Interpretation of Quaternary Sediments and Depth to Bedrock, Peace Project Area, Northeastern British Columbia: Project Update

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Introduction

Montney Formation tight siltstone reservoirs in northeastern British Columbia are being developed intensively for gas, liquids and oil production using horizontal drilling and multiple hydraulic fracture completions. Drilling and completions operations require substantial volumes of water, which must be obtained while minimizing impacts on other stakeholders, such as First Nations, and agricultural and municipal consumers. As well, costs to source and transport water can be critical components of project economics.

Geoscience BC has worked in partnership with industry, government agencies and local stakeholders to assess available water resources in the BC Montney play fairway; results to date are summarized on the Montney Water Project website (http://www.geosciencebc.com/s/Montney.asp). Even though substantial progress has been made in understanding water resources in deep saline aquifers and in surface water bodies, nonsaline groundwater resources in unconsolidated aquifers and shallow bedrock are not as well known.

The Peace Project has been undertaken to map groundwater resources in an area of more than 8000 km^2 in the Peace Region through the use of airborne geophysics (Figure 1; Brown et al., 2016). Information from the project will serve as a key component of the Northeast Water Strategy, currently under development by the provincial government in partnership with local governments, regulatory bodies, Treaty 8 First Nations, Geoscience BC and industry, by providing knowledge to enable the Northeast Water Strategy's enhanced water monitoring system.

Keywords*: Peace Project, airborne geophysics, Quaternary geology, shallow bedrock, Montney Formation, cased-hole gamma-ray log*

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The Peace Project is a collaborative effort involving Geoscience BC, BC Ministry of Forests, Lands and Natural Resource Operations, BC Ministry of Environment, BC Oil and Gas Commission, BC Ministry of Natural Gas Development, Progress Energy Canada Ltd., ConocoPhillips Canada, Northern Development Initiative Trust, and BC Oil and Gas Research and Innovation Society with additional support from the Peace River Regional District and the Canadian Association of Petroleum Producers.

The current report reviews the initial phase of the Peace Project, in which Quaternary sediments and shallow bedrock are assessed and interpreted using existing surficial geology maps and information from petroleum boreholes. Results will be used to calibrate interpretations from the airborne geophysical data to provide the most complete possible assessment of shallow aquifers and the contained groundwater resources.

Project Summary – Initial Phase

Petrel Robertson Consulting Ltd. and Quaternary Geosciences Inc. have undertaken the investigation of Quaternary and other near-surface bedrock formations in the Peace Project area, using cased-hole gamma logs run through surface casings in petroleum boreholes. Properly interpreted, these logs can yield valuable information about the depth to bedrock (and hence thickness of Quaternary cover) and the nature and distribution of Quaternary aquifers and aquitards.

The objective of the initial phase of the project is to generate a map of Quaternary sediment thickness, and to identify potential groundwater aquifers and aquitards in the Quaternary section. The following steps are being undertaken to meet this objective:

1) Compile a digital surficial geology map for the project area from available sources, including the Geological Survey of Canada, BC Geological Survey and the BC Ministry of Environment (Figure 2). The scale of the original source maps varies from 1:20 000 to 1:250 000,

