COAL ASSESSMENT REPORT TITLE PAGE AND SUMMARY

TITLE OF REPORT:
Coal Assessment Report for Hermann West coal licences, Mt. Frame area, British Columbia

TOTAL COST: $5000

AUTHOR(S): C.G.Cathyl-Huhn, P.Geo. and L. Avery, B.Sc.
SIGNATURE(S):

NOTICE OF WORK PERMIT NUMBER(S)/DATE(S):
STATEMENT OF WORK EVENT NUMBER(S)/DATE(S): None

YEAR OF WORK: 2013

PROPERTY NAME: Hermann West

COAL LICENSE(S) (on which work was done): 416931, 416932, 416933, 416934, and 417485

MINERAL INVENTORY MINFILE NUMBER(S),IF KNOWN: 93P 020

MINING DIVISION: Liard
NTS / BCGS: NTS 93P/3 and 93I/14; BCGS 093I.094, 093P.095, 093P.004, and 093P.005
LATITUDE: 55° 00’ 30" North
LONGITUDE: 121° 13’ 30" West (at centre of work)
UTM Zone: 10 EASTING: 613450 NORTHING: 6097200 (at centre of work)

OWNER(S): Walter Canadian Coal Partnership

MAILING ADDRESS: 800-688 West Hastings Street, Vancouver, B.C. V6B 1P1

OPERATOR(S): 0541237 B.C. Ltd. On behalf of Walter Canadian Coal Partnership

MAILING ADDRESS: 800-688 West Hastings Street, Vancouver, B.C. V6B 1P1

REPORT KEYWORDS (lithology, age, stratigraphy, structure, alteration, mineralization, size and attitude)
Coal, sandstone, Early Cretaceous, Fort St. John Group, Gates Formation, Notikewin Member, Babcock Unit, Falher Member, Torrens Member, Sherriff Sandstone, Quintette Sandstone, Moosebar Formation, Spieker Member, unnamed mudstone member, Bullhead Group, Gething Formation, Chamberlain Member, Bullmoose Member, Bluesky Member, Gaylard Member, Cadomin Formation, Minnes Group, Monach Formation, Meadow Syncline, Mast Syncline, triangle zone, Bullmoose Thrust, East Bullmoose Thrust, Frame North Thrust, bituminous coal

REFERENCES TO PREVIOUS ASSESSMENT WORK AND ASSESSMENT REPORT NUMBERS:
Coal Assessment Reports 597, 601, 606, 607, 609, 613, 615, 616, 617, 826, 850

TYPE OF WORK IN THIS REPORT	EXTENT OF WORK (in metric units)	ON WHICH CLAIMS	PROJECT COSTS APPORTIONED (incl. support)
GEOLOGICAL (scale, area)			
Ground, mapping			
Photo interpretation	3,265 hectares	416931, 416932, 416933, 416934, 417485	$454.71 $2272.00 $907.88 $1136.00 $228.12
GEOPHYSICAL (line-kilometres)			
Ground			
(Specify types)			
Airborne			
(Specify types)			
Borehole			
Gamma, Resistivity,			
Resistivity			
Caliper			
Deviation			
Dip			
Others (specify)			
DRILLING (total metres, number of holes, size, storage location)			
Core			
Non-core			
SAMPLING AND ANALYSES	Number of samples		
Proximate			
Ultimate			
Petrographic			
Vitrinite reflectance			
Coking			
Wash tests			
PROSPECTING (scale/area)			
PREPARATORY / PHYSICAL			
Line/grid (km)			
Topo/Photogrammetric (scale, area)			
Road, local access (km)/trail			
Trench (number/metres)			
Underground development (metres)			
Bulk sample(s)			
Other			

1 Table of contents

1.1 List of tables

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2 Introduction and situation

This report, titled *Coal Assessment Report for Hermann West coal licences, Mt. Frame area, British Columbia,* is intended to present current understanding of the geology of a group of Crown coal tenures comprising Coal Licences 416931, 416932, 416933, 416934, and 417485. These tenures were awarded by the Crown to Western Canadian Corp. (WCC) in June and July of 2005, and subsequently acquired by Walter Energy Inc. and associated firms – including the Walter Canadian Coal Partnership (WCCP) – in the course of a corporate merger in 2011.

No exploratory work is known to have been done by WCC, WCCP, or associated companies, prior to the year-2013 photogeological study here reported. However, a considerable volume of historic exploration work, including trenching, geological mapping, and the drilling of 39 exploratory boreholes, was done by Denison Mines Ltd., and its successor firms. Denison's work, which in this report is mentioned in summary only, directly led to the discovery of metallurgical-grade coal atop Mt. Frame, and in turn to Quintette Coal Limited's opening and operation of their Wolverine coal mine (formerly termed the 'Frame Pit') atop Mt. Frame.

Results of the year-2013 study are intended to guide WCCP's ongoing coal-resource appraisal, coal-quality investigations, and long-range mine-planning.

2.1 Note concerning historic and current coal-quality data

The present report does not include a review of historic coal-quality information, for which only censored results (in keeping with the provisions of the *Coal Act* and associated regulations) are available within historic coal-assessment reports. No current coal-quality data are available, owing to such investigations having not yet been done.

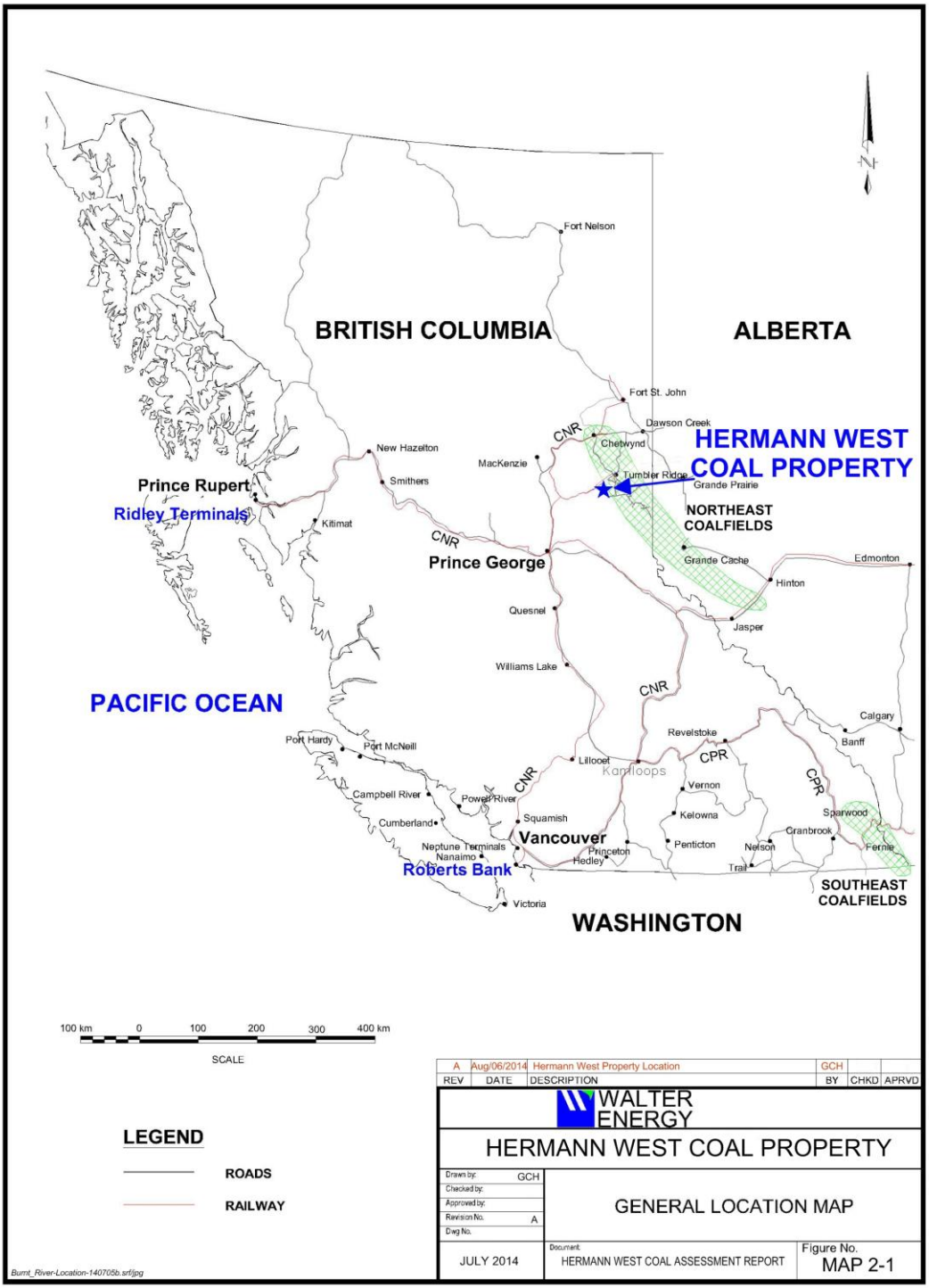
2.2 Location and access

General location of the property is depicted as **Map 2-1**, and coal tenure (**Table 2-1**) is depicted in relation to the local topographic setting of the Hermann West coal property as **Map 2-2**.

The Hermann West coal property is located 110 kilometres south of Chetwynd town, and 30 kilometres west of Tumbler Ridge town, within map-areas 93 P/03 and 93I/14 of Canada's National Topographic System. Highway access is via route BC-29, connecting Chetwynd and Tumbler Ridge. From a point 10.5 kilometres northwest of Tumbler Ridge, access is gained to the Wolverine Forest Service Road (FSR), running westward along the Wolverine River valley.

2.2.1 Access to southeastern end of property

At kilometre 8.3 of the Wolverine FSR, the Mast Creek Petroleum Development Road (PDR), crosses Wolverine River on a steel bridge. After 13.9 kilometres of southward travel on the Mast PDR, a four-way junction is reached. The Mast PDR continues eastward (to the left), while the gated-off Mesa mine-access road continues northwestward (to the right). Initially running southeastward from the four-way junction, the non-status Nabors Road turns and continues southwestward for approximately 7 kilometres to its termination at a natural-gas wellsite (CNRL et al Murray d-64-J / 93-I-14). The wellsite lies within Coal Licence 416931.


BRITISH COLUMBIA
ALBERTA
PACIFIC OCEAN
WASHINGTON
HERMANN WEST COAL PROPERTY
Fort Nelson
Fort St. John
Dawson Creek
Chetwynd
Tumbler Ridge
Grande Prairie
MacKenzie
New Hazelton
Smithers
Prince Rupert
Ridley Terminals
Kitimat
Prince George
NORTHEAST COALFIELDS
Grande Cache
Edmonton
Hinton
Jasper
Quesnel
Williams Lake
Calgary
Banff
Revelstoke
Port Hardy
Port McNeill
Lillooet
Kamloops
Vernon
Kelowna
Campbell River
Powell River
Squamish
Cumberland
Vancouver
Neptune Terminals
Nanaimo
Roberts Bank
Princeton
Hedley
Penticton
Nelson
Trail
Cranbrook
Sparwood
Fernie
SOUTHEAST COALFIELDS
Victoria
CNR
CPR
100 km 0 100 200 300 400 km
SCALE
LEGEND
ROADS
RAILWAY
A Aug/06/2014 Hermann West Property Location GCH
REV DATE DESCRIPTION BY CHKD APRVD
WALTER ENERGY
HERMANN WEST COAL PROPERTY
Drawn by: GCH
Checked by:
Approved by:
Revision No. A
Dwg No.
GENERAL LOCATION MAP
JULY 2014
Document: HERMANN WEST COAL ASSESSMENT REPORT
Figure No. MAP 2-1
Burnt_River-Location-140705b.srfjpg

2.2.2 Access to centre of property

From the four-way junction, follow the Mesa mine access road approximately 2 kilometres, then follow mine-service roads (now presumed to be deactivated and hence only passable by walking or via all-terrain vehicle) across the southeastern slopes of Mt. Sheriff and Mt. Frame, thus entering the central portion of Coal Licence 416932. Access to the western and southern portions of this tenure is only practicable by cross-country walking, possibly shortened by the use of helicopter landing-sites constructed in the course of oilfield seismic surveys.

2.2.3 Access to northwestern end of property

Wolverine FSR and the nearby Canadian National railway tracks cross the northern extremity of Coal Licence 416933. At kilometre 17.3, an oilfield service road formerly crossed Wolverine River on a now-removed bridge. The road is driveable down to the bridge-site, but the river must be forded on foot. The remainder of the service road is walkable but partially blocked by fallen trees, ultimately allowing access to another natural-gas wellsite (BP et al Perry b-43-C / 93-P-3). The service road crosses the northern end of Coal Licence 416934, and the wellsite is situated near the centre of Coal Licence 416933. Access to southern parts of these two coal tenures is most conveniently gained by helicopter, landing at one of several helipads which were constructed by geophysical crews. Hand-cut seismic lines cross these tenures, affording relatively straightforward walking access through the otherwise-dense forest cover.

