RESPONSE TO WORKING GROUP AND PUBLIC COMMENTS ON THE SITE C CLEAN ENERGY PROJECT ENVIRONMENTAL IMPACT STATEMENT

Technical Memo

PALAEONTOLOGY

MAY 8, 2013

Subject: Palaeontology

Purpose

The purpose of this technical memorandum is to provide supplementary information of the descriptions of palaeontological resources provided in Section 32 and Volume 4 Appendix C of the EIS to address comments provided to BC Hydro during the Comment Period on the EIS.

All of the information presented in this technical memorandum was obtained through the literature review, during the extensive field program described in the EIS, can be found in the EIS, and was used in the effects assessment.

Synthesis of Geological, Stratigraphic and Palaeontological Context

The following section provides a summary and synthesis of the geological, stratigraphic and palaeontological context for the LAA, based on current data from background research and recent field work presented in the EIS. Please also see Volume 4 Appendix C for descriptions of the geological setting (Section 4.2.1.1) and the geological strata (Section 4.2.1.2) related to the LAA, which are further referenced in the following sections.

Locations where significant clusters of fossils were identified during field work were assigned to eleven fossil complexes that are formed by geographical and stratigraphical concentrations of major palaeontological sites with similar fossiliferous content in specific geographic areas within and directly adjacent to the LAA. These fossil complexes are listed in Section 4.2.2 of Volume 4 Appendix C. In short, the fossil complexes encapsulate the primary areas where palaeontological resources have been observed. However, some positive palaeontological sensitivity areas (PSAs) are excluded from these fossil complexes, and in turn the following summation, due to their lack of significance, isolation, and/or redundancy. References to non-positive PSAs are utilized for positional descriptive purposes. All referenced PSAs in this document are displayed on the maps included in Volume 4, Appendix C, Figures 4.6.1 to 4.6.31 and 4.8.1 to 4.8.31 and the fossil complex locations described below are presented in the attached Figures 1a and 1b.

The tables express a synthesis of the positive PSAs and the observed fossils within them, and synthesize this information with the results of the significance assessment and resultant classification of PSAs (see EIS Section 32.2.2.2.1). The lists of fossil occurances are condensed within a generalized taxonomic classification system in order to simplify and provide a contextual summation of the various forms observed in relation to significance and possible future mitigation strategies. Within the tables, PSAs with one asterisk are Class I sites (e.g.,, PS119D*); PSAs with two asterisks are Class II sites (e.g.,, PS001A**); PSAs with no indicator are Class III sites; and PSAs surrounded by brackets are located beyond the LAA, but are still considered as part of the Fossil Complexes.

Tables 1 to 11 provide summaries of palaeontological content of the stratigraphic units that were observed in the LAA during the 2011 and 2012 field seasons, along with stratigraphically coincident PSAs. Please see Volume 4, Appendix C for descriptions of each stratigraphic unit (Section 4.2.1.2) and each positive PSA (Appendix E). In each section below, a description/definition of the fossil complex is provided followed by a table that synthesizes the available palaeontological data in each complex. This information is then further summarized to provide additional context related to field

observations and generally identifies interesting or important palaeontological features found in the complex.

Fossil Complexes

The Fossil Complexes are described generally from east to west from the proposed Dam site upstream to the Peace Canyon Dam and then to the Transmission system, and finally to include the Quaternary complex that encompasses the LAA (see Figures 1a and 1b).

North Dam Upper Shaftesbury Fossil Complex

The North Dam Upper Shaftesbury Fossil Complex is located along the north bank of the Peace River in the vicinity of the proposed Dam and Generating Station and the adjacent areas of the Reservoir, spillway and access roads. A number of PSAs in this complex have good to excellent exposures of grey friable shales of the upper Shaftesbury Formation that reflect the palaeontological resource potential to be encountered during construction. On the north bank of the Peace River (ND01I and PS001A), a veneer of grey glacio-lacustrine silty/clay covers the slope and has narrow exposures and dislodged concretions in rills and slumps. Further to the northwest, a small coulee erodes the upper portions of the section along terrace bluffs, where Cretaceous silty shales of a higher stratigraphic level is exposed; regionally known as the “Fish Scale Zone”. These sediments are overlain by Quaternary sands and silts. On the highest terraces the Cenomanian Dunvegan Formation could underlie the Quaternary deposits.

Table 1 Summary Features of the North Dam Upper Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PSND01I** PS001A** PS001C** PS002B PS002C	Shaftesbury Formation (middle to upper)	CRETACEOUS • Early Cenomanian • Middle?-Late Albian	**PALAEOFAUNA** VERTEBRATES • Fish Scales INVERTEBRATES • Ammonites o *Rapidoplacenticeras* o *Neogastroplites* o Gastroplitids • Pelecypods o *Pelecypod indet.* • Shell hash • Trace fossils **PALAEOFLORA** ANGIOSPERMS • “Water lily” plant *(Menispermites reniformis)* GYMNOSPERMS • Cycad pinnules o *Ctenis/Podzamites* • Wood OTHER • Algae form A

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
not observed	Dunvegan Formation	CRETACEOUS • Cenomanian	• not exposed, but possibly encountered during excavation

North Dam Upper Shaftesbury Fossil Complex Features

- The scattered corroded sideritic concretions slumped from higher levels containing highly fractured ammonites of the *Rapidoplacenticeras* and *Neogastroplites* types, as well as other molluscs. Less weathered concretions are anticipated to occur deeper in the formation, as well as in exposures experiencing more active erosion downstream.
- Upper silty intervals have abundant *in situ* fish scales suggesting the possibility of finding other fish skeletal elements
- Fragmented plant materials are common. However, the presence of a "water-lily" leaf attributable to *Menispermites reniformis* is notable.

Moberly River Upper Shaftesbury Fossil Complex

The Moberly River Upper Shaftesbury Fossil Complex includes the area in the vicinity of the Moberly River confluence with the Peace River and continues to the farthest limit of the proposed Reservoir along the Moberly River valley. Numerous positive PSAs are located along the Moberly River comprising dark-grey marine friable shales with common to abundant *in situ* concretions and ironstone beds. Recent flooding has eroded the riverbanks, exposing well-preserved upper Shaftesbury Formation sections, which rise stratigraphically upstream through the Fish Scale Zone. The Fish Scale Zone was also encountered on the high southeast banks of the Moberly River. Quaternary sands and silts cap the series of terraces. At the far upstream end of this fossil complex, within and adjacent the LAA, lower terraces comprise thick sections of exposed Quaternary sands and silts with minor organics.

