.3 There is no comment in the section on Ellison Feeder 1 on the routing of lines to adjust for the major road construction in the vicinity of UBCO. Why is that not included? In that the UBCO is part of the City of Kelowna Gateway Project and the opportunity for community enhancement by burying the lines is a desired goal, will you extend the burying of lines to include the area fronting UBCO as well? If not, why not?

A4.3 Please refer to the response to QRRA IR1 Q4.1.

5.0 Reference Application, pp. 13, lines 6-13

Ellison Feeder 4

The reference is made to a specific length of new feeder but the location in this section and on the map pp 15 is not specified.

Q5.1 Is the building of this new feeder to coincide with the construction of the new roadway know in city planning as the McKinley road? Can a request for pole lines, if deemed necessary, to be placed on the north side of the roadway farthest from the existing residential development be honoured by Fortis?

A5.1 The design for the lines on the road to McKinley will be determined by the landscape of the road. FortisBC is not willing to make any commitments to where the lines will be located until the road plans are finalized. FortisBC will consider all developments along the new road understanding that there may be future development to the north of the road also.

Q5.2 In that new roadway construction plans may see the construction of an east-west roadway in the vicinity of the UBCO precede the McKinley roadway, will you choose this roadway as your corridor for the transmission lines?

A5.2 No transmission lines are proposed in the 20 year planning window, so a transmission circuit is not anticipated along that corridor. However, FortisBC believes that the question above is directed towards a distribution line. When this corridor becomes available, FortisBC would consider this as another distribution line corridor if and when the growth in the area requires it.

5.3 Residents in the Quail Community were beginning to hear rumours about a pending power substation in the summer of 2006. Although no notice had been received and no public meeting was offered, a new transmission line suddenly appeared on the immediate northern border of our community with the terminal pole a mere 10 yards from a residence on Quail Crescent. Naturally this initiative by Fortis, which by virtue of the actual stated intent, had a very real possibility of being a positive factor for the community (a second loop to ensure continuity of power to the community), instead left Fortis appearing "bullish" and conveyed a choice of proceeding with transmission pole installation without any prior notice or consultation whatsoever with the home owner negatively affected by the terminal pole. The action of Fortis was alarming to the owners of the residence and to the community at large. Although you may challenge us to substantiate our opinion, we believe that installing a power pole within 10 yards of a residence in a community where power poles do not exist does serve as a deterrent to some buyers and in effect might very well have lowered the property value of this fine residence. Will you in good faith remove this pole and bury the lines that span from the second last pole to the point near the Quail Crescent home where the new loop now connects into the Quail Community underground system? If not, why not?

A5.3 The line in question is a 13 kV distribution line, not a transmission line. FortisBC installed this line in anticipation of a future road ROW along the corridor in which it was placed. Since overhead is standard construction for distribution lines, FortisBC cannot

install underground facilities unless it obtains a customer contribution to pay for the incremental cost of upgrading to the underground option. Please also refer to the response in QRRA IR1 Q4.1.

Q6.0 Reference Application, pp. 20, lines 1-13

Electrical and magnetic Fields ("EMF")

This entry in your submission and the notations in the Bulletin ~ Power Sense ~ suggest that you are dependent on the standards set by Health Canada. Science and findings related to this aspect of Science ~ Electrical and magnetic Fields ~ are constantly evolving and new findings are impacting the standards that one must aspire to ensure the safety of the community. When was the last time you reviewed and adjusted your standards? How many of the scientific findings that you are dependent on to set your parameters for E.M. F.'s are based on pre 2003 data?

A6.0 Historical and current studies related to EMF were presented and reviewed as part of the Nk'Mip CPCN Application regulatory process that included expert testimony on the subject. FortisBC recognizes the public concern with EMF and is committed to the health, safety and welfare of the public and its employees. FortisBC works with regulatory agencies, government and the Canadian Electricity Association.

Our goal is to communicate up-to-date EMF information to the public, employees and regulatory agencies as the information become available.

FortisBC through its Manager Environment, Health and Safety monitors ongoing activities with respect to EMF. FortisBC is a member of the CEA (Canadian Electrical Association) EMF Communication Working Group. CEA through its Transmission Group has the mandate to monitor worldwide research, guidelines, standards and policy developments around the possible health effects of electric and magnetic fields.

The CEA position with respect to EMF as outlined on its Website: http://www.canelect.ca/EMF/emfpositionstatement.html, states that - "Scientific evidence to date has not established a causal link between adverse health effects and EMF".

FortisBC monitors the position of the following national and international bodies

regarding their position on the matter:

1. Health Canada: http://www.hc-sc.gc.ca/iyh-vsv/environ/magnet_e.html
2. BC Centre for Disease Control: http://www.bccdc.org/content.php?item=57
3. The World Health Organization's International EMF Project ("WHO"): http://www.who.int/peh-emf/project/en/
4. International Commission on Non-Ionizing Radiation Protection ("ICNIRP"): http://www.icnirp.de
5. The National Institute of Environmental Health Sciences (U.S.) Q&A on EMF: http://www.niehs.nih.gov/oc/news/emfnew.htm
6. Federal-Provincial-Territorial Radiation Protection Committee-Canada ("FPTRPC"): http://www.bccdc.org/downloads/pdf/rps/reports/FPTRPC%20ELF%20fields%20and%20health%20document%20-%20050117.pdf

The WHO position with respect to the ICNIRP Guidelines is as noted:

"The exposure limits for EMF fields developed by the ICNIRP – a non-governmental organization formally recognized by WHO, were developed following reviews of all the peer-reviewed scientific literature, including thermal and non-thermal effects. The standards are based on evaluations of biological effects that have been established to have health consequences. The main conclusion from WHO reviews is that EMF exposures below the limits recommended in the ICNIRP International Guidelines do not appear to have any known consequences on health" (http://www.who.int/peh-emf/standards/en/)

Please find the following documents attached as Appendix A6.0:

1. Health Canada - Position Statement: Updated April 2004.

   The statement is also available at: http://www.hc-sc.gc.ca/iyh-vsv/alt_formats/cmcd-dcmc/pdf/emflow_e.pdf

2. FPTRPC - Position Statement: Issued January 30, 2005.

The statement is available at:
http://www.bccdc.org/downloads/pdf/rps/reports/ELF%20position%20statement%20E-050120.pdf

3. ICNIRP Guidelines for limiting exposure to time-varying Electric, Magnetic and Electromagnetic Fields (up to 300GHz)

The Guideline is also available at: http://www.icnirp.de/documents/emfgdl.pdf

7.0 Reference Application, pp. 30-31,

Q7.1 Have you taken any actions, built any segment of the project or committed funding to any aspects of the proposal related to Option 1 that presuppose approval by BCUC for Option1? If yes, what are they and why would the choice to pre-empt the decision making authority of the BCUC be taken?

A7.1 The line route from the Duck Lake Substation to Old Vernon Road has a right of way that will allow for a double circuit 13 kV line or a 138 kV line and bottom circuit 13 kV line. This line was built originally for expanding the distribution flexibility and load carrying capacity into the Ellison area. FortisBC designed the line to be able to handle the capacity of two circuits at the same time. This line would be utilized as a double circuit independent of which option is chosen. This choice does not pre-empt the authority of the BCUC because it allows for any of the three options to work.

8.0 Reference Application, pp. 49, 50 lines 27-5

This 8 line entry, that appears to be the only reference to meetings with the stakeholders in proximity to the new location, serves as a misrepresentation and an injustice to the residents who attended the October 24th meeting. See 1.6 above!!

Q8.1 Please provide us with your assessment of the effectiveness of the segment of the October 24th meeting that was managed by the Fortis Team. Those of us "on the ground" in Quail realize, especially with the passing of time, the wide divergence of understanding and perception that resulted from the meeting.

A8.1 FortisBC considers the October 24, 2006 meeting to be effective. The Company rarely sees more than 50 attendees at its public information sessions. FortisBC is encouraged

that over a hundred people attended the presentation and were able to voice their opinion about the Project. FortisBC recognizes that the majority of interveners for this project are from the Quail Ridge area and encourages the participation of interested stakeholders to arrive at a satisfactory outcome for this project.

Q8.2 Several members of the QRRA Board, joined by two community members, organized a subsequent meeting with Mr. Sones where a series of the questions that were needing clarification were answered and the information from the answers was scripted and later, following a review by all in attendance, shared by email with QRRA members who subscribe to email membership. Please provide us with your assessment of the effectiveness this meeting.

A8.2 The Company believes the meeting was effective as there was some good communication between the parties. While some of the attendees had concerns about the impacts of the proposed project, many of those concerns were addressed by the Company providing detailed and related information. The two community members acknowledged that others within the Quail Ridge community had contacted many residents without the benefit of all the project information, which in large part had lead to the relatively high volume of concern.

The attendees seemed sincerely interested in getting Project information from the Company and appeared satisfied that their questions were answered. Since the Company believed its responses met the residents' concerns, it concluded that the November 10, 2006 meeting was effective.

9.0 Reference Application, pp.52 lines 22-25

This entry notes that the substation will be constructed adjacent to the Pier Mac gravel pit.

Q9.1 Whereas phases of the Pier Mac remain operational as a gravel pit, the entire property is undergoing a change that will result in a Business and Industrial Park transforming the property dramatically. Quail community residents are patiently

waiting for the complete transition of the mining operation to the Business and Industrial Park. Our gateway to our community is through their site.

Are you aware of the plans for the Business and Industrial Park?

Have you met with the management of Pier Mac Inc.?

A9.1 FortisBC is aware of the plans for the Business and Industrial Park and has included the load forecast for this area in the CPCN Application on page 77, Table G1. The electrical infrastructure for the first phase of the park was completed in early 2006. FortisBC met with the development consultant to complete this design.

Q9.2 Reference is made to vegetation management and vegetation screening for the Lochrem site. At the August meeting we were shown a picture of the substation super imposed behind the vegetation currently surrounding the site as viewed from Quail Ridge Blvd., our entry road. If this site is chosen, we would ask that there be maintenance of a healthy effective vegetation screening in perpetuity. There is substantial evidence that the coniferous vegetation in the Kelowna area and many areas of BC is subject to disease and destruction. How can you assure of this outcome? How is this achieved in a manner that will convey reassurance to the community?

A9.2 Native tree species vegetation screening for the Lochrem site may be preferable to non-native species from both an esthetic viewpoint (i.e. screening is accomplished with look-alike species similar to the surrounding forested lands) and a survivability perspective. Native species generally have a better survival rate than non-native, require less maintenance, and are expected to be “genetically comfortable” in the soil and weather conditions of the area.

The coniferous disease referred to in the question (pine beetle?) predominantly affects large mature trees, whereas the smaller more heavily needled immature trees that would be better suited for screening purposes are not generally affected by pine or bark beetle.

Planting success is never guaranteed. However, FortisBC is proposing to initially provide and maintain appropriate vegetation screening.

10.0 Reference Application, Appendix A1

Whereas the inclusion of Appendix A1 may attest to the thoroughness of consideration that Fortis normally affords stakeholders it is not a valid document for this application.

Q10.1 Do you realize that the inclusion of this appendix and the possible depiction of this section as affirmation that Fortis has done due diligence with property owners and stakeholders serves to chide, sadden and anger the actual property owners and stakeholders for the new site who were not given this same level of consideration.

Why was the same level of consideration not provided for them? How can this omission be corrected prior to the formality of the January 9th Public Hearing?

A10.1 FortisBC recognizes that the registration of the property owners as interveners as their opportunity to express their opinion about the Lochrem Road site.

The Company did not intend the stakeholder reaction noted in this question. The Company is providing information to help with the project review process.

As stated in the response to QRRA IR1 Q1.4, the Company has undertaken two public information sessions and numerous one-on-one discussions with stakeholders of this project. FortisBC believes it has appropriately consulted with stakeholders in the proximity of the proposed substation.

ELECTRIC AND MAGNETIC FIELDS AT EXTREMELY LOW FREQUENCIES

The Issue

There are concerns that daily exposure to electric and magnetic fields (EMFs) may cause health problems. These concerns are reflected in a number of reports that have attempted to link EMF exposure to a variety of health issues, including childhood cancer.

Background

Electricity plays a central role in modern society. It is used to light homes, prepare food, run computers and operate other household appliances, such as TVs and radios. In Canada, appliances that plug into a wall socket use electric power that flows back and forth at a frequency of 60 cycles per second (60 hertz).

Every time you use electricity and electrical appliances, you are exposed to electric and magnetic fields (EMFs) at extremely low frequencies (ELF). The term "extremely low" is used to describe any frequency below 300 hertz. EMFs produced by the transmission and use of electricity belong to this category.

Electric and Magnetic Fields (EMFs)

Electric and magnetic fields are invisible forces that surround electrical equipment, power cords, and wires that carry electricity, including outdoor power lines. You cannot see or feel EMFs.

Electric Fields: These are formed whenever a wire is plugged into an outlet, even when the appliance is not turned on. The higher the voltage, the stronger the electric field.

Magnetic Fields: These are formed when electric current is flowing within a device or wire. The greater the current, the stronger the magnetic field.

Electric and magnetic fields can occur separately or together. For example, when you plug the power cord for a lamp into a wall socket, it creates an electric field along the cord. When you turn the lamp on, the flow of current through the cord creates a magnetic field. Meanwhile, the electric field is still present.

The Strength of EMFs

Electric and magnetic fields are strongest when close to their source. As you move away from the source, the strength of the fields fades rapidly. This means you are exposed to stronger electric and magnetic fields when standing close to a source (e.g., right beside a transformer box or under a high voltage power line), and you are exposed to weaker fields as you move away. When you are indoors at home, the magnetic fields from high voltage power lines and transformer boxes are very weak when compared to the fields from electrical household appliances.

Typical Canadian Exposures to EMFs at ELF

On a daily basis, most Canadians are exposed to EMFs generated by household wiring, fluorescent lighting, and any electrical appliance that plugs into the wall, including hair dryers, vacuum cleaners and toasters. In the work-place, common sources include video display terminals (computer monitors), air purifiers, photocopiers, fax machines, fluorescent lights, electric heaters and electric tools in machine shops, such as drills, power saws, lathes and welding machines.

Typical Exposures Present No Known Health Risks

Research has shown that EMFs from electrical devices and power lines can induce weak electric currents to flow through the human body. However, these currents are much smaller than those produced naturally by your brain, nerves and heart, and are not associated with any known health risks.

There have been many studies about the effects of exposure to electric and magnetic fields at extremely low frequencies. Scientists at Health Canada are aware that some studies have suggested a possible link between exposure to ELF fields and certain types of childhood cancer. However, when all of the studies are evaluated, the evidence appears to be very weak.

After a recent evaluation of the scientific data, the International Agency for Research on Cancer classified ELF magnetic fields as "possibly carcinogenic" to humans based on studies of childhood cancer. However, the evidence is not strong enough to conclude that EMFs definitely cause cancer in children. More studies are needed to draw firm conclusions.