2.2.4 Airborne access

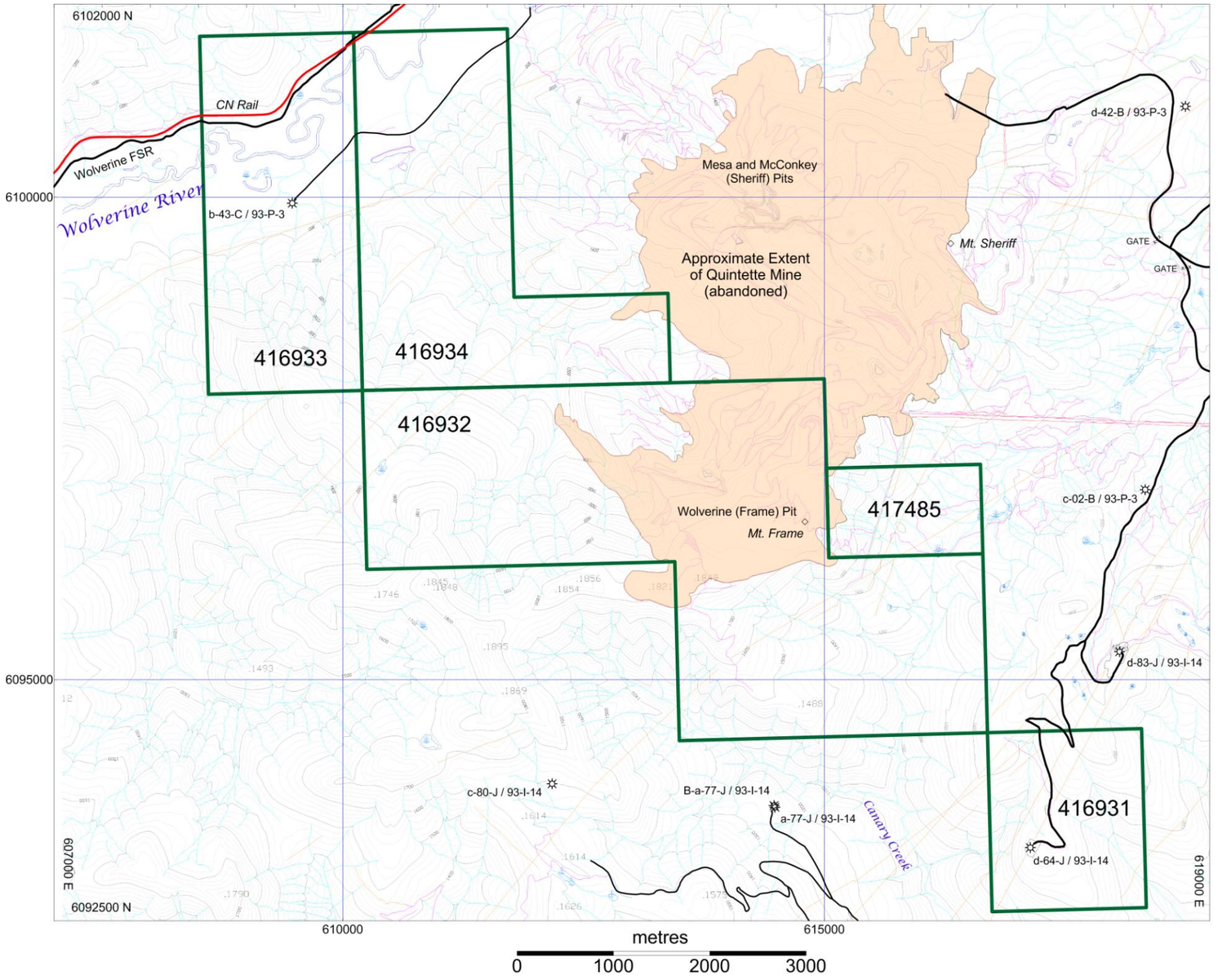
An unattended but paved airstrip is situated south of Tumbler Ridge; the airstrip is served by various chartered air-transportation firms, from airports at Prince George, Chetwynd and Dawson Creek. Two unmaintained (and perhaps no longer usable) grass landing-strips are situated within the valley-bottom of Wolverine River, and numerous helicopter landing-points are available atop ridges and mountains above timberline.

2.2.5 Regulatory setting

Surface access for drilling and other exploratory works is regulated by the provincial government, subject to the *Coal Act Regulations* and the *Mines Act*. The Hermann West coal property is situated within the Wapiti PSYU (Public Sustained Yield Unit), and timber cutting is subject to the terms of a Free Use Permit issued by the Ministry of Forests. Area-based stumpage fees are in effect.

2.3 Property description

The Hermann West property comprises 5 coal licences (**Maps 2-2 and 2-3**) which were acquired from the Crown by Western Canadian Coal in 2005 and subsequently acquired by Walter Energy in the course of its merger with Western Canadian Coal. **Table 2-1** presents details of the coal tenures, whose aggregate area is 3,265 hectares, and whose annual rental cost is $32,650.



Access (not classified as to trafficability):

- Railway (freight only)
- Road (highgrade)
- Road (lowgrade)
- Trail
- Seismic line

Land classification:

- Coal licence (with current Crown tenure number)

Drainage:

- River or creek
- Stream (perennial or intermittent flow)

- Natural gas wells (not classified as to activity)
- Pipeline (where not along road) -- not all pipelines are shown

Base map source: Province of British Columbia TRIM map-sheets 093P.004 and .005, and 093.I.094 and .095. Note that not all current access routes are shown, owing to the vintage of the base-maps. Additional road details derived from Google Earth images.

Hermann_West-topography-drainage-roads_140808b.srf/jpg

Scale: as shown	WALTER ENERGY	
UTM NAD 83	COAL TENURE AND TOPOGRAPHY	
Revision: A		
Drawn: GCH		
AUG 2014	HERMANN WEST COAL ASSESSMENT REPORT	MAP 2-2

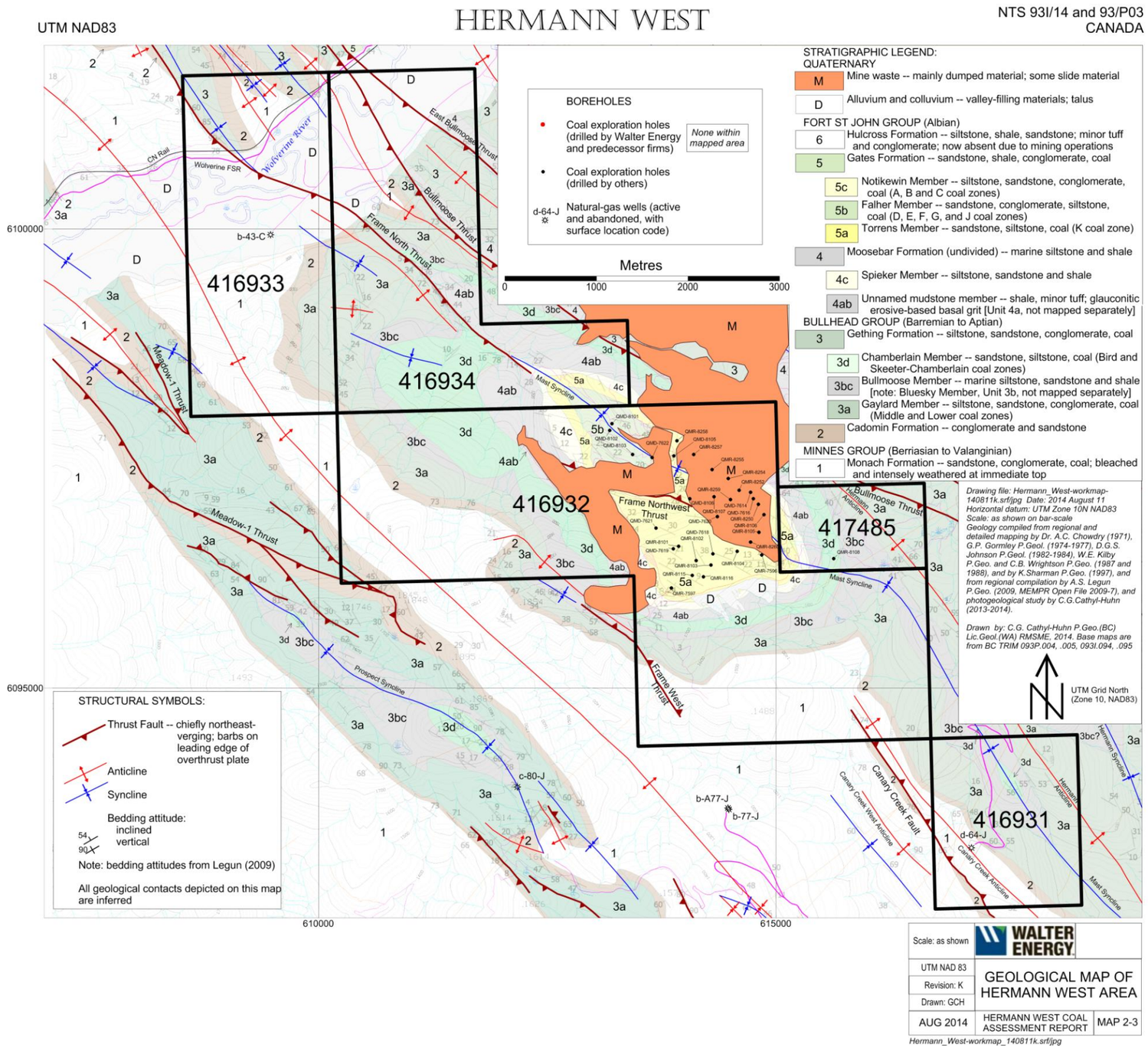

HERMANN WEST
UTM NAD83
NTS 93I/14 and 93/P03
CANADA
BOREHOLES
Coal exploration holes (drilled by Walter Energy and predecessor firms)
None within mapped area
Coal exploration holes (drilled by others)
d-64-J
Natural-gas wells (active and abandoned, with surface location code)
Metres
0 1000 2000 3000
STRATIGRAPHIC LEGEND:
QUATERNARY
M Mine waste -- mainly dumped material; some slide material
D Alluvium and colluvium -- valley-filling materials; talus
FORT ST JOHN GROUP (Albian)
6 Hulcross Formation -- siltstone, shale, sandstone; minor tuff and conglomerate; now absent due to mining operations
5 Gates Formation -- sandstone, shale, conglomerate, coal
5c Notikewin Member -- siltstone, sandstone, conglomerate, coal (A, B and C coal zones)
5b Falher Member -- sandstone, conglomerate, siltstone, coal (D, E, F, G, and J coal zones)
5a Torrens Member -- sandstone, siltstone, coal (K coal zone)
4 Moosebar Formation (undivided) -- marine siltstone and shale
4c Spieker Member -- siltstone, sandstone and shale
4ab Unnamed mudstone member -- shale, minor tuff; glauconitic erosive-based basal grit [Unit 4a, not mapped separately]
BULLHEAD GROUP (Barremian to Aptian)
3 Gething Formation -- siltstone, sandstone, conglomerate, coal
3d Chamberlain Member -- sandstone, siltstone, coal (Bird and Skeeter-Chamberlain coal zones)
3bc Bullmoose Member -- marine siltstone, sandstone and shale [note: Bluesky Member, Unit 3b, not mapped separately]
3a Gaylard Member -- siltstone, sandstone, conglomerate, coal (Middle and Lower coal zones)
2 Cadomin Formation -- conglomerate and sandstone
MINNES GROUP (Berriasian to Valanginian)
1 Monach Formation -- sandstone, conglomerate, coal; bleached and intensely weathered at immediate top
416933
416934
416932
417485
416931
Wolverine River
Wolverine FSR
CN Rail
East Bullmoose Thrust
Bullmoose Thrust
Frame North Thrust
Meadow-1 Thrust
Mast Syncline
Frame Northwest Thrust
Frame West Thrust
Prospect Syncline
Canary Creek Fault
Canary Creek West Anticline
Canary Creek Anticline
Hermann Anticline
Hermann Syncline
b-43-C
c-80-J
b-A77-J
b-77-J
d-64-J
6100000
6095000
610000
615000
STRUCTURAL SYMBOLS:
Thrust Fault -- chiefly northeast-verging; barbs on leading edge of overthrust plate
Anticline
Syncline
Bedding attitude: inclined vertical
Note: bedding attitudes from Legun (2009)
All geological contacts depicted on this map are inferred
Drawing file: Hermann_West-workmap-140811k.srf/jpg Date: 2014 August 11
Horizontal datum: UTM Zone 10N NAD83
Scale: as shown on bar-scale
Geology compiled from regional and detailed mapping by Dr. A.C. Chowdry (1971), G.P. Gormley P.Geol. (1974-1977), D.G.S. Johnson P.Geol. (1982-1984), W.E. Kilby P.Geo. and C.B. Wrightson P.Geo. (1987 and 1988), and by K.Sharman P.Geo. (1997), and from regional compilation by A.S. Legun P.Geo. (2009, MEMPR Open File 2009-7), and photogeological study by C.G.Cathyl-Huhn (2013-2014).
Drawn by: C.G. Cathyl-Huhn P.Geo.(BC) Lic.Geol.(WA) RMSME, 2014. Base maps are from BC TRIM 093P.004, .005, 093I.094, .095
UTM Grid North (Zone 10, NAD83)
Scale: as shown
WALTER ENERGY
UTM NAD 83
Revision: K
Drawn: GCH
AUG 2014
GEOLOGICAL MAP OF HERMANN WEST AREA
HERMANN WEST COAL ASSESSMENT REPORT
MAP 2-3
Hermann_West-workmap_140811k.srf/jpg