Table 2 Summary Features of the Moberly River Upper Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS114D** \PS114E** PS114G** PS115A** PS115E** PS115F** PS116C/D** PS116F** PS116G** PS117A** PS117E** PS117F** PS117G** PS117H** PS117I**	Shaftesbury Formation (upper)	CRETACEOUS • Early Cenomanian • Middle?-Late Albian	**PALAEOFAUNA** VERTEBRATES • Fish Scales INVERTEBRATES • Ammonites: o *Beudanticeras* o *Neogastroplites* o *Rapidoplacenticeras* • Gastropods o *Gastropod indet.* • Pelecypods o *Cremnoceramus* o *Corbuculid?* • Trace Fossils: o *Arenocolites*

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS118C** PS119B** PS119C** PS119D* PS120D* PS121D* PS122A** PS122B* PS123C* (PSX22Z**)			o *Gastrochaenolites* o *Thalassanoides* **PALAEOFLORA** ANGIOSPERMS o *Menispermites reniformis?* GYMNOSPERMS • Conifer needles o *Abeitites* • Cycad pinnules o *Zamites?* • Wood fragments

Moberly River Upper Shaftesbury Fossil Compex Features

- In the lower stretch of the Moberly River abundant concretions are present within the exposures. Those concretions that have been opened usually contain fossil specimens including both mature and juvenile ammonites, and other fossils. Whole unopened concretions have been collected for future analysis. Discontinuous ironstone beds yield ammonites, pelecypods and fish elements.
- In the upper stretches of the LAA numerous ammonites where observed in dislodged concretions from exposures along the secondary channels. Cylindrical puncture marks were observed on some of the ammonite specimens, which are considered to be limpet burrows.
- Abundant fish elements encompass mostly scales, although other skeletal elements including vertebrae and fin rays were found in the most upstream exposures. A good example has been found in PS122B in a concretion.
- Abundant fish scales occur along the higher benches near the confluence of the Moberly River with the Peace River

Tea Creek Confluence Middle to Upper Shaftesbury Fossil Complex

The Tea Creek Confluence Middle to Upper Shaftesbury Fossil Complex encompasses areas on the south and north banks of the Peace River, and the reservoir zone along the Tea Creek coulee. Several PSAs in this fossil complex have good to excellent exposures of grey friable shales of the upper Shaftesbury Formation. Along the north bank of the Peace River a veneer of fine scree and grey glacio-lacustrine silty clay often covers the slope with narrow exposures and dislodged corroded concretions in rills and slumps. Where land access was available along better-exposed bedrock, less weathered concretions occur (e.g.,, PS005D and PS005E-F). Cretaceous shale sections are covered by grey glaciolacustrine deposits. The upper portions of the section along terrace bluffs, where Cretaceous silty shales of higher stratigraphic level are exposed, are regionally known as the “Fish Scale Zone”. Quaternary sands, gravels, and charcoal-bearing reddish palaeosol horizons cap the bedrock on the lower terrace. The Tea Creek coulee has extensive exposures (e.g.,, PS005B) with a prominent concretion layer occurring at middle level on the slope. At the base of the slope dislodged concretions are corroded. These sediments are overlain by Quaternary sands and silts. Along the south bank of Peace River (e.g.,, PS110E-F and PS111A) are small exposures of grey fissile marine shale with numerous concretions. Dislodged fossiliferous concretions are abundant along the base of the

slope in PS110E-F, which is exposed at low water levels. Upstream, the Quaternary sediments cover the slope with large slumps and mudflows.

Table 3 Tea Creek Confluence Upper Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS004A** PS004D** PS005B** PS005D** PS005E-F** PS006A** PS006C** PS110E-F** PS111A** PS111B**	Shaftesbury Formation (middle to upper)	CRETACEOUS • Early Cenomanian • Middle?-Late Albian	**PALAEOFAUNA** VERTEBRATES • Fish scales o Ganoid forms INVERTEBRATES • Ammonites: o Beudanticeras o Neogastroplites o Rapidoplacenticeras • Pelecypods o Camptonectes? o Cremnoceramus o Inoceramids o Pelecypod indet • Sponges o Haplosclerida? **PALAEOFLORA** GYMNOSPERMS • Cycad pinnules o Ctenis/Podozamites • Wood OTHER • Algal forms

Tea Creek Confluence Middle to Upper Shaftesbury Fossil Complex Features

- Abundant dislodged concretions and ironstone fragments litter the beach at PS110E-F, which most likely have been washed out of the exposures adjacent and immediately upstream. These include interesting fossil scapes, with wood and multiple ammonite specimens of juvenile *Neogastroplites.*
- High along banks of the north shore, silty intervals have fish elements which include scales and possibly fin rays
- Abundant fragments of concretions
- The ammonite fossils within dislodged concretions tend to be weathered; however, better preserved *in situ* concretions may be present in the bedrock matrix, some of which are very large and could contain ammonites greater than 1 m in diameter

Wilder Creek Middle to Upper Shaftesbury Fossil Complex

The Wilder Creek Middle to Upper Shaftesbury Fossil Complex is located along the Wilder Creek coulee from the confluence with the Peace River, upstream to the proposed reservoir limits. The Wilder

Creek coulee has numerous positive PSAs at meander bends, which are often hidden by the dense forest cover. The steep exposures comprise predominantly fissile, grey marine shales with abundant fossiliferous concretions and a few ironstone horizons. The exposed stratigraphic section rises progressively upstream into the Fish Scale Zone offering an opportunity for a continuous composite section to be measured and studied. The terraces are covered by thick Quaternary sands and silts, which are exposed at higher levels and drape over the bluffs along the banks of the Peace River.