Concerns about Electromagnetic Interference

At typical exposure levels, EMFs may cause interference with electronic devices. For example, office workers may notice image movement (jitter) on their computer screens if the computer is in an area where magnetic fields are slightly above typical levels found in offices. Some sources that generate these slightly elevated levels are the cables that bring electrical power into an office area, and common electrical equipment, such as power transformers.

Magnetic fields that cause jitter on computer screens are well below the levels that would cause human health effects. To solve the jitter problem, simply move the computer to another part of the room where the magnetic fields are weaker.

Minimizing Your Risk

You do not need to take action regarding typical daily exposures to electric and magnetic fields at extremely low frequencies. There is no conclusive evidence of any harm caused by exposures at levels normally found in Canadian living and working environments.

Health Canada's Role

Health Canada, along with the World Health Organization, monitors scientific research on EMFs and human health as part of its mission to help Canadians maintain and improve their health. At present, there are no Canadian government guidelines for exposure to EMFs at ELF. Health Canada does not consider guidelines necessary because the scientific evidence is not strong enough to conclude that typical exposures cause health problems.

Some national and international organizations have issued exposure guidelines for EMFs at ELF. However, these guidelines are not based on a consideration of risks related to cancer or other health problems. Rather, the point of the guidelines is to make sure that the electric currents in the body caused by exposure to EMFs are not stronger than the ones produced naturally by the brain, nerves and heart. For the most part, typical EMF exposures in Canadian homes, offices and other work sites, are far below these guidelines.

Need More Info?

For further information contact:
The Consumer and Clinical Radiation Protection Bureau
Health Canada
775 Brookfield Road
Ottawa, Ontario K1A 1C1
Telephone: (613) 954-6699
Fax: (613) 952-7584
E-mail: CCRPB-PCRPCC @hc-sc.gc.ca

Also, see the following Fact Sheets on the World Health Organization (WHO) Web site:

- Electromagnetic Fields and Public Health: Extremely Low Frequency(ELF) at www.who.int/docstore/peh-emf/publications/facts_press/efact/efs205.html
- Electromagnetic Fields and Public Health: Extremely Low Frequency Fields and Cancer at www.who.int/docstore/peh-emf/publications/facts_press/efact/efs263.html

And visit these Web sites:

The International Agency for Research on Cancer (IARC), Static and extremely low-frequency (ELF) electric and magnetic fields. Report No. 80 at http://193.51.164.11/htdocs/monographs/vol80/80.html

The U.S. National Institute of Environmental Health Sciences (NIEHS), Questions and Answers about EMF at www.niehs.nih.gov/emfrapid/booklet/home.htm

Also, see:

It's Your Health, Safety of Exposure to Electric and Magnetic Fields from Computer Monitors and Other Video Display Terminals at http://www.hc-sc.gc.ca/english/iyh/products/vdt.html

Additional It's Your Health articles can be found at:
www.healthcanada.ca/iyh
You can also call (613) 957-2991

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Canada

Federal-Provincial-Territorial Radiation Protection Committee – Canada

Position Statement for the General Public on the Health Effects of Power-Frequency (60 Hz) Electric and Magnetic Fields – Issued on January 20, 2005

1. Electric and magnetic fields (EMFs) are produced by the generation, transmission, distribution and use of electrical energy at power frequencies (60 Hz in Canada). People are exposed to these fields while in close proximity to power lines and other electrical facilities, as well as electrical wiring, equipment and appliances in homes, schools and workplaces.

2. Studies to investigate the health effects of these fields have taken place around the world for more than thirty years. These studies include laboratory research into effects on cells and animals, as well as epidemiological (human health) studies looking at possible associations between exposures and diseases in the population. Short- and long-term scientific investigations have been conducted and are continuing.

3. Laboratory research has shown that power-frequency EMFs can interact with biological systems; however, results to date have not provided conclusive evidence that these fields cause adverse health effects, such as cancer. Epidemiological studies have not established an association between exposure to power-frequency EMFs and the development of cancer in adults. The evidence associating cancer in children with exposure to power-frequency EMFs remains inconclusive.

4. After a recent evaluation of the scientific data, the International Agency for Research on Cancer classified extremely-low-frequency (ELF) magnetic fields as "possibly carcinogenic to humans" based on studies of childhood cancer (http://monographs.iarc.fr). "Possibly carcinogenic to humans" is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals. In the case of ELF fields, the evidence is not strong enough to conclude that they cause cancer in children. More studies are needed to draw firm conclusions.

5. Immediate biological effects can result from direct exposure but only at field strength levels well above those typically found in living environments. Peripheral nerve and muscle stimulation can be caused by intense magnetic fields and hair stimulation by intense electric fields. Minor shocks may be caused by touching poorly-grounded, conducting (metallic) objects located under some high voltage lines, as a result of electrical charge induced by high intensity electric or magnetic fields.

6. Based on the available scientific evidence to date, the Federal Provincial Territorial Radiation Protection Committee (FPTRPC) concludes that adverse health effects from exposure to power-frequency EMFs, at levels normally encountered in homes, schools and offices, have not been established. Protection of the public against acute effects, such as minor shocks that may occur from contact with conducting objects under high voltage power lines, can be achieved through awareness initiatives undertaken by the electrical power industry.

7. There have been increasing requests from concerned citizens that the precautionary principle (PP) be used in a number of areas, including exposure to EMFs. It should be noted that the extent of PP covers a variety of measures ranging from moderate methods such as monitoring scientific developments and providing information, through participation in the process of acquiring new knowledge by carrying out research, to stronger measures such as lowering exposure limits. Since there is no conclusive evidence that exposure to EMFs at levels normally found in Canadian living and working environments is harmful, FPTRPC is of the opinion that moderate measures and participation in the process of acquiring new knowledge are sufficient. These types of activity are consistent with the Canadian government framework on precaution.

8. The FPTRPC will continue to monitor scientific research relating to the health effects of power-frequency EMFs and will reassess its position periodically as new information becomes available.

Notes:

(a) This Position Statement replaces the previous Position Statement (first released by the FPTRPC in November 1998 and updated in October 2002).

(b) This Position Statement is not intended to provide direction on health and safety aspects of electromagnetic interference by EMFs with medical electronic devices, including cardiac pacemakers. Electromagnetic interference with such devices requires different considerations from those used in the evaluation of human health effects.

GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

International Commission on Non-Ionizing Radiation Protection*†

INTRODUCTION

In 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR), which examined the problems arising in the field of protection against the various types of NIR. At the IRPA Congress in Paris in 1977, this working group became the International Non-Ionizing Radiation Committee (INIRC).

In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO's Environmental Health Criteria Programme, sponsored by the United Nations Environment Programme (UNEP). Each document includes an overview of the physical characteristics, measurement and instrumentation, sources, and applications of NIR, a thorough review of the literature on biological effects, and an evaluation of the health risks of exposure to NIR. These health criteria have provided the scientific database for the subsequent development of exposure limits and codes of practice relating to NIR.

At the Eighth International Congress of the IRPA (Montreal, 18–22 May 1992), a new, independent scientific organization—the International Commission on Non-Ionizing Radiation Protection (ICNIRP)—was established as a successor to the IRPA/INIRC. The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, develop international guidelines on NIR exposure limits, and deal with all aspects of NIR protection.

Biological effects reported as resulting from exposure to static and extremely-low-frequency (ELF) electric and magnetic fields have been reviewed by UNEP/WHO/IRPA (1984, 1987). Those publications and a number of others, including UNEP/WHO/IRPA (1993) and Allen et al. (1991), provided the scientific rationale for these guidelines.

A glossary of terms appears in the Appendix.

PURPOSE AND SCOPE

The main objective of this publication is to establish guidelines for limiting EMF exposure that will provide protection against known adverse health effects. An adverse health effect causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect.

Studies on both direct and indirect effects of EMF are described; direct effects result from direct interaction of fields with the body, indirect effects involve interactions with an object at a different electric potential from the body. Results of laboratory and epidemiological studies, basic exposure criteria, and reference levels for practical hazard assessment are discussed, and the guidelines presented apply to occupational and public exposure.

Guidelines on high-frequency and 50/60 Hz electromagnetic fields were issued by IRPA/INIRC in 1988 and 1990, respectively, but are superseded by the present guidelines which cover the entire frequency range of time-varying EMF (up to 300 GHz). Static magnetic fields are covered in the ICNIRP guidelines issued in 1994 (ICNIRP 1994).

In establishing exposure limits, the Commission recognizes the need to reconcile a number of differing expert opinions. The validity of scientific reports has to be considered, and extrapolations from animal experi-

* ICNIRP Secretariat, c/o Dipl.-Ing. Rüdiger Matthes, Bundesamt für Strahlenschutz, Institut für Strahlenhygiene, Ingolstädter Landstrasse 1, D-85764 Oberschleissheim, Germany.

† During the preparation of these guidelines, the composition of the Commission was as follows: A. Ahlbom (Sweden); U. Bergqvist (Sweden); J. H. Bernhardt, Chairman since May 1996 (Germany); J. P. Césarini (France); L. A. Court, until May 1996 (France); M. Grandolfo, Vice-Chairman until April 1996 (Italy); M. Hietanen, since May 1996 (Finland); A. F. McKinlay, Vice-Chairman since May 1996 (UK); M. H. Repacholi, Chairman until April 1996, Chairman emeritus since May 1996 (Australia); D. H. Sliney (USA); J. A. J. Stolwijk (USA); M. L. Swicord, until May 1996 (USA); L. D. Szabo (Hungary); M. Taki (Japan); T. S. Tenforde (USA); H. P. Jammet (Emeritus Member, deceased) (France); R. Matthes, Scientific Secretary (Germany).

During the preparation of this document, ICNIRP was supported by the following external experts: S. Allen (UK), J. Brix (Germany), S. Eggert (Germany), H. Garn (Austria), K. Jokela (Finland), H. Korniewicz (Poland), G.F. Mariutti (Italy), R. Saunders (UK), S. Tofani (Italy), P. Vecchia (Italy), E. Vogel (Germany). Many valuable comments provided by additional international experts are gratefully acknowledged.

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ments to effects on humans have to be made. The restrictions in these guidelines were based on scientific data alone; currently available knowledge, however, indicates that these restrictions provide an adequate level of protection from exposure to time-varying EMF. Two classes of guidance are presented:

- Basic restrictions: Restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects are termed "basic restrictions." Depending upon the frequency of the field, the physical quantities used to specify these restrictions are current density (**J**), specific energy absorption rate (SAR), and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.
- Reference levels: These levels are provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded. Some reference levels are derived from relevant basic restrictions using measurement and/or computational techniques, and some address perception and adverse indirect effects of exposure to EMF. The derived quantities are electric field strength (**E**), magnetic field strength (**H**), magnetic flux density (**B**), power density (**S**), and currents flowing through the limbs (I_L). Quantities that address perception and other indirect effects are contact current (I_C) and, for pulsed fields, specific energy absorption (SA). In any particular exposure situation, measured or calculated values of any of these quantities can be compared with the appropriate reference level. Compliance with the reference level will ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded. However, whenever a reference level is exceeded it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary.

These guidelines do not directly address product performance standards, which are intended to limit EMF emissions under specified test conditions, nor does the document deal with the techniques used to measure any of the physical quantities that characterize electric, magnetic, and electromagnetic fields. Comprehensive descriptions of instrumentation and measurement techniques for accurately determining such physical quantities may be found elsewhere (NCRP 1981; IEEE 1992; NCRP 1993; DIN VDE 1995).

Compliance with the present guidelines may not necessarily preclude interference with, or effects on, medical devices such as metallic prostheses, cardiac pacemakers and defibrillators, and cochlear implants. Interference with pacemakers may occur at levels below the recommended reference levels. Advice on avoiding these problems is beyond the scope of the present document but is available elsewhere (UNEP/WHO/IRPA 1993).

These guidelines will be periodically revised and updated as advances are made in identifying the adverse health effects of time-varying electric, magnetic, and electromagnetic fields.

QUANTITIES AND UNITS

Whereas electric fields are associated only with the presence of electric charge, magnetic fields are the result of the physical movement of electric charge (electric current). An electric field, **E**, exerts forces on an electric charge and is expressed in volt per meter (V m^{-1}). Similarly, magnetic fields can exert physical forces on electric charges, but only when such charges are in motion. Electric and magnetic fields have both magnitude and direction (i.e., they are vectors). A magnetic field can be specified in two ways—as magnetic flux density, **B**, expressed in tesla (T), or as magnetic field strength, **H**, expressed in ampere per meter (A m^{-1}). The two quantities are related by the expression:

$$\mathbf{B} = \mu\mathbf{H}, \tag{1}$$

where μ is the constant of proportionality (the magnetic permeability); in a vacuum and in air, as well as in non-magnetic (including biological) materials, μ has the value $4\pi \times 10^{-7}$ when expressed in henry per meter (H m^{-1}). Thus, in describing a magnetic field for protection purposes, only one of the quantities **B** or **H** needs to be specified.

In the far-field region, the plane-wave model is a good approximation of the electromagnetic field propagation. The characteristics of a plane wave are:

- The wave fronts have a planar geometry;
- The **E** and **H** vectors and the direction of propagation are mutually perpendicular;
- The phase of the **E** and **H** fields is the same, and the quotient of the amplitude of E/H is constant throughout space. In free space, the ratio of their amplitudes E/H = 377 ohm, which is the characteristic impedance of free space;
- Power density, **S**, i.e., the power per unit area normal to the direction of propagation, is related to the electric and magnetic fields by the expression:

$$\mathbf{S} = \mathbf{EH} = E^2/377 = 377H^2. \tag{2}$$

The situation in the near-field region is rather more complicated because the maxima and minima of E and H fields do not occur at the same points along the direction of propagation as they do in the far field. In the near field, the electromagnetic field structure may be highly inhomogeneous, and there may be substantial variations from the plane-wave impedance of 377 ohms; that is, there may be almost pure E fields in some regions and almost pure H fields in others. Exposures in the near field are

Table 1. Electric, magnetic, electromagnetic, and dosimetric quantities and corresponding SI units.

Quantity	Symbol	Unit
Conductivity	σ	siemens per meter (S m^{-1})
Current	I	ampere (A)
Current density	**J**	ampere per square meter (A m^{-2})
Frequency	f	hertz (Hz)
Electric field strength	**E**	volt per meter (V m^{-1})
Magnetic field strength	**H**	ampere per meter (A m^{-1})
Magnetic flux density	**B**	tesla (T)
Magnetic permeability	μ	henry per meter (H m^{-1})
Permittivity	ϵ	farad per meter (F m^{-1})
Power density	**S**	watt per square meter (W m^{-2})
Specific energy absorption	SA	joule per kilogram (J kg^{-1})
Specific energy absorption rate	SAR	watt per kilogram (W kg^{-1})

more difficult to specify, because both E and H fields must be measured and because the field patterns are morecomplicated; in this situation, power density is no longer an appropriate quantity to use in expressing exposure restrictions (as in the far field).