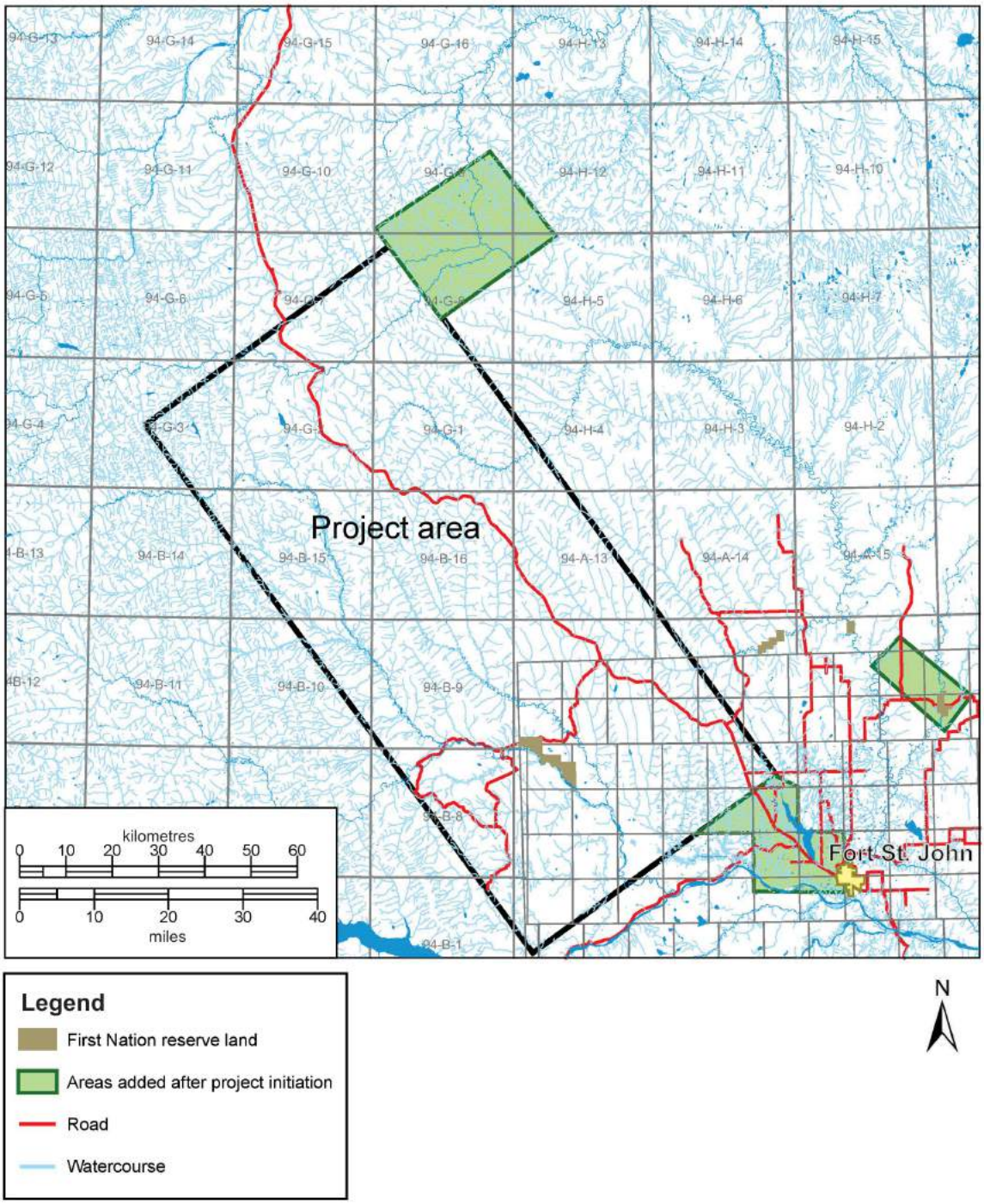

Figure 1. Peace Project area, northeastern British Columbia. Note that supplemental areas were added to the project scope after project initiation.

so units on more detailed maps have been simplified to provide reasonable uniformity. Map boundary issues arise from using a wide range of map scales, and there are varied legends arising from the different purposes of the original mapping. Note that the project area shown in Figure 2 reflects the original Peace Project area, prior to the addition of areas after project initiation (compare to Figure 1).