Table 4 Summary Features of the Wilder Creek Middle to Upper Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS012A** PS012C** PS012C/A** PS012D** PS012E** PS012F PS012H** PS013C** PS013D** PS013E* PS013F* PS013G**	Shaftesbury Formation (middle to upper)	CRETACEOUS • Early Cenomanian • Middle?-Late Albian	**PALAEOFAUNA** VERTEBRATES • fish scales INVERTEBRATES • Ammonites o *Neogastroplites* o *Rapidoplacenticeras* • Gastropods • Pelecypods o *Cremnoceramus* o *Inoceramid* • Trace Fossils **PALAEOFLORA** GYMNOSPERMS • Cycad pinnules • Wood OTHER • Algal mat • Algal form • Horsetail Fern o *Equisitites*

<u>Wilder Creek Middle to Upper Shaftesbury Fossil Complex Features</u>

- Common fossiliferous concretions occur at most cutbank exposures and contain large ammonites of *Neogastroplites* and *Rapidoplacenticeras.* The preservation is variable and often septarian. Intervals of the stream bed are littered with dislodged concretions, ammonites are commonly exhibited.
- At the upper limits of the LAA, abundant fish scales are present, sometimes forming fish scale hash
- Septarian concretions contain an interior surface suggestive of algal mat
- PS013E has an excellent exposure, approximately 70 m high, that has abundant *in situ* concretions jutting out from the bedrock surface. An exceptionally large sandstone concretion, about midway up the slope, appears to be formed in a small incised palaeochannel, with round concretions at the base.

Cache Creek Middle to Upper Shaftesbury Fossil Complex

The Cache Creek Middle to Upper Shaftesbury Fossil Complex encompasses the area from the Highway No. 29 bridge crossing the Cache Creek Coulee upstream to the upper limit of the proposed reservoir limits. The extensive exposures that surround Cache Creek and its tributary Red Creek as they descend through the terraces and benches of the north Peace River Valley have numerous positive PSAs at meander bends. The steep exposures comprise predominately fissile, grey, marine shales of the Shaftesbury Formation with abundant fossiliferous concretions and ironstone horizons. Below the crossing of Highway No. 29 the Cache Creek coulee opens onto gravel banks. Exposures along north shoulder of Highway No. 29 (PS024A, B) have partially vegetated, weathered shales. A bench extends upstream along the Peace River into the base of a bluff (PS023A, B) with portions of erosional rills exposing grey marine shales.

The extensive exposures in the Cache Creek coulee occur just north of Highway No. 29, near the confluence with Red Creek, and upstream, where the fissile, grey, marine shales of the Shaftesbury Formation exhibit abundant concretions and ironstone beds. The streambed is often littered with abundant dislodged concretions and ironstone fragments. The valley of Red Creek is densely forested with small exposures occurring at meander bends. Thin beds of mud-cracked, iron-stained sandstones occur within the silty shales of the Shaftesbury Formation. The bluff faces of high terraces along the upper portions of Red Creek are covered by shale scree with slumped Quaternary sands and silts. The exposed stratigraphic section rises progressively upstream along Cache Creek through Red Creek into the Fish Scale Zone offering an opportunity for a continuous composite section to be measured and studied.

Table 5 Summary Features of the Cache Creek Middle to Upper Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS025B** PS025E* PS026A** PS026C* PS026D* PS026F** PS026G** PS027A** PS027F** PS027G** PS027H** PS027I/J** PS027J* PS027K* PSX07A* PSX07B** PS028A** PS028B* PS029A** PS029B** PS029C** PS029D**	Shaftesbury Formation (middle to upper)	CRETACEOUS • Early Cenomanian • Middle-Late Albian	**PALAEOFAUNA** VERTEBRATES • Bird tracks? • Fish o Fish scales o Fish vertebrae o ?Fish teeth • Turtle? Scrapings • Coprolite? INVERTEBRATES • Ammonites: o Ammonite indet. o Beudanticeras o Neogastroplites o Rapidoplacenticeras • Echinoderm spine o Echinoderm spine o Echinoderm? plates • Gastropods o Gastropod indet. • Pelecypods o Acila (Truncacila) sp.

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS029E* PS029E/F** PS029G			o Corbiculid o Cremnoceramus o Inoceramids o Posidonia o Unio sp. • Trace Fossils: o Conichus sp. o ?Chondrites sp. o Planolites sp. o Asterosoma sp. **PALAEOFLORA** ANGIOSPERMS GYMNOSPERMS • Conifer needles • *Nageia/Phyllocladus* type trunk • Cycad bark • Cycad pinnule o Ctenis/Podozamites o Zamites? sp. • Cycad rachis • Cycad stem

Cache Creek Middle to Upper Shaftesbury Fossil Complex Features

- The west bank of Cache Creek at PS025E exhibits an extensive exposure with *in situ* fossiliferous concretions. The streambed is littered with fragmented concretions containing ammonites and pelecypods. Opposite banks have discontinuous exposures with dislodged fossil elements.
- Further upstream, an exceptional exposure occurs at PS026C that has abundant, well-preserved concretions and ironstones with numerous invertebrates including large inoceramid clams and ammonites
- Similar excellent assemblages continue upstream along both Cache Creek and Red Creek. Flat large concretions (i.e.,, >1m in diameter) in PS027G are similar in shape to those that have produced the ammonite *Rapidoplacenticeras.*

Halfway River Lower to Middle Shaftesbury Fossil Complex

The Halfway River Lower to Middle Shaftesbury Fossil Complex encompasses the area from the Highway No. 29 bridge crossing the Halfway River valley upstream through several major meanders to the upper limit of the proposed reservoir limits. An area just upstream beyond the proposed reservoir limits is considered to belong to this fossil complex, as significant fossil assemblages have been discovered. Numerous positive PSAs exhibit extensive exposures of Shaftesbury Formation bedrock capped with Quaternary sediments within the Halfway River Valley and along the south bank of the Peace River opposite the confluence (e.g.,, PS086A, PS098E and PS090A). In the downstream areas the Shaftesbury Formation comprises massive, fissile, dark grey, marine shales and gravel banks line the mouth of the Halfway River. At the Highway No. 29 crossing and upstream, almost vertical slopes of

freshly exposed bedrock (e.g.,, PS040D, PS053A-D, PSR02E) have abundant concretions jutting out of the banks, which are only accessible by jet boat. The higher terrace faces comprise glacial sands and gravels. Further upstream a series of large meanders have eroded steep banks where swift water inhibits close inspection (e.g.,, PS043A-E, PS046B-C, PS047A, and PS051B-C). Near the upper limits of the LAA more resistant silty shales with ironstone beds and concretions form an exposed bench along the south bank (PS049 B, PS049C). The stratigraphic level along the river tends to become lower within the Shaftesbury Formation, and also changes towards more proximal palaeoenvironments; from restricted marine to marginal marine facies towards the northwest, possibly transitioning into the Hulcross Formation. Upstream beyond the LAA (e.g.,, PSX09E, PSX09G, and PSX09Z) another series of tight meanders has exposed steep, high, extensive cliff faces comprising grey friable shales underlain by more erosionally-resistant silty beds near the water level.