Exposure to time-varying EMF results in internal body currents and energy absorption in tissues that depend on the coupling mechanisms and the frequency involved. The internal electric field and current density are related by Ohm's Law:

$$\mathbf{J} = \sigma \mathbf{E}, \tag{3}$$

where σ is the electrical conductivity of the medium. The dosimetric quantities used in these guidelines, taking into account different frequency ranges and waveforms, are as follows:

- Current density, **J**, in the frequency range up to 10 MHz;
- Current, I, in the frequency range up to 110 MHz;
- Specific energy absorption rate, SAR, in the frequency range 100 kHz–10 GHz;
- Specific energy absorption, SA, for pulsed fields in the frequency range 300 MHz–10 GHz; and
- Power density, **S**, in the frequency range 10–300 GHz.

A general summary of EMF and dosimetric quantities and units used in these guidelines is provided in Table 1.

BASIS FOR LIMITING EXPOSURE

These guidelines for limiting exposure have been developed following a thorough review of all published scientific literature. The criteria applied in the course of the review were designed to evaluate the credibility of the various reported findings (Repacholi and Stolwijk 1991; Repacholi and Cardis 1997); only established effects were used as the basis for the proposed exposure restrictions. Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF. In the case of potential long-term effects of exposure, such as an increased risk of cancer, ICNIRP concluded that available data are insufficient to provide a basis for setting exposure restrictions, although epidemiological research has provided suggestive, but unconvincing, evidence of an association between possible carcinogenic effects and exposure at levels of 50/60 Hz magnetic flux densities substantially lower than those recommended in these guidelines.

In-vitro effects of short-term exposure to ELF or ELF amplitude-modulated EMF are summarized. Transient cellular and tissue responses to EMF exposure have been observed, but with no clear exposure-response relationship. These studies are of limited value in the assessment of health effects because many of the responses have not been demonstrated *in vivo*. Thus, *in-vitro* studies alone were not deemed to provide data that could serve as a primary basis for assessing possible health effects of EMF.

COUPLING MECHANISMS BETWEEN FIELDS AND THE BODY

There are three established basic coupling mechanisms through which time-varying electric and magnetic fields interact directly with living matter (UNEP/WHO/IRPA 1993):

- coupling to low-frequency electric fields;
- coupling to low-frequency magnetic fields; and
- absorption of energy from electromagnetic fields.

Coupling to low-frequency electric fields

The interaction of time-varying electric fields with the human body results in the flow of electric charges (electric current), the polarization of bound charge (formation of electric dipoles), and the reorientation of electric dipoles already present in tissue. The relative magnitudes of these different effects depend on the electrical properties of the body—that is, electrical conductivity (governing the flow of electric current) and permittivity (governing the magnitude of polarization effects). Electrical conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the applied field. Electric fields external to the body induce a surface charge on the body; this results in induced currents in the body, the distribution of which depends on exposure conditions, on the size and shape of the body, and on the body's position in the field.

Coupling to low-frequency magnetic fields

The physical interaction of time-varying magnetic fields with the human body results in induced electric fields and circulating electric currents. The magnitudes of the induced field and the current density are propor-

tional to the radius of the loop, the electrical conductivity of the tissue, and the rate of change and magnitude of the magnetic flux density. For a given magnitude and frequency of magnetic field, the strongest electric fields are induced where the loop dimensions are greatest. The exact path and magnitude of the resulting current induced in any part of the body will depend on the electrical conductivity of the tissue.

The body is not electrically homogeneous; however, induced current densities can be calculated using anatomically and electrically realistic models of the body and computational methods, which have a high degree of anatomical resolution.

Absorption of energy from electromagnetic fields

Exposure to low-frequency electric and magnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to electromagnetic fields at frequencies above about 100 kHz can lead to significant absorption of energy and temperature increases. In general, exposure to a uniform (plane-wave) electromagnetic field results in a highly non-uniform deposition and distribution of energy within the body, which must be assessed by dosimetric measurement and calculation.

As regards absorption of energy by the human body, electromagnetic fields can be divided into four ranges (Durney et al. 1985):

- frequencies from about 100 kHz to less than about 20 MHz, at which absorption in the trunk decreases rapidly with decreasing frequency, and significant absorption may occur in the neck and legs;
- frequencies in the range from about 20 MHz to 300 MHz, at which relatively high absorption can occur in the whole body, and to even higher values if partial body (e.g., head) resonances are considered;
- frequencies in the range from about 300 MHz to several GHz, at which significant local, non-uniform absorption occurs; and
- frequencies above about 10 GHz, at which energy absorption occurs primarily at the body surface.

In tissue, SAR is proportional to the square of the internal electric field strength. Average SAR and SAR distribution can be computed or estimated from laboratory measurements. Values of SAR depend on the following factors:

- the incident field parameters, i.e., the frequency, intensity, polarization, and source–object configuration (near- or far-field);
- the characteristics of the exposed body, i.e., its size and internal and external geometry, and the dielectric properties of the various tissues; and
- ground effects and reflector effects of other objects in the field near the exposed body.

When the long axis of the human body is parallel to the electric field vector, and under plane-wave exposure conditions (i.e., far-field exposure), whole-body SAR reaches maximal values. The amount of energy absorbed depends on a number of factors, including the size of the exposed body. “Standard Reference Man” (ICRP 1994), if not grounded, has a resonant absorption frequency close to 70 MHz. For taller individuals the resonant absorption frequency is somewhat lower, and for shorter adults, children, babies, and seated individuals it may exceed 100 MHz. The values of electric field reference levels are based on the frequency-dependence of human absorption; in grounded individuals, resonant frequencies are lower by a factor of about 2 (UNEP/WHO/IRPA 1993).

For some devices that operate at frequencies above 10 MHz (e.g., dielectric heaters, mobile telephones), human exposure can occur under near-field conditions. The frequency-dependence of energy absorption under these conditions is very different from that described for far-field conditions. Magnetic fields may dominate for certain devices, such as mobile telephones, under certain exposure conditions.

The usefulness of numerical modeling calculations, as well as measurements of induced body current and tissue field strength, for assessment of near-field exposures has been demonstrated for mobile telephones, walkie-talkies, broadcast towers, shipboard communication sources, and dielectric heaters (Kuster and Balzano 1992; Dimbylow and Mann 1994; Jokela et al. 1994; Gandhi 1995; Tofani et al. 1995). The importance of these studies lies in their having shown that near-field exposure can result in high local SAR (e.g., in the head, wrists, ankles) and that whole-body and local SAR are strongly dependent on the separation distance between the high-frequency source and the body. Finally, SAR data obtained by measurement are consistent with data obtained from numerical modeling calculations. Whole-body average SAR and local SAR are convenient quantities for comparing effects observed under various exposure conditions. A detailed discussion of SAR can be found elsewhere (UNEP/WHO/IRPA 1993).

At frequencies greater than about 10 GHz, the depth of penetration of the field into tissues is small, and SAR is not a good measure for assessing absorbed energy; the incident power density of the field (in W m^{-2}) is a more appropriate dosimetric quantity.

INDIRECT COUPLING MECHANISMS

There are two indirect coupling mechanisms:

- contact currents that result when the human body comes into contact with an object at a different electric potential (i.e., when either the body or the object is charged by an EMF); and
- coupling of EMF to medical devices worn by, or implanted in, an individual (not considered in this document).

The charging of a conducting object by EMF causes electric currents to pass through the human body in contact with that object (Tenforde and Kaune 1987; UNEP/WHO/IRPA 1993). The magnitude and spatial distribution of such currents depend on frequency, the size of the object, the size of the person, and the area of contact; transient discharges—sparks—can occur when an individual and a conducting object exposed to a strong field come into close proximity.

BIOLOGICAL BASIS FOR LIMITING EXPOSURE (UP TO 100 KHZ)

The following paragraphs provide a general review of relevant literature on the biological and health effects of electric and magnetic fields with frequency ranges up to 100 kHz, in which the major mechanism of interaction is induction of currents in tissues. For the frequency range >0 to 1 Hz, the biological basis for the basic restrictions and reference levels are provided in ICNIRP (1994). More detailed reviews are available elsewhere (NRPB 1991, 1993; UNEP/WHO/IRPA 1993; Blank 1995; NAS 1996; Polk and Postow 1996; Ueno 1996).

Direct effects of electric and magnetic fields

Epidemiological studies. There have been many reviews of epidemiological studies of cancer risk in relation to exposure to power-frequency fields (NRPB 1992, 1993, 1994b; ORAU 1992; Savitz 1993; Heath 1996; Stevens and Davis 1996; Tenforde 1996; NAS 1996). Similar reviews have been published on the risk of adverse reproductive outcomes associated with exposure to EMF (Chernoff et al. 1992; Brent et al. 1993; Shaw and Croen 1993; NAS 1996; Tenforde 1996).

Reproductive outcome. Epidemiological studies on pregnancy outcomes have provided no consistent evidence of adverse reproductive effects in women working with visual display units (VDUs) (Bergqvist 1993; Shaw and Croen 1993; NRPB 1994a; Tenforde 1996). For example, meta-analysis revealed no excess risk of spontaneous abortion or malformation in combined studies comparing pregnant women using VDUs with women not using VDUs (Shaw and Croen 1993). Two other studies concentrated on actual measurements of the electric and magnetic fields emitted by VDUs; one reported a suggestion of an association between ELF magnetic fields and miscarriage (Lindbohm et al. 1992), while the other found no such association (Schnorr et al. 1991). A prospective study that included large numbers of cases, had high participation rates, and detailed exposure assessment (Bracken et al. 1995) reported that neither birth weight nor intra-uterine growth rate was related to any ELF field exposure. Adverse outcomes were not associated with higher levels of exposure. Exposure measurements included current-carrying capacity of power lines outside homes, 7-d personal exposure measurements, 24-h measurements in the home, and self-reported use of electric blankets, heated water beds, and VDUs. Most currently available information fails to support an association between occupational exposure to VDUs and harmful reproductive effects (NRPB 1994a; Tenforde 1996).

Residential cancer studies. Considerable controversy surrounds the possibility of a link between exposure to ELF magnetic fields and an elevated risk of cancer. Several reports on this topic have appeared since Wertheimer and Leeper reported (1979) an association between childhood cancer mortality and proximity of homes to power distribution lines with what the researchers classified as *high current configuration*. The basic hypothesis that emerged from the original study was that the contribution to the ambient residential 50/60 Hz magnetic fields from external sources such as power lines could be linked to an increased risk of cancer in childhood.

To date there have been more than a dozen studies on childhood cancer and exposure to power-frequency magnetic fields in the home produced by nearby power lines. These studies estimated the magnetic field exposure from short term measurements or on the basis of distance between the home and power line and, in most cases, the configuration of the line; some studies also took the load of the line into account. The findings relating to leukemia are the most consistent. Out of 13 studies (Wertheimer and Leeper 1979; Fulton et al. 1980; Myers et al. 1985; Tomenius 1986; Savitz et al. 1988; Coleman et al. 1989; London et al. 1991; Feychting and Ahlbom 1993; Olsen et al. 1993; Verkasalo et al. 1993; Michaelis et al. 1997; Linet et al. 1997; Tynes and Haldorsen 1997), all but five reported relative risk estimates of between 1.5 and 3.0.

Both direct magnetic field measurements and estimates based on neighboring power lines are crude proxy measures for the exposure that took place at various times before cases of leukemia were diagnosed, and it is not clear which of the two methods provides the more valid estimate. Although results suggest that indeed the magnetic field may play a role in the association with leukemia risk, there is uncertainty because of small sample numbers and because of a correlation between the magnetic field and proximity to power lines (Feychting et al. 1996).

Little is known about the etiology of most types of childhood cancer, but several attempts to control for potential confounders such as socioeconomic status and air pollution from motor vehicle exhaust fumes have had little effect on results. Studies that have examined the use of electrical appliances (primarily electric blankets) in relation to cancer and other health problems have reported generally negative results (Preston-Martin et al. 1988; Verreault et al. 1990; Vena et al. 1991, 1994; Li et al. 1995). Only two case-control studies have evaluated use of appliances in relation to the risk of childhood leukemia. One was conducted in Denver (Savitz et al. 1990) and suggested a link with prenatal use of electric blankets; the other, carried out in Los Angeles (London

et al. 1991), found an association between leukemia and children using hair dryers and watching monochrome television.

The fact that results for leukemia based on proximity of homes to power lines are relatively consistent led the U.S. National Academy of Sciences Committee to conclude that children living near power lines appear to be at increased risk of leukemia (NAS 1996). Because of small numbers, confidence intervals in the individual studies are wide; when taken together, however, the results are consistent, with a pooled relative risk of 1.5 (NAS 1996). In contrast, short-term measurements of magnetic field in some of the studies provided no evidence of an association between exposure to 50/60 Hz fields and the risk of leukemia or any other form of cancer in children. The Committee was not convinced that this increase in risk was explained by exposure to magnetic fields, since there was no apparent association when exposure was estimated from magnetic field meter readings in the homes of both leukemia cases and controls. It was suggested that confounding by some unknown risk factor for childhood leukemia, associated with residence in the vicinity of power lines, might be the explanation, but no likely candidates were postulated.

After the NAS committee completed its review, the results of a study performed in Norway were reported (Tynes and Haldorsen 1997). This study included 500 cases of all types of childhood cancer. Each individual's exposure was estimated by calculation of the magnetic field level produced in the residence by nearby transmission lines, estimated by averaging over an entire year. No association between leukemia risk and magnetic fields for the residence at time of diagnosis was observed. Distance from the power line, exposure during the first year of life, mothers' exposure at time of conception, and exposure higher than the median level of the controls showed no association with leukemia, brain cancer, or lymphoma. However, the number of exposed cases was small.

Also, a study performed in Germany has been reported after the completion of the NAS review (Michaelis et al. 1997). This was a case-control study on childhood leukemia based on 129 cases and 328 controls. Exposure assessment comprised measurements of the magnetic field over 24 h in the child's bedroom at the residence where the child had been living for the longest period before the date of diagnosis. An elevated relative risk of 3.2 was observed for $>0.2\ \mu$T.

A large U.S. case-control study (638 cases and 620 controls) to test whether childhood acute lymphoblastic leukemia is associated with exposure to 60-Hz magnetic fields was published by Linet et al. (1997). Magnetic field exposures were determined using 24-h time-weighted average measurements in the bedroom and 30-s measurements in various other rooms. Measurements were taken in homes in which the child had lived for 70% of the 5 y prior to the year of diagnosis, or the corresponding period for the controls. Wire-codes were assessed for residentially stable case-control pairs in which both had not changed their residence during the years prior to diagnosis. The number of such pairs for which assessment could be made was 416. There was no indication of an association between wire-code category and leukemia. As for magnetic field measurements, the results are more intriguing. For the cut off point of 0.2 μT the unmatched and matched analyses gave relative risks of 1.2 and 1.5, respectively. For a cut off point of 0.3 μT, the unmatched relative risk estimate is 1.7 based on 45 exposed cases. Thus, the measurement results are suggestive of a positive association between magnetic fields and leukemia risk. This study is a major contribution in terms of its size, the number of subjects in high exposure categories, timing of measurements relative to the occurrence of the leukemia (usually within 24 mo after diagnosis), other measures used to obtain exposure data, and quality of analysis allowing for multiple potential confounders. Potential weaknesses include the procedure for control selection, the participation rates, and the methods used for statistical analysis of the data. The instruments used for measurements took no account of transient fields or higher order harmonics. The size of this study is such that its results, combined with those of other studies, would significantly weaken (though not necessarily invalidate) the previously observed association with wire code results.