2) Compile a Quaternary stratigraphy database for the project area, including BC Ministry of Environment water well data and stratigraphic sections described by government and university researchers. Depth-to-bedrock data are extracted for all available sites in the project area. From these datasets, preliminary depth-to-bedrock interpretations have been made. Areas of near-surface bedrock are readily identified from units mapped as till

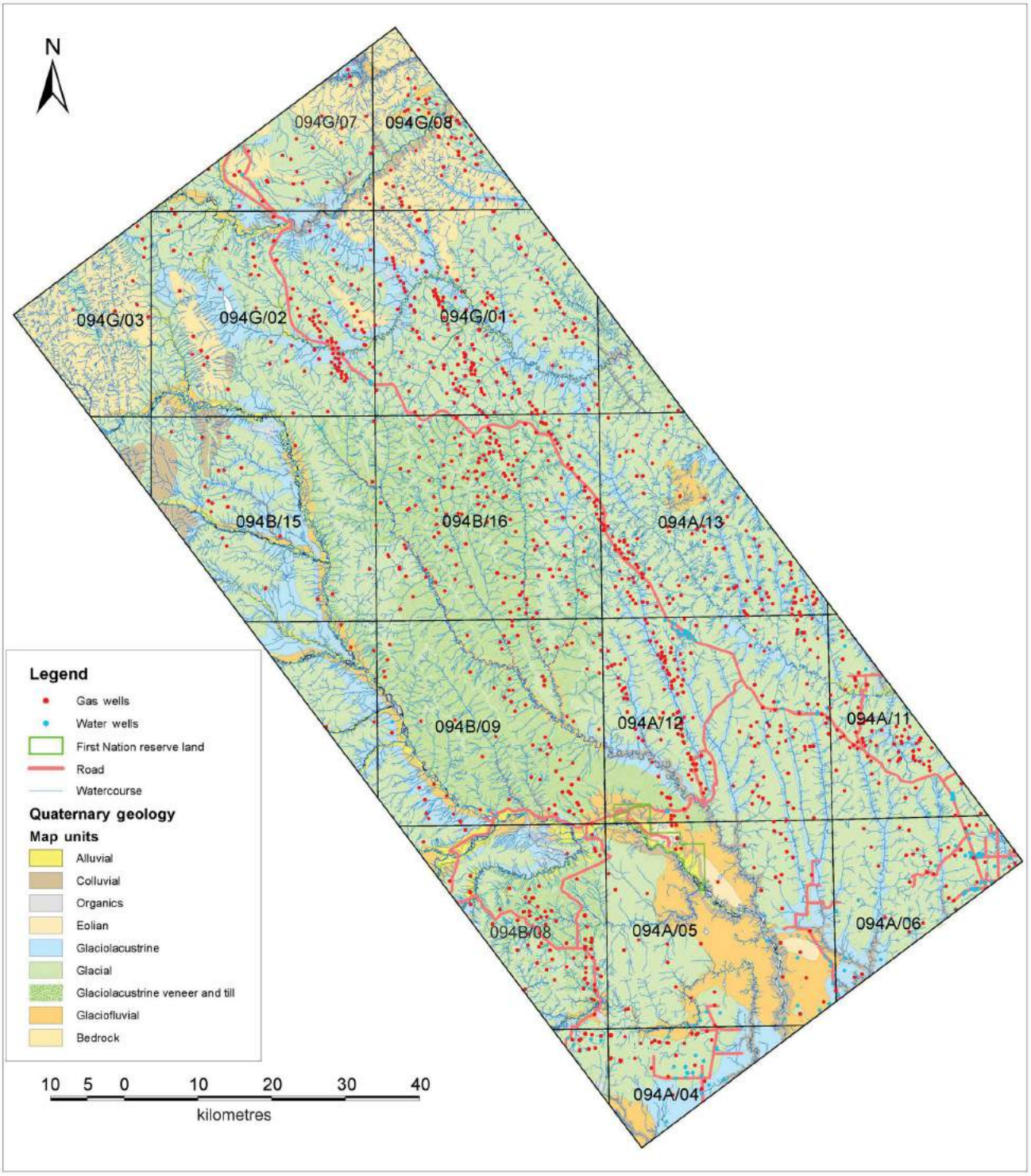

Figure 2. Preliminary surficial geology map, Peace Project area, assembled from existing maps (Lord and Green, 1971, 1986; Lord, 1973, 1977; Green and Lord, 1975; Mathews et al., 1975; Mathews, 1978; BC Ministry of Environment, 1980, 1986, 1987, 1988a, b; Bednarski, 1999, 2000, 2001). Map reflects the original Peace Project area, prior to addition of supplemental areas after project initiation. Surficial geology for the final modified map area will be included in the final project report.