Table 6 Halfway River Lower to Middle Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS040D* PS042A* PS043C** PS043D PS045A-E** PS045D** PS046B-C**PS047A** PS047B PS048B* PS049B* PS049C* PS050A** PS051B-C* PS052A-D** PS053A-D* PS056A-B* PS098E PS090A** (PSX09E*) (PSX09G*) (PSX09Z*)	Shaftesbury (lower to middle)	CRETACEOUS • Middle-Late Albian	**PALAEOFAUNA** VERTEBRATES • Dinosaur remains o Therapod teeth o Therapod eggs? o 3 bone sites INVERTEBRATES • Gastropods • Pelecypods o Camptonectes? o Corbiculids o Pelecypod indet. • Trace Fossils: o Incertae sedis o Teredolites? o Rosselia choniodes **PALAEOFLORA** ANGIOSPERMS • Monocotyledon form GYMNOSPERMS • Conifer wood log • Cycad Pinnules o Ctenis/Podozamites o Ctenis borealis o Nageiopsis anglica? • Wood fragment OTHER • Algal form sp. A

Halfway River Lower to Middle Saftesbury Fossil Complex Features

- Unusual concretions were observed in most of the well-exposed lower levels of the Shaftesbury Formation, which contain what appears to be single algal individuals with branching broad fronds and stypes that are most likely in living position. The algal fossils are three-dimensional, composed of a dark grey translucent cherty, polygonal-fractured mineral with segments separated by white calcareous septa. Some individual specimens near the Highway No. 29 bridge are not contained within concretions, but occur free along shale bed partings. These algal fossils appear to be confined to a specific stratigraphic interval within the LAAat the Halfway River and also occur in exposures along Peace River near the Halfway River confluence.
- Common pectinoid shells occur in angular blocks; however, the *in situ* source was not discovered, and could represent ice rafted blocks from further upstream
- Podocarpaceous branchlets with affinity to *Nageiopsis anglica* commonly occur near the base of a well-exposed section at PS050A. One specimen appears to have reproductive cones.
- Near the upstream limit of the LAA in PS049C common fossiliferous ironstones and concretions contain the algal fronds in association with a large petrified conifer log
- Upstream beyond the upper limits of the LAA dislodged dinosaur teeth occur in a coarse gravel bar below the riverbank exposure that exhibited the algal frond concretions (PSX09G). In addition, further upstream beyond the LAA at a helicopter landing site, multiple chance finds of large vertebrate bones were identified along the bench produced by the lower, more silty lithologies of the Shaftesbury Formation(PSX09Z). The age of the sediment is probably Middle Albian and, if confirmed, these could be oldest dinosaur remains in western Canada.

Gates Island Gates - Hulcross - Shaftesbury Fossil Complex

The Gates Island Gates – Hulcross – Shaftesbury Fossil Complex encompasses the area along the north and south banks of the Peace River from the Farrell Creek confluence upstream to include the Dry Creek confluence, Gates Island, and to include the rocky sandstone cliffs further upstream by approximately 1.5km. Several positive PSAs occur along the north and south banks of the Peace River in the vicinity of Gates Island. The area is characterized by facies changes marked by transitioning environments, both laterally and vertically. The high cliff faces of Gates Island and the opposing river banks expose massive, thickly bedded, paralic sandstones of the type locality of the Gates Formation, which are overlain by the concretion bearing, marginally marine silty shales of the Hulcross Formation. These lithologies, in turn, grade into the restricted marine shales of lower Shaftesbury Formation (partially equivalent to the Hasler Formation). Above Highway No. 29 good exposures of the lower Shaftesbury Formation comprise silty shales with concretions and ironstones high on the road-cut slopes and coulees. Further upstream on the Peace River, towards Farrell Creek, the steep exposures along the riverbanks comprise the Hulcross Formation grading into the lower Shaftesbury Formation, which is also considered in part, equivalent to the Hasler Formation. Overlying these bedrock exposures, as well as the banks of the Peace River downstream and upstream from this fossil complex, have exposures of Quaternary clays, silts, sands and gravels.

Table 7 Summary Features of the Gates Island Gates – Hulcross - Shaftesbury Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS062B** PS063A** PS064A** PS064B** PS064C** PS065A** PS079G** PS080A	Hulcross Formation/ lower Shaftesbury Formation	CRETACEOUS • Middle Albian	**PALAEOFAUNA** INVERTEBRATES • Ammonites o Ammonite indet. o *Arcthoplites* o *Cleoniceras* (Grycia) dubium? • Jelly Fish o Hydrozoan indet. • Pelecypods o Camptonectes? o Corbiculid s o Inoceramids o Pelecypod indet. • Trace Fossils: o Chondrites o Conichnus o Helminthopsis o Rosselia choniodes o Planolites o Teichichnus o Thalassinoides **PALAEOFLORA** ANGIOSPERMS • Monocotyledonous reeds (possibly cycad pinnule fragments) GYMNOSPERMS • Cycad pinnules • Cycad rachis • Wood form • Wood fragment OTHER • Water *Fern* o Isoetites
PS064D PS065A** PS078G** PS079A** PS079E** PS079H	Gates Formation	CRETACEOUS • Early to Middle Albian	**PALAEOFAUNA** VERTEBRATES • Dinosaur tracks? • Fish scales INVERTEBRATES • Pelecypods o Corbiculids • Trace Fossils o Arenocolites sp.

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
			o Chondrites sp. o Diplocraterion sp. o Ophiomorpha sp. o Planolites sp. o Rosselia sp. o Thalassinoides sp. o Trace fossils – undifferentiated **PALAEOFLORA** ANGIOSPERMS • Lilioid plant o Lilites sp. • Seed form • Monocotyledon form (possibly cycad pinnule fragments) GYMNOSPERMS • Conifer needles o Abietites o Needle indet • Conifer branchlets o Pagiophyllum magnifolium o Elatocladus sp. • Cycad log • Cycad rachis • Cycad pinnules o Ctenis/Podozamites o Desmiophyllum o Wood fragments OTHER • Algal form B • Horsetail Fern o Equisetites sp. • Water Fern o Isoetites sp. • Plant material undifferentiated.