Table 2-1: Coal tenures at Hermann West

Land description			Area	Dates		Annual rental at $10/ha
Tenure	Blocks	Units		Issued on	Renew by	
416931	93I/14 Block J	63, 64, 73, 74	297 ha (4 units)	June 22, 2005	June 22, 2014	$2,970
416932	93I/14 Block J 93P/3 Block B 93P/3 Block C	85, 86, 87, 88, 95, 96, 97, 98 7, 8, 9, 10, 17 18, 19, 20 1, 2, 11, 12	1484 ha (20 units)	June 22, 2005	June 22, 2014	$14,840
416933	93P/3 Block C	23, 24, 33, 34, 43, 44, 53, 54	593 ha (8 units)	June 22, 2005	June 22, 2014	$5,930
416934	93 P/3 Block B 93 P/3 Block C	29,30 21, 22, 31, 32, 41, 42, 51, 52	742 ha (10 units)	June 22, 2005	June 22, 2014	$7,420
417485	93 P/3 Block B	05, 06	149 ha (2 units)	July 20, 2006	July 20, 2014	$1,490
5 coal licences / 44 units			3265 ha			$32,650

Coal licences grant to their holder the exclusive right to explore for coal, subject to consultation with local First Nations, coordination of access with other tenure-holders (such as oil and gas firms, other mineral-tenure holders, guide-outfitters, trappers, and timber companies), and the successful submission of an exploratory work plan. Coal licences do not, in and of themselves, confer the ownership of coal upon their holder (as the coal remains the property of the Crown via the province of British Columbia), but they can under appropriate circumstances be converted into coal leases, upon which a scheme of mining may be established.

The term of coal licences is one year, which may normally be extended upon the payment of an area-based annual rental fee as prescribed by the provincial Coal Act Regulation. Hermann West is now within its second five-year span of increased rental fees, at $10/hectare.

2.4 Infrastructure and geomatics

Electrical power is potentially available from B.C. Hydro's Tumbler Ridge substation, served by 230-KV transmission line 2L313, although the only distribution line presently in place near the Hermann West property is a 25-KV line along the northern side of Wolverine River, serving Perry Creek Mine.

Telecommunications are available via satellite and cellular telephone systems. Satellite access is excellent in upland areas, but unreliable in the heavily-wooded hillsides. Cellular coverage also likely to be inconsistent, owing to distance from transmitters, and issues of line-of-sight in mountainous country.

Base-mapping for Hermann West is freely available from the provincial government's Base Map Online Store, which affords a facility for downloading shaded-relief topographic maps

of the British Columbia Geographic System (BCGS) at 1:20,000 scale. BCGS map-sheets 093I.094, 093I.095, 093P.004, and 093P.005 cover the property.

Georeferenced satellite photography is freely available via the *Google Earth* web-service, as discussed further below. In general, this imagery is sufficiently detailed for studies of gross geological and geomorphological structure, and for the general tracing of roadways and vehicular access trails.

2.5 Physiography, landscapes and climate of the Hermann West property

Terrain is generally mountainous, with very steep hillslopes, capped by rolling sub-alpine plateaux which have been dissected by steep gullies, ravines and glacial cirques.

Coniferous forest covers the lower slopes of the property, declining in size and vigour with increasing altitude and wind-exposure. Near the treeline, forest cover is diminished to dense tangles of wind-sculpted krummholz. Soil cover is generally patchy, consisting mainly, till, alluvium and peat at lower elevations, and talus and colluvium at higher elevations. Thicker soils (including unconsolidated parent materials) are inferred to be present within the deep, glacially-rounded valley of Wolverine River.

Hermann West has a continental montane to alpine climate, characterised by long, moderately cold, snowy winters and short, rainy summers. Snow and frost may occur in any month of the year, and isolated snowfields persist on north-facing slopes into July. Winds are generally gusty and ongoing, with rare calm periods. Convective thunderstorms frequently occur during summer months, bringing intense rain-showers and occasional hail.

2.6 Year-2013 work

Year-2013 exploratory work performed at Hermann West comprised the assembly of a geological map (presented as **Map 2-3**), compiled from previous work by others (as noted on the map itself, and referenced within **Section 7** of this report). Much of the compilation work was guided by interpretation of aerial and satellite imagery.

The most useful imagery was obtained via *Google Earth*, consisting of year-2012 Landsat imagery, and a higher-resolution year-2014 image of unknown origin, covering the old Quintette mine workings.

Workflow for the *Google Earth* imagery was as follows:

- Find Hermann West area by panning and rotation as required, using known positions of Quintette mines as landmarks.
- Reduce vertical exaggeration of 3-dimensional terrain model to lowest available setting (at exaggeration factor of 0.01).
- Select vertical viewpoint.
- Locate Hermann West coal licences via British Columbia governmental web-mapping *.kmz* files.

- Adjust viewing scale to allow tracing of entire property outline.
- Trace outline with *Google Earth* add|polygon tool, setting line-width of 2.0 and red colour (for contrast against bare rock and forested areas).
- Export marked-up image as *.jpg* file.
- Import image into *Photoshop*, and rotate property lines to correct angle from project north (which in this case is UTM grid north).
- Export rotated image as *.jpg* file with amended filename.
- Import rotated image into Surfer 10 cartographic software and adjust image coordinates to obtain best fit of marked-up property outline.
- Digitise features of interest, including mine waste dumps, formation contacts and fold traces.
- Save digitised linework and polygons as *.bln* ASCII-format point-streams.
- Import digitised layers into geological map, as base-map layers.

A similar process was used for importing scanned historic maps as base-map layers, save that the scans generally required georeferencing and warping to fit the UTM grid. Coal-licence corners were taken as known NAD-27 control points within *Didger*, a georeferencing-software system. Warped images were then reassigned UTM NAD-83 coordinates by means of the Yellowstone Research Coordination Network's online coordinate-conversion tool (available via *http://www.rcn.montana.edu/Resources/Converter.aspx*, and most recently referenced on 6 August 2014).

2.7 Cross-reference to selected earlier studies

Geological mapping of the Hermann West property has been undertaken by staff of several companies since exploration commenced in 1970, and reported on an ongoing basis in Coal Assessment Reports 597, 601, 606, 607, 609, 615, 616, 617, and 850. Structural mapping and measurement of stratigraphic sections has also been undertaken by researchers working on behalf of both the federal and provincial geological surveys, two oil companies, and two universities. Citations to selected earlier work are presented in summary form as **Table 2-2**, below, and presented in full bibliographic detail later in this report.

2.7.1 Cross-references to historic drilling

Outside of the Gates Formation outlier within the core of the Mast Syncline,(largely within Coal Licence 416932, and formerly the site of Quintette Coal's Wolverine open-pit mine), the Hermann West coal property is essentially undrilled. The exception is an isolated borehole, QMR-8108, drilled within the Gething Formation along the trace of the Mast Syncline (in Coal Licence 417485)

In all, 32 historic boreholes were drilled between the years 1975 and 1984, with aggregate depth of 5833 metres. Of these holes, 19 (totalling 3329 metres) were drilled by open-hole methods and 13 (totalling 2504 metres) were drilled by diamond-coring. Summary statistics and cross-references to historic coal-assessment reports are presented below in **Table 2-3**,

incorporating data from the B.C. Geological Survey Branch's *COALFILE* database.

In addition to the historic coal-exploration boreholes, at least two natural-gas exploration wells have been drilled within the Hermann West coal property, as shown on **Map 2-3** and summarised below as **Table 2-4**. Both of these wells started within the Monach Formation (the uppermost part of the Minnes Group), and therefore did not intersect the known major coal-exploration targets within the Gates and Gething formations.

Information concerning natural-gas wells and associated exploratory activities is known to be incomplete, with the most recent access to the Province's database (as maintained by the Oil and Gas Commission) being obtained in 2011. The operating status of the natural-gas wells at Hermann West is not definitively known, although the more northwesterly well (b-43-C / 93-P-05) may be presumed to be abandoned, on account of the bridge having been removed from its access road.

Table 2-2: Cross-references to previous work

Year	*Report author(s) and venue of publication*	*Sponsoring organisation*	*Nature of work done*
1970	C.D.A. Dahlstrom, *Bulletin of Canadian Petroleum Geology*	Chevron Standard Limited	Geological mapping
1971	A.C. Chowdry, Coal Assessment Report 597	Denison Mines Limited	Geological mapping
1972	A.A. Johnson, Coal Assessment Report 601	Denison Mines Limited	Geological mapping
1974	G.P. Gormley, Coal Assessment Report 606	Denison Mines Limited	Geological mapping
1976	G.P. Gormley, Coal Assessment Report 607	Denison Mines (B.C.) Limited	Mapping and drilling
1977	G.P. Gormley, Coal Assessment Report 609	Denison Coal Limited	Mapping and drilling
1979	P.B. Jones, Petroleum Resources Branch Open File 863	Triad Oil Co. Ltd.	Geological mapping
1981	P.McL.D. Duff and R.D. Gilchrist, *MEMPR* Paper 1981-3	B.C. Geological Survey Branch	Correlation studies
1982	D.G.S. Johnson, Coal Assessment Report 615	Quintette Coal Limited	Mapping and drilling
1982	D.W. Gibson, *GSC* Bulletin 431	Geological Survey of Canada	Stratigraphic sections
1982	D.W. Gibson, *GSC* Bulletin 440	Geological Survey of Canada	Stratigraphic sections
1983	D.G.S. Johnson, Coal Assessment Report 616	Quintette Coal Limited	Mapping and drilling
1983	S.M.M. Carmichael, Ph.D. dissertation	University of British Columbia	Geological mapping
1984	D.G.S. Johnson, Coal Assessment Report 617	Quintette Coal Limited	Mapping and drilling
1987	W.E. Kilby and C.B. Wrightson, *MEMPR* Open File 1987-06	B.C. Geological Survey Branch	Geological mapping
1987	J.C. Broatch, M.Sc. thesis	University of British Columbia	Palynology
1988	G.P. Gormley, *CIM Bulletin* volume 81	Quintette Coal Limited	Structural studies
1988	W.E. Kilby and C.B. Wrightson, *MEMPR* Open File 1988-22	B.C. Geological Survey Branch	Geological mapping
1996	Z. Wan, Ph.D. dissertation	University of Saskatchewan	Palaeobotany
1997	K. Sharman, Coal Assessment Report 850	Quintette Operating Corporation	Geological mapping
2006-2009	A.S. Legun; *Geological Fieldwork*	B.C. Geological Survey Branch	Correlation studies
2009	A.S. Legun, *MEMPR* Open File 2009-7	B.C. Geological Survey Branch	Geological mapping

Table 2-3: Historic drilling within Hermann West property

Borehole	NAD83 position		Ass't. Rep't	Tenure	Year drilled	Method	Depth (metres, approximate)
	Easting	Northing					
QMR-7596	614845	6096450	607	416932	1975	Rotary	185
QMR-7597	613857	6096092	607	416932	1975	Rotary	42
QMD-7614	614721	6097134	609	416932	1976	Diamond core	118
QMD-7616	614751	6097064	609	416932	1976	Diamond core	152
QMD-7618	614310	6096462	609	416932	1976	Diamond core	177
QMD-7619	613877	6096518	609	416932	1976	Diamond core	73
QMD-7620	614359	6096868	609	416932	1976	Diamond core	249
QMD-7621	613688	6096744	609	416932	1976	Diamond core	96
QMD-7622	613647	6097510	609	416932	1976	Diamond core	223
QMD-8101	613206	6097880	615	416932	1981	Diamond core	157
QMD-8102	613183	6097806	615	416932	1981	Diamond core	196
QMD-8103	613433	6097546	615	416932	1981	Diamond core	280
QMD-8105	613884	6097528	615	416932	1981	Diamond core	185
QMD-8106	614056	6097064	615	416932	1981	Diamond core	262
QMD-8107	614324	6097084	615	416932	1981	Diamond core	336
QMR-8101	613934	6096544	615	416932	1981	Reverse circulation	119
QMR-8102	614128	6096390	615	416932	1981	Reverse circulation	153
QMR-8103	614288	6096340	615	416932	1981	Reverse circulation	148
QMR-8104	614576	6096490	615	416932	1981	Reverse circulation	214
QMR-8105	614813	6096698	615	416932	1981	Rotary	238
QMR-8106	614867	6096890	615	416932	1981	Rotary	234
QMR-8108	615631	6096412	615	417485	1981	Rotary	130
QMR-8115	614085	6096228	615	416932	1981	Rotary	140
QMR-8116	614207	6096214	615	416932	1981	Rotary	202
QMR-8250	614808	6097002	616	416932	1982	Reverse circulation	232
QMR-8252	614596	6097154	616	416932	1982	Reverse circulation	225
QMR-8254	614478	6097282	616	416932	1982	Reverse circulation	200
QMR-8255	614302	6097380	616	416932	1982	Reverse circulation	190
QMR-8257	614099	6097544	616	416932	1982	Reverse circulation	159
QMR-8258	613916	6097694	616	416932	1982	Reverse circulation	128
QMR-8259	614502	6097054	616	416932	1982	Reverse circulation	235
QMR-8260	614722	6096592	616	416932	1982	Reverse circulation	155

Notes:

32 boreholes, totalling 5833 metres, of which 19/3329 were open-hole and 13/2504 were diamond core.