Over the years there also has been substantial interest in whether there is an association between magnetic field exposure and childhood brain cancer, the second most frequent type of cancer found in children. Three recent studies completed after the NAS Committee's review fail to provide support for an association between brain cancer and children's exposure to magnetic fields, whether the source was power lines or electric blankets, or whether magnetic fields were estimated by calculations or by wire codes (Guénel et al. 1996; Preston-Martin et al. 1996a, b; Tynes and Haldorsen 1997).

Data on cancer in adults and residential magnetic field exposure are sparse (NAS 1996). The few studies published to date (Wertheimer and Leeper 1979; McDowall 1985; Seversen et al. 1988; Coleman et al. 1989; Schreiber et al. 1993; Feychting and Ahlbom 1994; Li et al. 1996; Verkasalo 1996; Verkasalo et al. 1996) all suffer to some extent from small numbers of exposed cases, and no conclusions can be drawn.

It is the view of the ICNIRP that the results from the epidemiological research on EMF field exposure and cancer, including childhood leukemia, are not strong enough in the absence of support from experimental research to form a scientific basis for setting exposure guidelines. This assessment is also in agreement with recent reviews (NRPB 1992, 1994b; NAS 1996; CRP 1997).

Occupational studies. A large number of epidemiological studies have been carried out to assess possible links between exposure to ELF fields and cancer risk among workers in electrical occupations. The first study of this type (Milham 1982) took advantage of a death certificate database that included both job titles and

information on cancer mortality. As a crude method of assessing exposure, Milham classified job titles according to presumed magnetic field exposure and found an excess risk for leukemia among electrical workers. Subsequent studies (Savitz and Ahlbom 1994) made use of similar databases; the types of cancer for which elevated rates were noted varied across studies, particularly when cancer subtypes were characterized. Increased risks of various types of leukemia and nervous tissue tumors, and, in a few instances, of both male and female breast cancer, were reported (Demers et al. 1991; Matanoski et al. 1991; Tynes et al. 1992; Loomis et al. 1994). As well as producing somewhat inconsistent results, these studies suffered from very crude exposure assessment and from failure to control for confounding factors such as exposure to benzene solvent in the workplace.

Three recent studies have attempted to overcome some of the deficiencies in earlier work by measuring ELF field exposure at the workplace and by taking duration of work into consideration (Floderus et al. 1993; Thériault et al. 1994; Savitz and Loomis 1995). An elevated cancer risk among exposed individuals was observed, but the type of cancer of which this was true varied from study to study. Floderus et al. (1993) found a significant association with leukemia; an association was also noted by Thériault et al. (1994), but one that was weak and not significant, and no link was observed by Savitz and Loomis (1995). For subtypes of leukemia there was even greater inconsistency, but numbers in the analyses were small. For tumors of nervous tissue, Floderus et al. (1993) found an excess for glioblastoma (astrocytoma III–IV), while both Thériault et al. (1994) and Savitz and Loomis (1995) found only suggestive evidence for an increase in glioma (astrocytoma I–II). If there is truly a link between occupational exposure to magnetic fields and cancer, greater consistency and stronger associations would be expected of these recent studies based on more sophisticated exposure data.

Researchers have also investigated the possibility that ELF electric fields could be linked to cancer. The three utilities that participated in the Thériault et al. (1994) study of magnetic fields analyzed electric field data as well. Workers with leukemia at one of the utilities were reported to be more likely to have been exposed to electric fields than were control workers. In addition, the association was stronger in a group that had been exposed to high electric and magnetic fields combined (Miller et al. 1996). At the second utility, investigators reported no association between leukemia and higher cumulative exposure to workplace electric fields, but some of the analyses showed an association with brain cancer (Guénel et al. 1996). An association with colon cancer was also reported, yet in other studies of large populations of electric utility workers this type of cancer has not been found. At the third utility, no association between high electric fields and brain cancer or leukemia was observed, but this study was smaller and less likely to have detected small changes, if present (Baris et al. 1996).

An association between Alzheimer's disease and occupational exposure to magnetic fields has recently been suggested (Sobel and Davanipour 1996). However, this effect has not been confirmed.

Laboratory studies. The following paragraphs provide a summary and critical evaluation of laboratory studies on the biological effects of electric and magnetic fields with frequencies below 100 kHz. There are separate discussions on results obtained in studies of volunteers exposed under controlled conditions and in laboratory studies on cellular, tissue, and animal systems.

Volunteer studies. Exposure to a time-varying electric field can result in perception of the field as a result of the alternating electric charge induced on the body surface, which causes the body hairs to vibrate. Several studies have shown that the majority of people can perceive 50/60 Hz electric fields stronger than 20 kV m^{-1}, and that a small minority can perceive fields below 5 kV m^{-1} (UNEP/WHO/IRPA 1984; Tenforde 1991).

Small changes in cardiac function occurred in human volunteers exposed to combined 60-Hz electric and magnetic fields (9 kV m^{-1}, 20 μT) (Cook et al. 1992; Graham et al. 1994). Resting heart rate was slightly, but significantly, reduced (by 3–5 beats per minute) during or immediately after exposure. This response was absent on exposure to stronger (12 kV m^{-1}, 30 μT) or weaker (6 kV m^{-1}, 10 μT) fields and reduced if the subject was mentally alert. None of the subjects in these studies was able to detect the presence of the fields, and there were no other consistent results in a wide battery of sensory and perceptual tests.

No adverse physiological or psychological effects were observed in laboratory studies of people exposed to 50-Hz fields in the range 2–5 mT (Sander et al. 1982; Ruppe et al. 1995). There were no observed changes in blood chemistry, blood cell counts, blood gases, lactate levels, electrocardiogram, electroencephalogram, skin temperature, or circulating hormone levels in studies by Sander et al. (1982) and Graham et al. (1994). Recent studies on volunteers have also failed to show any effect of exposure to 60-Hz magnetic fields on the nocturnal melatonin level in blood (Graham et al. 1996, 1997; Selmaoui et al. 1996).

Sufficiently intense ELF magnetic fields can elicit peripheral nerve and muscle tissue stimulation directly, and short magnetic field pulses have been used clinically to stimulate nerves in the limbs in order to check the integrity of neural pathways. Peripheral nerve and muscle stimulation has also been reported in volunteers exposed to 1-kHz gradient magnetic fields in experimental magnetic resonance imaging systems. Threshold magnetic flux densities were several millitesla, and corresponding induced current densities in the peripheral tissues were about 1 A m^{-2} from pulsed fields produced by rapidly switched gradients. Time-varying magnetic fields that induce current densities above 1 A m^{-2} in

tissue lead to neural excitation and are capable of producing irreversible biological effects such as cardiac fibrillation (Tenforde and Kaune 1987; Reilly 1989). In a study involving electromyographic recordings from the human arm (Polson et al. 1982), it was found that a pulsed field with dB/dt greater than 10^4 T s^{-1} was needed to stimulate the median nerve trunk. The duration of the magnetic stimulus has also been found to be an important parameter in stimulation of excitable tissues.

Thresholds lower than 100 mA m^{-2} can be derived from studies of visual and mental functions in human volunteers. Changes in response latency for complex reasoning tests have been reported in volunteers subjected to weak power-frequency electric currents passed through electrodes attached to the head and shoulders; current densities were estimated to lie between 10 and 40 mA m^{-2} (Stollery 1986, 1987). Finally, many studies have reported that volunteers experienced faint flickering visual sensations, known as magnetic phosphenes, during exposure to ELF magnetic fields above 3–5 mT (Silny 1986). These visual effects can also be induced by the direct application of weak electric currents to the head. At 20 Hz, current densities of about 10 mA m^{-2} in the retina have been estimated as the threshold for induction of phosphenes, which is above the typical endogenous current densities in electrically excitable tissues. Higher thresholds have been observed for both lower and higher frequencies (Lövsund et al. 1980; Tenforde 1990).

Studies have been conducted at 50 Hz on visually evoked potentials that exhibited thresholds for effects at flux densities of 60 mT (Silny 1986). Consistent with this result, no effects on visually evoked potentials were obtained by either Sander et al. (1982), using a 50-Hz, 5-mT field, or Graham et al. (1994), using combined 60-Hz electric and magnetic fields up to 12 kV m^{-1} and 30 μT, respectively.

Cellular and animal studies. Despite the large number of studies undertaken to detect biological effects of ELF electric and magnetic fields, few systematic studies have defined the threshold field characteristics that produce significant perturbations of biological functions. It is well established that induced electric current can stimulate nerve and muscle tissue directly once the induced current density exceeds threshold values (UNEP/WHO/IRPA 1987; Bernhardt 1992; Tenforde 1996). Current densities that are unable to stimulate excitable tissues directly may nevertheless affect ongoing electrical activity and influence neuronal excitability. The activity of the central nervous system is known to be sensitive to the endogenous electric fields generated by the action of adjacent nerve cells, at levels below those required for direct stimulation.

Many studies have suggested that the transduction of weak electrical signals in the ELF range involves interactions with the cell membrane, leading to cytoplasmic biochemical responses that in turn involve changes in cellular functional and proliferative states. From simple models of the behavior of single cells in weak fields it has been calculated that an electrical signal in the extracellular field must be greater than approximately 10–100 mV m^{-1} (corresponding to an induced current density of about 2–20 mA m^{-2}) in order to exceed the level of endogenous physical and biological noise in cellular membranes (Astumian et al. 1995). Existing evidence also suggests that several structural and functional properties of membranes may be altered in response to induced ELF fields at or below 100 mV m^{-1} (Sienkiewicz et al. 1991; Tenforde 1993). Neuroendocrine alterations (e.g., suppression of nocturnal melatonin synthesis) have been reported in response to induced electrical fields of 10 mV m^{-1} or less, corresponding to induced current densities of approximately 2 mA m^{-2} or less (Tenforde 1991, 1996). However, there is no clear evidence that these biological interactions of low-frequency fields lead to adverse health effects.

Induced electric fields and currents at levels exceeding those of endogenous bioelectric signals present in tissue have been shown to cause a number of physiological effects that increase in severity as the induced current density is increased (Bernhardt 1979; Tenforde 1996). In the current density range 10–100 mA m^{-2}, tissue effects and changes in brain cognitive functions have been reported (NRPB 1992; NAS 1996). When induced current density exceeds 100 to several hundred mA m^{-2} for frequencies between about 10 Hz and 1 kHz, thresholds for neuronal and neuromuscular stimulation are exceeded. The threshold current densities increase progressively at frequencies below several hertz and above 1 kHz. Finally, at extremely high current densities, exceeding 1 A m^{-2}, severe and potentially life-threatening effects such as cardiac extrasystoles, ventricular fibrillation, muscular tetanus, and respiratory failure may occur. The severity and the probability of irreversibility of tissue effects becomes greater with chronic exposure to induced current densities above the level 10 to 100 mA m^{-2}. It therefore seems appropriate to limit human exposure to fields that induce current densities no greater than 10 mA m^{-2} in the head, neck, and trunk at frequencies of a few hertz up to 1 kHz.

It has been postulated that oscillatory magnetomechanical forces and torques on biogenic magnetite particles in brain tissue could provide a mechanism for the transduction of signals from ELF magnetic fields. Kirschvink et al. (1992b) proposed a model in which ELF magnetic forces on magnetite particles are visualized as producing the opening and closing of pressure-sensitive ion channels in membranes. However, one difficulty with this model is the sparsity of magnetite particles relative to the number of cells in brain tissue. For example, human brain tissue has been reported to contain a few million magnetite particles per gram, distributed in 10^5 discrete clusters of 5–10 particles (Kirschvink et al. 1992a). The number of cells in brain tissue thus exceeds the number of magnetite particles by a factor of about 100, and it is difficult to envisage how oscillating magnetomechanical interactions of an ELF

field with magnetite crystals could affect a significant number of pressure-sensitive ion channels in the brain. Further studies are clearly needed to reveal the biological role of magnetite and the possible mechanisms through which this mineral could play a role in the transduction of ELF magnetic signals.

An important issue in assessing the effects of electromagnetic fields is the possibility of teratogenic and developmental effects. On the basis of published scientific evidence, it is unlikely that low-frequency fields have adverse effects on the embryonic and postnatal development of mammalian species (Chernoff et al. 1992; Brent et al. 1993; Tenforde 1996). Moreover, currently available evidence indicates that somatic mutations and genetic effects are unlikely to result from exposure to electric and magnetic fields with frequencies below 100 kHz (Cridland 1993; Sienkiewicz et al. 1993).

There are numerous reports in the literature on the *in-vitro* effects of ELF fields on cell membrane properties (ion transport and interaction of mitogens with cell surface receptors) and changes in cellular functions and growth properties (e.g., increased proliferation and alterations in metabolism, gene expression, protein biosynthesis, and enzyme activities) (Cridland 1993; Sienkiewicz et al. 1993; Tenforde 1991, 1992, 1993, 1996). Considerable attention has focused on low-frequency field effects on Ca^{++} transport across cell membranes and the intracellular concentration of this ion (Walleczek and Liburdy 1990; Liburdy 1992; Walleczek 1992), messenger RNA and protein synthesis patterns (Goodman et al. 1983; Goodman and Henderson 1988, 1991; Greene et al. 1991; Phillips et al. 1992), and the activity of enzymes such as ornithine decarboxylase (ODC) that are related to cell proliferation and tumor promotion (Byus et al. 1987, 1988; Litovitz et al. 1991, 1993). However, before these observations can be used for defining exposure limits, it is essential to establish both their reproducibility and their relevance to cancer or other adverse health outcomes. This point is underscored by the fact that there have been difficulties in replicating some of the key observations of field effects on gene expression and protein synthesis (Lacy-Hulbert et al. 1995; Saffer and Thurston 1995). The authors of these replication studies identified several deficiencies in the earlier studies, including poor temperature control, lack of appropriate internal control samples, and the use of low-resolution techniques for analyzing the production of messenger RNA transcripts. The transient increase in ODC activity reported in response to field exposure is small in magnitude and not associated with *de novo* synthesis of the enzyme (unlike chemical tumor promoters such as phorbol esters) (Byus et al. 1988). Studies on ODC have mostly involved cellular preparations; more studies are needed to show whether there are effects on ODC *in vivo*, although there is one report suggesting effects on ODC in a rat mammary tumor promotion assay (Mevissen et al. 1995).