<u>Gates Island Gates – Hulcross – Shaftesbury Fossil Complex Features</u>

- The Gates Formation has abundant plant material within the sandstone, including a small lily-like plant impression with a faint central stem terminating with possibly a seedpod. Petrified gymnospermous wood, in the form of small conifer and cycad logs, branches, and leaf elements occur scattered through the formation. The straight rhizomous roots of the water fern *Isoetites* are common.

- Intervals exhibiting load casts occur along the middle and upper slopes on Gates Island, that could be deformational flow rolls or possibly dinosaur tracks similar to those upstream near Alwin Holland Memorial Park.
- Both the Gates and Hulcross formations have a variety of interesting trace fossils
- Rare ammonites in the Hulcross/lower Shaftesbury interval were observed on the northwest banks of the Peace River, and at the confluence with Farrell Creek
- A single instance of a small jellyfish impression occurs on the exposure (PS063A) of lower Shaftesbury Formation at the confluence with Farrell Creek
- Gates Island area, historically, has been a frequent place to inspect and study the stratigraphy, resulting in numerous published fossil occurrences. The abundance of ammonites and other invertebrates observed during recent field work is lower than expected, suggesting it has been frequently visited and the surface gleaned by fossil collectors.

Lynx Creek Gates Fossil Complex

The Lynx Creek Gates Fossil Complex encompasses the area of the northwest banks of the Peace River adjacent to the Lynx Creek confluence and extends up the reservoirportion of the Lynx Creek valley. A few small, yet significant positive PSAs near the confluence of Lynx Creek and the Peace River exhibit exposures of the paralic Gates Formation. These flat lying sandstones occur along the banks of Lynx Creek as well as on the streambed forming cascades, upstream from the Highway No. 29 crossing in PS067A. Quaternary sands and gravels overly the bedrock and also form bluffs along the northwest bank of the Peace River.

Table 8 Summary Features of the Lynx Creek Gates Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS066E PS067A** PSR05H**	Gates Formation	CRETACEOUS • Early to Middle Albian	**PALAEOFAUNA** VERTEBRATES • Dinosaur tracks o Therapod o Bird? tracks o *Amblydactylus* INVERTEBRATES • Ammonites o Arcthoplites (glacial clast) • Pelecypods o *Camptonectes* o *Unio* sp.? • Trace Fossils: o Arenocolites o Glossifungites o Thalassinoides o Zoophycos **PALAEOFLORA** ANGIOSPERMS • Monocotyledon form (possibly cycad pinnule

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
			fragments) GYMNOSPERMS • Cycad pinnules o Ctenis/Podozamites • Conifer needles

Lynx Creek Gates Fossil Complex Features

- The sandstones of the Gates Formation have partial load casts in the slightly dislodged sandstone blocks in PS067A that are potentially dinosaur tracks. Similar features can be vaguely observed in sandstone beds through the water.
- Further upstream at in PSR05H, a bench of *in situ* sandstone exhibits good therapod tracks along with smaller tracks that are similar to those formed by birds along with other invertebrate trace fossils
- The Cretaceous ammonite *Arcthoplites* occurs as a reworked glacial clast within Quaternary gravels

Hudson's Hope Moosebar – Gates Fossil Complex

The Hudson's Hope Moosebar – Gates Fossil Complex is defined as the area along both the south and north banks of the Peace River from Hudson's Hope and the Maurice Creek confluence upstream to the Peace Dam, as well as the proposed reservoir area of the Maurice Creek Coulee. The downstream portion of the Peace River Canyon, from the Peace Dam to Hudson's Hope including the confluence of Maurice Creek, offers almost continuous cliffs of bedrock along the banks of the river including several rocky fluvial islands near Alwin Holland Memorial Park. The bedrock at the lower levels comprises the Moosebar Formation, which is a dark grey shale with iron-cemented sandstones. The resistant upper cliff faces have the paralic sandstones of the Gates Formation. These sandstones, in turn, are capped by Quaternary travertines, sands, gravels and clays on the adjacent terraces. Due to faulting and shallow folding the Gates Formation descends to river level near Alwin Holland Memorial Park and near the Highway No. 29 bridge at the Peace Canyon Dam. Travertine deposits, which are continually forming along the cliff faces below Hudson's Hope are associated with nearby springs and obscure the partially exposed bedrock.

Table 9 Summary Features of the Hudson's Hope Moosebar – Gates Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS070A** PS070C** PS070D** PS072B** PS072C** PS073C** PS073D** PS073F** PS073I** PST01B**	Gates Formation	CRETACEOUS • Early to Middle Albian	**PALAEOFAUNA** VERTEBRATES • Dinosaur tracks o *Amblydactylus* load casts o *Tetrapodosaurus* (questionable partial tracks, bioturbation) INVERTEBRATES • Trace Fossils: o *Asterocites* o *Cruziana*

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
			o *Planolites* o *Scoyenia* o *Spirorhaphe* o *Thalassinoides* o *Trace fossils - undifferentiated* **PALAEOFLORA** ANGIOSPERMS GYMNOSPERMS • Cycad pinnules o *Ctenis/Podozamites* • Conifer Wood log o *Dacrydioides/Nageai/Afrocarpus affinities* OTHER • Plant material undifferntiated • Roots
PS069D** PS069E** PS070C** PS070D** PS073B PS073I**	Moosebar Formation	CRETACEOUS • Early Albian	**PALAEOFAUNA** INVERTEBRATES • Ammonites o *Arcthoplites (Lemuroceras) belli* o *Arcthoplites* o *Gastroplitid?* • Gastropod o Gastropod indet • Pelecypod o *Cremnoceramus* o *Pelecypods indet.* o *Shell fragments* o *Unio* • Trace Fossils o *Conichnus* o *Hippuritidae* o *Planolites* o *Rosselia choniodes* o *Thalassinoides* **PALAEOFLORA** ANGIOSPERMS • Monocotyledonous reed (possibly cycad pinnule) GYMNOSPERMS • Conifer needles • Conifer branchlet o *Araucaria branchlet (pyritized)* • Cycad pinnules o *Ctenis/Podozamites*

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
			• Cycad rachis • Wood OTHER • Water Fern o *Isoetites sp.* • Roots