Cross-reference for Coal Assessment Reports to authorship: 607: Gormley (1976a); 609: Gormley (1976b); 615: Johnson (1982); 616: Johnson (1983).

Table 2-4: Known natural-gas wells within Hermann West property

Well Authorisation (WA) number	Well name	Year	NAD 83 position	
			Easting	Northing
4573	BP et al Perry b-43-C / 93-P-3	1978	609475	6099938
9034	CNRL et al Murray d-64-J / 93-I-14	1998	617136	6093261

2.8 Acknowledgements and professional responsibility

Thanks are due to Preetpal Singh (at Walter Energy) for assistance with scanning and organisation of source materials, and for help with the assembly of this report into a coherent whole. Thanks are also due to senior geologist Blake Snodsmith, at Jim Walter Resources, for assistance with base-mapping, and to Dave Richardson P.Geo. and Sara McPhail P.Geo., at the B.C. Ministry of Natural Gas Operations, for assistance in locating details of natural-gas wells.

Gwyneth Cathyl-Huhn P.Geo. accepts overall professional responsibility for the contents of this report.

3 Geology

Regional and local geology (**Map 2-3**) of Hermann West and the Sukunka-Quintette coalfield is known mainly from the extensive work of D.F. Stott (1960; 1961; 1963; 1968; 1973; 1974; 1982; 1998), and D.W. Gibson (1992a, 1992b) on behalf of the Geological Survey of Canada (1968; 1973; 1982; 1998). As well, numerous coal-company reports (cited in **Section 7** of this report, and cross-referenced in **Table 2-2**) are available as open file documents from the provincial Geological Survey Branch. Copies of the reports are freely available for download via the provincial Survey's website, and may also be purchased in CD or DVD format at a cost of $20 per report.

3.1 Regional Geology

The Hermann West coal property lies within the Sukunka-Quintette coalfield of northeastern British Columbia, part of the Foothills structural province of the Canadian Cordillera. All rocks exposed at the ground surface are of Early Cretaceous age, belonging to the Minnes (Berriasian to Valanginian stages), Bullhead (Barremian to Aptian stages) and Fort St. John (Albian stage) groups. Where the entire section has been preserved from erosion, total thickness of the Lower Cretaceous rocks is 2500 to 3000 metres, although some of this thickness is attributable to thrust-induced structural telescoping of the rock.

The majority of sedimentary rocks within the Sukunka-Quintette coalfield are clastic in nature, ranging in grain-size from claystones and mudstones through conglomerates. Lesser amounts of biologically- and chemically-derived sedimentary rocks are present, comprising coals, banded and nodular ironstones, glauconite-rich sandstones and gritstones, and impure dolomites.

Volcanic rocks constitute a very small component of the Early Cretaceous strata, comprising very fine- to fine-grained tuffs (locally altered to bentonites or tonsteins), interpreted to have originated as wind-borne distal ash-fall deposits from contemporaneous volcanoes situated upwind and far to the southwest of the property. The volcanic rocks characteristically occur as very thin (at most a few decimetres) yet regionally-extensive bands, which are of use as markers for structural and stratigraphic correlations.

3.1.1 Regional stratigraphy

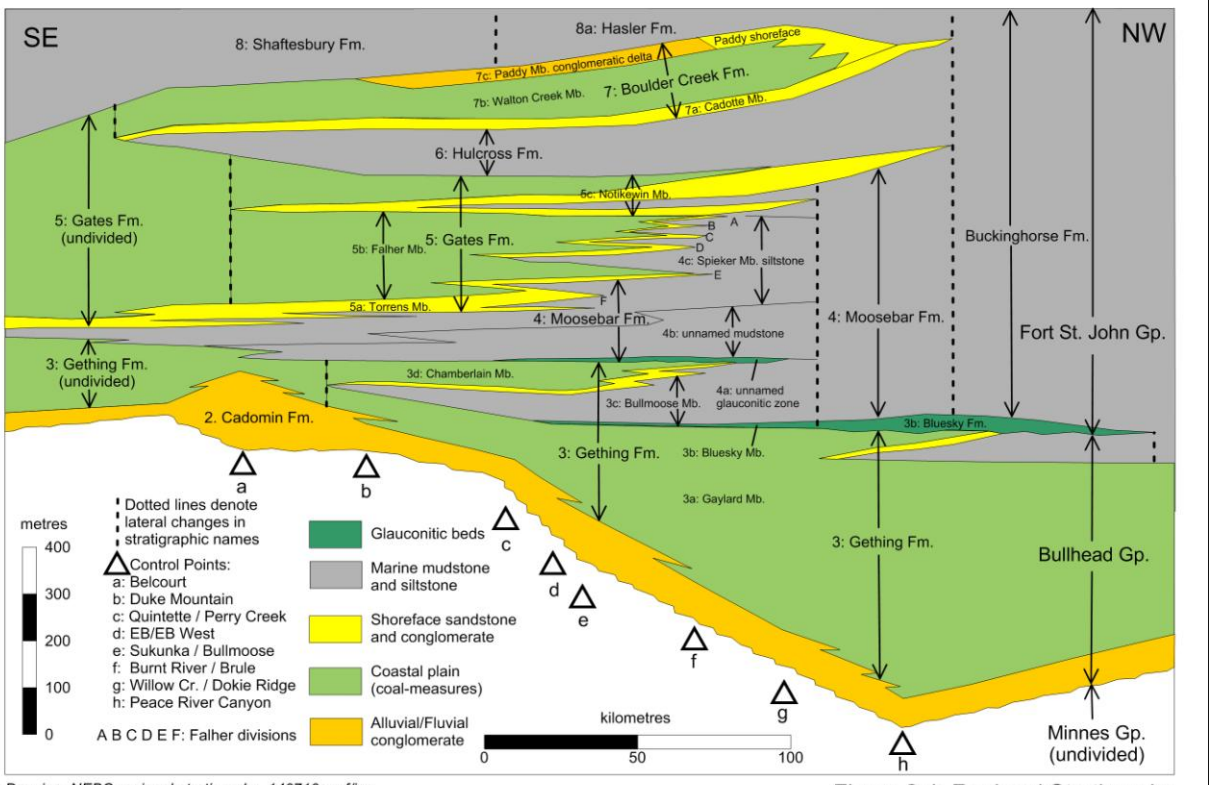
During much of the Early Cretaceous, the Western Interior of North America was occupied by a shallow seaway, variably-designated by different authors as the Western Interior Sea, the Boreal Sea, or by various analogues of formation names, such as the Clearwater Sea, Hulcross Sea or Moosebar Sea. Depths of the seaway, magnitude of accommodation space for sediments, and overall shoreline trends, were largely controlled by vertical movements within a complexly-block-faulted crystalline basement terrane of Precambrian age, the Peace River Arch.

Sediments of the Minnes Group and the basal part of the Bullhead Group were derived from actively-eroding upland areas within the North American craton, particularly from the Peace River Arch. The receiving basin during this early time period lay to the west of the craton, within an actively-subsiding continental shelf which prograded westwards into the

ancestral Pacific Ocean. Subsequently, slightly later within the earliest Cretaceous era, sediments of the upper part Bullhead Group and the Fort St. John Group were derived from actively-rising thrust-faulted tectonic forelands situated to the west and southwest of the seaway, synchronous with the docking of allochthonous tectonic terranes against the western margin of the North American craton.

Coal deposits formed within the non-marine portions of the clastic sedimentary successions. Kalkreuth and Leckie (1989) recognised the close association between actively-subsiding shoreface sandstone deposits and the overlying presence of thick coal beds; this association is well-established within the upper part of the Gething Formation and the middle part of the Gates Formation, within the Sukunka-Quintette coalfield, including the Hermann West property.

Figure 3-1, substantially adapted from Kalkreuth and Leckie's Figure 3 of their 1989 paper, summarises regional stratigraphic relationships within the Bullhead Group and the lower part of the Fort St. John Group. Younger beds, which elsewhere form the top of the Fort St. John Group, have been completely removed by erosion within the Hermann West area, and so are omitted from the stratigraphic diagram. Details of the older Minnes Group (including the Monach Formation, which immediately underlies the Cadomin Formation) are not shown, as these rocks have been minimally-explored to date.



Drawing: NEBC-regional-stratigraphy_140710e.srf/jpg
Date: 5.July 2014 Scale: diagrammatic, as shown
Drawn by: C.G.Cathyl-Huhn P.Geo. Lic.Geol. RMSME,
modified from work by W.Kalkreuth and D.A. Leckie (1989)

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Figure 3-1: Regional Stratigraphy of the Lower Cretaceous Bullhead Group and basal part of the Fort St. John Group

Within the diagram, the Early Cretaceous rocks are broadly classified by facies, with the most economically-significant facies being the coastal-plain coal-measures of the various

paleodeltas. All of the coastal-plain strata contain coal, although within the Sukunka-Quintette coalfield the bulk of known coal resources lie within the Chamberlain Member of the Gething Formation, and the Falher Member of the Gates Formation.

3.1.2 Regional structure

The Hermann West coal property, and the coalfield within which it is contained, is characterised by a thin-skinned deformational style comprising folded, laterally-arcuate thrust faults and associated fault-bend folds (Chowdry, 1971; Jones, 1979).

Age relationships amongst the thrusts are as generally observed within the Cordilleran fold-thrust belts of North America, with the oldest thrusts occupying stratigraphically-higher positions, generally to the tectonic inboard side (hence, to the southwest) of the stratigraphically-lower and younger thrusts. Most, but not all, of the thrusts dip generally to the southwest and strike to the northwest. Thrusts typically exhibit northeastward vergence, consistent with an overall northeastward direction of tectonic transport. Exceptions to this general rule occur, for example, the southwest-verging faults near Mt. Frame, and a southwest-verging thrust bounding the northern end of the Prospect Syncline. These backthrusts may represent the uppermost leading-edge structures within a triangle zone.

Thrusts range in scale from mesocopic features with stratigraphic displacements of a few decimetres to a few metres, to regionally-throughgoing faults and fault zones (such as the Bullmoose and East Bullmoose faults) with stratigraphic displacements of several hundred metres. Thrusts characteristically overlap in *en echelon* manner, with displacement gradually transferring from one fault to another via trains of folds. In contrast with the Hermann West area, further to the northwest along strike, much of the tectonic shortening in the Hermann West area appears to have been accomplished by folding, rather than by overthrusting.

Bedding dips within the Sukunka-Quintette coalfield are generally less than 20 degrees within the broad synclinoria which characterise the coalfield. Steep dips (rarely near-vertical to overturned) are occasionally observed within tightly-folded displacement-transfer zones near the ends of *en echelon* thrusts.

Regionally, the Moosebar Formation is often a zone of detachment, characterised by near-bedding-parallel thrust faults (Cooper and others, 2004). At and near Hermann West, detachments are also occasionally seen within soft muddy siltstones and mudstones of the basal Falher Member of the Gates Formation, as well as within the fine-grained Bullmoose Member of the Gething Formation.