There is no evidence that ELF fields alter the structure of DNA and chromatin, and no resultant mutational and neoplastic transformation effects are expected. This is supported by results of laboratory studies designed to detect DNA and chromosomal damage, mutational events, and increased transformation frequency in response to ELF field exposure (NRPB 1992; Murphy et al. 1993; McCann et al. 1993; Tenforde 1996). The lack of effects on chromosome structure suggests that ELF fields, if they have any effect on the process of carcinogenesis, are more likely to act as promoters than initiators, enhancing the proliferation of genetically altered cells rather than causing the initial lesion in DNA or chromatin. An influence on tumor development could be mediated through epigenetic effects of these fields, such as alterations in cell signalling pathways or gene expression. The focus of recent studies has therefore been on detecting possible effects of ELF fields on the promotion and progression phases of tumor development following initiation by a chemical carcinogen.

Studies on *in-vitro* tumor cell growth and the development of transplanted tumors in rodents have provided no strong evidence for possible carcinogenic effects of exposure to ELF fields (Tenforde 1996). Several studies of more direct relevance to human cancer have involved *in-vivo* tests for tumor-promoting activity of ELF magnetic fields on skin, liver, brain, and mammary tumors in rodents. Three studies of skin tumor promotion (McLean et al. 1991; Rannug et al. 1993a, 1994) failed to show any effect of either continuous or intermittent exposure to power-frequency magnetic fields in promoting chemically induced tumors. At a 60-Hz field strength of 2 mT, a co-promoting effect with a phorbol ester was reported for mouse skin tumor development in the initial stages of the experiment, but the statistical significance of this was lost by completion of the study in week 23 (Stuchly et al. 1992). Previous studies by the same investigators had shown that 60-Hz, 2-mT field exposure did not promote the growth of DMBA-initiated skin cells (McLean et al. 1991).

Experiments on the development of transformed liver foci initiated by a chemical carcinogen and promoted by phorbol ester in partially hepatectomized rats revealed no promotion or co-promotion effect of exposure to 50-Hz fields ranging in strength from 0.5 to 50 μT (Rannug et al. 1993b, c).

Studies on mammary cancer development in rodents treated with a chemical initiator have suggested a cancer-promoting effect of exposure to power-frequency magnetic fields in the range 0.01–30 mT (Beniashvili et al. 1991; Löscher et al. 1993; Mevissen et al. 1993, 1995; Baum et al. 1995; Löscher and Mevissen 1995). These observations of increased tumor incidence in rats exposed to magnetic fields have been hypothesized to be related to field-induced suppression of pineal melatonin and a resulting elevation in steroid hormone levels and breast cancer risk (Stevens 1987; Stevens et al. 1992). However, replication efforts by independent laboratories are needed before conclusions can be drawn regarding the implications of these findings for a promoting effect of ELF magnetic fields on mammary tumors. It should

also be noted that recent studies have found no evidence for a significant effect of exposure to ELF magnetic fields on melatonin levels in humans (Graham et al. 1996, 1997; Selmaoui et al. 1996).

Indirect effects of electric and magnetic fields

Indirect effects of electromagnetic fields may result from physical contact (e.g., touching or brushing against) between a person and an object, such as a metallic structure in the field, at a different electric potential. The result of such contact is the flow of electric charge (contact current) that may have accumulated on the object or on the body of the person. In the frequency range up to approximately 100 kHz, the flow of electric current from an object in the field to the body of the individual may result in the stimulation of muscles and/or peripheral nerves. With increasing levels of current this may be manifested as perception, pain from electric shock and/or burn, inability to release the object, difficulty in breathing and, at very high currents, cardiac ventricular fibrillation (Tenforde and Kaune 1987). Threshold values for these effects are frequency-dependent, with the lowest threshold occurring at frequencies between 10 and 100 Hz. Thresholds for peripheral nerve responses remain low for frequencies up to several kHz. Appropriate engineering and/or administrative controls, and even the wearing of personal protective clothing, can prevent these problems from occurring.

Spark discharges can occur when an individual comes into very close proximity with an object at a different electric potential, without actually touching it (Tenforde and Kaune 1987; UNEP/WHO/IRPA 1993). When a group of volunteers, who were electrically insulated from the ground, each held a finger tip close to a grounded object, the threshold for perception of spark discharges was as low as 0.6–1.5 kV m^{-1} in 10% of cases. The threshold field level reported as causing annoyance under these exposure conditions is about 2.0–3.5 kV m^{-1}. Large contact currents can result in muscle contraction. In male volunteers, the 50th percentile threshold for being unable to release a charged conductor has been reported as 9 mA at 50/60 Hz, 16 mA at 1 kHz, about 50 mA at 10 kHz, and about 130 mA at 100 kHz (UNEP/WHO/IRPA 1993).

The threshold currents for various indirect effects of fields with frequencies up to 100 kHz are summarized in Table 2 (UNEP/WHO/IRPA 1993).

Table 2. Ranges of threshold currents for indirect effects, including children, women, and men.

Indirect effect	Threshold current (mA) at frequency: 50/60 Hz	1 kHz	100 kHz
Touch perception	0.2–0.4	0.4–0.8	25–40
Pain on finger contact	0.9–1.8	1.6–3.3	33–55
Painful shock/let-go threshold	8–16	12–24	112–224
Severe shock/breathing difficulty	12–23	21–41	160–320

Summary of biological effects and epidemiological studies (up to 100 kHz)

With the possible exception of mammary tumors, there is little evidence from laboratory studies that power-frequency magnetic fields have a tumor-promoting effect. Although further animal studies are needed to clarify the possible effects of ELF fields on signals produced in cells and on endocrine regulation—both of which could influence the development of tumors by promoting the proliferation of initiated cells—it can only be concluded that there is currently no convincing evidence for carcinogenic effects of these fields and that these data cannot be used as a basis for developing exposure guidelines.

Laboratory studies on cellular and animal systems have found no established effects of low-frequency fields that are indicative of adverse health effects when induced current density is at or below 10 mA m^{-2}. At higher levels of induced current density (10–100 mA m^{-2}), more significant tissue effects have been consistently observed, such as functional changes in the nervous system and other tissue effects (Tenforde 1996).

Data on cancer risk associated with exposure to ELF fields among individuals living close to power lines are apparently consistent in indicating a slightly higher risk of leukemia among children, although more recent studies question the previously observed weak association. The studies do not, however, indicate a similarly elevated risk of any other type of childhood cancer or of any form of adult cancer. The basis for the hypothetical link between childhood leukemia and residence in close proximity to power lines is unknown; if the link is not related to the ELF electric and magnetic fields generated by the power lines, then unknown risk factors for leukemia would have to be linked to power lines in some undetermined manner. In the absence of support from laboratory studies, the epidemiological data are insufficient to allow an exposure guideline to be established.

There have been reports of an increased risk of certain types of cancer, such as leukemia, nervous tissue tumors, and, to a limited extent, breast cancer, among electrical workers. In most studies, job titles were used to classify subjects according to presumed levels of magnetic field exposure. A few more recent studies, however, have used more sophisticated methods of exposure assessment; overall, these studies suggested an increased risk of leukemia or brain tumors but were largely inconsistent with regard to the type of cancer for which risk is increased. The data are insufficient to provide a basis for ELF field exposure guidelines. In a large number of epidemiological studies, no consistent evidence of adverse reproductive effects have been provided.

Measurement of biological responses in laboratory studies and in volunteers has provided little indication of adverse effects of low-frequency fields at levels to which people are commonly exposed. A threshold current density of 10 mA m^{-2} at frequencies up to 1 kHz has been estimated for minor effects on nervous system functions. Among volunteers, the most consistent effects

of exposure are the appearance of visual phosphenes and a minor reduction in heart rate during or immediately after exposure to ELF fields, but there is no evidence that these transient effects are associated with any long-term health risk. A reduction in nocturnal pineal melatonin synthesis has been observed in several rodent species following exposure to weak ELF electric and magnetic fields, but no consistent effect has been reported in humans exposed to ELF fields under controlled conditions. Studies involving exposures to 60-Hz magnetic fields up to 20 μT have not reported reliable effects on melatonin levels in blood.

BIOLOGICAL BASIS FOR LIMITING EXPOSURE (100 kHz–300 GHz)

The following paragraphs provide a general review of relevant literature on the biological effects and potential health effects of electromagnetic fields with frequencies of 100 kHz to 300 GHz. More detailed reviews can be found elsewhere (NRPB 1991; UNEP/WHO/IRPA 1993; McKinlay et al. 1996; Polk and Postow 1996; Repacholi 1998).

Direct effects of electromagnetic fields

Epidemiological studies. Only a limited number of studies have been carried out on reproductive effects and cancer risk in individuals exposed to microwave radiation. A summary of the literature was published by UNEP/WHO/IRPA (1993).

Reproductive outcomes. Two extensive studies on women treated with microwave diathermy to relieve the pain of uterine contractions during labor found no evidence for adverse effects on the fetus (Daels 1973, 1976). However, seven studies on pregnancy outcomes among workers occupationally exposed to microwave radiation and on birth defects among their offspring produced both positive and negative results. In some of the larger epidemiological studies of female plastic welders and physiotherapists working with shortwave diathermy devices, there were no statistically significant effects on rates of abortion or fetal malformation (Källen et al. 1982). By contrast, other studies on similar populations of female workers found an increased risk of miscarriage and birth defects (Larsen et al. 1991; Ouellet-Hellstrom and Stewart 1993). A study of male radar workers found no association between microwave exposure and the risk of Down's syndrome in their offspring (Cohen et al. 1977).

Overall, the studies on reproductive outcomes and microwave exposure suffer from very poor assessment of exposure and, in many cases, small numbers of subjects. Despite the generally negative results of these studies, it will be difficult to draw firm conclusions on reproductive risk without further epidemiological data on highly exposed individuals and more precise exposure assessment.

Cancer studies. Studies on cancer risk and microwave exposure are few and generally lack quantitative exposure assessment. Two epidemiological studies of radar workers in the aircraft industry and in the U.S. armed forces found no evidence of increased morbidity or mortality from any cause (Barron and Baraff 1958; Robinette et al. 1980; UNEP/WHO/IRPA 1993). Similar results were obtained by Lillienfeld et al. (1978) in a study of employees in the U.S. embassy in Moscow, who were chronically exposed to low-level microwave radiation. Selvin et al. (1992) reported no increase in cancer risk among children chronically exposed to radiation from a large microwave transmitter near their homes. More recent studies have failed to show significant increases in nervous tissue tumors among workers and military personnel exposed to microwave fields (Beall et al. 1996; Grayson 1996). Moreover, no excess total mortality was apparent among users of mobile telephones (Rothman et al. 1996a, b), but it is still too early to observe an effect on cancer incidence or mortality.

There has been a report of increased cancer risk among military personnel (Szmigielski et al. 1988), but the results of the study are difficult to interpret because neither the size of the population nor the exposure levels are clearly stated. In a later study, Szmigielski (1996) found increased rates of leukemia and lymphoma among military personnel exposed to EMF fields, but the assessment of EMF exposure was not well defined. A few recent studies of populations living near EMF transmitters have suggested a local increase in leukemia incidence (Hocking et al. 1996; Dolk et at. 1997a, b), but the results are inconclusive. Overall, the results of the small number of epidemiological studies published provide only limited information on cancer risk.

Laboratory studies. The following paragraphs provide a summary and critical evaluation of laboratory studies on the biological effects of electromagnetic fields with frequencies in the range 100 kHz–300 GHz. There are separate discussions on results of studies of volunteers exposed under controlled conditions and of laboratory studies on cellular, tissue, and animal systems.

Volunteer studies. Studies by Chatterjee et al. (1986) demonstrated that, as the frequency increases from approximately 100 kHz to 10 MHz, the dominant effect of exposure to a high-intensity electromagnetic field changes from nerve and muscle stimulation to heating. At 100 kHz the primary sensation was one of nerve tingling, while at 10 MHz it was one of warmth on the skin. In this frequency range, therefore, basic health protection criteria should be such as to avoid stimulation of excitable tissues and heating effects. At frequencies from 10 MHz to 300 GHz, heating is the major effect of absorption of electromagnetic energy, and temperature rises of more than 1–2 °C can have adverse health effects such as heat exhaustion and heat stroke (ACGIH 1996). Studies on workers in thermally stressful environments have shown worsening performance of simple tasks as

body temperature rises to a level approaching physiological heat stress (Ramsey and Kwon 1988).

A sensation of warmth has been reported by volunteers experiencing high-frequency current of about 100–200 mA through a limb. The resulting SAR value is unlikely to produce a localized temperature increment of more than 1°C in the limbs (Chatterjee et al. 1986; Chen and Gandhi 1988; Hoque and Gandhi 1988), which has been suggested as the upper limit of temperature increase that has no detrimental health effects (UNEP/WHO/IRPA 1993). Data on volunteers reported by Gandhi et al. (1986) for frequencies up to 50 MHz and by Tofani et al. (1995) for frequencies up to 110 MHz (the upper limit of the FM broadcast band) support a reference level for limb current of 100 mA to avoid excessive heating effects (Dimbylow 1997).

There have been several studies of thermoregulatory responses of resting volunteers exposed to EMF in magnetic resonance imaging systems (Shellock and Crues 1987; Magin et al. 1992). In general, these have demonstrated that exposure for up to 30 min, under conditions in which whole-body SAR was less than 4 W kg^{-1}, caused an increase in the body core temperature of less than 1°C.

Cellular and animal studies. There are numerous reports on the behavioral and physiological responses of laboratory animals, including rodents, dogs, and nonhuman primates, to thermal interactions of EMF at frequencies above 10 MHz. Thermosensitivity and thermoregulatory responses are associated both with the hypothalamus and with thermal receptors located in the skin and in internal parts of the body. Afferent signals reflecting temperature change converge in the central nervous system and modify the activity of the major neuroendocrine control systems, triggering the physiological and behavioral responses necessary for the maintenance of homeostasis.

Exposure of laboratory animals to EMF producing absorption in excess of approximately 4 W kg^{-1} has revealed a characteristic pattern of thermoregulatory response in which body temperature initially rises and then stabilizes following the activation of thermoregulatory mechanisms (Michaelson 1983). The early phase of this response is accompanied by an increase in blood volume due to movement of fluid from the extracellular space into the circulation and by increases in heart rate and intraventricular blood pressure. These cardiodynamic changes reflect thermoregulatory responses that facilitate the conduction of heat to the body surface. Prolonged exposure of animals to levels of microwave radiation that raise the body temperature ultimately lead to failure of these thermoregulatory mechanisms.

Several studies with rodents and monkeys have also demonstrated a behavioral component of thermoregulatory responses. Decreased task performance by rats and monkeys has been observed at SAR values in the range 1–3 W kg^{-1} (Stern et al. 1979; Adair and Adams 1980; de Lorge and Ezell 1980; D'Andrea et al. 1986). In monkeys, altered thermoregulatory behavior starts when the temperature in the hypothalamic region rises by as little as 0.2–0.3°C (Adair et al. 1984). The hypothalamus is considered to be the control center for normal thermoregulatory processes, and its activity can be modified by a small local temperature increase under conditions in which rectal temperature remains constant.