The Hudson's Hope Moosebar – Gates Fossil Complex Features

- Some of the load casts along the upper surface of a Gates Formation sandstone bed are interpreted as casts of dinosaur tracks. Other potential dinosaur tracks occur in the flat lying sandstones downstream from the Highway No. 29 bridge on the south bank.
- Abundant plant material occurs in the Gates Formation. A large *in situ* podocarpaceous log imbedded in sandstones occurs upstream and downstream from the Hwy 29 bridge along the south bank in PS072C. Another similar displaced log fragment occurs downstream in PS073C.
- Both the Gates and Moosebar formations have a variety of interesting trace fossils
- Good assemblage of Moosebar Formation fossils comprising small ammonites, clams and numerous burrows, as well as a pyritized *Araucaria* branchlet (the monkey-puzzle tree), cycad rachis and pinnules, and water ferns occur in PS069D and PS070C
- A make-shift cobble table with scattered fossil debris and numerous beds with hammered chips suggest strong fossil depletion due to amatuer fossil collecting in the vicinity of Alwin Holland Memorial Park

Upper Maurice Creek Cruiser Complex

The Upper Maurice Creek Cruiser Complex is located along the Maurice Creek coulee and two of its tributaries within the bounds of the proposed corridor for the transmission system. At the he proposed transmission line crossings of Maurice Creek and its tributaries, small dales have been eroded through the paralic sandstones and siltstones of the Cruiser Formation that is interbedded with shales possibly transitioning to the marine Shaftesbury Formation. The bedrock is covered by exposed Quaternary glacio-fluvial sands.

Table 10 Summary Features of the Upper Maurice Creek Cruiser Fossil Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PST02E** PST03B**	Cruiser Formation	CRETACEOUS Middle Albian	**PALAEOFAUNA** VERTEBRATES • Dinosaur o *Therapod?* teeth • Fish o *Pisces corroded form* o *Fish Scale sp. indet.* INVERTEBRATES • Trace Fossils o *Arenicolites* o *Asterosoma* o *Bergaueria* o *Cosmorhaphe* o *Diplocraterion* o *Lorenzinia* o *Nereites* o *Planolites*

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
			o *Rhyzocorallium* o *Rossellia socialis* o *Shaubcylindrichnus freyi?* o *Syringopora* o *Thalassinoides* o *Zoophycos* o *Bioturbation structure undif.* **PALAEOFLORA** ANGIOSPERMS GYMNOSPERMS • Cycad pinnule • Wood sp. OTHER • Plant material undifferentiated

Upper Maurice Creek Cruiser Complex Features

- The floors and slopes of Maurice Creek and its tributary (PST02E and PST03B) are abundant with invertebrate trace fossils of the *Cruisiana* Ichnofacies
- Specimens are well preserved and provide excellent examples of many burrow, feeding, and grazing structures, as well as fish scales found within the same sample as a sea anemone trace
- Cusped elements with dark enamel-like surfaces were observed in sandstone at PST02E and are tentatively identified as vertebrate teeth fossils

Quaternary Complex

The Quaternary Complex encompasses the entire LAA and these deposits form an almost continous blanked over the underlying bedrock.. These deposits consist of a variety of grain-size from silts, sands to coarse gravels representing glacio-lacustrine and glacio-fluvial deposits. Exposures were evident in cutbanks with fresh erosional surfaces predominantly along the terraces of the Peace River valley, Highway No. 29 road cuts, and other incised gullies. Sedimentary features include wavy lamination, cross lamination, normal grading, dropstones, peaty layers, palaeofire horizons and palaeosols.

Extensive sand and gravel exposures occur above the bedrock along the south bank of the Peace River, across from the confluence with Halfway River. Travertine deposits are located along the north bank of the Peace River near Hudson’s Hope, as well as along the banks of the Halfway River.

During background research and map review, several ponds located in abandoned river channels on the middle terraces were noted within the LAA. The first are elongated ponds on the south side of the Peace River, upstream from the confluence with the Halfway River near PS085A. The second grouping of ponds includes a series of well-eutrophicated ponds on the north side of the Peace River, downstream from Bear Flat between PS021G and PS022A. The ponds can represent relatively undisturbed reservoirs of the local pollen record. that reflect changing palaeovegetation and palaeofaunal patterns subsequent to terrace development.

Table 11 Summary Features of the Quaternary Complex

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
PS001C** PS005D** PS024B PS025E* PS026C* PS037B** PS048A** PS062A** PS062B** PS062L PS063A** PS064A** PS064C** PS065A** PS067A** PS067B PS070A** PS070B** PS070D** PS076E PS078G** PS114D** PS116E** PSQ02A** PSR01B6** PSR01B7** PSR01H2** PSR01I3** PST12A** PSX22Z**	• Laurentide tills • Glacial-lacustrine deposits • Glacio-fluvial deposits	QUATERNARY Pleistocene to Post-Wisconsin	**PALAEOFAUNA** VERTEBRATES • Mammals o *Canine bones* o *Canid skull filled with rat scat - Modern bones* o *Rodent femur, rib* o *Rodent jaw (beaver?) - Modern* o *Rodent bone elements* o *Mammal bone fragment?* o *Large ungulate scapula – probably Modern* o *Vole skeletal elements* • Birds o *Bird-like bone fragment?* o *Bird bone sp. indet.* o *Large bird femur - recent* Mammals identified in Hebda et al. 2008 • Voles: o *Clethrionomys gapperi* o *Microtus xanthognathus* o *Microtus pennsylvanicus* o *Microtus pennsylvanicus?* • Mice: o *Peromyscus maniculatus* • Hares: o *Lepus americanus* o *Lepus americanus?* • Squirrels: o *Tamiasciurus* o *Hudsonicus* INVERTEBRATES • Gastropods o *Discus whitneyi?* o *Discus shimekii?* o *Fossaria obrussa* o *Heliosoma trivolvis* o *Lymnaea stagnalis – dwarf* o *Stagnicola elodes* o *Succinea strigata* o *Vallonia gracilicosta* • Gastropods o *Pelecypod sp. indet.* • Trace Fossils

Positive PSAs	Stratigraphic Unit	Period/Age(s)	Fossil Types Observed/ Collected
			o *Skolithos* **PALAEOFLORA** • Angiosperms o *Poplus sp.* • Coal or charred wood • Stump form • Wood form OTHER • Palaeosol carbon layer • Charcoal/peat ball • Palaeosol • Charcoal • Peaty organic matter • Travertine (with fossil impressions)