3.2 Local geology

A generalised stratigraphic profile of the coal beds and associated sedimentary rocks at Hermann West is presented as **Table 3-1**.

Table 3-1: Bedrock stratigraphic units, coal zones, and coal beds at Hermann West

Geological Age		Lithostratigraphic Units				Thickness	Map-Units		Coal Beds/Coal Zones	
		Group	Formation	Member	Division				Bed	Zone
Early Cretaceous	Middle Albian	Fort St. John	Hulcross			105 m	6			
	Late Early Albian		Gates	Notikewin		85 to 90 m	5	5c	A coal bed	
									B coal bed	
									C coal bed	
				Falher		88 to 92 m		5b	D coal bed	
									E1 coal bed	E
									E2 coal bed	
									F1 coal bed	F
									F2 coal bed	
									G1 coal bed	G
									G2 coal bed	
									J1 coal bed	J
									J2 coal bed	
									J3 coal bed	
				Torrens	Quintette ('Sherriff') sandstone	32 m		5a		
					(unnamed siltstone)	20 m			K (No.1) coal bed	
					Torrens sandstone	20 m				
			Moosebar	Spieker		50 m	4	4c		
				unnamed mudstone unit		105 to 135 m		4b		
				basal glauconitic zone		nil to 1 m		4a		
		Bull-head	Gething	Chamberlain		55 m?	3	3d	Bird coal zone	
									Skeeter – Chamberlain coal zone	
				Bullmoose		80 m?		3c		
				Bluesky		nil to 1 m		3b		
	Late Aptian to Late Early Albian			Gaylard		115 m?		3a	Middle coal zone	
									Lower coal zone	
	Hauterivian to Barremian		Cadomin			15 to 45 m?	2			
	Berriasian to Valanginian	Minnes	Monach (and older formations below?)			2100 m?	1		Coals present; no details known	

3.2.1 Local stratigraphy

Within the Hermann West property, rocks belonging to the Bullhead and Fort St. John groups are exposed at the ground surface, with the older rocks of the Minnes Group inferred to be present within the deeper subsurface. Approximately 700 metres of Bullhead and Fort St. John rocks remain in place, following Tertiary-Quaternary episodes of fluviatile erosion and glacial scouring, and more recent open-pit mining activities.

Formations mapped (see **Map 3-1** and **Table 3-1**) as being present at outcrop range downwards from the Gates Formation (map-unit 5, the youngest mapped formation, although younger rocks of the Hulcross Formation, map-unit 6, were formerly present, prior to their removal by open-pit mining operations) to the Monach Formation (map-unit 1, the oldest mapped formation). The ages of these rocks span 145 to 108.7 million years before present, based on paleontological evidence and limited tephrachronological dating.

3.2.2 Local structure

The Hermann West coal property consists, essentially, of a moderately-deformed stack of marine and non-marine strata, generally present in normal ('tops-up') stratigraphic position.

Exceptions to this general situation are presented by several throughgoing, northeast-verging, northwest-striking thrust faults, defining variably-broad structural 'plates' (thrust sheets) separated by complexly-crumpled smash zones adjacent to the thrusts. Each of the structural plates is thus telescoped upon the underlying plate, acting to structurally shorten (in a southwest-northeast direction) and thicken (in a vertical direction) the overall section of sedimentary rocks. Thrust faults are inferred to have developed in the typical downward-younging sequence of successive faulting.

Of the faults enumerated above, the Bullmoose Thrust is the major through-going structural feature at regional scale, with associated anticlines and synclines forming a passive fold train atop the fault's crush zone. Stratigraphic displacement across the Bullmoose Thrust is inferred to be several hundred metres, as yet unproven by detailed mapping nor by drilling.

The most economically-significant of the folds is the Mast Syncline, which passes over the crest of Mt. Frame, and thus was the major structure within Quintette Coal's Wolverine open-pit mine (Morash, 1988). Also of significance is the Canary Creek Anticline, which bounds the southwestern margin of the Gething coal-measures within Coal Licences 416931 and 416932.

Fault-to-bedding cutoff angles (alpha-angles) may be assumed to range from near-zero within incompetent rocks such as mudstones and volcanic ash bands, through 30 degrees in well-indurated, thick-bedded to massive sandstones and conglomerates.

4 Stratigraphic synopsis

The following discussion presents details of the lithology, contained coal beds, inferred origin, typical thickness and contact relationships of the various surficial and bedrock units present at Hermann West, keyed to the map-unit numbers used in **Map 2-3** and **Table 3-1**. Geological units are discussed in stratigraphic order from uppermost (youngest) to lowermost (oldest) within the exposed sequence of strata.

4.1 Quaternary surficial deposits

Unconsolidated surficial deposits of Quaternary age comprise mine waste (map-unit M) and valley-bottom Drift (map-unit D). The extent of both classes of surficial deposits has been mapped by means of *Google Earth* satellite imagery, and by interpretation of topographic boundaries adjacent to the valley-floor of Wolverine River.

4.1.1 Mine waste (map-unit M)

Associated with the historic open-pit mining operations at Mt. Frame are mine waste dumps, and flowslides deriving from localised dump failures (Tassie, 1988, Dawson and others, 1998). Waste dumps consist of overburden and interburden rocks removed during mining operations, whereas flowslides consist of an admixture of residemented dump material and native surficial soils. Dumps and flowslides have not been mapped separately, as their distinction on satellite imagery is difficult. Thickness of dumped material is inferred to be substantial, locally greater than 100 metres; more-precise determination would require access to dump plans and associated operating records.

4.1.2 Drift (map-unit D)

The flat-bottomed floor of the Wolverine River valley is occupied by the river's meander-belt, and by adjoining alluivial fans of tributary creeks which drain nearby upland areas. The banks of the river, where exposed by channel-migration processes, show crudely-bedded silts, sands and gravels which are interpreted as fluvial deposits. Glacial and glaciolacustrine sediments, of broadly Pleistocene age, may underlie the near-surface fluvial deposits, but this supposition remains untested by drilling. Thickness of the valley-filling Drift likely ranges from a few tens of metres to perhaps 200 metres, although that upper estimate remains speculative in the absence of drilling or other definitive exploratory work.

4.2 Fort St. John Group (map-units 6 through 4a)

An incomplete section of the Fort St. John Group is (or was, pre-mining) present at Hermann West, owing to the group's uppermost formations having been stripped off by erosion and by open-pit mining operations.

4.2.1 Hulcross Formation (map-unit 6)

The Hulcross Formation, which formerly overlay the Gates Formation within the Mast Syncline at Mt. Frame (within Coal Licence 416932) has now been largely if not completely removed by Quintette Coal Limited's mining operations at Mt. Frame.

The Hulcross Formation, of Middle Albian age within the Early Cretaceous (Stelck and Leckie, 1988; Gibson, 1992b) formerly comprised 105 metres of thinly-interbedded, locally-

concretionary medium grey siltstone, fine-grained sandstone and dark grey mudstone with occasional very thin but extremely-persistent interbeds of soft, light grey to white, tuffaceous volcanic ash. Mesoscale (a few decimetres to a few metres thick) fining-upward sequences reminiscent of proximate turbidites or tempestites are common within the Hulcross, as are trace-fossils and poorly-preserved shell fossils. Fine-grained pyrite is locally-abundant within the Hulcross rocks, which are inferred to have been deposited beneath a stratified water column within a restricted-circulation seaway (Stelck and Leckie, 1988).

The Hulcross Formation was formerly considered a member of the Commotion Formation (Stott, 1968), and that obsolete usage is evident in texts and illustrations accompanying historic coal-assessment reports from the Sukunka-Quintette coalfield, including the Hermann West area.

The immediate base of the Hulcross Formation is marked by a thin (generally a few decimetres, and rarely up to a metre or so thick) erosive-based bed of cherty pebbly sandstone or gritstone. The erosional base of the Hulcross Formation may represent a low-angle unconformity above the Gates Formation.

4.2.2 Gates Formation (map-unit 5)

The Gates Formation, of late Early Albian age within the Early Cretaceous (Stott, 1982; Wan, 1996), comprises 250 metres of interbedded sandstone, siltstone, conglomerate, shale and coal at Hermann West. The Gates Formation, as were the Boulder Creek and Hulcross formations, was formerly considered a member of the Commotion Formation (Stott, 1968), and that obsolete usage is evident in old coal assessment reports from the Sukunka-Quintette coalfield, including the Hermann West area.

At Hermann West, and within the Sukunka-Quintette coalfield generally, the Gates Formation may be usefully subdivided into three members, in order from top down:

- Notikewin Member (map-unit 5c), comprising 85 to 90 metres of interbedded, locally-glauconitic sandstone and siltstone, with minor conglomerate, carbonaceous mudstone and generally-thin coal (A, B and C coal zones);

- Falher Member (map-unit 5b), comprising 88 to 92 metres of muddy to sandy siltstone, channel-filling sandstone and generally-thick coal (D, E, F, G and J coal zones), with lesser amounts of carbonaceous mudstone and silty mudstone; and

- Torrens Member (map-unit 5a), comprising 70 to 74 metres of sandstone, with minor siltstone and mudstone, and one thin coal (Quintette Coal's K zone; termed 'No.1 zone' by Carmichael, 1983).

Coals of the Gates Formation, and their enclosing sedimentary rocks, were deposited on the shoreline of the Western Interior Seaway between 108.7 and 111.0 million years ago, as part of an extensive complex of coastal plains, deltas and estuaries within the Sukunka-Quintette coalfield. Throughout the period of Gates Formation sedimentation, the shallow waters of the Western Interior Seaway generally lay a few tens of kilometres northeast of Hermann West,

with the exception of a few isolated 'marine bands' within the Notikewin Member, associated with more substantial transgressions of the sea into and atop coal-forming coastal plain sediments. Splits were occasionally induced within the Gates coal beds, by crevasse-splays from river channels, and perhaps also by drowning of coal-forming wetlands beneath lakes and ponds.

Within the Hermann West coal property, numerous coal zones, each comprising one or more individually-recognisable coal beds, are present within the Gates Formation. Coal zones and coal beds are designated by an upward-progressing system of lettering, from the K zone near the base of the formation, to the C, B and A zones near the top of the formation. This scheme of designation has been generally applied within the Quintette portion of the coalfield, and is the inverse of the 'bottoms-up' naming scheme used at Sukunka, Bullmoose and East Bullmoose.

4.2.2.1 Notikewin Member (map-unit 5c)

As in the case of the Hulcross Formation, the Notikewin Member of the Gates Formation within the Mast Syncline at Mt. Frame (within Coal Licence 416932) has now been largely if not completely removed by Quintette Coal Limited's mining operations at Mt. Frame. The following discussion is offered for completeness.

The Notikewin Member of the Gates Formation formerly (pre-mining) comprised 85 to 90 metres of siltstone and sandstone with minor conglomerate, variably-carbonaceous, locally root-bearing mudstone, and thin coal beds.

Regionally, the Notikewin is finer-grained than the underlying Falher Member of the Gates Formation (Leckie and Walker, 1982), and it tends to be more recessive-weathering than the Falher Member. Within the Quintette portion of the coalfield, the basal Notikewin sandstones and conglomerates frequently form a cliff band above the Falher coal-measures, leading to their informal naming as 'The Caprock'. The basal part of the Notikewin has also been informally termed the 'Babcock Member' by Quintette Coal's geologists.

Carmichael (1983) established a more-detailed but still informal subdivision of the Notikewin Member into several sub-units within the Quintette area. Their recognition within the Hermann West property is now largely rendered moot by the past mining operations which have removed these rocks.

4.2.2.2 Falher Member (map-unit 5b)

The Falher Member of the Gates Formation comprises 88 to 92 m of muddy to sandy siltstone, channel-filling sandstone and generally thick coal (within the D, E, F, G and J coal zones), accompanied by lesser proportions of carbonaceous mudstone and silty mudstone. Overall, the Falher Member contains proportionately more coal than the overlying Notikewin Member.

The Falher Member is of Late Early Albian age (Wan, 1996). Its basal contact with the underlying Torrens Member of the Gates Formation is abrupt, marked by an undulating surface possibly originating as relict sandbars or sand-waves.

Regionally, within the Sukunka-Quintette coalfield and also within the adjoining Deep Basin hydrocarbon play area of northeastern British Columbia and northwestern Alberta, the Falher Member may readily be divided into five or six semi-formal subdivisions, designated by letters from top downwards, as the Falher A through Falher F. Such a subdivision may be possible at Hermann West, but as in the case of the Notikewin Member, the exercise is largely rendered moot by past mining of the bulk of the Falher's strata from its original position within the core of the Mast Syncline.