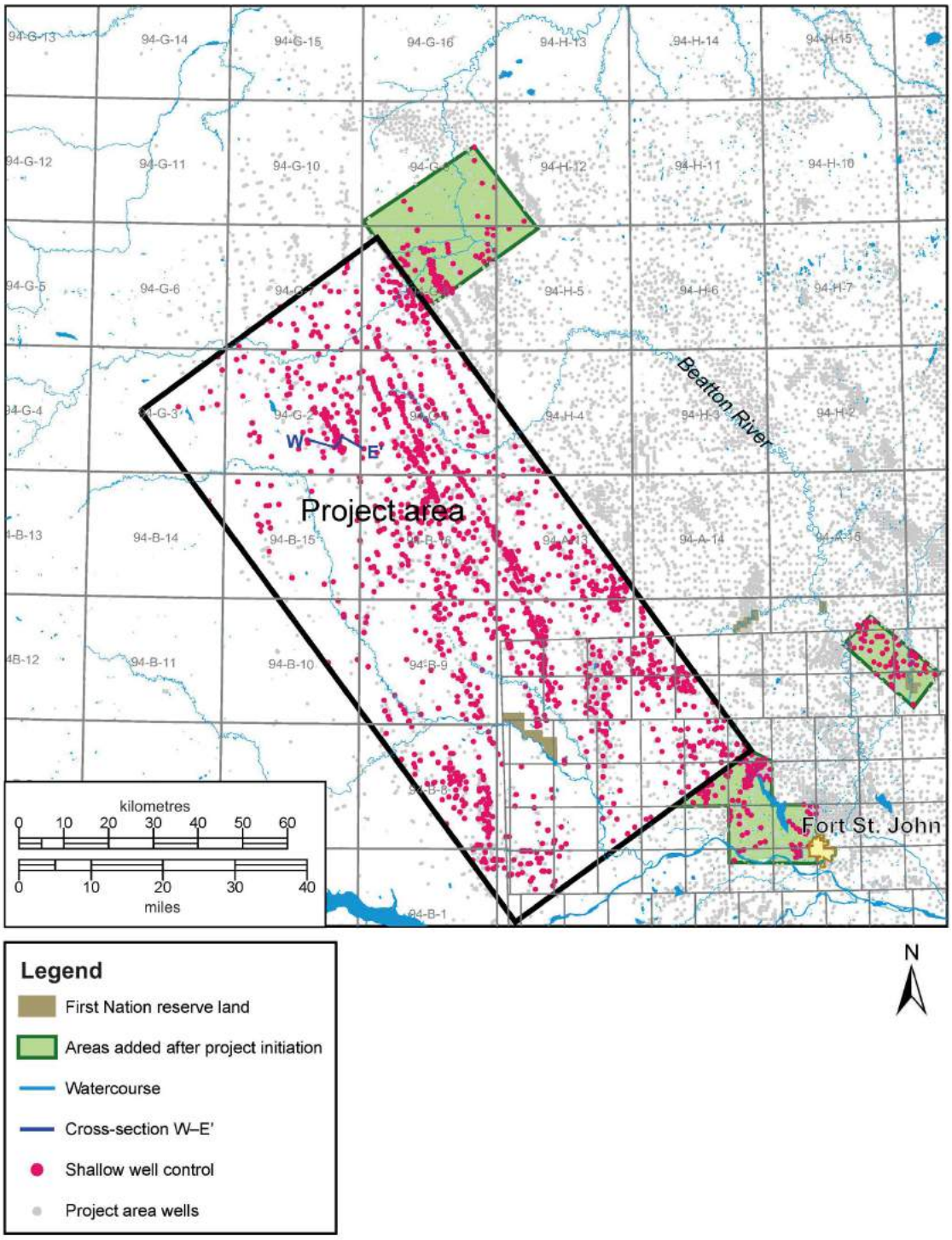

Figure 3. Petroleum borehole wells in Peace Project area. Wells highlighted with red have suitable cased-hole gamma-ray logs and were used in the project. Location of cross-section in Figure 5 is shown.

veneers or as outcrop/subcrop. Approximately 45% of the wells in the study area have been determined, to date, to be in areas of near-surface bedrock.

3) Review all available cased-hole gamma-ray logs from petroleum boreholes in the project area, and select those that have coverage above 50 m true vertical depth (TVD; Figure 3). A significant number of wells do not have gamma-ray–log data shallower than 50 m depth, and are therefore not usable.

- Particular attention was paid to areas where 3-D seismic data may be available to calibrate mapping. A small number of twinned wells, or wells very close to

wells already selected, were not digitized, as they would add little significant information to the study.

- A final well count of approximately 1300 is anticipated across the entire project area, including the supplemental areas added after project initiation.
- The statistical technique of Quartero et al. (2014) is applied to each cased-hole gamma-ray curve to correct for attenuation effects, thus producing a corrected gamma-ray curve. For each well, the upper portion of the uncorrected open-hole gamma-ray curve is merged with the corrected cased-hole gamma-ray curve to create sufficient stratigraphic coverage to complete stratigraphic correlations in the bedrock section. Results are presented as .pdf images (Figure 4) showing both original and corrected curves, and as final corrected curves in .las format.

4) Interpret each corrected gamma-ray curve to identify the unconsolidated sediment-bedrock contact. This is being done using two techniques:
   - from the bottom up, following the bedrock stratigraphy to identify the capping unconformity surface, where the regional succession is truncated; and
   - from the top down, identifying the contact by the contrast in gamma-ray log API values between bedrock and the Quaternary section.
5) Interpret aquifer and aquitard intervals within the Quaternary section, and relate them to the available Quaternary geology data compiled for this project.

In most boreholes, the Quaternary section appears to be very thin, and could not be detected despite log coverage as shallow as about 10 m below surface. Stratigraphic cross-section W-E′, near the Beatton River in the northern part of the study area, illustrates the correlation of Cretaceous markers in the Buckinghorse through Dunvegan formations and the top bedrock surface (Figure 5). Note marked incision of the upper Sully Formation shales on well-logs 200/d-077-A 094-G-02/00 and 200/a-096-A 094-G-02/00, whereas identification of the unconformity surface is less definitive on well-log 200/b-086-B 094-G02/00.