<u>Quaternary Complex Features</u>

- Travertine deposits near Hudson's Hope exhibit both plant leaf impressions and imbedded gastropods with good preservation. The gastropods found within dislodged travertine blocks are larger in diameter by a factor of 2 to 5 times when compared to other Quaternary gastropods found within the LAA.
- Near the confluence of the Peace River and Farrell Creek at PS062A an *in situ* lower mandible from a rodent is associated with gastropods within laminated sands
- Palaeopond sediment profiles are exposed in a number of locations. For example PS064C exhibits a shallow pond profile with three palaeosols, few gastropods possibly *in situ*, and a canine skeleton buried in overriding colluvium.
- Existing ponds also present the micropalaeontological opportunities
- Charcoals are distributed across the LAA as scattered fragments in the coarse glacio-fluvial gravels
- Upper Bear Flat hosts a diverse Quaternary fossil assemblage
- Green jade cobbles were observed on a gravel bank in PSO76E
- Reworked Cretaceous fossils were also found in Quaternary deposits

Appendix E of Volume 4, Appendix C

During preparation of the technical memorandum for Palaeontology, an error was found in Volume 4, Appendix C Heritage Resource Assessment Report: Appendix E – Summary of Palaeontological Results. The error appears to be the result of a global search and replacement of dashes (-) with "ND" in the tabular document that has created incongruences in the alpha numeric codes for PSA numbers and sequence references (i.e.,, PSA 001A-C becomes PSA 001ANDC), photo record numbers, waypoint numbers and locations where dashes were used to indicate expansions of an idea such as "Ammonites –". These errors have been corrected and a new Appendix E erratum has been produced. This update does not change the results of the effect assessment on palaeontological resources.

Further Reporting on the Palaeontological Assessment

A substantial palaeontological field program has been completed to date. It is BC Hydro's opinion that the data are complete for the purposes of the environmental assessment. As noted in EIS Section 32.2.2 additional field inventory will be completed in the following:

1) Areas where, for the EIS, a corridor or area was identified but not a specific footprint for construction activities. These areas include:
   - Construction of access roads
   - Off-site and one potential on-site construction materials area
   - Transmission connection to Peace Canyon Dam
   - Existing infrastructure that may require relocation (buried services and pipelines)
2) Private land where owners have not granted access to BC Hydro for the purpose of undertaking heritage field work. Field inventory in these areas would be undertaken prior to construction activities, when BC Hydro acquires access rights to these properties.

EIS Section 32.2.2 also includes BC Hydro's commitment to complete the inventory and assessment of the outstanding areas as detailed design proceeds in a manner consistent with the current heritage assessment prior to the start of construction in those areas, and to submit reports on future heritage assessment work to relevant Provincial agencies and Aboriginal groups in accordance with legislative and permit requirements.

Future reports will be used to inform mitigation discussions and development of mitigation measures for palaeontological resources with input from:

- The Royal British Columbia Museum
- The B.C. Ministry of Forests, Mines and Lands (Land Tenures Branch)
- Local stakeholders

Related Comments / Information Requests:

This technical memo provides information related to the following Information Requests:

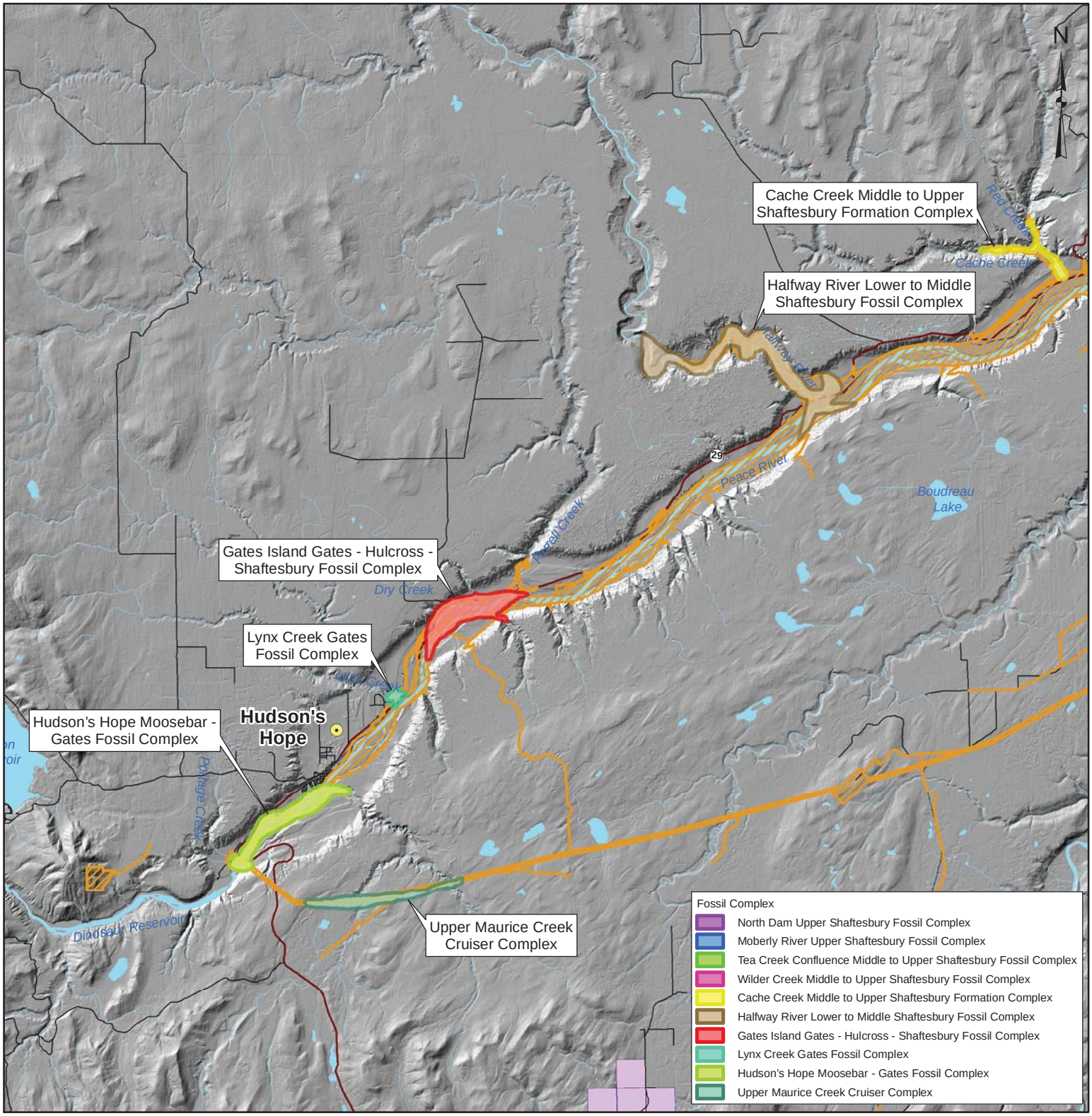
gov_0010-821	gov_0010-825	gov_0010-826	gov_0010-829	gov_0010-830
gov_0010-831	gov_0010-832	gov_0010-833	gov_0010-835	gov_0010-837
gov_0010-838	gov_0010-840	pub_0836-001		