At levels of absorbed electromagnetic energy that cause body temperature rises in excess of 1–2°C, a large number of physiological effects have been characterized in studies with cellular and animal systems (Michaelson and Elson 1996). These effects include alterations in neural and neuromuscular functions; increased blood-brain barrier permeability; ocular impairment (lens opacities and corneal abnormalities); stress-associated changes in the immune system; hematological changes; reproductive changes (e.g., reduced sperm production); teratogenicity; and changes in cell morphology, water and electrolyte content, and membrane functions.

Under conditions of partial-body exposure to intense EMF, significant thermal damage can occur in sensitive tissues such as the eye and the testis. Microwave exposure of 2–3 h duration has produced cataracts in rabbits' eyes at SAR values from 100–140 W kg^{-1}, which produced lenticular temperatures of 41–43°C (Guy et al. 1975). No cataracts were observed in monkeys exposed to microwave fields of similar or higher intensities, possibly because of different energy absorption patterns in the eyes of monkeys from those in rabbits. At very high frequencies (10–300 GHz), absorption of electromagnetic energy is confined largely to the epidermal layers of the skin, subcutaneous tissues, and the outer part of the eye. At the higher end of the frequency range, absorption is increasingly superficial. Ocular damage at these frequencies can be avoided if the microwave power density is less than 50 W m^{-2} (Sliney and Wolbarsht 1980; UNEP/WHO/IRPA 1993).

There has been considerable recent interest in the possible carcinogenic effects of exposure to microwave fields with frequencies in the range of widely used communications systems, including hand-held mobile telephones and base transmitters. Research findings in this area have been summarized by ICNIRP (1996). Briefly, there are many reports suggesting that microwave fields are not mutagenic, and exposure to these fields is therefore unlikely to initiate carcinogenesis (NRPB 1992; Cridland 1993; UNEP/WHO/IRPA 1993). By contrast, some recent reports suggest that exposure of rodents to microwave fields at SAR levels of the order of 1 W kg^{-1} may produce strand breaks in the DNA of testis and brain tissues (Sarkar et al. 1994; Lai and Singh 1995, 1996), although both ICNIRP (1996) and Williams (1996) pointed out methodological deficiencies that could have significantly influenced these results.

In a large study of rats exposed to microwaves for up to 25 mo, an excess of primary malignancies was noted in exposed rats relative to controls (Chou et al. 1992). However, the incidence of benign tumors did not differ between the groups, and no specific type of tumor

was more prevalent in the exposed group than in stock rats of the same strain maintained under similar specific-pathogen-free conditions. Taken as a whole, the results of this study cannot be interpreted as indicating a tumor-initiating effect of microwave fields.

Several studies have examined the effects of microwave exposure on the development of pre-initiated tumor cells. Szmigielski et al. (1982) noted an enhanced growth rate of transplanted lung sarcoma cells in rats exposed to microwaves at high power densities. It is possible that this resulted from a weakening of the host immune defense in response to thermal stress from the microwave exposure. Recent studies using athermal levels of microwave irradiation have found no effects on the development of melanoma in mice or of brain glioma in rats (Santini et al. 1988; Salford et al. 1993).

Repacholi et al. (1997) have reported that exposure of 100 female, *Eμ-pim1* transgenic mice to 900-MHz fields, pulsed at 217 Hz with pulse widths of 0.6 μs for up to 18 mo, produced a doubling in lymphoma incidence compared with 101 controls. Because the mice were free to roam in their cages, the variation in SAR was wide (0.01–4.2 W kg^{-1}). Given that the resting metabolic rate of these mice is 7–15 W kg^{-1}, only the upper end of the exposure range may have produced some slight heating. Thus, it appears that this study suggests a non-thermal mechanism may be acting, which needs to be investigated further. However, before any assumptions can be made about health risk, a number of questions need to be addressed. The study needs to be replicated, restraining the animals to decrease the SAR exposure variation and to determine whether there is a dose response. Further study is needed to determine whether the results can be found in other animal models in order to be able to generalize the results to humans. It is also essential to assess whether results found in transgenic animals are applicable to humans.

Special considerations for pulsed and amplitude-modulated waveforms

Compared with continuous-wave (CW) radiation, pulsed microwave fields with the same average rate of energy deposition in tissues are generally more effective in producing a biological response, especially when there is a well-defined threshold that must be exceeded to elicit the effect (ICNIRP 1996). The "microwave hearing" effect is a well known example of this (Frey 1961; Frey and Messenger 1973; Lin 1978): people with normal hearing can perceive pulse-modulated fields with frequencies between about 200 MHz and 6.5 GHz. The auditory sensation has been variously described as a buzzing, clicking, or popping sound, depending on the modulation characteristics of the field. The microwave hearing effects have been attributed to a thermoelastic interaction in the auditory cortex of the brain, with a threshold for perception of about 100–400 mJ m^{-2} for pulses of duration less than 30 μs at 2.45 GHz (corresponding to an SA of 4–16 mJ kg^{-1}). Repeated or prolonged exposure to microwave auditory effects may be stressful and potentially harmful.

Some reports suggest that retina, iris, and corneal endothelium of the primate eye are sensitive to low levels of pulsed microwave radiation (Kues et al. 1985; UNEP/WHO/IRPA 1993). Degenerative changes in light-sensitive cells of the retina were reported for absorbed energy levels as low as 26 mJ kg^{-1}. After administration of timolol maleate, which is used in the treatment of glaucoma, the threshold for retinal damage by pulsed fields dropped to 2.6 mJ kg^{-1}. However, an attempt in an independent laboratory to partially replicate these findings for CW fields (i.e., not pulsed) was unsuccessful (Kamimura et al. 1994), and it is therefore impossible at present to assess the potential health implications of the initial findings of Kues et al. (1985).

Exposure to intense pulsed microwave fields has been reported to suppress the startle response in conscious mice and to evoke body movements (NRPB 1991; Sienkiewicz et al. 1993; UNEP/WHO/IRPA 1993). The threshold specific energy absorption level at midbrain that evoked body movements was 200 J kg^{-1} for 10 μs pulses. The mechanism for these effects of pulsed microwaves remains to be determined but is believed to be related to the microwave hearing phenomenon. The auditory thresholds for rodents are about an order of magnitude lower than for humans, that is 1–2 mJ kg^{-1} for pulses <30 μs in duration. Pulses of this magnitude have also been reported to affect neurotransmitter metabolism and the concentration of the neural receptors involved in stress and anxiety responses in different regions of the rat brain.

The issue of athermal interactions of high-frequency EMF has centered largely on reports of biological effects of amplitude modulated (AM) fields under *in-vitro* conditions at SAR values well below those that produce measurable tissue heating. Initial studies in two independent laboratories led to reports that VHF fields with amplitude modulation at extremely low frequencies (6–20 Hz) produced a small, but statistically significant, release of Ca^{++} from the surfaces of chick brain cells (Bawin et al. 1975; Blackman et al. 1979). A subsequent attempt to replicate these findings, using the same type of AM field, was unsuccessful (Albert et al. 1987). A number of other studies of the effects of AM fields on Ca^{++} homeostasis have produced both positive and negative results. For example, effects of AM fields on Ca^{++} binding to cell surfaces have been observed with neuroblastoma cells, pancreatic cells, cardiac tissue, and cat brain cells, but not with cultured rat nerve cells, chick skeletal muscle, or rat brain cells (Postow and Swicord 1996).

Amplitude-modulated fields have also been reported to alter brain electrical activity (Bawin et al. 1974), inhibit T-lymphocyte cytotoxic activity (Lyle et al. 1983), decrease the activities of non-cyclic-AMP-dependent kinase in lymphocytes (Byus et al. 1984), and cause a transient increase in the cytoplasmic activity of ornithine decarboxylase, an essential enzyme for cell proliferation (Byus et al. 1988; Litovitz et al. 1992). In contrast, no effects have been observed on a wide variety

of other cellular systems and functional end-points, including lymphocyte capping, neoplastic cell transformation, and various membrane electrical and enzymatic properties (Postow and Swicord 1996). Of particular relevance to the potential carcinogenic effects of pulsed fields is the observation by Balcer-Kubiczek and Harrison (1991) that neoplastic transformation was accelerated in C3H/10T1/2 cells exposed to 2,450-MHz microwaves that were pulse-modulated at 120 Hz. The effect was dependent on field strength but occurred only when a chemical tumor-promoter, TPA, was present in the cell culture medium. This finding suggests that pulsed microwaves may exert co-carcinogenic effects in combination with a chemical agent that increases the rate of proliferation of transformed cells. To date, there have been no attempts to replicate this finding, and its implication for human health effects is unclear.

Interpretation of several observed biological effects of AM electromagnetic fields is further complicated by the apparent existence of "windows" of response in both the power density and frequency domains. There are no accepted models that adequately explain this phenomenon, which challenges the traditional concept of a monotonic relationship between the field intensity and the severity of the resulting biological effects.

Overall, the literature on athermal effects of AM electromagnetic fields is so complex, the validity of reported effects so poorly established, and the relevance of the effects to human health is so uncertain, that it is impossible to use this body of information as a basis for setting limits on human exposure to these fields.

Indirect effects of electromagnetic fields

In the frequency range of about 100 kHz–110 MHz, shocks and burns can result either from an individual touching an ungrounded metal object that has acquired a charge in a field or from contact between a charged individual and a grounded metal object. It should be noted that the upper frequency for contact current (110 MHz) is imposed by a lack of data on higher frequencies rather than by the absence of effects. However, 110 MHz is the upper frequency limit of the FM broadcast band. Threshold currents that result in biological effects ranging in severity from perception to pain have been measured in controlled experiments on volunteers (Chatterjee et al. 1986; Tenforde and Kaune 1987; Bernhardt 1988); these are summarized in Table 3. In general, it has been shown that the threshold currents that produce perception and pain vary little over the frequency range 100 kHz–1 MHz and are unlikely to vary significantly over the frequency range up to about 110 MHz. As noted earlier for lower frequencies, significant variations between the sensitivities of men, women, and children also exist for higher frequency fields. The data in Table 3 represent the range of 50th percentile values for people of different sizes and different levels of sensitivity to contact currents.

Table 3. Ranges of threshold currents for indirect effects, including children, women, and men.

Indirect effect	Threshold current (mA) at frequency: 100 kHz	1 MHz
Touch perception	25–40	25–40
Pain on finger contact	33–55	28–50
Painful shock/let-go threshold	112–224	Not determined
Severe shock/breathing difficulty	160–320	Not determined

Summary of biological effects and epidemiological studies (100 kHz–300 GHz)

Available experimental evidence indicates that the exposure of resting humans for approximately 30 min to EMF producing a whole-body SAR of between 1 and 4 W kg^{-1} results in a body temperature increase of less than 1 °C. Animal data indicate a threshold for behavioral responses in the same SAR range. Exposure to more intense fields, producing SAR values in excess of 4 W kg^{-1}, can overwhelm the thermoregulatory capacity of the body and produce harmful levels of tissue heating. Many laboratory studies with rodent and nonhuman primate models have demonstrated the broad range of tissue damage resulting from either partial-body or whole-body heating producing temperature rises in excess of 1–2°C. The sensitivity of various types of tissue to thermal damage varies widely, but the threshold for irreversible effects in even the most sensitive tissues is greater than 4 W kg^{-1} under normal environmental conditions. These data form the basis for an occupational exposure restriction of 0.4 W kg^{-1}, which provides a large margin of safety for other limiting conditions such as high ambient temperature, humidity, or level of physical activity.

Both laboratory data and the results of limited human studies (Michaelson and Elson 1996) make it clear that thermally stressful environments and the use of drugs or alcohol can compromise the thermoregulatory capacity of the body. Under these conditions, safety factors should be introduced to provide adequate protection for exposed individuals.

Data on human responses to high-frequency EMF that produce detectable heating have been obtained from controlled exposure of volunteers and from epidemiological studies on workers exposed to sources such as radar, medical diathermy equipment, and heat sealers. They are fully supportive of the conclusions drawn from laboratory work, that adverse biological effects can be caused by temperature rises in tissue that exceed 1°C. Epidemiological studies on exposed workers and the general public have shown no major health effects associated with typical exposure environments. Although there are deficiencies in the epidemiological work, such as poor exposure assessment, the studies have yielded no convincing evidence that typical exposure levels lead to adverse reproductive outcomes or an increased cancer risk in exposed individuals. This is consistent with the results of laboratory research on cellular and animal

models, which have demonstrated neither teratogenic nor carcinogenic effects of exposure to athermal levels of high-frequency EMF.

Exposure to pulsed EMF of sufficient intensity leads to certain predictable effects such as the microwave hearing phenomenon and various behavioral responses. Epidemiological studies on exposed workers and the general public have provided limited information and failed to demonstrate any health effects. Reports of severe retinal damage have been challenged following unsuccessful attempts to replicate the findings.

A large number of studies of the biological effects of amplitude-modulated EMF, mostly conducted with low levels of exposure, have yielded both positive and negative results. Thorough analysis of these studies reveals that the effects of AM fields vary widely with the exposure parameters, the types of cells and tissues involved, and the biological end-points that are examined. In general, the effects of exposure of biological systems to athermal levels of amplitude-modulated EMF are small and very difficult to relate to potential health effects. There is no convincing evidence of frequency and power density windows of response to these fields.

Shocks and burns can be the adverse indirect effects of high-frequency EMF involving human contact with metallic objects in the field. At frequencies of 100 kHz–110 MHz (the upper limit of the FM broadcast band), the threshold levels of contact current that produce effects ranging from perception to severe pain do not vary significantly as a function of the field frequency. The threshold for perception ranges from 25 to 40 mA in individuals of different sizes, and that for pain from approximately 30 to 55 mA; above 50 mA there may be severe burns at the site of tissue contact with a metallic conductor in the field.

GUIDELINES FOR LIMITING EMF EXPOSURE

Occupational and general public exposure limitations

The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to EMF. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure. It is these considerations that underlie the adoption of more stringent exposure restrictions for the public than for the occupationally exposed population.

Basic restrictions and reference levels

Restrictions on the effects of exposure are based on established health effects and are termed basic restrictions. Depending on frequency, the physical quantities used to specify the basic restrictions on exposure to EMF are current density, SAR, and power density. Protection against adverse health effects requires that these basic restrictions are not exceeded.

Reference levels of exposure are provided for comparison with measured values of physical quantities; compliance with all reference levels given in these guidelines will ensure compliance with basic restrictions. If measured values are higher than reference levels, it does not necessarily follow that the basic restrictions have been exceeded, but a more detailed analysis is necessary to assess compliance with the basic restrictions.

General statement on safety factors

There is insufficient information on the biological and health effects of EMF exposure of human populations and experimental animals to provide a rigorous basis for establishing safety factors over the whole frequency range and for all frequency modulations. In addition, some of the uncertainty regarding the appropriate safety factor derives from a lack of knowledge regarding the appropriate dosimetry (Repacholi 1998). The following general variables were considered in the development of safety factors for high-frequency fields:

- effects of EMF exposure under severe environmental conditions (high temperature, etc.) and/or high activity levels; and
- the potentially higher thermal sensitivity in certain population groups, such as the frail and/or elderly, infants and young children, and people with diseases or taking medications that compromise thermal tolerance.