Approximately 35 hectares of Falher Member rocks and associated coals remains in-place within the northwestern end of the Mast Syncline, downhill from and perhaps partially-overlain by one of the waste dumps constructed by Quintette Coal in the course of nearby mining operations.

4.2.2.3 Torrens Member (map-unit 5a)

Within the Sukunka-Quintette coalfield, the term 'Torrens Member' is often applied as a local name for the thick sandstone underlying the lowest of the mineable Gates coal beds. Within the northern part of the Quintette area (including the Hermann West and Hermann coal properties), however, there are two of these sandstone units, the Quintette and Torrens sandstones, separated by a thick medial fine-grained 'silty zone' of interbedded siltstone, sandstone and shale. The two sandstones are probably of marine origin, but the silty zone comprises both marine and non-marine rocks, including a thin coal bed.

In earlier historic reports, the Quintette Sandstone was frequently designated as the 'Sheriff Member' of the Gates Formation.

The top of the Quintette Sandstone is almost always root-penetrated, at times distinctly softer, darker and carbonaceous to coaly (likely a paleosol beneath the Quintette J coal zone), readily distinguishable from the harder, lighter-coloured and cleaner main body of the sandstone. The sandstone's surface undulates at the scale of a few metres to a few tens of metres, probably representative of relict sand-bars and sand-waves, formed within a shallow-marine setting. The Quintette Sandstone is 32 metres thick at Mt. Frame (Carmichael, 1983).

The medial silty zone contains a thin coal bed, designated as the No.1 coal bed by Carmichael (1983), and likely correlative with the K coal zone as extensively-drilled within the nearby Hermann coal property. The No.1/K coal bed is only 0.5 metres thick at Mt. Frame, and therefore not of interest for mining. The medial silty zone is 20 metres thick at Mt. Frame (Carmichael, *op. cit.*).

The Torrens Sandstone at Mt. Frame contains numerous thin to medium interbeds of silty sandstone. This unit has seldom been intersected by drilling, but in an outcrop section measured by Carmichael, the Torrens Sandstone is 20 metres thick.

The age of the Torrens Member is presumed to be Late Early Albian. The basal contact of the Torrens Member with the underlying Spieker Member of the Moosebar Formation is gradational by interbedding (Carmichael, 1983).

4.2.3 Moosebar Formation (map-unit 4)

The Moosebar Formation comprises 155 to 185 metres of dark grey, locally-concretionary mudstone and siltstone, with minor thin interbeds of sandstone and tuff, and a thin basal conglomerate. Concretions are sideritic, and distinctly rusty-weathering, concentrated in laterally-persistent bands, a few decimetres thick, which may represent diastem-induced hardgrounds. Tuff bands within the Moosebar Formation are very thin (a few millimetres to a few decimetres) but also laterally-persistent.Variations in the Moosebar's thickness are likely due to overthrusting and concomitant tectonic thickening of its incompetent shales.

The Moosebar Formation is of Early Albian age (Stott, 1968). Its basal contact with the underlying Gething Formation is abrupt, and generally erosional, characteristically marked by a very thin band of variably-glauconitic gritty sandstone or pebbly gritstone.

At Hermann West, and within the Sukunka-Quintette coalfield generally, the Moosebar Formation may be divided into three units. In order from top down, these are:

- Spieker Member (map-unit 4c): banded to fissile-weathering, thinly-interbedded siltstone and sandstone, 50 metres thick;
- Unnamed mudstone member (map-unit 4b): massive-appearing dark grey to black, variably- silty mudstone, with occasional thin bands of tuff, generally 105 metres thick, but locally tectonically-thickened to 135 metres thick;
- Basal gritstone member (map-unit 4a): variably-glauconitic gritty sandstone or pebbly gritstone, 0.1 to 1 metre thick.

At Hermann West, exposures of the Moosebar Formation are confined to high-relief areas such as creek channels or ravines (Johnson, 1982).

4.2.3.1 Spieker Member (map-unit 4c)

The Spieker Member comprises 50 metres of thinly-interbedded, overall coarsening-upward sandy siltstone and sandstone, pervasively-bioturbated and possibly originating as proximal shallow-marine turbidites (Leckie, 1983) in front of the advancing Falher/Torrens paleodelta. Sandstone beds become thicker, coarser, and more abundant towards the top of the Spieker, and on the whole the Spieker Member is a transitional unit (Duff and Gilchrist, 1981) between the lower Moosebar mudstone and the overlying Torrens sandstones. In some earlier reports, the Spieker Member is termed the 'Sukunka Member' (Wallis and Jordan, 1974) of the now-deprecated Commotion Formation. The Spieker Member is well-exposed on the southwestern shoulder of Mt. Frame, and locally also exposed in the northwest-flowing creek which drains the centre of the Mast Syncline.

The age of the Spieker Member is presumed to be Early Albian to possibly late Early Albian. The basal contact of the Spieker with the underlying unnamed mudstone member is drawn at the base of the lowest band of sandy siltstone overlying the mudstones. This contact is inferred to be locally abrupt or erosional, but regionally-interfingering.

4.2.3.2 Unnamed mudstone member (map-unit 4b)

The unnamed mudstone member of the Moosebar Formation comprises 105 to 135 metres of monotonous, rubbly-weathering, massive-appearing black mudstone, punctuated by

laterally-persistent bands crowded with ironstone concretions, locally-abundant dolomitic nodules, and several thin (a few millimetres to a few decimetres) but laterally-persistent bands of light olive drab to white tuff. The tuff bands are useful as local structural markers (Duff and Gilchrist, 1981; Kilby, 1984a).

The Moosebar mudstones are sparsely-bioturbated, and locally contain sparse to abundant burrow-fillings, irregular blebs and euhedral crystals of pyrite, indicative of overall anoxic depositional conditions. Pyrite is particularly abundant near the base of the mudstone unit.

The age of the Moosebar mudstones is Early Albian (Stott, 1968). The basal contact of the mudstones over the underlying basal gritstone unit is gradational to abrupt, and generally easily-recognised on geophysical logs, as well as in outcrops and cores, on account of the underlying gritstone's distinctive glauconite content.

4.2.3.3 Basal gritstone member (map-unit 4a)

The basal gritstone member of the Moosebar Formation comprises 0.2 to perhaps 1 metre of variably-glauconitic, chert-rich lithic arenite to pebble-conglomerate. Johnson (1982) suggested that the basal gritstone unit might be equivalent to the Bluesky Formation of the Alberta Plains, but that correlation is now understood to be incorrect (Kilby, 1984b; Gibson, 1992b). The age of the basal gritstone member is presumed to be Early Albian. Its basal contact with the underlying Chamberlain Member of the Gething Formation is presumed to be abrupt, and locally erosional.

Upon the accompanying geological map (**Map 2-3**), map-units 4a and 4b are depicted together as map-unit 4ab, owing to the impracticality of depicting the thin basal gritstone by itself at the given scale of mapping.

4.3 Bullhead Group (map-units 3 and 2)

The Bullhead Group consists of two formations, the Gething Formation which comprises the majority of the group's thickness, and the thinner basal Cadomin Formation (Stott, 1963; 1968; 1973). Both formations are well-represented in outcrop at Hermann West, although only the uppermost part of the Gething Formation has been tested by drilling.

4.3.1 Gething Formation (map-unit 3)

The Gething Formation, of Early Aptian to Early Albian age within the Early Cretaceous (Gibson, 1992), comprises thin to thick interbeds of siltstone, sandstone, mudstone and coal, with lesser amounts of gritstone, pebble-conglomerate, ironstone and tuff.

The Gething Formation originated as a complex of non-marine to shallow-marine sedimentary deposits, laid down by meandering and braided streams and rivers within a widely-extensive belt of coastal deltas, of which two (the Gaylard and Chamberlain paleodeltas) extended into the Quintette Mountain area, including the Hermann West coal property.

Coals of the Gething Formation at Hermann West, and their enclosing sedimentary rocks, were deposited between 111 and 123 million years ago (Gibson, *ibid.*), on the basis of regional plant-fossil and foraminiferal zonations.

Following upon suggestions made by coal-company geologists (Wallis and Jordan, 1974) and subsequent correlation by the British Columbia Geological Survey (Duff and Gilchrist, 1981; Legun, 1990), Gibson formally divided the Gething Formation into three members: the upper, non-marine to transitional Chamberlain Member, the middle marine Bullmoose Member, and the basal, non-marine to transitional Gaylard Member. A fourth member of the Gething Formation, the Bluesky Member, is also inferred to be present between the base of the Bullmoose Member and the top of the Gaylard Member.

In the geological map accompanying this report (**Map 2-3**), the Gething Formation is locally mapped as three stratigraphically-based map-units: the Chamberlain Member (map-unit 3d), the undivided Bullmoose and Bluesky members (map-unit 3bc) and the Gaylard Member (map-unit 3a). Where the extent of outcrop exposure does not support this cartographic distinction, the Gething Formation has been mapped as an undivided whole (map-unit 3).

4.3.1.1 Chamberlain Member (map-unit 3d)

The Chamberlain Member comprises about 55 metres of thickly-interbedded, brown-weathering sandstone and siltstone, containing two regionally-significant coal zones: the Bird Zone (containing one or more coal beds) near the member's top, and the Skeeter-Chamberlain Zone (again, containing one or more coal beds) within the member's middle. The basal quarter to third of the Chamberlain Member's thickness comprises one or two regionally-extensive thick beds of marine sandstone.

The Chamberlain Member is inferred to form a northeastward-facing dip-slope over a broad area within the undrilled southwestern limb of the Mast Syncline, northwest of Mt. Frame (within the southwestern part of Coal Licence 416934 and the northwestern part of Coal Licence 416932). An isolated outlier of the Chamberlain Member is also inferred to be present within the core of the Mast Syncline, southeast of Mt. Frame (within Coal Licence 416931).

The age of the Chamberlain Member is late Early Albian (Gibson, 1992a). The basal contact of the Chamberlain Member with the underlying Bullmoose Member is drawn at the base of the lowest of the (usually two) thick basal sandstones. This contact is generally abrupt at local scale, but probably gradational by interfingering at the regional scale.

4.3.1.2 Bullmoose Member (map-unit 3c)

The Bullmoose Member comprises about 80 metres of thinly-interbedded, recessive-weathering mudstone, siltstone and minor sandstone of turbiditic aspect, forming one or more coarsening-upward sequences. The Bullmoose does not contain any coal, other than isolated coalified logs and coarse, poorly-preserved 'plant trash', likely of drifted origin. The Bullmoose does, however, contain locally-abundant molluscan fossils, including *Pecten (Entolium)* cf. *irenense* McLearn (Gibson, 1992a) and *Yoldia kissoumi* (Duff and Gilchrist, 1981), which, although not age-diagnostic, are characteristic of the unit.

In a departure from historic mapping (which placed the Moosebar Formation there), the Bullmoose Member is interpreted to form the exposed core of the Mast

Syncline, along the southwest-facing hillsides above Canary Creek, extending southeasterly from Mt. Frame (and thus within the eastern extremity of Coal Licence 416932 and within the northeastern quarter of Coal Licence 416931).

The Bullmoose Member is of late Early Albian age (Gibson, 1992a); its basal contact with the underlying Bluesky Member is generally gradational but locally abrupt.

4.3.1.3 Bluesky Member (map-unit 3b)

The Bluesky Member comprises 0.2 to 1 metre of pebbly mudstone to gritty pebble-conglomerate, at times slightly to moderately glauconitic, with occasional pyrite flecks. The basal contact of the Bluesky with the underlying Gaylard Member has not been directly observed at Hermann West; however, elsewhere within the Sukunka-Quintette coalfield it is generally abrupt to erosional. The age of the Bluesky Member is likely to be late Early Albian. The Bluesky Member of the Gething Formation, as its name implies, is likely to be correlative (if not strictly coeval) with the Bluesky Formation of the Dawson Creek area.

Map-units 3b and 3c are depicted together as map-unit 3bc within Map 2-3, owing to the impracticabilty of representing the Bluesky Member separately at the given map-scale.

4.3.1.4 Gaylard Member (map-unit 3a)

The Gaylard Member comprises about 115 metres of thickly-interbedded siltstone, mudstone and brown-weathering channel-filling sandstone, accompanied by minor ironstone, tuff, gritstone and conglomerate. Regionally, the Gaylard Member is known to contain numerous coal beds; locally, however, it has not been completely intersected by boreholes, and thus its coal content is imperfectly known. Two coal zones have been recognised: the Middle Zone, near the top of the Gaylard, and the Lower Zone, near the base of the Gaylard.