RESPONSE TO WORKING GROUP AND PUBLIC COMMENTS ON THE SITE C CLEAN ENERGY PROJECT ENVIRONMENTAL IMPACT STATEMENT

Technical Memo - **Figure 1a**

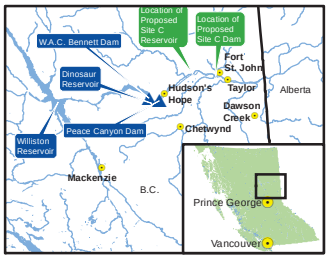
PALAEONTOLOGY

MAY 8, 2013



Legend

- Heritage Resources Local and Regional Assessment Area
- Indian Reserve
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Existing Road
- Existing Highway
- Existing Railway
- City/District Municipality



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Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

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SITE C CLEAN ENERGY PROJECT

Figure 1a Fossil Complex Locations

DATE	Apr. 18, 2013	1016-C14-A4993	R 0

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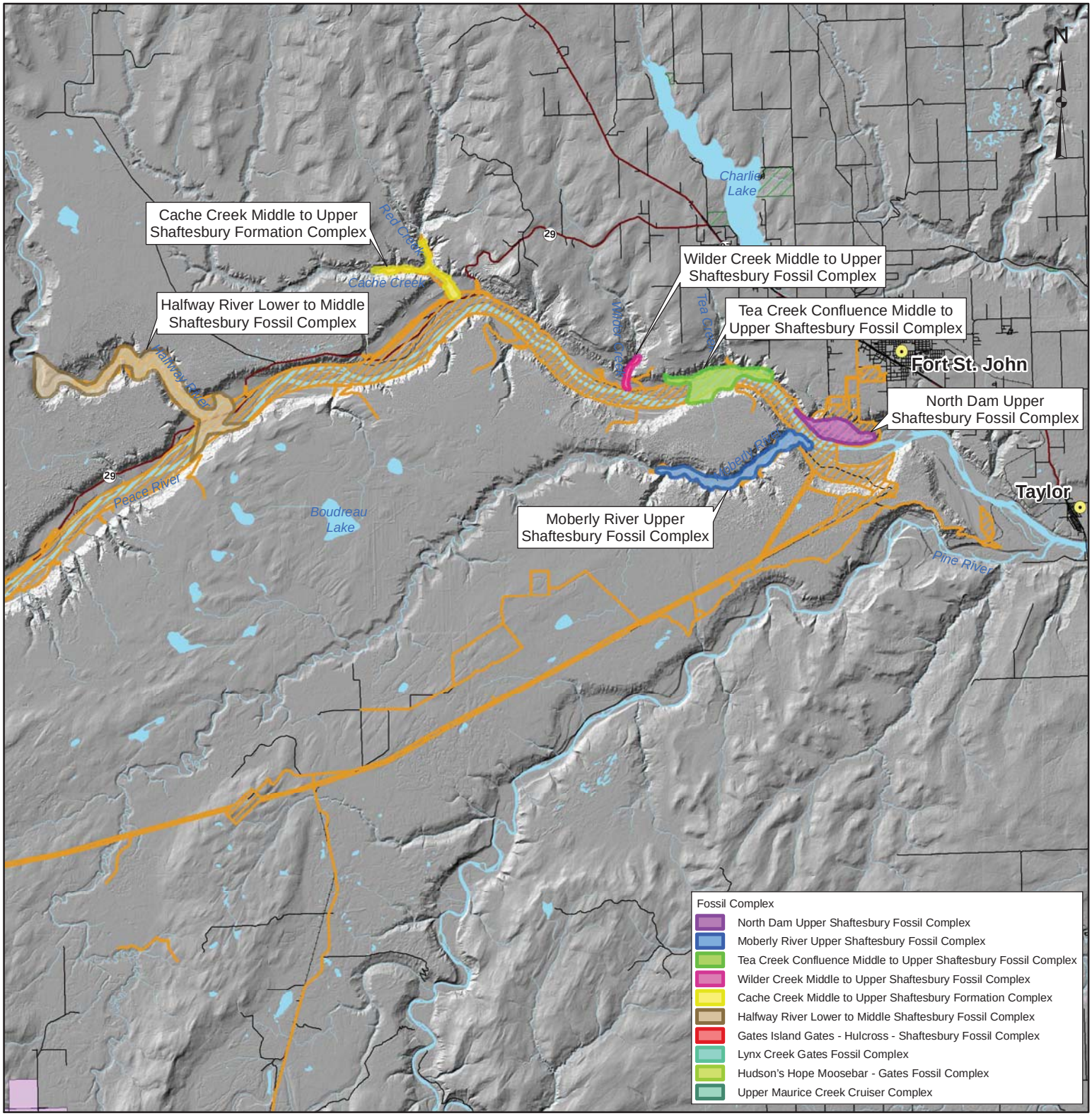
Construction of the Site C Clean Energy Project is subject to required regulatory approvals including environmental certification

RESPONSE TO WORKING GROUP AND PUBLIC COMMENTS ON THE SITE C CLEAN ENERGY PROJECT ENVIRONMENTAL IMPACT STATEMENT

Technical Memo - **Figure 1b**

PALAEONTOLOGY

MAY 8, 2013



Legend

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- City/District Municipality

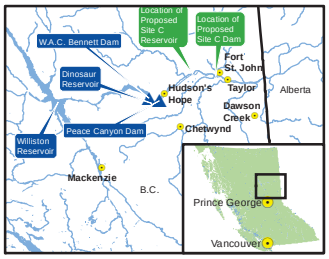

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Figure 1b Fossil Complex Locations

DATE	Apr. 18, 2013	1016-C14-A4993	R 0

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