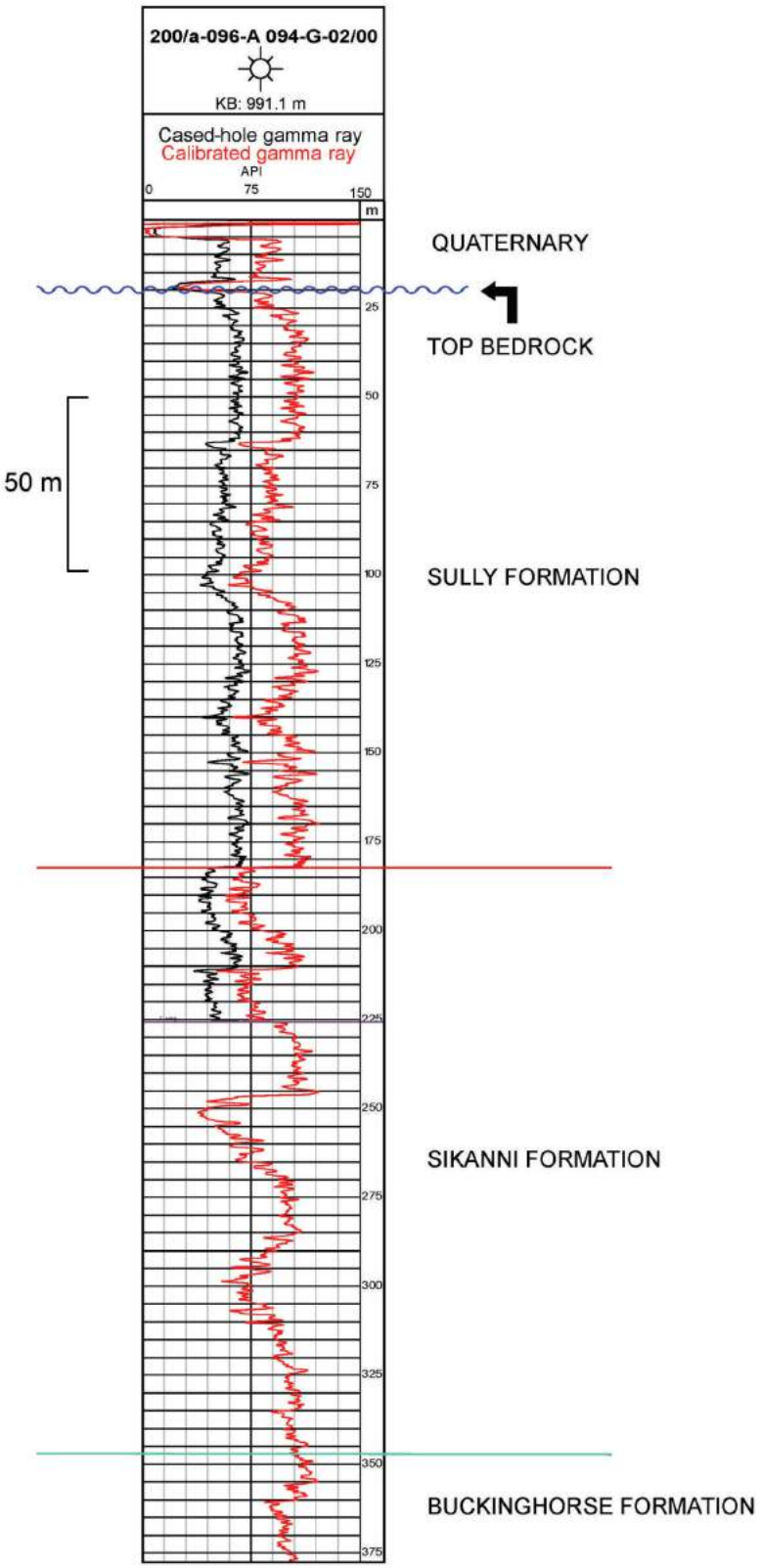

Figure 4. Sample gamma-ray log, well 200/a-096-A 094-G-02/00. Base of surface casing is at drill depth 229 m; the open-hole gamma-ray log is shown below that depth. Above, the cased-hole gamma-ray log is shown in black, whereas the log corrected with the Quartero method (Quartero et al., 2014) is shown in red. Stratigraphic picks can be readily made on the composite red curve. Abbreviation: KB, kelly bushing.