The Gaylard coal-measures occupy a northeast-facing dip-slope geometry within the undrilled southwestern limb of the Mast Syncline, northwest of Mt. Frame (within the southwestern corner of Coal Licence 416934, and the northwestern corner of Coal Licence 416932). Dip-slope geometries are also mapped along the trace of the Hermann Anticline, within Coal Licence 416931.

The age of the Gaylard Member is Hauterivian to late Early Albian (Gibson, 1992a). Its basal contact with the underlying Cadomin Formation is gradational by interfingering at local and regional scale (Stott, 1968; Johnson, 1972; Gibson, 1992a), drawn at the top of a bed of coarse-grained, often gritty and occasionally pebbly sandstone which may laterally grade into more typical pebble-conglomerate characteristic of the Cadomin.

4.3.2 Cadomin Formation (map-unit 2)

The Cadomin Formation immediately underlies the Gething Formation, forming the basal part of the Bullhead Group (Stott, 1968). The Cadomin is resistant to erosion, and typically forms ledges to cliffs beneath the more-subdued slopes of the Gaylard Member.

This ledge-forming geometry is locally well-developed along the southwest-facing slopes bounding Canary Creek, and along the southwestern shoulder of Mt. Frame.

The Cadomin Formation comprises one or more thick beds of coarse-grained, gritty to pebbly sandstone and pebble-to boulder-conglomerate (Johnson, 1972; McLean, 1981) with occasional lenses of siltstone and pebbly gritstone, and rare thin lenses of dirty coal. Sandy phases of the Cadomin Formation thus strongly resemble the basal pebbly sandstones of the Gaylard Member, and the Cadomin's distinction from the Gaylard locally rests mainly upon the Cadomin Formation's greater lateral continuity. The top of Cadomin Formation has not been reached by any of the boreholes drilled at Hermann West.

At Hermann West, the Cadomin Formation is 15 to 45 metres thick (Johnson, 1982). Its basal contact with the underlying Monach Formation is likely to be erosional, with considerable local scour into the older sediments. Regionally, the base of the Cadomin marks a northeastward-deepening angular contact, cutting down into successively-older rocks of the Minnes Group (Stott, 1973).

4.4 Minnes Group (map-unit 1)

The Minnes Group, despite being known to contain coal within its outcrop belt along the southwestern fringe of the Sukunka-Quintette coalfield, is virtually unexplored in the vicinity of the Hermann West property. The total thickness of the Minnes Group is at least 2100 metres.

The Minnes Group in the Hermann West area comprises three formations: from top down, the Monach, Beattie Peaks and Monteith formations. Of these three, only the Monach Formation is expected to outcrop at or near Hermann West.

4.4.1 Monach Formation (map-unit 1)

The Monach Formation comprises ledge-forming sandstone and quartzite, with lesser amounts of interbedded siltstone and conglomerate, and occasional thin coals, part of the Minnes Group (Stott, 1998). Coal beds within the Monach are reported to be very thin, typically less than 15 cm thick (Johnson, 1982). Cuttings descriptions from the two natural-gas wells at Hermann West (b-43-C within Coal Licence 416933, and d-64-J within Coal Licence 416931) do not indicate the obvious presence of thick coal zones within the near-surface Monach rocks.

The Monach Formation is of Berriasian to Valanginian age (Stott, 1998). The Monach Formation is at least 300 metres thick in the Hermann West area, but its base has not yet been observed in outcrop.

5 Coal resources and coal reserves

No current coal-resource estimate is known to exist for the Hermann West coal licences. The MINFILE report (Barlow, 2009) for the Wolverine open-pit mine, within the Hermann West property, notes that the mine operated from 1985 until its reported exhaustion in 1998, but does not provide production statistics specific to the mine. Reconciliation of historic estimates of coal resources and coal reserves to the deposit's current resource base is therefore not possible given information at hand.

6 Statement of costs

During year-2013, no detailed accounting was made of the division of geological labour involved in the regional photogeological compilation study, but a reasonable estimate of work time on the senior geologist's part (Gwyneth Cathyl-Huhn) is ten days at nine hours/day. Given direct labour cost of $55.58/hour, the 90 working hours would amount to $5002.20, which may be rounded to $5000 in keeping with the estimated nature of this cost. **Table 6-1** presents standardised cost breakdown by activity. The photogeological compilation is here allocated as 'report preparation.'

Table 6-1: Cost breakdown by activity

Item	Quantity [Q]	Unit cost [C]	Cost of work [Q x C]
Field personnel	0 person-days	not applicable	$nil
Consultants	0 person-days	not applicable	$nil
Food/accommodation	0 person-days	not applicable	$nil
Mobe/demob within BC	nil	$nil	$nil
Aircraft support	nil	$nil	$nil
Vehicle rentals	nil	$nil	$nil
Equipment/supplies	nil	$nil	$nil
Instrument rentals	nil	$nil	$nil
Laboratory analysis	nil	$nil	$nil
Contract jobs/unit costs	nil	$nil	$nil
Report preparation	90 hours	$55.58/hour	$5000 (rounded)
Management	0 person-days	not applicable	$nil
		TOTAL (rounded)	$5000

Table 6-2 presents apportioned costs of year-2013 work, ascribable to each coal licence on the basis of equal cost per hectare. Hectare cost basis was derived by dividing the $5000 estimated total cost by 3265 hectares' total area, yielding a cost per hectare of $1.531 per hectare.

Table 6-2: Apportioned costs of year-2013 work

Tenure	Area (hectares) [A]	Unit cost/hectare [C]	Cost of work [A x C]
416931	297	$1.531	$454.71
416932	1484	$1.531	$2272.00
416933	593	$1.531	$907.88
416934	742	$1.531	$1136.00
417485	149	$1.531	$228.12
		Sum of costs: $4998.71 (rounded, $5000.00)	

7 References

Barlow, N.
2009: Quintette (Frame) record summary; *British Columbia Ministry of Energy*, MINFILE Record No.093P 020.

Broatch, J.C.
1987: Palynologic zonation and correlation of the Peace River coalfield, northeastern British Columbia; *University of British Columbia*; unpublished M.Sc. thesis, 100 pages.

Carmichael, S.M.M.
1983: Sedimentology of the Lower Cretaceous Gates and Moosebar formations, northeast coalfields, British Columbia; *University of British Columbia*; unpublished Ph.D. dissertation, 285 pages; accessed August 2, 2014 via *https://circle.ubc.ca/handle/2429/24275/UBC_1983_A1%20C37.pdf?sequence=1*

1988: Linear estuarine conglomerate bodies formed during a mid-Albian marine transgression: "Upper Gates" Formation, Rocky Mountain Foothills of northeastern British Columbia; in D.P. James and D.A.Leckie (editors), Sequences, Stratigraphy, Sedimentology: Surface and Subsurface; *Canadian Society of Petroleum Geologists*, Memoir 15, pages 49 to 61.

Chowdry, A.C.
1971: Quintette Project geological report; in D.M. Parkes, Quintette Project Phase I summary report of drill results; unpublished report PR – Quintette 71(1)A dated May 1971, on behalf of Denison Mines Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.597.

Cooper, M., Brealey, C., Fermor, P. and Morrison, M.
2004: Structural models of subsurface thrust-related folds in the Foothills of British Columbia – case studies of sidetracked gas wells; in K.R. McClay (editor), Thrust tectonics and hydrocarbon systems; *American Association of Petroleum Geologists*, Memoir 82, pages 579 to 597.

Dahlstrom, C.D.A.
1970: Structural geology in the eastern margin of the Canadian Rocky Mountains; *Bulletin of Canadian Petroleum Geology*, volume 18, number 3, pages 332 to 406.

Dawson, R.F., Morgenstern, N.R. and Stokes, A.W.
1998: Liquefaction flowslides in Rocky Mountain coal mine waste dumps; *Canadian Geotechnical Journal*, volume 35, number 2, pages 328 to 343.

Duff, P.McL.D. and Gilchrist, R.D.
1981: Correlation of Lower Cretaceous coal measures, Peace River Coalfield, British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1981-3, 31 pages.

Gibson, D.W.
1992a: Stratigraphy, sedimentology, coal geology and depositional environments of the Lower Cretaceous Gething formation, northeastern British Columbia and west-central Alberta; *Geological Survey of Canada*, Bulletin 431, 127 pages.

1992b: Stratigraphy and sedimentology of the Lower Cretaceous Hulcross and Boulder Creek formations, northeastern British Columbia; *Geological Survey of Canada*, Bulletin 440, 111 pages.

Gormley, G.P.
1974: 1974 Wolverine exploration report; unpublished report PR – Quintette 74(1)C, dated December 16, 1974, on behalf of Denison Mines Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.606.

1976a: Quintette Coal Limited 1975 exploration & development report; unpublished report PR – Quintette 75(1)A, dated January 1976, on behalf of Denison Mines (BC) Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.607.

1976b: Quintette Coal Limited 1976 geological assessment report; unpublished report PR – Quintette 76(1)B, dated December, 1976, on behalf of Quintette Coal Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.609.

1988: Working with geological complexity at Quintette Coal Limited's Mesa open pit; *CIM Bulletin*, volume 81, number 917 (September 1988), pages 57 to 63.

Johnson, A.A. (editor)
1972: Quintette Project interim geological report; unpublished report PR – Quintette 72(1)B, dated March 15, 1972, on behalf of Denison Mines Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.601.

Johnson, D.G.S.
1982: 1981 Quintette geological report; unpublished report PR – Quintette 81(1)A, dated April 1982, on behalf of Quintette Coal Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.615.

1983: Quintette coal exploration 1982 geological report; unpublished report PR – Quintette 82(1)A, dated April 15, 1983, and amended August 14, 1984, on behalf of Quintette Coal Limited; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.616.

1984: 1983 Quintette geological report; unpublished report PR – Quintette 83(1)A, dated April 1984, on behalf of Quintette Coal Ltd.; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.617.

Jones, P.B.
1979: Report on geological fieldwork in the North Monkman area, British Columbia; Triad Oil Co. Ltd., unpublished technical report; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Petroleum Resources Branch Geological Report No.863.

Kalkreuth, W. and Leckie, D.A.
1989: Sedimentological and petrographical characteristics of Cretaceous strandplain coals: a model for coal accumulation from the North American Western Interior Seaway; *International Journal of Coal Geology*, volume 12, pages 381 to 424.

Kilby, W.E.
1984a: Tonsteins and bentonites in northeast British Columbia (93O, P, I); in Geological Fieldwork 1983, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 1984-1, pages 95 to 107.

1984b: The character of the Bluesky Formation in the Foothills of northeastern British Columbia (93 O, P, I); in Geological Fieldwork 1983, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 1984-1, pages 108 to 112.

Kilby, W.E. and Johnston, S.T.
1988a: Bedrock geology of the Kinuseo Creek area, northeast British Columbia, NTS 93I/15; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-21.

1988b: Bedrock geology of the Kinuseo Falls area, northeast British Columbia, NTS 93I/14; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-22.

Kilby, W.E. and Wrightson, C.B.
1987a: Bullmoose mapping and compilation project (93 P/3,4); in Geological Fieldwork 1986, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 1987-1, pages 373 to 378.

1987b: Bedrock geology of the Bullmoose Creek area (NTS 93P/3); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1987-06.

Leckie, D.A.
1983: Sedimentology of the Moosebar and Gates formations (Lower Cretaceous); *McMaster University*, unpublished Ph.D. dissertation, 515 pages.

1985: The Lower Cretaceous Notikewin Member (Fort St. John Group), northeastern British Columbia: a progradational barrier island system; *Bulletin of Canadian Petroleum Geology*, volume 33, number 1, pages 39 to 51.

Leckie, D.A. and Walker, R.G.
1982: Storm and tide-dominated shorelines in Cretaceous Moosebar-Lower Gates interval – outcrop equivalents of Deep Basin gas trap in western Canada; *American Association of Petroleum Geologists Bulletin*, volume 66, number 2, pages 138 to 157.

Legun, A.S.
1990: Stratigraphic trends in the Gething Formation; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 2006-13.

2006: The Gates Formation in the Wolverine River area, northeastern British Columbia; in Geological Fieldwork 2005, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 2005-1, pages 73 to 82.

2007: Mapping and review of coal geology in the Wolverine River area, Peace River coalfield (NTS 93P/03); in Geological Fieldwork 2006, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 2007-1, pages 67 to 76.

2008: Thickness trends of J seam, and its split at the Falher D shoreline, Wolverine River area, Peace River coalfield, northeastern British Columbia (parts of NTS 093I, P); in Geological Fieldwork 2007, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 2008-1, pages 39 to 48.

2009a: Bedrock and coal geology of the Wolverine River area, northeastern British Columbia (parts of NTS 093P/03, 093I/14); in Geological Fieldwork 2008, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Survey Branch Paper 2009-1, pages 55 to 61.