The following additional factors were taken into account in deriving reference levels for high-frequency fields:

- differences in absorption of electromagnetic energy by individuals of different sizes and different orientations relative to the field; and
- reflection, focusing, and scattering of the incident field, which can result in enhanced localized absorption of high-frequency energy.

Basic restrictions

Different scientific bases were used in the development of basic exposure restrictions for various frequency ranges:

- Between 1 Hz and 10 MHz, basic restrictions are provided on current density to prevent effects on nervous system functions;
- Between 100 kHz and 10 GHz, basic restrictions on SAR are provided to prevent whole-body heat stress and excessive localized tissue heating; in the 100 kHz–10 MHz range, restrictions are provided on both current density and SAR; and
- Between 10 and 300 GHz, basic restrictions are provided on power density to prevent excessive heating in tissue at or near the body surface.

In the frequency range from a few Hz to 1 kHz, for levels of induced current density above 100 mA m^{-2}, the thresholds for acute changes in central nervous system excitability and other acute effects such as reversal of the visually evoked potential are exceeded. In view of the safety considerations above, it was decided that, for frequencies in the range 4 Hz to 1 kHz, occupational exposure should be limited to fields that induce current densities less than 10 mA m^{-2}, i.e., to use a safety factor of 10. For the general public an additional factor of 5 is applied, giving a basic exposure restriction of 2 mA m^{-2}. Below 4 Hz and above 1 kHz, the basic restriction on induced current density increases progressively, corresponding to the increase in the threshold for nerve stimulation for these frequency ranges.

Established biological and health effects in the frequency range from 10 MHz to a few GHz are consistent with responses to a body temperature rise of more than 1°C. This level of temperature increase results from exposure of individuals under moderate environmental conditions to a whole-body SAR of approximately 4 W kg^{-1} for about 30 min. A whole-body average SAR of 0.4 W kg^{-1} has therefore been chosen as the restriction that provides adequate protection for occupational exposure. An additional safety factor of 5 is introduced for exposure of the public, giving an average whole-body SAR limit of 0.08 W kg^{-1}.

The lower basic restrictions for exposure of the general public take into account the fact that their age and health status may differ from those of workers.

In the low-frequency range, there are currently few data relating transient currents to health effects. The ICNIRP therefore recommends that the restrictions on current densities induced by transient or very short-term peak fields be regarded as instantaneous values which should not be time-averaged.

The basic restrictions for current densities, whole-body average SAR, and localized SAR for frequencies between 1 Hz and 10 GHz are presented in Table 4, and those for power densities for frequencies of 10–300 GHz are presented in Table 5.

REFERENCE LEVELS

Where appropriate, the reference levels are obtained from the basic restrictions by mathematical modeling and by extrapolation from the results of laboratory investigations at specific frequencies. They are given for the condition of maximum coupling of the field to the exposed individual, thereby providing maximum protection. Tables 6 and 7 summarize the reference levels for occupational exposure and exposure of the general public, respectively, and the reference levels are illustrated in Figs. 1 and 2. The reference levels are intended to be spatially averaged values over the entire body of the exposed individual, but with the important proviso that the basic restrictions on localized exposure are not exceeded.

For low-frequency fields, several computational and measurement methods have been developed for deriving field-strength reference levels from the basic restrictions.

Table 4. Basic restrictions for time varying electric and magnetic fields for frequencies up to 10 GHz.[a]

Exposure characteristics	Frequency range	Current density for head and trunk (mA m^{-2}) (rms)	Whole-body average SAR (W kg^{-1})	Localized SAR (head and trunk) (W kg^{-1})	Localized SAR (limbs) (W kg^{-1})
Occupational exposure	up to 1 Hz	40	—	—	—
	1–4 Hz	40/f	—	—	—
	4 Hz–1 kHz	10	—	—	—
	1–100 kHz	f/100	—	—	—
	100 kHz–10 MHz	f/100	0.4	10	20
	10 MHz–10 GHz	—	0.4	10	20
General public exposure	up to 1 Hz	8	—	—	—
	1–4 Hz	8/f	—	—	—
	4 Hz–1 kHz	2	—	—	—
	1–100 kHz	f/500	—	—	—
	100 kHz–10 MHz	f/500	0.08	2	4
	10 MHz–10 GHz	—	0.08	2	4

[a] Note:
1. f is the frequency in hertz.
2. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm^2 perpendicular to the current direction.
3. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by $\sqrt{2}$ (~1.414). For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$.
4. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.
5. All SAR values are to be averaged over any 6-min period.
6. Localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.
7. For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$. Additionally, for pulsed exposures in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed 10 mJ kg^{-1} for workers and 2mJ kg^{-1} for the general public, averaged over 10 g tissue.

Table 5. Basic restrictions for power density for frequencies between 10 and 300 GHz.[a]

Exposure characteristics	Power density (W m^{-2})
Occupational exposure	50
General public	10

[a] Note:
1. Power densities are to be averaged over any 20 cm^2 of exposed area and any $68/f^{1.05}$-min period (where f is in GHz) to compensate for progressively shorter penetration depth as the frequency increases.
2. Spatial maximum power densities, averaged over 1 cm^2, should not exceed 20 times the values above.

The simplifications that have been used to date did not account for phenomena such as the inhomogeneous distribution and anisotropy of the electrical conductivity and other tissue factors of importance for these calculations.

The frequency dependence of the reference field levels is consistent with data on both biological effects and coupling of the field.

Magnetic field models assume that the body has a homogeneous and isotropic conductivity and apply simple circular conductive loop models to estimate induced currents in different organs and body regions, e.g., the head, by using the following equation for a pure sinusoidal field at frequency f derived from Faraday's law of induction:

$$J = \pi R f \sigma \mathrm{B}, \tag{4}$$

where B is the magnetic flux density and R is the radius of the loop for induction of the current. More complex models use an ellipsoidal model to represent the trunk or the whole body for estimating induced current densities at the surface of the body (Reilly 1989, 1992).

If, for simplicity, a homogeneous conductivity of 0.2 S m^{-1} is assumed, a 50-Hz magnetic flux density of 100 μT generates current densities between 0.2 and 2 mA m^{-2} in the peripheral area of the body (CRP 1997). According to another analysis (NAS 1996), 60-Hz exposure levels of 100 μT correspond to average current densities of 0.28 mA m^{-2} and to maximum current densities of approximately 2 mA m^{-2}. More realistic calculations based on anatomically and electrically refined models (Xi and Stuchly 1994) resulted in maximum current densities exceeding 2 mA m^{-2} for a 100-μT field at 60 Hz. However, the presence of biological cells affects the spatial pattern of induced currents and fields, resulting in significant differences in both magnitude (a factor of 2 greater) and patterns of flow of the induced current compared with those predicted by simplified analyses (Stuchly and Xi 1994).

Electric field models must take into account the fact that, depending on the exposure conditions and the size, shape, and position of the exposed body in the field, the surface charge density can vary greatly, resulting in a variable and non-uniform distribution of currents inside the body. For sinusoidal electric fields at frequencies below about 10 MHz, the magnitude of the induced current density inside the body increases with frequency. The induced current density distribution varies inversely with the body cross-section and may be relatively high in the neck and ankles. The exposure level of 5 kV m^{-1} for exposure of the general public corresponds, under worst-case conditions, to an induced current density of about 2 mA m^{-2} in the neck and trunk of the body if the E-field vector is parallel to the body axis (ILO 1994; CRP 1997). However, the current density induced by 5 kV m^{-1} will comply with the basic restrictions under realistic worst-case exposure conditions.

For purposes of demonstrating compliance with the basic restrictions, the reference levels for the electric and magnetic fields should be considered separately and not additively. This is because, for protection purposes, the currents induced by electric and magnetic fields are not additive.

For the specific case of occupational exposures at frequencies up to 100 kHz, the derived electric fields can be increased by a factor of 2 under conditions in which adverse indirect effects from contact with electrically charged conductors can be excluded.

At frequencies above 10 MHz, the derived electric and magnetic field strengths were obtained from the whole-body SAR basic restriction using computational and experimental data. In the worst case, the energy coupling reaches a maximum between 20 MHz and several hundred MHz. In this frequency range, the derived reference levels have minimum values. The derived magnetic field strengths were calculated from the electric field strengths by using the far-field relationship between E and H (E/H = 377 ohms). In the near-field, the SAR frequency dependence curves are no longer valid; moreover, the contributions of the electric and magnetic field components have to be considered separately. For a conservative approximation, field exposure levels can be used for near-field assessment since the coupling of energy from the electric or magnetic field contribution cannot exceed the SAR restrictions. For a less conservative assessment, basic restrictions on the whole-body average and local SAR should be used.

Reference levels for exposure of the general public have been obtained from those for occupational exposure by using various factors over the entire frequency range. These factors have been chosen on the basis of effects that are recognized as specific and relevant for the various frequency ranges. Generally speaking, the factors follow the basic restrictions over the entire frequency range, and their values correspond to the mathematical relation between the quantities of the basic restrictions and the derived levels as described below:

- In the frequency range up to 1 kHz, the general public reference levels for electric fields are one-half of the values set for occupational exposure. The value of 10 kV m^{-1} for a 50-Hz or 8.3 kV m^{-1} for a 60-Hz occupational exposure includes a sufficient safety margin to prevent stimulation effects from contact currents under all possible conditions. Half of this value was chosen for the general public reference levels, i.e.,

Table 6. Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	1.63×10^5	2×10^5	—
1–8 Hz	20,000	$1.63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—
8–25 Hz	20,000	$2 \times 10^4/f$	$2.5 \times 10^4/f$	—
0.025–0.82 kHz	$500/f$	$20/f$	$25/f$	—
0.82–65 kHz	610	24.4	30.7	—
0.065–1 MHz	610	$1.6/f$	$2.0/f$	—
1–10 MHz	$610/f$	$1.6/f$	$2.0/f$	—
10–400 MHz	61	0.16	0.2	10
400–2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2–300 GHz	137	0.36	0.45	50

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width, does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. Electric shock from low impedance sources is prevented by established electrical safety procedures for such equipment.

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4{,}000/f$	$5{,}000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

5 $kV\ m^{-1}$ for 50 Hz or 4.2 $kV\ m^{-1}$ for 60 Hz, to prevent adverse indirect effects for more than 90% of exposed individuals;

- In the low-frequency range up to 100 kHz, the general public reference levels for magnetic fields are set at a factor of 5 below the values set for occupational exposure;
- In the frequency range 100 kHz–10 MHz, the general public reference levels for magnetic fields have been increased compared with the limits given in the 1988 IRPA guideline. In that guideline, the magnetic field strength reference levels were calculated from the electric field strength reference levels by using the far-field

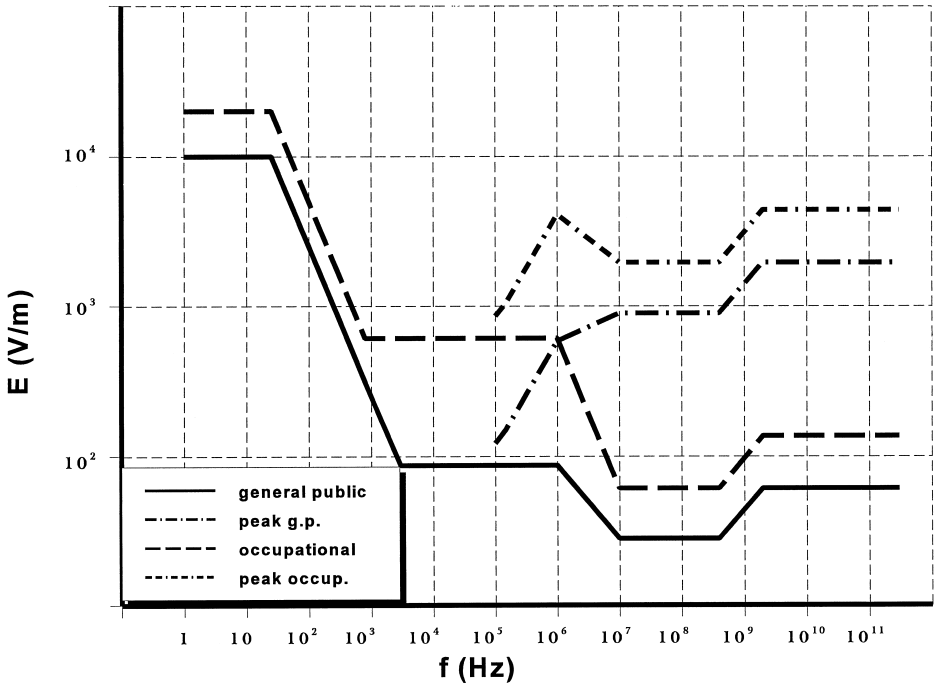

Fig. 1. Reference levels for exposure to time varying electric fields (compare Tables 6 and 7).

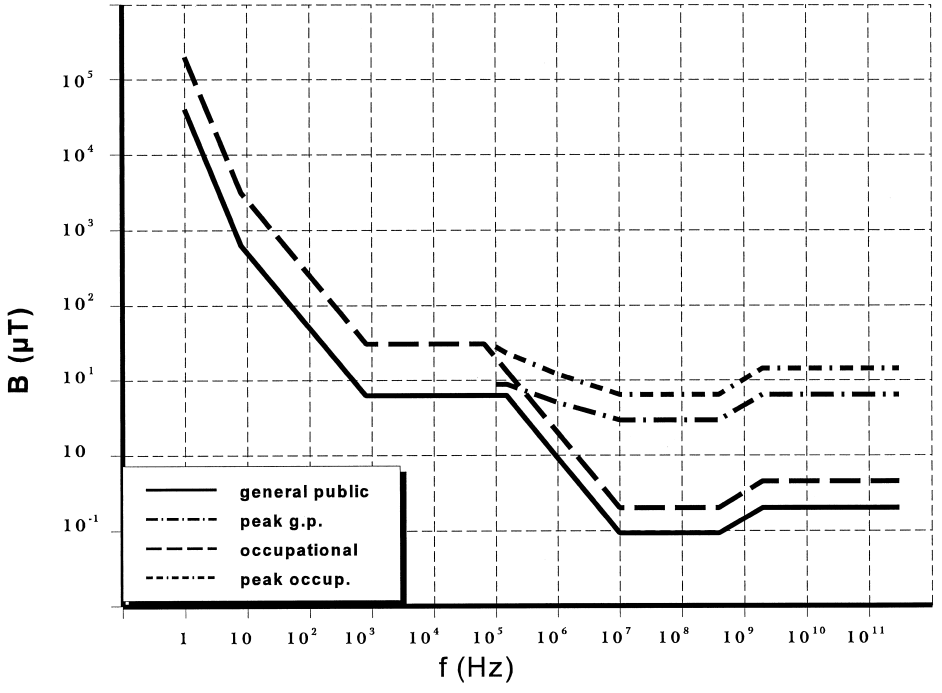

Fig. 2. Reference levels for exposure to time varying magnetic fields (compare Tables 6 and 7).

formula relating E and H. These reference levels are too conservative, since the magnetic field at frequencies below 10 MHz does not contribute significantly to the risk of shocks, burns, or surface charge effects that form a major basis for limiting occupational exposure to electric fields in that frequency range;

- In the high-frequency range 10 MHz–10 GHz, the general public reference levels for electric and magnetic fields are lower by a factor of 2.2 than those set for occupational exposure. The factor of 2.2 corresponds to the square root of 5, which is the safety factor between the basic restrictions for occupational exposure and those for general public

exposure. The square root is used to relate the quantities "field strength" and "power density;"

- In the high-frequency range 10–300 GHz, the general public reference levels are defined by the power density, as in the basic restrictions, and are lower by a factor of 5 than the occupational exposure restrictions;
- Although little information is available on the relation between biological effects and peak values of pulsed fields, it is suggested that, for frequencies exceeding 10 MHz, S_{eq} as averaged over the pulse width should not exceed 1,000 times the reference levels or that field strengths should not exceed 32 times the field strength reference levels given in Tables 6 and 7 or shown in Figs. 1 and 2. For frequencies between about 0.3 GHz and several GHz, and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion the specific absorption from pulses must limited. In this frequency range, the threshold SA of 4–16 mJ kg^{-1} for producing this effect corresponds, for 30-μs pulses, to peak SAR values of 130–520 W kg^{-1} in the brain. Between 100 kHz and 10 MHz, peak values for the field strengths in Figs. 1 and 2 are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz.
- In Tables 6 and 7, as well as in Figs. 1 and 2, different frequency break-points occur for occupational and general public derived reference levels. This is a consequence of the varying factors used to derive the general public reference levels, while generally keeping the frequency dependence the same for both occupational and general public levels.