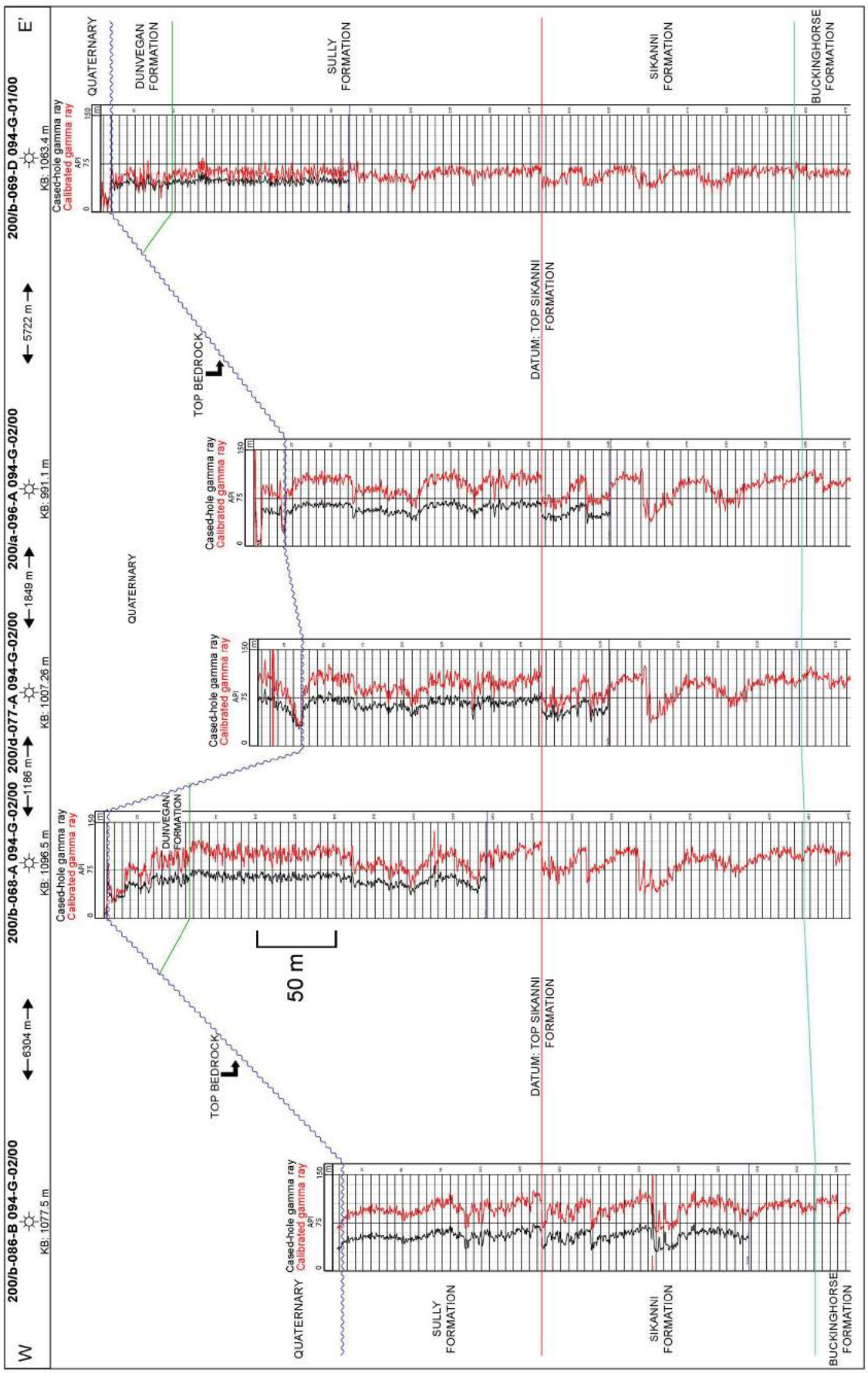

Figure 5. Well-log cross-section, showing erosional relief on the pre-Quaternary unconformity (wavy line). Location of cross-section shown on Figure 3. Abbreviation: KB, kelly bushing.

Next Steps

Completion of the initial phase of the project is scheduled for the end of December 2015, after which comparison and calibration with airborne geophysics results can be undertaken.

Acknowledgments

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