2009b: Geology of Wolverine River area, Peace River coalfield; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 2009-7; available via *www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/OpenFiles/2009/Documents/OF2009-7/OF2009-7.pdf*

McLean, J.R.
1977: The Cadomin Formation: stratigraphy, sedimentology, and tectonic implications; *Bulletin of Canadian Petroleum Geology*, volume 25, number 4, pages 792 to 827.

McMechan, M.E.
1985: Low-taper triangle-zone geometry: an interpretation for the Rocky Mountain Foothills, Pine Pass – Peace River area, British Columbia; *Bulletin of Canadian Petroleum Geology*, volume 33, number 1 (March 1985), pages 31 to 38.

Morash, B.J.
1988: Matching mining methods to complex coal geology; *CIM Bulletin*, volume 81, number 917, pages 64 to 69.

Sharman, K.
1997: 1996 Quintette Operating Corporation 1996 assessment report for Coal Lease #6 and Licences; unpublished report dated April 2, 1997, on behalf of Quintette Operating Corporation; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.850.

Sharman, K. and Szalkal, S.
1995: Quintette Operating Corporation 1974 geological report – Mesa Extension; unpublished report dated June 15, 1995, on behalf of Quintette Operating Corporation; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report No.826.

Stelck, C.R. and Leckie, D.A.
1988: Foraminiferal inventory and lithologic description of the Lower Cretaceous (Albian) Hulcross Shale, Monkman area, northeastern British Columbia; *Canadian Journal of Earth Sciences*, volume 25, pages 793 to 798.

Stott, D.F.
1960: Cretaceous rocks between Smoky and Pine rivers, Rocky Mountain Foothills, Alberta and British Columbia; *Geological Survey of Canada*, Paper 60-16, 52 pages.

1961: Type sections of some formations of the Lower Cretaceous Fort St. John Group near Pine River, British Columbia; *Geological Survey of Canada*, Paper 61-11, 61 pages.

1963: Stratigraphy of the Lower Cretaceous Fort St. John Group, Gething and Cadomin formations, Foothills of northern Alberta and British Columbia; *Geological Survey of Canada*, Paper 62-39, 48 pages.

1968: Lower Cretaceous Bullhead and Fort St. John groups, between Smoky and Peace rivers, Rocky Mountain Foothills, Alberta and British Columbia; *Geological Survey of Canada*, Bulletin 152, 279 pages.

1973: Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, Northeastern British Columbia; *Geological Survey of Canada*, Bulletin 219, 228 pages.

1974: Lower Cretaceous coal measures of the Foothills of west-central Alberta and northeastern British Columbia; *Canadian Mining and Metallurgical Bulletin*, volume 67, number 749, pages 87 to 101.

1982: Lower Cretaceous Fort St. John Group and Upper Cretaceous Dunvegan Formation of the Foothills and Plains of Alberta, British Columbia, District of Mackenzie and Yukon Territory; *Geological Survey of Canada*, Bulletin 328, 124 pages.

1998: Fernie Formation and Minnes Group (Jurassic and lowermost Cretaceous), northern Rocky Mountain Foothills, Alberta and British Columbia; *Geological Survey of Canada*, Bulletin 516, 516 pages.

Tassie, W.P.
1988: Waste dump management at Quintette Coal Limited; *CIM Bulletin*, volume 81, number 917, pages 35 to 39.

Wallis, G.R. and Jordan, G.R.
1975: The stratigraphy and structure of the Lower Cretaceous Gething Formation of the Sukunka River coal deposit in B.C.; *CIM Bulletin*, volume 67, number 743, pages 142 to 147.

Wan, Z.
1996: The Lower Cretaceous flora of the Gates Formation from western Canada; *University of Saskatchewan*, unpublished doctoral dissertation, 304 pages.

8 Conclusions

The Hermann West coal property contains coal-measures of Early Cretaceous age, within the Minnes, Bullhead and Fort St. John groups of sedimentary rocks. These rocks are deformed by folded, imbricate thrust faults and associated folds, consistent with the overall thin-skinned structural style of the Rocky Mountain Foothills of northeastern British Columbia.

The most recent historic coal-exploration work at Hermann West known to have been done by Denison Mines Limited and successor companies, as has previously been reported in various Coal Assessment Reports as cited within the present report. Most of the historic exploration effort has been devoted to the Falher coals within the Gates Formation, and minimal attention has, as yet, been paid to the coals of the older Gething and Monach formations.

The present work on the Hermann West coal property, here reported as concerns the year 2013, comprises the construction of a geological map from aerial and satellite imagery, supported by collection and re-interpretation of data from previous reports. This work was conducted by members of WCCP's regional geological staff, as part of a broader examination of coal properties within the Brazion and Sukunka-Quintette coalfields of northeastern British Columbia, Canada.

The Hermann West property merits further work.

9 Statements of qualifications

I, Laura Rose Avery B.Sc. B.Ed., do hereby certify that:

a) I am currently employed on a full-time basis by Walter Canadian Coal Partnership, a subsidiary of Walter Energy, in their Northeast British Columbia office in Chetwynd, British Columbia.

b) This certificate applies to the current report, titled *Coal Assessment Report for Hermann West coal licences, Mt. Frame area, British Columbia*, dated August 11, 2014.

c) I am in the processes of applying for my Professional Engineers and Geoscientists of British Columbia status.

d) I received my Bachelor of Science from Saint Mary's University in Halifax in 2006.

e) I have worked in the coal industry for 2 years and 10 months.

f) I have been pit geologist for the Brazion group since March 2012.

g) I have been co-chair of the Joint Occupational Health, Safety and Environment Committee for both Brule and Willow for 2 years.

I, C.G. Cathyl-Huhn P.Geo.(BC) Lic.Geol.(WA) RMSME, do hereby certify that:

a) I am currently employed on a full-time basis by Walter Canadian Coal Partnership, a subsidiary of Walter Energy, in their Northeast British Columbia office in Tumbler Ridge, British Columbia.

b) This certificate applies to the current report, titled *Coal Assessment Report for Hermann West coal licences, Mt. Frame area, British Columbia,* dated August 11, 2014.

c) I am a member (Professional Geoscientist, Licence No.20550) of the Association of Professional Engineers and Geoscientists of British Columbia, licenced as a geologist (Licence No.2089) in Washington State, and a founding Registered Member of the Society for Mining, Metallurgy and Exploration (SME, Member No.518350). I have worked as a colliery geologist in several countries for over 36 years since my graduation from university.

d) I certify that by reason of my education, affiliation with professional associations, and past relevant work experience, having written numerous published and private geological reports and technical papers concerning coalfield geology, coal-mining geology and coal-resource estimation, that I am qualified as a Qualified Person as defined by Canadian *National Instrument 43-101* and a Competent Person as defined by the Australian *JORC Code*.

e) My most recent visit to the Hermann West coal property was in June 2014. I previously conducted geological mapping within the property in the summer of 1976, whilst employed by Denison Mines Limited.

f) I am principal author of this report, titled *Coal Assessment Report for Hermann West coal licences, Mt. Frame area, British Columbia,* dated August 11, 2014, concerning the Hermann West coal property.

g) As of the date of this report's writing, I am not independent of Walter Canadian Coal Partnership and Walter Energy, pursuant to the tests in Section 1.4 of *National Instrument 43-101*.

"original signed and sealed by"

Dated this 11th day of August, 2014. C.G. Cathyl-Huhn P.Geo. Lic.Geol. RMSME

6102000 N

6100000

6095000

607000 E

6092500 N

619000 E

610000

615000

CN Rail

Wolverine FSR

Wolverine River

b-43-C / 93-P-3

Mesa and McConkey (Sheriff) Pits

Approximate Extent of Quintette Mine (abandoned)

Mt. Sheriff

d-42-B / 93-P-3

GATE

GATE

416933

416934

416932

417485

Wolverine (Frame) Pit

Mt. Frame

c-02-B / 93-P-3

d-83-J / 93-I-14

c-80-J / 93-I-14

B-a-77-J / 93-I-14

a-77-J / 93-I-14

Canary Creek

416931

d-64-J / 93-I-14

.1845 .1848 .1854 .1856 .1746 .1821 .1849 .1895 .1493 .1869 .1488 .1614 .1614 .1575 .1626 .1790

12

metres

0 1000 2000 3000

Access (not classified as to trafficability):

- Railway (freight only)
- Road (highgrade)
- Road (lowgrade)
- Trail
- Seismic line

Land classification:

- Coal licence (with current Crown tenure number)

Drainage:

- River or creek
- Stream (perennial or intermittent flow)

- Natural gas wells (not classified as to activity)
- Pipeline (where not along road) -- not all pipelines are shown

Base map source: Province of British Columbia TRIM map-sheets 093P.004 and .005, and 093.I.094 and .095. Note that not all current access routes are shown, owing to the vintage of the base-maps. Additional road details derived from Google Earth images.

N

Hermann_West-topography-drainage-roads_140808b.srf/jpg

Scale: as shown	WALTER ENERGY	
UTM NAD 83	COAL TENURE AND TOPOGRAPHY	
Revision: A		
Drawn: GCH		
AUG 2014	HERMANN WEST COAL ASSESSMENT REPORT	MAP 2-2

UTM NAD83

HERMANN WEST

NTS 93I/14 and 93/P03
CANADA

BOREHOLES

- Coal exploration holes (drilled by Walter Energy and predecessor firms) — *None within mapped area*
- Coal exploration holes (drilled by others)
- d-64-J ☼ Natural-gas wells (active and abandoned, with surface location code)

Metres
0 1000 2000 3000

STRATIGRAPHIC LEGEND:

QUATERNARY
- M — Mine waste -- mainly dumped material; some slide material
- D — Alluvium and colluvium -- valley-filling materials; talus

FORT ST JOHN GROUP (Albian)
- 6 — Hulcross Formation -- siltstone, shale, sandstone; minor tuff and conglomerate; now absent due to mining operations
- 5 — Gates Formation -- sandstone, shale, conglomerate, coal
  - 5c — Notikewin Member -- siltstone, sandstone, conglomerate, coal (A, B and C coal zones)
  - 5b — Falher Member -- sandstone, conglomerate, siltstone, coal (D, E, F, G, and J coal zones)
  - 5a — Torrens Member -- sandstone, siltstone, coal (K coal zone)
- 4 — Moosebar Formation (undivided) -- marine siltstone and shale
  - 4c — Spieker Member -- siltstone, sandstone and shale
  - 4ab — Unnamed mudstone member -- shale, minor tuff; glauconitic erosive-based basal grit [Unit 4a, not mapped separately]

BULLHEAD GROUP (Barremian to Aptian)
- 3 — Gething Formation -- siltstone, sandstone, conglomerate, coal
  - 3d — Chamberlain Member -- sandstone, siltstone, coal (Bird and Skeeter-Chamberlain coal zones)
  - 3bc — Bullmoose Member -- marine siltstone, sandstone and shale [note: Bluesky Member, Unit 3b, not mapped separately]
  - 3a — Gaylard Member -- siltstone, sandstone, conglomerate, coal (Middle and Lower coal zones)
- 2 — Cadomin Formation -- conglomerate and sandstone

MINNES GROUP (Berriasian to Valanginian)
- 1 — Monach Formation -- sandstone, conglomerate, coal; bleached and intensely weathered at immediate top

STRUCTURAL SYMBOLS:

- Thrust Fault -- chiefly northeast-verging; barbs on leading edge of overthrust plate
- Anticline
- Syncline
- Bedding attitude: inclined (54) / vertical (90)

Note: bedding attitudes from Legun (2009)

All geological contacts depicted on this map are inferred

Drawing file: Hermann_West-workmap-140811k.srf/jpg Date: 2014 August 11
Horizontal datum: UTM Zone 10N NAD83
Scale: as shown on bar-scale
Geology compiled from regional and detailed mapping by Dr. A.C. Chowdry (1971), G.P. Gormley P.Geol. (1974-1977), D.G.S. Johnson P.Geol. (1982-1984), W.E. Kilby P.Geo. and C.B. Wrightson P.Geo. (1987 and 1988), and by K.Sharman P.Geo. (1997), and from regional compilation by A.S. Legun P.Geo. (2009, MEMPR Open File 2009-7), and photogeological study by C.G.Cathyl-Huhn (2013-2014).

Drawn by: C.G. Cathyl-Huhn P.Geo.(BC) Lic.Geol.(WA) RMSME, 2014. Base maps are from BC TRIM 093P.004, .005, 093I.094, .095

UTM Grid North (Zone 10, NAD83)

Scale: as shown	WALTER ENERGY	
UTM NAD 83	GEOLOGICAL MAP OF HERMANN WEST AREA	
Revision: K		
Drawn: GCH		
AUG 2014	HERMANN WEST COAL ASSESSMENT REPORT	MAP 2-3

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