REFERENCE LEVELS FOR CONTACT AND INDUCED CURRENTS

Up to 110 MHz, which includes the FM radio transmission frequency band, reference levels for contact current are given above which caution must be exercised to avoid shock and burn hazards. The point contact reference levels are presented in Table 8. Since the threshold contact currents that elicit biological responses in children and adult women are approximately one-half and two-thirds, respectively, of those for adult men, the reference levels for contact current for the general public are set lower by a factor of 2 than the values for occupational exposure.

For the frequency range 10–110 MHz, reference levels are provided for limb currents that are below the basic restrictions on localized SAR (see Table 9).

SIMULTANEOUS EXPOSURE TO MULTIPLE FREQUENCY FIELDS

It is important to determine whether, in situations of simultaneous exposure to fields of different frequencies, these exposures are additive in their effects. Additivity should be examined separately for the effects of thermal and electrical stimulation, and the basic restrictions below should be met. The formulae below apply to relevant frequencies under practical exposure situations.

For electrical stimulation, relevant for frequencies up to 10 MHz, induced current densities should be added according to

$$\sum_{i=1\ \mathrm{Hz}}^{10\ \mathrm{MHz}} \frac{J_i}{J_{L,i}} \leq 1. \tag{5}$$

For thermal effects, relevant above 100 kHz, SAR and power density values should be added according to:

$$\sum_{i=100\ \mathrm{kHz}}^{10\ \mathrm{GHz}} \frac{SAR_i}{SAR_L} + \sum_{i>10\ \mathrm{GHz}}^{300\ \mathrm{GHz}} \frac{S_i}{S_L} \leq 1, \tag{6}$$

where

J_i = the current density induced at frequency i;
$J_{L,\,i}$ = the induced current density restriction at frequency i as given in Table 4;
SAR_i = the SAR caused by exposure at frequency i;
SAR_L = the SAR limit given in Table 4;
S_L = the power density limit given in Table 5; and
S_i = the power density at frequency i.

For practical application of the basic restrictions, the following criteria regarding reference levels of field strengths should be applied.

Table 8. Reference levels for time varying contact currents from conductive objects.[a]

Exposure characteristics	Frequency range	Maximum contact current (mA)
Occupational exposure	up to 2.5 kHz	1.0
	2.5–100 kHz	0.4f
	100 kHz–110 MHz	40
General public exposure	up to 2.5 kHz	0.5
	2.5–100 kHz	0.2f
	100 kHz–110 MHz	20

[a] f is the frequency in kHz.

Table 9. Reference levels for current induced in any limb at frequencies between 10 and 110 MHz.[a]

Exposure characteristics	Current (mA)
Occupational exposure	100
General public	45

[a] Note:
1. The public reference level is equal to the occupational reference level divided by $\sqrt{5}$.
2. For compliance with the basic restriction on localized SAR, the square root of the time-averaged value of the square of the induced current over any 6-min period forms the basis of the reference levels.

For induced current density and electrical stimulation effects, relevant up to 10 MHz, the following two requirements should be applied to the field levels:

$$\sum_{i=1\ \mathrm{Hz}}^{1\ \mathrm{MHz}} \frac{E_i}{E_{L,i}} + \sum_{i>1\ \mathrm{MHz}}^{10\ \mathrm{MHz}} \frac{E_i}{a} \leq 1, \qquad (7)$$

and

$$\sum_{j=1\ \mathrm{Hz}}^{65\ \mathrm{kHz}} \frac{H_j}{H_{L,j}} + \sum_{j>65\ \mathrm{kHz}}^{10\ \mathrm{MHz}} \frac{H_j}{b} \leq 1, \qquad (8)$$

where

E_i = the electric field strength at frequency i;
$E_{L,\,i}$ = the electric field reference level from Tables 6 and 7;
H_j = the magnetic field strength at frequency j;
$H_{L,\,j}$ = the magnetic field reference level from Tables 6 and 7;
a = 610 V m^{-1} for occupational exposure and 87 V m^{-1} for general public exposure; and
b = 24.4 A m^{-1} (30.7 μT) for occupational exposure and 5 A m^{-1} (6.25 μT) for general public exposure.

The constant values a and b are used above 1 MHz for the electric field and above 65 kHz for the magnetic field because the summation is based on induced current densities and should not be mixed with thermal considerations. The latter forms the basis for $E_{L,i}$ and $H_{L,j}$ above 1 MHz and 65 kHz, respectively, found in Tables 6 and 7.

For thermal considerations, relevant above 100 kHz, the following two requirements should be applied to the field levels:

$$\sum_{i=100\ \mathrm{kHz}}^{1\ \mathrm{MHz}} \left(\frac{E_i}{c}\right)^2 + \sum_{i>1\ \mathrm{MHz}}^{300\ \mathrm{GHz}} \left(\frac{E_i}{E_{L,i}}\right)^2 \leq 1, \qquad (9)$$

and

$$\sum_{j=100\ \mathrm{kHz}}^{1\ \mathrm{MHz}} \left(\frac{H_j}{d}\right)^2 + \sum_{j>1\ \mathrm{MHz}}^{300\ \mathrm{GHz}} \left(\frac{H_j}{H_{L,j}}\right)^2 \leq 1, \qquad (10)$$

where

E_i = the electric field strength at frequency i;
$E_{L,\,i}$ = the electric field reference level from Tables 6 and 7;
H_j = the magnetic field strength at frequency j;
$H_{L,\,i}$ = the magnetic field reference level from Tables 6 and 7;
c = 610/f V m^{-1} (f in MHz) for occupational exposure and 87/$f^{1/2}$ V m^{-1} for general public exposure; and
d = 1.6/f A m^{-1} (f in MHz) for occupational exposure and 0.73/f for general public exposure.

For limb current and contact current, respectively, the following requirements should be applied:

$$\sum_{k=10\ \mathrm{MHz}}^{110\ \mathrm{MHz}} \left(\frac{I_k}{I_{L,k}}\right)^2 \leq 1 \qquad \sum_{n=1\ \mathrm{Hz}}^{110\ \mathrm{MHz}} \frac{I_n}{I_{C,n}} \leq 1, \qquad (11)$$

where

I_k = the limb current component at frequency k;
$I_{L,\,k}$ = the reference level of limb current (see Table 9);
I_n = the contact current component at frequency n; and
$I_{C,\,n}$ = the reference level of contact current at frequency n (see Table 8).

The above summation formulae assume worst-case conditions among the fields from the multiple sources. As a result, typical exposure situations may in practice require less restrictive exposure levels than indicated by the above formulae for the reference levels.

PROTECTIVE MEASURES

ICNIRP notes that the industries causing exposure to electric and magnetic fields are responsible for ensuring compliance with all aspects of the guidelines.

Measures for the protection of workers include engineering and administrative controls, personal protection programs, and medical surveillance (ILO 1994). Appropriate protective measures must be implemented when exposure in the workplace results in the basic restrictions being exceeded. As a first step, engineering controls should be undertaken wherever possible to reduce device emissions of fields to acceptable levels. Such controls include good safety design and, where necessary, the use of interlocks or similar health protection mechanisms.

Administrative controls, such as limitations on access and the use of audible and visible warnings, should be used in conjunction with engineering controls. Personal protection measures, such as protective clothing, though useful in certain circumstances, should be regarded as a last resort to ensure the safety of the worker; priority should be given to engineering and administrative controls wherever possible. Furthermore, when such items as insulated gloves are used to protect individuals from high-frequency shock and burns, the basic restrictions must not be exceeded, since the insulation protects only against indirect effects of the fields.

With the exception of protective clothing and other personal protection, the same measures can be applied to the general public whenever there is a possibility that the general public reference levels might be exceeded. It is also essential to establish and implement rules that will prevent:

- interference with medical electronic equipment and devices (including cardiac pacemakers);

- detonation of electro-explosive devices (detonators); and
- fires and explosions resulting from ignition of flammable materials by sparks caused by induced fields, contact currents, or spark discharges.

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APPENDIX

Glossary

Absorption. In radio wave propagation, attenuation of a radio wave due to dissipation of its energy, i.e., conversion of its energy into another form, such as heat.

Athermal effect. Any effect of electromagnetic energy on a body that is not a heat-related effect.

Blood-brain barrier. A functional concept developed to explain why many substances that are transported by blood readily enter other tissues but do not enter the brain; the "barrier" functions as if it were a continuous membrane lining the vasculature of the brain. These brain capillary endothelial cells form a nearly continuous barrier to entry of substances into the brain from the vasculature.

Conductance. The reciprocal of resistance. Expressed in siemens (S).

Conductivity, electrical. The scalar or vector quantity which, when multiplied by the electric field strength, yields the conduction current density; it is the reciprocal of resistivity. Expressed in siemens per meter (S m^{-1}).

Continuous wave. A wave whose successive oscillations are identical under steady-state conditions.

Current density. A vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor. Expressed in ampere per square meter (A m^{-2}).

Depth of penetration. For a plane wave electromagnetic field (EMF), incident on the boundary of a good conductor, depth of penetration of the wave is the depth at which the field strength of the wave has been reduced to 1/e, or to approximately 37% of its original value.

Dielectric constant. See permittivity.

Dosimetry. Measurement, or determination by calculation, of internal electric field strength or induced current density, of the specific energy absorption, or specific energy absorption rate distribution, in humans or animals exposed to electromagnetic fields.

Electric field strength. The force (E) on a stationary unit positive charge at a point in an electric field; measured in volt per meter (V m^{-1}).

Electromagnetic energy. The energy stored in an electromagnetic field. Expressed in joule (J).

ELF. Extremely low frequency; frequency below 300 Hz.

EMF. Electric, magnetic, and electromagnetic fields.

Far field. The region where the distance from a radiating antenna exceeds the wavelength of the radiated EMF; in the far-field, field components (E and H) and the direction of propagation are mutually perpendicular, and the shape of the field pattern is independent of the distance from the source at which it is taken.

Frequency. The number of sinusoidal cycles completed by electromagnetic waves in 1 s; usually expressed in hertz (Hz).

Impedance, wave. The ratio of the complex number (vector) representing the transverse electric field at a point to that representing the transverse magnetic field at that point. Expressed in ohm (Ω).

Magnetic field strength. An axial vector quantity, H, which, together with magnetic flux density, specifies a magnetic field at any point in space, and is expressed in ampere per meter (A m^{-1}).

Magnetic flux density. A vector field quantity, B, that results in a force that acts on a moving charge or charges, and is expressed in tesla (T).

Magnetic permeability. The scalar or vector quantity which, when multiplied by the magnetic field strength, yields magnetic flux density; expressed in henry per meter (H m^{-1}). *Note:* For isotropic media, magnetic permeability is a scalar; for anisotropic media, it is a tensor quantity.

Microwaves. Electromagnetic radiation of sufficiently short wavelength for which practical use can be made of waveguide and associated cavity techniques in its transmission and reception. *Note:* The term is taken to signify radiations or fields having a frequency range of 300 MHz–300 GHz.

Near field. The region where the distance from a radiating antenna is less than the wavelength of the radiated EMF. *Note:* The magnetic field strength (multiplied by the impedance of space) and the electric field strength are unequal and, at distances less than one-tenth of a wavelength from an antenna, vary inversely as the square or cube of the distance if the antenna is small compared with this distance.

Non-ionizing radiation (NIR). Includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than about 12 eV, wavelengths greater than 100 nm, and frequencies lower than 3×10^{15} Hz.

Occupational exposure. All exposure to EMF experienced by individuals in the course of performing their work.

Permittivity. A constant defining the influence of an isotropic medium on the forces of attraction or repulsion between electrified bodies, and expressed in farad per metre (F m^{-1}); *relative permittivity* is the permittivity of a material or medium divided by the permittivity of vacuum.

Plane wave. An electromagnetic wave in which the electric and magnetic field vectors lie in a plane perpendicular to the direction of wave propagation, and the magnetic field strength (multiplied by the impedance of space) and the electric field strength are equal.

Power density. In radio wave propagation, the power crossing a unit area normal to the direction of wave propagation; expressed in watt per square meter (W m^{-2}).

Public exposure. All exposure to EMF experienced by members of the general public, excluding occupational exposure and exposure during medical procedures.

Radiofrequency (RF). Any frequency at which electromagnetic radiation is useful for telecommunication. *Note:* In this publication, radiofrequency refers to the frequency range 300 Hz –300 GHz.

Resonance. The change in amplitude occurring as the frequency of the wave approaches or coincides with a natural frequency of the medium; whole-body absorption of electromagnetic waves presents its highest value, i.e., the resonance, for frequencies (in MHz) corresponding approximately to $114/L$, where L is the height of the individual in meters.

Root mean square (rms). Certain electrical effects are proportional to the square root of the mean of the square of a periodic function (over one period). This value is known as the effective, or root-mean-square (rms) value, since it is derived by first squaring the function, determining the mean value of the squares obtained, and taking the square root of that mean value.

Specific energy absorption. The energy absorbed per unit mass of biological tissue, (SA) expressed in joule per kilogram (J kg^{-1}); specific energy absorption is the time integral of specific energy absorption rate.

Specific energy absorption rate (SAR). The rate at which energy is absorbed in body tissues, in watt per kilogram (W kg^{-1}); SAR is the dosimetric measure that has been widely adopted at frequencies above about 100 kHz.

Wavelength. The distance between two successive points of a periodic wave in the direction of propagation, at which the oscillation has the same phase.

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